

**SCIENCE STANDARDS OF LEARNING**  
***ENHANCED SCOPE & SEQUENCE***

**GRADE 6**

*Commonwealth of Virginia*  
*Department of Education*  
*Richmond, Virginia*  
*2007*

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P.O. Box 2120  
Richmond, Virginia 23218-2120  
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The CTE Resource Center is a Virginia Department of Education grant project administered by the Henrico County Public Schools.

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## Preface

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The *Science Standards of Learning Enhanced Scope and Sequence* is a resource intended to help teachers align their classroom instruction with the Science Standards of Learning that were adopted by the Board of Education in January 2003. The *Enhanced Scope and Sequence* contains the following:

- Units organized by topics from the 2003 *Science Standards of Learning Sample Scope and Sequence*. Each topic lists the following:
  - Standards of Learning related to that topic
  - Essential understandings, knowledge, and skills from the *Science Standards of Learning Curriculum Framework* that students should acquire
- Sample lesson plans aligned with the essential understandings, knowledge, and skills from the *Curriculum Framework*. Each lesson contains most or all of the following:
  - An overview
  - Identification of the related Standard(s) of Learning
  - A list of objectives
  - A list of materials needed
  - A description of the instructional activity
  - One or more sample assessments
  - One or more follow-ups/extensions
  - A list of resources
- Sample released SOL test items for each Organizing Topic.

School divisions and teachers can use the *Enhanced Scope and Sequence* as a resource for developing sound curricular and instructional programs. These materials are intended as examples of ways the essential understandings, knowledge, and skills might be presented to students in a sequence of lessons that has been aligned with the Standards of Learning. Teachers who use the *Enhanced Scope and Sequence* should correlate the essential understandings, knowledge, and skills with available instructional resources as noted in the materials and determine the pacing of instruction as appropriate. This resource is not a complete curriculum and is neither required nor prescriptive, but it can be a valuable instructional tool.

## Acknowledgments

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We wish to express our gratitude to the following individuals for their contributions to the *Science Standards of Learning Enhanced Scope and Sequence* for Grade 6:

Linda Chin  
Fairfax County Public Schools

Robin Curtis  
King and Queen County Public Schools

Beth Sellars  
Roanoke County Public Schools

Rachel MacMillan  
Virginia Beach City Schools

Jenny Sue Flannagan  
Virginia Beach Public Schools

## Organizing Topic — Investigating the Solar System

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- observations are made involving fine discrimination between similar objects and organisms;
  - a classification system is developed based on multiple attributes;
  - precise and approximate measurements are recorded;
  - scale models are used to estimate distance, volume, and quantity;
  - hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - a method is devised to test the validity of predictions and inferences;
  - one variable is manipulated over time, using many repeated trials;
  - data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - models are designed to explain a sequence; and
  - an understanding of the nature of science is developed and reinforced.
- 6.8 The student will investigate and understand the organization of the solar system and the relationships among the various bodies that comprise it. Key concepts include
- the sun, moon, Earth, other planets and their moons, meteors, asteroids, and comets;
  - relative size of and distance between planets;
  - the role of gravity;
  - revolution and rotation;
  - the mechanics of day and night and the phases of the moon;
  - the unique properties of Earth as a planet;
  - the relationship of the Earth’s tilt and the seasons;
  - the cause of tides; and
  - the history and technology of space exploration.

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- describe the nine planets and their relative position from the sun;
- design and interpret a scale model of the solar system; (A scale model may be a physical representation of an object or concept. It can also be a mathematical representation that uses factors such as ratios, proportions, and percentages.)
- explain the role of gravity in the solar system;
- compare and contrast revolution and rotation and apply these terms to the relative movements of planets (and moons);
- model and describe how day and night and the phases of the moon occur;

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- model and describe how the Earth’s axial tilt causes the seasons;
- describe the unique characteristics of planet Earth;
- discuss the relationship between the gravitational pull of the moon and the cycle of tides;
- compare and contrast the ideas of Ptolemy, Aristotle, Copernicus, and Galileo related to the solar system;
- create and interpret a timeline highlighting the advancements in solar system exploration over the past half century. This should include information on the first modern rockets, artificial satellites, orbital missions, missions to the moon, Mars robotic explorers, and exploration of the outer planets.

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## **Football-Field Solar System**

(This lesson comes from the online *Earth in Space Workshop 7: The Solar System*. Science Museum of Virginia. Used by permission.)

**Organizing Topic** Investigating the Solar System

**Overview** Students discover the immensity of the sun’s family of planets, model the order of the planets, and become acquainted with their sizes, characteristics, and distances from the sun. They also practice estimating and measuring.

**Related Standards of Learning** 6.1; 6.8

### **Objectives**

The students should be able to

- describe the nine planets and their relative positions from the sun;
- design and interpret a scale model of the solar system.

### **Materials**

Per class or small group

- Planet, asteroid, and comet cards made from the attached masters
- Copies of the attached observation sheet
- Copies of the attached glossary
- Colored pencils or fine-tip markers (yellow, blue, red, gray, blue-green, brown, light brown, black)
- Metric/inch rulers
- Long measuring tape
- Dowels or small flags
- Index cards
- Pencils

### **Instructional activity**

#### ***Content/Teacher Notes***

This activity illustrates the sizes of the planets and their distances from the sun in a graphic way, using a fairly accurate scale. Make sure students understand that the planets’ orbits are elliptical and that therefore, the distance of each planet from the sun varies; for the purposes of this activity, the *average* distance of each planet from the sun will be used to construct the scale. Also emphasize that the planets are very rarely arranged in a straight line, as this model depicts, but are usually found in different places in their orbits around the sun.

This activity works well if the students are divided into 11 groups — a group for each of the nine planets, one for comets, and one for asteroids. Each group will be responsible for completing one card and for making its own set of measurements down the field. Students should already be familiar with the use of the ruler and measuring tape, and this activity is a perfect opportunity for them to practice using metric measurements.

The main part of the activity is designed to take place on a standard football field or other 300-foot clear space. As an alternative, the extension that follows provides a spreadsheet that can be used to create a scale of your own choosing. The extension also provides further spreadsheet exercises for the class.

Attached to this lesson are master sheets for making the planet, comet, and asteroid cards. Copy each page onto white card stock, then fold each page in half at the dotted line and glue the halves together to

create heavy 5½ x 8½ inch cards with the drawing and name of the celestial body on the front and the accompanying information about it on the back. The back of each card provides a space for the students to draw the body to scale. Scale information may be found on the attached Solar System Student Observation Sheet, in the given information about each body, or by using the spreadsheet described in the Follow-up/extension. Ask the students either to color the drawings of the celestial bodies, using the given color information, or for greater realism, to paste color images of the actual bodies onto the cards. Images can be found on many of the Web sites listed in the resources section on the next page.

### ***Procedure***

1. Hand out a copy of the attached two-page observation sheet to each student.
2. Put the students into 11 groups, and give each group one of the “celestial body” cards. Ask each group to use the data in the first table on the observation sheet to estimate the scale-model diameter of their celestial body and draw and color a circle of this diameter on an index card without using a ruler. The Venus circle should have a black outline with the interior left white. Pluto, the dwarf planet should be done the same.
3. Allow each group to use a ruler to make an accurate scale-model drawing of their celestial body by drawing a correctly sized and colored circle on their planet card. Have the groups compare the estimated drawings with the accurate ones.
4. Take the students to a 300-foot clear space, such as a football field, recreation area, empty parking lot, or large clear area at a local park. Tape the sun card on a pole or wall at eye-level at one end of the clear space. All measurements will be made from this point.
5. Ask each “planet group” to use the data in the second table on the observation sheet to estimate the distance from the sun to their planet and show this estimation by having one of their members stand where they believe their planet should be. The asteroid can be placed between Mars and Jupiter, and the comet can be located just beyond Pluto, recently reclassified as a dwarf planet.
6. Next, have the other members of each group measure and mark the exact location of their planet’s scale-model distance from the sun, using the long measuring tape. Have them place their planet card at this spot, securing it with a rock or other paperweight. Ask, “How did your group’s estimation compare with the actual distance?”
7. Have the class walk the entire solar system model, stopping at each celestial body card for that body’s group to read the description to the rest of the class.
8. Once the students have completed their trip through the solar system model, ask them to answer the questions on the observation sheet.

### ***Observations and Conclusions***

1. Review the questions on the observation sheet, discuss findings, and answer students’ questions. Use the terms on the attached Glossary in the class discussion.

### **Sample assessment**

- Assess the observation sheets and student participation in the scale-model exercise.

### **Resources**

- *Build a Solar System*. Exploratorium: The museum of science, art and human perception at the Palace of Fine Arts. [http://www.exploratorium.edu/ronh/solar\\_system/](http://www.exploratorium.edu/ronh/solar_system/).
- *Chronology of Lunar and Planetary Exploration*. NASA. <http://nssdc.gsfc.nasa.gov/planetary/chrono.html>.

- *Complete Sun and Moon Data for One Day*. Astronomical Applications Department of the U.S. Naval Observatory. [http://aa.usno.navy.mil/data/docs/RS\\_OneDay.html](http://aa.usno.navy.mil/data/docs/RS_OneDay.html).
- *The Earth*. NASA. <http://heasarc.gsfc.nasa.gov/docs/cosmic/earth.html>. Offers a Web-based tour of solar system distance scales.
- *Earth and Moon Viewer*. Fourmilab Switzerland. <http://www.fourmilab.ch/earthview/vplanet.html>.
- *Earth in Space: Teacher Training Module*. Science Museum of Virginia. <http://www.smv.org/pubs/EIS/Default.asp>. A comprehensive set of astronomy lessons and resources for grades K–6.
- *Moon and Planets Exploration Timeline*. Space Today Online. <http://www.spacetoday.org/History/ExplorationTimeline.html>.
- *The Nine Planets: A Multimedia Tour of the Solar System*. <http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html>.
- *NSSDC Photo Gallery*. NASA. [http://nssdc.gsfc.nasa.gov/photo\\_gallery](http://nssdc.gsfc.nasa.gov/photo_gallery). NASA’s National Space Science Data Center photo gallery for the solar system.
- *Orbital Changes: The Tilt in the Earth’s Axis*. Classroom of the Future. Wheeling Jesuit University – Center for Educational Technologies. <http://www.cotf.edu/ete/modules/mseese/dinosaurflr/tilt.html>.
- *Scale Model Solar System (Middle School Version)*. Sommers Bausch Observatory. Astrophysical and Planetary Sciences. University of Colorado. [http://lyra.colorado.edu/sbo/mary/stars/solar\\_systemtm.html](http://lyra.colorado.edu/sbo/mary/stars/solar_systemtm.html).
- *Seasons Orbit - Overview*. Michigan State University. [http://www.msu.edu/~russellr/portfolio/seasons\\_orbit/seasons\\_orbit\\_intro.html](http://www.msu.edu/~russellr/portfolio/seasons_orbit/seasons_orbit_intro.html).
- *Solar System Simulator*. NASA. <http://space.jpl.nasa.gov>.
- *Weight Loss*. MathNote.com. [http://www.mathnotes.com/aw\\_weight.html](http://www.mathnotes.com/aw_weight.html). Shows how to develop a spreadsheet to calculate your weight on each planet.
- *Welcome to the Planets*. <http://pds.jpl.nasa.gov/planets/welcome.htm>. A multimedia tour of the solar system by NASA’s Jet Propulsion Laboratory.

### Answer Key for Student Observation Sheet

1. Is Venus bigger than Mercury? (*Yes*)
2. Is Earth bigger than Venus? (*Yes*)
3. Is Mars bigger than Earth? (*No*)
4. Is Jupiter bigger than Mars? (*Yes*)
5. Is Saturn bigger than Jupiter? (*No*)
6. Is Uranus bigger than Saturn? (*No*)
7. Is Neptune bigger than Uranus? (*No*)
8. Is the dwarf planet Pluto bigger than Neptune? (*No*)
9. Do the planets get bigger as they get farther away from the sun? (*No*)
10. Which two planet markers are closest together? (*Mercury and Venus*)
11. Which two adjacent planet markers are farthest apart? (*Uranus and Neptune*)
12. Is the distance between Earth and Venus greater than the distance between Venus and Mercury? (*Yes*)
13. Is the distance between Mars and Earth greater than the distance between Earth and Venus? (*Yes*)

14. Is the distance between Jupiter and Mars greater than the distance between Mars and Earth? (*Yes*)
15. Is the distance between Saturn and Jupiter greater than the distance between Jupiter and Mars? (*Yes*)
16. Is the distance between Uranus and Saturn greater than the distance between Saturn and Jupiter? (*Yes*)
17. Is the distance between Neptune and Uranus greater than the distance between Uranus and Saturn? (*Yes*)
18. Think about the planet markers in your model. What happens to the distances between them (with the exception of the dwarf planet Pluto, which has many odd aspects to its orbit) as their distance from the sun becomes greater? (*The distances become greater.*)

Conclusions will vary, but may include the following observations:

- *The planets are very small compared to the sun. The solar system is very large compared to the Earth.*
- *The planets are very far from the sun.*
- *The terrestrial (or Earth-like) planets are small, rocky, dense, and closer to the sun than are the gas giants.*
- *The gas giant (or Jupiter-like) planets are large, but they are still much smaller than the sun. They are made mostly of gas and have no visible solid surface. They are less dense than the Earth-like planets. They have rings and many moons and are farther from the sun than the Earth-like planets.*
- *The dwarf planet Pluto does not fit into either of these groups of planets. It is usually the farthest from the sun and has an icy composition, like a comet.*
- *Comets can be very far from the sun. They can also travel in long, thin orbits that carry them close to the sun. They are small and icy, but evaporate in the sun's heat, creating a tail.*
- *Asteroids are commonly found between Mars and Jupiter. They are dense and much smaller than our moon.*

# Solar System Student Observation Sheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

- Use the data in the table at right to estimate the scale-model diameter of your celestial body. Draw and color a circle of this diameter on an index card without using a ruler. The Venus and the dwarf planet Pluto circles should have a black outline with the interiors left white.

Body	Color	Diameter	Comparable to
Sun	Yellow	27.0 mm	A quarter
Mercury	Gray	0.10 mm	A pinpoint or a grain of salt
Venus	White	0.24 mm	A bigger pinpoint or a grain of sand
Earth	Blue	0.25 mm	A bigger pinpoint or a grain of sand
Mars	Red	0.13 mm	A tiny pinpoint or a grain of salt
Jupiter	Light brown	2.82 mm	A pencil eraser
Saturn	Light brown	2.38 mm	A little smaller than a pencil eraser
Uranus	Blue-green	1.02 mm	A peppercorn or large grain of sand
Neptune	Blue	0.95 mm	A peppercorn or large grain of sand
Pluto*	White	0.04 mm	A very tiny pinpoint or grain of salt

- Use a ruler to make an accurate scale-model drawing of your celestial body: draw a correctly sized and colored circle on your celestial body card. How do your two drawings compare? \_\_\_\_\_
- Use the data in the table at right to estimate the distance from the sun to your planet. Show your estimation by having one of your group members stand where you believe your planet should be. The asteroid should be between Mars and Jupiter, and the comet should be just beyond the dwarf planet Pluto.
- Next, have the other members of your group measure and mark the exact location of your planet's scale-model distance from the sun, using the long measuring tape. Place your planet card at this spot, securing it with a rock or other paperweight. How did your estimation compare with the actual distance? \_\_\_\_\_
- Once you have completed your trip through the football-field solar system, answer the questions below, using the data in the charts. \*dwarf planet Pluto

Planet	Distance from Sun	Distance from Sun
Sun	0 cm	0 m
Mercury	96.7 cm	1.0 m
Venus	180 cm	1.8 m
Earth	250 cm	2.5 m
Mars	380 cm	3.8 m
Jupiter	1,300 cm	13.0 m
Saturn	2,384 cm	23.8 m
Uranus	4,783 cm	47.8 m
Neptune	7,500 cm	75.0 m
Pluto*	9,833 cm	98.3 m

## Find out whether there is a pattern to the sizes (diameters) of the planets:

- Is Venus bigger than Mercury? \_\_\_\_\_
- Is Earth bigger than Venus? \_\_\_\_\_
- Is Mars bigger than Earth? \_\_\_\_\_
- Is Jupiter bigger than Mars? \_\_\_\_\_
- Is Saturn bigger than Jupiter? \_\_\_\_\_
- Is Uranus bigger than Saturn? \_\_\_\_\_
- Is Neptune bigger than Uranus? \_\_\_\_\_
- Is the dwarf planet Pluto bigger than Neptune? \_\_\_\_\_
- Do the planets get bigger as they get farther away from the sun? \_\_\_\_\_

## Make your observations about solar system distances:

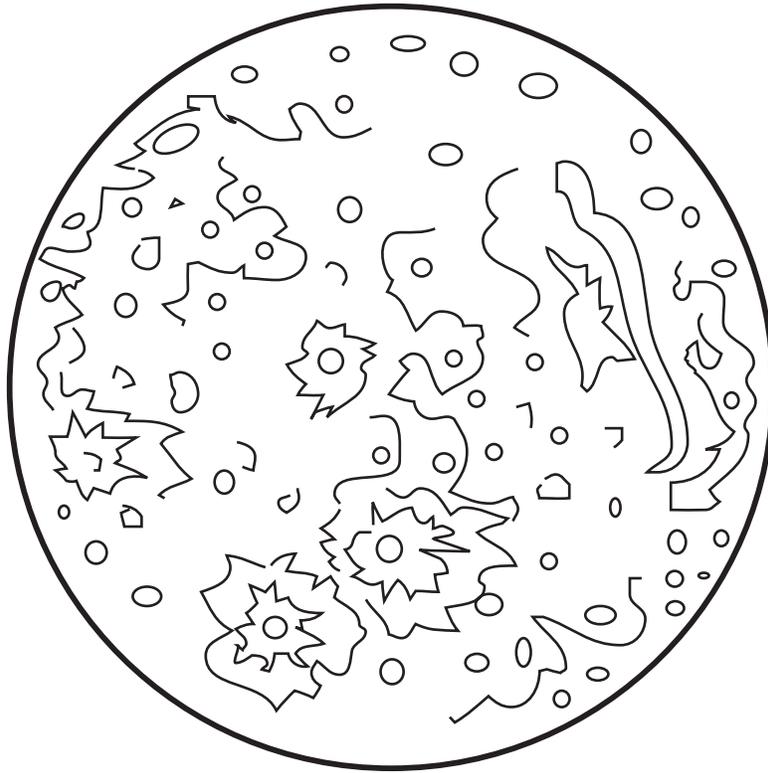
- Which two planet markers are closest together? \_\_\_\_\_



# Glossary

- asteroid.** Any of thousands of dense rocky objects typically in orbit around the sun between Mars and Jupiter. Asteroids are less than 300 km (186 miles) in diameter.
- comet.** A small object (10-25 km in diameter) composed of dust and frozen gases and in orbit around the sun. Comets are found at great distances from the sun (beyond the dwarf planet Pluto) in stable orbits or in long, elliptical orbits passing near the sun. A comet's tail is caused by evaporation of the surface of the comet by the heat of the sun.
- galaxy.** Any of numerous large-scale clusters of stars, gas, and dust that make up the universe. Galaxies contain an average of 100 billion solar masses and range in diameter from 1,500 to 300,000 light years.
- geometry.** The mathematics of the properties, measurement, and relationships of points, lines, angles, surfaces, and solids. From the Greek words meaning "to measure the Earth."
- moon.** The natural satellite of the Earth, having a mass of about 1/80 that of the Earth. Also, any natural satellite revolving around a planet.
- planet.** A nonluminous celestial body larger than an asteroid or comet and illuminated by light from a star, such as the sun, around which it revolves. In the solar system, there are nine known planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and the dwarf planet Pluto.
- solar system.** The sun together with the nine planets and all other celestial bodies that orbit the sun.
- sun.** The star that is the center of the solar system and that sustains life on Earth because it is the source of light and heat for the Earth. Also, any star that is the center of a planetary system.
- star.** A self-luminous celestial body consisting of a mass of gas held together by its own gravity and generating energy by nuclear reactions in its interior.
- universe.** All space, matter, and energy, including Earth, the galaxies and everything in them, and the contents of intergalactic space, regarded as a whole.

# Mercury



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**Mercury** is the planet closest to the sun. It looks very much like our moon, but is larger. It has the shortest year, moving very quickly around the sun, but because it rotates so slowly, a "day" on Mercury lasts 176 Earth days (measured from high noon to high noon on Mercury). Thus, a day on Mercury is actually longer than a year on Mercury.

Mercury has almost no atmosphere and gets very cold, with the temperature sometimes dropping to  $-183^{\circ}\text{C}$  ( $-300^{\circ}\text{F}$ ), and very hot, with the temperature climbing to  $467^{\circ}\text{C}$  ( $800^{\circ}\text{F}$ ). This characteristic is caused by its lack of atmosphere and its slow rotation.

Mercury was visited by a robot spacecraft named Mariner 10 in the 1970s, and we have many close-up photographs of its craters and mountains.

In a football-field-sized model, Mercury will be 0.10 mm in diameter and 1.14 m (3.75 ft.) from the sun model.

Place your scale-model drawing here:

## Venus



---

**Venus** is almost a twin of Earth in size and mass, but it has a very different atmosphere, climate, temperature, and daily rotation. The average temperature on Venus is  $480^{\circ}\text{C}$  ( $900^{\circ}\text{F}$ ). Venus is hotter than Mercury because of a strong *Greenhouse Effect* on Venus that traps heat. The atmosphere is mostly carbon dioxide, and the planet has an atmospheric pressure 90 times that of Earth. The upper cloud layers contain sulfuric acid, and winds can reach more than 360 kilometers/hour.

