Student Resources
## CONTENTS

### Science Skill Handbook

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing Magnets</td>
<td>747</td>
</tr>
<tr>
<td>Disappearing Dots</td>
<td>747</td>
</tr>
</tbody>
</table>

### Scientific Methods

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify a Question</td>
<td>724</td>
</tr>
<tr>
<td>Gather and Organize</td>
<td>724</td>
</tr>
<tr>
<td>Information</td>
<td>724</td>
</tr>
<tr>
<td>Form a Hypothesis</td>
<td>727</td>
</tr>
<tr>
<td>Test the Hypothesis</td>
<td>728</td>
</tr>
<tr>
<td>Collect Data</td>
<td>728</td>
</tr>
<tr>
<td>Analyze the Data</td>
<td>731</td>
</tr>
<tr>
<td>Draw Conclusions</td>
<td>732</td>
</tr>
<tr>
<td>Communicate</td>
<td>732</td>
</tr>
</tbody>
</table>

### Safety Symbols

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety in the Science Laboratory</td>
<td>733</td>
</tr>
<tr>
<td>General Safety Rules</td>
<td>734</td>
</tr>
<tr>
<td>Prevent Accidents</td>
<td>734</td>
</tr>
<tr>
<td>Laboratory Work</td>
<td>734</td>
</tr>
<tr>
<td>Laboratory Cleanup</td>
<td>735</td>
</tr>
<tr>
<td>Emergencies</td>
<td>735</td>
</tr>
</tbody>
</table>

### Extra Try at Home Labs

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Watch</td>
<td>736</td>
</tr>
<tr>
<td>Guppies of All Colors</td>
<td>736</td>
</tr>
<tr>
<td>Sports Drink Minerals</td>
<td>737</td>
</tr>
<tr>
<td>Rock Creatures</td>
<td>737</td>
</tr>
<tr>
<td>A Light in the Forest</td>
<td>738</td>
</tr>
<tr>
<td>Immovable Echinoderms</td>
<td>738</td>
</tr>
<tr>
<td>Measuring Movement</td>
<td>739</td>
</tr>
<tr>
<td>Earth’s Layers</td>
<td>739</td>
</tr>
<tr>
<td>Making Burrows</td>
<td>740</td>
</tr>
<tr>
<td>History in a Bottle</td>
<td>740</td>
</tr>
<tr>
<td>Creating Craters</td>
<td>741</td>
</tr>
<tr>
<td>Many Moons</td>
<td>741</td>
</tr>
<tr>
<td>Big Stars</td>
<td>742</td>
</tr>
<tr>
<td>Make An Electroscope</td>
<td>742</td>
</tr>
<tr>
<td>Research Race</td>
<td>743</td>
</tr>
<tr>
<td>Human Bonding</td>
<td>743</td>
</tr>
<tr>
<td>Mini Fireworks</td>
<td>744</td>
</tr>
<tr>
<td>Measuring Momentum</td>
<td>744</td>
</tr>
<tr>
<td>Friction in Traffic</td>
<td>745</td>
</tr>
<tr>
<td>Toolbox Simple Machines</td>
<td>745</td>
</tr>
<tr>
<td>Estimating Temperature</td>
<td>746</td>
</tr>
<tr>
<td>Bending Water</td>
<td>746</td>
</tr>
</tbody>
</table>

### Technology Skill Handbook

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Skills</td>
<td>748</td>
</tr>
<tr>
<td>Use a Word Processing Program</td>
<td>748</td>
</tr>
<tr>
<td>Use a Database</td>
<td>749</td>
</tr>
<tr>
<td>Use the Internet</td>
<td>749</td>
</tr>
<tr>
<td>Use a Spreadsheet</td>
<td>750</td>
</tr>
<tr>
<td>Use Graphics Software</td>
<td>750</td>
</tr>
</tbody>
</table>

### Presentation Skills

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop Multimedia Presentations</td>
<td>751</td>
</tr>
<tr>
<td>Computer Presentations</td>
<td>751</td>
</tr>
</tbody>
</table>

### Math Skill Handbook

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Review</td>
<td>752</td>
</tr>
<tr>
<td>Use Fractions</td>
<td>752</td>
</tr>
<tr>
<td>Use Ratios</td>
<td>755</td>
</tr>
<tr>
<td>Use Decimals</td>
<td>755</td>
</tr>
<tr>
<td>Use Proportions</td>
<td>756</td>
</tr>
<tr>
<td>Use Percentages</td>
<td>757</td>
</tr>
<tr>
<td>Solve One-Step Equations</td>
<td>757</td>
</tr>
<tr>
<td>Use Statistics</td>
<td>758</td>
</tr>
<tr>
<td>Use Geometry</td>
<td>759</td>
</tr>
</tbody>
</table>

### Science Applications

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure in SI</td>
<td>762</td>
</tr>
<tr>
<td>Dimensional Analysis</td>
<td>762</td>
</tr>
<tr>
<td>Precision and Significant Digits</td>
<td>764</td>
</tr>
<tr>
<td>Scientific Notation</td>
<td>764</td>
</tr>
<tr>
<td>Make and Use Graphs</td>
<td>765</td>
</tr>
</tbody>
</table>

### Reference Handbooks

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topographic Map Symbols</td>
<td>767</td>
</tr>
<tr>
<td>Physical Science Reference Tables</td>
<td>768</td>
</tr>
<tr>
<td>Periodic Table of the Elements</td>
<td>770</td>
</tr>
</tbody>
</table>

### English/Spanish Glossary

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>793</td>
</tr>
</tbody>
</table>

### Credits

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits</td>
<td>812</td>
</tr>
</tbody>
</table>
Scientists use an orderly approach called the scientific method to solve problems. This includes organizing and recording data so others can understand them. Scientists use many variations in this method when they solve problems.

**Identify a Question**

The first step in a scientific investigation or experiment is to identify a question to be answered or a problem to be solved. For example, you might ask which gasoline is the most efficient.

**Gather and Organize Information**

After you have identified your question, begin gathering and organizing information. There are many ways to gather information, such as researching in a library, interviewing those knowledgeable about the subject, testing and working in the laboratory and field. Fieldwork is investigations and observations done outside of a laboratory.

**Researching Information**

Before moving in a new direction, it is important to gather the information that already is known about the subject. Start by asking yourself questions to determine exactly what you need to know. Then you will look for the information in various reference sources, like the student is doing in Figure 1. Some sources may include textbooks, encyclopedias, government documents, professional journals, science magazines, and the Internet. Always list the sources of your information.

**Evaluate Sources of Information**

Not all sources of information are reliable. You should evaluate all of your sources of information, and use only those you know to be dependable. For example, if you are researching ways to make homes more energy efficient, a site written by the U.S. Department of Energy would be more reliable than a site written by a company that is trying to sell a new type of weatherproofing material. Also, remember that research always is changing. Consult the most current resources available to you. For example, a 1985 resource about saving energy would not reflect the most recent findings.

Sometimes scientists use data that they did not collect themselves, or conclusions drawn by other researchers. This data must be evaluated carefully. Ask questions about how the data were obtained, if the investigation was carried out properly, and if it has been duplicated exactly with the same results. Would you reach the same conclusion from the data? Only when you have confidence in the data can you believe it is true and feel comfortable using it.
Interpret Scientific Illustrations  As you research a topic in science, you will see drawings, diagrams, and photographs to help you understand what you read. Some illustrations are included to help you understand an idea that you can’t see easily by yourself, like the tiny particles in an atom in Figure 2. A drawing helps many people to remember details more easily and provides examples that clarify difficult concepts or give additional information about the topic you are studying. Most illustrations have labels or a caption to identify or to provide more information.

Figure 2  This drawing shows an atom of carbon with its six protons, six neutrons, and six electrons.

Concept Maps  One way to organize data is to draw a diagram that shows relationships among ideas (or concepts). A concept map can help make the meanings of ideas and terms more clear, and help you understand and remember what you are studying. Concept maps are useful for breaking large concepts down into smaller parts, making learning easier.

Network Tree  A type of concept map that not only shows a relationship, but how the concepts are related is a network tree, shown in Figure 3. In a network tree, the words are written in the ovals, while the description of the type of relationship is written across the connecting lines.

When constructing a network tree, write down the topic and all major topics on separate pieces of paper or notecards. Then arrange them in order from general to specific. Branch the related concepts from the major concept and describe the relationship on the connecting line. Continue to more specific concepts until finished.

Figure 3  A network tree shows how concepts or objects are related.

Events Chain  Another type of concept map is an events chain. Sometimes called a flow chart, it models the order or sequence of items. An events chain can be used to describe a sequence of events, the steps in a procedure, or the stages of a process.

When making an events chain, first find the one event that starts the chain. This event is called the initiating event. Then, find the next event and continue until the outcome is reached, as shown in Figure 4.
A specific type of events chain is a cycle map. It is used when the series of events do not produce a final outcome, but instead relate back to the beginning event, such as in Figure 5. Therefore, the cycle repeats itself.

To make a cycle map, first decide what event is the beginning event. This is also called the initiating event. Then list the next events in the order that they occur, with the last event relating back to the initiating event. Words can be written between the events that describe what happens from one event to the next. The number of events in a cycle map can vary, but usually contain three or more events.

Figure 5 A cycle map shows events that occur in a cycle.

Spider Map A type of concept map that you can use for brainstorming is the spider map. When you have a central idea, you might find that you have a jumble of ideas that relate to it but are not necessarily clearly related to each other. The spider map on sound in Figure 6 shows that if you write these ideas outside the main concept, then you can begin to separate and group unrelated terms so they become more useful.

Figure 6 A spider map allows you to list ideas that relate to a central topic but not necessarily to one another.
To illustrate how two subjects compare and contrast you can use a Venn diagram. You can see the characteristics that the subjects have in common and those that they do not, shown in Figure 7.

To create a Venn diagram, draw two overlapping ovals that are big enough to write in. List the characteristics unique to one subject in one oval, and the characteristics of the other subject in the other oval. The characteristics in common are listed in the overlapping section.

Make and Use Tables One way to organize information so it is easier to understand is to use a table. Tables can contain numbers, words, or both.

To make a table, list the items to be compared in the first column and the characteristics to be compared in the first row. The title should clearly indicate the content of the table, and the column or row heads should be clear. Notice that in Table 1 the units are included.

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>Paper (kg)</th>
<th>Aluminum (kg)</th>
<th>Glass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>5.0</td>
<td>4.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Wednesday</td>
<td>4.0</td>
<td>1.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Friday</td>
<td>2.5</td>
<td>2.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Make a Model One way to help you better understand the parts of a structure, the way a process works, or to show things too large or small for viewing is to make a model. For example, an atomic model made of a plastic-ball nucleus and pipe-cleaner electron shells can help you visualize how the parts of an atom relate to each other. Other types of models can be devised on a computer or represented by equations.

Form a Hypothesis

A possible explanation based on previous knowledge and observations is called a hypothesis. After researching gasoline types and recalling previous experiences in your family’s car you form a hypothesis—our car runs more efficiently because we use premium gasoline. To be valid, a hypothesis has to be something you can test by using an investigation.

Predict When you apply a hypothesis to a specific situation, you predict something about that situation. A prediction makes a statement in advance, based on prior observation, experience, or scientific reasoning. People use predictions to make everyday decisions. Scientists test predictions by performing investigations. Based on previous observations and experiences, you might form a prediction that cars are more efficient with premium gasoline. The prediction can be tested in an investigation.

Design an Experiment A scientist needs to make many decisions before beginning an investigation. Some of these include: how to carry out the investigation, what steps to follow, how to record the data, and how the investigation will answer the question. It also is important to address any safety concerns.
Test the Hypothesis

Now that you have formed your hypothesis, you need to test it. Using an investigation, you will make observations and collect data, or information. This data might either support or not support your hypothesis. Scientists collect and organize data as numbers and descriptions.

Follow a Procedure

In order to know what materials to use, as well as how and in what order to use them, you must follow a procedure. Figure 8 shows a procedure you might follow to test your hypothesis.

Procedure

1. Use regular gasoline for two weeks.
2. Record the number of kilometers between fill-ups and the amount of gasoline used.
3. Switch to premium gasoline for two weeks.
4. Record the number of kilometers between fill-ups and the amount of gasoline used.

Many experiments also have a control—an individual instance or experimental subject for which the independent variable is not changed. You can then compare the test results to the control results. To design a control you can have two cars of the same type. The control car uses regular gasoline for four weeks. After you are done with the test, you can compare the experimental results to the control results.

Collect Data

Whether you are carrying out an investigation or a short observational experiment, you will collect data, as shown in Figure 9. Scientists collect data as numbers and descriptions and organize it in specific ways.

Observe

Scientists observe items and events, then record what they see. When they use only words to describe an observation, it is called qualitative data. Scientists’ observations also can describe how much there is of something. These observations use numbers, as well as words, in the description and are called quantitative data. For example, if a sample of the element gold is described as being “shiny and very dense” the data are qualitative. Quantitative data on this sample of gold might include “a mass of 30 g and a density of 19.3 g/cm³.”

Identify and Manipulate Variables and Controls

In any experiment, it is important to keep everything the same except for the item you are testing. The one factor you change is called the independent variable. The change that results is the dependent variable. Make sure you have only one independent variable, to assure yourself of the cause of the changes you observe in the dependent variable. For example, in your gasoline experiment the type of fuel is the independent variable. The dependent variable is the efficiency.

Figure 9 Collecting data is one way to gather information directly.
When you make observations you should examine the entire object or situation first, and then look carefully for details. It is important to record observations accurately and completely. Always record your notes immediately as you make them, so you do not miss details or make a mistake when recording results from memory. Never put unidentified observations on scraps of paper. Instead they should be recorded in a notebook, like the one in Figure 10. Write your data neatly so you can easily read it later. At each point in the experiment, record your observations and label them. That way, you will not have to determine what the figures mean when you look at your notes later. Set up any tables that you will need to use ahead of time, so you can record any observations right away. Remember to avoid bias when collecting data by not including personal thoughts when you record observations. Record only what you observe.

**Estimate** Scientific work also involves estimating. To estimate is to make a judgment about the size or the number of something without measuring or counting. This is important when the number or size of an object or population is too large or too difficult to accurately count or measure.

**Sample** Scientists may use a sample or a portion of the total number as a type of estimation. To sample is to take a small, representative portion of the objects or organisms of a population for research. By making careful observations or manipulating variables within that portion of the group, information is discovered and conclusions are drawn that might apply to the whole population. A poorly chosen sample can be unrepresentative of the whole. If you were trying to determine the rainfall in an area, it would not be best to take a rainfall sample from under a tree.

**Measure** You use measurements everyday. Scientists also take measurements when collecting data. When taking measurements, it is important to know how to use measuring tools properly. Accuracy also is important.

**Length** To measure length, the distance between two points, scientists use meters. Smaller measurements might be measured in centimeters or millimeters.

Length is measured using a metric ruler or meter stick. When using a metric ruler, line up the 0-cm mark with the end of the object being measured and read the number of the unit where the object ends. Look at the metric ruler shown in Figure 11. The centimeter lines are the long, numbered lines, and the shorter lines are millimeter lines. In this instance, the length would be 4.50 cm.

**Figure 10** Record data neatly and clearly so it is easy to understand.

**Figure 11** This metric ruler has centimeter and millimeter divisions.
Mass  The SI unit for mass is the kilogram (kg). Scientists can measure mass using units formed by adding metric prefixes to the unit gram (g), such as milligram (mg). To measure mass, you might use a triple-beam balance similar to the one shown in Figure 12. The balance has a pan on one side and a set of beams on the other side. Each beam has a rider that slides on the beam.

When using a triple-beam balance, place an object on the pan. Slide the largest rider along its beam until the pointer drops below zero. Then move it back one notch. Repeat the process for each rider proceeding from the larger to smaller until the pointer swings an equal distance above and below the zero point. Sum the masses on each beam to find the mass of the object. Move all riders back to zero when finished.

Instead of putting materials directly on the balance, scientists often take a tare of a container. A tare is the mass of a container into which objects or substances are placed for measuring their masses. To mass objects or substances, find the mass of a clean container. Remove the container from the pan, and place the object or substances in the container. Find the mass of the container with the materials in it. Subtract the mass of the empty container from the mass of the filled container to find the mass of the materials you are using.

Liquid Volume  To measure liquids, the unit used is the liter. When a smaller unit is needed, scientists might use a milliliter. Because a milliliter takes up the volume of a cube measuring 1 cm on each side it also can be called a cubic centimeter (cm³ = cm × cm × cm).

You can use beakers and graduated cylinders to measure liquid volume. A graduated cylinder, shown in Figure 13, is marked from bottom to top in milliliters. In lab, you might use a 10-mL graduated cylinder or a 100-mL graduated cylinder. When measuring liquids, notice that the liquid has a curved surface. Look at the surface at eye level, and measure the bottom of the curve. This is called the meniscus. The graduated cylinder in Figure 13 contains 79.0 mL, or 79.0 cm³, of a liquid.

Temperature  Scientists often measure temperature using the Celsius scale. Pure water has a freezing point of 0°C and boiling point of 100°C. The unit of measurement is degrees Celsius. Two other scales often used are the Fahrenheit and Kelvin scales.

Figure 12  A triple-beam balance is used to determine the mass of an object.

Figure 13  Graduated cylinders measure liquid volume.
Scientists use a thermometer to measure temperature. Most thermometers in a laboratory are glass tubes with a bulb at the bottom end containing a liquid such as colored alcohol. The liquid rises or falls with a change in temperature. To read a glass thermometer like the thermometer in Figure 14, rotate it slowly until a red line appears. Read the temperature where the red line ends.

**Form Operational Definitions** An operational definition defines an object by how it functions, works, or behaves. For example, when you are playing hide and seek and a tree is home base, you have created an operational definition for a tree.

Objects can have more than one operational definition. For example, a ruler can be defined as a tool that measures the length of an object (how it is used). It can also be a tool with a series of marks used as a standard when measuring (how it works).

**Analyze the Data** To determine the meaning of your observations and investigation results, you will need to look for patterns in the data. Then you must think critically to determine what the data mean. Scientists use several approaches when they analyze the data they have collected and recorded. Each approach is useful for identifying specific patterns.

**Interpret Data** The word *interpret* means “to explain the meaning of something.” When analyzing data from an experiment, try to find out what the data show. Identify the control group and the test group to see whether or not changes in the independent variable have had an effect. Look for differences in the dependent variable between the control and test groups.

**Classify** Sorting objects or events into groups based on common features is called classifying. When classifying, first observe the objects or events to be classified. Then select one feature that is shared by some members in the group, but not by all. Place those members that share that feature in a subgroup. You can classify members into smaller and smaller subgroups based on characteristics. Remember that when you classify, you are grouping objects or events for a purpose. Keep your purpose in mind as you select the features to form groups and subgroups.

**Compare and Contrast** Observations can be analyzed by noting the similarities and differences between two more objects or events that you observe. When you look at objects or events to see how they are similar, you are comparing them. Contrasting is looking for differences in objects or events.

**Figure 14** A thermometer measures the temperature of an object.
Recognize Cause and Effect  A cause is a reason for an action or condition. The effect is that action or condition. When two events happen together, it is not necessarily true that one event caused the other. Scientists must design a controlled investigation to recognize the exact cause and effect.

Draw Conclusions

When scientists have analyzed the data they collected, they proceed to draw conclusions about the data. These conclusions are sometimes stated in words similar to the hypothesis that you formed earlier. They may confirm a hypothesis, or lead you to a new hypothesis.

Infer  Scientists often make inferences based on their observations. An inference is an attempt to explain observations or to indicate a cause. An inference is not a fact, but a logical conclusion that needs further investigation. For example, you may infer that a fire has caused smoke. Until you investigate, however, you do not know for sure.

Apply  When you draw a conclusion, you must apply those conclusions to determine whether the data supports the hypothesis. If your data do not support your hypothesis, it does not mean that the hypothesis is wrong. It means only that the result of the investigation did not support the hypothesis. Maybe the experiment needs to be redesigned, or some of the initial observations on which the hypothesis was based were incomplete or biased. Perhaps more observation or research is needed to refine your hypothesis. A successful investigation does not always come out the way you originally predicted.

Avoid Bias  Sometimes a scientific investigation involves making judgments. When you make a judgment, you form an opinion. It is important to be honest and not to allow any expectations of results to bias your judgments. This is important throughout the entire investigation, from researching to collecting data to drawing conclusions.

Communicate

The communication of ideas is an important part of the work of scientists. A discovery that is not reported will not advance the scientific community’s understanding or knowledge. Communication among scientists also is important as a way of improving their investigations.

Scientists communicate in many ways, from writing articles in journals and magazines that explain their investigations and experiments, to announcing important discoveries on television and radio. Scientists also share ideas with colleagues on the Internet or present them as lectures, like the student is doing in Figure 15.

Figure 15  A student communicates to his peers about his investigation.
<table>
<thead>
<tr>
<th>SAFETY SYMBOLS</th>
<th>HAZARD</th>
<th>EXAMPLES</th>
<th>PRECAUTION</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISPOSAL</td>
<td>Special disposal procedures need to be fol-</td>
<td>certain chemicals, living organisms</td>
<td>Do not dispose of these materials in the sink or trash can.</td>
<td>Dispose of wastes as directed by your teacher.</td>
</tr>
<tr>
<td>Biological</td>
<td>Organisms or other biological materials</td>
<td>bacteria, fungi, blood, unpreserved tissues, plant materials</td>
<td>Avoid skin contact with these materials. Wear mask or gloves.</td>
<td>Notify your teacher if you suspect contact with material. Wash hands thoroughly.</td>
</tr>
<tr>
<td>Extreme</td>
<td>Objects that can burn skin by being too</td>
<td>boiling liquids, hot plates, dry ice, liquid nitrogen</td>
<td>Use proper protection when handling.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td>Temperature</td>
<td>cold or too hot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharp Object</td>
<td>Use of tools or glassware that can easily</td>
<td>razor blades, pins, scalpels, pointed tools, dissecting probes, broken glass</td>
<td>Practice common-sense behavior and follow guidelines for use of the tool.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td></td>
<td>puncture or slice skin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fume</td>
<td>Possible danger to respiratory tract from</td>
<td>ammonia, acetone, nail polish remover, heated sulfur, moth balls</td>
<td>Make sure there is good ventilation. Never smell fumes directly. Wear a mask.</td>
<td>Leave foul area and notify your teacher immediately.</td>
</tr>
<tr>
<td></td>
<td>fumes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Possible danger from electrical shock or</td>
<td>improper grounding, liquid spills, short circuits, exposed wires</td>
<td>Double-check setup with teacher. Check condition of wires and apparatus.</td>
<td>Do not attempt to fix electrical problems. Notify your teacher immediately.</td>
</tr>
<tr>
<td></td>
<td>burn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irritant</td>
<td>Substances that can irritate the skin or</td>
<td>pollen, moth balls, steel wool, fiberglass, potassium permanganate</td>
<td>Wear dust mask and gloves. Practice extra care when handling these materials.</td>
<td>Go to your teacher for first aid.</td>
</tr>
<tr>
<td></td>
<td>mucous membranes of the respiratory tract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td>Chemicals can react with and destroy tissue and other materials</td>
<td>bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammonia, sodium hydroxide</td>
<td>Wear goggles, gloves, and an apron.</td>
<td>Immediately flush the affected area with water and notify your teacher.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic</td>
<td>Substance may be poisonous if touched,</td>
<td>mercury, many metal compounds, iodine, poinsettia plant parts</td>
<td>Follow your teacher’s instructions.</td>
<td>Always wash hands thoroughly after use. Go to your teacher for first aid.</td>
</tr>
<tr>
<td></td>
<td>inhaled, or swallowed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable</td>
<td>Flammable chemicals may be ignited by open flame, spark, or exposed heat</td>
<td>alcohol, kerosene, potassium permanganate</td>
<td>Avoid open flames and heat when using flammable chemicals.</td>
<td>Notify your teacher immediately. Use fire safety equipment if applicable.</td>
</tr>
<tr>
<td>Open Flame</td>
<td>Open flame in use, may cause fire.</td>
<td>hair, clothing, paper, synthetic materials</td>
<td>Tie back hair and loose clothing. Follow teacher’s instruction on lighting and extinguishing flames.</td>
<td>Notify your teacher immediately. Use fire safety equipment if applicable.</td>
</tr>
</tbody>
</table>

**Eye Safety**  
Proper eye protection should be worn at all times by anyone performing or observing science activities.

**Clothing Protection**  
This symbol appears when substances could stain or burn clothing.

**Animal Safety**  
This symbol appears when safety of animals and students must be ensured.

**Handwashing**  
After the lab, wash hands with soap and water before removing goggles.
Safety in the Science Laboratory

The science laboratory is a safe place to work if you follow standard safety procedures. Being responsible for your own safety helps to make the entire laboratory a safer place for everyone. When performing any lab, read and apply the caution statements and safety symbol listed at the beginning of the lab.

General Safety Rules
1. Obtain your teacher’s permission to begin all investigations and use laboratory equipment.
2. Study the procedure. Ask your teacher any questions. Be sure you understand safety symbols shown on the page.
3. Notify your teacher about allergies or other health conditions which can affect your participation in a lab.
4. Learn and follow use and safety procedures for your equipment. If unsure, ask your teacher.

5. Never eat, drink, chew gum, apply cosmetics, or do any personal grooming in the lab. Never use lab glassware as food or drink containers. Keep your hands away from your face and mouth.
6. Know the location and proper use of the safety shower, eye wash, fire blanket, and fire alarm.

Prevent Accidents
1. Use the safety equipment provided to you. Goggles and a safety apron should be worn during investigations.
2. Do NOT use hair spray, mousse, or other flammable hair products. Tie back long hair and tie down loose clothing.
3. Do NOT wear sandals or other open-toed shoes in the lab.
4. Remove jewelry on hands and wrists. Loose jewelry, such as chains and long necklaces, should be removed to prevent them from getting caught in equipment.
5. Do not taste any substances or draw any material into a tube with your mouth.
6. Proper behavior is expected in the lab. Practical jokes and fooling around can lead to accidents and injury.
7. Keep your work area uncluttered.

Laboratory Work
1. Collect and carry all equipment and materials to your work area before beginning a lab.
2. Remain in your own work area unless given permission by your teacher to leave it.
3. Always slant test tubes away from yourself and others when heating them, adding substances to them, or rinsing them.

4. If instructed to smell a substance in a container, hold the container a short distance away and fan vapors towards your nose.

5. Do NOT substitute other chemicals/substances for those in the materials list unless instructed to do so by your teacher.

6. Do NOT take any materials or chemicals outside of the laboratory.

7. Stay out of storage areas unless instructed to be there and supervised by your teacher.

**Laboratory Cleanup**

1. Turn off all burners, water, and gas, and disconnect all electrical devices.

2. Clean all pieces of equipment and return all materials to their proper places.

3. Dispose of chemicals and other materials as directed by your teacher. Place broken glass and solid substances in the proper containers. Never discard materials in the sink.

4. Clean your work area.

5. Wash your hands with soap and water thoroughly BEFORE removing your goggles.

**Emergencies**

1. Report any fire, electrical shock, glassware breakage, spill, or injury, no matter how small, to your teacher immediately. Follow his or her instructions.

2. If your clothing should catch fire, STOP, DROP, and ROLL. If possible, smother it with the fire blanket or get under a safety shower. NEVER RUN.

3. If a fire should occur, turn off all gas and leave the room according to established procedures.

4. In most instances, your teacher will clean up spills. Do NOT attempt to clean up spills unless you are given permission and instructions to do so.

5. If chemicals come into contact with your eyes or skin, notify your teacher immediately. Use the eyewash or flush your skin or eyes with large quantities of water.

6. The fire extinguisher and first-aid kit should only be used by your teacher unless it is an extreme emergency and you have been given permission.

7. If someone is injured or becomes ill, only a professional medical provider or someone certified in first aid should perform first-aid procedures.
**Animal Watch**

**Real-World Question**
What does your favorite wild animal do?

**Possible Materials**
- meterstick
- metric ruler
- binoculars
- hand lens
- microscope slide
- aquatic net
- insect net
- collecting jar
- hiking equipment
- waders or boots

**Procedure**
1. Choose a wild animal to observe. You may choose a common animal such as an ant, squirrel, or backyard bird, or you may choose an animal that only lives in a forest or stream.
2. Create a data chart to record your observations and measurements about your animal. Consider using an electronically generated chart.
3. Observe the physical characteristics of your animal including its approximate size, color, and distinct features.
4. Observe the behavior of your animal. If possible, observe what it eats and how it behaves. Try to measure the distance it travels.
5. Record all your observations and measurements in your data chart.
6. Compare your data with the data collected by your classmates.

**Conclude and Apply**
1. Describe several new facts you learned about your animal.
2. Explain why careful observations are a vital skill for life scientists.

**Guppies of All Colors**

**Real-World Question**
How can the effects of selective breeding be observed?

**Possible Materials**
- metric ruler
- pencil
- Science Journal
- access to a pet store

**Procedure**
1. Go to a pet store with an adult and ask an employee if you would be able to observe the store’s guppies for a school assignment.
2. Ask the employee to show you the aquaria housing plain guppies, which are sold as “feeder fish,” and fancy tail guppies.
3. Observe the different varieties of plain guppies. Estimate their average body length and tail size. Describe their colors.
4. Observe all the fancy tail guppies. Estimate their average body length and tail size. Describe their colors.
5. Record any other differences in the traits of plain and fancy tail guppies you observe.

**Conclude and Apply**
1. Compare the traits of the plain guppies to the fancy tail guppies.
2. Infer why the fancy tail guppies have such a large variety of colors.
### Sports Drink Minerals

**Real-World Question**
How do the minerals compare in sports drinks and natural foods?

**Possible Materials**
- sport drink bottle labels (several different brands)
- orange juice bottle or carton

**Procedure**
1. Create a data chart in your Science Journal to record your data. Make a Food and Drinks column, and columns for two important minerals needed by athletes, Potassium and Sodium.
2. Read the Nutrition Facts labels of the sport drinks and the orange juice. For a large variety of drinks, visit your local grocery store with an adult and record the information you need. In your data chart, record the amounts of sodium and potassium found in each.
3. Research the amount of potassium and sodium in a banana or other type of fruit. Record these numbers on your data chart.

**Conclude and Apply**
1. Compare the amount of potassium and sodium found in the different drinks and foods.
2. Infer why a person may not need sodium in a sports drink.
3. The minerals in a sports drink are not needed unless a person exercises continually for at least an hour. Interview several of your friends who drink sports drinks and evaluate whether or not they need the drink.

### Rock Creatures

**Real-World Question**
What types of organisms live under stream rocks?

**Possible Materials**
- waterproof boots
- ice cube tray (white)
- aquarium net
- bucket
- collecting jars
- guidebook to pond life

**Procedure**
1. With permission, search under the rocks of a local stream. Look for aquatic organisms under the rocks and leaves of the stream. Compare what you find in fast- and slow-moving water.
2. With permission, carefully pull organisms you find off the rocks and put them into separate compartments of your ice cube tray. Take care not to injure the creatures you find.
3. Use your net and bucket to collect larger organisms.
4. Use your guidebook to pond life to identify the organisms you find.
5. Release the organisms back into the stream once you identify them.

**Conclude and Apply**
1. Identify and list the organisms you found under the stream rocks.
2. Infer why so many aquatic organisms make their habitats beneath stream rocks.
A Light in the Forest

**Real-World Question**
Does the amount of sunlight vary in a forest?

**Possible Materials**
- empty toilet paper or paper towel roll
- Science Journal

**Procedure**
1. Copy the data table into your Science Journal.
2. Go with an adult to a nearby forest or large grove of trees.
3. Stand near the edge of the forest and look straight up through your cardboard tube. Estimate the percentage of blue sky and clouds you can see in the circle. This percentage is the amount of sunlight reaching the forest floor.
4. Record your location and estimated percentage of sunlight in your data table.
5. Test several other locations in the forest. Choose places where the trees completely cover the forest floor and where sunlight is partially coming through.

**Data Table**

<table>
<thead>
<tr>
<th>Location</th>
<th>% of Sunlight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclude and Apply**
1. Explain how the amount of sunlight reaching the forest floor changed from place to place.
2. Infer why it is important for leaves and branches to stop sunlight from reaching much of the forest floor.

---

Echinoderm Hold

**Real-World Question**
How do echinoderms living in intertidal ecosystems hold on to rocks?

**Possible Materials**
- plastic suction cup
- water
- paper towel or sponge

**Procedure**
1. Moisten a paper towel or sponge with water.
2. Press a plastic suction cup on the moist towel or sponge until the entire bottom surface of the cup is wet.
3. Firmly press the suction cup down on a kitchen counter for 10 s.
4. Grab the top handle of the suction cup and try removing the cup from the counter by pulling it straight up.

