GRADE

8

TAKS STUDY GUIDE

Texas Assessment of Knowledge and Skills

Science

A Student and Family Guide to Grade 8 Science

TAKS STUDY GUIDE

Texas Assessment of Knowledge and Skills

Grade 8

Science

A Student and Family Guide

Copyright © 2005, Texas Education Agency. All rights reserved. Reproduction of all or portions of this work is prohibited without express written permission from Texas Education Agency.

Cover photo credits: *Top Left* © Gabe Palmer/CORBIS; *Top Right* © Jim Cummins/CORBIS; *Bottom Left* © Gabe Palmer/CORBIS; *Bottom Right* © H. Benser/zefa/CORBIS.

Dear Student and Parent:

The Texas Assessment of Knowledge and Skills (TAKS) is a comprehensive testing program for public school students in grades 3–11. TAKS replaces the Texas Assessment of Academic Skills (TAAS) and is designed to measure to what extent a student has learned, understood, and is able to apply the important concepts and skills expected at each tested grade level. In addition, the test can provide valuable feedback to students, parents, and schools about student progress from grade to grade.

Students are tested in mathematics in grades 3–11; reading in grades 3–9; writing in grades 4 and 7; English language arts in grades 10 and 11; science in grades 5, 8, 10, and 11; and social studies in grades 8, 10, and 11. Every TAKS test is directly linked to the Texas Essential Knowledge and Skills (TEKS) curriculum. The TEKS is the state-mandated curriculum for Texas public school students. Essential knowledge and skills taught at each grade build upon the material learned in previous grades. By developing the academic skills specified in the TEKS, students can build a strong foundation for future success.

The Texas Education Agency has developed this study guide to help students strengthen the TEKS-based skills that are taught in class and tested on TAKS. The guide is designed for students to use on their own or for students and families to work through together. Concepts are presented in a variety of ways that will help students review the information and skills they need to be successful on the TAKS. Every guide includes explanations, practice questions, detailed answer keys, and student activities. At the end of this study guide is an evaluation form for you to complete and mail back when you have finished the guide. Your comments will help us improve future versions of this guide.

There are a number of resources available for students and families who would like more information about the TAKS testing program. Information booklets are available for every TAKS subject and grade. Brochures are also available that explain the Student Success Initiative promotion requirements and the new graduation requirements for eleventh-grade students. To obtain copies of these resources or to learn more about the testing program, please contact your school or visit the Texas Education Agency website at www.tea.state.tx.us.

Texas is proud of the progress our students have made as they strive to reach their academic goals. We hope the study guides will help foster student learning, growth, and success in all of the TAKS subject areas.

Sincerely,

Lisa Chandler
Director of Student Assessment
Texas Education Agency

Contents

Science

SCIENCE

What is the TAKS Grade 8 Science Study Guide?

The TAKS Grade 8 Science Study Guide is a booklet that has been provided to help improve students' understanding of the Texas Essential Knowledge and Skills (TEKS) for Grades 6 through 8. These are the skills and concepts tested on the Grade 8 science TAKS test. The study guide provides explanations, examples, and opportunities for students to practice their skill at answering science questions.

The TAKS Grade 8 Science Study Guide is designed to strengthen skills that will affect performance on the TAKS test. It is a highly recommended resource for students who have had difficulty with any portion of the Grade 8 science TAKS test. However, any science student can benefit from using the study guide as a review and reinforcement of skills and knowledge already mastered.

All eighth-grade students in Texas will take a science test. Most students will take the test on paper, using a printed booklet. However, some students may also be tested using an online version of the test; this decision is made by the local school districts. This study guide contains information useful to all science students, regardless of which type of test they may end up taking.

How is the Science Study Guide organized?

In middle school there are five objectives tested on the science TAKS test. The Grade 8 Science Study Guide is therefore organized into five sections.

- Objective 1: The Nature of Science
- Objective 2: Living Systems and the Environment
- Objective 3: The Structures and Properties of Matter
- Objective 4: Motion, Forces, and Energy
- Objective 5: Earth and Space Systems

For each objective there is a review and a set of practice questions. Start by reading the review of each objective. After you read the review, you can test your knowledge of the objective by trying the practice questions.

Will this study guide tell me everything I need to know about science?

No, but it's a great place to get more information about the five TAKS objectives. This study guide explains many, but not all, of the basic science ideas that you should know and understand. You can also add to your science knowledge and skills using:

- Science books from your school or a library
- Notes from your science classes
- Science tests, quizzes, and activity sheets
- Laboratory reports and notes from field investigations
- Internet exploration on specific topics of interest
- Online resources provided on the Texas Education Agency website: http://www.tea.state.tx.us/curriculum/science/scienceresources.html

- Visits to museums, parks, and zoos
- Investigations using everyday materials and objects found in nature

What kinds of practice questions are in the Science Study Guide?

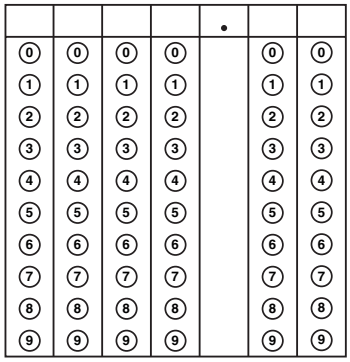
The Science Study Guide has questions similar to those found on the middle school science TAKS test. There are three types of questions in the study guide.

- **Multiple-Choice Questions:** Most of the practice questions are multiple-choice items with four answer choices. Many of these questions follow a short passage, a chart, a diagram, or a combination of these. Read each passage carefully. If there is a chart or diagram, study it. Passages, charts, and diagrams contain details, data, or other information that will help you answer the question. Then read the question carefully and think about what you are being asked. Read each answer choice before you choose the best answer. It's always a good idea to read the question again after you have thought about each answer choice.
- **Cluster Questions:** Some multiple-choice questions are grouped in a cluster. Each cluster begins with an introduction that may include a passage, a diagram, a chart, or a combination of these. The information in the introduction will help you answer the cluster questions. The introduction is followed by three to five multiple-choice questions. The cluster questions usually test several different science objectives. However, the questions are all related to the topic introduced at the beginning of the cluster. You should read and study the introduction carefully before you answer the cluster questions. Then think about what you already know from your study of science. You will see examples of science clusters on pages 122–130.
- **Griddable Questions:** Some questions use a seven-column answer grid like the one used on the Grade 8 mathematics TAKS test.

  Griddable questions ask you to measure something or to use math to solve a science problem. You will see an example of a griddable question on page 9.

How do I use an answer grid?

The answer grid contains four columns of numerals followed by a fixed decimal point and then two additional columns of numerals. Your answer will always be limited to a number from 0 through 9,999.99.



This is the grid found on the actual TAKS answer document.

To grid your answer, locate the decimal point in the answer grid. Then place digits to the left and right of the decimal point as they appear in your answer. Then carefully fill in the appropriate circles underneath for the numerals at the top of each column. Columns without numerals can be left blank or filled in with zeros. Be sure to check your answer for the correct placement of each digit in your answer and that the circles are correctly filled in below each numeral. A common mistake is to bubble the answer in the wrong columns.

Let's look at an example of a griddable question.

Example question:

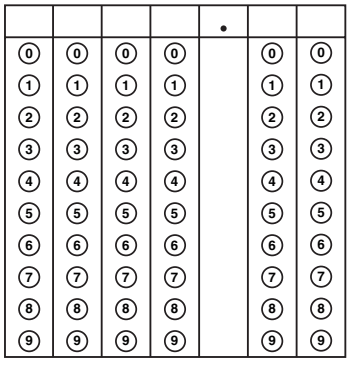
In an experiment, ten sunflower seeds were placed in moist soil in each of four identical pots. Each pot was kept in the same environment for five days. The results in the data table below show the number of seeds that sprouted and grew.

Seed Sprouting

Trial #	Sprouted
1	7
2	3
3	8
4	4

On your answer sheet, grid in the total number of seeds that sprouted in this experiment.

Fill in the correct answer on the blank grid below.



The correct answer to this example question can be found in the answer key section of the study guide on page 139.

How will I know whether I answer the practice questions correctly?

The answers to the practice questions are in an answer key at the back of the study guide starting on page 139. For most questions, the answer key explains why each answer choice is correct or incorrect. After you answer the practice questions, you can check your answers to see how you did. If you chose the wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

If you still do not understand the correct answer, ask a friend, family member, or teacher for help. Even if you choose the correct answer, it is still a good idea to read the answer explanation for the correct answer. It may help you better understand why the answer is correct or why another answer you thought might be correct really is not correct.

Is there anything else in the Science Study Guide?

Yes! A formula chart is provided on page 12 of this study guide. It is identical to the formula chart that is provided to you when you take the Grade 8 science TAKS test. You will need the formula chart to answer some of the practice questions. Although you don't have to memorize the formulas and conversions, you do need to know how to use them to solve science problems. Remember, knowing which formula to use is just as important as knowing how to use it. You'll learn more about formulas, constants, and conversions in the review for Objectives 3 and 4. The formula chart also contains a 20-centimeter ruler.

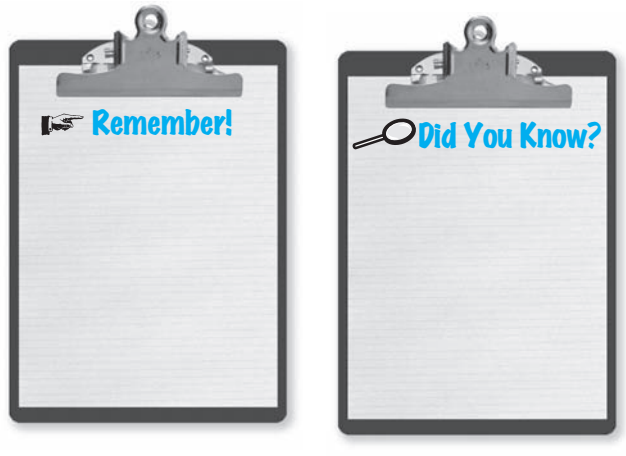
A periodic table of the elements is provided on page 11. An identical periodic table is provided when you take the Grade 8 science TAKS test. You will need information from the periodic table to answer some of the practice questions. You will learn more about the periodic table in the review for Objective 3.

In addition to the materials on pages 11 and 12, a tear-out copy of the formula chart and periodic table is provided at the back of the study guide.

There is a science activity called "Sudden Impact! Crashing the Crater Mystery" on page 131. You can do this activity at home. It will help you practice and strengthen some of the science skills that you'll review in Objective 1 beginning on page 14. After you complete the activity, you can compare your results with the sample results on page 149.

On each of the review pages, a space labeled My Notes has been provided in the page margin for you to write notes as you read. You should use this space to write down anything you think will help you remember the information you are reading. You can also add information from your own science knowledge that may not be in the study guide.

Many of the review pages contain clipboards. The clipboards contain tips, helpful information, important facts, and interesting details.



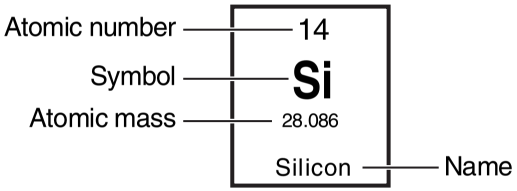
Remember! clipboards contain information that you have probably learned before. They help you refresh your memory.

Did You Know? clipboards contain fun science facts that are probably not familiar to you.

How do I use this study guide?

Carefully read each section. If you do not understand something, ask your parents or a teacher for help. Then answer the practice questions. Use the answer key at the back of the study guide to check your answers. It is a good idea to read all the sections and answer all the practice questions even if you passed some of these objectives on the TAKS test. Study at a pace that is comfortable for you. The Science Study Guide contains a lot of information. If you plan to read all the reviews and answer all the practice questions, you may want to allow yourself several weeks.

Periodic Table of the Elements



	Group 1	2											13	14	15	16	17	18
1	1 H 1.008 Hydrogen																	2 He 4.0026 Helium
2	3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.179 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium	3	4	5	6	7	8	9	10	11	12	13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.08 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc (98) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.763 Antimony	52 Te 127.60 Tellurium	53 I 126.904 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.905 Cesium	56 Ba 137.33 Barium	57 La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po (209) Polonium	85 At (210) Astatine	86 Rn (222) Radon
7	87 Fr (223) Francium	88 Ra 226.025 Radium	89 Ac 227.028 Actinium	104 Rf (261) Rutherfordium	105 Db (262) Dubnium	106 Sg (263) Seaborgium	107 Bh (262) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 (269)								

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (145) Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.930 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
Actinide Series	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (251) Californium	99 Es (252) Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

FORMULA CHART
Middle School Science
Grade 8

Work = force × distance	$W = Fd$
Speed = $\frac{\text{distance}}{\text{time}}$	$s = \frac{d}{t}$
Force = mass × acceleration	$F = ma$
Weight = mass × acceleration due to gravity	$Weight = mg$
Density = $\frac{\text{mass}}{\text{volume}}$	$D = \frac{m}{v}$

Constants/Conversions
g = acceleration due to gravity = $9.8 \frac{\text{m}}{\text{s}^2}$
speed of light = $3 \times 10^8 \frac{\text{m}}{\text{s}}$
speed of sound = $343 \frac{\text{m}}{\text{s}}$ at sea level and 20°C
$1 \text{ cm}^3 = 1 \text{ mL}$

A tear-out copy of the formula chart and periodic table can be found in the back of this study guide.

Things I Need to Know

Objective 1

The student will demonstrate an understanding of the nature of science.

My Notes

Through scientific investigations, you should be able to demonstrate an understanding of the nature of science.

What is "the nature of science"?

The nature of science is just a way of looking at the world around us. Science is a process of trying to answer questions based on evidence. Scientists make observations and measurements to gather evidence during their investigations. Without thinking about it, we use the same processes that scientists use.

We do? How?

When we ask questions about our world, we are thinking like scientists. Let's say that you are in gym class and are about to run a 400-meter race. What question might you ask?

How long will it take me to run 400 meters?

Good question! Now you need to find the answer. How can you do that?

Can I run the 400 meters and have someone time me?

That will work. You just made a plan to answer your question. What do you think the answer will be?

My Notes

I think I can run 400 meters in 60 seconds.

Good! You just made a hypothesis. When we investigate questions, we usually try to predict the answer first. It's called making a *hypothesis*. A hypothesis is a reasonable prediction that can be tested. What is your hypothesis? And, by the way, why did you say 60 seconds?

Well, I know I can run 100 meters in 12 seconds. But I would have to run at a little slower pace to go 400 meters.

Great job! You used data to make your hypothesis. That's thinking like a scientist. After you run the 400 meters, you can check to see whether your hypothesis was correct.

O.K., so I've made a hypothesis about the 400 meters. Am I ready to run?

Yes, and we need to measure your time. Let's say you run and it takes you 72 seconds. Now you have some data.

But what if I was just really slow that day?

That's a very good point. If we want to be more sure of our data, we should repeat the investigation several times. For example, you might run the 400 meters three times during each gym class for one week. You could record your time for each run in a data table like the one below.

400-meter Run Times

Day	Time (s)			Average Time (s)
	Run 1	Run 2	Run 3	
Monday	72	73	72	72
Tuesday	71	73	72	72
Wednesday	73	72	70	72
Thursday	70	71	72	71
Friday	73	71	71	72

Now what am I supposed to do with the run times in my table?

You now have enough data to draw a *conclusion*. A conclusion involves looking at your data and comparing it to your hypothesis. Your hypothesis was that you could run the 400 meters in 60 seconds. Study the data in the table. What did you learn?

My Notes

My results don't agree with my hypothesis! So the investigation failed, right?

Not at all! We still learn something important when the results of an investigation do not support the hypothesis. For instance, you learned that your 400-meter run time is about six times greater than your 100-meter run time. You didn't know that until you did the investigation.

O.K., that's a good everyday example. What about when we do science experiments?

Well, before we begin an experiment, what is the first thing your teacher always reminds you about?

Lab safety, right?

Yes! The first rule of scientific experimentation is to be safe.

Wait! Can I show you the poster our lab group made that shows some of the important safety rules?

Sure, let's see it.

Laboratory Safety Rules

1. Know the location of all safety equipment (eye wash, fire extinguisher, fire blanket, fire alarm) and the correct route to leave the lab in case of an emergency.
2. Tie back loose clothing and hair. Wear all required safety equipment for a lab (goggles, apron, gloves, etc.) at all times unless you are told to remove them.
3. Do not taste, smell, or handle any material in the laboratory unless told to do so.
4. Never run, push, or play in the laboratory.
5. Handle lab equipment with care and use the proper tools.
6. Report any accident or equipment problem to the teacher immediately.

That's a great list of important safety rules. I'm sure your teacher will tell you about special safety issues related to the specific experiments you do. And you should also be familiar with the safety symbols used in the lab.

Now we are ready to experiment. What would you like to investigate?

My Notes

When I walk home on sunny days, it seems like I feel warmer when I wear black clothes than when I wear white clothes. Can we do an experiment to find out whether black clothes really gain more heat?

Sure! So let's put our experimental problem in the form of a question that can easily be tested. How about stating it like this: Will a black T-shirt gain more heat in sunlight than a white T-shirt will?

Next you will need to make a hypothesis. What prediction can you make about what will happen in your experiment?

Since I seem to feel warmer when I wear black clothes, I predict that the black T-shirt will gain more heat. Does that sound good?

That sounds reasonable. Now we need to plan an experiment to test the hypothesis. First we need to decide what equipment to use.

Obviously, we need two T-shirts—one black and one white. And we need a thermometer or temperature probe to measure temperature. Let's see. Have I forgotten anything?

You want the shirts to be identical except for color. Also, you need something to measure the length of time the shirts are in the sun.

If we need to measure time, won't we need a watch?

Good choice. I think those materials will work. Now we need to use them to test the hypothesis.

First we need to identify the *variables*. Variables are the values or quantities that change (vary) during an experiment. Which variable will we measure to see whether sunlight makes the black T-shirt gain more heat?

The temperature. We think it will go up, right?

That's right. In our experiment, temperature is the *dependent* (responding) *variable*. We observe the dependent variable to see whether it changes (responds) during the experiment.

Another important variable is the *independent* (manipulated) *variable*. This is the variable that we change on purpose (manipulate) to try to get a response out of the dependent variable. What is the independent variable in our T-shirt experiment?

Isn't the independent variable the color of the T-shirts?

That's right.

But what if something else makes one T-shirt gain more heat than the other? For example, what if one T-shirt gets more sunlight than the other?

You're really thinking like a scientist now! We need to make sure that

My Notes

all the other possible variables are the same for both T-shirts. The other variables are called *controlled variables* (constants), because we want to keep them the same (controlled) for both T-shirts.

We can start by folding the T-shirts into squares the same size and putting them in the sun side by side. This way they will have equal areas exposed to the sunlight. They will also need to be in as close to the same environment as possible.

I think we also need to make sure the T-shirts are in the sun for the same amount of time. Are we going to control the time?

Yes, you're right. We can shade both shirts until we are ready to start the experiment. Then we can take temperature readings of both shirts at the start and after 15 minutes and after 30 minutes.

Let's summarize the design of our experiment:

1. My question: "Will a black T-shirt gain more heat in the same amount of time in sunlight than a white T-shirt?"
2. My hypothesis: "The black T-shirt will gain more heat than the white T-shirt."
3. The variables:
   - Independent variable: color of T-shirt (white versus black)
   - Dependent variable: temperature change of T-shirts
   - Controlled variables: size of T-shirts, time T-shirts are in sunlight
4. The materials:
   - 2 thermometers
   - 2 T-shirts the same size, one black and one white
   - Watch
   - Piece of cardboard to use as a shade
5. The procedure:
   a. Fold T-shirts into 20 cm squares and lay them on a flat surface in the sun. Cover them with a piece of cardboard.
   b. Place a thermometer inside the fold of each T-shirt.
   c. Remove the cardboard shade and record temperature of each T-shirt at 0, 15, and 30 minutes.

My Notes

O.K., now I'll make a data table for our temperature measurements. Once I've done that, are we ready to start the experiment?

Yes, let's do it. You can read the temperatures, and I'll record them in the data table.

Here's what the data table looks like after the experiment is finished:

T-Shirt Temperature (°C)

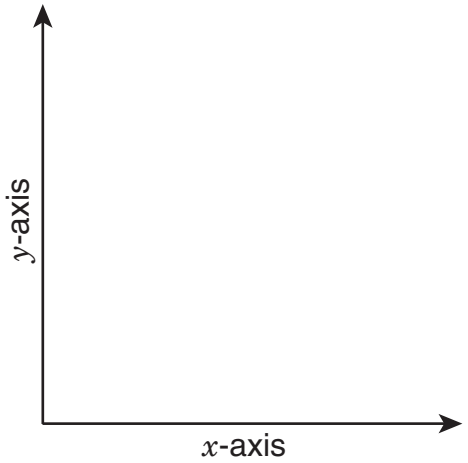
T-Shirt Color	Time (min)		
	0	15	30
Black	32	35	37
White	32	33	35

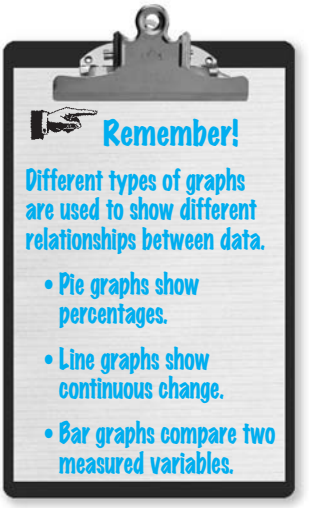
Are there other ways to show our results?

Yes, we can make a graph. Graphs can make data easier to read and compare. What kind of graph would you suggest? A pie graph, a bar graph, or a line graph?

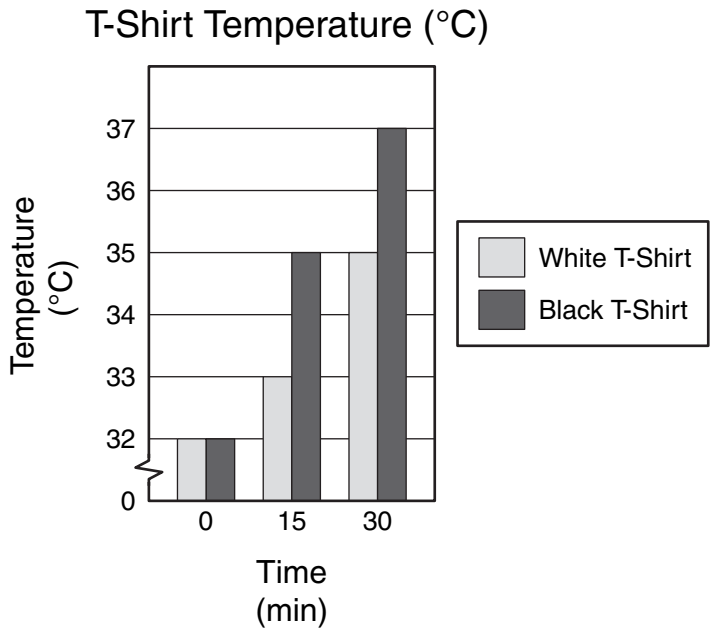
Let's see. We are comparing the two T-shirts at equal times. How about a bar graph?

Yes, a bar graph would help us see the temperature difference between the two colors very easily. Bar graphs compare two variables that do not affect each other, such as the T-shirt colors. The bars for the two variables being compared are placed side by side at points along the *x*-axis. The scale for the values is placed on the *y*-axis.





My Notes



Wow! The graph does make it easier to see the results. What now?

Now that we have results, we can reach a conclusion. Remember, the data may or may not support the hypothesis you made. Was your hypothesis supported by the data?

Yes, the temperature of the black T-shirt was greater. But what if somebody doesn't agree with the data or my conclusion?

That's a very important question. A scientific conclusion doesn't become accepted until more investigation is done. Experiments are usually repeated, or the data are checked with other research. This is called verifying scientific data.

So we can use data to see whether someone is making a false statement about something they have done or maybe a product they are selling?

That's exactly right. Advertising has good examples of this. Sometimes products are advertised with claims that are not supported by scientific results. It is important for buyers to be able to look at the data and come to their own conclusions. If there are no data, or if a poor investigation produced unreliable data, then the advertising claims may not be true.

My Notes

Here, I have a cookie package in my backpack. The label on the back gives information about the cookies. What does the label tell us?

Oatmeal Cookies	
Nutrition Information	
Serving size: 28 g (about 3 cookies)	
Calories:	128
Protein:	2 g
Fat:	5 g
Carbohydrate:	19 g
Fiber:	1 g
Sugar:	7 g

The label names the product and shows how much product is in one serving (serving size). The energy (in Calories) and mass (in grams) of each nutrient in one serving is also shown.

How could this information be useful?

Let's say the cookie company produces a TV commercial that shows a man eating the oatmeal cookies. The man says four servings of the cookies supply all the protein he needs each day. Is this statement true? Let's check it out.

How do I know whether the advertisement's claim is true or false?

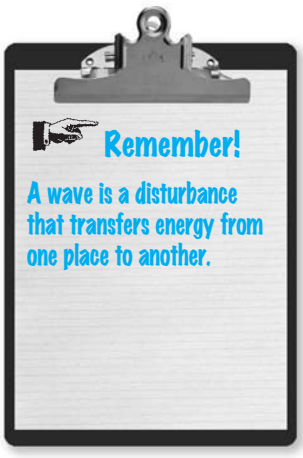
According to its website, the Food and Drug Administration (FDA) recommends that the diet of an adult man should contain 56 grams of protein per day.

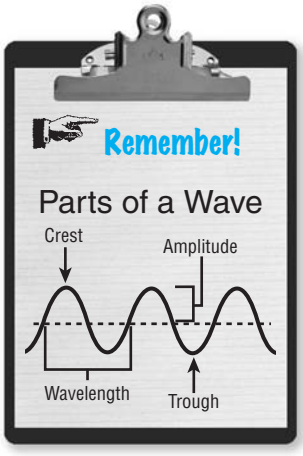
The label says that each serving (3 cookies) supplies 2 grams of protein. So four servings would contain only eight grams of protein ($2\text{ g} \times 4 = 8\text{ g}$). But according to the FDA, he needs 56 grams per day. This would mean that he still needs 48 more grams of protein ($56\text{ g} - 8\text{ g} = 48\text{ g}$). So the man in the advertisement is making a false statement.

We've looked at data in tables, graphs, and on labels. What's another way that we can gain information to help us understand the things and events that we observe?

Observations may lead us to discover patterns in the natural world. From these patterns we can form *models*. A model is a description or representation of something that cannot be directly observed. What's a natural pattern you can think of that might be modeled?

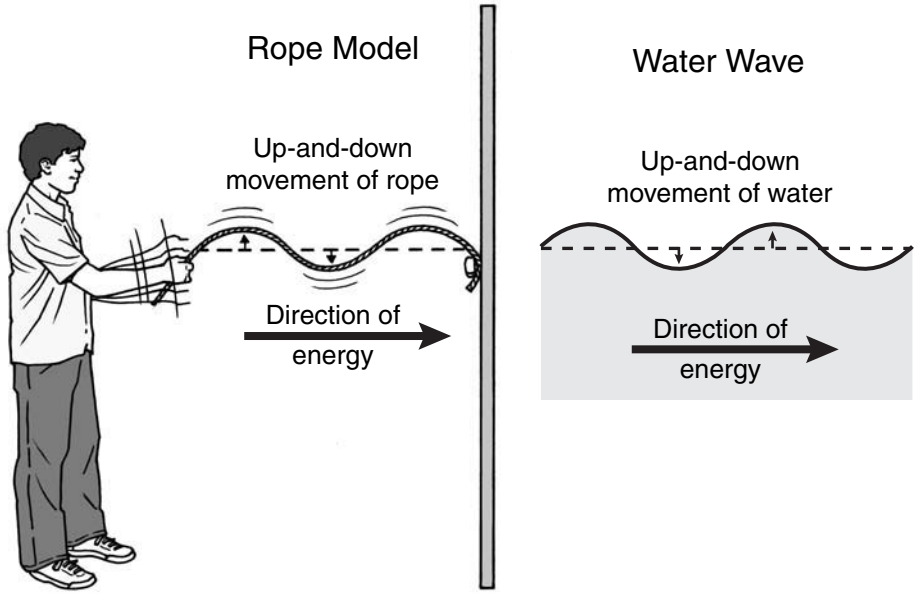
My Notes





How about wave patterns on water?

That's a good example. Let's say data show that water is moved up and down by a passing wave. To model this, we might tie a piece of rope at one end and swing it up and down on the other end. The energy passing through the rope models the way energy passes through the water.



Using this model, we can show what will happen to the wave if we add more energy. To do this, we swing the rope up and down with more energy. This makes the rope travel higher. We can see from the model that water waves will get higher if the wind blows harder.

That's pretty neat! Do models work for everything?

No. Models help us, but they also have limitations. For example, the rope model above does not tell us how a water wave will act when it reaches the shore. When a wave reaches shallow water, its shape changes. This causes a wave to "break," or fall forward. We can't easily model this using a rope. Models must be examined and tested before we can know how well they represent real-world situations.

So with good data and accurate models we can make predictions about our world?

Yes, that's an important part of science. Data and models often show trends or patterns that allow us to predict events. From a trend or pattern, we can make a reasonable guess about data we haven't measured yet.

My Notes

For example, let's look back at our T-shirt experiment. In our experiment the black T-shirt's temperature increased 5°C and the white T-shirt's temperature increased 3°C in 30 minutes.

How does that help us make a prediction?

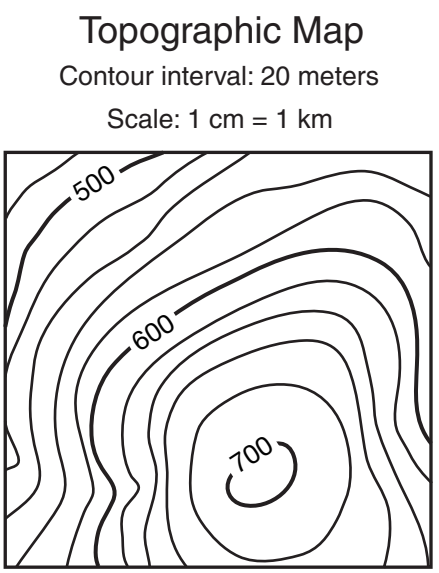
We might use the data to make a prediction about the temperature change in a black-and-white striped T-shirt. We could predict that under the same experimental conditions, the temperature of the black-and-white T-shirt would increase 4°C in 30 minutes.

Of course, predictions do not always prove true. In another experiment the black-and-white striped T-shirt may not increase in temperature 4°C in 30 minutes. But based on our data, we can reasonably expect the result we have predicted.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose a wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 1



What is the major landform shown on the topographic map above?

A River

B Hill

C Plain

D Lake

Answer Key: page 139

Question 2

The closed terrarium shown above models a plant growing in an ecosystem. The plant cannot survive in the terrarium over a long period of time. Which of the following most limits the growth of the plant?

A Decrease in carbon dioxide

B Decrease in oxygen

C Evaporation of water

D Lack of sunlight

Answer Key: page 139

Question 3

The student shown above is digging to collect a soil sample. Which of the following is the least important safety practice for this activity?

A Wearing goggles

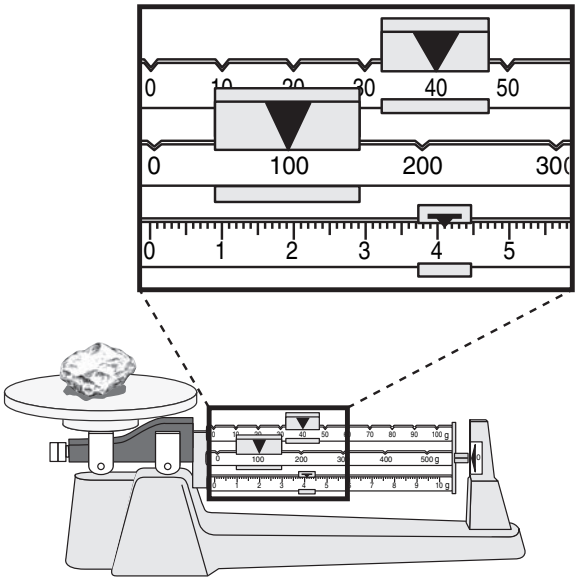
B Wearing close-toed shoes

C Knowing where the shovel is kept

D Removing jewelry

Answer Key: page 139

Question 4

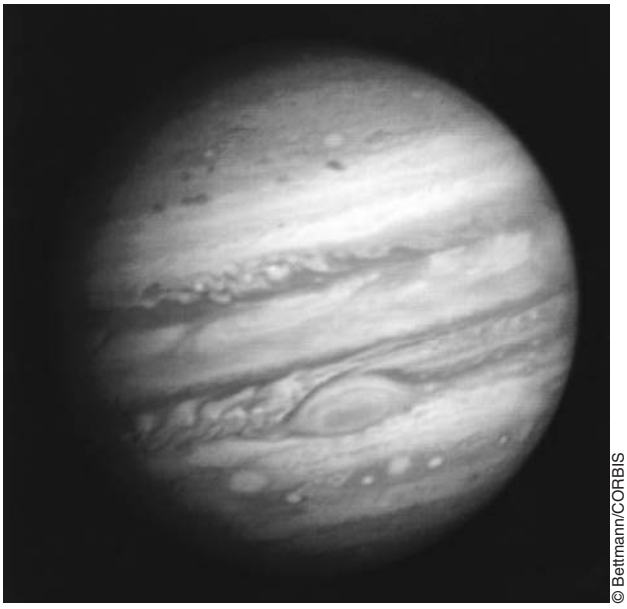


The diagram above shows a close-up view of a triple-beam balance that is being used to measure the mass of a rock. What is the mass of the rock in grams according to the diagram? Record and bubble in your answer to the tenths place below.

				.		
0	0	0	0		0	0
1	1	1	1		1	1
2	2	2	2		2	2
3	3	3	3		3	3
4	4	4	4		4	4
5	5	5	5		5	5
6	6	6	6		6	6
7	7	7	7		7	7
8	8	8	8		8	8
9	9	9	9		9	9

Answer Key: page 139

Question 5



© Bettmann/CORBIS

The planet Jupiter has dark-colored bands and large spots in its outer atmosphere that constantly change. Which of the following tools would be most useful in observing Jupiter's bands and spots from Earth?

A Telescope

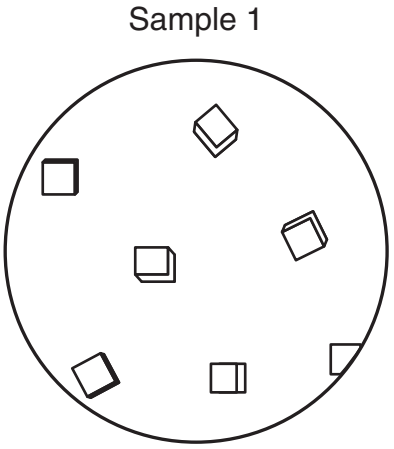
B Microscope

C Hand lens

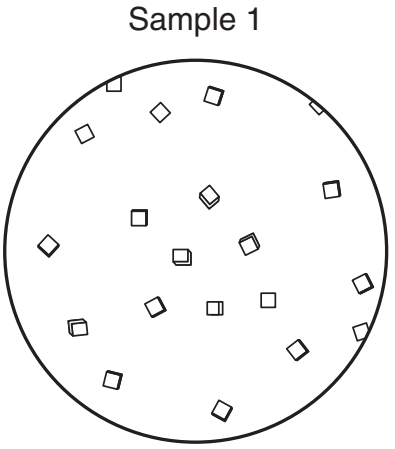
D Computer probe

Answer Key: page 139

Question 6



View A



View B

The two images above are views of the same sample of salt grains under a microscope. Which action would most likely cause the difference in the size of the individual salt grains as seen in the two views?

