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Name: ______________________ Date: ______________

SKILL and PRACTICE
1.1

Using Your Textbook

Your textbook is a tool to help you understand and enjoy science. Colors, shapes, and symbols are used in the book to help you find information quickly. Take a few minutes to get familiar with these features—it will help you get the most out of your book all year long.

PRACTICE

Part 1: The Introduction

Take a look at the introduction found at the beginning of your textbook. These pages are easy to find because they have a light blue background. Use these pages and the rest of your book to answer the questions below.

1. What color is used to identify Unit 5?
2. List two important vocabulary words for section 5.2.
3. What color are the boxes in which you found these vocabulary words?
4. What is the main idea of the first paragraph on page 24?
5. Where do you find section review questions?
6. What is the first key question for chapter 9?
7. List the four sections found in each Chapter Assessment.

Part 2: The Table of Contents

The Table of Contents is found after the introduction pages. Use it to answer the following questions.

1. How many units are in the textbook? List their titles.
2. Which unit will be the most interesting to you? Why?
3. At the end of each chapter is a two-page article called a “Connection” which describes an interesting application of topics in the chapter. Look at all the Connection titles and list the three that interest you most.
4. What is on the page after each Connection?

Part 3: Tools at the end of the text

At the back of the book, you will find tools to help you use the text. Use these tools to answer the questions.

1. What is the name for the section of the book that lists definitions of words?
2. What is the definition for magma?
3. What is the first page in the text that contains information on the scientific method?
4. On what page will you find information on divergent boundaries?

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SKILL and PRACTICE
1.1

What’s Your Hypothesis?

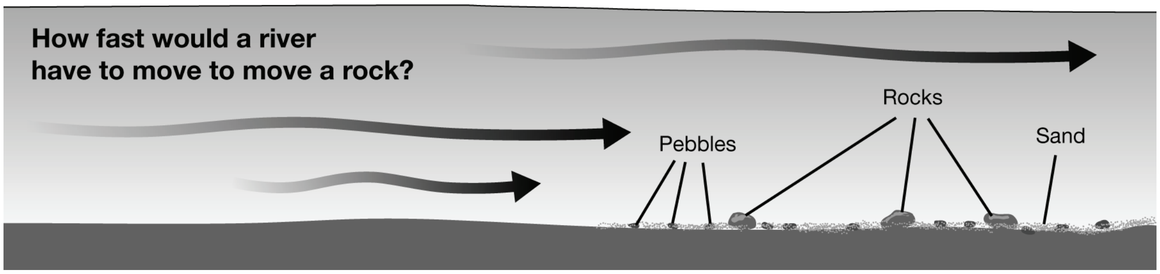
READ

After making observations, a scientist forms a question based on observations and then attempts to answer that question. A guess or a possible answer to a scientific question based on observations is called a **hypothesis**. It is important to remember that a hypothesis is not always correct. A hypothesis must be testable so that you can determine whether or not it is correct.

EXAMPLE

In science class your teacher has told you that the ability of a river to transport material depends on how fast the river is flowing. Imagine the river has three speeds—slow, medium, and fast. Now, imagine the river bottom has sand, marble-sized pebbles, and baseball-sized rocks. Come up with a hypothesis for the answer to the following question. Then, justify your reasoning:

Research question: At which flow rate—slow, medium, or fast—would a river be able to transport baseball-sized rock?



Example hypothesis and justification: The river would have to be flowing at a fast flow rate to be able to transport baseball-sized rocks. It takes more force to move larger rocks than small pebbles and sand. Fast flowing water has more pushing force than medium or slow flowing water. I know this from an experience I had wading in a river one time. As I waded from still water to areas where the river was flowing faster, I could feel the water pushing against my legs more and more.

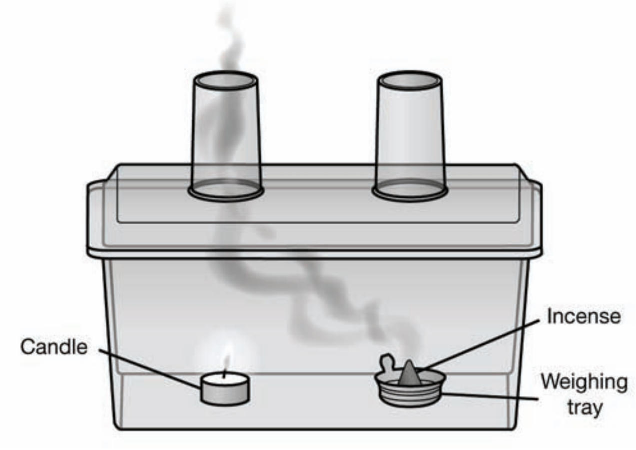
PRACTICE

1. You left a glass full of water by a window in your house in the morning. Three hours later you walk by the glass, and the water level is noticeably lower than it was in the morning. You have made the observation that the water level in the cup is lower. Then, you ask the following question: “Why is the water level in the cup lower?”

   What is a possible hypothesis you could make?

2. Your teacher shows you a demonstration in which there is a box with two chimneys. Under one chimney is a lit candle, and under the other chimney is smoke from burning incense. You observe that the smoke always goes towards the candle and then exits the box from the chimney above the candle. You ask the following question: "Why does the smoke go toward the candle and leave the chimney above the candle?"

   What is a possible hypothesis you could make?



3. You have learned in science class that *evaporation* is a process that describes when a liquid turns to a gas at a temperature below the boiling point. You are now about to investigate evaporation and factors that may increase the rate at which it occurs. You ask the question, "What causes the evaporation rate of water to increase?"

   What is a possible hypothesis you could make?

4. Rivers and streams flow at various speeds. You ask, "What factors increase the flow rate of a river?"

   What is a possible hypothesis you could make?

5. It is late fall and you notice that flower bulbs in your yard have been dug up and some have been eaten. You ask, "What has happened?"

   What is a possible hypothesis you could make?

6. You know that sea otters eat sea urchins and that sea urchins eat kelp. You ask, "What would happen to this ecosystem if all the kelp died?"

   What is a possible hypothesis you could make?

7. In Alaska, lynx (wild cats) are predators of the snowshoe hare. In the wintertime, the coat of the snowshoe hare turns from brown to white. You ask, "Why does the snoeshoe hare change color in the winter?"

   What is a possible hypothesis you could make?

8. In the deserts of the southwestern United States, coyotes are dog-like animals that eat many different things such as small animals and cactus fruit. They are also scavengers, which means they eat dead and decaying animals. You ask, "Are there coyote-like animals that serve as predator-scavengers in other deserts on other continents?"

   What is a possible hypothesis you could make?

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SKILL and PRACTICE 1.2

Averaging

READ

The most common type of average is called the *mean*. Usually when someone (who's not your math teacher) asks you to find the average of something, it is the *mean* that they want. To find the mean, just sum (add) all the data, then divide the total by the number of items in the data set. This type of average is used daily by many people. Teachers and students use it to average grades. Meteorologists use it to average normal high and low temperatures for a certain date. Sports statisticians use it to calculate batting averages and many other things.

EXAMPLE

- William has had three tests so far in his English class. His grades are 80%, 75%, and 90%. What is his average test grade?

  Solution:

  a. Find the sum of the data: 80 + 75 + 90 = 245

  b. Divide the sum (245) by the number of items in the data set (3): 245 ÷ 3 ≈ 82%

  William's average (mean) test grade in English (so far) is about 82%

PRACTICE

1. The families on Carvel Street were cleaning out their basements and garages to prepare for their annual garage sale. At 202 Carvel Street, they found seven old baseball gloves. At 208, they found two baseball gloves. At 214, they found four gloves, and at 221 they found two gloves. If these are the only houses on the street, what is the average number of old baseball gloves found at a house on Carvel Street?

2. During a holiday gift exchange, the members of the winter play cast set a limit of $10 per gift. The actual prices of each gift purchased were: $8.50, $10.29, $4.45, $12.79, $6.99, $9.29, $5.97, and $8.33. What was the average price of the gifts?

3. During weekend baby sitting jobs, each sitter charged a different hourly rate. Rachel charged $4.00, Juanita charged $3.50, Michael charged $4.25, Rosa charged $5.00, and Smith charged $3.00.

   a. What was the average hourly rate charged among these baby sitters?

   b. If they each worked a total of eight hours, what was their average pay for the weekend?

4. The boys on the sixth grade basketball team at Fillmore Middle School scored 22 points, 12 points, 8 points, 4 points, 4 points, 3 points, 2 points, 2 points, and 1 point in Thursday's game. What was the average number of points scored by each player in the game?

5. Jerry and his friends were eating pizza together on a Friday night. Jerry ate a whole pizza (12 slices) by himself! Pat ate three slices, Jack ate seven slices, Don and Dave ate four slices each, and Teri ate just two slices. What was the average number of slices of pizza eaten by one of these friends that night?

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SKILL and PRACTICE 1.2

Stopwatch Math

READ

What do horse racing, competitive swimming, stock car racing, speed skating, many track and field events, and some scientific experiments have in common? It’s the need for some sort of stopwatch, and people to interpret the data. For competitive athletes in speed-related sports, finishing times (and split times taken at various intervals of a race) are important to help the athletes gauge progress and identify weaknesses so they can adjust their training and improve.

EXAMPLE ▶

Three boys ran the following times for 400 meters (one lap around the track) in their gym class: Joe ran 1:13.02 (1 minute, 13.02 seconds), Rocco ran 1:13.2 (1 minute, 13.2 seconds), and Eric ran 1:13 (1 minute, 13 seconds.) In what order did they finish?

The boy who came in first is the one with the fastest (smallest) time. Compare each time digit by digit, starting with the largest place-value (the largest place value is the one that is farthest to the left). Here, that would be the minutes place.

There is a “1” in the minutes' place of each time, so next, compare the seconds' place. Notice that the second's place in each case has a different number of digits. It is helpful to rewrite each one so that it has the same number of digits to the right of the decimal point. The table below shows the rewriting process and makes it easy to compare the times:

Name	Given Time	Rewritten Time	Finishing Place
Joe	1:13.02	1:13.02	
Rocco	1:13.2	1:13.20	
Eric	1:13	1:13.00	

Since Rocco's time has larger numbers in the seconds' place (13.20) than Joe (13.02) or Eric (13.00), his time is larger (slower) than the other two. We know Rocco finished third out of the three boys. Now, comparing Joe's time (13.02) to Eric's (13.00), notice that Joe's time is larger (slower) than Eric's (13.02 > 13.00). This means that Eric's time was fastest (smallest), so he finished first, followed by Joe. Rocco's time was the slowest (largest).

PRACTICE

1. Put each set of times in order from fastest to slowest. Use the tables to help you compare the times. After using the tables to help rank the times, rewrite them in order from fastest to slowest.

a. 5.07 0.507 0.57

Given time	Rewritten time	Rank
5.07		
0.507		
0.57		

b. 33.033 33.3 33.03 33 33.303

Given time	Rewritten time	Rank
33.033		
33.3		
33.03		
33		
33.303		

2. The table below gives the winners and their times from eight USA track and field championship races in the women's 800 meter run. Rewrite the table so that the times are in order from fastest to slowest. Please include the times and the years.

Year	2005	2004	2003	2002	2001	2000	1999	1998
Time	1:59.74	1:59.06	1:58.84	1:58.83	2:00.43	1:58.97	1:59.47	1:58.78
Name	Hazel Clark	Jearl Miles-Clark	Jearl Miles-Clark	Nicole Teter	Regin Jacobs	Hazel Clark	Jearl Miles-Clark	Jearl Miles-Clark

Time								
Year								

3. The following are times recorded during an experiment with rolling a ball down hill. Put them in order from fastest to slowest.

   a. 1:07.3 1:06 1:07.1 1:05.03 1:06.03 1:05.3 1:07.05 1:06.11 1:05.32

Fastest								Slowest

   b. 1:04 1:08.02 1:05.3 1:05.05 1:04.25 1:08 1:04.44 1:08.3 1:05

Fastest								Slowest

   c. 1:03.7 1:06.02 1:03.09 1:04.11 1:03 1:06.033 1:04.01 1:04.55 1:06.9

Fastest								Slowest

   d. From a, b, and c above, what are the three fastest times overall?

4. Write a set of five times (in order from fastest to slowest) that are all between 6:10 and 6:11. Do not include the given numbers in your set.

Name: ______________________________ Date: ______________

Reading Strategies (SQ3R)

READ

Commonly, we read a science textbook as if we were watching a movie—we just sit there and expect to take it all in. Actually, reading a science book is more like playing a video game. You have to interact with it! This skill sheet will teach you active strategies that will improve your reading and study skills. Remember—just like in video game playing—the more you practice these strategies, the more skilled you will become.

The **SQ3R** active reading method was developed in 1941 by Francis Robinson to help his students get the most out of their textbooks. Using the SQ3R method will help you interact with your text, so that you understand and remember what you read. “SQ3R” stands for:

- **Survey**
- **Question**
- **Read**
- **Recite**
- **Review**

Your student text has many features to help you organize your reading. These features are highlighted in Chapter 1: Science Is Everywhere. Open your text to Chapter 1 so that you can see the features for yourself.

Survey the chapter first.

- Skim the *introduction* on the first page of every chapter. Notice the *key questions*. The key questions are thought-provoking and will engage you in the chapter. See if you can answer these questions after you have read the entire chapter.
- You will find *vocabulary* words in the blue box with the definition on the right side of the page.Vocabulary words are scattered throughout the chapter. Write down any vocabulary words that are unfamiliar to you to help you recognize them later.
- Next, skim the chapter to get an overview. Notice the *section numbers and titles*. These divide the chapter into major topics. The *subheadings* in each section outline important points. Vocabulary words are highlighted in bold. Tables, charts, and figures summarize important information throughout each section.
- Read the *section review* questions at the end of each section. The questions help you identify what you are expected to know when you finish your reading. You will also find *Challenge* or *Solve It!* boxes with the section review. These boxes provide an interesting way to learn more about information in the section.
- At the end of each chapter you will find a reading called the *Chapter Connection* and the *Chapter Activity.* Connection readings are like magazine articles with interesting science facts. Chapter connection articles always end with a set of engaging questions for you to answer to test your reading comprehension. The chapter activity is a hands-on project that you can do in school or at home. The activity will help you learn more about the information in the chapter.
- Carefully read the *Chapter Assessment* at the end of the chapter to see what kinds of questions you will need to be able to answer. Notice that it is divided into four subtitles: Vocabulary, Concepts, Math and Writing Skills, and Chapter Project. These questions are listed by chapter section. The chapter project provides you with an additional way to practice new skills or learn information.

Question what you see. Turn headings into questions.

- Look at each of the section headings and subheadings, found at the top of pages in your text. Change each heading to a question by using words such as who, what, when, where, why, and how. For example, **Section 1.1: Learning about Science** could become *How do we learn about science?* The subheading **What is science?** would remain the same. The subheading **Fields of science** could become *What are some fields of science?* Write down each question and try to answer it. Doing this will help you pinpoint what you already know and what you need to learn as you read.

Read and look for answers to the questions you wrote.

- Pay special attention to the *sidenotes* in the left margin of each page. For example, under the subheading **What is science?** the sidenotes are **Observe, Ask a question,** and **Make a hypothesis.** These phrases and short sentences are designed to guide you to the main idea of each paragraph. Also note the sidebars and illustrations on the right side of the page with additional explanations and concepts. For example, **Figure 1.3** on page 6 of your text illustrates some important scientific fields.
- Slow your reading pace when you come to a difficult paragraph. Read difficult paragraphs out loud. Copy a confusing sentence onto paper. These methods force you to slow down and allow you time to think about what the author is saying.

Recite concepts out loud.

- This step may seem strange at first, because you are asked to talk to yourself! But studies show that saying concepts out loud can actually help you to record them in your long-term memory.
- At the end of each section, stop reading. Ask yourself each of the questions you wrote in step two on the previous page. Answer each question out loud, in your own words. Imagine that you are explaining the concept to someone who hasn't read the text.
- You may find it helpful to write down your answers. By using your senses of seeing, hearing, and touch (when you write) as you learn, you create more memory paths in your brain.

Review it all.

- Once you have finished the entire chapter, go back and answer all of the questions that you wrote for each section. If you can't remember the answer, go back and reread that portion of the text. Recite and write the answer again.
- Next, reread the key questions at the beginning of the chapter. Can you answers these?
- Complete the section reviews and different parts of the chapter assessment at the end of the chapter. Use the glossary and index at the back of the book to help you locate specific definitions.

PRACTICE

The SQ3R method may seem time-consuming, but it works! With practice, you will learn to recognize the important concepts quickly.

Active reading helps you learn and remember what you have read, so you have less to re-learn as you study for quizzes and tests.

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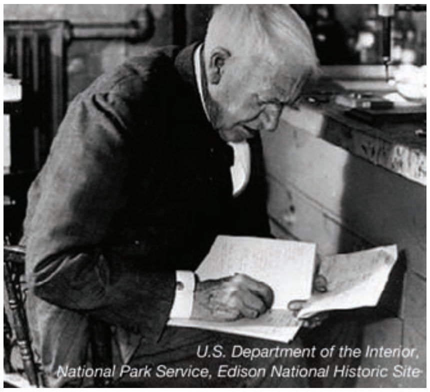
Lab Notebooks

READ

A laboratory notebook is an important tool in science. The photograph at the right shows Thomas Edison writing in his notebook. He was a important inventor in the development of the modern light bulb.


U.S. Department of the Interior, National Park Service, Edison National Historic Site

What does a lab notebook look like?

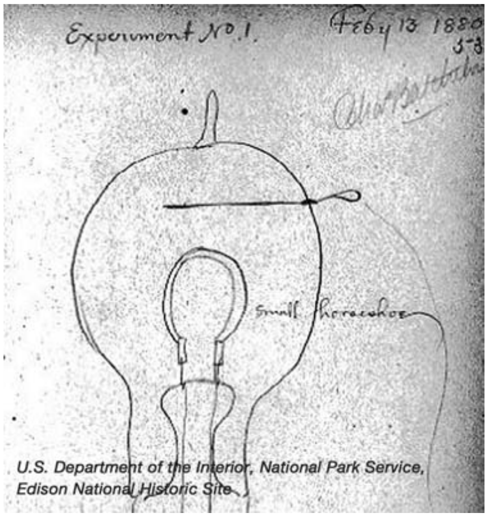
- Lab notebooks should be permanently bound.
- Each page should be numbered and dated.
- Write on pages in order. Make notes with page numbers if an entry has to continue on the following page or another page.
- Use ink when writing so that the information is not easily erased. Ball point pens or gel pens are good for resisting water spills.
- Write legibly in your notebook so that other people can read it.

PRACTICE

1. Why do you think it's important for the lab notebook to be permanently bound? In other words, why would you NOT want to use a loose-leaf or spiral-bound notebook?
2. Sylvia has just realized that she has discovered a new formula for toothpaste. She applies for a patent on her formula and learns that someone else has invented the same formula! She has kept her laboratory notebook up-to-date throughout her research. Could her notebook could help her prove that she discovered the formula first? If so, how?

What does a lab notebook contain?

A scientist's notebook contains observations and conclusions, experiments, drawings, and graphs. The image at the right is a page from the notebook of Thomas Edison. Study this image to answer the following questions.



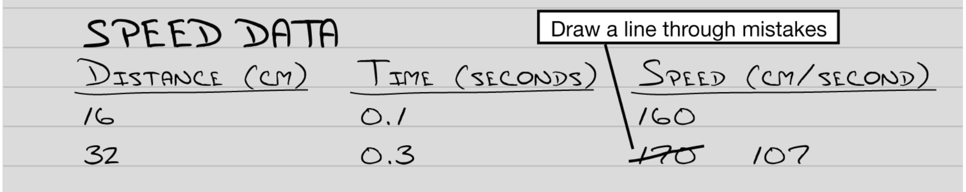
U.S. Department of the Interior, National Park Service, Edison National Historic Site

3. When was this page entered into Edison's notebook?
4. Why is it important to write the date on each page of your lab notebook?
5. To which number experiment is the drawing related?
6. Why might it be important to number your experiments in a scientific study?
7. What object does Thomas Edison's drawing represent?
8. Based on this lab notebook page, come up with a hypothesis about what Edison might have been working on or studying when he wrote this page.

Mistakes are okay in a lab notebook

Mistakes are common in a lab notebook. This is because lab notebooks are a record of a thought process. It is always important to write down ideas even if they are far-fetched. Of course, because a lab notebook is not a polished document, it is easy to make small written mistakes.

No matter what kind of mistake is made, you should never erase the mistake. This is because mistakes are an important record of the thought process and, importantly, mistakes can spark new ideas or discoveries. When a mistake is made, a line is drawn through it so that the word or number is still readable (see example below).



SPEED DATA

DISTANCE (CM)	TIME (SECONDS)	SPEED (CM/SECOND)
16	0.1	160
32	0.3	~~170~~ 107

Draw a line through mistakes

9. You write the following incorrect statement in your lab notebook: *The formula for speed of a car is time divided by distance*. Re-write this statement and draw a line through the incorrect part. Above the statement, write the correction.

10. State one reason why it is not a good idea to erase a mistake in a lab notebook.

Lab notebook format

Part of notebook	
Title page	Name, location, date (the first page).
Table of contents	Lists all contents of the notebook and is completed as the notebook pages are filled (two - three pages right after the title page).
What to write	The science process helps you know what to write. You should record your observations and book or Internet research that you do before, during, and after any experiment. Also, you should write your research question and your hypothesis. Write a short paragraph that justifies why you are making a particular hypothesis. Then record all the details of the experimental procedure (including a materials list), data, and calculations. Data can be descriptions or measurements. Tables and graphs of your data are very important. A conclusions paragraph summarizes your experiment and its results. In this paragraph, you state whether or not your hypothesis was correct and state any new hypotheses you have.

11. Why is it important to have a table of contents in your lab notebook?

12. You are about to begin an experiment to test which of two brands of sugarless gum keeps its flavor the longest. Make a sample lab notebook page for this experiment. Your materials include samples of two brands of sugarless gum and a stopwatch or watch with a second-hand. You will also need a group of people to test the gum. After you have made your sample page, compare it with others made by your classmates. Alternatively, your teacher might have a classroom discussion to talk about the important items to include on this sample page.

13. State two reasons why it is important to keep a detailed laboratory notebook of all your work in a lab.

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SKILL and PRACTICE 1.2

Observations versus Opinions

READ

An observation is an accurate description of a thing or an event. An observation is a statement of fact. Here are some examples of facts based on evidence or observation:

- 2 + 2 = 4
- The Sun is the center of our solar system.
- My pizza has cheese and mushrooms on top of it.

These observations or facts can be proven to be true. On the other hand, an opinion about a subject is unique to the person that has that opinion. Opinions are based on one’s experiences or beliefs. Here are some examples of opinions:

- Math is fun!
- In ten years, more people will be driving hybrid cars than will be driving gasoline-only powered cars.
- I don’t like mushrooms on my pizza.

Now, practice identifying and interpreting observations and opinions.

PRACTICE

1. The mathematical statement, 2 + 2 = 4, is a fact. Imagine you have a bunch of apples. How could you use the apples to prove this statement is a fact?
2. The mathematical statement, 10 ÷ 2 = 5, is a fact. Imagine you have a 10 oranges. How could you use the oranges to prove this statement is a fact?
3. The statement, Earth rotates one time each day (24 hours), is a fact. List some pieces of evidence that support this fact.
4. The statement, “Math is fun!” is an opinion. How can you prove that this statement is an opinion? Write a short paragraph to answer this question.
5. Your teacher has ordered three pizzas for your class. One is a cheese pizza, one is a cheese and mushroom pizza, and one is a cheese and pepperoni pizza. After lunch, you notice that the cheese pizza is all gone. You also notice that half of the pepperoni pizza is left over and half of the cheese and mushroom pizza is left over. Make a statement of fact about this situation based on this pizza data.
6. Your school wants to pick new school colors. You would like the colors to be green and yellow. A survey of all the students reveals that 60% of the students prefer blue and yellow, 15% prefer green and yellow, and 25% prefer red and yellow. From this scenario, state one opinion and one observation.
7. Next year, you will be one year older and in the next grade. State one opinion about next year. Now, state one fact about next year that you know to be true.

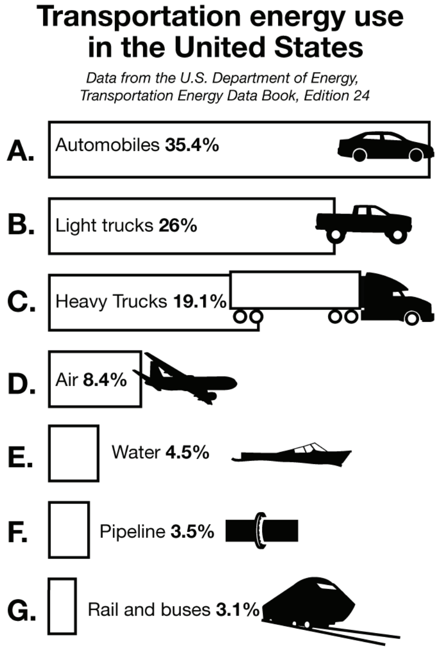
8. A hypothesis is a type of opinion based on observations and evidence. If a hypothesis is proven by one experiment, it may be true. However, in science, many experiments need to occur to fully test a hypothesis. From the following data collected by growing four plants grown under different colors of light, state a hypothesis.

Color of light	White light	Blue light	Green light	Red light
Plant number and height	#1, 10 cm	#2, 8 cm	#3, 5 cm	#4, 7 cm

9. The five senses are seeing, hearing, touching, tasting, and smelling. Each of these senses can be valuable in making observations.
Imagine that you are at a baseball game. What kinds of things would you see, hear, touch, taste, and smell at a baseball game? In the table below list possible observations for each sense. In the next column, list an opinion related to each sense.

Sense	Observation	Opinion
Seeing		
Hearing		
Touching		
Tasting		
Smelling		

10. Here is a bar graph of transportation energy use in the United States. List five observations about this bar graph. Then, list two opinions that you can form from studying this graph.



Name:____ Date:_______________

Geerat (Gary) Vermeij

Gary Vermeij probably knows more about molluscs—a group of animals including snails and shellfish—than anyone else alive today. He studies both mollusc fossils and living molluscs from around the world.

Early years in Holland

Photo courtesy of Mary Doval Graziose

Gary Vermeij (Ver-MAY) was born in Holland in 1947. There, his parents learned that extra fluid inside Gary's eyes was damaging his vision. Gary remembers seeing colors, but shapes were never very sharp. Doctors tried to fix the problem. But when Gary was three, he became completely blind.

Gary's parents loved the outdoors. They took him on walks where he picked up shells, pine cones, and little creatures that lived in the grass. He wanted to know the names of each one.

Gary went to a boarding school for blind students. He hated being away from home. When he was nine, his family moved from Holland to New Jersey. There, he could live at home and go to the local school.

Fourth grade discoveries

When Gary was in fourth grade, his teacher went to Florida. She brought back a bunch of shells and set them on a windowsill to decorate the classroom.

The shells amazed Gary. The shapes were so fancy. These shells were smoother and felt more polished than shells he had collected in Holland and New Jersey.

Gary says the first scientific question he asked himself was, "Why are these Florida shells so much prettier than the shells from Holland? Why don't they have the same chalky texture?"

A growing interest

Gary's interest in shells grew. His family made trips to the shore, where he added to his collection. His parents and brother read aloud every book they could find on seashore animals and plants.

Gary worked hard in school. He had Braille textbooks and used a typewriter for his homework. He finished high school with the highest grades in his class!

More questions

In college, Gary studied biology and geology. Then he went to Yale University. There, he had to write a long paper that answered a scientific question.

Can you guess what he chose to write about? Gary's paper explained some reasons why snails from warm oceans are different from cool ocean ones.

Gary discovered that a cool-water snail has to use a lot more energy to build a shell than a warm-water snail does, so its home is usually simpler.

Warm-water snails, Gary found, also have stronger, fiercer predators. They need stronger shells in order to survive.

A scientist's life

Gary's days are busy. He teaches classes in biology, ecology, and geology at the University of California-Davis.

He also does a lot of field work—which means getting into the water to observe molluscs where they live. He says, "I have been stung by rays and bitten by crabs, and I have slipped on rocks and suffered from stomach cramps. There isn't a field scientist who hasn't had things like these happen. Life without risk is life without challenge. You can't hope to understand nature without experiencing it firsthand."

Gary writes books and articles in science journals to share what he learns. He writes about predator-prey relationships, why some molluscs have become extinct, and what happens when an animal invades a new area.

If you want to be a scientist…

Gary has some advice for students who want to be scientists. He says you need to be curious, hard working, and willing to risk being wrong sometimes.

Reading reflection

1. What did Gary like to do as a little boy in Holland?
2. How did Gary first become interested in shells?
3. How did his family help him learn about shells?
4. Gary said, “I have been stung by rays and bitten by crabs, and I have slipped on rocks and suffered from stomach cramps. There isn’t a field scientist who hasn’t had things like these happen. Life without risk is life without challenge.”

   Think about the statement, “Life without risk is life without challenge.”
   There are two kinds of risks: foolish risks, like riding in a car without buckling your seat belt, and healthy risks, like trying out for the soccer team even though you might not make it.
   List three healthy risks you have taken in your life. Write a paragraph to explain what you learned from each one.
5. Gary says to be a scientist you have to be willing to risk being wrong sometimes. Why do you think this is important?

Extension:

6. Think about a time when you were curious about something in nature. What scientific question did you ask?
7. Name three ways you could get more information to answer your scientific question. (Example: E-mail a university professor.)
8. **Research:** Choose one way to get information to answer your question. Write a paragraph to read out loud so you can share your answer with your classmates.

Name: Date:

Types of Graphs

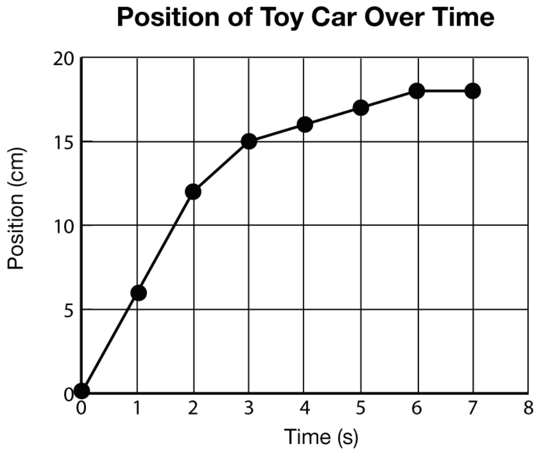
READ

A graph is a picture that helps you understand data. Graphs are easier to read than tables of numbers, so they are often used to display data collected during an experiment. The three main types of graphs you will use are line graphs, bar graphs, and pie graphs. With a little practice, you will be able to identify these types of graphs and recognize which type of data best fits which type of graph.

EXAMPLES

Line Graph

A line graph shows how the *independent variable* causes the *dependent variable* to change in value. The data graphed at right shows how far a toy car traveled down a ramp over a period of time. For this data set, the independent variable is the time traveled. The dependent variable is the position of the car. The two variables are related. The position of the car **depends** on how long it has been traveling.



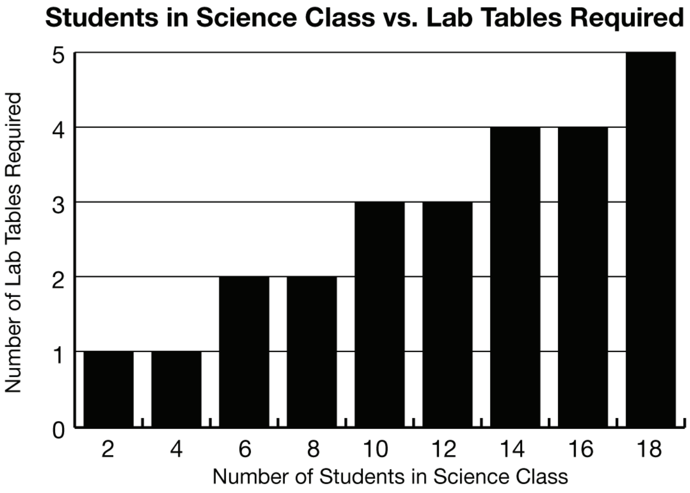
Line graphs are the best type of graph to use when your independent variable is *continuous*, meaning that the data continues uninterrupted between each of the points in your data set.

Time is a continuous independent variable because you can divide it into smaller and smaller pieces, like half a second or a tenth of a second, or even smaller. The data could have been collected at any of these points.

If your data is continuous and one of your variables causes the other to change in value, use a line graph.

Bar Graph

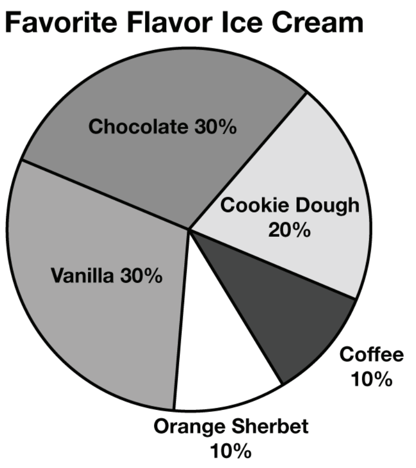
A bar graph is best for comparing separate categories of information. The graph is made of a series of "bars" of different values drawn along an axis. The data shown in this bar graph relates the number of students in a science classroom to how many lab tables are needed.



Like line graphs, bar graphs have an independent and a dependent variable. For this data set, the independent variable is the number of students and the dependent variable is the number of lab tables needed. The number of lab tables **depends** on the number of students.

Use a bar graph when your variables compare categories of information, or when your data is *not continuous*. This means that your data consists of exact values—like a certain number of students. You can have an exact number of students, like four or six or ten, but you cannot have a continuous number, like 4.5 students. If your data is something that was counted rather than measured, it is probably *not continuous*.

Pie Graphs



A pie graph is a circular graph that compares the parts of something to the whole. The data is usually written in percentages or fractions of the whole. Each part is drawn as a “slice” of the pie, so you can compare the different sizes of the “slices” to each other **and** to the whole pie. Surveys usually give data sets that work well in pie graphs.

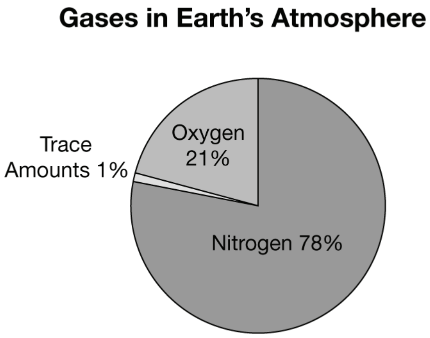
For this graph, a class of sixth grade students was given a survey asking them to identify their favorite flavor of ice cream.

PRACTICE 1

Name the type of graph shown in the following four examples

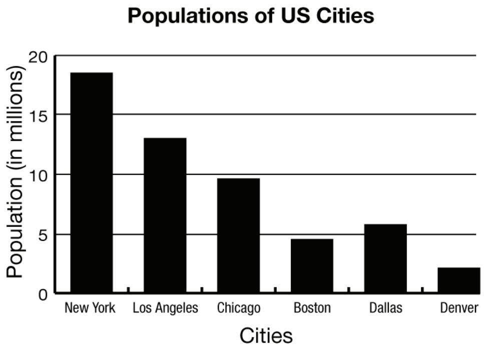
.

Graph #1:



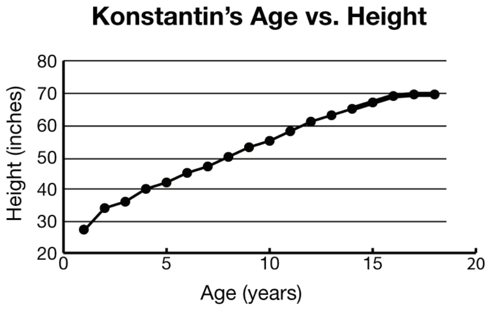
Type of graph ________________________

Graph #2:



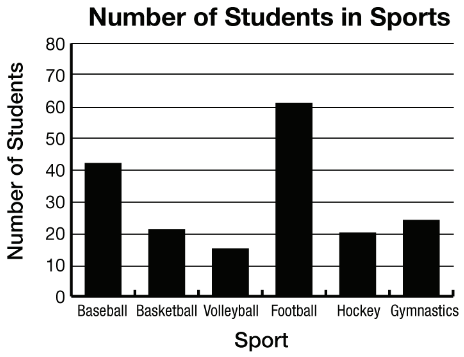
Type of graph ________________________

Graph #3:



Type of graph ________________________

Graph #4:



Type of graph ________________________

PRACTICE 2

Describe which type of graph—line graph, bar graph, or pie graph—would be most appropriate for the following data sets. Explain your reason.

Data Set #1: Most Popular Dog Breeds in Middleton

Dog Breed	Percent of Middleton dog owners who own this breed of dog	Type of graph you would use:
Golden Retriever	30%	Reason:
German Shepherd	20%	
Beagle	20%	
Poodle	20%	
Rottweiler	10%	

Data Set #2: Length of Students' First Names

First Name	Number of letters	Type of graph you would use:
Jasmine	7	Reason
Alejandra	9	
Kenji	5	
Lola	4	
Jordan	6	

Data Set #3: Air Temperature

Time	Air Temperature (°F)	Type of graph you would use:
3 pm	86	Reason
4 pm	88	
5 pm	84	
6 pm	80	
7 pm	79	

Data Set #4: How Students Get to School

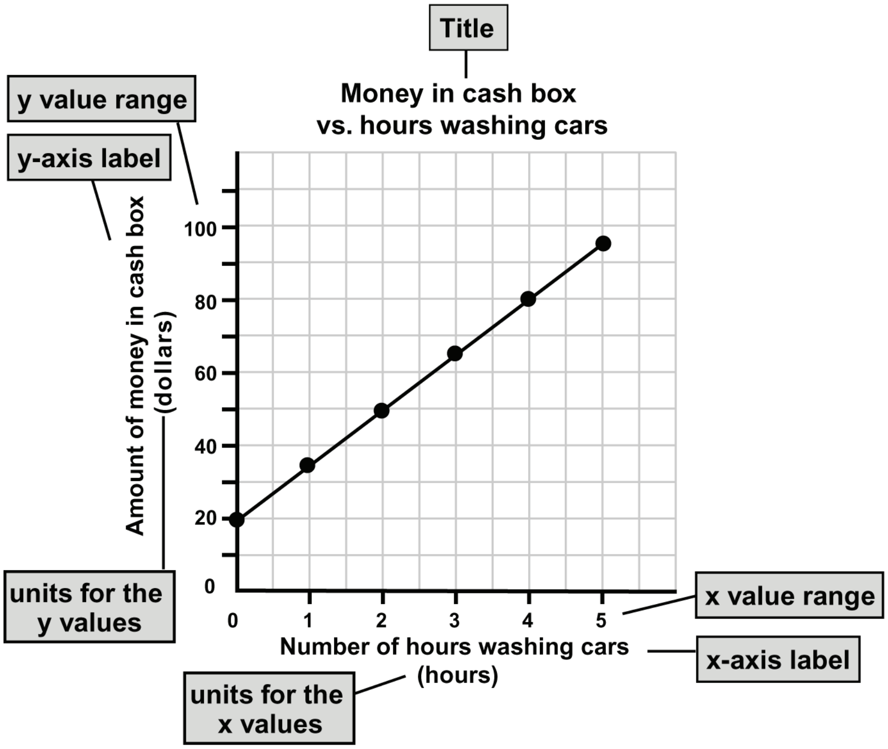
Method	Number of students who get to school with this method	Type of graph you would use:
Bus	16	Reason
Walk	10	
Car	8	
Taxi	1	
Bicycle	3	

Name: ______________________________ Date: ____________________

Reading Graphs

READ

- The three main kinds of graphs are line graphs, bar graphs, and pie graphs.
- To learn how to interpret graphs, we will start with an example of a line graph. The data presented on the graph below is the money earned during a car wash that lasted for five hours. Use this graph to follow the steps and answer the questions below.



PRACTICE

Step 1: Read the labels on the graph.

1. What is the title of the graph?

2. Read the labels for the *x*-axis and the y-axis. What two variables are represented on the graph?

Step 2: Read the units used for the variable on the *x*-axis and the variable on the *y*-axis.

3. What unit is used for the variable on the *x*-axis?

4. What unit is used for the variable on the *y*-axis?

Step 3: Look at the range of values on the *x*- and *y*-axes. Do the range of values make sense? What would the data look like if the range of values on the axes was spread out more or less?

5. What is the range of values for the x-axis?

6. The range of values for the *y*-axis is 0 to $120. What would the graph look like if the range of values was 0 to $500? Where would the data appear on the graph if this were the case?

Step 4: After looking at the parts of the graph, pay attention to the data that is plotted. Is there a relationship between the two variables?

7. Is there a relationship between the variables that are represented on the graph?

Step 5: Write a sentence that describes the information presented on the graph. For example, you may say, "As the values for the variable on the *x*-axis increase, the values for the variable on the *y*-axis decrease."

8. Write your own description of the graph on page one.

9. The theater club at your school needs to raise $1000 for a trip that they want to take. They will be taking the trip next fall. It is now April. Based on the graph, would you recommend that the group wash cars to raise money? Write out a detailed response to this question. Be sure to provide evidence to support your reasons for your recommendation.

PRACTICE

Now apply what you know about interpreting graphs to a bar graph. Use the steps from part one to help you answer the questions.

1. What is the title of this graph?

2. What variables are represented on the graph? (Hint: there are three variables.) Describe each variable in terms of the categories or the range of values used.

3. Write a sentence that describes how the percentage of teenagers employed compares from city to city. Do not state any conclusions about the data in your sentence.

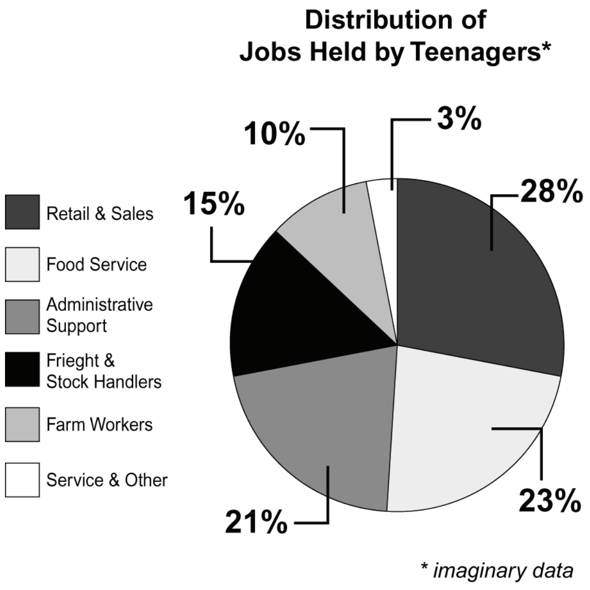
4. Write a sentence that describes how the percentage of boys employed compares to the percentage of girls employed. Do not state any conclusions about the data in your sentence.

5. Based on the data represented in the graph, come up with a hypothesis for why the percentage of teenagers employed differs from city to city.

6. Based on the data represented in the graph, come up with a hypothesis to explain the employment differences between boys and girls in these cities.

PRACTICE

Now apply what you know about interpreting graphs to a pie graph. Use the steps from part one to help you answer the questions.



1. What is the title of this graph?
2. What variables are represented on the graph? (Hint: there are two variables.)
3. Are any units used in this graph? Explain your answer.
4. If you were going to report on this data, what would you say? Write two to three sentences that describe this graph. Do not state any conclusions about the data in your sentence.
5. Come up with a hypothesis based on the data in this graph. Briefly describe how you would test your hypothesis.
6. Do you have a job? If so, in which category does your job fit? Do you think this pie graph accurately represents the working teenager population in your area? Explain your response.

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Name: ____________________ Date: ____________________

Study Notes

READ

This skill sheet will help you take notes while you read. Each paragraph in the text has a sidenote. Fill in the table as you read each section of your textbook. Use the information to study for tests!

- First, write in the number of the section that you are reading. For example, the first section of the text is 1.1. This is the first section in chapter 1 of the text.
- For each paragraph that you read, write the sidenote. Then, write a question based on this sidenote. As you read the paragraph, answer your own question.
- When you study, fold this paper so that the answers are hidden. Use separate paper to write answers to each of your questions. Then unfold this paper and check your work.

EXAMPLE

An example of how to fill in the table:

Page number	Sidenote text	Question based on sidenote	Answer to question
4	Make a hypothesis	How do I make a hypothesis?	First I make observations that lead to a scientific question. A hypothesis is a possible answer to the question based on my observations.

PRACTICE

Section number: __________

Page number	Sidenote text	Question based on sidenote	Answer to question

Section number: __________

Page number	Sidenote text	Question based on sidenote	Answer to question

Name: ______________________ Date: ______________

SKILL and PRACTICE
1.3

Scientific Method

READ

The scientific method helps you find answers to your questions about the world. It starts with a question and a possible answer to the question based on your observations. This “answer” is called your hypothesis. The next step is to test your hypothesis by creating experiments that can be repeated by other people in other places. If your experiment is repeated many times with the same results and conclusions, this information becomes part of the scientific knowledge we have about the world.

Steps to the Scientific Method
1. Make observations.
2. Ask a question.
3. State a hypothesis.
4. Collect data.
5. Draw conclusions.

- Read the following story. You will use this story to practice using the scientific method.

  Anna and her father are going away for a week to visit relatives. The relatives live ten hours away by car. It is warm outside when they leave for the trip, so her father closes the windows and turns on the air conditioning. Anna has been learning about energy conservation in science class and wonders if the air conditioning makes the car use a lot more gas. The car is driving on the freeway, and there is not a lot of traffic. Opening the windows would keep the car cool enough. She asks her father if he thinks it would be better to open the windows to save on fuel. Her father believes that opening the windows would be worse because it makes the car less aerodynamic. Anna thinks he is wrong. They decide to do an experiment to find out whether it is better to use the air conditioner or open the windows.

- Now, answer the following questions about the process they used to reach their conclusion.

PRACTICE

Make observations

1. What are the observations that Anna has made?

Ask a question

2. What question do Anna and her father want to answer during the experiment?

State a hypothesis

3. What is Anna’s father’s hypothesis for the experiment?

4. What is Anna’s hypothesis for the experiment?

Collect data

5. What data will Anna and her father have to collect during the experiment?

   They get off the freeway at the next exit and fill the gas tank.They decide to drive for the next three hours with the air conditioning on and the windows closed.

6. What piece of data should they record before they start driving?

   Three hours later, they stop for lunch and fill up the gas tank.

7. What two pieces of data should they record while they are at the gas station?

   When they get back on the freeway, they turn off the air conditioning and drive with the windows down. They stop again for gas in three hours.

8. What information should they record?

Draw conclusions

When the air conditioning was on, they drove 187 miles and used 5.5 gallons of gas. With the windows open, they drove 160 miles and used 5 gallons of gas.

9. If you look at the data (without doing calculations), can you tell which way of driving was more efficient?
10. The car’s fuel efficiency can be evaluated by calculating the number of miles traveled per gallon of gasoline used. Divide the miles traveled by the gallons of gas used to calculate the mpg for each way of driving.
11. What should Anna and her father conclude about this experiment?
12. Were the conditions of the two parts of the experiment identical? Explain.
13. How do you think Anna and her father could get more accurate results?

Name: ______________________________ Date: ______________

SKILL and PRACTICE
2.1

Dimensional Analysis

READ

Dimensional analysis is a way to tell what the correct label (also called units or dimensions) for the solution to a problem should be. In dimensional analysis, we treat the units the same way that we treat the numbers. For example, this problem shows how you can “cancel” the sixes and then perform the multiplication:

$$\frac{5}{\cancel{6}} \bullet \frac{\cancel{6}}{7} = \frac{5}{7}$$

In some problems, there are no numerical cancellations to make, but pay close attention to the units (or dimensions):

$$\frac{9\text{ weeks}}{1} \bullet \frac{7\text{ days}}{1\text{ week}} = \frac{9 \bullet 7 \bullet \text{weeks} \bullet \text{days}}{1\text{ week}} = \frac{63\ \cancel{\text{weeks}}\text{ days}}{\cancel{1\text{ week}}} = 63\text{ days}$$

The “weeks” may be cancelled either before or after the multiplication.

The goal of dimensional analysis is to simplify a problem by focusing on the units of measurement (dimensions).

Dimensional analysis is very useful when converting between units (like converting inches to yards, or converting between the metric and English systems of measurement.

EXAMPLE ▶

- How many minutes are there in one day?

  Solution:

  a. Determine what it is that we want to find out: $\frac{\text{minutes}}{\text{day}}$.

  It’s important to remember that if the solution is to have the label $\frac{\text{minutes}}{\text{day}}$:

  Minutes should be kept in the numerator (or top part of the fraction).
  Day(s) should be kept in the denominator (or bottom part of the fraction).

  b. Determine what we know. We know that there are **60** minutes in an hour and **24** hours in a day.

  c. Write what you know mathematically (fractions). Here, we have: $\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}}$

  d. Set up the problem by focusing on the units (dimensions).

  Just writing the information from #3 as a multiplication problem, we have: $\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}}$

  Looking *only* at the units, hr(s) cancel, leaving just: $\frac{\text{min}}{\cancel{\text{hr}}} \bullet \frac{\cancel{\text{hr}}}{\text{day}} = \frac{\text{min}}{\text{day}}$

e. Calculate:

$$\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}} = \frac{60 \bullet 24\text{ min} \bullet \cancel{\text{hr}}}{1\ \cancel{\text{hr}} \bullet \text{day}} = \frac{1{,}440\text{ min}}{\text{day}}$$

Notice that canceling the units can be done either before or after the multiplication.

f. Check your solution for reasonableness: Since there are 60 minutes in just one hour, it is expected that there would be many minutes in an entire day. It does seem reasonable that there are 1,440 minutes in a day.

PRACTICE

1. Multiply. Be sure to label your answers.

   a. $\frac{30\text{ mi}}{1\text{ gallon}} \bullet \frac{12\text{ gallons}}{1\text{ tank}}$

   b. $\frac{70\text{ feet}}{\text{second}} \bullet 60\text{ seconds}$

   c. $\frac{15\text{ mi}}{\text{hr}} \bullet \frac{1\text{ hr}}{60\text{ min}} \bullet 30\text{ min}$

2. Use dimensional analysis to convert each. You may need to use a reference to find some conversion factors. Show all of your work.

   a. 15 pints to some number of quarts

   b. 30,000 feet to some number of miles

   c. 28,800 seconds to some number of hours

3. Use dimensional analysis to find each solution. You may need to use a reference to find some conversion factors. Show all of your work.

   a. On Saturday, Sammie ran a 5k road race. How far is this in miles?

   b. DeAndre earns $6.25 per hour. He works 6 hours each day, five days each week. What are his weekly earnings?

   c. Using the information from “b”: If DeAndre has two weeks of unpaid vacation this year, how much does he earn for the year?

   d. Simon fills his gas tank. Gas costs $3.39 per gallon. His tank will hold 12 gallons of gas. How much does it cost Simon to fill his tank?

   e. A wide receiver for a professional football team has a 40-inch vertical jump. How much is this in centimeters?

   f. Lorraine has set a goal of collecting at least 100 pieces of candy during trick-or-treating this Halloween. From past years, she thinks she will average 2 pieces of candy from each home she visits. Her brother expects to do the same. Lorraine can also count on collecting half of her little brother's candy. If she goes with her brother, how many houses must Lorraine visit in order to accomplish her goal?

   g. Greg can type 33 words in 1 minute. How many words does he average per second?

Name: Date:

SI System

READ

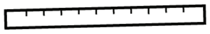
Scientists do experiments to test their ideas. They share their results in science magazines and journals. Other scientists repeat the experiments to see if they get the same results. When results are confirmed, we learn more about how the world works.

If you want other people to be able to repeat your work, you need to make careful measurements. Scientists use SI units because they are easy to convert from one measurement to another. In the English system, there are 12 inches in a foot, 3 feet in a yard, and 5,280 feet in a mile. SI units are in multiples of 10. There are 10 millimeters in a centimeter, 100 centimeters in a meter, and 1,000 meters in a kilometer.

In this skill sheet, you will learn how easy it is to convert one SI unit to another.

Basic units

The table below shows some basic units you will use for measuring things in your science classes:

When you are measuring:	Use this basic unit:	Symbol of unit:
Mass 	gram	g
Length 	meter	m
Volume 	liter	l

Prefixes

When measuring things that are much larger or much smaller than the basic unit, you'll use a prefix along with the basic unit. The following prefixes tell you to multiply the basic unit by a certain amount. For example, the prefix kilo- means "multiplied by 1,000." A kilometer is equal to 1,000 meters, and a kilogram is equal to 1,000 grams.

Prefix:	kilo-	hecto-	deka-	Basic unit (no prefix)	deci-	centi-	milli-
Symbol:	k	h	da	m, l, g	d	c	m
Multiply the basic unit by:	1,000	100	10	1	0.1	0.01	0.001

SI Unit Conversions

Converting between SI units becomes easy with a little practice. Below you'll find a method that uses a place value chart to help you keep track of where to move the decimal point.

EXAMPLES ▶

- **How many centimeters are in 50 meters?**

(1) Restate the question: 50 meters = __________ centimeters

(2) Use the place value chart below to figure out what to multiply 50 meters by:

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

Since we want to convert meters (ones place) to centimeters (hundredths place), count the number of places on the chart it takes to move from the ones place to the hundredths place.

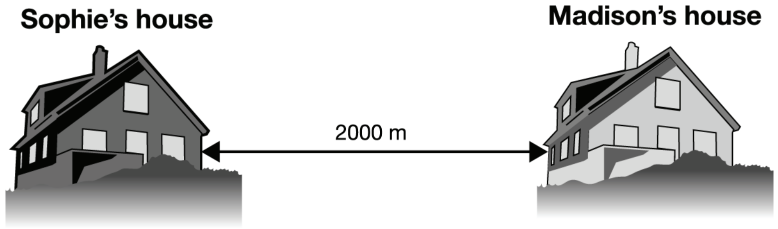
Since it takes 2 moves to the right, you multiply by 100.

$$1.\underset{\curvearrowright}{00}=100.$$

Solution: multiply 50 × 100 = 5,000. **Answer:** There are 5,000 centimeters in 50 meters.

Did you notice that multiplying by 100 is the same as moving the decimal two places to the right? The chart tells you where to move the decimal place, so that you don't even need to do the multiplication!

- **How many kilometers is it from Sophie's house to Madison's house?**



(1) Restate the question: 2,000 meters = __________ kilometers

(2) Use the place value chart to figure out what to multiply 2,000 meters by.

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

Since we want to convert meters (ones place) to kilometers (thousands place), count the number of places on the chart it takes to move from the ones place to the thousands place.

Since it takes 3 moves to the left, multiply by 0.001.

$$0\underset{\curvearrowleft}{001}.=0.001$$

Solution: multiply 2,000 × 0.001 = 2. **Answer:** The distance is 2 kilometers.

In the second example problem, did you notice that multiplying by 0.001 is the same as moving the decimal three places to the left? Use this shortcut to solve the problems on the following pages.

PRACTICE

1. How many grams are in 1 kilogram?

   a. Restate the question: 1 kg = __________ g

   b. Use the place value chart to figure out where to move the decimal point:

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

   I will move the decimal **3** places to the **right**.

   c. 1 kg = _____ g

2. How many centimeters are there in one millimeter?

   a. Restate the question: 1 mm = __________ cm

   b. Use the place value chart to figure out where to move the decimal point:

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

   I will move the decimal **1** place to the **left**.

   c. 1 mm = _____ cm

3. Convert 420 centimeters to meters.

   a. Restate the question: 420 cm = __________

   b. Use the place value chart to figure out where to move the decimal point:

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

   I will move the decimal __________ places to the __________.

   c. 420 cm = __________

4. How many milliliters are in 5 liters?

   a. Restate the question: __________ = __________

   b. Use the place value chart to figure out where to move the decimal point:

   I will move the decimal __________ places to the __________.

   c. __________ = __________

Challenge!

Use the place value chart to answer the following questions:

prefix	kilo-	hecto-	deka-	meter, liter or gram	deci-	centi-	milli-
place value	thousands	hundreds	tens	ones	tenths	hundredths	thousandths

5. How many centimeters are in 6 kilometers?
6. A car has a mass of 1,200 kilograms. How many grams is this?
7. Convert 50 dekameters to decimeters.
8. How many hectoliters are equal to 150 deciliters?
9. Seven hundred sixty two centiliters is equal to how many liters?
10. Sixteen milliseconds is equal to how many seconds?
11. How many milliseconds are in 60 seconds?
12. How many times smaller than a meter is a centimeter?
13. How many times larger than a gram is a kilogram?
14. Name the volume that is 100 times larger than a liter.

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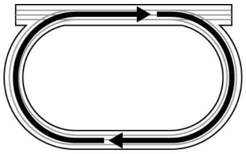
SI-English Unit Conversions

READ

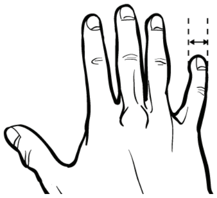
How many inches are there in a foot? How many quarts in a gallon? How many ounces in a pound? The answers to these questions (12, 4, and 16) may be quite simple for you. Most people who have grown up in the United States can answer these questions because the English system of measurement is used in their daily lives.

You may also have learned that it's quite easy to convert between SI units (like meters to centimeters) by knowing the SI prefix place-values, and how to move the decimal point. If you have lived in another country, you are probably very familiar with SI units. Occasionally (especially in science), it is necessary to convert SI units to English (like kilometers to miles), and English units to SI units (like ounces to grams). It may be helpful to be familiar with some common examples of how SI units compare with English measurements:

One kilometer (1 km) is about two and a half times around a standard running track.



One centimeter (1 cm) is about the width of your little finger.



One kilogram (1 kg) is about the mass of a full one-liter bottle of drinking water.

One gram (1 g) is about the mass of a paper clip.

One liter (1 l) is a common size of a small bottle of drinking water.

One milliliter (1 mL) is about one droplet of liquid.

When precise conversions between the two systems are needed, use these conversion factors:

English - metric measurement equivalents

Measurement	Equivalents
Length	1 inch = 2.54 centimeters 1 kilometer ≈ 0.62 mi
Volume	1 liter ≈ 1.06 quart
Mass	1 ounce ≈ 28 grams 1 kilogram ≈ 2.2 pounds

EXAMPLES ▶

How many inches are equivalent to 10 centimeters?

1. Restate the question, starting with what is known: 10 centimeters = _____ inches.
2. Find the conversion factor from the table: 1 in = 2.54 cm.
3. Write the information from steps 1 and 2 as ratios: $\frac{10\text{ cm}}{1}$, and $\frac{1\text{ in}}{2.54\text{ cm}}$
4. Multiply the ratios. Make sure the units cancel correctly to produce the desired type of unit in the answer. In this case, centimeters cancel, leaving inches, which is what we are supposed to be finding.

$$\frac{10\ \cancel{\text{cm}}}{1} \times \frac{1\text{ in}}{2.54\ \cancel{\text{cm}}} = \frac{10\text{ in}}{2.54\text{ cm}} \approx 3.9\text{ cm}$$

What is the mass of a 5 pound bag of flour in kilograms?

1. Restate the question: 5 lbs ≈ ____ kg.
2. Find the conversion factor from the table: 1 kg ≈ 2.2 lb (The abbreviation for *pound* is *lb*.)
3. Write the information from steps 1 and 2 as ratios: $\frac{5\text{ lb.}}{1}$, and $\frac{1\text{ kg}}{2.2\text{ lb}}$
4. Multiply the ratios making sure that the unwanted units cancel, leaving kilograms in the numerator:

$$\frac{5\ \cancel{\text{lb.}}}{1} \times \frac{1\text{ kg}}{2.2\ \cancel{\text{lb.}}} \approx 2.3\text{ kg}$$

How many quarts are equivalent to 3 liters?

1. Restate the question: 3 liters ≈ ______quarts.
2. Find the conversion factor from the table: 1 × L ≈ 1.06 qt.
3. Write the information from steps 1 and 2 as ratios: $\frac{3\text{ L}}{1}$, and $\frac{1\text{ L}}{1.06\text{ qt}}$
4. Multiply the ratios making sure that the unwanted units cancel, leaving only the desired units (quarts) in the answer: Notice that in this case, the units do not cancel the way they should. To correct this, just rewrite the

ratios so that they do cancel the way they need to (here liters should cancel, leaving “quarts” in the numerator):

$$\frac{3\,\cancel{\text{L}}}{1} \times \frac{1.06\text{ qt}}{1\cancel{\text{L}}} \approx 3.18\text{ qt}$$

PRACTICE

1. 250 g ≈ _____ oz
2. 8 L ≈ _____ qt
3. 100 kg ≈ _____ lbs
4. How many inches are equivalent to 15 centimeters?
5. How many liters are equivalent to 1.8 quarts?
6. Josh ran an 8K (8 kilometer) road race last Saturday. How many miles did he run?
7. The letter that Mrs. Gibson needs to mail today weighs 2.4 ounces. How many grams does the letter weigh?
8. Jordan's house is two and one half miles away from the park. How far is this in kilometers?
9. A sign for a kiddie ride at a carnival says you must be under 42 inches tall to ride. How tall is this in centimeters?
10. Challenge: The basketball hoop in Marvin's driveway is 9 ½ feet tall. How tall is this in centimeters?

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Name:

Temperature Scales

READ

The Fahrenheit and Celsius temperature scales are commonly used for reporting temperature values. Scientists use the Celsius scale almost exclusively, as do many countries of the world. The United States relies on the Fahrenheit scale for reporting temperature information. You can convert information reported in degrees Celsius to degrees Fahrenheit or vice versa using conversion formulas.

Fahrenheit (°F) to Celsius (°C) conversion formula: $°C = \frac{5}{9}(°F - 32)$

Celsius (°C) to Fahrenheit (°F) conversion formula: $°F = \left(\frac{9}{5} \times °C\right) + 32$

EXAMPLES

- What is the Celsius value for 65° Fahrenheit?

Step 1: Subtract $°C = \left(\frac{5}{9}\right)(65°F - 32)$

Step 2: Multiply $°C = \left(\frac{5}{9}\right)(33) = (5 \times 33) \div 9$

Step 3: Divide $°C = (165) \div 9$

$°C = 18.3$

- 200°C is the same temperature as what value on the Fahrenheit scale?

$°F = \left(\frac{9}{5}\right)(200°C) + 32$

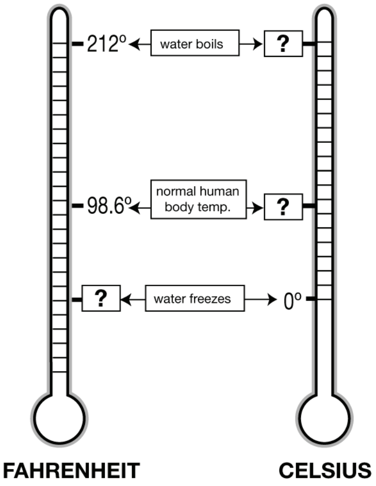
Step 1: Multiply $°F = [(9 \times 200°C) \div 5] + 32$

Step 2: Divide $°F = [1800 \div 5] + 32$

Step 3: Add $°F = 360 + 32$

$°F = 392$

PRACTICE



1. For each of the problems below, show your calculations. Follow the steps from the examples above.
    a. What is the Celsius value for 212°F?
    b. What is the Celsius value for 98.6°F?
    c. What is the Celsius value for 40°F?
    d. What is the Celsius value for 10°F?
    e. What is the Fahrenheit value for 0°C?
    f. What is the Fahrenheit value for 25°C?
    g. What is the Fahrenheit value for 75°C?