One of the strangest things about Venus is its rotation. It rotates backward (clockwise) compared to the other planets. This makes a day on Venus as long as 117 Earth days. Venus has been visited by robot spacecraft, so we have many photographs of its surface. In a football-field-size model, Venus will be 0.24 mm in diameter and 2.13 m (6.98 ft.) from the sun model.

Place your scale-model drawing here:

# Earth



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**Earth** orbits the sun between Venus (super hot) and Mars (super cold). This distance from the sun gives Earth its moderate temperatures and makes oceans of liquid water possible. Earth is the only planet known to have life.

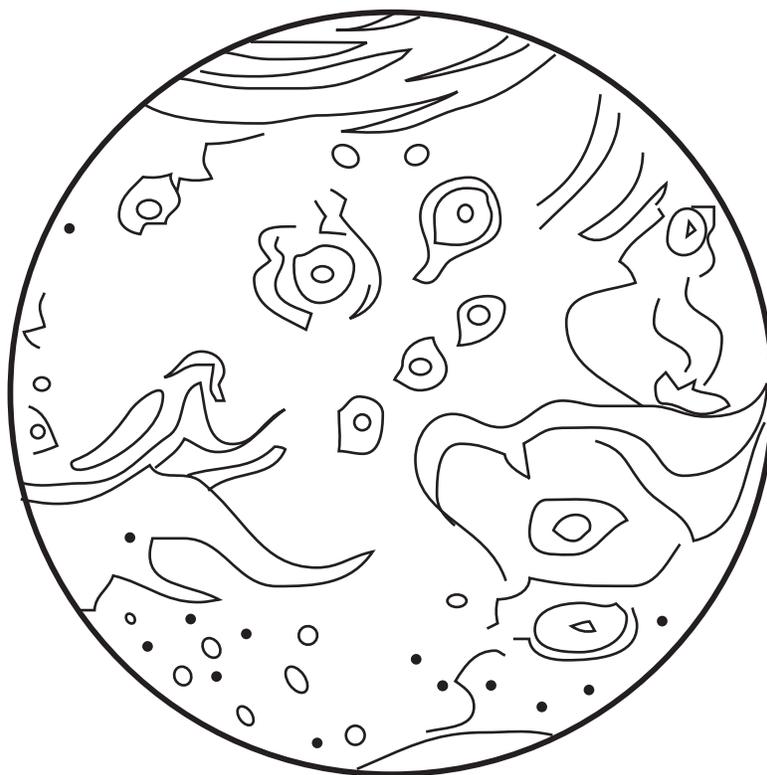
Earth's volcanoes and tectonic plate motions continually renew and re-shape Earth's thin crust. Life has played a large part in the makeup of Earth's atmosphere, with plants and animals helping to maintain a balance of nitrogen, oxygen, and carbon dioxide. Earth's ozone layer protects the surface from ultraviolet light.

The Earth's moon is about 1/4 the diameter of Earth — quite large in relation to Earth when compared to other planets and their moons. The moon has no atmosphere. The same side of the moon faces Earth at all times. Large lava basins, called *maria*, give the moon its familiar appearance.

In a football-field-size model, Earth will be 0.25 mm in diameter and 2.95 m (9.69 ft.) from the sun model.

Place your scale-model drawing here:

# Mars



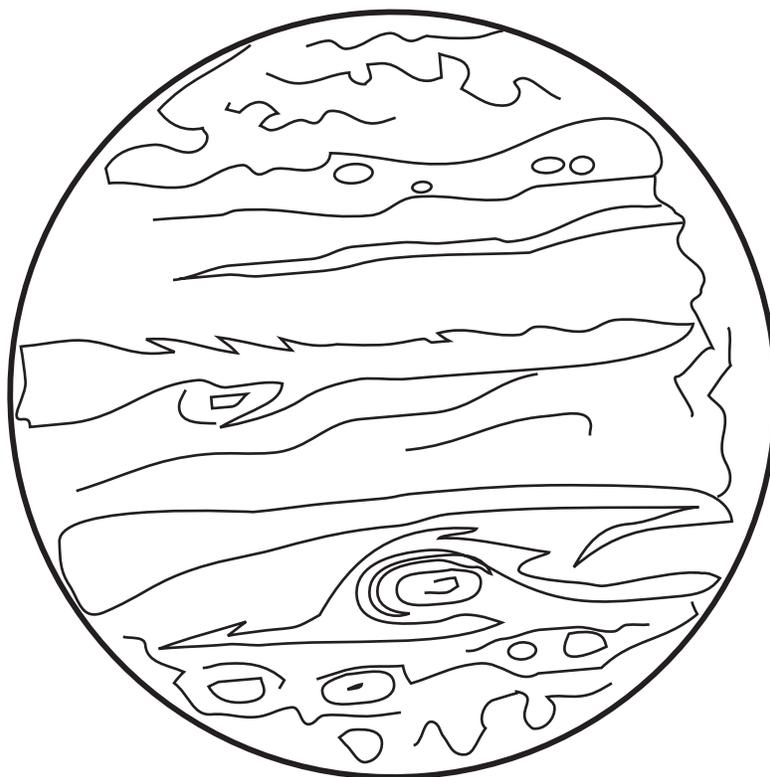
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**Mars** is about half the diameter of Earth, but has about the same amount of dry surface as Earth does. The atmosphere on Mars is made up mostly of carbon dioxide, but is much thinner than Earth's atmosphere, so humans could not survive there without a spacesuit. The rotation of Mars is very similar to Earth's, and a Martian day is 24 hours and 35 minutes. The Martian year is 687 Earth days. The surface of Mars appears red due to the rust from iron in the rocks on the surface. Mars has huge volcanoes, much taller than any mountain on Earth, and canyons that stretch for thousands of miles. Water flowed in rivers on Mars long ago, but the planet's water is now frozen in the soil. The average temperature on Mars is  $-48^{\circ}\text{C}$  ( $-54^{\circ}\text{F}$ ), which is much colder than Earth. Life may have existed on Mars in the form of microbes, but it is not likely that life exists there today. Humans have never explored Mars in person, but there are plans to have humans visit the planet in this century. Several robot spacecraft have explored Mars.

In a football-field-size model, Mars is 0.13 mm in diameter and 4.51 m (14.79 ft.) from the sun model.

Place your scale-model drawing here:

# Jupiter



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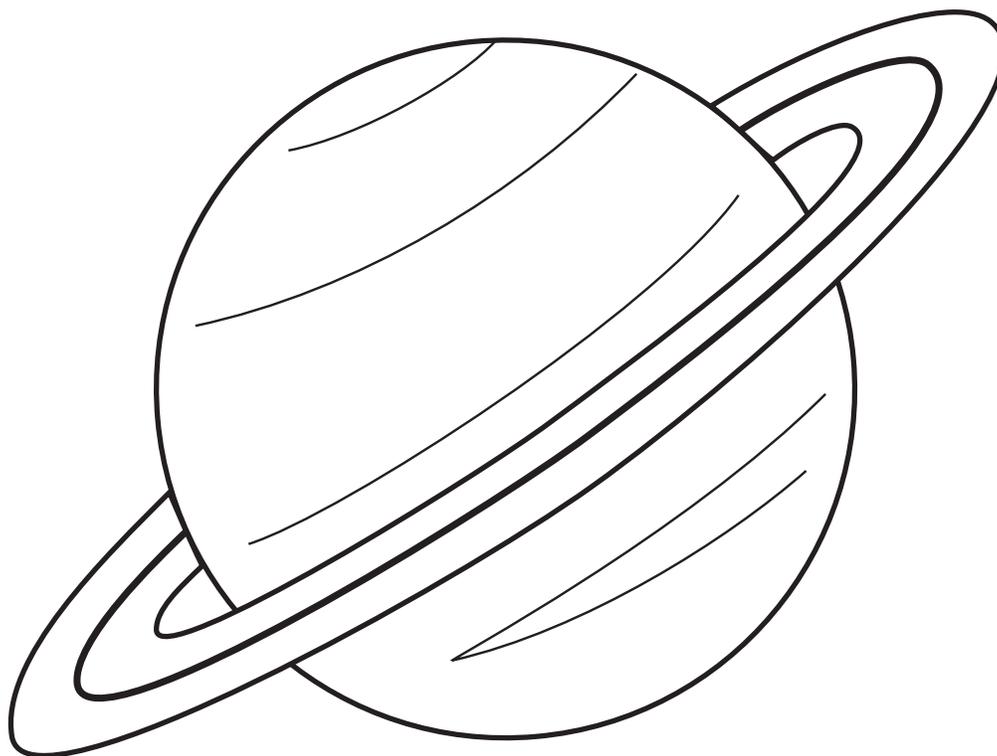
**Jupiter** is the largest of the planets and has more mass than all the other planets combined. It is mostly made of gas, and has a composition much like that of our sun, consisting mainly of hydrogen and helium.

The pressure of the atmosphere on Jupiter's center is millions of times that of Earth's atmospheric pressure. Jupiter has at least 28 moons and a system of thin rings that are hard to see from Earth. Winds and storms on Jupiter make its atmosphere an interesting system to watch. The Red Spot, a huge storm in Jupiter's atmosphere, is larger than Earth, and has been seen through telescopes for hundreds of years. Scientists are not sure of the size and composition of a solid core at the center of Jupiter, but they believe that below the atmosphere there is a huge ocean of liquid hydrogen. This ocean of liquid hydrogen may be the source of Jupiter's powerful magnetic field.

In a football-field-size model, Jupiter is 2.8 mm in diameter and 15.37 m (50.42 ft.) from the sun model.

Place your scale-model drawing here:

# Saturn



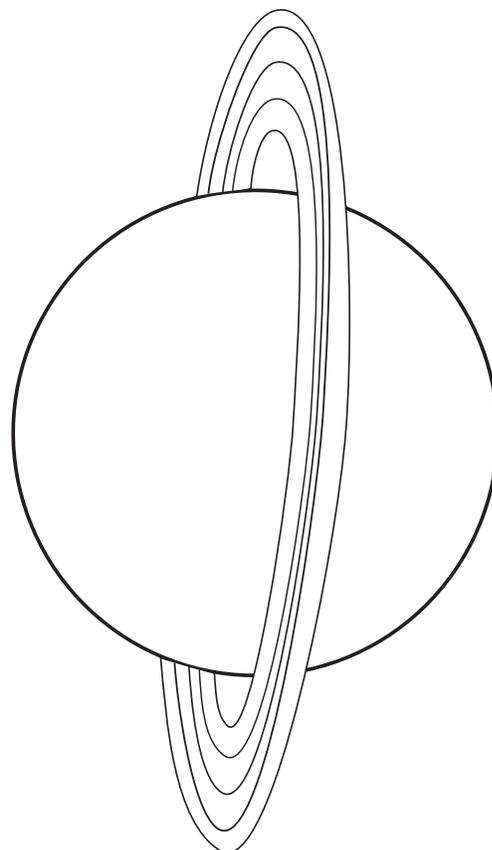
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**Saturn** is the second largest planet and is a gas giant similar to Jupiter. It is more distant from the sun and colder than Jupiter, so its cloud surface is not as colorful as Jupiter's. Saturn has a dense atmosphere made mostly of hydrogen. There may be a deep ocean of liquid hydrogen under the atmosphere and a solid core at the center. Winds at the equator of Saturn can reach 1,100 miles per hour (1,770 kilometers per hour). The view of Saturn is striking because of its huge system of bright rings, which are only a few kilometers thick but about 300,000 kilometers (180,000 miles) across. The rings are composed of small bits of ice and rock that reflect the sunlight. Saturn has at least 30 moons, many of which are very small. The largest of these is Titan, the only moon in the solar system with a dense atmosphere. Titan may have huge oceans of liquid methane.

In a football-field-size model, Saturn is 2.4 mm in diameter and 28.16 m (92.4 ft.) from the sun model.

Place your scale-model drawing here:

# Uranus



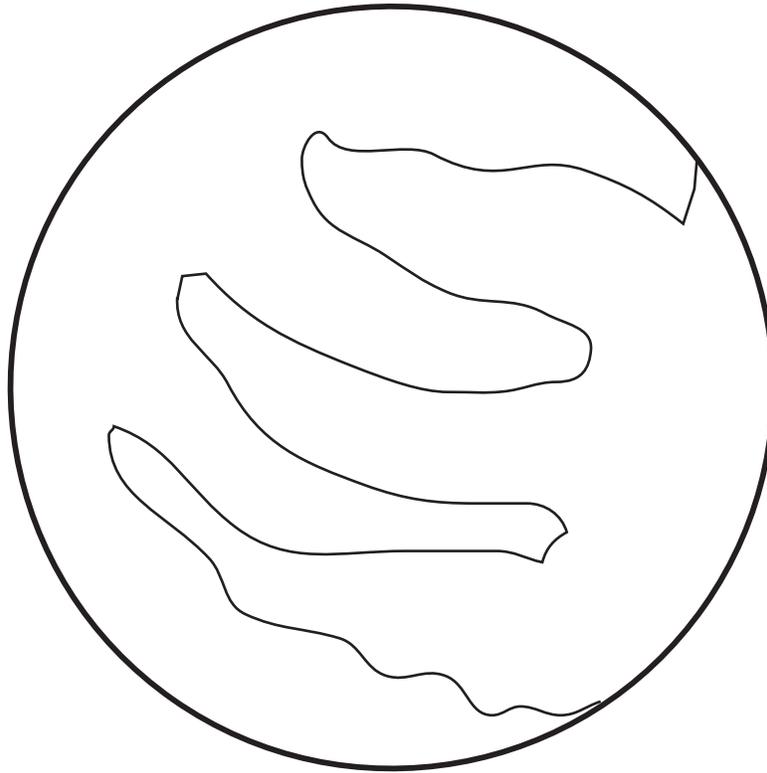
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**Uranus** is the third gas giant planet. It is less than half the diameter of Saturn and much colder. It has an unusual rotation pattern. Its axis of rotation, or pole, lies almost in the plane of its orbit. This means that it orbits the sun like a rolling pin or a ball rolling on a flat surface. It is possible that the unusual rotation was caused by a huge collision long ago. The atmosphere of Uranus is largely hydrogen and helium, but it contains methane and other hydrocarbons as well as ammonia. Like the other gas giant planets, Uranus has a very dense atmosphere, and there may be an ocean of liquid ammonia below the atmosphere. Uranus has a series of thin rings, which are dark and cannot be seen easily. The rings were discovered from Earth because they blocked starlight as Uranus moved in its orbit. Uranus has 21 moons.

In a football-field-size model, Uranus is 1.0 mm in diameter and 53.97 m (177.08 ft.) from the sun model.

Place your scale-model drawing here:

# Neptune



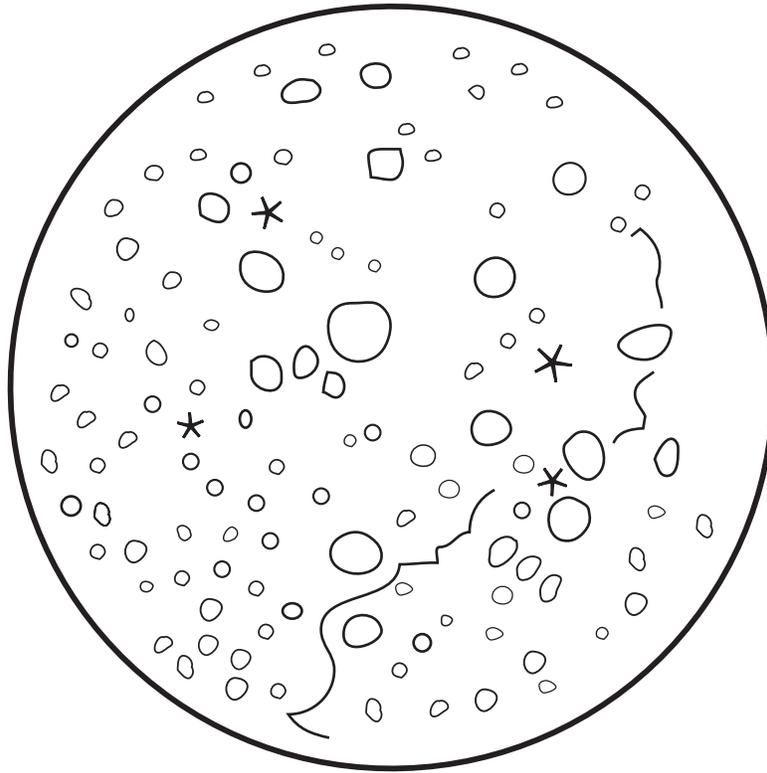
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**Neptune** is the most distant of the gas giant, or Jovian, planets. Neptune cloud tops are colder than  $-214^{\circ}\text{C}$  ( $-353^{\circ}\text{F}$ ). Neptune is similar to Uranus in size and composition, but is bluer in color and has storms on its surface, which appear as white areas. Neptune's atmosphere contains hydrogen, helium, methane, and ammonia and has winds up to 2,000 kilometers per hour (1,243 miles per hour). Neptune has at least eight moons. Its largest moon, Triton, is believed to have nitrogen in solid and liquid forms.

In a football-field-size model, Neptune is 0.95 mm in diameter and 88.58 m (290.6 ft.) from the sun model.

Place your scale-model drawing here:

# The Dwarf Planet Pluto



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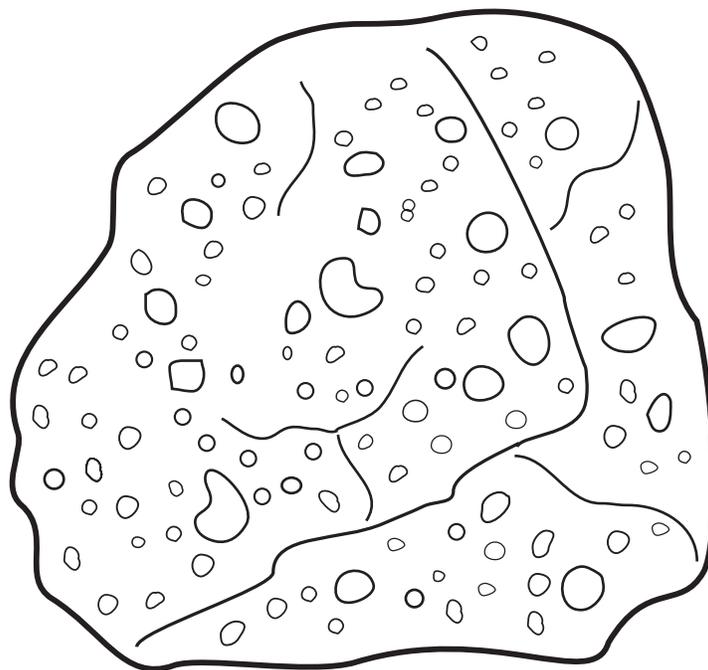
**Pluto** is smaller than our moon and is the only dwarf planet that has never been visited by one of our spacecraft or probes. Pluto has an unusually elliptical orbit. At its closest, it is about 4.4 billion kilometers (2.7 billion miles) from the sun, but it travels as far as 7.5 billion kilometers (4.7 billion miles) from the sun.

The surface of the dwarf planet is probably composed of frozen gases and ice. In this way, it is similar to comets in composition. In fact, Pluto orbits near a region of the solar system where comets are found. Some scientists say that Pluto has more in common with comets or moons of Neptune than with the other planets because of its location, orbit, and composition. Pluto has a moon, called Charon, which is almost half the size of Pluto.

In a football-field-size model, Pluto is 0.04 mm in diameter and 91.44 m (300 ft.) from the sun model.

Place your scale-model drawing here:

# Asteroid



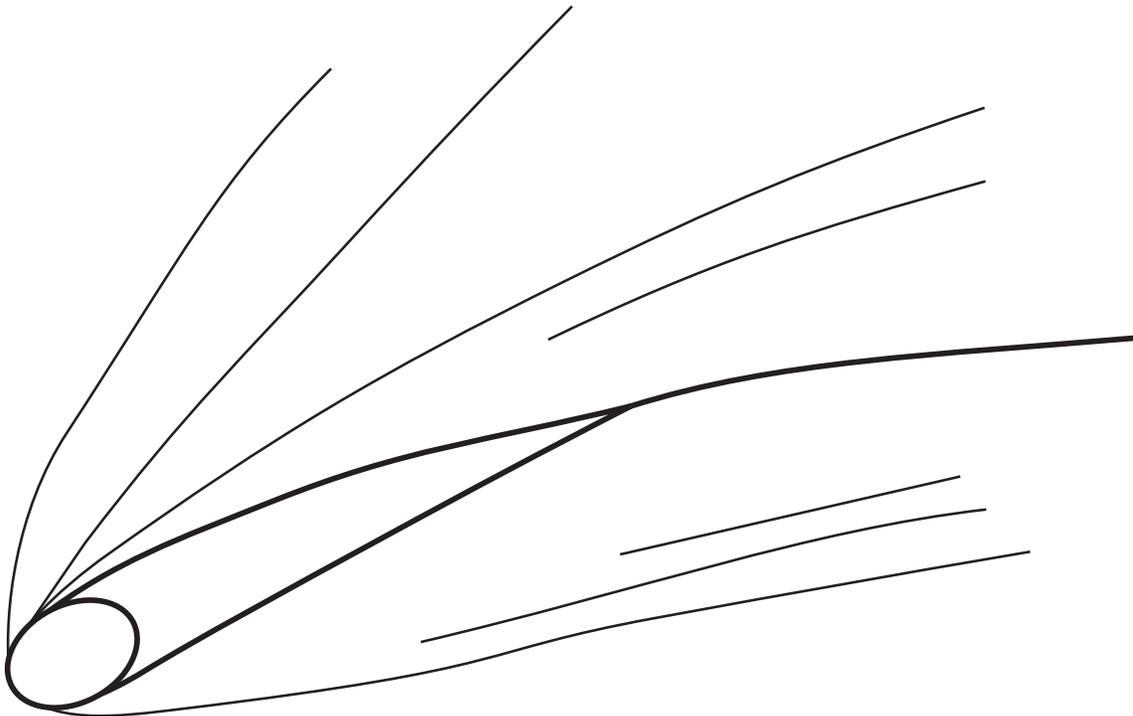
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**Asteroids** are solid chunks of matter that never came together to become a single planet. Most of them are found between the orbits of Mars and Jupiter. The largest of the asteroids are more than 300 km (200 miles) in diameter, but most are much smaller. Over 20,000 asteroids have been discovered. All together, they do not have as much mass as our moon.