A Switching the objective lens

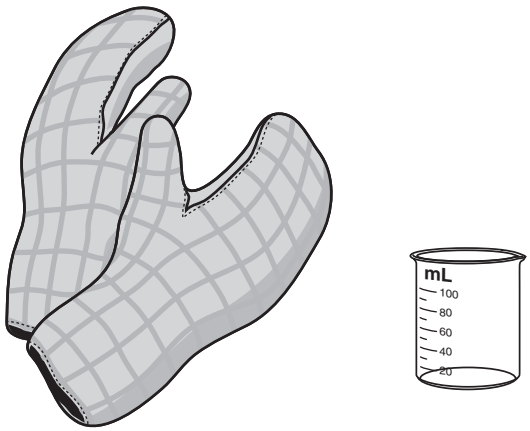
B Adjusting the diaphragm

C Turning the fine adjustment knob

D Changing the angle of the light source

Answer Key: page 140

Question 7



Which of the following activities would most likely require the equipment shown above?

A Catching fish in an aquarium

B Heating a mixture of two liquids

C Measuring outdoor temperatures

D Finding the mass of a rock sample

Answer Key: page 140

Question 8

A microscope would be the best tool for gathering data in which of the following activities?

A Observing the structure of onion cells

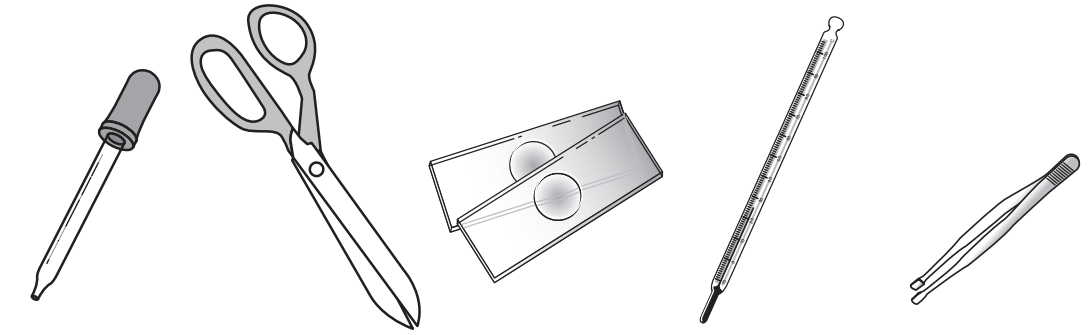
B Measuring the size and shape of craters on Mars

C Observing the color change of two mixed liquids

D Measuring the heat reflected by a sheet of aluminum foil

Answer Key: page 140

Question 9



Which of the following sets of equipment would be most useful when examining a sample of pond water with a microscope?

A Slides and forceps

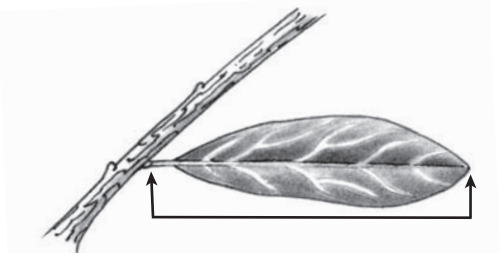
B Eyedropper and slides

C Eyedropper and scissors

D Scissors and thermometer

Answer Key: page 140

Question 10



When compared to a leaf that is 32 mm long, how much longer is the leaf shown above?

A 3 mm

B 10 mm

C 42 mm

D 74 mm

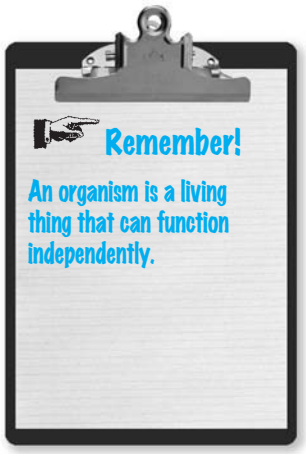
Answer Key: page 140

Objective 2

The student will demonstrate an understanding of living systems and environment.

My Notes

From your studies in science, you should be able to show an understanding of living systems and their environments.



What are "living systems"?

That's a good question. A system is made up of different parts. An example of a living system is an ecosystem or a single organism made up of many parts—such as a human being. We have bones, muscles, and nerves, as well as many other parts. These parts all work together to help us live. All these parts are made up of cells, the smallest unit of a living system.

I know something about cells. They are very small, right?

Yes, you're right. We need a microscope to see most cells. Tell me what else you know about cells.

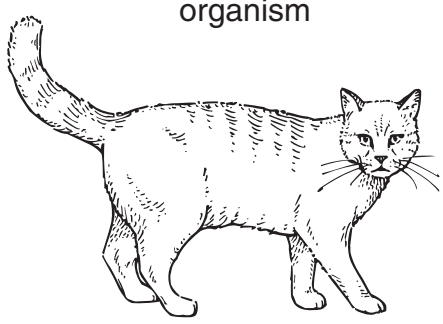
All living things are made up of cells, aren't they?

Correct. Some organisms are made up of only one cell. These organisms are called single-celled (unicellular). Other organisms are made up of many cells. Larger organisms, such as humans, have billions of cells. Organisms with many cells are called multicellular.

Single-celled organism

(magnified view)

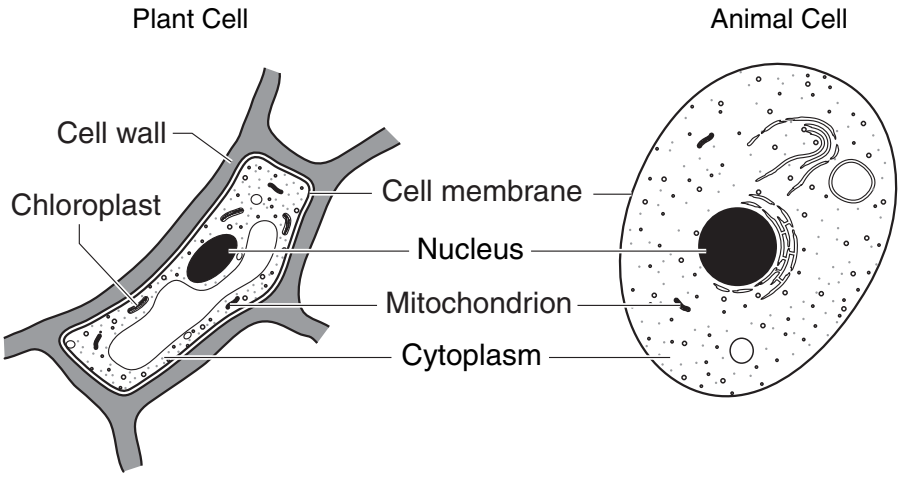
Multicellular organism



My Notes

So all cells are the same?

No, not really. All cells have many of the same basic structures. Look at the diagram below of a plant cell and an animal cell. Do you see any structures that are the same?



They both have a cell membrane, a nucleus, and cytoplasm, right?

Yes. Both plant and animal cells have these parts. But plant cells also have cell walls for support and chloroplasts to carry out photosynthesis. Plant and animal cells both have mitochondria to provide the energy needed for cell activities.

Do all plant and animal cells look like the ones shown above?

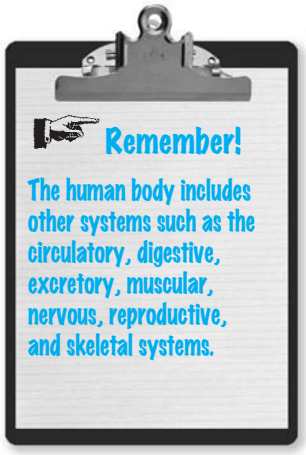
No. These two cells just give us an idea of the basic structure of cells. Plant and animal cells actually have many different shapes and sizes, depending on their function.

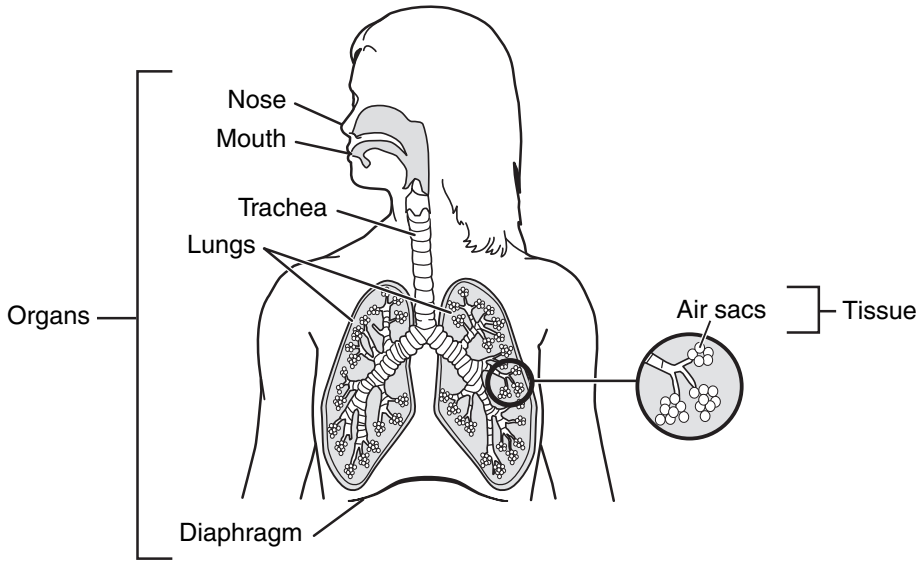
In a single-celled organism, one cell must perform all the functions of that organism. In multicellular organisms, different cells perform different functions. In the human body, for example, nerve cells transmit signals and muscle cells aid in movement. There are many different types of *cells* that make up the *tissues*, *organs*, and *organ systems* in the human body. Tissues are made up of many similar cells doing a single job. Organs are made up of different kinds of tissues that work together. An organ system is a group of organs working together.

My Notes

I don't quite understand the difference between tissues, organs, and organ systems. Can you give me an example?

Sure! Let's look at the respiratory system. Here's a diagram of the human respiratory system.



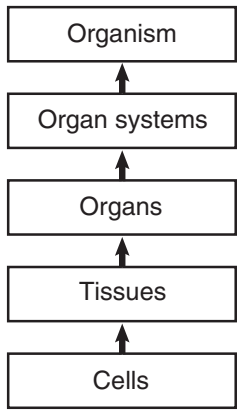


When you breathe, cells in your lungs help move oxygen into your bloodstream. Many of these cells together form an air sac, which is a kind of lung tissue. These and other tissues together form a lung, which is an organ. The mouth, nose, and trachea are other organs that work together with the lungs to help you breathe. These are some of the organs that make up the respiratory system. The respiratory system is just one of many organ systems in the whole human organism.

So cells make up tissues, tissues make up organs, organs make up organ systems, and organ systems make up an organism?

You've got it! Here's a diagram to help you remember the levels of organization within your body.

Levels of Organization



My Notes

O.K., I get it. The human body is one big organism with lots of smaller systems that function together, right?

That's exactly right.

So what keeps all those parts working together?

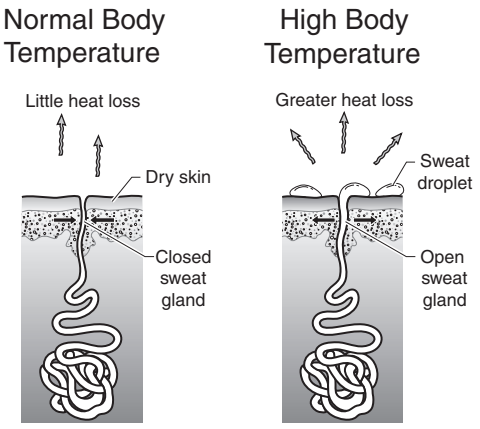
Systems must work together to carry out various life functions. For example, when a runner runs around a track, different systems have to work together. Muscles move the runner's arms and legs. This uses up oxygen, which must be provided through the bloodstream. The heart starts beating faster to move more blood to the muscle cells that need oxygen. As the breathing rate increases, the lungs have to take in oxygen and get rid of carbon dioxide more quickly. The brain sends signals to the lungs, heart, and muscles to coordinate all these activities. It's really amazing how well the parts of the human body work together.

What about conditions that need to stay constant, such as body temperature?

The body has ways of adjusting to different conditions. Keeping conditions such as body temperature constant is called *equilibrium* (homeostasis). Equilibrium occurs when a system is balanced.

When we exercise, isn't sweating somehow involved in keeping our body temperature from getting too high?

Yes, that's part of the story. If the body temperature gets too high, sweat glands open up, causing a person to sweat. The sweat then evaporates, carrying heat energy away from the body. This cools the skin. When the body temperature returns to normal, another nerve signal is sent out to close the sweat glands. Sweating is one type of *feedback mechanism*. A feedback mechanism is a response of an organism to a given change, such as temperature or the amount of light.



Are there any other types of feedback mechanisms?

Sure. One controls the amount of water in cells. Others control chemical reactions in the body and in cells. But all feedback

My Notes

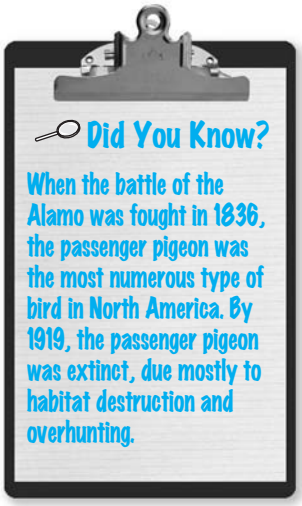
mechanisms are designed to recognize and respond to the changing needs of organisms.

What happens when an organism can't maintain equilibrium in its environment?

Sometimes an organism becomes sick or injured. Sometimes a temporary change in the organism's environment is too extreme (for example, extremely cold temperatures or lack of rainfall). The organism may die if it cannot maintain equilibrium. However, most organisms are *adapted* to the environment where they live. Their body systems and behaviors adjust or change to allow them to survive in the new environment.

What happens to an organism if the environment changes permanently, such as when a warm climate becomes gradually colder?

If an organism does not have adaptations that allow it to live in the colder climate, then it must move to a warmer environment or it will die. This can affect single organisms as well as whole populations. Occasionally, such long-term changes cause the death of every member of a species. The loss of an entire species is called *extinction*.



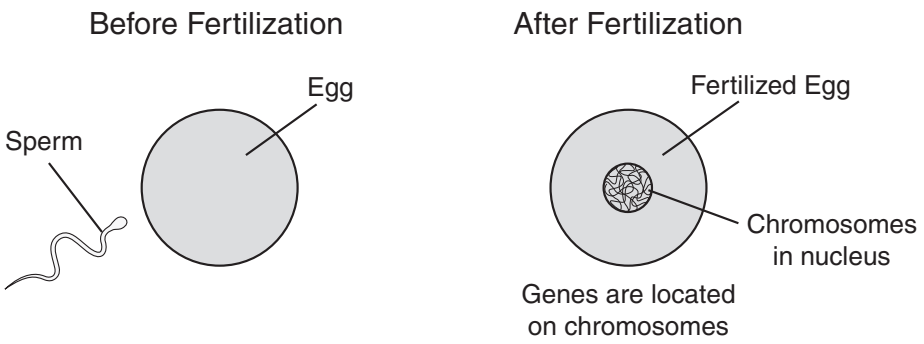
You keep talking about adaptations. What are adaptations and how do organisms get them?

Some organisms may be able to survive cold weather because they have an advantage such as thick fur. *Genes* passed from parents to offspring may cause the offspring to have thick fur. A gene is a segment of DNA on a chromosome. This type of characteristic is called a *genetic trait*. A gene is a portion of DNA that contains information for a specific trait. A genetic trait that helps an organism survive in its environment is called an adaptation. Adaptations can be either physical characteristics or behaviors.

O.K., I get that genes control traits. But how are genes passed from parents to offspring?

During reproduction, the parents' genes in the *sex cells* (egg and sperm) will create the new organism. This is called *sexual reproduction*. In sexual reproduction, both parents pass the genes for traits on to their offspring. Half the genes for these traits come from the male parent, and half come from the female parent. Sexual reproduction therefore results in genetic diversity due to the large number of gene combinations that may occur.

My Notes

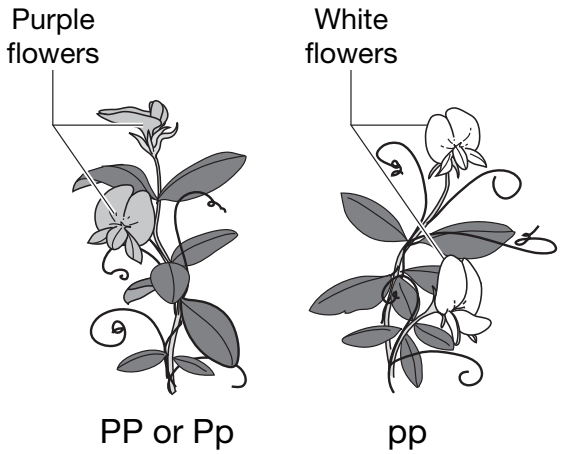


That's interesting. I thought all the parents' traits were passed down to the offspring. How do genes combine to produce different traits?

Each parent has genes that occur in pairs and, due to the production of the special sex cells, only one of the *alleles* of a gene pair will be in each sex cell. Alleles are forms of the same gene. So the offspring receive one allele of a gene from the mother and one from the father. They often occur in two forms called *dominant* and *recessive*. If a *dominant allele* of a gene is present, the dominant trait will appear in an organism. A capital letter is used to show a dominant allele. In order for a recessive trait to be expressed, both alleles of the gene must be recessive. A lowercase letter is used to show a recessive allele.

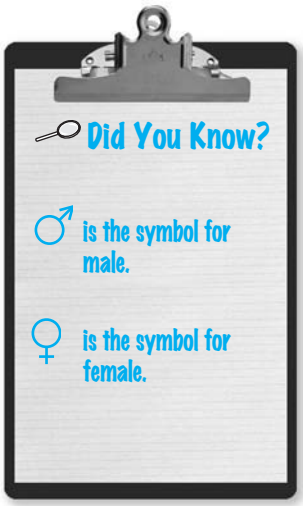
This is all getting a little confusing. Can we look at an example?

Sure. Let's look at a simple dominant-recessive trait in pea plants. A pea plant can have purple or white flowers. The dominant trait is purple flowers, which is an expression of the dominant allele (P). The recessive trait is white flowers, which is an expression of the recessive allele (p).



A pea plant will have purple flowers if it receives a dominant allele from one or both parents (Pp or PP). A plant will have white flowers only when both parents contribute an allele for the recessive trait (pp).

My Notes



So what happens when a purple pea plant is crossed with a white pea plant?

Let's say a purple-flowered male with one dominant and one recessive allele (Pp) is crossed with a white-flowered female with two recessive alleles (pp). To show the combinations of alleles that can occur, we can use a Punnett square. A *Punnett square* is a table showing all the possible combinations of the alleles for a trait that can occur in offspring from a genetic cross.

Punnett Square

pp ♀ \ Pp ♂	P	p
p	Pp	pp
p	Pp	pp

O.K., the Punnett square shows four combinations. Does that tell us there will be only four offspring?

No. Each box in the square represents one possible combination of alleles. An offspring has an equal chance of getting any one of these combinations. Since there are four combinations, there is a 25% chance that an offspring will end up with the allele combination given in a particular box. At the same time, there might be any number of offspring, each with the same chance of having one of the four possible combinations of alleles.

What do the allele combinations "Pp" and "pp" from the Punnett square tell us?

Two out of every four (50%) of the offspring are likely to have purple flowers because they have one dominant allele (Pp). Two out of every four offspring (50%) are likely to have white flowers because they have two recessive alleles (pp). Actual offspring do not always occur exactly in these ratios because of random chance in the combining of genes.

My Notes

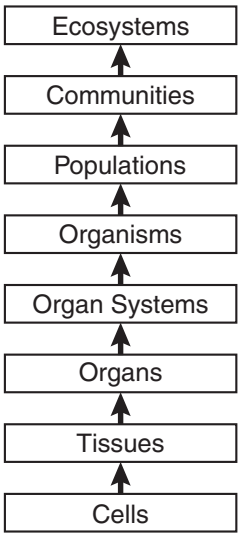
So is this the way all genes are inherited?

No, not all traits are inherited in this simple dominant-recessive pattern. This pattern was explained by Gregor Mendel in the 1860s. Since that time we have discovered that some traits result from other genetic patterns. You will learn more about these other patterns in high school biology.

O.K., I understand levels of organization and how traits are passed on to offspring. How does all this fit into an ecosystem?

Let's look at the parts of an ecosystem first. An *ecosystem* includes the living and nonliving parts of an environment. The nonliving part includes water, soil, light, and air. The living part includes plants, animals, and other living organisms. The living part of the ecosystem makes up the *community*. A community is a group of different types or *populations* of plants, animals, and other organisms living and interacting with one another in an environment. Each population of plant, animal, or other organism in a community lives in a particular part of that environment called a *habitat*. A habitat is the specific place in which an organism makes its home.

Remember the levels of organization we talked about earlier? We can add population, community, and ecosystem to the diagram. As we move up the diagram, each level is more complex.



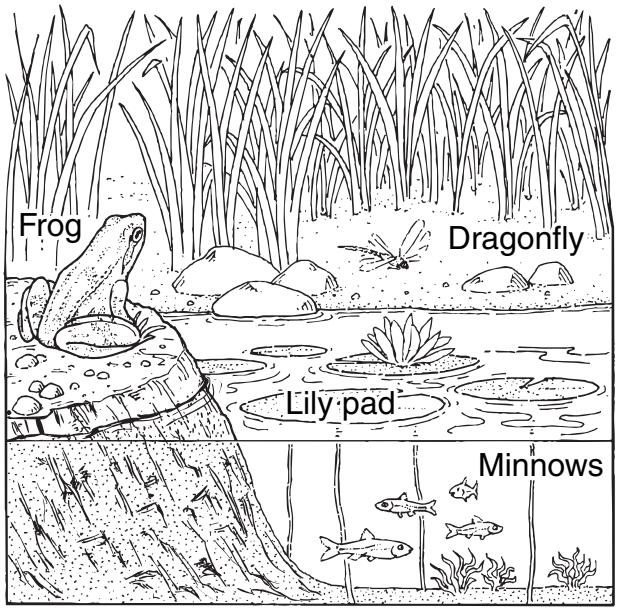
My Notes

All organisms interact with their environment. For example, minnows, frogs, lily pads, and dragonflies might live together in a pond community. They are each affected by the other organisms and by nonliving things, like sunlight, water, and air. Each part of the community has its own function, but together they form the entire pond ecosystem.

Remember!

Biotic parts of an ecosystem are the living organisms. Abiotic parts can be either nonliving materials or environmental factors.

Pond Ecosystem



You said all the pond organisms are affected by one another. How are they connected?

They are connected by the energy that flows through the pond community. Both plants and animals require energy. This flow begins with the plants using energy from the sun and continues through all the organisms in an ecosystem.

Plants change radiant energy from the sun into chemical energy through a process called *photosynthesis*. During photosynthesis, carbon dioxide and water are converted into sugar and oxygen. The process of photosynthesis is shown in the equation below:

Photosynthesis

$$6CO_2 \text{ (carbon dioxide)} + 6H_2O \text{ (water)} \xrightarrow{\text{(sunlight energy)}} C_6H_{12}O_6 \text{ (sugar (chemical energy))} + 6O_2 \text{ (oxygen)}$$

My Notes

Why is sugar important in an ecosystem?

Sugar is food for the plants and for other organisms. When plants are eaten, the energy in the plant matter is passed on to other organisms in a food chain. The sugar produced during photosynthesis provides the energy used by all organisms in an ecosystem.

So chemical energy passes from plants to animals through a food chain. How does that work?

Organisms that can make their own food, such as plants, are called *producers*. *Primary consumers* are animals that get their energy from eating plants. But energy flows even further in an ecosystem. Where would the energy keep flowing?

Animals eat other animals, right?

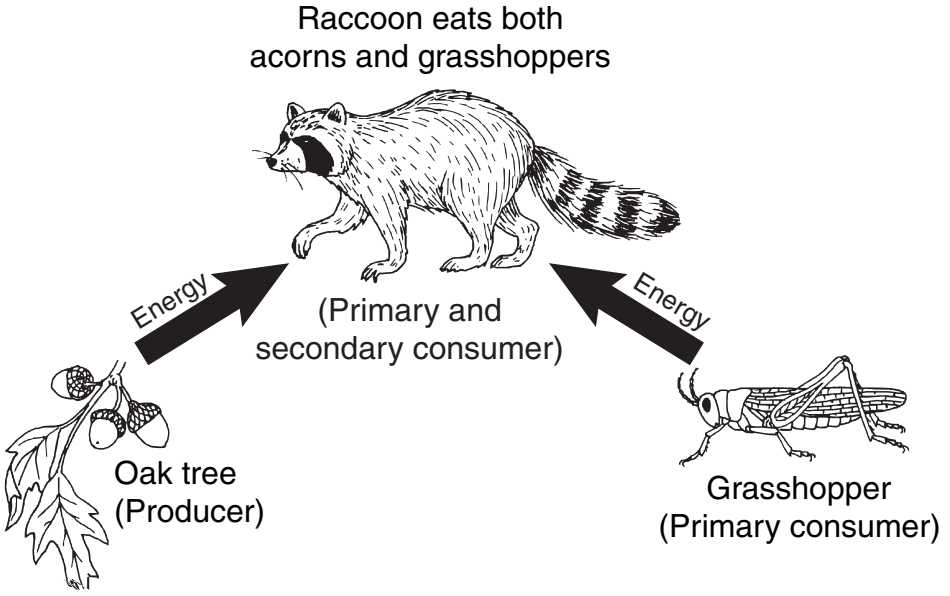
Yes! Some animals get their energy from the other animals they eat. These are *secondary* (second-order) *consumers*. They eat animals that are primary consumers.

Does each animal have just one role in the ecosystem?

Not necessarily. Sometimes an animal's diet may include more than one type of organism, such as plants and different types of consumers. For example, a raccoon eats acorns from oak trees as well as grasshoppers. Oak trees are producers, and grasshoppers are primary consumers. So the raccoon is both a primary consumer and a secondary consumer.

Remember!

Arrows in a food chain or food web point in the direction that energy is being passed.



My Notes

Remember!

Organisms that make their own food are called producers, and those that depend on other organisms for food are called consumers. Organisms that feed on dead plants and animals are called decomposers.

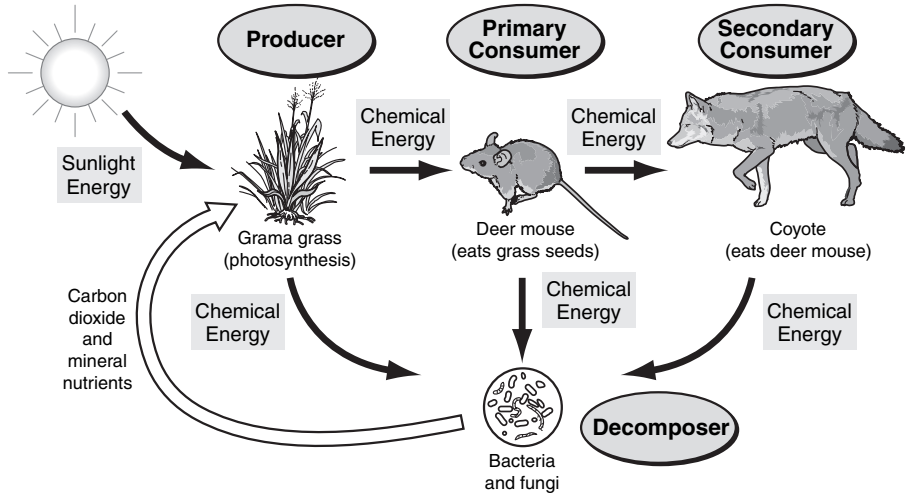
Aren't there special names for animals to describe what materials they eat?

Yes. Animals are also classified according to whether they eat plants, animals, or both. Animals that eat only plants are called *herbivores*. Animals that eat only other animals are called *carnivores*. Animals that eat both plants and animals are called *omnivores*.

What happens to the dead plants and animals?

Organisms called *decomposers* feed on dead plants and animals. This releases the chemical energy and nutrients in the dead plants and animals back into the environment. Bacteria and fungi are common decomposers. Decomposers play an important role in recycling nutrients and energy.

Grassland Food Chain



O.K., I see now. Energy produced by plant photosynthesis flows to each organism in turn, and then decomposers recycle nutrients. Is this what we call a food chain?

Yes. A *food chain* shows the flow of energy from one organism to another to yet another. But the relationships in ecosystems are more complex than just these food chains.

Really? In what way are they more complex?

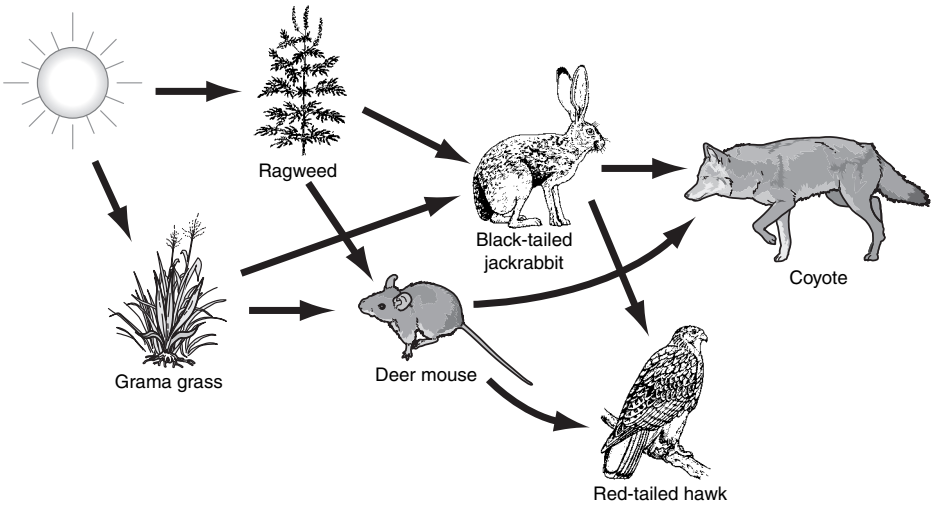
In communities there are many species of producers and consumers. The primary consumers may feed on more than one species of producer. Several different types of secondary consumers may eat the primary consumers. The different food chains overlap, so energy passes in many different directions through all the organisms.

A complex system of energy flow through overlapping food chains is called a *food web*. In a food web diagram, arrows point in the direction that energy flows from one organism to the next. An example of a

My Notes

grassland food web is shown in the following diagram. Note the direction of energy flow from sun to grass to mouse to coyote.

Grassland Food Web



So what about the "balance of nature"? How does that work in a food web?

Every organism in a community has an effect on every other organism. For example, you might wonder how a producer could have an effect on a secondary consumer that doesn't eat producers.

Let's take a closer look at the grassland food web. Can you find a food chain that links a producer and a secondary consumer?

Well, the grama grass is a producer, the deer mouse eats the grass, and the coyote eats the deer mouse, right?

Correct. You're getting the hang of this now. O.K., let's suppose that a rancher plants more grama grass. The new grass will grow and reproduce grass seeds. The deer mice will have more seeds to eat, so their population will increase. What effect could more mice have on the coyotes?

The coyotes will have more mice to eat.

Right!

The coyote population might increase too, right?

Right again. This is an example of how secondary consumers are indirectly dependent on producers. Similar relationships exist throughout ecosystems, linking all the organisms together.

My Notes

When environmental factors such as rainfall are reduced, do populations always decrease?

Not always. Remember, the relationships between species in a food web can be complex. Some species can benefit from changes in the environment.

Can you give me an example?

O.K. Let's look at a stream ecosystem. Imagine that there is a lack of rainfall on the land area that drains into the stream. This might reduce the flow of the stream, trapping minnows in shallow pools. This will make the minnows easy for predators to catch and would reduce the minnow population.

However, the great blue herons that eat the minnows might benefit from this sudden increase in available food, and their population might increase. When the minnow population is reduced too low, the herons can fly to other areas where there are more minnows.

Remember!

Succession occurs when populations in a community change due to events in the environment. These changes may be sudden or they may happen very slowly.

A change in living (biotic) or nonliving (abiotic) parts of an ecosystem affects both local communities and the whole ecosystem. Every organism is dependent on the environment and the other organisms in one way or another.

But what happens to populations when conditions in an environment change permanently?

Permanent environmental change can affect species and populations. This change may be gradual, occurring as the environmental conditions in a community slowly change. Or it may be more sudden, such as when floods, fires, or other natural disasters occur. This rebuilding of populations in a community or ecosystem that has been changed is called *succession*.

My Notes

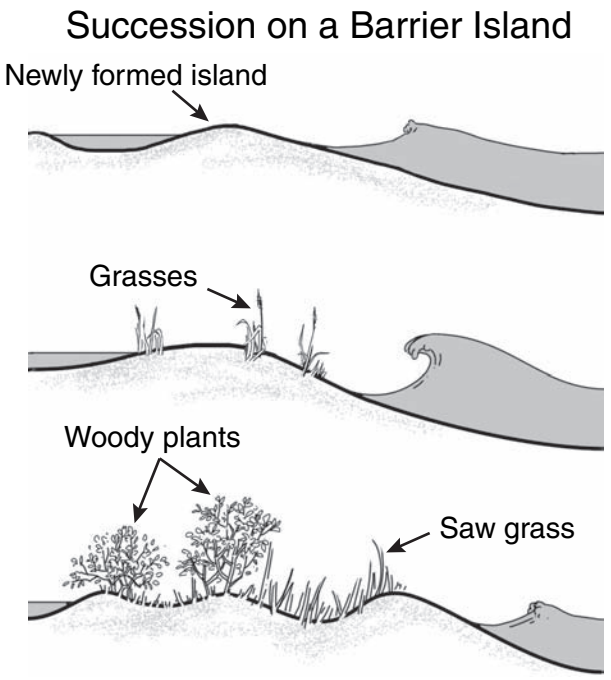
How does succession happen?

Let's look at an example of an island that forms in the Gulf of Mexico. The island begins as bare sand, with no plants or animals. Seeds from plants on neighboring islands can be carried to the island by wind, water, or animals. Some may sprout and begin to grow.

So, will any kind of plant grow on the island?

No, only those plants that are adapted to the conditions on the island. Since the island is bare, flat sand, it gets washed with ocean water quite often. The plants must be able to grow in these conditions.

But gradually, the conditions on the island change. As the first plants take root, they trap blowing sand, building the island higher. This creates areas where plants that are not adapted to constant waves can now grow.



So the first plant types create a place for the second plant types to grow?

Exactly. This pattern continues, until the island may have a variety of plants and animals. These changes may happen quickly, or they may continue slowly for a very long time. Often an environment such as the island reaches a stage where the plants and animals remain stable for a long time.

Does succession happen only on newly formed islands?

No, succession can happen in any environment where change occurs. For example, succession may occur in a plowed farm field, a burned forest, or grassland that gradually receives less rainfall.

Objective 2

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose a wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 11

When a goat eats grass, what form of energy passes directly from the grass to the goat?

A Heat

B Light

C Electrical

D Chemical

Answer Key: page 140

Question 12

When a softball player swings at a pitched ball, which of the following sets of body systems must work most closely together?