2. The weatherman reports that today will reach a high of 45°F. Your friend from Sweden asks what the temperature will be in degrees Celsius. What value would you report to your friend?

3. Your parents order an oven from England. The temperature control on the new oven is calibrated in degrees Celsius. If you need to bake a cake at 350°F in the new oven, at what temperature should you set the dial?

4. A German automobile's engine temperature gauge reads in Celsius, not Fahrenheit. The engine temperature should not rise above about 225°F. What is the corresponding Celsius temperature on this car's gauge?

5. Your grandmother in Ireland sends you her favorite cookie recipe. Her instructions say to bake the cookies at 190.5°C. To what Fahrenheit temperature would you set the oven to bake the cookies?

6. A scientist wishes to generate a chemical reaction in his laboratory. The temperature values in his laboratory manual are given in degrees Celsius. However, his lab thermometers are calibrated in degrees Fahrenheit. If he needs to heat his reactants to 232°C, what temperature will he need to monitor on his lab thermometers?

7. You call a friend in Denmark during the winter holidays and say that the temperature in Boston is 15 degrees. He replies that you must enjoy the warm weather. Explain his comment using your knowledge of the Fahrenheit and Celsius scales. To help you get started, fill in this table. What is 15°F on the Celsius scale? What is 15°C on the Fahrenheit scale?

°F		°C
15°F	=	
	=	15°C

8. Challenge questions:

   a. A gas has a boiling point of -175°C. At what Fahrenheit temperature would this gas boil?

   b. A chemist notices some silvery liquid on the floor in her lab. She wonders if someone accidentally broke a mercury thermometer, but did not thoroughly clean up the mess. She decides to find out if the silver stuff is really mercury. From her tests with the substance, she finds out that the melting point for the liquid is 35°F. A reference book says that the melting point for mercury is -38.87°C. Is this substance mercury? Show your work and explain your answer.

   c. It is August 1 and you are at a Science Camp in Florida. During an outdoor science quiz, you are asked to identify the temperature scale for a thermometer that reports the current temperature as 90. Is this thermometer calibrated for the Fahrenheit or the Celsius temperature scale? Fill in the table below to answer this question.

°F		°C
90°F	=	
	=	90°C

Name: Date:

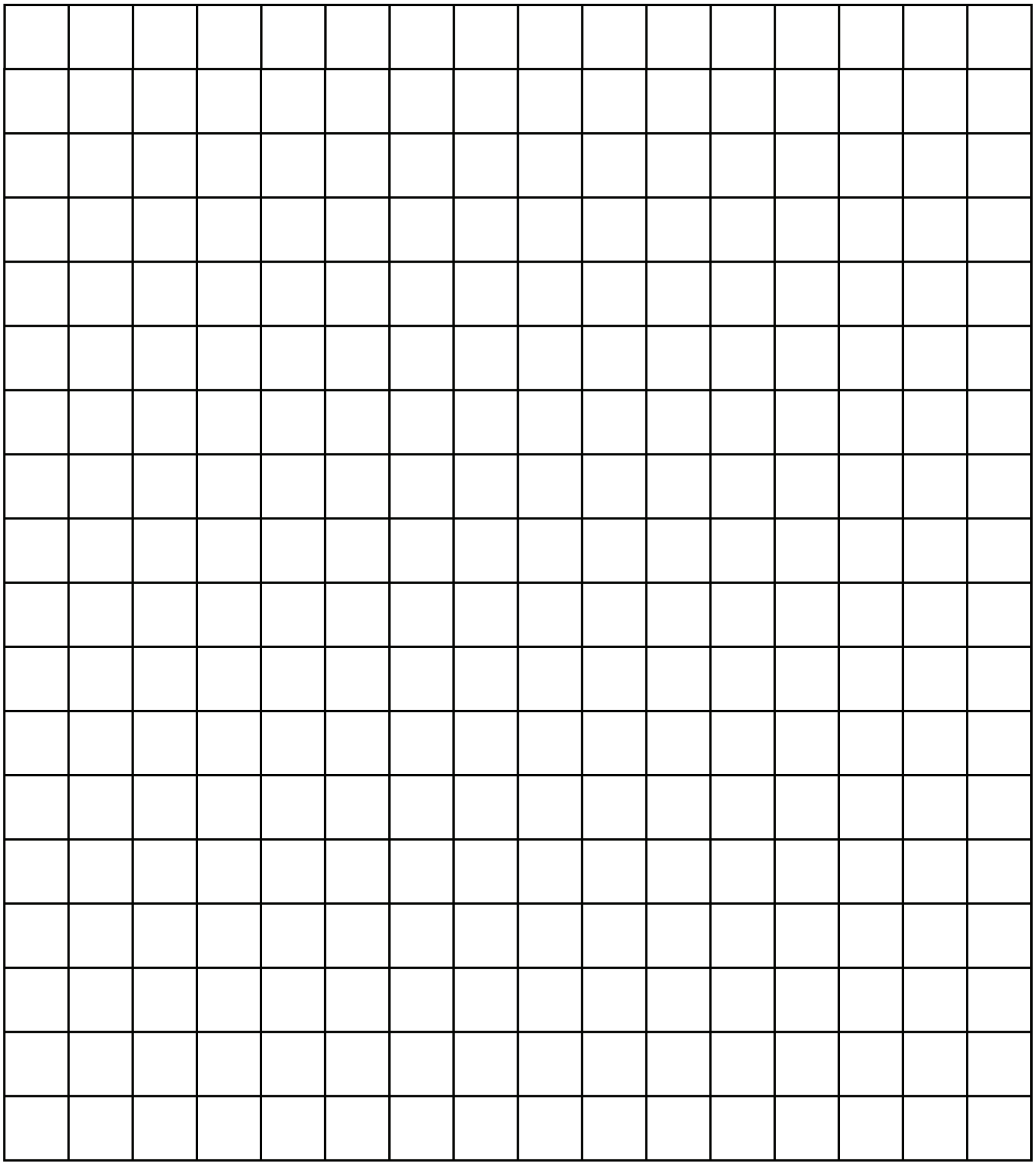
SKILL and PRACTICE 2.3

Calculating Area

READ

Suppose you want to buy a new carpet for your room. How do you figure out what size to get? You need to know how much floor space needs to be covered. Areas like floor space are measured in square units. Below you can see a grid measured off in square centimeters. In Earth Science class, you'll also become familiar with square meters and square kilometers.

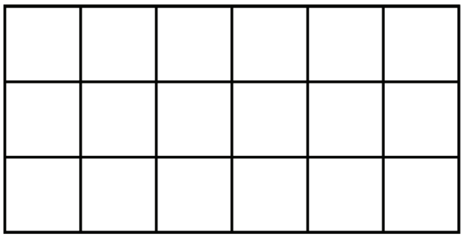
Cut out the grid below. You'll use it as a measuring tool to answer the problems on the next page.



EXAMPLE

- Measure the space below using your grid as a guide. Give your answer in square centimeters.

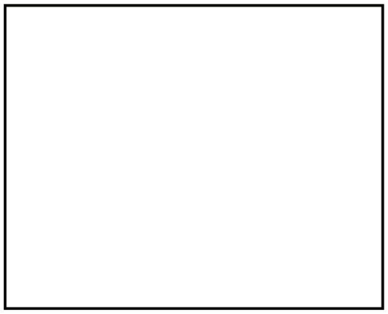
Solution:
18 cm^3



PRACTICE

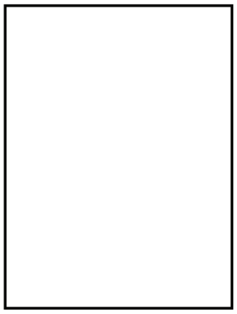
1. Measure the spaces below using your grid as a guide. Give your answer in square centimeters.

Shape A

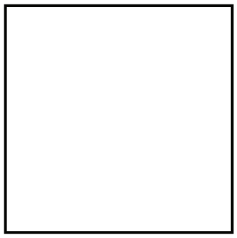


Shape B

Shape C



Shape D



2. How many squares wide is each shape above? How many squares long?

Shape A: ___________ wide ___________ long
Shape B: ___________ wide ___________ long
Shape C: ___________ wide ___________ long
Shape D: ___________ wide ___________ long

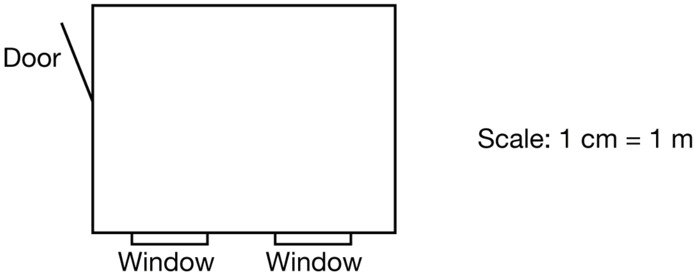
3. What is the relationship between length, width, and area for a rectangle?

Area and mapping

Maps are an important tool for Earth science. On maps, one small unit (like a square centimeter) is used to represent a larger unit (like a square meter or a square kilometer). When reading a map, you will measure area using the small unit, and then convert your measurement to the larger unit.

EXAMPLE

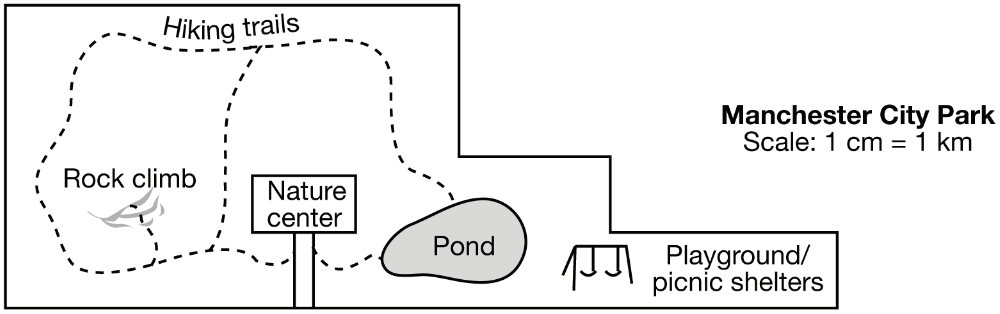
How much carpet does Talia need to buy to cover the floor in her room?



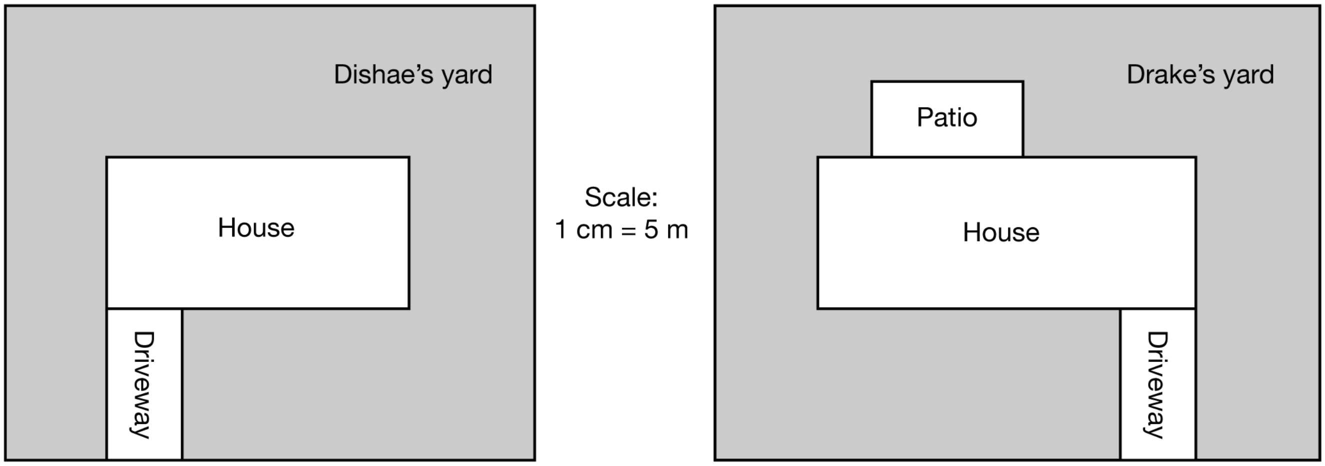
On the map, Talia's room measures 3 cm by 4 cm. One square centimeter on the map is equal to one square meter in Talia's room. Talia needs to buy 12 square meters of carpet.

PRACTICE

1. How many square kilometers will the city of Manchester's new park occupy?



2. Dishae and Drake have each been asked to mow the lawn. How many square meters of yard does each student have to mow? Hint: 1 cm^2 on the map = 25 m^2 to mow!



3. **Challenge!** Use your grid sheet and the back of this paper to make up your own area problem.

Name: ______________________ Date: ______________

SKILL and PRACTICE 2.3

Science Vocabulary

READ CPO Science

When you study science, you may see words that are new to you. Many words in the English language can be broken down into roots, prefixes, and suffixes to understand their meaning. These word parts often come from Latin or Greek words. In this exercise, you will become familiar with how to break a word into its parts and discover the meaning of a variety of scientific words.

Building blocks of language

Roots, prefixes, and suffixes are the building blocks of language.

- A *root* is a word base—the part that gives the word its core meaning. A root can appear at the beginning, middle, or end of a word.
- A *prefix* is a word part added to the beginning of a word or root.
- A *suffix* is a word part added to the end of a word or root.

EXAMPLES ▶

Using prefixes, roots, and suffixes

Below is a list of words you may encounter studying earth science. Look for prefixes, suffixes, and roots. Separate the word into it parts using the columns next to the word. All words should have a root word. Hint: all three columns will not be used in every case.

Do some of the word parts look familiar already? You will get a chance to review their meanings in the next section.

Word	Prefix	Root	Suffix
geology		*geo-*	*-logy*
lithosphere			
paleontology			
astronomy			
seismogram			

Building science vocabulary

Now that you know how to break a word into its parts, you are ready to learn the meaning of some common word parts in science. Some of these words come from early Greek and Latin and were borrowed by English, French, Spanish, and Italian languages. If you speak one of these languages, the word parts and meanings may be familiar to you.

Prefixes		Roots		Suffixes	
alt-	high	*aqua-*	water	*-al*	of, relating to
circum-	around	*astro-*	star	*-ate*	to act on or change
equ-	equal	*cycl-*	circle	*-gram*	a written record
hemi-	half	*form-*	to shape	*-graph*	something written or drawn
litho-	rock	*geo-*	earth, land	*-ic*	related to
paleo-	ancient	*onto-*	to break	*-ism*	the act, state, or theory of
pre-	before	*photo-*	light	*-ist*	person who is or does
semi-	half	*scope-*	to see	*-ity, -ty*	degree of
strat-	to spread	*seismo-*	shake, earthquake	*-logy*	study of
sub-	under	*sphere-*	ball, globe	*-meter*	to measure
tele-	distant	*terra-*	earth, land	*-nomy*	to name, to manage

PRACTICE

Learning new words

Using the table above, write in the meanings of the word parts below. Then give your best definition of the word. There is room for you to make up two words of your own from the word parts listed above.

Word	Prefix	Root	Suffix	Definition
geology				
lithosphere				
paleontology				
astronomy				
seismogram				

Check the meaning

Now, using a dictionary, look up the words from the table. Write the formal definitions in the spaces below. Try looking up your words, too! Were you close to the correct meaning?

1. geology:
2. lithosphere:
3. paleontology:
4. astronomy:
5. seismogram:
6. ________________________:
7. ________________________:

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SKILL and PRACTICE
2.3

Variables

READ

Science experiments are designed with an experimental variable and control variables. An experimental variable is the variable in the experiment that is changed on purpose. In order to study the effect of the experimental variable, everything else in the experiment must remain the same. A variable that is kept the same in an experiment is called a control variable.

EXAMPLE

John has observed different air temperatures above different surfaces on Earth. He asked, “What types of surfaces are identified with warmer temperatures in the air?” John hypothesized that the air temperature above dark soil would be warmer than the air temperature above a body of water. In order to test his hypothesis, John followed the following procedure.

a. Obtain two identical glass containers with glass lids.

b. Put 5 centimeters of room temperature water in one container and 5 centimeters of room temperature soil in the other container. Put a thermometer (same brand and model) in each container.

c. Place the lid on both containers.

d. Set each container 30 centimeters away from an incandescent light. Make sure each container is exactly the same distance from the light. Also, be sure that the lights are identical and that the bulbs have the same wattage.

e. Record the temperature of each container.

f. Turn the lights on.

g. Record the temperature of each container every minute for 15 minutes.

The experimental variable in this experiment is the material at the surface of Earth. There are several control variables. They include the size, shape, and material of the containers, the depth of the surface, the light source, the distance from the light source, the time exposed to light.

PRACTICE

1. You observe that dew forms very often on summer mornings. You ask, “What temperature would our classroom have to be in order for dew to form on the various surfaces in the room?” You and your classmates hypothesize that dew will form at 5°C. In order to test your hypothesis, you and your classmates complete the following experiment.

   a. All students complete the experiment at the same time.

   b. Obtain a metal can from your teacher.

   c. Record the air temperature in the room in degrees Celsius.

   d. Fill the metal can ½ full with room-temperature water.

   e. Put a thermometer in the water and allow it to sit for 1 minute.

   f. At this point, slowly begin adding ice chips. Continually stir the water in the can with the thermometer.

g. When you see condensation or dew on the outside of the can, record the temperature. (This is the dew point of the room.)

h. Repeat the experiment three times with the same materials. Find the average starting air temperature and the dew point temperature for all four trials.

Identify the experimental variable and three control variables in the experiment.

2. You have learned the following in science class. When water turns from a liquid to gas below the boiling temperature, the process is called evaporation. You have observed that water evaporates at different speeds in different conditions. You ask, “What causes the rate of evaporation of water to increase?” You hypothesize that when water is heated, the rate of evaporation will increase. In order to test your hypothesis, you and your classmates complete the following experiment.

   a. Obtain two 50-mL glass beakers.

   b. Fill each beaker with 50 mL of water at 25°C. Put a thermometer in each of the filled beakers.

   c. Place one beaker on the counter in the classroom.

   d. Place another beaker under an incandescent lamp. Be sure the light does not shine on the other beaker. Turn on the light.

   e. Record the water level of each beaker and the temperature of each beaker every hour for 10 hours.

   Identify the experimental variable and three control variables in the experiment.

3. Throughout your life you have seen many streams. You have noticed that different streams flow at various speeds. You ask, “What factors cause streams to flow at a faster rate?” You hypothesize that streams that have a steep slope will flow faster than streams that have a gentle slope. In order to test your hypothesis you perform the following experiment.

   a. Obtain one stream table.

   b. Place one end of the stream table 5 cm above the lab bench. Place the other end of the stream on the lab bench.

   c. Put a bucket at the end of the stream table where it is resting on the lab bench.

   d. Pour 500 mL of water from high end of the stream so that it flows toward the bucket.

   e. Record how long it takes for all of the water to empty into the bucket.

   f. Now prop the end of the stream table that was 5 cm above the lab bench to 10 cm above the lab bench.

   g. Repeat steps d and e.

   h. Now prop the end of the stream table that was 10 cm above the lab bench to 15 cm above the lab bench.

   i. Repeat steps d and e.

   j. Finally, prop the end of the stream table that was 15 cm above the lab bench to 20 cm above the lab bench.

   k. Repeat steps d and e.

   Identify the experimental variable in the experiment and two control variables in the experiment.

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SKILL and PRACTICE 2.4

Types of Graphs

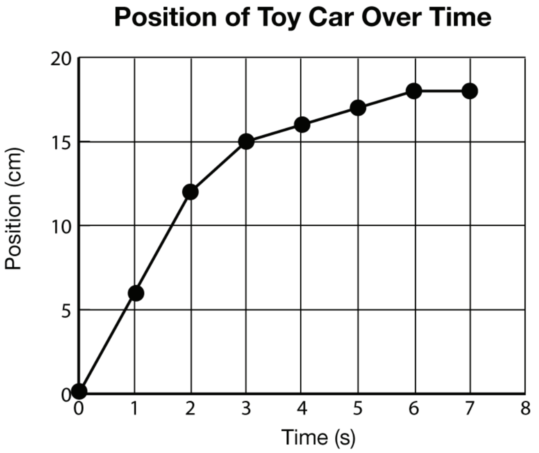
READ

A graph is a picture that helps you understand data. Graphs are easier to read than tables of numbers, so they are often used to display data collected during an experiment. The three main types of graphs you will use are line graphs, bar graphs, and pie graphs. With a little practice, you will be able to identify these types of graphs and recognize which type of data best fits which type of graph.

EXAMPLES

Line Graph

A line graph shows how the *independent variable* causes the *dependent variable* to change in value. The data graphed at right shows how far a toy car traveled down a ramp over a period of time. For this data set, the independent variable is the time traveled. The dependent variable is the position of the car. The two variables are related. The position of the car **depends** on how long it has been traveling.



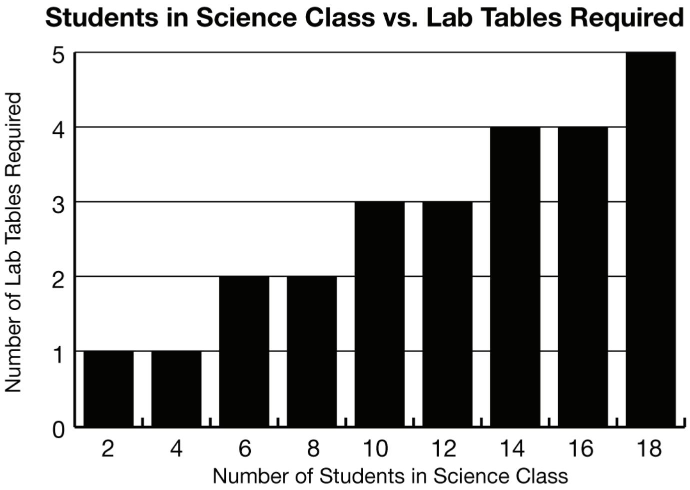
Line graphs are the best type of graph to use when your independent variable is *continuous*, meaning that the data continues uninterrupted between each of the points in your data set.

Time is a continuous independent variable because you can divide it into smaller and smaller pieces, like half a second or a tenth of a second, or even smaller. The data could have been collected at any of these points.

If your data is continuous and one of your variables causes the other to change in value, use a line graph.

Bar Graph

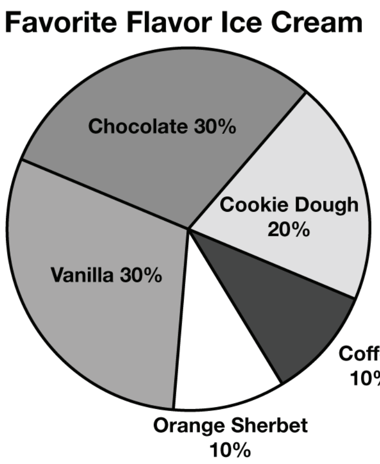
A bar graph is best for comparing separate categories of information. The graph is made of a series of “bars” of different values drawn along an axis. The data shown in this bar graph relates the number of students in a science classroom to how many lab tables are needed.



Like line graphs, bar graphs have an independent and a dependent variable. For this data set, the independent variable is the number of students and the dependent variable is the number of lab tables needed. The number of lab tables **depends** on the number of students.

Use a bar graph when your variables compare categories of information, or when your data is *not continuous*. This means that your data consists of exact values—like a certain number of students. You can have an exact number of students, like four or six or ten, but you cannot have a continuous number, like 4.5 students. If your data is something that was counted rather than measured, it is probably *not continuous*.

Pie Graphs



A pie graph is a circular graph that compares the parts of something to the whole. The data is usually written in percentages or fractions of the whole. Each part is drawn as a “slice” of the pie, so you can compare the different sizes of the “slices” to each other **and** to the whole pie. Surveys usually give data sets that work well in pie graphs.

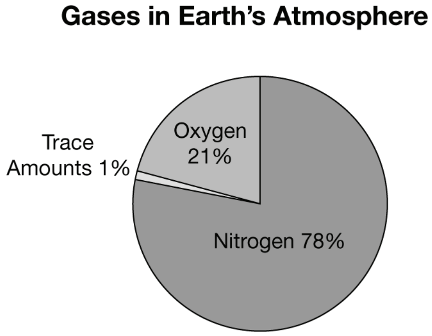
For this graph, a class of sixth grade students was given a survey asking them to identify their favorite flavor of ice cream.

PRACTICE 1

Name the type of graph shown in the following four examples

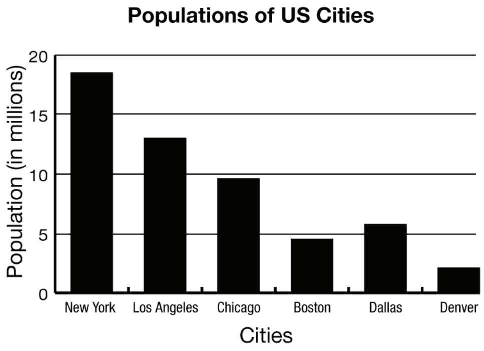
.

Graph #1:



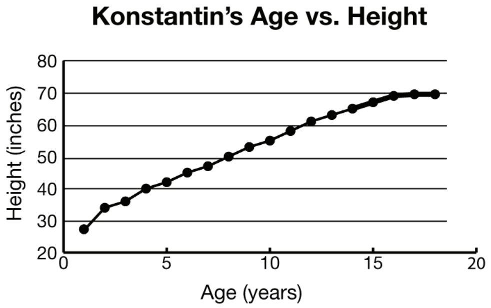
Type of graph ______________________

Graph #2:



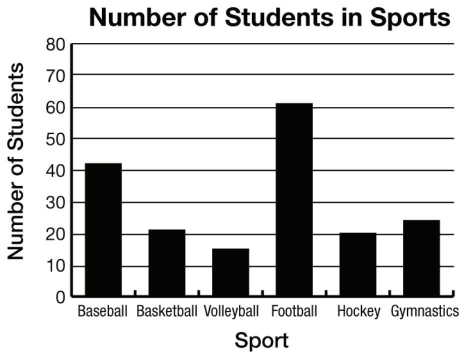
Type of graph ______________________

Graph #3:



Type of graph ______________________

Graph #4:



Type of graph ______________________

PRACTICE 2

Describe which type of graph—line graph, bar graph, or pie graph—would be most appropriate for the following data sets. Explain your reason.

Data Set #1: Most Popular Dog Breeds in Middleton

Dog Breed	Percent of Middleton dog owners who own this breed of dog	Type of graph you would use:
Golden Retriever	30%	Reason:
German Shepherd	20%	
Beagle	20%	
Poodle	20%	
Rottweiler	10%	

Data Set #2: Length of Students’ First Names

First Name	Number of letters	Type of graph you would use:
Jasmine	7	Reason
Alejandra	9	
Kenji	5	
Lola	4	
Jordan	6	

Data Set #3: Air Temperature

Time	Air Temperature (°F)	Type of graph you would use:
3 pm	86	Reason
4 pm	88	
5 pm	84	
6 pm	80	
7 pm	79	

Data Set #4: How Students Get to School

Method	Number of students who get to school with this method	Type of graph you would use:
Bus	16	Reason
Walk	10	
Car	8	
Taxi	1	
Bicycle	3	

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Drawing Line Graphs

READ

Graphs allow you to present data in a form that is easy to understand. Line graphs include these important parts:

1. **Data pairs:** Graphs are made using pairs of numbers. Each pair of numbers represents one data point on a graph. The first number in the pair represents the independent variable and is plotted on the *x*-axis. The second number represents the dependent variable and is plotted on the *y*-axis.
2. **Axis labels:** The label on the *x*-axis is the name of the independent variable. The label on the *y*-axis is the name of the dependent variable. Be sure to write the units of each variable in parentheses after its label.
3. **Scale:** The scale is the quantity represented per line on the graph. The scale of the graph depends on the number of lines available on your graph paper and the range of the data. Divide the range by the number of lines. To make the calculated scale easy-to-use, round the value to a whole number.
4. **Title:** The format for the title of a graph is: "Dependent variable name versus independent variable name."

PRACTICE

1. For each data pair in the table, identify the independent and dependent variable. Then, rewrite the data pair according to the headings in the next two columns of the table The first two data pairs are done for you.

	Data pair (not necessarily in order)		Independent (*x*-axis)	Dependent (*y*-axis)
1	Temperature	Hours of heating	Hours of heating	Temperature
2	Stopping distance	Speed of a car	Speed of a car	Stopping distance
3	Number of people in a family	Cost per week for groceries		
4	Stream flow rate	Amount of rainfall		
5	Tree age	Average tree height		
6	Test score	Number of hours studying for a test		
7	Population of a city	Number of schools needed		

2. Using the variable range and number of lines, calculate the scale for an axis. The first two are done for you.

Variable range	Number of lines	Range ÷ Number of lines	Calculated scale	Adjusted scale
13	24	13 ÷ 24 =	0.54	1
83	43	83 ÷ 43 =	1.93	2
31	35			
100	33			
300	20			
900	15			

3. Here is a data set for you to plot as a graph. Follow these steps to make the graph.

   a. Place this data set in the table below. Each data point is given in the format of (*x*, *y*). The *x*- values represent time in minutes. The *y*-values represent distance in kilometers.
   (0, 5.0), (10, 9.5), (20, 14.0), (30, 18.5), (40, 23.0), (50, 27.5), (60, 32.0).

Independent variable (*x*-axis)	Dependent variable (*y*-axis)

   b. What is the range for the independent variable?

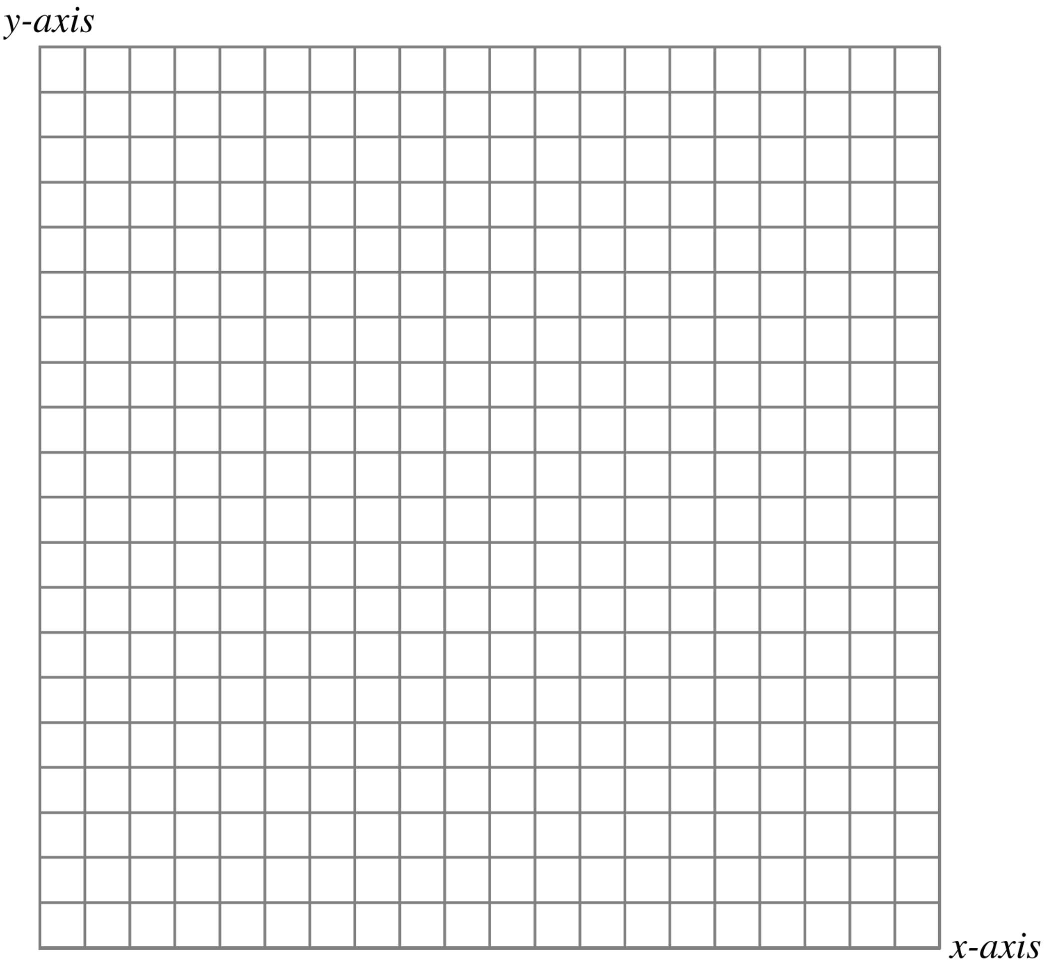
   c. What is the range for the dependent variable?

   d. Make your graph using the blank graph below. Each axis has twenty lines (boxes). Use this information to determine the adjusted scale for the *x*-axis and the *y*-axis.

   e. Label your graph. Add a label for the *x*-axis, *y*-axis, and provide a title.

   f. Draw a smooth line through the data points.

g. Question: What is position value after 45 minutes? Use your graph to answer this question.



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What’s the Scale?

READ

Graphs allow you to present data in a form that is easy to understand. With a graph, you can see whether your data shows a pattern and you can picture the relationship between your variables.

The **scale** on a graph is the quantity represented per line on the graph. Your graph’s scales will depend on the data you are plotting. Each of your graph’s axes has its own separate scale. You need to be consistent with your scales. If one line on a graph represents 1 cm on the *x*-axis, then it has to stay that way for the entire *x*-axis.

When figuring out the scale for your graph, you first need to know the **range**. When you want your axis to start at zero, your range is equal to your highest data value. Once you have the range, you can calculate the scale. Count the number of lines you have available on your graph paper. Now, divide the range by the number of lines. This number is your scale. Then you adjust your scale by rounding up to a whole number.

EXAMPLE ▶

Calculate the scales for the data set listed in the table below. Your graph paper is 20 boxes by 20 boxes.

Time (hours)	Amount of rainfall (mL)
5	5
10	11
15	21
20	28
25	37
30	59

Identify the variables.

1. Which is the independent variable? Time is your independent variable; it goes on the *x*-axis.
   Which is the dependent variable? Amount of rainfall is your dependent variable; it goes on the *y*-axis.

Find the ranges.

2. What is the range of data for the x-axis? 30 hours
   What is the range of data for the y-axis? 59 mL

Calculate the scales

3. What is the scale for your *x*-axis? 30 hrs divided by 20 boxes = 1.5 hrs/box rounded up to 2 hrs/box
   Each line on the graph is equal to 2 hours
   The *x*-axis will start at zero and go up to 40 hours, with each line counting as 2 hours.

   What is the scale for your *y*-axis? 59 mL divided by 20 boxes = 2.95 mL/box rounded up to 3 mL/box
   Each line on the graph is equal to 3 mL
   The *y*-axis will start at zero and go up to 60 mL, with each line counting as 3 mL.

PRACTICE

1. Given the variable range and the number of lines, calculate the scale for an axis. Often the calculated scale is not an easy-to-use value. To make the calculated scale easy-to-use, round the value and write this number in the column with the heading “Adjusted scale.” The first two are done for you.

Range from 0	Number of Lines	Range ÷ Number of Lines	Calculated scale	Adjusted scale (whole number)
14	10	14 ÷ 10 =	1.4	2
8	5	8 ÷ 5 =	1.6	2
1000	20	1000 ÷ 20 =		
547	15	547 ÷ 15 =		
99	30	99 ÷ 30 =		
35	12	35 ÷ 12 =		

2. Calculate the range and the scale for the *x*-axis starting at zero, given the following data pairs and a 30 box by 30 box piece of graph paper. Each data point is given in the format of (*x*, *y*):
(1, 27), (30, 32), (20, 19), (6, 80), (15, 21).

3. Calculate the range and the scale for the *y*-axis starting at zero, given the following data pairs and a 10 box by 10 box piece of graph paper. Each data point is given in the format of (*x*, *y*):
(1, 5), (2, 10), (3, 15), (4, 20), (5, 25).

4. Calculate the scale for both the *x*-axis and the *y*-axis of a graph using the data set in the table below. Your graph paper is 20 boxes by 20 boxes. Start both the *x*- and *y*-axis at zero.
   a. Which is the independent variable? Which is the dependent variable?
   b. What is the range of data for the *x*-axis? What is the range of data for the *y*-axis?
   c. What is the scale for your *x*-axis? What is the scale for your *y*-axis?

Day	Average Daily Temperature (°F)
1	67
3	68
5	73
7	66
9	70
11	64

Name: ______________________________ Date: ______________

SKILL and PRACTICE 3.1

Internet Research Skills

READ

The Internet is a valuable tool for finding answers to your questions about the world. A search engine is like an on-line index to information on the World Wide Web. There are many different search engines from which to choose. Search engines differ in how often they are updated, how many documents they contain in their index, and how they search for information. Your teacher may suggest several search engines for you to try.

EXAMPLE

Search engines ask you to type a word or phrase into a box known as a *field*. Knowing how search engines work can help you pinpoint the information you need. However, if your phrase is too vague, you may end up with a lot of unhelpful information.

How could you find out who was the first woman to participate in a space shuttle flight?

First, put **key phrases** in quotation marks. You want to know about the "first woman" on a "space shuttle." Quotation marks tell the engine to search for those words together.

Second, if you only want websites that contain both phrases, **use a + sign** between them. Typing **"first woman" + "space shuttle"** into a search engine will limit your search to websites that contain both phrases.

If you want to broaden your search, use the word **or** between two terms. For example, if you type **"first female" or "first woman" + "space shuttle"** the search engine will list any website that contains either of the first two phrases, as long as it also contains the phrase "space shuttle."

You can narrow a search by using the word **not.** For example, if you wanted to know about marine mammals other than whales, you could type **"marine mammals" not "whales"** into the field. Please note that some search engines use the minus sign (-) rather than the word **not**.

PRACTICE 1

1. If you wanted to find out about science museums in your state that are not in your own city or town, what would you type into the search engine?
2. If you wanted to find out which dog breeds are not expensive, what would you type into the search engine?
3. How could you research alternatives to producing electricity through the combustion of coal or natural gas?

READ

The quality of information found on the Internet varies widely. This section will give you some things to think about as you decide which sources to use in your research.

1. **Authority:** How well does the author know the subject matter? If you search for “Newton’s laws” on the Internet, you may find a science report written by a fifth grade student, and a study guide written by a college professor. Which website is the most authoritative source?
   Museums, national libraries, government sites, and major, well-known “encyclopedia sources” are good places to look for authoritative information.
2. **Bias:** Think about the author’s purpose. Is it to inform, or to persuade? Is it to get you to buy something? Comparing several authoritative sources will help you get a more complete understanding of your subject.
3. **Target audience:** For whom was this website written? Avoid using sites designed for students well below your grade level. You need to have an understanding of your subject matter at or above your own grade level. Even authoritative sites for younger students (children’s encyclopedias, for example) may leave out details and simplify concepts in ways that would leave gaps in your understanding of your subject.
4. **Is the site up-to-date, clear, and easy to use?** Try to find out when the website was created, and when it was last updated. If the site contains links to other sites, but those links don’t work, you may have found a site that is infrequently or no longer maintained. It may not contain the most current information about your subject. Is the site cluttered with distracting advertisements? You may wish to look elsewhere for the information you need.

PRACTICE 2

1. What is your favorite sport or activity? Search for information about this sport or activity. List two sites that are authoritative and two sites that are not authoritative. Explain your reasoning. Finally, write down the best site for finding out information about your favorite sport.
2. Search for information about an earth science topic of your choice on the Internet (for example: “earthquakes,” “hurricanes,” or “plate tectonics”). Find one source that you would NOT consider authoritative. Write the key words you used in your search, the web address of the source, and a sentence explaining why this source is not authoritative.
3. Find a different source that is authoritative, but intended for a much younger audience. Write the web address and a sentence describing who you think the intended audience is.
4. Find three sources that you would consider to be good choices for your research here. Write a two to three sentence description of each. Describe the author, the intended audience, the purpose of the site, and any special features not found in other sites.

Name: ______________________________ Date: ______________

SKILL and PRACTICE 3.1

Bibliographies

READ

When you write a research paper or prepare a presentation for your class, it is important to document your sources. A bibliography serves two purposes. First, a bibliography gives credit to the authors who wrote the material you used to learn about your subject. Second, a bibliography provides your audience with sources they can use if they would like to learn more about your subject.

This skill sheet provides bibliography formats and examples for research materials you may use when preparing science papers and presentations

EXAMPLES

Books:

Author last name, First name. (Year published). *Title of book*. Place of publication: Name of publisher.

Vermeij, Geerat. (1997). *Privileged Hands: A Scientific Life*. New York: W.H. Freeman and Company.

Newspaper and Magazine Articles:

Author listed:

Author last name, First name. (Date of publication). Title of Article. *Title of Newspaper or Magazine*, page # or #'s.

Searcy, Dionne. (2006, March 20). Wireless Internet TV Is Launched in Oklahoma. *The Wall Street Journal*, p. B4.

Brody, Jane. (2006, February/March). 10 Kids' Nutrition Myth Busters. *Nick Jr Family Magazine*, pp. 72-73.

No author listed:

Title of article. (Date of publication). *Title of Newspaper or Magazine*, page # or #'s.

Chew on this: Gum may speed recovery. (2006, March 20). *St. Louis Post-Dispatch*, p.H2.

Adventures in Turning Trash into Treasure: (2006, April). *Reader's Digest*, p. 24.

Online Newspaper or Magazine:

Author listed:

Author last name, First name. (Date of publication). Title of Article. *Title of Newspaper or Magazine*, Retrieved date, from web address.

Dybas, Cheryl Lyn. (2006, March 20). Early Spring Disturbing Life on Northern Rivers. *The Washington Post*, Retrieved March 22, 2006, from www.washingtonpost.com.)

No author listed:

Title of Article. (Date of publication). *Title of Newspaper or Magazine*. Retrieved date, from web address.

Comet mystery turns from hot to cold. (2006, March 20). *The Boston Globe*, retrieved March 22, 2006, from Boston.com.

Online document:

Author listed:

Author last name, author first name. (Date of publication). *Title of document*. Retrieved date, from web address.

Martinez, Carolina. (2006, March 9). *NASA's Cassini Discovers Potential Liquid Water on Enceladus*. Retrieved March 22, 2006, from http://www.nasa.gov/mission_pages/cassini/media/cassini-20060309.html

No Author listed:

National Science Foundation. (2005, December 15). *A fish of a different color.* Retrieved March 22, 2206 from http://www.nsf.gov/news/news_summ.jsp?cntn_id=105661&org=NSF&from=news.

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Averaging

READ

The most common type of average is called the *mean*. Usually when someone (who's not your math teacher) asks you to find the average of something, it is the *mean* that they want. To find the mean, just sum (add) all the data, then divide the total by the number of items in the data set. This type of average is used daily by many people. Teachers and students use it to average grades. Meteorologists use it to average normal high and low temperatures for a certain date. Sports statisticians use it to calculate batting averages and many other things.

EXAMPLE

- William has had three tests so far in his English class. His grades are 80%, 75%, and 90%. What is his average test grade?

  Solution:

  a. Find the sum of the data: 80 + 75 + 90 = 245

  b. Divide the sum (245) by the number of items in the data set (3): 245 ÷ 3 ≈ 82%

  William's average (mean) test grade in English (so far) is about 82%

PRACTICE

1. The families on Carvel Street were cleaning out their basements and garages to prepare for their annual garage sale. At 202 Carvel Street, they found seven old baseball gloves. At 208, they found two baseball gloves. At 214, they found four gloves, and at 221 they found two gloves. If these are the only houses on the street, what is the average number of old baseball gloves found at a house on Carvel Street?

2. During a holiday gift exchange, the members of the winter play cast set a limit of $10 per gift. The actual prices of each gift purchased were: $8.50, $10.29, $4.45, $12.79, $6.99, $9.29, $5.97, and $8.33. What was the average price of the gifts?

3. During weekend baby sitting jobs, each sitter charged a different hourly rate. Rachel charged $4.00, Juanita charged $3.50, Michael charged $4.25, Rosa charged $5.00, and Smith charged $3.00.

   a. What was the average hourly rate charged among these baby sitters?

   b. If they each worked a total of eight hours, what was their average pay for the weekend?

4. The boys on the sixth grade basketball team at Fillmore Middle School scored 22 points, 12 points, 8 points, 4 points, 4 points, 3 points, 2 points, 2 points, and 1 point in Thursday's game. What was the average number of points scored by each player in the game?

5. Jerry and his friends were eating pizza together on a Friday night. Jerry ate a whole pizza (12 slices) by himself! Pat ate three slices, Jack ate seven slices, Don and Dave ate four slices each, and Teri ate just two slices. What was the average number of slices of pizza eaten by one of these friends that night?

Name: ______________________ Date: ______________

Understanding Math in Words

READ

Math and reading skills are important to understanding science. Throughout your study of science, you will be asked to solve math problems. This exercise will show how key words help you to understand the problem and give you a clue to solving it. You will gain practice reading and solving a variety of math word problems.

EXAMPLES ▶

When you have a math problem, the first step is to find out what operation to perform. The following examples show you which operation is required. The key words in bold mean “do this operation.”

- **Addition:** Sue has 5 blue beads and 4 red beads. How many beads does she have **all together**?
- **Subtraction:** John has $3. The toy cost $1.50. After he buys the toy, how much money does he have **left over**?
- **Multiplication:** The egg carton had 12 eggs. One sixth **of** the 12 eggs are gone. How many are gone?
- **Division:** The speed limit is 55 miles **per** hour. Traveling at the speed limit, how many hours did it take to travel 55 miles?

Math problems may be written in different ways. Here are more examples of phrases that tell which operation is needed.

Addition	Subtraction	Multiplication	Division
How many **all together**?	Find the number **left over**.	A fraction (or percent) **of** another number	A number **per** a unit
How many **in all**?	**Take away** one number from another.	a number **times** another number	a number **divided by** another number
Find the **sum**.	Which is **more**?	Find the **product** of two numbers.	the **ratio** of two numbers
What is the **total**?	How many **remain**?	The **discount** is 10% **off of** the original price.	a measurement **versus** another measurement
	Find the **difference**.	Find the **interest earned** on a dollar amount.	Find the **quotient and remainder**.
	How many **more are needed**?	A number **at a given rate** gives another number.	a number **out of** the total
			A divisor **goes into** a dividend how many times?

PRACTICE 1

Solve the problems in the examples above. Show your work.

1. Addition: ____

2. Subtraction: ______________________________________

3. Multiplication: ____________________________________

4. Division: ____

Now, rewrite the word problems using different phrases to mean “do this operation.” The problems should have the same answer as the original examples.

1. ____

2. ____

3. ____

4. ____

EXAMPLE

Fractions can be written in different ways. Sometimes they look like a number over another number, for example, ${}^{2}/_{5}$, or they can be written as percents, ratios, and proportions. The following examples will give you a chance to work with fractions and recognize them in different mathematical expressions.

Percent tells how many out of 100. The data below shows that 55% of students drink milk at school. That means 55 out of 100 students drink milk. The fraction is ${}^{55}/_{100}$. It also can be simplified to ${}^{11}/_{20}$.

PRACTICE 2

Fill in the missing percentages in Table 1 below. Then, answer the following questions to show you understand the concept of fractions and percent.

Table 1: Lunch drinks consumed by students at Fredrick Elementary School

Drink	Number of students	Percent
Whole milk	45	
Strawberry milk	10	10%
Orange juice	20	
Water	25	
Total	100	100%

Refer to Table 1 to answer these following questions.

1. Give the total number of students surveyed at Fredrick Elementary School.
2. What percentage of students drink whole milk?
3. Write a fraction for the number of students that drink orange juice out of the total number of students surveyed. (HINT: “Out of” means “divided by.”)
4. Put the fraction of students who drink strawberry milk in its simplest form.
5. Show how the author found that 55% of students drink milk.
6. If the survey was done with 200 students and the percentage of students drinking each drink stayed the same, what number of students out of 200 drink water? Show how you found your answer.

EXAMPLE ▶

A ratio compares two numbers and can be written as a fraction. A ratio uses the wording, “the ratio of this to that.” When you write out the numbers as a fraction, be sure to write them in the correct order. The first number in a ratio is the numerator, and the second number is the denominator.

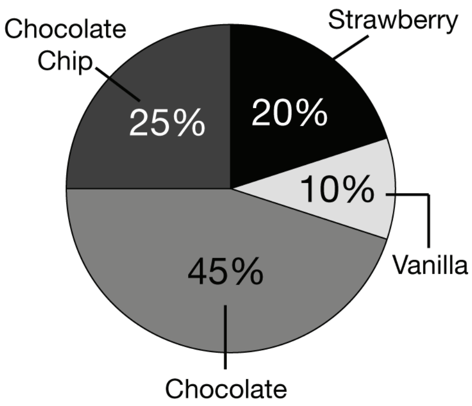
In the previous example, the ratio of the least popular drink, strawberry milk, to the most popular drink, whole milk, is 10 to 45. Ratios can be written as 10 to 45, 10:45, or $^{10}/_{45}$. Ratios can be simplified the same way fractions can. A proportion is an equation that shows two ratios are equal.

The ratio $^{10}/_{45} = {}^{2}/_{9}$. This is a proportion. When one of the numbers in the proportion is unknown, you can find the unknown value by using cross products.

PRACTICE 3

Pie graphs are a useful way of showing percentages for a set of data. Below is a pie graph. In the following exercise you will gain practice working with percentages and fractions for a set of data.

Percentage of Ice Cream Flavors Eaten by Carlton Middle School Students



1. Fill in the missing percentages in the table below based on the information in the pie graph titled, “Percentage of Ice Cream Flavors Eaten by Carlton Middle School Students.” You will need to solve for the number of students out of 1000 that ate each type of ice cream. Calculate the simplest fraction for each type of ice cream out of the total.

Table 2: Ice cream flavors eaten by students at Carlton Middle School

Ice cream flavor	Number of students	Percent	Fraction of students eating that type of ice cream
Chocolate			
Vanilla		25%	
Chocolate chip			
Strawberry			
Total	1000	100%	

2. What is the ratio of students eating chocolate ice cream to the total number of students eating ice cream?
3. What is the fraction of students eating chocolate ice cream out of the total number of students eating ice cream?
4. Do your answers for questions 2 and 3 agree? Explain.
5. List the number of students eating chocolate chip ice cream in the following four different ways:
   a. the number of students
   b. as a percentage of the total
   c. as a fraction of the total
   d. as a ratio of chocolate chip to vanilla

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Heat Transfer

READ

Heat, as a form of energy, can be transferred from one object to another. Heat always moves from warmer objects to cooler objects. Conduction, convection, and radiation are different ways that heat transfer occurs in nature. Conduction is the transfer of heat by the direct contact of atoms and molecules in solids. Convection is the transfer of heat through the motion of gases and liquids such as air and water. Finally, radiation is heat transfer that involves energy waves and no direct contact or movement of atoms.

EXAMPLE

You are cooking dinner for your little brother and sister. You decide that you will make them spaghetti, which requires you to boil water. The diagram at right shows how the pot is heated, and how heat is transferred throughout the water in the pot in order to make the water boil. What type of heat transfer is this?

Solution: This is convection because it is the transfer of heat through the motion of a liquid.

PRACTICE

1. You are outside in your yard at noon time. You start to feel quite warm due to heat from the sun. What type of heat transfer is this? Explain how you know.
2. There is a snowstorm one night and your driveway has quite a bit of snow. You have to help your dad shovel the driveway. At one point you take your glove off and touch the metal shaft of the shovel, and your hand immediately feels cold. What type of heat transfer is this? Explain how you know.
3. Earth’s mantle is made of liquid molten material. The inner part of the mantle is hotter than the outer part. Therefore, currents carry molten material up to Earth’s surface. Then, they cool off so much that they sink back down into the warmer area. What type of heat transfer is this? Explain how you know.
4. When you are sitting on a beach in the late afternoon, there is generally a cool breeze that blows off of the ocean. This is called a sea breeze. The reason that a sea breeze builds up in the afternoon is because the sea is cooler than the land, and therefore wind currents are created. What type of heat transfer is this? Explain how you know.
5. John is sitting by a campfire at night with his friends. He feels a tremendous amount of warmth from the fire on this cool evening. What type of heat transfer is this? Explain how you know.
6. You order a hot chocolate at a nearby coffee shop. When you take your first sip, the hot chocolate is so hot that you burn your tongue. What type of heat transfer is this? Explain how you know.
7. Cold water in Earth’s oceans sinks to the bottom of the ocean, while warm water in Earth’s oceans rises to the surface of the ocean. This motion creates what scientists have called ocean currents. These ocean currents are caused by the transfer of heat. What type of heat transfer is this? Explain how you know.

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Density

Density is a physical property of matter. A *physical property* can be measured or viewed without making any changes to the material. Some physical properties, like mass, depend on how much matter is present. The density of a substance does not depend on how much matter is present.

Suppose you were given a solid gold bar and a gold ring. How do you think the density of the gold bar would compare to the density of the gold ring? As long as both the bar and ring are made entirely of gold, their densities are equal. The density of a material is always the same, even if its size or shape changes.

- The formula for density is: $\text{density} = \frac{\text{mass}}{\text{volume}}$
- One milliliter takes up the same amount of space as one cubic centimeter. Therefore, density can be expressed in units of g/mL or g/cm^3. Liquid volumes are most commonly expressed in milliliters, while volumes of solids are usually expressed in cubic centimeters.
- Density can also be expressed in units of kilograms per cubic meter (kg/m^3).

You can rearrange the density equation to find out the mass or volume of a substance.

Equation...	Gives you...	If you know...
$D = m/v$	density	mass and volume
$m = v \times D$	mass	volume and density
$v = m/D$	volume	mass and density

EXAMPLES ▶

- **Example 1:** What is the density of cork if a 1.5-gram sample has a volume equal to 6.25 cm^3?

  Solution:

$$\text{density} = \frac{m}{v} = \frac{1.5\text{ g}}{6.25\text{ cm}^3} = 0.24\text{ g/cm}^3$$

  The density of cork is 0.24 g/cm^3.

- **Example 2:** What is the volume of a lead block with a density of 11.3 g/cm^3 and a mass of 60.5 grams?

  Solution:

$$\text{volume} = \frac{m}{D} = \frac{60.5\text{ g}}{11.3\text{ g/cm}^3} = 5.35\text{ cm}^3$$

  The volume of the lead block is 5.35 cm^3.

PRACTICE

1. What is the mass of a sample of rubber if its density is 1.1 g/cm^3 and it has a volume of 6.0 cm^3?

2. Daniel found an oddly-shaped object while walking to school. He asked the science teacher to borrow a balance to find the mass of the object. Daniel determined the object's mass to be 4.55 grams. He then added 20.0 milliliters of water to a graduated cylinder and placed the object inside.

   a. After adding the object to the graduated cylinder, Daniel observed that the water level rose to 26.5 milliliters. What is the volume of the object?

   b. What is the density of the object?

3. What is the density of a substance if 1.50 cubic meters has a mass of 1.89 kilograms?

4. Use the data in the table below to answer questions 4a-e.

Material	Density (g/cm^3)
mercury	13.6
silver	10.5
water	1.00
iron	7.86
gold	19.3
platinum	21.4

   a. Jada read a story about a miner who lived during the time of the California "gold rush." The miner found a gold-colored nugget and passed it along to his grandson as a keepsake. The miner's grandson was curious about whether the nugget was really gold. He used a balance and found the mass of the nugget to be 12.1 grams. When placed in a graduated cylinder with water, the nugget caused the water level to increase by 2.42 milliliters. Was the nugget really gold? Explain your answer. (Hint: Remember 1 mL = 1 cm^3)

   b. What is the mass of a sample of mercury if its volume is 4.35 cubic centimeters?

   c. Suppose you had one cubic centimeter (1 cm^3) of each material listed in the table. Which material would have the greatest mass? Which would have the least mass?

   d. What is the volume of a 2.45 gram sample of iron?

   e. Christopher found a shiny coin on the playground. The coin had a mass of 18.9 grams. He placed the coin in a graduated cylinder filled with water to the 25.0-milliliter mark. The coin sank to the bottom of the cylinder and the water level rose to the 26.8-milliliter mark. Of what material was the coin made?

5. The density of ice is 0.920 g/cm^3. What is the mass of a block of ice with a volume equal to 16.0 cubic centimeters?

Name: ____________________ Date: ______________

Buoyancy

READ

When an object is placed in a fluid like water, the fluid pushes up on the object. This upward force is called a **buoyant force**. At the same time, there is an attractive force between the object and Earth, which we call the force of gravity. It acts as a *downward force*.

- If the buoyant force pushing up on an object is greater than the force of gravity pulling down on the object, then the object floats.
- If the buoyant force pushing up on an object is less than the force of gravity pulling down on an object, then the object sinks.

Suppose you completely fill a bucket with water. What happens if you place a brick in the bucket? The water will spill over the sides of the bucket. The brick *displaces* (or takes the place of) some of the water, which causes the water level in the bucket to rise.

An object placed in a fluid displaces a volume of the fluid. The volume of fluid displaced is equal to the volume of the object that sinks below the surface of the fluid. If the volume of a brick equals 500 cm^3, then the water pushed aside by the brick is 500 cm^3. On Earth, the 500 cm^3 volume of water displaced by the brick weighs 4.9 newtons. Because the water displaced by the brick weighs 4.9 newtons, the buoyant force acting on the brick is also 4.9 newtons. **The buoyant force acting on an object in a fluid is equal to the weight of the fluid the object displaces.**

Buoyancy is related to density. If you know the density of an object and the density of the fluid in which it is placed, you can predict whether it will sink or float. When an object is *less dense* than the fluid it is in, the object will **float**. An object that is *more dense* than the fluid it is in will **sink**.

Sometimes an object placed in a fluid neither sinks nor floats, but is suspended in the fluid. This occurs when the upward buoyant force is equal to the downward force of gravity and is called *neutral buoyancy.*

EXAMPLES ▶

Example 1: A teacher places a golf ball in a beaker filled with water. If the density of the golf ball is 1.17 g/cm^3 and the density of water is 1.00 g/cm^3, will the golf ball sink or float? **Answer:** Sink. The golf ball is more dense than the water.

Example 2: Stuart bought a goldfish from the pet store. When placed in a bowl of water, the goldfish neither sank nor floated. What inference can Stuart make about the forces acting on the goldfish? **Answer:** Two forces are acting on the goldfish: buoyancy and gravity. The goldfish does not sink or float because the forces of buoyancy and gravity are equal but opposite of one another. The goldfish demonstrates neutral buoyancy.

Example 3: Jennifer placed 24.2 milliliters of water in a graduated cylinder. She carefully placed a rock in the cylinder, which caused the water level to rise to 26.7 milliliters. What volume of water is pushed aside by the rock? **Answer:** The volume of water pushed aside by the rock is equal to the rise in the water level within the graduated cylinder.

$$26.7 \text{ mL} - 24.2 \text{ mL} = 2.5 \text{ mL}$$

PRACTICE

1. A lead block placed in water sinks. If 875 cm^3 of water is pushed aside by the block, what is the volume of the block?

2. The density of a piece of wood is 0.9 g/cm^3. Will the piece of wood sink or float in water?

3. The same piece of wood is placed in mercury, which has a density of 13.6 g/cm^3. Will it sink or float?

4. Suppose a ball is placed in each of the fluids listed in the table below. If the density of the ball is 0.84 g/cm^3, in which fluids will it float? In which fluids will the ball sink?

Material	Density (g/cm^3)
gasoline	0.73
water	1.00
vegetable oil	0.89
kerosene	0.82
milk	1.03

5. A 3.24-gram object has a volume of 5.46 milliliters.
   a. What is the density of the object?
   b. Does the object sink or float in vegetable oil?

6. Carrie found a strange rectangular-shaped object in her backyard. She determined its mass to be 5.84 grams.
   a. Carrie used her ruler to measure the object. She recorded its length as 4.00 centimeters, its width as 2.00 centimeters, and its height as 1.00 centimeter. What is the volume of the object?
   b. What is the density of the object Carrie found?
   c. Carrie placed the object in water. Did it sink or float?
   d. Would this object sink or float in gasoline? Explain your answer.

7. An object has a volume of 1,550 cm^3.
   a. What volume of water is displaced by the object if you push it underwater?
   b. Suppose the object weighs 450 newtons. What is the buoyant force acting on the object?

8. The force of gravity acting on an object on Earth is 9.8 newtons. If the buoyant force acting on the object is 5.6 newtons, does the object sink or float? Explain your answer.

9. A cube placed in water neither sinks nor floats. What can you infer about the forces acting on the cube?

10. The density of paraffin wax is 0.87 g/cm^3. A student places a block paraffin wax in water. Will it sink or float?

Name: _______________ Date: _______________

SKILL and PRACTICE 3.3

Mass vs. Weight

READ

What is the difference between mass and weight?

mass	weight
• Mass is a measure of the amount of matter in an object. Mass is not related to gravity. • The mass of an object does not change when it is moved from one place to another. • Mass is commonly measured in grams or kilograms.	• Weight is a measure of the gravitational force between two objects. • The weight of an object does change when the amount of gravitational force changes, as when an object is moved from Earth to the moon. • Weight is commonly measured in newtons or pounds.

Weightlessness: When a diver dives off of a 10-meter diving board, she is in free-fall. If the diver jumped off of the board with a scale attached to her feet, the scale would read zero even though she is under the influence of gravity. She is “weightless” because her feet have nothing to push against. Similarly, astronauts and everything inside a space shuttle seem to be weightless because they are in constant free fall. The space shuttle moves at high speed, therefore, its constant fall toward Earth results in an orbit around the planet.

EXAMPLES

- On Earth’s surface, the force of gravity acting on one kilogram is 2.22 pounds. So, if an object has a mass of 3.63 kilograms, the force of gravity acting on that mass on *Earth* will be:

$$3.63 \text{ kg} \times \frac{2.22 \text{ pounds}}{\text{kg}} = 8.06 \text{ pounds}$$

- On the moon’s surface, the force of gravity is about 0.370 pounds per kilogram. The same object, if it traveled to the moon, would have a mass of 3.63 kilograms, but her weight would be just 1.33 pounds.

$$3.63 \text{ kg} \times \frac{0.370 \text{ pounds}}{\text{kg}} = 1.33 \text{ pounds}$$

PRACTICE

1. What is the weight (in pounds) of a 7.0-kilogram bowling ball on Earth’s surface?
2. What is the weight of a 7.0-kilogram bowling ball on the surface of the moon?
3. What is the mass of a 7.0-kilogram bowling ball on the surface of the moon?
4. Describe what would happen to the spring in a bathroom scale if you were on the moon when you stepped on it. How is this different from stepping on the scale on Earth?
5. Would a balance function correctly on the moon? Why or why not?
6. **Activity:** Take a bathroom scale into an elevator. Step on the scale.
    a. What happens to the reading on the scale as the elevator begins to move upward? to move downward?
    b. What happens to the reading on the scale when the elevator stops moving?
    c. Why does your weight appear to change, even though you never left Earth’s gravity?

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SKILL and PRACTICE
4.1

Internet Research Skills

READ

The Internet is a valuable tool for finding answers to your questions about the world. A search engine is like an on-line index to information on the World Wide Web. There are many different search engines from which to choose. Search engines differ in how often they are updated, how many documents they contain in their index, and how they search for information. Your teacher may suggest several search engines for you to try.

EXAMPLE

Search engines ask you to type a word or phrase into a box known as a *field*. Knowing how search engines work can help you pinpoint the information you need. However, if your phrase is too vague, you may end up with a lot of unhelpful information.