In a football-field-size model, the asteroids would be about 21 m (about 70 ft.) from the sun model.

Place your scale-model drawing here:

# Comet



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**Comets** are small chunks of ice and frozen gases mixed with dust and other matter. They are only a few miles in diameter. Most of them have existed since before the planets formed. They can be found in orbit far from the sun beyond the dwarf planet Pluto and sometimes in long elliptical orbits around the sun. If a comet is close enough to the sun (closer than Mars), it has a tail, caused by the evaporation of its surface due to the heat of the sun. The constant force of particles from the sun and the pressure of sunlight blow a comet's tail away from the sun as the comet orbits. Eventually, a comet evaporates completely, leaving only bits of dust. Some of these bits may collide with the Earth as "shooting stars" in a meteor shower.

In a football-field-size model, a comet might be as close as a few feet or as far away as 112 km (180 miles) from the sun model.

Place your scale-model drawing here:

## ***Round and Round the Earth We Go***

(This lesson is adapted from an online activity included in the Educator’s Guide for the NASA SciFiles™ video program “The Case of the Galactic Vacation.” NASA. Used by permission.)

**Organizing Topic** Investigating the Solar System

**Overview** Students use a model to observe how the phases of the moon are created.

**Related Standards of Learning** 6.1j; 6.8e

### **Objectives**

The students should be able to

- model and describe how the phases of the moon occur.

### **Materials needed**

- Lamp without shade and preferably with a clear bulb
- Tennis ball

### **Instructional activity**

#### ***Content/Teacher Notes***

As Earth’s only natural satellite, the moon has long been an object of fascination and misunderstanding. Over the course of a 28-day cycle (lunar cycle), the moon shows us many different faces (shapes). These different shapes are called *phases*, and they are the result of the way the sun lights up the moon’s surface as the moon orbits Earth. The moon can be seen only as a result of the sun’s light reflecting off it, because it does not produce any light of its own.

It is recommended that you review the full Educator’s Guide related to “The Case of the Galactic Vacation” (see “Resources”).

#### ***Introduction***

1. Assess the students to see what they remember from grade four regarding the moon phases. Be sure to clear up any misconceptions that the students may have regarding this topic. It is essential that students understand the difference between the terms *revolve* and *rotate* in this context: a celestial body *rotates on its axis* and *revolves around another body*.

#### ***Procedure***

Have students work in pairs to complete the following experiment, using the instructions below:

1. Place the lamp, representing the sun, in a position so that the bare bulb is at the same height as your eyes. Use a table or other furniture, or have your partner hold the lamp in the right position. Turn the lamp on, and otherwise darken the room.
2. Your head represents Earth. Face the “sun” (lamp), and hold the “moon” (tennis ball) in your left hand at arm’s length in front of you and slightly overhead (see Diagram 1).
3. Observe the moon, noting that the sun lights up the half of the moon facing away from “Earth” (you) and that you can see only the unlit half. This moon phase is called a *new moon*, and you now observe that it occurs when the moon is *between* the sun and the Earth.
4. While you are still facing the sun, move (revolve) the moon around to your left side, and note the portion of the moon’s surface that you can see lit. How much of the surface can you see lit? The

moon has now revolved one quarter of the way around Earth, a process that takes approximately one week after a new moon. This phase is known as a *first-quarter moon*.

5. To model the next phase, place your back to the sun, and hold the moon straight out in front of you (Earth) but still slightly overhead (see Diagram 2). Notice that it is this inclined orbit position that allows you to see the full half of the moon facing you lit up even when the Earth is between the sun and the moon — Earth’s shadow does not fall on the moon. When you can see the entire half of the moon lit up, it is called a *full moon*. The moon has now completed half of its revolution around Earth, which takes about two weeks after a new moon.
6. Put the moon in your right hand, and move (revolve) it around to your right side. Once again, you can see only half of a half (a quarter) of the moon lit up. This phase is known as a *third-quarter moon*, and it appears approximately three weeks after a new moon.
7. Face the sun again, and hold the moon straight out in front of you and slightly overhead. Once again, you can see only the unlit or dark half of the moon — a new moon that begins another lunar cycle.
8. In your science journal, describe and illustrate what you observed.
9. Repeat the experiment with your partner as the moon and you as the sun.

### ***Observations and Conclusions***

1. Pose the following questions, and discuss student responses:
  - What happened as the moon revolved around the Earth?
  - Why did the shadows change?
  - The moon rotates on its axis once every 28 days, and it revolves around Earth once every 28 days. Why do we see only one side of the moon? Hint: Mark a spot on the ball (moon) and revolve it around you (Earth) without letting it rotate on its axis. What do you observe about the side of the ball facing you? Now, repeat while rotating the ball on its axis at the same rate as its revolution.

### **Sample assessment**

- Have students draw the phases of the moon and a model showing the positions of the sun, moon, and Earth at each phase.

### **Resources**

- “The Case of the Galactic Vacation.” *NASA SciFiles™*. NASA. <http://scifiles.larc.nasa.gov/educators/index.html?p=episodes/guides>. Click “2002–2003 Season” — “The Case of the Galactic Vacation” — “Download the Full Guide.”
- *Earth in Space: Teacher Training Module*. Science Museum of Virginia. <http://www.smv.org/pubs/EIS/Default.asp>. A comprehensive set of astronomy lessons and resources for grades K–6.
- “Earth’s Axial Tilt and the Seasons.” *NASA’s Imagine the Universe*. NASA. [http://imagine.gsfc.nasa.gov/docs/ask\\_astro/answers/980211f.html](http://imagine.gsfc.nasa.gov/docs/ask_astro/answers/980211f.html).
- *The Phases of the Moon*. Enchanted Learning. <http://www.enchantedlearning.com/subjects/astronomy/moon/Phases.shtml>.

## ***Tilting into Season***

(This lesson is adapted from “Tilt-a-World,” an online lesson from *Everyday Classroom Tools: An inquiry-based science curriculum for kindergarten through sixth grade*. Smithsonian Institution. Used by permission.)

**Organizing Topic** Investigating the Solar System

**Overview** Students investigate how the tilt of the Earth’s axis causes the seasons.

**Related Standards of Learning** 6.1j; 6.8g

### **Objectives**

The students should be able to

- model and describe how the Earth’s axial tilt causes the seasons.

### **Materials needed**

- Globe
- Lamp without shade and preferably with a clear bulb
- Styrofoam balls
- Dowels or knitting needles
- Rubber bands
- Pushpins

### **Instructional activity**

#### ***Content/Teacher Notes***

Imagine a line running through the Earth from the South Pole to the North Pole. As the Earth rotates, that line always points to Polaris, the North Star. For this reason, the Earth’s axis tilts about  $23.5^\circ$  off of a  $90^\circ$  angle with respect to the plane of the flat orbit it makes around the sun.

On the first day of summer, the sun is above the horizon for the maximum number of hours and gets highest in the sky at noon. The angle at which light rays from the sun hit the Earth affects the temperature on Earth — i.e., the more direct the rays are, the more light and heat are absorbed and the higher the temperature becomes. In summer, when the sun is high in the sky at noon, its rays strike Earth almost perpendicular to the surface, because light travels in straight lines. As the Earth revolves around the sun, parts of the Earth get hit with rays *directly* (at nearly a  $90^\circ$  angle), and parts are hit with rays *indirectly* (at more oblique angles). The seasons at any given region of the Earth are a consequence of the directness of the rays and the length of days in that region. In winter when the sun is low in the sky at noon, its rays hit the Earth indirectly at a more oblique angle, and the light and heat are more dispersed (spread out). Also, the days are shorter, allowing for less heating to occur. In summer, not only are the rays more direct, resulting in more intense light and heat, but there are more hours of light, so that the land, sea, and air have more time to absorb the light and heat.

Summer and winter solstices: The sun rises and sets in different spots throughout the year. In the Northern Hemisphere, the sun rises at its most southerly point in midwinter. This event is known as the *winter solstice* and occurs on December 21. The sun rises at its most northerly point in midsummer, an event known as the *summer solstice*, which occurs on June 21.

Spring and fall equinoxes: There are two days in the year when every place on Earth experiences a 12-hour day — i.e., the length of the day and the night are equal. These special days occur midway between the solstices. The sun rises due east and sets due west on the *spring (or vernal) equinox* (around March 21) and the *autumnal equinox* (around September 22). The word *equinox* is derived from Latin and

means “equal night.” Very little change occurs in sunrise and sunset times in the weeks before and after the solstices. In the weeks around the equinoxes, the sunrise- and sunset-time changes and the sun-position changes are considerable.

Here are some common misconceptions:

- “There are seasons because the Earth moves in an orbit that is closer to the sun in the summer and farther away from the sun in winter.” In fact, Earth travels in a relatively circular orbit around the sun, staying about 150 million kilometers from it throughout the year. Many textbooks illustrate the solar system from an angle rather than from a point of view that is directly above so that the Earth’s orbit looks more like an ellipse rather than almost a circle, as it should. Nearly all the planets revolve in circular, not elliptical, orbits about the sun.
- “Because of the tilt, the Northern Hemisphere is closer to the sun during its summer.” In fact, the Earth is closest to the sun around January 3 and farthest from the sun about July 5; therefore, the slight change of distance from the sun due to Earth’s slightly noncircular orbit has nothing to do with the seasons.
- “The hemisphere that is tilted toward the sun will experience summer (true) because it is closer to the sun (false).” Actually, the Earth is so much smaller than the sun and so far away from it that the difference in distance from the sun to each of the two hemispheres at a given time is negligible. Again, the seasons are dependent on the angle of the sun’s rays and the length of the days, not on the distance of the Earth from the sun.

Understanding seasons is difficult for many people, so you should not expect all students to gain a complete understanding from this lesson.

### ***Introduction***

1. Tell students that astronomers long ago discovered that the reason the sun looks like it is taking a different path through the sky in different seasons of the year is because the Earth’s axis is tilted at an angle that is  $23.5^\circ$  less than a  $90^\circ$  angle with respect to the plane of the flat orbit it makes around the sun. The reason for this tilt is that the North Pole end of the Earth’s axis always points to Polaris, the North Star. These statements may be hard for students to visualize and understand without a graphic demonstration, which is provided in the demonstration exercise describe under Procedure below.
2. You may wish to do the following demonstration before (or instead of) having the students undertake the exercise themselves. Place a small representation of Polaris somewhere high up in the room, and point it out to the students. Tell them that the globe represents Earth, the floor represents the plane of Earth’s flat orbit around the sun, and the lamp elevated in the center of the room represents the sun.
3. Turn on the lamp (the sun), hold up the globe (the Earth) at the same level as the lamp, and tilt the globe on an angle to the floor (its orbit) so that the North Pole points to Polaris. Revolve the Earth around the sun, being careful to keep the North Pole pointing at Polaris at all times. Have the students notice how the sun’s light falls on the Earth in the various seasons of the year. Make sure they really see that as the Earth revolves around the sun, the North Pole is tilted *in the direction of* the sun in our Northern Hemisphere summer (pause and demonstrate) and *in the direction away from* the sun in our winter (pause and demonstrate). You may wish to stick a small toy figure onto the globe at your location and point out why this person in your spot on Earth will see the noon sun higher in the sky in the summer and lower in winter.

### **Procedure**

1. Give each student a Styrofoam ball (representing the Earth) with a knitting needle or dowel stuck through it (representing its axis) and a rubber band around the middle (representing the equator). Also, give each student a pushpin to represent a person. Point out Polaris (the North Star) placed high up in the room.
2. Ask, “Where is the North Pole? Where is the equator?” Tell students to put their pin-person somewhere in the Northern Hemisphere to represent a person in Virginia.
3. Have the students slowly orbit their Earth around the sun (lamp in center of room), carefully keeping the axis pointing to Polaris at all times, until their Earth’s axis is tilted *in the direction of* the sun. Now, have them rotate their Earth on its axis so that it is noon for the pin person. Ask, “To the pin person, would the sun look high or low in the sky? What season is it for the pin person, who is located in the Northern Hemisphere? What season is it in the Southern Hemisphere?”
4. Have the students continue to orbit their Earth, keeping the axis pointing to Polaris as always, until the axis is pointing *in the direction away from* the sun. Again, have them rotate their Earth so that the pin person is in the noon-day sun. Ask the same questions as before. Also, ask them whether it is possible to see the difference in the lengths of the pin’s shadow at noon in the two seasons. (*The shadow is longer in winter than in summer.*) Ask whether they can see why winter days are shorter than summer days even though the Earth rotates on its axis at a constant speed at all times. (*With the Northern Hemisphere tilted away from the sun, the northern regions experience a lower sun arcing a shorter distance across the sky — i.e., a shorter day.*)
5. Now, have the students orbit their Earth to the spring equinox or the fall equinox positions, reminding them that only on these two days are the lengths of the day and night equal. Have them observe that the Earth is now in the part of its orbit where the axis tilt is *neither in the direction of nor in the direction away from* the sun. The sun strikes directly over the equator; therefore, in both hemispheres, there is no extreme sun height during these times of year. Ask, “What could the word *equinox* mean?” (*Equal night and day*) “How many hours of day and how many of night would that be?” (*12 and 12*)

### **Observations and Conclusions**

1. After students work through the physical model, have them draw a representation of the Earth’s revolution around the sun.
2. Reinforce that it is not a changing distance of the Earth from the sun, but the tilt of the Earth and the resulting indirect or direct sun rays that cause the seasons.

### **Sample assessment**

- Create scenarios that challenge students to decide in each case what season it would be.

### **Resources**

- *Earth in Space: Teacher Training Module*. Science Museum of Virginia. <http://www.smv.org/pubs/EIS/Default.asp>. A comprehensive set of astronomy lessons and resources for grades K–6.
- “Earth’s Axial Tilt and the Seasons.” *NASA’s Imagine the Universe*. NASA. [http://imagine.gsfc.nasa.gov/docs/ask\\_astro/answers/980211f.html](http://imagine.gsfc.nasa.gov/docs/ask_astro/answers/980211f.html).
- “Tilt-a-World.” *Everyday Classroom Tools: An inquiry-based science curriculum for kindergarten through sixth grade*. Smithsonian Institution. <http://hea-www.harvard.edu/ECT/Tilt/tilt.html#46>.

## Telling Tides

(This lesson is adapted from “Telling Tides,” a lesson plan in *Your Backyard Classrooms*, a publication of the Virginia State Parks, Virginia Department of Conservation and Recreation.)

### Organizing Topic Investigating the Solar System

**Overview** Students learn to read a tide chart to determine the times of the high and low tides for a particular day at a standard reference point. They also investigate the tidal height relative to mean low water (MLW).

### Related Standards of Learning 6.1i; 6.8h

### Objectives

The students should be able to

- discuss the relationship between the gravitational pull of the moon and the cycle of tides.

### Materials needed

- Copies of the attached handouts
- Rulers

### Instructional activity

#### *Content/Teacher Notes*

A tide is a special type of wave that is perceived as the vertical movement of ocean waters. Tides are caused by the gravitational pull of the moon and sun. Although the moon is very small compared to the sun, it is much closer to Earth. As a result, its influence on ocean tides is more than twice that of the sun. These gravitational forces “pile up” water into bulges, which move as long waves around Earth and are called *tides*. The heights of the tides in a given location are not the same every day of the year; indeed, they vary throughout each month. As the moon revolves around Earth, the relative positions of the sun, moon, and Earth change, and the way they are aligned directly affects the heights of the tides.

The following definitions are useful for students to know:

**semidiurnal tides.** Two high and two low tides every 24 hours and 40 minutes, occurring in many locations on Earth, such as the Chesapeake Bay.

**diurnal tides.** One high and one low every day, occurring in certain locations on Earth, such as the Gulf of Mexico.

**spring tide.** A tide in which the change in water level between high and low tides is the greatest. A spring tide is created when the moon, sun, and Earth align in a relatively straight line, resulting in a combination of their gravitational forces. Spring tides occur twice a month — when the moon is full and when it is new.

**neap tide.** A tide in which the change in water level between high and low tides is the least. A neap tide is created when the sun and moon are at right angles and their gravitational forces counteract one another to a certain degree. Neap tides also occur twice a month — when the moon is in its first-quarter and third-quarter phases.

**flood tide.** A tide in which the high tide is approaching and the water level is rising.

**ebb tide.** A tide in which the high tide is departing and the water level is dropping.

**slack water.** The period just before the tide changes direction, when the tidal current movement is minimal.

**mean low water.** The average height of all low tides measured at a given location over a 19-year period.

**mean high water.** The average height of all high tides measured at a given location over a 19-year period.

**sea level.** The mean level of the ocean halfway between high and low tide, used as a standard in reckoning land elevations and sea depths.

The ability to predict tides is useful to many people — fishermen, boaters, oceanographers, marine biologist, meteorologists, vacationers, to name only a few. For example, meteorologists tracking hurricanes are able to gauge the potential impact of a hurricane on a shoreline in terms of water level by knowing the phase of the moon at the time of the storm and the resulting times of high tide and low tide.

### ***Introduction***

1. Tide charts are widely published for most locations throughout the Bay and its tributaries. Most tide charts list (1) the time for each high and low tide during a span of dates and (2) the heights of the tides relative to mean low water for the location. Such charts can usually be obtained from tackle shops and marinas near tidal areas. Some agencies also publish tide charts based on the tides at a given location and showing conversion figures to calculate the times and heights of tides at other places in the vicinity. In the Bay region, tides are most often listed relative to Hampton Roads (Sewell’s Point), Washington, D.C., or Baltimore. Daily tide information can be obtained from many newspapers, from recorded telephone services, from some radio stations, and from the Internet.
2. Review the background information on tides, under Content/Teacher Notes, with the class. Lead a discussion based on the students’ responses to the following questions: Why is it important to be able to predict the times and heights of tides? Who do you think uses tide charts?

### ***Procedure***

1. Give each student a copy of the accompanying “Tide Calendar” and the “Tidal Differences Table.” Explain that these are excerpts taken from tables used by scientists to predict tides in the Chesapeake Bay.
2. Explain how to interpret the calendar, using a similar diagram on the overhead or the board. Point out the following:
  - The curved line represents the change in the level of the tide with time. The highpoints, or crests, represent high tides, while the low points, or troughs, represent low tides.
  - The  $y$ -axis represents the tide height above or below mean low water (the zero mark). It is marked off in half-foot increments.
  - The  $x$ -axis represents the change in time. It is marked off in one-hour increments up to 24 hours. To convert times after 12:00 noon to conventional time, subtract 12. Thus 18 would be 6:00 p.m. Each day is marked with a tall vertical line.
  - The second row of numbers below the  $x$ -axis gives the tide height for each high tide. A short, vertical line extends from each of these numbers through the  $x$ -axis, directly below each crest. This makes it easy to pinpoint the time of the tide.
  - The third row of numbers below the  $x$ -axis gives the height for each low tide. A positive number means the tide is above mean low water, while a negative number means the tide is below mean low water. Again, a short vertical line extends from the number through the  $x$ -axis to facilitate reading the time.
3. Explain that the tide times and heights differ throughout the Bay, and review the Tidal Difference Table. Point out the following:
  - The “PLACE” column represents the exact locations for which the tides can be predicted.

- The “TIDAL DIFFERENCES, Time” columns list the average differences in time (in hours and minutes) at each location from the tidal times at Sewell’s Point in Hampton Roads. Since the average differences are not usually the same for high and low tides, these are listed under the columns marked “HW” and “LW,” respectively. A “plus” indicates the tide occurs *after* the tide at Hampton Roads and the time difference must be added. A “minus” means the tide occurs *before* the tide at Hampton Roads and the time difference must be subtracted.
  - The “TIDAL DIFFERENCES, Height” columns list the average differences in height (in feet) at each location from the tidal heights at Sewell’s Point. Again, since the average differences are not usually the same for high and low tides, these are listed under the columns marked “HW” and “LW,” respectively. A “plus” indicates the tide is higher than that at Hampton Roads and the height difference must be added. A “minus” means the tide is lower than that at Hampton Roads and the height difference must be subtracted.
4. Give each student several copies of the Telling Tides Worksheet. Complete one with the class as an example, using a specific date and location and the steps listed.
  5. Have students calculate tides for other dates and locations on their own.

### ***Observations and Conclusions***

1. Review the results the students found.

### **Sample assessment**

- Have students describe how tides are formed.
- Have students create a model of the Earth, sun, and moon to demonstrate how the sun and moon affect the tides.