A Skeletal and immune

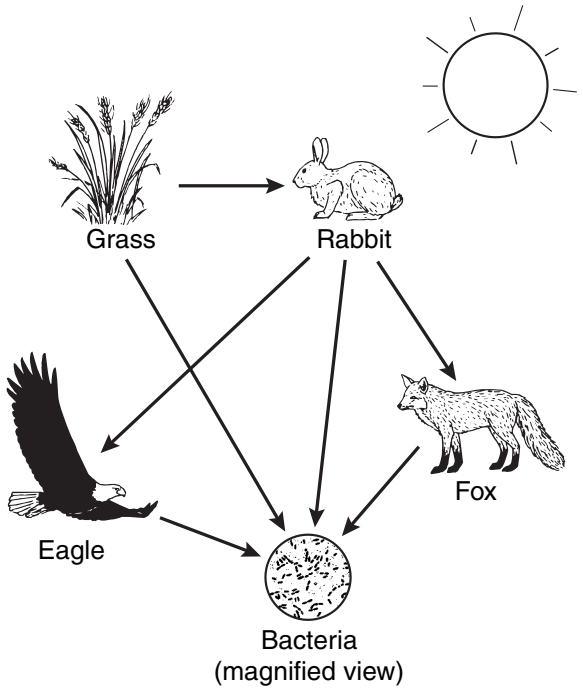
B Nervous and muscular

C Circulatory and digestive

D Respiratory and excretory

Answer Key: page 141

Question 13



In the food web shown above, which organism is a decomposer?

A Rabbit

B Eagle

C Bacteria

D Fox

Answer Key: page 141

Question 14

Grass → Rabbits → Wolves

Which statement best describes a likely relationship between the organisms in the food chain shown above?

A If the rabbit population decreases, the wolf population will increase.

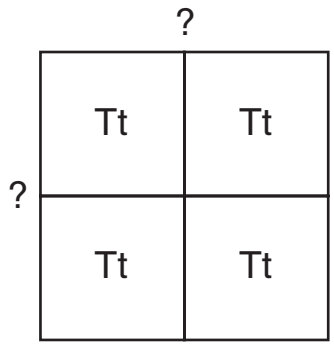
B If the grass population decreases, the wolf population will remain the same.

C If the rabbit population increases, the grass population will increase.

D If the grass population increases, both the rabbit and wolf populations will increase.

Answer Key: page 141

Question 15



Tall plants (T) are dominant over short plants (t) in peas. A short (t) pea plant crossed with an unknown parent produced 172 offspring that were all (100%) tall. Which of the following crosses would most likely produce these offspring?

A TT × tt

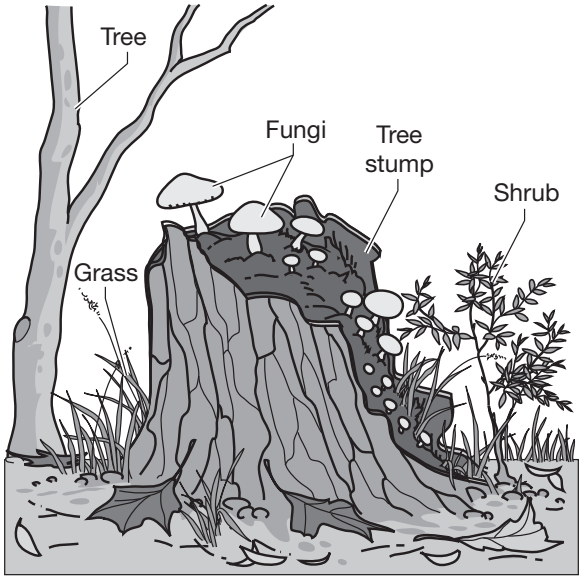
B TT × TT

C tt × tt

D Tt × tt

Answer Key: page 141

Question 16



The fungi shown in the picture above are decomposers. Decomposers are an important part of an ecosystem because they —

A produce oxygen

B provide food for carnivores

C break down dead organisms

D convert sunlight to food energy

Answer Key: page 142

Question 17

Plants ➔ Grasshoppers ➔ Birds

What is the original source of energy for all the organisms in the food chain shown above?

A Soil particles

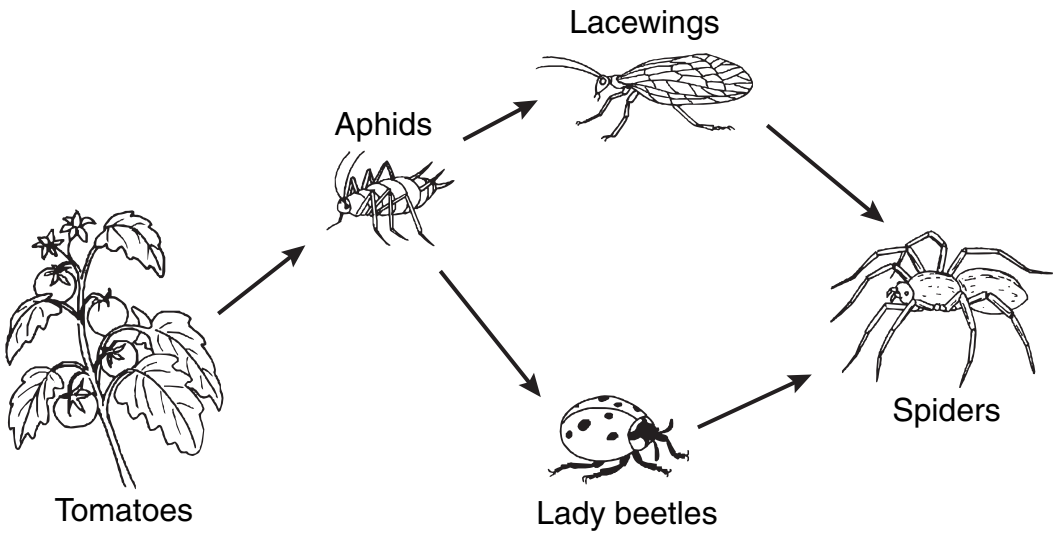
B Carbon dioxide

C Sunlight

D Oxygen

Answer Key: page 142

Question 18



In the food web shown above, which organism's food supply would be least affected by a spray that kills large numbers of aphids?

A Tomatoes

B Lacewings

C Lady beetles

D Spiders

Answer Key: page 142

Question 19

Which natural event would be most likely to cause succession in a grassy field?

A All the soil remains wet for several days after a heavy rain.

B Most of the grass is blown flat by a strong wind.

C Many grass plants die after a long period of no rainfall.

D The grass leaves are injured by a frost.

Answer Key: page 142

Question 20

Apple Orchard Data

Location	Average May Temperature (°C)	Full Bloom Date	Ripe Fruit Color	Average Fruit Size (g)	Days from Bloom to Harvest
Tyler, TX	22	May 22	Green	252	143
Austin, TX	24	May 17	Green	263	147
Victoria, TX	25	May 10	Green	237	150

Several orchards in different regions were planted with apple trees produced from a single parent tree. The table above shows data gathered at the three apple orchards. Which characteristic in the table above is most likely inherited and not affected by the environment?

A Full bloom date

B Ripe fruit color

C Average fruit size

D Days from bloom to harvest

Answer Key: page 142

Objective 3

The student will demonstrate an understanding of the structures and properties of matter.

My Notes

Through your studies in science, you should be able to demonstrate an understanding of the structures and properties of matter.

Remember!

Mass is the amount of matter in an object and is constant anywhere in the universe.

Volume is the amount of space that matter occupies.

What do we mean by "matter"?

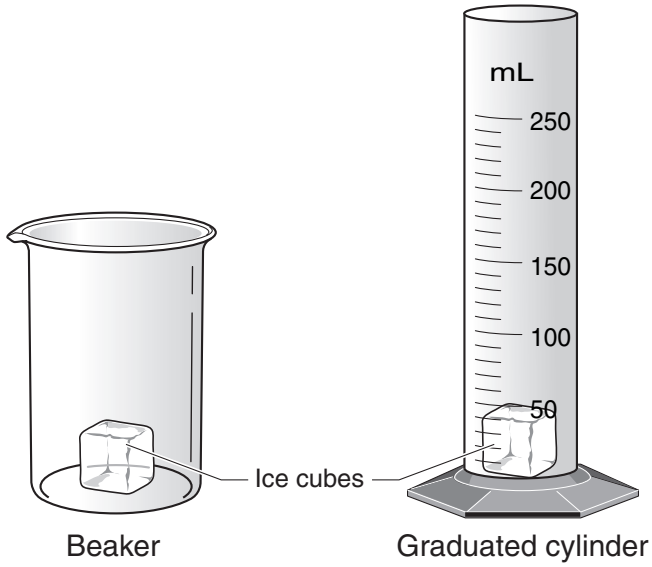
Matter is anything that has mass and takes up space (volume). Most of the matter in our everyday world is either solid, liquid, or gas. Solid, liquid, and gas are called states of matter.

Oh, you mean like ice, water, and water vapor?

Yes. Water is a solid (ice) at temperatures below 0°C. Water is a liquid at room temperature. Water is a gas (steam) at temperatures above 100°C. Water in a gaseous state is also called steam or *water vapor*.

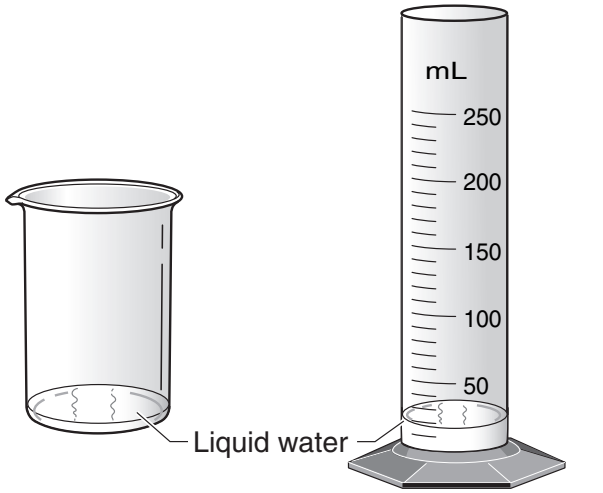
So what makes these states of matter different?

Let's say I have two identical cubes of solid ice. If I put the ice cubes in separate containers that have different shapes, the ice will still be shaped like a cube. Each cube will have a definite volume. *Solids* have a definite shape and a definite volume.



My Notes

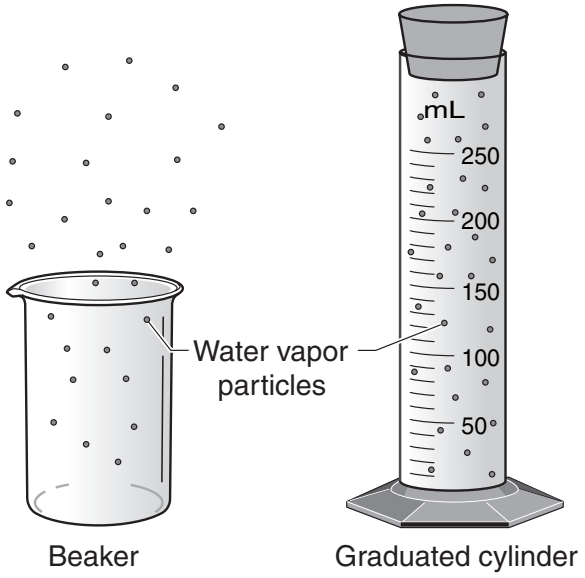
If we let the ice melt into liquid water, the shape of the water in the two containers will be different. *Liquids* have a definite volume, but not a definite shape. Their shape changes to match the shape of their container.



What if the water evaporates into a gas?

When water is heated, it gains energy. When water gains enough heat energy, it evaporates into a gas. It is composed of tiny particles too small for us to see. If we closed one of the containers with a stopper, the particles of water vapor in that container would spread out to fill up the available space. In the open container, many of the water vapor particles would escape and mix with the surrounding air.

Gases have no definite shape. Their shape changes to match the shape of their container. Gases also have no definite volume. Their volume can change so that they completely fill their container.



My Notes

You said gas is made of particles. What are these particles?

The tiny particles that compose most forms of matter are called *atoms*. An atom is the simplest unit of an element. An *element* is a substance that contains only one kind of atom. There are over 100 known elements.

When two or more atoms join chemically, a molecule may form. A molecule is a larger particle than an atom. It may be made up of atoms of the same element or of different elements.

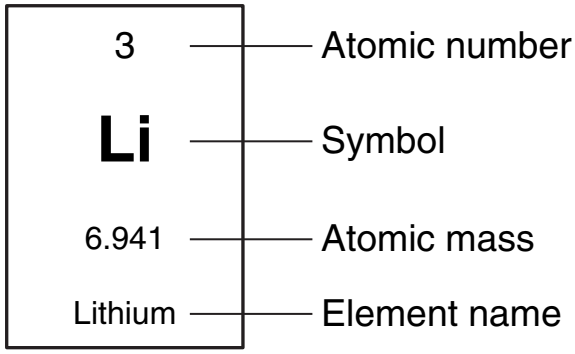
A compound is a substance made up of atoms of two or more elements joined chemically.

Is there something I can use to help me understand the elements?

Yes, you can use the periodic table of the elements. The periodic table is a tool that can help us predict the physical and chemical properties of elements.

What kind of information can I find in the periodic table?

Each element has a symbol, an atomic number, and an atomic mass. Look at the periodic table. The elements are arranged in vertical columns called groups or families. The elements are also ordered in horizontal rows called periods. Let's take the element lithium (Li) as an example. Find lithium (Li) on the periodic table. Note that lithium is located in Group 1 (the first column) and in Period 2 (the second row) of the table.

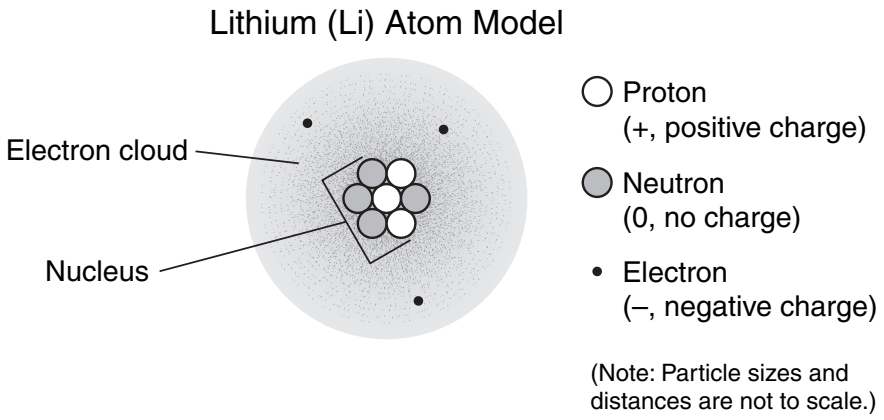


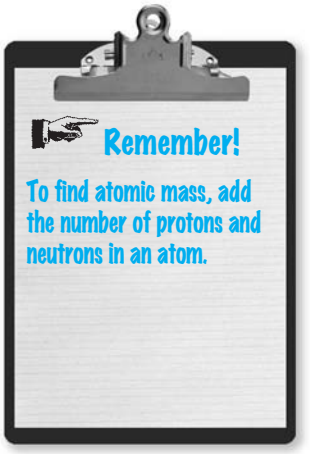
What do the different numbers mean?

Good question! But first we need to know a little bit about the parts of the atom. The three basic parts are called protons, neutrons, and electrons. These parts, or particles, determine the characteristics of elements. The periodic table gives us information about how many of each of these particles are found in the atoms of each element.

Lithium, for example, has an atomic number of 3. This means that a lithium atom has three *protons*. Each proton has an atomic mass of approximately 1 unit and a positive charge. Protons are found in the nucleus of the atom.

My Notes





So the atomic number always tells us how many protons are in an atom of that element?

Correct. It tells us something else too. Since atoms have a neutral charge, the number of protons tells us how many negatively charged particles must also be present in an atom to make it neutral. Which particle carries a negative charge?

That would be the electron, right?

Right again. So in lithium three negatively charged *electrons* balance the three positively charged protons. Electrons are very small, have very little mass, and are found outside the nucleus. They constantly move in an area of mostly empty space surrounding the nucleus. This area is called the *electron cloud*.

What about the neutrons in the diagram?

Neutrons are particles with no electric charge. Neutrons have an atomic mass of approximately 1 atomic mass unit and are found in the nucleus along with protons. Protons and neutrons together make up most of the mass of an atom.

How do we know how many neutrons are in an atom?

To find the number of neutrons in an atom, we look again at the periodic table. Remember that protons and neutrons each have an atomic mass of approximately 1 atomic mass unit. On the periodic table we find the atomic mass of lithium. It is 6.941. First we will round this to the nearest whole number, which is 7. Since we know there are three protons in lithium, we can subtract 3 from 7 to find the number of neutrons in lithium. Since 7 – 3 = 4, lithium has four neutrons. This is the procedure to follow for the elements you have studied in class.

My Notes

Let's summarize what we've learned about the basic parts of the atom in the table below.

Did You Know?

Protons and neutrons have nearly equal masses, but electrons have an extremely small mass. The mass of an electron is approximately 1/2000 the mass of a proton.

Basic Parts of the Atom

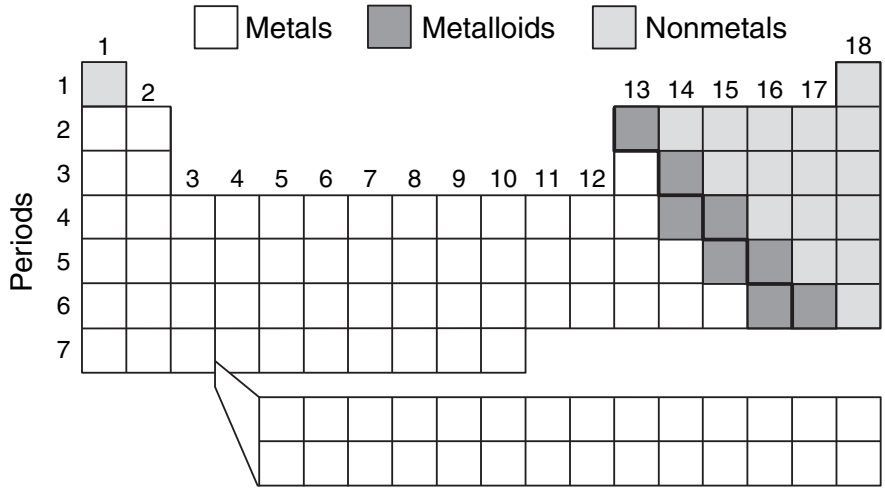
Subatomic Particle	Approximate Atomic Mass (amu)	Electrical Charge	Location in Atom
Proton	1	Positive (+)	Nucleus
Neutron	1	None (0)	Nucleus
Electron	0	Negative (–)	Electron cloud

Wow! That's pretty amazing. What other information can I get from the periodic table?

The periodic table of the elements is the result of many observations of elements and their properties. Scientists all over the world have studied the physical and chemical properties of the known elements. Elements with similar properties were placed in the same group in the periodic table.

Look at the periodic table of the elements again. A stair-step line separates the elements into metals and nonmetals.

Periodic Table of the Elements



What is the difference between metals and nonmetals?

Most of the elements are *metals*. Metals are good conductors of heat and electricity. At room temperature most metals are hard, shiny solids that can be bent without breaking.

My Notes

The *nonmetals* are located on the upper right side of the periodic table. At room temperature some of the nonmetal elements are solids that crack or break easily. Others are gases at room temperature. Nonmetals at room temperature typically are not shiny and do not conduct heat or electricity very well.

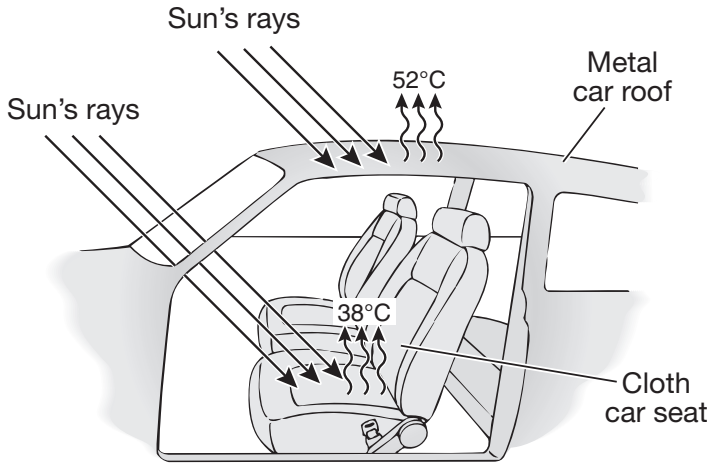
Along the line separating the metals and nonmetals is a third group of elements known as *metalloids*. Metalloids have some properties of metals and some properties of nonmetals.

Did You Know?

Dmitri Mendeleev overcame his own illness and family tragedies and created the first periodic table of elements in 1869.

You mentioned that metals are good conductors of heat and nonmetals are not. How do we know that?

Have you ever touched the door of a car on a hot afternoon? The metal door can get so hot that it hurts your skin. But once you open the car door and touch the cloth seat, you notice that the cloth isn't nearly as hot as the metal.



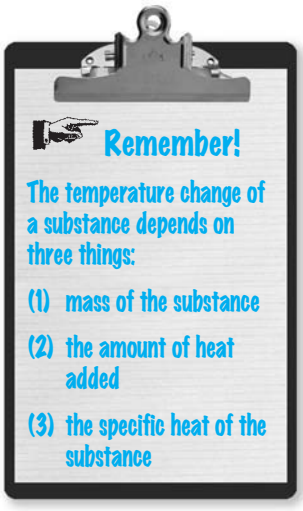
Not all substances heat up at the same rate. Some substances get hot very quickly when exposed to heat. Other substances do not rise in temperature very quickly when exposed to the same amount of heat. This is what keeps the car's cloth seat cooler than the metal door. This is caused by each substance's different ability to absorb and conduct heat.

Can we measure how much heat matter can absorb?

Now you're thinking like a scientist! Yes we can, and this measurement is called *specific heat*. It is the measure of how much heat energy it takes to make 1 gram of a substance rise 1°C in temperature. Heat energy can be measured in calories. A *calorie* is the amount of heat needed to make 1 g of water rise 1°C in temperature.

The higher a substance's specific heat, the harder it is to increase its temperature (as with the cloth car seat). The opposite is also true: a substance with a low specific heat increases in temperature very easily (as with the metal car door).

My Notes



Wait, isn't that backward? If something stays cooler, how can its specific heat be higher?

Specific heat can be confusing because it is a measure of thermal energy, not temperature. Specific heat can be viewed as the resistance of a substance to a change in temperature. So a higher specific heat means that more energy is required to change that substance's temperature.

Low specific heat = Less energy to change temperature

High specific heat = More energy to change temperature

I think I get it now. If we wanted to keep the temperature of something from changing very much, we could build it out of a material with a high specific heat, right?

You've got it! The table below shows the specific heat of some common substances. Note that most metals have low specific heats, while nonmetal compounds and mixtures such as water, wood, soil, and air have relatively high specific heats.

Specific Heat of Some Common Substances

Substance	Cal/g • °C
Water	1.00
Wood	0.40
Soil	0.25
Air	0.25
Aluminum	0.22
Iron	0.11
Copper	0.09

Wow! Water has a really high specific heat. Does that affect the conditions on Earth?

It sure does. Oceans cover about two-thirds of Earth's surface. Water's characteristic of retaining heat is important to our climate. It means that our climate stays much more stable than it would if there were less water on Earth.

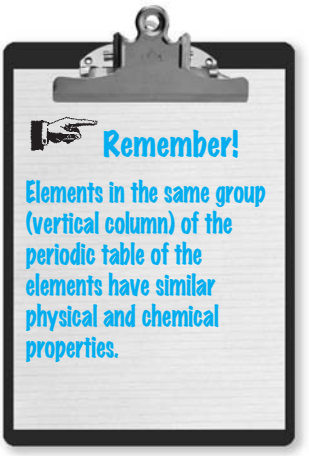
My Notes

Iron and copper gain heat very quickly. Are they metals?

Yes! Look back at the periodic table. Remember the line that separates the metals and nonmetals? Find iron (Fe) and copper (Cu) on the periodic table. They are both located to the left of this line, indicating that they are metals.

Didn't you say that elements in the same group also share common properties?

Yes, elements in the same group of the periodic table often share many of the same physical properties. For example, copper (Cu), silver (Ag), and gold (Au) are three of the best conductors of electricity out of all the elements. Notice that they are all found in Group 11 of the periodic table.



Elements within a group or family also share chemical properties. For example, the elements in Group 17 are called halogens, which means "salt-formers." When they react chemically with other elements, the product is often a type of salt. An example of this is when sodium (Na) reacts with the Group 17 element chlorine (Cl). The product of this reaction is sodium chloride (NaCl), or the table salt we put on food. The elements in each group have certain common properties that make them different from the elements in the other groups. We'll talk more about physical and chemical properties later.

O.K., I think I understand atoms and elements now. But what are molecules?

Molecules are formed when two or more atoms chemically join, or bond together. With over 100 elements there are millions of possible combinations.

What kinds of substances are made of molecules?

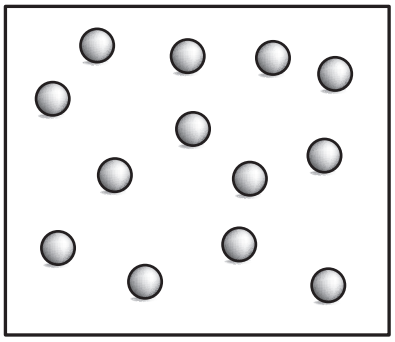
If two or more atoms of the same element bond together, we have a molecule of a pure element. Oxygen (O_2) is an example of a commonly occurring molecule that is also a pure element.

But if atoms of different elements are joined chemically, they form a *compound*. The properties of compounds are different from the properties of the individual elements they contain.

My Notes

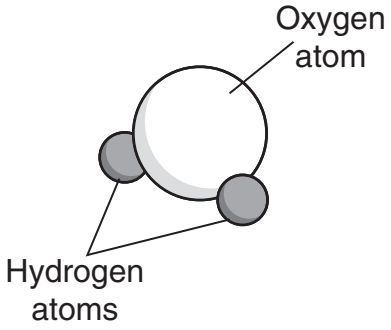
Samples of matter that are made up of all the same atom or all the same molecule are called *pure substances*. For example, pure gold is made up only of atoms of the element gold (Au).

Atoms of Gold



Since water is a compound, it is made up only of molecules of water. Each water molecule has two atoms of hydrogen and one atom of oxygen.

Water Molecule



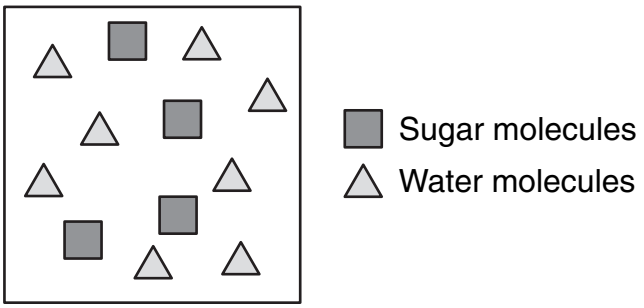
Oh, I see. Then all substances are either compounds or elements?

Well, that's true for pure substances, which are made of only one element or compound. But it's not quite the whole picture. Many substances are actually *mixtures*. Mixtures are a combination of two or more pure substances. These substances have been mixed together but have not reacted to form any new molecules.

My Notes

For example, sugar (a compound) dissolves in water (a compound) to form a mixture. The molecules of sugar and water do not change chemically. They just become mixed together.

Mixture of Sugar and Water



I remember when we separated some mixtures in science class. Can all mixtures be separated into their original parts?

Yes, that is a characteristic of mixtures. We could separate the sugar-water mixture by putting the mixture in an open container and allowing the water to evaporate. Sugar crystals would be left in the container after the water evaporates.

If the solid particles in a mixture are different sizes, we can separate the mixture using a filter. For example, suppose we mix gravel and sand together. We could then separate them by pouring the sand-gravel mixture through a certain kind of screen. The sand would fall through the screen, but the gravel would collect on top of the screen.

O.K., there are over 100 elements and millions of different compounds and mixtures. This is getting wild! If there are so many different kinds of matter, how can we tell the difference between them?

That's a good question. When we examine a substance, we are interested in its properties. A *property* is something about a substance that can help to define it. Let's look at water, for example.

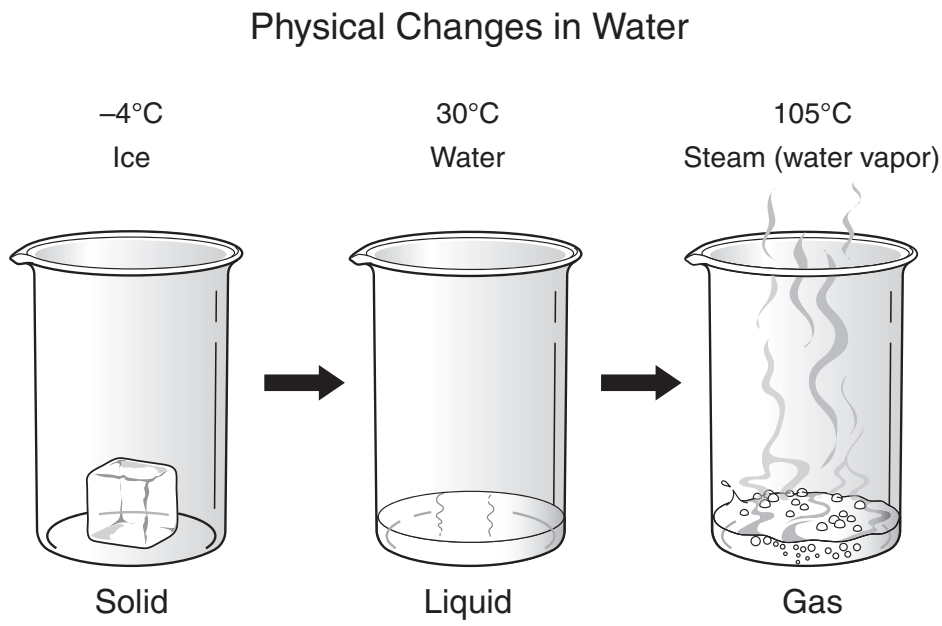
Some Properties of Water

- It is a liquid at room temperature, so it takes the shape of its container.
- It is transparent, because light passes through it.
- It will freeze at about 0°C and boil at about 100°C.

My Notes

There are two main types of properties that help us classify substances. *Physical properties* can be observed without changing the substance into a different substance. There are many different physical properties we might observe. The properties of water listed in the box are all physical properties.

When a substance changes but doesn't become a new substance, we say that a physical change has occurred. Remember water's different states of matter? Each change in state of matter as water passes from solid to liquid to gas is a physical change.



What about chemical properties?

Chemical properties are characteristics of a substance that are observed when it reacts (changes) to produce one or more different substances. For instance, water can be changed into hydrogen gas and oxygen gas using an electric current. When water molecules change chemically into hydrogen gas and oxygen gas, we say that a chemical change has occurred. Hydrogen gas and oxygen gas each have a different set of properties. Substances change into different substances through chemical reactions.

How do chemical reactions cause substances to change into other substances?

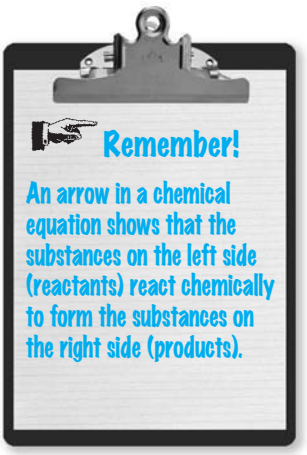
The atoms in the original substances are rearranged during a *chemical reaction*. During a chemical reaction, bonds in the original substance may be broken and new bonds may be formed between different atoms. This produces one or more different substances. The substances produced may be either pure elements or compounds. The products of

My Notes

a chemical reaction always have different chemical and physical properties than the original substance or substances.

Could you show me an example of a chemical reaction?

O.K. Have you ever noticed a dark coating of tarnish on silver jewelry that hasn't been used in a while? This coating is the product of a chemical reaction between the silver metal and the hydrogen sulfide gas in the atmosphere. The reaction produces silver sulfide (tarnish) and hydrogen gas.



silver (metal) + hydrogen sulfide → silver sulfide (tarnish) + hydrogen gas

Here is the chemical equation for this reaction:

$$2Ag + H_2S \rightarrow Ag_2S + H_2$$

Here is a table to show all the parts of this chemical equation:

Reactants and Products in a Chemical Equation

$2Ag$	+	H_2S	⟶	Ag_2S	+	H_2
2 atoms of silver	reacted with	1 molecule of hydrogen sulfide	to produce	1 molecule of silver sulfide	and	1 molecule of hydrogen gas

Before the reaction, silver exists as individual atoms in the silver jewelry. Each molecule of hydrogen sulfide contains two hydrogen atoms bonded to a sulfur atom.

After the reaction, each molecule of silver sulfide produced contains two silver atoms bonded to one atom of sulfur. Each molecule of hydrogen gas produced contains two atoms of hydrogen bonded together.

What do the letters and numbers mean in the chemical equation?

The letters tell us what substances are involved in the reaction. The numbers tell us how many atoms or molecules are in the equation. The equation also tells us how the atoms of each substance are rearranged. Let's look first at how we name the substances.

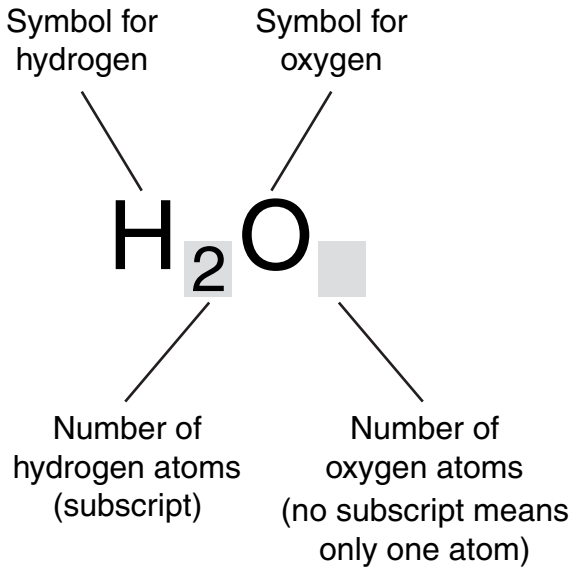
Scientists have developed a system using symbols to represent different elements. The symbol for each element is either one or two letters. These symbols can be found on the periodic table of the elements.

My Notes

What does it mean when there is more than one symbol in a substance, such as the Ag and the S in silver sulfide?

Compounds are represented by a formula that uses symbols for all the elements present in the compound. A formula for a compound shows the number and types of atoms in one molecule of the compound. In addition to the element symbols, numbers called *subscripts* are used. Subscripts tell us how many atoms of each element are in a molecule and are written to the right and slightly lower than the element symbol.

The diagram below explains the formula for one water molecule.



O.K., the formulas make sense to me. Now I want to see how the equation was written. Can you show me?

Sure. We start by writing the formulas for silver, hydrogen sulfide, silver sulfide, and hydrogen gas.

Silver: Ag

Hydrogen sulfide: H_2S

Silver sulfide: Ag_2S

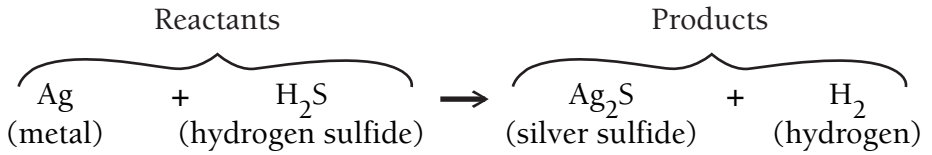
Hydrogen gas: H_2

Next we write the formulas for the original substances. The substances that exist before a reaction takes place are called *reactants*. The reactants are separated by a plus sign (+). In this case, silver and hydrogen sulfide are the reactants. An arrow comes next to show us that a chemical change has occurred.

My Notes

What goes on the right side of the equation?

The formulas for the *products* are written on the right side of the arrow. The products are the substances that are made as a result of the chemical change. Products are also separated by a plus sign (+). In this case, silver sulfide and hydrogen gas are the products.