How could you find out who was the first woman to participate in a space shuttle flight?

First, put **key phrases** in quotation marks. You want to know about the "first woman" on a "space shuttle." Quotation marks tell the engine to search for those words together.

Second, if you only want websites that contain both phrases, **use a + sign** between them. Typing **"first woman" + "space shuttle"** into a search engine will limit your search to websites that contain both phrases.

If you want to broaden your search, use the word **or** between two terms. For example, if you type **"first female" or "first woman" + "space shuttle"** the search engine will list any website that contains either of the first two phrases, as long as it also contains the phrase "space shuttle."

You can narrow a search by using the word **not.** For example, if you wanted to know about marine mammals other than whales, you could type **"marine mammals" not "whales"** into the field. Please note that some search engines use the minus sign (-) rather than the word **not**.

PRACTICE 1

1. If you wanted to find out about science museums in your state that are not in your own city or town, what would you type into the search engine?
2. If you wanted to find out which dog breeds are not expensive, what would you type into the search engine?
3. How could you research alternatives to producing electricity through the combustion of coal or natural gas?

READ

The quality of information found on the Internet varies widely. This section will give you some things to think about as you decide which sources to use in your research.

1. **Authority:** How well does the author know the subject matter? If you search for “Newton’s laws” on the Internet, you may find a science report written by a fifth grade student, and a study guide written by a college professor. Which website is the most authoritative source?
   Museums, national libraries, government sites, and major, well-known “encyclopedia sources” are good places to look for authoritative information.

2. **Bias:** Think about the author’s purpose. Is it to inform, or to persuade? Is it to get you to buy something? Comparing several authoritative sources will help you get a more complete understanding of your subject.

3. **Target audience:** For whom was this website written? Avoid using sites designed for students well below your grade level. You need to have an understanding of your subject matter at or above your own grade level. Even authoritative sites for younger students (children’s encyclopedias, for example) may leave out details and simplify concepts in ways that would leave gaps in your understanding of your subject.

4. **Is the site up-to-date, clear, and easy to use?** Try to find out when the website was created, and when it was last updated. If the site contains links to other sites, but those links don’t work, you may have found a site that is infrequently or no longer maintained. It may not contain the most current information about your subject. Is the site cluttered with distracting advertisements? You may wish to look elsewhere for the information you need.

PRACTICE 2

1. What is your favorite sport or activity? Search for information about this sport or activity. List two sites that are authoritative and two sites that are not authoritative. Explain your reasoning. Finally, write down the best site for finding out information about your favorite sport.

2. Search for information about an earth science topic of your choice on the Internet (for example: “earthquakes,” “hurricanes,” or “plate tectonics”). Find one source that you would NOT consider authoritative. Write the key words you used in your search, the web address of the source, and a sentence explaining why this source is not authoritative.

3. Find a different source that is authoritative, but intended for a much younger audience. Write the web address and a sentence describing who you think the intended audience is.

4. Find three sources that you would consider to be good choices for your research here. Write a two to three sentence description of each. Describe the author, the intended audience, the purpose of the site, and any special features not found in other sites.

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Bibliographies

READ

When you write a research paper or prepare a presentation for your class, it is important to document your sources. A bibliography serves two purposes. First, a bibliography gives credit to the authors who wrote the material you used to learn about your subject. Second, a bibliography provides your audience with sources they can use if they would like to learn more about your subject.

This skill sheet provides bibliography formats and examples for research materials you may use when preparing science papers and presentations

EXAMPLES ▶

Books:

Author last name, First name. (Year published). *Title of book*. Place of publication: Name of publisher.

Vermeij, Geerat. (1997). *Privileged Hands: A Scientific Life*. New York: W.H. Freeman and Company.

Newspaper and Magazine Articles:

Author listed:

Author last name, First name. (Date of publication). Title of Article. *Title of Newspaper or Magazine*, page # or #'s.

Searcy, Dionne. (2006, March 20). Wireless Internet TV Is Launched in Oklahoma. *The Wall Street Journal*, p. B4.

Brody, Jane. (2006, February/March). 10 Kids' Nutrition Myth Busters. *Nick Jr Family Magazine*, pp. 72-73.

No author listed:

Title of article. (Date of publication). *Title of Newspaper or Magazine*, page # or #'s.

Chew on this: Gum may speed recovery. (2006, March 20). *St. Louis Post-Dispatch*, p.H2.

Adventures in Turning Trash into Treasure: (2006, April). *Reader's Digest*, p. 24.

Online Newspaper or Magazine:

Author listed:

Author last name, First name. (Date of publication). Title of Article. *Title of Newspaper or Magazine*, Retrieved date, from web address.

Dybas, Cheryl Lyn. (2006, March 20). Early Spring Disturbing Life on Northern Rivers. *The Washington Post*, Retrieved March 22, 2006, from www.washingtonpost.com.)

No author listed:

Title of Article. (Date of publication). *Title of Newspaper or Magazine*. Retrieved date, from web address.

Comet mystery turns from hot to cold. (2006, March 20). *The Boston Globe*, retrieved March 22, 2006, from Boston.com.

Online document:

Author listed:

Author last name, author first name. (Date of publication). *Title of document*. Retrieved date, from web address.

Martinez, Carolina. (2006, March 9). *NASA's Cassini Discovers Potential Liquid Water on Enceladus*. Retrieved March 22, 2006, from http://www.nasa.gov/mission_pages/cassini/media/cassini-20060309.html

No Author listed:

National Science Foundation. (2005, December 15). *A fish of a different color.* Retrieved March 22, 2206 from http://www.nsf.gov/news/news_summ.jsp?cntn_id=105661&org=NSF&from=news.

Name: ______________________ Date: ______________

SKILL and PRACTICE 4.2

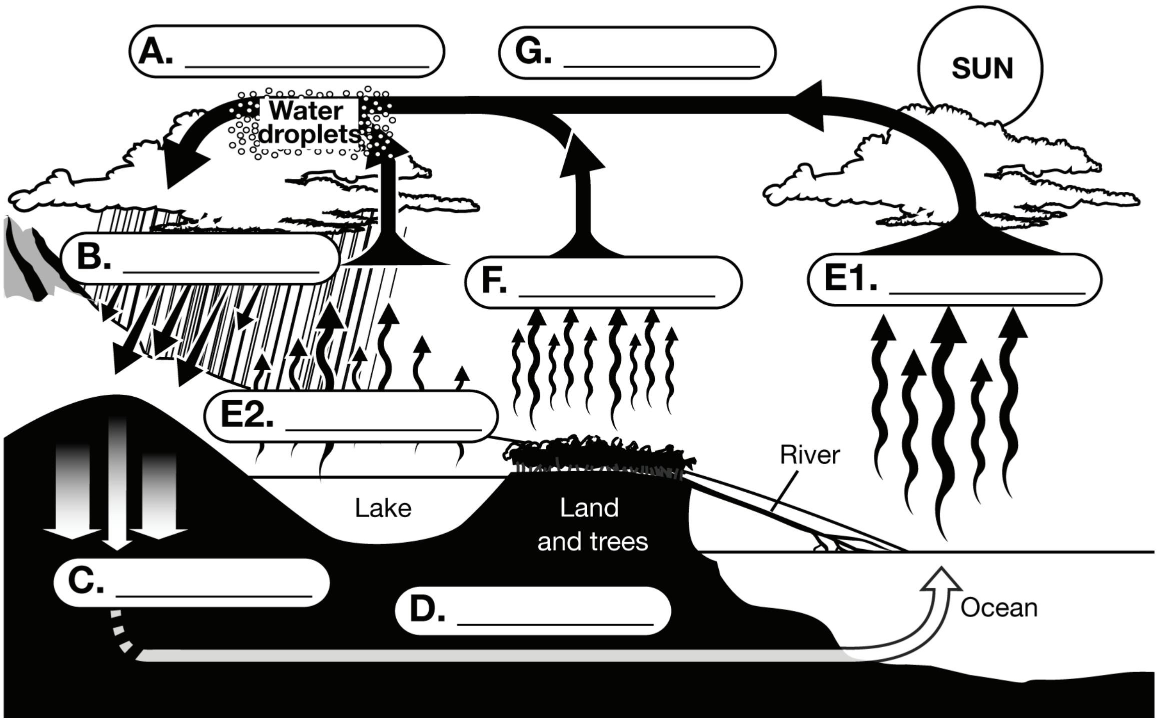
The Water Cycle

READ

As you study Section 4.2 in your student text, you will learn about the processes that move water around our planet. Together, these processes form the water cycle. Use the word box to help you label the water cycle diagram below. Some words may be used more than once.

- condensation
- percolation
- groundwater flow
- transpiration
- evaporation
- precipitation
- water vapor transport

The Water Cycle



PRACTICE

Answer the following questions. Use the diagram above and Section 4.2 of your text to help you.

1. Name two water cycle processes that are driven by the Sun. Explain the Sun's role in each.
2. How is wind involved in the water cycle?
3. How does gravity affect the water cycle?

Name: ______________________________ Date: ______________

SKILL and PRACTICE 4.2

Groundwater and Wells Project

READ

When it rains, some of the water that falls on Earth seeps into the ground, while some water flows over the surface into local streams or lakes. Some water is absorbed by plants and some evaporates back into the atmosphere. The water that seeps into the ground flows downward, moving through empty spaces between soil, sand, or rocks. It continues its journey until it reaches rock through which it cannot easily move. Then, it starts to fill the spaces between the rock and soil above. The top of this wedge of water is called the *water table*.

The water that fills the empty spaces is called *groundwater*. Areas that groundwater easily moves through are called *aquifers*. *Aquitards* are bodies of rock where water can move through—but very slowly. If the aquitard does not allow any water to pass, it is called an *aquiclude*. Groundwater comes from precipitation (rain and snow melt), from lakes or rivers that leak water, and even from extra water not used by agricultural crops when they are irrigated.

Groundwater is a very important source of drinking water. According to the US Geological Survey, 51% of Americans get their drinking water from groundwater. 99% of the rural population in the US uses groundwater for drinking. 37% of agricultural water, which is mostly used for irrigation comes from groundwater. Groundwater is obtained by digging wells. The water fills the well underground and a pump inside pumps it up to the surface where it travels through pipes to bring it to our homes and businesses.

This project will help you learn more about groundwater movement and wells.

Materials:

- GeoBox
- Plastic wrap
- Wooden skewer or dowel with diameter less than 0.5"
- ½”to 3/4” white stone; rounded is better (approximately 1,800 mL total)
- Food dye - dark colors
- 3 wells (1/2” inside diameter PVC pipe with caps; 4 well holes near cap drilled with 13/64 drill bit)
- ¼” plastic foam; one piece 7 3/4” x 13 ¾”; second piece 7 ¾” x 9"
- 8-10 cotton swabs
- Watering can or beaker
- Caulk or plumbers putty (something that can be molded around the PVC wells for waterproofing)
- Tape

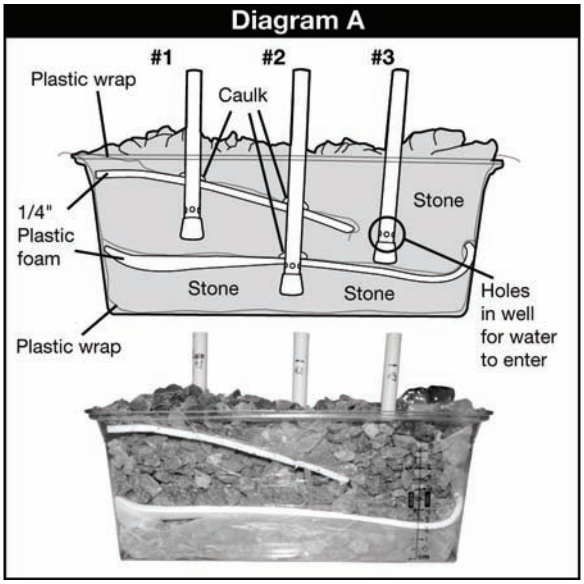
Constructing the model:

1. Line the inside of the GeoBox with plastic wrap so that it comes up and over the edges of the box.

2. Hold well #2 in the middle of the GeoBox, with the cap end sitting directly on the bottom of the GeoBox. Add approximately 1,800 mL of the rock, surrounding the well. The rock should just cover the holes of the well and the well should stand on its own.

3. The larger plastic foam sheet will be layered next on top of the rock. In order to put it down, carefully poke the well through it so it fits over the well. Now place on top of it the plastic wrap that will come up and over the edges. Because you need to also make a hole in the plastic wrap through which to fit the well, use the caulk or putty to mold around the well and onto the plastic wrap to keep it water proof.

Diagram A



4. Once this is set, hold well #3 in place on the right side (diagram A) and add approximately 2,000 mL of stone down on the surface, so that it surrounds well #3 and holds it upright.

5. Now add approximately 1,300 mL of stone to the left side of the GeoBox to create a diagonal plane of stone that runs highest from the left edge to level just right of well #2.

6. Place well #1 in the built up area of stone on the left side of the GeoBox, just above, but not touching the first plastic foam layer (as well #3 is). Make sure that the stone is covering the holes in the well.

7. Place the smaller plastic foam sheet over well #1 and well #2, again poking holes in the plastic foam so that the sheet can sit on the rock layers below. This sheet will be slanted down towards the middle.

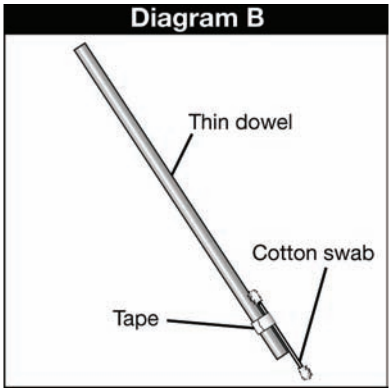
8. Again you will cover just the sheet with plastic wrap which will come up and over the edge on three sides. Caulk the two wells that poke through this sheet.

9. Use the remaining 3,000 mL of stone to fill the tray up to the top so that what is visible is just stone and three well tops. See photo at right.

10. Tape one cotton swab to the end of the skewer or wooden rod so that the cotton swab reaches out from the end of the wood. See diagram B at right.

11. Dye the water that you will be using for precipitation a dark color, such as blue, red, or green.

Diagram B



Making predictions:

a. Which well/s would you expect to collect water when it rains?

b. If contamination entered from the surface, what well would you expect to first show contaminated water?

c. Will well #2 get contaminated from surface contamination? Why?

Testing the model:

1. Watch the water flow closely as you do this experiment.
2. Sprinkle or pour the dyed water into the top layer of rock to simulate precipitation, without allowing the water to precipitate into the wells. The dye will make it easier to see the water as it travels.
3. Regularly check the wells with the cotton swab/dowel rods to see if water has entered the wells. In this way, you can also see which well collected water the quickest.
4. For a demonstration of the movement of surface pollution—dye water another color and allow this contaminated water to percolate through the layers. Use new cotton swabs attached to the wooden rods to visualize if and when the wells will get contaminated. The cotton swab should change color as the two dyes mix.

Thinking about what you observed:

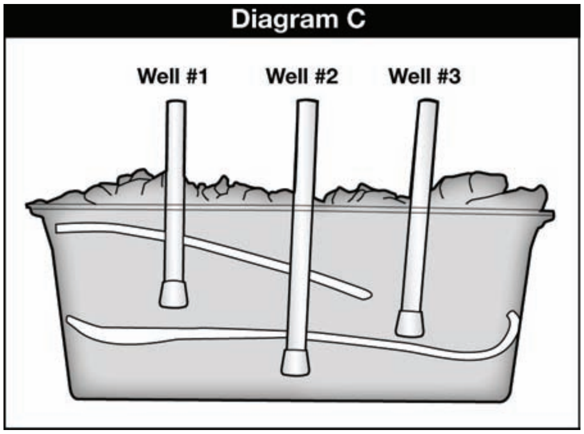
a. Which wells collected water when it rained? Was your hypothesis correct?

b. Which well was first to be contaminated? Was your hypothesis correct?

c. What does the plastic wrap/plastic foam layer represent? Label diagram C appropriately.

d. What do the rock layers represent? Label diagram C appropriately.

Diagram C



e. Did well #2 get contaminated from surface contamination? Why? Was your hypothesis correct?

f. What effect would pumping from well #1 have on movement of surface contamination? Pumping from well #2?

g. What would happen if there was a dry spell and the water table and thus the groundwater was lowered to below well #1? Would any well be able to pump water?

h. If well #3 were located near the coast, what effect might pumping freshwater too quickly have on the water in the well?

i. When you dig a well, how might you decide how deep to dig it?

Name: ____________________________ Date: ________________

Dimensional Analysis

READ

Dimensional analysis is a way to tell what the correct label (also called units or dimensions) for the solution to a problem should be. In dimensional analysis, we treat the units the same way that we treat the numbers. For example, this problem shows how you can "cancel" the sixes and then perform the multiplication:

$$\frac{5}{\cancel{6}} \bullet \frac{\cancel{6}}{7} = \frac{5}{7}$$

In some problems, there are no numerical cancellations to make, but pay close attention to the units (or dimensions):

$$\frac{9\text{ weeks}}{1} \bullet \frac{7\text{ days}}{1\text{ week}} = \frac{9 \bullet 7 \bullet \text{weeks} \bullet \text{days}}{1\text{ week}} = \frac{63\ \cancel{\text{weeks}}\text{ days}}{\cancel{1\text{ week}}} = 63\text{ days}$$

The "weeks" may be cancelled either before or after the multiplication.

The goal of dimensional analysis is to simplify a problem by focusing on the units of measurement (dimensions).

Dimensional analysis is very useful when converting between units (like converting inches to yards, or converting between the metric and English systems of measurement.

EXAMPLE

- How many minutes are there in one day?

Solution:

a. Determine what it is that we want to find out: $\frac{\text{minutes}}{\text{day}}$.

It's important to remember that if the solution is to have the label $\frac{\text{minutes}}{\text{day}}$:

Minutes should be kept in the numerator (or top part of the fraction).
Day(s) should be kept in the denominator (or bottom part of the fraction).

b. Determine what we know. We know that there are **60** minutes in an hour and **24** hours in a day.

c. Write what you know mathematically (fractions). Here, we have: $\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}}$

d. Set up the problem by focusing on the units (dimensions).

Just writing the information from #3 as a multiplication problem, we have: $\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}}$

Looking *only* at the units, hr(s) cancel, leaving just: $\frac{\text{min}}{\cancel{\text{hr}}} \bullet \frac{\cancel{\text{hr}}}{\text{day}} = \frac{\text{min}}{\text{day}}$

e. Calculate:

$$\frac{60\text{ min}}{1\text{ hr}} \bullet \frac{24\text{ hr}}{1\text{ day}} = \frac{60 \bullet 24\text{ min} \bullet \cancel{\text{hr}}}{1\ \cancel{\text{hr}} \bullet \text{day}} = \frac{1{,}440\text{ min}}{\text{day}}$$

Notice that canceling the units can be done either before or after the multiplication.

f. Check your solution for reasonableness: Since there are 60 minutes in just one hour, it is expected that there would be many minutes in an entire day. It does seem reasonable that there are 1,440 minutes in a day.

PRACTICE

1. Multiply. Be sure to label your answers.

a. $\frac{30\text{ mi}}{1\text{ gallon}} \bullet \frac{12\text{ gallons}}{1\text{ tank}}$

b. $\frac{70\text{ feet}}{\text{second}} \bullet 60\text{ seconds}$

c. $\frac{15\text{ mi}}{\text{hr}} \bullet \frac{1\text{ hr}}{60\text{ min}} \bullet 30\text{ min}$

2. Use dimensional analysis to convert each. You may need to use a reference to find some conversion factors. Show all of your work.

a. 15 pints to some number of quarts

b. 30,000 feet to some number of miles

c. 28,800 seconds to some number of hours

3. Use dimensional analysis to find each solution. You may need to use a reference to find some conversion factors. Show all of your work.

a. On Saturday, Sammie ran a 5k road race. How far is this in miles?

b. DeAndre earns $6.25 per hour. He works 6 hours each day, five days each week. What are his weekly earnings?

c. Using the information from “b”: If DeAndre has two weeks of unpaid vacation this year, how much does he earn for the year?

d. Simon fills his gas tank. Gas costs $3.39 per gallon. His tank will hold 12 gallons of gas. How much does it cost Simon to fill his tank?

e. A wide receiver for a professional football team has a 40-inch vertical jump. How much is this in centimeters?

f. Lorraine has set a goal of collecting at least 100 pieces of candy during trick-or-treating this Halloween. From past years, she thinks she will average 2 pieces of candy from each home she visits. Her brother expects to do the same. Lorraine can also count on collecting half of her little brother's candy. If she goes with her brother, how many houses must Lorraine visit in order to accomplish her goal?

g. Greg can type 33 words in 1 minute. How many words does he average per second?

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Internet Research Skills

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PRACTICE 1

1. If you wanted to find out about science museums in your state that are not in your own city or town, what would you type into the search engine?
2. If you wanted to find out which dog breeds are not expensive, what would you type into the search engine?
3. How could you research alternatives to producing electricity through the combustion of coal or natural gas?

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1. **Authority:** How well does the author know the subject matter? If you search for “Newton’s laws” on the Internet, you may find a science report written by a fifth grade student, and a study guide written by a college professor. Which website is the most authoritative source?
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2. **Bias:** Think about the author’s purpose. Is it to inform, or to persuade? Is it to get you to buy something? Comparing several authoritative sources will help you get a more complete understanding of your subject.

3. **Target audience:** For whom was this website written? Avoid using sites designed for students well below your grade level. You need to have an understanding of your subject matter at or above your own grade level. Even authoritative sites for younger students (children’s encyclopedias, for example) may leave out details and simplify concepts in ways that would leave gaps in your understanding of your subject.

4. **Is the site up-to-date, clear, and easy to use?** Try to find out when the website was created, and when it was last updated. If the site contains links to other sites, but those links don’t work, you may have found a site that is infrequently or no longer maintained. It may not contain the most current information about your subject. Is the site cluttered with distracting advertisements? You may wish to look elsewhere for the information you need.

PRACTICE 2

1. What is your favorite sport or activity? Search for information about this sport or activity. List two sites that are authoritative and two sites that are not authoritative. Explain your reasoning. Finally, write down the best site for finding out information about your favorite sport.

2. Search for information about an earth science topic of your choice on the Internet (for example: “earthquakes,” “hurricanes,” or “plate tectonics”). Find one source that you would NOT consider authoritative. Write the key words you used in your search, the web address of the source, and a sentence explaining why this source is not authoritative.

3. Find a different source that is authoritative, but intended for a much younger audience. Write the web address and a sentence describing who you think the intended audience is.

4. Find three sources that you would consider to be good choices for your research here. Write a two to three sentence description of each. Describe the author, the intended audience, the purpose of the site, and any special features not found in other sites.

Name: ______________________________ Date: ______________

Layers of the Atmosphere

READ

Use the table below to organize the information in Section 5.2 of your text. You can use the table as a study guide as you review for tests.

PRACTICE

Layer	Distance from Earth's Surface	Thickness	Facts
Troposphere			
Stratosphere			
Mesosphere			
Thermosphere			
Exosphere			

Name: ______________________ Date: ______________

Drawing Line Graphs

READ

Graphs allow you to present data in a form that is easy to understand. Line graphs include these important parts:

1. **Data pairs:** Graphs are made using pairs of numbers. Each pair of numbers represents one data point on a graph. The first number in the pair represents the independent variable and is plotted on the *x*-axis. The second number represents the dependent variable and is plotted on the *y*-axis.
2. **Axis labels:** The label on the *x*-axis is the name of the independent variable. The label on the *y*-axis is the name of the dependent variable. Be sure to write the units of each variable in parentheses after its label.
3. **Scale:** The scale is the quantity represented per line on the graph. The scale of the graph depends on the number of lines available on your graph paper and the range of the data. Divide the range by the number of lines. To make the calculated scale easy-to-use, round the value to a whole number.
4. **Title:** The format for the title of a graph is: "Dependent variable name versus independent variable name."

PRACTICE

1. For each data pair in the table, identify the independent and dependent variable. Then, rewrite the data pair according to the headings in the next two columns of the table The first two data pairs are done for you.

	Data pair (not necessarily in order)		Independent (*x*-axis)	Dependent (*y*-axis)
1	Temperature	Hours of heating	Hours of heating	Temperature
2	Stopping distance	Speed of a car	Speed of a car	Stopping distance
3	Number of people in a family	Cost per week for groceries		
4	Stream flow rate	Amount of rainfall		
5	Tree age	Average tree height		
6	Test score	Number of hours studying for a test		
7	Population of a city	Number of schools needed		

2. Using the variable range and number of lines, calculate the scale for an axis. The first two are done for you.

Variable range	Number of lines	Range ÷ Number of lines	Calculated scale	Adjusted scale
13	24	13 ÷ 24 =	0.54	1
83	43	83 ÷ 43 =	1.93	2
31	35			
100	33			
300	20			
900	15			

3. Here is a data set for you to plot as a graph. Follow these steps to make the graph.

   a. Place this data set in the table below. Each data point is given in the format of (*x*, *y*). The *x*- values represent time in minutes. The *y*-values represent distance in kilometers.
   (0, 5.0), (10, 9.5), (20, 14.0), (30, 18.5), (40, 23.0), (50, 27.5), (60, 32.0).

Independent variable (*x*-axis)	**Dependent variable (*y*-axis)**

   b. What is the range for the independent variable?

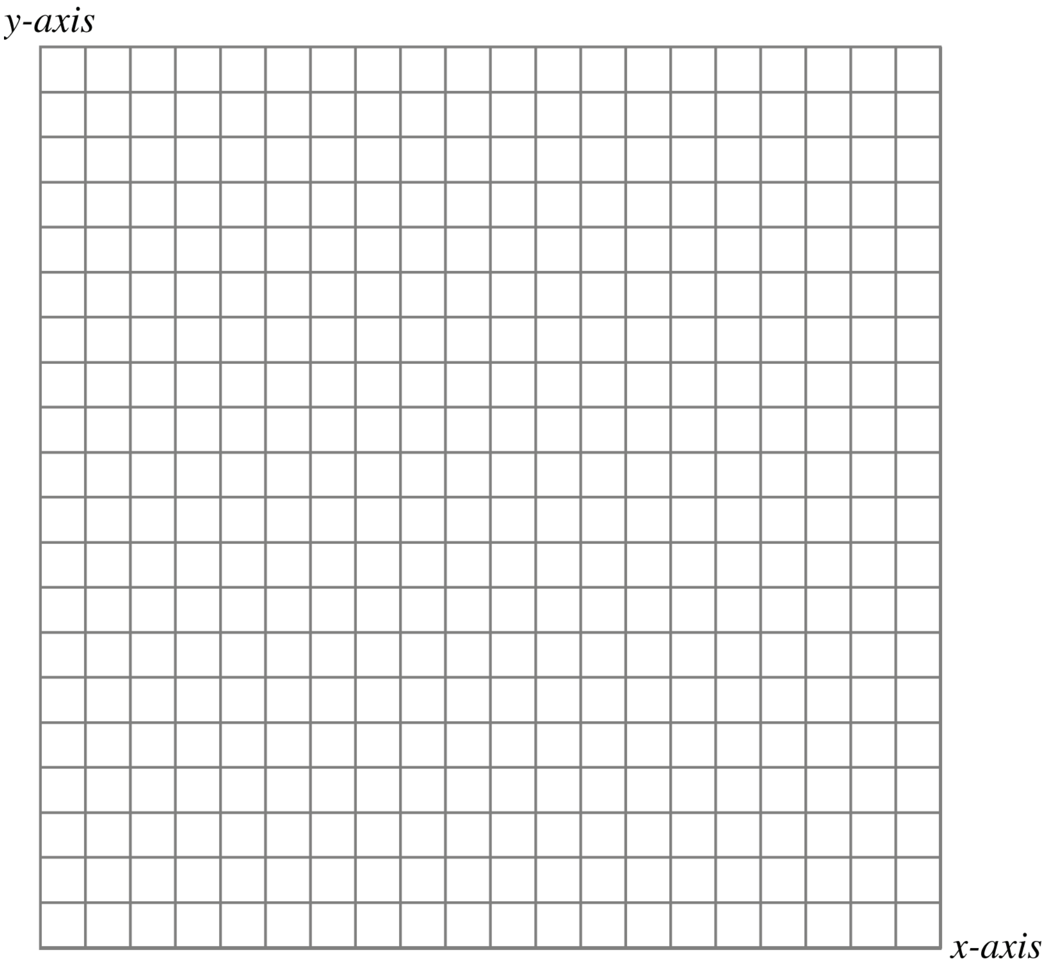
   c. What is the range for the dependent variable?

   d. Make your graph using the blank graph below. Each axis has twenty lines (boxes). Use this information to determine the adjusted scale for the *x*-axis and the *y*-axis.

   e. Label your graph. Add a label for the *x*-axis, *y*-axis, and provide a title.

   f. Draw a smooth line through the data points.

g. Question: What is position value after 45 minutes? Use your graph to answer this question.



Name: ______________________________ Date: ______________

Specific Heat

READ

Specific heat is the amount of thermal energy needed to raise the temperature of 1 gram of a substance 1°C.

Specific heat is one physical characteristic of a material. Some materials have high specific heat values. This means it takes a lot of thermal energy to raise their temperature. Materials with high specific heat values also have to release more thermal energy to lower their temperature than materials with lower specific heat values. Some sample specific heat values are presented in the table below:

Material	Specific Heat (J/kg °C)
water (pure)	4,184
aluminum	897
silver	235
oil	1,900
concrete	880
gold	129
wood	1,700

Water has the highest specific heat of the listed types of matter. This means that water is slower to heat but is also slower to lose heat.

PRACTICE

Using the table above, solve the following heat problems.

1. If 100 joules of energy were applied to all of the substances listed in the table at the same time, which would have the greatest temperature change? Explain your answer.
2. Which of the substances listed in the table would you choose as the best thermal insulator? A thermal insulator is a substance that requires a lot of heat energy to change its temperature. Explain your answer.
3. Which substance—wood or silver—is the better thermal conductor? A thermal conductor is a material that requires very little heat energy to change its temperature. Explain your answer.
4. Which has more thermal energy, 1 kg of aluminum at 20°C or 1 kg of gold at 20°C?
5. How much heat in joules would you need to raise the temperature of 1 kg of water by 5°C?
6. How does the thermal energy of a large container of water compare to a small container of water at the same temperature?

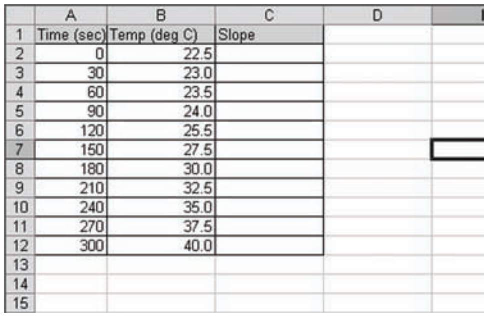
Name: Date:

SKILL and PRACTICE 6.1

Using Computer Spreadsheets

READ

Computer spreadsheets provide an easy way to organize and evaluate data that you collect from an experiment. Numbers are typed into boxes called “cells.” The cells are organized in rows and columns. You can find the average of a lot of numbers or do more complicated calculations by writing formulas into the cells. Each cell has a name based on its column letter and row number. For example, the first cell in most spreadsheets is “A1.”



	A	B	C	D
1	Time (sec)	Temp (deg C)	Slope	
2	0	22.5		
3	30	23.0		
4	60	23.5		
5	90	24.0		
6	120	25.5		
7	150	27.5		
8	180	30.0		
9	210	32.5		
10	240	35.0		
11	270	37.5		
12	300	40.0		
13				
14				
15				

This skill sheet will show you how to:

1. Record data in a computer spreadsheet program.

2. Do simple calculations for many data values at once using the spreadsheet.

3. Make a graph with the data set.

To complete this skill sheet, you will need:

- Simple calculator
- Access to a computer with a spreadsheet program

EXAMPLE

1. **Adding data:** Open the spreadsheet program on your computer. You will see a window open that has rows and columns. The rows are numbered. The columns are identified by a letter.

   a. As shown in the graphic above, add headings for columns A, B, and C:
   cell A1, type “Time (sec)”
   cell B1, type “Temp (deg C)”
   cell C1, type “Slope”
   NOTE: You can change the width of the columns on your spreadsheet by clicking on the right-hand border and dragging the border to the left or right.

   b. Highlight column B. Then, go to the **Format** menu item and click on **Cells**. Make the format of these cells **Number** with one decimal place. Highlight column C and make the format of these cells Number with two decimal places.

   c. Type in the data for Time and Temperature as shown in the graphic above.

2. **Making a graph:** Now, you will use the data you have added to the skill sheet to make a graph.

   a. Use your mouse to highlight the titles and data in columns A and B.

   b. Then, go to **Insert** and click on **Chart**.

   c. In step 1 of the chart wizard, choose the **XY (Scatter)** format for your chart and click “Next.”

   d. In step 2 of the chart wizard, you will see a graph of your data. Click “Next” again to get to step 3. Here, you can change the appearance of the graph.

   e. In step 3 of the chart wizard add titles and uncheck the show legend-option. In the box for the chart title write “Temperature vs. Time.” In the box for the value *x*-axis, write “Time (seconds).” In the box for the value for *y*-axis, write “Temperature (deg Celsius).”

f. In step 4 of the chart wizard, click the option to show the graph as an object in Sheet 2. At this point you will finish your work with the chart wizard.

g. Setting the scale on the x-axis: Place the cursor on the x-axis and double click. Set the minimum of the scale to be 0, the maximum to be 310. Set the major unit to be 100 and the minor unit to be 20. Then, click OK. *Note: Make sure the boxes to the left of the changed values are NOT checked.*

h. Setting the scale on the y-axis.: Place the cursor on the y-axis and double click. Set the minimum of the scale to be 20, the maximum to be 41. Set the major unit to be 10 and the minor unit to be 2. Then, click OK. *Note: Make sure the boxes to the left of the changed values are UNchecked.*

i. You are now finished with your graph. It is located on Sheet 2 of your spreadsheet.

3. Performing calculations:

a. Return to Sheet 1 of your spreadsheet.

b. The third column of data, “Slope,” will be filled by performing a calculation using data in the other two columns.

c. Highlight the second cell from the top in the Slope column (cell C2). Type the following and hit enter:
= (B3-B2)/(A3-A2)
Explanation of the formula: The equal sign (=) indicates that the information you type into the cell is a formula. The formula for the slope of a line is as follows. Do you see why the formula for cell C2 is written the way it is?

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

d. Adding the formula to all the cells: Highlight cell C2, then drag the mouse down the column until the cells (C2 to C11) are highlighted. Then click **Edit**, then **Fill**, then **Down**. The formula will copy into each cell in column C. However, the formula pattern will be appropriate for each cell. For example, the formula for C2 reads: = (B3-B2)/(A3-A2). The formula for C3 reads: = (B4-B3)/(A4-A3). Note: The “=” sign is important. Do not forget to add it to the formula.

e. In column C, you will see the slope for pairs of data points. Now, answer the questions below.

PRACTICE

1. Which is the independent variable—time or temperature? Which is the dependent variable?
2. When setting up the data in a spreadsheet, which data set goes in the first column, the independent variable or the dependent variable?
3. Use the graph you created in step 2 of the example to describe the relationship between temperature and the time it takes to heat up a volume of water.
4. Look at the values for slope. How do these values change for the graph of temperature versus time?

5. The following data is from an experiment in which the temperature of a substance was taken as it was heated. Transfer this data into an Excel file and make an XY(Scatter) graph.

Time (seconds)	Temperature (°C)
Independent data	Dependent data
10	7.5
20	10.8
30	11.6
40	11.9
50	13.3
60	21.9
70	26.3
80	26.6
90	29.1
100	31.1

6. Use the following data set to make a graph in Excel. Find the slope for pairs of data points along the plot of the graph. Is the slope the same for every pair of points?

Independent data	Dependent data
1	5
2	7
2.5	8
3.2	9.4
1.5	6
0.5	4
4	11
2.8	8.6
4.2	11.4
5	13

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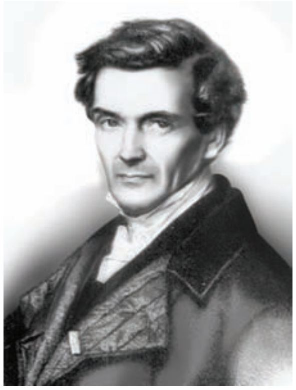
Name:____ Date:_____________________

Gaspard Gustave de Coriolis

Gaspard Gustave de Coriolis was a French mechanical engineer and mathematician in the early 1800's. His name is famous today for his work on wind deflection by the Coriolis effect.

From Paris to Nancy to Paris again



Gaspard Gustave de Coriolis (Kor-e-olis) was born in 1792 in Paris, France.

Shortly after his birth, his family left Paris and settled in the town of Nancy, pronounced *nasi* in French. It was here in Nancy that Coriolis grew up and attended school.

He was exceptionally gifted in the area of mathematics, and took the entrance exam for Ecole Polytechnique when he was 16 years old. Ecole is French for school. Ecole Polytechnique is one of the best-known French Grandes ecoles (Great Schools) for engineering. Coriolis ranked second out of all the students entering Ecole Polytechnique that year.

After graduating from Ecole Polytechnique, he continued his studies at Ecole des Ponts et Chaussees (School of Bridges and Roads) in Paris.

Then Coriolis' dreams of becoming an engineer were put on hold. Faced with the responsibility of supporting his family after his father's death in 1816, he accepted a position as a tutor in mathematical analysis and mechanics back at Ecole Polytechnique. At this time, Coriolis was only 24 years old.

The tutor becomes a professor

Coriolis earned great respect for his studies and research in mechanics, engineering, and mathematics. He published his first official work in 1829 titled *On the Calculation of Mechanical Action*. This same year he became professor of mechanics at Ecole Centrales des Artes et Manufactures. Coriolis became one of the leading scientific thinkers by introducing the terms *work* and *kinetic energy*.

In 1830 he once again found himself back at Ecole Polytechnique after accepting the position of professor. Coriolis went on to be elected chair of the Academie des Sciences, and later appointed director of studies at Ecole Polytechnique.

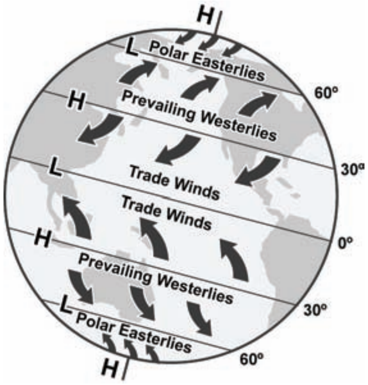
The paper that made him famous

In 1835, Coriolis published the paper that made his name famous: *On the Equations of Relative Motion of Systems of Bodies*. The paper discussed the transfer of energy in rotating systems. Coriolis's research helped explain how the Earth's rotation causes the motion of air to curve with respect to the surface of the Earth.

His name did not become linked with meteorology until the beginning of the twentieth century. He is noted for the explanation of the bending of air currents known as the **Coriolis effect**.

Bending of currents

There are patterns of winds that naturally cover the Earth. The global surface wind patterns in the northern and southern hemisphere bend due to the Earth's rotation.



For example, the Coriolis effect bends the trade winds moving across the surface. They flow from northeast to southwest in the northern hemisphere, and from southwest to northeast in the southern hemisphere.

The Coriolis effect has helped scientist explain many rotational patterns, yet it does not determine the direction of water draining in sinks, bathtubs, and toilets (as some have suggested). However, it does explain the rotation of cyclones.

Gaspard Gustave de Coriolis died in 1843 in Paris, France.

Reading reflection

1. How did Coriolis's education influence his work?
2. Explain the importance of Coriolis's first book titled *On the Calculation of Mechanical Action*.
3. To understand why Earth's rotation affects the path of air currents, imagine the following situation: You are a pilot who wants to fly an airplane from St. Paul, Minnesota, 700 miles south to Little Rock, Arkansas. If you set your compass and try to fly straight south, you will probably end up in New Mexico! Why would you end up in New Mexico instead of Little Rock?
4. Compare the Coriolis effect in the northern hemisphere with the Coriolis effect in the southern hemisphere.
5. Research the following global surface wind patterns: **trade winds, polar easterlies, prevailing westerlies,** and explain the Coriolis effect on each wind pattern.
6. Research why Coriolis's work on Earth's rotation was not accepted until long after his death in 1843.
7. Research the other books that Coriolis wrote, such as *Mathematical Theory of the Game of Billiards* and *Treatise on the Mechanics of Solid Bodies,* and explain their scientific impact.

Name:____ Date: __________________

Joanne Simpson

Dr. Joanne Simpson was the first woman to serve as president of the American Meteorological Society. Her road to success was not easy. She chose to forge ahead in the field of meteorology for the sake of women who would enter the field after her.

Early goals

Joanne Simpson was born in 1923 in Boston, Massachusetts. At a young age, Simpson was determined to have a career that would provide her with financial independence. Her mother, a journalist, remained in a difficult marriage because she could not afford to provide for her children on her own. Simpson knew at age ten that she wanted to be able to support herself and any future children.

So Simpson's journey began. As a child, Simpson loved clouds. She spent time gazing at clouds when she sailed off the Cape Cod coast. Simpson's father, aviation editor for the Boston Herald newspaper, probably sparked Simpson's interest in flight. Joanne loved to fly and earned her pilot's license at 16. Her interest in weather took off.

The sky's the limit

Simpson earned her degree from the University of Chicago in 1943. It was here that she developed a love for science. She planned to study astrophysics. However, as a student pilot she was required to take a meteorology course. Meteorology was fascinating. She wanted to take more courses. Carl-Gustaf Rossby, a great twentieth century meteorologist, had just started an institute of meteorology at the university. Simpson met with Rossby and enrolled in the World War II meteorology program as a teacher-in-training. She taught meteorology to aviation cadets.

Women temporarily filled the roles of men away at war. At the end of the war, most women returned home, but not Simpson. She completed a master's degree and wanted to earn a Ph.D. Her advisor said that women did not earn Ph.D.s in meteorology. The all-male faculty felt that women were unable to do the work which included night shifts and flying planes. She was even told that if she earned the degree no one would ever hire a woman.

Determined even more, Simpson pursued her dream. She took a course with Herbert Riehl, a leader in the field of tropical meteorology. She asked Riehl if he would be her advisor and he agreed. Not surprisingly, Simpson chose to study clouds. Her new advisor thought it would be a perfect topic "for a little girl to study." Throughout her Ph.D. program, she studied in an unsupportive academic environment. She persevered and became the first woman to earn a Ph.D. in meteorology.

Working woman

As a woman, Simpson did have difficulty finding a job. Eventually she became an assistant physics professor. Two years later, she took a job at Woods Hole Oceanographic Institute to study tropical clouds. People at the time believed clouds were produced by the weather and were not the cause for weather. Simpson, studying cumulus clouds in the tropics, proved that clouds do affect the weather. She found that very tall clouds near the equator created enough energy to circulate the atmosphere. Together, Simpson and Riehl developed the "Hot Tower Theory." Tall cloud towers can carry moist ocean air as high as 50,000 feet into the air, create heat, and release energy.

While studying hurricanes, Simpson discovered that hot towers release energy to the hurricane eye and act as the hurricane's engine. Simpson's work with clouds continued as she created the first cloud model. Using a slide rule, she created a model well before computers were invented. She later became the first person to create a computerized cloud model.

A life of achievement

Simpson's career spans many decades, many institutions, and many positions. She has won numerous awards including the Carl-Gustaf Rossby Research Award. In 1979, she joined NASA's Goddard Space Flight Center and enjoyed finally working with other female scientists. As a NASA chief scientist, Simpson does not plan to retire. Today, she continues to study rainfall, satellite images, and hurricanes.

Reading reflection

1. Dr. Simpson achieved many “firsts” in the field of meteorology. Identify three of these first time achievements.
2. Simpson’s road to success in the field of meteorology was not easy. What obstacles did she overcome on her journey to eventual success?
3. What have you learned about working towards goals based on Simpson’s biography?
4. **Research:** What is a slide rule? What caused the slide rule to fade from use?
5. **Research:** What is the Carl-Gustaf Rossby Research Award?
6. **Research:** Where is the Woods Hole Oceanographic Institute located and what does it do?
7. **Research:** Use a library or the Internet to find a photo or sketch of hot tower clouds. Present the image to your class, citing your source.

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Name: ______________________________ Date: ______________

Weather Maps

READ

You have learned how the Sun heats Earth and how the heating of land is different than the heating of water. In this skill sheet, you will analyze the national weather forecast and make inferences as to what causes differences in weather across the nation. To complete this skill sheet, you will need a national weather forecast from a daily newspaper and a map of North America from an atlas.

PRACTICE

Analyzing temperature

Study the national weather forecast from a daily newspaper. Locate the list of the temperature and sky cover in cities around the country. Also, locate the weather map showing sunny regions, the temperature, high- and low-pressure regions, and fronts. Record the high and low temperatures for cities in the table below. Then find the difference between the two temperature readings. Sky cover and pressure will be filled in later.

City	High	Low	Temp difference	Sky cover	Pressure
Seattle, Washington					
Los Angeles, California					
Las Vegas, Nevada					
Phoenix, Arizona					
Atlanta, Georgia					
Tampa, Florida					
San Francisco, California					
Oklahoma City, Oklahoma					
New Orleans, Louisiana					
Kansas City, Kansas					
Tucson, Arizona					
Denver, Colorado					
Dallas, Texas					
Houston, Texas					
Minneapolis, Minnesota					
Memphis, Tennessee					
Chicago, Illinois					
Miami, Florida					
New York, New York					
Baltimore, Maryland					

What causes the wide variety of temperature conditions across the map?

Use the table on the first page to respond to the following questions. It will also be helpful for you to study a map of the United States that includes the Pacific and Atlantic Oceans and details about major topographical features.

1. Give examples of differences in the cities' high temperatures due to latitude. For example, Dallas, Texas is in a lower latitude than Seattle, Washington. Explain why these differences exist.

2. Give examples of differences in the cities' high temperatures due to geographical features such as the Pacific Ocean, the Rocky Mountains, the Great Lakes, or the Atlantic Ocean. Explain why geography influences temperatures.

3. Fill in the table for the sky cover for each city. How does the sky cover affect the temperatures of cities near the same latitude? Why do you think this is?

What does atmospheric pressure tell us about the weather?

4. On your weather map, over which states are areas of high pressure centered? Over which states are low-pressure areas centered?

5. In the sixth column of the table (the heading is Pressure), record whether you think each city is in a region of high pressure, low pressure, or in-between.

6. What kind of cloud cover or weather is associated with high-pressure regions? Look at the sky cover for the cities in the high-pressure regions. What do you think the humidity is like in these regions?

7. What kind of cloud cover or weather is associated with low-pressure regions? Look at the sky cover for the cities in the low-pressure regions. What do you think the humidity is like in these regions?

8. Locate the fronts shown on the weather map. The flags on the fronts tell us the direction of the wind. The cold fronts are symbolized by triangular flags, the warm fronts by semicircular flags. Are fronts associated with high- or low-pressure regions?

9. What type of weather is associated with a warm front? What type of weather is associated with a cold front?

10. Based on what you have learned so far about low- and high-pressure regions, let's investigate the effect they have on the wind. High-pressure regions tend to push air toward low-pressure regions. Do you think the air in a low-pressure region tends to sink or rise? Does the air in a high-pressure region sink or rise?

11. Based on those conclusions, how do you think low-pressure regions contribute to the formation of rainstorms?

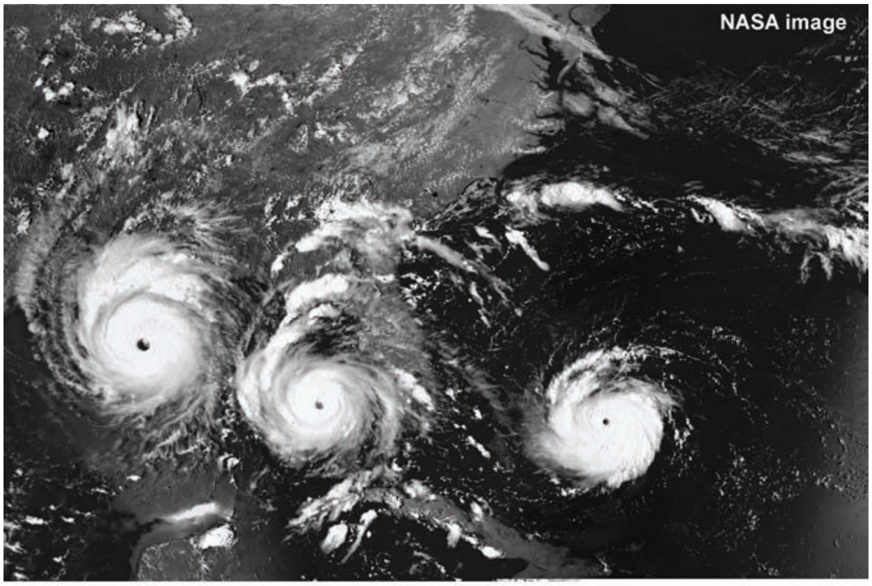
12. Precipitation occurs when warm, moist air is cooled to a certain temperature called the dew point. At the dew point temperature water in the air condenses into droplets of water called "dew" and soon these droplets fall out of the sky as precipitation. Why would a low-pressure region be a good place for a volume of air to reach the dew point temperature?

Name: ______________________ Date: ______________

Tracking a Hurricane

READ

Hurricane Andrew (August 1992) was one of the most devastating storms of the twentieth century. Originally labelled a Category 4 storm, it was recently upgraded to a Category 5, the most severe type of hurricane. Scientists use satellite data and weather instruments dropped by aircraft to measure the storm's intensity. As research techniques improve, weather experts can more accurately analyze data collected by these instruments. NOAA scientists have now determined that Andrew's sustained winds reached at least 165 miles per hour. In this activity, you will track Hurricane Andrew's treacherous journey.



Time-lapse satellite image of Hurricane Andrew's path

The storm's beginning

Hurricane Andrew was born as a result of a tropical wave which moved off the west coast of Africa and passed south of the Cape Verde Islands. On August 17, 1992, it became a tropical storm. That means it had sustained winds of 39-73 miles per hour.

1. At 1200 Greenwich Mean Time (GMT) on August 17, Tropical Storm Andrew was located at 12.3°N latitude and 42.0°W longitude. The wind speed was 40 miles per hour. Plot the storm's location on your map.
2. For the next four days, Tropical Storm Andrew moved uneventfully west-northwest across the Atlantic. Plot the storm's path as it traveled toward the Caribbean Islands.

Table 1:Tropical Storm Andrew's path

Date	Time (GMT)	Latitude (°N)	Longitude (°W)	Wind speed (mph)
8/18/1992	1200	14.6	49.9	52
8/19/1992	1200	18.0	56.9	52
8/20/1992	1200	21.7	60.7	46
8/21/1992	1200	24.4	64.2	58

The storm intensifies

Late on August 21, a deep high pressure center developed over the southeastern United States and extended eastward to an area just north of Tropical Storm Andrew. In response to this more favorable environment, the storm strengthened rapidly and turned westward. At 1200 GMT on August 22, the storm reached hurricane status, meaning it had sustained winds of at least 74 miles per hour.

1. Plot Hurricane Andrew's path over the next two days.

Table 2:Hurricane Andrew's path

Date	Time (GMT)	Latitude (°N)	Longitude (°W)	Wind speed (mph)
8/22/1992	1200	25.8	68.3	81
8/23/1992	1200	25.4	74.2	138

2. Hurricane watches are issued when hurricane conditions are *possible* in the area, usually within 36 hours. Hurricane warnings are issued when hurricane conditions are *expected* in the area within 24 hours. Look at the distance the hurricane travelled in the last 24 hours and use that information to predict where it might be in 24 hours, and in 36 hours. Name one area that you would declare under a hurricane watch, and an area that you would declare under a hurricane warning.

Landfall

On the evening of August 23, Hurricane Andrew first made landfall. Landfall is defined as when the center of the hurricane's eye is over land.

1. Plot the point of Hurricane Andrew's first landfall.

Table 3:Hurricane Andrew's first landfall

Date	Time (GMT)	Latitude (°N)	Longitude (°W)	Wind speed (mph)
8/23/1992	2100	25.4	76.6	150

2. Where did this first landfall occur?

Hurricane Andrew crosses the Gulf Stream and strikes the U.S.

During the night of August 23, Hurricane Andrew briefly weakened as it moved over land. However, once the storm moved back over open waters, it rapidly regained strength. The warm water of the Gulf Stream increased the intensity of the hurricane's convection cycle. At 0905 GMT on August 24, Hurricane Andrew made landfall again.

1. Plot the point of Hurricane Andrew's next landfall.

Table 4:Hurricane Andrew's next landfall

Date	Time (GMT)	Latitude (°N)	Longitude (°W)	Wind speed (mph)
8/24/1992	0905	25.5	80.3	144

2. Where did this landfall occur?

____

____

The final landfall

After making its first landfall in the United States (where it caused an estimated $25 billion in damage), Hurricane Andrew moved northwest across the Gulf of Mexico. On the morning of August 26, 1992, Hurricane Andrew made its final landfall. Afterward, Andrew weakened rapidly to tropical storm strength in about 10 hours, and then began to dissipate.

1. Plot Andrew's course across the Gulf of Mexico and its final landfall.

Table 5:Hurricane Andrew's next landfall

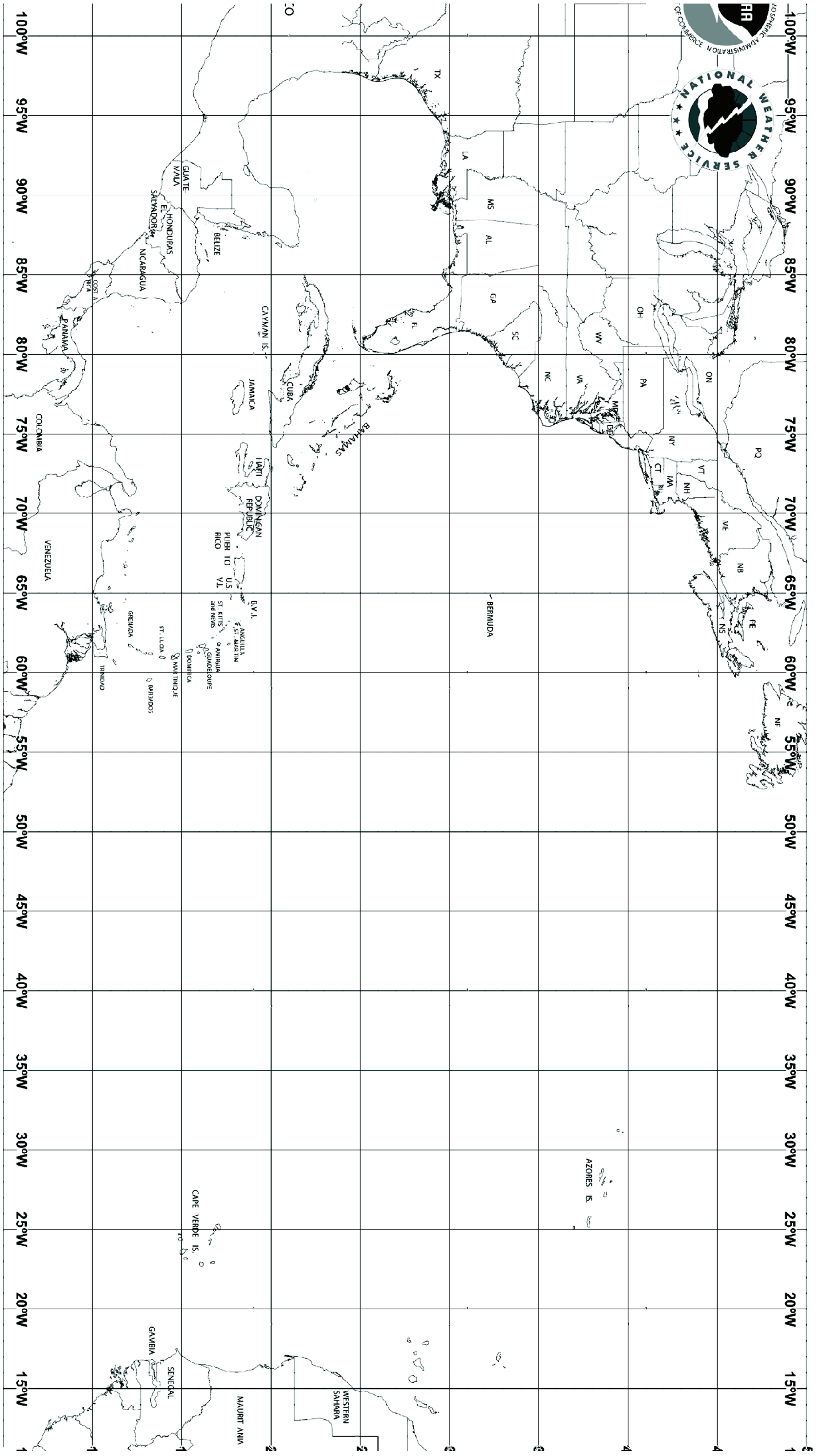
Date	Time (GMT)	Latitude (°N)	Longitude (°W)	Wind speed (mph)
8/24/1992	1800	25.8	83.1	133
8/25/1992	1800	27.8	89.6	138
8/26/1992	0830	29.6	91.5	121

2. In which state did Hurricane Andrew's final landfall occur?

____

____

Hurricane information provided by National Oceanographic and Atmospheric Administration's National Hurricane Center.



Atlantic Basin Hurricane Tracking Chart
National Hurricane Center, Miami, Florida

This is a reduced version of the chart used to track hurricanes at the National Hurricane Center

Name: ______________________________ Date: ______________

SKILL and PRACTICE 6.3

Degree Days

READ

Freezing winter weather or sweltering summer heat—in either condition, people use energy to keep their homes, schools, and businesses comfortable. You can use degree day values to help predict how much energy will be needed each month to heat or cool a building. In this activity, you will learn how degree day values are calculated and how to use them to evaluate energy needs.

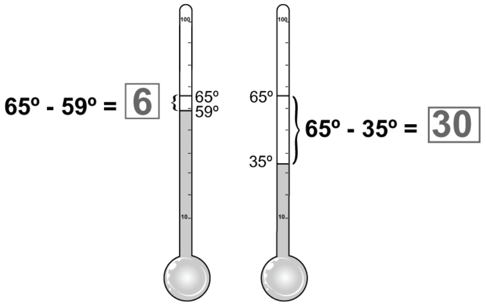
Understanding degree days

Degree day values are calculated by comparing a day's average temperature to 65° Fahrenheit. The more extreme the temperature, the higher the degree day value. For example, if the average daily temperature were 72°F, the degree day value would be 72 minus 65, or 7. On a day with an average temperature of 35°F, the degree day value would be 65 minus 35, or 30.

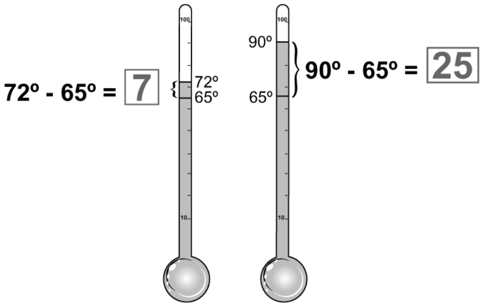
When the average daily temperature is *lower* than 65°F, we use the term **heating degree day value**, because you need to add heat to a building to bring it to a comfortable temperature. When the average daily temperature is *higher* than 65°F, we talk about the **cooling degree day value**.

We compare the daily average temperature to 65°F because 65°F is a temperature at which most people are comfortable without heating or air conditioning. If the average temperature is close to 65°F, you won't need to spend much money heating or cooling your home that day. However, if the average temperature is well above or below 65°F, you'll be spending a lot more money on electricity or fuel.

Heating Degree Day Values



Cooling Degree Day Values



PRACTICE

1. On July 22, 2002, the average daily temperature in St. Louis, Missouri, was 88°F. Calculate the cooling degree day value.

2. On January 22, 2003, the average daily temperature in St. Louis was 14°F. Calculate the cooling degree day value.

3. On which day—July 22, 2002 or January 22, 2003—was the heating degree day value zero? On which day was the cooling degree day value zero?

Using temperature data to calculate degree day values

The table below shows temperature data recorded by the National Weather Service in May 2003.

Table 1: Temperature data for St. Louis, May 1-14, 2003

Day	High temp (°F)	Low temp (°F)	Average temp (high +low)÷2	Heating degree day value	Cooling degree day value
1	73	61	(73+61)÷2 = 67	0	2
2	63	52			
3	70	44			
4	65	52			
5	83	58			
6	79	59			
7	74	60			
8	71	53			
9	90	70			
10	82	62			
11	65	52			
12	71	52			
13	74	56			
14	75	60			
Two week totals:					

1. Calculate the average temperature, the heating degree day value, and the cooling degree day value for each day. Record your answers in the Table 1. The first one is done for you.
2. During the first two weeks of May, on how many days were St. Louis residents more likely to use their heating systems? On how many days were they more likely to cool their homes?

Calculating monthly totals for degree day values

3. Find the sum of the numbers in the fifth column of Table 1. This will give you the *total heating degree day value* for May 1-14, 2003. Record your answer in the table's last row.
4. Find the *total cooling degree day value* for same time period by finding the sum of the sixth column of Table 1. Record your answer in the table's last row.
5. The total heating degree day value for May 15-31, 2003 was 31. The total cooling degree day value was 32. Find the *monthly* total heating and cooling degree day values.

6. In St. Louis, the average total heating degree day value for May is 79. The average total cooling degree day value for May is 114. How was May 2003 different from the average? Do you think residents used more energy than usual to keep their homes comfortable, or less?

Using average monthly degree day values

The National Weather Service provides average monthly degree day values to help citizens better evaluate their energy needs.

Average monthly heating degree day (HDD) and cooling degree day (CDD) values for St. Louis

January		February		March		April		May		June	
HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD
1097	0	844	0	613	7	294	32	79	114	6	316

Average monthly heating degree day (HDD) and cooling degree day (CDD) values for St. Louis

July		August		September		October		November		December	
HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD	HDD	CDD
0	461	1	396	46	196	246	36	583	3	949	0

1. On a separate piece of paper, make a bar graph showing the average monthly heating and cooling degree day values for St. Louis. Place months on the *x*-axis and monthly average degree day values on the *y*-axis. Use red bars for the heating degree day values and blue bars for the cooling degree day values. Use your graph to answer the following questions:

2. In which month should a St. Louis resident budget the most money for heating costs?

3. In which month should a St. Louis resident budget the most money for cooling costs?

4.
   a. In which month do you think a St. Louis resident will spend the least amount of money to keep their home at a comfortable temperature? Explain.

   b. Challenge! What additional information would you need to calculate the actual monthly heating and cooling costs for a particular building?

All climate data courtesy of the National Weather Service St. Louis Weather Station.

Name: ________________________ Date: ____________

Internet Research Skills

READ

The Internet is a valuable tool for finding answers to your questions about the world. A search engine is like an on-line index to information on the World Wide Web. There are many different search engines from which to choose. Search engines differ in how often they are updated, how many documents they contain in their index, and how they search for information. Your teacher may suggest several search engines for you to try.

EXAMPLE

Search engines ask you to type a word or phrase into a box known as a *field*. Knowing how search engines work can help you pinpoint the information you need. However, if your phrase is too vague, you may end up with a lot of unhelpful information.

How could you find out who was the first woman to participate in a space shuttle flight?