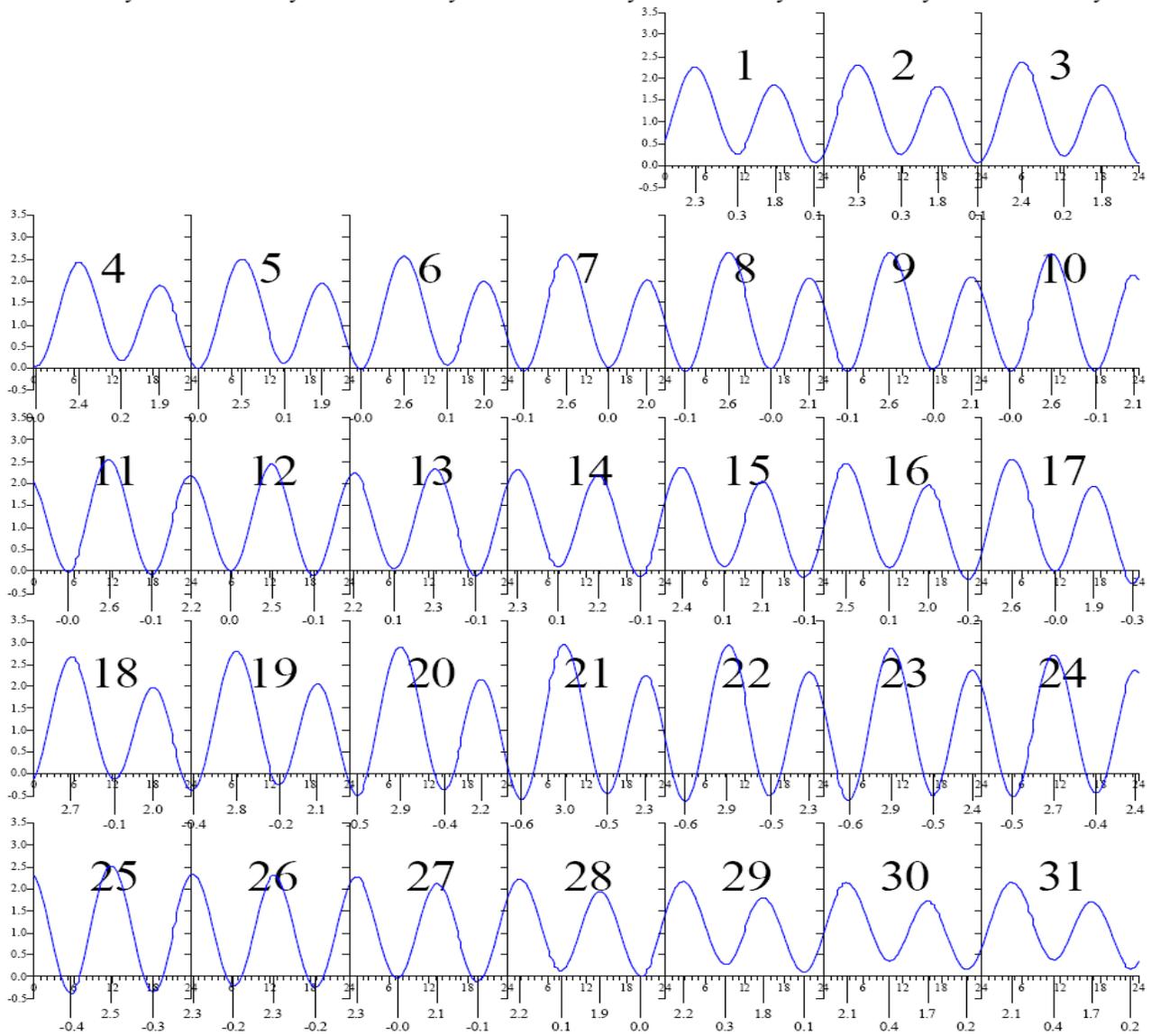
### **Resources**

- *Hampton Roads, Virginia*. <http://www.mobilegeographics.com:81/locations/2403.html>. Shows a tidal chart for Hampton Roads area.
- “How Can the Moon Affect Tides?” *BoatSafeKids*. <http://www.boatsafe.com/kids/tides.htm>.
- “Telling Tides.” *Bay Link*. [http://www.baylink.org/lessons/3fr\\_tides.html](http://www.baylink.org/lessons/3fr_tides.html). A lesson plan from *Your Backyard Classrooms*. Virginia State Parks. Virginia Department of Conservation and Recreation.
- *Tide Calendars for 2006*. Virginia Institute of Marine Science. <http://www.vims.edu/resources/tides/2006.html>.

# Tide Calendar

**HAMPTON ROADS, VA — Jan 2004** EASTERN STANDARD TIME.

Sunday      Monday      Tuesday      Wednesday      Thursday      Friday      Saturday



Heights are in FEET above MEAN LOWER LOW WATER.  
0 and 24 are midnight, 12 is noon.

## Tidal Differences Table

PLACE	TIDAL DIFFERENCES			
	Time (hrs. :mins.)		Height (ft.)	
	HW	LW	HW	LW
<b>York River</b>				
Tues Marshes Light	-0:09	-0:07	-0.3	0.0
Gloucester Point	+0:16	+0:07	-0.1	0.0
Yorktown	+0:07	+0:01	-0.1	0.0
West Point	+2:03	+2:28	+0.3	0.0
<b>James River</b>				
Mulberry Point	+1:56	+2:16	-0.1	0.0
Hog Point	+2:11	+2:28	-0.4	0.0
Jamestown Island	+2:54	+3:26	-0.5	0.0
<b>Outer Coast of Virginia</b>				
Virginia Beach	-1:30	-1:35	+0.9	0.0
<b>Chesapeake Bay Eastern Shore</b>				
Onancock	+2:52	+3:09	-0.7	0.0
Fisherman's Island	-0:47	-1:00	+0.5	0.0

# Telling Tides Worksheet

**Name:** \_\_\_\_\_ **Date:** \_\_\_\_\_ **Class:** \_\_\_\_\_

**Procedure**

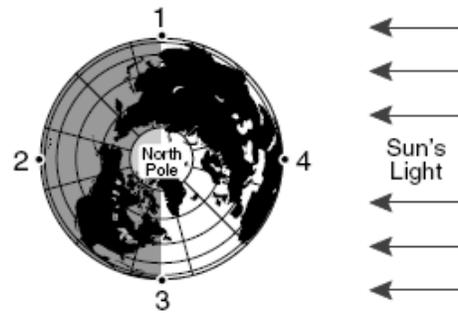
1. Enter the date and location.
2. In the "Hampton Roads" column, enter the times and heights of the tides for the selected date, as found on the Tide Calendar.
3. In the "Tidal Differences" column, enter the corresponding figures from the Tidal Differences Table. Be sure to indicate + or -.
4. Sum the figures (either add #1 and #2, or subtract #2 from #1. Watch the + and - signs!) in the "Hampton Roads" and "Tidal Difference" columns to complete the "Corrected Tides" column.

<b>Name:</b>	<b>Date:</b>		
	<b>Location:</b>		
	<b>#1</b> Hampton Roads	<b>#2</b> Tidal Difference	<b>#3</b> Corrected Tides
Time of first high tide			
Height (ft.) of first high tide above mean low water			
Time of first low tide			
Height (ft.) of first low tide below mean low water			
Time of second high tide			
Height (ft.) of second high tide above mean low water			
Time of second low tide			
Height (ft.) of second low tide below mean low water			

## Sample Released Test Items

Which of these resources would give the most current, complete and accurate information on planets?

- F Planet website by Round Rock Middle School
- G The NASA website
- H A set of general encyclopedias
- J A science book about the planets



Which of these planets in the solar system was the most recently discovered?

- A Mars
- B Venus
- C Jupiter
- D Pluto

At which of these points is it 12:00 noon?

- F 1
- G 2
- H 3
- J 4

Which body in the solar system usually contains an atmosphere?

- F An asteroid
- G A planet
- H A meteor
- J A comet

Planet	Average Distance from Sun (kilometers)
Earth	149.5 million
Jupiter	777.3 million
Mars	227.9 million
Mercury	57.9 million
Venus	108.2 million

According to this chart, which planet will most likely have the highest temperatures?

- F Earth
- G Mars
- H Mercury
- J Venus

## Organizing Topic — Investigating Atoms, Elements, Molecules, and Compounds

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- a) observations are made involving fine discrimination between similar objects and organisms;
  - b) a classification system is developed based on multiple attributes;
  - c) precise and approximate measurements are recorded;
  - d) scale models are used to estimate distance, volume, and quantity;
  - e) hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - f) a method is devised to test the validity of predictions and inferences;
  - g) one variable is manipulated over time, using many repeated trials;
  - h) data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - i) data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - j) models are designed to explain a sequence; and
  - k) an understanding of the nature of science is developed and reinforced.
- 6.4 The student will investigate and understand that all matter is made up of atoms. Key concepts include
- a) atoms are made up of electrons, protons, and neutrons;
  - b) atoms of any element are alike but are different from atoms of other elements;
  - c) elements may be represented by chemical symbols;
  - d) two or more atoms may be chemically combined;
  - e) compounds may be represented by chemical formulas;
  - f) chemical equations can be used to model chemical changes; and
  - g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- create and interpret a simplified model of the structure of an atom;
- compare and contrast the atomic structure of two different elements;
- explain that elements are represented by symbols;
- identify the name and number of each element present in a simple molecule or compound, such as O<sub>2</sub>, H<sub>2</sub>O, CO<sub>2</sub>, or CaCO<sub>3</sub>;
- model a simple chemical change with an equation and account for all atoms, distinguishing the types of elements and number

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of each element in the chemical equation; (Balancing equations will further be developed in Physical Science.)

- name some of the predominant elements found in the atmosphere, the oceans, living matter, and the Earth's crust.

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## ***Which Elements, Where?***

**Organizing Topic** Investigating Atoms, Elements, Molecules, and Compounds

**Overview** Students are introduced to elements and investigate some properties of elements.

**Related Standards of Learning** 6.4c, g

### **Objectives**

The students should be able to

- explain that elements are made up of one type of atom and are represented by symbols;
- name some of the predominant elements found in the atmosphere, the oceans, living matter, and the Earth's crust.

### **Materials needed**

- Copies of the attached handout
- Scissors
- Reference materials about elements
- Periodic table of the elements for each student

### **Instructional activity**

#### ***Content/Teacher Notes***

Before doing this short activity, students should be introduced to the content below. You may wish to use resources you have in your classroom to expand on this basic information.

Elements are the basic building blocks of matter. Elements are considered to be pure substances in that they are made up of only one type of atom and cannot be broken down further. All of the known elements are listed on a chart known as the periodic table of the elements, where each element is represented by a unique symbol consisting of one or two letters. The symbols are derived from the Latin names of the elements. Some of these Latin names resemble the English names, and some do not; therefore, some of the symbols seem to match the English names of the elements, while other do not match at all. For instance, the symbol for carbon is C because the Latin name for carbon is *carbonium*, but the symbol for sodium is Na because the Latin name for sodium is *natrium*, or the symbol for lead is Pb because the Latin name for lead is *plumbum*.

#### ***Introduction***

1. Activate students' prior knowledge and engage their interest in the learning process by providing samples of some elements for them to examine. Your school may have a kit containing a set of elements, or you could show examples of products made of carbon, aluminum, gold, copper, lead, or other elements.
2. Ask students how each item is different from the others and how it is similar to the others. Lead them to understand that, even though the items look very different from each other, each one is composed of atoms of only one type: i.e., it is composed of a single element.
3. Ask students to predict which elements they would expect to find in the Earth's atmosphere, the Earth's crust, the oceans, and living things. Will the elements be the same or very different?

### **Procedure**

1. Give each pair of students a copy of the “Common Elements of the Earth and Living Things” sorting sheet. Point out that there are four letters, each corresponding to one of the four lists of places that elements are found — the Earth’s atmosphere (A), the Earth’s crust (C), the oceans (O), and living things (L). Have the students cut out the cards and sort them into four piles, as follows:
  - Elements found in all four places (*hydrogen, oxygen*)
  - Elements found in three out of four places (*carbon, calcium, magnesium, potassium, sodium*)
  - Elements found in two out of four places (*chlorine, nitrogen, sulfur*)
  - Elements found in only one of the places (*aluminum, argon, iron, phosphorus, silicon*)
2. Give each pair a copy of the “Element Discovery Sheet,” and have them write these 15 elements in this order in the first column of the chart.
3. Allow each pair to use available resources (textbooks and other books, the Internet, and the periodic table) to conduct research to obtain information about the elements. Have them fill in the blocks on the chart with the required information.
4. Display a large color-coded periodic table that shows basic information — each element’s name, atomic number, and symbol; color coding indicating solid, liquid, or gas; and an indication of whether the element is a metal, metalloid, or a nonmetal. Review with students what each of the colors mean, and, if necessary, explain what it means for an element to be a metal, metalloid, or nonmetal. (Determining whether the element is a metal, metalloid, or nonmetal is not a main objective at this level.)
5. When the student pairs have completed their element research and charts, have them post their charts on the classroom wall so that the groups can benefit from each other’s research.

### **Observations and Conclusions**

1. Review with the class what they have discovered about the elements. Emphasize that the reason these particular elements were chosen is because they are some of the more common elements found on Earth. Pose thought-provoking questions that require students to use the information from their discovery sheet. Examples are: “What if there were no more oxygen atoms? What might be affected?” (*Everything*) “Where might we expect to find the greatest percentage of nitrogen atoms?” (*In the atmosphere*)

### **Sample assessment**

- Use the completed “Element Discovery Sheets” to check for completion and depth of answers.
- Informally assess students through classroom discussion.

### **Follow-up/extension**

- Extend this activity by having students use some of the many interactive Web sites about the periodic table, elements, and such to research the history of the discovery of some of the elements. Ask students to connect their findings to the nature of science.

### **Resources**

- *Science Education*. Jefferson Lab. <http://education.jlab.org/>. Provides periodic table.
- *The Visual Elements Periodic Table*. <http://www.chemsoc.org/viselements/pages/pertable fla.htm>. Interactively provides detailed information about each element.
- *WebElements Periodic Table*. <http://www.webelements.com/>. Offers interactive periodic table.



## Common Elements of the Earth and Living Things

Atmosphere	Crust	Ocean	Living Things
A nitrogen	C calcium	O hydrogen	L sulfur
A oxygen	C iron	O oxygen	L chlorine
A carbon	C aluminum	O sodium	L nitrogen
A hydrogen	C silicon	O potassium	L calcium
A argon	C oxygen	O chlorine	L hydrogen
	C potassium	O magnesium	L oxygen
	C sodium	O sulfur	L carbon
	C carbon	O calcium	L potassium
	C hydrogen		L phosphorus
	C magnesium		L sodium
			L magnesium

## ***Modeling the Atom***

**Organizing Topic** Investigating Atoms, Elements, Molecules, and Compounds

**Overview** Students use simple materials to make models of atoms of several elements.

**Related Standards of Learning** 6.1d; 6.4a, b, c

### **Objectives**

The students should be able to

- create and interpret a simplified model of the structure of an atom;
- compare and contrast the atomic structure of two different elements;
- explain that elements are represented by symbols.

### **Materials needed**

- Modeling clay in three different colors
- Plastic knives
- Copies of the attached handout
- Large bag of candy, such as M&M's or jelly beans, in two colors
- Large bag of smaller-size candy in one color
- Metric rulers
- Large, round paper plates
- Overhead transparency of atomic structure

### **Instructional activity**

#### ***Content/Teacher Notes***

An element is made of identical, or nearly identical atoms. An atom is the smallest unit of matter and consists of a dense, central, positively charged nucleus surrounded by a complex system of electron orbitals. Atoms are not divisible by ordinary chemical or physical means.

There are three basic subatomic particles that make up an atom: the proton, the neutron, and the electron. (There are smaller parts, called *quarks*, that make up these subatomic particles, but that is not the focus at this level.) An atom can be distinguished from other atoms by how many protons it has in its nucleus. For example, an atom of hydrogen has one proton in its nucleus, whereas helium has two protons in its nucleus. The number of protons in a particular atom determines the atom's identity and, therefore, is always the same. Protons have a positive charge and electrons have a negative charge. In a neutral atom, the number of electrons is the same as the number of protons. Protons and neutrons are found only in the nucleus of the atom. Electrons are found in complex orbitals around the nucleus and are constantly in motion. Sometimes atoms of the same element may have varying numbers of neutrons.

As students use the materials provided in this activity to construct simple models of several different atoms, stress that the area in which the electrons move is very complex and cannot be adequately depicted with a model. They will learn how to represent the various electron orbitals when they study chemistry in high school. For the purpose of this activity, they need only to have their model represent the relative positions of each of the subatomic particles that make up the atom.

### **Introduction**

1. Divide the class into pairs of students, and have each pair brainstorm objects that have certain matter on the outside and different matter at the center and that are made of different materials. Start them off by mentioning how an egg has a hard shell, a white, and a yolk at its center.
2. Have the groups share their answers, writing them on the board to create a master list.
3. Show the class a diagram of an atom, and explain that atoms could also be added to the list. Explain that atoms have a nucleus in the center and that electrons are found in an area surrounding the nucleus.
4. Have each group revisit its list and identify which part of each object would be similar to the nucleus. Once groups have completed their lists, work as a class to identify the “nucleus” of each object on the master list.
5. Explain that the nucleus is made up of two kinds of particles, writing the following definitions on the board:
  - **proton.** A stable particle with *positive* charge.
  - **neutron.** A particle with a *neutral* charge.

Help the class decide a way to remember that a proton is positively charged; for example, *pro* means supporting something and feeling *positive* toward it. Work with the class to come up with a motion that indicates “positive” for proton, such as thumbs up or a smile. Explain that if something is neutral, it takes no sides, and that in this case, it means that the particle has no charge. Come up with a motion that indicates “no” for neutron, such as shaking head or an umpire’s safe motion to show there is no out.

6. Have the students fill in the blanks and use the motions they have come up with as you read the following sentences: “The center of an atom is called the \_\_\_\_\_. The nucleus is made up of two kinds of particles, the \_\_\_\_\_ and the \_\_\_\_\_. Protons have a \_\_\_\_\_ charge, and neutrons have \_\_\_\_\_ charge.”
7. Show the diagram of the atom once more, and ask the class what surrounds the nucleus, writing the following definition on the board:
  - **electron.** A particle with a *negative* charge.

Work with the class to come up with a motion that indicates “negative” for electron, such as thumbs down or a frown.

8. Review the parts of the atom again, incorporating the motions.

### **Procedure**

1. To help students grasp the concept of an atom being three dimensional, have them make clay models, using at least three different colors of clay to represent the three different kinds of particles. Have them make several small balls of one color to represent the protons and of another color to represent the neutrons in the nucleus. Have them gently push the protons and neutrons together to form a sphere to represent the nucleus.
2. Explain to students that electrons move very, very fast and that we cannot pinpoint exactly where a given electron is at any point in time, but only the area in which it is likely to be found (uncertainty principle). The area where we expect to find the electrons is called the *electron cloud*. Point out to students that they may see illustrations in textbooks that depict the electrons in circular orbits around the nucleus, and explain that this is an outdated and incorrect model of the atom that was proposed by Neils Bohr in the early 1900s. This model was soon disproved and is not considered to be an accurate representation of the atom. The electron cloud model is the model of the atom accepted by the scientific community.

3. Instruct students to gently cover their clay “nucleus” with a layer of the third color of clay to represent the electron cloud region in which the electrons are found. Then, have students use plastic knives to cut their “atom” in half in order to observe its cross section.
4. Hand out the “Atomic Structure” worksheets, and allow time for students to draw their atom’s “cross section.” Ask them to label the parts of their drawing to show where we might expect to find the nucleus, a proton, a neutron, and an electron.
5. Have students separate the large candies into two color groups — one color to represent protons and another color to represent neutrons. Each student will need at least eight pieces of each color.
6. Have the students arrange the large candies in the center of their paper plate to represent the nucleus of a carbon atom. The nucleus should contain six of each of two different colors (for a total of 12) to represent the nucleus of the carbon atom. Discuss with the class where the six electrons should be placed. Should they all go in a clump in the center? All around the rim? Evenly spaced out in an area outside the nucleus? Spaced along concentric rings outside the nucleus? Help students to understand that due to the electrons’ complex motion in the electron cloud region, none of these arrangements will accurately depict the electrons’ positions within the cloud region. Have students come to consensus on how they want to show the electrons in the cloud region.
7. Have students make a simple drawing of their model of the carbon atom.
8. Have students make, using the same candy pieces, and then draw simple models of the hydrogen, nitrogen, and oxygen atoms.

### ***Observations and Conclusions***

1. Discuss the different elements and how the atomic composition of each defines the characteristics of that element.

### **Sample assessment**

- Informally assess through class discussion the students’ understanding of the charge and location of each type of subatomic particle.
- Assess the drawings of the atom models, checking that, for sixth graders, the protons and neutrons are found in the central nucleus and the electrons are shown in the “electron cloud” outside the nucleus.

### **Follow-up/extension**

- Create a periodic table, using the plate and candy method. This will require a lot of candy, so you may want to limit it to the first 30 elements.
- Have the students create models of additional atoms, using the plate and candy method. Extend this activity into a mathematics lesson.

### **Resources**

- *Atom*. [http://encarta.msn.com/encyclopedia\\_761567432\\_10/Atom.html](http://encarta.msn.com/encyclopedia_761567432_10/Atom.html). Encarta encyclopedia history of atomic models.
- “Atom Basics: Structure.” *Chem4Kids.com*. [http://www.chem4kids.com/files/atom\\_structure.html](http://www.chem4kids.com/files/atom_structure.html).
- Atomic Structure. <http://web.jjay.cuny.edu/~acarpi/NSC/3-atoms.htm>. Presents background information on the atom.
- *Grand Orbital Table*. <http://www.orbitals.com/orb/orbtable.htm>. Presents an Orbital Viewer to demonstrate that electrons are *not* found in circular orbits.