**Conclude and Apply**
1. Describe what happened when you tried to remove the cup from the counter.
2. Infer how echinoderms living in intertidal ecosystems withstand the constant pull of ocean waves and currents.
7  Measuring Movement

**Real-World Question**
How can we model continental drift?

**Possible Materials**
- flashlight, nail, rubber band or tape, thick circle of paper
- protractor
- mirror
- stick-on notepad paper
- marker
- metric ruler
- calculator

**Procedure**
1. Cut a circle of paper to fit around the lens of the flashlight. Use a nail to make a hole in the paper. Fasten the paper with the rubber band or tape. You should now have a flashlight that shines a focused beam of light.
2. Direct the light beam of the flashlight on a protractor held horizontally so that the beam lines up to the 90° mark.
3. Darken a room and aim the light beam at a mirror from an angle. Measure the angle. Observe where the reflected beam hits the wall.
4. Have a partner place a stick-on note on the wall and mark the location of the beam on the paper with a marker.
5. Move the flashlight to a 100° angle and mark the beam’s location on the wall with a second note.
6. Measure the distance between the two points on the wall and divide by ten to determine the distance per degree.

**Conclude and Apply**
1. What was the distance per degree of your measurements?
2. Calculate what the distance would be between the first spot and a third spot marking the location of the flashlight at a 40° angle. Test your calculations.
3. Explain how this lab models measuring continental drift.

8  Earth’s Layers

**Real-World Question**
What is the relative thickness of Earth’s different layers?

**Possible Materials**
- meterstick
- masking tape

**Procedure**
1. Use a piece of masking tape to mark a spot on the floor. This spot represents the center of Earth.
2. Measure a distance of 1.22 m from the first tape mark and place a second piece of tape.
3. From the second piece of tape, measure a distance of 2.27 m and place a third piece of tape.
4. From the third piece of tape, measure a distance of 2.89 m and place a fourth piece of tape.
5. From the fourth piece of tape, make two measurements. Measure a distance of 0.005 m and a distance of 0.06 m. Place two more pieces of tape to mark these two distances.

**Conclude and Apply**
1. Identify the name of each of the levels you drew.
2. Calculate the scale you used for the thickness of your earth layers.
9 Making Burrows

**Real-World Question**
How does burrowing affect sediment layers?

**Possible Materials**
- clear-glass bowl
- white flour
- colored gelatin powder (3 packages)
- paintbrush
- pencil

**Procedure**
1. Add 3 cm of white flour to the bowl. Flatten the top of the flour layer.
2. Carefully sprinkle gelatin powder over the flour to form a colored layer about 0.25 cm thick.
3. The two layers represent two different layers of sediment.
4. Use a paintbrush or pencil to make “burrows” in the “sediment.”
5. Make sure to make some of the burrows at the edge of the bowl so that you can see how it affects the sediment.
6. Continue to make more burrows and observe the effect on the two layers.

**Conclude and Apply**
1. How did the two layers of powder change as you continued to make burrows?
2. Were the “trace fossils” easy to recognize at first? How about after a lot of burrowing?
3. How do you think burrowing animals affect layers of sediment on the ocean floor? How could this burrowing be recognized in rock?

10 History in a Bottle

**Real-World Question**
What does the geologic column look like?

**Possible Materials**
- clear-plastic 2-liter bottle
- scissors
- 3-in × 5-in index cards
- colored markers
- permanent marker
- transparent tape
- metric ruler
- sand (3 different colors)
- aquarium gravel (3 different colors)

**Procedure**
1. Cut the top 5 cm off a clear-plastic 2-L soda bottle. Remove the label.
2. Cut 12 square cards measuring 2 cm × 2 cm.
3. Draw a picture of a trilobite, coral, fish, amphibian, insect, reptile, mouse, coniferous tree, dinosaur, bird, flower, large mammal, and human on the 12 cards.
4. Starting at the bottom, inside of the bottle and working up, tape the trilobite, coral, fish, amphibian, insect, and reptile pictures face out in that order. The reptile picture should be about half way up the bottle.
5. Pour red sand into the bottle until it covers your reptile picture.
6. Tape the mouse, conifer tree, dinosaur, bird, and flower pictures above the red sand in that order. Pour in blue sand until it covers the flower picture.
7. Tape the large mammal and human pictures above the blue sand. Pour green sand into the bottle until it covers the person.

**Conclude and Apply**
1. Research what era each color of sand represents.
2. Infer why few fossils of organisms living before the Paleozoic Era are found.
Creating Craters

**Real-World Question**
Why does the Moon have craters?

**Possible Materials**
- drink mix or powdered baby formula
- black pepper or paprika
- large, deep cooking tray or large bowl
- marbles
- small, round candies
- aquarium gravel
- tweezers
- bag of cotton balls

**Procedure**
1. Pour a 3-cm layer of powder over the bottom of a large, deep cooking tray.
2. Sprinkle a fine layer of black pepper over the powder.
3. Lay a 2–3 cm layer of cotton over half of the powder.
4. Drop marbles and other small objects into the powder not covered by the cotton. Carefully remove the objects with tweezers and observe the craters and impact patterns they make.
5. Drop objects on to the half of the tray covered by cotton.
6. Remove the objects and cotton and observe the marks made by objects in the powder.

**Conclude and Apply**
1. Compare the impacts made by the objects in the powder not covered by cotton with the impacts in the powder covered by cotton.
2. Infer why the Moon has many craters on its surface but Earth does not.

Many Moons

**Real-World Question**
How do the number of moons of the nine planets compare?

**Possible Materials**
- golf balls (5)
- softballs (4)
- colored construction paper
- hole puncher
- pennies (10)
- quarters (8)
- meterstick

**Procedure**
1. Lay the golf balls and softballs on the floor in a row to represent the nine planets. The golf balls should represent the terrestrial planets and the softballs the gas planets.
2. Next to the golf ball representing Earth place one quarter. A quarter represents a moon with a diameter greater than 1,000 km. Research which planets have moons this size and place quarters next to them.
3. Use pennies to represent moons with a diameter between 200–1,000 km. Place pennies next to the planets with moons this size.
4. Use a hole punch to punch out holes from colored construction paper. These holes represent moons smaller than 200 km in diameter. Research which planets have moons this size and place the holes next to them.

**Conclude and Apply**
1. Infer why terrestrial planets have fewer moons than gas planets.
2. Infer why astronomers do not believe all the moons in the solar system have been discovered.
**Big Stars**

**Real-World Question**
How does the size of Earth compare to the size of stars?

**Possible Materials**
- metric ruler
- meterstick
- tape measure
- masking tape
- white paper
- black marker

**Procedure**
1. Tape a sheet of white paper to the floor.
2. Draw a dot in the center to the paper. Measure a 1-mm distance from the dot and draw a second dot. This distance represents the diameter of Earth.
3. Measure a distance of 10.9 cm from the first dot and draw a third dot. This distance represents the diameter of the Sun.
4. Measure a distance of 5 m from the first dot and mark the location on the floor with a piece of masking tape. This distance represents the average diameter of a red giant star.
5. Measure a distance of 30 m from the first dot and mark the location on the floor with a piece of masking tape. This distance represents the diameter of the supergiant star Antares.

**Conclude and Apply**
1. The diameter of Earth is 12,756 km. What is the diameter of the Sun?
2. What is the diameter of an average red giant?

**Make an Electroscope**

**Real-World Question**
How can you test the radiation coming from an old television or your smoke detector?

**Materials**
- glass jar
- thin cardboard
- paper clip
- aluminum foil
- hammer and nail
- tape
- plastic rod
- fur, wool, or cotton cloth

**Procedure**
1. Cut two identical pieces of foil about 1.25 cm by 2.5 cm.
2. Hang the two pieces of foil side by side on one loop of the paper clip.
3. Straighten the other loop of the paper clip. Use the hammer and nail to tap a small hole in the cardboard lid, and push the paper clip through the hole so that the straightened portion of the paper clip sticks out. If necessary, tape the clip in place at right angles to the card. Put the lid on the jar.
4. Charge the plastic rod by rubbing with the cloth or fur. Touch it to the straightened portion of the paper clip. The leaves of foil will get equal charges and repel each other.
5. Observe how much time it takes for the leaves to lose their charge and fall back together. Now, recharge your electroscope and bring it near an old television or smoke detector. If radiation is present, the leaves will fall back together much more quickly than they did without the radiation present.

**Conclude and Apply**
1. Why do you think the foil leaves discharge faster when there is ionizing radiation present?
2. If you touch the top of the electroscope with your finger, the leaves fall back together. Why is this?
**Research Race**

**Real-World Question**
How many secrets of the periodic table’s elements can you find by research?

**Possible Materials**
- reference materials
- access to library

**Procedure**
1. Get together with a team of your friends. Look at the Race Questions and divide them between you.
2. Try to get as many answers as you can in a certain amount of time.
3. Be sure to keep a record of each resource. You get a point for each correct answer. You also get a point for each properly listed book, magazine, or Web site that you list.

**Race Questions:**
- List colored compounds of transition metals.
- List uses of colored transition metal compounds.
- List elements that are dangerous to human health, especially heavy metals. Where are they found in society?
- List elements that are needed for human health. What food sources are each found in?
- List any other interesting information about elements that show up as you do your research.

**Conclude and Apply**
1. Which resources did you find most helpful?
2. Name an interesting fact you found.

---

**Human Bonding**

**Real-World Question**
How can humans model atoms bonding together?

**Possible Materials**
- family members or friends
- sheets of blank paper
- markers
- large safety pins
- large colored rubber bands

**Procedure**
1. Draw a large electron dot diagram of an element you choose. Have other activity participants do that too.
2. Pin the diagram to your shirt.
3. How many electrons does your element have? Gather that many rubber bands.
4. Place about half of the rubber bands on one wrist and half on the other.
5. Form bonds by finding someone who has the number of rubber bands you need to total eight. Try to form as many different compounds with different elements as you can. (You may need two or three of another element’s atoms to make a compound.) Record the compounds you make in your Science Journal. Label each compound as ionic or covalent.

**Conclude and Apply**
1. Which elements don’t form any bonds?
2. Which elements form four bonds?
17 Mini Fireworks

**Real-World Question**
Where do the colors in fireworks come from?

**Possible Materials**
- candle
- lighter
- wooden chopsticks (or a fork or tongs)
- penny
- water in an old cup
- steel wool

**Procedure**
1. Light the candle.
2. Use the chopsticks to get a firm grip on the penny.
3. Hold the penny in the flame until you observe a change. *(Hint: this experiment is more fun in the bathroom with the lights off!)*
4. Drop the penny in the water when you are finished and plunge the burning end of the chopsticks or hot part of the fork into the water as well.
5. Repeat the procedure using steel wool.

**Conclude and Apply**
1. What color did you see?
2. Infer why copper and iron are used in fireworks.
3. Research what other elements are used in fireworks.

18 Measuring Momentum

**Real-World Question**
How much momentum do rolling balls have?

**Possible Materials**
- meterstick
- orange cones or tape
- scale
- stopwatch
- bucket
- bowling ball
- plastic baseball
- golf ball
- tennis ball
- calculator

**Procedure**
1. Use a balance to measure the masses of the tennis ball, golf ball, and plastic baseball. Convert their masses from grams to kilograms.
2. Find the weight of the bowling ball in pounds. The weight should be written on the ball. Divide the ball’s weight by 2.2 to calculate its mass in kilograms.
3. Go outside and measure a 10-m distance on a blacktop or concrete surface. Mark the distance with orange cones or tape.
4. Have a partner roll each ball the 10-m distance. Measure the time it takes each ball to roll 10 m.
5. Use the formula: velocity = distance / time to calculate each ball’s velocity.

**Conclude and Apply**
1. Calculate the momentum of each ball.
2. Infer why the momentums of the balls differed so greatly.
19 Friction in Traffic

Real-World Question
How do the various kinds of friction affect the operation of vehicles?

Possible Materials
• erasers taken from the ends of pencils (4)
• needles (2)
• small match box
• toy car

Procedure
1. Build a match box car with the materials listed, or use a toy car.
2. Invent ways to demonstrate the effects of static friction, sliding friction, and rolling friction on the car. Think of hills, ice or rain conditions, graveled roads and paved roads, etc.
3. Make drawings of how friction is acting on the car, or how the car uses friction to work.

Conclude and Apply
1. In what ways are static, sliding, and rolling friction helpful to drivers?
2. In what ways are static, sliding, and rolling friction unfavorable to car safety and operation?
3. Explain what your experiment taught you about driving in icy conditions.

20 Simple Machines

Real-World Question
What types of simple machines are found in a toolbox?

Possible Materials
• box of tools

Procedure
1. Obtain a box of tools and lay all the tools and other hardware from the box on a table.
2. Carefully examine all the tools and hardware, and separate all the items that are a type of inclined plane.
3. Carefully examine all the tools and hardware, and separate all the items that are a type of lever.
4. Identify and separate all the items that are a wheel and axle.
5. Identify any pulleys in the toolbox.
6. Identify any tools that are a combination of two or more simple machines.

Conclude and Apply
1. List all the tools you found that were a type of inclined plane, lever, wheel and axle, or pulley.
2. List all the tools that were a combination of two or more simple machines.
3. Infer how a hammer could be used as both a first class lever and a third class lever.
### Estimate Temperature

**Real-World Question**
How can we learn to estimate temperatures?

**Possible Materials**
- thermometer
- bowl
- ice

**Procedure**
1. If you have a dual-scale weather thermometer, you can learn twice as much by trying to do your estimation in degrees Fahrenheit and Celsius each time.
2. Fill a bowl with ice water. Submerge your fingers in the water and estimate the water temperature.
3. Place the thermometer in the bowl and observe the temperature.
4. Place a bowl of warm water in direct sunlight for 20 min. Submerge your fingers in the water and estimate the water temperature.
5. Place the thermometer in the bowl and observe the temperature.
6. Place the thermometer outside in a location where you can see it each day.
7. Each day for a month, step outside and estimate the temperature. Check the accuracy of your estimates with the thermometer. Record the weather conditions as well.

**Conclude and Apply**
1. Describe how well you can estimate air temperatures after estimating the temperature each day for a month. Did the cloudiness of the day affect your estimation skills?
2. Infer why understanding the Celsius scale might be helpful to you in the future.

### Bending Water

**Real-World Question**
How can a plastic rod bend water without touching it?

**Possible Materials**
- plastic rod
- plastic clothes hanger
- 100% wool clothing
- water faucet

**Procedure**
1. Turn on a faucet until a narrow, smooth stream of water is flowing out of it. The stream of water cannot be too wide, and it cannot flow in a broken pattern.
2. Vigorously rub a plastic rod on a piece of 100% wool clothing for about 15 s.
3. Immediately hold the rod near the center of the stream of water. Move the rod close to the stream. Do not touch the water.
4. Observe what happens to the water.

**Conclude and Apply**
1. Describe how the plastic rod affected the stream of water.
2. Explain why the plastic rod affected the water.
**Testing Magnets**

**Real-World Question**
How do the strengths of kitchen magnets compare?

**Possible Materials**
- several kitchen magnets
- metric ruler
- small pin or paper clip

**Procedure**
1. Place a small pin or paper clip on a flat, nonmetallic surface such as a wooden table.
2. Holding your metric ruler vertically, place it next to the pin with the 0 cm mark on the tabletop.
3. Hold a kitchen magnet at the 10 cm mark on the ruler.
4. Slowly lower the magnet toward the pin. At the point where the pin is attracted to the magnet, measure the height of the magnet from the table. Record the height in your Science Journal.
5. Repeat steps 2–4 to test your other kitchen magnets.

**Conclude and Apply**
1. Describe the results of your experiment.
2. Infer how the kitchen magnets should be used based on the results of your experiment.

**Disappearing Dots**

**Real-World Question**
Do your eyes have a blind spot?

**Possible Materials**
- white paper
- metric ruler
- colored pencils

**Procedure**
1. Hold a sheet of white paper horizontally. Near the left edge of the paper, draw a black dot about 0.5 cm in diameter.
2. Draw a red dot 5 cm to the right of the black dot.
3. Hold the paper out in front of you, close your left eye, and look at the black dot with your right eye. Slowly move the paper toward you and observe what happens to the red dot.
4. Draw a blue dot 10 cm to the right of the black dot and a green dot 15 cm from the black dot.
5. Hold the paper out at arm’s length, close your left eye, and look at the black dot with your right eye. Slowly move the paper toward you and observe what happens to the dots.

**Conclude and Apply**
1. Describe what happened to the red, blue, and green dots as you moved the paper toward you.
2. The optic nerve carries visual images to the brain, and it is attached to the retina in your eye. Infer why the dots disappeared.
People who study science rely on computers, like the one in Figure 16, to record and store data and to analyze results from investigations. Whether you work in a laboratory or just need to write a lab report with tables, good computer skills are a necessity. Using the computer comes with responsibility. Issues of ownership, security, and privacy can arise. Remember, if you did not author the information you are using, you must provide a source for your information. Also, anything on a computer can be accessed by others. Do not put anything on the computer that you would not want everyone to know. To add more security to your work, use a password.

Use a Word Processing Program

A computer program that allows you to type your information, change it as many times as you need to, and then print it out is called a word processing program. Word processing programs also can be used to make tables.

Learn the Skill  To start your word processing program, a blank document, sometimes called “Document 1,” appears on the screen. To begin, start typing. To create a new document, click the New button on the standard tool bar. These tips will help you format the document.

- The program will automatically move to the next line; press Enter if you wish to start a new paragraph.
- Symbols, called non-printing characters, can be hidden by clicking the Show/Hide button on your toolbar.
- To insert text, move the cursor to the point where you want the insertion to go, click on the mouse once, and type the text.
- To move several lines of text, select the text and click the Cut button on your toolbar. Then position your cursor in the location that you want to move the cut text and click Paste. If you move to the wrong place, click Undo.
- The spell check feature does not catch words that are misspelled to look like other words, like “cold” instead of “gold.” Always reread your document to catch all spelling mistakes.
- To learn about other word processing methods, read the user’s manual or click on the Help button.
- You can integrate databases, graphics, and spreadsheets into documents by copying from another program and pasting it into your document, or by using desktop publishing (DTP). DTP software allows you to put text and graphics together to finish your document with a professional look. This software varies in how it is used and its capabilities.
Use a Database

A collection of facts stored in a computer and sorted into different fields is called a database. A database can be reorganized in any way that suits your needs.

**Learn the Skill** A computer program that allows you to create your own database is a database management system (DBMS). It allows you to add, delete, or change information. Take time to get to know the features of your database software.

- Determine what facts you would like to include and research to collect your information.
- Determine how you want to organize the information.
- Follow the instructions for your particular DBMS to set up fields. Then enter each item of data in the appropriate field.
- Follow the instructions to sort the information in order of importance.
- Evaluate the information in your database, and add, delete, or change as necessary.

Use the Internet

The Internet is a global network of computers where information is stored and shared. To use the Internet, like the students in **Figure 17**, you need a modem to connect your computer to a phone line and an Internet Service Provider account.

**Learn the Skill** To access internet sites and information, use a “Web browser,” which lets you view and explore pages on the World Wide Web. Each page is its own site, and each site has its own address, called a URL. Once you have found a Web browser, follow these steps for a search (this also is how you search a database).

- Be as specific as possible. If you know you want to research “gold,” don’t type in “elements.” Keep narrowing your search until you find what you want.
- Web sites that end in .com are commercial Web sites; .org, .edu, and .gov are non-profit, educational, or government Web sites.
- Electronic encyclopedias, almanacs, indexes, and catalogs will help locate and select relevant information.
- Develop a “home page” with relative ease. When developing a Web site, NEVER post pictures or disclose personal information such as location, names, or phone numbers. Your school or community usually can host your Web site. A basic understanding of HTML (hypertext mark-up language), the language of Web sites, is necessary. Software that creates HTML code is called authoring software, and can be downloaded free from many Web sites. This software allows text and pictures to be arranged as the software is writing the HTML code.
Use a Spreadsheet

A spreadsheet, shown in Figure 18, can perform mathematical functions with any data arranged in columns and rows. By entering a simple equation into a cell, the program can perform operations in specific cells, rows, or columns.

Learn the Skill Each column (vertical) is assigned a letter, and each row (horizontal) is assigned a number. Each point where a row and column intersect is called a cell, and is labeled according to where it is located—Column A, Row 1 (A1).

- Decide how to organize the data, and enter it in the correct row or column.
- Spreadsheets can use standard formulas or formulas can be customized to calculate cells.
- To make a change, click on a cell to make it activate, and enter the edited data or formula.
- Spreadsheets also can display your results in graphs. Choose the style of graph that best represents the data.

Figure 18 A spreadsheet allows you to perform mathematical operations on your data.

Use Graphics Software

Adding pictures, called graphics, to your documents is one way to make your documents more meaningful and exciting. This software adds, edits, and even constructs graphics. There is a variety of graphics software programs. The tools used for drawing can be a mouse, keyboard, or other specialized devices. Some graphics programs are simple. Others are complicated, called computer-aided design (CAD) software.

Learn the Skill It is important to have an understanding of the graphics software being used before starting. The better the software is understood, the better the results. The graphics can be placed in a word-processing document.

- Clip art can be found on a variety of internet sites, and on CDs. These images can be copied and pasted into your document.
- When beginning, try editing existing drawings, then work up to creating drawings.
- The images are made of tiny rectangles of color called pixels. Each pixel can be altered.
- Digital photography is another way to add images. The photographs in the memory of a digital camera can be downloaded into a computer, then edited and added to the document.
- Graphics software also can allow animation. The software allows drawings to have the appearance of movement by connecting basic drawings automatically. This is called in-betweening, or tweening.
- Remember to save often.
Presentation Skills

Develop Multimedia Presentations

Most presentations are more dynamic if they include diagrams, photographs, videos, or sound recordings, like the one shown in Figure 19. A multimedia presentation involves using stereos, overhead projectors, televisions, computers, and more.

Learn the Skill  Decide the main points of your presentation, and what types of media would best illustrate those points.

- Make sure you know how to use the equipment you are working with.
- Practice the presentation using the equipment several times.
- Enlist the help of a classmate to push play or turn lights out for you. Be sure to practice your presentation with him or her.
- If possible, set up all of the equipment ahead of time, and make sure everything is working properly.

Figure 19  These students are engaging the audience using a variety of tools.

Computer Presentations

There are many different interactive computer programs that you can use to enhance your presentation. Most computers have a compact disc (CD) drive that can play both CDs and digital video discs (DVDs). Also, there is hardware to connect a regular CD, DVD, or VCR. These tools will enhance your presentation.

Another method of using the computer to aid in your presentation is to develop a slide show using a computer program. This can allow movement of visuals at the presenter’s pace, and can allow for visuals to build on one another.

Learn the Skill  In order to create multimedia presentations on a computer, you need to have certain tools. These may include traditional graphic tools and drawing programs, animation programs, and authoring systems that tie everything together. Your computer will tell you which tools it supports. The most important step is to learn about the tools that you will be using.

- Often, color and strong images will convey a point better than words alone. Use the best methods available to convey your point.
- As with other presentations, practice many times.
- Practice your presentation with the tools you and any assistants will be using.
- Maintain eye contact with the audience. The purpose of using the computer is not to prompt the presenter, but to help the audience understand the points of the presentation.
**Use Fractions**

A fraction compares a part to a whole. In the fraction $\frac{2}{3}$, the 2 represents the part and is the numerator. The 3 represents the whole and is the denominator.

**Reduce Fractions** To reduce a fraction, you must find the largest factor that is common to both the numerator and the denominator, the greatest common factor (GCF). Divide both numbers by the GCF. The fraction has then been reduced, or it is in its simplest form.

**Example** Twelve of the 20 chemicals in the science lab are in powder form. What fraction of the chemicals used in the lab are in powder form?

**Step 1** Write the fraction.

\[
\frac{\text{part}}{\text{whole}} = \frac{12}{20}
\]

**Step 2** To find the GCF of the numerator and denominator, list all of the factors of each number.

Factors of 12: 1, 2, 3, 4, 6, 12 (the numbers that divide evenly into 12)

Factors of 20: 1, 2, 4, 5, 10, 20 (the numbers that divide evenly into 20)

**Step 3** List the common factors.

1, 2, 4.

**Step 4** Choose the greatest factor in the list.

The GCF of 12 and 20 is 4.

**Step 5** Divide the numerator and denominator by the GCF.

\[
\frac{12 \div 4}{20 \div 4} = \frac{3}{5}
\]

In the lab, $\frac{3}{5}$ of the chemicals are in powder form.

**Practice Problem** At an amusement park, 66 of 90 rides have a height restriction. What fraction of the rides, in its simplest form, has a height restriction?

**Add and Subtract Fractions** To add or subtract fractions with the same denominator, add or subtract the numerators and write the sum or difference over the denominator. After finding the sum or difference, find the simplest form for your fraction.

**Example 1** In the forest outside your house, $\frac{1}{8}$ of the animals are rabbits, $\frac{3}{8}$ are squirrels, and the remainder are birds and insects. How many are mammals?

**Step 1** Add the numerators.

\[
\frac{1}{8} + \frac{3}{8} = \frac{(1 + 3)}{8} = \frac{4}{8}
\]

**Step 2** Find the GCF.

\[
\frac{4}{8} \quad \text{(GCF, 4)}
\]

**Step 3** Divide the numerator and denominator by the GCF.

\[
\frac{4}{4} = 1, \quad \frac{8}{4} = 2
\]

$\frac{1}{2}$ of the animals are mammals.

**Example 2** If $\frac{7}{16}$ of the Earth is covered by freshwater, and $\frac{1}{16}$ of that is in glaciers, how much freshwater is not frozen?

**Step 1** Subtract the numerators.

\[
\frac{7}{16} - \frac{1}{16} = \frac{(7 - 1)}{16} = \frac{6}{16}
\]

**Step 2** Find the GCF.

\[
\frac{6}{16} \quad \text{(GCF, 2)}
\]

**Step 3** Divide the numerator and denominator by the GCF.

\[
\frac{6}{2} = 3, \quad \frac{16}{2} = 8
\]

$\frac{3}{8}$ of the freshwater is not frozen.

**Practice Problem** A bicycle rider is going 15 km/h for $\frac{4}{9}$ of his ride, 10 km/h for $\frac{2}{9}$ of his ride, and 8 km/h for the remainder of the ride. How much of his ride is he going over 8 km/h?
**Unlike Denominators** To add or subtract fractions with unlike denominators, first find the least common denominator (LCD). This is the smallest number that is a common multiple of both denominators. Rename each fraction with the LCD, and then add or subtract. Find the simplest form if necessary.

**Example 1** A chemist makes a paste that is \( \frac{1}{2} \) table salt (NaCl), \( \frac{1}{3} \) sugar (C\(_6\)H\(_{12}\)O\(_6\)), and the rest water (H\(_2\)O). How much of the paste is a solid?

**Step 1** Find the LCD of the fractions.
\[
\frac{1}{2} + \frac{1}{3} \quad \text{(LCD, 6)}
\]

**Step 2** Rename each numerator and each denominator with the LCD.
\[
1 \times 3 = 3, 
2 \times 3 = 6, 
1 \times 2 = 2, 
3 \times 2 = 6
\]

**Step 3** Add the numerators.
\[
\frac{3}{6} + \frac{2}{6} = \frac{(3 + 2)}{6} = \frac{5}{6}
\]

\( \frac{5}{6} \) of the paste is a solid.

**Example 2** The average precipitation in Grand Junction, CO, is \( \frac{7}{10} \) inch in November, and \( \frac{3}{5} \) inch in December. What is the total average precipitation?

**Step 1** Find the LCD of the fractions.
\[
\frac{7}{10} + \frac{3}{5} \quad \text{(LCD, 10)}
\]

**Step 2** Rename each numerator and each denominator with the LCD.
\[
7 \times 1 = 7, 
10 \times 1 = 10, 
3 \times 2 = 6, 
5 \times 2 = 10
\]

**Step 3** Add the numerators.
\[
\frac{7}{10} + \frac{6}{10} = \frac{(7 + 6)}{10} = \frac{13}{10}
\]

\( \frac{13}{10} \) inches total precipitation, or \( 1\frac{3}{10} \) inches.

**Practice Problem** On an electric bill, about \( \frac{1}{8} \) of the energy is from solar energy and about \( \frac{1}{10} \) is from wind power. How much of the total bill is from solar energy and wind power combined?

**Example 3** In your body, \( \frac{7}{10} \) of your muscle contractions are involuntary (cardiac and smooth muscle tissue). Smooth muscle makes \( \frac{3}{15} \) of your muscle contractions. How many of your muscle contractions are made by cardiac muscle?

**Step 1** Find the LCD of the fractions.
\[
\frac{7}{10} - \frac{3}{15} \quad \text{(LCD, 30)}
\]

**Step 2** Rename each numerator and each denominator with the LCD.
\[
7 \times 3 = 21, 
10 \times 3 = 30, 
3 \times 2 = 6, 
15 \times 2 = 30
\]

**Step 3** Subtract the numerators.
\[
\frac{21}{30} - \frac{6}{30} = \frac{(21 - 6)}{30} = \frac{15}{30}
\]

**Step 4** Find the GCF.
\[
\frac{15}{30} \quad \text{(GCF, 15)}
\]

\( \frac{1}{2} \)

\( \frac{1}{2} \) of all muscle contractions are cardiac muscle.

**Example 4** Tony wants to make cookies that call for \( \frac{3}{4} \) of a cup of flour, but he only has \( \frac{1}{3} \) of a cup. How much more flour does he need?

**Step 1** Find the LCD of the fractions.
\[
\frac{3}{4} - \frac{1}{3} \quad \text{(LCD, 12)}
\]

**Step 2** Rename each numerator and each denominator with the LCD.
\[
3 \times 3 = 9, 
4 \times 3 = 12, 
1 \times 4 = 4, 
3 \times 4 = 12
\]

**Step 3** Subtract the numerators.
\[
\frac{9}{12} - \frac{4}{12} = \frac{(9 - 4)}{12} = \frac{5}{12}
\]

\( \frac{5}{12} \) of a cup of flour.

**Practice Problem** Using the information provided to you in Example 3 above, determine how many muscle contractions are voluntary (skeletal muscle).
**Multiply Fractions** To multiply with fractions, multiply the numerators and multiply the denominators. Find the simplest form if necessary.

**Example** Multiply $\frac{3}{5}$ by $\frac{1}{3}$.

**Step 1** Multiply the numerators and denominators.

$$\frac{3}{5} \times \frac{1}{3} = \frac{(3 \times 1)}{(5 \times 3)} = \frac{3}{15}$$

**Step 2** Find the GCF.

$$\frac{3}{15} \text{ (GCF, 3)}$$

**Step 3** Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \quad \frac{15}{3} = 5$$

$$\frac{1}{5}$$

$\frac{3}{5}$ multiplied by $\frac{1}{3}$ is $\frac{1}{5}$.

**Practice Problem** Multiply $\frac{3}{14}$ by $\frac{5}{16}$.

**Find a Reciprocal** Two numbers whose product is 1 are called multiplicative inverses, or reciprocals.

**Example** Find the reciprocal of $\frac{3}{8}$.

**Step 1** Inverse the fraction by putting the denominator on top and the numerator on the bottom.

$$\frac{8}{3}$$

The reciprocal of $\frac{3}{8}$ is $\frac{8}{3}$.

**Practice Problem** Find the reciprocal of $\frac{4}{9}$.

**Divide Fractions** To divide one fraction by another fraction, multiply the dividend by the reciprocal of the divisor. Find the simplest form if necessary.

**Example 1** Divide $\frac{1}{9}$ by $\frac{1}{3}$.

**Step 1** Find the reciprocal of the divisor.

The reciprocal of $\frac{1}{3}$ is $\frac{3}{1}$.

**Step 2** Multiply the dividend by the reciprocal of the divisor.

$$\frac{1}{9} \times \frac{3}{1} = \frac{(1 \times 3)}{(9 \times 1)} = \frac{3}{9}$$

**Step 3** Find the GCF.

$$\frac{3}{9} \text{ (GCF, 3)}$$

**Step 4** Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \quad \frac{9}{3} = 3$$

$$\frac{1}{3}$$

$\frac{1}{9}$ divided by $\frac{1}{3}$ is $\frac{1}{3}$.

**Example 2** Divide $\frac{3}{5}$ by $\frac{1}{4}$.

**Step 1** Find the reciprocal of the divisor.

The reciprocal of $\frac{1}{4}$ is $\frac{4}{1}$.