First, put **key phrases** in quotation marks. You want to know about the “first woman” on a “space shuttle.” Quotation marks tell the engine to search for those words together.

Second, if you only want websites that contain both phrases, **use a + sign** between them. Typing **“first woman” + “space shuttle”** into a search engine will limit your search to websites that contain both phrases.

If you want to broaden your search, use the word **or** between two terms. For example, if you type **“first female” or “first woman” + “space shuttle”** the search engine will list any website that contains either of the first two phrases, as long as it also contains the phrase “space shuttle.”

You can narrow a search by using the word **not.** For example, if you wanted to know about marine mammals other than whales, you could type **“marine mammals” not “whales”** into the field. Please note that some search engines use the minus sign (-) rather than the word **not**.

PRACTICE 1

1. If you wanted to find out about science museums in your state that are not in your own city or town, what would you type into the search engine?
2. If you wanted to find out which dog breeds are not expensive, what would you type into the search engine?
3. How could you research alternatives to producing electricity through the combustion of coal or natural gas?

READ

The quality of information found on the Internet varies widely. This section will give you some things to think about as you decide which sources to use in your research.

1. **Authority:** How well does the author know the subject matter? If you search for “Newton’s laws” on the Internet, you may find a science report written by a fifth grade student, and a study guide written by a college professor. Which website is the most authoritative source?
   Museums, national libraries, government sites, and major, well-known “encyclopedia sources” are good places to look for authoritative information.

2. **Bias:** Think about the author’s purpose. Is it to inform, or to persuade? Is it to get you to buy something? Comparing several authoritative sources will help you get a more complete understanding of your subject.

3. **Target audience:** For whom was this website written? Avoid using sites designed for students well below your grade level. You need to have an understanding of your subject matter at or above your own grade level. Even authoritative sites for younger students (children’s encyclopedias, for example) may leave out details and simplify concepts in ways that would leave gaps in your understanding of your subject.

4. **Is the site up-to-date, clear, and easy to use?** Try to find out when the website was created, and when it was last updated. If the site contains links to other sites, but those links don’t work, you may have found a site that is infrequently or no longer maintained. It may not contain the most current information about your subject. Is the site cluttered with distracting advertisements? You may wish to look elsewhere for the information you need.

PRACTICE 2

1. What is your favorite sport or activity? Search for information about this sport or activity. List two sites that are authoritative and two sites that are not authoritative. Explain your reasoning. Finally, write down the best site for finding out information about your favorite sport.

2. Search for information about an earth science topic of your choice on the Internet (for example: “earthquakes,” “hurricanes,” or “plate tectonics”). Find one source that you would NOT consider authoritative. Write the key words you used in your search, the web address of the source, and a sentence explaining why this source is not authoritative.

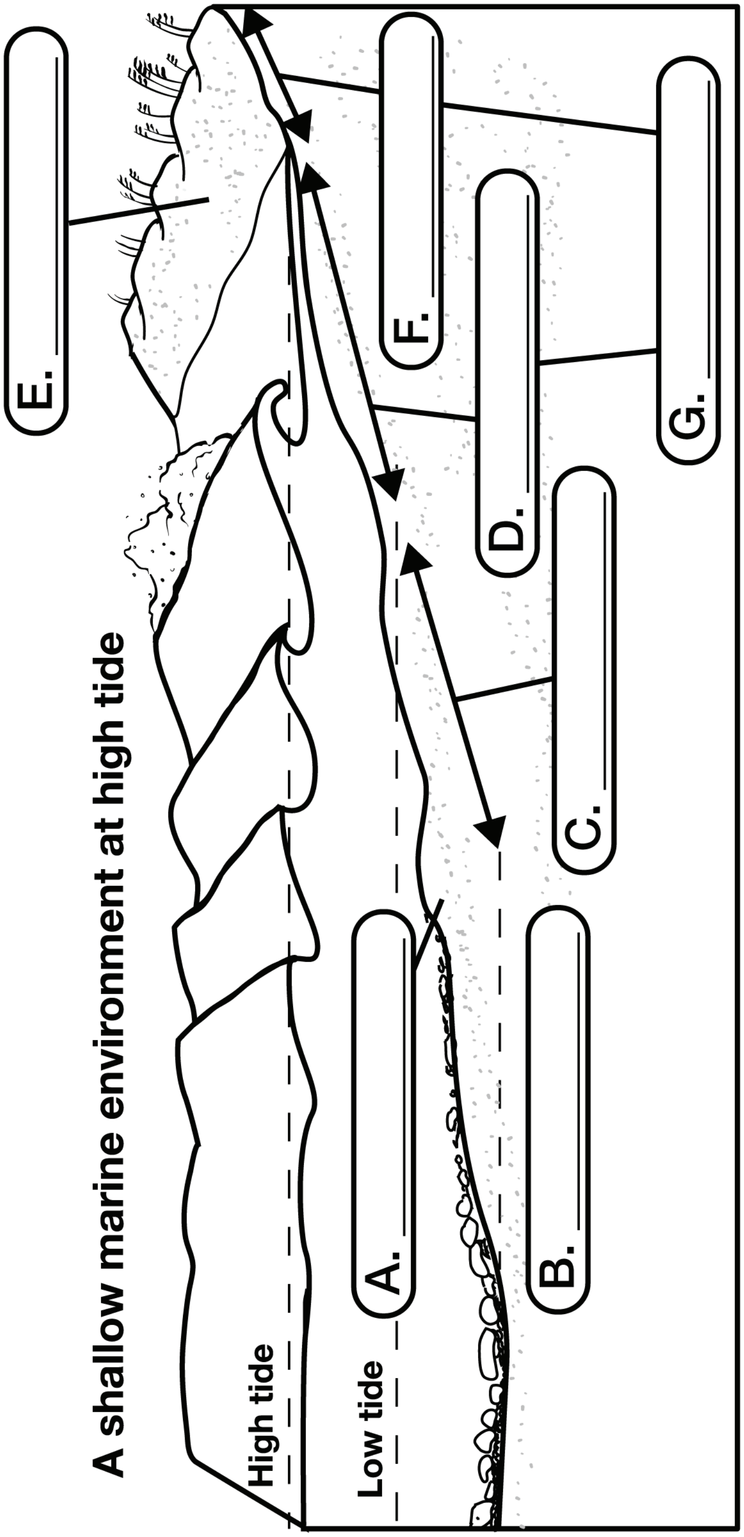
3. Find a different source that is authoritative, but intended for a much younger audience. Write the web address and a sentence describing who you think the intended audience is.

4. Find three sources that you would consider to be good choices for your research here. Write a two to three sentence description of each. Describe the author, the intended audience, the purpose of the site, and any special features not found in other sites.

Name: ______________________ Date: ______________

SKILL and PRACTICE
7.3

The Shallow Marine Environment



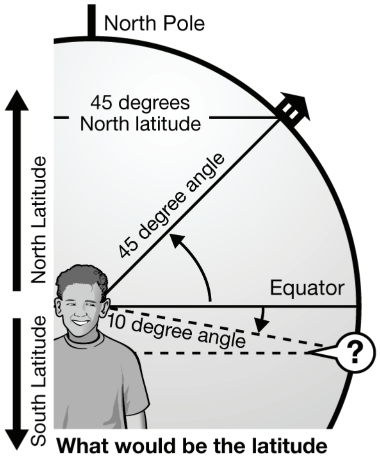
A shallow marine environment at high tide

Name: Date:

Latitude and Longitude

READ

History: Latitude and longitude are part of a grid system that describes the location of any place on Earth. When formalized in the mid-18th century, the idea of a grid system was not a new one. More than 2000 years ago, ancient Greeks drew maps with grids that looked much like our maps today. Using mathematics and logic, they postulated that Earth could be mapped in degrees north and south of the Equator and east and west of a line of reference. From the ancient times, geographers and navigators used devices such as the cross-staff, astrolabe, sextant, and astronomical tables to determine latitude. But determining longitude required accurate timepieces, and they were not reliably designed until the 1700's.



What would be the latitude of the question mark?

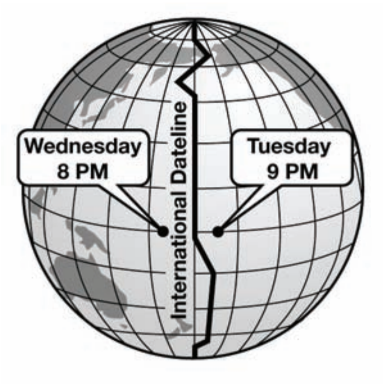
Latitude: Think of Earth as a transparent sphere, just as the ancient Greeks did. Now imagine yourself standing so that your eyes are at the center of that sphere. If you tip your head back and look straight up, you will see the North Pole above you. If you look straight down, you will see the South Pole below you. If you turn around while looking straight out at the middle of the sphere, your eyes will follow the Equator, the line around the middle of Earth. The ancient Greeks realized that they could describe the location of any place by using its angle from the Equator as measured from that imaginary place at the center of Earth.

All latitude lines run parallel to the Equator, creating circles that get smaller and smaller until they encircle the Poles. Because latitude lines never intersect, latitude lines are sometimes referred to as *parallels*.

At first, you might be confused because when latitude lines are placed on a map. They appear to run from the left side of the page to the right. You might think they measure east and west, but they don't. The graphic at the right shows latitude lines. If you think of them as steps on a ladder, then you will see the lines are taking you “up” toward the north or “down” toward the south. (Of course, there is no real “up” or “down” on a map or globe, but the association of LAdder and LAtitude may help you.)

The Equator is designated as 0º. The North Latitude lines measure from the Equator (0º) to the North Pole (90ºN). The South Latitude lines measure from the Equator (0º) to the South Pole (90ºS). There are other special latitude lines to note. The Tropic of Cancer is at 23.5ºN latitude, and at 23.5ºS latitude is the Tropic of Capricorn. These lines represent the farthest north and farthest south where the sun can shine directly overhead at noon. Latitudes of 66.5º N and 66.5º S mark the Arctic and Antarctic Circles, respectively. Because of the tilt of the Earth, there are winter days when the Sun does not rise and summer days when the sun does not set at these locations.

Longitude: Now imagine yourself back in the transparent sphere. Look up at the North Pole and begin to draw a continuous line with your eyes along the outside of the sphere to the South Pole. Turn to face the opposite side of the sphere and draw a line from the South Pole to the North Pole. These lines, and all other longitude lines, are the same length because they start and end at the poles. Look at the graphic below and see that although longitude lines are drawn from north to south, they measure distance from east or west.



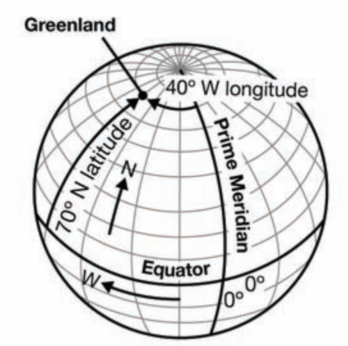
There are no special longitude lines, so geographers had to choose one from which to measure east and west. Longitude lines are also called *meridians*, so this special line is called the Prime Meridian and is labeled 0º. The ancient Greeks chose a *Prime Meridian* that passed through the Greek Island of Rhodes. In the 1700's, the French chose one that passed through Ferro, an island in the Canary Islands. There are maps that show that America even used Philadelphia as their special reference location. But in 1884, the International Meridian Conference met in Washington, DC. They chose to adopt a Prime Meridian that passes through an observatory in Greenwich, England. At the same conference, they also determined a point exactly opposite of the Prime Meridian. This second important longitude line is the 180º meridian. Longitude lines measure eastward and westward from the Prime Meridian (0º) to the180º meridian. Superimposed on the 180º meridian is the *International Dateline*. This special line does not follow the 180º meridian exactly. It zigzags a bit to stay in the ocean, which is an unpopulated area. International agreements dictate that the date changes on either side of the Dateline.

GPS and decimal notations. In the past, latitude and longitude lines always had measurement labels of degrees (º), minutes ('), and seconds ("). The labels of "minutes" and "seconds" did not denote time in these cases. Instead they described places between whole degrees of longitude or latitude more exactly. For example, consider Sacramento, CA. Traditionally, its location was said to be at 38º 34' 54"N (38 degrees, 34 minutes, 54 seconds North) and 121º 29' 36"W (121 degrees 29 minutes, 36 seconds West). Now GPS (Global Positioning System), in decimal notation would say Sacramento is located at 38.58ºN and 121.49ºW. Note: As a matter of custom when giving locations, latitude is listed first and longitude second.

EXAMPLES

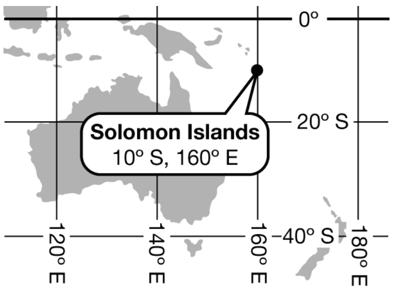
Finding a Location on a Globe

You can find any location by using latitude and longitude on a globe. See the example in the diagram. The position is 70ºN and 40ºW. First on the globe, you would find the latitude line 70ºN, seventy degrees north of the Equator. Next you would find the longitude line 40ºW, forty degrees west of the Prime Meridian. Trace the lines with your fingers. Where they intersect, you will find the location. In this case, you have located Greenland.



Finding a Location on a Map

You use the same procedure to find any location on a map. Look at the graphic below. The position is 10ºS and 160ºE. First you would find the latitude line 10ºS, ten degrees south of the Equator. Next you would find the longitude 160ºE, one hundred-sixty degrees east of the Prime Meridian. You have located the Solomon Islands.



PRACTICE 1

Use an atlas or globe to answer these practice questions.

1. What country will you find at the following latitude and longitude?
   a. 65ºN 20ºW
   b. 35ºN 5º E
   c. 50º S 70ºW
   d. 20ºS 140ºE
   e. 40ºS 175ºE
2. What body of water will you find at the following latitude and longitude?
   a. 20ºN 90ºW
   b. 40ºN 25ºE
   c. 20ºN 38º E
   d. 25ºN 95ºW
   e. 0ºN 60ºW

EXAMPLE

Converting Traditional Notation To Decimal Notation

Sometimes you need to convert the traditional notation of degrees, minutes, and seconds into decimal notation. First you must understand this traditional notation, which was a base-60 system.

One degree = 60 minutes
One minute = 60 seconds
One degree = 3,600 seconds (60 × 60)

Let's look at 34º 15' (thirty-four degrees 15 minutes).

Regardless of the system, the notation will begin with 34 degrees. To change the minutes into a decimal, you must divide 15 by 60, the number of minutes in one degree (15/60). The answer is 0.25. Therefore, the decimal notation would be 34.25º or thirty-four and twenty-five hundredths degrees.

Let's look at 12º 20' 38" (twelve degrees, twenty minutes, thirty-eight seconds). We know the notation will begin with 12 degrees. Next we have to convert the 20 minutes into seconds (20 × 60 = 1,200 seconds. Then we add the 38 seconds for a total of 1,238 seconds. There are 3,600 seconds in one degree, so you must divide 1,238 by 3,600. (1,238 / 3,600). The answer is 0.34. Therefore the decimal notation would be 12.34º or twelve and thirty-four hundredths degrees.

PRACTICE 2

3. Convert the following latitudes in traditional notation to decimal notation. (Round your answer to the nearest hundredth.)
   a. 30º 20' N
   b. 45º 45' N
   c. 20º 36' 40" S
   d. 60º 19' 38" S
4. Convert the following longitudes in traditional notation to decimal notation. (Round your answer to the nearest hundredth.)
   a. 25º 55' E
   b. 145º 15' E
   c. 130º 37' 10" W
   d. 85º 26' 8" W

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Name: ______________________ Date: ______________

Map Scales

READ

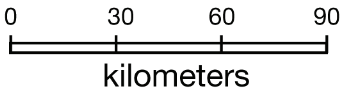
Mapmakers have developed a tool that allows them to accurately draw the entire world on a single piece of paper. It's not magic—it's drawing to scale. To be useful, maps must be accurately drawn to scale. The mapmaker must also reveal the scale that was used so that a map-reader can appreciate the larger real-life distances. The scale is usually written in or near the map's legend or key.

There are thee kinds of map scales: fractional, verbal, and bar scales. A fractional scale shows the relationship of the map to actual distance in the form of a fraction. A scale of 1/100,000 means that one centimeter on the map represents 100,000 centimeters (or 1 kilometer) of real life distance.

A verbal scale expresses the relationship using words. For example, "1 centimeter equals 500 kilometers." This is a more usable scale, especially with large real-life distances. With a scale of 1cm = 500 km, you could make a scale drawing of North America on one piece of paper.

A bar scale is the most user-friendly scale tool of all. It is simply a bar drawn on the map with the size of the bar equal to a distance in real life. Even if you do not have a ruler, you can measure distances on the map with a bar scale. Just line up the edge of an index card under the bar scale and transfer the vertical marks to the card. Label the distances each mark represents. You can then move the card around your map to determine distances. You might wonder what you should do if a location falls between the vertical interval lines. You must use estimation to determine that distance. Be careful to look at the scale before estimating. For example, if the distance falls half-way between the 10 and the 20 kilometer scale marks, estimate 15 kilometers. If the scale is different and the distance falls half-way between 30 and 60 kilometer marks, you must estimate 45 kilometers.

Types of map scales

Fractional	Verbal	Bar
1/1,000,000	1 cm = 1 km	

Let's explore the different kinds of scales. You will need centimeter graph paper, plain paper, an index card, and a centimeter ruler or measuring tape for these activities.

EXAMPLES

Fractional scale

Materials: Graph paper

Trace a simple object on a piece of graph paper. (A large paper clip, pen, small scissors, or paperback book work well.) Now make a scale drawing of the object using the fractional scale of 1/4. (Remember this means that for every 4 blocks occupied in the original tracing, you will have only one block on the scale drawing.) Be sure to label the scale on the finished scale drawing.

Verbal scale

Materials: Centimeter graph paper and centimeter measuring tape or ruler.

You are going to make a scale drawing of a person. Ask a classmate to stand against a wall with his/her arms outstretched to the side. Take 4 measurements in centimeters: 1) Distance from top of head to floor. 2) Distance from right finger tip to left finger. 3) Distance from top of head to shoulders. 4) Distance from shoulders to waist. Write the verbal scale of “1 cm equals 10 cm” on the bottom of a piece of centimeter graph paper. On that paper translate the measurements that your took into a simple figure drawing of your classmate. (Remember if a measurement is 25 centimeters in real life, you will have to make a drawing that is within 2 ½ centimeter blocks of the graph paper.)

Bar scale

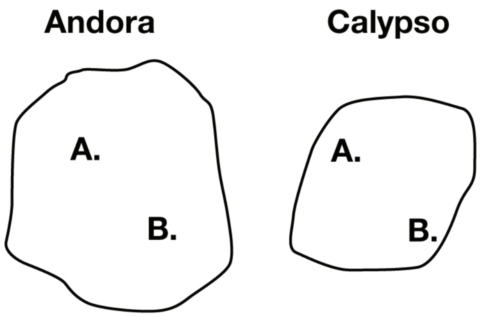
Materials: Plain paper and centimeter ruler or tape.

Position the paper so that it is wider than it is long.

Draw a bar scale that is a total of 6 centimeters long at bottom of the paper. Make four vertical marks at 0 cm, 2 cm, 4 cm, and 6 cm. Write “0”over the first mark, “50” over the second, “100” over the third and “150” of the last mark. Underneath the bar write “Kilometers.” Mark “N” for north at the top of your paper. Now use your imagination to draw an island (of any shape) that is 450 miles long and 200 miles wide at its widest point. Draw a star to mark the capital city, which is located on the northern coast 100 miles from the west end of the island.

PRACTICE

1. Answer these questions about Andora and Calypso:
   a. Which island appears bigger?
   b. Can you tell whether you can ride a bike in one day from point A to point B on either map? If no, why not?
   c. Measure the distance from the center of the dot to the right of A to the center of the dot to the left of B on both maps. Are the measurements the same?
   d. If the measurements are the same on both maps, does that mean the distance from point A to point B is the same on both maps? Explain your answer.
   e. Let’s write in the scale for these two islands. Write the scale of 1cm = 5 km on Andora. Write the scale of 1 cm = 1000 km on Calypso. Now answer the question, which island is bigger?



2. On the next page is a map of Monitor Island. Use the bar scale to find distances on this island. Assume that you are measuring “as the crow flies.” That means from point to point by air because there are no roads to follow. Always measure from dot to dot, and be sure to label your answers in kilometers.
   a. Point L to Point M
   b. Point Y to Point Z
   c. Point Z to Point P
   d. Point P to Point M

e. Point Q to Point T

f. Point Q to Point M

g. Point T to Point M

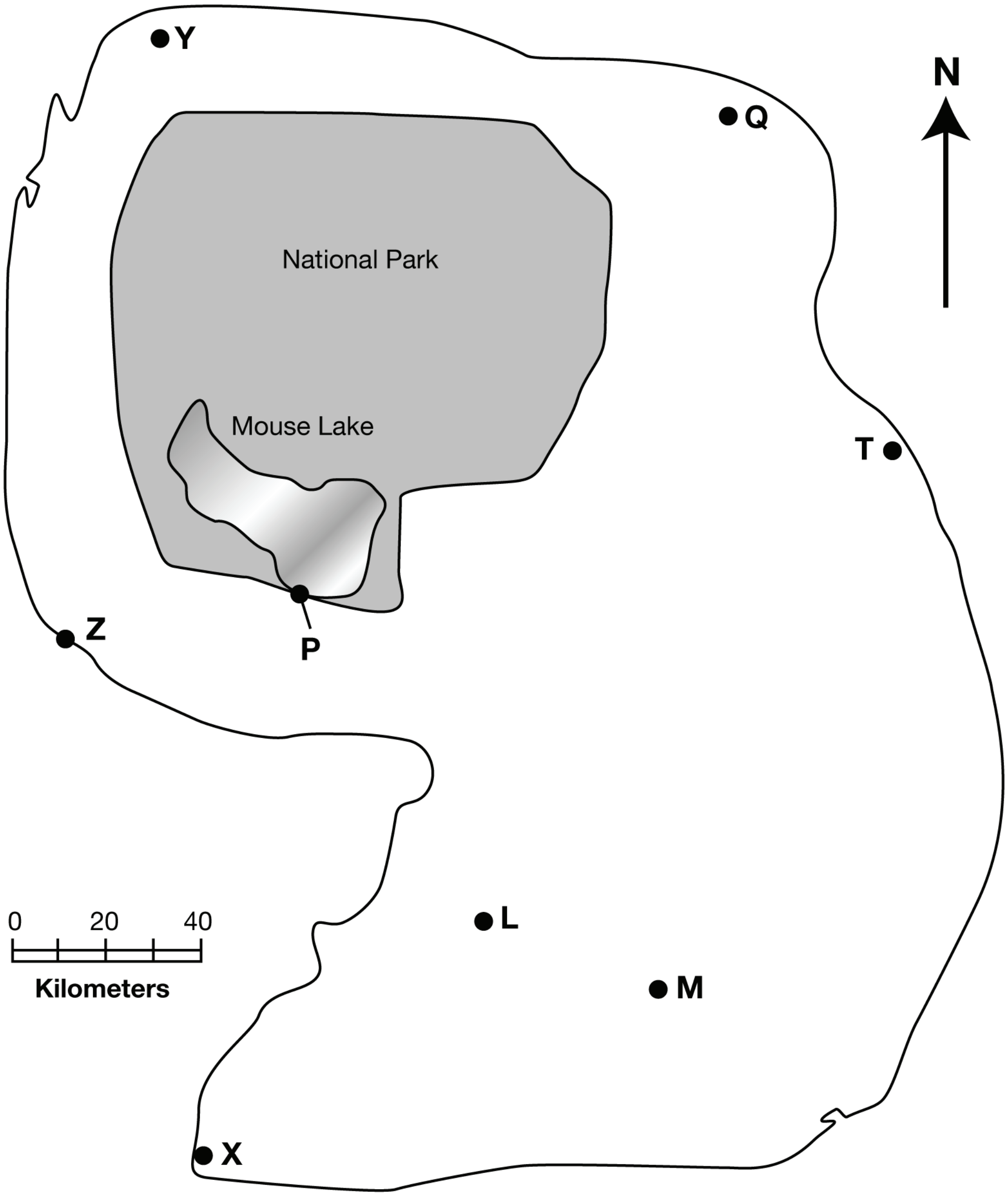
h. Point Z to Point P to Point X

i. Point X to Point L to Point M

j. Point X to Point P to Point Z to Point Y

Bonus: Measure around the coast of Monitor Island. It's hard to be exact, but write your best estimate.

Monitor Island



Name: ______________________ Date: ______________

Navigation Project

READ

Nautical charts have long been used by ship captains to navigate the oceans. As land has been increasingly developed and harbors built, more and more information is needed to safely navigate near shore. Additionally, offshore shallow banks, reefs, islands, seamounts, and other obstructions needed to be identified so that they don't hinder the passage of boats.

In this project, you and two other captains will navigate through the waters around Puerto Rico and some of the Virgin Islands using three real nautical maps. Your journey includes a stop at Isla de Vieques, which was a US Navy testing ground for bombs, missiles, and other weapons. It was vacated in May 2003 and now is used by locals and tourists. Bon Voyage.

Materials:

- NOAA map #25640 (laminated)
- NOAA map #25641 (laminated)
- NOAA map #25647 (laminated)

Note:
Laminated maps are available from NOAA (www.noaa.gov) or boating/marine supply stores, as well as some Coast Guard Stations.

- Internet access
- Erasable overhead projector marker

Getting started:

1. Have all three maps accessible.
2. Before beginning your imaginary journey, spend some time studying the maps. Look at any legends (example: note on pipelines and cables), abbreviation lists, and Notes (such as Note E on map 25640). Look at the map scale. Note whether the soundings are in fathoms or feet.
3. Note that the maps are laminated, so you can use an erasable marker to outline your path.

Making predictions:

a. What kind of ecosystem do you expect to find in these warm, sunlit waters?

b. What does this mean about navigating this area?

It’s time to go!

1. You and your two partners are tri-captains on a boat that is 12 feet deep. On board, you have a small row boat. Besides your clothes and toiletries for the trip, you will bring along wading boots, a solar still, a radio, your three maps, water, and food.
2. You will be traveling from the west coast of Puerto Rico, eventually ending your trip on the island of St. John. As captains, you will be making decisions about the course the boat will be taking based on directions given below. You will need to look out for (among other things) shallow water, pipelines, and other obstructions. Listen to what the map is telling you.
3. Let's start with map 25640. What is the scale of this map?
4. What does that mean?
5. How many feet are there in a fathom? Hint: The answer is outside the border of the map.
6. Find Punta Higuero on the west coast of Puerto Rico. What is located here? Use your abbreviations. You will probably have to look it up.
7. You will now be moving south along the west coast and then the south coast of Puerto Rico. Notice the light blue area around the coast. At the seaward edge of this area is a line. Every few inches along this line, you will see a number 10. What this means is that anywhere along this line the depth of the water is 10 fathoms. Remember, your boat is 12 feet deep. How many fathoms is this?
8. So your boat is fine anywhere along the line. However, as you head toward the coast from this 10-fathom line, the depth decreases, but since the depth is not marked again, you do not know how quickly it decreases and thus can't take your boat any closer to the shore. Remember this as you travel. So start traveling south. What do you encounter near the Bahia de Mayaguez?
9. What does this mean?
10. Is the depth of the water still suitable for traveling?
11. Travel around the marine conservation district. Should anyone be fishing here?
12. Can you pass between Bajas Gallardo and the Marine Conservation District?   If so, trace the path through and if not, find another way around towards the south shore.
13. Stay near to shore so you can have great views of the beautiful shallow blue waters. Find Punta Cayito and Punta Barrancas on the south shore. In the area offshore, there is a section between the 10 fathoms line and the next depth line of 100 fathoms were there are several abbreviated notations. Name three by noting the abbreviation and what it means.
14. Find the lighthouse near Cayos de Ratones. What type of lighthouse is it and why is that different than occulting?
15. 5M means that it can be seen for 5 nautical miles, which is 1.852 kilometers or 1.15 miles.
16. As you travel towards the southeastern coast of Puerto Rico, what area in a square dashed purple box do you see?
17. Do you think it would be a good or bad idea to drop anchor there?

18. Head to Isla de Vieques. There are supposed to be two beautiful bays that are filled with organisms that are bioluminescent. These one-celled organisms give off a blue-green glow when disturbed. You'll have to wait here till night-time in order to see this natural wonder. Can you take your ship right up to the shore? If not, what can you do to get there?
19. How many lighthouses are there on the Island?
20. Two lighthouses are flashing. One is occulting. What is the fourth, what does the symbol mean, and what two colors are associated with it?
21. How far out can you see the flashing and occulting lighthouse lights on the Island?
22. Your next stop is Savana Isle, a small island just west of St. Thomas. As you travel in that direction, what do you notice there are many of in the area of the Virgin Passage?
23. What does that mean you should NOT do in this area?
24. Can you bring your boat in directly to Savana Isle?
25. What does the (269) mean?
26. Now you are going to move to map 25641. The soundings are done in what units?
27. Orient yourselves for a minute. You are currently at Savana Isle. Find it on the map.
28. What is the scale on this map?
29. You can see that the scales on the maps are quite different. What do you notice when you look at the maps themselves. How are they different?
30. When you are sailing in this area, where do you call to report spills of oil and hazardous substances? There are two choices.
31. For weather information, to what station do you tune?
32. From Savana Isle, head toward Cricket Rock using Salt Cay or Dutchcap Passage. How many fathoms deep is the coastline?
33. Should you anchor and row in or go right up to the shore?
34. How much rock is covered and uncovered?
35. What are the local bottom characteristics?
36. By the way, what is a cay?

37. Now you will head to White Horseface Reef at Hans Lollik Isle. Watch your depths as you travel in that direction. What is submerged en route to the Isle?

38. Anchor where you can and spend some time snorkeling. Once you have completed your swim and returned to the ship, start heading through the Leeward Passage. Move to map 25647 at this point. In what units are the soundings measured?

39. What is the scale?

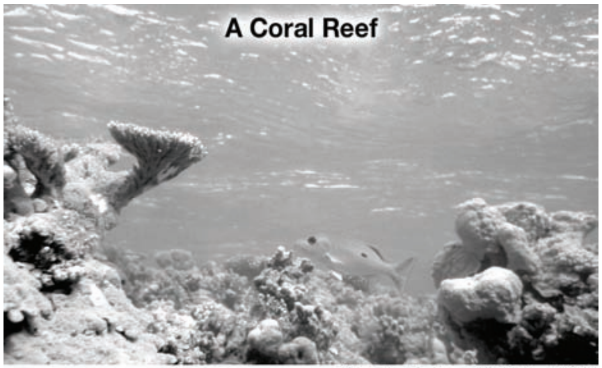


Photo by Dr. James P. McVey, NOAA.

40. Once again, what do you notice about the scale and amount of detail in the map?

41. On this map, what do the green solid and dashed green lines represent?

42. How does that affect your boat?

43. Heading through Leeward Passage and south of Thatch Cay, there is a rectangular box with a blue tint in the waterway. It is there to let you know, as captains, that there is an obstruction, a fish haven, which is an artificial reef. These are usually made of rock, concrete, car bodies, and other debris. If you'll notice, inside the box, it states an authorized minimum depth of 60 feet. If you look at the depth of the water on the map around the box, the values are deeper than 60 feet. Because of the artificial reef, the map is telling you that you can be assured to not have any obstruction down to 60 feet, but it is hazardous after that depth. The minimum depth is checked by sweeping the area with a length of horizontal wire. If there is an obstruction, the wire would get snagged. Is your boat okay to travel through this area?

44. Continue to Cabrita Point and through to St. James Bay. You are headed towards Jersey Bay, but you are going to have to be very careful navigating the Jersey Bay area as you will then head into Banner Bay Channel. It is recommended by the map that you seek local knowledge about some broken piles (wooden columns driven into the harbor sand beds on which structures can be built in the water) which may be below the waterline and are not marked on the map. As you look at the channel, make note of the depth of the water. Will you be able to take your boat in or row in? How can you tell?

45. Bring your wading boots just in case you need them. The symbols that look like ties (colored in green and purple) will help you navigate your way. These are buoys. The first letter of each buoy is either an R for ‘red’ or G for ‘green.’ The rule of thumb is to keep red buoys to the right (starboard) when returning to a harbor and green buoys to the left (port). Using that rule, get yourself to the coast and have some lunch in town, especially after all that rowing.

46. Take a taxi ride west of the harbor to the mangrove lagoon. Can you wade in there with your boots?

47. Mangroves are trees and shrubs that grown in saline marine areas. The mangrove roots impede the water flow. Since the water is carrying sediment, the slowed water deposits the sediment over time and actually builds coastline. These are very special ecosystems.

48. Spend some time here, take the taxi back to the row boat, and get back to your ship.

A Mangrove Lagoon

Photo by Ben Mieremet, NOAA.

49. Find a path to St. John and choose a landing site. Describe three more nautical notations that you encounter and how they influenced your route.

50. Congratulations! Your voyage has ended. Hope you learned how important map reading is for nautical navigation. Show your teacher your route.

Name: ______________________ Date: ______________

SKILL and PRACTICE 8.1

Geography Scavenger Hunt

READ

Being able to find your way around a world map or globe is a handy skill. With practice, you can hone that skill.

Today, you will work in teams of three or four members. Let's see how quickly your team can complete the following scavenger hunt. Work together to find the answers to these 15 questions about places around the world. When your team has completed this skill sheet, send one member to the teacher who will immediately correct your team's answers. However, your teacher will only tell you, “Congratulations, your skill sheet is correct,” or “Sorry, you have ___ error(s). Go back and find them.”

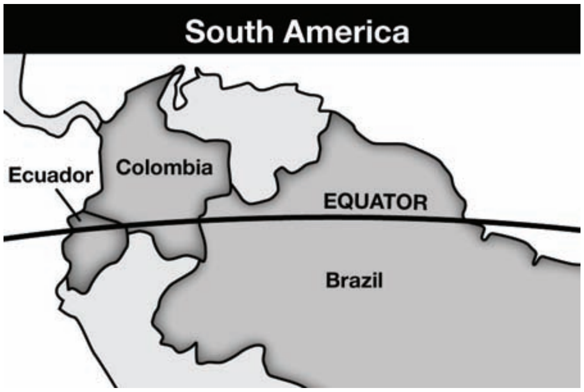
If you have an error or two, quickly review all your answers and try to find it. Go back to your teacher with the corrected paper as soon as possible. Work quickly and quietly so other teams will not hear your answers.

EXAMPLE

The Equator passes through which three South American countries?

The answer is Ecuador, Columbia, and Brazil.

Note: Be certain to use capital letters and correct spelling in your answers. Otherwise, your teacher may consider this type of carelessness an error.



PRACTICE

Wait until your teacher says, “GO!” Try to be the first team to answer ALL the following questions.

Table 1:

Can you find...	Answer...
1. What country is located where the Prime Meridian crosses the Tropic of Cancer?	
2. What country lies east of Pakistan and south of Nepal?	
3. What island country is found in the North Atlantic and its northern border passes through the Arctic Circle?	
4. The Andes Mountains run through 4 countries found on the western coast of South America. What are these 4 countries?	

Table 1:

Can you find...	Answer...
5. What country lies on the 100ºE meridian and is bordered by Laos and Cambodia?	
6. What is the large North American country that spans from Newfoundland on the Atlantic Ocean to Vancouver Island on the Pacific Ocean?	
7. What country is made up of a chain of islands east of North Korea and South Korea?	
8. What island continent is found on the Tropic of Capricorn and is bordered by both the Indian and Pacific Oceans?	
9. What bay separates Greenland and Canada?	
10. What is the name of the boot-shaped country in the Mediterranean Sea where Mount Vesuvius and Mt. Etna are found?	
11. What two central American countries border Mexico on the south?	
12. What country lies between the Black Sea, the Aegean Sea, and the Mediterranean Sea?	
13. What is the name of the sea that is bordered by Central America on the west, South America on the south, and Cuba on the north?	
14. What country can be found at 30ºS and 30ºE?	
15. What oceans surround Antarctica?	

Name: ____________________ Date: ____________________

PRACTICE 8.2

Topographic Maps

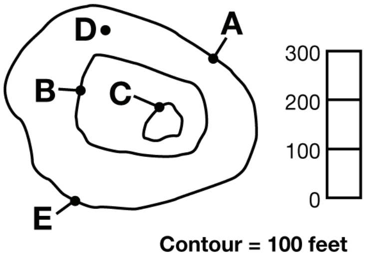
READ

Flat maps can easily show landmasses and political boundaries. However, mapmakers need to draw special maps, called topographic maps, to show hills, valleys, and mountains. Mapmakers use contour lines to show the elevation of land features. The 0 contour line refers to sea level. The height above sea level is measured in equal intervals. Always look at the legend to see the elevation of each contour line interval. Sometimes these contour lines describe an increase of 20 feet. On other maps, especially those showing mountains, the contour lines may show elevation intervals of 100 to 1000 feet.

EXAMPLES

- **Contour lines and elevations**

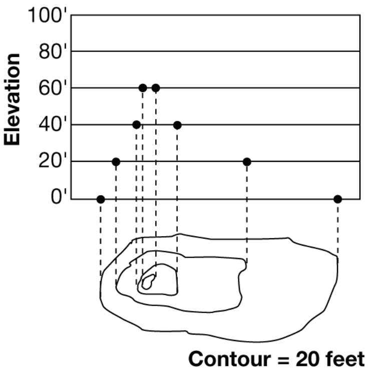
  Look at Figure 1. On this map, the contour interval is 100 feet. Let's look at the letters marked on the map. Point A is at sea level. That means it is on the 0 contour line all the way around the island. Point B is on the next contour line. That means that B is 100 feet above sea level. What is the elevation at Point C? If you said 200 feet, you would be correct. At what elevation is Point D? The correct answer is somewhere between 0 and 100 feet. You can't be exact because D is not on a contour line. Where is Point E? Yes, it's at sea level, the same level as A.



  Take a minute to color the contour key and the map. Color green between 0 and 100 feet, color yellow between 100 and 200 feet, color red between 200 and 300 feet. Mapmakers generally use blue for water only, so do not use it in a contour key.

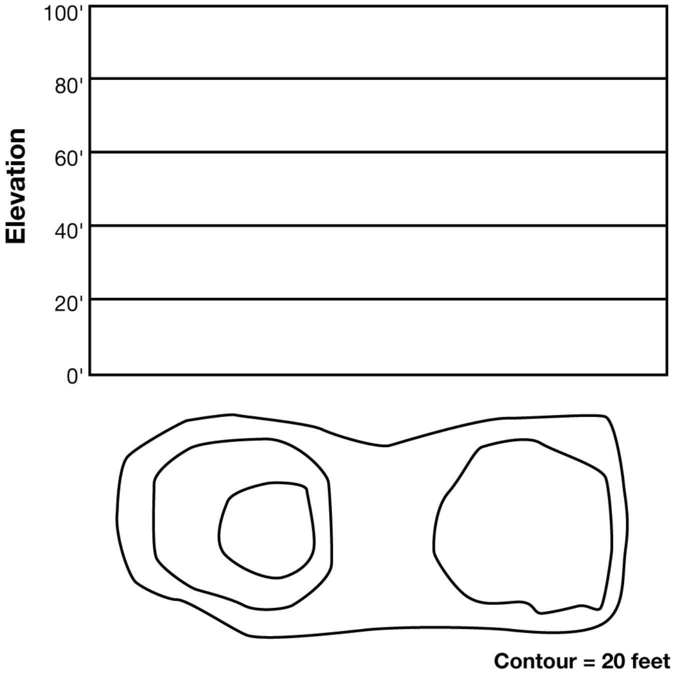
- **Profile Maps**

  You can also translate contour lines into a profile map. In this way you can actually draw what you would see if you were approaching by sea. Look at the following map as you read the steps to create a profile map. First, you draw a graph above the map that shows the intervals. The contour is 20 feet so you would label the elevation in 20-foot intervals on the left. Your task is to make dots on the lines of the graph directly above the island contour lines. Put a ruler against the left hand edge of the island, and make a dot on the 0' line of the graph. Slide your ruler to the right hand edge of the island and make a second dot on the 0' line. Next go to the second contour line and mark two dots on the 20-foot interval line in the graph above the map. Continue marking two dots at the widest dimensions for contour lines 40 feet and 60 feet. Now connect the dots. This shows you the profile of the island. Note, the island's elevation is probably a little more than 60 feet, so you could draw a peak on the top of the hill taller than 60 but less than 80 feet. Even if the island were 79 feet tall, there would not be an 80-foot contour line.

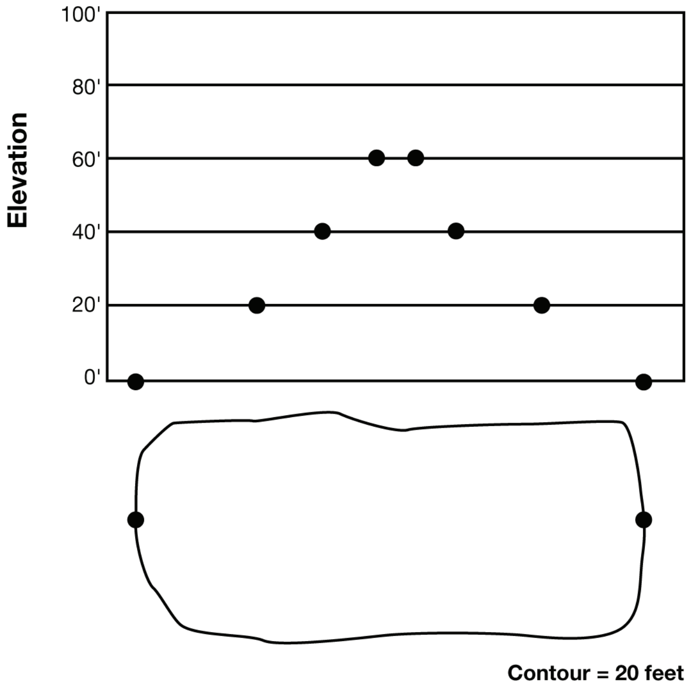


PRACTICE

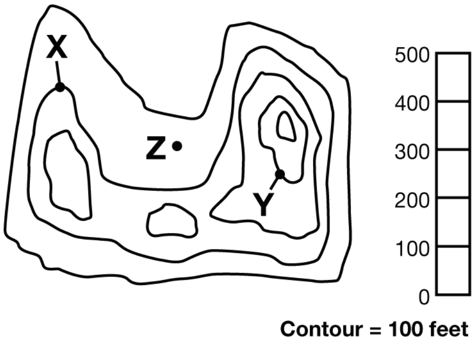
1. Draw a profile map of the island in Figure 3. (Hint: You will have four dots on the 20' line.)



2. Reverse the process to make a topographic map from the profile map. For each dot on the graph, you will make a small dot on the map showing where the contour line begins or ends. Draw a free form contour line that runs through the two dots. The 0' contour (sea level) has been done for you.



3. Color the following map and contour key, and answer the questions.



a. What is the lowest elevation on this map? ________

b. What is the highest elevation on this map? ________

c. What is the elevation at X? ________

d. What is the elevation at Y? ________

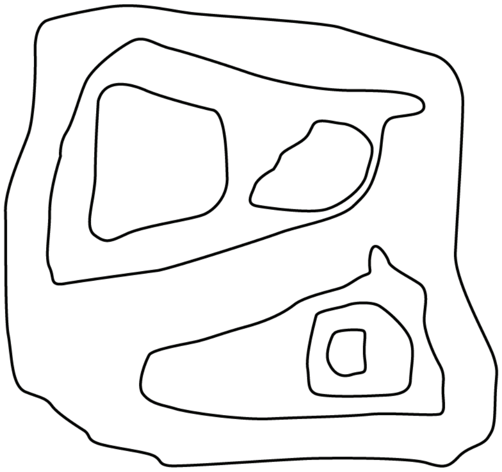
e. What is the elevation at Z? ________

4. Today scientists worry that global warming may cause the ice caps to melt, causing the sea levels to rise. Look at the map below. It has a contour of 15 feet.

a. Let's pretend that the sea level has risen 15 feet. Color the first contour (0-15') of the map dark blue, so that the new sea level is revealed. How has this island changed?

b. Now let’s pretend that the sea level rises another 15 feet. Color the next contour light blue and describe the changes in the original island.

c. What if the sea level rose by 30 feet due to global warming, and a hurricane hit the island? Could the people find dry land if there were a 35 -foot storm wave?



Contour = 15 feet

Name: ________________________________ Date: ______________

SKILL and PRACTICE 8.3

Bathymetric Maps

READ

Imagine that all the water in the oceans disappeared. If this happened, you would be able to see what the bottom of the ocean looks like. Fortunately, we don’t have to drain water from the ocean to get a picture of the ocean floor. Instead, scientists use echo sounding and other techniques to “see” the ocean floor. The result is a bathymetric map. This skill sheet will provide you with the opportunity to practice reading a bathymetric map.

PRACTICE

Main features on a bathymetric map

1. Main features on a bathymetric map are mid-ocean ridges, rises, deep-ocean trenches, plateaus, and fracture zones. Find one example of each of these on a bathymetric map.
    a. Mid-ocean ridge:_____________________
    b. Rise: _____________________
    c. Deep-ocean trench: _____________________
    d. Plateau: _____________________
    e. Fracture zones: _____________________
2. All the ridges you see on the bathymetric map behave in the same way even though they may not be in the middle of an ocean. What happens at mid-ocean ridges?
3. Find the Rio Grande Rise on the bathymetric map. Then, find the East Pacific Rise.
    a. Which of these features is an example of a mid-ocean ridge?
    b. Find another example of a rise that is a mid-ocean ridge. Justify your answer.
    c. Find another example of a rise that is **not** a mid-ocean ridge. Justify your answer.
4. There are a number of deep-ocean trenches on the western side of the North Pacific Ocean. What process is going on at these trenches?
5. What plate tectonic process probably caused the fracture zones in the North Pacific Ocean? Justify your answer.

How is the East Pacific Rise different from the Mid-Atlantic Ridge?

6. Look carefully at the Mid-Atlantic Ridge. Describe what this ridge looks like. Be detailed in your description.
7. Now, look carefully at the East Pacific Rise. Describe what this ridge looks like. Be detailed in your description.
8. Which of these features has a noticeable dark line running along the middle of the feature? Look at the legend at the bottom of the map. What does this dark line indicate?

9. Based on your observations of these two features, draw a cross-section of each in the boxes below.

Mid-Atlantic Ridge cross-section	**East Pacific Rise cross-section**

10. One of these mid-ocean ridges has a very fast spreading rate. The other has a very slow spreading rate. Which one is which? Justify your answer based on your answer to questions 8 and 9.

Name:____ Date:________________

Tanya Atwater

Tanya Atwater is a professor of Earth Science at the University of California, Santa Barbara. She has studied sea floor spreading and propagating rifts. She is currently researching the plate tectonic history of western North America. One of her main goals as a geologist is to educate people about our Earth.

Artist and adventurer

While growing up, Tanya Atwater wanted to be an artist. She loved figuring out how to record on paper the things she could see in three dimensions.

Atwater and her family went on many vacations, where, she says, "I always hogged the maps, taking great pleasure in translating between the paper map and the passing countryside." Whether it was camping, hiking, or river rafting, all of the trips had one thing in common—adventure. As a result, Atwater developed a deep love for the outdoors.

Geology in the mountains and at sea

Atwater started her college career at the Massachusetts Institute of Technology (MIT). She tried a variety of majors, including physics, chemistry, and engineering. Atwater then attended the Indiana University geology summer field camp in Montana. There, she learned about geological mapping and how land structures translate into lines and symbols. Atwater was hooked on geology!

Atwater transferred to the University of California at Berkley. She had already completed many math and physics courses at MIT, so she decided to major in geophysics.

After graduation, Atwater held an internship at Woods Hole Oceanographic Institute in Massachusetts. There, she combined the adventures of ocean sailing with geophysics.

A close look in a tiny submarine

In 1967, Atwater began graduate school at the Scripps Oceanographic Institution in La Jolla, California. During this time, many exciting geological discoveries were being made. The concept of sea floor spreading was emerging, leading to the current theory of plate tectonics.

While at Scripps, Atwater joined a research group that used sophisticated equipment on ships to study the sea floor near California.

Part of Atwater's later research on sea floor spreading involved twelve trips down to the ocean floor in the tiny submarine Alvin. Only Atwater and two other people could fit in it. Using mechanical arms, they collected samples on the ocean floor nearly two miles underwater! Atwater's firsthand view through Alvin's portholes gave her a better understanding of the pictures and sonar records she had studied.

She was also amazed to see hot springs gushing out of the ocean floor near volcanoes. She adds, "A whole bunch of brand new kinds of animals were living there. We saw giant white tubes with bright red worms living in them, giant clams, octopuses, crabs, giant anemones, and lots of slimy things. Weird!"

Propagating rifts

In the 1980s, Atwater was part of a team that researched propagating rifts near the Galapagos Islands off the coast of Ecuador. Propagating rifts are created when sea floor spreading centers realign themselves in response to changes in plate motion or uneven magma supplies.

Atwater also discovered many propagating rifts on the sea floor in the northeast Pacific Ocean and in ancient sea floor records worldwide.

An Earth educator

Atwater has been a professor at the University of California, Santa Barbara for over 25 years. She has received many awards for her work in geophysics. She currently studies the plate tectonic history of western North America. This includes how the San Andreas Fault and Rocky Mountains were formed.

Atwater also works with media, museums, and teachers and she creates educational animations to educate people about Earth. She explains, "My job as a geoscience educator is to help as many students as possible to know and understand and respect our planet—to help them really care about it and act on their caring."

Reading reflection

1. How did Atwater's family contribute to her passion for planet Earth?
2. Why was it an exciting time to study geology while Atwater was in graduate school?
3. Describe how Atwater has gotten close-up views of the ocean floor.
4. What are propagating rifts and where has Atwater observed them?
5. How does Atwater educate people about Earth?
6. **Research:** The Woods Hole Oceanographic Institution—Marine Operations has used the submarine Alvin for many research endeavors for over 40 years. Describe some of Alvin's noteworthy trips.

Name: ______________________________ Date: ____________________

SKILL and PRACTICE 9.1

Relative Dating

READ

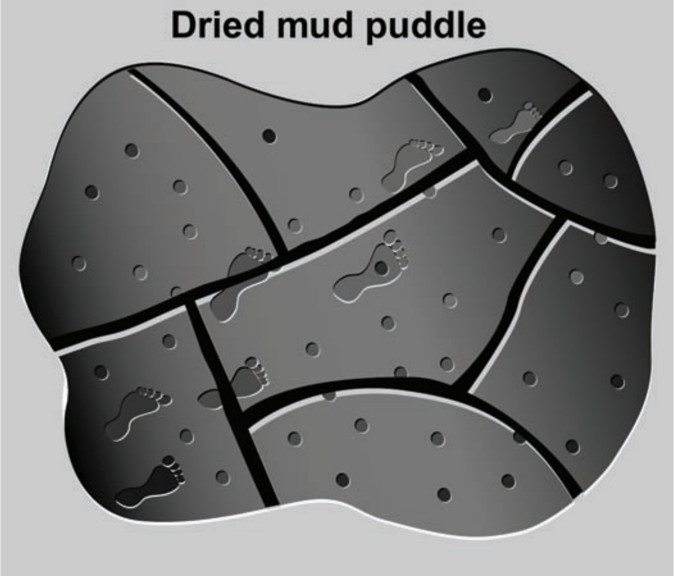
Earth is very old and many of its features were formed before people came along to study them. For that reason, studying Earth now is like detective work—using clues to uncover fascinating stories. The work of geologists and paleontologists is very much like the work of forensic scientists at a crime scene. In all three fields, the ability to put events in their proper order is the key to unraveling the hidden story.

Relative dating is a method used to determine the general age of a rock, rock formation, or fossil. When you use relative dating, you are not trying to determine the exact age of something. Instead, you use clues to sequence events that occurred first, then second, and so on. A number of concepts are used to identify the clues that indicate the order of events that made a rock formation.

PRACTICE

Sequencing events after a thunderstorm

Carefully examine this illustration. It contains evidence of the following events:

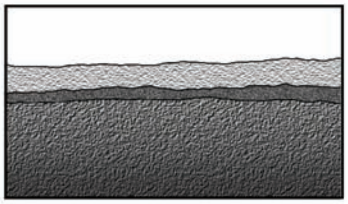


- The baking heat of the sun caused cracks to formed in the dried mud puddle.
- A thunderstorm began.
- The mud puddle dried.
- A child ran through the mud puddle.
- Hailstones fell during the thunderstorm.

1. From the clues in the illustration, sequence the events listed above in the order in which they happened.
2. Write a brief story that explains the appearance of the dried mud puddle and includes all the events. In your story, justify the order of the events.

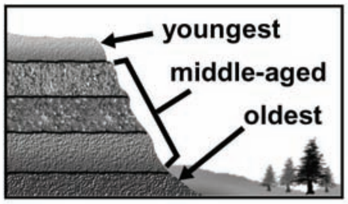
Determining the relative ages of rock formations

Relative dating is an earth science term that describes the set of principles and techniques used to sequence geologic events and determine the relative age of rock formations. Below are graphics that illustrate some of these basic principles used by geologists. You will find that these concepts are easy to understand.



A. Original Horizontality

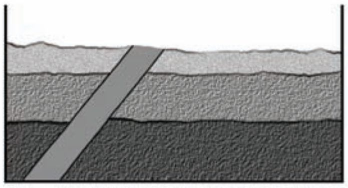
B. Lateral continuity



C. Superposition

D. Inclusions

E. Unconformities



F. Cross-cutting relationships

Match each principle to its explanation. One relative dating term will be new to you! Which is it? There is one explanation that does not have a matching picture. Write the name of this explanation.

Explanations

3. In undisturbed rock layers, the oldest layer is at the bottom and the youngest layer is at the top.
4. In some rock formations, layers or parts of layers may be missing. This is often due to erosion. Erosion by water or wind removes sediment from exposed surfaces. Erosion often leaves a new flat surface with some of the original material missing.
5. Sediments are originally deposited in horizontal layers.
6. Any feature that cuts across rock layers is younger than the layers.
7. Sedimentary layers or lava flows extend sideways in all directions until they thin out or reach a barrier.
8. Any part of a previous rock layer, like a piece of stone, is older than the layer containing it.
9. Fossils can be used to identify the relative ages of the layers of a rock formation.

Sequencing events in a geologic cross-section

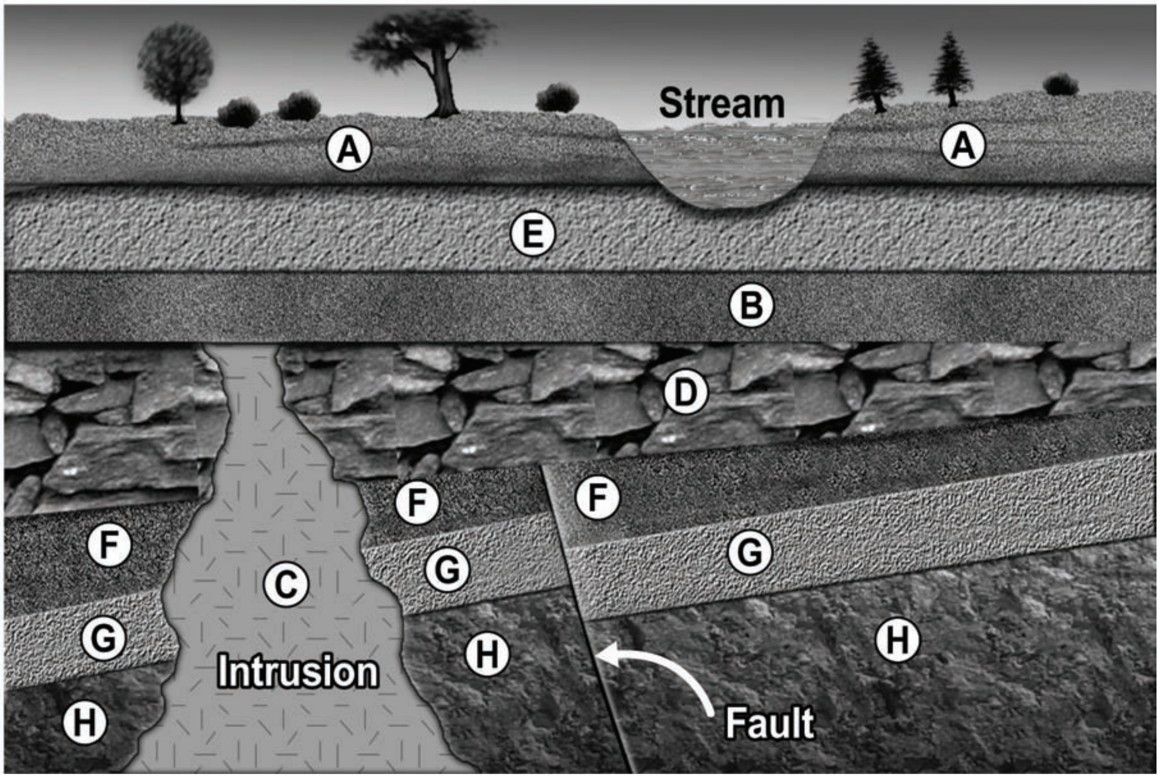
Understanding how a land formation with its many layers of soil was created begins with the same time-ordering process you used earlier in this skill sheet. Geologists use logical thinking and geology principles to determine the order of events for a geologic formation. Cross-sections of Earth, like the one shown below, are our best records of what has happened in the past.

Rock bodies in this cross-section are labeled A through H. One of these rock bodies is an intrusion. Intrusions occur when molten rock called magma penetrates into layers from below. The magma is always younger than the layers that it penetrates. Likewise, a fault is always younger than the layers that have faulted. A fault is a crack or break that occurs across rock layers, and the term faulting is used to describe the occurrence of a fault. The broken layers may move so that one side of the fault is higher than the other. Faulted layers may also tilt.

10. List the rock bodies illustrated below in order based on when they formed.

11. Relative to the other rock bodies, when did the fault occur?

12. Compared with the formation of the rock bodies, when did the stream form? Justify your answer.



Extension—Creating clues for a story

Collect some materials to use to create a set of clues that will tell a story. Examples of materials: construction paper, colored markers, tape, glue, scissors, different colors of modeling clay, different colors of sand or soil, rocks, an empty shoe box or a clear tank for clues.

Then, give another group in your class the opportunity to sequence the clues into a story. Follow these guidelines in setting up your story:

- Set up a situation that includes clues that represent at least five events.
- Each of the five events must happen independently. In other words, two events cannot have happened at the same time.
- Use at least one geology principle that you learned through this skill sheet.
- Answer the questions below.

13. Describe your set of clues in a paragraph. Include enough details in your paragraph so that someone can re-create the set of clues.

14. What relative dating principles are represented with your set of clues? Explain how these principles are represented.

15. Now, have a group of your classmates put your set of clues in order. When they are done, evaluate their work. Write a short paragraph that explains how they did and whether or not they figured out the correct sequence of clues. Describe the clue they missed if they made an error.

Name:____ Date: __________________

Nicolas Steno

Nicolas Steno was a keen observer of nature at a time when many scientists were content to learn about the world by reading books. Through dissection, Steno made important advances in the field of medicine. Later he applied his observational skills to the field of geology, identifying three important principles that geologists still use to determine the order in which geological events occurred.

Steno's childhood

Nicolas Steno was born in 1638 in Copenhagen, Denmark. He became ill at age three and spent most of his time indoors until age six. He saw few children, but spent time listening to adults discuss religion. Religion later became an important part of his life.

Steno, the son of a goldsmith, had skillful hands like his father. However, his skill was not in making jewelry. He was an expert in dissecting animals to learn about anatomy. He was fascinated by the structure of living things.

The young scientist

When Nicolas was not yet ten years old, his father died. He spent his teen years living in Copenhagen with a half-sister and her husband. Steno was smart, curious, and a good listener. He gained the attention of two scholars in Copenhagen.

The first scholar, Ole Borch, welcomed Steno into his alchemy laboratory. There, Steno watched as sediments settled out of liquid solutions. He thought it was interesting that even when the bottom of the jar was bumpy, the sediments formed a smooth horizontal layer on top of the bumpy surface.

Thomas Bartholin, a famous anatomist from the University of Copenhagen, also mentored Steno. Perhaps through this friendship, Steno developed a keen interest in dissection and anatomy. In 1660, he left Denmark to study medicine at the University of Leiden in the Netherlands. There, through careful dissection of mammals, he made discoveries related to glands, ducts, the heart, brain, and muscles.

A shark's tooth unlocks a mystery

In 1665, Steno moved to Italy. The following year, fishermen there captured a great white shark. The Italian Duke Ferdinand sent the head to Steno for dissection. Steno carefully observed the shark's teeth. They looked like glossopetrae or "tongue stones," common stony items found inside rocks.

While we now know that these tongue stones are fossilized remains of living things, in Steno's time many people believed tongue stones either grew inside rocks, fell from the sky, or even fell from the Moon.

Steno suggested a different explanation for the tongue stones. He said they had once been actual shark teeth! Then Steno started to think about how a solid object, like a shark tooth, could get inside another solid object, like a rock.

Three important principles

Based on his work, Steno came up with three important principles of geology.

- The principle of superposition says that layers of sediment settle on top of each other. The oldest layers are on the bottom and the more recent layers are on top.
- The principle of original horizontality says that sedimentary rock layers form in horizontal patterns, even if they form on a bumpy surface.
- The principle of lateral continuity says that sediment layers spread out until they reach something that stops the spreading.

Steno explained that the shark teeth had been in soft sediment that eventually hardened into a layer of rock. Steno used his principles to write a book about the geology of a region of Italy called Tuscany. Even today, geologists use Steno's principles to determine the order in which geologic events occurred.

Father Steno

In 1675, Steno gave up science to become a priest. He died in 1686 at the age of 48. In 1988, Pope John Paul II beatified Steno, the first step in the process of naming someone a saint. Today, the Steno Museum in Denmark and craters on both Mars and the Moon bear his name.

Reading reflection

1. Name and briefly describe the three important principles of geology developed by Steno.
2. How did most people in the 1600s explain the origin of fossils?
3. How did Steno explain the existence of tongue stones or shark teeth in rocks?
4. How did Steno's medical background and skills help him with his geological discoveries?
5. Observing is very important in science. What things do you like to observe? What have you learned through observation?
6. **Research:** Steno's father was a goldsmith and one of his teachers was interested in alchemy. What does a goldsmith do? What is alchemy? How could these two fields have been helpful to Steno's work?

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Name:____ Date:__________________

Edmund Schulman

Schulman discovered Methuselah, the world's oldest known tree. The tree's exact location remains a secret to protect it from accidental or intentional damage.

In search of trees

Edmund Schulman started his scientific career as an astronomer. However, his interest turned to climate research. Schulman conducted climate studies for nearly 20 years in the western United States.

He was a student of Andrew Ellicott Douglass, the man responsible for the science of dendrochronology. Schulman worked as an assistant to Douglass at the Laboratory of Tree-Ring Research in Arizona. He did a great deal of work in Idaho looking for very old pines. Then Schulman heard about the White Mountains of California and decided to travel there searching again for old trees.

Bristlecones

Schulman studied all layers of the forest. However, higher zone trees tend to be more reliable in providing data because they are affected less by ground water.

The short bristlecone pines grow in this zone. They are a hardy tree with resinous wood that survives in a cold and dry environment. They are also able to withstand wind and the sun's ultraviolet rays. These trees grow in alkaline soils with minimal groundcover around.