# Atomic Structure

**Name:** \_\_\_\_\_ **Date:** \_\_\_\_\_ **Class:** \_\_\_\_\_

## Materials

- Modeling clay in three different colors
- Large, round paper plate
- Pencil
- Centimeter ruler (optional)
- Large candies in two different colors
- Smaller candies in one color

## Procedure

1. In the space below, draw a diagram to illustrate the clay model of a typical atom you created. Label the following parts: nucleus, proton, neutron, electron cloud region.

2. Use a pencil to draw a circle with a diameter of roughly 5-6 cm. in the center of the paper plate.

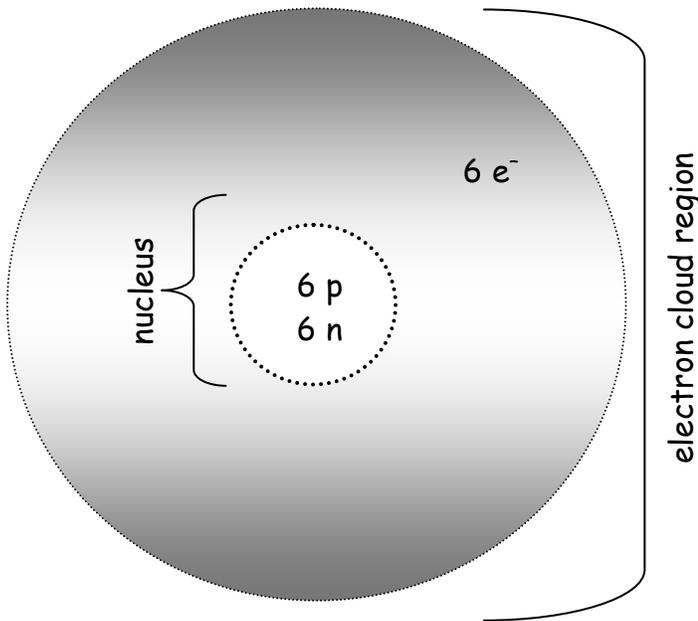
3. Using the large candy pieces to represent protons and neutrons and the small candies to represent electrons, make simple models of carbon, hydrogen, oxygen, and nitrogen atoms. Fill in and label each

Element	Symbol	Protons (+)	Neutrons	Electrons (-)
Carbon	C	6	6	6
Hydrogen	H	1	1	1
Oxygen	O	8	8	8
Nitrogen	N	7	7	7

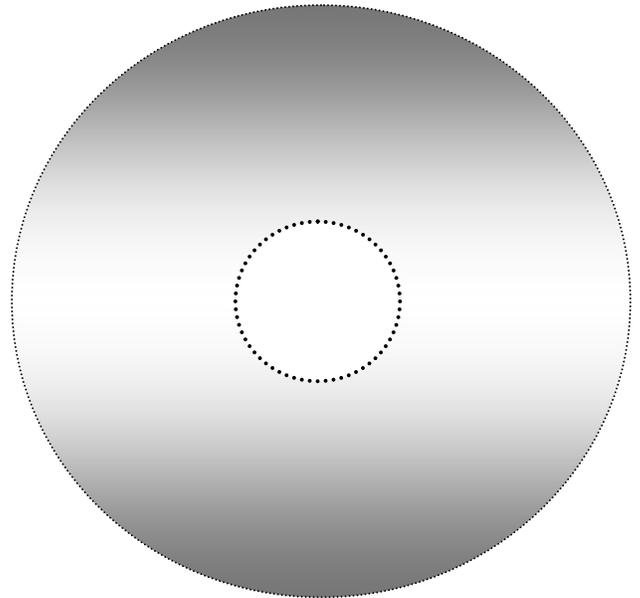
diagram on the following page to illustrate the relative position of each atom's parts. Make sure to label the following parts: nucleus, proton, neutron, electron cloud region.

## Atomic Structure continued

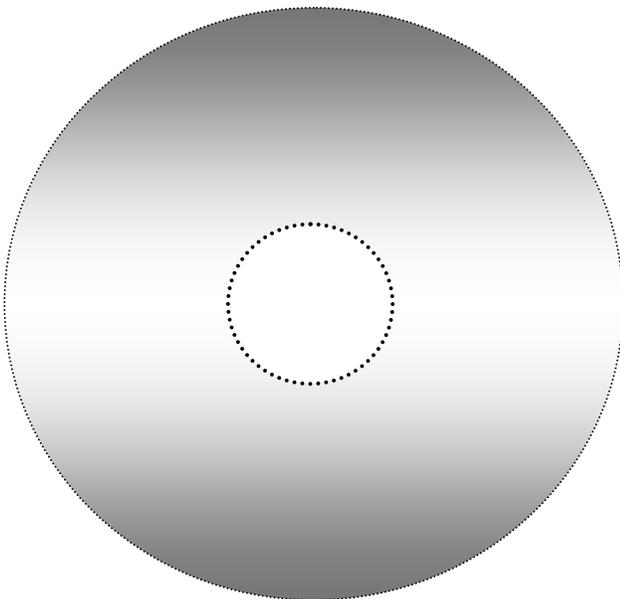
**Carbon**



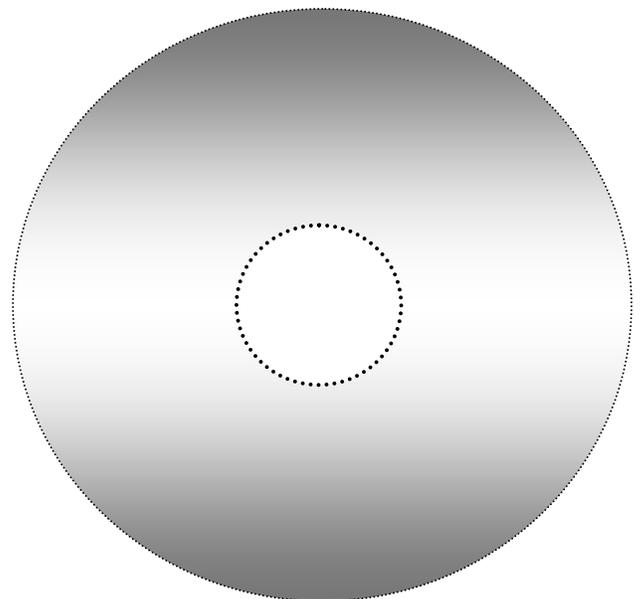
**Hydrogen**



**Oxygen**



**Nitrogen**



## **Sample Released Test Items**

**Which of the following molecules does *not* contain three atoms?**

- A  $O_3$
- B  $N_2$
- C  $H_2O$
- D  $CO_2$

**A compound is a molecule made up of atoms from at least two elements. Which of the following gases is a compound?**

- A Ozone ( $O_3$ )
- B Oxygen ( $O_2$ )
- C Methane ( $CH_4$ )
- D Nitrogen ( $N_2$ )

**Which of these belongs in the outermost shell (energy level) of an atom?**

- A Electrons
- B Protons
- C Neutrons
- D Photons

**A substance made up of two or more elements that have been chemically combined is called —**

- F an atom
- G a compound
- H an element
- J a mixture

## Organizing Topic — Investigating Energy

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- observations are made involving fine discrimination between similar objects and organisms;
  - a classification system is developed based on multiple attributes;
  - precise and approximate measurements are recorded;
  - scale models are used to estimate distance, volume, and quantity;
  - hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - a method is devised to test the validity of predictions and inferences;
  - one variable is manipulated over time, using many repeated trials;
  - data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - models are designed to explain a sequence; and
  - an understanding of the nature of science is developed and reinforced.
- 6.2 The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include
- potential and kinetic energy;
  - the role of the sun in the formation of most energy sources on Earth;
  - nonrenewable energy sources (fossil fuels including petroleum, natural gas, and coal);
  - renewable energy sources (wood, wind, hydro, geothermal, tidal, and solar); and
  - energy transformations (heat/light to mechanical, chemical, or electrical energy).
- 6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include
- management of renewable resources (water, air, soil, plant life, animal life);
  - management of nonrenewable resources (coal, oil, natural gas, nuclear power, mineral resources).

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- comprehend and apply basic terminology related to energy sources and transformations;
- compare and contrast potential and kinetic energy through common examples found in the natural environment;
- create and interpret a model or diagram of an energy transformation;
- analyze and describe the transformations of energy involved with the formation and burning of coal and other fossil fuels;
- compare and contrast renewable and nonrenewable energy sources;

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- design an investigation that demonstrates light energy being transformed into other forms of energy;
- design an application of the use of solar and wind energy;
- chart and analyze the energy a person uses during a 24-hour period, and determine the sources;
- compare and contrast energy sources in terms of their origins, ways they are utilized, and their availability;
- analyze the advantages and disadvantages of using various energy sources;
- analyze and describe how energy use in the U.S. has changed over time;
- predict the potential impact of unanticipated energy shortages;
- differentiate between renewable and nonrenewable resources;
- analyze how renewable and nonrenewable resources are used and managed within the home, school, and community.

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# Comparing and Contrasting Energy Sources

**Organizing Topic** Investigating Energy

**Overview** Students investigate the most common sources of energy and compare and contrast the advantages and disadvantages of using renewable and nonrenewable sources of energy.

**Related Standards of Learning** 6.2c, d; 6.9a, b

## Objectives

The students should be able to

- compare and contrast energy sources in terms of their origins, their use, and their availability;
- differentiate between renewable and nonrenewable resources;
- compare and contrast renewable and nonrenewable energy sources;
- analyze advantages and disadvantages of using various energy sources.

## Materials needed

- Index cards
- Research materials
- Copies of the attached handout

## Instructional activity

### *Content/Teacher Notes*

Energy is causing things to happen all around us. The sun is giving out light and heat energy. At night, street lamps are using electrical energy to make light. Cars driving by are being powered by gasoline, which contains stored energy. We eat food, which has energy in it and which our bodies use to play or study. Energy makes everything happen.

Energy can be divided into two different *types*, depending on whether the energy is stored or moving:

- *Potential energy* is energy that is stored.
- *Kinetic energy* is energy that is moving.

Energy cannot be created or destroyed; it can only be changed, or *transformed*, into other forms. Here are some examples of transformation of energy from one form to another:

- The sun shines on a plant, which transforms the solar energy into food.
- Humans eat the plant, transforming the potential chemical energy stored in it into kinetic mechanical energy or into another form of potential chemical energy stored as fat.
- Potential chemical energy in flashlight batteries is transformed into electrical energy and then light energy when the flashlight is turned on.
- A car engine transforms the potential chemical energy in gasoline into heat, which creates kinetic mechanical energy to power the car.
- A toaster transforms electrical energy into heat (thermal) energy.
- A television transforms electrical energy into light and sound energy.
- A power plant transforms some form of potential or kinetic energy into electrical energy, i.e., electricity. Most power plants use big boilers to burn a fuel to make heat. This heat energy is then used to boil water to make steam. The steam is fed under high pressure to a turbine, which spins. The turbine's spinning shaft is connected to a turbogenerator that changes the mechanical spinning energy into electricity.

The most commonly used **sources of energy** are the following:

- **Sun.** *Solar energy* comes to Earth from the sun in two forms — heat and light. Solar radiation can be used directly to make electricity in a solar cell, or it can be changed into steam for making electricity, heating homes, or heating water.
- **Wind.** Wind, like the sun, is a source of energy that has been used by mankind throughout history. Wind is still used to turn big blades on windmills, and the resulting movement can be used to pump water or produce electricity.
- **Water motion – hydro.** Moving water, such as water flowing in a stream or river or falling over a waterfall or dam can be used to generate electricity, or *hydro power*. The water turns wheels that run turbines that, in turn, run generators that make electricity.
- **Water motion – tidal.** Water in motion because of the ebb and flow of the ocean tides can also run turbines that generate electricity.
- **Earth’s heat.** *Geothermal energy* is the natural heat of the Earth, originating at the Earth’s core and flowing outward to the surface. This heat can be used in its unchanged form to heat homes, among other things, or it can be harnessed in the form of steam to turn turbines and generate electricity.
- **Fossil fuels.** Fossil fuels, like petroleum (oil), natural gas, and coal, are the results of solar energy being transformed in the distant past into potential chemical energy. These fuels are found under the ground or ocean, and it is usually necessary to drill deeply into the Earth to extract them. These fuels are used to make heat and/or electricity, as well as other products, like gasoline.
- **Wood.** Wood is another example of solar energy being transformed into potential chemical energy. Unlike fossil fuels, however, it is a renewable resource, as more trees can be always by grown to make more wood. When wood is burned, it gives off heat, which can be used for various purposes.
- **Atomic fuel.** *Nuclear energy* is made in power plants by splitting the nuclei of heavy atoms, such as uranium. This splitting of nuclei (nuclear fission) releases a very large amount of energy. This heat can be used to boil water and make steam, which then turns turbines to make electricity.

People and other living organisms are dependent upon many renewable and nonrenewable sources of energy, but use of these resources must be considered in terms of their cost/benefit tradeoffs. All living organisms also depend on having clean air and water — i.e., a healthy environment. Many sources of energy are managed and supplied by the private sector (private individuals and corporations), often at considerable cost to the environment. Local, state, and federal governments have significant roles in managing and protecting the environment. The need for sources of energy and the need for protecting the environment are often at odds, and the government must set priorities. Ultimately, however, resource conservation and environmental protection begin with the individual.

### ***Introduction***

1. Tell students that they are going to research the eight most commonly used energy sources to compare and contrast them. Make sure students understand that there are two *types* of energy, kinetic and potential, and that the many *forms* of energy, such as electrical and chemical, can be classified as one type or the other. Also, emphasize that there are many *sources* of energy, most of which, with the exception of geothermal and tidal, originate directly or indirectly with the sun.
2. Provide each student with the information outlined under “Content/Teacher Notes,” and review each energy source briefly. Discuss the meaning of *renewable* and *nonrenewable*.

### ***Procedure***

1. Write the name of each energy source on an index card. Divide the students into eight groups, and have each group draw a card to determine the energy source that will be their research topic.

2. Have the groups use classroom, library, and Internet resources to research the answers to the following questions and gather data for a classroom presentation and discussion:
  - What is your energy source?
  - What is the origin of your energy source?
  - What uses does your energy source currently have?
  - How readily available is your energy source? What is required to acquire this source?
  - What advantages does your energy source have? Is it renewable or nonrenewable?
  - What disadvantages does your energy source have?
  - Has the use of this energy source changed over time?
  - How long will your energy source be available on Earth?
  - What type of management is necessary for your energy source?
  - Rate your energy source on a scale of 1 to 10 in terms of overall desirability. Be prepared to defend your answer.
3. Have the student groups present their answers to the research questions and other data orally in class. During the presentations, have students individually fill in the attached “Sources of Energy” chart, comparing and contrasting the various energy sources. Use this data to lead a discussion of each source of energy.

### ***Observations and Conclusions***

1. Based on the data presented in the group reports, have the class rank the various sources of energy in terms of desirability, considering whether the sources are renewable, whether they cause pollution, whether they are readily available, whether they are economical, and other factors.

### **Sample assessment**

- Use the “Sources of Energy” chart to generate additional activities and assessment.

### **Follow-up/extension**

- See the “Energy in the Balance” project in Chapter 5 of the *Virginia Naturally* Web site: <http://www.vanaturally.com/guide.html> for additional project ideas.

### **Resources**

- *The Electric Universe*. American Electric Power. <http://aep.electricuniverse.com>.
- *Energy Kid’s Page*. The National Energy Information Center (NEIC). <http://www.eia.doe.gov/kids/>.
- *Global Warming Kid’s Site*. United States Environmental Protection Agency. <http://www.epa.gov/globalwarming/kids/games/index.html>.
- *The Need Project: Putting Energy into Education*. National Energy Education Development Project. <http://www.need.org/>.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

# Sources of Energy

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Energy Source	Advantages	Disadvantages
Sun		
Wind		
Water motion: hydro		
Water motion: tidal		
Earth's heat		
Fossil fuels		
Wood		
Atomic fuel		

## ***Transforming Energy into Electricity***

**Organizing Topic** Investigating Energy

**Overview** Students investigate the transformation of energy.

**Related Standards of Learning** 6.2b, e; 6.9a, b

### **Objectives**

The students should be able to

- comprehend and apply basic terminology related to energy sources and transformations;
- analyze and describe the transformations of energy involved with the formation and burning of coal and other fossil fuels;
- create and interpret a model or diagram of an energy transformation.

### **Materials needed**

- “Sources of Energy” chart from the previous activity
- Index cards
- White drawing paper

### **Instructional activity**

#### ***Content/Teacher Notes***

See teacher notes from “Comparing and contrasting Energy Sources.”

#### ***Introduction***

1. Tell students that they will use the data in their “Sources of Energy” chart from the previous activity to explore how energy from each source can be transformed into useable electrical energy.
2. Explain the process of generating electricity. Numerous Web sites provide information on this process. See <http://www.hawaii.gov/dbedt/info/energy/renewable/electricitygeneration/> and <http://www.tva.gov/power/fossil.htm>, both of which provide excellent graphics.

#### ***Procedure***

1. Lead a class discussion in which you list the steps in the process of generating electricity in a traditional power plant using a fossil fuel. Be sure to remind students that the sun is the original source of the energy stored in the fuel. Write each step on an index card.
2. Divide the class into groups, distribute one card to each group, and have the members of the group illustrate their step on drawing paper.
3. Have the groups present their illustrations *in order* of the process and describe their step.

#### ***Observations and Conclusions***

1. Review the transformations of energy that take place during the process of generating electricity.
2. Have students compare and contrast the three common fossil fuels as energy sources for the generation of electricity, pointing out the various advantages and disadvantages of each fuel.
3. Have the students use their “Sources of Energy” chart from the previous activity to compare and contrast the generation of electricity from the other energy sources. Which sources use similar techniques? Which sources use unique processes?

## Sample assessment

- Have the students list the steps for the generation of electricity from the renewable energy sources: sun, wind, water motion (hydro and tidal), and Earth’s heat. Have them answer the following questions: “Are these sources currently being used? If so, how extensive is the use of each source? What are the advantages and disadvantages of using each of these sources?”
- Have students investigate the reasons that wood is not used as an energy source for the generation of electricity. Have them investigate biomass — a new technology, similar to wood, that is being developed for this purpose.
- Follow the same process of card distribution, illustration, and discussion of the production of electricity from each of the other energy sources.

## Resources

- *The Electric Universe*. American Electric Power. <http://aep.electricuniverse.com>.
- *Energy Kid’s Page*. The National Energy Information Center (NEIC). <http://www.eia.doe.gov/kids/>.
- *Fossil-Fuel Generation*. Tennessee Valley Authority. <http://www.tva.gov/power/fossil.htm>. Explains generation of electricity by the use of fossil fuels.
- *Global Warming Kid’s Site*. United States Environmental Protection Agency. <http://www.epa.gov/globalwarming/kids/games/index.html>.
- *How is Electricity Produced?* State of Hawaii. <http://www.hawaii.gov/dbedt/info/energy/renewable/electricitygeneration/>.
- *The Need Project: Putting Energy into Education*. National Energy Education Development Project. <http://www.need.org/>.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

# ***Investigating Energy***

**Organizing Topic** Investigating Energy

**Overview** Students investigate the transfer of energy within living and Earth systems in order to understand the forms of energy and their transformations from one form to another.

**Related Standards of Learning** 6.2a

## **Objectives**

The students should be able to

- chart and analyze the energy a person uses during a 24-hour period and determine the sources;
- compare and contrast potential and kinetic energy through common examples found in the natural environment.

## **Materials needed**

- Pencils
- Chart paper

## **Instructional activity**

### ***Content/Teacher Notes***

See Content/Teacher Notes from “Comparing and Contrasting Energy Sources.”

### ***Introduction***

1. Informally assess the students’ energy awareness. Promote inquiry with questions such as:
  - What is the Earth’s energy source?
  - How is the sun’s energy converted into the chemical energy of food?
  - Why is energy necessary?
  - What would life be like without energy?
2. Review the two *types* of energy, potential and kinetic, using the following demonstration activity:
  - Have the students put a pencil at the side of their desk and then push it off the edge. *As the pencil is falling, it has kinetic energy.*
  - Have them pick up the pencil and put it back on the desk. Tell them that they used their own energy to lift and move the pencil back to the desk. Moving it anywhere higher than the floor adds potential energy to it. The higher it is, the farther it could fall, so *the higher the pencil is raised, the more potential energy it has.*
3. Reinforce this demonstration by discussing a rubber band: If you use energy to stretch out a rubber band and hold it in that position, the stretched rubber band has potential energy. If you let it go, it moves and has kinetic energy.
4. Create a working model of energy transformation. For example, illustrate the transformation of wind energy into mechanical energy, using a simple pinwheel, or illustrate how heat can be transformed into mechanical energy, using the heat from a candle. Have the students brainstorm other common examples.
5. Provide the students with a list of basic terminology related to energy sources and energy transformations (see Content/Teacher Notes above).

### ***Procedure***

1. Have small groups of students brainstorm ways they depend on energy every day. Have them create a preliminary list of energy uses.
2. Have the groups share and discuss their lists of everyday energy needs. For each need, ask the class to answer the following questions:
  - What *form* of energy is needed? (e.g., electrical)
  - How does that form of energy become available to us?
  - Where does it come from?
  - How it is created/transformed for our use?
3. Have the students record all the ways they interact with energy in their lives over a 24-hour period. Whenever possible, the students should identify the *form* of energy (e.g., electricity) and its *source* (e.g., coal-fired power plant).