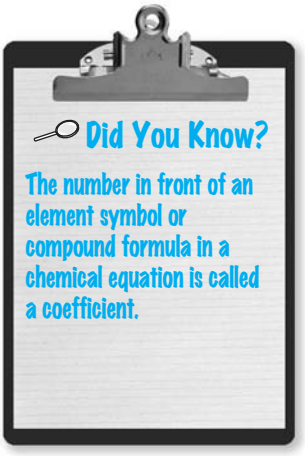
I see that there is a number 2 in front of silver (Ag) in the equation written earlier. What does this number 2 represent?

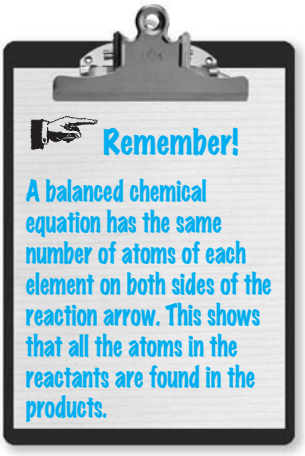
In this case the number 2 tells us that there are two atoms of silver (Ag) present on the reactant side of this equation. These numbers (called coefficients) are put in front of reactants or products to tell us how many atoms or molecules occur on each side of a reaction. When there is no number written in front of a reactant or product, we understand that number to be 1 (one). So, in this equation, there are two atoms of silver and one molecule of hydrogen sulfide (H_2S) on the reactant side of the equation and one molecule of silver sulfide (Ag_2S) and one molecule of hydrogen gas (H_2) on the product side of the equation.

$$2Ag + H_2S \rightarrow Ag_2S + H_2$$

Now we can count the number of atoms on each side of the equation. There must be the same quantity of each type of atom on each side of a reaction. In chemical reactions matter is neither created nor destroyed, so the same types and quantity of atoms must be in the reactants and in the products of the reaction.

Atoms in reactants:	→	Atoms in products:
2 Ag	→	2 Ag
2 H	→	2 H
1 S	→	1 S





Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose a wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 21

Which lab procedure described below would provide information about the chemical properties of a clear liquid substance?

A Cooling it to find its freezing temperature

B Observing the rate at which it evaporates

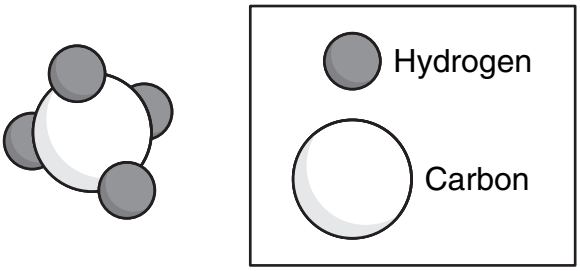
C Comparing its density to the density of water

D Adding an acid to see whether a gas is produced

Answer Key: page 143

Question 22

Model of Methane Molecule



The methane molecule shown above contains —

A five elements

B two elements

C two compounds

D one atom

Answer Key: page 143

Question 23

$4Fe$	+	$3O_2$	$\longrightarrow$	$2Fe_2O_3$
iron		oxygen		rust

Which statement below best describes the process shown in the equation above?

A Iron is broken down into oxygen and rust.

B Iron is combined with oxygen to form rust.

C Rust is broken down into iron and oxygen.

D Rust is combined with oxygen to form iron.

Answer Key: page 143

Question 24

Temperature Change of Liquid Samples

Sample #	Mass (g)	Starting Temperature (°C)	Ending Temperature (°C)
1	200	21	69
2	200	20	66
3	200	22	62
4	200	20	64

Four liquids are heated on the same hot plate at the same temperature setting for ten minutes. The temperature change of each sample is recorded in the table above. Which sample has the greatest specific heat?

A 1

B 2

C 3

D 4

Answer Key: page 143

Question 25

Procedure

- **Place a thermometer and a 100 g sample of a different solid into each of 4 containers.**
- **Record the temperature of the dry solid.**
- **Add 100 mL of vinegar.**
- **Record observations of each mixture in the data table below.**

Data Table

Solid #	Observations
1	Some of the solid dissolves. No temperature change.
2	All of the solid dissolves and gas bubbles out of the clear liquid. Temperature decreases slightly.
3	All the solid dissolves and mixture is clear. No temperature change.
4	None of the solid dissolves. No temperature change.

Based on these observations, which solid most likely reacted chemically when mixed with vinegar?

A 1

B 2

C 3

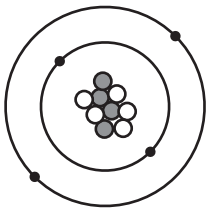
D 4

Answer Key: page 143

Question 26

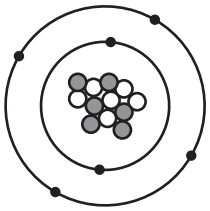
According to the periodic table, which of the following models best represents an atom of the element carbon (C)?

A



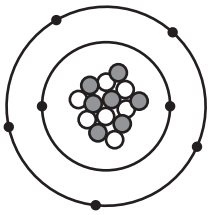
Proton
Neutron
Electron

B



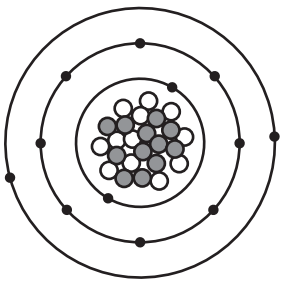
Proton
Neutron
Electron

C



Proton
Neutron
Electron

D



Proton
Neutron
Electron

Answer Key: page 143

Question 27

If an atom has an atomic mass of 101 and an atomic number of 44, how many neutrons would it have?

A 44

B 57

C 101

D 145

Answer Key: page 144

Question 28

A teacher mixes two clear liquids in a beaker. White solid particles form in the beaker and settle to the bottom. If a chemical change took place in the beaker, which of the following best describes the white solid particles?

A An atom not present in the original liquids

B An element not present in the original liquids

C A solid dissolved in one of the two original liquids

D A substance with different properties than the original liquids

Answer Key: page 144

Question 29

Based on the periodic table, which of the following elements has properties most like neon's?

A Hydrogen (H)

B Fluorine (F)

C Krypton (Kr)

D Sodium (Na)

Answer Key: page 144

Question 30

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

During cell respiration, sugar ($C_6H_{12}O_6$) reacts to form carbon dioxide (CO_2) and water (H_2O). Which of the following best explains what happens during cell respiration?

A Single atoms are formed into different elements.

B Atoms are rearranged into different compounds.

C A molecule is broken down into its pure elements.

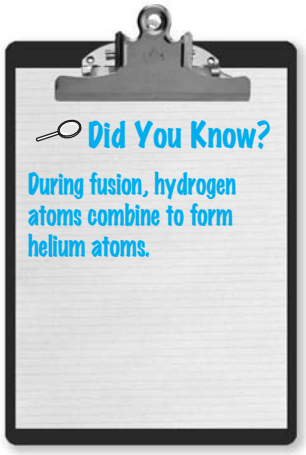
D Two elements are formed into one compound.

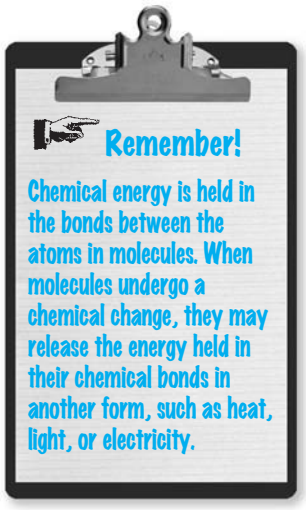
Answer Key: page 144

Objective 4

The student will demonstrate an understanding of motion, forces, and energy.

My Notes





Through your studies in science, you should be able to demonstrate an understanding of motion, forces, and energy.

What are motion, forces, and energy?

Motion, forces, and energy are three closely related ideas. Each helps explain how and why things happen the way they do in our physical world.

I think I know what energy means. We get most of our energy on Earth from the sun, right?

That's right. *Energy* is the ability to do work or cause change. *Light* from the sun is one form of energy. Sunlight is a product of a nuclear fusion reaction inside the sun. This process releases a tremendous amount of energy. Some of this energy reaches Earth in the form we call sunlight.

What happens to sunlight energy once it reaches Earth?

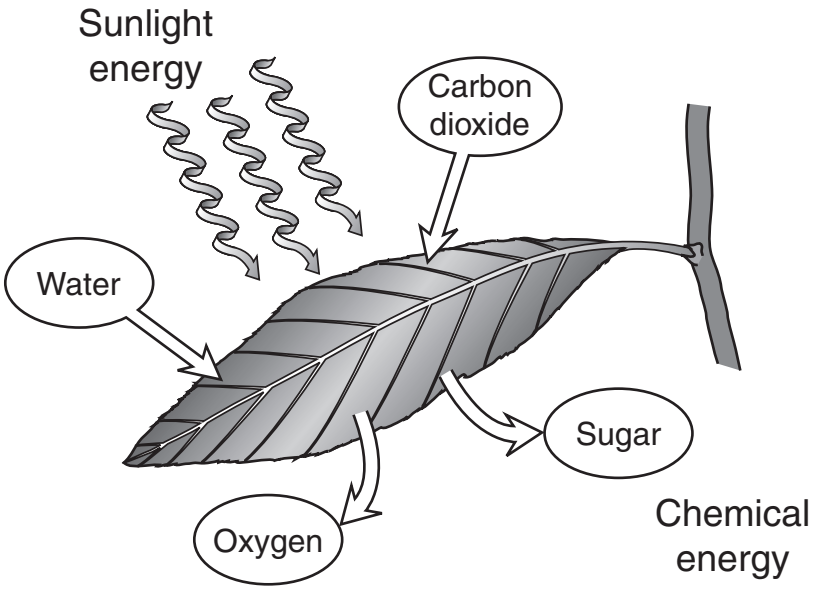
Quite a few things may happen to it. Let's first discuss how energy from sunlight enters ecosystems.

Remember our discussion of photosynthesis? Plants use energy from sunlight to change carbon dioxide and water into sugar during photosynthesis. So some of the energy in sunlight is converted to the energy in the bonds of the sugar molecules. This is one way light energy is converted to *chemical energy*.

My Notes

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Sunlight energy → Chemical energy



Are there ways besides photosynthesis that sunlight energy is transformed?

Yes. Another important energy transformation occurs when sunlight strikes water. What happens to water and land that are exposed to sunlight?

They heat up, right?

Right. The water absorbs the energy of the sunlight, and the water temperature rises. The increased temperature tells us that the water has gained *heat* energy. The same process occurs when sunlight strikes land and other solids. The ability of a substance to absorb heat energy is a property called specific heat.

So sunlight can be transformed into chemical or heat energy. Are there energy transformations that don't involve sunlight?

Sure. Think about what happens in a CD player. It needs energy to play music. Where does this energy come from?

Well, I just plug it in and get electricity from the wall outlet, don't I?

Yes, that's one way for the CD player to get energy. Plugging it in allows *electrical energy* to flow from the outlet to the CD player. A flow of electrons (current) through a conductor produces electrical energy. What causes electrons to flow in the conductors inside the wall outlet?

My Notes

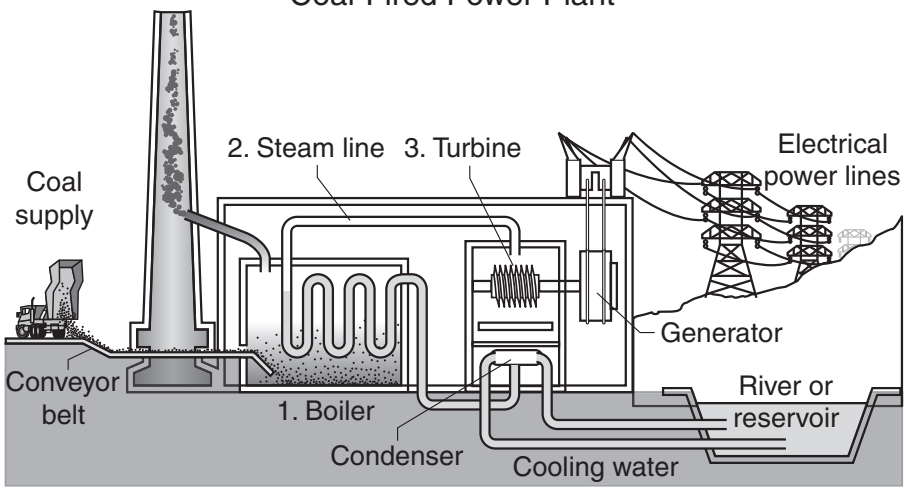
Remember!

During energy transformations, energy is often released as light, heat, or sound. Although energy can change into different forms, it is never lost. This is known as the law or principle of conservation of energy.

Power lines carry electricity to my house. But where does the electrical energy in the power lines come from?

Electrical power can be generated in several ways. For example, coal or natural gas may be burned to generate electricity. The energy transformations used in generating electrical power from burning coal are shown below.

Coal-Fired Power Plant



Energy Transformations in a Coal Power Plant

Process	Energy Transformation
1. Coal being burned	Chemical to Thermal
2. Water boiling to form steam	Thermal to Mechanical
3. Turning of a turbine	Mechanical to Electrical

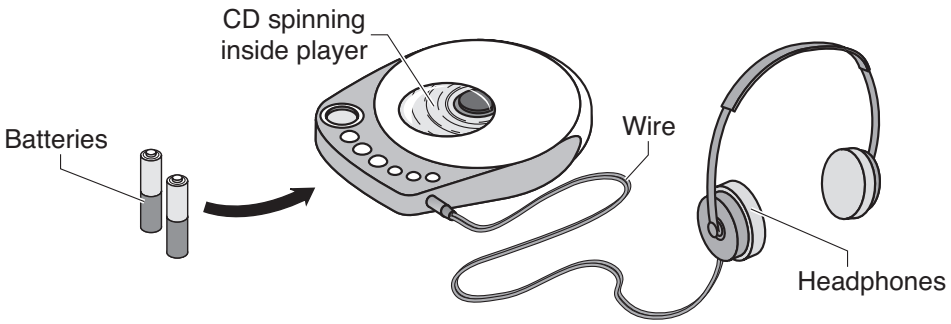
What ways of generating electrical power are there besides burning fuels?

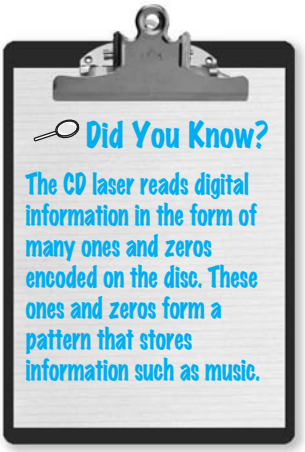
The water flowing through a dam in a river can be used to move turbines to generate electricity. Wind generators use the energy of moving wind to operate a generator that produces electricity. Nuclear power plants convert atomic energy into heat. This heat boils water to form steam and then follows the same energy transformations as in a coal power plant. The electrical energy generated in all these ways can then be sent through power lines to houses and other buildings.

My Notes

Wow! There are a lot of ways to generate electricity. Am I still using energy if I just run my CD player on batteries?

Yes, you are still using energy. Batteries store chemical compounds that react when they are used to power the CD player. This produces a flow of electrons in the circuits of the CD player. Chemical energy in the batteries is converted to electrical energy in the CD player. There are even more energy transformations that occur in the CD player to produce the actual music that you hear.





Really? What other transformations happen in the CD player to produce music?

Well, the CD player also uses electricity to spin the CD. The spinning CD has mechanical energy. *Mechanical energy* is the energy in an object due to its position or motion. So another energy transformation in the CD player is electrical energy to mechanical energy.

O.K., but how does the CD player produce the music from the CD?

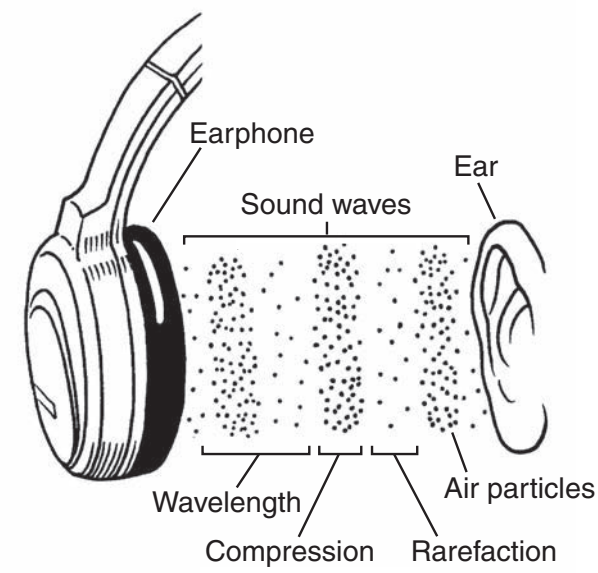
The CD player uses a laser to convert the digital information on the CD's surface into electrical energy. This energy is carried to the headphones. There is a material inside the headphones that vibrates in response to the electrical energy. What kind of energy do vibrating objects transmit?

My Notes

Isn't it sound energy?

That's right. *Sound* consists of mechanical energy waves created by vibrating objects. Sound must travel through something such as air, water, or a solid. This "something" is called a medium. The *medium* carries the energy of the wave from one place to another. In our example, air transmits the energy of the vibrating material in the headphones to your eardrums.

A *vacuum* is a space that contains little or no matter. Sound cannot travel through a vacuum since there are no particles to squeeze together (compression) or spread apart (rarefaction).



Did You Know?

Light waves travel at a constant speed in a vacuum. The constant speed of light is used to calculate the vast distances between objects in the universe.

Do other forms of energy travel by waves?

Sure. *Light waves* are in the sunlight we discussed earlier. Light waves don't need a medium to transmit energy. They can even travel through empty space. *Seismic waves* caused by earthquakes transmit mechanical energy through Earth's layers. *Water waves* are a form of wave that transmits mechanical energy across the surface of water.

Remember!

All energy is either potential or kinetic. Energy can be classified by its source (heat, chemical, electrical, etc.) and its type (potential or kinetic).

I've also heard my teacher talk a lot about potential and kinetic energy. What are these forms of energy?

Besides the types of energy we have already discussed, energy can also be classified as *kinetic energy* or *potential energy*. Kinetic energy is the energy an object has due to its motion. Potential energy is stored energy due to an object's position.

So whenever an object moves, it has kinetic energy?

That's right. Two things affect the amount of kinetic energy in a moving object: speed and mass. Speed is important because the faster an object moves, the greater its kinetic energy. We'll talk about mass later.

My Notes

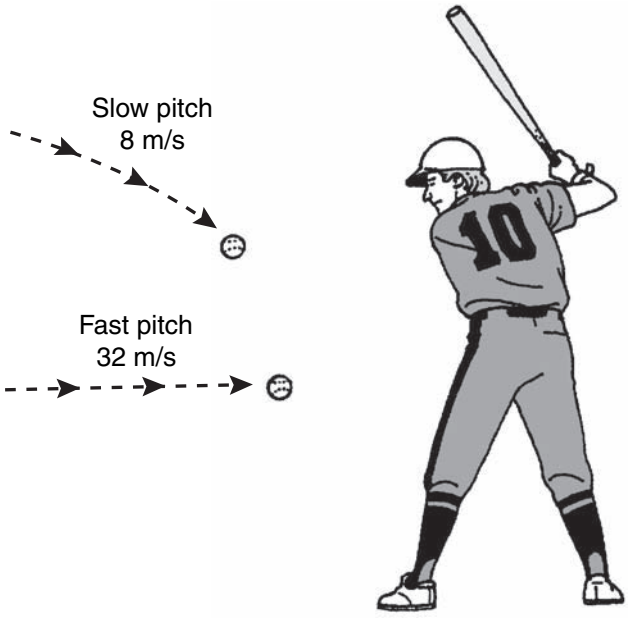
How do we know that a faster object has more kinetic energy?

Let's look at an example. Imagine you are at bat in a softball game. The pitcher throws a high pitch slowly toward home plate, but instead of passing over home plate, the ball hits you. How does it feel?

Well, it might hurt a little, but not much. Why does it matter how it feels to get hit by the softball?

Follow me a little further. Now imagine you are at bat in another softball game. This time the pitcher hurls a lightning-fast pitch straight toward you, and again the ball hits you. Now how does it feel?

Which Pitch Strikes with More Force?



Ouch! All right, I get your point. The faster ball will hit with a lot more force. What else besides speed affects the kinetic energy of an object?

The kinetic energy of objects is also related to the mass of the object. An object with more mass has more kinetic energy than an object with less mass if both objects are traveling at the same speed.

My Notes

How do we know that?

Let's use our imagination again. First let me ask you this: If I drop a pebble and a large rock from the same height at the same time, which one will hit the ground first?

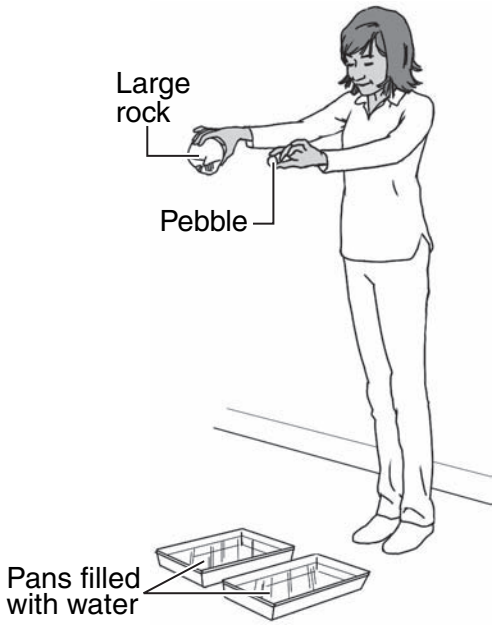
That's a trick question! But I know the answer. They will hit the ground at the same time.

Good answer! So they both travel at the same speed. Which one has a greater mass?

The large rock, of course. But how do we know it has more kinetic energy?

Well, imagine that you hold the pebble and the rock out in front of you at the same height. You drop both of them into identical pans filled to the top with water. Which object will create a bigger splash when the pebble and rock land in the water?

Which Object Will Make a Bigger Splash?



The large rock will make a bigger splash. So more mass means more force, which creates a bigger splash, right?

Right. Since the larger rock lands with more force than the pebble, we know that it has more kinetic energy.

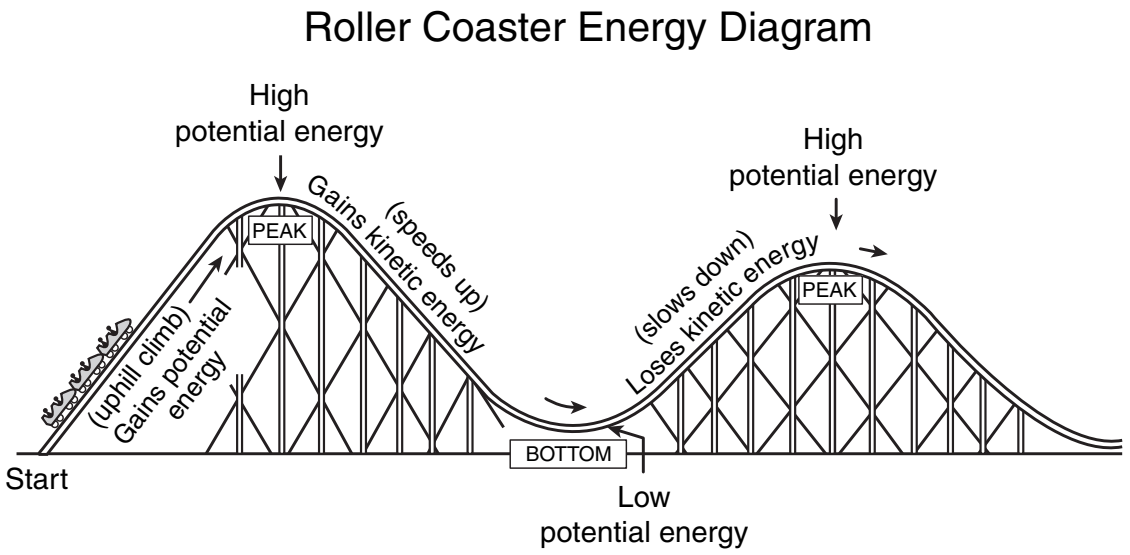
O.K., I see. Both speed and mass affect the kinetic energy of an object, right?

Yes, that's right.

My Notes

You said potential energy is stored energy or energy due to position. How does position give an object energy?

Think of a roller coaster at an amusement park. Have you ever noticed how the highest peak on the roller coaster is always the first one?



Yes, I've noticed that on several roller coasters. Why is that?

It's because potential energy has to be built up in the roller coaster. The roller coaster is brought high above the ground so that gravity can pull it downward. The force of gravity then converts the potential energy of the roller coaster at the top of the track to kinetic energy as the coaster rolls downhill. This kinetic energy carries the roller coaster all the way to the end of the ride.

See, as the roller coaster moves uphill, it gains potential energy. Because the roller coaster gains this energy by being moved, we can say that it gains stored energy due to a change in its position.

Does the roller coaster lose potential energy when it starts going downhill?

Yes. But remember that the faster an object moves, the more kinetic energy it has. So as the roller coaster picks up speed going downhill, it gains kinetic energy. The roller coaster's speed and kinetic energy will be greatest at the bottom of the downhill run. This is also where the roller coaster's potential energy will be lowest.

As the roller coaster starts its climb to the next peak, it will slow down and lose kinetic energy. But as it gets higher, it gains potential energy again. This cycle repeats several times during the roller coaster ride.

My Notes

O.K., I think I understand. Gravity is the force behind the roller coaster's potential energy. So is there potential energy in anything that can be moved by a force like gravity?

Yes. A *force* is a pushing or pulling action that may change motion. Forces may move objects or transfer energy between objects. Water at the top of a waterfall has potential energy to be pulled down to the sea by the force of gravity. There are many other examples of potential energy in the world around us.

How do forces cause objects to move?

Motion is the change in position of an object. Anything that is moving is in motion. When you pick up a pencil, the pencil is in motion. After you put the pencil down or hold it still, it is no longer in motion.

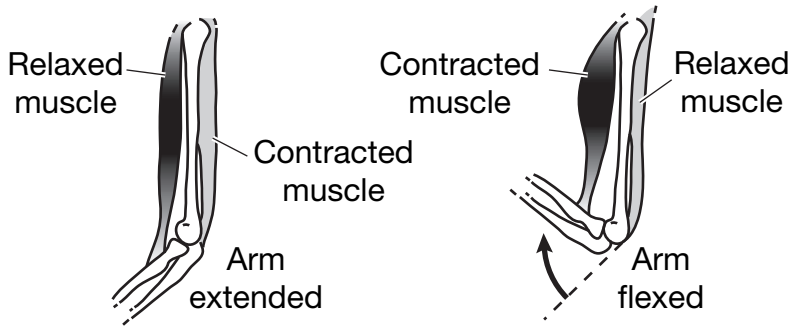
So I use force to move my body?

That's right. For example, when you bend your arm, your muscles contract, which applies force to your arm bones. Your arm responds to this force by moving.

Did You Know?

Skeletal muscles of many animals work in pairs. One muscle contracts to exert force while the other muscle relaxes.

Movement of Elbow Joint



Other systems in your body also use force. For example, during breathing, muscles contract (use force) to move air in and out of the lungs. The heart also contracts (uses force) to pump blood through the blood vessels, carrying oxygen to the muscles.

Remember!

Living organisms use energy to exert force to produce motion. Motion is one way that organisms respond to environmental changes.

Do all living things use force to move?

They sure do. Organisms rely on force to create motion. Emerging seedlings, for example, exert force on the surrounding soil. This force pushes the stem of the young plant out of the ground. Plants also exert force to open flower petals, curl and uncurl leaves, and push roots through the soil.

Fish exert force to swim by pushing against the water. Force is used to move materials in and out of cells. Force and motion can be found working together throughout the living world.

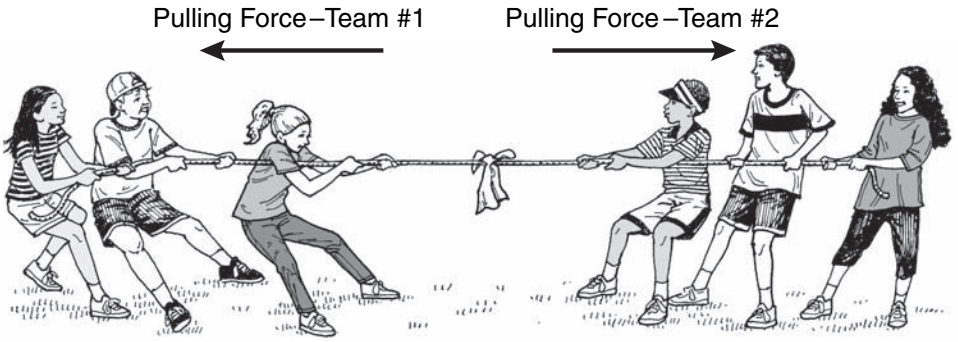
My Notes

Then force always results in motion?

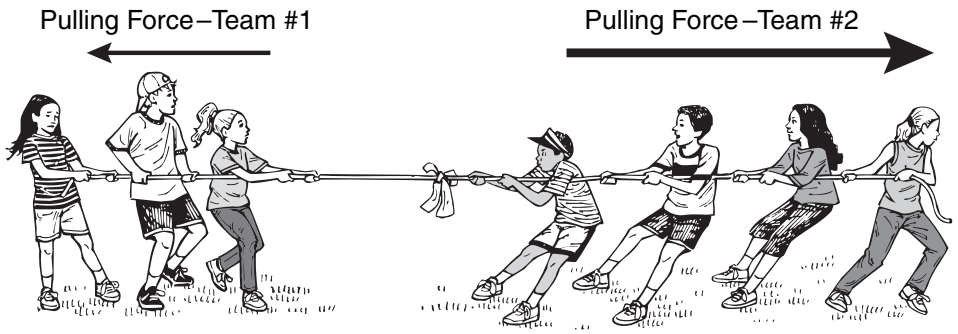
Not always. In order for a force to move something, it must be an *unbalanced force*. This means that a force is stronger in one direction than the forces in the opposite direction.

Oh, so it's like a game of tug-of-war?

Great example! In tug-of-war a team on one end of the rope is pulling with a force in one direction. A team on the other end of the rope is pulling with a force in the opposite direction. If they both pull with the same amount of force, the rope won't move at all. When forces have the same strength in opposite directions, we say the forces are *balanced*.



Now imagine that another person joins one team. That team now pulls with more force than the other team. The net force has now changed in favor of the team with more people. Both teams are pulling, but one team's force is greater than the other's.



When the forces acting on an object are not equal, we say they are *unbalanced*. The greater force will cause an object to move in the direction of its push or pull. In the game of tug-of-war, the rope will move toward the side of the team that pulls with the most force.

O.K., let's say I'm pushing my skateboard. How much force would it take to do that?

That's a good question. The answer depends on two things. First, we have to know how much mass you and your skateboard have together.

Did You Know?

Mass is the amount of matter in an object and is the same anywhere in the universe for a given object. Weight is the force that gravity exerts on an object, so it varies at different locations.

My Notes

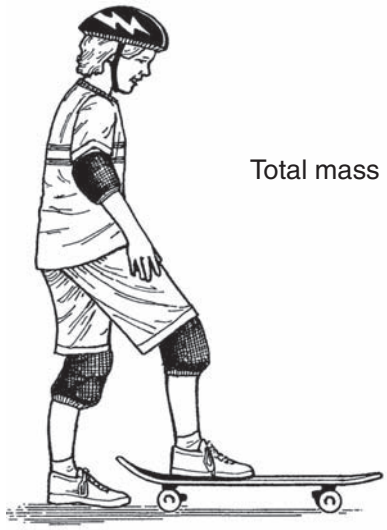
Second, we have to know how fast your skateboard is accelerating.

Why should I care about my mass or the mass of my skateboard?

Remember how the large rock exerted more force on the pan of water than the small pebble? Well, it takes more force to get that large rock moving in the first place. The greater an object's mass, the more force is required to make it move at a given speed.

Well, I know my mass is 50 kilograms and my skateboard has a mass of about 2 kilograms.

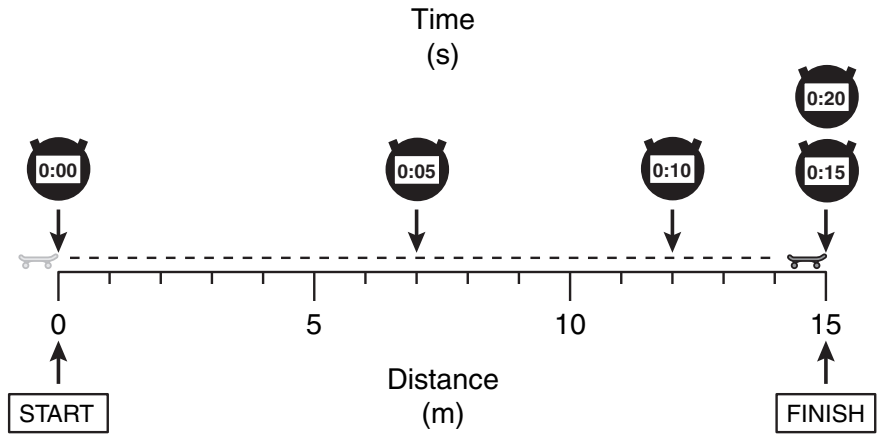
O.K., that's about 52 kilograms total.



Now should we measure me riding my skateboard?

Sure. Let's say we time your ride and measure the distance you travel every five seconds. The diagram below shows the data we might collect from your ride.

Diagram of Skateboard Ride



My Notes

Can we put this data in table form?

Great idea! In the left column, let's record the time every five seconds for 20 seconds. You can see that your motion ended at 15 seconds, and from 15 to 20 seconds you were stopped. In the right column, let's record the total distance in meters you had traveled at each time measurement.

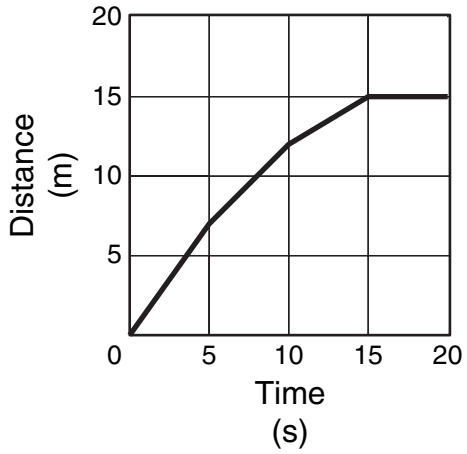
Table of Skateboard Ride Data

Time (s)	Distance (m)	
0	0	
5	7	
10	12	
15	15	← (Skateboard has stopped moving.)
20	15	

That looks good. Can we graph it, too?

Sure. From the data in the table, we can create a distance-time line graph. The distance-time graph of your skateboard ride is shown below.

Graph of Skateboard Ride Data



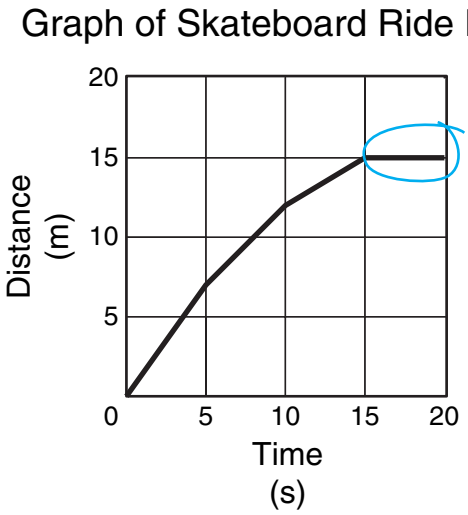
Remember!

- A line graph best shows a change in one variable.
- A bar graph best shows a comparison of two or more dependent variables.
- A pie graph or pie chart is a comparison of several parts to the whole (fractions or percentages).

Look at your graph of distance over time. *Speed* is the change in distance divided by time. The unit for speed is meters per second (m/s). Since you went 15 meters in 15 seconds (15 meters/15 seconds = 1 meter/1 second = 1 m/s), your average speed was 1 m/s.