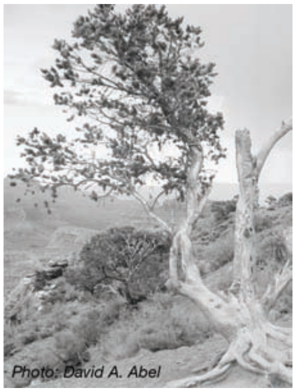

Photo: David A. Abel

Since only the bristlecone seems to be able to survive under these conditions, they are able to utilize all the nutrients available in the soil. This sustains their growth and contributes to their longevity. Bristlecones survive a long time compared to other types of trees and are found in regions stretching from Colorado to California.

In the 1950s, Schulman searched the upper layer of the White Mountains for the oldest trees. From 1954-1957, he scoured the forest for ancient bristlecone pines. He was driven by the desire to understand the climatic history of the western United States.

Methuselah

The Ancient Bristlecone Pine Forest, a 28,000 acre preserve, is located in the Inyo National Forest of the White Mountains. This pine forest is nearly 11,000 feet above sea level. The dead wood of these pines decays slowly and some dead trees date as far back as 10,000 years. The living trees often appear dead because they do consist of mostly dead wood. But a thin layer of bark is enough to keep the trees alive. Even when a tree has died, it may not decay for another 1,000 years due to its thick, protective wood.

Most people at the time of Schulman thought sequoias were the oldest living trees. However, Schulman discovered some bristlecones 3000-4000 years old. In 1957, Schulman further confirmed this fact by finding a bristlecone 4,760+ years old. The living tree, found surrounded by dead trees on the ground, was named Methuselah. According to the Bible, Methuselah was a person who lived to be 969 years old. Now the oldest living tree was found. The Methuselah tree has been growing since the time of the great pyramids of Egypt.

Schulman's tree remains the world's oldest living tree. In 1964, scientists sampling a tree in Nevada ran into trouble when their wood coring tool jammed within the tree. The decision was made to cut down the tree to save the expensive piece of equipment. Upon examining the tree further, scientists discovered that the tree, known as Prometheus, was nearly 4,900 years old! The world's oldest living tree had been destroyed.

History is rewritten

Methuselah has helped scientists develop a continuous chronology of nearly 8,000 years. Schulman's work was extremely important to archaeologists around the world. In Europe, archaeologists determined that some of their wood samples were nearly 1,000 years older than they originally believed. In addition, Schulman's work refined and corrected radiocarbon dating.

Schulman died in 1958 at age 49 of a heart attack, shortly before his findings were published in National Geographic Magazine. Schulman Grove is named in his honor.

Reading reflection

1. Under what type of conditions can bristlecone pines survive?
2. What helps the bristlecone pine survive?
3. **Research:** Methuselah may be the oldest living tree on Earth. Using the Internet, research what scientists believe may be the oldest living thing on Earth.
4. **Research:** What and where is the world's largest bristlecone pine?
5. **Research:** What is Schulman Grove?

Name:_______________________________________ Date: _______________

Andrew Ellicott Douglass

Douglass, a successful American astronomer, is better known as the father of dendrochronology. His accomplishments in tree ring analysis and cross-dating allowed him to create a tree calendar dating back to AD 700 for the American Southwest.

Vermont Native


Laboratory of Tree-Ring Research, The University of Arizona

Andrew Ellicott Douglas was born on July 5, 1867 in Windsor, Vermont. Andrew was one of five children born to Sarah and Malcolm Douglass. Malcolm, an Episcopalian minister, and his wife moved frequently. They settled for a period of time in Windsor where Malcolm became a minister for St. Pauls Church and they raised their children.

Douglass attended Trinity College in Hartford, Connecticut. An astronomer, Douglass worked at Harvard College Observatory from 1889-1894. While working for the observatory, he traveled to Peru to find a suitable location for another observatory. He helped to establish the Harvard Southern Hemisphere Observatory in Arequipa, Peru.

From sunspots to tree rings

When Douglass returned home, he met astronomer Percival Lowell of Boston, Massachusetts. Working for Lowell, Douglass set out again to find a location for an observatory, but this time in Arizona. In 1894, he found a site on a Flagstaff mesa and oversaw the building of the Lowell Observatory. While at the observatory, Douglass was Lowell's chief assistant and worked with Lowell to observe the planet Mars. However, Douglass and Lowell did not always agree on how to use the gathered data and Lowell fired Douglass.

Douglass remained in Flagstaff to teach Spanish and geography at what is now known as Northern Arizona University. While in Flagstaff, he became interested in tree rings and their possible connection to sunspot cycles. While researching the eleven-year sunspot cycle, he examined ponderosa pine tree rings. He noted that rings held information about weather patterns and hoped he could find a link between periods of drought and sunspot activity.

In 1906, Douglass moved to Tucson, Arizona and taught at the University of Arizona. Here, he created the science of dendrochronology. He found that differences in tree ring width corresponded to weather patterns. A period of drought produced narrower rings than a time of increased rainfall. In 1929, Douglass was able to place a date on Native American ruins in Arizona with accuracy. He studied Ponderosa pine tree rings dating back to the time of these Native American dwellings. He matched wooden beam samples against pine tree rings to determine a precise date for the ancient ruins. Douglass development of this cross-dating technique was a tremendous breakthrough in the field of archaeology. Archaeologists now had a tool to date ancient ruins.

Despite his work in tree ring analysis, Douglass remained an active astronomer. From 1918 to 1937, Douglass worked at the Steward Observatory at the University of Arizona. Within this period of time, he also wrote *Climate Cycles and Tree Growth, Volumes I, II, and III*. In 1937, he retired as director of the observatory and devoted his time to tree ring research.

Dendrochronology and beyond

Douglass quickly discovered that tree ring studies required time and physical space. He asked the University of Arizona president for a tree ring research facility. In 1938, Douglass became the first directory of the Laboratory of Tree-Ring Research at the University of Arizona. The Laboratory of Tree-Ring Research has the largest number of tree ring samples in the world. He remained director of the laboratory until 1958.

In 1984, an asteroid was identified and named Minor Planet or Asteroid (2196) Ellicott, after Douglass middle name. Douglass died on March 20, 1962 at age 94. Later, Spacewatch astronomer Tom Gehrels discovered an asteroid in 1998 using a telescope that Douglass had dedicated to the Steward Observatory many years earlier. A second asteroid was then named after Douglass. On the planet Mars, a crater has also been named in honor of Douglass.

Reading reflection

1. How did Douglass move from studying planets and stars to studying trees?
2. What is the name of the science and specific technique that Douglass discovered?
3. How has Douglass work with tree rings been useful to archaeologists?
4. **Research:** The first asteroid named after Douglass is called Minor Planet (2196) Ellicott. What is the name of the second asteroid named after Douglass?
5. **Research:** The Harvard Southern Hemisphere Observatory, also called the Boyden Observatory, was originally located in Arequipa, Peru. It has moved. Where is the observatory now located?
6. **Research:** Tom Gehrels is an astronomer associated with the Spacewatch program. What is the Spacewatch program?

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Name:____ Date: _________________

Jules Verne

Jules Verne was an enormously successful nineteenth century author. He introduced the world to science fiction. His stories of adventure and imaginative methods of travel were decades ahead of their time. His ideas have entertained and inspired generations of readers. Several of his books have been made into popular movies.

A great imagination yearning for adventure

Jules Verne was born on February 8, 1828 in the busy port city of Nantes, France. The oldest of five children, Jules came from a family with a strong seafaring tradition rich with the spirit for travel and adventure.

The family's summer home just outside the city of Nantes may have inspired Jules to search for adventure. The house was on the banks of the Loire River. Jules and his younger brother Paul would often play outside and watch ships from all over the world sail down the river.

The boys would make up stories about these ships; where they were from, where they were going, the characters aboard the vessels, and especially the wild escapades they had during their journeys.

While Jules' father was part of a family that included many travelers, he did not intend his sons to follow in those footsteps. Both Jules and Paul were sent to a boarding school, right in their hometown of Nantes. There they were expected to get an education that would take them out of the seafaring class and into wealthy society.

Expectations and creativity clash

After graduating from the boarding school, Verne's father sent him to Paris in 1847, where he was expected to study law. While he studied and prepared for the bar exam, Verne found his time was increasingly spent writing.

An uncle that had been asked to check up on Verne saw that he was having some quiet success writing the words for operas. This uncle understood Verne's true calling. He began to introduce Verne to people involved with Paris' literary circles.

Verne managed to get a few plays published and even performed. Although busy, he still was able to get his law degree. This came in handy, because as soon as Verne's father found out about his writing, he furiously stopped sending his son money. With his money supply gone, Verne took a job as a stockbroker. He hated this job, yet was quite good at it.

A career takes off

Around this time Verne began to meet important authors like Alexander Dumas and Victor Hugo. They offered advice to the young writer. In 1857 Verne married, and was encouraged by his wife to pursue his dream of writing.

Verne became a fan of Edgar Allen Poe, modelling some of his early work on Poe's style, and in 1897 he wrote a sequel to one of Poe's unfinished novels. In 1862 Verne met Pierre-Jules Hetzel, an editor with a keen eye and feel for what a story needed to be successful.

Verne's writing had often been criticized for being too scientific. Hetzel knew how to make Verne's stories appeal to the common person. In 1863, Verne began publishing his "Extraordinary Voyages" series of novels and thankfully quit his stockbroking job.

In rapid succession Verne tackled the sky, the sea, the land, and even space in his novels. In 1863 he wrote *Five Weeks in a Balloon*, a story about exploring Africa in a hot air balloon. In 1864 he wrote *Journey to the Center of the Earth*, a trek by scientists down a volcano on their way to Earth's core. In 1865 he wrote *From Earth to the Moon*, a visionary work that preceded NASA missions by 100 years. He published *20,000 Leagues Under the Sea* in 1869, introducing the world to Captain Nemo, a mysterious genius who built the futuristic submarine *The Nautilus*.

Jules Verne's 65 novels took readers on marvelous adventures, introducing futuristic ideas that while not always based on scientific facts, incorporated concepts that inspired future thinkers and entertained millions. Verne died in 1905, as the world's most translated author, making up for his lack of scientific training and actual travel experience with a vivid imagination.

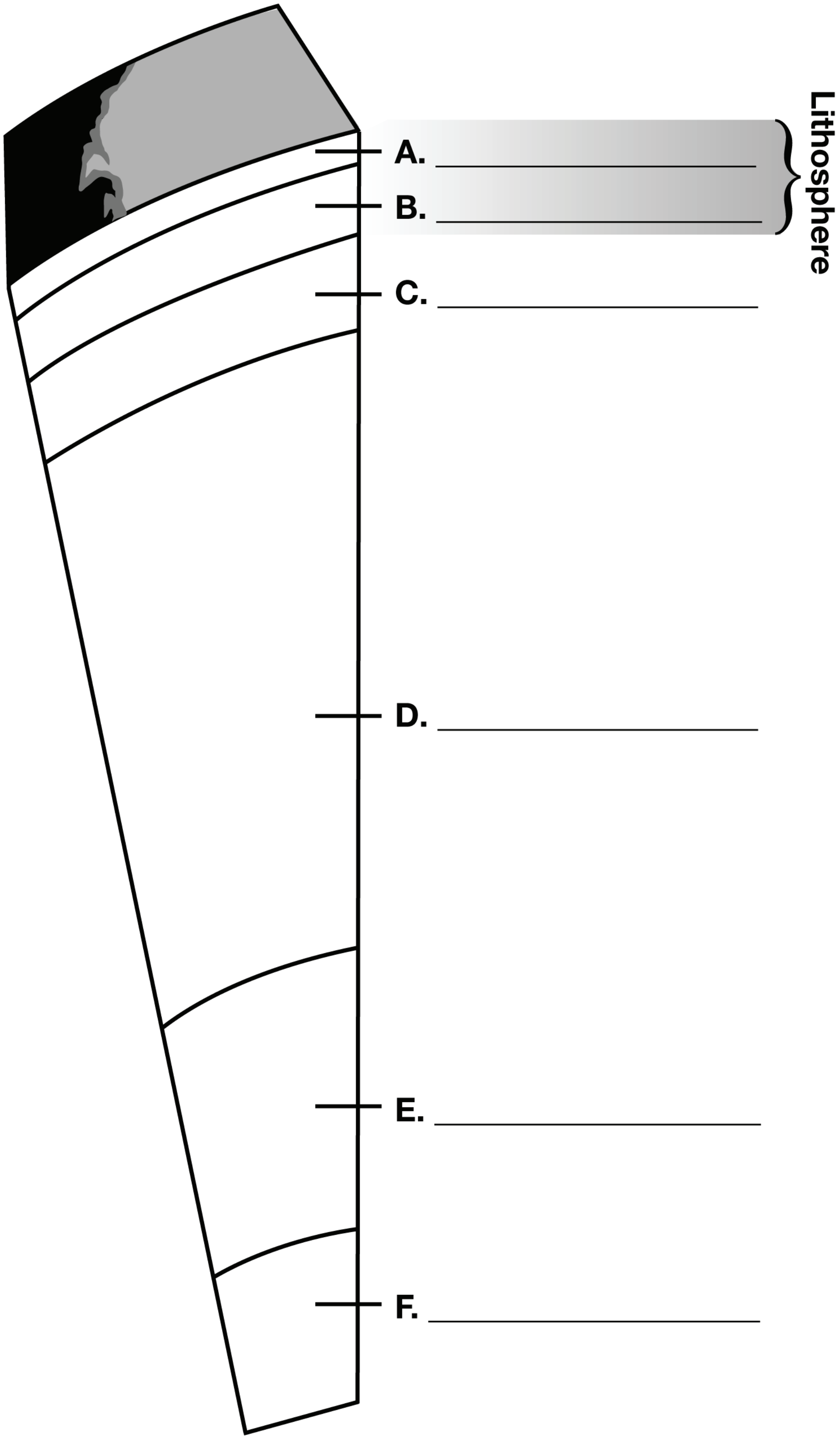
Reading reflection

1. Why do you think Jules Verne's novels appealed so widely to readers around the world?
2. **Research** which novels written by Verne have been made into movies. Have any of them won awards?
3. **Research** the bar exam. Why would Jules Verne need to pass it?
4. **Research** Victor Hugo and explain why meeting him may have been important to Verne.
5. **Research** some of the machines, ideas, and predictions Verne made in his novels that have come to exist today.

Name: ______________________________ Date: ______________

SKILL and PRACTICE
10.2

Earth's Interior



Name:____ Date: ____________________

Alfred Wegener

Alfred Wegener was a man ahead of his time. He was an astronomer and a meteorologist, yet his greatest work was in the field of earth science. His theory of plate tectonics is widely accepted today. Yet, in 1912 when he proposed the idea, he was ridiculed. It took fifty years for other scientists to find the evidence that would prove his theory.

The young man


Photograph courtesy of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Alfred Wegener was born in Berlin in 1880. He was the son of a German minister who ran an orphanage. As a boy, he became interested in Greenland, and as a scientist, he went to Greenland several times to study the movement of air masses over the ice cap. This was at a time when most scientists doubted the existence of the jet stream. Just after his fiftieth birthday, he died there in a blizzard during one of his expeditions.

Wegener graduated from the University of Berlin in 1905 with a degree in astronomy. Soon, however, his interest shifted to meteorology. This was a new and exciting field of science. Wegener was one of the first scientists to track air masses using weather balloons. No doubt, he got the idea from his hobby of flying in hot air balloons. In 1906, he and his brother set a world record by staying up in a balloon for over fifty-two hours.

The search for evidence

In 1910, in a letter to his future bride, Wegener wrote about the way that South America and Africa seemed to fit together like pieces of a puzzle. To Wegener, this was not just an odd coincidence. It was a mystery that he felt he must solve. He began to look for evidence to prove that the continents had once been joined together and had moved apart.

Fossils of a small reptile had been found on the west coast of Africa and the east coast of South America. That meant that this reptile had lived in both places at the same time millions of years ago. Wegener figured that the only way this was possible was if the two continents were connected when animals were alive. They could not have traveled across the ocean.

Geological evidence

There was also geological evidence. The rock structures and types of rocks on the coasts of these two continents were identical. Again, Wegener could find no explanation for how this could have happened by accident on opposite sides of the ocean. The rock structures had to have been formed at the same time and place under the same conditions.

A study of climates produced other evidence. Coal deposits had been found in Antarctica and in England. Since coal is formed only from plants that grow in warm, wet climates, Wegener concluded that those land masses must have once been near the equator, far from their locations today.

Ridiculed and rejected

Wegener explained that all of the continents had been part of one large land mass about 300 million years ago. This super-continent was called Pangaea, a Greek word that means “all earth.” It broke up over time, and the pieces have been drifting apart ever since. Wegener compared the drifting continents to icebergs.

Wegener’s peers called his theory “utter rot!” Many scientists attacked him with rage and hostility. Wegener had two main problems. First, he was an unknown outsider, not a geologist, who was challenging everything that scientists believed at the time. Second, he was not able to explain what caused the continents to drift. While there seemed to be evidence to show that they had indeed moved, he could not identify a force that made it happen.

About fifty years after Wegener proposed his theory, a scientist named Harry Hess made a discovery about sea floor spreading that seemed to support Wegener’s ideas. As a result, the theory of plate tectonics was finally accepted by most scientists.

Reading reflection

1. Explain the significance of Greenland in Wegener's life.
2. What world record did Wegener set in 1906?
3. Why could Wegener be called an interdisciplinary scientist? Identify the fields of science of which he was knowledgeable.
4. Explain how the fossil of a small reptile provided evidence to help prove Wegener's theory of drifting continents.
5. How did the discovery of coal deposits in England and Antarctica strengthen Wegener's argument?
6. **Research:** In his search for evidence to support his theory of drifting continents, Wegener studied the rock strata in the Karroo section of South Africa and the Santa Catarina section of Brazil. He also studied the Appalachian Mountains in North America and the Scottish Highlands. Use a library or the Internet to research these areas. What evidence do they provide for Wegener's theory? Share your findings with the class.
7. What were the two main problems that Wegener faced when he tried to convince others that his theory of drifting continents was valid?
8. **Research:** Wegener and some colleagues drew maps of what they thought the world looked like at different times as the super continent broke up and the continents drifted apart. Use a library or the Internet to find pictures of these maps. Make a poster displaying Wegener's vision of the world at:
    - 300 million years ago (Pangaea)
    - 225 million years ago (Permian period)
    - 200 million years ago (Triassic period)
    - 135 million years ago (Jurassic period)
    - 65 million years ago (Cretaceous period)
    - Today

Name:____ Date:__________________

Harry Hess

Harry Hammond Hess was a geology professor at Princeton University and served many years in the U.S. Navy. In 1962, Hess published a landmark paper that described his theory of sea floor spreading. Hess also made major contributions to our national space program.

A globe-trotting geologist

Courtesy Archives of Department of Geosciences, Princeton University

Harry Hammond Hess was born in New York City on May 24, 1906. He first studied electrical engineering at Yale University, but later changed his major to geology. He received his degree in 1927.

After graduation, Hess worked for two years as a mineral prospector in southern Rhodesia (currently Zimbabwe, Africa). He then returned to the United States to study at Princeton University. In 1932, Hess became a professor of geology at Princeton. Years later, his geological research took him to the far depths of the Pacific Ocean floor.

The Navy commander

Harry Hess was part of the Naval Reserve. In 1941 he was called to active duty. His first duty during World War II was in New York City where he tracked enemy positions in the North Atlantic. He later commanded an attack transport ship in the Pacific.

Although he was a Naval commander, Hess seized the opportunity of being on a ship to further his geological research. Between battles, Hess and his crew gathered data about the structure of the ocean floor using the ship's sounding equipment. They recorded thousands of miles worth of depth recordings.

In 1945, Hess measured the deepest point of the ocean ever recorded—nearly 7 miles deep. He also discovered hundreds of flat-topped mountains lining the Pacific Ocean floor. He named these unusual mountains "guyouts" (after his first geology professor at Princeton).

A ground breaking theory

After the war, Hess continued to study guyouts, midocean ridges, and minerals. In 1959, his research led him to propose the ground breaking theory of sea floor spreading. At first, Hess' idea was met with some resistance because little information was available to test this concept.

In 1962, his sea floor spreading theory was published in a paper titled "History of Ocean Basins." Hess explained that sea floor spreading occurs when molten rock (or magma) oozes up from inside the Earth along the mid-oceanic ridges. This magma creates new sea floor that spreads away from the ridge and eventually sinks into the deep-ocean trenches where it is destroyed. Hess' theory became one of the most important contributions to the study of plate tectonics.

The sea floor spreading theory explained many unsolved geological questions. Most geologists at the time believed that the oceans had existed for at least 4 billion years. But they wondered why there wasn't more sediment deposited on the ocean floor after such a long time period.

Hess explained that the ocean floor is continually being recycled and that sediment has been accumulating for no more than 300 million years. This is about the time period needed for the ocean floor to spread from the ridge crest to the trenches. Hess's theory helped geologists understand why the oldest fossils found on the sea floor are 180 million years old at most, while marine fossils found on land may be much older.

From the ocean to the moon

Harry Hess also played a key role in developing our country's space program. In 1962, President John F. Kennedy appointed Hess as Chairman of the Space Science Board—a NASA advisory group. During the late 1960s, Hess helped plan the first landing of humans on the moon. He was part of a committee assigned to analyze rock samples brought back by the Apollo 11 crew.

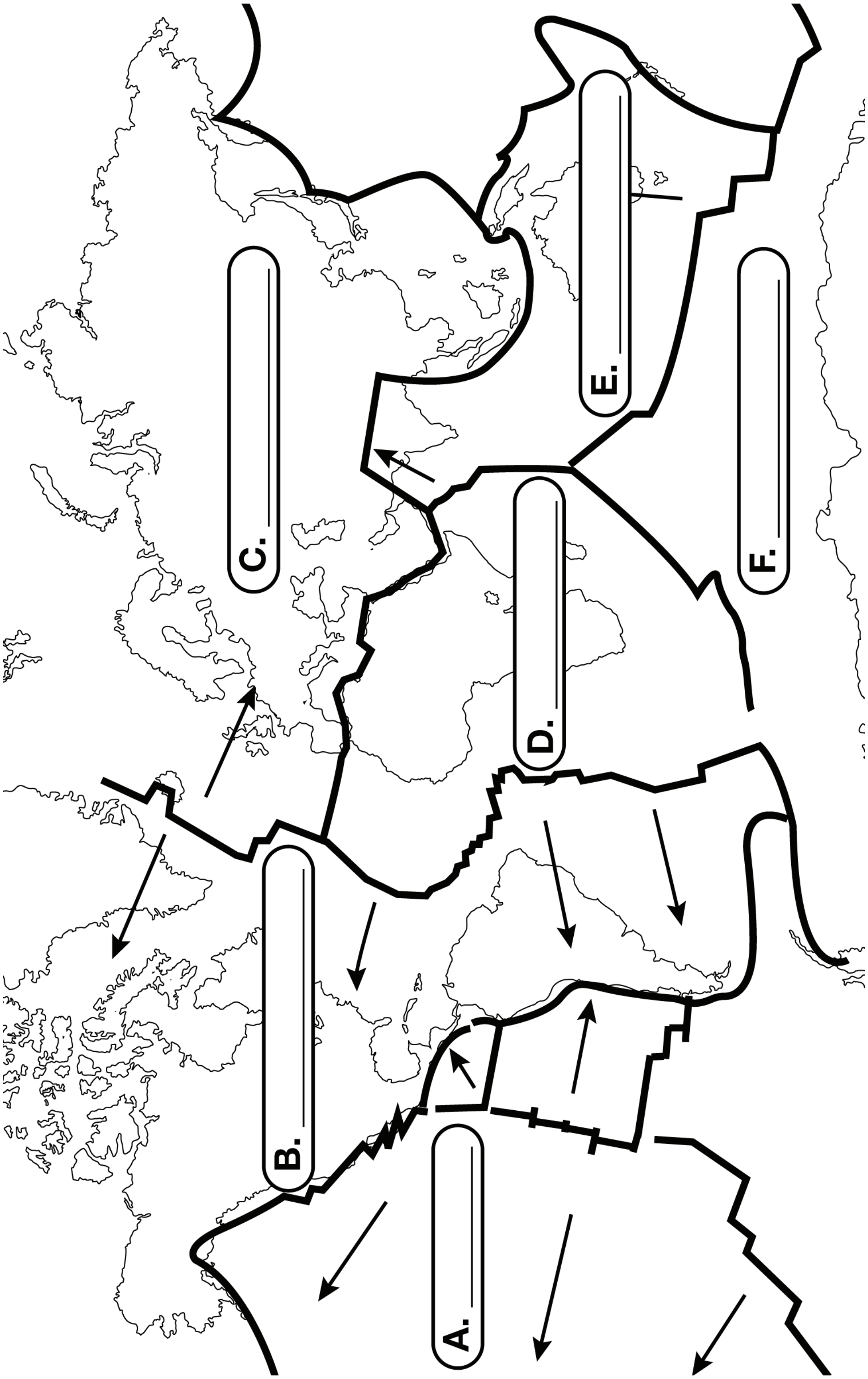
Harry Hess died in August 1969, only one month after the successful Apollo 11 lunar mission. He was buried in the Arlington National Cemetery. After his death, he was awarded NASA's Distinguished Public Service Award.

Reading reflection

1. How did Harry Hess' career in the Navy contribute to his geological research?
2. What were some of the geological discoveries Hess made while aboard his attack transport ship?
3. Describe Hess' theory of sea floor spreading.
4. How did Hess' sea floor spreading theory explain why so little sediment is deposited on the ocean floor?
5. What were Hess' contributions to space research?
6. **Research:** Harry Hess made significant contributions in the fields of geology, geophysics, and mineralogy. What scientific society established the Harry H. Hess Medal and what achievements does it recognize?

Name: ______________________ Date: ______________

Earth’s Largest Plates



Name:____ Date:_______________

John Tuzo Wilson

John Tuzo Wilson was a professor at the University of Toronto whose love for adventure helped him make major contributions in the field of geophysics. His research on plate tectonics explained volcanic island formation and led to the discovery of transform faults. He also described the formation of oceans, a process later named the Wilson Cycle.

A noteworthy family

John Tuzo Wilson was born in Ottawa, Canada on October 24, 1908. His adventurous parents helped to expand Canada's frontiers. Wilson's mother, Henrietta Tuzo, was a famous mountaineer. Mount Tuzo in western Canada was named in her honor after she scaled its peak. Wilson's father, also named John, helped plan the Canadian Arctic Expedition of 1913 to 1918. He also helped develop airfields throughout Canada.

In 1930, Wilson was the first graduate of geophysics from the University of Toronto. He earned a second degree from Cambridge University. In 1936, Wilson received a doctorate in geology from Princeton University.

An adventurous scholar

Throughout his career, Wilson enjoyed traveling to unusual locations. While a student at Princeton, Wilson became the first person to scale Mount Hague in Montana—an elevation of 12,328 feet.

When World War II broke, Wilson served in the Royal Canadian Army. After the war, Wilson led an expedition called Exercise Musk-Ox. He directed ten army vehicles 3,400 miles through the Canadian Arctic. This journey proved that people could travel to Canada's north country.

In 1946, Wilson began his 30-year career as a professor of geophysics at the University of Toronto. While a professor, Wilson mapped glaciers in Northern Canada. Between 1946 and 1947, he became the second Canadian to fly over the North Pole during his search for unknown Arctic islands.

Plate tectonics and a hot idea

Many scientists contributed to the development of the plate tectonics theory. However, they had difficulty explaining the formation of volcanic islands. These islands, like the Hawaiian Islands, are thousands of kilometers away from plate boundaries.

In the early 1960s, Wilson solved the volcanic island mystery. He explained that sometimes a single hot mantle plume will break through a plate and form a volcanic island. As the plate moves over the mantle plume, a chain of islands forms. At first this theory was rejected. Finally, in 1963, Wilson published his paper.

Slipping and sliding plates

In 1965, Wilson proposed that a type of plate boundary must connect ocean ridges and trenches. He suggested that a plate boundary ends abruptly and transforms into major faults that slip horizontally. Wilson called these boundaries "transform faults."

Wilson's idea was confirmed and quickly became a major milestone in the plate tectonics theory. The San Andreas Fault of southern California is a well-known transform fault.

Opening and closing ocean basins

Wilson was one of the first geologists to link seafloor spreading with land geology. In 1967, Wilson published an article that described the repeated process of ocean basins opening and closing. This process later became known as the Wilson Cycle.

Geologists believe that the Atlantic Ocean basin closed millions of years ago. This event led to the formation of the Appalachian and Caledonian mountain systems. The basin later re-opened to form today's Atlantic Ocean.

An honored geologist

Wilson's contributions to the field of geophysics led to many honors and awards throughout his career. In 1967, Wilson became the principle of Erindale College at the University of Toronto. From 1974 to 1985, Wilson served as director of the world-renowned Ontario Science Center. On April 15, 1993, Wilson died at age 84.

Reading reflection

1. How did John Tuzo Wilson's parents contribute to his passion for the outdoors?
2. Why is Wilson sometimes referred to as an adventurous scholar?
3. Describe Wilson's theory of how volcanic islands are formed.
4. What did Wilson discover about plate boundaries and the formation of faults?
5. What is the Wilson Cycle? Give an example of this process.
6. **Research:** On which continent are mountains named in honor of John Tuzo Wilson?

Name: Date:

Averaging

READ

The most common type of average is called the *mean*. Usually when someone (who's not your math teacher) asks you to find the average of something, it is the *mean* that they want. To find the mean, just sum (add) all the data, then divide the total by the number of items in the data set. This type of average is used daily by many people. Teachers and students use it to average grades. Meteorologists use it to average normal high and low temperatures for a certain date. Sports statisticians use it to calculate batting averages and many other things.

EXAMPLE

- William has had three tests so far in his English class. His grades are 80%, 75%, and 90%. What is his average test grade?

  Solution:

  a. Find the sum of the data: 80 + 75 + 90 = 245

  b. Divide the sum (245) by the number of items in the data set (3): 245 ÷ 3 ≈ 82%

  William's average (mean) test grade in English (so far) is about 82%

PRACTICE

1. The families on Carvel Street were cleaning out their basements and garages to prepare for their annual garage sale. At 202 Carvel Street, they found seven old baseball gloves. At 208, they found two baseball gloves. At 214, they found four gloves, and at 221 they found two gloves. If these are the only houses on the street, what is the average number of old baseball gloves found at a house on Carvel Street?

2. During a holiday gift exchange, the members of the winter play cast set a limit of $10 per gift. The actual prices of each gift purchased were: $8.50, $10.29, $4.45, $12.79, $6.99, $9.29, $5.97, and $8.33. What was the average price of the gifts?

3. During weekend baby sitting jobs, each sitter charged a different hourly rate. Rachel charged $4.00, Juanita charged $3.50, Michael charged $4.25, Rosa charged $5.00, and Smith charged $3.00.

   a. What was the average hourly rate charged among these baby sitters?

   b. If they each worked a total of eight hours, what was their average pay for the weekend?

4. The boys on the sixth grade basketball team at Fillmore Middle School scored 22 points, 12 points, 8 points, 4 points, 4 points, 3 points, 2 points, 2 points, and 1 point in Thursday's game. What was the average number of points scored by each player in the game?

5. Jerry and his friends were eating pizza together on a Friday night. Jerry ate a whole pizza (12 slices) by himself! Pat ate three slices, Jack ate seven slices, Don and Dave ate four slices each, and Teri ate just two slices. What was the average number of slices of pizza eaten by one of these friends that night?

Name: ______________________ Date: ______________

Speed

READ

If you ride your bike with your father for an hour, and the two of you cover 8 miles total, it might be obvious to you that you that you had been riding at a speed of 8 miles per hour (mph).

In this situation it's pretty easy to determine your speed (in miles per hour). In other situations, the solution may not be quite as obvious (even though the method is really the same). In those situations, you may find it useful to use this formula:

$$\text{speed} = \frac{\text{distance}}{\text{time}} \qquad \text{OR} \qquad s = \frac{d}{t}$$

To calculate speed, you need to divide the distance traveled by the time it took to cover that distance. Typically, we will be working with distances measured in SI units. Common SI units for speed include *kilometers per second (km/s)*, *meters per second (m/s)*, *centimeters per second (cm/s)*, and *kilometers per hour (km/hr)*.

EXAMPLE

- It took Beverly 3 seconds to walk 70 centimeters. How fast was she walking?

  Solution:

  Using the formula: $\text{speed} = \frac{\text{distance}}{\text{time}}$, divide the distance (70 cm) by the time (3 s).

  Doing this arithmetic tells us that Beverly's speed is $23.\overline{3}$ cm/s (or $23.\overline{3}$ centimeters per second).
  In other words, Beverly was walking extremely slowly.

PRACTICE

1. A small ball is rolling on a flat table that is 30 centimeters wide. It takes the ball 12 seconds to complete its trip across the width of the table. How fast is the ball rolling?

2. Paul throws a paper wad to Alex who is sitting exactly 3.2 meters away. The paper wad was only in the air for 1.2 seconds. How fast was it traveling?

3. The distance from home plate to the pitcher's mound in professional baseball is about 18.44 meters. If it takes a pitched ball about 0.4 seconds to travel from the mound to home plate, how fast was the ball traveling?

4. Serina is a ballet dancer. During her dance, she dances in a "Z" pattern on the stage. It takes her about 30 seconds to complete the "Z." The top and bottom of the "Z" are equal distances of about 3 meters each. The middle part of the "Z" is about 5 meters long. How quickly (in meters per second) is she traveling during this part of the dance?

5. It takes an unmanned drone 9.5 years to travel 4,340,000,000 kilometers to Pluto. How fast is the drone traveling?

6. Jessie walks about two and one half kilometers to get to her friend Emma's house. It takes her about 1/3 hour (20 minutes) to get there. She loses track of time and has to run in order to make it back by the time her dad asked her to be home. She makes it home in just 1/6 hour (10 minutes). Answer each in kilometers per hour:

   a. How fast was Jessie traveling on her way to Emma's house?

   b. How fast was she running on her way home?

   c. What was her average speed for the entire trip?

7. Heather ran steadily at 2.5 meters/second for about 10 minutes (600 seconds). How far did she run?

8. Nate threw a football to his friend Tom who was 15 meters away. The ball was traveling slowly at just 5 meters per second. How long did it take the ball to get to Tom?

Name: _____________________________________ Date: ___________________

Internet Research Skills

READ

The Internet is a valuable tool for finding answers to your questions about the world. A search engine is like an on-line index to information on the World Wide Web. There are many different search engines from which to choose. Search engines differ in how often they are updated, how many documents they contain in their index, and how they search for information. Your teacher may suggest several search engines for you to try.

EXAMPLE

Search engines ask you to type a word or phrase into a box known as a *field*. Knowing how search engines work can help you pinpoint the information you need. However, if your phrase is too vague, you may end up with a lot of unhelpful information.

How could you find out who was the first woman to participate in a space shuttle flight?

First, put **key phrases** in quotation marks. You want to know about the “first woman” on a “space shuttle.” Quotation marks tell the engine to search for those words together.

Second, if you only want websites that contain both phrases, **use a + sign** between them. Typing **“first woman” + “space shuttle”** into a search engine will limit your search to websites that contain both phrases.

If you want to broaden your search, use the word **or** between two terms. For example, if you type **“first female” or “first woman” + “space shuttle”** the search engine will list any website that contains either of the first two phrases, as long as it also contains the phrase “space shuttle.”

You can narrow a search by using the word **not.** For example, if you wanted to know about marine mammals other than whales, you could type **“marine mammals” not “whales”** into the field. Please note that some search engines use the minus sign (-) rather than the word **not**.

PRACTICE 1

1. If you wanted to find out about science museums in your state that are not in your own city or town, what would you type into the search engine?
2. If you wanted to find out which dog breeds are not expensive, what would you type into the search engine?
3. How could you research alternatives to producing electricity through the combustion of coal or natural gas?

READ

The quality of information found on the Internet varies widely. This section will give you some things to think about as you decide which sources to use in your research.

1. **Authority:** How well does the author know the subject matter? If you search for “Newton’s laws” on the Internet, you may find a science report written by a fifth grade student, and a study guide written by a college professor. Which website is the most authoritative source?
   Museums, national libraries, government sites, and major, well-known “encyclopedia sources” are good places to look for authoritative information.

2. **Bias:** Think about the author’s purpose. Is it to inform, or to persuade? Is it to get you to buy something? Comparing several authoritative sources will help you get a more complete understanding of your subject.

3. **Target audience:** For whom was this website written? Avoid using sites designed for students well below your grade level. You need to have an understanding of your subject matter at or above your own grade level. Even authoritative sites for younger students (children’s encyclopedias, for example) may leave out details and simplify concepts in ways that would leave gaps in your understanding of your subject.

4. **Is the site up-to-date, clear, and easy to use?** Try to find out when the website was created, and when it was last updated. If the site contains links to other sites, but those links don’t work, you may have found a site that is infrequently or no longer maintained. It may not contain the most current information about your subject. Is the site cluttered with distracting advertisements? You may wish to look elsewhere for the information you need.

PRACTICE 2

1. What is your favorite sport or activity? Search for information about this sport or activity. List two sites that are authoritative and two sites that are not authoritative. Explain your reasoning. Finally, write down the best site for finding out information about your favorite sport.

2. Search for information about an earth science topic of your choice on the Internet (for example: “earthquakes,” “hurricanes,” or “plate tectonics”). Find one source that you would NOT consider authoritative. Write the key words you used in your search, the web address of the source, and a sentence explaining why this source is not authoritative.

3. Find a different source that is authoritative, but intended for a much younger audience. Write the web address and a sentence describing who you think the intended audience is.

4. Find three sources that you would consider to be good choices for your research here. Write a two to three sentence description of each. Describe the author, the intended audience, the purpose of the site, and any special features not found in other sites.

Name:____ Date:__________________

SKILL and PRACTICE
12.1

Charles Richter

Richter is the most recognized name in seismology due to the earthquake magnitude scale he codeveloped. But Earth science was never a subject of interest to this bright young physicist, until a mentor made an interesting suggestion and a "happy accident" introduced him to seismology.

The unexpected path


Photo - courtesy of USGS

Charles F. Richter was born on April 26, 1900 in Hamilton, Ohio. When he was 16, Charles and his mother left their Ohio farm and moved to Los Angeles. Richter attended the University of Southern California from 1916–1917, and then earned a bachelor's degree in physics at Stanford University.

It was during his Ph.D. studies in **theoretical physics** at the California Institute of Technology (Caltech) that Richter began his work in seismology, quite by accident.

In 1927, Richter was working on his Ph.D. under the Nobel Prize winning physicist Dr. Robert Millikan. One day, Dr. Millikan called Richter into his office and presented him with an opportunity. The Caltech **Seismology** Laboratory was in need of a physicist, and although Richter had never done any Earth science work, Dr. Millikan thought he might be a good person for the job.

Richter was a little surprised, but decided to talk to Harry Wood, the lead scientist in charge of the lab. Richter became intrigued and decided to join the seismology lab located in Pasadena, California. Richter described this introduction to the science that would become his life's work as a "happy accident."

Doing something ordinary

One of Charles Richter's most famous sayings is based on looking back at his own life: "Don't wait for extraordinary circumstance to do good; try to use ordinary situations."

When he first started at the seismology lab, Richter was busy with the routine work of measuring **seismograms** and locating earthquakes, so that a catalog of epicenters and occurrence times could be set up. At the time, this kind of earthquake study was new. Harry Wood was leading the effort to use southern California's active seismic setting to gain a better understanding of earthquakes.

This creative setting allowed Richter to attempt to develop new ways to "rate" earthquakes based on the seismic waves they produced. Since the lab used seven seismographs to record activity, Richter suggested that they compare quakes to one another using the amplitude of each quake measured at all seven locations. To do this, the seismic readings needed to be corrected to take into account the differences in distance from the epicenters. Richter had learned of a method to do this based on large earthquakes, but the magnitudes that Richter was studying ranged from tiny to very large.

Collaboration and success

Richter thought that the size difference in the magnitudes was unmanageably large. Fellow scientist Dr. Beno Gutenberg suggested that they plot the magnitudes using powers of 10. A **magnitude** two earthquake would represent 10 times the amplitude of ground motion of a magnitude one. A magnitude three would be 100 times a magnitude one, a four would be 1,000 times a magnitude one, and so on.

Richter realized this was the obvious answer to his problem. When he used this method and graphed the results, it worked! At first it could be used only for southern California, because the system was only meant to compare quakes of that region using the seven **seismographs** in their lab.

A new way to rate earthquakes

In 1935, Richter and Gutenberg published their magnitude scale system. By 1936, they had worked out how their system could be used in all parts of the world, with any type of instrument. Before this, the Mercalli scale had been used to rate the magnitude of earthquakes, but it was based on local damage to buildings and people's reactions to a quake.

Richter and Gutenberg's scale allowed for a more absolute and scientific method to be used by anyone, anywhere in the world.

Reading reflection

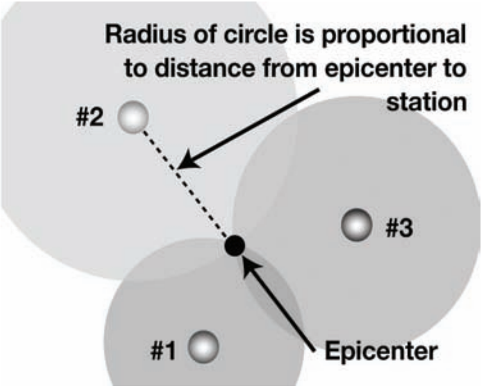
1. Look up the definition of each boldface word in the article. Write down the definitions and be sure to credit your source.
2. What do you think you would feel like if a world reknown scientist like Dr. Robert Millikan recommended you for a job? How would you feel if accepting that job meant that you could no longer work closely with Dr. Millikan?
3. How did Richter respond to his new job?
4. Who helped Richter refine his idea into a working model?
5. Name a scale other than the Richter scale that scientists use to evaluate earthquakes.
6. **Research:** Why do scientists use different scales to rate earthquakes?
7. **Research:** What is the difference between a seismograph and a seismometer?

Name:

Finding an Earthquake Epicenter

READ

The location of an earthquake’s epicenter can be determined if you have data from at least three seismographic stations. One method of finding the epicenter utilizes a graph and you need to know the difference between the arrival times of the P- and S-waves at each of three seismic stations. Another method uses a formula and you need to know the arrival times and speeds of the P- and S-waves. The only other items you need to find an epicenter are a calculator, a compass, and a map.



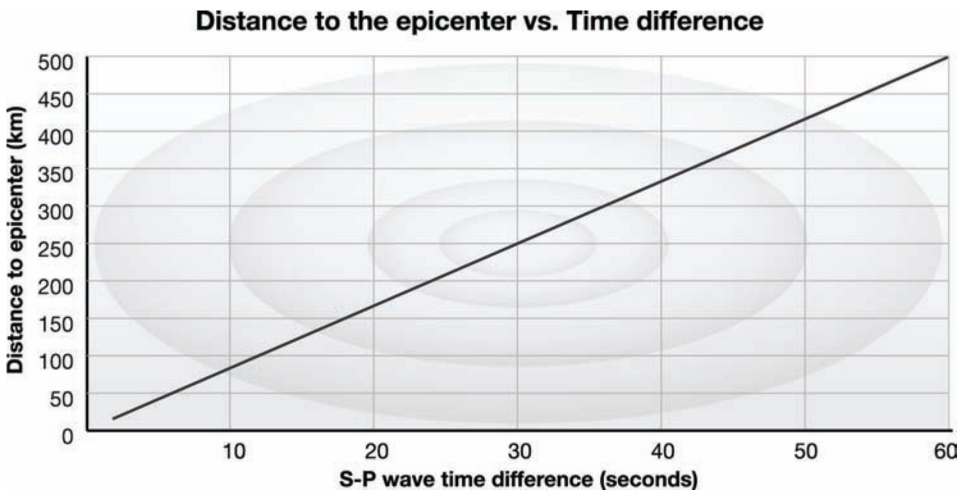
PRACTICE 1

Finding the epicenter using a graph

Table 1 provides the arrival time difference between P- and S-waves. Use this value to find the distance to the epicenter on the graph. Record the distance values in the table in the third column from the left.

Table 1: Seismic wave arrival time and distance to the epicenter

Station name	Arrival time difference between P- and S-waves	Distance to epicenter in kilometers	Scale distance to epicenter in centimeters
1	15 seconds		
2	25 seconds		
3	42 seconds		



Locating the epicenter on a map

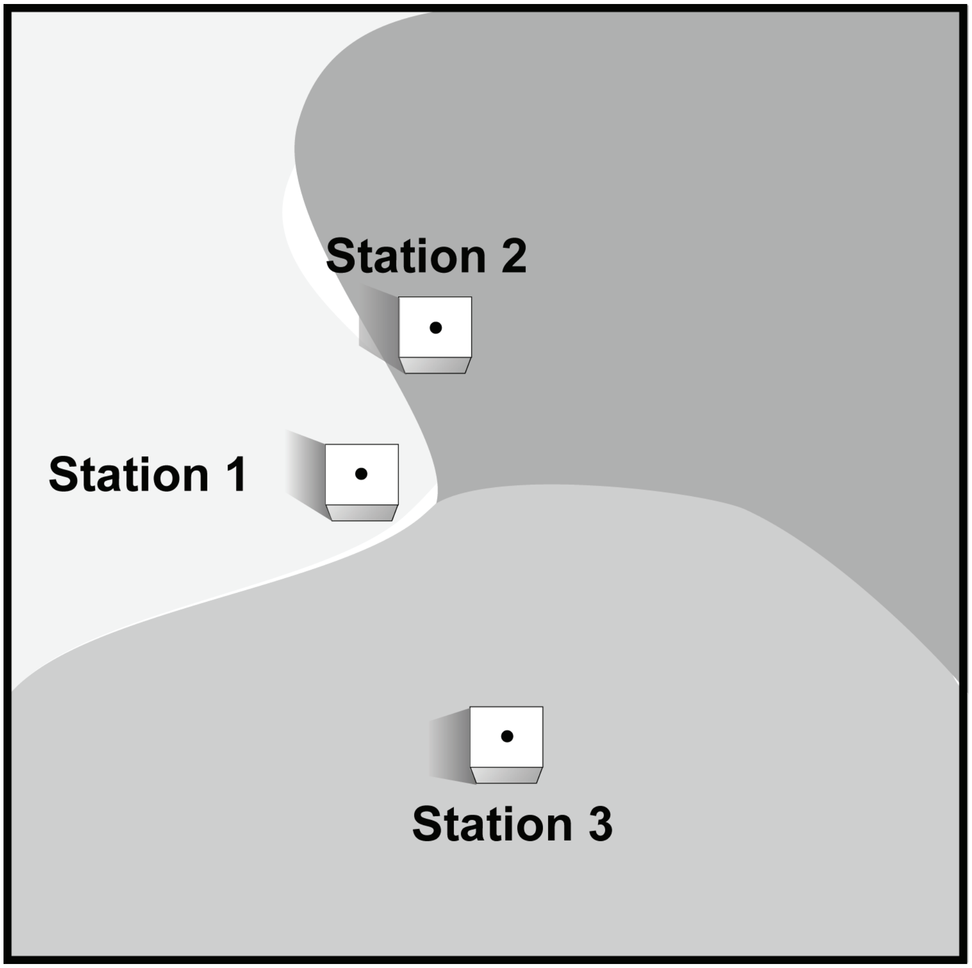
Once you have determined the distance to the epicenter for three stations in kilometers, you can use a map to locate the epicenter. The steps are as follows:

Step 1: Determine the radius of a circle around each seismographic station on a map. The radius will be proportional to distance from the epicenter. Use the formula below to convert the distances in kilometers to distances in centimeters. For this situation, we will assume that 100 kilometers = 1 centimeter. Record the scale distances in centimeters in the fourth column of Table 1.

$$\frac{1\text{ cm}}{100\text{ km}} = \frac{x}{\text{distance to epicenter in km}}$$

Step 2: Draw circles around each seismic station. Use a geometric compass to make circles around each station. Remember that the radius of each circle is proportional to the distance to the epicenter.

Step 3: The location where the three circles intersect is the location of the epicenter.



EXAMPLE ▶

Finding the epicenter using a formula

To calculate the distance to the epicenter for each station, you will use the equation:

$$\text{Distance} = \text{Rate} \times \text{Time}$$

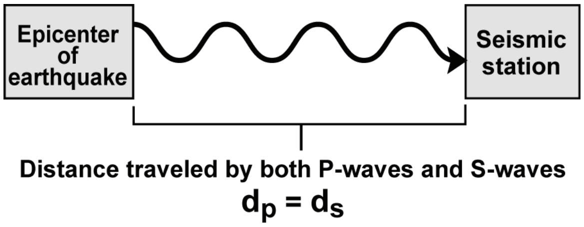
Table 2 lists the variables that are used in the equation for finding the distance to the epicenter. This table also lists values that are given to you.

Table 2: Variables for the equation to calculate the distance to the epicenter

Variable	What it means	Given
d_p	distance traveled by P-waves	r_p = 5 km/sec r_s = 3 km/sec $d_p = d_s$
r_p	speed of P-waves	
t_p	travel time of P-waves	
d_s	distance traveled by S-waves	
r_s	speed of S-waves	
t_s	travel time of S-waves	

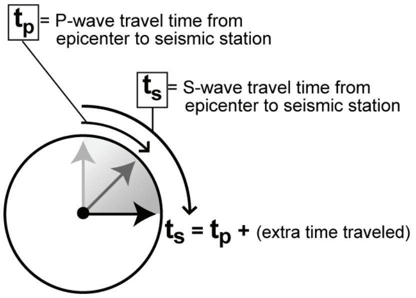
For each of the practice problems, assume that the speed of the P-waves will be 5 km/s and the speed of the S-waves will be 3 km/sec. Also, because the P- and S-waves come from the same location, we can assume the distance travelled by both waves is the same.

$$\begin{aligned} \text{distance traveled by P-waves} &= \text{distance traveled by S-waves} \\ d_p &= d_s \\ r_p \times t_p &= r_s \times t_s \end{aligned}$$



Since the travel time for the S-waves is longer, we can say that,

$$\begin{aligned} \text{travel time of S-waves} &= (\text{travel time of P-waves}) + (\text{extra time}) \\ t_s &= t_p + (\text{extra time}) \\ r_p \times t_p &= r_s \times (t_p + \text{extra time}) \end{aligned}$$



PRACTICE 2

For each of the practice problems, assume that the speed of the P-waves is 5 kilometers per second, and the speed of the S-waves is 3 kilometers per second. The first problem is done for you. Show your work for all problems.

1. S-waves arrive to seismographic station A 85 seconds after the P-waves arrive. What is the travel time for the P-waves?

$$\frac{5\text{ km}}{\text{sec}} \times t_p = \frac{3\text{ km}}{\text{sec}} \times (t_p + 85\text{ sec})$$

$$\left(\frac{5\text{ km}}{\text{sec}}\right)t_p = \left(\frac{3\text{ km}}{\text{sec}}\right)t_p + 255\text{ km}$$

$$\left(\frac{2\text{ km}}{\text{sec}}\right)t_p = 255\text{ km}$$

$$t_p = 128\text{ sec}$$

2. S-waves arrive to another seismographic station B 80 seconds after the P-waves. What is the travel time for the P-waves to this station?

3. A third seismographic station C records that the S-waves arrive 120 seconds after the P-waves. What is the travel time for the P-waves to this station?

4. From the calculations in questions 1, 2, and 3, you know the travel times for P-waves to three seismographic stations (A, B, and C). Now, calculate the distance from the epicenter to each of the stations using the speed and travel time of the P-waves. Use the equation: distance = speed × time.

5. Challenge question: You know that the travel time for P-waves to a seismographic station is 200 seconds.
   a. What is the difference between the arrival times of the P- and S-waves?
   b. What is the travel time for the S-waves to this station?

6. Table 3 includes data for three seismographic stations. Using this information, perform the calculations that will help you fill in the rest of the table, except for the scale distance row.

Table 3: Calculating the distance to the epicenter

	Variables	Station 1	Station 2	Station 3
Speed of P-waves	r_p	5 km/sec	5 km/sec	5 km/sec
Speed of S-waves	r_s	3 km/sec	3 km/sec	3 km/sec
Time between the arrival of P- and S-waves	$t_s - t_p$	70 seconds	115 seconds	92 seconds
Total travel time of P-waves	t_p			
Total travel time of S-waves	t_s			
Distance to epicenter in kilometers	d_p, d_s			

Table 3: Calculating the distance to the epicenter

Scale distance to epicenter in centimeters				

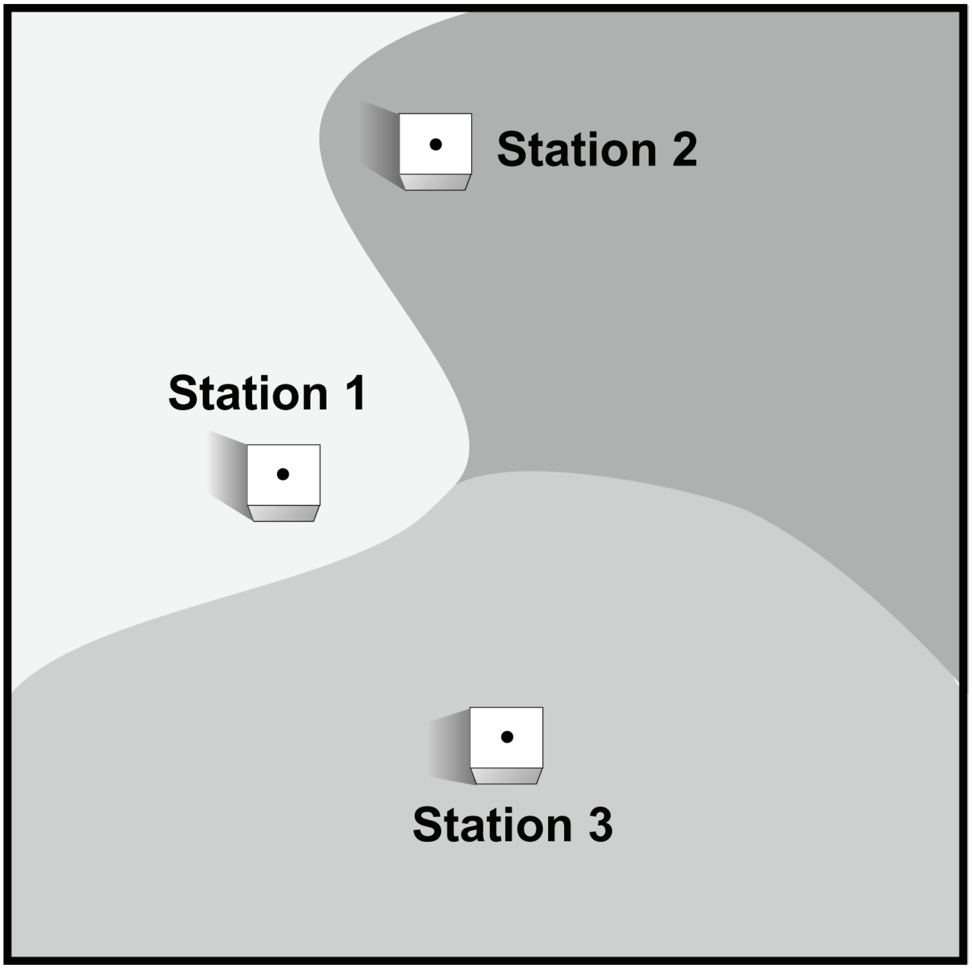
Once you have determined the distance to the epicenter for three stations in kilometers, you can use a map to locate the epicenter. The steps are as follows:

Step 1: Determine the radius of a circle around each seismographic station on a map. The radius will be proportional to distance from the epicenter. Use the formula below to convert the distances in kilometers to distances in centimeters. For this situation, we will assume that 200 kilometers = 1 centimeter. Record the scale distances in centimeters in the last row of Table 3.

$$\frac{1\text{ cm}}{200\text{ km}} = \frac{x}{\text{distance to epicenter in km}}$$

Step 2: Draw circles around each seismic station. Use a geometric compass to make circles around each station. Remember that the radius of each circle is proportional to the distance to the epicenter.

Step 3: The location where the three circles intersect is the location of the epicenter.



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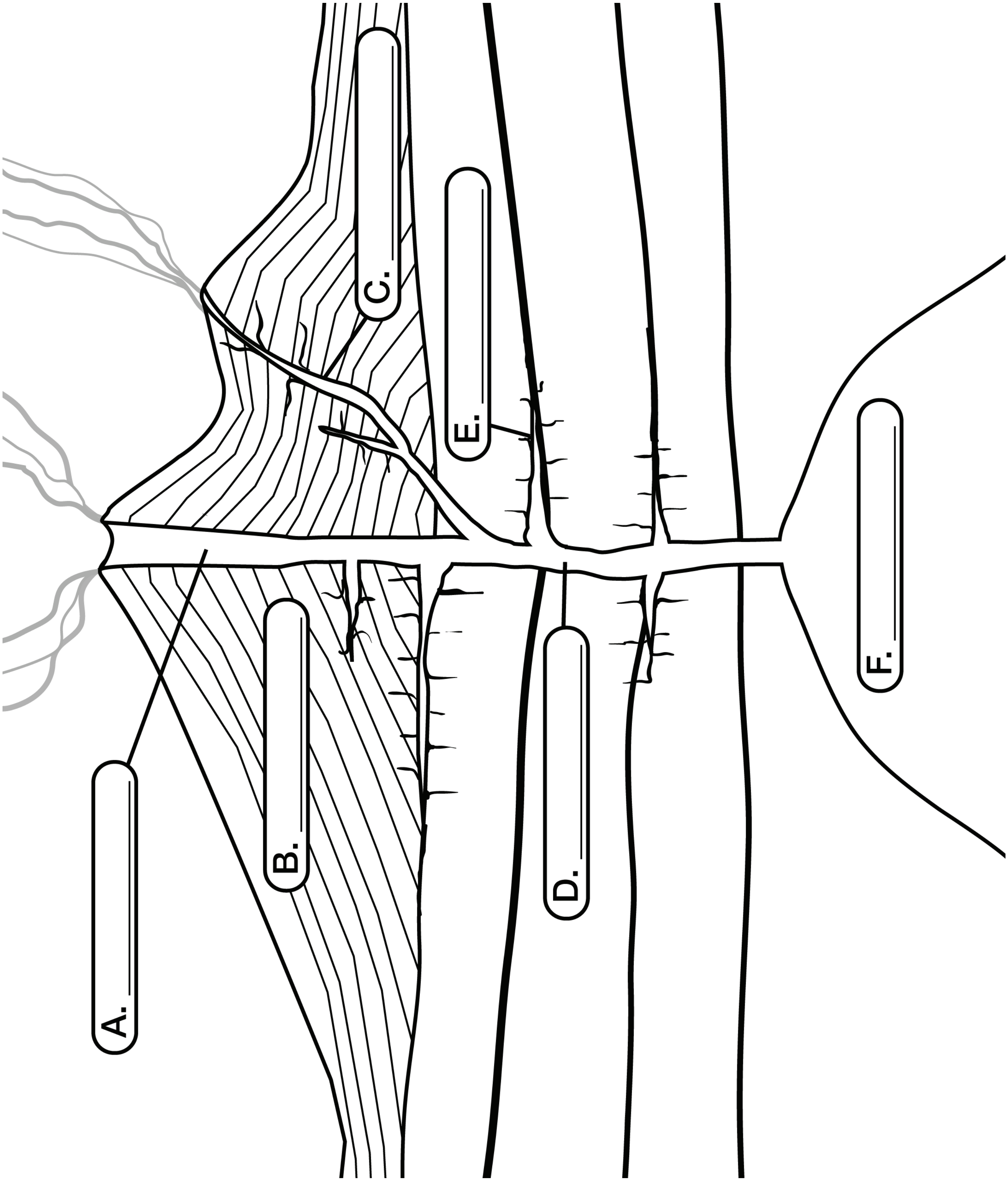
Volcano Parts

SKILL and PRACTICE
12.2



Name: Date:

SKILL and PRACTICE 12.2

Responding to Natural Disasters

READ

You have learned that plate tectonics helps explain why certain natural disasters like earthquakes, volcanic eruptions, and tsunamis occur. You have also learned about storms and global warming—two conditions that can cause coastal flooding.

In this project, you will:

(1) Review articles about a natural disaster and evaluate the science in these articles,

(2) Discuss how communities and the world at large respond to natural disasters, and

(3) Develop a plan for how your class can respond to this disaster and help the community affected by it.

Examples of where to find articles and information on the Internet	
Web site	**Description**
Any news agency web site	
http://www.usgs.gov/ http://neic.usgs.gov/	The web site for the United States Geological Survey (USGS), and The Current Worldwide Earthquake List
http://www.fema.gov/	The web site for the United States Federal Emergency Management Agency (FEMA)
http://www.noaa.gov/ http://www.noaanews.noaa.gov/	The web site and news magazine for the National Oceanographic and Atmospheric Agency
http://ochaonline.un.org/	The web site for the United Nations Office for the Coordination of Human Affairs
http://www.unicef.org/	The web site for the United Nations Children's Fund (formerly United Nations International Children's Emergency Fund).
http://www.redcross.org/ http://www.icrc.org/	The web sites for the American Red Cross and the International Red Cross
http://www.disasterrelief.org/EarthWatch	A web link that shows a map of recent natural disasters.

PRACTICE

Part 1: Reviewing articles

1. Obtain copies of local and national papers to learn about recent natural disasters. As a class, select a natural disaster for this project. You may want to chose an event that has occurred close to where you live. Here is a list of natural disasters that received extensive news coverage:

- Hurricane Katrina: Category 5 Atlantic Hurricane that hit the Gulf Coast of the United States in August 2005.
- Earthquakes in Iran: (1) the 6.6 magnitude quake in Bam, December 2003, or (2) the 6.4 magnitude earthquake in central Iran, February 22, 2005.
- Tsunami: The Indian Ocean tsunami that resulted from two undersea earthquakes—one at 9.0 magnitude and one at 7.3, December 26, 2004
- Hurricanes in Florida: Five hurricanes hit Florida’s coastline during the hurricane season of 2004.
- Storms and mudslides: Record rains in 2004-05 and storms caused severe mudslides, tornadoes, and avalanches in Los Angeles, California in February, 2005.

2. From a number of different papers, magazines, and news sites on the Internet, collect at least five articles.
    a. Read each article carefully and highlight important statements.
    b. Create a display for your articles. Either paste them to a poster board or make a portfolio of the articles.
3. Based on these articles, write a brief description of the disaster. In the description include the following information: the date it happened, where it happened, what caused the disaster, and the impact of the disaster on people and communities.
4. Discuss the science presented in the articles you collected. Does it seem correct? Did the reporters writing the articles seem to understand the science that caused the natural disaster? (Your teacher may invite an expert to come to your class to help you with this step of the project.)
5. Based on your reading, research, and discussions, write another paragraph describing why this disaster happened. For example, the 2004 tsunami was caused by movement of tectonic plates. Be as detailed as you can in your paragraph. For more information about the science, you may need to visit government web sites such as www.noaanews.noaa.gov or www.usgs.gov.

Part 2: Discussion

In response to a natural disaster, people tend to work together to help victims, raise money, provide medical aid, and rebuild the disaster area. Research and find out what is being done in response to the natural disaster your class chose to focus on for this project.