### ***Observations and Conclusions***

1. Have the students share their records of interaction with energy. Have them use their observations to chart the forms of energy most frequently used and the sources of this energy. Create a class chart of this data.
2. Discuss our dependence on energy, particularly electricity. Ask, “What happens when we temporarily lose power for a period of time? What would we do if we ran out of power? How would this affect our lives?”

### **Sample assessment**

- Have students use the records they created in step 3 under Procedure to write a short personal narrative describing a day when they wake up and discover there is no energy.

### **Resources**

- *The Electric Universe*. American Electric Power. <http://aep.electricuniverse.com>.
- *Energy Kid’s Page*. The National Energy Information Center NEIC). <http://www.eia.doe.gov/kids/>.
- *Global Warming Kid’s Site*. United States Environmental Protection Agency. <http://www.epa.gov/globalwarming/kids/games/index.html>.
- *The Need Project: Putting Energy into Education*. National Energy Education Development Project. <http://www.need.org/>.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

## ***Generating Electricity: What Sources Do We Use?***

**Organizing Topic** Investigating Energy

**Overview** Students investigate the types of energy sources used to generate electricity in the United States.

**Related Standards of Learning** 6.9a, b; 6.2c, d, e

### **Objectives**

The students should be able to

- analyze and describe how energy use in the U.S. has changed over time;
- analyze ways renewable and nonrenewable resources are used and managed within the home, school, and community.

### **Materials needed**

- “Sources of Energy” chart from the “Comparing and Contrasting Energy Sources” activity
- Copies of the attached handouts
- Colored pencils or markers (black, orange, red, blue, yellow, green)

### **Instructional activity**

#### ***Content/Teacher Notes***

Energy is causing things to happen all around us. The sun is giving out light and heat energy. At night, street lamps are using electrical energy to make light. Cars driving by are being powered by gasoline, which contains stored energy. We eat food, which has energy in it and which our bodies use to play or study. Energy makes everything happen.

Energy can be divided into two different *types*, depending on whether the energy is stored or moving:

- *Potential energy* is energy that is stored.
- *Kinetic energy* is energy that is moving.

Energy cannot be created or destroyed; it can only be changed, or *transformed*, into other forms. Here are some examples of transformation of energy from one form to another:

- The sun shines on a plant, which transforms the solar energy into food.
- Humans eat the plant, transforming the potential chemical energy stored in it into kinetic mechanical energy or into another form of potential chemical energy stored as fat.
- Potential chemical energy in flashlight batteries is transformed into electrical energy and then light energy when the flashlight is turned on.
- A car engine transforms the potential chemical energy in gasoline into heat and kinetic mechanical energy to power the car.
- A toaster transforms electrical energy into heat (thermal) energy.
- A television transforms electrical energy into light and sound energy.
- A power plant transforms some form of potential or kinetic energy into electrical energy, i.e., electricity. Most power plants use big boilers to burn a fuel to make heat. This heat energy is then used to boil water to make steam. The steam is fed under high pressure to a turbine, which spins. The turbine’s spinning shaft is connected to a turbogenerator that changes the mechanical spinning energy into electricity.

The most commonly used **sources of energy** are the following:

- **Sun.** *Solar energy* comes to Earth from the sun in two forms — heat and light. Solar radiation can be used directly to make electricity in a solar cell, or it can be changed into steam for making electricity, heating homes, or heating water.
- **Wind.** Wind, like the sun, is a source of energy that has been used by mankind throughout history. Wind is still used to turn big blades on windmills, and the resulting movement can be used to pump water or produce electricity.
- **Water motion – hydro.** Moving water, such as water flowing in a stream or river or falling over a waterfall or dam can be used to generate electricity, or *hydro power*. The water turns wheels that run turbines that, in turn, run generators that make electricity.
- **Water motion – tidal.** Water in motion because of the ebb and flow of the ocean tides can also run turbines that generate electricity.
- **Earth’s heat.** *Geothermal energy* is the natural heat of the Earth, originating at the Earth’s core and flowing outward to the surface. This heat can be used in its unchanged form to heat homes, among other things, or it can be harnessed in the form of steam to turn turbines and generate electricity.
- **Fossil fuels.** Fossil fuels, like petroleum (oil), natural gas, and coal, are the results of solar energy being transformed in the distant past into potential chemical energy. These fuels are found under the ground or ocean, and it is usually necessary to drill deep into the Earth to extract them. These fuels are used to make heat and/or electricity, as well as other products, like gasoline.
- **Wood.** Wood is another example of solar energy being transformed into potential chemical energy. Unlike fossil fuels, however, it is a renewable resource, as more trees can be always by grown to make more wood. When wood is burned, it gives off heat, which can be used for various purposes.
- **Atomic fuel.** *Nuclear energy* is made in power plants that use uranium, an atomic fuel that when split gives off heat. This heat can be used to boil water and make steam, which then turns turbines to make electricity.

People and other living organisms are dependent upon many renewable and nonrenewable sources of energy, but use of these resources must be considered in terms of their cost/benefit tradeoffs. All living organisms also depend on having clean air and water — i.e., a healthy environment. Many sources of energy are managed and supplied by the private sector (private individuals and corporations), often at considerable cost to the environment. Local, state, and federal governments have significant roles in managing and protecting the environment. The need for sources of energy and the need for protecting the environment are often at odds, and the government must set priorities. Ultimately, however, resource conservation and environmental protection begin with the individual.

### ***Introduction***

1. Discuss the things the students have learned from the previous activities — for example, what energy sources should be developed and why; what energy sources should be phased out and why.
2. Tell students that the following activity will help them form and defend an informed opinion of the current status of electricity generation in the United States.

### ***Procedure***

1. Have students investigate the energy sources most commonly used for electricity production in Virginia. Direct them to visit (or provide them with information from) the *Virginia Naturally* Web page “Virginia’s Minerals & Energy Resources,” found at <http://www.vanaturally.com/guide/mineralsandenergy.html>. Scroll down to “Part Two: Energy Resources” to read about the sources of energy used in Virginia.

2. Give each student a copy of the “U.S. Electrical Energy Sources” handout and the “U.S. Electrical Energy Sources Data Table.” Have the students investigate the energy sources most commonly used for electricity production in the U.S. by following the directions on the handout. Have them use this data to formulate and defend opinions on the status of energy production in the U.S.

### ***Observations and Conclusions***

1. Ask, “What conclusions can we draw from analysis of the completed map? How do the actual sources of energy being used compare with the class discussion of sources to be developed or phased out? Were there surprises in this activity?”
2. Ask, “What implication does the conclusion of this activity hold? How could you use the data to raise awareness of the need for greater use of renewable, clean energy sources in the U.S.?”

### **Sample assessment**

- Use the completed handouts for assessment.

### **Follow-up/extension**

- Brainstorm extension activities that could be used to create awareness in the community of the need for greater use of renewable, clean energy sources.

### **Resources**

- *The Electric Universe*. American Electric Power. <http://aep.electricuniverse.com>.
- *Energy Kid’s Page*. The National Energy Information Center (NEIC). <http://www.eia.doe.gov/kids/>.
- *Global Warming Kid’s Site*. United States Environmental Protection Agency. <http://www.epa.gov/globalwarming/kids/games/index.html>.
- *The Need Project: Putting Energy into Education*. National Energy Education Development Project. <http://www.need.org/>.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

# U.S. Electrical Energy Sources

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Directions

1. On the accompanying "U.S. Electrical Energy Sources Data Table," highlight the most used energy source for each state.
2. List the state(s) that use the *most* of the following energy sources, and list the percentage used:  
Coal: \_\_\_\_\_ Nuclear: \_\_\_\_\_  
Petroleum: \_\_\_\_\_ Hydro: \_\_\_\_\_  
Natural gas: \_\_\_\_\_ Other renewables: \_\_\_\_\_  
Other gases: \_\_\_\_\_ Other: \_\_\_\_\_
3. Color each state on the map below to indicate each state's *primary* energy source – i.e., the energy source used to generate the *most* electricity in that state. Color key: coal = black; petroleum = orange; natural gas = red; hydro = blue; nuclear = yellow; other sources = green.



# U.S. Electrical Energy Sources Data Table

State	Coal	Petroleum	Natural Gas	Other Gases	Nuclear	Hydro	Other Renewables	Other
Alabama	58%	0%	8%	<1%	24%	7%	4%	<1%
Alaska	8%	14%	58%	0%	0%	20%	<1%	0%
Arkansas	52%	2%	6%	0%	31%	5%	3%	<1%
Arizona	45%	<1%	14%	0%	32%	9%	<1%	0%
California	0%	2%	56%	1%	17%	13%	10%	<1%
Colorado	77%	<1%	20%	0%	0%	3%	<1%	0%
Connecticut	10%	19%	14%	<1%	50%	1%	6%	0%
Delaware	50%	25%	23%	2%	0%	0%	0%	0%
Florida	36%	21%	23%	<1%	17%	<1%	3%	<1%
Georgia	63%	1%	3%	0%	28%	2%	3%	0%
Hawaii	15%	77%	0%	<1%	0%	<1%	6%	0%
Idaho	1%	<1%	16%	0%	0%	77%	6%	<1%
Iowa	85%	<1%	1%	0%	10%	2%	1%	0%
Illinois	44%	1%	2%	<1%	52%	<1%	<1%	0%
Indiana	95%	<1%	2%	2%	0%	1%	<1%	0%
Kansas	71%	1%	4%	0%	23%	<1%	0%	0%
Kentucky	95%	<1%	<1%	0%	0%	4%	0%	0%
Louisiana	24%	4%	47%	<1%	20%	<1%	3%	<1%
Massachusetts	29%	22%	31%	0%	13%	0%	5%	0%
Maryland	58%	6%	4%	1%	27%	2%	1%	0%
Maine	3%	11%	51%	<1%	0%	12%	22%	1%
Michigan	61%	1%	12%	<1%	24%	<1%	2%	<1%
Missouri	83%	1%	5%	0%	11%	1%	<1%	0%
Minnesota	66%	1%	2%	0%	24%	8%	5%	0%
Mississippi	37%	10%	32%	0%	19%	0%	<1%	0%
Montana	70%	2%	<1%	<1%	0%	27%	<1%	0%
N. Carolina	62%	<1%	1%	<1%	32%	2%	2%	<1%
N. Dakota	95%	<1%	<1%	<1%	0%	4%	<1%	0%
Nebraska	66%	1%	1%	0%	29%	4%	1%	0%
N. Hampshire	25%	3%	1%	0%	58%	7%	7%	0%
N. Jersey	16%	2%	28%	<1%	51%	0%	2%	0%
N. Mexico	84%	<1%	15%	0%	0%	1%	<1%	0%
N. York	16%	12%	27%	<1%	28%	15%	2%	0%
Nevada	52%	3%	34%	0%	0%	7%	4%	<1%
Ohio	87%	<1%	1%	<1%	11%	<1%	<1%	0%
Oklahoma	63%	<1%	32%	<1%	0%	4%	<1%	0%
Oregon	10%	<1%	24%	0%	0%	63%	2%	0%
Pennsylvania	56%	2%	2%	0%	38%	1%	1%	0%
R. Island	0%	1%	98%	0%	0%	<1%	1%	0%
S. Carolina	41%	<1%	1%	<1%	55%	<1%	2%	0%
S. Dakota	49%	1%	4%	0%	0%	46%	<1%	0%
Tennessee	62%	<1%	1%	<1%	30%	6%	1%	0%
Texas	37%	1%	49%	1%	1%	<1%	1%	<1%
Utah	94%	<1%	4%	1%	0%	1%	<1%	0%
Virginia	51%	8%	6%	0%	35%	0%	2%	0%
Vermont	0%	1%	<1%	<1%	76%	16%	7%	0%
Washington	11%	<1%	11%	<1%	10%	66%	2%	0%
Wisconsin	70%	1%	4%	0%	20%	3%	2%	0%
W. Virginia	98%	<1%	<1%	<1%	0%	1%	<1%	<1%
Wyoming	96%	<1%	1%	<1%	0%	2%	1%	<1%
<b>U.S. TOTAL</b>	<b>51%</b>	<b>3%</b>	<b>17%</b>	<b>2%</b>	<b>21%</b>	<b>6%</b>	<b>2%</b>	<b>&lt;1%</b>

Source: National Energy Information Center, United States Department of Energy. 2001 data released in March 2003 report.

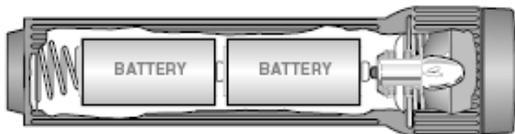
## Sample Released Test Items

Which system shows a transformation from chemical to electrical and light energy?

- A A car battery causes the headlights to shine.
- B A candle burns and lights up the room.
- C A display of fireworks in the night sky.
- D An avalanche rolls down a steep mountain.

Because burning fossil fuels creates much pollution, alternatives are being investigated. What might limit the use of wind as a major energy source?

- F The strength of the wind varies.
- G Wind machines have huge blades to capture the wind.
- H Turbines and generators in the wind machines create electricity.
- J Wind power does not create pollution.



This flashlight uses three different forms of energy. Which of these shows the energy changes in the correct order?

- A Mechanical → heat → chemical
- B Heat → chemical → light
- C Electrical → mechanical → chemical
- D Chemical → electrical → light

Because it can be transported easily and converted into other forms of energy, the energy form *most* commonly used in households is —

- F chemical
- G nuclear
- H heat
- J electrical

An example of kinetic energy continuously being changed to potential energy and back again might be —

- F a girl swinging on a swing
- G a train moving down a track
- H electric charges moving in a straight path
- J a plate sitting on the edge of a table

## Organizing Topic — Investigating Conservation

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- a) observations are made involving fine discrimination between similar objects and organisms;
  - b) a classification system is developed based on multiple attributes;
  - c) precise and approximate measurements are recorded;
  - d) scale models are used to estimate distance, volume, and quantity;
  - e) hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - f) a method is devised to test the validity of predictions and inferences;
  - g) one variable is manipulated over time, using many repeated trials;
  - h) data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - i) data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - j) models are designed to explain a sequence; and
  - k) an understanding of the nature of science is developed and reinforced.
- 6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include
- c) the mitigation of land-use and environmental hazards through preventive measures; and
  - d) cost/benefit tradeoffs in conservation policies.

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- describe the role of local and state conservation professionals in managing natural resources. These include wildlife protection; forestry and waste management; and air, water, and soil conservation;
- analyze resource-use options in everyday activities, and determine how personal choices have costs and benefits related to the generation of waste;
- analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs/benefits in real-life situations;
- evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment.

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# **Conservation and the Environment**

**Organizing Topic** Investigating Conservation

**Overview** Students gain an understanding of personal responsibility and public policy decisions relating to the environment.

**Related Standards of Learning** 6.1; 6.9

## **Objectives**

The students should be able to

- analyze resource-use options in everyday activities and determine how personal choices have costs and benefits related to the generation of waste;
- evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment;
- analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs/benefits in real-life situations;
- describe the role of local and state conservation professionals in managing natural resources. These include wildlife protection; forestry and waste management; and air, water, and soil conservation.

## **Materials needed**

- Internet access
- Four large plastic trash cans or other containers
- Floor scale or balance
- Rubber gloves

## **Instructional activity**

### **Content/Teacher Notes**

The following statements are found in the Constitution of Virginia, Article XI:

To the end that the people have clean air, pure water, and the use and enjoyment for recreation of adequate public lands, waters, and other natural resources, it shall be the policy of the Commonwealth to conserve, develop, and utilize its natural resources, its public lands, and its historical sites and buildings. Further, it shall be the Commonwealth's policy to protect its atmosphere, lands, and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth.

Conservation means using our resources wisely and protecting them for the future. *Virginia Naturally* is the Commonwealth of Virginia's environmental education network, providing a gateway to statewide environmental education resources, including information about volunteer opportunities, educational classes, places to visit, community events, watershed maps, lesson plans, and recreational activities. This Web site gives students the ability to explore, describe, analyze, and evaluate conservation opportunities and policies in the state of Virginia. As an introduction to Standard of Learning 6.9, it is imperative to spend the necessary time investigating and becoming familiar with the potential of each link on this Web site. *Virginia's Natural Resources Education Guide*, located at <http://www.deq.state.va.us/vanaturally/guide.html>, is an excellent resource for teacher and student education. Links entitled "Public Policy and Environmental Management" and "Waste Management and Pollution Prevention" provide background information essential to the understanding of standard 6.9.

### **Introduction**

1. Pose and discuss the following questions to generate awareness of environmental concerns involving resource use and waste management:

- What do you do with things you no longer want or need?
- Where does your trash go when it leaves your trashcan? (Trace as far as possible.)
- Does your family recycle? Why, or why not?
- Have you ever visited a landfill? What do you know about one?
- How does waste disposal increase our use of energy? How does this impact our natural resources?

### **Activity 1: How Much Waste Do We Create?**

#### ***Procedure***

1. With permission of the school administration, have students collect one classroom's solid waste trash for five days.
2. Each morning, have students record the weight of the collected trash from the previous day and record the data on a spreadsheet and graph.
3. Instruct students to use rubber gloves to sort the trash into boxes in the following four categories: (a) nonwhite paper (notebook paper, newsprint, construction paper, catalogs); (b) white paper (computer paper, copy paper); (c) plastic; (d) other.
4. At the end of the week, have students calculate the weight of the trash in each category and the total weight of all trash collected. Have them record this data on a spreadsheet and graph and reflect on the results.

#### ***Observations and Conclusions***

1. Have students examine results to draw conclusion.
2. Ask the following questions:
  - Were the findings surprising?
  - What materials collected were recyclable?
  - What materials collected could have been reused?
  - Looking at the data for each category, what was thrown away most frequently?
  - Where will this trash go after it is no longer needed for this activity?
  - What impact does throwing away these things have on our natural resources? On our environment?

#### **Sample assessment**

- Have students chart the results and create graphs, as directed.
- Assess student spreadsheets and graphs for accuracy and understanding.
- Using questioning strategies, assess student understanding of the far-reaching effects of waste management on natural resources.

### **Activity 2: Perspectives on Real-Life Situations**

#### ***Procedure***

1. Have students access the *Virginia Naturally* Web site at <http://www.deq.state.va.us/vanaturally/> and click on the current month's news to read current environmental news stories from Virginia media sources.
2. Direct students to locate and read reports concerning the following:
  - Waste collection or management success/failure stories
  - Examples of resource management success/failure
  - Current noteworthy news reports concerning resource and waste management

### ***Observations and Conclusions***

1. Have students, individually or in groups, provide their responses to the readings.
2. Discuss success stories, asking, “Who was responsible for the success? What was the motivation for improvement? What will be the present and future results?”
3. Discuss stories with negative environmental concerns, asking, “How can the problem be overcome? What predictions can be made for the future? How can we make a difference in this problem?”
4. Have students formulate a plan to address the issue, including the possibility of contacting appropriate legislators.

### **Sample assessment**

- Give the students a selected media article from the *Virginia Naturally* Web site, and have them identify the location of the news event, the natural resource(s) affected, and the cost/benefit of the situation.

### **Activity 3: Resource Management**

#### ***Procedure***

1. Discuss with students the fact that an important aspect of conservation is people’s ability to find and tap into community and municipal resources that are designed to assist people in resource management.
2. Divide students into six teams, and give each team one of the following topics: wildlife, forestry, air, water, soil, waste management.
3. Have the teams search the *Virginia Naturally* Web site to
  - identify local and state conservation professionals who assist in the conservation and management of their resource
  - locate a specific service or professional who may be contacted to provide educational assistance to their class or school.
  - locate a project-oriented activity that their group agrees is feasible for their class or school.
4. Assist each team in contacting one resource specialist to share in some way with the class.

### **Follow-up/extension**

- Have students create a multimedia slide show presentation to highlight current environmental issues in the news with the purpose of raising public awareness.
- Have students select one or more waste-reduction projects for school-wide implementation (see “Creating Less Trash at School” below).

### **Resources**

- *Alliance to Save Energy*. <http://www.ase.org/educators/download.htm>. Offers lesson plans on resource management.
- “Creating Less Trash at School.” *Minnesota Office of Environmental Assistance*. <http://www.moea.state.mn.us/campaign/school/index.html>.
- *United States Environmental Protection Agency*. <http://www.epa.gov/>. Offers lesson plans on all aspects of conservation.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

## ***Sample Released Test Items***

There are many reasons why the use of oil needs to be managed carefully. Which of the following is *not* one of these reasons?

- F There are only limited supplies of oil in the Earth.
- G Oil spills at sea have killed many marine animals.
- H Burning oil contributes to acid rain and the greenhouse effect.
- J Oil was created by plants and animals.

## Organizing Topic — Investigating Water

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- a) observations are made involving fine discrimination between similar objects and organisms;
  - b) a classification system is developed based on multiple attributes;
  - c) precise and approximate measurements are recorded;
  - d) scale models are used to estimate distance, volume, and quantity;
  - e) hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - f) a method is devised to test the validity of predictions and inferences;
  - g) one variable is manipulated over time, using many repeated trials;
  - h) data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - i) data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - j) models are designed to explain a sequence; and
  - k) an understanding of the nature of science is developed and reinforced.
- 6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include
- a) water as the universal solvent;
  - b) the properties of water in all three states;
  - c) the action of water in physical and chemical weathering;
  - d) the ability of large bodies of water to store heat and moderate climate;
  - e) the origin and occurrence of water on Earth;
  - f) the importance of water for agriculture, power generation, and public health.