**Step 2** Multiply the dividend by the reciprocal of the divisor.

$$\frac{3}{5} \times \frac{4}{1} = \frac{(3 \times 4)}{(5 \times 1)} = \frac{12}{5}$$

$$\frac{3}{5} \text{ divided by } \frac{1}{4} \text{ is } \frac{12}{5} \text{ or } 2\frac{2}{5}$$

**Practice Problem** Divide $\frac{3}{11}$ by $\frac{7}{10}$.
**Use Ratios**

When you compare two numbers by division, you are using a ratio. Ratios can be written 3 to 5, 3:5, or $\frac{3}{5}$. Ratios, like fractions, also can be written in simplest form.

Ratios can represent probabilities, also called odds. This is a ratio that compares the number of ways a certain outcome occurs to the number of outcomes. For example, if you flip a coin 100 times, what are the odds that it will come up heads? There are two possible outcomes, heads or tails, so the odds of coming up heads are 50:100. Another way to say this is that 50 out of 100 times the coin will come up heads. In its simplest form, the ratio is 1:2.

**Example 1**  A chemical solution contains 40 g of salt and 64 g of baking soda. What is the ratio of salt to baking soda as a fraction in simplest form?

**Step 1** Write the ratio as a fraction.

\[
\text{salt} : \text{baking soda} = \frac{40}{64}
\]

**Step 2** Express the fraction in simplest form. 

The GCF of 40 and 64 is 8.

\[
\frac{40}{64} = \frac{40 \div 8}{64 \div 8} = \frac{5}{8}
\]

The ratio of salt to baking soda in the sample is 5:8.

**Example 2**  Sean rolls a 6-sided die 6 times. What are the odds that the side with a 3 will show?

**Step 1** Write the ratio as a fraction.

\[
\frac{\text{number of sides with a 3}}{\text{number of sides}} = \frac{1}{6}
\]

**Step 2** Multiply by the number of attempts.

\[
\frac{1}{6} \times 6 \text{ attempts} = \frac{6}{6} \text{ attempts} = 1 \text{ attempt}
\]

1 attempt out of 6 will show a 3.

**Practice Problem**  Two metal rods measure 100 cm and 144 cm in length. What is the ratio of their lengths in simplest form?

---

**Use Decimals**

A fraction with a denominator that is a power of ten can be written as a decimal. For example, $0.27$ means $\frac{27}{100}$. The decimal point separates the ones place from the tenths place.

Any fraction can be written as a decimal using division. For example, the fraction $\frac{5}{8}$ can be written as a decimal by dividing 5 by 8. Written as a decimal, it is 0.625.

**Add or Subtract Decimals**  When adding and subtracting decimals, line up the decimal points before carrying out the operation.

**Example 1**  Find the sum of 47.68 and 7.80.

**Step 1** Line up the decimal places when you write the numbers.

\[
\begin{array}{c}
47.68 \\
+ 7.80 \\
\hline
55.48
\end{array}
\]

The sum of 47.68 and 7.80 is 55.48.

**Example 2**  Find the difference of 42.17 and 15.85.

**Step 1** Line up the decimal places when you write the number.

\[
\begin{array}{c}
42.17 \\
- 15.85 \\
\hline
26.32
\end{array}
\]

The difference of 42.17 and 15.85 is 26.32.

**Practice Problem**  Find the sum of 1.245 and 3.842.
**Multiply Decimals** To multiply decimals, multiply the numbers like any other number, ignoring the decimal point. Count the decimal places in each factor. The product will have the same number of decimal places as the sum of the decimal places in the factors.

**Example** Multiply 2.4 by 5.9.

**Step 1** Multiply the factors like two whole numbers.

\[
\begin{array}{c}
24 \\
59
\end{array}
\begin{array}{c}
1100 \\
1100
\end{array}
\begin{array}{c}
1416
\end{array}
\]

**Step 2** Find the sum of the number of decimal places in the factors. Each factor has one decimal place, for a sum of two decimal places.

**Step 3** The product will have two decimal places.

\[14.16\]

The product of 2.4 and 5.9 is 14.16.

**Practice Problem** Multiply 4.6 by 2.2.

**Divide Decimals** When dividing decimals, change the divisor to a whole number. To do this, multiply both the divisor and the dividend by the same power of ten. Then place the decimal point in the quotient directly above the decimal point in the dividend. Then divide as you do with whole numbers.

**Example** Divide 8.84 by 3.4.

**Step 1** Multiply both factors by 10.

\[
\begin{array}{c}
3.4 \\
6
\end{array}
\begin{array}{c}
10 \\
10
\end{array}
\begin{array}{c}
34, 88.4 \\
88.4
\end{array}
\begin{array}{c}
10 \\
10
\end{array}
\begin{array}{c}
10 \times 10 = 100, 88.4 \times 10 = 88.4
\end{array}
\]

**Step 2** Divide 88.4 by 34.

\[
\begin{array}{c}
2.6 \\
34 \div 88.4
\end{array}
\begin{array}{c}
10 \\
10
\end{array}
\begin{array}{c}
-68 \\
-68
\end{array}
\begin{array}{c}
204 \\
204
\end{array}
\begin{array}{c}
0 \\
0
\end{array}
\]

8.84 divided by 3.4 is 2.6.

**Practice Problem** Divide 75.6 by 3.6.

---

**Use Proportions**

An equation that shows that two ratios are equivalent is a proportion. The ratios \(\frac{2}{4}\) and \(\frac{5}{10}\) are equivalent, so they can be written as \(\frac{2}{4} = \frac{5}{10}\). This equation is a proportion.

When two ratios form a proportion, the cross products are equal. To find the cross products in the proportion \(\frac{2}{4} = \frac{5}{10}\), multiply the 2 and the 10, and the 4 and the 5. Therefore \(2 \times 10 = 4 \times 5\), or \(20 = 20\).

Because you know that both proportions are equal, you can use cross products to find a missing term in a proportion. This is known as solving the proportion.

**Example** The heights of a tree and a pole are proportional to the lengths of their shadows. The tree casts a shadow of 24 m when a 6-m pole casts a shadow of 4 m. What is the height of the tree?

**Step 1** Write a proportion.

\[
\frac{\text{height of tree}}{\text{height of pole}} = \frac{\text{length of tree’s shadow}}{\text{length of pole’s shadow}}
\]

**Step 2** Substitute the known values into the proportion. Let \(h\) represent the unknown value, the height of the tree.

\[
\frac{h}{6} = \frac{24}{4}
\]

**Step 3** Find the cross products.

\[
h \times 4 = 6 \times 24
\]

**Step 4** Simplify the equation.

\[
4h = 144
\]

**Step 5** Divide each side by 4.

\[
\frac{4h}{4} = \frac{144}{4}
\]

\[
h = 36
\]

The height of the tree is 36 m.

**Practice Problem** The ratios of the weights of two objects on the Moon and on Earth are in proportion. A rock weighing 3 N on the Moon weighs 18 N on Earth. How much would a rock that weighs 5 N on the Moon weigh on Earth?
**Use Percentages**

The word *percent* means “out of one hundred.” It is a ratio that compares a number to 100. Suppose you read that 77 percent of the Earth’s surface is covered by water. That is the same as reading that the fraction of the Earth’s surface covered by water is \(\frac{77}{100}\). To express a fraction as a percent, first find the equivalent decimal for the fraction. Then, multiply the decimal by 100 and add the percent symbol.

**Example** Express \(\frac{13}{20}\) as a percent.

**Step 1** Find the equivalent decimal for the fraction.

\[
\begin{array}{c|c}
20 & 13.00 \\
\hline
12 & 100 \\
100 & \\
0 & \\
\end{array}
\]

**Step 2** Rewrite the fraction \(\frac{13}{20}\) as 0.65.

**Step 3** Multiply 0.65 by 100 and add the % sign.

\[0.65 \times 100 = 65 = 65\%\]

So, \(\frac{13}{20} = 65\%\).

This also can be solved as a proportion.

**Example** Express \(\frac{13}{20}\) as a percent.

**Step 1** Write a proportion.

\[
\frac{13}{20} = \frac{x}{100}
\]

**Step 2** Find the cross products.

\[1300 = 20x\]

**Step 3** Divide each side by 20.

\[
\frac{1300}{20} = \frac{20x}{20} = 65% = x
\]

**Practice Problem** In one year, 73 of 365 days were rainy in one city. What percent of the days in that city were rainy?

**Solve One-Step Equations**

A statement that two things are equal is an equation. For example, \(A = B\) is an equation that states that \(A\) is equal to \(B\).

An equation is solved when a variable is replaced with a value that makes both sides of the equation equal. To make both sides equal the inverse operation is used. Addition and subtraction are inverses, and multiplication and division are inverses.

**Example 1** Solve the equation \(x - 10 = 35\).

**Step 1** Find the solution by adding 10 to each side of the equation.

\[
x - 10 = 35
\]

\[
x - 10 + 10 = 35 + 10
\]

\[
x = 45
\]

**Step 2** Check the solution.

\[
x - 10 = 35
\]

\[
45 - 10 = 35
\]

\[
35 = 35
\]

Both sides of the equation are equal, so \(x = 45\).

**Example 2** In the formula \(a = bc\), find the value of \(c\) if \(a = 20\) and \(b = 2\).

**Step 1** Rearrange the formula so the unknown value is by itself on one side of the equation by dividing both sides by \(b\).

\[
\frac{a}{b} = c
\]

\[
\frac{20}{2} = c
\]

\[
10 = c
\]

**Step 2** Replace the variables \(a\) and \(b\) with the values that are given.

\[
\frac{a}{b} = c
\]

\[
\frac{20}{2} = c
\]

\[
10 = c
\]

**Step 3** Check the solution.

\[
\frac{a}{b} = c
\]

\[
\frac{20}{2} = 10\times 10
\]

\[
20 = 20
\]

Both sides of the equation are equal, so \(c = 10\) is the solution when \(a = 20\) and \(b = 2\).

**Practice Problem** In the formula \(h = gd\), find the value of \(d\) if \(g = 12.3\) and \(h = 17.4\).
Use Statistics

The branch of mathematics that deals with collecting, analyzing, and presenting data is statistics. In statistics, there are three common ways to summarize data with a single number—the mean, the median, and the mode.

The **mean** of a set of data is the arithmetic average. It is found by adding the numbers in the data set and dividing by the number of items in the set.

The **median** is the middle number in a set of data when the data are arranged in numerical order. If there were an even number of data points, the median would be the mean of the two middle numbers.

The **mode** of a set of data is the number or item that appears most often.

Another number that often is used to describe a set of data is the range. The **range** is the difference between the largest number and the smallest number in a set of data.

A **frequency table** shows how many times each piece of data occurs, usually in a survey. Table 2 below shows the results of a student survey on favorite color.

<table>
<thead>
<tr>
<th>Color</th>
<th>Tally</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>purple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yellow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the frequency table data, which color is the favorite?

**Example**  The speeds (in m/s) for a race car during five different time trials are 39, 37, 44, 36, and 44.

**To find the mean:**

**Step 1** Find the sum of the numbers.

\[ 39 + 37 + 44 + 36 + 44 = 200 \]

**Step 2** Divide the sum by the number of items, which is 5.

\[ 200 \div 5 = 40 \]

The mean is 40 m/s.

**To find the median:**

**Step 1** Arrange the measures from least to greatest.

36, 37, 39, 44, 44

**Step 2** Determine the middle measure.

36, 37, 39, 44, 44

The median is 39 m/s.

**To find the mode:**

**Step 1** Group the numbers that are the same together.

44, 44, 36, 37, 39

**Step 2** Determine the number that occurs most in the set.

44, 44, 36, 37, 39

The mode is 44 m/s.

**To find the range:**

**Step 1** Arrange the measures from largest to smallest.

44, 44, 39, 37, 36

**Step 2** Determine the largest and smallest measures in the set.

44, 44, 39, 37, 36

**Step 3** Find the difference between the largest and smallest measures.

\[ 44 - 36 = 8 \]

The range is 8 m/s.

**Practice Problem** Find the mean, median, mode, and range for the data set 8, 4, 12, 8, 11, 14, 16.
Use Geometry

The branch of mathematics that deals with the measurement, properties, and relationships of points, lines, angles, surfaces, and solids is called geometry.

Perimeter  The perimeter \( P \) is the distance around a geometric figure. To find the perimeter of a rectangle, add the length and width and multiply that sum by two, or \( 2(l + w) \). To find perimeters of irregular figures, add the length of the sides.

Example 1  Find the perimeter of a rectangle that is 3 m long and 5 m wide.

Step 1  You know that the perimeter is 2 times the sum of the width and length.
\[
P = 2(3 \text{ m} + 5 \text{ m})
\]
Step 2  Find the sum of the width and length.
\[
P = 2(8 \text{ m})
\]
Step 3  Multiply by 2.
\[
P = 16 \text{ m}
\]
The perimeter is 16 m.

Example 2  Find the perimeter of a shape with sides measuring 2 cm, 5 cm, 6 cm, 3 cm.

Step 1  You know that the perimeter is the sum of all the sides.
\[
P = 2 + 5 + 6 + 3
\]
Step 2  Find the sum of the sides.
\[
P = 2 + 5 + 6 + 3
\]
\[
P = 16
\]
The perimeter is 16 cm.

Practice Problem  Find the perimeter of a rectangle with a length of 18 m and a width of 7 m.

Practice Problem  Find the perimeter of a triangle measuring 1.6 cm by 2.4 cm by 2.4 cm.

Area of a Rectangle  The area \( A \) is the number of square units needed to cover a surface. To find the area of a rectangle, multiply the length times the width, or \( l \times w \). When finding area, the units also are multiplied. Area is given in square units.

Example  Find the area of a rectangle with a length of 1 cm and a width of 10 cm.

Step 1  You know that the area is the length multiplied by the width.
\[
A = (1 \text{ cm} \times 10 \text{ cm})
\]
Step 2  Multiply the length by the width. Also multiply the units.
\[
A = 10 \text{ cm}^2
\]
The area is 10 cm\(^2\).

Practice Problem  Find the area of a square whose sides measure 4 m.

Area of a Triangle  To find the area of a triangle, use the formula:

\[
A = \frac{1}{2}(\text{base} \times \text{height})
\]
The base of a triangle can be any of its sides. The height is the perpendicular distance from a base to the opposite endpoint, or vertex.

Example  Find the area of a triangle with a base of 18 m and a height of 7 m.

Step 1  You know that the area is \( \frac{1}{2} \) the base times the height.
\[
A = \frac{1}{2}(18 \text{ m} \times 7 \text{ m})
\]
Step 2  Multiply \( \frac{1}{2} \) by the product of 18 \( \times \) 7. Multiply the units.
\[
A = \frac{1}{2}(126 \text{ m}^2)
\]
\[
A = 63 \text{ m}^2
\]
The area is 63 m\(^2\).

Practice Problem  Find the area of a triangle with a base of 27 cm and a height of 17 cm.
**Circumference of a Circle** The diameter \((d)\) of a circle is the distance across the circle through its center, and the radius \((r)\) is the distance from the center to any point on the circle. The radius is half of the diameter. The distance around the circle is called the **circumference** \((C)\). The formula for finding the circumference is:

\[ C = 2\pi r \quad \text{or} \quad C = \pi d \]

The circumference divided by the diameter is always equal to 3.1415926... This nonterminating and nonrepeating number is represented by the Greek letter \(\pi\) (pi). An approximation often used for \(\pi\) is 3.14.

**Example 1** Find the circumference of a circle with a radius of 3 m.

**Step 1** You know the formula for the circumference is 2 times the radius times \(\pi\).

\[ C = 2\pi(3) \]

**Step 2** Multiply 2 times the radius.

\[ C = 6\pi \]

**Step 3** Multiply by \(\pi\).

\[ C = 19 \text{ m} \]

The circumference is 19 m.

**Example 2** Find the circumference of a circle with a diameter of 24.0 cm.

**Step 1** You know the formula for the circumference is the diameter times \(\pi\).

\[ C = \pi(24.0) \]

**Step 2** Multiply the diameter by \(\pi\).

\[ C = 75.4 \text{ cm} \]

The circumference is 75.4 cm.

**Practice Problem** Find the circumference of a circle with a radius of 19 cm.

**Area of a Circle** The formula for the area of a circle is:

\[ A = \pi r^2 \]

**Example 1** Find the area of a circle with a radius of 4.0 cm.

**Step 1** \[ A = \pi(4.0)^2 \]

**Step 2** Find the square of the radius.

\[ A = 16\pi \]

**Step 3** Multiply the square of the radius by \(\pi\).

\[ A = 50 \text{ cm}^2 \]

The area of the circle is 50 cm².

**Example 2** Find the area of a circle with a radius of 225 m.

**Step 1** \[ A = \pi(225)^2 \]

**Step 2** Find the square of the radius.

\[ A = 50625\pi \]

**Step 3** Multiply the square of the radius by \(\pi\).

\[ A = 158962.5 \]

The area of the circle is 158,962 m².

**Example 3** Find the area of a circle whose diameter is 20.0 mm.

**Step 1** You know the formula for the area of a circle is the square of the radius times \(\pi\), and that the radius is half of the diameter.

\[ A = \pi\left(\frac{20.0}{2}\right)^2 \]

**Step 2** Find the radius.

\[ A = \pi(10.0)^2 \]

**Step 3** Find the square of the radius.

\[ A = 100\pi \]

**Step 4** Multiply the square of the radius by \(\pi\).

\[ A = 314 \text{ mm}^2 \]

The area is 314 mm².

**Practice Problem** Find the area of a circle with a radius of 16 m.
**Volume** The measure of space occupied by a solid is the volume \((V)\). To find the volume of a rectangular solid multiply the length times width times height, or \(V = l \times w \times h\). It is measured in cubic units, such as cubic centimeters \((\text{cm}^3)\).

**Example** Find the volume of a rectangular solid with a length of 2.0 m, a width of 4.0 m, and a height of 3.0 m.

**Step 1** You know the formula for volume is the length times the width times the height.
\[ V = 2.0 \, \text{m} \times 4.0 \, \text{m} \times 3.0 \, \text{m} \]

**Step 2** Multiply the length times the width times the height.
\[ V = 24 \, \text{m}^3 \]

The volume is 24 m\(^3\).

**Practice Problem** Find the volume of a rectangular solid that is 8 m long, 4 m wide, and 4 m high.

To find the volume of other solids, multiply the area of the base times the height.

**Example 1** Find the volume of a solid that has a triangular base with a length of 8.0 m and a height of 7.0 m. The height of the entire solid is 15.0 m.

**Step 1** You know that the base is a triangle, and the area of a triangle is \(\frac{1}{2}\) the base times the height, and the volume is the area of the base times the height.
\[ V = \left(\frac{1}{2} (b \times h)\right) \times 15 \]

**Step 2** Find the area of the base.
\[ V = \left(\frac{1}{2} (8 \times 7)\right) \times 15 \]
\[ V = \left(\frac{1}{2} \times 56\right) \times 15 \]

**Step 3** Multiply the area of the base by the height of the solid.
\[ V = 28 \times 15 \]
\[ V = 420 \, \text{m}^3 \]

The volume is 420 m\(^3\).

**Example 2** Find the volume of a cylinder that has a base with a radius of 12.0 cm, and a height of 21.0 cm.

**Step 1** You know that the base is a circle, and the area of a circle is the square of the radius times \(\pi\), and the volume is the area of the base times the height.
\[ V = (\pi r^2) \times 21 \]
\[ V = (\pi (12^2)) \times 21 \]

**Step 2** Find the area of the base.
\[ V = 144\pi \times 21 \]
\[ V = 452 \times 21 \]

**Step 3** Multiply the area of the base by the height of the solid.
\[ V = 9490 \, \text{cm}^3 \]

The volume is 9490 cm\(^3\).

**Example 3** Find the volume of a cylinder that has a diameter of 15 mm and a height of 4.8 mm.

**Step 1** You know that the base is a circle with an area equal to the square of the radius times \(\pi\). The radius is one-half the diameter. The volume is the area of the base times the height.
\[ V = (\pi r^2) \times 4.8 \]
\[ V = \left[\pi \left(\frac{1}{2} \times 15\right)^2\right] \times 4.8 \]
\[ V = (\pi 7.5^2) \times 4.8 \]

**Step 2** Find the area of the base.
\[ V = 56.25\pi \times 4.8 \]
\[ V = 176.63 \times 4.8 \]

**Step 3** Multiply the area of the base by the height of the solid.
\[ V = 847.8 \]

The volume is 847.8 mm\(^3\).

**Practice Problem** Find the volume of a cylinder with a diameter of 7 cm in the base and a height of 16 cm.
Science Applications

Measure in SI

The metric system of measurement was developed in 1795. A modern form of the metric system, called the International System (SI), was adopted in 1960 and provides the standard measurements that all scientists around the world can understand.

The SI system is convenient because unit sizes vary by powers of 10. Prefixes are used to name units. Look at Table 3 for some common SI prefixes and their meanings.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilo-</td>
<td>k</td>
<td>1,000 thousand</td>
</tr>
<tr>
<td>hecto-</td>
<td>h</td>
<td>100 hundred</td>
</tr>
<tr>
<td>deka-</td>
<td>da</td>
<td>10 ten</td>
</tr>
<tr>
<td>deci-</td>
<td>d</td>
<td>0.1 tenth</td>
</tr>
<tr>
<td>centi-</td>
<td>c</td>
<td>0.01 hundredth</td>
</tr>
<tr>
<td>milli-</td>
<td>m</td>
<td>0.001 thousandth</td>
</tr>
</tbody>
</table>

Example  How many grams equal one kilogram?

Step 1 Find the prefix kilo in Table 3.

Step 2 Using Table 3, determine the meaning of kilo. According to the table, it means 1,000. When the prefix kilo is added to a unit, it means that there are 1,000 of the units in a "kilo unit."

Step 3 Apply the prefix to the units in the question. The units in the question are grams. There are 1,000 grams in a kilogram.

Practice Problem Is a milligram larger or smaller than a gram? How many of the smaller units equal one larger unit? What fraction of the larger unit does one smaller unit represent?

Dimensional Analysis

Convert SI Units  In science, quantities such as length, mass, and time sometimes are measured using different units. A process called dimensional analysis can be used to change one unit of measure to another. This process involves multiplying your starting quantity and units by one or more conversion factors. A conversion factor is a ratio equal to one and can be made from any two equal quantities with different units. If 1,000 mL equal 1 L then two ratios can be made.

\[
\frac{1,000 \text{ mL}}{1 \text{ L}} = \frac{1 \text{ L}}{1,000 \text{ mL}} = 1
\]

One can convert between units in the SI system by using the equivalents in Table 3 to make conversion factors.

Example 1 How many cm are in 4 m?

Step 1 Write conversion factors for the units given.

From Table 3, you know that 100 cm = 1 m. The conversion factors are

\[
\frac{100 \text{ cm}}{1 \text{ m}} \quad \text{and} \quad \frac{1 \text{ m}}{100 \text{ cm}}
\]

Step 2 Decide which conversion factor to use. Select the factor that has the units you are converting from (m) in the denominator and the units you are converting to (cm) in the numerator.

\[
\frac{100 \text{ cm}}{1 \text{ m}}
\]

Step 3 Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. There are 400 cm in 4 m.

\[
4 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 400 \text{ cm}
\]

Practice Problem How many milligrams are in one kilogram? (Hint: You will need to use two conversion factors from Table 3.)
Convert Between Unit Systems  Table 4

gives a list of equivalents that can be used to convert between English and SI units.

**Example**  If a meterstick has a length of 100 cm, how long is the meterstick in inches?

**Step 1**  Write the conversion factors for the units given. From Table 4, 1 in = 2.54 cm.

\[
\frac{1 \text{ in}}{2.54 \text{ cm}} \quad \text{and} \quad \frac{2.54 \text{ cm}}{1 \text{ in}}
\]

**Step 2**  Determine which conversion factor to use. You are converting from cm to in. Use the conversion factor with cm on the bottom.

\[
\frac{1 \text{ in}}{2.54 \text{ cm}}
\]

**Step 3**  Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. Round your answer based on the number of significant figures in the conversion factor.

\[
100 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 39.37 \text{ in}
\]

The meterstick is 39.4 in long.

**Practice Problem**  A book has a mass of 5 lbs. What is the mass of the book in kg?

**Practice Problem**  Use the equivalent for in and cm (1 in = 2.54 cm) to show how 1 in$^3$ = 16.39 cm$^3$. 
**Precision and Significant Digits**

When you make a measurement, the value you record depends on the precision of the measuring instrument. This precision is represented by the number of significant digits recorded in the measurement. When counting the number of significant digits, all digits are counted except zeros at the end of a number with no decimal point such as 2,050, and zeros at the beginning of a decimal such as 0.03020. When adding or subtracting numbers with different precision, round the answer to the smallest number of decimal places of any number in the sum or difference. When multiplying or dividing, the answer is rounded to the smallest number of significant digits of any number being multiplied or divided.

**Example** The lengths 5.28 and 5.2 are measured in meters. Find the sum of these lengths and record your answer using the correct number of significant digits.

**Step 1** Find the sum.

\[
\begin{array}{c}
5.28 \text{ m} \\
+ 5.2 \text{ m}
\end{array}
\]

2 digits after the decimal

1 digit after the decimal

\[
\begin{array}{c}
10.48 \text{ m}
\end{array}
\]

**Step 2** Round to one digit after the decimal because the least number of digits after the decimal of the numbers being added is 1.

The sum is 10.5 m.

**Practice Problem** How many significant digits are in the measurement 7,071,301 m? How many significant digits are in the measurement 0.003010 g?

**Practice Problem** Multiply 5.28 and 5.2 using the rule for multiplying and dividing. Record the answer using the correct number of significant digits.

**Scientific Notation**

Many times numbers used in science are very small or very large. Because these numbers are difficult to work with scientists use scientific notation. To write numbers in scientific notation, move the decimal point until only one non-zero digit remains on the left. Then count the number of places you moved the decimal point and use that number as a power of ten. For example, the average distance from the Sun to Mars is 227,800,000,000 m. In scientific notation, this distance is \(2.278 \times 10^{11}\) m. Because you moved the decimal point to the left, the number is a positive power of ten.

The mass of an electron is about 0.000 000 000 000 000 000 000 000 000 000 911 kg. Expressed in scientific notation, this mass is \(9.11 \times 10^{-31}\) kg. Because the decimal point was moved to the right, the number is a negative power of ten.

**Example** Earth is 149,600,000 km from the Sun. Express this in scientific notation.

**Step 1** Move the decimal point until one non-zero digit remains on the left.

1.496 000 00

**Step 2** Count the number of decimal places you have moved. In this case, eight.

**Step 3** Show that number as a power of ten, \(10^8\).

The Earth is \(1.496 \times 10^8\) km from the Sun.

**Practice Problem** How many significant digits are in 149,600,000 km? How many significant digits are in 1.496 \(10^8\) km?

**Practice Problem** Parts used in a high performance car must be measured to \(7 \times 10^{-6}\) m. Express this number as a decimal.

**Practice Problem** A CD is spinning at 539 revolutions per minute. Express this number in scientific notation.
Make and Use Graphs

Data in tables can be displayed in a graph—a visual representation of data. Common graph types include line graphs, bar graphs, and circle graphs.

**Line Graph** A line graph shows a relationship between two variables that change continuously. The independent variable is changed and is plotted on the x-axis. The dependent variable is observed, and is plotted on the y-axis.

**Example** Draw a line graph of the data below from a cyclist in a long-distance race.

**Step 1** Determine the x-axis and y-axis variables. Time varies independently of distance and is plotted on the x-axis. Distance is dependent on time and is plotted on the y-axis.

**Step 2** Determine the scale of each axis. The x-axis data ranges from 0 to 5. The y-axis data ranges from 0 to 40.

**Step 3** Using graph paper, draw and label the axes. Include units in the labels.

**Step 4** Draw a point at the intersection of the time value on the x-axis and corresponding distance value on the y-axis. Connect the points and label the graph with a title, as shown in Figure 20.

**Find a Slope** The slope of a straight line is the ratio of the vertical change, rise, to the horizontal change, run.

\[
\text{Slope} = \frac{\text{vertical change (rise)}}{\text{horizontal change (run)}} = \frac{\text{change in } y}{\text{change in } x}
\]

**Example** Find the slope of the graph in Figure 20.

**Step 1** You know that the slope is the change in y divided by the change in x.

\[
\text{Slope} = \frac{\text{change in } y}{\text{change in } x}
\]

**Step 2** Determine the data points you will be using. For a straight line, choose the two sets of points that are the farthest apart.

\[
\text{Slope} = \frac{40\text{ km}}{5\text{ hr}}
\]

**Step 3** Find the change in y and x.

\[
\text{Slope} = \frac{40\text{ km}}{5\text{ h}}
\]

**Step 4** Divide the change in y by the change in x.

\[
\text{Slope} = \frac{8\text{ km}}{\text{h}}
\]

The slope of the graph is 8 km/h.

---

**Table 5 Bicycle Race Data**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
</tbody>
</table>
Bar Graph To compare data that does not change continuously you might choose a bar graph. A bar graph uses bars to show the relationships between variables. The x-axis variable is divided into parts. The parts can be numbers such as years, or a category such as a type of animal. The y-axis is a number and increases continuously along the axis.

Example A recycling center collects 4.0 kg of aluminum on Monday, 1.0 kg on Wednesday, and 2.0 kg on Friday. Create a bar graph of this data.

Step 1 Select the x-axis and y-axis variables. The measured numbers (the masses of aluminum) should be placed on the y-axis. The variable divided into parts (collection days) is placed on the x-axis.

Step 2 Create a graph grid like you would for a line graph. Include labels and units.

Step 3 For each measured number, draw a vertical bar above the x-axis value up to the y-axis value. For the first data point, draw a vertical bar above Monday up to 4.0 kg.

Circle Graph To display data as parts of a whole, you might use a circle graph. A circle graph is a circle divided into sections that represent the relative size of each piece of data. The entire circle represents 100%, half represents 50%, and so on.

Example Air is made up of 78% nitrogen, 21% oxygen, and 1% other gases. Display the composition of air in a circle graph.

Step 1 Multiply each percent by 360° and divide by 100 to find the angle of each section in the circle.

\[
\begin{align*}
78\% & \times \frac{360^\circ}{100} = 280.8^\circ \\
21\% & \times \frac{360^\circ}{100} = 75.6^\circ \\
1\% & \times \frac{360^\circ}{100} = 3.6^\circ 
\end{align*}
\]

Step 2 Use a compass to draw a circle and to mark the center of the circle. Draw a straight line from the center to the edge of the circle.

Step 3 Use a protractor and the angles you calculated to divide the circle into parts. Place the center of the protractor over the center of the circle and line the base of the protractor over the straight line.

Practice Problem Draw a bar graph of the gases in air: 78% nitrogen, 21% oxygen, 1% other gases.