1. What is the affected community doing?
2. What is the United States doing?
3. What is the world doing?

Part 3: Taking action

1. With your class brainstorm a list of things you could do to help victims of the natural disaster. List one thing your class could to for each of the following categories. How could your class:
    a. Raise awareness about the type of disaster so people are safer in the future?
    b. Raise money to help victims of the disaster?
    c. Volunteer to help victims of the disaster or organizations that help the disaster victims?

2. With your class, choose one thing to do in response to this natural disaster. Then, create a time line and an action plan for accomplishing this project. The action plan should include a list of tasks that need to happen and who will accomplish those tasks.

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SKILL and PRACTICE
13.1

Mohs Hardness Scale

READ

The Mohs hardness scale was developed in 1812 by Friedrick Mohs (an Austrian mineral expert) as a method to identify minerals. This scale uses 10 common minerals to represent variations in hardness. You can identify a mineral's place on the hardness scale by whether it can scratch another mineral. For example, gypsum (hardness = 2) scratches talc (hardness = 1). The hardest mineral, a diamond, can scratch all other minerals. Pure minerals of the same hardness scratch each other. During this activity, you will practice using Mohs Hardness Scale and work with the minerals in your Rocks and Minerals Set.

Collecting the minerals of Mohs Hardness Scale

1. From your Rocks and Minerals Set, collect the minerals listed in Table 1. **To complete the activity, you will need to obtain gypsum, topaz and corundum from your teacher.** The only mineral you will not find is a diamond. Why?
2. The piece of ceramic tile (known as the streak plate) in your set is used to determine the streak color of minerals. Scratch each mineral on the streak plate and record the streak color in the third column of Table 1.
3. In the fourth column, describe what each mineral looks like. Describe its color, texture, and anything else that would help you distinguish this mineral. Use the small magnifying glass in the kit to help you.

Table 1: Mohs Hardness Scale

Mineral	Hardness	Color of Streak on Streak plate	Description
Talc	1		
Gypsum	2		
Calcite	3		
Fluorite	4		
Apatite	5		
Orthoclase (Feldspar)	6		
Quartz	7		
Topaz	8		
Corundum	9		
Diamond	10	N/A	clear, sparkly

PRACTICE

1. Prove to yourself that the placement of the minerals on the Mohs Hardness Scale is correct. How would you do this? Write your procedure as a short paragraph and then perform the procedure.
2. Is the Mohs Hardness Scale value for a mineral quantitative or qualitative? Justify your answer.
3. List two pros and two cons for using the Mohs hardness scale to identify minerals.
4. Is the Mohs Hardness Scale useful for identifying rocks? Why or why not?
5. Some varieties of the mineral corundum are gemstones. Rubies and sapphires are two examples. Imagine that you have heard a report that there is a newly discovered mine that is rich in corundum. You have been hired to verify the reports. For your first field trip, design two tests you will use to determine if the mineral in the mine is in fact corundum.
6. **Challenge:** Find the hardness values for other objects.

   When geologists are in the field, they do not have a whole set of mineral samples to represent each hardness value on the Mohs Hardness Scale. Instead, they often use things like a pocket knife or fingernail to identify the hardness of mineral samples.

   Use the clues (a - g) to help you identify the hardness values for the objects listed in Table 2. First, read the following instructions for how to fill in the table.

   Instructions for filling in Table 2: In the top row are items that you could use to identify the hardness of a mineral. Read the clues to identify the hardness of each. The information in Table 1 will be helpful to you as well. Place a circle (**O**) in the table cell where the object and its hardness match. Where hardness and the object do not match up, place an **X**. The first two clues are done for you to illustrate how to fill in the table.

   Clues:

   a. A diamond is considered to be the hardest mineral.
   b. Pyrite is harder than calcite. (You can find pyrite in your Rocks and Minerals Set).
   c. The hardness of a fingernail is 2.5. Ice does not leave scratches on a fingernail.
   d. Calcite and copper have similar hardness.
   e. A pocket knife is helpful in that it can scratch half of the minerals on the Mohs Hardness Scale.
   f. Pure apatite and fluorite can be scratched by iron. Iron can be scratched by quartz.
   g. A pocket knife can scratch fool’s gold.

Table 2: Mohs Hardness Scale

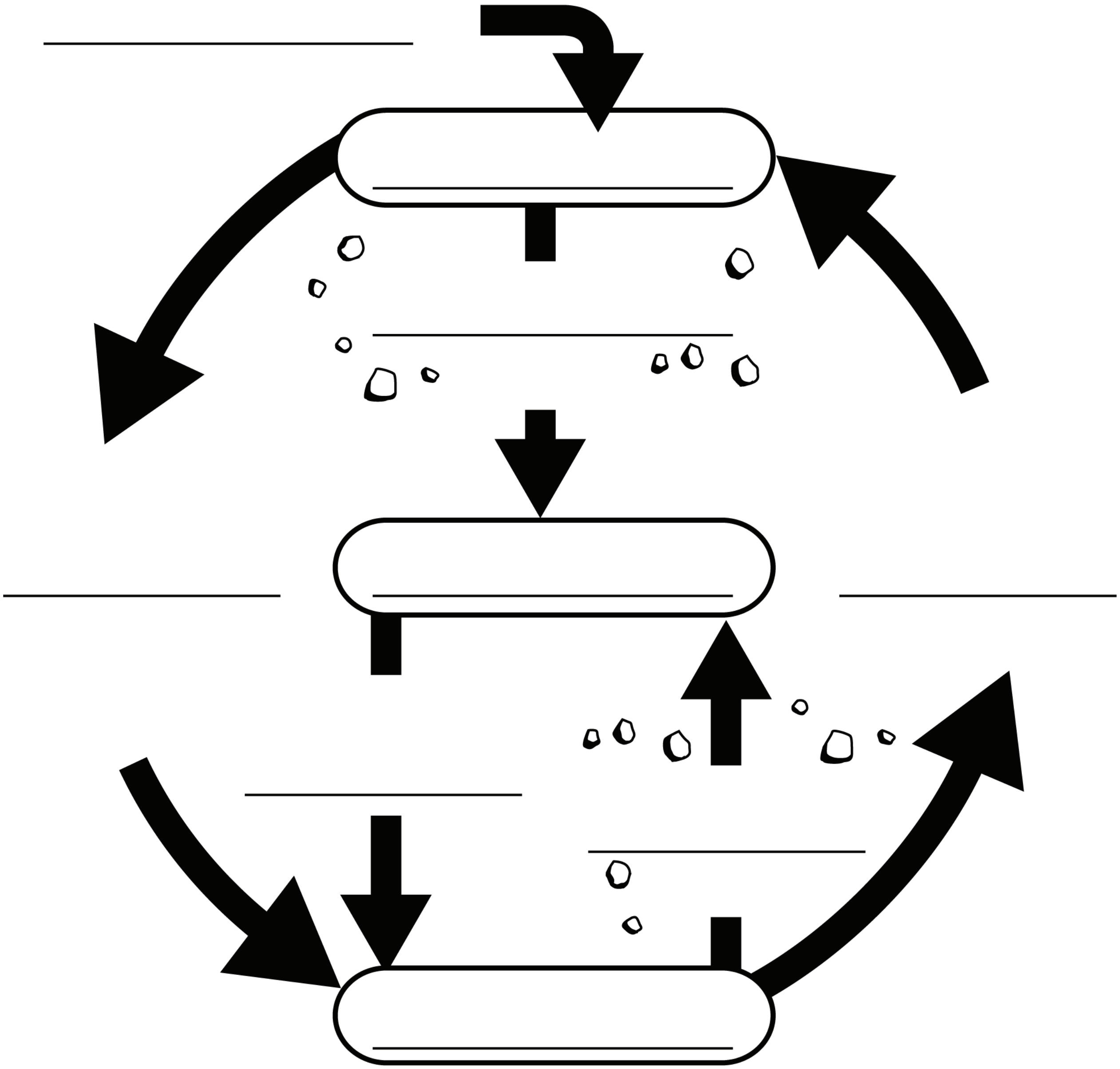
	Copper wire	Pocketknife	Pyrite	Diamond	Iron nail	Ice
1.5			X	X		
3			X	X		
4-5				X		
5.5				X		
6-6.5				X		
10	X	X	X	O	X	X

Name: ______________________ Date: ______________

The Rock Cycle

PRACTICE

In Section 13.1 of your student text, you will learn about the rock cycle. Place the three main groups of rocks in the ovals below. Then, fill in the blank lines with the materials or processes at work in each stage of the rock cycle. Use this diagram as a study aid. Describe to a friend or family member what is happening at each stage.



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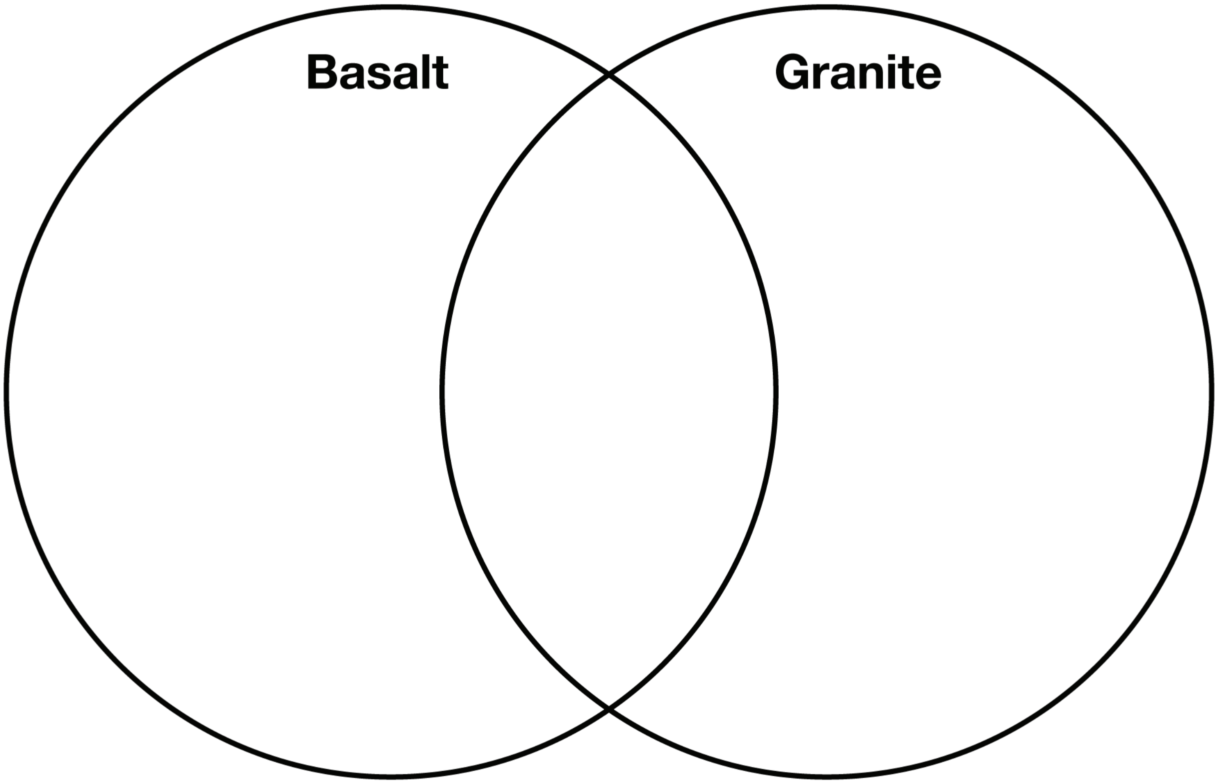
Name: ______________________ Date: ______________

Basalt and Granite

READ

As you read Section 13.2 of your student text, you will learn about how basalt and granite form. You'll learn about ways they are alike and ways that they are different. The Venn diagram below can help you organize this information. As you learn about these types of rock, place facts that apply to both in the space where the circles intersect. Place facts that apply to only one type of rock in its individual space. Use this diagram as a study aid.

PRACTICE



1.

Name: ______________________________ Date: ____________________

Continental United States Geology

READ

You have learned about the plates that make up the surface of Earth. You have also learned how plates are formed at mid-ocean ridges and are destroyed at subduction zones. Here is a very brief look at how plate tectonics formed the land mass that we call the United States. It covers only the last chapter of the Earth history of the 48 contiguous states.

The full history of the surface of Earth is a very long and complicated story. To give you an idea of the difficulty of understanding the full story, imagine this: A young child is given a new box of modeling clay. In the box are four sticks of differently colored clay. The child plays with the clay for hours making different figures. First a set of animals, then a fort, and so on. Between each idea, the child balls up all of the clay. Now imagine that it's the next day and the ball of swirled clay colors is in your hand. Your task is to figure out what the child made and in what order.

That sounds impossible, and it probably is. The amazing thing is that geologists have figured out a lot of the equally difficult story of Earth's surface. We have a pretty good idea about how the early crust was formed. And we know that there was a super continent called Rodinia that formed before Pangaea, the last super continent. But like the child's clay figures, the further back we look, the more the clues are mixed up.

The last chapter

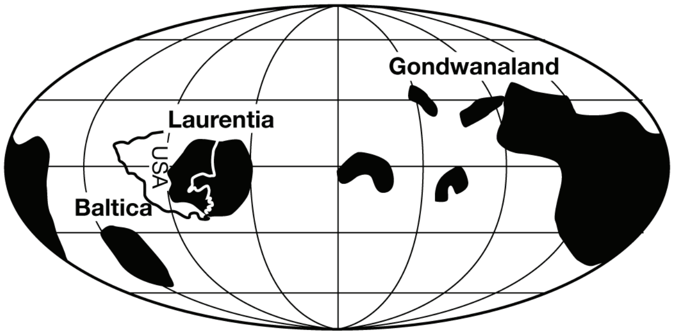
Our story begins late. Most of the history of Earth has already passed. During this time rift valleys formed that split continents into smaller pieces. First the land moved apart on both sides of a rift valley. Then, once the rift valley opened wide enough, water flooded in and a new ocean was born. Underwater, the rift valley then became a mid-ocean ridge.

At the same time, subducting plates acted like conveyor belts. Anything that was part of a subducting plate was carried toward the subduction zone. In this way continents were carried together. Collisions between continents welded them together. Mountain ranges formed at the point of contact.

The combination of rifting and subduction worked together to form, destroy, and reform the early continents. You can see that the result is very much like playing with modeling clay.

The craton

Even though most of Earth's history had passed, it was still an incredibly long time ago. Rifting had broken up Rodinia, but subduction had not yet formed Pangaea. The break-up of Rodinia left six continents scattered across the world oceans. These continents were not the continents that we see today. One of these, Gondwanaland, was larger than the others put together.

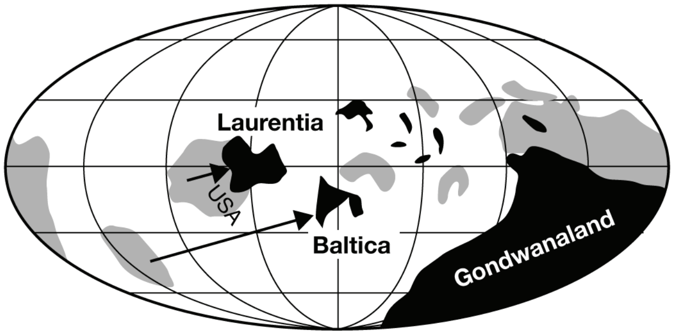


Two other continents are important to our story. They are called Baltica and Laurentia. At the center of Laurentia was a core piece that was very old even then. This core piece is called the craton. The craton had been changed again and again, but it was stable inside Laurentia. Today the craton of Laurentia forms the central United States.

You may wonder where these names came from. After all, these continents were gone many millions of years before humans appeared on Earth. They are modern names proposed and adopted by geologists.

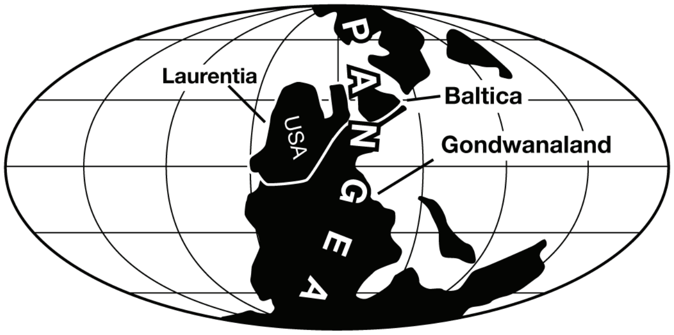
The first collision

Rifting and subduction caused Baltica to move in a jerky path. Eventually, Baltica collided with Laurentia to form a larger combined continent. This new continent is called Laurasia. A high mountain range formed where the colliding continents made contact. This mountain range lay deep inside Laurasia. Today the remains of this high mountain range form our northern Appalachian Mountains.



Gondwanaland collides

Subduction continued to bring continents together. Next mighty Gondwanaland was drawn ever closer to Laurasia. Gondwanaland collided just below where Laurentia and Baltica collided with each other. This new collision raised another set of mountains that continued the northern Appalachians into what are now the southern Appalachians. The combined Appalachians were as high as the Himalayans of today! The super continent Pangaea was then complete and the lofty Appalachian Mountains stood near its center.



Pangaea breaks up

Pangaea did not remain together for very long, only a few tens of millions of years. The same rifting process that broke up Rodinia split the new super continent into smaller pieces. Our future East Coast had been deep inside the central part of Pangaea. But in the break-up, a rift valley split our eastern shore away from what is now Africa. Instead of an inland place, our East Coast became an eastern shore.

The East Coast after Pangaea

One of the amazing things in geology is how quickly mountain ranges are eroded away. After Pangaea broke up, the Appalachians completely eroded away. All that was left was a flat plain! The sediments produced from this erosion formed deep layers on the eastern shore and near-shore waters. These coastal margin sediments make up most of the eastern states today. But wait a minute; today we see rounded mountains where there had been only flat plains. What formed the rounded Appalachian Mountains of today?

When a mountain is formed, some of it is pressed deep into the mantle by the weight of the mountain above. It's like stacking wood blocks in water. As the stack grows taller, it also sinks deeper. Erosion takes a tall mountain down quickly. With the top gone, its bottom rebounds back to the surface. In this way, the Appalachian Mountains that we see today are actually the rebounded lower section of the mountains that once had been pressed deep below Earth's surface.

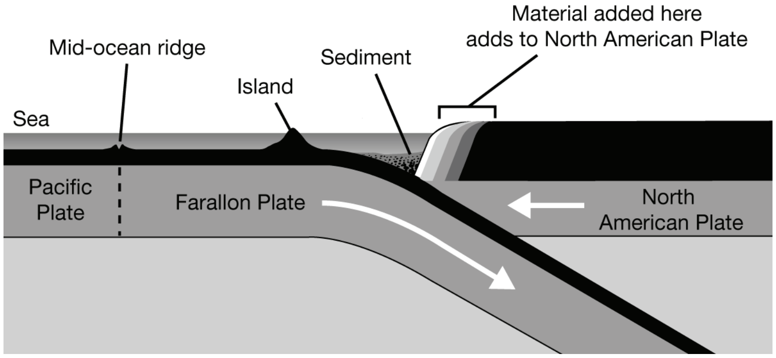
The West Coast and the Ancestral Rocky Mountains

There are two Rocky Mountain ranges. The first is called the Ancestral Rocky Mountains. The Ancestral Rocky Mountains were formed when subduction caused an ancient collision with Laurentia. The collision struck Laurentia on the side that would become our western states. In other words, the Ancestral Rocky Mountains already existed before Pangaea formed. The Ancestral Rockies were then heavily weathered and the sediment deposited on the surrounding plains. Today the Front Range of Colorado is part of the exposed remains of the Ancestral Rocky Mountains.

Pangaea and the West Coast

Our West Coast did not exist as Pangaea began to break up. The shoreline was near the present eastern border of California. What would become our West Coast states were sediments and islands scattered in the ocean to the west.

North America began to move westward as it was rifted apart from Pangaea. A subduction zone appeared in front of the moving continent. As the ocean floor dove under the westward-moving continent, these sediments, islands and even pieces of ocean floor became permanently attached to the continent. Our western shore grew in this way, forming the shape that we see today.



The modern Rocky Mountains

The mid-ocean ridge that was forming the subducting ocean plate was not too far away to the west. As the plate subducted, the mid-ocean ridge got closer and closer to the edge of the continent. This changed the way that the plate subducted. The result was that stronger push pressure caused the continent to buckle well back from its edge. In this way, the modern Rocky Mountains were formed near the remains of the Ancestral Rocky Mountains.

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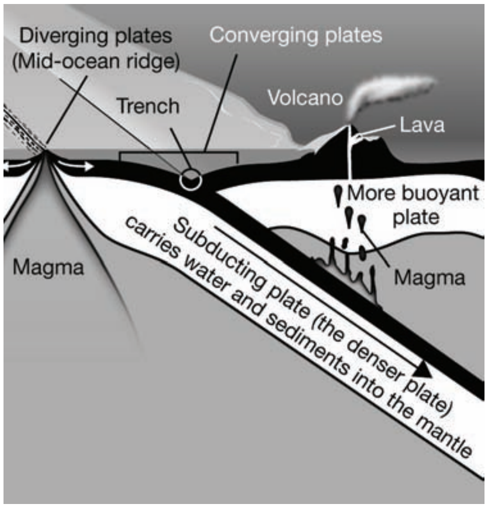
Inland volcanoes

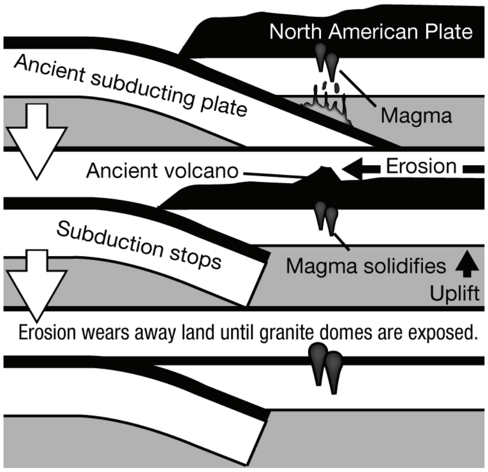
The subducting plate also caused volcanoes to form and erupt inland. These eruptions produced the Sierra Nevada Mountains to the south and High Cascades to the north.



A small plate disappears

The plate that had been subducting along the southern West Coast was small. Eventually it disappeared when its mid-ocean ridge was subducted. This changed the western edge of the United States from a converging boundary to a transform boundary. Now instead of one plate diving under another, the remaining Pacific Plate slides by the West Coast. Today this slide-by motion is well known as the San Andreas Fault.

When subduction stopped along the lower West Coast, the Sierra volcanoes became extinct. Magma cooled and solidified below the surface. Today this cooled magma is exposed as the domes of Yosemite National Park. Further north, the Pacific Plate is still subducting under the West Coast. That subduction continues to drive the volcanoes of the High Cascades.



The United States today

In geologic terms, the East Coast is quiet and the West Coast is active. The contiguous United States are part of the North American Plate. The active eastern boundary of the plate lies in the middle of the Atlantic Ocean, far from our East Coast. But the active western boundary is also our western shore. The San Andreas Fault slowly moves slivers of California northward. Baja California will eventually be attached to San Diego. Map makers won't have to redraw New England, but they will have to watch for West Coast changes. The good news is that they'll have plenty of time to make those changes.

Name: ______________________ Date: ______________

Soil Texture

READ

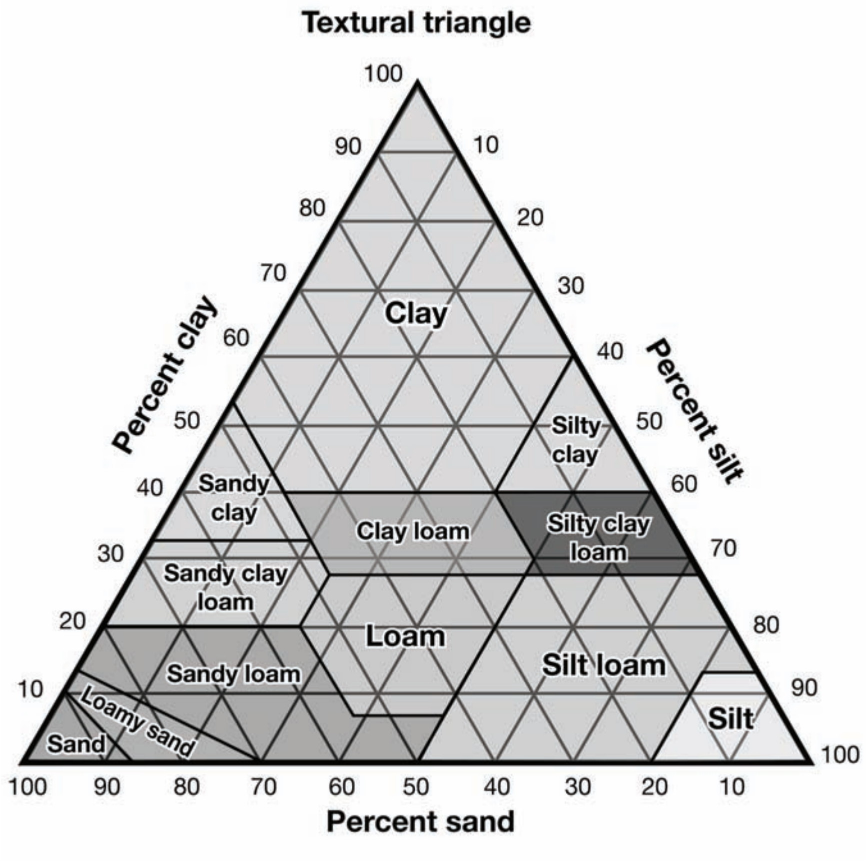
What determines a soil’s texture? It’s the percentages of sand, silt and clay that are mixed together to form the soil. Scientists, gardeners and engineers are all interested in soil texture for different reasons. Soil texture affects things like drainage, nutrient availability, how well the soil can support buildings, and how likely it is to be affected by erosion.

Of the three kinds of soil material, sand particles are the largest. They range in size from 0.05 mm to 2 mm. The irregular shapes and sizes of sand particles make it easy for water and dissolved nutrients to drain quickly through sandy soils. As a result, sandy soils are less fertile.

Clay particles are the smallest of the three types of soil material. Clay particles are no larger than 0.002 mm. The particles are flat and closely packed. Because of these characteristics, clay does not allow water to easily flow through. Nutrients don’t drain away quickly either—however, plant roots have a hard time growing through the closely packed particles to get to the nutrients. Wet clay tends to be sticky and dense, and dry clay is hard—almost brick-like.

Silt, the intermediate particle, has some characteristics of each of the other soil ingredients. Like sand, it is irregularly shaped, and it tends to have a coating of clay on it.

Soils are almost always a combination of these three particles. In order to describe soil texture, a textural triangle like the one shown below is used. For gardeners, the “ideal” soil is loam. Loam provides enough water and nutrients for plants, but also allows for some drainage. Both of these properties are helpful for plant growth.

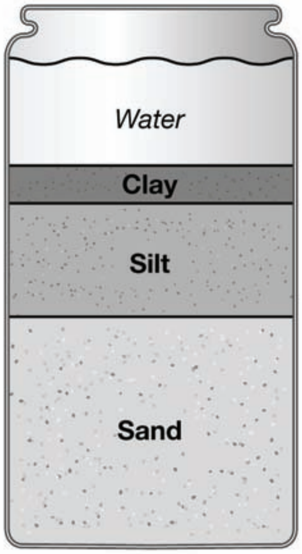


PRACTICE

To use the textural triangle, find the percentage of each soil particle type on the sides of the triangle. Follow the lines until they intersect. Find the soil type at the point of intersection.

Using the textural triangle, answer the following questions. The particle type percentages should always add up to 100 percent.

1. If a soil has 30 percent sand, 60 percent silt, and 10 percent clay, what is its soil texture?
2. If a soil has 40 percent clay, 50 percent sand, and 10 percent silt, what is its soil texture?
3. What percentages could be used to describe loam?
4. Based on what you know about things that live or are found in and around the soil environment, name three living things that could help improve soil texture, and describe how they do so.
5. If you were outside and didn't have a way to figure out the exact percentages of sand, silt, and clay, how could you use water and your hands to get an idea if the soil was mostly silt, sand, or clay? Use the information you learned in the reading section to help you answer this question.
6. Below is an image of a jar with soil that has been collected from a specific location. The soil was put in the jar and covered with water. The jar was shaken vigorously to break up all the clumps of soil. After a few days had passed, the sand, silt, and clay particles settled to the bottom of the jar. The sand, because it is largest and heaviest, settled first, then silt, and finally the clay. It is your job to figure out the percentage of each particle type in the soil. Hint: you will need a ruler and a calculator.



7. Now, use those percentages to figure out the texture of this soil.

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Supplying Our Energy Needs

READ

Do you know where your electricity comes from? Do you know what kind of power plant produces it? In this research project, you will investigate energy sources used to generate electricity. Each group in the class will research one type of power plant. When all the groups have completed their work, the class will review and discuss the information. Each group will be responsible for providing evidence that demonstrates the pros and cons of their energy source.

The final goal of this project is for your class to determine the best energy source for generating electricity in your community, considering questions of efficiency, cost-effectiveness, and environmental impact.

Possible sources of energy for generating electricity include coal, oil, natural gas, nuclear, hydroelectric, solar, wind, and geothermal.

Where to find information on the Internet:		
www.energy.gov	www.fe.doe.gov/education/index.html	www.eere.energy.gov/biomass
www.ase.org	http://energy.inel.gov/renewable	www.eia.doe.gov
www.energy.ca.gov	www.ne.doe.gov	Use a search engine with your energy source as the keyword.

PRACTICE

1. Choose one of the energy sources listed in the introductory paragraph.
2. Make a list of facts about this energy source. Come up with at least 10 pros and 10 cons. Cover these topics:
    a. How much does it cost to build a power plant for generating energy using your source?
    b. How much does it cost to maintain this type of power plant?
    c. How much does the energy source cost to use?
    d. How energy-efficient is this source?
    e. How does the use of your energy source affect human health?
    f. What are the environmental issues associated with using your energy source?
    g. How long into the future is this source projected to last?
3. As you make your list, fill in details to explain each point.
4. Prepare a one-page handout for your classmates which summarizes each point.
5. Prepare a poster highlighting two or three of the most important things you would like classmates to remember about your energy source.

Share your results

1. Decide as a class how you would like to learn about all of the energy sources. Some ideas include:
   - Have each group make a five-minute presentation to the class.
   - Make a booklet for each student that contains the summary sheet from each group. Each student should come up with a list of three questions they have after reading the booklet. Then give each student an opportunity to ask one question of another group.
2. Once you are familiar with the pros and cons of each source, consider these three questions separately:
   a. Which one is the most efficient for your area of the country?
   b. Which one is most cost-effective?
   c. Which one is the safest for your environment?
3. If you were part of a commission studying which type of power plant to build in your community, how would you balance these three concerns? Is there one source which is best in every category?
4. Come up with a final recommendation for the best energy source for your community. Your class might choose to:
   - Form new groups, each with one person who studied each energy source. Each group should act as a commission responsible for making a recommendation to your community.
   - Have each person submit a statement about the best overall energy source for your community. Your teacher can divide the class into groups of students who share the same conclusion. Then, hold a debate among the groups.

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Mass vs. Weight

READ

What is the difference between mass and weight?

mass	weight
• Mass is a measure of the amount of matter in an object. Mass is not related to gravity. • The mass of an object does not change when it is moved from one place to another. • Mass is commonly measured in grams or kilograms.	• Weight is a measure of the gravitational force between two objects. • The weight of an object does change when the amount of gravitational force changes, as when an object is moved from Earth to the moon. • Weight is commonly measured in newtons or pounds.

Weightlessness: When a diver dives off of a 10-meter diving board, she is in free-fall. If the diver jumped off of the board with a scale attached to her feet, the scale would read zero even though she is under the influence of gravity. She is “weightless” because her feet have nothing to push against. Similarly, astronauts and everything inside a space shuttle seem to be weightless because they are in constant free fall. The space shuttle moves at high speed, therefore, its constant fall toward Earth results in an orbit around the planet.

EXAMPLES

- On Earth’s surface, the force of gravity acting on one kilogram is 2.22 pounds. So, if an object has a mass of 3.63 kilograms, the force of gravity acting on that mass on *Earth* will be:

$$3.63\text{ kg} \times \frac{2.22\text{ pounds}}{\text{kg}} = 8.06\text{ pounds}$$

- On the moon’s surface, the force of gravity is about 0.370 pounds per kilogram. The same object, if it traveled to the moon, would have a mass of 3.63 kilograms, but her weight would be just 1.33 pounds.

$$3.63\text{ kg} \times \frac{0.370\text{ pounds}}{\text{kg}} = 1.33\text{ pounds}$$

PRACTICE

1. What is the weight (in pounds) of a 7.0-kilogram bowling ball on Earth’s surface?
2. What is the weight of a 7.0-kilogram bowling ball on the surface of the moon?
3. What is the mass of a 7.0-kilogram bowling ball on the surface of the moon?
4. Describe what would happen to the spring in a bathroom scale if you were on the moon when you stepped on it. How is this different from stepping on the scale on Earth?
5. Would a balance function correctly on the moon? Why or why not?
6. **Activity:** Take a bathroom scale into an elevator. Step on the scale.
   a. What happens to the reading on the scale as the elevator begins to move upward? to move downward?
   b. What happens to the reading on the scale when the elevator stops moving?
   c. Why does your weight appear to change, even though you never left Earth’s gravity?

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Name: ____ Date: ____________________

Astronomical Units

READ

Talking and writing about distances in our solar system can be cumbersome. The Sun and Neptune are on average 4,500,000,000 (or four billion, five hundred million) kilometers apart. Earth's average distance from the Sun is 150,000,000 (one hundred fifty million) kilometers. It can be difficult to keep track of all the zeroes in such large numbers. And it's not easy to compare numbers that large.

Astronomers often switch to astronomical units (abbreviated AU) when describing distances in our solar system. One astronomical unit is 150,000,000 km—the same as the distance from Earth to the Sun.

Neptune is 30 AU from the Sun. Not only is 30 an easier number to work with than 4,500,000,000; but using astronomical units allows us to see immediately that Neptune is 30 times as far from the Sun as Earth.

In this skill sheet, you will practice working with astronomical units.

EXAMPLE

- Jupiter is 778 million kilometers from the Sun, on average. Find this distance in astronomical units.

  Solution: Divide 778 million km by 150 million km: 778,000,000 ÷ 150,000,000 = 5.19 AU

- The average distance from Mars to the Sun is 1.52 AU. Find this distance in kilometers.

  Solution: Multiply 1.52 AU by 150 million km: 1.52 × 150,000,000 = 228,000,000 km

PRACTICE

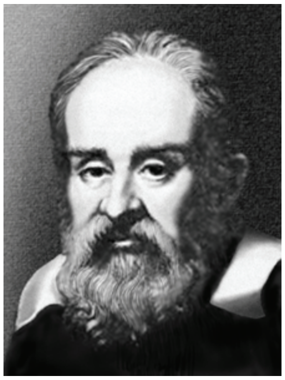
1. The average distance from Saturn to the Sun is 1.43 billion kilometers. Find this distance in astronomical units.
2. The average distance from Venus to the Sun is 108 million kilometers. Find this distance in astronomical units.
3. Mercury's average distance from the Sun is 0.387 astronomical units. How far is this in kilometers?
4. The average distance from Uranus to the Sun is 19.13 astronomical units. How far is this in kilometers?
5. Is the distance from Earth to the moon more or less than one astronomical unit? How do you know?
6. Which planet is almost 20 times as far away from the Sun as Earth?
7. Which planet is less than half as far away from the Sun as Earth?
8. Which planet is almost twice as far from the Sun as Jupiter?
9. An unmanned spacecraft launched from Earth has traveled 10 astronomical units in the direction away from the Sun. It most recently passed through the orbit of which planet?
10. An unmanned spacecraft launched from Earth has traveled 0.5 astronomical units toward the Sun. Has it passed through the orbit of Venus yet?

Name:_______________________________________ Date:_______________

Galileo Galilei

Galileo Galilei was a mathematician, scientist, inventor, and astronomer. His observations led to advances in our understanding of pendulum motion and free fall. He invented a thermometer, water pump, military compass, and microscope. He refined a Dutch invention, the telescope, and used it to revolutionize our understanding of the solar system.

An incurable mathematician



Galileo Galilei was born in Pisa, Italy, on February 15, 1564. His father, a musician and wool trader, hoped his son would find a more profitable career. He sent Galileo to a monastery school at age 11 to prepare for medical school. After four years there, Galileo decided to become a monk.

The eldest of seven children, he had sisters who would need dowries in order to marry, and his father had planned on Galileo's support. His father decided to take Galileo out of the monastery school.

Two years later, he enrolled as a medical student at the University of Pisa, though his interests were mathematics and natural philosophy. Galileo did not really want to pursue medical studies. Eventually, his father agreed to let him study mathematics.

Seeing through the ordinary

Galileo was extremely curious. At 20, he found himself watching a lamp swinging from a cathedral ceiling. He used his pulse like a stopwatch and discovered that the lamp's long and short swings took the same amount of time. He wrote about this in an early paper titled “On Motion.” Years later, he drew up plans for an invention, a pendulum clock, based on this discovery.

Inventions and experiments

Galileo started teaching at the University of Padua in 1592 and stayed for 18 years. He invented a simple thermometer, a water pump, and a compass for accurately aiming cannonballs. He also performed experiments with falling objects, using an inclined plane to slow the object's motion so it could be more accurately timed. Through these experiments, he realized that all objects fall at the same rate unless acted on by another force.

Crafting better telescopes

In 1609, Galileo heard that a Dutch eyeglass maker had invented an instrument that made things appear larger. Soon he had created his own 10-powered telescope. The senate in Venice was impressed with its potential military uses, and in a year, Galileo had refined his invention to a 30-powered telescope.

Star gazing

Using his powerful telescope, Galileo's curiosity now turned skyward. He discovered craters on the moon, sunspots, Jupiter's four largest moons, and the phases of Venus. His observations led him to conclude that Earth could not possibly be the center of the universe, as had been commonly accepted since the time of the Greek astronomer Ptolemy in the second century.

Instead, Galileo was convinced that Polish astronomer Nicolaus Copernicus (1473-1543) must have been right: The sun is at the center of the universe and the planets revolve around it.

House arrest

The Roman Catholic Church held that Ptolemy's theory was truth and Copernican theory was heresy. Galileo had been told by the Inquisition in 1616 to abandon Copernican theory and stop pursuing these ideas.

Despite these threats, in February 1632, he published his ideas in the form of a conversation between two characters. He made the one representing Ptolemy's view seem foolish, while the other, who argued Copernicus's theory, seemed wise.

This angered the church, whose permission was needed for publishing books. Galileo was called to Rome before the Inquisition. He was given a formal threat of torture and so he abandoned his ideas that promoted Copernican theory. He was sentenced to house arrest, and lived until his death in 1642 watched over by Inquisition guards.

Reading reflection

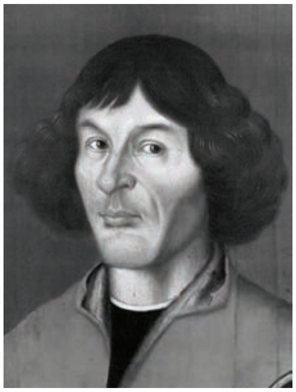
1. What scientific information was presented in Galileo’s paper “On Motion”?
2. **Research** one of Galileo’s inventions and draw a diagram showing how it worked.
3. How were Galileo’s views about the position of Earth in the universe supportive of Copernicus’s ideas?
4. Imagine you could travel back in time to January 1632 to meet with Galileo just before he publishes his “Dialogue Concerning the Two Chief World Systems.” What would you say to him?
5. In your opinion, which of Galileo’s ideas or inventions had the biggest impact on history? Why?

Name:____ Date: _________________

Nicolaus Copernicus

Nicolaus Copernicus was a church official, mathematician, and influential astronomer. His revolutionary theory of a heliocentric (sun-centered) universe became the foundation of modern-day astronomy.

Wealth, education, and religion



Nicolaus Copernicus was born on February 19, 1473 in Torun, Poland. Copernicus' father was a successful copper merchant. His mother also came from wealth. Being from a privileged family, young Copernicus had the luxury of learning about art, literature, and science.

When Copernicus was only 10 years old, his father died. Copernicus went to live his uncle, Lucas Watzenrode, a prominent Catholic Church official who became bishop of Varmia (now part of modern-day Poland) in 1489. The bishop was generous with his money and provided Copernicus with an education from the best universities.

From church official to astronomer

Copernicus lived during the height of the Renaissance period when men from a higher social class were expected to receive well-rounded educations. In 1491, Copernicus attended the University of Krakow where he studied mathematics and astronomy. After four years of study, his uncle appointed Copernicus a church administrator. Copernicus used his church wages to help pay for additional education.

In January 1497, Copernicus left for Italy to study medicine and law at the University of Bologna. Copernicus' passion for astronomy grew under the influence of his mathematics professor, Domenico Maria de Novara. Copernicus lived in his professor's home where they spent hours discussing astronomy.

In 1500, Copernicus lectured on astronomy in Rome. A year later, he studied medicine at the University of Padua. In 1503, Copernicus received a doctorate in canon (church) law from the University of Ferrara.

Observations with his bare eyes

After his studies in Italy, Copernicus returned to Poland to live in his uncle's palace. He resumed his church duties, practiced medicine, and studied astronomy. Copernicus examined the sky from a palace tower. He made his observations without any equipment. In the late 1500s, the astronomer Galileo used a telescope and confirmed Copernicus' ideas.

A heliocentric universe

In the 1500s, most astronomers believed that Earth was motionless and the center of the universe. They also thought that all celestial bodies moved around Earth in complicated patterns. The Greek astronomer Ptolomy proposed this geocentric theory more than 1000 years earlier.

However, Copernicus believed that the universe was heliocentric (sun-centered), with all of the planets revolving around the sun. He explained that Earth rotates daily on its axis and revolves yearly around the sun. He also suggested that Earth wobbles like a top as it rotates.

Copernicus' theory led to a new ordering of the planets. In addition, it explained why the planets farther from the sun sometimes appear to move backward (retrograde motion), while the planets closest to the sun always seem to move in one direction. This retrograde motion is due to Earth moving faster around the sun than the planets farther away.

Copernicus was reluctant to publish his theory and spent years rechecking his data. Between 1507 and 1515, Copernicus circulated his heliocentric principles to only a few astronomers. A young German mathematics professor, George Rheticus, was fascinated with Copernicus' theory. The professor encouraged Copernicus to publish his ideas. Finally, Copernicus published The Revolutions of the Heavenly Orbs near his death in 1543.

Years later, several astronomers (including Galileo) embraced Copernicus' sun-centered theory. However, they suffered much persecution by the church for believing such ideas. At the time, church law held great influence over science and dictated a geocentric universe. It wasn't until the eighteenth century that Copernicus' heliocentric principles were completely accepted.

Reading reflection

1. How did Copernicus' privileged background help him become knowledgeable in so many areas of study?
2. Which people influenced Copernicus in his work as a church official and an astronomer?
3. How did Copernicus make his observations of the sky?
4. What did astronomers believe of the universe prior to the sixteenth century?
5. Describe Copernicus' revolutionary heliocentric theory of the universe.
6. Why did so many astronomers face persecution by the church for their beliefs in a heliocentric universe?
7. **Research:** Using the library or Internet, find out which organizations developed the Copernicus Satellite (OAO-3) and why it was used.

Name:____ Date: _________________

Johannes Kepler

Johannes Kepler was a mathematician who studied astronomy. He lived at the same time as two other famous astronomers, Tycho Brahe and Galileo Galilei. Kepler is recognized today for his use of mathematics to solve problems in astronomy. Kepler explained that the orbit of Mars and other planets is an ellipse. In his most famous books he defended the sun-centered universe and his three laws of planetary motion.

Early years in Germany

Johannes Kepler was born December 27, 1571, in Weil der Stadt, Wurttemburg, Germany, now called the "Gate to the Black Forest." He was the oldest of six children in a poor family. As a child he lived and worked in an inn run by his mother's family. He was sickly, nearsighted, and suffered from smallpox at a young age. Despite his physical condition, he was a bright student.

The first school Kepler attended was a convent school in Adelberg monastery. Kepler's original plan was to study to become a Lutheran minister. In 1589, Kepler received a scholarship to attend the University of Tubingen. There he spent three years studying mathematics, philosophy, and theology. His interest in math led him to take a mathematics teaching position at the Academy in Graz. There he began teaching and studying astronomy.

Influenced by Copernicus

At Tubingen, Kepler's professor, Michael Mastlin, introduced Kepler to Copernican astronomy. Nicholaus Copernicus (1473-1543), had published a revolutionary theory in, "On the Revolutions of Heavenly Bodies." Copernicus' theory stated that the sun was the center of the solar system. Earth and the planets rotated around the sun in circular orbits. At the time most people believed that Earth was the center of the universe.

Copernican theory intrigued Kepler and he wrote a defense of it in 1596, Mysterium Cosmographicum. Although Kepler's original defense was flawed, it was read by several other famous European astronomers of the time, Tycho Brahe (1546-1601) and Galileo Galilei (1546-1642).

Kepler published many books in which he explained how vision, optics, and telescopes work. His most famous work, though, dealt with planetary motion.

Working with Tyco Brahe

In 1600, Brahe invited Kepler to join him. Brahe, a Danish astronomer, was studying in Prague, Czechoslovakia. Every night for years Brahe recorded planetary motion without a telescope from his observatory. Brahe asked Kepler to figure out a scientific explanation for the motion of Mars. Less than two years later, Brahe died. Kepler was awarded Brahe's position as Imperial Mathematician. He inherited Brahe's collection of planetary observations to use to write mathematical descriptions of planetary motion.

Kepler's Laws of Planetary Motion

Kepler discovered that Mars' orbit was an ellipse, not a circle, as Copernicus had thought. Kepler published his first two laws of planetary motion in Astronomia Nova in 1609. The first law of planetary motion stated that planets orbit the sun in an elliptical orbit with the sun in one of the foci. The second law, the law of areas, said that planets speed up as their orbit is closest to the sun, and slow down as planets move away from the sun. Kepler published a third law, called the harmonic law, in 1619. The third law shows how a planet's distance from the sun is related to the amount of time it takes to revolve around the sun. His work influenced Isaac Newton's later work on gravity. Kepler's calculations were done before calculus was invented!

Other scientific discoveries

Kepler sent his book in 1609 to Galileo. Galileo's theories did not agree with Kepler's ideas and the two scientists never worked together. Despite his accomplishments, when Kepler died at age 59, he was poor and on his way to collect an old debt. It would take close to a century for his work to gain the recognition it deserved.

Reading reflection

1. Why was Copernicus' idea of the sun at the center of the solar system considered revolutionary?
2. Explain how Brahe helped Kepler make important discoveries in astronomy.
3. How was Kepler's approach to astronomy different than Brahe's and Galileo's?
4. Kepler discovered that Mars and other planets traveled in an ellipse around the sun. Does this agree with Copernicus' theory?
5. Describe Kepler's three laws of planetary motion.
6. Kepler observed a supernova in 1604. It challenged the way people at the time thought about the universe because people did not know the universe could change. When people have to change their beliefs about something because scientific evidence says otherwise, that is called a "paradigm shift." Find three examples in the text of scientific discoveries that led to a "paradigm shift."

Name: ______________________ Date: ______________

Water on Mars

READ

NASA's Exploration Rover Mission is an exciting effort to determine whether or not life ever arose on Mars. In pursuit of this aim, NASA has landed rovers on the planet that are capable of looking for clues in the rocks and soil.

In this project, you will:

(1) Learn why evidence for life depends on finding evidence for water on Mars, and

(2) Learn about one of the tools the rover uses to detect water on Mars.

PRACTICE

Part 1: Why does water indicate life?

1. Visit the Mars Rover Project Site on-line at http://marsrovers.jpl.nasa.gov/home/index.html. Additionally, a link to the project site is found at www.nasa.gov. Become familiar with this web site.
2. How many rovers are on Mars? What are the names of the rovers?
3. What do we know at this time about the existence of water on Mars?
4. Why is finding water so important to the NASA scientists?
5. What do we know at this time about the existence of life on Mars?
6. Write a short essay that explains why water is necessary for life.
7. **Extension:** With your class have a discussion about whether or not it is worthwhile to search for the existence of life on other planets. What are the pros for this kind of exploration? What are the cons?

Part 2: Tools for detecting water

1. At the Mars Rover Project Site, find out what tools on the rovers are used to find evidence of water on Mars. Read about all the tools and select one to study.
2. Write a paragraph describing how this tool works and where it is located on the rover.
3. What data is collected by the tool?
4. Write a paragraph explaining how the collected data helps provide evidence for whether or not there is water on Mars.
   Note to student: If you have trouble understanding what your tool does and why, ask an expert. Experts who may be able to help you include geologists, meteorologists, and other scientists. You can find an expert by going to the web site of a university near where you live. Usually, these web sites provide the email address or phone number of scientists. If you do contact an expert, be respectful of that person's time. Your teacher can help you determine what you would like to ask the expert and the best way to ask for advice.
5. By yourself or with a group prepare a presentation about the tool you studied. Ideas for presentations include: (1) making a poster with colorful graphics and written descriptions, (2) making a model of the tool, or (3) presentation in PowerPoint® format.

Name: ______________________ Date: ______________

Touring the Solar System

READ

What would a tour of our solar system be like? How long would it take? How much food would you have to bring? In this skill sheet, you will calculate the travel distances and times for a tour of the solar system. Your mode of transportation will be a space vehicle travelling at 250 meters per second or 570 miles per hour.

Part 1: Planets on the tour

Starting from Earth, the tour itinerary is: **Earth to Mars to Saturn to Neptune to Venus and then back to Earth.** The distances between each planet on the tour are provided in Table 1. The space vehicle travels at 250 meters per second or 900 kilometers per hour. Using this rate and the speed formula, find out how long it will take to travel each leg of the itinerary. An example for how to calculate how many hours it will take to travel from Earth to Mars is provided below. For the table, calculate the time in days and years as well.

EXAMPLE

- How many days will it take to travel from Earth to Mars? The distance from Earth to Mars is 78 million kilometers.

  Solution:

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\text{time to travel from Earth to Mars} = \frac{78\text{ million km}}{900\dfrac{\text{km}}{\text{hour}}}$$

$$\text{time to travel from Earth to Mars} = 86{,}666\text{ hours}$$

$$86{,}666\text{ hours} \times \frac{1\text{ day}}{24\text{ hours}} = 3{,}611\text{ days}$$

PRACTICE

Table 1: Solar System Trip

Legs of the trip	Distance traveled for each leg (km)	Hours traveled	Days traveled	Years traveled
Earth to Mars	78,000,000			
Mars to Saturn	1,202,000,000			
Saturn to Neptune	3,070,000,000			
Neptune to Venus	4,392,000,000			
Venus to Earth	42,000,000			

Part 2: Provisions for the trip

A trip through the solar system is a science fiction fantasy. Answer the following questions as if such a journey were possible.

1. It is recommended that a person drink eight glasses of water each day. To keep yourself hydrated on your trip. How many glasses of water would you need to drink on the leg from Earth to Mars?
2. An average person needs 2,000 food calories per day. How many food calories will you need for the leg of the journey from Neptune to Venus?
3. Proteins and carbohydrates provide 4 calories per gram. Fat provides 9 calories per gram. Given this information, would it be more efficient to pack the plane full of foods that are high in fat or high in protein for the journey? Explain your answer.
4. You decide that you want to celebrate Thanksgiving each year of your travel. How many frozen turkeys will you need for the entire journey?

Part 3: Planning your trip for each planet

Section 17.2 of your student text presents a table that lists the properties of the nine planets. Use this table to answer the following questions.

1. On which planet would there be the most opportunities to visit a moon?
2. Which planets would require high-tech clothing to endure high temperatures? Which planets would require high-tech clothing to endure cold temperatures?
3. Which planet has the longest day?
4. Which has the shortest day?
5. On which planet would you have the most weight? How much would you weigh in newtons?
6. On which planet would you have the least weight? How much would you weigh in newtons? Use proportions to answer this question.
7. Which planet would take the longest time to travel around?
8. Which planet would require your spaceship to orbit with the fastest orbital speed? Explain your answer.

Name:____ Date:_________________

Benjamin Banneker

Benjamin Banneker was a farmer, naturalist, civil rights advocate, self-taught mathematician, astronomer and surveyor who published his detailed astronomical calculations in popular almanacs. He was appointed by President George Washington as one of three surveyors of the territory that became Washington D.C.

Early times

Benjamin Banneker was born in rural Maryland in 1731. His family was part of a population of about two hundred free black men and women in Baltimore county. They owned a small farm where they grew tobacco and vegetables, earning a comfortable living.

A mathematician builds a clock

Benjamin's grandmother taught him to read, and he briefly attended a Quaker school near his home. Benjamin enjoyed school and was especially fond of solving mathematical riddles and puzzles.

When he was 22, Benjamin borrowed a pocket watch, took it apart, and made detailed sketches of its inner workings. Then he carved a large-scale wooden model of each piece, fashioned a homemade spring, and built his own clock that kept accurate time for over 50 years.

A keen observer of the night sky

As a young adult, Benjamin designed an irrigation system that kept his family farm prosperous even in dry years. The Bannekers sold their produce at a nearby store owned by a Quaker family, the Ellicotts. There, Benjamin became friends with George Ellicott, who loaned him books about astronomy and mathematics.

Banneker was soon recording detailed observations of the night sky. He performed complicated calculations to predict the positions of planets and the timing of eclipses.

From 1791 to 1797, Banneker published his astronomical calculations along with weather and tide predictions, literature, and commentaries in six almanacs. The almanacs were widely read in Maryland, Delaware, Pennsylvania, and Virginia, bringing Banneker a measure of fame.

A keen observer of nature

Banneker was also a keen observer of the natural world and is believed to be the first person to document the cycle of the 17-year cicada, an insect that exists in the larval stage underground for 17 years, and then emerges to live for just a few weeks as a loud buzzing adult.

Banneker writes Thomas Jefferson

Banneker sent a copy of his first almanac to then-Secretary of State Thomas Jefferson, along with a letter challenging Jefferson's ownership of slaves as inconsistent with his assertion in the Declaration of Independence that "all men are created equal."

Jefferson sent a letter thanking Banneker for the almanac, saying that he sent it onto the Academy of Sciences of Paris as proof of the intellectual capabilities of Banneker's race.

Although Jefferson's letter stated that he "ardently wishes to see a good system commenced for raising the condition both of [our black brethren's] body and mind," regrettably, he never freed his own slaves.

Designing Washington D.C.

In 1791, George Ellicott's cousin Andrew Ellicott asked him to serve as an astronomer in a large surveying project. George Ellicott suggested that he hire Benjamin Banneker instead.

Banneker left his farm in the care of relatives and traveled to Washington, where he became one of three surveyors appointed by President George Washington to assist in the layout of the District of Columbia.

After his role in the project was complete, Banneker returned to his Maryland farm, where he died in 1806. Banneker Overlook Park, in Washington D.C., commemorates his role in the surveying project. In 1980, the U.S. Postal Service issued a stamp in Banneker's honor.

Reading reflection

1. Benjamin Banneker built a working clock that lasted 50 years. Why would his understanding of mathematics have been helpful in building the clock?
2. Identify one of Banneker's personal strengths. Justify your answer with examples from the reading.
3. Benjamin Banneker lived from 1731 to 1806. During his lifetime, he advocated equal rights for all people. Find out the date for each of the following "equal rights" events:
   (a) the Emacipation Proclamation
   (b) the end of the Civil War
   (c) women gain the right to vote
   (d) the desegregation of public schools (due to the Supreme Court case, Brown vs. the Board of Education).
4. Name three of Benjamin Banneker's lifetime accomplishments.
5. What do you think motivated Banneker during his lifetime? What are some possible reasons that he was persistent in his scientific work?
6. **Research:** Find a mathematical puzzle written by Banneker. Try to solve it with your class.

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Name: ________________________________ Date: ____________________

Measuring the Moon’s Diameter

READ

In this skill sheet you will explore how to measure the moon’s diameter using simple tools and calculations.

Materials

Here are the materials you will need to measure the moon’s diameter:

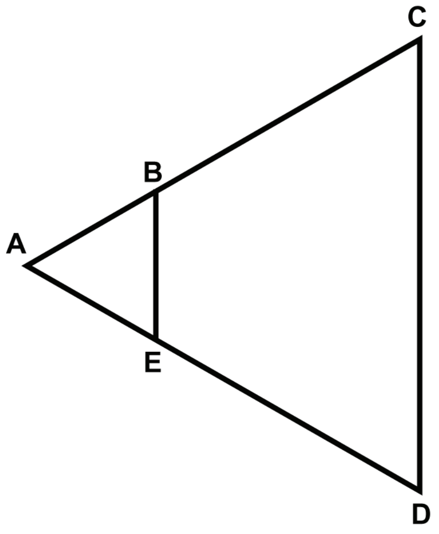
- A 3-meter piece of string
- A metric tape measure
- A small metric ruler
- Tape
- Scissors
- Marker
- One-centimeter semi-circle card (Cut out from the bottom of the last page)

PRACTICE

Proportions and Geometry

The method you will use to measure the moon’s diameter depends on the properties of similar triangles. The following exercise demonstrates these properties.

Below is a large triangle. A line drawn from one side to the other of the large triangle results in a smaller triangle inside the larger one. The ends of each line are labeled with letters.



1. Make the following measurements of the lines on the triangle:

Distance AC: ______________________ cm

Distance AD: ______________________ cm

Distance AB: ______________________ cm

Distance AE: ______________________ cm

Distance BE: ______________________ cm

Distance CD: ______________________ cm

2. How is the distance from AB related to AC?
3. How is the distance from BE related to CD?
4. Based on your measurements and your answers to questions (2) and (3), come up with a statement that explains the properties of similar triangles.

Finding the diameter of the moon

Now, you are ready to use your supplies to find the diameter of the moon. Follow these steps carefully and answer the questions as you go.

1. Locate a place where you can see the moon from a window. This is possible at night or early in the morning.
2. Use scissors to carefully cut out the semi-circle card found on the next page.
3. Tape this card to the window when you can see the full (or gibbous) moon through the window.
4. Tape one end of the 3-meter piece of string to the card directly underneath the semi-circle.
5. Now, slowly move backward from the window while holding on to the string. Watch your step! As you move backward, pay attention to the moon. You want to move back far enough so that the bottom half of the moon "sits" in the semi-circle cutout. You want the semi-circle to be the same size as the lower half to the moon.
6. When the lower half of the moon is the same size as the semi-circle cut out, stop moving backward and hold the string up to the side of one of your eyes. Have a friend carefully mark the string at this distance.
7. Now, measure the distance from the window to the mark on the string to the nearest millimeter. Convert this distance to meters. Write the string distance in Table 1.

Table 1:Finding the moon's diameter data

Semi-circle diameter	0.01 meter
String distance	
Diameter of the moon	???
Distance from Earth to the moon	384, 400, 000 meters

Finding the moon's diameter

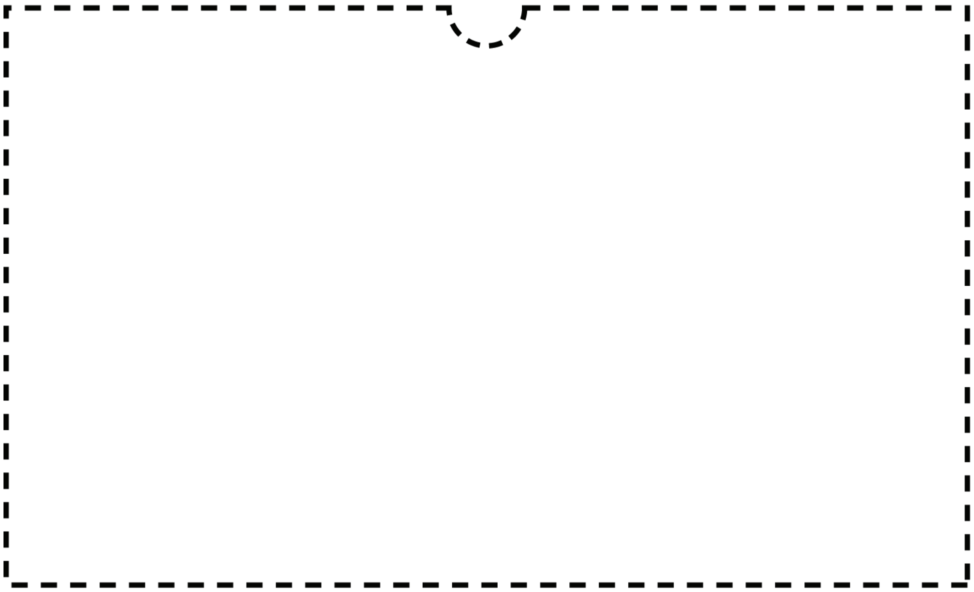
1. You have three out of four measurements in Table 1. The only measurement you need is the moon's diameter. You can find the moon's diameter using proportions. Which calculation will help you?

a. $\frac{\text{semi-circle diameter}}{\text{moon diameter}} = \frac{\text{distance to semi-circle}}{\text{distance from Earth to the moon}}$	b. $\frac{\text{semi-circle diameter}}{\text{distance to semi-circle}} = \frac{\text{moon diameter}}{\text{distance from Earth to the moon}}$
c. $\frac{\text{moon diameter}}{\text{semi-circle diameter}} = \frac{\text{distance to semi-circle}}{\text{distance from Earth to the moon}}$	d. $\frac{\text{moon diameter}}{\text{semi-circle diameter}} = \frac{\text{distance from Earth to the moon}}{\text{distance to semi-circle}}$

2. Use the proportion that you selected in question (1) to calculate the moon's diameter.
3. How is performing this calculation like the exercise you did in part 2?