My Notes

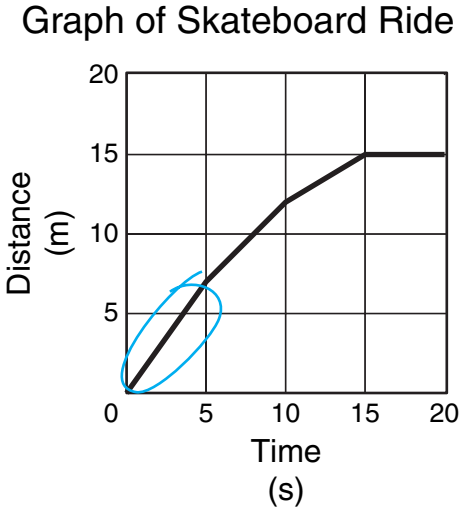
Looking at the graph, I can see that my speed changed several times.



That's right. Let's look closely at your graph. Notice the section where the line is flat (horizontal). I've circled that part in the graph above. On a distance-time graph, an object is not moving if the line is flat.

So, from 15 to 20 seconds I was stopped. But it looks like I started out really fast.

Yes, you did. Look at the line segment circled below from 0 to 5 seconds. The graphed line is steepest in this section. On a distance-time graph like this, the faster an object is moving, the steeper (more vertical) the line will be. From the graph we can see that you started out moving pretty fast, but then you slowed down and stopped after 15 seconds.



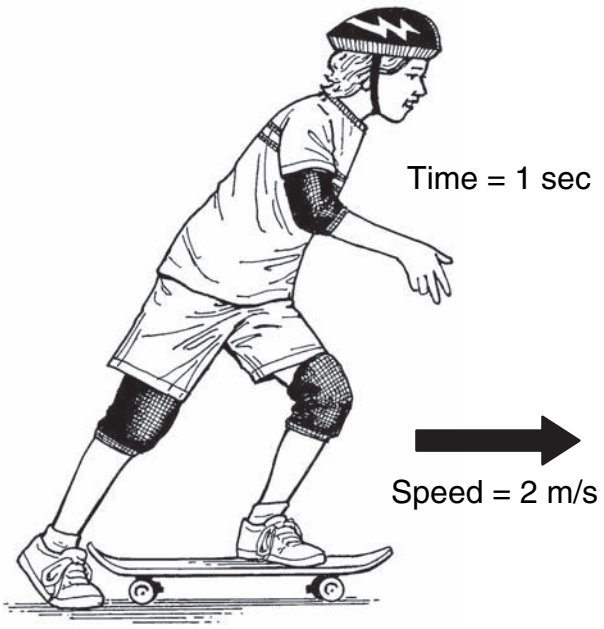
My Notes

That makes sense. But can you explain acceleration?

To understand acceleration, let's go back to the softball example. Remember the difference between the slow softball pitch and the fast softball pitch? It took a lot more force to get that softball moving quickly than to get it moving slowly. The two softballs were the same mass in both situations, so what was different in each case?

The speed of the pitch was different, right?

That's right. The ball went from being motionless in the pitcher's hand to moving toward you. The 32 m/s pitch accelerated faster than the 8 m/s pitch. *Acceleration* of an object moving in one direction is the change in speed (m/s) per unit of time (s), or change in speed divided by time. The unit for acceleration is m/s^2.



So let's say I go from 0 m/s at the start to moving 2 m/s one second after I push off down the sidewalk. What is my acceleration?

Your change in speed is 2 m/s, and the time it took you to change speed is one second. So 2 m/s ÷ 1 s = $2\ m/s^2$.

My Notes

But what's the relationship between force and motion?

Force is measured in units called *newtons* (N). One newton is the force on a 1 kg mass that will accelerate that mass to 1 m/s^2. Motion can be measured as either the speed of an object in a given direction or the distance an object travels in a given direction per unit of time.

Did You Know?

The unit called the newton was named in honor of Sir Isaac Newton, a scientist who made important discoveries about the relationship between force and motion.

Now can we calculate the force of my skateboard push?

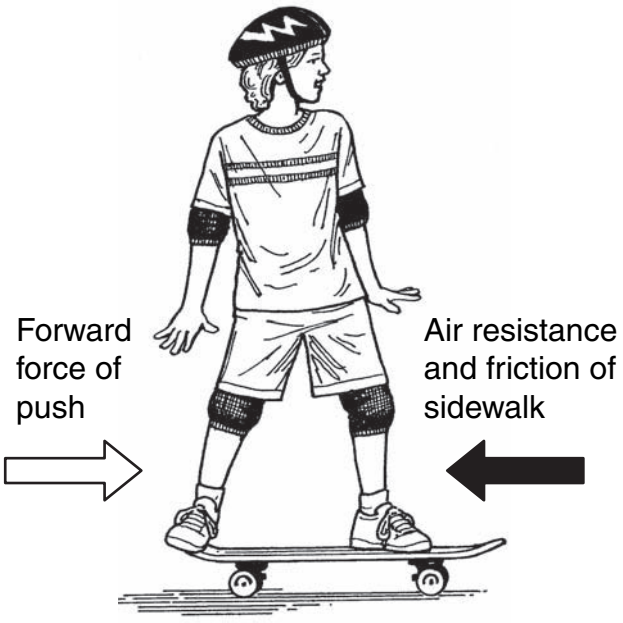
Yes. Once we know the acceleration and mass, the force can be calculated using the following formula: Force = mass × acceleration, or $F = ma$. So for your skateboard push: F = 52 kg · 2 m/s^2 = 104 kg · m/s^2 = 104 N of force.

But when I ride my skateboard down the sidewalk, I slow down and eventually stop. Why don't I just keep moving at 2 m/s?

Remember how it takes an unbalanced net force to cause motion? You would continue at 2 m/s if the force of your push remained unbalanced. But as soon as you start moving forward, the force of air and the friction between the wheels and sidewalk both oppose the motion of your skateboard.

Remember!

The units of kilograms (kg) for mass, meters (m) for distance, and seconds (s) for time can be combined into one unit called the newton (N).
1 N = 1 kg • m/s^2.



My Notes

How long will it take for me to stop?

That depends on the strength of the *resistance forces*. Resistance forces are those forces that oppose the motion of an object. For example, whether the wind is blowing with or against you affects the amount of air resistance. *Friction* is also a force that resists motion. The roughness or smoothness of the sidewalk also affects the amount of friction against the wheels.

I'm wondering why we would ever need to know how much force we use to do something.

Well, for one thing, it could help us make the work we do easier.

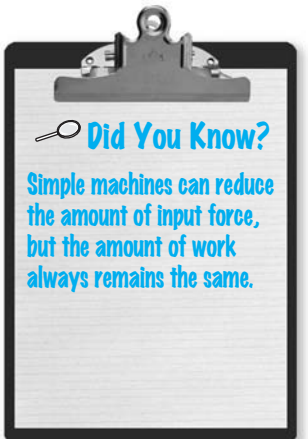
Work? You mean something like carrying out the trash?

Sure. You do work to lift the trash can. Lifting is one form of work. Work can be made easier with the help of a *machine*. A simple machine changes how much input force is needed to do work. *Input force* is the amount of force that is applied to a machine.

How do machines change how much input force is needed to do work?

It takes a certain amount of force to get a given amount of work done. Let's look at your example of lifting. For our purpose let's say it's a heavy rock you are trying to lift instead of a trash can. It's too heavy for you to lift just by pulling up on it. Your lifting force is not enough to overcome the force of gravity pulling the rock downward.

My Notes



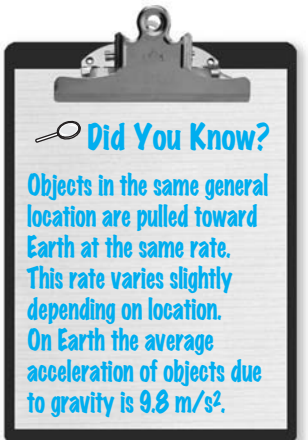
So I need to increase my input force, right?

Perhaps you could, but you've already exerted all your force once, and it wasn't enough to lift the rock. In this case the trick is not to increase your force. What a machine can do for you is decrease the input force needed to lift the rock.

But gravity keeps pulling down on the rock with the same force. How can I decrease my input force and still lift the rock?

You can take advantage of the relationship between work, force, and distance. When you do *work*, you are applying a force over a distance. This is shown in the formula Work = force × distance, or $W = fd$. Since the unit for force is newtons and the unit for distance is meters, work is expressed in newton-meters (N·m).

Distance and force combine to produce work. So, to lift your heavy rock without applying more force, you can increase the distance over which you apply the force.



But wouldn't that just lift the rock higher?

Good question. We could lift the rock higher, but that would require more work. We are trying to reduce the amount of input force used to do the same amount of work. So we need to lift the rock the same distance but use less input force to do it.

That's where machines come into the picture. We need a machine that will allow you to apply your force over a greater distance than you are lifting the rock.

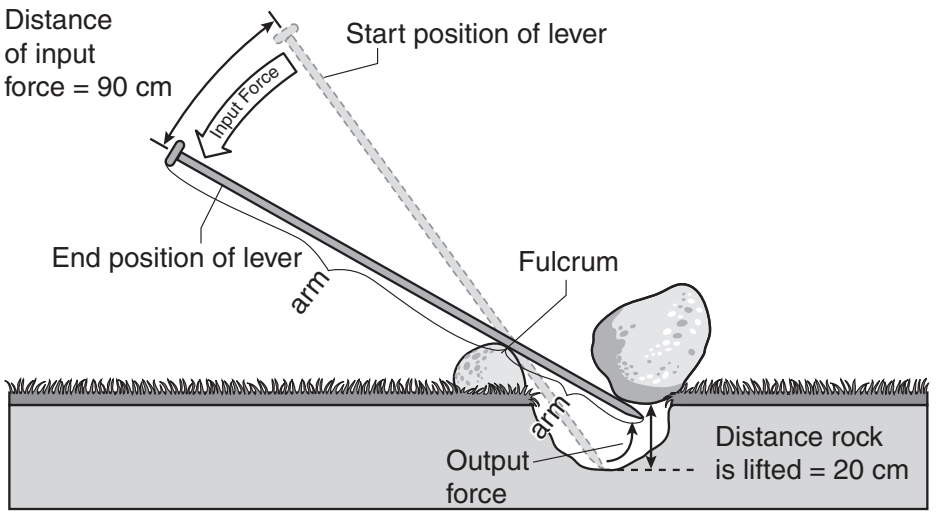
What kind of machine can do that?

Let's look at a simple machine called the *lever*. A lever has two *arms*: one that does the lifting and one that is used to apply the input force. The lever has a pivot point called the *fulcrum* that changes the direction of the force. Moving the fulcrum changes the distance each arm moves under a force.

O.K., so how does the distance one arm moves reduce the input force I need to lift the rock?

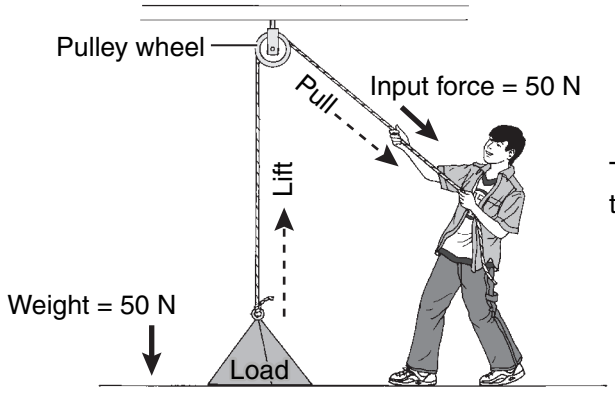
Let's say that you use a lever to lift the rock the same distance that a strong person could lift it by hand. The work done in each case is the same since the same rock is being moved the same distance. However, the distance one arm moves under your applied force is much greater than the distance the other arm moves to lift the rock. So your work is being done over a longer distance. The force you apply to lift the rock with the lever is less than the force required to lift the rock without a machine.

My Notes



Are there simple machines besides levers that help us do work?

Yes, there are several simple machines. Another example of a simple machine is the *pulley*. Pulleys use wheels and rope to move a load. When a rope passes over a wheel, it changes the direction of effort (pull) needed to move the load.



The boy pulls down to lift the load.

This pulley system has one wheel, so it changes the direction of pull one time. The input force is the same as the weight using this pulley.

Did You Know?

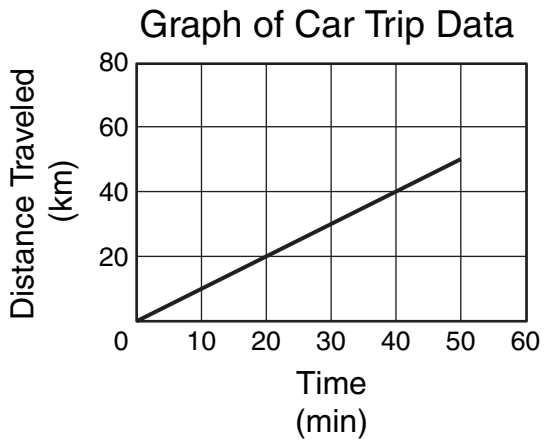
Simple machines include the pulley, the wedge, the lever, the inclined plane, and the wheel and axle.

Objective 4

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose a wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 31



The graph above shows a student's travel time in minutes during a 50 km car trip. What was the car's average speed in kilometers per hour (km/h) during the trip?

A 45 km/h

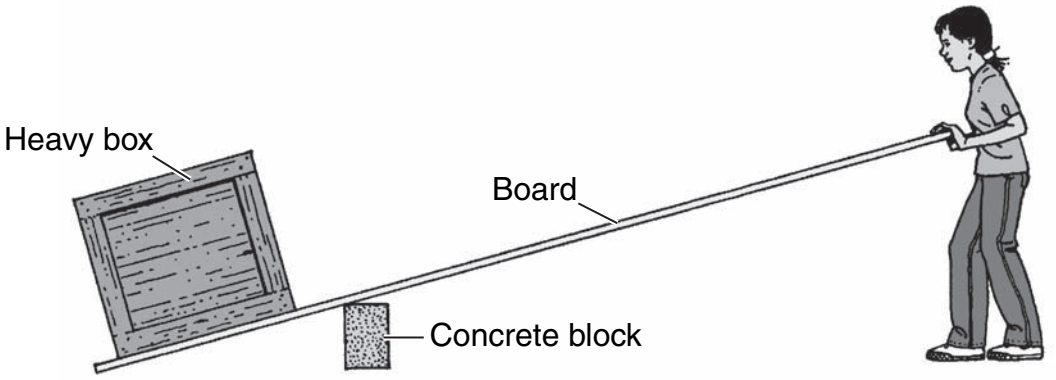
B 50 km/h

C 54 km/h

D 60 km/h

Answer Key: page 144

Question 32



The girl in the picture above is using a lever to lift a heavy box. Using the lever makes the girl's task easier by —

A reducing the input force

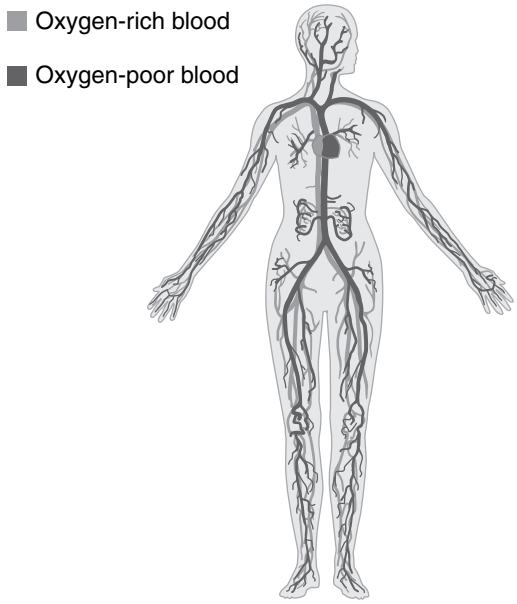
B reducing the box's mass

C increasing the amount of work done

D increasing the distance the box is lifted

Answer Key: page 144

Question 33



Which activity supplies the force that maintains blood pressure in the human circulatory system?

A Blood passing through the lungs

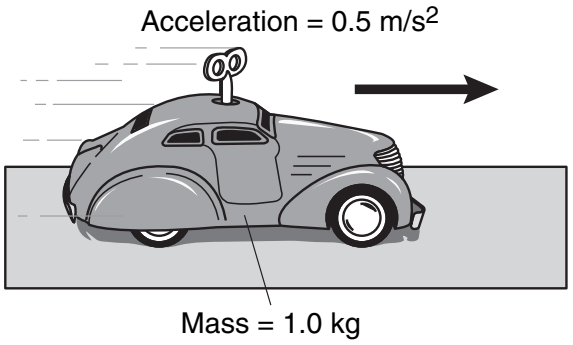
B Blood flowing out to the capillaries

C The kidneys filtering waste from blood

D The heart pumping blood through vessels

Answer Key: page 145

Question 34



When a toy car is wound up and released on a tile floor, it accelerates as shown in the diagram above. What is the force in newtons that the car's wheels exert on the floor when it is released?

A 0.05 N

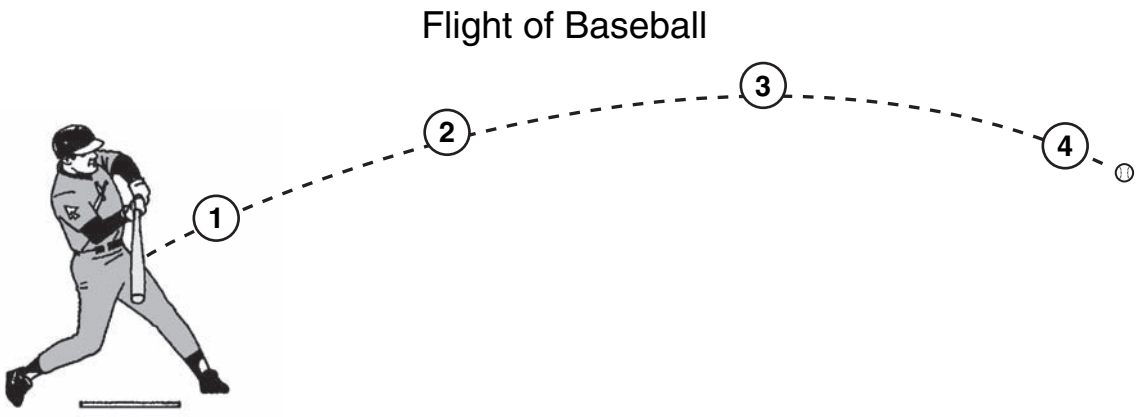
B 0.5 N

C 5 N

D 50 N

Answer Key: page 145

Question 35



At which point along the baseball's flight path is its potential energy greatest?

A 1

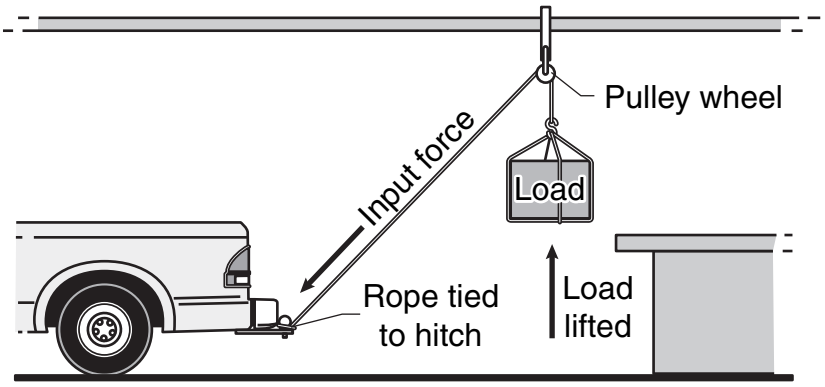
B 2

C 3

D 4

Answer Key: page 145

Question 36



In the diagram shown above, which of the following does the pulley system change?

A The amount of work done

B The direction of force used

C The amount of force used

D The mass of the load

Answer Key: page 145

Question 37

A ball with a mass of 5 kg is accelerating at 2 m/s^2 while being thrown. About how much force was used to throw the ball?

A 4 N

B 5 N

C 10 N

D 20 N

Answer Key: page 145

Question 38

When charcoal burns completely, it starts out as a solid and changes to gases and ash. Which of the following energy transformations occurs when charcoal is burned?

A Chemical to heat

B Electrical to light

C Light to chemical

D Mechanical to electrical

Answer Key: page 145

Objective 5

The student will demonstrate an understanding of Earth and space systems.

My Notes

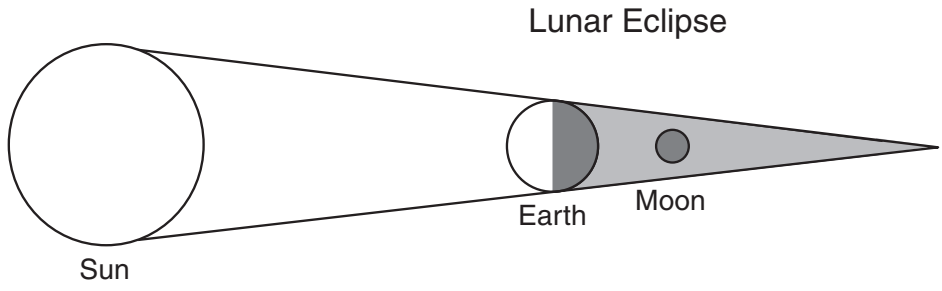
Through your studies in science, you should be able to demonstrate an understanding of Earth and space systems.

I saw something recently. It was really cool. The full moon turned orange and then got really dark. What was it?

What you saw is called a lunar eclipse. What could have made the full moon turn dark like that?

Something must have moved between the sun and the moon, right?

Correct. A *lunar eclipse* occurs when Earth blocks sunlight from reaching the moon. This puts the moon in Earth's shadow. The model below shows the positions of the sun, Earth, and moon during a lunar eclipse.



Note: Sizes and distances are not to scale.

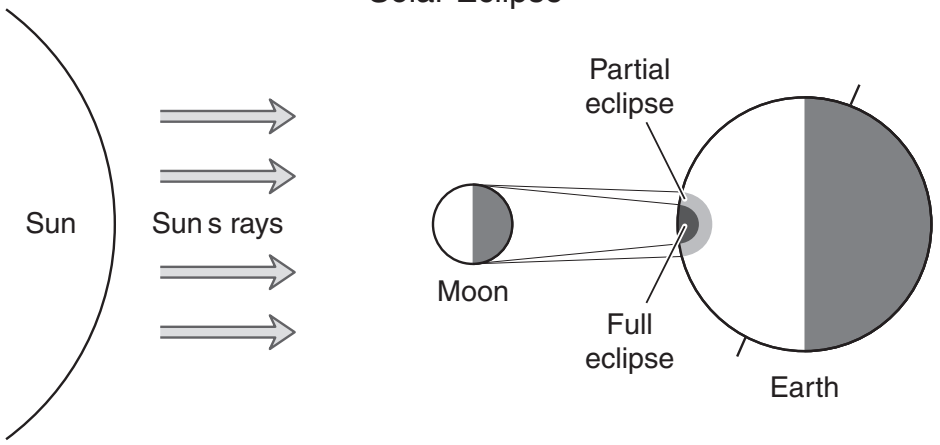
What happens when the moon moves between the sun and Earth?

When the moon is aligned so that its shadow falls on Earth's surface, the sun's light is blocked from reaching part of Earth. This kind of eclipse is called a *solar eclipse* because it is the sun that is being blocked from our view.

My Notes

Since the moon is much closer to Earth than the sun is, the moon's shadow is cast over only a small portion of Earth's sunlit side. For this reason, a solar eclipse is not observed over the entire surface of Earth. The diagram below shows the positions of the sun, Earth, and moon during a solar eclipse.

Solar Eclipse



Note: Sizes and distances are not to scale.

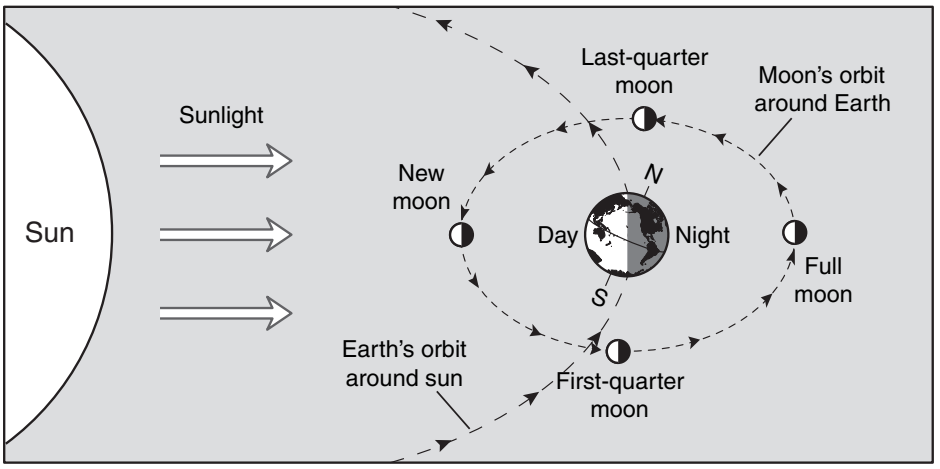
Remember!

- A solar eclipse occurs when Earth moves into the moon's shadow, blocking part of Earth from the sun's light.
- A lunar eclipse occurs when the moon moves into Earth's shadow, blocking part of the moon from the sun's light.

I see. So how does the moon change positions?

The moon revolves around Earth in a regular orbit. One orbit takes about 30 days. The moon's position relative to Earth and the sun gradually changes each day. The moon also rotates once on its axis about every 30 days. As a result, we always see the same side of the moon from Earth.

Positions of Earth, the Sun, and the Moon

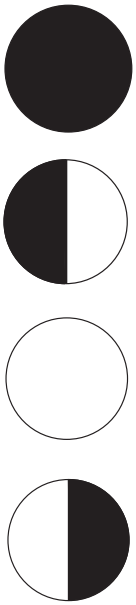


My Notes

Why does the moon's appearance change from day to day? Sometimes it's round like a disc, and other times it's a half circle or shaped like the tip of a fingernail.

The moon doesn't orbit Earth quite as fast as Earth rotates on its axis. The time of moonrise and moonset occurs later by almost an hour each day. This causes the moon's position in our sky to change each day. The sun's rays strike the moon from a slightly different angle each day. These regular changes in the moon's appearance are called *moon phases*.

There are four main phases of the moon.

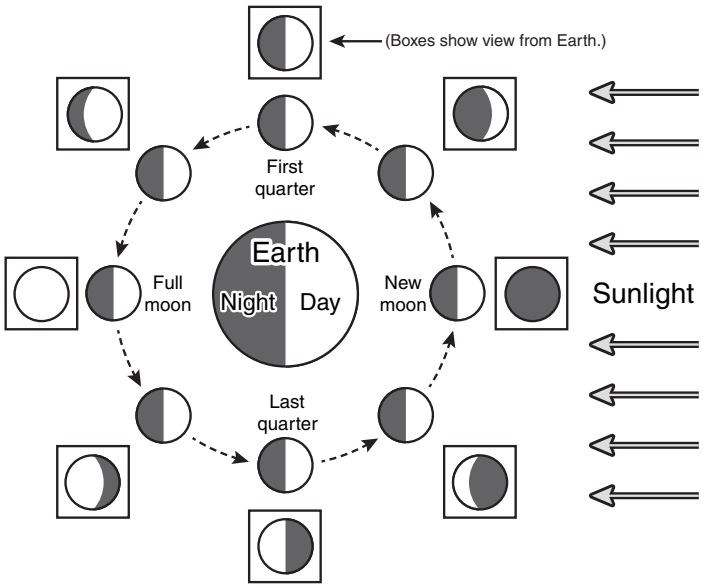


(1) The *new moon* rises around sunrise and sets around sunset. The entire side of the moon we see from Earth is in shadow and appears dark. Also, the moon is in the sky during the daytime, making it even harder to see clearly.

(2) The *first-quarter moon* rises around noon and sets around midnight. The side of the moon we see from Earth is half sunlit and half in shadow.

(3) The *full moon* rises around sunset and sets around sunrise. The entire side of the moon visible from Earth is sunlit.

(4) The *last-quarter moon* rises around midnight and sets around noon. The side of the moon we see from Earth is half sunlit and half in shadow.



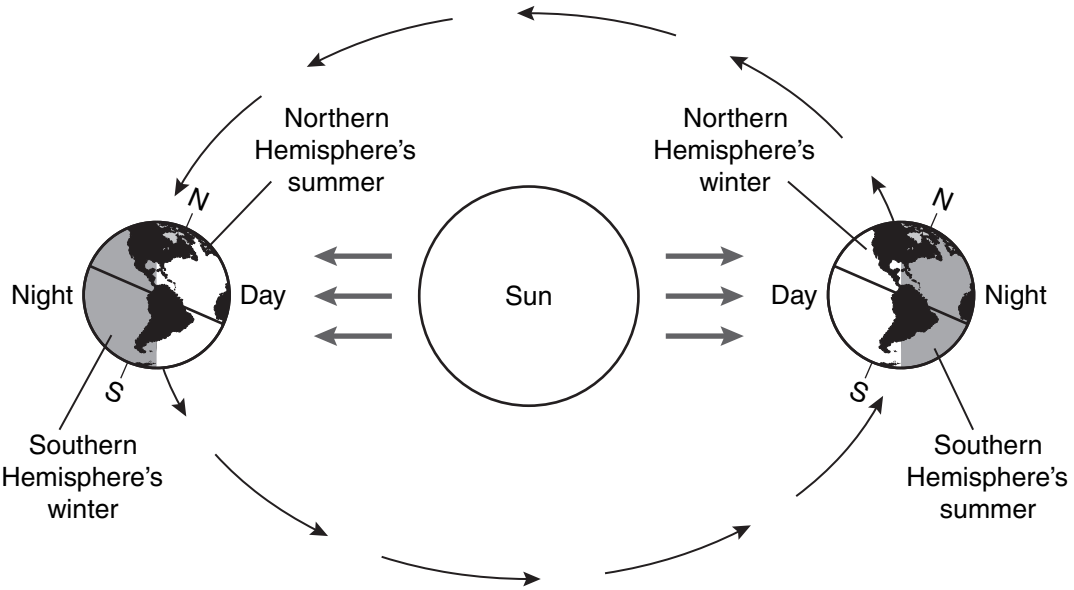
As the moon revolves around Earth, Earth revolves around the sun, right?

That's right. It takes just a little over 365 days (one Earth year) for Earth to revolve around the sun.

My Notes

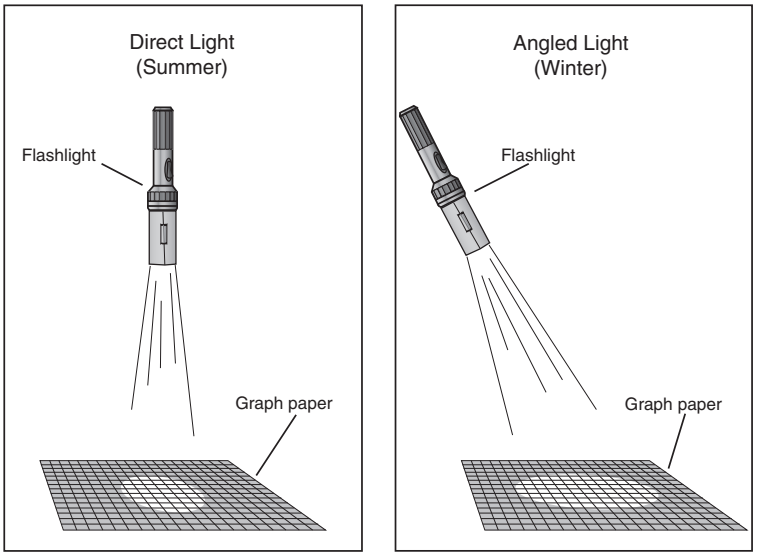
I remember hearing that Earth's tilt while it orbits the sun is the reason we have seasons. Is that correct?

It sure is. Have you ever noticed that the sun travels lower across the sky in winter than in summer? This is because Earth is tilted on its axis at a 23.5° angle.



During winter part of Earth tilts away from the sun. This causes the sun's rays to strike that part of Earth at a lower angle than in the summer.

To demonstrate this, use a flashlight shining on a piece of graph paper. Shine the light directly over (at a 90° angle) the graph paper. Then tilt the light source (at ~20° angle) so that the same amount of light is spread out over a greater area of the graph paper.



Remember!

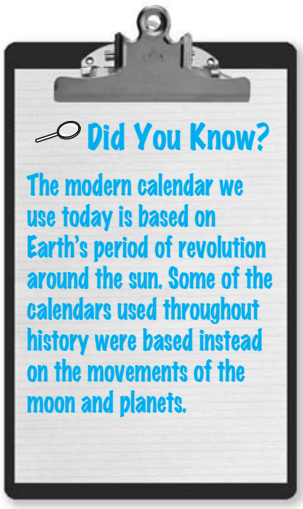
Seasons on Earth are determined by the tilt of Earth's axis, not by Earth's distance from the sun.

Did You Know?

Earth is closest to the sun in January.

My Notes

Days are shorter and nights are longer during winter. The shortest day of winter is called the winter solstice. The winter solstice occurs in December for the Northern Hemisphere and in June for the Southern Hemisphere. Each hemisphere receives less sunlight and therefore less heat energy during winter. This is why temperatures are colder during winter.

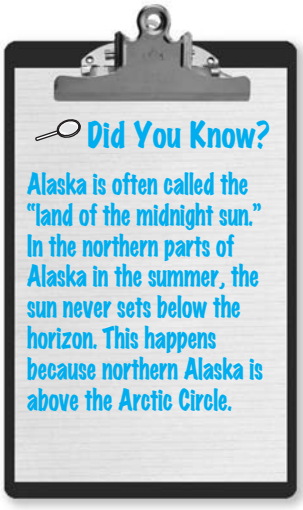


So how does winter change to summer?

Earth's revolution around the sun causes a part of Earth to tilt more toward the sun at different times of the year. This causes that part of Earth to receive sunlight at a more direct angle. This is also why the days are longer and the nights are shorter in summer. The longest day of summer is called the summer solstice. The summer solstice occurs in June for the Northern Hemisphere and in December for the Southern Hemisphere.

You've told me about Earth, the moon, and the sun, but how do they fit into the entire universe?

Earth, the moon, and the sun are all part of our solar system. Our solar system contains many things, such as the sun, the planets that orbit the sun, the asteroid belt, the Oort cloud, and the many moons that orbit some of the planets. Scientists who study the solar system are always looking for signs of more planets, so the number of planets may change.



What else do scientists know about other planets in our solar system?

The planets in our solar system follow regular orbits around the sun. Some planets are made of rock. Others are made mostly of frozen chemicals that would be gases at the temperatures we have on Earth. The planets vary in size and temperature. Some planets have many moons, while others have only a few or none at all. The table below displays some basic physical data for eight known planets in our solar system.

Planet	Primary Composition	Average Distance from the Sun (x 1,000,000 km)	Diameter (x 1,000 km)	Average Temperature (°C)
Mercury	Rock	57.90	5.49	167
Venus	Rock	108.2	12.1	464
Earth	Rock	149.6	12.8	15
Mars	Rock	228.0	6.80	–65
Jupiter	Gas	778.0	143	–110
Saturn	Gas	1,427	121	–140
Uranus	Gas	2,869	51.2	–195
Neptune	Gas	4,497	49.5	–200

My Notes

Why do all the planets revolve around the sun?

The sun is the largest body in our solar system, so its gravity is much greater than any planet's gravity. The sun's strong gravity holds the planets in their orbits. The sun is a star similar to the billions of other stars in our universe.

Is our sun really a star?

Yes, our sun is a medium-size yellow star. In the sun, hydrogen undergoes nuclear *fusion*, a process that releases vast amounts of energy. During fusion hydrogen atoms join to form helium atoms. Hydrogen fusion is the source of light, heat, and other radiation from the sun.