Practice Problem Draw a circle graph to represent the amount of aluminum collected during the week shown in the bar graph to the left.
## Topographic Map Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary highway, hard surface</td>
<td>Index contour</td>
</tr>
<tr>
<td>Secondary highway, hard surface</td>
<td>Supplementary contour</td>
</tr>
<tr>
<td>Light-duty road, hard or improved surface</td>
<td>Intermediate contour</td>
</tr>
<tr>
<td>Unimproved road</td>
<td>Depression contours</td>
</tr>
<tr>
<td>Railroad: single track</td>
<td></td>
</tr>
<tr>
<td>Railroad: multiple track</td>
<td>Boundaries: national</td>
</tr>
<tr>
<td>Railroads in juxtaposition</td>
<td>State</td>
</tr>
<tr>
<td>Buildings</td>
<td>County, parish, municipal</td>
</tr>
<tr>
<td>Schools, church, and cemetery</td>
<td>Civil township, precinct, town, barrio</td>
</tr>
<tr>
<td>Buildings (barn, warehouse, etc.)</td>
<td>Incorporated city, village, town, hamlet</td>
</tr>
<tr>
<td>Wells other than water (labeled as to type)</td>
<td>Reservation, national or state</td>
</tr>
<tr>
<td>Tanks: oil, water, etc. (labeled only if water)</td>
<td>Small park, cemetery, airport, etc.</td>
</tr>
<tr>
<td>Located or landmark object; windmill</td>
<td>Land grant</td>
</tr>
<tr>
<td>Open pit, mine, or quarry; prospect</td>
<td>Township or range line, U.S. land survey</td>
</tr>
<tr>
<td>Marsh (swamp)</td>
<td>Township or range line, approximate location</td>
</tr>
<tr>
<td>Wooded marsh</td>
<td>Perennial streams</td>
</tr>
<tr>
<td>Woods or brushwood</td>
<td>Elevated aqueduct</td>
</tr>
<tr>
<td>Vineyard</td>
<td>Water well and spring</td>
</tr>
<tr>
<td>Land subject to controlled inundation</td>
<td>Small rapids</td>
</tr>
<tr>
<td>Submerged marsh</td>
<td>Large rapids</td>
</tr>
<tr>
<td>Mangrove</td>
<td>Intermittent lake</td>
</tr>
<tr>
<td>Orchard</td>
<td>Intermittent stream</td>
</tr>
<tr>
<td>Scrub</td>
<td>Aqueduct tunnel</td>
</tr>
<tr>
<td>Urban area</td>
<td>Glacier</td>
</tr>
<tr>
<td>Spot elevation</td>
<td>Small falls</td>
</tr>
<tr>
<td>Water elevation</td>
<td>Large falls</td>
</tr>
<tr>
<td>Dry lake bed</td>
<td></td>
</tr>
</tbody>
</table>
### Reference Handbooks

#### Physical Science Reference Tables

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>meter</td>
<td>length</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
<td>mass</td>
</tr>
<tr>
<td>Pa</td>
<td>pascal</td>
<td>pressure</td>
</tr>
<tr>
<td>K</td>
<td>kelvin</td>
<td>temperature</td>
</tr>
<tr>
<td>mol</td>
<td>mole</td>
<td>amount of a substance</td>
</tr>
<tr>
<td>J</td>
<td>joule</td>
<td>energy, work, quantity of heat</td>
</tr>
<tr>
<td>s</td>
<td>second</td>
<td>time</td>
</tr>
<tr>
<td>C</td>
<td>coulomb</td>
<td>electric charge</td>
</tr>
<tr>
<td>V</td>
<td>volt</td>
<td>electric potential</td>
</tr>
<tr>
<td>A</td>
<td>ampere</td>
<td>electric current</td>
</tr>
<tr>
<td>Ω</td>
<td>ohm</td>
<td>resistance</td>
</tr>
</tbody>
</table>

#### Wavelengths of Light in a Vacuum

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>400</td>
</tr>
<tr>
<td>Blue</td>
<td>470</td>
</tr>
<tr>
<td>Green</td>
<td>530</td>
</tr>
<tr>
<td>Yellow</td>
<td>590</td>
</tr>
<tr>
<td>Orange</td>
<td>630</td>
</tr>
<tr>
<td>Red</td>
<td>700</td>
</tr>
</tbody>
</table>

#### Physical Constants and Conversion Factors

- **Acceleration due to gravity** \( g \): \( 9.8 \, \text{m/s}^2 \)
- **Avogadro’s Number** \( N_A \): \( 6.02 \times 10^{23} \) particles per mole
- **Electron charge** \( e \): \( 1.6 \times 10^{-19} \) C
- **Electron rest mass** \( m_e \): \( 9.11 \times 10^{-31} \) kg
- **Gravitation constant** \( G \): \( 6.67 \times 10^{-11} \) N m/kg²
- **Mass-energy relationship**: \( 1 \, \text{u (amu)} = 9.3 \times 10^{6} \) MeV
- **Speed of light in a vacuum** \( c \): \( 3.00 \times 10^8 \) m/s
- **Speed of sound at STP**: \( 331 \) m/s
- **Standard Pressure**: 1 atmosphere, 101.3 kPa, 760 mmHg, or 14.7 lb/in²

#### The Index of Refraction for Common Substances

<table>
<thead>
<tr>
<th>Substance</th>
<th>Index of Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1.00</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.36</td>
</tr>
<tr>
<td>Canada Balsam</td>
<td>1.53</td>
</tr>
<tr>
<td>Corn Oil</td>
<td>1.47</td>
</tr>
<tr>
<td>Diamond</td>
<td>2.42</td>
</tr>
<tr>
<td>Glass, Crown</td>
<td>1.52</td>
</tr>
<tr>
<td>Glass, Flint</td>
<td>1.61</td>
</tr>
<tr>
<td>Glycerol</td>
<td>1.47</td>
</tr>
<tr>
<td>Lucite</td>
<td>1.50</td>
</tr>
<tr>
<td>Quartz, Fused</td>
<td>1.46</td>
</tr>
<tr>
<td>Water</td>
<td>1.33</td>
</tr>
</tbody>
</table>

#### Heat Constants

<table>
<thead>
<tr>
<th>Substance</th>
<th>Specific Heat (kJ/kg °C) / (J/g °C)</th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
<th>Heat of Fusion (kJ/kg) (J/g)</th>
<th>Heat of Vaporization (kJ/kg) (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol (ethanol)</td>
<td>2.43 (liq.)</td>
<td>−117</td>
<td>79</td>
<td>109</td>
<td>855</td>
</tr>
<tr>
<td>Aluminium (solid)</td>
<td>0.90 (sol.)</td>
<td>660</td>
<td>2467</td>
<td>396</td>
<td>10500</td>
</tr>
<tr>
<td>Ammonia (liq.)</td>
<td>4.71 (liq.)</td>
<td>−78</td>
<td>−33</td>
<td>332</td>
<td>1370</td>
</tr>
<tr>
<td>Copper (solid)</td>
<td>0.39 (sol.)</td>
<td>1083</td>
<td>2567</td>
<td>205</td>
<td>4790</td>
</tr>
<tr>
<td>Iron (solid)</td>
<td>0.45 (sol.)</td>
<td>1535</td>
<td>2750</td>
<td>267</td>
<td>6290</td>
</tr>
<tr>
<td>Lead (solid)</td>
<td>0.13 (sol.)</td>
<td>328</td>
<td>1740</td>
<td>25</td>
<td>866</td>
</tr>
<tr>
<td>Mercury (liquid)</td>
<td>0.14 (liq.)</td>
<td>−39</td>
<td>357</td>
<td>11</td>
<td>295</td>
</tr>
<tr>
<td>Platinum (solid)</td>
<td>0.13 (sol.)</td>
<td>1772</td>
<td>3827</td>
<td>101</td>
<td>229</td>
</tr>
<tr>
<td>Silver (solid)</td>
<td>0.24 (sol.)</td>
<td>962</td>
<td>2212</td>
<td>105</td>
<td>2370</td>
</tr>
<tr>
<td>Tungsten (solid)</td>
<td>0.13 (sol.)</td>
<td>3410</td>
<td>5660</td>
<td>192</td>
<td>4350</td>
</tr>
<tr>
<td>Water (solid)</td>
<td>2.05 (sol.)</td>
<td>−100</td>
<td>−100</td>
<td>334</td>
<td>−</td>
</tr>
<tr>
<td>Water (liquid)</td>
<td>4.18 (liq.)</td>
<td>907</td>
<td>907</td>
<td>113</td>
<td>1770</td>
</tr>
<tr>
<td>Water (vapor)</td>
<td>2.01 (gas)</td>
<td>−100</td>
<td>−100</td>
<td>334</td>
<td>−</td>
</tr>
<tr>
<td>Zinc (solid)</td>
<td>0.39 (sol.)</td>
<td>420</td>
<td>907</td>
<td>113</td>
<td>1770</td>
</tr>
</tbody>
</table>
PERIODIC TABLE OF THE ELEMENTS

Columns of elements are called groups. Elements in the same group have similar chemical properties.

The first three symbols tell you the state of matter of the element at room temperature. The fourth symbol identifies elements that are not present in significant amounts on Earth. Useful amounts are made synthetically.

Rows of elements are called periods. Atomic number increases across a period.

The arrow shows where these elements would fit into the periodic table. They are moved to the bottom of the table to save space.

The number in parentheses is the mass number of the longest-lived isotope for that element.
The color of an element’s block tells you if the element is a metal, nonmetal, or metalloid.

* The names and symbols for elements 112 and 114 are temporary. Final names will be selected when the elements’ discoveries are verified.
Glossary/Glosario

Pronunciation Key

Use the following key to help you sound out words in the glossary.

<table>
<thead>
<tr>
<th>English</th>
<th>Español</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>abiótico</td>
</tr>
<tr>
<td>ay</td>
<td>características inertes y físicas del medio ambiente, incluyendo el aire, el agua, la luz solar, el suelo, la temperatura y el clima. (p. 122)</td>
</tr>
<tr>
<td>ah</td>
<td>abiótico</td>
</tr>
<tr>
<td>ow</td>
<td>características inertes y físicas del medio ambiente, incluyendo el aire, el agua, la luz solar, el suelo, la temperatura y el clima. (p. 122)</td>
</tr>
<tr>
<td>ar</td>
<td>edad absoluta</td>
</tr>
<tr>
<td>e</td>
<td>medida de la cantidad real de luz que genera una estrella. (p. 372)</td>
</tr>
<tr>
<td>ee</td>
<td>absorción</td>
</tr>
<tr>
<td>ih</td>
<td>proceso mediante el cual las moléculas de los alimentos pasan a través de las paredes de las vellosidades intestinales y entran al torrente sanguíneo. (p. 75)</td>
</tr>
<tr>
<td>oh</td>
<td>aceleración</td>
</tr>
<tr>
<td>aw</td>
<td>es igual al cambio de velocidad dividido por el tiempo que toma en realizarse dicho cambio; sucede cuando un objeto aumenta su velocidad, la disminuye o gira. (p. 528)</td>
</tr>
<tr>
<td>or</td>
<td>actínido</td>
</tr>
<tr>
<td>oy</td>
<td>la segunda serie de los elementos de transición interna que abarca desde el torio hasta el laurencio. (p. 450)</td>
</tr>
<tr>
<td>oo</td>
<td>metales alcalinos</td>
</tr>
<tr>
<td>ew</td>
<td>comida</td>
</tr>
<tr>
<td>yoo</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>yew</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>uh</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>u</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>sh</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>ch</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>g</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>j</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>ing</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>zh</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>k</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>s</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
<tr>
<td>z</td>
<td>elemento en el grupo 1 de la tabla periódica. (p. 441)</td>
</tr>
</tbody>
</table>

Cómo usar el glosario en español:
1. Busca el término en inglés que desees encontrar.
2. El término en español, junto con la definición, se encuentran en la columna de la derecha.
alkaline earth metals: elements in group 2 of the periodic table. (p. 442)
alleles (uh LEEL): an alternate form that a gene may have for a single trait; can be dominant or recessive. (p. 45)
alpha particle: consists of a particle containing two protons and two neutrons. (p. 417)
alternating current (AC): electric current that changes its direction repeatedly. (p. 678)
alveoli (al VEE uh li): in the lungs, the tiny, thin-walled sacs surrounded by capillaries where exchange of oxygen and carbon dioxide takes place. (p. 76)
amplitude: for a transverse wave, one half the distance between a crest and a trough. (p. 697)
apparent magnitude: measure of the amount of light from a star that is received on Earth. (p. 372)
arovoid: a piece of rock or metal made up of material similar to that which formed the planets; mostly found in the asteroid belt between the orbits of Mars and Jupiter. (p. 358)
aspheres (as THE nuh sfhr): plasticlike layer of Earth on which the lithospheric plates float and move around. (p. 190)
atmosphere: air surrounding Earth; is made up of gases, including 78 percent nitrogen, 21 percent oxygen, and 0.03 percent carbon dioxide. (p. 123)
atomic number: number of protons in the nucleus of an atom of a given element. (p. 415)
aurora: light display that occurs when charged particles trapped in the magnetosphere collide with Earth’s atmosphere above the poles. (p. 677)
average speed: equals the total distance traveled divided by the total time taken to travel the distance. (p. 525)
average: imaginary vertical line that cuts through the center of Earth and around which Earth spins. (p. 307)
balanced forces: two or more forces whose effects cancel each other out and do not change the motion of an object. (p. 551)
beta particle: a high-energy electron that comes from the nucleus. (p. 418)
big bang theory: states that about 13.7 billion years ago, the universe began with a huge, fiery explosion. (p. 391)
metals alkalinite: elements in the group 2 of the periodic table. (p. 442)
alleles: forma alterna que puede tener un gen para un solo rasgo; un alelo puede ser dominante o recesivo. (p. 45)
partícula alfa: partícula que contiene dos protones y dos neutrones. (p. 417)
corriente alterna (CA): corriente eléctrica que cambia de dirección repetidamente. (p. 678)
alvéolos: en los pulmones, los pequeños sacos de paredes delgadas rodeados por capilares en donde se realiza el intercambio de oxígeno y dióxido de carbono. (p. 76)
amplitud: para una onda transversal, es la mitad de la distancia entre la cresta y la depresión. (p. 697)
magnitud aparente: medida de la cantidad de luz recibida en la Tierra desde una estrella. (p. 372)
asteroide: pedazo de roca o metal formado de material similar al que forma los planetas; se encuentran principalmente en el cinturón de asteroides entre las órbitas de Marte y Júpiter. (p. 358)
astenosfera: capa flexible de la Tierra en la que las placas litoséricas flotan y se mueven de un lugar a otro. (p. 190)
atmosfera: aire que rodea a la Tierra; está compuesta de gases, incluyendo 78% de nitrógeno, 21% de oxígeno y 0.03% de dióxido de carbono. (p. 123)
número atómico: número de protones en el núcleo de un átomo de un elemento determinado. (p. 415)
aurora: despliegue de luz que se produce cuando partículas cargadas atrapadas en la magnetosfera chocan contra la atmósfera terrestre por encima de los polos. (p. 677)
velocidad promedio: es igual al total de la distancia recorrida dividida por el tiempo total necesario para recorrer dicha distancia. (p. 525)
eje: línea vertical imaginaria que atraviesa el centro de la Tierra y alrededor de la cual gira ésta. (p. 307)
fuerzas balanceadas: dos o más fuerzas cuyos efectos se cancelan mutuamente sin cambiar el movimiento de un objeto. (p. 551)
partícula beta: electrón de alta energía que proviene del núcleo. (p. 418)
teoría de la gran explosión: establece que hace aproximadamente 13.7 billones de años el universo se originó con una enorme explosión. (p. 391)
<table>
<thead>
<tr>
<th>English term</th>
<th>Spanish term</th>
</tr>
</thead>
<tbody>
<tr>
<td>biomes (Bl ohmz): large geographic areas with similar climates and ecosystems; includes tundra, taiga, desert, temperate deciduous forest, temperate rain forest, tropical rain forest, and grassland. (p. 154)</td>
<td>biomas: grandes áreas geográficas con climas y ecosistemas similares; incluyen la tundra, la taiga, el desierto, el bosque caducifolio templado, el bosque lluvioso templado, la selva húmeda tropical y los pastizales. (p. 154)</td>
</tr>
<tr>
<td>biosphere: part of Earth that supports life, including the top portion of Earth’s crust, the atmosphere, and all the water on Earth’s surface. (p. 93)</td>
<td>biosfera: capa de la Tierra que alberga la vida, incluyendo la porción superior de la corteza terrestre, la atmósfera y toda el agua de la superficie terrestre. (p. 93)</td>
</tr>
<tr>
<td>biotic (bi AH tihk): features of the environment that are alive or were once alive. (p. 122)</td>
<td>biótico: características del ambiente que tienen o alguna vez tuvieron vida. (p. 122)</td>
</tr>
<tr>
<td>black hole: final stage in the evolution of a very massive star, where the core’s mass collapses to a point that its gravity is so strong that not even light can escape. (p. 384)</td>
<td>agujero negro: etapa final en la evolución de una estrella masiva, en donde la masa del núcleo se colapsa hasta el punto de que su gravedad es tan fuerte que ni siquiera la luz puede escapar. (p. 384)</td>
</tr>
<tr>
<td>carbon cycle: model describing how carbon molecules move between the living and nonliving world. (p. 135)</td>
<td>ciclo del carbono: modelo que describe cómo se mueven las moléculas de carbono entre el mundo vivo y el mundo inerte. (p. 135)</td>
</tr>
<tr>
<td>carbon film: thin film of carbon residue preserved as a fossil. (p. 244)</td>
<td>película de carbono: capa delgada de residuos de carbono preservada como un fósil. (p. 244)</td>
</tr>
<tr>
<td>carrying capacity: largest number of individuals of a particular species that an ecosystem can support over time. (p. 101)</td>
<td>capacidad de carga: el mayor número de individuos de una especie en particular que un ecosistema puede albergar en un periodo de tiempo. (p. 101)</td>
</tr>
<tr>
<td>cast: a type of body fossil that forms when crystals fill a mold or sediments wash into a mold and harden into rock. (p. 245)</td>
<td>vaciado: tipo de cuerpo fósil que se forma cuando los cristales llenan un molde o los sedimentos son lavados hacia un molde y se endurecen convirtiéndose en roca. (p. 245)</td>
</tr>
<tr>
<td>catalyst: substance that speeds up a chemical reaction but is not used up itself or permanently changed. (pp. 449, 507)</td>
<td>catalizador: sustancia que acelera una reacción química pero que ella misma ni se agota ni sufre cambios permanentes. (pp. 449, 507)</td>
</tr>
<tr>
<td>cell: smallest functional unit of an organism. (p. 68)</td>
<td>célula: la unidad funcional más pequeña de un organismo. (p. 68)</td>
</tr>
<tr>
<td>cellular respiration: series of chemical processes in which oxygen combines with food molecules, energy is released, and carbon dioxide and water are given off as wastes. (p. 76)</td>
<td>respiración celular: serie de procesos químicos en los que el oxígeno se mezcla con las moléculas de los alimentos, se libera energía y el dióxido de carbono y el agua son desechados como residuos. (p. 76)</td>
</tr>
<tr>
<td>Cenozoic (sen uh ZOH ihk) Era: era of recent life that began about 66 million years ago and continues today; includes the first appearance of Homo sapiens about 400,000 years ago. (p. 292)</td>
<td>Era Cenozoica: era de vida reciente que comenzó hace aproximadamente 66 millones de años y continúa hasta hoy; incluye la aparición del Homo sapiens cerca de 400,000 años atrás. (p. 292)</td>
</tr>
<tr>
<td>center of mass: point in an object that moves as if all of the object’s mass were concentrated at that point. (p. 562)</td>
<td>centro de masa: punto en un objeto que se mueve como si toda la masa del objeto estuviera concentrada en ese punto. (p. 562)</td>
</tr>
<tr>
<td>chemical bond: force that holds two atoms together. (p. 471)</td>
<td>enlace químico: fuerza que mantiene a dos átomos unidos. (p. 471)</td>
</tr>
</tbody>
</table>
chemical equation: shorthand form for writing what reactants are used and what products are formed in a chemical reaction; sometimes shows whether energy is produced or absorbed. (p. 494)

chemical formula: combination of chemical symbols and numbers that indicates which elements and how many atoms of each element are present in a molecule. (p. 480)

chemical reaction: process that produces chemical change, resulting in new substances that have properties different from those of the original substances. (p. 492)

chemosynthesis (kee moh SIN thuh sus): process in which producers make energy-rich nutrient molecules from chemicals. (p. 137)

chromosphere: layer of the Sun’s atmosphere above the photosphere. (p. 375)

cinder cone volcano: relatively small volcano formed by moderate to explosive eruptions of tephra. (p. 222)

circuit: closed conducting loop in which electric current can flow continually. (p. 643)

climate: average weather conditions of an area over time, including wind, temperature, and rainfall or other types of precipitation such as snow or sleet. (p. 127)

climax community: stable, end stage of ecological succession in which balance is in the absence of disturbance. (p. 153)

comet: space object made of dust and rock particles mixed with frozen water, methane, and ammonia that forms a bright coma as it approaches the Sun. (p. 356)

commensalism: a type of symbiotic relationship in which one organism benefits and the other organism is not affected. (p. 108)

community: all the populations of different species that live in an ecosystem. (p. 96)

composite volcano: steep-sided volcano formed from alternating layers of violent eruptions of tephra and quieter eruptions of lava. (p. 223)

compound: pure substance that contains two or more elements. (p. 473)

compound machine: machine made up of a combination of two or more simple machines. (p. 591)

compressional wave: mechanical wave that causes particles in matter to move back and forth along the direction the wave travels. (p. 695)
Glossary/Glosario

**concentration/cyanobacteria**

- **concentration**: describes how much solute is present in a solution compared to the amount of solvent. (p. 505)
- **condensation**: process that takes place when a gas changes to a liquid. (p. 131)
- **conduction**: transfer of thermal energy by direct contact; occurs when energy is transferred by collisions between particles. (p. 613)
- **conductor**: material in which electrons can move easily (p. 612); material that transfers heat easily. (p. 640)
- **constant**: variable that stays the same during an experiment. (p. 21)
- **constellation**: group of stars that forms a pattern in the sky that looks like a familiar object (Libra), animal (Pegasus), or character (Orion). (p. 370)
- **consumer**: organism that cannot create energy-rich molecules but obtains its food by eating other organisms. (p. 107)
- **continental drift**: Wegener’s hypothesis that all continents were once connected in a single large landmass that broke apart about 200 million years ago and drifted slowly to their current positions. (p. 182)
- **control**: sample that is treated like other experimental groups except that the independent variable is not applied to it. (p. 22)
- **convection**: transfer of thermal energy by the movement of particles from one place to another in a gas or liquid. (p. 614)
- **convection current**: current in Earth’s mantle that transfers heat in Earth’s interior and is the driving force for plate tectonics. (p. 195)
- **coral reef**: diverse ecosystem formed from the calcium carbonate shells secreted by corals. (p. 167)
- **corona**: outermost, largest layer of the Sun’s atmosphere; extends millions of kilometers into space and has temperatures up to 2 million K. (p. 375)
- **covalent bond**: chemical bond formed when atoms share electrons. (p. 475)
- **cyanobacteria**: chlorophyll-containing, photosynthetic bacteria thought to be one of Earth’s earliest life-forms. (p. 281)

**concentración/cianobacteria**

- **concentración**: describe la cantidad de soluto presente en una solución en relación con la cantidad de solvente. (p. 505)
- **condensación**: proceso que tiene lugar cuando un gas cambia a estado líquido. (p. 131)
- **conducción**: transferencia de energía térmica por contacto directo; se produce cuando la energía se transfiere mediante colisiones entre las partículas. (p. 613)
- **conductor**: material en el cual los electrones se pueden mover fácilmente (p. 612); material que transfiere calor fácilmente. (p. 640)
- **constante**: variable que permanece igual durante un experimento. (p. 21)
- **constelación**: grupo de estrellas que forma un patrón en el cielo y que semeja un objeto (Libra), un animal (Pegaso) o un personaje familiar (Orión). (p. 370)
- **consumidor**: organismo que no puede fabricar moléculas ricas en energía por lo que debe obtener su alimento ingiriendo otros organismos. (p. 107)
- **deriva continental**: hipótesis de Wegener respecto a que todos los continentes estuvieron alguna vez conectados en una gran masa terrestre única que se fraccionó cerca de 200 millones de años atrás y sus trozos se han movilizado lentamente a la deriva hasta sus posiciones actuales. (p. 182)
- **control**: muestra que es tratada de igual manera que otro grupo de experimentos, con la excepción de que no se le aplica la variable independiente. (p. 22)
- **convección**: transferencia de energía térmica por el movimiento de partículas de un sitio a otro en un líquido o un gas. (p. 614)
- **corriente de convección**: corriente en el manto de la Tierra que transfiere calor en el interior de la Tierra y es la causa de la tectónica de placas. (p. 195)
- **arrecife de coral**: ecosistema diverso conformado de caparazones de carbonato de calcio secretados por los corales. (p. 167)
- **corona**: capa más externa y más grande de la atmósfera solar; se extiende millones de kilómetros dentro del espacio y tiene una temperatura hasta de 2 millones de grados Kelvin. (p. 375)
- **enlace covalente**: enlace químico que se forma cuando los átomos comparten electrones. (p. 475)
- **cianobacteria**: bacteria fotosintética que contiene clorofila; se cree que es una de las primeras formas de vida que surgió en la tierra. (p. 281)
dependent variable: factor that is being measured during an experiment. (p. 21)
descriptive research: answers scientific questions through observation. (p. 13)
desert: driest biome on Earth with less than 25 cm of rain each year; has dunes or thin soil with little organic matter, where plants and animals are adapted to survive extreme conditions. (p. 160)
diffraction: bending of waves around an object. (p. 700)
digestion: breakdown of foods into smaller and simpler molecules that can be used by the cells of the body. (p. 74)
direct current (DC): electric current that flows only in one direction. (p. 679)
dominant (DAH muh nunt): describes a trait that covers over, or dominates, another form of that trait. (p. 45)
earthquake: movement of the ground that occurs when rocks inside Earth pass their elastic limit, break suddenly, and experience elastic rebound. (p. 210)
ecology: study of the interactions that take place among organisms and their environment. (p. 95)
ecosystem: all the living organisms that live in an area and the nonliving features of their environment. (p. 95)
efficiency: equals the output work divided by the input work; expressed as a percentage. (p. 589)
electric current: the flow of electric charge, measured in amperes (A). (p. 643)
electric discharge: rapid movement of excess charge from one place to another. (p. 641)
electric field: surrounds every electric charge and exerts forces on other electric charges. (p. 639)
Earth: third planet from the Sun; has an atmosphere that protects life and surface temperatures that allow water to exist as a solid, liquid, and gas. (p. 344)
terremoto: movimiento del suelo que ocurre cuando las rocas del interior de la Tierra sobrepasan su límite de elasticidad, se rompen súbitamente y experimentan rebotes elásticos. (p. 210)
tierra: tercer planeta más cercano al sol; tiene una atmósfera que protege la vida y temperaturas en su superficie que permiten la presencia de agua en estado sólido, líquido y gaseoso. (p. 344)
etapa: estudio de las interacciones que se dan entre los organismos y su medio ambiente. (p. 95)
etapa: conjunto de organismos vivos que habitan en un área y las características de su medio ambiente. (p. 95)
eficiencia: equivale al trabajo aplicado dividido el trabajo generado y se expresa en porcentaje. (p. 589)
corriente eléctrica: flujo de carga eléctrica, el cual se mide en amperios (A). (p. 643)
descarga eléctrica: movimiento rápido de carga excesiva de un lugar a otro. (p. 641)
campo eléctrico: campo que rodea a todas las cargas eléctricas y que ejerce fuerzas sobre otras cargas eléctricas. (p. 639)
Glossary/Glosario

**electric force/epoch**

**electric force**: attractive or repulsive force exerted by all charged objects on each other. (p. 639)

**electric power**: rate at which electrical energy is converted into other forms of energy, measured in watts (W) or kilowatts (kW). (p. 652)

**electromagnet**: magnet created by wrapping a current-carrying wire around an iron core. (p. 673)

**electromagnetic spectrum**: complete range of electromagnetic wave frequencies and wavelengths. (p. 708)

**electromagnetic waves**: waves that can travel through matter or empty space, includes radio waves, infrared waves, visible light waves, ultraviolet waves, X rays, and gamma rays. (p. 707)

**electron**: negatively-charged particle that exists in an electron cloud formation around an atom's nucleus. (p. 407)

**electron cloud**: region surrounding the nucleus of an atom, where electrons are most likely to be found. (pp. 404, 473)

**electron dot diagram**: chemical symbol for an element, surrounded by as many dots as there are electrons in its outer energy level. (p. 470)

**element**: substance that cannot be broken down into simpler substances. (p. 405)

**ellipse (ee LIHPS)**: elongated, closed curve that describes Earth's yearlong orbit around the Sun. (p. 309)

**endothermic (en duh THUR mihk) reaction**: chemical reaction in which heat energy is absorbed. (p. 499)

**energy level**: the different positions for an electron in an atom. (p. 465)

**energy pyramid**: model that shows the amount of energy available at each feeding level in an ecosystem. (p. 139)

**enzyme (EN zime)**: a type of protein that regulates chemical reactions in cells without being changed or used up itself. (pp. 75, 508)

**eon**: longest subdivision in the geologic time scale that is based on the abundance of certain types of fossils and is subdivided into eras, periods, and epochs. (p. 273)

**epicenter**: point on Earth's surface directly above an earthquake's focus. (p. 212)

**epoch**: next-smaller division of geologic time after the period; is characterized by differences in life-forms that may vary regionally. (p. 273)
**equinox/fossils**

**equinox (EE kwuh nahks):** twice-yearly time—each spring and fall—when the Sun is directly over the equator and the number of daylight and nighttime hours are equal worldwide. (p. 311)

**era:** second-longest division of geologic time; is subdivided into periods and is based on major worldwide changes in types of fossils. (p. 273)

**estuary:** extremely fertile area where a river meets an ocean; contains a mixture of freshwater and saltwater and serves as a nursery for many species of fish. (p. 168)

**evaporation:** process that takes place when a liquid changes to a gas. (p. 130)

**evolution:** change in the genetics of a species over time. (p. 50)

**excretion:** in humans, the removal of waste products from the body through combined efforts of the circulatory, respiratory, and excretory systems. (p. 78)

**exothermic (ek soh THUR mihk) reaction:** chemical reaction in which heat energy is released. (p. 499)

**experimental research design:** used to answer scientific questions by testing a hypothesis through the use of a series of carefully controlled steps. (p. 13)

**extinction:** occurs when the last member of a species dies; causes a loss of diversity among living things. (p. 53)

---

**fault:** fracture that occurs when rocks break and that results in relative movement of opposing sides; can form as a result of compression (reverse fault), being pulled apart (normal fault), or shear (strike-slip fault). (p. 211)

**focus:** point deep inside Earth where energy is released, causing an earthquake. (p. 212)

**food web:** model that shows the complex feeding relationships among organisms in a community. (p. 138)

**force:** a push or a pull. (p. 550)

**fossils:** remains, imprints, or traces of prehistoric organisms that can tell when and where organisms once lived and how they lived. (p. 243)

---

**falla:** fractura que ocurre cuando al romperse una roca se presentan relativos movimientos de los lados opuestos; se pueden formar como resultado de una compresión (falla reversa), al separarse (falla normal) o al deslizarse (falla por desplazamiento). (p. 211)

**foco:** punto profundo de la Tierra donde se genera energía causando un terremoto. (p. 212)

**cadena alimenticia:** modelo que muestra las complejas relaciones alimenticias entre los organismos de una comunidad. (p. 138)