Semi-Circle Card:

Diameter = 1 cm

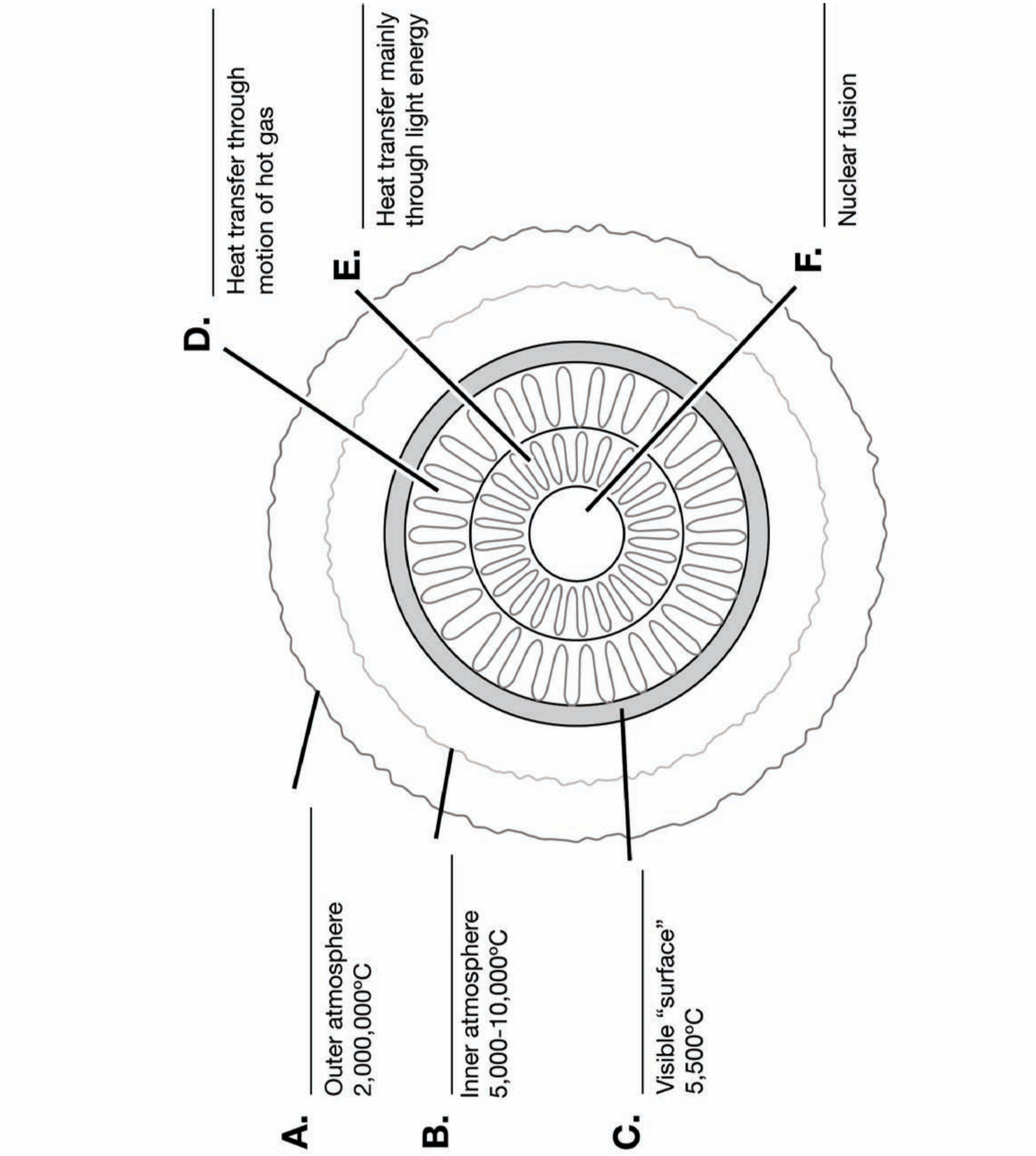


Semi-circle card
(cut out along dotted lines)

Name: ______________________ Date: ______________

SKILL and PRACTICE 18.3

The Sun: A Cross-Section



Name:_______________________________________ Date: ________________

Arthur Walker

Arthur Walker pioneered several new space-based research tools that brought about significant changes in our understanding of the sun and its corona. He was instrumental in the recruitment and retention of minority students at Stanford University, and he advised the United States Congress on physical science policy issues.

Not to be discouraged

Arthur Walker was born in Cleveland in 1936. His father was a lawyer and his mother a social worker. When he was 5, the family moved to New York. Arthur was an excellent student and his mother encouraged him to take the entrance exam for the Bronx High School of Science.

Arthur passed the exam, but when he entered school a faculty member told him that the prospects for a black scientist in the United States were bleak.

Rather than allow him to become dissuaded from his aspirations, Arthur's mother visited the school and told them that her son would pursue whatever course of study he wished.

Making his mark in space

Walker went on to earn a bachelor's degree in physics, with honors, from Case Institute of Technology in Cleveland and, by 1962, his master's and doctorate from the University of Illinois.

Next, he spent three years' active duty with the Air Force, where he designed a rocket probe and satellite experiment to measure **radiation** that affects satellite operation. This work sparked Walker's lifelong interest in developing new space-based research tools.

After completing his military service, Walker worked with other scientists to develop the first X-ray **spectrometer** used aboard a satellite. This device helped determine the temperature and composition of the sun's corona and provided new information about how matter and radiation interact in **plasma**.

Snapshots of the sun

In 1974, Walker joined the faculty at Stanford University. There he pioneered the use of a new multilayer mirror technology in space observations. The mirrors selectively reflected **X rays** of certain wavelengths, and enabled Walker to obtain the first high-resolution images showing different temperature regions of the solar atmosphere.

Walker then worked to develop telescopes using the multilayer mirror technology, and launched them into space on rockets. The telescopes produced detailed photos of the sun and its corona. One of the pictures was featured on the cover of the journal *Science* in September 1988.

A model for student scientists

Walker was a mentor to many graduate students, including Sally Ride, who went on to become the first American woman in space. He worked to recruit and retain minority applicants to Stanford's natural and mathematical science programs. Walker was instrumental in helping Stanford University graduate more black doctoral physicists than any university in the United States.

At work in other orbits

Public service was important to Walker, who served on several committees of the National Aeronautics and Space Administration (NASA), National Science Foundation, and National Academy of Science, working to develop policy recommendations for Congress. He was also appointed to the presidential commission that investigated the 1986 space shuttle Challenger accident.

Walker died of cancer in April 2001.

Reading reflection

1. Use your textbook, an Internet search engine, or a dictionary to find the definition of each word in bold type. Write down the meaning of each word. Be sure to credit your source.
2. What have you learned about pursuing goals from Arthur Walker's biography?
3. Why is a spectrometer a useful device for measuring the temperature and composition of something like the sun's corona?
4. **Research:** Use a library or the Internet to find one of Walker's revolutionary photos of the sun and its corona. Present the image to your class.
5. **Research:** Use a library or the Internet to find more about the commission that investigated the explosion of the space shuttle Challenger in 1986. Summarize the commission's findings and recommendations in two or three paragraphs.

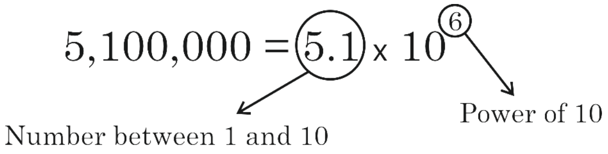
Name: ______________________________ Date: ______________

SKILL and PRACTICE
19.1

Scientific Notation

READ

A number like 5,100,000 (5 million, 100 thousand) can take a long time to write, and an even longer time to read. Because they frequently encounter very large numbers like this one, scientists developed a shorthand method for writing these types of numbers. This method is called scientific notation. A number is written in scientific notation when it is written as the product of two factors, where the first factor is a number that is greater than or equal to 1, but less than 10, and the second factor is an integer (whole, not a fraction or decimal) power of 10.



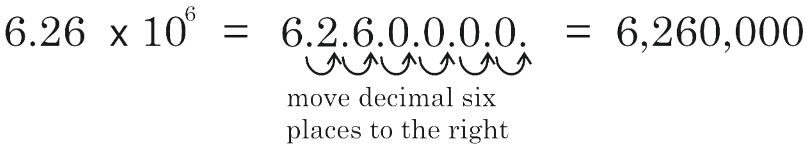
EXAMPLES

Rewrite large numbers (given in scientific notation) in standard form

- Express 6.26×10^6 in standard form.

  Solution:

  Move the decimal point (in 6.26) 6 places to the right. The exponent of the “10” is 6, giving us the number of places to move the decimal.



Rewrite large numbers (given in standard form) in scientific notation

- Express 6,020,000,000 in scientific notation.

  Solution:

  You need to rewrite this number so that it fits into the form:

  $\underline{\hspace{3cm}}.\underline{\hspace{3cm}} \times 10^{\underline{\hspace{1cm}}}$

  Place the decimal point in 6 0 2 so that the number is greater than or equal to one but less than ten. This gives the first factor (6.02). To get from 6.02 to 6,020,000,000 the decimal point has to move 9 places to the right, so the power of ten is 9.

  $6{,}020{,}000{,}000 = 6.02 \times 10^9$

PRACTICE

1. Rewrite each number (given in scientific notation) into standard form.
    a. 1.222×10^5
    b. 9.01×10^7
    c. 3.6×10^3
    d. 7.003×10^2
    e. 5.2722×10^4

2. Rewrite each number (given in standard form) into scientific notation: ___________.___________ $\times 10^{\_\_\_}$
    a. 4,051,000
    b. 1,300,000,000
    c. 1,003,000
    d. 16,020
    e. 9,999,900,000,000

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Name: ______________________ Date: ______________

SKILL and PRACTICE 19.1

Understanding Light Years

How far is it from Los Angeles to New York? Pretty far, but it can still be measured in miles or kilometers. How far is it from Earth to the Sun? It's about one hundred forty-nine million, six hundred thousand kilometers (149,600,000, or 1.496×10^8 km). Because this number is so large, and many other distances in space are even larger, scientists developed bigger units in order to measure them. An Astronomical Unit (AU) is 1.496×10^8 km (the distance from Earth to the sun). This unit is usually used to measure distances within our solar system. To measure longer distances (like the distance between Earth and stars and other galaxies), the light year (ly) is used. A light year is the distance that light travels through space in one year, or 9.468×10^{12} km.

EXAMPLES ▶

1. **Converting light years (ly) to kilometers (km)**

   Earth's closest star (Proxima Centauri) is about 4.22 light years away. How far is this in kilometers?

   Explanation/Answer: Multiply the number of kilometers in one light year (9.468×10^{12} km/ly) by the number of light years given (in this case, 4.22 ly).

$$\frac{(9.468 \times 10^{12})\text{ km}}{1\text{ ly}} \times 4.22\text{ ly} \approx 3.995 \times 10^{13}\text{ km}$$

2. **Converting kilometers to light years**

   Polaris (the North Star) is about 4.07124×10^{15} km from the earth. How far is this in light years?

   Explanation/Answer: Divide the number of kilometers (in this case, 4.07124×10^{15} km) by the number of kilometers in one light year (9.468×10^{12} km/ly).

$$4.07124 \times 10^{15}\text{ km} \div \frac{9.468 \times 10^{12}\text{ km}}{1\text{ ly}} = \frac{4.07124 \times 10^{15}\text{ km}}{1} \times \frac{1\text{ ly}}{9.468 \times 10^{12}\text{ km}} \approx 430\text{ light years}$$

PRACTICE ▷

Convert each number of light years to kilometers.

1. 6 light years
2. 4.5×10^6 light years
3. 4×10^{-3} light years

Convert each number of kilometers to light years.

4. 5.06×10^{16} km
5. 11 km
6. 11,003,000,000,000 km

Solve each problem using what you have learned.

7. The second brightest star in the sky (after Sirius) is Canopus. This yellow-white supergiant is about 1.13616×10^{16} kilometers away. How far away is it in light years?

8. Regulus (one of the stars in the constellation Leo the Lion) is about 350 times brighter than the sun. It is 85 light years away from the earth. How far is this in kilometers?

9. The distance from earth to Pluto is about 28.61 AU from the earth. Remember that an AU = 1.496×108 km. How many kilometers is it from Pluto to the earth?

10. If you were to travel in a straight line from Los Angeles to New York City, you would travel 3,940 kilometers. How far is this in AU’s?

11. Challenge: How many AU’s are equivalent to one light year?

Name: ______________________________ Date: ______________

Calculating Luminosity

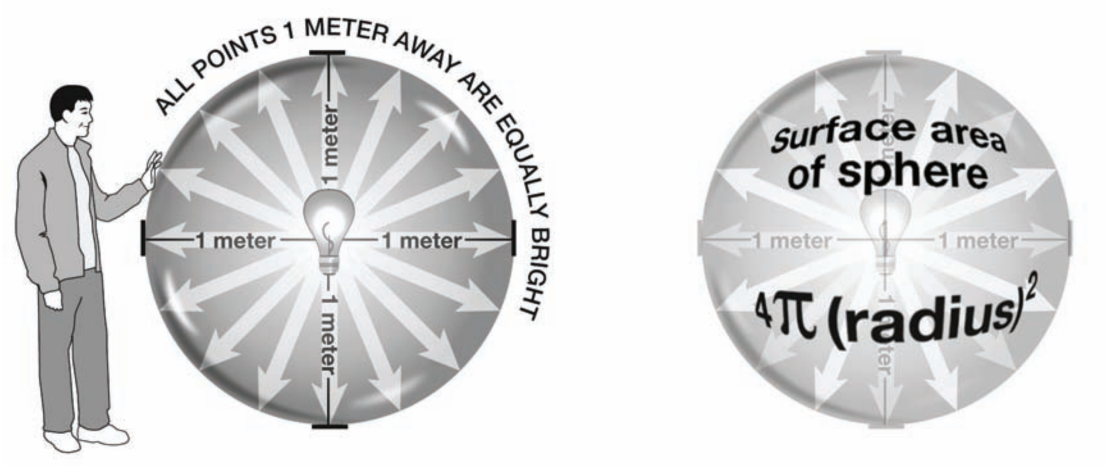
READ

You have learned that in order to understand stars, astronomers want to know their luminosity. *Luminosity* describes how much light is coming from the star each second. Luminosity can be measured in watts (W).

Measuring the luminosity of something as far away as a star is difficult to do. However, we can measure its brightness. *Brightness* describes the amount of the star's light that reaches a square meter of Earth each second. Brightness is measured in watts/square meter (W/m^2).

The brightness of a star depends on its luminosity and its distance from Earth. A star, like a light bulb, radiates light in all directions. Imagine that you are standing one meter away from an ordinary 100-watt incandescent light bulb. These light bulbs are about ten percent efficient. That means only ten percent of the 100 watts of electrical power is used to produce light. The rest is wasted as heat. So the luminosity of the bulb is about ten percent of 100 watts, or around 10 watts.

The brightness of this bulb is the same at all points one meter away from the bulb. All those points together form a sphere with a radius of one meter, surrounding the bulb.



If you want to find the brightness of that bulb, you take the luminosity (10 watts) and divide it by the amount of surface area it has to cover—the surface area of the sphere. So, the formula for brightness is:

$$\text{brightness} = \frac{\text{luminosity}}{\text{surface area of sphere}} = \frac{\text{luminosity}}{4\pi(\text{radius})^2}$$

The brightness of the bulb at a distance of one meter is:

$$\frac{10\text{ watts}}{4\pi(1\text{ meter})^2} = \frac{10\text{ watts}}{12.6\text{ meter}^2} = 0.79\text{ W/m}^2$$

Notice that the radius in the equation is the same as the distance from the bulb to the point at which we're measuring brightness. If you were standing 10 meters away from the bulb, you would use 10 for the radius in the equation. The surface area of your sphere would be $4\pi(100)$ or 1, 256 square meters! The same 10 watts of light energy is now spread over a much larger surface. Each square meter receives just 0.008 watts of light energy. Can you see why distance has such a huge impact on brightness?

If we know the brightness and the distance, we can calculate luminosity by rearranging the equation:

$$\text{luminosity} = \text{brightness} \times \text{surface area of sphere} = \text{brightness} \times 4\pi(\text{distance})^2$$

This is the same formula that astronomers use to calculate the luminosity of stars.

EXAMPLE

You are standing 5 meters away from another incandescent light bulb. Using a light-meter, you measure its brightness at that distance to be 0.019 watts/meter^2. Calculate the luminosity of the bulb. Assuming this bulb is also about ten percent efficient, estimate how much electric power it uses (this is the wattage printed on the bulb).

Step 1: Plug the known values into the formula:

$$\text{luminosity} = \frac{0.019 \text{ watts}}{\text{meter}^2} \times \frac{4\pi(5 \text{ meters})^2}{1}$$

Step 2: Solve for luminosity:

$$\text{luminosity} = 0.019 \times 100\pi \text{ watts} = 6 \text{ watts}$$

Step 3: If the bulb is only about ten percent efficient, the electric power used must be about ten times the luminosity. The bulb must use about 10 × 6 watts, or 60 watts, of electric power.

PRACTICE

1. Ten meters away from a flood lamp, you measure its brightness to be 0.024 W/m^2. What is the luminosity of the flood lamp? What is the electrical power rating listed on the bulb, assuming it is ten percent efficient?

2. You hold your light-meter a distance of one meter from the light bulb in your refrigerator. You measure the brightness to be 0.079 W/m^2. What is the luminosity of this light bulb? What is its power rating, assuming it is ten percent efficient?

3. **Challenge:** Finding the luminosity of the sun.

You can use the same formula to calculate the luminosity of the sun.

Astronomers have measured the average brightness of the sun at the top of Earth's atmosphere to be 1,370 W/m^2. This quantity is known as the *solar constant.*

We also know that the distance from Earth to the sun is 150 billion meters (or 1.5×10^{11} meters).

What is the luminosity of the sun?

Hints:

1. You may wish to rewrite the solar constant as 1.370×10^3 W/m^2.
2. $(10^{11})^2$ is the same as $10^{11} \times 10^{11}$. To find the product, add the exponents.
3. Don't forget to find the square of 1.5!

Name:_______________________________________ Date: _________________

Edwin Hubble

Edwin Hubble was an accomplished academic that many astronomers credit with “discovering the universe.”

A good student and even better athlete

Courtesy, Carnegie Observatories, Carnegie Institution of Washington

Edwin Hubble was born on November 29, 1889, in Marshfield, Missouri. His family moved to Chicago when he was ten years old.

Hubble was an active, imaginative boy. He was an avid reader of science fiction. Jules Verne’s adventure novels were among his favorite stories. Science fascinated Hubble, and he loved the way Verne wove futuristic inventions and scientific content into stories that took the reader on voyages to some strange and exotic destinations.

Hubble was a very good student and also an excellent athlete. In 1906 he set an Illinois state record for the high jump, and in that same season he took seven first place medals and one third place medal in a single high school track meet.

Focus turns to academics

Hubble continued his athletic success by participating in basketball and boxing at the University of Chicago. Eventually though, his studies became his primary focus. Hubble graduated with a bachelors degree in Mathematics and **Astronomy** in 1910.

Hubble was selected as a Rhodes Scholar and spent the next three years at the University of Oxford, in England. Instead of continuing his studies in math and science, he decided to pursue a law degree. He completed the degree in 1913 and returned to the United States. He set up a law practice in Louisville, Kentucky. However, it was a short lived law career.

Returning to Astronomy

It took Hubble less than a year to become bored with his law practice, and he returned to the University of Chicago to study astronomy. He did much of his work at the Yerkes Observatory, and received his Ph.D. in astronomy in 1917.

Hubble joined the army at this time and served a tour of duty in World War I. He attained the rank of Major. When he returned in 1919, he was offered a job by George Ellery Hale, the founder and director of Carnegie Institution's Mount Wilson Observatory, near Pasadena, California.

The best tool for the job

The timing could not have been better. The 100-inch Hooker telescope, the world’s most powerful telescope at the time, had just been constructed. This telescope could easily focus images that were fuzzy, too dim, or too small to be seen clearly through other large telescopes.

The Hooker telescope enabled Hubble to make some astounding discoveries. Astronomers had believed that the many large fuzzy patches they saw through their powerful telescopes were huge gas clouds within our own Milky Way **galaxy**. They called these fuzzy patches “nebulae,” a Greek word meaning “cloud.”

Hubble’s observations in 1923 and 1924 proved that while a few of these fuzzy objects were inside our galaxy, most were in fact entire galaxies themselves, not only separate from the Milky Way but millions of light years away. This greatly enlarged the accepted size of the universe, which many scientists at the time believed was limited to the Milky Way alone.

Another landmark discovery

Hubble also used **spectroscopy** to study galaxies. He observed that galaxies’ spectral lines were shifting toward the red end of the spectrum, which meant they were moving away from each other. He showed that the farther away a galaxy was, the faster it was moving away from Earth. In 1929, Hubble and fellow astronomer Milton Humason announced that all observed galaxies are moving away from each other with a speed proportional to the distance between them. This became known as Hubble’s Law, and it proved that the universe was expanding.

Albert Einstein visited Hubble and personally thanked him for this discovery, as it matched with Einstein’s calculations, providing observable evidence confirming his predictions.

Hubble worked at the Wilson Observatory until his death in 1953. He is considered the father of modern **cosmology**. To honor him, scientists have named a space telescope, a crater on the moon, and an asteroid after him.

Reading reflection

1. Look up the definition of each boldface word in the article. Write down the definitions and be sure to credit your source.
2. **Research:** What is a Rhodes Scholarship?
3. **Research:** Why does a larger telescope allow astronomers to see more?
4. Imagine you knew Edwin Hubble. Describe how you think he may have felt when Albert Einstein came to visit and thank him for his discoveries.
5. **Research:** Before Hubble’s discovery, people thought that the universe had always been about the same size. How did Hubble’s discovery that the universe is currently expanding change scientific thought about the size of the universe *in the past*?

Name:____ Date:________________

Henrietta Leavitt

Leavitt, although deaf, had a keen eye for observing the stars. Her ability to identify the magnitude of stars set the standard for determining a star's distance—hundreds or even millions of light years away.

Star struck

Photo courtesy of the American Association of Variable Star Observers

Henrietta Swan Leavitt was born on July 4, 1868 in Lancaster, Massachusetts. Henrietta's family lived in Cambridge, Massachusetts and later moved to Cleveland, Ohio. In Ohio, Leavitt attended Oberlin College for two years and was enrolled in the school's conservatory of music. She then moved back to Cambridge and attended Radcliffe College, which was then known as the Society for the Collegiate Instruction of Women.

In her last year of college, Henrietta took an astronomy course—then began her fascination with and love for the stars. She graduated in 1892 and later became a volunteer research assistant working at the Harvard College Observatory.

Computing the stars

In the 1880s, Harvard College established a goal to catalog the stars. Edward Pickering, a former professor at the Massachusetts Institute of Technology, became director of the Harvard Observatory. Pickering was an authority in photographic photometry—determining a star's magnitude from a photograph. He wanted to gather information about the brightness and color of stars.

In order to complete this work, Pickering needed people to perform the tedious task of examining photographs of stars. Men typically did not perform this type of work, but women were hired and known as “computers.” Leavitt was hired at a rate of $.30 per hour to complete this painstakingly detailed work.

Leavitt was not a healthy woman, struggling with complete hearing loss and other illnesses during college and throughout her career. Despite these setbacks, she became a super computer, devoting her life to studying the stars. She eventually became the head of the photographic stellar photometry department.

Leavitt catalogued variable stars that altered in brightness over the course of a few days, weeks, or even months. She studied Cepheid variable stars in the Magellanic Clouds, two galaxies near the Milky Way.

Leavitt examined photographic plates, comparing the same regions on several plates taken at different times. Stars that had changed in brightness would look different in size. Leavitt continued to examine plates, discovering nearly 2,000 new variable stars in the Magellenic Clouds.

Leavitt found an inverse relationship between a star's brightness cycle and its magnitude. A stronger star took longer to cycle between brightness and dimness. Therefore, brighter Cepheid stars took longer to rotate between brightness and dimness. In 1912, Leavitt had established the Period-Luminosity relation.

These stars, all located within the Magellenic Clouds, were roughly the same distance from the Earth. This rule provided astronomers with the ability to measure distances within and beyond our galaxy.

Astronomical findings

Leavitt's discovery had a tremendous impact on future research in the field of astronomy. Astronomers could now determine distances to galaxies and within the universe overall. Ejnar Hertzsprung was able to plot the distance of Cepheid stars. Harlow Shapley, using Leavitt's findings, was able to map the Milky Way and determine its size. Edwin Hubble applied her rule to establish the age of the Universe.

An unsung heroine

In 1925, the Swedish Academy of Sciences wished to nominate Leavitt for a Nobel Prize. However, she had died of cancer nearly four years earlier at the age of 53. The Nobel Prize must be given during a recipient’s lifetime.

In addition to her discovery of numerous variable stars, Leavitt discovered four novas and developed the standard method for determining the magnitude of stars. An asteroid and crater on the moon are named in her honor.

Reading reflection

1. How did Henrietta Leavitt discover new variable stars?
2. What were Leavitt's two significant contributions to the field of astronomy?
3. **Research:** What is the name of the asteroid named in Leavitt's honor?
4. **Research:** When was the Harvard Observatory established and what does It do now?
5. **Research:** State three facts about each of these astronomers: Ejnar Hertzsprung, Harlow Shapley, and Edwin Hubble.
6. **Research:** What is the Nobel Prize?

Skill Sheet 1.1: Using Your Text

Part 1 answers:

1. Green
2. Any two of the following words: troposphere, stratosphere, mesosphere, thermosphere, exosphere, ionosphere
3. Blue
4. A measurement is a number plus a unit.
5. At the end of each section
6. How is the Grand Canyon like a history book?
7. Vocabulary, concepts, math and writing skills, chapter project

Part 2 answers:

1. There are six units: Studying Earth Science, Water and Weather, Introducing Earth, The Changing Earth, Earth’s Resources, and Astronomy.
2. Example answer: The Water and Weather unit will be the most interesting to me because I want to know more about meteorology.
3. Example answer: Wild World of Caves, Hurricane Hunters, How Do You Grow a Diamond?
4. There is a chapter activity after each connection.

Part 3 answers:

1. The glossary
2. Underground melted rock
3. Page 13
4. Page 255

Skill Sheet 1.1: What’s Your Hypothesis?

1. Sample hypothesis: The water level in the cup is lower because the Sun heated the water in the cup and that caused evaporation of the water.
2. Sample hypothesis: The candle heats up the air above it. Warm air is less dense so it rises. The effect causes the air in the box to move in the area above the candle. When the smoke from moves above the candle, it gets heated and rises out of the chimney above the candle.
3. Sample hypothesis: Increasing the temperature of water will increase the rate at which evaporation occurs.
4. Sample hypothesis: If the river is flowing down a mountain, it will flow faster than if it is flowing along flat land. In other words, the force of gravity causes river water to flow faster if the water is moving from a high to a lower place.
5. Sample hypothesis: I think the flower bulbs have been dug up and eaten by squirrels.
6. Sample hypothesis: Since kelp is a food source for the sea urchins, the urchin population might die out. Without a sea urchin population as a food source, the sea otter population might die out.
7. Sample hypothesis: Snowshoe hares turn white in the winter so that they can blend in with the snow and avoid being caught by lynx. In the summertime, the brown coat of the hare blends in with the color of the ground.
8. Sample hypothesis: Yes, I think there would be animals like coyotes in other deserts. [Example: The jackal in the Kalahari Desert in Southwest Africa plays a similar ecological role as the coyote.]

Skill Sheet 1.2: Averaging

1. 4 gloves per household
2. On average, a gift cost about $8.33.
3. $3.95; $31.60
4. ≈ 6 points each ($6.\bar{2}$)
5. ≈ 5 slices each ($5\ {}^1/_3$ slices each)

Skill Sheet 1.2: Stopwatch Math

1. Answers are:
   a. 0.507, 0.57, 5.07
   b. 33, 33.03, 33.033, 33.3, 33.303
2. Answers are:

Time	1:58.78	1:58.83	1:58.84	1:58.97
Year	1998	2002	2003	2000

Time	1:59.06	1:59.47	1:59.74	2:00.43
Year	2004	1999	2005	2001

3. Answers are:
   a. 1:05.03, 1:05.3, 1:05.32, 1:06, 1:06.03, 1:06.11, 1:07.05, 1:07.1, 1:07.3
   b. 1:04, 1:04.25, 1:04.44, 1:05, 1:05.05, 1:05.3, 1:08, 1:08.02, 1:08.3
   c. 1:03, 1:03.09, 1:03.7, 1:04.01, 1:04.11, 1:04.55, 1:06.02, 1:06.033, 1:06.9
   d. 1:03, 1:03.09, 1:03.7
4. Infinitely many solutions possible. Example: 6:10.1, 6:10.2, 6:10.3, 6:10.4, 6:10.5.

Skill Sheet 1.2: SQ3R Reading Strategies

No student responses are required.

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Skill Sheet 1.2: Lab Notebooks

1. A lab notebook is a permanent record of notes from laboratory work. Therefore, it is important that the pages be securely attached to the book so that they are always in order and cannot be lost or torn out. If a science invents something new or needs to prove results, a lab notebook can be used as evidence.
2. Yes, Sylvia's lab notebook could help her prove that she discovered the new formula first. Her notebook would have a date listed on the page where she recorded her discovery.
3. The date is February 13, 1880.
4. The date helps you keep your records and work in order.
5. The drawing is related to experiment number 1.
6. Similarly to recording a date, it is important to number experiments so that you can keep track of which experiments worked and which didn't and so that you can refer to them when you record your results and conclusions.
7. The drawing looks like a picture of a light bulb. Thomas Edison was an important inventor in the development of the modern light bulb.
8. It looks like Thomas Edison was working on the design of the interior of the light bulb. Based on the comment, "small horseshoe," I hypothesize that he was working on the design of the filament in the light bulb.
9. Answer:

The formula for the speed of a car

distance **time**
is ~~time~~ divided by ~~distance~~.

10. By not erasing a mistake, you show that you are collecting and evaluating your data honestly. Other good reasons for not erasing mistakes are that mistakes help show a thought process in scientific work and this thought process is helpful in developing a new and fresh perspective on a problem so that new discoveries can be made.
11. A table of contents helps any reader of the lab notebook find main topics and key experiments of work.
12. The sample lab notebook page should have all or most of these elements: Date, page number, name of experiment or research question (i.e., Which of two brands of sugarless gum has the longest lasting flavor?), a list of materials, a list of participants who will be testing the gum, a description of the research procedure, a hypothesis, and data. Other items to include on this or a following page: details about the brands of gum, graph of the data, results and conclusions paragraphs.
13. Keeping a detailed laboratory notebook of all work is important for proving discoveries and for helping the scientist know exactly what he or she did during an experiment. Any result from an experiment needs to point to the variable that caused the result. Ultimately, keeping detailed notes saves time because it helps the process be more efficient and it prevents mistakes from being repeated.

Skill Sheet 1.2: Observation versus Opinion

1. Sample answer: To prove that 2 + 2 = 4, I would make two piles each with two apples. The two piles would represent 2 + 2. Then, I would combine the two piles into a pile of four apples.
2. Sample answer: I would take the 10 oranges and divide them evenly into two piles. Once, I did this, it would be obvious that each pile has five oranges. This proves that 10 ÷ 2 = 5.
3. Sample answer: We know that this happens because for half the day Earth is facing the Sun so that we have daylight and for half the day it is night when Earth is facing away from the Sun. The tides also help prove that Earth rotates. One location on Earth's surface is either in line with the moon or at a right angle to it during a day. The effect is that many places on Earth's surface have two high tides and two low tides each day.
4. Sample answer: The statement, "Math is fun!" is an opinion because not everyone agrees with this statement. I asked 10 people what they thought of this statement. Six people agreed that math is fun, two people said that they thought math was exhilarating, and two people thought math was interesting but not fun.
5. Sample answer: A fact based on the pizza data: Today in class plain cheese pizza was chosen more often than cheese and mushroom pizza and more than cheese and pepperoni pizza.
6. Sample answer: One opinion—I like green and yellow. One fact—Sixty percent of the students in my school like blue and yellow for the new school colors.
7. Sample answer: One opinion—Seventh grade will be harder than sixth grade because I will have to take more tests. One fact—Next year in the seventh grade, I will be in a new building.
8. Sample answer: My hypothesis is that white light is best for growing plants.
9. Sample table:

Sense	Observation	Opinion
Seeing	The baseball field is green.	I see that the best pitcher in baseball is on the mound right now.
Hearing	I hear someone selling hot dogs in the stands.	The person in front of me singing "take me out to the ball game" could use some voice lessons!
Touching	My seat is sticky because someone spilled a drink on it.	The seat next to me is a better place to sit.
Tasting	My soda tastes sweet.	I like cream soda better than cola.
Smelling	I smell popcorn.	I like the smell of popcorn.

10. Sample answers: Five observations: (1) Automobiles are the number one form of transportation energy use in the U.S. (2) Trucks make up 45.1% of the transportation energy use in the U.S. (3) Public transportation like rail and buses make up only 3.1% of the transportation energy use in the U.S. (4) Air transportation energy use is a little less than twice the water transportation energy use. (5) This data was compiled by the U.S. Department of Energy.
Two opinions: (1) People prefer driving their cars rather than taking public transportation by rail or buses. (2) More people would use public transportation for their transportation energy use if the price of gasoline triples.

Skill Sheet 1.2: Gary Vermeij

1. Gary liked to pick up natural objects while walking outdoors. He asked his parents to help him find the names of the shells, pine cones, and little creatures he found.
2. Gary's fourth grade teacher brought back some shells from Florida to her classroom in New Jersey. Gary was fascinated by the differences in shells from different places.
3. Gary's family took trips to the seashore and read outloud to him all the books they could find about seashore animals and plants.
4. Example answer: Last fall I auditioned for the lead part in the school musical. Although I didn't get it, I was asked to join the chorus and I had a minor role in two scenes. I learned a lot about what goes into putting on a big theater production. I also had the chance to show the director that I am hard working, dependable, and good at listening to directions. I hope that will help me land a bigger part next year. Other examples of healthy risk-taking: trying broccoli, saying hello to a new student, etc.
5. When you do science experiments, you state a hypothesis before you do the work. It's unlikely that the hypothesis will always be right. Scientists have to be honest about what they really find, even if they are disappointed. But sometimes, the unexpected results lead to new discoveries.
6. Example answer: When I first moved to Los Angeles, I wondered whether we could grow sugar maples in this climate.
7. I could try an Internet search using the keywords "sugar maple" + California, or call a local tree nursery, or ask my biology teacher.
8. Answers will vary.

Skill Sheet 1.3: Types of Graphs

Part 1 answers:

1. pie graph
2. bar graph
3. line graph
4. bar graph

Part 2 answers:

1. Type of graph: pie graph
   Reason: the data is in the form of percentages of a whole.
2. Type of graph: bar graph
   Reason: the independent variable is in the form of categories.
3. Type of graph: line graph
   Reason: the independent variable is time, which is continuous.
4. Type of graph: bar graph
   Reason: the independent variable is in the form of categories.

Skill Sheet 1.3: Reading Graphs

Part 1 answers:

1. Graph title: "Money in cash box vs. hours washing cars."
2. The two variables are number of hours washing cars and the amount of money in the cash box.
3. Hours
4. Dollars
5. 0 to 5
6. The data would be concentrated toward the bottom quarter of the graph. All the data would appear within the first three grid boxes of the *y*-axis.
7. Yes, there is a relationship between the variables.
8. As the time spent washing cars increases, the money in the cash box increases.
9. If the theater club worked for five hours a Saturday for at least 14 Saturdays, they could earn $1050. This amount is based on earning $75 during the five hour period (assuming $20 is the starting about of money in the cash box). Between April and the fall, there would be the Saturdays in May, June, July, and August for doing the car wash; a total of about 16 Saturdays. This would be enough time to earn $1000.

Part 2 answers:

1. Graph title: "Percentage of teenagers that are employed in four cities."
2. The two variables represented on the *x*-axis are cities (four are represented) and gender (boys and girls). The variable represented on the *y*-axis is the percentage of teenagers that are employed. The range of values is from 0 to 80.
3. The highest percentages of boys and girls employed is in city C. The lowest percentages is in city D. The percentages of boys and girls employed is about the same in city A which has the second highest percentage of teenagers employed. Girls employed outnumber boys employed in cities B and D.
4. In cities A and C, the percentage of boys employed is greater than the percentage of girls employed. In cities B and D, the percentage of girls employed is greater than the percentage of boys employed.
5. Example answer: The type of businesses in city C are suited to hiring workers that can only work in the afternoons or evenings for a pay rate that is suitable to teenagers. The type of jobs in city D are more suited to people who can work full time.
6. Example answer: In city C, the kinds of jobs that are available to teenagers may tend to be more appealing to boys. The opposite is true for city B; there, the jobs may tend to be more appealing to girls. By doing a survey of the teens in city C, this hypothesis could be tested.

Part 3 answers:

1. Graph title: "Percent distribution of jobs held by teenagers."
2. Types of jobs held by teenagers and the percentages.
3. No units are used in this graph. Instead, the graph is showing how categories (jobs in this case) are related to each other.
4. The majority of jobs held by teenagers are in the retail industry (28%). Working teenagers are next likely to work in the food service industry (23%) and administrative support (21%). Other kinds of jobs held by teenagers include freight and stock handling (15%) and farm work (10%). Three percent of working teenagers participate in jobs that are not included in these categories.
5. Answers will vary. A sample hypothesis based on this data is: The numbers of teenage girls and boys working in each job category is equal. I could test this hypothesis by interviewing employed teenagers that represent each job category. I would compare the numbers of girls and boys working in each category to see if my hypothesis is correct.
6. Answers will vary.

Skill Sheet 1.3: Study Notes

This worksheet is intended for use as a study aid. Answers will vary.

Skill Sheet 1.3: Scientific Method

1. Anna has observed that the air conditioning is on, it is warm outside, and there is not a lot of traffic on the freeway.
2. Will the car get better gas mileage if the air conditioning is on or if the windows are open?
3. The car will get better gas mileage if the air conditioning is on with the windows closed.
4. The car will get better gas mileage if the windows are open with the air conditioning off.
5. They have to find out the distance the car drives and the amount of gas it uses with the windows open and no air conditioning, and then with the windows closed and the air conditioner running.
6. They should write down the mileage on the car's odometer.
7. They should write down the mileage on the car and the number of gallons of gas it takes to fill the car.
8. They should write down the mileage on the car and the number of gallons of gas it takes to fill the car.
9. No. The car used less gas when the windows were open but it also drove less distance.
10. Air conditioning: 34 mpg; windows open: 32 mpg.
11. The car was more efficient when the windows were closed and the air conditioning was on.
12. No. The drive was not exactly the same for the two parts of the experiment. The speeds were different. There may have been more hills or wind during one part of the trip. It may have gotten warmer or cooler as the day went on, so air conditioning use may not have been constant.
13. They should repeat the experiment a few more times, trying to keep as many factors constant as possible. They could repeat their experiment on the way home using the same stretches of road but reversing the windows/AC segments.

Skill Sheet 2.1: Dimensional Analysis

1. Answers are:
   - a. 360 mi/tank
   - b. 4,200 ft
   - c. 7.5 min
2. Answers are:
   - a. 7.5 qt
   - b. ≈ 5.7 miles
   - c. 8 hrs
3. Answers are:
   - a. 3.1 miles
   - b. $187.50/week
   - c. $9,375/year
   - d. $40.68/tank
   - e. 102 cm
   - f. 34 houses
   - g. 0.55 words/second

Skill Sheet 2.1: SI System

1. 1000 g
2. 0.1 cm
3. Answers are:
   - a. 420 cm = ______m
   - b. 2; left
   - c. 420 cm = 4.2 m
4. Answers are:
   - a. 5 L = ______mL
   - b. 3; right
   - c. 5,000mL
5. 600,000 cm
6. 1,200,000 g
7. 5,000 dm
8. 0.150 hL
9. 7.62 L
10. .0.016 s
11. 60,000 ms
12. 100 times
13. 1,000 times
14. hectoliter

Skill Sheet 2.1: SI-English Unit Conversions

1. ≈ 8.9 oz.
2. ≈ 8.5 qt
3. ≈ 220 lbs
4. ≈ 5.9 in
5. ≈ 1.7 L
6. ≈ 5 mi
7. ≈ 67 g
8. ≈ 4.0 km
9. ≈ 107 cm
10. ≈ 290 cm tall

Skill Sheet 2.2: Temperature Scales

1. Answers are:
   a. 100°C
   b. 37°C
   c. 4.4°C
   d. - 12.2°C
   e. 32°F
   f. 77°F
   g. 167°F
2. 7.2°C
3. 177°C
4. 107°C
5. 375°F
6. 450°F

7. The friend assumed you were speaking of degrees Celsius. 15°C = 59°F, which is a much milder outdoor temperature than 15°F (15°F = -9.4°C).
8. Answers are:

a. - 283°F

b. 35°F = 1.7°C (not -38.87°C). No the mysterious, silver substance is not mercury. The mysterious substance has a higher melting point than mercury.

c. The thermometer is calibrated to the Fahrenheit scale. On the Celsius scale, 90°C is too hot, just 10 degrees less than the boiling point of water. 90°F = 32°C. 90°C = 194°F

Skill Sheet 2.3: Calculating Area

Part 1 answers:

1. Answers are:
   Shape A: 20 cm^2
   Shape B: 14 cm^2
   Shape C: 12 cm^2
   Shape D: 9 cm^2
2. Answers are:
   Shape A: 5 wide, 4 long
   Shape B: 7 wide, 2 long
   Shape C: 3 wide, 4 long
   Shape D: 3 wide, 3 long
3. Length times width equals area.

Part 2 answers:

1. Manchester’s city park occupies 31 km^2.
2. Dishae mows 800 m^2. Drake mows 850 m^2.
3. Answers will vary.

Skill Sheet 2.3: Science Vocabulary

Word	Prefix	Root	Suffix
geology		geo-	-logy
lithosphere	litho-	-sphere	
paleontology	paleo-	-onto-	-logy
astronomy		astro-	-nomy
seismogram		seismo-	-gram

Word	Prefix	Root	Suffix	Definition
geology		earth, land	study of	the study of Earth and land
lithosphere	rock	ball, globe		the globe of rock
paleontology	ancient	being	study	the study of ancient beings
astronomy		star	naming, ordering	naming, ordering the stars
seismogram		shake, earthquake	written record	written record of earthquake vibrations

1. geology: the science of the history of the earth, its rocks and physical changes
2. lithosphere: the earth's crust
3. paleontology: the study of extinct plants and animals
4. astronomy: the science of the material universe beyond earth's atmosphere
5. seismogram: the record of vibrations of the earth caused by earthquakes
6. __________: student answers will vary
7. __________: student answers will vary

Skill Sheet 2.3: Variables

1. Experimental variable: temperature of water
   Control variables: time of day, metal can, air temperature, amount of water.
2. Experimental variable: light exposure (light vs. no light)
   Control variables: type of beakers, amount of water at start, duration of experiment
3. Experimental variable: steepness of stream table slope
   Control variables: stream table setup, amount of water

Skill Sheet 2.4: Types of Graphs

Part 1 answers:

1. pie graph
2. bar graph
3. line graph
4. bar graph

Part 2 answers:

1. Type of graph: pie graph
   Reason: the data is in the form of percentages of a whole.
2. Type of graph: bar graph
   Reason: the independent variable is in the form of categories.
3. Type of graph: line graph
   Reason: the independent variable is time, which is continuous.
4. Type of graph: bar graph
   Reason: the independent variable is in the form of categories.

Skill Sheet 2.4: Drawing Line Graphs

1. Answers are:

Data pair not necessarily in order		Independent	Dependent
Temp.	Hours of heating	Hours of heating	Temp.
Stopping distance	Speed of a car	Speed of a car	Stopping distance
Number of people in family	Cost per week for groceries	Number of people in family	Cost per week for groceries
Stream flow	Rainfall	Amount of rainfall	Rate of stream flow
Tree age	Average tree height	Tree age	Average tree height
Test score	Number of hours studying for a test	Number of hours studying	Test score
Population of a city	Number of schools needed	Population of a city	Number of schools needed

2. Answers are:

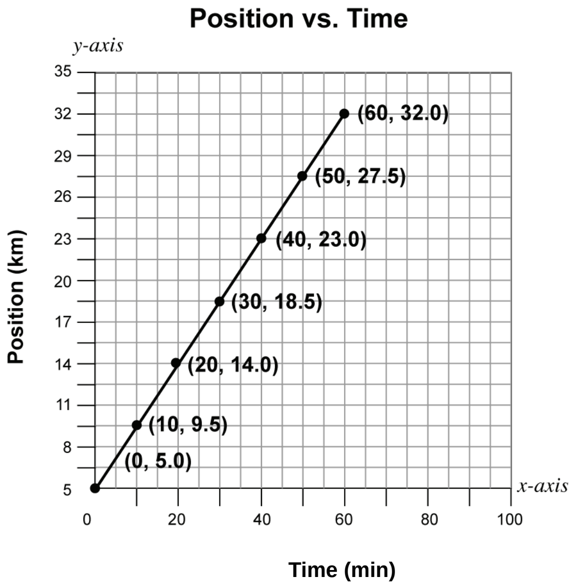
Range	Number of lines	Range ÷ No. of lines	Calculated scale (per line)	Adj. scale (per line)
13	24	13 ÷ 24	0.54	1
83	43	83 ÷ 43	1.9	2
31	35	31 ÷ 35	0.88	1
100	33	100 ÷ 33	3.03	5
300	20	300 ÷ 20	15	15
900	15	900 ÷ 15	60	60

3. Answers are:
   a. Table answers:

Independent variable	Dependent variable
0	5.0
10	9.5
20	14.0
30	18.5
40	23.0
50	27.5
60	32.0

   b. 60 minutes
   c. 27.0 kilometers
   d. Adjusted scale for the x-axis: 3 per line or 5 per line; adjusted scale for the y-axis: 1.5 per line or 2 per line

   e. & f.
   Graph of position (km) vs. time (min)



   g. After 45 minutes, the position would be about 25.3 km.

Skill Sheet 2.4: What’s the Scale?

1. Answers are:

Range from 0	# of Lines	Range ÷ # of Lines	Calculated scale	Adj. scale (whole #)
14	10	14 ÷ 10 =	1.4	2
8	5	8 ÷ 5 =	1.6	2
1000	20	1000 ÷ 20 =	50	50
547	15	547 ÷ 15 =	36.5	37
99	30	99 ÷ 30 =	3.3	4
35	12	35 ÷ 12 =	2.9	3

2. The range is 30 and the scale is 1 per line.
3. The range is 25 and the scale is 3 per line.
4. Answers are:
    a. Independent variable: days; Dependent variable: ave temp
    b. Range for *x*-axis = 11; Range for *y*-axis = 73
    c. Scale for *x*-axis = 1 days/box; Scale for *y*-axis = 4 °F/box

Skill Sheet 3.1: Internet Research Skills

Part 1 answers:

1. “science museum” + “south carolina” not “columbia”
2. “dog breeds” not “expensive” (or) “dog breeds” + “inexpensive”
3. “producing electricity” not “coal” not “natural gas”

Part 2 answers:

1. Answers will vary. Sites that may be authoritative include non-profit sites (recognizable by having “org” as the extension in the web address) or government sites such as www.nasa.gov (recognizable by the “gov” extension address) or college/university websites (recognizable by the “edu” extension address). These sites often provide information to large, diverse groups and are not typically supported by advertising. Sites that are supported by advertising can be authoritative, but may be biased in the information presented. Another characteristic of authoritative sites are that they are actively updated on a regular basis.
2. Answers will vary. Reasons why a source may not seem to be authoritative include: the author of the site is not affiliated with an organization and does not have obvious credentials, and the information seems to be one-sided. Many science topic searches will lead to student papers published on the Internet. These may contain mistakes, or they may have been written by a younger student.
3. Answers will vary. Intended audiences can be young children, pre-teens, teenagers, adults, or select groups of people (women, men, people who like dogs, etc.).
4. Answers will vary.

Skill Sheet 3.1: Bibliographies

No student responses are required.

Skill Sheet 3.2: Averaging

1. 4 gloves per household
2. On average, a gift cost about $8.33.
3. $3.95; $31.60
4. ≈ 6 points each ($6.\overline{2}$)
5. ≈ 5 slices each (5 $^1/_3$ slices each)

Skill Sheet 3.2: Understanding Math in Words

Part 1 answers:

1. 5 + 4 = 9
2. $3.00 – $1.50 = $1.50
3. $\frac{1}{6} \times 12 = 2$
4. $\frac{55\text{ miles}}{\text{hour}} \times 1\text{ hour} = 55\text{ miles}$

1. Answers will vary. Example: Sue had 5 blue beads and 4 red beads. What is the total number of beads?
2. Example: John had $3. The toy cost $1.50. What is the difference between the cost of the toy and the amount of money John has?
3. Example: The egg carton has 12 eggs. Five-sixths of the eggs remain. How many are gone?
4. Example: The speed limit can be written as a ratio of 55 miles to one hour. How many miles can a car go in one hour at the speed limit?

Part 2 answers:

Lunch drinks consumed by students at Fredrick Elementary School

Drink	No. of students	Percent
Whole milk	45	45%
Strawberry milk	10	10%
Orange juice	20	20%
Water	25	25%
Total	100	100%

1. 100 students
2. 45%
3. $\frac{20}{100}$
4. $\frac{1}{10}$
5. $\frac{(45 + 10)}{100} \times 100\% = 55\%$

6. $25\% = \frac{25}{100} = \frac{50}{200}$

Part 3 answers:

1. Answers are:

Ice cream flavors eaten by students at Carlton Middle School

Ice cream flavor	No. of students	Percent	Fraction of students eating that type of ice cream
Chocolate	450	45%	$\frac{9}{20}$
Vanilla	250	25%	$\frac{1}{4}$
Chocolate chip	200	20%	$\frac{1}{5}$
Strawberry	100	10%	$\frac{1}{10}$
Total	1000	100%	$\frac{1}{1}$

2. 9:20
3. $\frac{9}{20}$
4. Yes, the ratio and the fraction are the same. Ratios can be written as fractions.
5. Answers are:
    a. 200
    b. 20%
    c. $\frac{1}{5}$
    d. 200:250

Skill Sheet 3.2: Heat Transfer

1. This is radiation because the Sun's energy transfers heat to your body through energy waves and no direct contact.
2. This is conduction because heat is transferred from your hand to the metal shaft of the shovel by direct contact of atoms in the solids.
3. This is convection because the molten material in the mantle is transferring heat through the motion of the mantle, which is a liquid.
4. This is convection because the wind is transferring heat through the motion of air, which is a gas.
5. This is radiation because the heat felt from the fire is from energy waves from the fire, and not from direct contact with the fire.
6. This is conduction because there is direct contact between the hot chocolate and your tongue. The heat is transferred from the hot chocolate to your tongue by the direct contact of atoms.
7. This is convection because the ocean currents are transferring heat through the motion of the liquid water.

Skill Sheet 3.3: Density

1. 6.6 grams
2. Answers are:
    a. 6.5 cm^3
    b. 0.7 g/mL
3. 1.26 kg/m^3
4. Answers are:
    a. The nugget is not gold because its density is 5.00 g/mL. The density of gold (from the table) is 19.3 g/mL. It may be a fun extension for students to learn about "fool's gold" or iron pyrite, which actually has a density equal to 5.00 g/mL. Iron pyrite contains iron and sulfur.
    b. 59.2 grams
    c. platinum; water
    d. 0.321 cm^3
    e. silver
5. 14.7 grams

Skill Sheet 3.3: Buoyancy

1. 875 cm^3
2. Float
3. Float
4. The ball will float when placed in water, milk, and vegetable oil. It will sink when placed in gasoline and kerosene.
5. Answers are:
    a. 0.593 g/mL
    b. Float
6. Answers are:
    a. 8.00 cm^3
    b. 0.73 g/cm^3
    c. Float
    d. The object would neither sink nor float. The object has neutral buoyancy.
7. Answers are:
    a. 1,550 cm^3
    b. 450 N
8. The object sinks because the force of gravity pushing down on the object is greater than the buoyant force pushing up.
9. The forces of buoyancy and gravity acting on the cube are equal and opposite. Therefore the cube has neutral buoyancy.
10. Float

Skill Sheet 3.3: Mass versus Weight

1. 15 pounds
2. 2.6 pounds
3. 7.0 kilograms
4. If you stepped on a bathroom scale on the moon, the spring would be compressed one-sixth as much as it would on Earth. The dial would tell you that your weight was one-sixth of your Earth weight.
5. Yes, a balance would function correctly on the moon. The unknown mass would tip the balance one-sixth as far as it would on Earth, but the masses of known quantity would tip the balance one-sixth as far in the opposite direction as they did on Earth. The net result is that it would take the same amount of mass to equalize the balance on the moon as it did on Earth. (In the free fall environment of the space shuttle, however, the masses wouldn't stay on the balance, so the balance would *not* work).
6. Answers are:
   a. As the elevator begins to accelerate upward, the scale reading is greater than the normal weight. As the elevator accelerates downward, the scale reads less than the normal weight.
   b. When the elevator is at rest, the scale reads the normal weight.
   c. The weight appears to change because the spring is being squeezed between the top and the bottom of the scale. When the elevator accelerates upward, it is as if the bottom of the scale is being pushed up while the top is being pushed down. The upward force is what causes the spring to be compressed more than it is normally. When the elevator accelerates downward, the bottom of the scale provides less of a supporting force for the feet to push against. Therefore, the spring is not compressed as much and the scale reads less than the normal weight.

Skill Sheet 4.1: Internet Research Skills

Part 1 answers:

1. "science museum" + "south carolina" not "columbia"
2. "dog breeds" not "expensive" (or) "dog breeds" + "inexpensive"
3. "producing electricity" not "coal" not "natural gas"

Part 2 answers:

1. Answers will vary. Sites that may be authoritative include non-profit sites (recognizable by having "org" as the extension in the web address) or government sites such as www.nasa.gov (recognizable by the "gov" extension address) or college/university websites (recognizable by the "edu" extension address). These sites often provide information to large, diverse groups and are not typically supported by advertising. Sites that are supported by advertising can be authoritative, but may be biased in the information presented. Another characteristic of authoritative sites are that they are actively updated on a regular basis.
2. Answers will vary. Reasons why a source may not seem to be authoritative include: the author of the site is not affiliated with an organization and does not have obvious credentials, and the information seems to be one-sided. Many science topic searches will lead to student papers published on the Internet. These may contain mistakes, or they may have been written by a younger student.
3. Answers will vary. Intended audiences can be young children, pre-teens, teenagers, adults, or select groups of people (women, men, people who like dogs, etc.).
4. Answers will vary.

Skill Sheet 4.1: Bibliographies

No student responses are required.

Skill Sheet 4.2: The Water Cycle

Part 1 answers:

A. condensation
B. precipitation
C. percolation
D. groundwater flow
E1. evaporation
E2. evaporation
F. transpiration
G. water vapor transport.

Part 2 answers:

1. evaporation—The Sun's heat provides energy to enable water molecules to enter the atmosphere in the gas phase; transpiration—The Sun's energy makes photosynthesis possible, which in turn causes plants to release water into the atmosphere in a process known as transpiration.
2. Wind pushes water in the atmosphere to new locations, so that the water doesn't always fall back to Earth as precipitation in the same spot from which it evaporated.
3. Gravity causes water to run down a mountain toward the coast, and causes water droplets to fall to Earth as precipitation. Gravity is also the primary force that moves water from Earth's surface through the ground to become groundwater.

Skill Sheet 4.2: Groundwater and Wells

Making predictions:

   a. 1,3
   b. 3
   c. No, because water can't pass through the cling wrap/foam layer.

Thinking about what you observed:

   a. 1,3; yes
   b. 3; yes
   c. Aquiclude
   d. Aquifer
   e. No, because the well is below the aquiclude. Yes, hypothesis was correct.
   f. The surface contamination would move toward well #1. If well #2 was being pumped, it would not have an effect on the movement of surface contamination because it is located below the aquiclude.
   g. Well #3 would possibly be able to provide water. It depends on how low the water table became.

h. It might pull in salt water from the ocean. That is a form of contamination.

i. Answers will vary. Sample answer: Look up how low the water table got during the worst drought of the last 100 years. Dig the well a little lower than that level.

Skill Sheet 5.1: Dimensional Analysis

1. Answers are:
   a. 360 mi/tank
   b. 4,200 ft
   c. 7.5 min
2. Answers are:
   a. 7.5 qt
   b. ≈ 5.7 miles
   c. 8 hrs
3. Answers are:
   a. 3.1 miles
   b. $187.50/week
   c. $9,375/year
   d. $40.68/tank
   e. 102 cm
   f. 34 houses
   g. 0.55 words/second

Skill Sheet 5.2: Internet Research

Part 1 answers:

1. “science museum” + “south carolina” not “columbia”
2. “dog breeds” not “expensive” (or) “dog breeds” + “inexpensive”
3. “producing electricity” not “coal” not “natural gas”

Part 2 answers:

1. Answers will vary. Sites that may be authoritative include non-profit sites (recognizable by having “org” as the extension in the web address) or government sites such as www.nasa.gov (recognizable by the “gov” extension address) or college/university websites (recognizable by the “edu” extension address). These sites often provide information to large, diverse groups and are not typically supported by advertising. Sites that are supported by advertising can be authoritative, but may be biased in the information presented. Another characteristic of authoritative sites are that they are actively updated on a regular basis.
2. Answers will vary. Reasons why a source may not seem to be authoritative include: the author of the site is not affiliated with an organization and does not have obvious credentials, and the information seems to be one-sided. Many science topic searches will lead to student papers published on the Internet. These may contain mistakes, or they may have been written by a younger student.
3. Answers will vary. Intended audiences can be young children, pre-teens, teenagers, adults, or select groups of people (women, men, people who like dogs, etc.).
4. Answers will vary.

Skill Sheet 5.2: Layers of the Atmosphere

Layer	Distance from Earth’s surface	Thickness	Facts
Troposphere	0 - 11 km	11 km	• Most of Earth’s water vapor, carbon dioxide, dust, airborne pollutants, and terrestrial life forms are found in this layer. • The temperature drops as you go higher into the troposphere.
Stratosphere	11 - 50 km	39 km	• The ozone layer is located here. • The temperature increases as you go higher into the stratosphere.
Mesosphere	50 - 80 km	30 km	• The mesosphere is the coldest layer of the atmosphere.
Thermosphere	80 - approx. 500 km	420 km	• Very low density of air molecules in this layer. • Very high temperatures because the Sun’s rays hit here first.
Exosphere	500 km - no specific outer limit	undefined	• Lightweight atoms and molecules escape into space. • Many man-made satellites orbit in this region, about 36,000 km above the equator.

Skill Sheet 5.3: Drawing Line Graphs

1. Answers are:

Data pair not necessarily in order		Independent	Dependent
Temp.	Hours of heating	Hours of heating	Temp.
Stopping distance	Speed of a car	Speed of a car	Stopping distance
Number of people in family	Cost per week for groceries	Number of people in family	Cost per week for groceries
Stream flow	Rainfall	Amount of rainfall	Rate of stream flow
Tree age	Average tree height	Tree age	Average tree height
Test score	Number of hours studying for a test	Number of hours studying	Test score
Population of a city	Number of schools needed	Population of a city	Number of schools needed

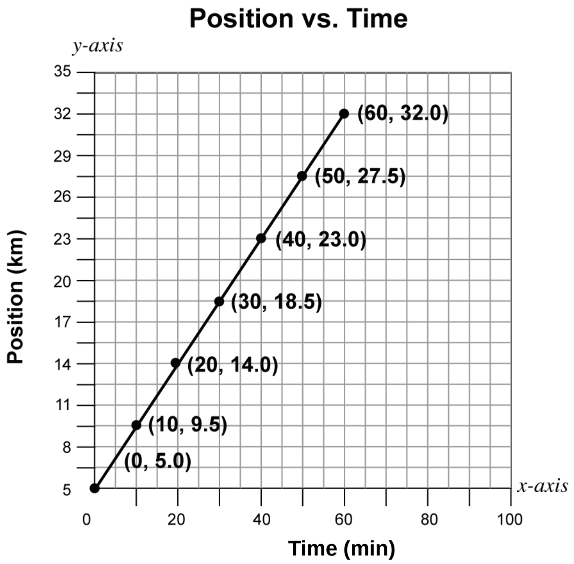
2. Answers are:

Range	Number of lines	Range ÷ No. of lines	Calculated scale (per line)	Adj. scale (per line)
13	24	13 ÷ 24	0.54	1
83	43	83 ÷ 43	1.9	2
31	35	31 ÷ 35	0.88	1
100	33	100 ÷ 33	3.03	5
300	20	300 ÷ 20	15	15
900	15	900 ÷ 15	60	60

3. Answers are:
   a. Table answers:

Independent variable	Dependent variable
0	5.0
10	9.5
20	14.0
30	18.5
40	23.0
50	27.5
60	32.0

   b. 60 minutes
   c. 27.0 kilometers
   d. Adjusted scale for the x-axis: 3 per line or 5 per line; adjusted scale for the y-axis: 1.5 per line or 2 per line
   e. & f.
   Graph of position (km) vs. time (min)



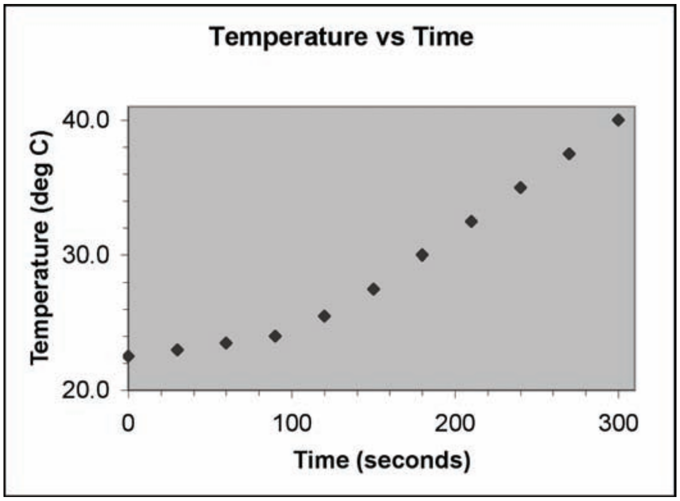
   g. After 45 minutes, the position would be about 25.3 km.

Skill Sheet 5.3: Specific Heat

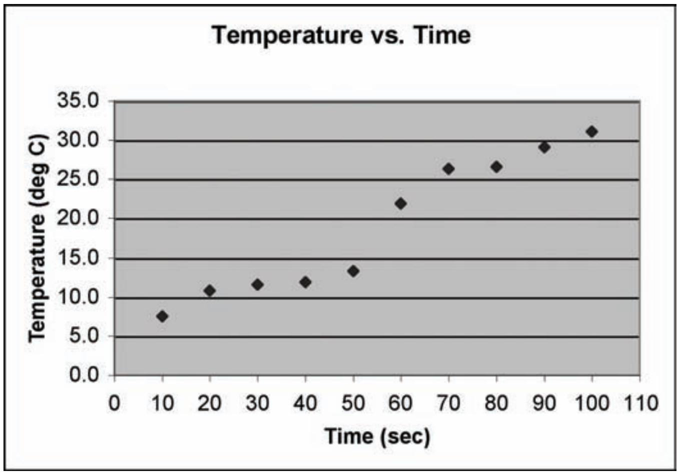
1. Gold would heat up the quickest because it has the lowest specific heat.
2. Pure water is the best insulator because it has the highest specific heat.
3. Silver is a better conductor of heat than wood because its specific heat is lower than that of wood.
4. Aluminum, because it has the higher specific heat.
5. 5°C × 4,184J/kg°C = 20,920 J
6. At the same temperature, the larger mass of water contains more thermal energy.

Skill Sheet 6.1: Using Spreadsheets

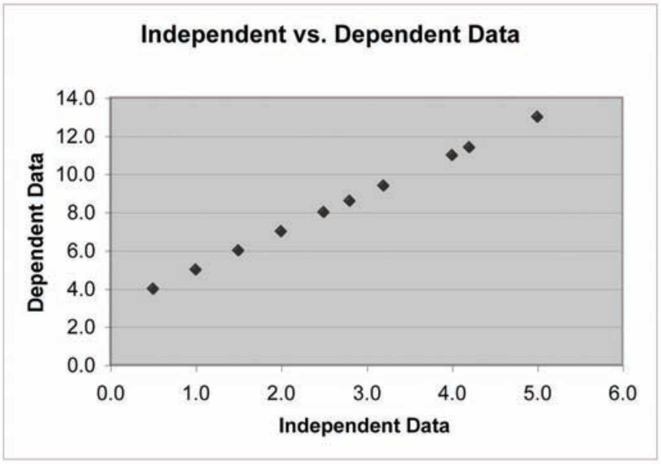
Example graph:



1. Time is the independent variable; temperature is the dependent variable.
2. The independent variable goes in the first column.
3. The temperature increases slowly for the first 90 seconds and then increases much more rapidly from 90-300 seconds.
4. The slope for the first 90 seconds is 0.02 degrees per second, and then it increases to 0.08 degrees per second for the period from 180 to 300 seconds.
5. Graph:



6. Graph:



The slope is the same (2.0) until you get to the final segment, when it increases to 2.6.