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- comprehend and apply key terminology related to water and its properties and uses;
- model and explain the shape and composition of a water molecule;
- design an investigation to determine the relative density of liquid and solid water at various temperatures;
- compare the relative density of liquid and solid water;
- comprehend the adhesive and cohesive properties of water;
- design an investigation to determine the effects of heat on the states of water;
- model and explain why ice is less dense than liquid water;
- relate the three states of water to the water cycle;
- design an investigation to demonstrate the ability of water to dissolve materials;

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- design an investigation to determine the presence of water in plant material (e.g., a fruit);
- infer how the unique properties of water are key to the life processes of organisms;
- design an investigation to model the action of freezing water on rock material;
- design an investigation to model the action of acidified water on building material such as concrete, limestone, or marble;
- chart, record, and describe evidence of chemical weathering in the local environment;
- explain the role of water in power generation;
- analyze and explain the difference between average winter temperatures in central and western Virginia and those in areas along the Chesapeake Bay and Atlantic coast.

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## ***Molecular Attraction***

**Organizing Topic** Investigating Water

**Overview** Students examine water’s unique properties of adhesion, cohesion, surface tension, and capillarity.

**Related Standards of Learning** 6.5b

### **Objectives**

The students should be able to

- comprehend the adhesive and cohesive properties of water.

### **Materials needed**

- Overhead projector
- Petri dishes
- Water
- Pepper
- Detergent
- Blue and red food coloring
- Rubbing alcohol
- Toothpicks
- Eyedroppers
- Pennies
- Beakers
- Paper towels
- Plastic film canisters
- Paper clips
- Plastic cups
- Forks
- Wax paper
- Glass slides
- Chromatography paper or paper towels
- 50-mL graduated cylinders
- Wet erase markers
- Metric rulers
- Stopwatches
- Copies of the attached handouts

### **Instructional activity**

#### ***Content/Teacher Notes***

Although a water molecule has an overall neutral charge, one of water’s unique properties is that one side of the molecule is slightly negative (oxygen) and the other is slightly positive (hydrogen). This polarity of water molecules causes them to attract each other like little magnets: the slightly positive side is attracted to the slightly negative side of an adjacent water molecule. This attraction of one water molecule to another is called *cohesion*, which is the reason water molecules “stick together” and form a “skin” at the surface known as *surface tension*. Surface tension enables water to support small objects, such as water bugs, and it also allows water to form drops and bubbles. A drop of water falling from a faucet will stretch itself very thin before it finally falls. Once it falls, it immediately forms the shape of a sphere.

Water molecules also stick to molecules of other substances. The attraction of water molecules to other substances, like grass or glass, is called *adhesion*. It is adhesion that causes water’s surface to rise near a container’s walls; if there were no opposing forces, the water would creep up the walls higher and higher until it overflowed the container. However, in most cases, cohesion causes the formation of a “bridge” in the liquid. The various forces — adhesion between water and glass, cohesion between water molecules, and the force of gravity on the water — work in opposition until equilibrium is reached. It is these forces that lead to the concave *meniscus* in a graduated cylinder or test tube.

*Capillarity* is also the result of a combination of adhesion and cohesion, but one in which adhesion overcomes gravity and cohesion. *Capillary action* is the phenomenon in which the surface of a liquid is elevated or depressed where it comes in contact with a solid. When a glass tube is placed in water, the water rises in the tube, just as water rises in a piece of paper when a portion of it is placed in water. In

such cases, water’s adhesion to the glass and paper overcomes gravity and its own cohesion. Water moves to the tops of tall trees against the force of gravity due to capillary action.

This lesson involves four lab activities that can be conducted on four separate days or on one day at four lab stations through which pairs of students rotate.

### ***Introduction***

1. Lead a class discussion about how some insects can walk on water. How is this possible? Also, ask the students to explain how water can rise to the tops of tall trees when there is no “pumping mechanism” in a tree.
2. Place a petri dish with water on the overhead projector. Sprinkle some pepper on the surface of the water, and discuss the reason that it stays on the surface and evenly distributes across the surface. (*Surface tension, due to the cohesive hydrogen bonds among water molecules, holds the pepper on the surface.*) Very carefully add one drop of detergent to the center of the dish. Ask students to make observations and to explain what happened. (*The pepper moved to sides of the container because the detergent disrupted the hydrogen bonds that cause the surface tension.*)
3. Tell students that they will do other activities like this one to discover the unique properties of water.

### ***Procedure***

#### **Activity 1: It’s in the Liquid**

1. This is a good activity for students to do first. Properties covered in this activity include adhesion, cohesion, and surface tension.
2. Prepare the blue liquid (water with blue food coloring) and the red liquid (rubbing alcohol with red food coloring).
3. Distribute a copy of the “It’s in the Liquid” handout to each pair of students, and have them follow the directions.

#### **Activity 2: Molecular Attraction**

1. Properties covered in this activity include cohesion and surface tension. Students will predict and count how many drops of water a penny can hold before overflowing.
2. Give a copy of the “Molecular Attraction” handout to each pair of students, and have them follow the directions.

#### **Activity 3: It’s All Over**

1. Properties covered in this series of quick activities include adhesion, cohesion, and surface tension.
2. Provide a copy of the “It’s All Over” handout to each pair of students, and have them follow the directions.

#### **Activity 4: Climbing Trees**

1. In this activity, students will observe the capillary action of water in absorbent paper.
2. Prepare 10 x ½ inch paper strips, using chromatography paper or paper towels.
3. Distribute a copy of the “Climbing Trees” handout to each pair of students, and have them follow the directions.

### ***Observations and Conclusions***

1. Discuss with students the reasons that these properties of water are essential to life processes. (*Capillary action of water, with cohesion and adhesion, helps water reach the tops of trees and helps carry blood throughout organisms.*)
2. Have students complete all activity pages. Discuss adhesion, cohesion, capillary action, and surface tension, and have students draw pictures illustrating these terms.

### **Sample assessment**

- Assess the completed activity pages.
- Have students explain the difference between adhesion and cohesion and give an example of each.

### **Follow-up/extension**

- Allow students to do the above activities with other substances, such as soapy water, syrup, vegetable oil, and salt water.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources.* Virginia Naturally. <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “Virginia Water Central.” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

# It's in the Liquid

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Materials

Blue liquid, red liquid, toothpicks, two eyedroppers, petri dish

## Procedure

1. Place a dime-size drop of the blue liquid in the petri dish. Use a toothpick to move it around. Record observations.

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2. How can you explain this? What inferences can be made based on your observations?

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3. Place a dime-size drop of the red liquid in the petri dish. *Do not* allow the red and blue liquids to touch. Use another toothpick to move the red liquid around. Record observations. \_\_\_\_\_

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4. How can you explain this? What inferences can be made based on your observations?

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5. Allow the drops of blue and red liquids to mix in the petri dish. Observe the liquids as they mix, and record observations. \_\_\_\_\_

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6. How can you explain this? What inferences can be made based on your observations?

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## Inferences

7. The blue liquid stayed in a drop shape because \_\_\_\_\_.

8. The blue liquid followed the toothpick because \_\_\_\_\_.

9. The red liquid spread out because \_\_\_\_\_.

10. The red liquid did not follow the toothpick because \_\_\_\_\_.

11. When the liquids mixed, the blue liquid spread out because \_\_\_\_\_.

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12. When the liquids mixed, they fizzed because \_\_\_\_\_.

### About the Liquids

13. Fill in the blanks below, using the word bank at right.

The blue liquid is water and blue food coloring. Water is a very special liquid with special properties. Water molecules are strongly attracted to each other. This attraction is called *cohesion*. The water molecules like to stick together, and they attract each other the most at the surface. This is called *surface tension*. Water has extremely high surface tension. The reason it hurts when you do a belly flop into a swimming pool is because of \_\_\_\_\_.

Although water molecules like to

\_\_\_\_\_, there are some things to which they don't like to stick. One of these things is plastic. When water is placed on plastic, it \_\_\_\_\_. The water follows the toothpick around because water likes to stick to the \_\_\_\_\_ more than to the \_\_\_\_\_. Water's attraction to other substances is called *adhesion*. When other substances, such as soap or rubbing alcohol, are mixed with water, the water molecules cannot stick together as well. The red liquid is rubbing alcohol and red food coloring, which causes the water molecules to \_\_\_\_\_. The water and alcohol would not follow the toothpick because the alcohol disrupted the water's \_\_\_\_\_. When the red and blue liquids were mixed, the surface tension of the water was \_\_\_\_\_. That prevented the purple drop of water and alcohol from following the toothpick.

<p><b>Word Bank</b></p> <p><i>cohesion</i></p> <p><i>surface tension</i></p> <p><i>beads up</i></p> <p><i>plastic</i></p> <p><i>toothpick</i></p> <p><i>broken</i></p> <p><i>stick together</i></p> <p><i>break apart</i></p>
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### In Your Own Words

14. Explain in your own words what happened with the blue and red liquids.

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# Molecular Attraction

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Materials

Penny, beaker of plain water, detergent, eyedropper, paper towel, metric ruler

## Procedure

1. Make sure the eyedropper is clean.
2. Predict how many drops of water will fit on the surface of a penny before it overflows.

	Number of drops on clean, dry penny	Number of drops on detergent penny
Name: _____		
Name: _____		
Average:		

3. Practice *slowly* dropping water *one drop at a time* from the eyedropper onto the paper towel. Pay attention to how hard you squeeze the dropper. When you have perfected this technique, go to the next step.
4. Place the penny on a dry area of the paper towel. Slowly and carefully drop one drop of water onto the penny. Observe the penny closely from the side, and draw a picture in the appropriate space below of the penny viewed from the side with one drop on it.
5. Continue dropping one drop at a time (*Keep careful count of each drop!*) until the penny is half full. Record this number, and draw a picture of the way this looks.
6. Continue dropping one drop at a time until the water overflows. Count each drop until the water almost overflows, and record this number. Draw a picture of the way the water looked just before overflowing.

Dry Penny			Detergent Penny		
One drop	Half full: ____ drops	Near overflow: ____ drops	One drop	Half full: ____ drops	Near overflow: ____ drops

7. Dry off the penny. Repeat step 6 for two more trials, varying the side of the penny used, and record data in the table below. Find the average number of drops for the three trials, and record.
8. Again, dry off the penny. Use your finger to spread one small drop of detergent across the surface of the dry penny. Repeat step 6 for three trials, and find the average number.

Coin	Number of Drops Near Overflow			
	Trial 1	Trial 2	Trial 3	Average
Dry Penny				
Detergent Penny				

### Reflection on the Dry Penny

1. Did the number of drops change when using the "heads" side versus the "tails" side? \_\_\_\_\_
2. Did the size of the drops change during the experiment? \_\_\_\_\_
3. Did the same person do each trial? \_\_\_\_\_
4. Did the height and speed of the drop stay the same with each trial? \_\_\_\_\_
5. Were your trials consistent? \_\_\_\_\_ Explain why or why not.

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6. Were your predictions close? \_\_\_\_\_ Explain why or why not.

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7. Why did the water form a dome on the penny? Use cohesion and surface tension to explain your answer.

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8. What caused the drops that spilled over the side of the penny?

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### Reflection on the Detergent Penny

1. Did the detergent make a difference? \_\_\_\_\_ Describe the effects of the detergent.

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2. What does the detergent do to the water to have this effect?

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### Extension

1. Do the same experiment with different coins, or use different liquids, such as soapy water, salt water, vegetable oil, syrup, or other liquids. How do those results compare with the data collected from plain water? \_\_\_\_\_ Are there any differences? \_\_\_\_\_ Why?

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# It's All Over

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Materials

Two plastic film canisters, eyedropper, paper clips, paper towel, plastic cups, fork, petri dish, toothpick, wax paper, glass slide

## Procedure

### Part A

1. Fill a plastic film canister to the brim with water. How many paper clips do you think you could add before it overflows? \_\_\_\_\_
2. Carefully add paper clips, counting each one.
3. How many paper clips did you add before the water overflowed? \_\_\_\_\_
4. What property of water allows you to add paper clips? \_\_\_\_\_

### Part B

5. Fill a plastic film canister to the brim with water. How many more drops of water do you think you could add before it overflows? \_\_\_\_\_
6. Carefully add drops of water, counting each one.
7. How many drops of water did you add before the water overflowed? \_\_\_\_\_
8. What property of water allows you to add drops? \_\_\_\_\_

### Part C

9. How many paper clips do you think you'll be able to rest on top of the water? \_\_\_\_\_
10. Using a steady hand, see if you can get a paper clip to rest on the surface of the water in such a way that it does not sink. If this doesn't work, try placing the paper clip on the prongs of a fork and gently lowering it onto the water. This may take several tries.
11. How many paper clips could you rest on the surface of the water? \_\_\_\_\_
12. What property of water allows a paper clip to rest on its surface? \_\_\_\_\_

### Part D

13. What will a drop of water look like on a piece of wax paper? Draw it.  
\_\_\_\_\_

14. What will a drop of water look like on a glass slide? Draw it.  
\_\_\_\_\_

15. Place several drops of water on each surface, and draw the results.

\_\_\_\_\_

wax paper

\_\_\_\_\_

glass

16. Compare the results. Record your observations.

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17. What property of water would explain the results? \_\_\_\_\_

**Part E**

18. Place three drops of water near each other, but not touching, on a piece of wax paper.

19. Use a toothpick to gently push the water drops toward each other.

20. What did you observe? \_\_\_\_\_

21. What property of water caused the drops to be attracted to each other? \_\_\_\_\_

22. Using the toothpick, try to separate the water drops.

23. What property of water keeps the water together? \_\_\_\_\_

**Part F**

24. Fill the eyedropper with water.

25. Place as many *separate* drops of water as will fit on the petri dish.

26. Quickly turn the dish over so that the drops are hanging.

27. Using a toothpick, move the drops of water together. Record your observations.

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28. What property of water kept the drops from falling and allowed you to move the drops with the toothpick? \_\_\_\_\_

29. What property of water attracted the drops to each other? \_\_\_\_\_

**Part G**

30. Use the word bank at right to fill in the blanks below.

Water molecules have an attraction to each other, which is called \_\_\_\_\_ . This attraction is due to the fact that each molecule has a positive side and a negative side (polarity). The positive, or hydrogen, side of the molecule attracts the negative, or oxygen, side of another molecule. The attraction is similar to the attraction between a magnet and a paper clip, and it causes the molecules to stick together. This attraction is especially strong at the surface of the water: because the molecules at the surface have nothing above them to which to be attracted, they are attracted even more to the water molecules at their sides and below them. The pulling between molecules forms a "skin" over the water, which we call \_\_\_\_\_. Water molecules also stick to molecules of other substances. The attraction of water molecules to other substances, like grass or glass, is called \_\_\_\_\_. This force causes water to adhere to the walls of a glass container and causes the water's surface to rise near the container's walls.

<p><b>Word Bank</b> <i>adhesion</i> <i>cohesion</i> <i>surface tension</i></p>
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# Climbing Trees

**Names:** \_\_\_\_\_ **Date:** \_\_\_\_\_ **Class:** \_\_\_\_\_

How long do you think it would take for water to climb a strip of absorbent paper that is 1.5 cm wide? Estimate how long it would take to climb 4 cm up the strip: \_\_\_\_\_ minutes.

**Materials**

Paper strips, water, 50-mL graduated cylinder, wet erase markers, metric ruler, stopwatch

**Procedure**

1. Put a paper strip into the graduated cylinder so that one end reaches the bottom of the cylinder and the other end hangs over the top.
2. Use the marker to put a small spot of ink 4 cm from the bottom of the paper strip. Put additional spots every 4 cm along the strip all way to the other end. Let the ink dry.
3. Put 10 mL of water into the graduated cylinder.
4. Place the paper strip in the cylinder so that the bottom end is immersed in the water but the first ink spot is just above the surface of the water. Fold the top of the paper over the top of the cylinder.
5. Start the stopwatch.
6. Record observations every 5 minutes.

Time (minutes)	Distance (cm)
0	
5	
10	
15	
20	
25	
30	

7. If the water reaches the top of the paper, remove the paper and let it dry.

**Reflection**

1. How did the ink change?

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2. Water's ability to climb upward against the force of gravity is called *capillarity*. With adhesion and cohesion, capillarity allows trees and other plants to absorb water and nutrients through their roots and distribute them throughout the entire plant. When moving through roots, water molecules cling, or adhere, to the inside of the root and move upward. As the first molecules move up, others follow due to the attraction of cohesion.

## ***The Key to Life***

**Organizing Topic** Investigating Water

**Overview** Students investigate the presence of water in living organisms and the ways that the properties of water are essential to life processes.

**Related Standards of Learning** 6.5

### **Objectives**

The students should be able to

- design an investigation to determine the presence of water in plant material (e.g., a fruit);
- infer how the unique properties of water are key to the life processes of organisms.

### **Materials needed**

- Two hot plates
- Two metal pots
- Water
- Oven mitts
- Orange, grapes, carrots, plums
- Triple beam balance
- Knife
- Beaker
- Microwave
- Plant
- Clear plastic bag
- Copies of the attached handouts

### **Instructional activity**

#### ***Content/Teacher Notes***

Earth is a unique planet in our solar system in that it is the only planet that we are aware of having liquid water. As a result, Earth is the only planet that can support life as we know it. Water's unique properties help keep the planet from getting too hot or too cold. Water is the only compound that commonly exists in all three states (solid, liquid, gas) on Earth. The unique properties of water are a major factor in the ability of Earth to sustain life.

Most of Earth's water (97 percent) is salt water in the oceans. Available non-frozen, fresh water makes up less than 1 percent of the water on Earth.

Water occurs on Earth in oceans, lakes, rivers, streams, and in rock layers underground, called *aquifers*. A large amount of water is also found in the bodies of living things.

About two-thirds of our body weight is water. Water helps control body temperature. Blood vessels widen when we are hot so that the warm blood can travel to sweat glands on the surface of skin where the water is released. We feel cooler as sweat evaporates into the air, taking excess heat away from our bodies. Water also lubricates our muscles so they can move. People can live a few weeks without food but not without water. Everyday we need about 2 liters of water to make up for the water we lose when we sweat, breathe, and urinate.

The first human settlements were established near springs, rivers, and lakes. Reliable fresh water sources and irrigation systems allowed civilizations to grow and flourish. As cities grew, different strategies (tunnels, aqueducts, wells, cisterns, pumps, reservoirs) were employed to collect and store water.

Water is essential for agriculture. Crops watered by reliable irrigation systems are more productive, and harvests more dependable. All foods contain some water. Even dry seeds are between 5 and 10 percent water. Milk is 87 percent water. Fruits and vegetables contain the most water.

### **Introduction**

1. Place two metal pots on two hot plates, and turn on the heat. Put water in one pot and leave the other empty. Let them sit for several minutes. (CAUTION! Keep an eye on the empty pot.) While the pots are heating, discuss with students the unique properties of water that they have learned so far. Ask, “Why is water necessary for life? What does water do for us? How do the properties of water help it sustain life?” Discuss responses.
2. Point out what is happening to the two pots: the empty pot is becoming excessively hot (red hot), but the pot with water is not so excessively hot. Tell students that as long as there is water in the pot, this will be the case, no matter how long the pot heats. Why? (*The water absorbs heat energy as it boils and turns into steam.*) Tell the students to think of the Earth as being like a pot, and ask, “What would happen to our climate if we had no water?” (*Without water absorbing the sun’s heat, it would be much too hot on Earth for life to exist.*) “If you think of the water in the pot being like the oceans, what do the oceans do for us?” (*They absorb some of the heat energy from the sun and keep the planet from getting too hot.*)

### **Procedure**

1. Pass out copies of the “Inquiry Graphic Organizer.”
2. Cut an orange in half, and tell students to make observations about it, listing these on the graphic organizer. Ask students, “How much water is in an orange? How much water is in our bodies? Why is there water in living things?” A general reason can be listed under “Relevant Theory or Rule.”
3. Review the properties of water that have been covered so far, and have students infer why they are important to life. These answers can be listed under “Possible Explanation.”
  - Density of water — Ice is less dense than water and therefore floats on water. If ice sank, life in lakes and rivers would be very different if it existed at all.
  - Cohesion, adhesion, and capillary action — Water is moved throughout plants by capillary action, adhesion/cohesion, root pressure, and transpiration.
  - Universal solvent — Water dissolves many substances, including food (minerals and other nutrients), and transports these nutrients throughout organisms.
  - Effects of heat — The water cycle causes the continuous supply of fresh water. The massive exchange of heat plays an important role in the redistribution of heat energy in Earth’s atmosphere, thus moderating climate on Earth.
4. Give students time to think individually about the following questions: “How could we design an investigation to determine the presence of water in a plant material, for example an orange? What could we do?” Have them use an “Inquiry Graphic Organizer” to organize their thoughts.
5. Have student pairs discuss their ideas. Then, have teams of four or five students each design and conduct an investigation. Have teams write up their proposed lab procedure and get your approval before beginning their investigation. Possible investigations could include the following:
  - **Finding the percent of water in an orange:** Determine mass of the orange. Squeeze all the juice out. Find mass of the juice, and find mass of the peel. Let water in peel and in juice evaporate completely. Find total mass of remaining dry substances (peel + juice residue). Subtract total ending mass from original mass to find mass of the water. Calculate percent of original mass that was water by dividing water mass by original mass.
  - **Finding the percent of water in a piece of fruit or vegetable:** Determine mass of the piece of fruit or vegetable, such as a grape, plum, or carrot. Place fruit in a dehydrator or microwave, and dry it. Find mass of the dried fruit or vegetable. Subtract ending mass from original mass to find mass of the water. Calculate percent of original mass that was water by dividing water mass by original mass.

- **Observing transpiration:** Tie a clear plastic bag around a plant. Observe water droplets forming on leaves and on the inside of bag over a period of days.