What other objects are there in our solar system?

Well, besides the sun, planets, and their moons, there are also *comets* and *asteroids*, which are both much smaller than planets or moons. Comets are usually made of various solids and ice crystals. When their orbits take them close to the sun, dust and ice heat up and produce a "tail" behind the comet. Larger comets may even become visible without the aid of a telescope.

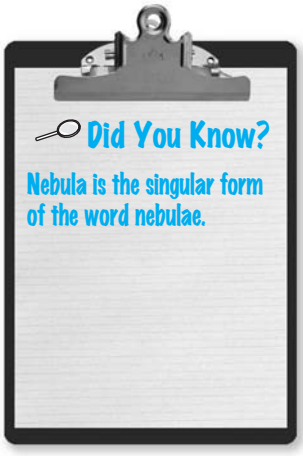
Comet Halley

© NASA

My Notes

Asteroids are rocky and usually follow regular orbits around the sun. One area between Mars and Jupiter contains a large number of asteroids orbiting the sun. This area is called the asteroid belt.

Asteroid Gaspra



What kinds of objects exist beyond our solar system?

There are actually quite a few different kinds of objects. The most easily observed objects are stars, nebulae, and galaxies.

O.K., I know that our sun is a star, but what are nebulae?

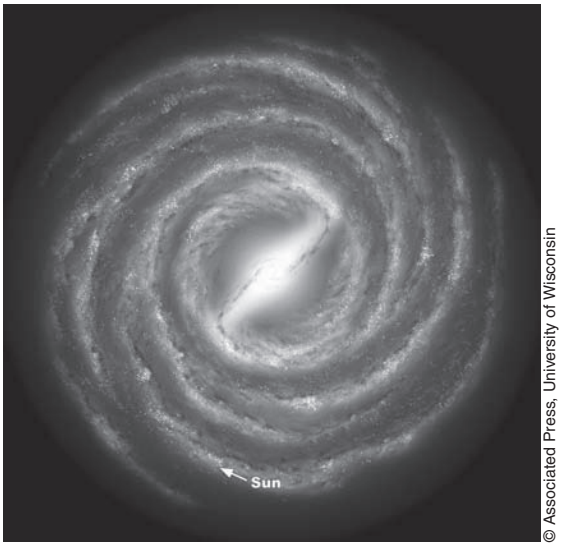
Nebulae are huge clouds of dust and gas. Some scientists think that our solar system was formed from a nebula.

I've heard that our solar system is part of the Milky Way galaxy. What is a galaxy?

Yes, our solar system is part of the Milky Way galaxy. *Galaxies* are groups of millions or billions of stars. Our Milky Way galaxy, for example, has over 100 billion stars and would take 100,000 years to travel across at the speed of light! And remember that light travels extremely fast—almost 300,000,000 meters per second.

My Notes

Milky Way Galaxy



© Associated Press, University of Wisconsin

That's too huge to even imagine! How close is the nearest star to us, besides our sun?

The nearest star is Proxima Centauri. Traveling at the speed of light, it would take about 4 years and 3 months to reach Proxima Centauri from Earth. Or, to put it another way, it is about 280,000 times farther away from Earth than our sun.

How many other galaxies are there besides the Milky Way?

Scientists think that there are billions of galaxies in the universe. Most of these are too far away to see, so we can only estimate the actual number.

Remember!

The speed of light is 3×10^8 m/s. That is a 3 with eight zeros, or 300,000,000 meters per second.

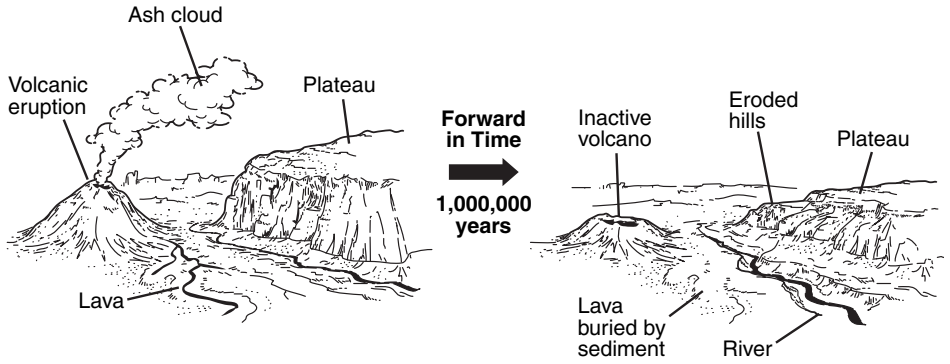
My Notes

Space systems are amazing! O.K., I'd like to come back to Earth now. What about some of those Earth systems you mentioned earlier?

Earth systems can be found as deep as the inner layers of Earth and as far out as the upper layers of Earth's atmosphere. Earth systems are all driven by energy, and many of these systems occur in cycles. Energy for Earth's rock cycle comes from heat energy in Earth's core. Energy for Earth's water and nutrient cycles comes mainly from the sun's radiant heat and light energy.

You mentioned the rock cycle. What is the rock cycle?

The *rock cycle* is the continuous change of rocks from one type to another. When we see Earth's crust, it usually looks solid and stable. But imagine that we could watch a time-lapse video of Earth's crust. Suppose this imaginary video could show us what has happened over the last 3,000,000 years in only a few minutes of time. We would see a very different picture of Earth's crust.



So, what would we see in a time-lapse video covering 3,000,000 years of time?

Suppose we let the video show the first 1,000,000 years. At first we might see mountains, hills, and plateaus. Volcanoes would spit out ashes and chunks of rock again and again. Volcanic rock would pile up all around the volcanoes. Layer after layer of volcanic ash would settle on the ground. In some places, rivers of lava would flow like melted candle wax across Earth's surface.

In reality most of these changes happen too slowly for us to notice. But our time-lapse video would allow us to see Earth's changes more easily.

I get it. We're watching what really took thousands of years happen in just a few seconds. What else would we see?

Let's fast-forward our video a million years. Now we see that the mountains, hills, and plateaus have changed. Some of the exposed rock is worn away before our eyes by wind and water. This process of rock breaking down into smaller pieces is called *weathering*.

Did You Know?

- A glacier is a huge mass of ice that moves very slowly over the land.
- Glaciers can cause major changes in landforms, such as carving out the Great Lakes.

My Notes

In our time-lapse video, soil seems to flow like water. Weathered particles of rock are transported by gravity, living organisms, water, glaciers, and wind. This movement of particles from one location to another is called *erosion*.

O.K., pause the video for a second. Soil doesn't really move like water. What is actually happening to the eroded particles?

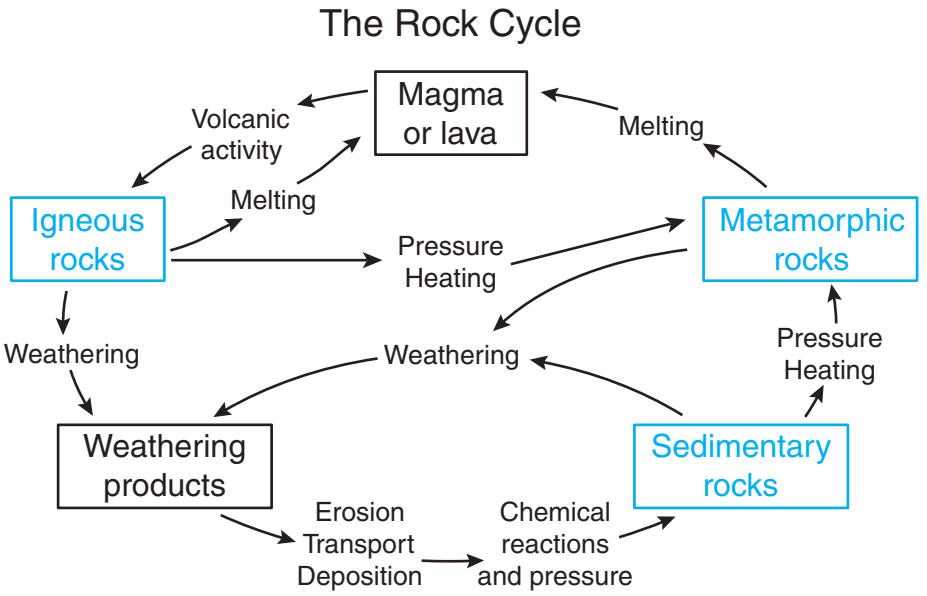
Good question. Eroded particles settle wherever they are transported by wind or water as sediment. This process is called *deposition*. Many of the soil particles that were eroded from higher areas settled in valleys and plains. The soil in these areas became deeper. From our viewpoint, it just appeared as though soil was flowing into these lower areas.

Suppose our video could also show the activity beneath oceans and lakes. We would see layers of mud, sand, and other materials steadily build up on the ocean and lake floors. These particles were washed by runoff into bodies of water and slowly settled there over time.

I know cycles have to come back around to where they started. So how do deposited particles like soil and the ocean floor become rock again?

Good point. Chemical reactions and the pressure of many layers deposited with time gradually change sediment into rock again. Sediment that gets transformed into solid rock is called *sedimentary rock*.

The lower levels of buried rock were also pushed deeper into Earth's crust. Here this rock came under great pressure and heat. These stresses caused the properties of this rock to change. Rock that has been transformed by intense heat and pressure is called *metamorphic rock*.



My Notes

Our time-lapse video showed lots of volcanic activity. What caused all these volcanoes?

Extreme heat and pressure deep in the ground caused rock to *melt*, changing it into its liquid form, which is called *magma*. At cracks in Earth's crust, magma erupted onto Earth's surface as *lava*. The lava then cooled and hardened, forming solid rock again. Rock formed from hardened magma or lava is called *igneous rock*.

Remember!

There are three basic types of rock.

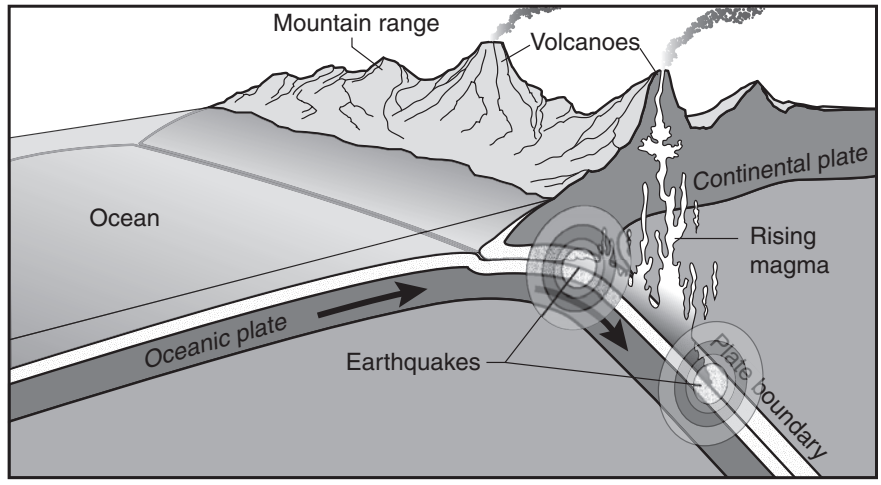
- Sedimentary rock is hardened layers of deposited sediment.
- Igneous rock is solidified lava or magma.
- Metamorphic rock is rock transformed by heat and/or pressure into rock with different properties.

O.K., that explains a lot. But I'm still curious how some of the mountains, hills, and plateaus were pushed up from Earth's crust. What caused that?

If you watched the time-lapse video closely, you may have noticed that Earth's crust seemed to be moving gradually in different directions. A theory called *plate tectonics* explains the movement of large sections of Earth's crust called tectonic plates. The force behind tectonic plate movement is thought to be currents of magma flowing in Earth's mantle.

The tectonic plates slowly collide against one another along *plate boundaries*. As a result of these collisions, sections of the plates may break off and be pushed down, up, or to the side. This is why mountain ranges, ocean trenches, earthquakes, and volcanic activity are all common along plate boundaries.

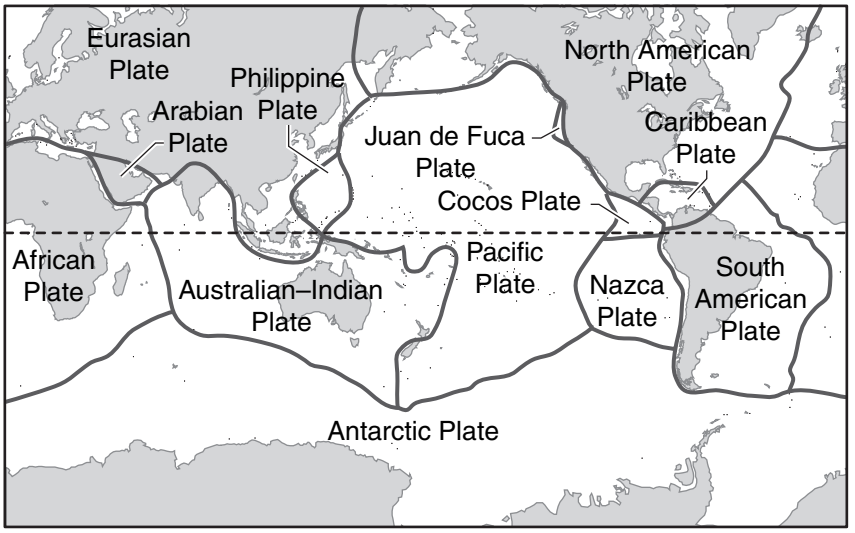
Tectonic Plate Boundary



Some plates move apart, allowing magma to rise up and cool to form new land. Earthquakes also occur around these locations. An example is the mid-Atlantic ridge, where new seafloor and land are being formed slowly. Some plate boundaries slide past each other, causing earthquakes. An example is the San Andreas Fault in California.

My Notes

Major Tectonic Plates of Earth



We've looked above and below the land and at the bottom of the ocean in our time-lapse video. What would we see if we looked along the ocean shoreline?

Well, the daily tides caused by the gravitational pull of the moon and sun would be just a blur on a time scale of thousands of years per second! But ocean waves carry a lot of energy, and over time this energy can move a lot of beach soil. The process of ocean waves changing the form of the shoreline is called *beach erosion*. We would see shorelines grow, shrink, and change shape in various areas over the entire 3,000,000 years of our imaginary video.

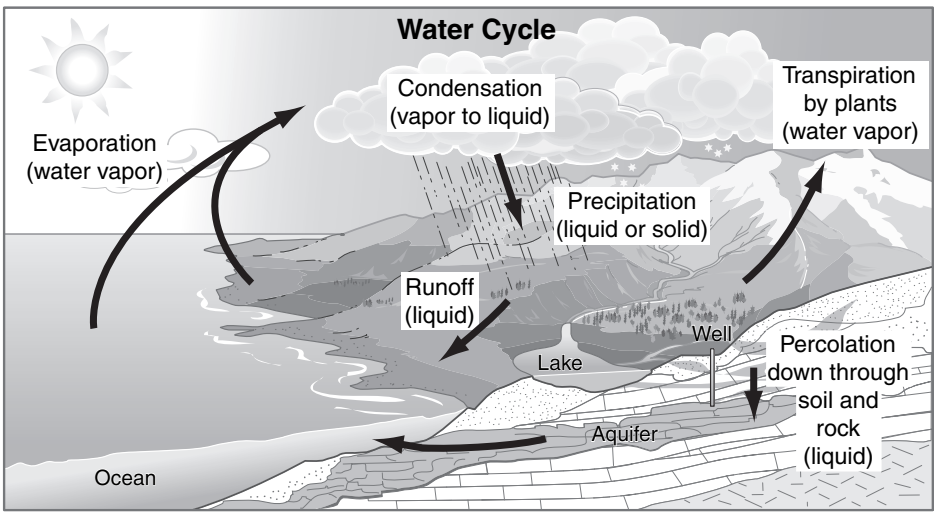
Does water go through a cycle?

Water does go through a cycle. Water naturally occurs as a solid (ice), a liquid (water), and a gas (steam, water vapor) in the range of Earth's temperatures. As water changes between these states, it moves between land, bodies of water, and the atmosphere. When water moves over the surface of Earth, it is called *surface water*. Water that percolates (soaks) down through soil and rock is called *groundwater*. Some groundwater may collect in underground reservoirs called *aquifers*. This movement of water through its different states of matter is called the *water cycle*.

Remember!

When water changes state, it gains or loses heat energy. This movement of heat energy is an important force that drives weather systems.

My Notes



If water keeps cycling, why do some cities have to conserve water?

Good question. Even though water moves in cycles, there is only a limited amount in aquifers, lakes, and rivers at any one time. Once the water is used, it takes time for these water sources to be replenished by the water cycle. In hot, dry weather people may use large amounts of water from these sources in a short amount of time. Shallow wells may become dry or polluted, and ecosystems that depend on lake and river water become threatened.

Remember!

Water has a very high specific heat (1 cal/g • °C), so it can absorb a lot of heat yet have a relatively small temperature increase. Because of this, oceans and lakes tend to store a lot of heat energy.

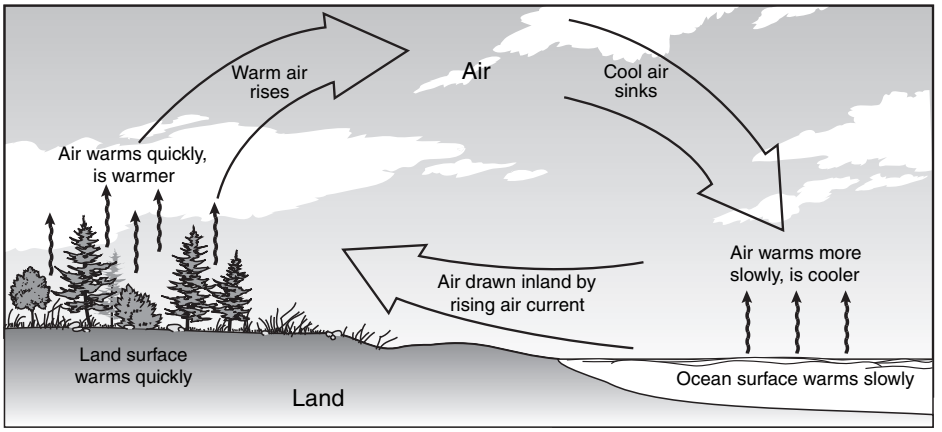
The diagram of the water cycle shows that water vapor can form clouds. Do oceans affect the climate on land?

Nice observation. There are two important ways that oceans affect the climate on land:

(1) Land heats up faster than water because land has a lower specific heat than water does. This causes the air over land to heat faster than the air over water. The warm air rises, starting a convection current that pulls air toward land from the ocean. This pattern is seen on all the continents of Earth. This keeps air over the land from getting too hot. It also brings moist ocean air inland.

My Notes

Daytime Convection Currents
Caused by Different Heating of Ocean and Land



(2) Warm air holds more water vapor than cold air does. When warm, moist air is cooled, clouds form and can produce precipitation. This warm air can be cooled by rising into the colder upper atmosphere, by moving over cold ocean or lake water, or by mixing with colder air.

We see an example of warm air mixing with cold air when a frontal boundary moves through the atmosphere. This is the edge where the cool, dry air meets the warm, moist air. This mixing of different air masses often causes stormy weather.

O.K., I've seen how water moves in cycles. Are there other important cycles on Earth?

Yes, there are. Two other important cycles are the nitrogen cycle and the carbon cycle. In the nitrogen cycle, the element nitrogen changes back and forth from nitrogen gas to the nitrogen compounds used by plants and animals. In the carbon cycle, carbon changes back and forth from carbon dioxide gas to plant and animal carbon compounds. These cycles provide essential nutrients to plants and animals. Without them, there wouldn't be any life on Earth.

My Notes

The *nitrogen cycle* is the continuous circulation or flow of nitrogen through the environment. Nitrates from the soil are absorbed by plants, which are eaten by animals that die and decay, returning the nitrogen back to the soil.

What can you tell me about nitrogen in the environment?

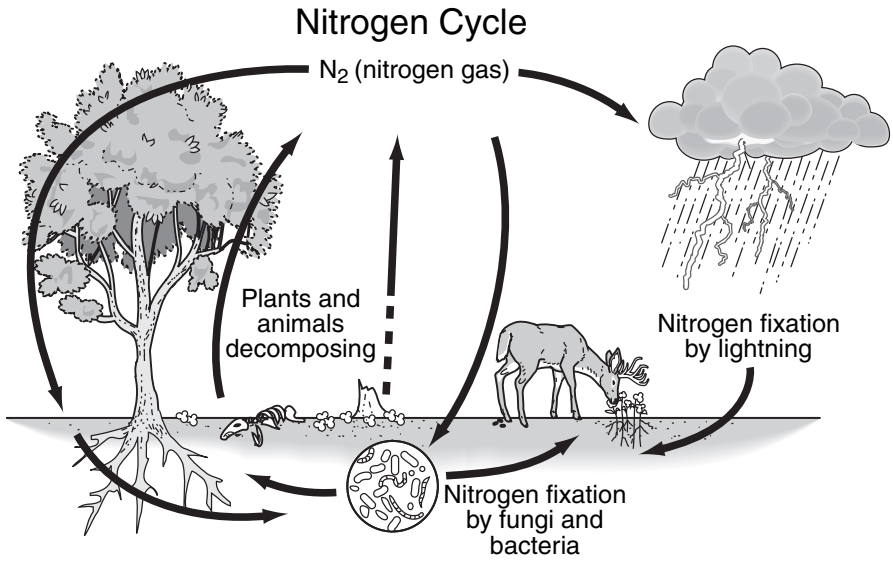
Don't some fertilizers contain nitrogen?

That's right. Some fertilizers contain nitrogen compounds because plants need nitrogen to grow. Though there is plenty of nitrogen gas in the atmosphere, plants can't use this form of nitrogen. In nature nitrogen can be changed from a gas to a form that plants can use by lightning or by soil bacteria and fungi in a process called nitrogen fixation.

Did You Know?

A chemical involved in photosynthesis is chlorophyll. One type of atom in chlorophyll molecules is nitrogen. Without nitrogen, plants could not make their own food.

Nitrogen is also passed from plants to other organisms through food webs in the ecosystem. Once plants and animals use the nitrogen, it returns to the atmosphere as a gas, completing the cycle.



So the more fertilizer containing nitrogen compounds we use, the faster plants will grow?

No, not necessarily. There is a limit to how much fertilizer is helpful. Too much nitrogen could harm the plants we are trying to help. But more importantly, all the extra fertilizer containing nitrogen could have negative effects on the ecosystem.

My Notes

What else besides the plants would be affected by too much nitrogen?

Overuse of fertilizer containing nitrogen can cause a buildup of nitrogen in groundwater and surface water in a watershed. High levels of nitrogen in a watershed can contribute to human health problems. Too much nitrogen in runoff water may also have harmful effects on fish, animals, and plants in lakes and rivers.

What about the carbon cycle?

The *carbon cycle* is the continuous circulation of carbon through the environment. Plants use the carbon dioxide from the air to make food. Animals put carbon dioxide back into the air through respiration. As fungi and bacteria break down dead plants and animals, carbon is released back into the soil.

I know plants use carbon dioxide in photosynthesis. Is this part of the carbon cycle?

Yes, it's a very important step. All living things are built from molecules that contain carbon. Some carbon comes from the atmosphere as carbon dioxide. You may recall that plants use carbon dioxide during photosynthesis to make sugar. The carbon in sugar is used as an energy source in plant and animal cells. Sugar also serves as a basic material for building other carbon compounds that make up plant and animal tissues.

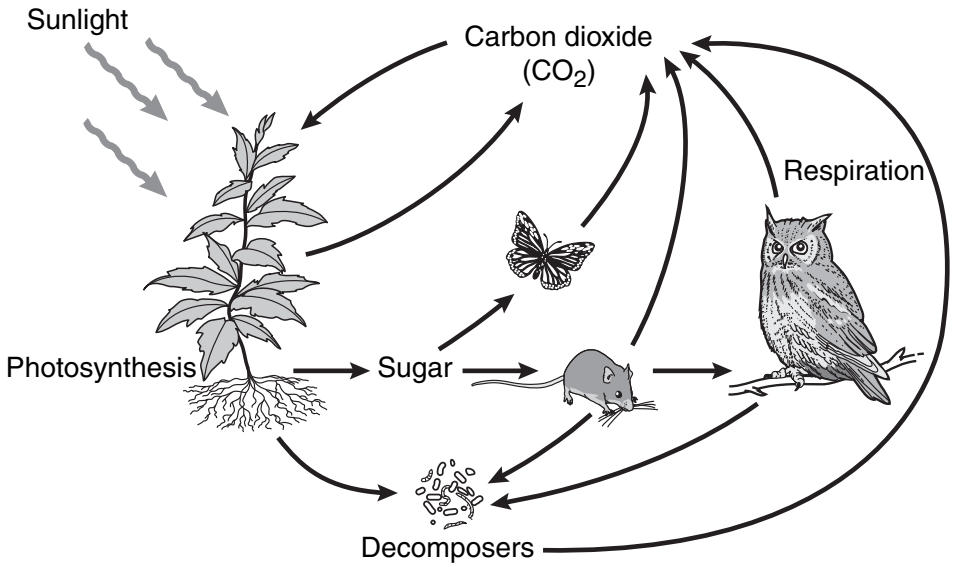
When animals eat plants and other animals, they convert these carbon compounds into energy and various materials in their bodies. Most compounds in animal tissues contain carbon.

So how do all these carbon compounds become carbon dioxide again?

When plants and animals use sugar to produce energy during respiration, carbon dioxide is given off. Decomposers change the carbon compounds in dead plants and animals into carbon dioxide. Both respiration and decomposition complete the cycle, releasing carbon dioxide back into the atmosphere.

My Notes

The Carbon Cycle



Do humans affect the carbon cycle?

Yes, we do. One of the biggest ways humans affect the carbon cycle is by burning fossil fuels. Fossil fuels are coal, oil, and natural gas. These fuels were formed from the buried remains of ancient plant and animal life. Over millions of years, heat and pressure have changed the carbon in these organisms into coal, oil, or natural gas. Burning these fuels transforms the carbon into carbon dioxide. Burning fossil fuels produces carbon dioxide much faster than the natural decay process does.

I see. So how does this extra carbon dioxide affect the environment?

Higher levels of carbon dioxide cause the atmosphere to hold more heat energy. Rising carbon dioxide levels may be the cause of warmer temperatures measured in recent years on Earth. This is sometimes called "the greenhouse effect." This could affect the climate in many places. The kinds of plants and animals able to survive in these climates may change if the warming continues.

Whew! That's a lot of information. Can we summarize this in a table?

Sure. Have a look at this.

My Notes

Nitrogen and Carbon Cycle Effects

Cycle	Importance to Plants	Importance to Animals	Forms in the Environment
Nitrogen	Supplies vital nutrients	Supplies vital nutrients	Water-soluble nitrogen compounds in soil and water; nitrogen gas in atmosphere
Carbon	Basic energy source (sugar); building block of organic molecules	Energy source and building material for cells, tissues, organs	Mineral carbon in rocks; carbon dioxide in atmosphere; carbon in organic products (wood, paper, meat, vegetables, etc.)

I see how human activities affect these cycles. What about when a natural disaster occurs?

Natural disasters can have far-reaching effects on Earth systems. For example, large meteorites striking Earth or volcanoes erupting can cause environmental change. These events can change the amount of sunlight and heat reaching the atmosphere, land, and water on Earth. This can affect the amount of energy available for Earth's cycles.

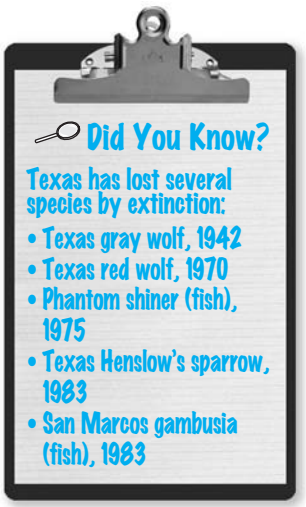
What would happen if a large meteorite struck the Earth?

If a very large meteorite impact or volcanic eruption occurred, it would fill the atmosphere with tiny dust particles. Dust particles can stay in the upper atmosphere for years. This would block sunlight and therefore reduce the total energy available on Earth. As Earth's cycles slowed down, climates and ecosystems would be altered. There is evidence in the fossil record of *mass extinctions* following these kinds of disasters. The extinction of the dinosaurs may have been caused by such an event.

Haven't humans also caused some species of plants and animals to become extinct?

Unfortunately, human activities have been the cause of some extinctions. Humans affect Earth in many ways. We change the quality of the air, water, and soil we use. We change ecosystems by removing plants and animals and by introducing new species, such as invasive plants and pets. *Invasive species* do not naturally live in the ecosystem where they are introduced. These species sometimes compete with or drive out *native* species. Native species are those that live naturally in an ecosystem.

Fire ants are an invasive species accidentally introduced to North America from South America. In North America they have few predators and aggressively attack and kill many kinds of native plants and animals. They have upset the balance of ecosystems in many southern states.

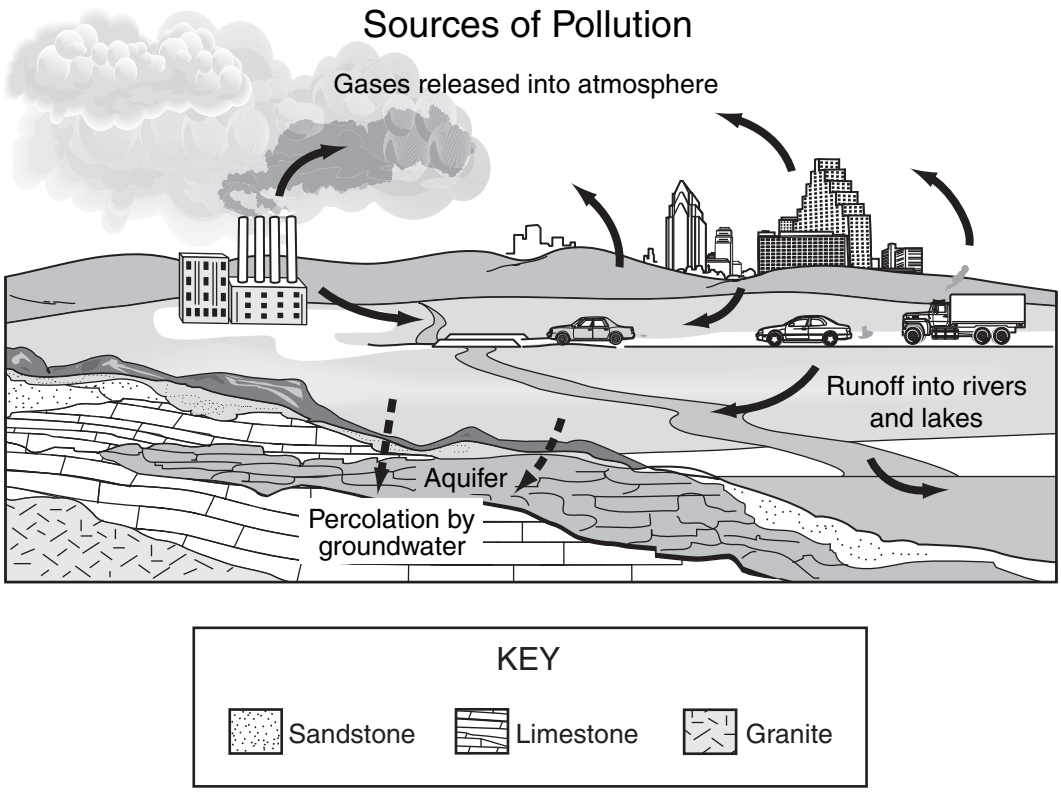


My Notes

Changes in habitat can make it difficult for some species to survive. Some species are able to adapt, but others become threatened or endangered. A few species even become extinct, lost from Earth forever.

So humans change the quality of resources such as air, water, and soil. How do we do that?

We've identified some of these changes in our discussion of Earth's cycles. But there are many ways humans can alter the environment. One of the main ways we do this is by producing harmful chemical waste materials. These harmful products cause pollution. Two common forms of pollution include: (1) gases released into the atmosphere and (2) chemicals that are carried by water into a watershed.



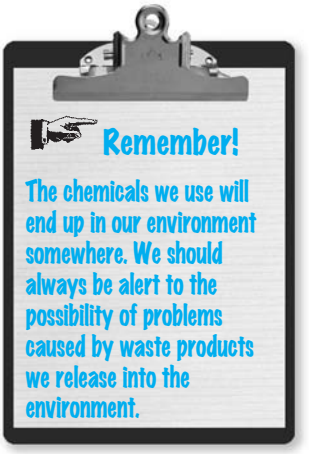
How do chemicals harm the atmosphere?

Well, let's look at a class of chemicals called chlorofluorocarbons (CFCs). CFCs were used in air conditioners, refrigerators, and pressurized sprays. But when CFCs evaporate, they rise into the upper layers of the atmosphere. There CFCs destroy ozone, a gas that protects Earth from the sun's harmful ultraviolet rays. Once the effects of CFCs were discovered, other chemicals were used instead of CFCs in order to preserve the ozone layer.

My Notes

How does pollution affect water and soil?

Many industrial waste products are compounds that dissolve easily in water. When we clear and plow land, we expose soil to erosion. Eroded soil and waste products can move into rivers, lakes, and aquifers. These eroded materials can ultimately harm water ecosystems. Harmful chemicals may also enter the water supplies we use for drinking, cooking, and other household uses.



So pollution damages resources that we need in order to live. When we damage a resource, can we repair the damage?

That's a very important question. That depends a lot on which resource is damaged. Some resources may recover in just a few years, and others may not recover for thousands of years or more.

Which resources can recover quickly from damage?

Renewable resources usually recover sooner than other types of resources. Renewable resources are replaced regularly through natural events once they have been damaged. Surface water, for example, will re-enter the water cycle after it has been polluted. Evaporation will usually separate pure water from any pollutants in it. The evaporated water will eventually fall to Earth as precipitation, and we will be able to use it again.

What other types of resources are there besides renewable resources?

Resources that have a limited supply and are not being recycled or replaced naturally are *nonrenewable*. Fossil fuels are an example of a nonrenewable energy resource because they take many millions of years to form.

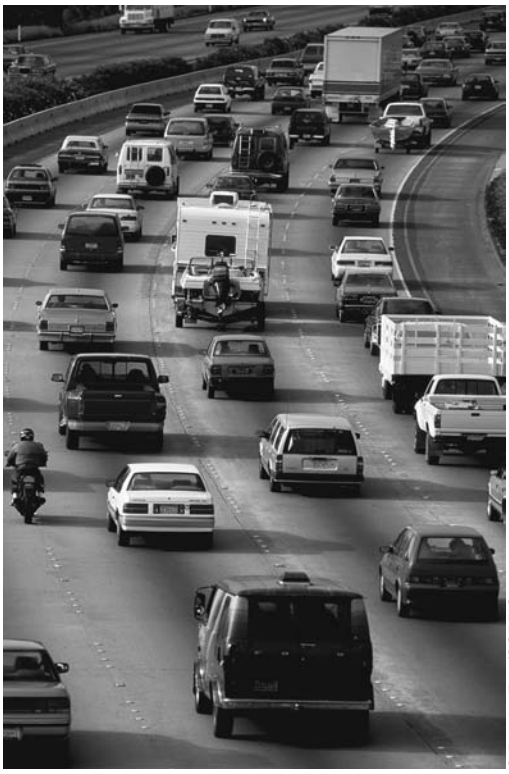
What if a resource is so plentiful that we will never run out of it?

Inexhaustible resources are so abundant or continuous that they do not require replacement. An example of this is sunlight. It arrives daily over most of the planet in vast amounts. It is probably impossible for us to use all the sunlight that Earth receives.

Well, obviously most resources aren't that plentiful. That means we have to be careful how we use our resources, right?