Skill Sheet 6.1: Gustave-Gaspard Coriolis

1. Coriolis attended one of the best-known engineering schools in France. His exceptional ability coupled with great schooling provided him with a solid foundation for his thoughts, research, and studies.
2. His first book presented mechanics in a way that could easily be applied. It was the foundation and establishment of applying the concept of work to the field of mechanics. Coriolis was intent on using and applying proper terms. He was the first to derive formulas expressing kinetic energy and mechanical work.
3. As you are flying overhead, Earth is rotating from west to east beneath you. By the time you are ready to land, Earth has rotated far enough that Little Rock is east of your current position.
4. In the northern hemisphere, the Coriolis effect bends winds to the right. In the southern hemisphere it bends winds to the left.
5. Answers will vary, but should include the following:
   Trade winds are surface wind currents that move between 30 degrees North latitude and the equator. The Coriolis effect bends the trade winds moving across the surface so they flow from northeast to southwest in the northern hemisphere and from southwest to northeast in the southern hemisphere.
   Polar easterlies form when the air over the poles cools and sinks, and spreads along the surface to about the 60 degree latitude. The polar wind is bent by the Coriolis effect and the air flows from northeast to southwest in the northern hemisphere, and from southeast to northwest in the southern hemisphere. Bands of cold air move away from the poles.
   Prevailing westerlies are created when air bends to the right due to the Coriolis effect. These winds blow towards the poles from the west and are bent to the right in the northern hemisphere and to the left in the southern hemisphere.
6. His work was not accepted outside the field of mechanics until 1859 when the French Academy of Science arranged for a discussion on Earth's rotation and its effects on water currents. His work on Earth's rotation was discussed and linked to the field of meteorology in the late 1800's early 1900's.
7. Coriolis was able to connect theory with application in each of these books. The billiard book was published in 1835 and provided the mathematical theory of spin, friction, and collision in the game of billiards. Coriolis discussed how physics determines and explains the game of billiards. The Treatise book was published after his death in 1944.

Skill Sheet 6.2: Joanne Simpson

1. Simpson is the first woman to earn a Ph.D. in meteorology, the first person to create a computerized cloud model, and the first woman to have served as president of the American Meteorological Society.
2. Simpson faced discrimination based on the fact that she was a woman. At the end of the war, most women returned home after temporarily filling the roles of men away during the war. Simpson was not one of those women. She continued on with her studies after teaching meteorology to aviation cadets. She earned a master's degree and was so interested in meteorology that she wanted to go on for a Ph.D. Her advisor and the all-male faculty at her university did not support a woman going on for an advanced degree. They felt that women were unable to do the work which included shifts and flying planes. Simpson did finally find an advisor to support her Ph.D., but even he had negative comments about her topic. Simpson did have difficulty finding a job, but eventually landed a position as an assistant professor of physics. She continued to move into numerous positions and did not let others' opinions and comments stop her career pursuits.
3. Students should comment on Simpson's determination despite the obstacles she faced along her journey to complete her degree and to work in the field of meteorology. Students will understand that if you really want to achieve a goal, you need to stay focused, work hard, and not be discouraged by negative opinions along the way.
4. A slide rule is a mechanical tool used to calculate complicated mathematical problems involving multiplication, divisions, square roots, cube roots, and trigonometry. The invention of the slide rule dates back to the 16th century. The slide rule, a handheld tool, was used commonly in science and engineering. The scientific calculator and computers made the slide rule obsolete.
5. This is the highest award given by the American Meteorological Society for atmospheric science including meteorology, climatology, atmospheric physics, and atmospheric chemistry. It is named after Carl-Gustaf Rossby, a leader in the fields of oceanography and meteorology. He was also the 2nd recipient of this award.
6. Woods Hole Oceanographic Institute (WHOI) is located in Woods Hole, Massachusetts on Cape Cod. Scientists at WHOI study oceans, their function, and their interaction with the Earth. WHOI provides opportunities for research and higher education. Students can visit the WHOI website on the Internet for more information.
7. Students can locate hot tower clouds in scientific articles or websites. Hot towers are commonly associated with hurricanes. The NASA website provides some specific information about hot towers.

Skill Sheet 6.2: Weather Maps

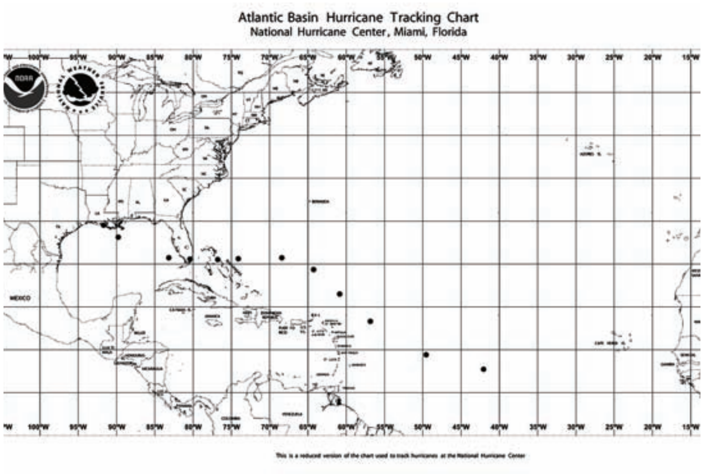
Sample table with answers:

City	High	Low	Temp difference	Sky cover	Pressure
Seattle	72	54	18	Partly cloudy	High
Los Angeles	85	68	17	Sunny	High
Las Vegas	108	81	27	Pcldy	High
Phoenix	108	86	22	Pcldy	High
Atlanta	89	66	23	Pcldy	Low
Tampa	88	74	14	T-storms	Low
San Francisco	76	56	20	Sunny	Low
Oklahoma City	101	74	27	Pcldy	High
New Orleans	94	76	18	T-storms	Low
Kansas City	91	70	21	Pcldy	Low
Tucson	103	76	27	Pcldy	High
Denver	94	62	32	Pcldy	Low
Dallas	105	78	27	Sunny	High
Houston	98	76	22	Pcldy	High
Minneapolis	86	64	22	Sunny	High
Memphis	94	73	21	Sunny	High
Chicago	85	66	19	T-storms	Low
Miami	93	75	18	T-storms	Low
New York	73	63	20	T-storms	Low
Baltimore	78	70	8	T-storms	Low

1. The highest temperatures (daily high over 95°F) are in the lower latitudes such as Las Vegas, Phoenix, Tucson, Dallas, and Houston. The coolest temperatures (daily high under 82°F) are found in Seattle, Chicago, and New York. These cities are at higher latitudes. The Sun is more directly overhead in lower latitude regions, and it is lower on the horizon and therefore less intense at midday in the higher latitude regions.
2. Even though Los Angeles is the southern part of the continent, its high temperature was only 85°F. This is due to the cooling effect of the Pacific Ocean. Chicago is farther south than Minneapolis, but it is cooler because it sits on the shore of Lake Michigan. Denver, with its Rocky Mountain location, cools down to a nighttime low of 62°F in the summer.
3. On the map, the thickest cloud cover is in the Northeast, where it cools Baltimore and New York. Baltimore and Kansas City are near the same latitude, but Kansas City (with less cloud cover) was 13°F warmer. During the day, the clouds reflect some of the sun's heat away.
4. Sample answers: The high-pressure regions center on Oregon, New Mexico, and Quebec. The low-pressure regions center on Wyoming, North Dakota, and North Carolina.
5. See the table for answers.
6. High pressure regions tend to have sunny weather, since less air is rising, cooling, and condensing. Humidity is much lower in these regions.
7. Low-pressure regions tend to be overcast and/or stormy. The humidity is higher.
8. Fronts are associated with low pressure regions. Fronts tend to bring precipitation.
9. Cold fronts are associated with stormy areas. Warm fronts tend to be accompanied by bands of light precipitation.
10. The air in a low-pressure region rises. The air in a high pressure region sinks.
11. In a low pressure region, warm, moist air can be carried upward by convection. As the air cools, water condenses into clouds and precipitation.
12. A low-pressure region is a good place for a volume of air to reach the dew point temperature because the warm, moist air in this region rises. As this air rises, it cools to the dew point temperature. The result is that the water in the air mass condenses, clouds form, and eventually precipitation occurs.

Skill Sheet 6.2: Tracking a Hurricane

Map answers:



Part 2 answers:

2. Students may mention Florida or Cuba as likely hurricane watch areas. The Bahamas should be mentioned as a hurricane warning area. Here are the actual watches and warnings issued by the Tropical Prediction Center for this time period:

Date	Time (GMT)	Action	Region
8/22/1992	1500	Hurricane watch	Northwest Bahamas
8/22/1992	2100	Hurricane warning	Northwest Bahamas
8/22/1992	2100	Hurricane watch	Florida east coast from Titusville through the Florida keys
8/23/1992	0600	Hurricane warning	Central Bahamas
8/23/1992	1200	Hurricane warning	Florida east coast from Vero Beach southward through the Florida keys
8/23/1992	1200	Hurricane watch	Florida west coast south of Bayport including greater Tampa area to north of Flamingo

Parts 3, 4, and 5 answers:

3.2 The Bahama islands. Note: The National Hurricane Center reported that landfall occurred at the northern Eleuthera Island, Bahamas.

4.2 Southern Florida. Note: The National Hurricane Center reported that landfall occurred at Homestead Air Force Base, Florida.

5.2 Louisiana. Note: The National Hurricane Center reported that landfall occurred at Point Chevreuil, Louisiana.

Skill Sheet 6.3: Degree Days

Part 1 answers:

1. Cooling degree day value = 88-65 = 23.
2. Heating degree day value = 65-14 = 51.
3. On July 22, 2002 the heating degree day value was zero. On January 22, 2003 the cooling degree day value was zero.

Part 2 answers:

1. Answers:

Day	High temp	Low temp	Average temp 2	Heating degree day	Cooling degree day
1	73	61	67	0	2
2	63	52	58	7	0
3	70	44	57	8	0
4	65	52	59	6	0
5	83	58	71	0	6
6	79	59	69	0	4
7	74	60	67	0	2
8	71	53	62	3	0
9	90	70	80	0	15
10	82	62	72	0	7
11	65	52	59	6	0
12	71	52	62	3	0
13	74	56	65	0	0
14	75	60	68	0	3
Two week totals:				33	39

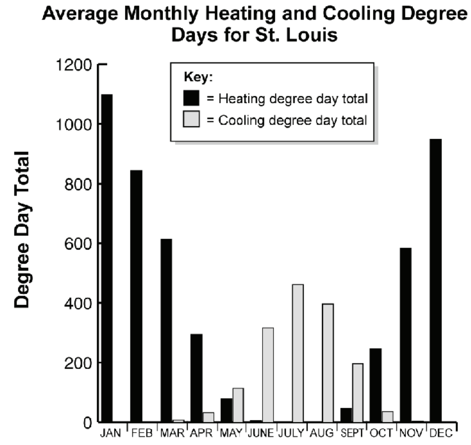
2. St. Louis residents were more likely to use heating systems on six days and more likely to cool their homes on seven days. However, many of these days had such small degree day values that residents may have used either system only rarely. The most likely day to use energy for heating or cooling was May 9, with a cooling degree day value of 15.

Part 3 answers:

1. Total heating degree day value: 33
2. Total cooling degree day value: 39
3. The monthly total heating degree day value for May 2003 was 33+31, or 64. The monthly total cooling degree day value was 39+32, or 71.
4. May 2003's total heating degree day value was 15 less than normal, and its total cooling degree day value was 43 less than normal. With average temperatures closer to 65°F, St. Louis residents probably used less energy for heating and cooling in May than is usually needed.

Part 4 answers:

1. Graph:



2. January
3. July
4. Answers are:
    a. I chose May because the total heating and cooling degree day values are significantly less than any other month, and because many days with low degree day values probably won't require any actual heating or cooling.

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b. You would need to know how much energy it takes to run each system per hour, the type of fuel used to run it, and the cost of the fuel. Natural gas and heating oil are commonly used for home heating systems, while electricity (most commonly generated by coal or natural gas) is commonly used for air conditioning systems. Electricity is often more expensive than natural gas or heating oil. As a result, cooling a home is often more expensive than heating it.

Skill Sheet 7.3: Internet Research

Part 1 answers:

1. "science museum" + "south carolina" not "columbia"
2. "dog breeds" not "expensive" (or) "dog breeds" + "inexpensive"
3. "producing electricity" not "coal" not "natural gas"

Part 2 answers:

1. Answers will vary. Sites that may be authoritative include non-profit sites (recognizable by having "org" as the extension in the web address) or government sites such as www.nasa.gov (recognizable by the "gov" extension address) or college/university websites (recognizable by the "edu" extension address). These sites often provide information to large, diverse groups and are not typically supported by advertising. Sites that are supported by advertising can be authoritative, but may be biased in the information presented. Another characteristic of authoritative sites are that they are actively updated on a regular basis.
2. Answers will vary. Reasons why a source may not seem to be authoritative include: the author of the site is not affiliated with an organization and does not have obvious credentials, and the information seems to be one-sided. Many science topic searches will lead to student papers published on the Internet. These may contain mistakes, or they may have been written by a younger student.
3. Answers will vary. Intended audiences can be young children, pre-teens, teenagers, adults, or select groups of people (women, men, people who like dogs, etc.).
4. Answers will vary.

Skill Sheet 7.3: Shallow Marine Environment

A. Offshore sandbar
B. Offshore
C. Shoreface
D. Foreshore
E. Sand dunes
F. Backshore
G. Beach

Skill Sheet 8.1: Latitude and Longitude

Part 1 answers:

1. Answers are:
    a. Iceland
    b. Algeria
    c. Argentina
    d. Australia
    e. New Zealand
2. Answers are:
    a. Bay of Bengal
    b. Aegean Sea
    c. Red Sea
    d. Gulf of Mexico
    e. Baffin Bay

Part 2 answers:

1. Answers are:
    a. 30.33°N
    b. 45.75°N
    c. 20.61°S
    d. 60.33°S
2. Answers are:
    a. 25.92°E
    b. 145.25°E
    c. 130.62°W
    d. 85.44°W

Skill Sheet 8.1: Map Scales

1. Answers are:
    a. Andora
    b. No. I need to know the scale to answer the question.
    c. Yes. They are both 1.5 cm.
    d. No. One centimeter could represent different distances on each island.
    e. Calypso is much bigger.
2. Answers are:

(Note: Allow answers that are + or - 3 kilometers.)
    a. 40 km
    b. 128 km
    c. 50 km
    d. 110 km
    e. 80 km
    f. 185 km
    g. 125 km
    h. 170 km (50 + 120)
    i. 118 km (78 + 40)
    j. 298 km (120 + 50 + 128)

Bonus: Give credit for estimates between 850 - 950 km.

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Skill Sheet 8.1: Navigation

Note to teacher: It is highly recommended that you do a trial run yourself before doing this activity with your students. This will enable you to help the students more efficiently during the activity, especially when it comes to finding locations on the maps.

Making predictions:

a. I expect to find coral reefs.
b. We will need to watch where we navigate our boat because coral reefs exist close to the surface and could be an obstruction for our boat.

It's time to go!

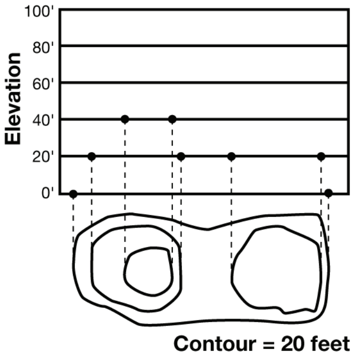
1. No student response required.
2. No student response required.
3. 1:326,856
4. It means that one unit on the map represents 326,856 of those units in real life.
5. There are six feet in a fathom.
6. There is a lighthouse with an occulting light, which means the period of darkness when the light is covered or obscured is less than the time period when the light is showing.
7. Two fathoms
8. Dump site of dredged material
9. Dredged material is material that was dug by machine (usually from another channel or river bed) and has been dumped here.
10. Yes
11. No
12. Yes
13. S Sh—Sand and shells on the bottom, Co Sh—coral shells on bottom, h S—hard sand on bottom, Co S—coral sand on bottom, bk SH—broken shells on bottom, bk Co—broken coral on bottom, Sh Co—shells and coral on bottom
14. It is a flashing lighthouse. The light is obscured for longer than it is showing (the opposite is true with an occulting light).
15. No student response required.
16. Explosive Dumping Area
17. A bad idea!
18. No. Lower the anchor and use the rowboat to get ashore.
19. Four
20. The fourth is aeronautical, which means that it displays flashes, in this case, of white and green, to indicate the location of an airport, a heliport, a landmark, a certain point of a federal airway in mountainous terrain, or an obstruction.
21. Seven nautical miles
22. Cables
23. Drop anchor
24. No
25. It means that the rocks on the isle are covered and uncovered by water and that they reach a height of 269 feet.
26. Fathoms
27. No student response required.
28. 1:100,000
29. You can see more detail on the second map.
30. National Response Center or the nearest US Coast Guard facility
31. WXM-96; 162.475 Hz
32. 2.5 fathoms
33. Going right up to the shore gives you three feet of water below the ship—that's not very much. It is recommended to anchor further out and row or perhaps swim to shore.
34. 46 feet
35. Coral shells
36. A cay is a small, low island or reef made mostly of sand or coral.
37. Cables
38. feet
39. 1:15,000
40. More detail is evident in this map than the other two.
41. The lines represent areas that have been swept clear, called wire-dragged areas. The depth is noted on the map to 42 feet offshore of the solid line and to 36 feet between the solid and dashed lines.
42. We know that our boat is clear in this area because our boat is 12 feet deep.
43. Yes
44. Row in—it is a very shallow channel with many areas even less than five feet deep.
45. No student response required.
46. Yes
47. No student response required.
48. No student response required.
49. Answers will vary.
50. No student response required.

Skill Sheet 8.1: Geography

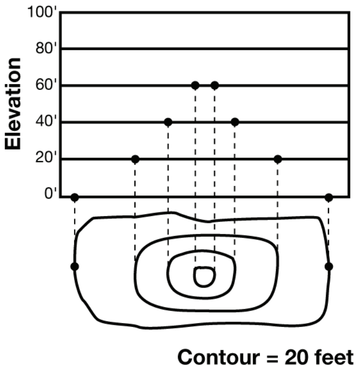
1. Algeria
2. India
3. Iceland
4. Columbia, Ecuador, Peru, & Chile
5. Thailand,
6. Canada
7. Japan
8. Australia
9. Baffin Bay
10. Italy
11. Belize and Guatemala,
12. Turkey
13. Caribbean Sea
14. South Africa
15. Atlantic, Pacific, & Indian Oceans

Skill Sheet 8.2: Topographic Maps

1. Answer graphic:



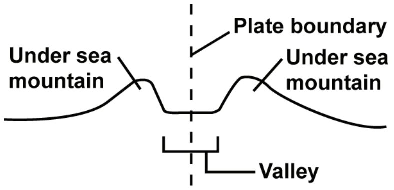
2. Answer graphic (at right):
3. Answers are:
   a. 0 or sea level
   b. 400-499 feet
   c. 100 feet
   d. 300 feet
   e. between 0 and 100 feet.
4. Answers are:
   a. The island becomes two islands.
   b. The original island is now three islands.
   c. No, the storm wave would wash over the island.



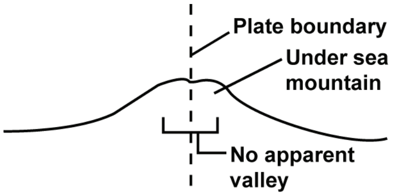
Skill Sheet 8.3: Bathymetric Maps

1. Example answers:
   a. Mid-Atlantic Ridge
   b. East Pacific Rise
   c. Middle America Trench or Mariana Trench
   d. Falkland Plateau
   e. Mendocino Fracture Zone
2. Two tectonic plates move apart.
3. Answers are:
   a. East Pacific Rise
   b. Chile Rise; this rise looks like the Mid-Atlantic Ridge
   c. Chatham Rise; this feature seems to be a plateau on the sea floor
4. Subduction
5. A combination of two diverging plates at the East Pacific Rise and subduction zones in the northern part of the North Pacific Ocean. The plate movement associated with these features may have caused the fracture zone.
6. The ridge has a lot of faults. There is a thin, dark-blue line in the middle of the ridge. The white areas around the ridge are not very prominent.
7. This rise is less jagged. The white area near the rise is more prominent here than at the Mid-Atlantic Ridge.
8. Mid-Atlantic Ridge; the dark line indicates a valley in the middle of the ridge
9. Cross-sections of the Mid-Atlantic Ridge and the East Pacific Rise (Based on viewing the bathymetric map):

Mid-Atlantic Ridge cross-section



East Pacific Rise cross-section



10. The Mid-Atlantic Ridge has a slow spreading rate, while the spreading rate of the East Pacific Rise is fast. Because the Mid-Atlantic Ridge is so slow, a valley has developed between the two separating plates.

Skill Sheet 8.3: Tanya Atwater

1. Tanya Atwater came from a family of scientists—her father was an engineer and her mother a botanist. Atwater recalls many dinner discussions about science and she eventually shared in her parents' passion. Atwater and her family went on many vacations. The family often found the most remote places to explore. This explains Atwater's deep love for the outdoors.
2. In 1967, Atwater began graduate school at the Scripps Oceanographic Institution in La Jolla, California. During this time, many exciting geological discoveries were being made. The concept of sea floor spreading was emerging, leading to the current theory of plate tectonics.
3. While at Scripps, Atwater joined a research group that used sophisticated equipment to study the sea floor off of northern California. It was her first close look at sea floor spreading. Atwater also took twelve trips down to the ocean floor in the tiny submarine Alvin. She collected samples nearly 2 miles down on the ocean floor using mechanical arms. Atwater's firsthand view through Alvin's portholes gave her a better understanding of the pictures and sonar records she had previously studied.
4. Propagating rifts are created when sea floor spreading centers realign themselves. This realignment is in response to changes in plate motion or uneven magma supplies. In the 1980s, Atwater was part of a team that researched propagating rifts near the Galapagos Islands off the coast of Ecuador. She has also discovered many propagating rifts on the sea floor off the northeast Pacific Ocean and evidence of propagating rifts in ancient sea floor records worldwide.
5. Atwater has been a geology professor at the University of California, Santa Barbara for over 25 years. Atwater also works with the media, museums, and teachers to educate them about the Earth. She has created presentations and an animated teaching film, “Continental Drift and Plate Tectonics,” that has been used by educators from the elementary school level through college.

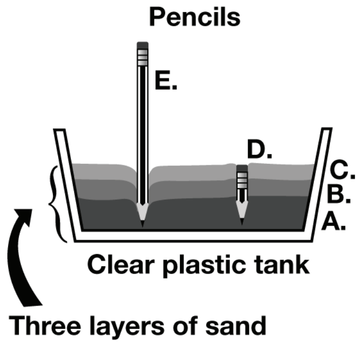
6. Answers may vary. Some of Alvin's noteworthy trips include locating a hydrogen bomb accidentally dropped in the Mediterranean Sea (1966), several trips to the Mid-Atlantic Ridge and Galapagos Rift, surveying the sunken ocean liner Titanic (1986), and IMAX filming off of the San Diego coast for a deep sea feature production (2002).

Skill Sheet 9.1: Relative Dating

1. A thunderstorm began. A child ran through a mud puddle leaving footprints. Hail began to fall. Finally, the mud puddle dried and cracked.
2. One April afternoon, a thunderstorm began. A child was outside playing. When the rain began to fall hard, the child ran home. Her footprints were left in a mud puddle. Fortunately, she made it home just in time because small hailstones suddenly began to fall. The hailstorm lasted for a few minutes and then the clouds cleared. The next morning was bright and sunny. The mud puddle dried and then cracked in many places.
3. C
4. E (This is the term that will be new to students.)
5. A
6. F
7. B
8. D
9. There is no matching picture for this concept. The name of this concept is faunal succession.
10. The rock bodies formed in this order: H, G, F, D, C, B, E, and A.
11. The fault formed after layer F and before both layer D and the intrusion.
12. The stream formed after layer A. Like an intrusion, the stream cut across the rock bodies.

Extension

13. The set of clues includes three layers of colored sand in a clear tank. The layers were made while a small pencil was held upright. The sand filled in around the pencil. After the layers were created, a second, longer pencil was pushed through the layers.



14. The concepts of original horizontality and lateral continuity are demonstrated here. Pencil E represents cross-cutting relationships. Pencil D represents the idea of inclusions.
15. The order of the events is D, A, B, C, and E. My classmates successfully figured out the correct order of the events.

Skill Sheet 9.1: Nicolas Steno

1. Steno is responsible for the following three principles of geology:
    - The principle of superposition states that layers of sedimentary rock settle on top of each other. The oldest layers are at the bottom and the younger layers are on top. The bottom layers are formed first with younger layers sitting above. Geologists use this principle to determine the relative ages of layers.
    - The principle of original horizontality states that sedimentary rock layers form horizontally.
    - The principle of lateral continuity states that rock layers spread out until they reach something that stops this spreading. The layers will continue to move out in all directions horizontally until they are stopped.
2. People did not understand how fossils formed and what fossils truly were. Common misconceptions included the following: fossils grew inside rocks, fossils fell from the sky, and fossils fell from the moon. People did not consider extinction or have an understanding of geological principles to understand fossils and fossil formation.
3. Steno identified tongue stones as ancient shark teeth. He understood that particles settled in sediment. The shark teeth had settled into soft sediment that eventually hardened. Sharks had once lived in the mountains that at one time had been covered by the sea. Shark teeth became buried in mud and rock layers formed around the teeth. These layers became buried under new layers of rock
4. As an anatomist, Steno developed keen observation skills. He was comfortable examining something in depth and trying to understand how something worked. He was not merely satisfied with viewing something. He liked to take things apart. His medical background and work in anatomy made him a hands-on researcher. He took his observation and interest in understanding structure and applied those skills to geology. Unlike many of his counterparts who simply read scholarly works, Steno was a true field scientist. He traveled, observed, and touched.
5. Answers will vary. Students might suggest observations they have made in a science lab, at the beach, or on a field trip. In general, observation often teaches us that things are not what they may initially appear. Observation means paying attention to the details, even if minute or mundane.
6. A goldsmith is a metalworker who often makes jewelry. A goldsmith will solder, file, and polish. A goldsmith does not work only with gold, but will handle a variety of metals. Most work by a goldsmith is done by hand. Steno's father's goldsmith shop was a laboratory providing him with the opportunity to use his hands to handle various tools and materials.
   Alchemy is the early ancestor of chemistry. This ancient form of chemistry included herbs and metals. Alchemists often looked for cures for illnesses. Goldsmith work and alchemy both took place in a laboratory-like setting providing Steno exposure to scientific concepts and materials. Alchemists liked to experiment and tried to understand the world around them. Steno used observation and his hands throughout his career as a scientist to make sense of the world around him.

Skill Sheet 9.1: Edmund Schulman

1. Bristlecone pines can thrive under very harsh conditions including the wind, cold, ultraviolet radiation, and dryness.
2. The bristlecones can survive because of their thick, resinous wood bark. They do well in alkaline soil and are able to draw nutrients out of the soil without other plants or trees competing for the same resources.
3. The oldest living thing on Earth may be a creosote bush outside Palm Springs, California. The bush may be more than 11,700 years old.
4. The world's largest bristlecone pine is located 12 miles north of the Schulman Grove. The Patriarch Grove is home to a bristlecone with a width of 39 feet and a height over 50 feet. However, it is only 1,500 years old, considerably younger than the Methuselah tree.
5. Schulman Grove is located within the Ancient Bristlecone Pine Forest and is the area where Edmund Schulman conducted most of his research.

Skill Sheet 9.2: Andrew Douglass

1. Douglass originally started as an astronomer. He helped to set-up observatories and also studied Mars with Percival Lowell. He noticed a possible relationship between sunspot cycles and the climate and wished to study this further. He noted that tree rings held information about weather patterns and hoped he could find a link between periods of drought and sunspot activity. This marked his move away from astronomy and toward tree ring analysis.
2. Douglass created the science of dendrochronology or tree ring dating. He specifically developed cross-dating as a technique to match tree ring samples with ancient ruins.
3. Douglass, in 1929, was able to date with accuracy Native American ruins in Arizona. He studied pine tree rings dating back to the time of Native American dwellings. He matched wooden beam samples against pine tree rings to determine a precise date for the ancient ruins. This cross-dating technique provided a tool for all archaeologists to date prehistoric remains and ruins.
4. The second asteroid is called Minor Planet or Asteroid (15420) Aedouglass.
5. The Boyden Observatory is now located in Bloemfontein, South Africa.
6. The Spacewatch Project is located at the University of Arizona's Lunar and Planetary Laboratory. Scientists at Spacewatch study and explore small objects in the solar system including asteroids and comets. The Project was founded by Professor Tom Gehrels and Dr. Robert S. McMillan in 1980.

Skill Sheet 10.1: Jules Verne

1. Verne’s novels offered people an opportunity to go on voyages into unknown realms of the world, and even space. Tales like these are still popular today, but during Verne’s time, fewer people had the opportunity to travel. Verne’s novels pulled readers away from their everyday life and allowed their imaginations to consider futuristic inventions and machines that were far removed from life in the nineteenth century.
2. *From Earth to the Moon*, *20,000 Leagues Under the Sea*, *Journey to the Center of the Earth*, *Around the World in 80 Days*, and *The Mysterious Island* have all been made into movies several times. *Around the World in 80 Days* won five academy awards in 1956 including best picture and best cinematography.
3. The bar exam is a written test that must be passed in order to qualify a person to practice law.
4. Victor-Marie Hugo (February 26, 1802–May 22, 1885) is recognized as the most influential French Romantic writer of the 19th century and is often identified as the greatest French poet. Two of his best known works are Les Misérables and The Hunchback of Notre-Dame. Verne must have been inspired to meet the most famous and well-respected author of his time.
5. Airplanes, movies, guided missiles, submarines, the electric chair, air conditioning, the fax machine, gas-powered cars, and an elevated mass transit system are among his best known. One of his most eerily true-to-life ideas appears in both *From Earth to the Moon* (1865) and *All Around the Moon (1870)*. In these stories an aluminum craft launched from central Florida achieves a speed of 24,500 miles per hour, circles the moon and splashes down in the Pacific. A century later Apollo 8, made of aluminum and traveling at 24,500 miles an hour, took off from central Florida. It circled the moon and splashed down in the Pacific.

Skill Sheet 10.2: Earth’s Interior

A. Crust
B. Upper mantle
C. Asethenosphere
D. Lower mantle
E. Outer core
F. Inner core

Skill Sheet 11.1: Alfred Wegener

1. He developed an interest in Greenland when he was a young boy. As an adult scientist, he went there on several scientific expeditions to study the movement of air masses over the polar ice cap. He studied the movement of air masses long before the common acceptance of the jet stream. He died there during a blizzard on one of his expeditions just a few days after his fiftieth birthday.
2. He and his brother set the world record for staying aloft in a hot air balloon for the longest period of time, 52 hours.
3. Wegener studied and used several different fields of science in his work. His main areas of expertise were astronomy and meteorology, however, he also explored paleontology (fossils), geology, and climatology as he gathered evidence for his drifting continent theory.
4. Fossils of the small reptile were found only on the eastern coast of Brazil and the western coast of Africa. Since there was no way that the reptile could have crossed the Atlantic Ocean, Wegener figured that those two continents must have been connected when that reptile was alive.

5. Coal can only be formed under certain conditions. It can be formed only from plants that grow in warm, wet climates. Those type of plants could not grow in either England or Antarctica today. That means that at some time, England and Antarctica must have been located somewhere around the equator where those type of plants could survive, and they must have moved away from the equator to their present locations.
6. Answers will vary.
7. Wegener was a relatively unknown scientist at the time, and geology wasn't even his field of expertise, yet he was proposing a theory that went against everything that scientists at the time believed about geology. The most famous scientists alive at that time attacked him viciously and called his theory utter rot! Also, even though he had gathered what appeared to be a lot of evidence to show that the continents had indeed moved over millions of years, he could never explain how or why that happened. He could never explain what driving force could be powerful enough to move continents.
8. Answers will vary.

Skill Sheet 11.2: Harry Hess

1. Hess used his time in the Navy to further his geological research. Between battles, Hess and his crew gathered data about the structure of the ocean floor using the ship's sounding equipment. They recorded thousands of miles worth of depth recordings.
2. While in the Navy, Hess measured the deepest point of the ocean ever recorded-nearly 7 miles deep. He also discovered hundreds of flat-topped mountains lining the Pacific Ocean floor. He named these unusual mountains “guyouts”.
3. Hess explained that sea floor spreading occurs when molten rock (or magma) oozes up from inside the Earth along the mid-oceanic ridges. This magma creates new sea floor that spreads away from the ridge and then sinks into the deep-ocean trenches where it is destroyed.
4. Hess explained that the ocean floor is continually being recycled and that sediment has been accumulating for no more than 300 million years. This is the amount of time needed for the ocean floor to spread from the ridge crest to the trenches. Therefore, the oldest fossils found on the sea floor are no more than 180 million years old.
5. In 1962, President John F. Kennedy appointed Hess as Chairman of the Space Science Board -an advisory group for the National Aeronautics and Space Administration (NASA). During the late 1960s, Hess helped plan the first landing of humans on the moon. He was part of a committee assigned to analyze rock samples brought back from the moon by the Apollo 11 crew.
6. In 1984, the American Geophysical Union established the Harry H. Hess medal in recognition of “outstanding achievements in research in the constitution and evolution of Earth and sister planets.”

Skill Sheet 11.3: Earth’s Largest Plates

A. Pacific Plate
B. American Plate
C. Eurasian Plate
D. African Plate
E. Indo-Australian Plate
F. Antarctic Plate

Skill Sheet 11.3: John Tuzo Wilson

1. Wilson's adventurous parents helped to expand Canada's frontiers. Wilson's mother, Henrietta Tuzo, was a famous mountaineer who had Mount Tuzo in western Canada named in her honor. Wilson's father, also named John, helped plan the Canadian Arctic Expedition of 1913 to 1918. He also helped develop airfields throughout Canada.
2. Wilson is sometimes called an adventurous scholar because he enjoyed traveling to unusual locations. He became the first person to scale Mount Hague in Montana. Wilson also led an expedition called Exercise Musk-Ox in which ten army vehicles traveled 3,400 miles through the Canadian Arctic. While a professor, Wilson mapped glaciers in Northern Canada and became the second Canadian to fly over the North Pole during his search for unknown Arctic islands.
3. Volcanic islands, like the Hawaiian Islands, are found thousands of kilometers away from plate boundaries. In 1963, Wilson published a paper that explained how plates move over stationary “hotspots” in the earth's mantle and form volcanic islands.
4. In 1965, Wilson proposed that a type of plate boundary must connect ocean ridges and trenches. He suggested that a plate boundary ends abruptly and transforms into major faults that slip horizontally. Wilson called these boundaries “transform faults”.
5. In 1967, Wilson published an article that described the repeated process of ocean basins opening and closing-a process later named the Wilson Cycle. Geologists believe that the Atlantic Ocean basin closed millions of years ago and caused the formation of the Appalachian and Caledonian mountain systems. The basin later re-opened to form today's Atlantic Ocean.
6. Antarctica

Skill Sheet 12.1: Averaging

1. Four gloves per household
2. On average, each person spent about $8.33.
3. $3.95; $31.60
4. ≈ 6 points each
5. ≈ 5 slices each (5 $^{1}/_{3}$ slices each)

Skill Sheet 12.1: Speed

1. 2.5 cm/sec
2. $2.\overline{6}$ m/sec
3. 46.1 m/sec
4. $0.3\overline{6}$ m/sec
5. 456,842,110 km/yr
6. Answers are:
   a. 7.5 km/hr
   b. 15 km/hr
   c. 10 km/hr
7. 1,500 meters
8. 3 seconds

Skill Sheet 12.1: Internet Research

Part 1 answers:

1. “science museum” + “south carolina” not “columbia”
2. “dog breeds” not “expensive” (or) “dog breeds” + “inexpensive”
3. “producing electricity” not “coal” not “natural gas”

Part 2 answers:

1. Answers will vary. Sites that may be authoritative include non-profit sites (recognizable by having “org” as the extension in the web address) or government sites such as www.nasa.gov (recognizable by the “gov” extension address) or college/university websites (recognizable by the “edu” extension address). These sites often provide information to large, diverse groups and are not typically supported by advertising. Sites that are supported by advertising can be authoritative, but may be biased in the information presented. Another characteristic of authoritative sites are that they are actively updated on a regular basis.
2. Answers will vary. Reasons why a source may not seem to be authoritative include: the author of the site is not affiliated with an organization and does not have obvious credentials, and the information seems to be one-sided. Many science topic searches will lead to student papers published on the Internet. These may contain mistakes, or they may have been written by a younger student.
3. Answers will vary. Intended audiences can be young children, pre-teens, teenagers, adults, or select groups of people (women, men, people who like dogs, etc.).
4. Answers will vary.

Skill Sheet 12.1: Charles Richter

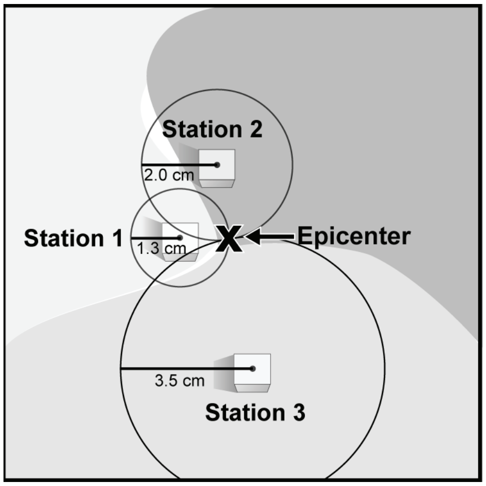
1. Answers are:
   - theoretical physics - a branch of physics that attempts to understand the world by making a model of reality, used for rationalizing, explaining, and predicting physical phenomena through a “physical theory.”
   - seismology - The study of earthquakes and of the structure of the Earth by natural and artificial seismic waves.
   - seismograms - A written record of an earthquake, recorded by a seismograph.
   - magnitude - the property of relative size or extent (whether large or small)
   - seismographs - An instrument for automatically detecting and recording the intensity, direction, and duration of a movement of the ground, especially of an earthquake.
2. Sample answer: I would feel proud that a leader in the field considered me above anyone else. It would be disappointing to lose the opportunity to work with Dr. Millikan, but if he considered me ready for the job, maybe he felt I had learned all I could and was ready to move on.
3. Richter responded by taking on routine tasks and making something extraordinary out of something ordinary.
4. Dr. Beno Gutenburg
5. Answers will vary. Correct answers include:
   a. Mercalli scale
   b. Moment magnitude scale
   c. JMA scale (Japanese Meteorological Agency)
   d. MSK scale (Medvedev, Sponheuer and Karnik)
   e. European Macroseismic scale
   f. Rossi-Forel scale
   g. Omori scale
6. Some scales measure intensity (like the Mercalli scale), while others measure magnitude (like the Richter scale). Intensity scales measure how strongly a quake affects a specific place, while magnitude scales indicate how much total energy a quake expends. Also, many times different countries have different building codes or standards of construction. Some of the scales used to measure earthquakes are based on traditional construction materials and techniques, which can vary around the world. These scales may be used to define the quake resistant construction guidelines adopted by different countries or regions with different occurrences of earthquakes.
7. Seismograph and seismometer are usually interchangeable, as they both describe devices designed to do the same thing. Seismometer seems to be the more modern term.

Skill Sheet 12.1: Finding an Earthquake Epicenter

Practice 1:

Table 1 answers:

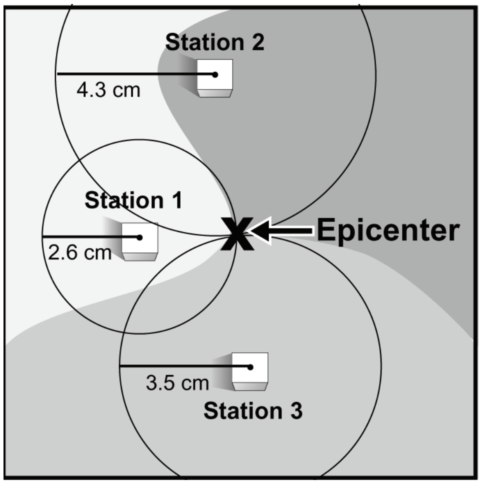
Station name	Arrival time difference between P- and S-waves	Distance to epicenter in kilometers	Scale distance to epicenter in centimeters
1	15 seconds	130 km	1.3 cm
2	24 seconds	200 km	2.0 cm
3	42 seconds	350 km	3.5 cm



Practice 2:

1. First problem is done for students.
   Station A: t_p = 128 seconds
2. Station B:
   5 km/sec × t_p = 3 km/sec × (t_p + 80 sec)
   (2 km/sec) t_p = 240 km
   t_p = 120 seconds
3. Station C: t_p = 180 seconds
4. Station A: distance = 5 km/s × 128 sec = 640 km
   Station B: distance = 5 km/s × 120 sec = 600 km
   Station C: distance = 5 km/s × 180 sec = 900 km
5. Answers are:
   (a) 5 km/s × 200 s = 3 km/s × (200 s + **x**)
   1000 km = 600 km + (3 km/s)**x**
   400 km = (3 km/s)**x**
   x = 133 s = time between the P-waves and S-waves
   (b) 133 s + 200 s = 333 s = t_s
6. Table 3 answers:

	Variables	Station 1	Station 2	Station 3
Speed of P-waves	r_p	5 km/s	5 km/s	5 km/s
Speed of S-waves	r_s	3 km/s	3 km/s	3 km/s
Time between the arrival of P- and S-waves	$t_s - t_p$	70 seconds	115 seconds	92 seconds
Total travel time of P-waves	t_p	105 seconds	173 seconds	138 seconds
Total travel time of S-waves	t_s	175 seconds	288 seconds	230 seconds
Distance to epicenter	d_p, d_s	525 km	865 km	690 km
Scale distance to epicenter		2.6 cm	4.3 cm	3.5 cm



Note: For this skill sheet the graph is set up to have time on the *x*-axis. It is also common to have time on the *y*-axis. This is how the graph of time and distance to the epicenter is presented in the text.

Skill Sheet 12.2: Volcano Parts

A. Vent
B. Volcano
C. Dike
D. Conduit
E. Sill
F. Magma chamber

Skill Sheet 12.2: Responding to Natural Disasters

Student responses will vary based on project chosen.

Skill Sheet 13.1: Mohs Hardness Scale

Teacher's note: Gypsum, topaz, and corundum can be purchased through a science supply catalogue.

Part 1 answers:

1. Diamonds are precious minerals and expensive.

Table 1 answers:

Mineral	Hardness	Color of Streak on Streak plate	Description
Talc	1	white	soft, gray and white, powdery
Gypsum	2	white	clear, light weight
Calcite	3	white, breaks into small crystals	cloudy, rhomboidal
Fluorite	4	white	green, cloudy, shiny
Apatite	5	white	green, cluster of chunky bits
Orthoclase (Feldspar)	6	white; difficulty scratching	salmon pink, shiny parts
Quartz	7	no scratch	cloudy white, angular
Topaz	8	no scratch	yellow-green
Corundum	9	no scratch	dark gray with pores, gold sparkles
Diamond	10	N/A	clear, sparkly

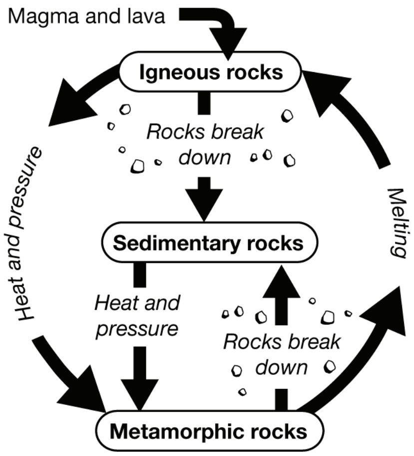
Part 2 answers:

1. Procedure: First, I would see if a mineral with a higher hardness number can scratch a mineral with a lower hardness number. Then, I will see if the mineral with the lower hardness can scratch the mineral with the higher hardness.

   Results: In all cases the higher hardness mineral scratched the lower hardness mineral. For example, gypsum left scratches on talc. However, for the minerals with higher hardness, it seemed more difficult to cause a scratch. In some cases, the harder mineral causes pieces of the softer mineral to break off. In all cases, the softer mineral left powdery streaks on the harder mineral. These powdery streaks were easily rubbed. off.
2. The Mohs Hardness Scale is qualitative. In order to tell hardness, you need to compare minerals to other minerals. Therefore, this unitless numerical value is a description of how a mineral compares to another, and not a quantitative measurement of a property of the mineral.
3. Pros: (1) the Mohs Hardness Scale is easy to use. and (2) the scale can be used anywhere (inside or outside); Cons: (1) diamonds are rarely included or available because they are too expensive, and (2) the hardness test is only useful if you are certain that your sample is a mineral (and not a rock)—sometimes this may be difficult to determine.
4. Rocks are mixtures of minerals. Therefore, the Mohs Hardness Scale may be helpful in identifying some components of a rock—especially if it is a large sample. However, other features and properties of the rock would have to be identified to help identify a rock.
5. Test 1: I would use a piece of topaz to perform scratch tests on the samples in the mine. If the samples can scratch topaz, then I could identify the hardness to be "9"—this is the hardness value for corundum. Test 2: I would also compare known samples of corundum to the samples in the mine.
6. Table 2 answers:

	Copper wire	Pocket knife	Pyrite	Diamond	Iron nail	Ice
1.5	X	X	X	X	X	O
3	O	X	X	X	X	X
4 - 5	X	X	O	X	X	X
5.5	X	O	X	X	X	X
6 - 6.5	X	X	X	X	O	X
10	X	X	X	O	X	X

Skill Sheet 13.1: The Rock Cycle



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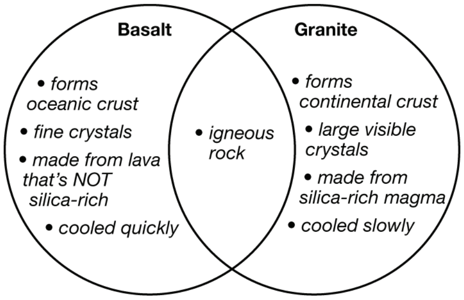
Skill Sheet 13.2: Basalt and Granite

Sample student answer:



Skill Sheet 14.3: Continental United States Geography

No student responses are required.

Skill Sheet 15.3: Soil Texture

1. Silt loam
2. Sandy clay
3. Approximately 40 percent sand, 40 percent silt, and 20 percent clay.
4. Sample student response:
   - Earthworms tunnel and aerate the soil
   - Rodents churn up the soil
   - Plant roots add organic matter to the soil
5. If the damp soil can be made into a rope or worm shape by rolling it between your hands, it is primarily clay. If the soil, moistened by water, feels gritty between your fingers, it is sandy. If the damp soil feels smooth, it is silty.
6. 60 percent sand, 30 percent silt, 10 percent clay
7. Sandy loam

Skill Sheet 16.2: Supplying Our Energy Needs

Answers to this project-based skill sheet will vary according to energy source chosen and environmental conditions in students' home region.

Skill Sheet 17.1: Mass vs. Weight

1. 15 pounds
2. 2.6 pounds
3. 7.0 kilograms
4. Yes, a balance would function correctly on the moon. The unknown mass would tip the balance one-sixth as far as it would on Earth, but the masses of known quantity would tip the balance one-sixth as far in the opposite direction as they did on Earth. The net result is that it would take the same amount of mass to equalize the balance on the moon as it did on Earth. (In the free fall environment of the space shuttle, however, the masses wouldn't stay on the balance, so the balance would *not* work).
5. Answers are:
   a. As the elevator begins to accelerate upward, the scale reading is greater than the normal weight. As the elevator accelerates downward, the scale reads less than the normal weight.
   b. When the elevator is at rest, the scale reads the normal weight.
   c. The weight appears to change because the spring is being squeezed between the top and the bottom of the scale. When the elevator accelerates upward, it is as if the bottom of the scale is being pushed up while the top is being pushed down. The upward force is what causes the spring to be compressed more than it is normally. When the elevator accelerates downward, the bottom of the scale provides less of a supporting force for the feet to push against. Therefore, the spring is not compressed as much and the scale reads less than the normal weight.

Skill Sheet 17.1: Astronomical Units

1. 9.53 AU
2. 0.72 AU
3. 58 million kilometers
4. 2.87 billion kilometers
5. Less. The moon is not nearly as far from Earth as the Sun.
6. Uranus
7. Mercury
8. Saturn
9. Saturn
10. yes

Skill Sheet 17.1: Galileo Galilei

1. "On Motion" described how a pendulum's long and short swings take the same amount of time.
2. Galileo's many inventions include the thermometer, water pump, military compass, microscope, telescope, and pendulum clock. Information and illustrations of the inventions can be found using the Internet or library.
3. Galileo observed the motion of Jupiter's moons and realized that despite what Ptolemy said, heavenly bodies do not revolve exclusively around Earth. He also realized that his observation of the phases of Venus showed that Venus was revolving around the sun, not around Earth. Galileo therefore concluded that Copernicus' assertion that the sun, not Earth, was at the center must be correct.
4. Answers will vary. Students might suggest that Galileo use a less abrasive approach to convince people that the Copernican view is correct.
5. Galileo's telescope is the most likely student response, because it so profoundly changed our understanding of the solar system. However, students may choose another invention as long as they provide valid reasons for their decision.

Skill Sheet 17.1: Nicolaus Copernicus

1. Because he was from a privileged family, young Copernicus had the luxury of learning about art, literature, and science. When Copernicus was only 10 years old, his father died. Copernicus went to live his uncle who was generous with his money and provided Copernicus with an education from the best universities. Copernicus lived during the height of the Renaissance period when men from a higher social class were expected to receive well-rounded educations.
2. Copernicus' uncle, Lucas Watzenrode, was a prominent Catholic Church official who became bishop of Varmia in 1489. After Copernicus finished four years of study at the University of Krakow, Watzenrode appointed Copernicus a church administrator. Copernicus used his church wages to help pay for additional education. While studying at the University of Bologna, Copernicus' passion for astronomy grew under the influence of his mathematics professor, Domenico Maria de Novara. Copernicus lived in his professor's home where they spent hours discussing astronomy.
3. Copernicus examined the sky from a tower in his uncle's palace. He made his observations without any equipment.
4. Prior to the 1500s, most astronomers believed that Earth was motionless and the center of the universe. They also thought that all celestial bodies moved around Earth in complicated patterns. The Greek astronomer Ptolomy proposed this geocentric theory more than 1000 years earlier.
5. Copernicus believed that the universe was heliocentric (sun-centered), with all of the planets revolving around the sun. He explained that Earth rotates daily on its axis and revolves yearly around the sun. He also suggested that Earth wobbles like a top as it rotates. Copernicus' theory led to a new ordering of the planets. In addition, it explained why the planets farther from the sun sometimes appear to move backward (retrograde motion), while the planets closest to the sun always seem to move in one direction. This retrograde motion is due to Earth moving faster around the sun than the planets farther away.
6. At the time, Church law held great influence over science and dictated a geocentric universe.
7. The Copernicus Satellite, or Orbiting Astronomical Observatory 3 (OAO-3) was a collaborative project of both the United States' National Aeronautics and Space Administration (NASA) and the United Kingdom's Science and Engineering Research Council (SERC). The satellite operated from August 1972 to February 1981. The main experiment on the satellite was a Princeton University ultraviolet (UV) telescope. An x-ray astronomy experiment created by the University College London/Mullard Space Science Laboratory was also onboard. The Copernicus Satellite gathered a series of high-resolution ultraviolet spectral scans of over 500 objects, most of them being bright stars.

Skill Sheet 17.1: Johannes Kepler

1. Copernicus' idea that the sun was at the center of the solar system was revolutionary because people believed Earth was the center of the universe.
2. Brahe helped Kepler make his important discoveries in several ways. Brahe invited Kepler to come and work with him. He asked Kepler to solve the problem of Mars' orbit. When Brahe died, Kepler gained all of his observational records. Kepler also got Brahe's job.
3. Kepler used mathematics to solve problems in astronomy. For this reason, Kepler is considered a theoretical positional astronomer. Brahe was an observational astronomer. He made and recorded the motion of planets and the stars in the night sky without a telescope. Galileo was also an observational astronomer. He used and improved the telescope, but he was not a mathematician.
4. Kepler's discovery that Mars traveled in an elliptical orbit was different than Copernicus' theory which said planets traveled in circular orbits.
5. Kepler's three laws of planetary motion are:
   - Planets orbit the sun in an elliptical orbit with the sun in one of the foci.
   - The law of areas says that planets speed up as they travel in their orbit closer to the sun and they slow down as they travel in their orbit farther away from the sun.
   - The harmonic law says that a planet's distance from the sun is mathematically related to the amount of time it takes the planet to revolve around the sun.
6. Three examples of a paradigm shift:
   - Copernicus' theory that the sun and not Earth was the center of the solar system.
   - Kepler's discovery that planets orbit the sun in an elliptical and not a circular path.
   - Newton's laws of gravitational attraction.

Skill Sheet 17.1: Water on Mars

Answers to this project-based skill sheet will vary.

Skill Sheet 17.2: Touring the Solar System

Part 1 answers:

Legs of the trip	Distance travelled for each leg (km)	Hours travelled	Days travelled	Years travelled
Earth to Mars	78,000,000	86,666	3,611	9.9
Mars to Saturn	1,202,000,000	1,335,600	55,648	152
Saturn to Neptune	3,070,000,000	3,411,100	142,130	389
Neptune to Venus	4,392,000,000	4,880,000	203,330	557
Venus to Earth	42,000,000	46,667	1,944	5.3

Part 2 answers:

1.

$$\frac{8\text{ glasses}}{1\text{ day}} \times 3{,}611\text{ days} = 28{,}888\text{ glasses of water}$$

2.

$$\frac{2,000\text{ food calories}}{1\text{ day}} \times 203,330\text{ days} = 406{,}660{,}000\text{ food calories}$$

3. Pack foods high in fat for the journey because you get more calories per gram than from proteins and carbohydrates and you want a payload minimum.
4. Your entire trip will take 1,113 years, so you will need that many turkeys.

Part 3 answers:

1. Jupiter; it has 39 moons.
2. Venus has the hottest surface temperature; Pluto has the coldest surface temperature.
3. Venus; it takes 243 Earth days to rotate once around its axis.
4. Jupiter has the shorter day; it takes 0.41 Earth days to rotate.
5. Jupiter; it has the strongest gravitational force. You will weigh 2.36 times your Earth weight in Newtons.
6. Pluto; It has the weakest gravitational force. You will weigh 0.06 times your Earth weight in Newtons.
7. Jupiter; it has the largest diameter of 142,796 km.
8. Jupiter; it has the strongest gravitational force, therefore the spaceship must orbit at a fast speed to balance the gravitational force pulling the spaceship towards Jupiter’s surface.

Skill Sheet 18.2: Benjamin Banneker

1. An understanding of gear ratios was necessary for building the clock. He used geometry skills to figure out how to create a large-scale model of each tiny piece of the watch he examined.
2. Personal strengths identified from the reading include strong spacial skills (building the clock), creativity and problem solving skills (irrigation system), curiosity and attention to detail (astronomical observations, cicada observations, and almanac), concern for others (letter to Jefferson).
3. Dates are as follows:
   a. 1863
   b. 1865
   c. 1920
   d. 1954
4. Any three of the following answers is correct. Banneker’s accomplishments include:
   a. Designed an irrigation system
   b. Documented cycle of 17-year cicada
   c. Published detailed astronomical calculations in popular almanacs
   d. Served as surveyor of territory that became Washington D.C.
5. Banneker evidently had a strong innate curiosity about the natural world. He was passionate about improving the welfare of the black men and women in the United States and his letter to Jefferson stated that he hoped his scientific work would be seen as proof that people of all races are created equal.
6. Banneker's puzzles can be found on several web sites. Using an Internet search engine, look for “Benjamin Banneker” + puzzle. Some of the sites publish the answers while others do not. Here is one of Banneker's puzzles taken from the web site www.thefriendsofbanneker.org. Note that the puzzle was written in the 1700’s and is from Banneker’s personal journals.
   THE PUZZLE ABOUT TRIANGLES
   “Suppose ladder 60 feet long be placed in a Street so as to reach a window on the one side 37 feet high, and without moving it at bottom, will reach another window on the other side of the Street which is 23 feet high, requiring the breadth of the Street.” [No solution recorded in historic records.]

Skill Sheet 18.2: Measuring the Moon’s Diameter

Part 1 answers:

There are no questions to answer for Part 1.

Part 2 answers:

1. AC = 6 cm
   AD = 6 cm
   AB = 2 cm
   AE = 2 cm
   BE = 2 cm
   CD = 6 cm
2. Distance AB is 1/3 of the distance AC
3. Distance BE is 1/3 of the distance CD
4. If a triangle is drawn inside a larger triangle so that they share the same vertex and have bases that are parallel, then the sides and base of the small triangle will be proportional to the sides and base of the large triangle.

Part 3 answers:

Answers will vary. A string distance of about 1 meter will yield good results.

Part 4 answers:

1. A and D are the same, but D is most helpful because it is set up with the unknown in the numerator.
2. Answers will vary. A string distance of about 1 meter should give a value close to the accepted moon diameter; 3,476,000 meters.
3. The semi-circle diameter is the base of the small triangle; the base of the large triangle is what we are solving for: the moon’s diameter.

Skill Sheet 18.3: The Sun: A Cross-Section

A. Corona
B. Chromosphere
C. Photosphere
D. Convection zone
E. Radiation zone
F. Core

Skill Sheet 18.3: Arthur Walker

1. You may wish to have students compare and contrast their definitions with those of a student who used a different source. Discuss with the class the value of using a variety of sources and the importance of crediting these sources.
2. Walker didn't allow prejudice to dissuade him from pursuit of his goals. As a result he made important contributions to science and society. He also spent time and energy helping other members of minority groups achieve their own goals.
3. A spectrometer separates light into spectral lines. Each element has its own unique pattern of lines, so scientists use the patterns to identify the ions in the corona. Temperature can be determined by the colors seen in the corona. For example, red indicates cooler areas, while bluish light indicates a very hot area.
4. Magazines and journals that may have one of Walker's photographs can be found at public and university libraries. You might suggest that students contact a reference librarian for assistance.
5. The committee found that the accident was caused by a failure in a seal of the right solid rocket booster. They also made nine specific recommendations of changes to be made to the space shuttle program prior to another flight. These steps included:
    a. Redesign the solid rocket boosters.
    b. Upgrade the space shuttle landing system.
    c. Create a crew escape system that would allow astronauts to parachute to safety in certain situations.
    d. Improve quality control in both NASA and contractor manufacturing.
    e. Reorganize the space shuttle program to place astronauts in key decision-making roles.
    f. Revoke any waivers to current safety standards, especially those related to launches in poor weather conditions.
    g. Open the review of a mission's technical issues to independent government agencies.
    h. Set up an extensive open review system to evaluate issues related to each particular mission.
    i. Provide a means of anonymous, reprisal-free reporting of space shuttle safety concerns by any NASA employee or contractor.

Skill Sheet 19.1: Scientific Notation

1. Answers are:
    a. 122,200
    b. 90,100,000
    c. 3,600
    d. 700.3
    e. 52,722
2. Answers are:
    a. 4.051×10^{6}
    b. 1.3×10^{9}
    c. 1.003×10^{6}
    d. 1.602×10^{4}
    e. 9.9999×10^{12}

Skill Sheet 19.1: Understanding Light Years

1. 5.7×10^{13} km
2. 4.3×10^{19} km
3. 3.8×10^{10} km
4. 5,344 ly
5. 1.16×10^{-12} ly
6. 1.16 ly
7. 1,200 ly
8. 8.0478×10^{14} km
9. 4,280,056,000 km, or 4.28×10^{9} km
10. 0.000026336 AU, or 2.6×10^{-5} AU
11. 63,288 AU

Skill Sheet 19.2: Calculating Luminosity

1. luminosity = 30 watts
   power rating on bulb = 300 watts
2. luminosity = 1 watt
   power rating on bulb = 10 watts
3. Challenge:

$$\begin{aligned}\text{luminosity} &= 1.370 \times 10^{3}(4\pi)(1.5 \times 10^{11})^{2}\\ &= 1.370 \times 10^{3}(4\pi)(2.25 \times 10^{22})\\ &= 39 \times 10^{25}\\ &= 3.9 \times 10^{26}\text{ watts}\end{aligned}$$

Skill Sheet 19.3: Edwin Hubble

1. Answers are:
    - astronomy - the study of matter in outer space, especially the positions, dimensions, distribution, motion, composition, energy, and evolution of celestial bodies and phenomena.
    - galaxy - a group of stars, dust, gas, and other objects held together by gravitational forces.
    - spectroscopy - a method of studying an object by examining the visible light and other electromagnetic waves it creates.
    - cosmology - the astrophysical study of the history, structure, and constituent dynamics of the universe.

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2. Outstanding students from around the world are nominated for the prestigious Rhodes scholarship. Rhodes Scholars are invited to study at the University of Oxford in England. Only about 90 students are selected each year. This scholarship is awarded by the Rhodes Trust, a foundation set up by Cecil Rhodes in 1902.
3. A larger telescope allows more light to be collected by the mirrors and/or lenses of the telescope. More light allows for a clearer image, which can then be magnified to show greater detail.
4. Example answer: Edwin was incredibly excited today. Albert Einstein came to visit him, and he even thanked him for all of his hard work. It's almost unbelievable! The most celebrated scientist of our lifetime came to visit him. Just to be associated with Einstein is an honor, let alone be thanked by him. Edwin works very hard, and he must be very proud of his new discoveries that have changed the world of astronomy.
5. The fact that the universe is expanding implies that it must have been smaller in the past than it is today. The expanding universe implies that the universe must have had a beginning. This idea led to the development of the Big Bang theory, which says that the universe exploded outward from a single point smaller than an atom into the vast expanse of today's universe.

Skill Sheet 19.3: Henrietta Swan Leavitt

1. Leavitt discovered new variable stars by comparing photographic plates. The photographs showed the same regions in the sky, but at different times. This allowed Leavitt to examine the photos and identify stars that had changed in size over time.
2. Leavitt studied Cepheid stars and found an inverse relationship between a star's brightness cycle and its magnitude. A stronger star took longer to cycle between brightness and dimness. As a result, she developed the Period-Luminosity relation.
3. The asteroid is called 5383 Leavitt.
4. The observatory was founded in 1839 and currently conducts research in astronomy and astrophysics.
5. Example Answers:

   Ejnar Hertzsprung:
   - Danish astronomer born October 8, 1873
   - Found the distance to the Small Magellan Cloud located outside of the Milky Way Galaxy in 1913.
   - Developed the Hertzsprung-Russell diagram which graphs the magnitude of stars against their surface temperature or color.

   Harlow Shapley:
   - Astronomer born November 2, 1885 in Nashville, Missouri
   - In addition to being an astronomer, Shapley was a writer.
   - Shapley determined the size of the Milky Way Galaxy.

   Edwin Hubble:
   - Astronomer born November 29, 1889 in Marshfield, Missouri.
   - Earned an undergraduate degree in math and astronomy, and went on to study law.
   - Developed a classification system for galaxies and created Hubble's Law which helped astronomers determine the age of the universe.
6. The Nobel Prize was established in 1901 and is awarded to individuals in the fields of physics, chemistry, physiology or medicine, literature, and peace. The prize includes a medal, diploma, and cash award.