**fuera:** presión o tracción. (p. 550)

**fósiles:** restos, huellas o trazas de organismos prehistóricos que pueden informar cuándo, dónde y cómo vivieron tales organismos. (p. 243)
<table>
<thead>
<tr>
<th>English Term</th>
<th>Spanish Term</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>frecuencia</td>
<td>696</td>
</tr>
<tr>
<td>friction</td>
<td>fricción</td>
<td>552</td>
</tr>
<tr>
<td>full moon</td>
<td>luna llena</td>
<td>313</td>
</tr>
<tr>
<td>galaxy</td>
<td>galaxia</td>
<td>386</td>
</tr>
<tr>
<td>gene</td>
<td>gen</td>
<td>40</td>
</tr>
<tr>
<td>generator</td>
<td>generador</td>
<td>678</td>
</tr>
<tr>
<td>genetics</td>
<td>genética</td>
<td>44</td>
</tr>
<tr>
<td>genotype</td>
<td>genotipo</td>
<td>40</td>
</tr>
<tr>
<td>geologic time scale</td>
<td>escala del tiempo geológico</td>
<td>272</td>
</tr>
<tr>
<td>giant</td>
<td>gigante</td>
<td>383</td>
</tr>
<tr>
<td>grasslands</td>
<td>pastizales</td>
<td>161</td>
</tr>
<tr>
<td>Great Red Spot</td>
<td>La Gran Mancha Roja</td>
<td>348</td>
</tr>
<tr>
<td>group</td>
<td>grupo</td>
<td>435</td>
</tr>
<tr>
<td>habitat</td>
<td>hábitat</td>
<td>97</td>
</tr>
<tr>
<td>half-life</td>
<td>vida media</td>
<td>256, 420</td>
</tr>
</tbody>
</table>
halogen/intensity

halogen: any element in group 17 of the periodic table. (p. 446)
heat engine: device that converts thermal energy into mechanical energy. (p. 619)
heat: thermal energy transferred from a warmer object to a cooler object. (p. 612)
homeostasis: process by which the body maintains a stable internal environment. (p. 79)
hot spot: hot, molten rock material that has been forced upward from deep inside Earth, which may cause magma to break through Earth’s mantle and crust and may form volcanoes. (p. 228)
hypothesis (hi PAH thuh sus): prediction or statement that can be tested and may be formed by prior knowledge, any previous observations, and new information. (p. 21)

impact basin: a hollow left on the surface of the Moon caused by an object striking its surface. (p. 323)
inclined plane: simple machine that is a flat surface, sloped surface, or ramp. (p. 591)
independent variable: variable that can be changed during an experiment. (p. 21)
index fossils: remains of species that existed on Earth for a relatively short period of time, were abundant and widespread geographically, and can be used by geologists to assign the ages of rock layers. (p. 247)
inertia: tendency of an object to resist a change in its motion. (p. 533)
infrared waves: electromagnetic waves with wavelengths between about one thousandth of a meter and 700 billionths of a meter. (p. 709)
inhibitor: substance that slows down a chemical reaction, making the formation of a certain amount of product take longer. (p. 506)
input force: force exerted on a machine. (p. 586)
instantaneous speed: the speed of an object at one instant of time. (p. 525)
insulator: material in which electrons cannot move easily. (p. 640)
intensity: amount of energy a wave carries past a certain area each second. (p. 702)

halógenos/intensidad

halógenos: elementos en el grupo 17 de la tabla periódica. (p. 446)
motor de calor: motor que transforma la energía térmica en energía mecánica. (p. 619)
calor: energía térmica transferida de un objeto con más calor a uno con menos calor. (p. 612)
homeostasis: proceso mediante el cual el cuerpo mantiene un entorno interno estable. (p. 79)
punto caliente: material de roca fundida, caliente, que ha sido lanzado hacia arriba desde lo más profundo de la Tierra y que puede producir que el magma se rompa a través del manto y la corteza pudiendo formar volcanes. (p. 228)
hipótesis: predicción o enunciado que puede ser probado y que se formula con base a previos conocimientos, previas observaciones y nuevas informaciones. (p. 21)
cráter de impacto: un hueco dejado en la superficie de la luna causada por un objeto que chocó contra su superficie. (p. 323)
plano inclinado: máquina simple que consiste en una superficie plana, inclinada, o una rampa. (p. 591)
variable independiente: variable que se puede cambiar durante un experimento. (p. 21)
fósiles índice: restos de especies que existieron sobre la Tierra durante un periodo de tiempo relativamente corto y que fueron abundantes y ampliamente diseminadas geográficamente; los geólogos pueden usarlos para inferir las edades de las capas rocosas. (p. 247)
inercia: tendencia de un objeto a resistirse a un cambio de movimiento. (p. 533)
ondas infrarrojas: ondas electromagnéticas con longitudes de onda entre aproximadamente una milésima y 700 billionésimas de metro. (p. 709)
inhibidor: sustancia que reduce la velocidad de una reacción química, haciendo que la formación de una determinada cantidad de producto tarde más tiempo. (p. 506)
fuerza aplicada: fuerza que se ejerce sobre una máquina. (p. 586)
velocidad instantánea: la velocidad de un objeto en un instante de tiempo. (p. 525)
aislante: material en el cual los electrones no se pueden mover fácilmente. (p. 640)
intensidad: cantidad de energía que transporta una onda al pasar por un área determinada en un segundo. (p. 702)
internal combustion engine: heat engine in which fuel is burned in a combustion chamber inside the engine. (p. 620)

inter tidal zone: part of the shoreline that is under water at high tide and exposed to the air at low tide. (p. 168)

ion (I ahn): atom that is positively or negatively charged because it has gained or lost one or more electrons. (pp. 473, 636)

ionic bond: attraction that holds oppositely charged ions close together. (p. 473)

isotopes (I suh tohps): atoms of the same element that have different numbers of neutrons. (p. 415)

Jupiter: largest and fifth planet from the Sun; contains more mass than all the other planets combined, has continuous storms of high-pressure gas, and an atmosphere mostly of hydrogen and helium. (p. 348)

lava: molten rock flowing onto Earth’s surface. (p. 219)

law of conservation of momentum: states that the total momentum of objects that collide with each other is the same before and after the collision. (p. 535)

law of reflection: states that the angle the incoming wave makes with the normal to the reflecting surface equals the angle the reflected wave makes with the surface. (p. 699)

lever: simple machine consisting of a rigid rod or plank that pivots or rotates about a fixed point called the fulcrum. (p. 594)

light-year: unit representing the distance light travels in one year—about 9.5 trillion km—used to record distances between stars and galaxies. (p. 373)

limiting factor: anything that can restrict the size of a population, including living and nonliving features of an ecosystem, such as predators or drought. (p. 100)

motor de combustión interna: motor de calor en el cual el combustible es quemado en una cámara de combustión dentro del motor. (p. 620)

zona litoral: parte de la línea costera que está bajo el agua durante la marea alta y expuesta al aire durante la marea baja. (p. 168)

ion: átomo cargado positiva o negativamente debido a que ha ganado o perdido uno o más electrones. (pp. 473, 636)

enlace iónico: atracción que mantiene unidos a iones con cargas opuestas. (p. 473)

isótopos: átomos del mismo elemento que tienen diferente número de neutrones. (p. 415)

Júpiter: el quinto planeta más cercano al sol, y también el más grande; contiene más masa que todos los otros planetas en conjunto, tiene tormentas continuas de gas a alta presión y una atmósfera compuesta principalmente por hidrógeno y helio. (p. 348)

lantánidos: la primera serie de los elementos de transición interna que va desde el cerio hasta el lutecio. (p. 450)

lava: roca fundida que fluye en la superficie terrestre. (p. 219)

ley de conservación de momento: establece que el momento total de los objetos que chocan entre sí es el mismo antes y después de la colisión. (p. 535)

ley de reflexión: establece que el ángulo que forman la onda que llega y la normal hacia la superficie reflejante es igual al ángulo que la onda reflejada forma con la superficie. (p. 699)

pala nca: máquina simple que consiste en una barra rígida que puede girar sobre un punto fijo llamado punto de apoyo. (p. 594)

año luz: unidad que representa la distancia que la luz viaja en un año—cerca de 9.5 trillones de kilómetros—usada para registrar las distancias entre las estrellas y las galaxias. (p. 373)

factor limitante: cualquier factor que pueda restringir el tamaño de una población, incluyendo las características biológicas y no biológicas de un ecosistema, tales como los depredadores o las sequías. (p. 100)
**lithosphere (LIH thuh sfihr):** rigid layer of Earth about 100 km thick, made of the crust and a part of the upper mantle. (p. 190)

**lunar eclipse:** occurs when Earth’s shadow falls on the Moon. (p. 316)

**magnetic domain:** group of atoms whose fields point in the same direction. (p. 668)

**magnetic field:** surrounds a magnet and exerts a magnetic force on other magnets. (p. 667)

**magnetosphere:** region of space affected by Earth’s magnetic field. (p. 669)

**magnitude:** a measure of the energy released by an earthquake. (p. 213)

**maria (MAHR ee uh):** dark-colored, relatively flat regions of the Moon formed when ancient lava reached the surface and filled craters on the Moon’s surface. (p. 317)

**Mars:** fourth planet from the Sun; has polar ice caps, a thin atmosphere, and a reddish appearance caused by iron oxide in weathered rocks and soil. (p. 344)

**mass:** amount of matter in an object. (p. 533)

**mass number:** the sum of neutrons and protons in the nucleus of an atom. (p. 416)

**mechanical advantage:** number of times the input force is multiplied by a machine; equal to the output force divided by the input force. (p. 587)

**Mercury:** smallest planet, closest to the Sun; does not have a true atmosphere; has a surface with many craters and high cliffs. (p. 342)

**Mesozoic (mez uh ZOH ihk) Era:** middle era of Earth’s history, during which Pangea broke apart, dinosaurs appeared, and reptiles and gymnosperms were the dominant land life-forms. (p. 288)

**metal:** element that has luster, is malleable, ductile, and a good conductor of heat and electricity. (p. 438)

**metallic bond:** bond formed when metal atoms share their pooled electrons. (p. 474)

**metalloid (MET ul oyd):** element that shares some properties with both metals and nonmetals. (p. 438)

**meteor:** a meteoroid that burns up in Earth’s atmosphere. (p. 357)

**meteorite:** a meteoroid that strikes the surface of a moon or planet. (p. 358)

**dominio magnético:** grupo de átomos cuyos campos apuntan en la misma dirección. (p. 668)

**campo magnético:** campo que rodea a un imán y ejerce fuerza magnética sobre otros imanes. (p. 667)

**magnetosfera:** región del espacio afectada por el campo magnético de la Tierra. (p. 669)

**magnitud:** medida de la energía generada por un terremoto. (p. 213)

**mares:** regiones relativamente planas, de color oscuro, que se encuentran en la luna y que fueron formadas cuando la lava antigua alcanzó la superficie y llenó los cráteres sobre la superficie lunar. (p. 317)

**Marte:** cuarto planeta más cercano al sol; tiene casquetes de hielo polar, una atmósfera delgada y una apariencia rojiza causada por el óxido de hierro presente en las rocas y suelo de su superficie. (p. 344)

**masa:** cantidad de materia en un objeto. (p. 533)

**número de masa:** la suma de neutrones y protones en el núcleo de un átomo. (p. 416)

**ventaja mecánica:** número de veces que la fuerza aplicada es multiplicada por una máquina; equivale a la fuerza producida dividida por la fuerza aplicada. (p. 587)

**Mercurio:** el planeta más pequeño y más cercano al sol; no tiene una atmósfera verdadera; tiene una superficie con muchos cráteres y grandes acantilados. (p. 342)

**Era Mesozoica:** era media de la historia de la Tierra durante la cual se escindió la Pangea y aparecieron los dinosaurios; los reptiles y gimnospermas fueron las formas de vida que dominaron la tierra. (p. 288)

**metal:** elemento que tiene brillo, es maleable, dúctil y buen conductor de calor y electricidad. (p. 438)

**enlace metálico:** enlace que se forma cuando átomos metálicos comparten sus electrones agrupados. (p. 474)

**metaloide:** elemento que comparte algunas propiedades de los metales y de los no metales. (p. 438)

**meteorito:** un meteorito que se incinera en la atmósfera de la Tierra. (p. 357)

**meteorito:** un meteorito que choca contra la superficie de la luna o de algún planeta. (p. 358)
**glossary**

**mineral:** inorganic substance required in small amounts that is involved in many of the chemical reactions that occur in the body and is needed to promote good health and fight disease. (p. 65)

**model:** represents something that is too big, too small, too dangerous, too time consuming, or too expensive to observe directly. (p. 16)

**mold:** a type of body fossil that forms in rock when an organism with hard parts is buried, decays or dissolves, and leaves a cavity in the rock. (p. 245)

**molecule (MAH lih kewl):** neutral particle formed when atoms share electrons. (p. 475)

**momentum:** a measure of how difficult it is to stop a moving object; equals the product of mass and velocity. (p. 534)

**moon phase:** change in appearance of the Moon as viewed from the Earth, due to the relative positions of the Moon, Earth, and Sun. (p. 313)

**motor:** device that transforms electrical energy into kinetic energy. (p. 676)

**mutation:** process that changes DNA to form new alleles. (p. 52)

**mutualism:** a type of symbiotic relationship in which both organisms benefit. (p. 108)

**natural selection:** process by which organisms that are suited to a particular environment are better able to survive and reproduce than organisms that are not. (pp. 50, 275)

**nebula:** large cloud of gas and dust that contracts under gravitational force and breaks apart into smaller pieces, each of which might collapse to form a star. (p. 382)

**negative feedback:** mechanism that helps the body change an internal condition and return to its normal state. (p. 80)

**Neptune:** usually the eighth planet from the Sun; is large and gaseous, has rings that vary in thickness, and is bluish-green in color. (p. 352)

**net force:** combination of all forces acting on an object. (p. 551)

**neutron (NEW trahn):** electrically-neutral particle that has the same mass as a proton and is found in an atom’s nucleus. (p. 411)

**selección natural:** proceso mediante el cual los organismos que están adaptados a un ambiente particular están mejor capacitados para sobrevivir y reproducirse que los organismos que no están adaptados. (pp. 50, 275)

**nebulosa:** nube grande de polvo y gas que se contrae bajo la fuerza gravitacional y se descompone en pedazos más pequeños, cada uno de los cuales se puede colapsar para formar una estrella. (p. 382)

**retroalimentación negativa:** mecanismo que ayuda a que el organismo cambie una condición interna para volver a su estado normal. (p. 80)

**Neptuno:** el octavo planeta desde el sol; es grande y gaseoso, tiene anillos que varían en espesor y tiene un color verde-azulado. (p. 352)

**fuerza neta:** la combinación de todas las fuerzas que actúan sobre un objeto. (p. 551)

**neutrón:** partícula con carga eléctrica neutra que tiene la misma masa que un protón y que se encuentra en el núcleo de un átomo. (p. 411)
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>neutron star</td>
<td>Collapsed core of a supernova that can shrink to about 20 km in diameter and contains only neutrons in the dense core.</td>
<td>384</td>
</tr>
<tr>
<td>new moon</td>
<td>Moon phase that occurs when the Moon is between Earth and the Sun, at which point the Moon cannot be seen because its lighted half is facing the Sun and its dark side faces Earth.</td>
<td>313</td>
</tr>
<tr>
<td>Newton's first law of motion</td>
<td>States that if the net force acting on an object is zero, the object will remain at rest or move in a straight line with a constant speed.</td>
<td>552</td>
</tr>
<tr>
<td>Newton's second law of motion</td>
<td>States that an object acted upon by a net force will accelerate in the direction of the force, and that the acceleration equals the net force divided by the object's mass.</td>
<td>556</td>
</tr>
<tr>
<td>Newton's third law of motion</td>
<td>States that forces always act in equal but opposite pairs.</td>
<td>563</td>
</tr>
<tr>
<td>niche</td>
<td>In an ecosystem, refers to the unique ways an organism survives, obtains food and shelter, and avoids danger.</td>
<td>109</td>
</tr>
<tr>
<td>nitrogen cycle</td>
<td>Model describing how nitrogen moves from the atmosphere to the soil, to living organisms, and then back to the atmosphere.</td>
<td>132</td>
</tr>
<tr>
<td>nitrogen fixation</td>
<td>Process in which some types of bacteria in the soil change nitrogen gas into a form of nitrogen that plants can use.</td>
<td>132</td>
</tr>
<tr>
<td>noble gases</td>
<td>Elements in group 18 of the periodic table.</td>
<td>446</td>
</tr>
<tr>
<td>nonmetal</td>
<td>Element that is usually a gas or brittle solid at room temperature and is a poor conductor of heat and electricity.</td>
<td>438</td>
</tr>
<tr>
<td>Ohm's law</td>
<td>States that the current in a circuit equals the voltage divided by the resistance in the circuit.</td>
<td>649</td>
</tr>
<tr>
<td>organ</td>
<td>Structure, such as the heart, that is made up of several different types of tissues that work together.</td>
<td>70</td>
</tr>
<tr>
<td>organ system</td>
<td>Group of organs that are interdependent and work together to do a certain job.</td>
<td>71</td>
</tr>
<tr>
<td>estrella de neutrones</td>
<td>Núcleo colapsado de una supernova que puede contraerse hasta tener un diámetro de 20 kilómetros y contiene sólo neutrones en su denso núcleo.</td>
<td>384</td>
</tr>
<tr>
<td>luna nueva</td>
<td>Fase lunar que ocurre cuando la luna se encuentra entre la Tierra y el sol, punto en el cual la luna no puede verse porque su mitad iluminada está frente al sol y su lado oscuro frente a la Tierra.</td>
<td>313</td>
</tr>
<tr>
<td>primera ley de movimientode Newton</td>
<td>Establece que si la fuerza neta que actúa sobre un objeto es igual a cero, el objeto se mantendrá en reposo o se moverá en línea recta a una velocidad constante.</td>
<td>552</td>
</tr>
<tr>
<td>segunda ley de movimientode Newton</td>
<td>Establece que si una fuerza neta se ejerce sobre un objeto, éste se acelerará en la dirección de la fuerza y la aceleración es igual a la fuerza neta dividida por la masa del objeto.</td>
<td>556</td>
</tr>
<tr>
<td>tercera ley de movimientode Newton</td>
<td>Establece que las fuerzas siempre actúan en pares iguales pero opuestos.</td>
<td>563</td>
</tr>
<tr>
<td>nicho</td>
<td>En un ecosistema, se refiere a las formas únicas en las que un organismo sobrevive, obtiene alimento, refugio y evita el peligro.</td>
<td>109</td>
</tr>
<tr>
<td>ciclo del nitrógeno</td>
<td>Modelo que describe cómo se mueve el nitrógeno de la atmósfera al suelo, a los organismos vivos y de nuevo a la atmósfera.</td>
<td>132</td>
</tr>
<tr>
<td>fijación del nitrógeno</td>
<td>Proceso en el cual algunos tipos de bacterias en el suelo transforman el nitrógeno gaseoso en una forma de nitrógeno que las plantas pueden usar.</td>
<td>132</td>
</tr>
<tr>
<td>gases inertos</td>
<td>Elementos en el grupo 18 de la tabla periódica.</td>
<td>446</td>
</tr>
<tr>
<td>no metal</td>
<td>Elemento que por lo general es un gas o un sólido frágil a temperatura ambiente y mal conductor de calor y electricidad.</td>
<td>438</td>
</tr>
</tbody>
</table>
### Organic Compounds

**organic compounds**: most compounds that contain carbon, including nucleic acids, proteins, carbohydrates, and lipids. (p. 66)

**organic evolution**: change of organisms over geologic time. (p. 274)

**output force**: force exerted by a machine. (p. 586)

### Paleozoic Era

**Paleozoic Era**: era of ancient life, which began about 544 million years ago, when organisms developed hard parts, and ended with mass extinctions about 245 million years ago. (p. 282)

**Pangaea (pan JEE uh)**: large, ancient landmass that was composed of all the continents joined together. (pp. 182, 279)

**parallel circuit**: circuit that has more than one path for electric current to follow. (p. 651)

**parasitism**: a type of symbiotic relationship in which one organism benefits and the other organism is harmed. (p. 108)

**period**: horizontal row of elements in the periodic table whose properties change gradually and predictably (p. 273); third-longest division of geologic time; is subdivided into epochs and is characterized by the types of life that existed worldwide. (p. 435)

**permineralized remains**: fossils in which the spaces inside are filled with minerals from groundwater. (p. 244)

**phenotype (FEE nuh tipe)**: observable product of genetic makeup and the environment's influences on that genetic makeup. (p. 40)

**photosphere**: lowest layer of the Sun’s atmosphere; gives off light and has temperatures of about 6,000 K. (p. 375)

**pioneer species**: first organisms to grow in new or disturbed areas. (p. 150)

**pitch**: human perception of the frequency of sound. (p. 703)

**plate**: a large section of Earth’s oceanic or continental crust and rigid upper mantle that moves around on the asthenosphere. (p. 190)

**plate tectonics**: theory that Earth’s crust and upper mantle are broken into plates that float and move around on a plasticlike layer of the mantle. (p. 190)

### Compuestos Orgánicos

**compuestos orgánicos**: la mayoría de los compuestos que contienen carbono, incluyendo los ácidos nucleicos, las proteínas, los carbohidratos y los lípidos. (p. 66)

**evolución orgánica**: cambio de los organismos a través del tiempo geológico. (p. 274)

**fuerza generada**: fuerza producida por una máquina. (p. 586)

### Palaeozoic Era

**Palaeozoic Era**: era de la vida antigua que comenzó hace 544 millones de años, cuando los organismos desarrollaron partes duras; terminó con extinciones en masa hace unos 245 millones de años. (p. 282)

**Pangea**: masa terrestre extensa y antigua que estaba compuesta por todos los continentes unidos. (pp. 182, 279)

**circuito paralelo**: circuito en el cual la corriente eléctrica puede seguir más de una trayectoria. (p. 651)

**parasitismo**: tipo de relación simbiótica en la que un organismo se beneficia y el otro es perjudicado. (p. 108)

**período**: fila horizontal de elementos en la tabla periódica cuyas propiedades cambian gradualmente y en forma predecible (p. 273); la tercera división más grande del tiempo geológico; está subdividido en épocas y se caracteriza por los tipos de vida que existieron en todo el mundo. (p. 435)

**restos permineralizados**: fósiles en los que los espacios interiores son llenados con minerales de aguas subterráneas. (p. 244)

**fenotipo**: producto de la composición genética que puede ser observado, así como la influencia del medio ambiente ejercida sobre dicha composición genética. (p. 40)

**fotosfera**: capa más interna de la atmósfera del sol; emite luz y tiene temperaturas de cerca de 6,000 grados Kelvin. (p. 375)

**especies pioneras**: primeros organismos que crecen en áreas nuevas o alteradas. (p. 150)

**tono**: percepción humana de la frecuencia del sonido. (p. 703)

**placa**: gran sección de la corteza terrestre u oceanica y del manto rígido superior que se mueve sobre la astenosfera. (p. 190)

**tectónica de placas**: teoría respecto a que la corteza terrestre y el manto superior están fraccionados en placas que flotan y se mueven sobre una capa plástica del manto. (p. 190)
<table>
<thead>
<tr>
<th>English Term</th>
<th>Spanish Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pluto: dwarf planet; has a solid icy-rock surface and three moons. (p. 353)</td>
<td>Plutón: planeta enano; tiene una superficie sólida de roca congelada y tres lunas. (p. 353)</td>
</tr>
<tr>
<td>polar bond: bond resulting from the unequal sharing of electrons. (p. 476)</td>
<td>enlace polar: enlace que resulta de compartir electrones en forma desigual. (p. 476)</td>
</tr>
<tr>
<td>population: all the organisms that belong to the same species living in a community. (p. 96)</td>
<td>población: todos los organismos que pertenecen a la misma especie dentro de una comunidad. (p. 96)</td>
</tr>
<tr>
<td>power: rate at which work is done; equal to the work done divided by the time it takes to do the work; measured in watts (W). (p. 583)</td>
<td>potencia: velocidad a la que se realiza un trabajo y que equivale al trabajo realizado dividido por el tiempo que toma realizar el trabajo; se mide en vatios (W). (p. 583)</td>
</tr>
<tr>
<td>Precambrian (pree KAM bree un) time: longest part of Earth's history, lasting from 4.0 billion to about 544 million years ago. (p. 280)</td>
<td>tiempo precámbrico: la parte más duradera de la historia de la Tierra; duró desde hace 4.0 billones de años hasta hace aproximadamente 544 millones de años. (p. 280)</td>
</tr>
<tr>
<td>principle of superposition: states that in undisturbed rock layers, the oldest rocks are on the bottom and the rocks become progressively younger toward the top. (p. 250)</td>
<td>principio de superposición: establece que en las capas rocosas no perturbadas, las rocas más antiguas están en la parte inferior y las rocas son más jóvenes conforme están más cerca de la superficie. (p. 250)</td>
</tr>
<tr>
<td>producer: organism, such as a green plant or alga, that uses an outside source of energy like the Sun to create energy-rich food molecules. (p. 106)</td>
<td>productor: organismo, como una planta o un alga verde, que utiliza una fuente externa de energía, como la luz solar, para producir moléculas de nutrientes ricas en energía. (p. 106)</td>
</tr>
<tr>
<td>product: substance that forms as a result of a chemical reaction. (p. 494)</td>
<td>producto: sustancia que se forma como resultado de una reacción química. (p. 494)</td>
</tr>
<tr>
<td>proton: positively-charged particle in the nucleus of an atom. (p. 410)</td>
<td>protón: partícula cargada positivamente en el núcleo de un átomo. (p. 410)</td>
</tr>
<tr>
<td>pulley: simple machine made from a grooved wheel with a rope or cable wrapped around the groove. (p. 596)</td>
<td>polea: máquina simple que consiste en una rueda acanalada con una cuerda o cable que corre alrededor del canal. (p. 596)</td>
</tr>
<tr>
<td>Punnett square: tool used to predict the probability of certain traits in offspring that shows the different ways alleles can combine. (p. 47)</td>
<td>cuadrado de Punnett: herramienta utilizada para predecir la probabilidad de ciertos rasgos en la descendencia y que muestra las diferentes formas en que pueden combinarse los alelos. (p. 47)</td>
</tr>
<tr>
<td>radiation: transfer of energy by electromagnetic waves. (p. 613)</td>
<td>radiación: transferencia de energía mediante ondas electromagnéticas. (p. 613)</td>
</tr>
<tr>
<td>radioactive decay: release of nuclear particles and energy from unstable atomic nuclei. (pp. 257, 416)</td>
<td>descomposición radioactiva: liberación de partículas nucleares y energía de un núcleo atómico inestable. (pp. 257, 416)</td>
</tr>
<tr>
<td>radiometric dating: process used to calculate the absolute age of rock by measuring the ratio of parent isotope to daughter product in a mineral and knowing the half-life of the parent. (p. 259)</td>
<td>fechado radiométrico: proceso utilizado para calcular la edad absoluta de las rocas midiendo la relación isótopo parental a producto derivado en un mineral y conociendo la vida media del parental. (p. 259)</td>
</tr>
<tr>
<td>rate of reaction: measure of how fast a chemical reaction occurs. (p. 504)</td>
<td>velocidad de reacción: medida de la rapidez con que se produce una reacción química. (p. 504)</td>
</tr>
<tr>
<td>reactant: substance that exists before a chemical reaction begins. (p. 494)</td>
<td>reactivo: sustancia que existe antes de que comience una reacción química. (p. 494)</td>
</tr>
</tbody>
</table>
Glossary/Glosario

recessive/seismic waves

recessive (rih SE sihv): describes a trait that is covered over, or dominated, by another form of that trait. (p. 45)

refraction: change in direction of a wave when it changes speed as it travels from one material into another. (p. 699)

relative age: the age of something compared with other things. (p. 251)

representative elements: elements in groups 1 and 2 and 13–18 in the periodic table that include metals, metalloids, and nonmetals. (p. 435)

resistance: a measure of how difficult it is for electrons to flow in a material; unit is the ohm (Ω). (p. 646)

reverberation: repeated echoes of sound waves. (p. 705)

revolution: Earth’s yearlong elliptical orbit around the Sun. (p. 309)

rift: long crack, fissure, or trough that forms between tectonic plates moving apart at plate boundaries. (p. 227)

rotation: spinning of Earth on its imaginary axis, which takes about 24 hours to complete and causes day and night to occur. (p. 307)

Saturn: second-largest and sixth planet from the Sun; has a complex ring system, at least 31 moons, and a thick atmosphere made mostly of hydrogen and helium. (p. 350)

science: process used to investigate what is happening around us in order to solve problems or answer questions; part of everyday life. (p. 6)

scientific methods: ways to solve problems that can include step-by-step plans, making models, and carefully thought-out experiments. (p. 13)

screw: simple machine that is an inclined plane wrapped around a cylinder or post. (p. 593)

seafloor spreading: Hess’s theory that new seafloor is formed when magma is forced upward toward the surface at a mid-ocean ridge. (p. 187)

seismic safe: describes the ability of structures to stand up against the vibrations caused by an earthquake. (p. 217)

seismic waves: earthquake waves, including primary waves, secondary waves, and surface waves. (p. 212)

Saturno: además de ser el sexto planeta más cercano al sol, también es el segundo en tamaño; tiene un sistema de anillos complejo, por lo menos 31 lunas y una atmósfera gruesa compuesta principalmente de hidrógeno y helio. (p. 350)

ciencia: proceso usado para investigar lo que sucede a nuestro alrededor con el fin de solucionar problemas o despejar dudas como parte de la vida diaria. (p. 6)

métodos científicos: formas de solucionar problemas, las cuales pueden incluir planes paso a paso, creación de modelos y elaboración cuidadosa de experimentos. (p. 13)

tornillo: máquina simple que consiste en un plano inclinado envuelto en espiral alrededor de un cilindro o poste. (p. 593)

expansión del suelo oceánico: teoría de Hess respecto a que se forma un nuevo suelo oceánico cuando el magma es empujado hacia la superficie a través de un surco en la mitad del océano. (p. 187)

seguridad antisuismic: describe la capacidad de las estructuras de resistir las vibraciones producidas por los terremotos. (p. 217)

ondas sísmicas: ondas producidas durante los terremotos, las cuales pu ser primarias, secundarias y superfluences. (p. 212)
seismograph/supergiant

seismograph: instrument used to record seismic waves. (p. 213)
semiconductor: element that does not conduct electricity as well as a metal but conducts it better than a nonmetal. (p. 443)
series circuit: circuit that has only one path for electric current to follow. (p. 650)
shield volcano: large, broad volcano with gently sloping sides that is formed by the buildup of basaltic layers. (p. 222)
simple machine: a machine that does work with only one movement; includes the inclined plane, wedge, screw, lever, wheel and axle, and pulley. (p. 591)
soil: mixture of mineral and rock particles, the remains of dead organisms, air, and water that forms the topmost layer of Earth's crust and supports plant growth. (p. 124)
solar eclipse: occurs when the Moon passes directly between the Sun and Earth and casts a shadow over part of Earth. (p. 315)
solar system: system of nine planets, including Earth, and other objects that revolve around the Sun. (p. 337)
solstice: twice-yearly point at which the Sun reaches its greatest distance north or south of the equator. (p. 310)
species: group of organisms that reproduces only with other members of their own group. (p. 274)
specific heat: amount of heat needed to raise the temperature of 1 kg of a substance by 1°C. (p. 616)
speed: equals the distance traveled divided by the time it takes to travel that distance. (p. 524)
sphere (SFIHR): a round, three-dimensional object whose surface is the same distance from its center at all points; Earth is a sphere that bulges somewhat at the equator and is slightly flattened at the poles. (p. 306)
static charge: imbalance of electric charge on an object. (p. 637)
succession: natural, gradual changes in the types of species that live in an area; can be primary or secondary. (p. 150)
sunspots: areas on the Sun's surface that are cooler and less bright than surrounding areas, are caused by the Sun's magnetic field, and occur in cycles. (p. 376)
supergiant: late stage in the life cycle of a massive star in which the core heats up, heavy elements form by fusion, and the star expands; can eventually explode to form a supernova. (p. 385)

sismógrafo/supergigante

sismógrafo: instrumento usado para registrar las ondas sísmicas. (p. 213)
semiconductor: elemento que no conduce electricidad tan bien como un metal pero que la conduce mejor que un no metal. (p. 443)
circuito en serie: circuito en el cual la corriente eléctrica sólo puede seguir una trayectoria. (p. 650)
volcán escudo: volcán grande y ancho con lados ligeramente inclinados que se forma por la aparición de capas basálticas. (p. 222)
máquina simple: máquina que ejecuta el trabajo con un solo movimiento; incluye el plano inclinado, la palanca, el tornillo, la rueda y el eje y la polea. (p. 591)
suelo: mezcla de partículas minerales y rocas, restos de organismos muertos, aire y del agua que forma la capa superior de la corteza terrestre y favorece el crecimiento de las plantas. (p. 124)
eclipse solar: ocurre cuando la luna pasa directamente entre el sol y la Tierra y se genera una sombra sobre una parte de la Tierra. (p. 315)
sistema solar: sistema de nueve planetas, incluyendo a la Tierra y otros objetos que giran alrededor del sol. (p. 337)
solsticio: punto en el cual dos veces al año el sol alcanza su mayor distancia al norte o al sur del ecuador. (p. 310)
especie: grupo de organismos que se reproduce sólo entre los miembros de su mismo grupo. (p. 274)
calor específico: cantidad de calor necesario para elevar la temperatura de 1 kilogramo de una sustancia en 1 grado centígrado. (p. 616)
rapidez: equivale a dividir la distancia recorrida por el tiempo que toma recorrer dicha distancia. (p. 524)
esfera: un objeto tridimensional y redondo donde cualquier punto de su superficie está a la misma distancia del centro; la Tierra es una esfera algo abultada en el ecuador y ligeramente achatada en los polos. (p. 306)
carga estática: desequilibrio de la carga eléctrica en un objeto. (p. 637)
sucesión: cambios graduales y naturales en los tipos de especies que viven en un área; puede ser primaria o secundaria. (p. 150)
manchas solares: áreas en la superficie solar que son más frías y menos brillantes que las áreas circun- dantes, son causadas por el campo magnético solar y ocurren en ciclos. (p. 376)
supergigante: etapa tardía en el ciclo de vida de una estrella masiva en la que el núcleo se calienta, se forma elementos pesados por fusión y la estrella se expande; eventualmente puede explotar para formar una supernova. (p. 385)
**symbiosis**: any close relationship between species, including mutualism, commensalism, and parasitism. (p. 108)

**taiga (Ti guh)**: world’s largest biome, located south of the tundra between 50°N and 60°N latitude; has long, cold winters, precipitation between 35 cm and 100 cm each year, cone-bearing evergreen trees, and dense forests. (p. 156)