Exactly. Fossil fuels are a good example. The supply of underground crude oil we use to make gasoline and diesel fuel decreases every year. Yet we keep pumping more oil from wells. If this continues, oil and gasoline will become so rare in the future that we won't be able to use them as much as we do now.

My Notes



© Royalty-Free/CORBIS

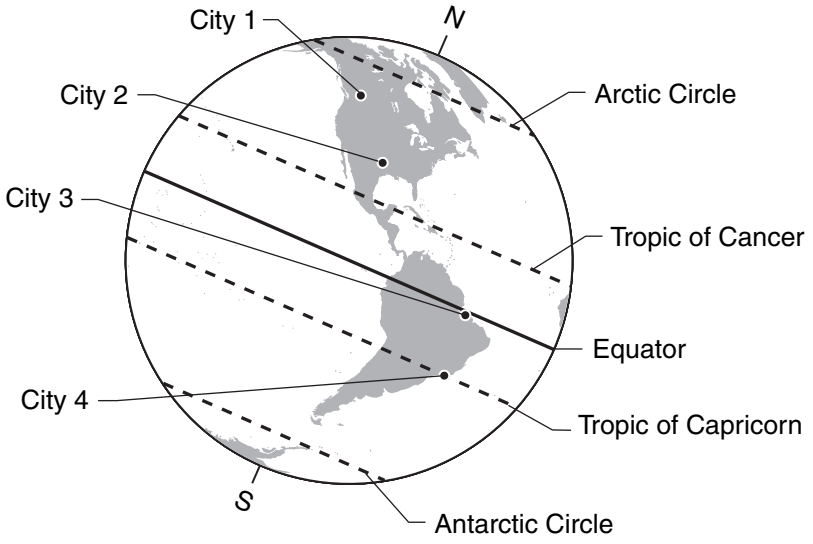
What will we use for energy when that happens?

We will have to find other sources of energy. Ideally, we will use renewable or inexhaustible resources so the supply won't run out. To replace fossil fuels, new energy resources must be found to produce large amounts of energy at a reasonable cost.

Now It's Your Turn

After you answer the practice questions, you can check your answers to see how you did. If you chose a wrong answer to a question, carefully read the answer explanation to find out why your answer is incorrect. Then read the explanation for the correct answer.

Question 39



Which of the following best explains why City 3 experiences the smallest change in day length between summer and winter out of the four cities shown in the diagram above?

A City 3 is closest to the sun during the Northern Hemisphere's winter.

B Earth completes one revolution of the sun about every 365 days.

C Earth rotates on its axis about once every 24 hours.

D City 3 is located closest to the equator.

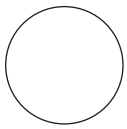
Answer Key: page 145

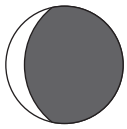
Question 40

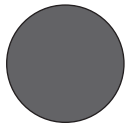
October 2005

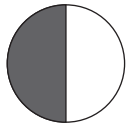
Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	New moon 3	4	5	6	7	8
9	10	11	12	13	14	15
16	Full moon 17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Which of the following best represents the appearance of the moon on October 10, 2005?

A 

B 

C 

D 

Answer Key: page 146

Question 41

Which of the following is the primary energy source that causes warm, moist air to rise over tropical oceans?

A The sun's rays

B Melting icebergs

C Earth's rotation

D Heat from Earth's core

Answer Key: page 146

Question 42

Which of the following processes is occurring when rainwater dissolves volcanic rock?

A Folding

B Deposition

C Erosion

D Faulting

Answer Key: page 146

Question 43

Nitrogen waste washing into a pond would most likely cause an increase in —

A fish reproduction

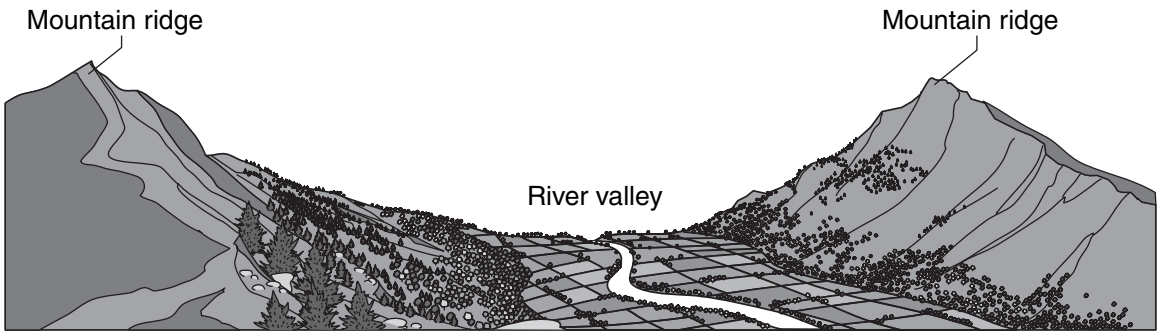
B flooding

C water plant growth

D evaporation

Answer Key: page 146

Question 44



Which two processes contributed most to the accumulation of soil in this river valley?

A Pressure and uplift

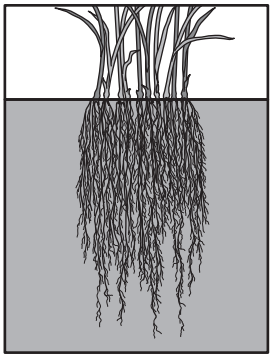
B Erosion and deposition

C Earthquakes and faulting

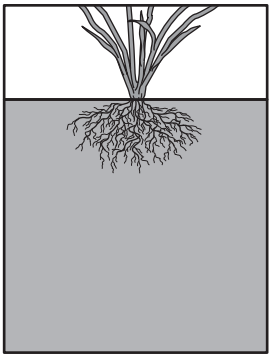
D Percolation and evaporation

Answer Key: page 146

Question 45



Prairie grass roots



Wheat roots

Prairie grass may be better at preventing erosion than wheat is because the prairie grass roots are able to —

A use more mineral nutrients

B hold more soil in place

C absorb more water

D grow more slowly

Answer Key: page 146

Question 46

The map above shows the western coast of South America. Which process caused the upward movement that formed the Andes Mountains?

A Seafloor spreading

B Deposition of sediment

C Tectonic plate collision

D Erosion of rock layers

Answer Key: page 147

Question 47

A forest area is cleared and replaced with a parking lot. Over several years, water quality in this area will likely be harmed most by —

A decreased water flow in streams

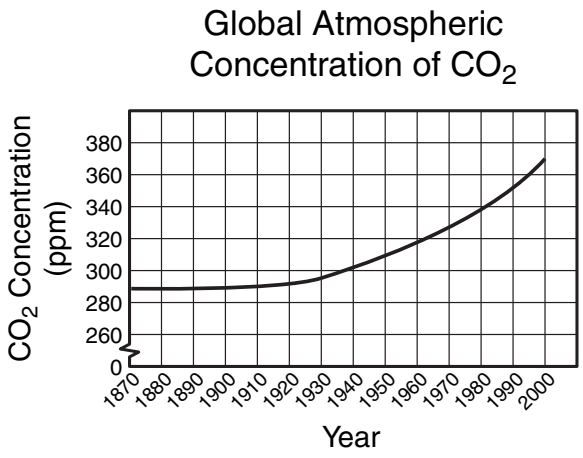
B increased sediments in runoff water

C increased oil products in groundwater

D decreased animal waste

Answer Key: page 147

Question 48



Which human activity most likely contributed to the rapid increase in atmospheric carbon dioxide (CO_2) after 1930?

A The burning of fossil fuels

B The extinction of animal species

C The destruction of natural wetlands

D The planting of additional farm crops

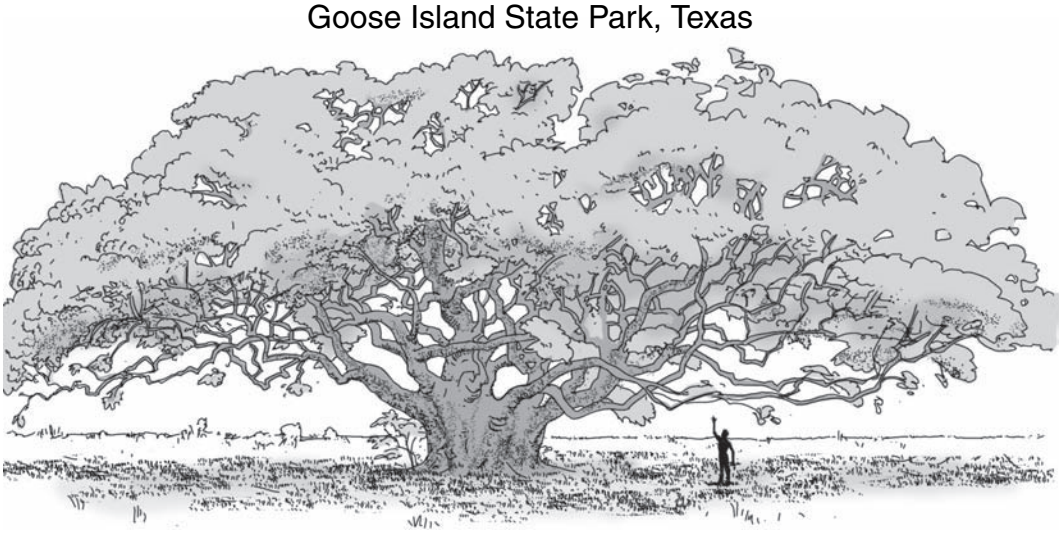
Answer Key: page 147

Cluster 1

Use the information below and your knowledge of science to answer questions 49–54.

The Big Tree

Goose Island State Park, Texas



A huge coastal live oak tree nicknamed "The Big Tree" grows in Goose Island State Park on the Gulf Coast of Texas. It is one of the largest known trees of its species in Texas. The Big Tree has a trunk diameter of about 11 meters, stands about 13 meters tall, and has spreading branches about 27 meters wide.

Coastal live oaks are an important part of the coastal plain ecosystem. The coastal live oak provides food and shelter for many types of animals. Their spreading branches provide anchors for smaller plants, and the acorns of the coastal live oak are an important food source for animals such as deer, blue jays, raccoons, and squirrels.

Question 49

Live Oak Flowers

Live oak acorns are produced from flowers that appear in spring and hang in clusters from the branch tips. What level of organization of the oak tree are these flowers?

A Cell

B Organ

C Organism

D Population

Answer Key: page 147

Question 50

Burning wood from a live oak would most directly increase which form of carbon in the carbon cycle?

A Elemental carbon in the ground

B Carbon atoms in plant sugar

C Carbon compounds in animals

D Carbon dioxide in the atmosphere

Answer Key: page 147

Question 51

A disease called oak wilt can kill live oak trees. This disease is caused by a fungus that is spread from tree to tree by a sap beetle. Sap beetles are eaten by wrens. Which organism is the host of the oak wilt disease?

A Fungus

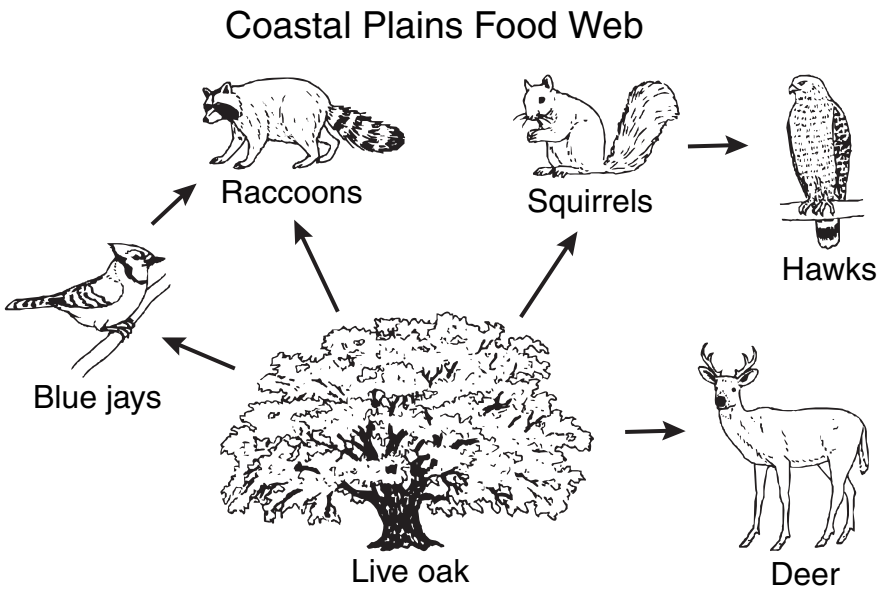
B Live oak

C Sap beetle

D Wren

Answer Key: page 147

Question 52



What is the role of the live oak tree in the food web shown above?

A Producer

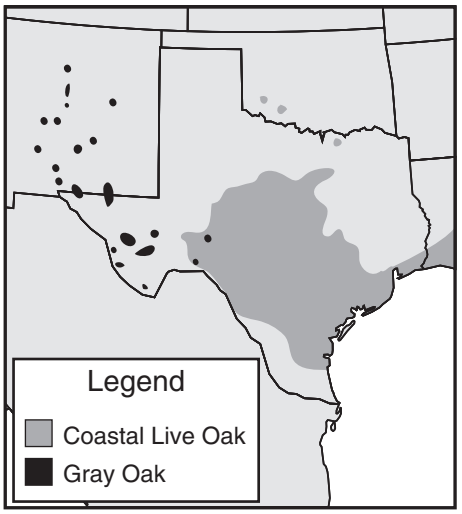
B Decomposer

C Primary consumer

D Secondary consumer

Answer Key: page 148

Question 53



The coastal live oak and the gray oak are related species that grow in the areas shown on the map above. The two species grow in different regions of Texas probably because they —

A have different leaf shapes

B are eaten by different consumers

C are adapted to different environments

D grow to different heights

Answer Key: page 148

Question 54

Wood Densities

Wood type	Density (g/cm^3)
Cypress	0.51
Ash	0.67
Maple	0.76

The table above shows the densities of dried samples of common types of wood. A 750 cm^3 sample of dry live oak wood has a mass of 660 g. How does the density of the live oak sample compare to the densities of the other woods in the table?

A Live oak is less dense than cypress, ash, and maple.

B Live oak is more dense than cypress but less dense than ash or maple.

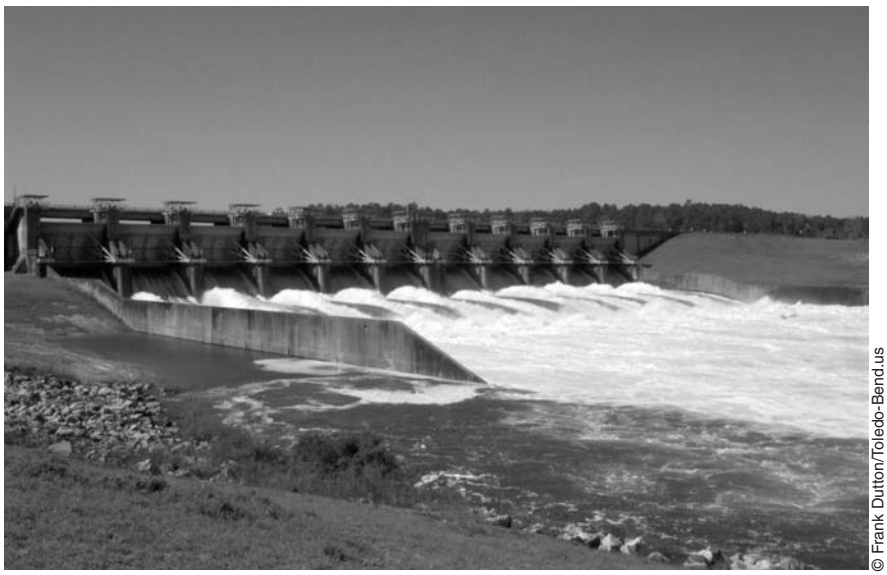
C Live oak is more dense than ash and cypress but less dense than maple.

D Live oak is more dense than cypress, ash, and maple.

Answer Key: page 148

Cluster 2

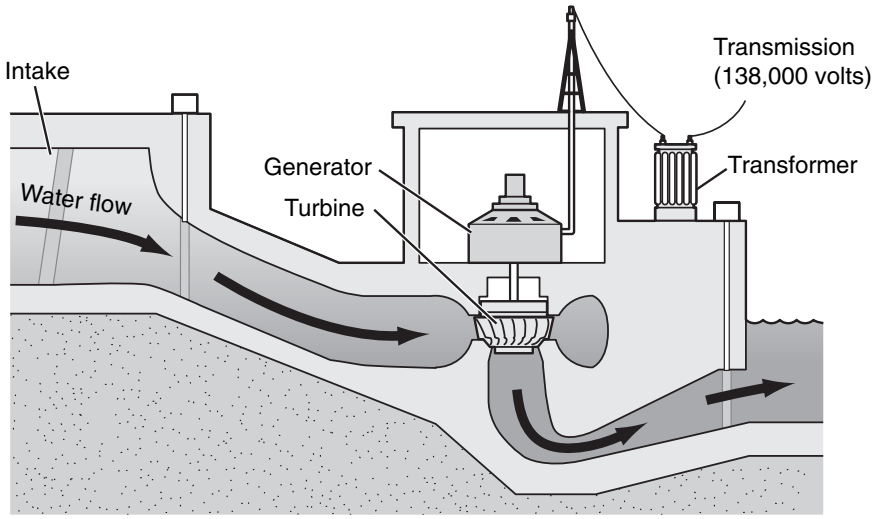
Use the information below and your knowledge of science to answer questions 55–60.



© Frank Dutton/Toledo-Bend.us

Toledo Bend Reservoir is located on the Texas-Louisiana border. It is the largest reservoir in Texas. At normal water level it holds 5.8 million cubic meters of water. Its surface covers 829 square kilometers. Boating, swimming, and fishing are favorite recreational activities of visitors to the reservoir.

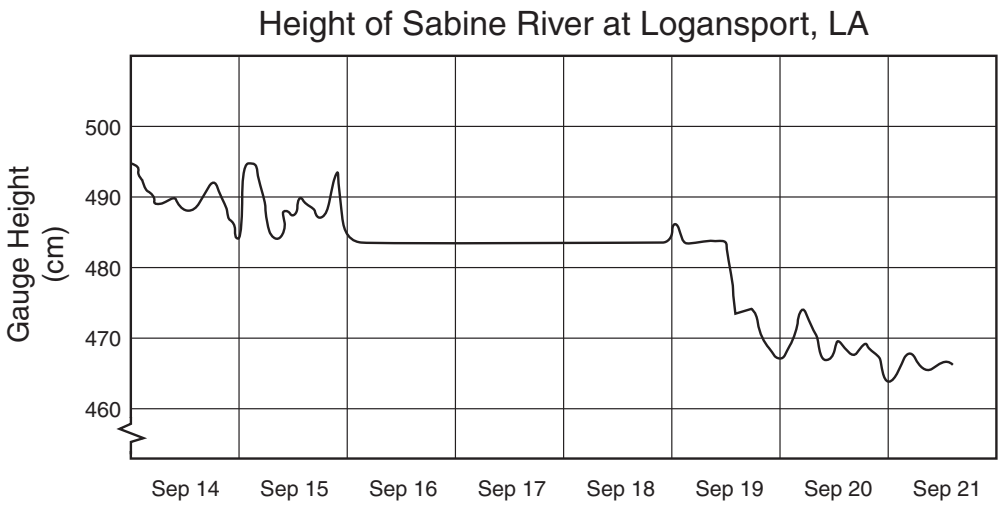
The flow of water through the dam provides electrical power to citizens of Louisiana and Texas. A hydroelectric power plant at the dam uses generators to produce electrical current. A diagram of a hydroelectric generator is shown below.



The steps used to generate electricity at the plant are:

1. Water enters intake and turns the turbine.
2. The turbine turns the generator shaft.
3. The generator produces electrical current that flows to the transformer.
4. The transformer changes the voltage and transmits electricity to power lines.

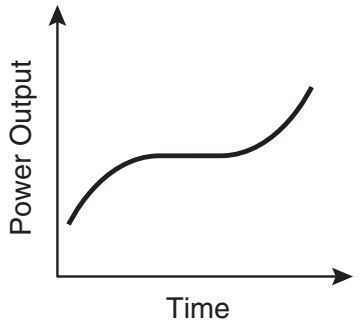
Question 55



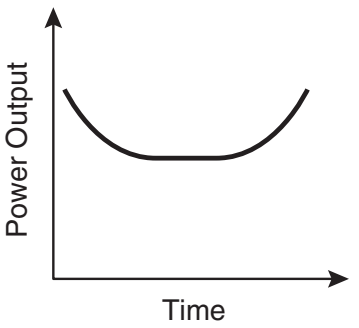
Source: USGS

To increase the amount of electricity generated by the power plant, more water must flow through the turbines. The graph above shows the height of the Sabine River just downstream from the dam from September 14 through 21, 2005. Which graph below shows the most likely change in electrical output of the power plant from September 14 to September 21?

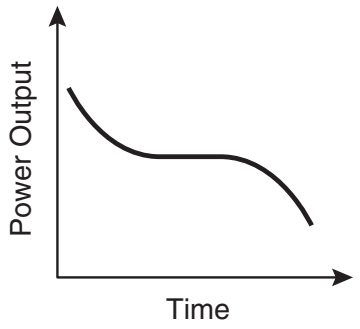
A



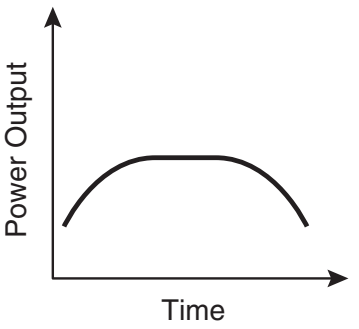
C



B

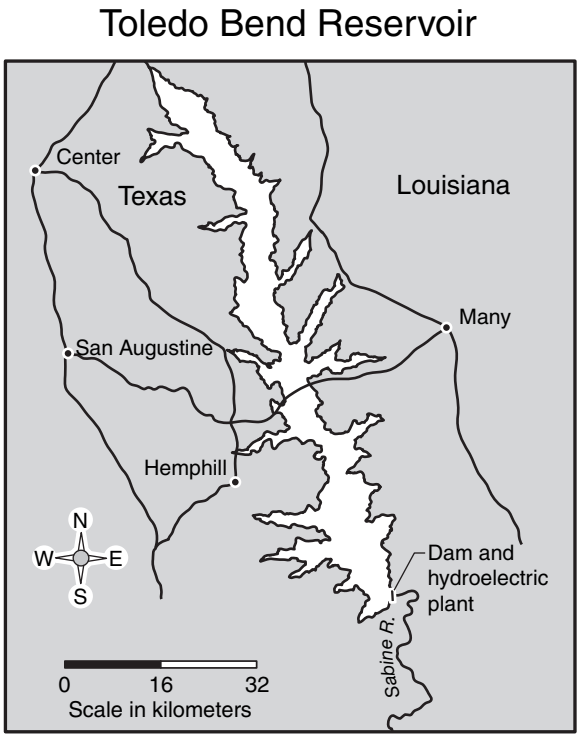


D



Answer Key: page 148

Question 56



About how far is it from the Toledo Bend Dam to the northernmost point of the reservoir?

A 64 km

B 77 km

C 100 km

D 128 km

Answer Key: page 148

Question 57

Which energy transformation produces the power generated by the Toledo Bend Reservoir power plant?

A Chemical to light

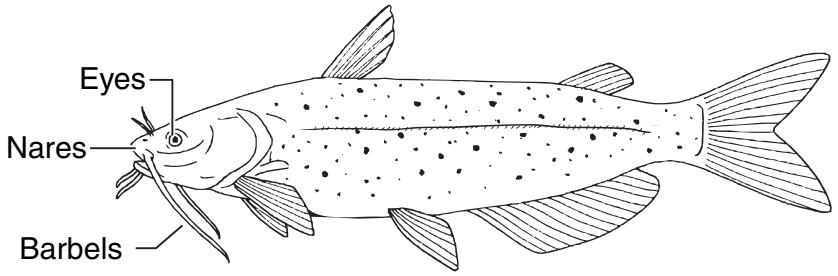
B Electrical to light

C Mechanical to chemical

D Mechanical to electrical

Answer Key: page 148

Question 58



Toledo Bend Reservoir contains some channel catfish. Some of the channel catfish's major sensory organs are labeled on the drawing above. The location of these organs most likely helps the catfish in which of the following activities?

A Finding food

B Circulating blood

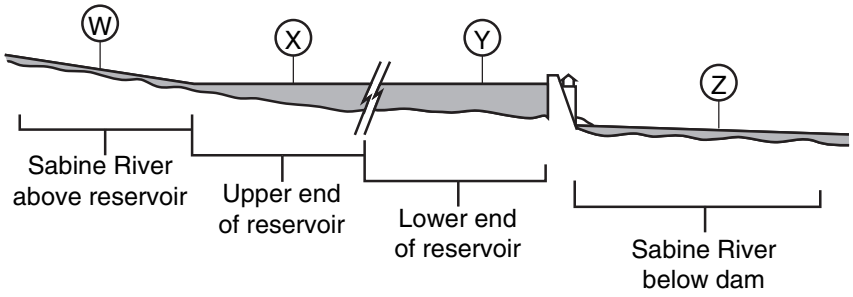
C Floating and sinking

D Breathing underwater

Answer Key: page 149

Question 59

Toledo Bend Reservoir and Sabine River



The diagram above shows a side elevation view of the Sabine River and Toledo Bend Reservoir. At which point on the diagram does water have the greatest potential energy?

A W

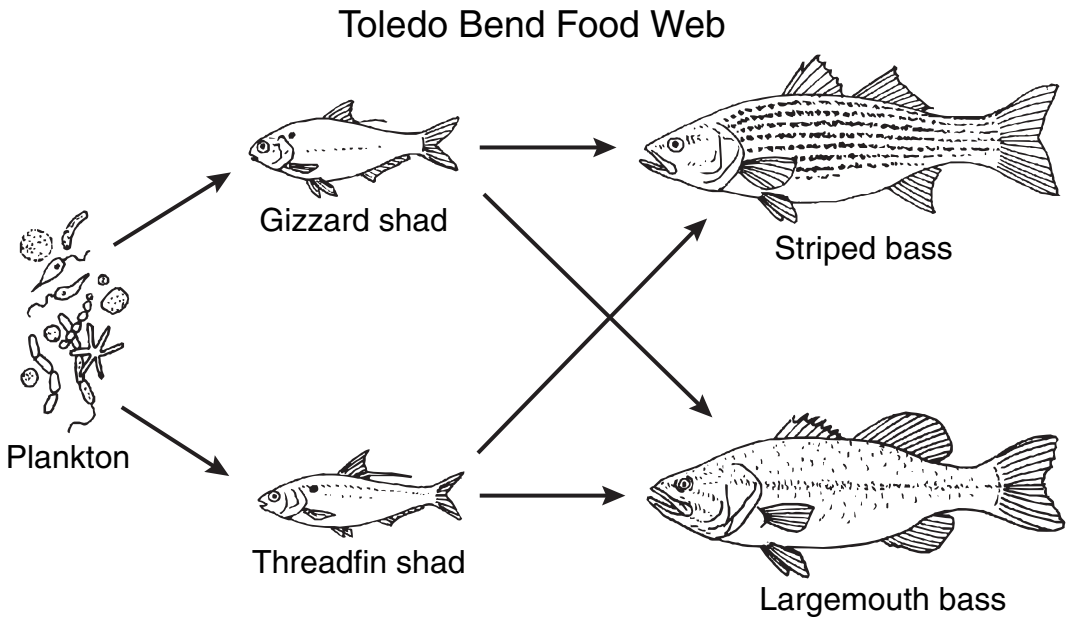
B X

C Y

D Z

Answer Key: page 149

Question 60



Which of the following changes would most likely occur if some of the gizzard shad grew too large for the largemouth bass to eat?

A Gizzard shad would eat less plankton.

B Threadfin shad would eat more plankton.

C Largemouth bass would eat fewer striped bass.

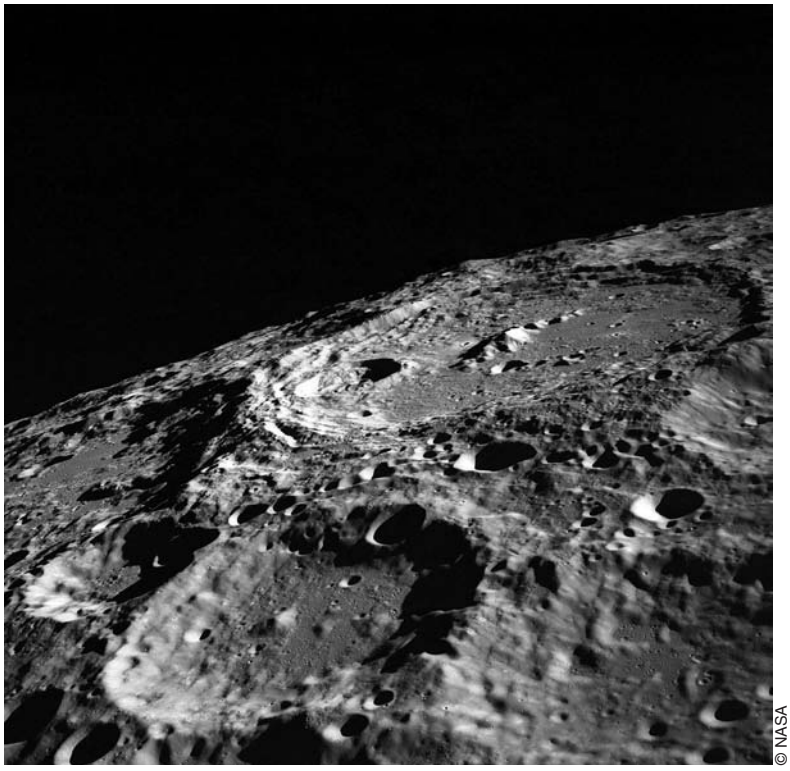
D Largemouth bass would eat more threadfin shad.

Answer Key: page 149

Science Activity

Sudden Impact! Crashing the Crater Mystery

Craters on Moon's Surface



If you have ever looked closely at the moon, you may have noticed that its surface is not smooth. It is covered by craters such as the ones shown in the photograph above. The large crater in the picture is about 80 kilometers across! Craters form when meteoroids collide with the surface of a planet or moon.

Have you ever wondered:

- why some craters are shallow but others are deep?
- why some craters are larger than others?
- why there are so many craters on the moon compared to Earth?

Scientists have asked these questions ever since telescopes first allowed us to view the moon in detail. It isn't practical to experiment on the moon's surface to see how craters form. But scientists can use models of the moon's surface to understand craters.

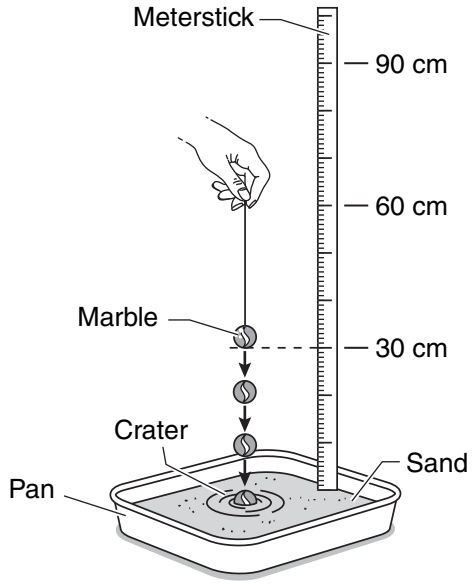
This activity lets you model craters like those on the moon. You will see how models help scientists answer questions. You may even come up with some answers of your own!

My Notes

Making a Crater Model

Here's what you will need to make your "moon" craters:

- A pan or dish at least 5 cm deep and 20 cm long on each side
- Enough dry sand to fill the bottom of the container to 3 cm deep
- A large marble
- 10 cm of masking tape
- 30 cm of string or thread
- Meterstick
- 30 cm ruler
- An index card



Tie a knot in one end of the string. Tape the knotted end of the string to the marble.

Fill the container with sand 3 cm deep. Smooth the surface of the sand with the index card. Place the sand-filled container outdoors.

Use the meterstick to measure a height of 30 cm above the sand's surface (be careful not to disturb the sand). Drop the marble from the 30 cm height into the center of the sand. Then carefully pick the marble up by the string and remove it from the sand. It is O.K. if a small amount of the dry sand slides back down into the crater when you pull the marble out.

Use the ruler to measure the width and depth of the crater made by the marble in the sand. Record your measurements in the data table below.

My Notes

Then smooth the sand back down to a flat surface. Repeat the marble drop from the same height two more times. Record these data in the table, too.

Then measure a 60 cm height above the sand surface. Drop the marble three times from 60 cm. Record all your data in the table.

Finally measure a 90 cm height and drop the marble three times from 90 cm. Record all your data in the table.

Crater Data Table

Drop Height (cm)	Drop 1		Drop 2		Drop 3		Average	
	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)
30								
60								
90								

What were the differences in the craters that formed when the marble was dropped from different heights? Support your answer with data from the table.

_____

_____

_____

_____

What was the purpose of dropping the marble three times at each height?

_____

_____

_____

_____

My Notes

Explain what the following parts of the crater model represent:

The sand represents _____

_____

The marble represents _____

_____

What are some weaknesses of your model?

_____

_____

_____

_____

How could you improve this model?

_____

_____

_____

_____

What does this crater model tell us about the craters found on the moon?

_____

_____

_____

_____

My Notes

Meteoroids usually travel at speeds faster than 11 km/s. In what way is the crater model unable to represent this accurately?

_____

_____

_____

_____

Barringer Meteor Crater, Arizona

© Charles & Josette Lenars/CORBIS

Earth Versus Moon Craters

The Earth and moon are estimated to be about the same age. The moon has tens of thousands of visible craters wider than 18 meters in diameter. Earth has fewer than 200 visible craters that size. Why is there such a big difference in the number of large craters visible on Earth and on the moon?

There is evidence that many more craters did exist on Earth in the past. One reason why we cannot see many of these craters is the rock cycle.

What are two processes in the rock cycle that might erase evidence of ancient craters on Earth's crust?

Process #1: _____

Process #2: _____

My Notes

Another reason Earth has fewer craters is that our atmosphere is a barrier to meteoroids. Traveling at high speed, meteoroids melt and vaporize from friction and other forces as they fall through Earth's atmosphere. Many never reach the ground at all but blaze out in a flash of light called a meteor. But some meteoroids in Earth's past were large enough to make it all the way to the ground, where they made a terrific impact!

Evaluate

A large meteorite impact can send millions of tons of dust and ash into the air. The dust may take months or even years to settle out of the atmosphere. Describe one effect that a thick layer of dust in the atmosphere would be likely to have on each of the following:

The water cycle:

_____

_____

_____

_____

The carbon cycle:

_____

_____

_____

_____

My Notes

Hypothesize

Look at the data you collected in the Crater Data Table. Suppose you repeated the activity using a ball with greater mass than the marble. Make a prediction about the result of using a ball with greater mass.

Prediction:

_____

_____

_____

_____

You Decide

Suppose you decide to use a golf ball. Which laboratory instrument could you use to find out whether the golf ball has a greater mass than the marble?

_____

_____

_____

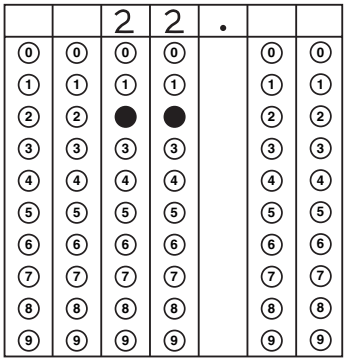
Look at the sample results on page 149 to see how your answers compare.

Science Answer Key

Answer to example question (page 9)

The total number of seeds that sprouted is found by adding all the seeds shown in the second column of the table (7 + 3 + 8 + 4 = 22).

Your correct answer grid would look like this:



Note: Zeros may be written and gridded in any of the empty place values. These extra zeros will not affect the correctness of the answer.

Objective 1

Question 1 (page 24)

A Incorrect. The elevations near a river decrease toward the river and increase as they move away from the river.

B Correct. The elevations reach a high point within the 700-meter circle. This indicates a hilltop.

C Incorrect. A plain is relatively flat. The elevation increases too much over too short a distance for the map to represent a plain.

D Incorrect. A lake would lie lower than the surrounding elevations. The map does not show these features.

Question 2 (page 24)

A Correct. Carbon dioxide is necessary for photosynthesis in the plant. Since there are no animals present in the closed terrarium system, carbon dioxide will not be recycled.

B Incorrect. Oxygen is a product of the plant's photosynthesis. Since there are no animals present in the closed terrarium system, oxygen will gradually increase. Also, oxygen will not directly affect the plant's ability to grow.

C Incorrect. Evaporated water cannot escape the closed terrarium system, so it will eventually condense and return to the soil. The water will therefore recycle in this system.

D Incorrect. The transparent bottle allows sunlight to pass freely into the terrarium and to the plant. Therefore there is no lack of sunlight.

Question 3 (page 25)

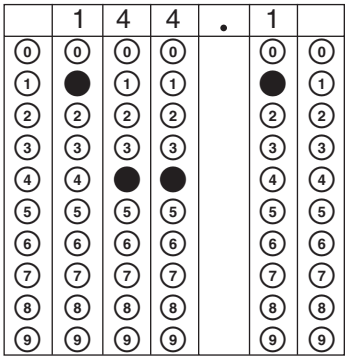
A Correct. Wearing goggles is not necessary for this activity because there is no likelihood of a splash.

B Incorrect. The digging tool is a sharp instrument that might injure toes during use.

C Incorrect. The student should be aware of where the tools for lab activities are kept.

D Incorrect. Using the tool while wearing jewelry might cause a minor injury.

Question 4 (page 25)



The middle beam reads 100 g. The top beam reads 40 g. The bottom beam is divided into grams and tenths of grams, so the reading is 4.1 g. The total mass is 100 + 40 + 4.1 = 144.1 g.

Note: Zeros may be written and gridded in any of the empty place values. These extra zeros will not affect the correctness of the answer.

Question 5 (page 26)

A Correct. A telescope is designed for viewing

distant astronomical objects such as Jupiter. It would provide the magnification and focus needed to view Jupiter's bands and spots from Earth.

B Incorrect. A microscope is designed for viewing very small objects in the laboratory. A large, faraway planet such as Jupiter could not be viewed using a microscope.

C Incorrect. A hand lens magnifies objects that are within reach. Jupiter is too far away, and its image would not be magnified well by a hand lens.

D Incorrect. A computer probe measures data from samples near the location of the attached computer. A computer probe on Earth would not be able to gather much data from a distant planet such as Jupiter.

Question 6 (page 27)

A Correct. The two views show the sample at different magnifications. The objective lens determines the magnification of the view, so switching the lens will change the size of the image.

B Incorrect. A change in the amount of light shining on the sample would make the sample appear darker or lighter, not larger or smaller.

C Incorrect. Turning the fine adjustment knob would change the focus of the image. This would not affect the size of the objects being viewed in the sample.

D Incorrect. Changing the angle of the light source might affect the shading on the salt grains. It would not affect the size of the objects being viewed in the sample.

Question 7 (page 28)

A Incorrect. Catching fish is not a reasonable use of insulated gloves and a beaker.

B Correct. Liquids should be heated in glassware such as a beaker. Hot beakers should be handled with insulated gloves.

C Incorrect. Temperatures are measured with a thermometer. No container or hand protection is needed to read a thermometer.

D Incorrect. No hand protection is required to find the mass of a rock sample. Glassware is used to find the volume of liquids.

Question 8 (page 28)

A Correct. Onion cells are too small to be seen without magnification. A microscope provides a magnified view of tiny objects such as plant cells.

B Incorrect. Telescopes are specially designed for observing distant objects. Microscopes can only be used to view nearby objects.

C Incorrect. Magnification is not required to detect color change.

D Incorrect. Heat radiation can be either felt or observed with special heat-sensing equipment. A microscope will not help detect heat.

Question 9 (page 29)

A Incorrect. The slides can be used to examine droplets of pond water under a microscope. However, the forceps would not be used in handling water samples.

B Correct. The eyedropper can be used to collect a water sample. Then the sample can be placed on the slide for examination.

C Incorrect. An eyedropper can be used to collect a water sample, but scissors would be unnecessary.

D Incorrect. Scissors are not needed to examine pond water under a microscope. A thermometer might be used to find the temperature of the pond water, but it is not needed to examine pond water under a microscope.

Question 10 (page 29)

B Correct. Use a ruler to measure the length of the leaf. The correct length of the leaf is 42 mm. The difference in the lengths of the leaves is found by subtraction.

$$42 \text{ mm} - 32 \text{ mm} = 10 \text{ mm}$$

Objective 2

Question 11 (page 44)

A Incorrect. The goat may release heat energy when digesting the grass, but it does not receive

heat energy directly from the grass.

B Incorrect. Grass uses light energy from the sun to make sugar and other substances. These nutrients are what the goat eats, not the light energy. Also, a goat is a consumer and cannot use light energy as a direct source of energy.

C Incorrect. Grass supplies the goat with sugar and other nutrients. These contain energy in chemical bonds, not electrical currents.

D Correct. The chemical reaction during photosynthesis converts the sun's light energy into sugar. The grass stores the sugar, which is then eaten by the goat. The goat releases the chemical energy in these materials during digestion.

Question 12 (page 44)

A Incorrect. While the arm's shoulder bones are involved in directing the swing, the immune system is not directly involved in the swing.

B Correct. A message is sent from the brain to the muscles. Continued coordination between muscles and sense organs is required during the swing.

C Incorrect. The heart and blood vessels play only an indirect or secondary role in swinging at a pitched ball. The digestive system is also not directly involved in this body movement.

D Incorrect. The respiratory system is not directly involved in the swing. Nor are glands or secretions of the excretory system directly involved in producing this coordinated movement.

Question 13 (page 44)

A Incorrect. The rabbit gets its energy from eating grass. It is a primary consumer.

B Incorrect. The eagle gets its energy from eating the rabbit. It is a secondary consumer.

C Correct. Bacteria decompose dead plants and animals, such as the grass, rabbit, eagle, and fox.

D Incorrect. The fox gets its energy from eating the rabbit. It is a secondary consumer.

Question 14 (page 45)

A Incorrect. Since the wolves rely on rabbits as a source of food, a decrease in the rabbit population would cause the wolf population to decrease as well.

B Incorrect. A shortage of grass would provide less food to the rabbits. This would likely cause the rabbit population to be reduced. This would in turn reduce the population of wolves.

C Incorrect. Because rabbits eat grass, an increase in the number of rabbits would reduce the amount of grass. This would mean a decrease, not an increase, in the grass population.

D Correct. More grass would supply rabbits with more food, increasing the rabbit population. With more rabbits available, the wolf population would increase.

Question 15 (page 45)

A Correct. The tall pea plant with both alleles dominant (TT) will always produce tall offspring. This is because it has only dominant alleles to contribute to its offspring. The Punnett square for this cross would be:

	T	T
t	Tt	Tt
t	Tt	Tt

The offspring are all Tt, which means tall plants because of the single dominant allele (T).

B Incorrect. Both parents in this cross have two dominant tall alleles (TT). In the problem, one of the parents is short (tt).

	T	T
T	TT	TT
T	TT	TT

C Incorrect. Both parents in this cross have two recessive alleles (tt). They have no dominant allele to contribute to their offspring. Therefore their offspring will all have two recessive alleles

(tt) and be short. The Punnett square for this cross would be:

	t	t
t	tt	tt
t	tt	tt

All the offspring are just like their parents: short with two recessive alleles.

D Incorrect. The offspring of this cross would probably not all be tall. The Punnett square for this cross would be:

	T	t
t	Tt	tt
t	Tt	tt

About half (50%) of the offspring would probably have one dominant allele (T) and be tall. The other half (50%) would probably have two recessive alleles (tt) and be short.

Question 16 (page 46)

A Incorrect. Fungi use oxygen.

B Incorrect. Carnivores feed only on animals. Fungi are not animals.

C Correct. The stump is no longer a living tree, and the fungus gets its nutrients from the stump. Therefore, the fungi are decomposers feeding off of a dead plant while breaking it down.

D Incorrect. Fungi get their food by digesting dead wood from the tree stump. They do not perform photosynthesis to convert sunlight to food energy.

Question 17 (page 46)

A Incorrect. Soil particles do not provide energy to plants during photosynthesis. Photosynthesis is fueled by the energy from sunlight.

B Incorrect. Carbon dioxide plays a role in photosynthesis, but it is not the source of energy for producing sugar. Sunlight supplies the energy needed by plants to perform photosynthesis.

C Correct. Sunlight is the energy source that plants use to produce sugar during photosynthesis.

D Incorrect. Oxygen is used by organisms to convert plant sugar to energy. However, it is not the source of energy used by plants to make sugar during photosynthesis.

Question 18 (page 47)

A Correct. The tomatoes are producers that make their own food by photosynthesis. Fewer aphids would not affect the tomatoes' ability to photosynthesize.

B Incorrect. Aphids are a food source for lacewings. Fewer aphids would reduce the lacewings' food supply.

C Incorrect. Aphids are a food source for lady beetles. Fewer aphids would reduce the lady beetles' food supply.

D Incorrect. Spiders rely on lacewings and lady beetles for food. Since both the lacewings and the lady beetles would have fewer aphids to eat, their population in the garden food web would probably decrease. This would in turn reduce the food supply for spiders.

Question 19 (page 48)

A Incorrect. The soil in the field is often wet because of rainfall. This would not result in the loss of plant life required for succession to occur.

B Incorrect. The flattening of leaves would not destroy the plants since they could grow new leaves.

C Correct. The loss of many grass plants would allow new plants to take their place. This is a form of succession.

D Incorrect. Frost is a normal, seasonal change, and the leaves would grow again in spring. This would not cause succession.

Question 20 (page 49)

A Incorrect. The difference in bloom dates is most likely due to different day length and temperature at the three locations.

B Correct. The color of the apples is the same at all three locations, even though the environments are different. This trait is most likely controlled by genes in the apple trees.

C Incorrect. The difference in average fruit size may be due to differences in rainfall, sunlight, or nutrients at the three locations.

D Incorrect. The difference in the number of days from bloom to harvest may be influenced by differences in the climate at three locations.

Objective 3

Question 21 (page 64)

A Incorrect. The freezing temperature is a physical property of matter. The solid molecules would still be the same substance as the liquid molecules, just in a different physical state.

B Incorrect. The evaporation rate of a liquid is a physical property. The substance's molecules would not change even if some of it were evaporated.

C Incorrect. Density is a ratio of the mass and volume of a substance. This is a physical property and would not describe any of the substance's chemical properties.

D Correct. The formation of a gas would be evidence of a chemical change. The gas would have different physical properties than the liquid compound. The rearrangement of atoms would have resulted in a new substance and would thus be a chemical change.

Question 22 (page 64)

A Incorrect. There are five atoms in the molecule, but four of them are the same color and size, so they must be of the same element. There are only two elements in the methane molecule.

B Correct. There are two elements, carbon and hydrogen, represented by the atoms in the methane molecule. There is one carbon atom and four hydrogen atoms in the molecule.

C Incorrect. There are two elements, but they are bonded into a single molecule. Each unique compound has its own unique arrangement of atoms.

D Incorrect. There is a single molecule, but it is composed of five atoms of two different elements.

Question 23 (page 65)

A Incorrect. Iron is not broken down but is combined with oxygen to form rust.

B Correct. The equation shows two reactants (iron and oxygen) combining to form one product (rust).

C Incorrect. Rust is the product, not the reactant, in this chemical change.

D Incorrect. Iron and oxygen are the reactants and rust is the product in this chemical reaction.

Question 24 (page 66)

A Incorrect. Sample #1 has a temperature gain of 48°C, the highest of the four samples.

B Incorrect. Sample #2 has a temperature gain of 46°C, the second highest of the four samples.

C Correct. Sample #3 has a temperature gain of 40°C, the lowest of the four samples. It therefore has the highest specific heat.

D Incorrect. Sample #4 has a temperature gain of 44°C, the second lowest of the four samples.

Question 25 (page 67)

A Incorrect. Partial dissolving is the only obvious change. Dissolving does not produce a new substance and so is a physical change and not a chemical change.

B Correct. A temperature change and production of a gas are evidence of a new substance being formed. This results from a chemical change.

C Incorrect. Dissolving is the only obvious change. Dissolving does not produce a new substance and so is not a chemical change.

D Incorrect. There is no evidence of any change in either substance, so no chemical change has occurred.

Question 26 (page 68)

A Incorrect. Carbon has the atomic number 6. This

means it has six protons in its nucleus. The model for this option has only four protons, making it a beryllium atom.

B Correct. Carbon has the atomic number 6. This means it has six protons in its nucleus. Its atomic mass is about 12, which means it also has six neutrons in its nucleus.

C Incorrect. Carbon has the atomic number 6. This means it has six protons in its nucleus. The model for this option has seven protons, making it a nitrogen atom.

D Incorrect. Carbon has the atomic number 6. This means it has six protons in its nucleus. The model for this option has 12 protons, making it a magnesium atom.

Question 27 (page 69)

B Correct. The atom has 44 protons, giving it an atomic number of 44. The mass of the rest of the nucleus is found by subtracting 44 from the total atomic mass of 101 (101 − 44 = 57). This remaining mass of 57 must be made up of 57 neutrons.

Question 28 (page 69)

A Incorrect. The atoms of any product must have been present in one of the original liquids.

B Incorrect. Any element present in the product must have been present in one of the original liquids.

C Incorrect. A solid that forms again from a solution represents a physical change. It is not a product of a chemical change.

D Correct. Chemical change produces substances that have different properties than the original substances.

Question 29 (page 69)

A Incorrect. Hydrogen is not located within the same family (Group 18) as neon. Therefore it is not the element with properties most like neon's.

B Incorrect. Fluorine is not located within the same family (Group 18) as neon. Therefore it does not have many of the same properties that neon does.

C Correct. Krypton is located within the same family (Group 18) as neon. Therefore it has physical properties most like neon's.

D Incorrect. Sodium is not located within the same family (Group 18) as neon. In fact, it is on the opposite side of the table, indicating that its properties are probably very different from neon's.

Question 30 (page 69)

A Incorrect. The atoms of sugar are rearranged, but the original elements in sugar are still present in carbon dioxide and water. There are not any new or different elements.

B Correct. The atoms in sugar are rearranged to form molecules of the compounds carbon dioxide and water.

C Incorrect. The sugar molecule is broken down, but the products carbon dioxide and water are compounds, each having more than one element in them.

D Incorrect. Sugar is a compound that is broken down to form two different compounds, carbon dioxide and water.

Objective 4

Question 31 (page 88)

D Correct. According to the graph, the car traveled 50 km in 50 minutes. To convert minutes to hours, multiply by 60 min/1 h. 50 km/50 min × 60 min/h = 60 km/h.

Another way to look at this problem is that the line travels straight from 0 to 50 minutes. This indicates a constant speed. Extending the straight line to 60 minutes (1 hour) will give you the distance in kilometers per hour. The line will pass through 60 minutes at 60 km, so the speed is 60 km/h.

Question 32 (page 89)

A Correct. The lever reduces the force the girl uses to lift the box by increasing the distance over which she applied the force.

B Incorrect. The lever does not affect the mass of the box.

C Incorrect. The work done by lifting the box a given distance will be the same no matter what method is used to lift the box.

D Incorrect. The distance the box is lifted will be less than the distance the girl must move her end of the lever.

Question 33 (page 90)

A Incorrect. Blood passing through the lungs gains oxygen, but this does not produce a force to pressurize the blood.

B Incorrect. Blood flowing out to the capillaries does not create pressure on blood in the circulatory system.

C Incorrect. The kidneys' filtering action does not exert force on blood in the vessels of the circulatory system.

D Correct. The heart's pumping action pushes blood through the vessels. This force helps maintain blood pressure in the circulatory system.

Question 34 (page 90)

B Correct. Force = mass × acceleration, or $F = ma$

$F = 1.0 \text{ kg} \times 0.5 \text{ m/s}^2$

$F = 0.5 \text{ kg} \times \text{m/s}^2$

$F = 0.5 \text{ N}$

Question 35 (page 91)

A Incorrect. The baseball is at a low point in the flight just after it has been hit, so its potential energy at this point is less than it will be later when it has reached its greatest height.

B Incorrect. The baseball is still rising, so it will reach a greater point of potential energy later in its flight.

C Correct. The baseball is at its highest point here, giving it the greatest potential energy in its flight.

D Incorrect. The baseball is falling, so it has lost some of the potential energy it gained earlier in its flight.

Question 36 (page 92)

A Incorrect. The amount of work done is the same no matter what machine is used.

B Correct. A pulley changes the direction of the force used to do work.

C Incorrect. A pulley does not change the amount of force used.

D Incorrect. A pulley does not change the mass being lifted.

Question 37 (page 93)

C Correct. Force = mass × acceleration, or $F = ma$

$F = 5 \text{ kg} \times 2 \text{ m/s}^2$

$F = 10 \text{ kg} \times \text{m/s}^2$

$F = 10 \text{ N}$

Question 38 (page 93)

A Correct. Burning is a chemical reaction because different products are made as a result. Burning releases heat in an exothermic reaction.

B Incorrect. Charcoal does not transform electrical energy into light energy when it burns.

C Incorrect. Charcoal does not transform light energy into chemical energy when it burns.

D Incorrect. Charcoal does not transform mechanical energy into electrical energy when it burns.

Objective 5

Question 39 (page 115)

A Incorrect. The distance between Earth and the sun does not produce changes in day length.

B Incorrect. Earth's period of revolution determines the time between changes in seasons, but it does not affect day length, which is always 24 hours.

C Incorrect. Earth's rotation determines the length of a day. However, this rotation is constant in all seasons, so it is not a factor in the change in day length at a particular location in different seasons.

D Correct. The areas on or near the equator experience the smallest change between summer and winter.

Question 40 (page 116)

A Incorrect. The entire visible side of the moon is lit during the full moon. The full moon occurred on October 17th.

B Incorrect. Only a small portion of the visible side of the moon is lit during a crescent moon. This crescent moon would have occurred a few days before the new moon. October 10th was seven days after the new moon, so much more of the visible portion of the moon would have been lit by that date.

C Incorrect. None of the visible side of the moon is lit during the new moon. The new moon occurred on October 3rd.

D Correct. About half the visible side of the moon is lit during a quarter moon. The first quarter moon occurred midway between the new and full moons, on about October 10th.

Question 41 (page 117)

A Correct. Sunlight absorbed by water is transformed into heat energy. The warm water evaporates more quickly, adding water vapor to the atmosphere. This increases the temperature and humidity of the air over the tropical oceans.

B Incorrect. Melting icebergs cool ocean waters and the air above them. Cool air tends to sink, not rise.

C Incorrect. Earth's rotation influences the circular motion of hurricanes, but it is not the energy source that causes warm, humid air to rise.

D Incorrect. Heat from Earth's core only influences the atmosphere in places where lava reaches Earth's surface.

Question 42 (page 117)

A Incorrect. Rock layers fold under great pressure below Earth's surface, and this process does not create erosion.

B Incorrect. Sediment deposition occurs when particles of rock are carried to a new location. Dissolved rock leaving the surface of solid rock does not necessarily involve particles of rock being carried to another location.

C Correct. The dissolving of rock is a type of erosion.

D Incorrect. Faulting is the movement of sections of Earth's crust and is not affected by the dissolving of rock by rainwater.

Question 43 (page 117)

A Incorrect. An effect of increased nitrogen levels is rapid plant growth. Rapid plant growth might interfere with fish survival and reproduction.

B Incorrect. Nitrogen would not affect the amount of water in the pond, only the quality of the water.

C Correct. Nitrogen is a nutrient needed for plant growth. Increased nitrogen levels would increase plant growth.

D Incorrect. Pond evaporation would not likely be increased by nitrogen in the pond water. The increased plant growth resulting from nitrogen might actually slow pond water evaporation.

Question 44 (page 118)

A Incorrect. Pressure and uplift may create mountains and valleys, but they would not increase the depth of soil directly.

B Correct. Erosion and deposition move soil from higher elevations (the ridges) to lower elevations (the valley), making the soil in the valley deeper.

C Incorrect. Earthquakes and faulting may shift the position of rock masses, but they do not typically move large amounts of soil from place to place.

D Incorrect. Percolation and evaporation are water movements that do not affect soil movement.

Question 45 (page 119)

A Incorrect. The use of mineral nutrients will have little effect on the prevention of soil erosion.

B Correct. The dense structure of the grass roots helps prevent wind and water from removing soil particles.

C Incorrect. The ability of the grass roots to absorb

water would not keep soil from being removed by wind or water erosion.

D Incorrect. A slower rate of grass root growth would more likely increase than decrease the loss of soil due to erosion.

Question 46 (page 120)

A Incorrect. Seafloor spreading occurs at diverging boundaries under the ocean, not along a converging boundary such as the one along the South American coastline.

B Incorrect. Deposition can build up terrain, but it does not cause the upward movement of large sections of Earth's crust required to form high mountains.

C Correct. A continental and oceanic plate converging at a plate boundary form mountains along a coastline.

D Incorrect. Erosion is a destructive process that wears away mountains. It does not create mountains.

Question 47 (page 120)

A Incorrect. The parking lot will not allow as much water to soak into the soil as the native forest did. Therefore, more runoff is likely to occur from the parking lot, which will increase stream flows.

B Incorrect. The parking lot will protect the soil from erosion, so there will be little sediment in the runoff from the parking lot. The forest that existed before would have been more likely to lose soil because of runoff.

C Correct. Some of the cars parked in a parking lot will leak gasoline and oil. These pollutants will be washed into the groundwater by rainwater.

D Incorrect. A decrease in animal waste would not decrease water quality. High levels of animal waste can contaminate groundwater.

Question 48 (page 121)

A Correct. The burning of fossil fuels is a source of carbon dioxide gas. An increase in human population and the use of automobiles has occurred. This would account for the increase shown in the graph.

B Incorrect. Species extinctions would remove animals that produce carbon dioxide. However, there would probably be little net effect on the amount of CO_2 in the atmosphere.

C Incorrect. Wetlands are only a small part of Earth's total area. Wetland destruction would not likely have the effect shown in the graph.

D Incorrect. Farm crops convert carbon dioxide into oxygen. This would decrease the carbon dioxide level, not increase it.

Cluster 1

Question 49 (page 123)

A Incorrect. The cell is the smallest unit of organization. Cells are very tiny and most cannot be seen without magnification. There are many cells in one flower.

B Correct. Each flower is made up of several special tissues that aid in reproduction. Together these tissues form an organ.

C Incorrect. An organism must be an individual plant or animal, not merely part of a plant or animal. The live oak flowers are part of the live oak. Therefore the flowers are not an organism.

D Incorrect. A population is a group of individuals of the same species in the same place. Since these flowers are not individual organisms, they cannot form a population.

Question 50 (page 123)

A Incorrect. Elemental carbon may be produced, but not in the ground.

B Incorrect. Carbon atoms are combined to form plant sugar during photosynthesis.

C Incorrect. Animals obtain carbon from eating plant materials, not from burning wood.

D Correct. Burning transforms the carbon compounds in the wood into carbon dioxide gas and soot, which enter the atmosphere as smoke.

Question 51 (page 123)

A Incorrect. The fungus causes the disease. The fungus is not the host.

B Correct. The live oak provides food to the fungus, which is the organism that causes oak wilt. The organism that provides food to a disease-causing organism is called the host.

C Incorrect. The sap beetle is unaffected by the disease. The beetle is simply a carrier of the disease-causing fungus.

D Incorrect. The wren is a predator that feeds on the beetles. The wren does not play a significant role in the transmission of oak wilt.

Question 52 (page 124)

A Correct. The live oak makes its own food from sunlight. Therefore it is a producer.

B Incorrect. Decomposers get their energy by consuming dead organisms. They don't make their own food from sunlight.

C Incorrect. Primary consumers get their energy from eating plants. The live oak is a producer that provides energy to the primary consumers in the food web.

D Incorrect. Secondary consumers get their energy from eating primary consumers. The live oak is a producer that provides energy to the primary consumers in the food web.

Question 53 (page 125)

A Incorrect. Plants with different leaf shapes can live in the same range. Leaf shape does not explain the different ranges of the two oaks.

B Incorrect. Where the oaks grow may have influenced the species that live in those ranges. However, which consumers eat the oaks does not necessarily determine where the oaks grow.

C Correct. The two species are adapted to different sets of environmental conditions. Therefore their range is different.

D Incorrect. The two trees probably grow to different heights, but their height is not the main reason they inhabit different regions of Texas.

Question 54 (page 125)

D Correct. Using the formula for density from the formula chart: Density = mass/volume, or

$D = m/v$
$D = 660 \text{ g}/750 \text{ cm}^3$
$D = 0.88 \text{ g/cm}^3$

The live oak sample has a density of 0.88 g/cm^3, which is the highest density of the four samples described.

Cluster 2

Question 55 (page 127)

B Correct. When the water level in the river below the dam decreases, that means that the amount of water flowing through the dam has decreased (the line on the graph slopes downward). This also means that the electrical output will follow the same pattern as the water level. The water level gradually decreases (the line on the graph slopes downward), remains steady (the line on the graph is flat) for about three days, and then decreases (the line on the graph slopes downward) again.

Question 56 (page 128)

C Correct. The map scale shows that 2.5 cm = 32 km. The distance from the dam to the northernmost point on the reservoir is 7.8 cm. And 7.8 cm/2.5 cm × 32 km = 100 km.

Question 57 (page 128)

A Incorrect. Chemical energy is not used to produce light in the power plant.

B Incorrect. A turning shaft operates the generator. This is a form of mechanical energy, not electrical energy. Also, it is electrical energy that is produced by the generator, not light energy.

C Incorrect. The generator uses mechanical energy, but it produces an electric current. An electric current is electrical energy, not chemical energy.

D Correct. The generator uses the motion of the turbine to turn a shaft. This is mechanical energy. The turning shaft generates electrical energy.

Question 58 (page 129)

A Correct. All the organs labeled are located on the outside of the catfish's body. Three of these organs are located near the catfish's mouth. They most likely help the catfish find food.

B Incorrect. Circulating blood happens inside the body. These sense organs are located outside the body.

C Incorrect. Organs inside the fish's body control floating and sinking. The sense organs are located on the outside of the body.

D Incorrect. These sense organs are not involved in breathing. Breathing is a function of the gills, which are not sense organs.

Question 59 (page 129)

A Correct. Potential energy is greatest at the highest elevation. According to the diagram, location W is the highest elevation. So water at this point would have the greatest potential energy.

B Incorrect. Potential energy is greatest at the highest elevation. Water at the upper end of the reservoir is at a higher elevation than water at the lower end.

C Incorrect. Potential energy is greatest at the highest elevation. Water at the lower end of the reservoir is at a higher elevation than the water in the river below the dam.

D Incorrect. Potential energy is greatest at the highest elevation. Water in the river below the dam is at a lower elevation than water in or above the reservoir.

Question 60 (page 130)

A Incorrect. If the gizzard shad grew larger, they would likely eat more plankton.

B Incorrect. The gizzard shad growing larger would not increase the amount of plankton available for the threadfin shad to eat.

C Incorrect. Since the largemouth bass could no longer eat the larger gizzard shad, more gizzard shad would be available for the striped bass to eat. The striped bass would likely eat more gizzard shad.

D Correct. If fewer gizzard shad were available, the largemouth bass would likely eat more threadfin shad.

Science Activity

Science Activity: Sudden Impact! Crashing the Crater Mystery (page 131)

Note: Your data may vary due to differences in experimental conditions.

Crater Data Table

Drop Height (cm)	Drop 1		Drop 2		Drop 3		Average	
	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)
30	33	11	37	14	36	12	35	12
60	40	15	44	16	40	16	41	16
90	49	17	50	18	52	20	50	18

What were the differences in the craters that formed when the marble was dropped from different heights? Support your answer with data from the table.

The width and depth of the craters increased as the height of the drop increased. The average width increased by 6 mm at the 60 cm height and by another 9 mm at the 90 cm height. The average depth increased by 4 mm at 60 cm and by another 2 mm at the 90 cm height.

What was the purpose of dropping the marble three times at each height?

Three drops produce more data. The more data that are collected, the more accurate the conclusion usually is.

Explain what the following parts of the crater model represent:

The sand represents *the surface of the moon.*

The marble represents *an object flying through space.*

What are some weaknesses of your model?

The size and scale of the model is smaller than the actual moon. The marble is traveling slower than a meteoroid. The sand has different properties than moon dust.

How could you improve this model?

I could use a larger scale, like a sandbox and a baseball dropped from a ladder. And I could use something that is more like moon dust, like flour or dry plaster mix.

What does this crater model tell us about the craters found on the moon?

Objects that were moving faster could have formed the larger and deeper craters.

Meteoroids usually travel at speeds faster than 11 km/s. In what way is the crater model unable to represent this accurately?

The marble does not travel nearly as fast as the meteoroids.

Earth Versus Moon Craters

What are two processes in the rock cycle that might erase evidence of ancient craters on Earth's crust?

Process #1: *weathering*

Process #2: *deposition*

Evaluate

Describe one effect that a thick layer of dust in the atmosphere would be likely to have on each of the following:

The water cycle: *Less sunlight would mean that less water would evaporate. Also, temperatures would be lower, so precipitation would fall more often as snow or ice*.

The carbon cycle: *Less sunlight would mean less photosynthesis. There would be less food for animals*.

Hypothesize

Make a prediction about the result of using a ball with greater mass.

Prediction: *Craters would be wider and deeper*.

You Decide

Which laboratory instrument could you use to find out whether the golf ball has a greater mass than the marble?

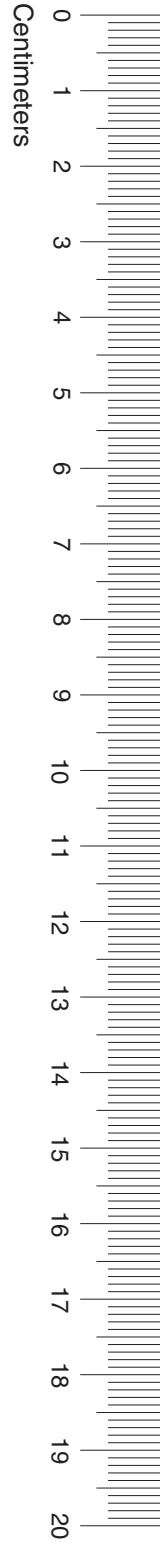
A balance would measure the difference in mass between the marble and golf ball.

FORMULA CHART
Middle School Science
Grade 8

Work = force × distance	$W = Fd$
Speed = $\frac{\text{distance}}{\text{time}}$	$s = \frac{d}{t}$
Force = mass × acceleration	$F = ma$
Weight = mass × acceleration due to gravity	$Weight = mg$
Density = $\frac{\text{mass}}{\text{volume}}$	$D = \frac{m}{v}$

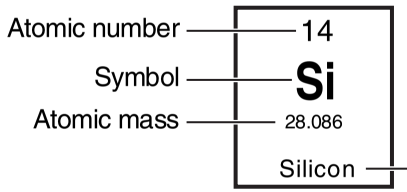
Constants/Conversions

g = acceleration due to gravity = $9.8 \frac{\text{m}}{\text{s}^2}$
speed of light = $3 \times 10^8 \frac{\text{m}}{\text{s}}$
speed of sound = $343 \frac{\text{m}}{\text{s}}$ at sea level and 20°C
$1 \text{ cm}^3 = 1 \text{ mL}$



Middle School Science

Periodic Table of the Elements



Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008 Hydrogen																	2 He 4.0026 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluorine	10 Ne 20.179 Neon
11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminum	14 Si 28.086 Silicon	15 P 30.974 Phosphorus	16 S 32.066 Sulfur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
19 K 39.098 Potassium	20 Ca 40.08 Calcium	21 Sc 44.956 Scandium	22 Ti 47.88 Titanium	23 V 50.942 Vanadium	24 Cr 51.996 Chromium	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc (98) Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.906 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.868 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.763 Antimony	52 Te 127.60 Tellurium	53 I 126.904 Iodine	54 Xe 131.29 Xenon
55 Cs 132.905 Cesium	56 Ba 137.33 Barium	57 La 138.906 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.948 Tantalum	74 W 183.84 Tungsten	75 Re 186.207 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.967 Gold	80 Hg 200.59 Mercury	81 Tl 204.383 Thallium	82 Pb 207.2 Lead	83 Bi 208.980 Bismuth	84 Po (209) Polonium	85 At (210) Astatine	86 Rn (222) Radon
87 Fr (223) Francium	88 Ra 226.025 Radium	89 Ac 227.028 Actinium	104 Rf (261) Rutherfordium	105 Db (262) Dubnium	106 Sg (263) Seaborgium	107 Bh (262) Bohrium	108 Hs (265) Hassium	109 Mt (266) Meitnerium	110 (269)								

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.908 Praseodymium	60 Nd 144.24 Neodymium	61 Pm (145) Promethium	62 Sm 150.36 Samarium	63 Eu 151.97 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.925 Terbium	66 Dy 162.50 Dysprosium	67 Ho 164.930 Holmium	68 Er 167.26 Erbium	69 Tm 168.934 Thulium	70 Yb 173.04 Ytterbium	71 Lu 174.967 Lutetium
Actinide Series	90 Th 232.038 Thorium	91 Pa 231.036 Protactinium	92 U 238.029 Uranium	93 Np 237.048 Neptunium	94 Pu (244) Plutonium	95 Am (243) Americium	96 Cm (247) Curium	97 Bk (247) Berkelium	98 Cf (251) Californium	99 Es (252) Einsteinium	100 Fm (257) Fermium	101 Md (258) Mendelevium	102 No (259) Nobelium	103 Lr (262) Lawrencium

FOLD AND TAPE BEFORE MAILING

TAKS STUDY GUIDE EVALUATION FORM

To complete the survey online, go to http://www.etesttx.com/studyguides/feedback.htm.

❶ Place a (✓) next to all statements that apply to you.

I am a

____ Student
____ Parent
____ Teacher
____ Tutor
____ Other (please specify) _____
_____
_____

I used this study guide

____ Alone
____ With a family member
____ With a tutor
____ With a teacher
____ With a friend

FOLD HERE

❷ Study Guide Questions

Use a (✓) to mark how much you agree with the following statements.

DETACH HERE BEFORE MAILING

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1. This study guide is easy to use and well organized.	❑	❑	❑	❑	❑
2. This study guide is interesting.	❑	❑	❑	❑	❑
3. I gained new knowledge and skills by using this study guide.	❑	❑	❑	❑	❑
4. I will be able to apply what I've learned from this study guide when I take the TAKS again.	❑	❑	❑	❑	❑
5. I believe my TAKS scores will improve as a result of using this study guide.	❑	❑	❑	❑	❑

FOLD HERE

❸ General Information

Use a (✓) to mark the grade and subject of this study guide.

Grade:

____ 3 ____ 8
____ 4 ____ 9
____ 5 ____ 10
____ 6 ____ 11 (Exit Level)
____ 7

Subject:

____ Reading
____ English Language Arts
____ Writing
____ Mathematics
____ Science
____ Social Studies

When you have finished with this evaluation form, please detach it from the booklet and mail it to

Pearson Educational Measurement
Study Guide Program Team
400 Center Ridge Drive, Suite F
Austin, TX 78753

Additional Comments _____
_____
_____
_____

Place
Stamp
Here

Pearson Educational Measurement
Study Guide Program Team
400 Center Ridge Drive, Suite F
Austin, TX 78753