**technology**: application of science to make useful products and tools, such as computers. (p. 9)

**temperate deciduous forest**: biome usually having four distinct seasons, annual precipitation between 75 cm and 150 cm, and climax communities of deciduous trees. (p. 157)

**temperate rain forest**: biome with 200 cm to 400 cm of precipitation each year, average temperatures between 9°C and 12°C, and forests dominated by trees with needlelike leaves. (p. 157)

**temperature**: a measure of the average value of the kinetic energy of the particles in a material. (p. 608)

**thermodynamic energy**: the sum of the kinetic and potential energy of the particles in a material. (p. 611)

**thermal pollution**: increase in temperature of a natural body of water; caused by adding warmer water. (p. 617)

**tissue**: group of similar cells, such as nerve cells, that work together to do a job. (p. 70)

**trait**: feature that an organism inherits from its parents, such as eye color, that is coded for by DNA. (p. 39)

**transformer**: device used to increase or decrease the voltage of an alternating current. (p. 680)

**transition elements**: elements in groups 3–12 in the periodic table, all of which are metals. (p. 435)

**transmutation**: the change of one element into another through radioactive decay. (p. 416)

**transverse wave**: mechanical wave that causes particles in matter to move at right angles to the direction the wave travels. (p. 695)

**trilobite (TRI luh bite)**: organism with a three-lobed exoskeleton that was abundant in Paleozoic oceans and is considered to be an index fossil. (p. 273)
tropical rain forest: most biologically diverse biome; has an average temperature of 25°C and receives between 200 cm and 600 cm of precipitation each year. (p. 158)

tsunami: powerful seismic sea wave that begins over an ocean-floor earthquake, can reach 30 m in height when approaching land, and can cause destruction in coastal areas. (p. 215)

tundra: cold, dry, treeless biome with less than 25 cm of precipitation each year, a short growing season, permafrost, and winters that can be six to nine months long. Tundra is separated into two types: arctic tundra and alpine tundra. (p. 155)

ultraviolet waves: electromagnetic waves with wavelengths between about 400 billionths and 10 billionths of a meter. (p. 710)

unbalanced forces: two or more forces acting on an object that do not cancel, and cause the object to accelerate. (p. 551)

unconformity (un kun FOR mih tee): gap in the rock layer that is due to erosion or periods without any deposition. (p. 252)

uniformitarianism: principle stating that Earth processes occurring today are similar to those that occurred in the past. (p. 261)

Uranus (YOOR uh nus): seventh planet from the Sun; is large and gaseous, has a distinct bluish-green color, and rotates on an axis nearly parallel to the plane of its orbit. (p. 351)

velocity: speed and direction of a moving object. (p. 527)

Venus: second planet from the Sun; similar to Earth in mass and size; has a thick atmosphere and a surface with craters, faultlike cracks, and volcanoes. (p. 343)

villi: tiny fingerlike projections that line the small intestine, contain many blood vessels, and increase the intestine’s surface area where food molecules are absorbed. (p. 75)
volcano/work

**volcano:** cone-shaped hill or mountain formed when hot magma, solids, and gas erupt onto Earth’s surface through a vent. (p. 219)

**voltage:** a measure of the amount of electrical potential energy an electron flowing in a circuit can gain; measured in volts (V). (p. 644)

waving: describes phases that occur after a full moon, as the visible lighted side of the Moon grows smaller. (p. 314)

**water cycle:** model describing how water moves from Earth’s surface to the atmosphere and back to the surface again through evaporation, condensation, and precipitation. (p. 131)

**wave:** disturbance that moves through matter and space and carries energy. (p. 694)

**wavelength:** distance between one point on a wave and the nearest point moving with the same speed and direction. (p. 696)

**waxing:** describes phases following a new moon, as more of the Moon’s lighted side becomes visible. (p. 314)

**wedge:** simple machine consisting of an inclined plane that moves; can have one or two sloping sides. (p. 592)

weight: gravitational force between an object and Earth. (p. 557)

**wetland:** a land region that is wet most or all of the year. (p. 165)

**wheel and axle:** simple machine made from two circular objects of different sizes that are attached and rotate together. (p. 594)

**white dwarf:** late stage in the life cycle of a comparatively low-mass main sequence star; formed when its core depletes its helium and its outer layers escape into space, leaving behind a hot, dense core. (p. 384)

**work:** is done when a force exerted on an object causes that object to move some distance; equal to force times distance; measured in joules (J). (p. 580)
A
Abiotic factors, 122, 122–129; air, 122, 123, 127; climate, 127, 127–128, 128; soil, 124, 124 lab, 129 lab; sunlight, 124, 124; temperature, 125, 125–126, 126; water, 122, 123, 123
Absolute ages, 257–261
Absolute magnitude, 372
Absorption, 75, 75
Acceleration, 528–532; calculating, 529–530, 530 act, 559, 559 act; equation for, 530; and force, 556, 556–557, 560; graph of, 532, 532; modeling, 531, 531 lab; and motion, 528–529; negative, 531, 531; positive, 531; and speed, 528, 528–529; unit of measurement with, 557; and velocity, 528, 528–529, 529
Acetic acid, 494, 495, 496
Actinides, 450, 451
Action and reaction, 563–566, 564, 566
Activation energy, 503, 503
Applying Science, 14, 192, 260, 319, 372, 439, 469, 669;
Adaptive radiation, 52
Advertising, science in, 7
Africa, savannas of, 161, 161
Age, absolute, 257–261; relative, 251–256, 256 lab
Agriculture, on grasslands, 161; isotopes in, 421 act, 423; and nitrogen fixation, 132, 133, 133; traits in corn, 38, 38
Air, as abiotic factor in environment, 122, 123, 127; early, 281
Air conditioners, 623
Air resistance, 561
Alchemist, 479
Algae, and mutualism, 108, 108; as producers, 106
Alkaline metals, 441, 441, 469, 469
Alkaline earth metals, 442, 442
Allele(s), 45, 45
Alligator(s), 110
Alpha Centauri, 378
Alpha decay, 258, 258, 417, 417
Alpha particle(s), 408, 409, 409, 410, 412, 417
Alternating current (AC), 678
Aluminum, 442
Alveoli, 76, 77
Amalgam, 452
Americium, 417, 417, 450
Ammeter, 674, 675
Ammonia, 444, 444
Amphibians, 284
Amplitude, 697; of compressional wave, 697, 697; and energy, 697; of transverse wave, 697, 697
Angiosperms, 290
Angular unconformities, 252, 252, 253
Animal(s). See also Invertebrate animals; Vertebrate animals, competition among, 98, 98; cooperation among, 110; in desert, 160, 160; Ediacaran, 282, 283; effect of momentum on motion of, 534; in energy flow, 137, 137, 138, 138; and food chain, 137, 137; in grasslands, 161, 161; habitats of, 97, 97, 98, 98, 109, 109; insulation of, 616; invertebrate, 281; migration of, 103; speed of, 524; on taiga, 156, 156; in temperate deciduous forest, 156, 157; in temperate rain forest, 157, 157; and temperature, 125, 125; in tropical rain forest, 158, 159; on tundra, 155, 155; warm-blooded v. cold-blooded, 289 act
Anode, 406, 406
Antares, 704, 704
Antarctica, 381, 381
Antibiotics, 75
Anvil (of ear), 704
Appalachian Mountains, 285, 285
Apparent magnitude, 372
Applying Math, Acceleration of a Bus, 530; Acceleration of a Car, 559; Calculating Efficiency, 589; Calculating Extinction by Using Percentages, 291; Calculating Mechanical Advantage, 587; Calculating Power, 583; Calculating Work, 582;
Index

Applying Science

Chapter Reviews, 33, 59, 87, 117, 145, 175, 205, 237, 267, 299, 331, 365, 397, 429, 459, 487, 515, 543, 575, 603, 629, 661, 689, 719; Conserving Mass, 498; Converting to Celsius, 610; Diameter of Mars, 346; Electric Power Used by a Lightbulb, 652; Find Half-Lives, 419; Lung Volume, 77; Momentum of a Bicycle, 534; Percent of Volume, 77; Ohm's law, 165; saltwater, 166–169, 172; act, 168, 169


Archean Eon, 280
Arctic, 94, 94, 96
Argon, 447, 447
Aristotle, 25, 306
Arsenic, 445

Arteries, modeling blood flow in, 63 lab
Artificial body parts, 600, 600
Artificial selection, 276, 276
Astatine, 446
Asteroid, 358–359, 359
Asteroid belt, 358, 358
Athenosphere, 190
Astronauts, 318
Astronomical unit (AU), 344
Atlantic Ocean, 292 lab
Atmosphere, as abiotic factor in environment, 122, 123; early, 281; and gravity, 127 act; of Jupiter, 348, 348; of Mercury, 343; of Neptune, 352, 352; of Saturn, 350; of Sun, 375, 375
Atomic number, 415
Aurora, 677, 677
Aurora borealis, 377, 377
Automobiles, air bags in, 572, 572; internal combustion engines in, 620, 620, 620 act, 621; safety in, 540–541 lab, 572, 572
Average speed, 525, 525, 525 lab
Awiakta, Marilou, 484
Axis, 307, 307, 309; magnetic, 308, 308; tilt of, 326–327 lab
Axle, See Wheel and axle

Bacteria, and digestion, 75; early, 281, 281; and food, 505
Baking soda, 494, 495, 496
Balanced chemical equations, 497, 498 act
Balanced forces, 551, 551
Balloon races, 569 lab
Basaltic lava, 222, 222
Basin(s), impact, 323, 323, 323 lab, 324

Batteries, chemical energy in, 645, 645; in electrical circuit, 644, 644; life of, 645; lithium, 441
Begay, Fred, 26
Beginning growth, 104
Beryllium, 442, 467
Beta decay, 258, 258, 418, 418
Beta particle, 418
Betelgeuse, 370, 370, 394, 394
Bias, eliminating in research, 15
Bicycles, 591, 591
Big bang theory, 388, 390, 391
Big Dipper, 371, 371
Binary stars, 378
Biological organization, 96, 96
Biomechanics, 551
Biomes, 154–161. See also Land biomes
Bionics, 600
Biosphere, 94, 94–95
Biotic factors, 122
Biotic potential, 102, 103 lab
Bird(s), and competition, 98, 98; habitats of, 97, 97, 98, 98; how birds fly, 564 act; interactions with other animals, 92, 92, 95, 95; migration of, 103; and natural selection, 51; origin of, 290, 290; selective breeding of, 52, 52
Birth, 81, 81
Birthrates, 102, 102 act
Bison, 95, 95
Black hole(s), 384, 384, 557
Blood, clotting of, 81
Blood cells, red, 69; white, 69
Blood vessels, arteries, 63 lab; capillaries, 76, 77, 84; dilation of, 79; modeling blood flow in, 63 lab; veins, 63 lab
Blue shift, 389, 389
Body, cells in. See Cell(s); elements in, 67; energy for, 76, 76–79, 77; feeding, 73–75, 74, 75; interdependence of systems in, 79–81; organization in. See Organization
Body parts, artificial, 600, 600
Body systems, 71; interactions of, 73, 73–83, 82–83 lab
Body temperature, 79, 79, 589
Bohr, Niels, 412
Bond(s), 472–481; chemical, 471, 471; covalent, 475, 475–476, 476; double, 476, 476; ionic, 472, 472–474, 473, 473, 474; metallic, 474, 474; polar, 476, 476; triple, 476, 476, 477
Bone(s), 65, 84
Boomerangs, 542, 542
Boron, 442
Boron family, 442, 442
Bromine, 446, 468
Bronchi, 76, 77
Bryce Canyon National Park, 254, 255
Bubbles, 494, 494
Building materials, insulators, 616, 616
Burning, 492, 492, 499, 499, 503, 503
Butterflies, 109
Butyl hydroxytoluene (BHT), 506

Cactus, 98, 98
Calcium, 65, 67
Calcium carbonate, 65, 67
Calcium phosphate, 245
Calendar, Mayan, 328, 328
Californium-252, 450
Callisto (moon of Jupiter), 349, 349
Camels, 125, 125
Camouflage, 43 lab
Cancer, treatment of, 423
Canis Major, 730
Canyonlands National Park, 254, 255
Capillaries, 76, 77, 84
Carbohydrates, 66, 66, 67
Carbon, 443, 443; isotopes of, 415, 415–416
Carbon cycle, 134, 135
Carbon dioxide, 258, 258
Carbon-14 dating, 258, 258, 258 lab, 259, 259, 260 act, 420, 420
Carbon group, 443, 443
Cardiac muscles, 69
Carnivores, 107, 107, 137, 137, 593
Carroll, Lewis, 296
Carrying capacity, 101, 104, 105
Car safety testing, 540–541 lab
Carson, Rachel, 165
Cascade Mountains, 128
Cassini space probe, 350
Cassiopeia, 371
Cast, 245, 245
 Catalysts, 449, 449, 507, 507–508, 508
Catalytic converters, 507, 507
Cathode, 406, 406
Cathode-ray tube (CRT), 406, 406, 407, 407
Cat(s), 41, 41, 276, 276, 296, 296
Cell(s), 68, 68–72, 69, 70. See also
Bacteria, 68–72, 73, 75
feeding, 73–75
nerve, 637, 638; observing, 72 lab
Cellular respiration, 76, 76
Celsius scale, 609, 609–610, 610 act
Cenozoic Era, 292
Chalk, 616
Chalk, 616
Charon (moon of Pluto), 353, 353
Chart(s), 18, 18
Chemical basis of life, 64–67, 66, 67
Chemical bonds, 471, 471
Chemical changes, 491 lab, 492, 492, 494 lab, 509 act
Chemical energy, 465, 465
Chemical equations, 494–496, 497, 497 act; balanced, 497, 498 act; energy in, 501, 501
Chemical formulas, 479, 480, 480
Chemical names, 494, 495
Chemical plant, 490, 490
Chemical reactions, 76 lab, 490–511, 492, 493, 589; describing, 494–495; endothermic, 499, 510–511 lab; energy in, 498–501, 499, 500; exothermic, 499, 500, 510–511 lab; heat absorbed in, 500, 500; heat released in, 499–500; identifying, 491 lab, 494; rates of, 504, 504–508, 505, 506; slowing down, 506, 506; speeding up, 507, 507–508, 508; and surface area, 506, 506
Chemosynthesis, 106, 136–137
Chesapeake Bay, 169
Childbirth, 81, 81
Chlorine, 65, 446, 446, 472, 472–473, 473, 476, 476
Chlorophyll, 106, 108, 495
Chromium, 449
Chromosome(s), 39, 39, 46, 46
Chromosphere, 375, 375
Cinder cone volcano, 222, 222
Circuit, 643, 648–657; electric energy in, 644, 644; parallel, 651, 651, 651, 651 lab; protecting, 651, 651, 651; resistance in, 646, 646–647, 647, 648, 648, 649; series, 650, 650; simple, 643, 643–644, 644, 650 lab
Circuit breakers, 651, 651
Circular motion, 560–561, 561
Circulatory system, 71. See also
Blood vessels; and digestion, 75, 75; and respiratory system, 73, 73
Circumference, of Earth, 307
Circumpolar constellations, 371
Cities, heat in, 626, 626
Classification, of stars, 380–381
Clean Water Act of 1987, 15
Climate, 127; as abiotic factor in environment, 127, 127–128, 128; change of, 248, 248; as evidence of continental drift, 184; extreme, 142, 142; fossils as indicators of, 248, 248, 249, 249; and land, 154; and mountains, 292
Climax community, 153, 153, 154
Clotting, 81
Clouds of Magellan, 387, 387
CMEs (coronal mass ejections), 377, 377
Coal, 245
Cobalt, 65, 448
Coelacanth, 264, 264
Collisions, 521 lab, 535, 535–538, 536, 537, 538, 539 lab, 540–541 lab
Color, seeing, 713, 713
Columbia River Plateau, 223, 223
Coma, 357, 357
Comet(s), 356, 356–357; Kuiper Belt of, 353; structure of, 357, 357
Commensalism, 108, 108
Communication, in science, 10, 10–11
Communities, 96; climax, 153, 153, 154; interactions within, 96, 106–110; symbiosis in, 108, 108
Compass, 308, 308 lab, 666, 671, 671, 671 act, 672 lab
Competition, 98, 98, 99, 99 lab
Composite volcano, 223, 223
Compound(s), 473; as chemical basis of life, 64; ionic, 472–474, 481 lab; organic, 66–17; symbols for, 479, 479
Compound machines, 591, 591
Compression, 211, 211
Compressional waves, 695, 695, 695, 696, 696; amplitude of, 697, 697; sound waves as, 701, 701
Compression forces, 197
Compressor, 622, 622
Computers, 9, 15, 27; and semiconductors, 443, 443
Concentration, 505; and rate of reaction, 505, 505
Conclusions, 14 act, 19, 19
Condensation, 131, 131
Conduction, 613, 613
Conductor, 615, 640, 640, 640 act
Cone(s), of eye, 713, 713
Connective tissue, 69
Conservation, of energy, 619; of mass, 496, 496, 496 lab, 498; of momentum, 535, 535–538, 536, 537
Constant, 17
Constant speed, 525, 525
Constellation, 370, 370–371, 371
Consumers, 107, 107, 120, 136, 137, 137
Continent(s), fitting together, 181
lab, 192, 192 act
Continental drift, 182–185, 183 act; course of, 185, 185; evidence for, 181 lab, 182, 183, 184, 184 lab
Control, 22
Convection, 614, 614–615, 615, 615 lab
Convection current, 195, 195, 195 act
Convergent plate boundaries, 192, 193, 193, 194, 197, 228
Coolant, 622, 622, 623, 623
Cooling, 618 lab
Cooperation, 110
Copernicus, Nicholas, 337, 340
Copper, 502, 502; in body, 65
Copper wire, 646
Coral reef, 94, 94, 167, 167, 167 lab
Corn, 38, 38
Cornea, 711, 711
Corona, 375, 375
Covalent bond, 475, 475–476, 476
Coyotes, 104
Crankshaft, 620
Cretaceous Period, 282, 289
Crickets, 98, 99, 100
Crinoid, 249, 249
Crookes, William, 405, 406
Crystal, ionic, 477, 478; molecular, 477, 478; structure of, 478
Curie point, 187
Current. See Electric current
Cyanobacteria, 281, 281
Cycles, 130–135; carbon, 134, 135; nitrogen, 132, 132–133, 133; water, 130, 130–131, 131
Cylinders, 620, 621
Dalton, John, 405, 405
Dark energy, 391
Darwin, Charles, 50, 51, 52, 275, 275
Data Source, 28, 170, 200, 262, 454
Data tables, 14 act, 18
Dating, carbon-14, 254, 258, 258, 259, 259, 260 act; radiocarbon, 420, 420; radiometric, 259, 259–260, 260; relative, 251 act; of rocks, 247, 247, 249, 259–260, 260, 282 lab
Days, length of, 309, 309
Death rates, 102, 102 act
Decibel scale, 703, 703
Decision making, 6, 6
Decomposers, 107, 107
Decompression melting, 228
Deer, 156
Deformation, 211 lab
Deimos (moon of Mars), 347
Dentistry, elements used in, 452
Deoxyribonucleic acid (DNA), 39, 39, 67
Dependent variable, 17
Descriptive research, 13–15, 15, 20
Desert(s), 94, 94, 160, 160; competition in, 98, 98; water in, 123
Desertification, 160
Design Your Own, Car Safety
Testing, 540–541; Comparing Thermal Insulators, 624–625; Does exercise affect respiration?, 82–83; Exothermic or Endothermic?, 510–511; Half-Life, 424–425; Measuring Parallax, 392–393; Modeling Motion in Two Directions, 570–571; Population Growth in Fruit Flies, 112–113; Pulley Power, 598–599
Devonian Period, 282, 282
Diamond, 443, 512, 512
Diffraction, 700; of waves, 700, 700
Digestion, 74, 74–75, 75
Digestive system, 71, 74, 74–75, 75
Dinosaurs, era of, 288; extinction of, 286, 291 act, 296, 296; fossils of, 242, 242, 243, 244, 270, 289, 289–290, 290; tracks of, 246, 246; warm-blooded v. cold-blooded, 289 act
Direct current (DC), 679
Direction, changing, 588, 588; of force, 581, 581, 588, 588
Disconformity, 252, 253
Diseases, and bacteria, 75; fighting, 8 act
Displacement, and distance, 523, 523
Distance, changing, 588, 588; and displacement, 523, 523; in space, 372 act, 373, 388 lab; and work, 582, 588, 588
Distance-time graph, 526, 526
Divergent plate boundaries, 191, 193, 193, 227
DNA (deoxyribonucleic acid), 39, 39, 67
Dodo, 296, 296
Dolphin, 293
Domain, magnetic, 668, 668
Dominant traits, 45, 45
Doppler shift, 370–389, 389
Double bonds, 476, 476

Earthquakes, 192 act, 210–218, 317, 697; building for, 209 lab, 234; causes of, 210, 210–211; damage caused by, 216, 234, 234; and Earth’s plates, 229–231, 231; epicenter of, 212, 214, 214; and faults, 211, 211, 212, 212, 218; focus of, 212, 212; locations of, 229, 229; magnitude of, 213, 214, 216, 216 act; measuring, 213, 213, 214, 214; predicting, 218, 218; preparation for, 209 lab, 217, 217–218, 234; and seismic waves, 212, 212–213, 214, 230, 230, 230 act, 232–233 lab
East African Rift Valley, 180
East Pacific Rise, 196
Echolocation, 705
Eclipses, 314, 314–316, 315 act; causes of, 315; lunar, 316, 316, 321 lab; solar, 314, 314, 315, 315
Ecological succession, 150–153, 152
Ecology, 95, 248
Ecosystem(s), 95, 95, 121 lab, 148–171; aquatic, 163–171, 164 lab, 170–171 lab; carrying capacity of, 101, 104, 105; changes in, 150, 150–153, 151, 152; competition in, 98, 98; habitats in, 97, 97, 98, 98, 109, 109; land, 154, 154–162, 162 lab; limiting factors in, 100; populations in, 96, 99–105, 109, 110, 112–113 lab
Eddyarkan fauna, 282, 283
Efficiency, 589–590, 590; calculating, 589 act; equation for, 589; and friction, 590
Einstein, Albert, 381
Elastic limit, 210, 210
Elastic rebound, 210
Electrical energy, 619
Electrical charge, 636, 636–645, 637, 640
Electric circuit. See Circuit
Electric current, 643–649, 655 lab; controlling, 648, 648–649; effect on body, 654; generating, 678, 678–679, 679; and magnetism, 673–681, 683; model for, 656–657 lab; in a parallel circuit, 655 lab; and resistance, 646, 646–647, 647, 648, 648, 649; types of, 678, 679
Electric discharge, 641, 641
Electric energy, in circuit, 644, 644; cost of, 653, 653 act; and resistance, 646, 646–647, 647, 648, 648, 649
Electric field, 639, 639
Electric forces, 635 lab, 639, 639, 644 lab
Electricity, 634–657; connecting with magnetism, 683; generating, 678, 678–679, 679; safety with, 653–654
Electric meter, 653, 653
Electric motors, 676, 676, 684–685 lab
Electric power, 652–653
Electric shock, 653–654
Electric wire, 640, 646, 646
Electromagnet(s), 673, 673–674, 674, 674 lab
Electromagnetic spectrum, 708–709, 709
Electromagnetic waves, 696, 707, 708, 708, 710, 710
Electron(s), 257, 407, 412–413, 413, 466 act, 636, 636–637, 637, 644; arrangement of, 465, 465–466, 466; energy levels of, 465, 465–467, 466, 467; in magnetic fields, 668, 668; model of energy of, 463 lab; movement of, 464, 464
Electron cloud, 413, 413, 464, 464
Electron dot diagrams, 470, 470 lab, 470–471
Element(s), 405, 438 act; atomic number of, 415; atomic structure of, 465, 465, 482–483 lab; boron family of, 442, 442; carbon group of, 443, 443; as chemical basis of life, 64; halogen family of, 468, 468; halogens, 446, 446; in human body, 67; identifying properties of, 469 act; isotopes of, 257, 415, 415–416, 421 act, 421–423, 422; metalloids, 438, 438, 442, 443, 443, 443, 446; metals, 438, 438, 441, 441–442, 442, 443, 443, 448–452; nitrogen group of, 444, 444; noble gases, 446, 446–447, 447, 468, 468;
nonmetals, 438, 438, 443, 443, 444, 444, 445, 446, 446; oxygen family of, 445, 445; periodic table of, 466–467, 467, 468, 468. See Periodic table; radioactive, 450, 451; representative, 435; symbols for, 440; synthetic, 421–423, 422, 450, 451; tracer, 421–423, 422; transition, 435, 448, 448–452, 449, 450, 451

Element keys, 439, 439

Elevation, and temperature, 126, 126, 126 act
Ellipse, 309, 309 act
Elliptical galaxy, 387, 387
Endocrine system, 71
Endothermic reactions, 499, 510–511 lab
Energy, activation, 503, 503; and amplitude, 697; chemical, 645, 645; in chemical reactions, 498–501, 499, 500; conservation of, 619; converting, 136, 136–137, 420; dark, 391; electrical, 619; in equations, 501, 501; flow of, 136–139; in food chain, 137, 137; forms of, 619; from fusion, 381–382, 382; for human body, 76, 76–79, 77; loss of, 139, 139; and mass, 381; mechanical, 619, 619, 621; nuclear, 619; obtaining, 106, 106–107, 107; and photosynthesis, 106, 136; and power, 584; radiant, 619; from Sun, 120; thermal. See Thermal energy; transfer of, 137, 137–138, 138; and waves, 694, 694; and work, 584
Energy levels, of electrons, 465, 465–467, 466, 467
Energy pyramids, 138–139, 139
Engines, 619, 619–621, 620, 620 act, 621
Environment, abiotic factors in, 122, 122–129, 129 lab; biotic factors in, 122; and fossils, 248, 248–249, 249; freshwater, modeling, 164 lab; for houseplants, 149 lab;

model of, 271 lab; and species, 50–53, 51, 52, 53, 54–55 lab; and survival, 49, 49–50, 50; and traits, 40, 40–42, 41, 42, 49–53

Environmental Protection Agency, 167
Enzymes, 75, 508; as catalysts, 507–508, 508
Eon, 273, 273
Epicenter, 212, 214, 214
Epithelial cells, 69
Epoch, 273, 273
Equation(s). See Chemical equations; acceleration, 530; for mechanical advantage, 587; one-step, 582 act, 583 act, 587 act, 589 act; for power, 583; simple, 559 act, 610, 649 act, 652 act, 698 act; for wave speed, 698; for work, 582
Equinox, 310, 311
Era, 273, 273
Eros (asteroid), 359
Eruptions, 220, 220, 220 lab, 225 lab; fissure, 223, 223; largest, 224; quiet, 221, 223; violent, 221, 223
Estuaries, 168–169, 169
Europa (moon of Jupiter), 349, 349
Europium oxide, 450
Evaporation, 130, 131
Event horizon, 383
Everglades, 165
Evolution, 50–52, 51; of mammals, 293, 293; organic, 274, 274–276, 275, 276; of stars, 382 act, 382–385
Excretion, 78, 78–79
Exercise, and respiration, 82–83 lab
Exhaling, 74 lab
Exhaust valve, 621
Exothermic reactions, 499, 500, 510–511 lab
Expansion, thermal, 609, 609
Experiment(s), 21, 21–23
Experimental research design, 13, 20, 21, 21–23, 22, 23
Exponential growth, 104, 105, 105
Extinction, 53, 53, 286, 286, 288, 291 act, 296, 296
Eye, 711, 711–713, 712, 713

Fahrenheit scale, 609, 609–610, 610 act
Fat(s), dietary, 66, 66, 67
Fault(s), 194, 194, 211, 212; measuring movement along, 218, 218; normal, 196; strike-slip, 198, 198; types of, 211, 211
Fault-block mountains, 196, 196
Feedback, negative, 80, 80, 80 act; positive, 81, 81
Fertilizer(s), 133 lab, 423, 444, 444
Field(s), electric, 639, 639; magnetic. See Magnetic field(s)
Filaments, 468, 647
Filtration, in kidneys, 78, 78
Fitches, 51
Fingerprinting, 37 lab
Fire. See Wildfires; chemical changes caused by, 492, 492, 493
Firefighting foam, 445, 445
Fireworks, 502, 502
First-class lever, 595
Fish, early, 264, 264, 282, 282, 284, 284; and environment, 54–55 lab; gender of, 42, 42; with lungs, 284, 284
Fissure eruptions, 223, 223
Fixed pulleys, 596, 597
Fleming, Alexander, 75
Flight, 564 act
Flint, 450, 450
Flood basalts, 223, 223
Florida Everglades, 165
Fluoride, 452
Fluorine, 65, 446, 468, 468
Foam, for firefighting, 445, 445
Focus, 212, 212
Foldables, 5, 37, 63, 93, 121, 149, 181, 209, 241, 271, 305, 335, 369, 403, 433, 463, 491, 521, 549, 579, 607, 635, 665, 693
Food, and bacteria, 505; getting to cells, 73–75, 74, 75; irradiated, 426, 426; reaction rates in, 504, 504, 505, 506
Food chain, 107, 107; energy in, 137, 137
Food web, 138, 138
Force(s), 550, 550–551;
and acceleration, 556, 556–557, 560; action and reaction, 563–566, 564, 566; balanced, 551, 551; changing, 587; combining, 551; comparing, 579 lab; compression, 197; direction of, 198, 581, 581, 588; effects of, 549 lab; electric, 635 lab, 639, 639, 644 lab; input, 586, 586; magnetic, 655 lab; net, 551, 560; output, 586, 586; shear, 211; strong nuclear, 416; unbalanced, 551; unit of measurement with, 557; and work, 579 lab, 581, 581, 585 lab, 587

**Force pairs**, 567 lab

**Forests.** See also Rain forests; as climax community, 153, 153, 154; temperate deciduous, 154, 156, 156–157; and wildfires, 148, 148, 151 act, 152, 658, 658

**Formulas**, chemical, 479, 480, 496

**Fossil(s)**, 242, 242–249, 243; and ancient environments, 248, 248–249, 249; changes shown by, 278; and climate, 248, 248, 249, 249; of dinosaurs, 270, 289, 289–290, 290; Ediacaran, 282, 283; formation of, 243, 243; index, 247, 247, 254 act; making model of, 241 lab; minerals in, 244, 244; organic remains, 246, 246; Paleozoic, 282; Precambrian, 280; preservation of, 243 lab, 243–247, 244, 245, 246; in rocks, 282 lab; trace, 246, 246, 262–263 lab

**Fossil record**, as evidence of continental drift, 183, 183, 184, 184 lab

**Four-stroke cycle**, 620, 621

**Fox**, 41

**Free fall**, 567, 567, 568

**Frequency**, 696; of light, 707; of sound waves, 703; unit of, 698

**Freshwater ecosystems**, 163–165; lakes and ponds, 164, 164 lab, 164–165; rivers and streams, 163, 163–164; wetlands, 165, 165, 170–171 lab, 172, 172

**Frisch, 552–555, 554 lab, 590, 590; rolling, 555, 555; sliding, 553, 554, 554, 555, 559, 562; static, 554

**Fruit flies**, phenotypes of, 46 lab; population growth in, 112–113 lab

**Fulcrum**, 594, 595

**Full moon**, 314, 314

**Fungi**, and mutualism, 108, 108

**Fuses**, 651

**Fusion**, 338, 339, 381–382, 382, 451

**Galaxies**, 368, 386–387; clusters of, 369 lab, 386; elliptical, 387, 387; irregular, 387, 387; spiral, 386, 386–387

**Galilei, Galileo**, 320, 337, 349, 376, 552, 553 act

**Galileo space probe**, 348, 359

**Gallium**, 442

**Galvanometer**, 674, 675

**Gamma rays**, 710

**Ganymede (moon of Jupiter)**, 348, 348

**Gas(es)**, exhalation of, 74 lab; noble, 468, 468

**Gaspra (asteroid)**, 359, 359

**Gender**, 42, 42, 42 act

**Gene**, 39, 39

**Generator**, 678, 678–679

**Genetics**, 44, 44–48; dominant and recessive factors in, 45, 45; early study of, 45, 45–46, 46; and mutations, 52; and traits, 44–48

**Genotype**, 39

**Geologic time scale**, 272–273, 273. See also Earth history

**Germanium**, 443

**Giants**, 381, 381, 383, 383, 384, 394, 394

**Giraffes**, 276, 276

**Glaciers**, as evidence of continental drift, 184

**Glass**, 443

**Global Surveyor space probe**, 345, 346

**Glomar Challenger (research ship)**, 187

**Glucagon**, 80

**Glucose**, 107; regulation of, 80, 80

**Glycogen**, 80

**Gondwanaland**, 288, 288

**Goodall, Jane**, 30, 30

**Grand Canyon National Park**, 254

**Graph(s)**, 18, 18; of accelerated motion, 532, 532; distance-time, 526, 526; of motion, 526, 526; speed-time, 532, 532

**Graphite**, 443

**Graptoleites**, 244, 244

**Grass**, life in, 93 lab

**Grasslands**, 161, 161

**Gravity**, 557–558; and air resistance, 561; and atmosphere, 127 act; effects of, 345 lab; and motion, 557, 560, 560, 561, 561; and stem growth, 40 lab

**Great Barrier Reef**, 167

**Great Dark Spot (Neptune)**, 352

**Great Red Spot (Jupiter)**, 167

**Great Rift Valley**, 191, 196

**Greenhouse effect**, 343

**Grounding**, 642, 642

**Group**, 435

**Growth**, beginning, 104; and environment, 40, 40; exponential, 104, 105, 105; of plants, 40, 40, 40 lab, 140–141 lab; of population, 102–105, 103, 104, 105, 112–113 lab

**Gymnosperms**, 290

**Habits**, 97, 97, 98, 98, 109, 109

**Hadean Eon**, 280

**Hale-Bopp comet**, 356, 356

**Half-life**, 258, 259, 418, 418 lab, 418–419, 419 act, 424–425 lab

**Halley, Edmund**, 222

**Halogens**, 446, 446, 468, 468

**Hammer (of ear)**, 704, 704

**Hawaiian Islands**, volcanoes in, 222, 222, 224, 228, 228

**Hawking, Stephen**, 26

**Health**, and heavy metals, 454–455 lab; and mercury, 452 act

**Hearing**, 493, 703, 704
Heart, interaction with lungs, 73, 73
Heat, 612–618, in chemical
reactions, 499–500, 500;
conduction of, 613, 613;
convection of, 614, 614–615, 615,
615 lab; radiation of, 613;
specific, 616; and thermal energy,
612–615; transfer of, 612, 612
Heat engines, 619, 619–621, 620,
620 act, 621
Heating, 618 lab
Heat island, 626, 626
Heat pumps, 623, 623
Heavy metals, 443, 443, 449,
449–455 lab
Helium, 446, 447, 447, 467, 468
Hemoglobin, 448
Herbivores, 107, 107, 137, 137, 593
Hertz (Hz), 698
Hertzprung, Ejnar, 380
Hertzprung-Russell (H-R) diagram, 380, 380, 381, 382
Hess, Harry, 187
Himalaya, 197, 197, 292, 292
History. See Earth history
Homeostasis, 79, 79
Homo sapiens, 293
Hopper, Grace Murray, 26
Horse, 293
Hot spots, 228, 228, 231
Hubble, Edwin, 389
Hubble Space Telescope, 352, 353, 353,
357, 384, 391
Human(s), origin of, 293
Human Genome Project, 44
Humus, 124, 129 lab
Hurricanes, on Neptune, 352
Hutton, James, 261
Hybrid, 48
Hydrogen, v. helium, 446; isotopes of, 257
Hydrogen chloride, 476, 476
Hydrothermal vents, 137
Hyoiliths, 286
Hypothesis, 21

Iceman, 260
Impact basin, 323, 323, 323,
324 lab
Impact theory, 319, 319
Inclined plane, 591–593, 592
Independent variable, 17
Index fossils, 247, 247, 254 act
Induced charge, 641, 641
Inertia, 533, 533
Inference, 9 lab
Infra red waves, 709
Inhibitor, 506, 506, 506 lab
Inner planets, 338, 342–347, 344,
344. See also Earth; Mars, 340,
344, 344–347, 354, 354, 360–361
lab; Mercury, 340, 342, 342–343,
354, 354, 360–361 lab; Venus,
336, 337, 340, 343, 353, 354, 354,
360–361 lab
Inner transition elements, 450,
450, 451
Inorganic substances, 65–66
Input force, 586, 586
Insect(s), and competition, 98;
counting population of; 99;
niches of, 109, 109, 110
Instantaneous speed, 525, 525
Insulator(s), 616, 616, 624–625 lab, 640, 640
Insulin, 80
Integrate Career, Environmental
Author, 165; Farmer, 127, 444;
Nobel Prize Winner, 467;
Seismology, 317; Volcanologist,
50, 197
Integrate Chemistry, Alkaline
Batteries, 645; Classifying
Elements, 456; Curie Point, 187;
DNA Structure, 39; Earth’s First
Air, 281; Glucose, 107; Melting
Point, 228; What determines
how a volcano erupts?, 221;
White Dwarf Matter, 383
Integrate Earth Science, Body
Elements, 67; Carbon Dating,
420; Desertification, 160;
Hydrothermal Vents, 137; rain
shadow effect, 128; seismic
waves, 696; volcanoes, 202
Integrate Environment, The Clean
Water Act, 15; Energy
Conversion, 420; nonliving
influences, 49; seashores, 168;
Integrate Health, dentistry and
dental materials, 452; Hearing
Damage, 703; magnetic
resonance imaging (MRI), 682;
reaction rates in food, 505;
variables, 21
Integrate History, Antibiotics, 75;
Breathe Easy, 507; The Currents
War, 681; James Prescott Joule,
589; Newton and Gravity, 557;
The Ohm, 646; Plant Poisons,
109; Protons, 412; 386
Supernova, 385
Integrate Language Arts, Friction,
229; Name of Planets, 352
Integrate Life Science, Ancient
Ecology, 248; Animal Insulation,
616; Autumn Leaves, 495;
Biomechanics, 551; Body
Temperature, 589; Cell Division
in Tumors, 423; Earth’s
Rotation, 307; flight, 564; Ions,
473, Poison Buildup, 445;
research for writing, 30; species,
274; Thermal Pollution, 617;
wedges in your body, 593
Integrate Physics, Bright Lights,
450; Direction of Forces, 198;
evolution of stars, 382; magnetic
clues, 187; magnetic field, 308;
motion of planets, 340; nuclear
fission, 484; radioactive decay,
257; Rotational Motion, 338
Integrate Social Studies, Coal
Mining, 245; Forensics and
Momentum, 534; Science in
Advertising, 7
Integumentary system, 71
Intensity, 702; of sound, 702, 702,
703
Interactions, of body systems, 73,
73–83, 82–83 lab; and survival,
50, 50
Internal combustion engines, 620,
620, 620 act, 621
International System of Units (SI),
17
International Union of Pure and
Applied Chemistry (IUPAC), 440
Internet, 28–29 lab. See Use the
Internet
Intertidal zone, 168, 168
Invertebrate animals, 281
Iodine, 65, 446, 470
Iodine-131, 422, 423
Io (moon of Jupiter), 349, 349
Ion(s), 473, 473, 636, 637, 637
Ionic bond, 472, 472–474, 473, 473, 474
Ionic compounds, 472–474, 481 lab
Ionic crystal, 477, 478
Iridium, 449
Iron, 448, 450; in body, 65
Iron triad, 448, 448
Irradiated food, 426, 426
Irregular galaxy, 387, 387
Isotopes, 257, 415, 415–416; radioactive, 421 act, 421–423, 422

James, Sarita M., 26
Jellyfish, 282
Joule, James Prescott, 589
Journal, 4, 36, 62, 92, 120, 148, 180, 208, 240, 270, 304, 334, 368, 402, 432, 462, 490, 520, 548, 578, 606, 634, 664, 692
Jupiter, 348, 348–349, 355, 355; distance from Sun, 360–361 lab; exploration of, 348; Great Red Spot on, 348, 348; moons of, 349, 349; orbital speed of, 340
Jurassic Period, 289

Kelvin scale, 610
Kepler, Johannes, 340
Kidney(s), filtration in, 78, 78; and waste elimination, 78, 78–79
Kilogram (kg), 557
Kilowatt-hour (unit of electric energy), 653
Krypton, 447
Kuiper Belt, 353

Lab(s), Balloon Races, 569; Battle of the Beverages Mixes, 12;
Bending Light, 710, 714–715; Building the Pyramids, 585; Changing Species, 287; Collisions, 539; Current in a Parallel Circuit, 653; Design Your Own, 82–83, 112–113, 392–393, 424–425, 510–511, 540–541, 570–571, 598–599, 624–625; Discovering the Past, 294–295; Disruptive Eruptions, 225; Exothermic or Endothermic?, 510–511; Feeding Habits of Planaria, 111; Half-Life, 418; Heating Up and Cooling Down, 618; How does an electric motor work?, 684–685; Humus Farm, 129; Ionic Compounds, 481; Jelly Bean Hunt, 43; Launch Labs, 5, 37, 63, 93, 121, 149, 181, 209, 241, 271, 305, 335, 369, 403, 433, 463, 491, 521, 549, 579, 607, 635, 665, 693; Make a Compass, 672; Making a Model of the Invisible, 414; Mini Labs, 9, 46, 76, 103, 133, 164, 195, 211, 258, 282, 323, 345, 388, 418, 435, 470, 494, 496, 531, 567, 596, 615, 650, 670, 710; Model and Invent, 262–263, 360–361, 482–483; Model for Voltage and Current, 656–657; Moon Phases and Eclipses, 321; Observing Cells, 72; Physical or Chemical Change?, 509; Planetary Orbits, 341; Relative Ages, 256; Seafloor Spreading Rates, 189; Seismic Waves, 232–233; Sound Waves in Matter, 706; Studying a Land Ecosystem, 162; Sunspots, 379; Tilt and Temperature, 326–327; Toothpick Fish, 54–55; Try at Home Mini Labs, 18, 40, 74, 99, 124, 158, 184, 220, 243, 292, 308, 313, 350, 371, 411, 475, 506, 525, 554, 583, 614, 644, 674, 699; Use the Internet, 28–29, 170–171, 200–201, 294–295, 454–455; Where does the mass of a plant come from?, 140–141

Law(s) on clean water, 15; Lakes, 164, 164–165
Land biomes, 154, 154–162, 162 lab; deserts, 160, 160; grasslands, 161, 161; taiga, 156, 156; temperate deciduous forests, 154, 156, 156–157; temperate rain forests, 157, 157; tropical rain forests, 154, 158, 158–159, 159; tundra, 155, 155
Lanthanides, 450, 450
Lanthanum, 450, 450
Large Magellanic Cloud, 387, 387
Lasers, 708 act
Latitude, and temperature, 125, 125
Launch Labs, Clues to Life’s Past, 241; Compare Forces, 579; Construct with Strength, 209; Earth Has Many Ecosystems, 121; Forcing and Motion, 549; How are people different?, 37; How can you tour the solar system?, 335; How do lawn organisms survive?, 93; Identify a Chemical Change, 491; Magnetic Forces, 665; Make a Model of a Periodic Pattern, 433; Measuring Temperature, 607; Measure Using Tools, 5; Model Blood Flow in Arteries and Veins, 63; Model Crater Formation, 335; Model Rotation and Revolution, 305; Model the Energy of Electrons, 463; Model the Unseen, 403; Motion After a Collision, 521; Observing Electric Forces, 635; Reassemble an Image, 181; Survival Through Time, 271; Wave Properties, 693; Were the continents connected?, 181; What are some properties of waves?, 693; What environment do houseplants need?, 149; Why do clumps of galaxies move apart?, 369
Laurasia, 288, 288
Lava, 219, 221, 222, 222, 223
Lava plateaus, 223, 223
Lavoisier, Antoine, 496

Lawrencium, 450

Lead, 443, 443, 450

Leaves, 158 lab; changing colors of, 495; and genetics, 41, 41

Lenses, of eye, 711, 711

Lever, 594, 594, 595

Lichens, and mutualism, 108, 108; as pioneer species, 150, 151

Life, chemical basis of, 64–67, 67; origins of, 56, 281, 281–282; unusual forms of, 282, 283

Life processes, 135

Light, 707–715; as abiotic factor in environment, 124, 124; bending, 710, 714–715 lab; frequency of, 707; seeing, 711; speed of, 707; visible, 709, 709; wavelength of, 707

Lightbulb, 449, 449, 468

Lightning, 658

Lightning rod, 642, 642

Light waves, in empty space, 707, 707; properties of, 708, 708

Light-year, 373

Limestone, 254, 254

Limiting factors, 100

Lipids, 66, 66, 67

Lithium, 441, 465, 465, 467, 469

Lithosphere, 190, 190, 191, 226, 227

Liver, 80

Lizards, 274

Local Group, 386, 389

Loudness, 702, 702–703, 703

Lunar eclipse, 316, 316, 321 lab

Lunar Orbiter, 322

Lunar Prospector, 324, 324

Lung(s), calculating volume of air held by, 77 act; interaction with heart, 73, 73; and respiration, 76, 77

Lutetium, 450

Lymphatic system, 71

Lynx, 156

Machine(s), 586–599; compound, 591, 591; and efficiency, 589–590, 590; and friction, 590, 590; and mechanical advantage, 586, 586–588, 594, 594; simple. See Simple machines

Magellan space probe, 343, 343

Maglev, 664, 664, 665

Magma, 187, 221, 222; silica-rich, 221

Magnesium, 448

Magnetic force, 655 lab

Magnetic properties, 448

Magnetic resonance imaging (MRI), 682, 682–683, 683

Magnetic time scale, 188

Magnetism, 664–683; early uses of, 683; making, 668, 668; observing, 670 lab; and seafloor spreading, 187–188, 188

Magnetic field lines, 667, 667

Magnetic field(s), 667, 667–671; of Earth, 187–188, 188, 308, 308, 669, 669–671, 670; making, 668, 668; observing, 670 lab; and seafloor spreading, 187–188, 188

Magnetic field lines, 667, 667

Magnetic force, 655 lab

Magnetic properties, 448

Magnetic resonance imaging (MRI), 682, 682–683, 683

Magnetic time scale, 188

Magnetism, 664–683; early uses of, 666; and electric current, 673–681, 683

Magnetite, 188, 666

Magnetometer, 188

Magnetosphere, 669, 669, 677, 677

Magnetude, 213, 214, 216, 216 act; absolute, 372; apparent, 372

Main sequence, 380, 380–381, 382–383

Maize, 38, 38

Mammal(s), evolution of, 293, 293; marsupials, 293, 293; origin of, 290, 290

Mammoth, 246, 296, 296

Manganese, 65

Mantle, of Earth, 195, 195

Map(s), 527, 527; of Moon, 324, 324–325

Maria, 317, 318, 320

Mariner space probes, 342, 343

Mars, 95, 344, 344–347, 354, 354; distance from Sun, 360–361 lab; Earth compared to, 345; exploration of, 344–346, 346 act; moons of, 347, 347; orbital speed of, 340; polar ice caps on, 344, 346; seasons on, 346; surface features of, 344, 344

Mars Odyssey, 345

Mars Pathfinder, 345

Marsupials, 293, 293

Mass, 533, 533; conservation of, 496, 496, 496 lab; and energy, 381; unit of measurement with, 557; and weight, 558

Mass number, 416

Materials, semiconductors, 443, 443

Matter, cycles of, 130–135; and motion, 522; recycling, 385

Mauna Loa, Hawaii, 222, 222

Mayan calendar, 328, 328

Measurement, of average speed, 525 lab; of distances in solar system, 336–337, 344, 360–361 lab; of earthquakes, 213, 213, 214, 216; of force pairs, 567 lab; of movement along faults, 218, 218; of parallax, 392–393 lab; of temperature, 609, 609–610; units of, 17, 530, 557, 583, 646, 653; using tools, 5 lab; of weight, 567, 567; of work, 584

Mechanical advantage, 586, 586–588, 587, 594, 594

Mercury

Mercury, 452, 452

Method, Lise, 440

Melting point, 228

Melting rates, 614 lab

Mendel, Gregor, 45–46, 47, 48

Mendelev, Dmitri, 434, 434, 435, 468

Mercury, 449, 452, 452 act
Mercury (planet), 95, 340, 342, 342–343, 354, 354, 360–361 lab
Mesoic Era, 288, 288–291, 289, 290
Metal(s), 438; alkali, 441, 441, 469, 469; alkaline earth, 442, 442; as catalysts, 449, 449; as conductors, 640; heavy, 443, 443, 449, 454–455 lab; iron triad, 448, 448; misch, 450, 450; on periodic table, 438, 438, 441, 441–442, 442, 443, 443, 448–452; transition, 435, 448, 448–452, 449, 450, 451
Metallic bond, 474, 474
Metalloids, 438, 438, 442, 443, 443, 445, 446
Meteor, 357, 357–358
Meteorite, 56, 260, 260, 358, 358, 362
Meteoroid, 357, 358
Meteor shower, 358
Meter, electric, 653, 653
Methane, 475 lab
Microwaves, 709
Mid-Atlantic Ridge, 191, 192, 196
Mid-ocean ridges, 186, 186, 191, 192, 196
Migration, 103
Milkweed plants, 109
Milky Way Galaxy, 368, 386, 386, 387
Millipedes, 109
Mineral(s), 65; in fossils, 244, 244
Mini Labs, Comparing Biotic Potential, 103; Comparing Fertilizers, 133; Dating Rock Layers with Fossils, 282; Designing a Periodic Table, 435; Drawing Electron Dot Diagrams, 470; Graphing Half-Life, 418; Identifying Simple Circuits, 650; Inferring Effects of Gravity, 345; Inferring from Pictures, 9; Making Your Own Compass, 308; Measuring Distance in Space, 388; Measuring Force Pairs, 567; Modeling Acceleration, 531; Modeling Carbon-14 Dating, 258; Modeling Convection Currents, 195; Modeling Freshwater Environments, 164; Observing a Chemical Change, 494; Observing a Chemical Reaction, 76; Observing Convection, 615; Observing Deformation, 211; Observing Fruit Fly Phenotypes, 46; Observing the Law of Conservation of Mass, 496; Observing Magnetic Fields, 670; Observing Pulleys, 596
Misch metal, 450, 450
Model(s), 16; of atom, 405, 405–414, 408, 410, 411, 414 lab; of unseen, 403 lab, 414 lab
Model and Invent, Atomic Structure, 482–483; Solar System Distance Model, 360–361; Trace Fossils, 262–263
Molds, of organic remains, 245, 245
Molecular crystal, 477, 478
Molecules, 475, 475; nonpolar, 477, 477; polar, 476, 476–477, 477, 477 act
Momentum, 534–538; calculating, 534 act; and collisions, 521 lab, 535, 535–538, 536, 537, 538, 539 lab, 540–541 lab; conservation of, 535, 535–538, 536, 537
Montserrart volcano, 219, 219, 220, 220, 221, 221 act, 224, 227
Moon(s), 312–325, 319 lab; craters on, 317, 317, 320; eclipse of, 316, 316, 321 lab; exploration of, 322, 322–325; ice on, 324, 325; interior of, 317, 317; of Jupiter, 349, 349; mapping, 324, 324–325; of Mars, 347, 347; movement of, 305 lab, 312, 312, 316, 322; of Neptune, 352, 352; origin of, 319, 319; of Pluto, 353, 353; of Saturn, 353, 353; of Uranus, 351
Moon phases, 313, 314, 321 lab
Moonquakes, 317, 317
Moseley, Henry, 435
Motion, 520, 522 act, 522–527, 548–571; and acceleration, 528–529, 556, 556–557, 560; after a collision, 521 lab; and air resistance, 561; and changing position, 522, 522–523;
circular, 560–561, 561; and friction, 552, 552–555; graphing, 526, 526, 532, 532; and gravity, 557, 557, 560, 560, 561, 561; and matter, 522; modeling in two directions, 570–571 lab; and momentum, 534–538; Newton’s first law of, 552–555, 565; Newton’s second law of, 556–562, 565; Newton’s third law of, 563–568, 565, 569 lab; on a ramp, 549 lab; relative, 523, 523; and speed, 524–525, 525; and work, 580, 580–581, 581
Motors, electric, 676, 676, 684–685 lab
Mountains, and climate, 292; as evidence of continental drift, 184; fault-block, 196, 196; formation of, 197, 197, 285, 285, 286, 292, 292; rain shadow effect in, 128, 128; and temperature, 126, 126
Mount St. Helens eruption (Washington state), 223, 224
Movable pulleys, 597, 597
Movement, of populations, 103, 103
MRI (magnetic resonance imaging), 682, 682–683, 683
Muscle(s), cardiac, 69; skeletal, 69; smooth, 69
Muscle tissue, 69
Muscular system, 71
Mutation, 52
Mutualism, 108, 108
Names, chemical, 494, 495
Nanometer, 707
National Aeronautics and Space Administration (NASA), 318, 324
National Geographic Unit Openers, How are Electricity and DNA Connected?, 2; How are Beverages and Wildlife Connected?, 90; How are Volcanoes and Fish Connected?, 178; How are Thunderstorms and Neutron Stars Connected?, 302;
How are Charcoal and Celebrations Connected?, 400; How are City Streets and Zebra Mussels Connected?, 518; How are Radar and Popcorn Connected?, 632

National Geographic Visualizing, The Big Bang Theory, 390; The Carbon Cycle, 134; Chemical Reactions, 493; Common Vision Problems, 712; The Conservation of Momentum, 537; Crystal Structure, 478; Descriptive and Experimental Research, 20; The Four-Stroke Cycle, 621; Human Cells, 69; Levers, 595; The Moon's Surface, 318; Natural Selection, 51; Nerve Impulses, 638; Newton's Laws in Sports, 565; Plate Boundaries, 193; Population Growth, 104; Secondary Succession, 152; The Solar System's Formation, 339; Synthetic Elements, 451; Tracer Elements, 422; Tsunamis, 215; Unconformities, 253; Unusual Life Forms, 283; Vision Defects, 712; Voltmeters and Ammeters, 675

Natural selection, 43 lab, 50, 51, 275, 275–276, 276

NEAR spacecraft, 359


Negative acceleration, 531, 531

Negative charge, 636, 636

Negative feedback, 80, 80, 80 act

Neodymium, 450, 450

Neon, 447, 447, 468, 468

Neutron, 79

Neptune, 340, 342, 342, 355, 355, 360–361 lab

Neptunium, 417, 417

Nerve cells, 637, 638

Nervous system, 71

Net force, 551, 560

Neurotransmitters, 638

Neutron(s), 257, 411, 415, 415, 636, 636

Neutron star, 384

New moon, 313, 314

Newton, Isaac, 552, 553 act

Newton (unit of force), 557

Newton's first law of motion, 552–555, 565

Newton's second law of motion, 556–562, 565; and air resistance, 561; and gravity, 557–558; using, 558, 558–560, 560

Newton's third law of motion, 563–568, 565, 569 lab

Niche, 109, 109–110

Nickel, 448

Nitrogen, 444, 444; electron dot diagram of, 470

Nitrogen cycle, 132, 132–133, 133

Nitrogen fixation, 132, 132

Nitrogen group, 444, 444

Noble gases, 446, 446–447, 447, 468, 468

Nonconformity, 252, 253

Nonmetals, 438, 438, 443, 444, 444, 444, 445, 446, 446; noble gases, 468, 468

Nonpolar molecules, 477, 477

Normal fault, 196, 211, 211

Northern lights, 377, 377, 677, 677

North Star (Polaris), 371, 371

Nuclear energy, 619

Nuclear fusion, 338, 339, 381–382, 382

Nuclear radiation, 417

Nucleic acid, 66, 66, 66, 67


Numbers, using, 419 act

Nutrient(s), 66, 66, 66; carbohydrates, 66, 66, 67; fats, 66, 66, 67; minerals, 65; proteins, 66, 66, 67; water, 66, 66 act

Ocean(s), age of, 292 lab

Ocean floor, mapping, 186; spreading of, 186, 187–188, 189 lab

Ocean water, 94, 94

Ochola, Ellen, 26

Ohm (unit of resistance), 646

Ohm's law, 649

Olympic torch, 503, 503

Omnivores, 107, 107, 137, 137

One-step equations, 582 act, 583 act, 587 act, 589 act

Oops! Accidents in Science, It Came from Outer Space, 362; What Goes Around Comes Around, 542; The World's Oldest Fish Story, 264

Oort, Jan, 356

Oort Cloud, 356

Orbit, of Earth, 309; of planets, 340, 341 lab; of satellite, 561; weightlessness in, 568, 568

Organ(s), 70, 70–71

Organic compounds, 66–67

Organic evolution, 274, 274–276, 275, 276

Organization, 64, 64; cells, 68, 68–71, 69, 70, 70 lab; chemical substances in, 64–67, 66, 67; organs, 70, 70–71; organ systems, 71; tissues, 70, 70

Organ systems, 71; interactions of, 73, 73–83, 82–83 lab

Orion, 370, 370, 371

Ortelius, Abraham, 182

Oscillating model of universe, 388

Osmium, 449


Output force, 586, 586

Oxygen, on periodic table, 445, 445; and respiration, 76, 77, 123; use in body, 67

Oxygen family, 445, 445

Ozone, 445

Pacific Ring of Fire, 228, 229

Paleozoic Era, 282, 282–286, 284, 284 act, 285, 286

Palladium, 449

Pancreas, 80, 80

Pangaea, 182, 182, 183, 279, 279, 286, 288, 288
Parallax

Parallax, 373, 373, 392–393 lab
Parallel circuit, 651, 651, 655 lab
Parasitism, 108, 108
Particle(s), alpha, 408, 409, 409, 410, 412, 417; beta, 418; charged, 407–409
Particle accelerator, 421, 421, 451, 451
Particle size, and rate of reaction, 506, 506
Penguins, 125, 125
Penicillin, 75
Pennsylvanian Period, 284
Penumbra, 315, 316
Percentages, 47 act, 291 act, 346 act
Period, 273, 273, 435. See also names of individual periods
Periodic pattern, making models of, 433 lab
Periodic table, 432–455, 436–437; boron family on, 442, 442; carbon group on, 443, 443; designing, 435 lab; development of, 434, 434–435; element keys on, 439, 439; and energy levels of electrons, 466–467, 467; halogen family on, 468, 468; halogens on, 446, 446; in identifying properties of elements, 469 act; metalloids on, 438, 438, 442, 443, 444, 445, 446; metals on, 438, 438, 441, 441–442, 442, 443, 448–452; nitrogen group on, 444, 444; noble gases on, 446, 446–447, 447, 468, 468; nonmetals on, 438, 438, 443, 444, 444, 445, 446, 446; oxygen family on, 445, 445; symbols for elements on, 440; zones on, 435, 435, 438, 438–440, 439
Permafrost, 155, 155
Permian Period, 286
Permineralized remains, 244, 244
Perspiration. See Sweat
Phases of Moon, 313, 314, 321 lab
Phenotype, 39; and environment, 40, 40–42, 41, 42; of fruit flies, 46 lab
Phobos (moon of Mars), 347, 347
Phosphorus, 444, 444; in bones, 65
Phosphorus-32, 423
Photosphere, 375, 375
Photosynthesis, 106, 108, 123, 124, 124; and energy, 136; and respiration, 135 lab
Physical changes, 492, 492, 509 lab
Physical properties, magnetic, 448
Pictures, inferring from, 9 lab
Pigeons, 52, 52
Pioneer species, 150, 151
Pistons, 620, 621
Pitch, 703
Plains, 161
Planaria, 111 lab
Planet(s). See also individual planets; distances between, 336–337, 344, 360–361 lab; formation of, 338; inner, 338, 342–347, 354, 354; modeling, 350 lab; moons of. See Moon(s); motions of, 340, 341 lab, 351, 351; orbital speed of, 340; orbits of, 340, 341 lab; outer, 338, 348–353, 355, 360–361 lab; ring systems of, 348, 348, 350, 350, 351
Planetaryariums, 335 lab
Plant(s), chlorophyll in, 495; and competition, 99 lab; as evidence of continental drift, 183, 184, 184; growth of, 40, 40, 40 lab, 140–141 lab; houseplants, 149 lab; leaves of, 41, 41, 495; movement of, 103, 103; and nitrogen fixation, 132, 132; photosynthesis in, 106, 123, 124, 124, 135 act, 136; and poison, 109; seed, 290; stems of, 40 lab
Plate(s), 190, 191; collisions of, 193, 194, 285, 285; composition of, 190, 190; and earthquakes, 229–231, 231; movement of, 226, 226, 227, 231; and volcanoes, 219, 219, 226, 226–228, 227
Plate boundaries, 191, 191; convergent, 192, 193, 193, 194, 197, 228; divergent, 191, 193, 193, 227; transform, 194, 194
Platelets, 69, 81
Plate tectonics, 180, 190–201; causes of, 195, 195; and Earth history, 279, 279, 285, 285;
features caused by, 196, 196–198, 197, 198; predicting activity, 200–201 lab; testing for, 198, 198–199
Platinum, 449
Platinum group, 449
Pluto, 340, 352, 353, 353, 355, 355, 360–361 lab
Plutonium, 450
Poisons, 109, 435
Polar bears, 616
Polar bond, 476, 476
Polaris (North Star), 371, 371
Polar molecules, 476, 476–477, 477, 477 act
Polar regions, 94, 94, 96
Pole(s), of Earth, 125; magnetic, 666, 666, 667, 669 act; of Moon, 325; South, 142
Pollution, thermal, 617, 617; of water, 165, 165, 172, 172
Polonium, 445
Ponds, 164, 164–165
Population(s), 96; biotic potential of, 102, 103 lab; data on, 96 act; growth of, 102–105, 103, 104, 105, 112–113 lab; movement of, 103, 103; size of, 99, 99–102, 100
Population density, 99, 99
Position, changing, 522, 522–523
Positive acceleration, 531
Positive charge, 636, 636
Positive feedback, 81, 81
Power, 583–584; calculating, 583, 583 act; electric, 652–653; and energy, 584; equation for, 583; of pulley, 598–599 lab; and work, 583 lab
Power plants, 679, 679, 679 act
Prairies, 161; life on, 96
Precambrian time, 280, 280–282, 281
Precipitation, extreme amounts of, 142; and land, 154
Predators, 43 lab, 50, 50, 110, 110
Prey, 43 lab, 50, 50, 110, 110
Primary succession, 150, 150–151, 153
Primordial soup, 56
Principle of superposition, 250, 250
Index

Principle of uniformitarianism, 261, 261
Problem solving, 6, 6, 8, 8, 12 lab, 12, 13, 14 act
Producers, 106, 106, 120, 123, 137, 137
Product, 494, 495, 496, 497
Project Apollo, 322
Promenades, 376, 377
Properties, of light waves, 708, 708; magnetic, 448; of waves, 693 lab, 696, 696–698, 697
Prostheses, 600, 600
Proptactinum, 450
Proteases, 508, 508
Proteins, 66, 66, 67
Proterozoic Eon, 280
Proton(s), 257, 410, 636, 636
Proxima Centauri, 373, 378
Pyarmigan, 155
Puley, 596 lab, 596–599; fixed, 596, 597; movable, 597, 597; power of, 598–599 lab
Pulley system, 597, 597, 598–599 lab
Punnet square, 47, 48
Pyramids, 579 lab, 585 lab
Pyroclastic flows, 220, 220, 221

Quartz, 443
Quasars, 384
Quaternary Period, 292

Rabbits, 99, 100
Raccoons, 50, 50
Radiant energy, 619
Radiation, 613; adaptive, 52; and food, 426, 426; nuclear, 417; from Sun, 310
Radiation therapy, 423
Radioactive elements, 450, 451
Radioactive isotopes, 421 act, 421–423, 422
Radioactive wastes, 420

Radioactive dating, 258, 258, 258 lab, 259, 259, 260 act, 420, 420
Radiometric dating, 259, 259–260, 260
Radio waves, 709
Radon, 447
Rain, extreme amounts of, 142
Rain forests, leaves in, 158 lab; life in, 94, 94; temperate, 157, 157; tropical, 154, 158, 158–159; water in, 123
Rainier, Mount (Washington state), 223
Rain shadow effect, 128, 128
Rasmussen, Knud, 686
Rate of reaction, 504, 504–508, 505, 506
Ratio, input coils/output coils, 681
Reactant, 494, 495, 496, 497
Reaction, and action, 563–566, 566, 566; chemical, 76 lab, 589. See Chemical reactions
Reaction rate, 504, 504–508, 505, 506
Recessive traits, 45
Recycling, 385
Red blood cells, 69
Red giants, 381, 381, 383, 383, 384, 394, 394
Red shift, 389, 389
Reef, 94, 94, 167, 167, 167 act
Reflection, law of, 699, 699; of sound, 705; of waves, 699, 699, 699 lab
Refraction, 699; of waves, 699, 699
Refrigerators, 622, 622
Regulation, of glucose levels, 80, 80
Relative ages, 251–256, 256 lab
Relative dating, 251 act
Relative motion, 523, 523
Representative elements, 435
Reproduction, artificial selection, 276, 276
Reproductive system, 71
Reptiles, 284, 284, 288, 296, 296
Research, 7; conclusions in, 19; data in, 18; descriptive, 13, 14–15, 15, 20; design of, 13, 15, 15, 21, 21–23, 22, 23; eliminating bias in, 15; equipment used in, 16, 17; experimental, 13, 20, 21, 21–23, 22, 23; in medicine, 27, 27; objective of, 14; scientific measurement in, 17; selecting materials for, 16, 16; using models in, 16
Resistance, 646, 646–647, 647, 648, 648, 649
Respiration, 76, 76; and exercise, 82–83 lab; and oxygen, 76, 77, 123; and photosynthesis, 135 lab
Respiratory system, 71, 76, 76; and circulatory system, 73, 73
Retina, 711, 711, 713, 713
Revolution, 705
Reverse fault, 211, 211
Revolution, 305 lab, 307, 309, 312
Rhinoceros, 92, 92
Rhodium, 449
Ribonucleic acid (RNA), 56, 67
Richter scale, 214, 216
Rift, 227
S

Salt(s), 441, 446, 446; in body, 66; bonding in, 472, 472–473, 473; movement of ions in, 637, 637
Saltwater ecosystems, 166–169; coral reefs, 167, 167, 167 act; estuaries, 168–169, 169; oceans, 167; seashores, 168, 168
San Andreas Fault, 194, 194, 198, 234
Sand, 443
San Francisco earthquake (1906), 234, 234
Satellite(s), 561
Satellite Laser Ranging System, 198, 198
Saturn, 340, 350, 350, 355, 355, 360–361 lab
Savannas, 161, 161
Science, 6–29; in advertising, 7; communication in, 10, 10–11; and problem solving, 6, 6, 8, 8, 12 lab, 13, 13, 14 act; and technology, 9, 24, 24–27, 25, 28–29 lab
Science and History, Quake, 234; Synthetic Diamonds, 512; The Census Measures a Human Population, 114; The Mayan Calendar, 328; Pioneers in Radioactivity, 426
Science and Language Arts, “Aagjuuk and Sivulliit” (Rasmussen), 686; “Anansi Tries to Steal All the Wisdom in the World”, 456; “Baring the Atom’s Heart” (Awiaatta), 484; The Everglades: River of Grass, 30; Listening In, 202
Science and Society, Air Bag Safety, 572; Bionic People, 600; Creating Wetlands to Purify Wastewater, 172; Fire in the Forest, 658; Food for Thought, 426; The Heat Is On, 626; How Did Life Begin?, 56
Science Online, Automobile Engines, 620; Birth and Death Rates, 102; Changing Gender, 42; Chemical Equations, 497; Collisions, 536; Compasses, 671; Continental Drift, 183; Coral Reefs, 167; Correlating with Index Fossils, 254; Cost of Electrical Energy, 653; Different Species, 52; Disease Control, 8; Earthquake Magnitude, 216; Earthquakes and Volcanoes, 192; Eclipses, 315; Electrons, 466; Elements, 438; Ellipses, 309; Eutrophication, 151; Evolution of Stars, 382; The Far Side, 323; Galileo and Newton, 553; Health Risks, 452; Historical Tools, 587; How Birds Fly, 564; Human Population Data, 96; Isotopes in Ice Cores, 260; Isotopes in Medicine and Agriculture, 421; James Watt, 584; Land Speed Record, 526; Lasers, 708; Life Processes, 135; Mars Exploration, 346; Montserrat Volcano, 221; Negative Feedback, 80; Olympic Torch, 503, 503; Paleozoic Life, 284; Polar Molecules, 477; Power Plants, 679; Radioactive Decay, 416; Relative Dating, 251; Seasons, 311; Solar System, 337; Space Weather, 377; Student Scientists, 25; Superconductors, 640; Warm Versus Cold, 289; Water, 66; Weather Data, 127
Science Stats, Astonishing Human Systems, 84; Extinct!, 296; Extreme Climates, 142; Stars and Galaxies, 394
Science writer, 165
Scientific information, use of, 27
Scientific measurement, 17
Index

Scorpion, 160
Screw, 593, 596
Sea anemone, 108, 108
Seafloor spreading, 186, 187–188, 189 lab
Seashores, 168, 168
Seasons, 309, 309–310, 310, 311 act, 326–327 lab; on Mars, 346
Sea stars, 168
Secondary succession, 151, 152, 153
Second-class lever, 595
Secretion, 78
Seed(s), movement of, 103, 103
Seedling competition, 99 lab
Seed plants, angiosperms, 290; gymnosperms, 290
Seismic-safe structures, 209 lab, 217, 217–218, 234
Seismograph, 213, 213, 214, 214
Selection, artificial, 276, 276; natural, 275, 275–276, 276
Selective breeding, 52, 52
Selenium, 445, 445
Semiconductors, 443, 443
Sense(s), hearing, 493, 703, 704; sight, 493; smell, 493; taste, 493; touch, 493; vision, 711–713, 712
Series circuit, 650, 650
Shark, 243
Shear forces, 211
Sheep, 103
Shield volcano, 222, 222
Shock, electric, 653–654
SI (International System of Units), 17
Sight. See Vision
Silicon, 443, 443
Silver tarnish, 480, 480, 497
Simple machines, 591–599; inclined plane, 591–593, 592; lever, 594, 594, 595, 595; pulley, 596 lab, 596–599, 597, 598–599 lab; screw, 593, 593; wedge, 592, 592–593, 593; wheel and axle, 594, 594, 596, 596
Sirius, 370, 372
Skeletal muscles, 69
Skeletal system, 71, 84
Sliding friction, 553, 554, 554, 555, 559, 562
Smell, 493
Smoke detectors, 417, 417
Smooth muscles, 69
Sodium, 65, 469, 472, 472–473, 473
Sodium bicarbonate, 494, 495, 496
Sodium chloride, 66, 441, 446, 446
Soil, 124; as abiotic factor in environment, 124, 124
Soil, 124; changing, 287 lab; differences within, 51, 52 act; and environment, 50–53, 51, 52, 53, 54–55 lab; extinction of, 53, 53, 286, 286, 288, 291 act, 296, 296; natural selection within, 276, 276; new, 276; pioneer, 150, 151
Specific heat, 616
Spectroscope, 374
Spectrum, electromagnetic, 708–709, 709; of star, 374, 374, 389, 389
Speed, 524–525; and acceleration, 528, 528–529; of animals, 524; average, 525, 525, 525 lab; calculating, 524 act; constant, 525, 525; and distance-time graphs, 526, 526; of heating and cooling, 618 lab; instantaneous, 525, 525; land, 526 act; of light, 707; and motion, 524–525, 525; of sound, 698 act, 702; and velocity, 527; of waves, 698
Speed-time graph, 532, 532
Sphere, 306, 306–307

Sound waves, 692, 698 act, 701–706; as compressional waves, 701, 701; frequency of, 703; making, 701, 701; in matter, 706 lab
South Pole, 142
Space, distance in, 372 act, 373, 388 lab; light waves in, 707, 707; measurement in, 373, 388 lab; weather in, 375 act
Space exploration, of Jupiter, 348; of Mars, 344–346, 346 lab; of Mercury, 342; of Moon, 322, 322–325; of Neptune, 352; of Pluto, 353; of Saturn, 350; of Uranus, 351; of Venus, 343
Space probes, Cassini, 350; Galileo, 348, 359; Global Surveyor, 345, 346; Magellan, 343, 343; Mariner, 342, 343; Mars Odyssey, 345; Mars Pathfinder, 345; NEAR, 359; Stardust, 357; Viking, 345, 346; Voyager, 348, 349, 349, 350, 351, 352
Space shuttle, 568, 568
Species, 274, 274; changing, 287 lab; differences within, 51, 52 act; and environment, 50–53, 51, 52, 53, 54–55 lab; extinction of, 53, 53, 286, 286, 288, 291 act, 296, 296; natural selection within, 276, 276; new, 276; pioneer, 150, 151
Sphere, 306, 306–307

808 STUDENT RESOURCES
Spiders, 109
Spiral galaxy, 386, 386–387
Sports, Newton’s laws in, 565
Star(s), 370–374; absolute magnitude of, 372; apparent magnitude of, 372; binary, 378; classifying, 380–381; constellations of, 370, 370–371, 371; evolution of, 382 act, 382–385, 383; fusion reaction in, 381–382, 382; life cycle of, 382–385, 383; main sequence, 380, 380–381, 382, 383; neutron, 384; patterns of, 371 lab; properties of, 374, 374; spectrum of, 374, 374, 389; Sun as, 375, 378; triple, 378
Star cluster, 378, 378
Stardust spacecraft, 357
Static charge, 637, 637
Static friction, 554
Steady state theory, 388
Steel, 448, 448
Stem(s), 40 lab
Stirrup (of ear), 704, 704
Stream(s), 163, 163–164
Strike-slip fault, 198, 198, 211, 211
Stromatolites, 270, 270, 281, 281
Strong nuclear force, 416
Student scientists, 25 act
Subduction zones, 192, 194, 228
Subscripts, 479, 496
Succession, 150–153, 152; primary, 150–151, 151, 153; secondary, 151, 152, 153
Sugars, in blood, 80, 80
Sulfur, 65, 645
Sulfuric acid, 445
Sun, 375–379, 385; atmosphere of, 375, 375; as center of solar system, 337; corona of, 375, 375; distance from Earth, 307, 309, 360–361 lab; and Earth’s rotation, 307; eclipse of, 314, 314, 315, 315; electromagnetic waves from, 710, 710; energy from, 120; layers of, 375, 375; origin of, 338, 339; radiation from, 310; as star, 375, 378; surface features of, 376, 376–377, 377; temperature of, 375
Sunlight, ultraviolet waves in, 710
Sunset Crater, Arizona, 222, 222
Sunspots, 376, 376, 379 lab
Superconductors, 640 act, 681, 681–682, 682
Supergiants, 381, 381, 384
 Supernova, 384
Superposition principle, 250, 250
Survival, and environment, 108
Symbiosis, 108, 108
Symbols, for atoms, 479, 479; for compounds, 479, 479; for elements, 440
Synthetic elements, 421–423, 422, 450, 451
System(s), See Body systems
Taiga, 156, 156
Tarnish, 480, 480, 497
Taste, 493
Technetium-99, 423
Technology, 9, 24, 24–27, 25, 28–29 lab. See also Space probes; advances in, 25, 25; air conditioners, 623; ammeter, 674, 675; bicycle, 591, 591; catalytic converters, 507, 507; cathode-ray tube (CRT), 406, 406, 407, 407; circuit breakers, 651, 651; compass, 308, 308 lab, 666, 671, 671 act, 672 lab; computers, 443, 443; in dentistry, 452; electric meter, 653, 653; electric motors, 676, 676, 684–685 lab; electromagnets, 673, 673–674, 674, 674 lab; fingerprinting, 37 lab; fireworks, 502, 502; fuses, 651, 651; galvanometer, 674, 675; generators, 678, 678–679; Hubble Space Telescope, 352, 353, 357, 384, 391; internal combustion engines, 620, 620, 620 act, 621; Internet, 28–29 lab; lasers, 708 act; lightbulb, 449, 449, 468; lightning rod, 642, 642; maglev, 664, 664, 665; magnetic resonance imaging (MRI), 682, 682–683, 683; magnetometer, 188; particle accelerator, 421, 421, 451, 451; power plants, 679, 679, 679 act; for predicting earthquakes, 218, 218; pyramids, 579 lab, 585 lab; radiation therapy, 423; refrigerators, 622, 622; rockets, 566, 566, 569 lab; Satellite Laser Ranging System, 198, 198; satellites, 561; seismograph, 213, 213, 214, 214; semiconductors, 443, 443; smoke detector, 417, 417; space shuttle, 568, 568; spectroscope, 374; superconductors, 681, 681–682, 682; synthetic elements, 421–423, 422, 450, 451; testing for plate tectonics, 198–199, 199; thermometers, 609, 609; transformers, 680, 680–681; Tsunami Warning System, 215; voltmeter, 674, 675; welding torch, 499
Tectonic plates. See Plate(s); Plate tectonics
Tectonics. See Plate tectonics
Teeth, dentistry, 452; of herbivores and carnivores, 593, 593
Telescopes, Hubble, 352, 353, 357, 384, 391
Tellurium, 445
Temperate deciduous forests, 154, 156, 156–157
Temperate rain forests, 157, 157
**Temperature**

- **Temperature**, 607 lab, 608, 608–610; as abiotic factor in environment, 125, 125–126, 126; of body, 589; converting measures of, 166 act; and elevation, 126, 126, 126 act; extreme, 142, 142; of human body, 79, 79; and land, 154; measuring, 609, 609–610; of oceans, 166; and rate of reaction, 504, 504–505, 505; of Sun, 375; and thermal energy, 611, 611; and tilt of axis, 326–327 lab
- **Temperature scales**, Celsius, 609, 609–610, 610 act; converting, 610, 610 act; Fahrenheit, 609, 609–610, 610 act; Kelvin, 610
- **Teosinte**, 38, 38
- **Tephra**, 219, 223
- **Termites**, 109, 109
- **Thermal conductors**, 615
- **Thermal energy**, 606–626, 609, 611, 619, 619, 621; and heat, 612–615; and temperature, 611, 611; transfer of, 612–614, 613, 614
- **Thermal expansion**, 609, 609
- **Thermal insulators**, 616, 616, 624–625 lab
- **Thermal pollution**, 617, 617
- **Thermometer**, 5 lab, 609, 609
- **Third-class lever**, 595
- **Thomson, J. J.**, 407–408, 410
- **Thorium**, 450
- **Thyroid gland**, 422, 423
- **TIME**, Science and History, 114, 234, 328, 426, 512; Science and Society, 56, 172, 426, 572, 600, 626, 658
- **Tin**, 443
- **Tissues**, 69, 70, 70
- **Titan (moon of Saturn)**, 350
- **Titania (moon of Uranus)**, 351
- **Tools**, historical, 587 act
- **Tornadoes**, 142
- **Touch**, 493
- **Trace fossils**, 246, 246, 262–263 lab
- **Tracer elements**, 421–423, 422
- **Tracks**, of dinosaurs, 246, 246
- **Traits**, 36–55, 38; dominant, 45, 45; and environment, 40, 40–41, 41, 42, 49–53; and genetics, 44–48; and mutations, 52; observing, 38, 38; predicting, 44–48; recessive, 45
- **Transformer**, 680, 680–681
- **Transform plate boundaries**, 194, 194
- **Transition elements**, 435, 448, 448–452, 449; in dentistry, 452; inner, 450, 450, 451
- **Transmutation**, 416–418, 421, 421
- **Transpiration**, 130
- **Transverse waves**, 695, 695, 696, 697, 697
- **Trials**, 22
- **Triassic Period**, 288, 288, 289
- **Triceratops**, 242
- **Trilobites**, 272, 272, 277, 277–278, 278
- **Triple bonds**, 476, 476, 477
- **Triple stars**, 378
- **Triton (moon of Neptune)**, 352, 352
- **Tropical rain forests**, 154, 158, 158–159, 159; life in, 94, 94
- **Try at Home Mini Labs**, Assembling an Electromagnet, 674; Calculating the Age of the Atlantic Ocean, 292; Comparing Paper Towels, 18; Comparing Rates of Melting, 614; Comparing the Sun and the Moon, 313; Constructing a Model of Methane, 475; Determining Soil Makeup, 124; Identifying Inhibitors, 506; Interpreting Fossil Data, 184; Investigating the Electric Force, 644; Measuring Average Speed, 525; Modeling an Eruption, 220; Modeling the Nuclear Atom, 411; Modeling Planets, 350; Modeling Rain Forest Leaves, 158; Modeling a Shaded-Impact Basin, 323; Observing Friction, 554; Observing Gravity and Stem Growth, 40; Observing Seedling Competition, 99; Observing Star Patterns, 371; Predicting Fossil Preservation, 243; Refraction of Light, 699; Work and Power, 583
- **Tsunami**, 215, 216
- **Tube worms**, 187
- **Tundra**, 155, 155
- **Tungsten**, 449, 449
- **Tyrannosaurus rex**, 243
- **Ultraviolet waves**, 710
- **Umbra**, 315, 316, 316
- **Unbalanced forces**, 551
- **Unconformities**, 252, 252, 253
- **Uniformitarianism**, 261, 261
- **Uranium**, 415, 416, 420, 450, 451
- **Uranus**, 340, 351, 351, 355, 355, 360–361 lab
- **Urinary system**, 71, 78, 78–79
- **Ursa Major**, 371, 371
- **Use the Internet**, Discovering the Past, 294–295; Exploring Wetlands, 170–171; Health Risks from Heavy Metals, 454–455; Predicting Tectonic Activity, 200–201; When is the Internet the busiest?, 28–29
- **Uterus**, 81, 81

**Vinegar**

- **Vinegar**, 494, 495, 496

**Variables**, dependent, 17; independent, 17

**Veins**, modeling blood flow in, 63 lab

**Velocity**, 527; and acceleration, 528, 528–529, 529; and speed, 527

**Venera space probe**, 343

**Venus**, 95, 336, 337, 340, 343, 354, 354, 360–361 lab

**Vertebrate animal(s)**, amphibians, 284; early, 282, 282, 284; mammals, 290, 290, 293, 293; reptiles, 284, 284, 288, 296, 296

**Viking space probes**, 345, 346

**Villi**, 75, 75
Visible light, 709, 709
Vision, 493, 711–713, 712
Vision defects, 712
Volcano(es), 219–225, in early Earth history, 280, 285, 285; and Earth’s plates, 219, 219, 226, 226–228, 227; eruptions of, 220, 220, 220; formation of, 219, 219–221, 227–228, 228; forms of, 221–223, 222, 223; on other planets, 344, 344, 349, 349; and plate tectonics, 192; risks of, 221, 221
Volcanologist, 202
Voltage, 644, 644, 648, 649, 649; changing direction of, 680–681
Voltmeter, 674, 675
Volume, calculating, 77
Voyager space probes, 348, 349, 349, 350, 351, 352
Wallace, Alfred Russell, 50
Waning, 314, 314
Waste(s), eliminating, 78, 78–79; production of, 76, 79; radioactive, 420
Wastewater, purifying, 172, 172
Water. See also Aquatic ecosystems; as abiotic factor in environment, 122, 123, 123; from hydrothermal vents, 137; as limiting factor in ecosystem, 100; in living things, 66, 66; molecules of, 477, 477; pollution of, 165, 165, 170–171; use of, 131
Water cycle, 130, 130–131, 131
Water waves, 692
Watt (W), 583
Watt, James, 583, 584
Wave(s), 694–700; amplitude of, 697, 697; changing direction of, 699, 699–700, 700; compressional, 695, 695, 696, 696, 697, 697, 701, 701; diffraction of, 700, 700; electromagnetic, 696, 707, 708, 708, 708, 710; electrons as, 413; and energy, 694, 694; frequency of, 696; infrared, 709; microwaves, 697; properties of, 693; radio, 709; reflection of, 699, 699, 699; refraction of, 699, 699; seismic, 212, 212–213, 214, 230, 230; sound. See Sound waves; speed of, 698; transverse, 695, 695, 696, 696, 697; tsunami, 215, 216; types of, 694–696; ultraviolet, 710; visible light, 709, 709; water, 692
Wavelength, 696, 696; of light, 707
Waxing, 314, 314
Waxing, 314, 314
Weather, 127; in space, 375
Wedge, 592, 592–593, 593
Wegener, Alfred, 182, 183, 184, 185
Weight, 557–558; and mass, 558; measuring, 567, 567
Weightlessness, 567, 567–568, 568
Welding, 499
Wetlands, 165, 165, 170–171
Whtales, 293
Wheel and axle, 594, 594, 596, 596
White blood cells, 69
White dwarf, 381, 383, 383
Wildebeests, 100
Wildfires, 148, 151; benefits of, 148, 152; in forests, 658, 658
Williams, Daniel Hale, 26
Wind, 127, 127, 142
Wire, copper, 646; electric, 640, 646, 646
Wombat, 293, 293
Woodpeckers, 97, 97, 98, 98
Work, 580–582; calculating, 582, 582; and distance, 582, 588, 588; and energy, 584; equation for, 582; and force, 579; 581, 585; lab, 587; measuring, 584; and mechanical advantage, 586, 586–588; and motion, 580, 580–581, 581; and power, 583
Xenon, 447
X rays, 710
Yttrium oxide, 450
Zewail, Ahmed H., 467, 484
Zinc, 65, 645
Credits

Magnification Key: Magnifications listed are the magnifications at which images were originally photographed.
LM—Light Microscope
SEM—Scanning Electron Microscope
TEM—Transmission Electron Microscope

Acknowledgments: Glencoe would like to acknowledge the artists and agencies who participated in illustrating this program: Absolute Science Illustration; Andrew Evansen; Argosy; Articulate Graphics; Craig Attebery represented by Frank & Jeff Lavaty; CHK America; John Edwards and Associates; Gagliano Graphics; Pedro Julio Gonzalez represented by Melissa Turk & The Artist Network; Robert Hynes represented by Mendola Ltd.; Morgan Cain & Associates; JTH Imaging; Laurie O’Keefe; Matthew Pippin represented by Beranbaum Artist’s Representative; Precision Graphics; Publisher’s Art; Rolin Graphics, Inc.; Wendy Smith represented by Beranbaum Artist’s Representative; Precision Graphics; Gagliano Graphics; Pedro Julio Gonzalez represented by Melissa Turk & The Artist Network; Kevin Torline represented by Berendens and Associates, Inc.; WILDlife ART; Phil Wilson represented by Cliff Knecht Artist Representative; Zoo Botanica.

Photo Credits
Cover PhotoDisc; i (bkgd)Arnulf Husmo/Getty Images, (l)Georgette Douwma/Getty Images, (r)John Lawrence/Getty Images; ii (bkgd)Arnulf Husmo/Getty Images, (l)Georgette Douwma/Getty Images, (r)John Lawrence/Getty Images; vii Aaron Haupt; viii John Evans; ix (t)PhotoDisc, (b)John Evans; x (l)John Evans, (r)Geoff Butler; xi (l)John Evans, (r)PhotoDisc; xii PhotoDisc; xiii Marian Bacon/Animals Animals; xiv (t)Dwight Kuhn, (b)John Kaprielian/Photo Researchers; xv Kevin Winst/AF/Wide World Photos; xvi (t)Pat O’Hara/CORBIS, (b)JPL; xvi Peter Menzel/Stock Boston; xviii Richard Megna/Fundamental Photographs/Photo Researchers; xix Philip Bailey/The Stock Market/CORBIS; xx AFP Photo/Hector Mata/CORBIS; xxi Matt Meadows; xxii Jeff J. Daly/Visuals Unlimited; xxiii Alexus Duclos/Liaison/Getty Images; xxvi Otto Hahn/Peter Arnold, Inc.; xxvii Bob Daemmrich; I R. Arndt/Visuals Unlimited; 2 (l)Sinclair Stammers/Science Photo Library/Photo Researchers, (r)James D. Wilson/Woodfin Camp & Assoc.; 2–3 (bkgd)WT Sullivan III/Science Photo Library/Photo Researchers; 4–5 TKE Image/Science Photo Library/Photo Researchers; 6 (tr)Stephen Webster, (others)KS Studios; 7 8 Aaron Haupt; 9 (t)Bob Daemmrich, (bl)Paul A. Souders/CORBIS, (br)KS Studios; 10 Aaron Haupt; 11 Geoff Butler; 14 KS Studios; 15 (l)Icon Images, (r)F. Fernandes/Washington Stock Photo; 16 Aaron Haupt; 17 Matt Meadows; 18 Doug Martin; 19 Aaron Haupt; 20 (tr)courtesy IWA Publishing, (others)Patricia Lanza; 21 Amanita Pictures; 22 John Evans; 23 Jeff Greenberg/Visuals Unlimited; 24 KS Studios; 25 The Image Bank/Getty Images; 26 (l)Sarita M. James, (tc)AFP/CORBIS, (tr)James D. Wilson/Liaison Agency/Getty Images, (c)Bob Rowan/Progressive Image/CORBIS, (cr)Fred Begay, (bl)NASA, (bc)CORBIS, (bcr)Providence Foundation/CED Photographic Service, (cl br)Bettmann/CORBIS; 27 The Image Bank; 28 (tr)Dominic Oldershaw, (bl)Richard Hutchings; 29 Dominic Oldershaw; 30 Gary Retherford/Photo Researchers; 33 Amanita Pictures; 34 (l)Aaron Haupt, (r)Geoff Butler; 35 (l)Doug Martin, (r)Aaron Haupt; 36–37 Tim Davis/CORBIS; 38 (l)Ronk/Schoenberger from Grant Heilman, (r)Alan Pitcairn from Grant Heilman; 40 Hermann Eisenbeiss/Photo Researchers; 41 (t)Alan & Sandy Carey/Photo Researchers, (b)Ronk/Schoenberger from Grant Heilman; 42 Marian Bacon/Animals Animals; 44 David Parker/Science Photo Library/Photo Researchers; 45 unknown; 48 Getty Images; 49 Ken Lucas/Visuals Unlimited; 50 Karl H. Maslowski/Photo Researchers; 51 (t)Mickey Gibson/Animals Animals, (others)Tui DeRoy/Bruce Coleman, Inc.; 52 (tl)Mark Stouffer/Animals Animals, (tc)Kenneth W. Fink/Photo Researchers, (tr)George F. Godfrey/Animals Animals, (bl)Cathy & Gordon/ILLG/Animals Animals; 54 Ian Adams; 55 David Woodfall/Stone/Getty Images; 56 (t)Keven Laubacher/FPG, (b) Michael Black/Bruce Coleman, Inc.; 57 Kenneth W. Fink/Photo Researchers; 58 Alan Pitcairn from Grant Heilman; 60 Ronk/Schoenberger from Grant Heilman; 61 Bios (Klein & Hubert)/Peter Arnold, Inc.; 62–63 Paul A. Souders/CORBIS; 64 Barry L. Runk from Grant Heilman; 66 Laura Sifferlin; 67 Prof. Oscar Miller/Science Photo Library/Photo Researchers; 69 (cw from top)Ken Eward/Science Source/Photo Researchers, Cabisco/Visuals Unlimited, Eric Grave/Science Source/Photo Researchers, Robert Knauf/Biology Media/Photo Researchers, Quest/Science Photo Library/Photo Researchers, Science Vu/Visuals Unlimited, Stan Elems/Visuals Unlimited, Cabisco/Visuals Unlimited; 70 72 76 Bob Daemmrich; 78 Laura Sifferlin; 79 Rolf Bruderer/The Stock Market/CORBIS; 82 (t)Bob Daemmrich, (b)KS Studios; 83 KS Studios; 89 National Cancer Institute/Science Photo Library/Photo Researchers; 90–91 (bkgd)Lynn M. Stone; 91 (inset)Mark Burnett; 92–93 Joe McDonald/Visuals Unlimited; 94 (tr)Richard Kolar/Animals Animals, (l)Adam Jones/Photo Researchers, (c)Tom Van Sant/Geosphere Project, Santa Monica/Science Photo Library/Photo Researchers, (br)G. Carleton Ray/Photo Researchers; 95 (t)John W. Bova/Photo Researchers, (b)David Young/Tom Stack & Assoc.; 97 (l)Zig Leszczynski/Animals Animals, (r)Gary W. Carter/Visuals Unlimited; 100 Mitsuaki Iwagoo/Minden Pictures; 101 Joel Sartore from Grant Heilman; 103 (t)Norm Thomas/Photo Researchers, (b)Maresa Pryor/Earth Scenes; 104 (r)Bud Neilson/Words & Pictures/PictureQuest, (others)Wayman P. Meiner; 106 (l)Michael Abbey/Photo Researchers, (r)OSF/Animals Animals, (b)Michael P. Gadomski/Photo Researchers; 107 (tc)Lynn M. Stone, (l)Larry Kimball/Visuals Unlimited, (bc)George D. Lepp/Photo Researchers, (bcr)Stephen J. Krassmann/Peter Arnold, Inc., (br)Mark Steinmetz, (others)William J. Weber; 108 (t)Milton Rand/Tom Stack & Assoc., (c)Marian Bacon/Animals Animals, (b)Sinclair Stammers/Science Photo Library/Photo Researchers; 109 (l)Raymond A. Mendez/Animals Animals, (br)Donald Specker/Animals Animals, (br)Joe McDonald/Animals Animals; 110 Ted Levin/Animals Animals; 111 Richard L. Carlton/Photo Researchers; 112 (t)Jean Claude Rey/PhotoTake, NYC, (b)OSF/Animals Animals; 113 Runk/Schoenberger from Grant Heilman; 114 Eric Larrañadie/Stone/Getty Images; 115 (l)C.K. Lorenz/Photo Researchers, (r)Hans Pfletsching/Peter Arnold, Inc.; 116 CORBIS; 118 (l)Michael P. Gadomski/Photo Researchers, (r)William J. Weber; 120–121 Ron Thomas/Getty Images; 122 Kenneth Murray/Photo Researchers; 123 (t)Jerry L. Ferrara/Photo Researchers, (b)Art Wolfe/Photo Researchers; 124 (t)Telegraph Colour Library/FPG/Getty Images, (b)Hal Berai/Visuals Unlimited; 125 (l)Fritz Polking/Visuals Unlimited,
650 Doug Martin; 651 (t) Doug Martin, (b) Geoff Butler; 
653 Bonnie Freer/Photo Researchers; 655 Matt Meadows; 
656 657 Richard Hutchings; 658 (bkdg) Tom & Pat Leeson/ 
Photo Researchers, (inset) William Munoz/Photo Researchers; 
662 J. Tinning/Photo Researchers; 663 Doug Martin; 
664–665 James Leynse/CORBIS; 667 Richard Megna/ 
Fundamental Photographs; 668 Amanita Pictures; 671 John 
Evans; 672 Amanita Pictures; 673 (l) Kodansha, (c) Manfred 
Kage/Peter Arnold, Inc., (t) Doug Martin; 677 Bjorn Backe/ 
Papilio/CORBIS; 679 Norbert Schafer/The Stock Market/ 
CORBIS; 681 AT&T Bell Labs/Science Photo Library/Photo 
Researchers, (t) Richard Hutchings, (b) Tony Freeman/ 
PhotoEdit, Inc.; 682 (t) Science Photo Library/Photo 
Researchers, (c) Fermilab/Science Photo Library/Photo 
Researchers, (b) SuperStock; 683 PhotoDisc; 684 (t) file photo, 
(b) Aaron Haupt; 685 Aaron Haupt; 686 John MacDonald; 
687 (l) SIU/Peter Arnold, Inc., (r) Latent Image; 691 John 
Evans; 692–693 Mark A. Johnson/CORBIS; 694 (l) David W. 
Hamilton/Getty Images, (r) Ray Massey/Getty Images; 
699 700 Richard Megna/Fundamental Photographs; 
702 David Young-Wolff/Photo Edit, Inc.; 703 (t) Ian 
O’Leary/Stone/Getty Images, (tr) David Young-Wolff/ 
PhotoEdit, Inc., (bl) Mark A. Schneider/Visuals Unlimited, 
(bc) Rafael Macia/Photo Researchers, (br) SuperStock; 
705 AFP Photo/Hector Mata/CORBIS; 706 Matt Meadows; 
707 James Blank/Getty Images; 712 (t) Nation Wong/ 
CORBIS, (b) Jon Feingersh/CORBIS; 713 Ralph C. Eagle 
Jr./Photo Researchers; 714 715 Matt Meadows; 
716 (t) Bettmann/CORBIS, (bl br) image courtesy of NRAO/ 
AUI; 721 (l) Edward Burchard/Index Stock, (r) David Young- 
Wolff/Photo Edit, Inc.; 722 PhotoDisc; 724 Tom Pantages; 
728 Michell D. Bridwell/PhotoEdit, Inc.; 729 (t) Mark 
Burnett, (b) Dominic Oldershaw; 730 StudiOhio; 
731 Timothy Fuller; 732 Aaron Haupt; 734 KS Studios; 
735 Matt Meadows; 738 Rod Planck/Photo Researchers; 
742 Runk/Schoenberger from Grant Heilman; 
744 (t) Amanita Pictures, (b) Mark Burnett; 747 Icon Images; 
748 Amanita Pictures; 749 Bob Daemmrich; 751 Davis 
Barber/PhotoEdit, Inc.