### *Observations and Conclusions*

1. Have students work in teams to complete the “Cause – Property – Effect” chart, which lists the properties of water. Students must add the causes of the properties and the effects on life processes.
2. Have students write a paragraph summarizing what they did in their investigation and what the results were. They should include data collecting and explain how the unique properties of water are essential for life processes of organisms.

### **Sample assessment**

- Use the summary paragraphs for assessment.
- Have students explain how the unique properties of water are key to the life processes of organisms.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources.* Virginia Naturally. <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “Virginia Water Central.” Virginia Water Resources Research Center. Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

### **Answer Key for Inquiry Graphic Organizer**

- **OBSERVATION:** *An orange is juicy. It’s orange in color.*
- **RELEVANT THEORY OR RULE:** *Water is the necessity of life. Without it, organisms would die.*
- **POSSIBLE EXPLANATION:** *Water helps our bodies dissolve and digest food. It transports dissolved nutrients and minerals throughout organisms.*
- **HYPOTHESIS:** *If an orange is massed and then dried out, over 50 percent of the mass will be shown to be water.*
- **ACTIVITY OR EXPERIMENT:**
  1. *Determine the mass of an orange. Predict how much of the mass is water.*
  2. *Squeeze all the juice out of the orange.*
  3. *Find the mass of the juice, and find the mass of the peel.*
  4. *Let the water in the peel and in the juice evaporate.*
  5. *Find the total mass of the remaining dry substances (peel + juice residue).*
  6. *Subtract the total ending mass from the original mass of the orange to find the mass of the water.*
  7. *Calculate percent of original mass that was water by dividing water mass by original mass.*

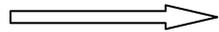
# The Key to Life: Cause - Property - Effect

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

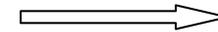
THE CAUSE

THE PROPERTY

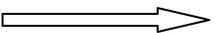
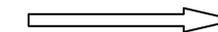
THE EFFECT



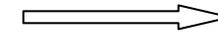
COHESION,  
ADHESION,  
CAPILLARITY



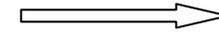
SOLID WATER IS  
LESS DENSE THAN  
LIQUID WATER.



WATER IS  
UNIVERSAL  
SOLVENT.

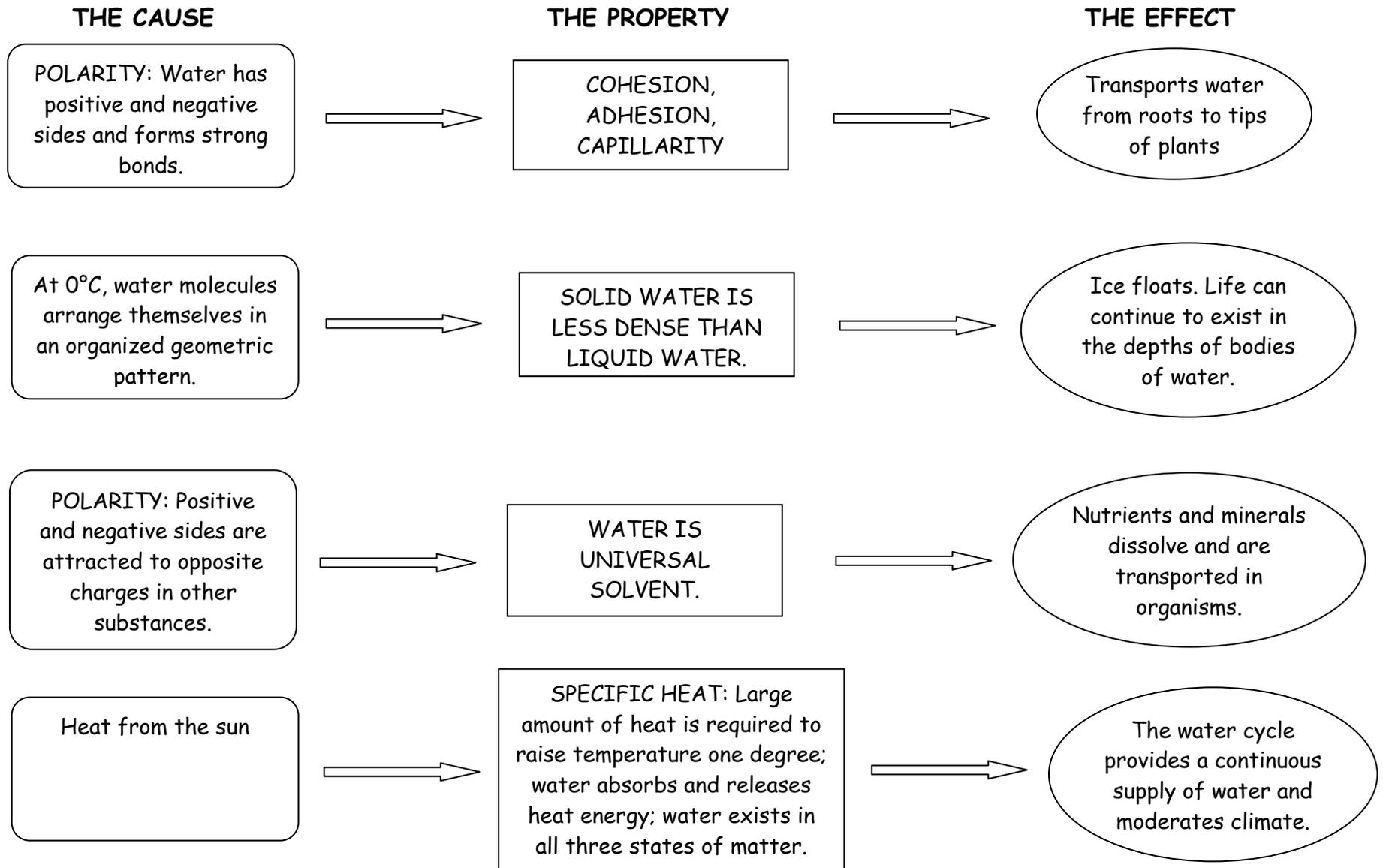


SPECIFIC HEAT: Large  
amount of heat is required to  
raise temperature one degree;  
water absorbs and releases  
heat energy; water exists in  
all three states of matter.



# The Key to Life: Cause - Property - Effect

## Answer Key



# Inquiry Graphic Organizer

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

**OBSERVATION:**



**RELEVANT FACTS OR RULE:**



**POSSIBLE EXPLANATION:**



**HYPOTHESIS:**



**ACTIVITY OR EXPERIMENT (list steps):**



**RESULTS:**

## **Water Formations**

**Organizing Topic** Investigating Water

**Overview** Students investigate the properties of water in all three states.

**Related Standards of Learning** 6.5b

### **Objectives**

The students should be able to

- comprehend and apply key terminology related to water and its properties and uses;
- model and explain the shape and composition of a water molecule;
- relate the three states of water to the water cycle.

### **Materials needed**

- Copies of the attached handouts
- Water K-W-L chart

### **Instructional activity**

#### *Content/Teacher Notes*

Water is the only compound that commonly exists on Earth in all three states (solid, liquid, gas). The unique properties of water are a major factor in the ability of our planet to sustain life.

Among water's unique properties is that one side of each water molecule is slightly negative and the other is slightly positive. Individual water molecules, therefore, attract other water molecules like little magnets as the slightly positive portion of a water molecule is attracted to the slightly negative portion of an adjacent water molecule. In this way, water molecules “stick together.”

#### *Introduction*

1. Have students use the attached K<sup>3</sup>C chart about water to sort vocabulary words into three columns. Tell students that they will use these terms throughout this unit of study.
2. At the bottom of the page is a “3-2-1” dealing with the states of water in the water cycle. Tell students to fill this out if they already know the answers. Walk around the room as students work (or collect the papers afterward) to get an idea of the students' prior knowledge. Most will probably already know the three states of water in the water cycle. If they do not, differentiate instruction, using the attached “Water Cycle” flow chart for those who need it. Have these students complete the “3-2-1” once they know the answers.

#### *Procedure*

1. Have the students construct a K-W-L chart, listing in the K-column everything they know about water and its physical and chemical properties (for example, the chemical formula for water; that water can be solid, liquid, or gas; that water is tasteless, colorless, clear, and odorless).
2. Have students share their list with a partner and add to their list anything they know from the partner's list.
3. Hold a class discussion about all the known properties of water, and make a class list of these on chart paper or the overhead.

4. Ask students to consider the questions shown on the K-W-L chart, letting them briefly discuss the questions with their partner.
5. Discuss the questions as a class. Allow students to speculate on the answers. Ask students whether they have any other questions about water to add to the W-column in the chart. Tell them that over the next few lessons, they will do activities to answer the questions.
6. Review atoms, asking the following questions:
  - What are the parts of the atom?
  - What do atoms of the same kind form? (*elements*)
  - What elements are in water? How many atoms are there of each element? (*2 hydrogen atoms and 1 oxygen atom*)
  - What might a water molecule look like? Have students draw a molecule of water.

### ***Observations and Conclusions***

1. Have students add to the L-column anything they learned or that was reaffirmed today. Throughout the unit, have students add to this list regularly.

### **Sample assessment**

- Use the “3-2-1” of the water cycle and states of water, the drawing of a water molecule, and the K-W-L charts for assessment.

### **Follow-up/extension**

- Activities demonstrating water’s unique properties will follow.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “*Virginia Water Central.*” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

# What Do You Know? K<sup>3</sup>C

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Directions

Look over the list of words and terms in the Word Bank. Which words are you so confident you know that you could teach them to the class? List those words in the "KNOW FOR SURE" column below. Which words do you kind of know but would need a little review before teaching the class? List those words in the "KIND OF KNOW" column. List all other words in the "CLUELESS" column.

KNOW FOR SURE	KIND OF KNOW	CLUELESS

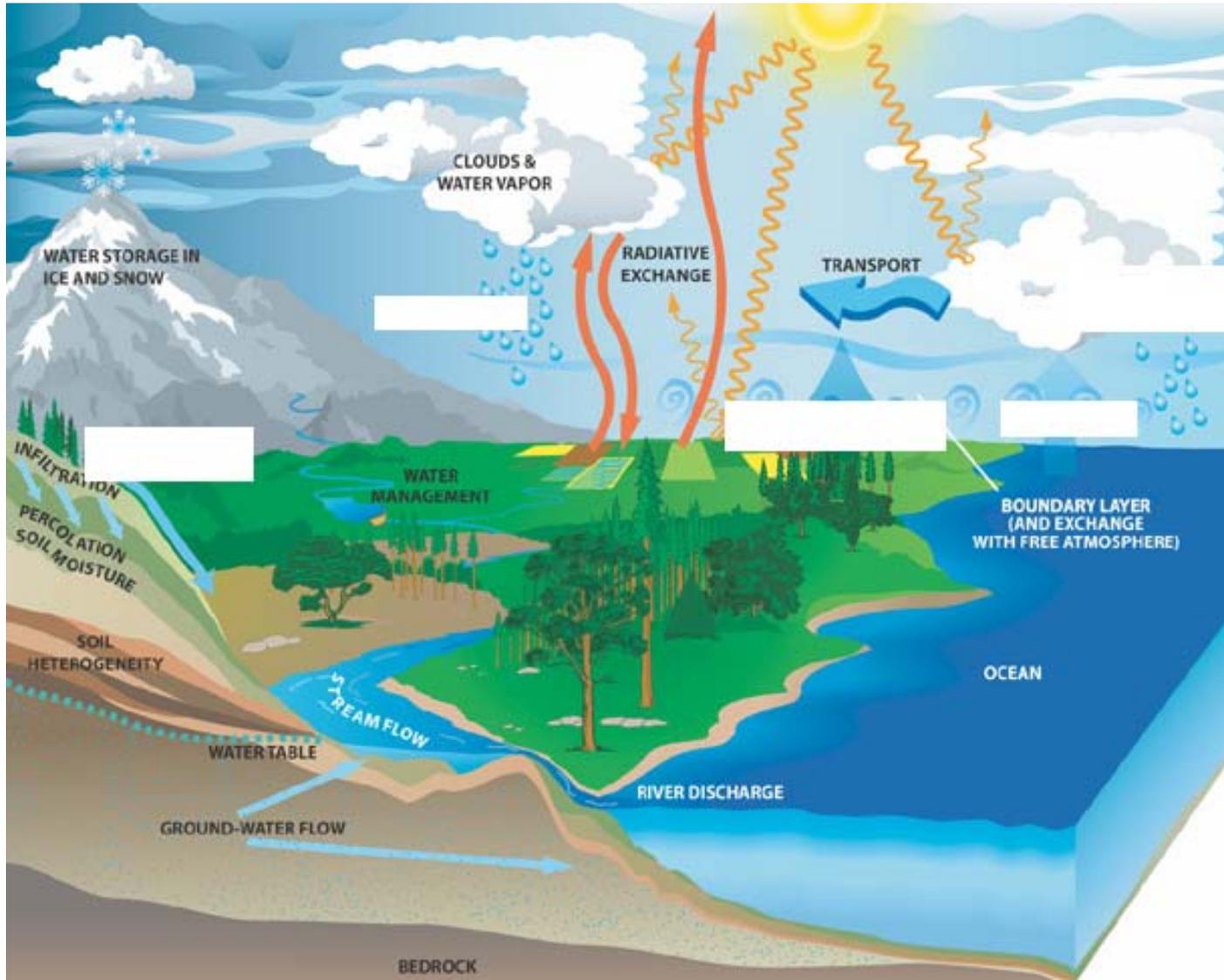
<u>Word Bank</u>
<i>adhesion</i>
<i>capillary action</i>
<i>chemical weathering</i>
<i>cohesion</i>
<i>condensation</i>
<i>density</i>
<i>evaporation</i>
<i>physical weathering</i>
<i>precipitation</i>
<i>solvent</i>
<i>surface tension</i>
<i>transpiration</i>

<b>3</b>	<p>List 3 states of water in the water cycle.</p> <p>1. _____</p> <p>2. _____</p> <p>3. _____</p>
<b>2</b>	<p>List 2 states of water in precipitation.</p> <p>1. _____</p> <p>2. _____</p>
<b>1</b>	<p>List 1 state of water in evaporation.</p> <p>1. _____</p>

# The Water Cycle

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

**Word Bank**  
*evaporation*  
*condensation*  
*runoff*  
*precipitation*  
*transpiration*



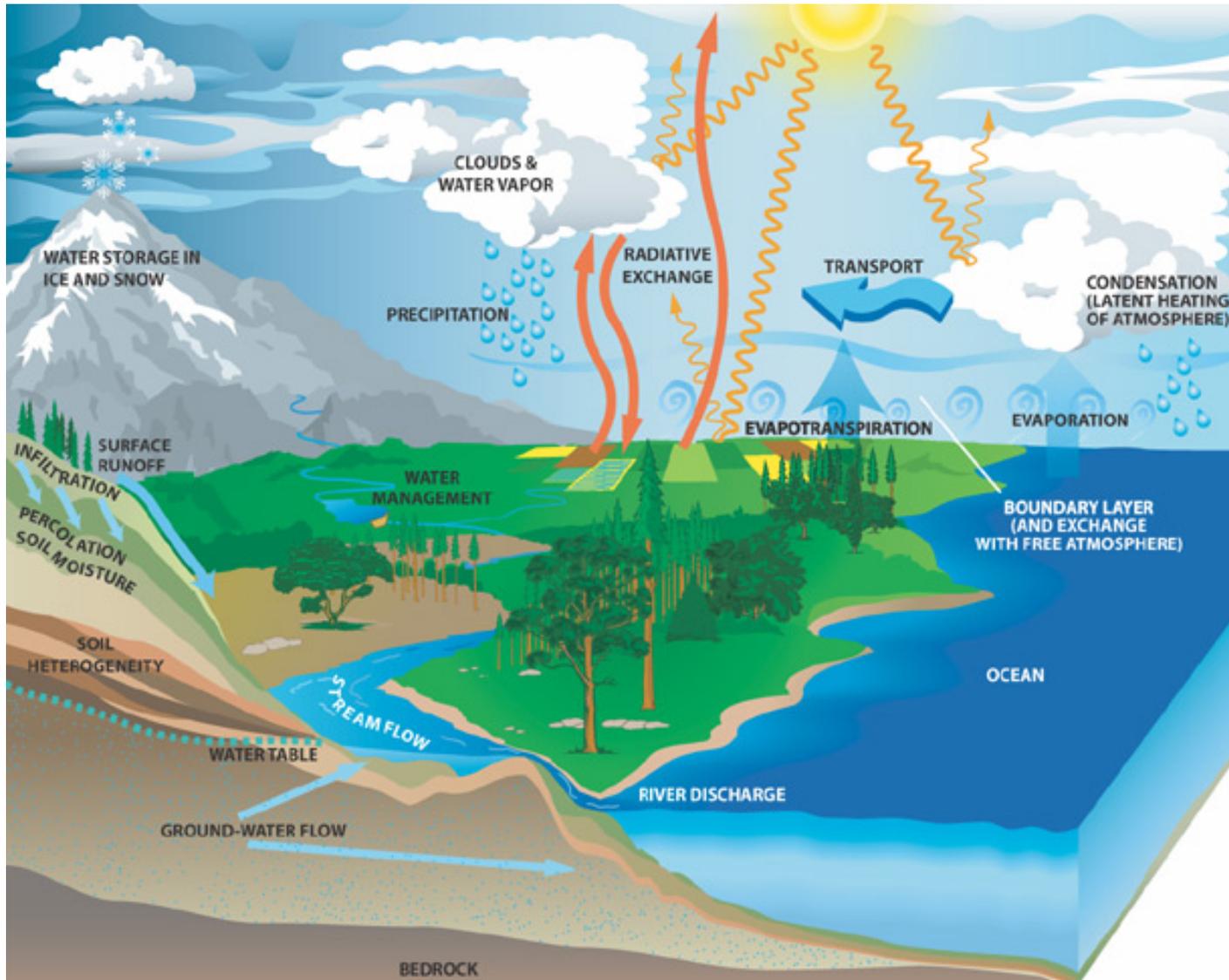
[http://gwec.gsfc.nasa.gov/images/watergraphic\\_low.jpg](http://gwec.gsfc.nasa.gov/images/watergraphic_low.jpg)

# The Water Cycle

## Answer Key

### Word Bank

*evaporation*  
*condensation*  
*runoff*  
*precipitation*  
*transpiration*



[http://gwec.gsfc.nasa.gov/images/watergraphic\\_low.jpg](http://gwec.gsfc.nasa.gov/images/watergraphic_low.jpg)

# WATER

## K-W-L Chart

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

WHAT I <b>K</b> NOW	WHAT I <b>W</b> ANT TO KNOW	WHAT I <b>L</b> EARNED
	<ul style="list-style-type: none"><li>• How does water rise from the roots of a tree to the tips of the branches?</li><li>• How do some insects walk on water?</li><li>• Why does ice float?</li><li>• Why would a person die if he/she were to go a week without water?</li><li>• What is it about water that makes it so important to us?</li><li>• What makes water water?</li></ul>	

# ***Heat and Water***

## **Organizing Topic** Investigating Water

**Overview** Students examine the relationship between heat and the states of water by designing an investigation and conducting an experiment that measures temperature as the water absorbs heat.

## **Related Standards of Learning** 6.5b, e

### **Objectives**

The students should be able to

- design an investigation to determine the effects of heat on the states of water;
- relate the three states of water to the water cycle.

### **Materials needed**

- Copies of the attached handouts
- Hot plates
- Beakers
- Celsius thermometers
- Ice cubes
- Water
- Goggles

### **Instructional activity**

#### ***Content/Teacher Notes***

Scientific evidence indicates that the Earth formed about 4.5 billion years ago from dust and debris orbiting the sun. Due to gravity, this debris became compacted and grew quite hot, creating hot gases, including water vapor and carbon dioxide. Over millions of years, the Earth and its gases cooled, and it is believed that seas formed when the Earth cooled enough for water vapor in the atmosphere to condense.

#### ***Introduction***

1. Pass out copies of the “Inquiry Graphic Organizer,” and lead students through the questions on it. Give students time to think and jot down their ideas on the organizer.

#### ***Procedure***

1. Have students share their ideas with a partner. Then, have partners share ideas with other partners and/or individuals to form lab teams of four or five students each.
2. Give each student a copy of the “Heat and Water” lab sheet, and have each team use the sheet to design an investigation of the effects of heat on the states of water. Approve all designs before allowing teams to perform their investigations. Here is a sample investigation: Students start with ice cubes in a beaker and record the temperature. They place the beaker on a hot plate and heat, recording the temperature every minute until all the ice becomes liquid. They continue heating and recording the temperature every minute until the liquid becomes steam. Finally, they graph the gathered data on a chart.

### ***Observations and Conclusions***

1. Discuss with students the discoveries they made during their investigations. Go over the Reflection questions on the lab sheet. Among other things, students should have discovered that
  - the temperature did not change during the phase changes.
  - the temperature range of water in the liquid state is 0–100°C.
  - as water vapor cools, it forms droplets and condenses.
2. Remind students that the planet Earth formed from dust and debris orbiting the sun when the dust and debris compacted due to gravity. As the debris grew hotter and hotter, gases, such as water vapor and carbon dioxide, were created. Ask, “How do you think the oceans formed?”
3. Have students write a conclusion for their investigation, including all discoveries they made.

### **Sample assessment**

- Use the completed “Heat and Water” lab reports and/or the conclusion paragraphs for assessment.

### **Follow-up/extension**

- Use this or a similar investigation to examine the effects of heat on water’s ability to dissolve materials.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources*. Virginia Naturally. <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “Virginia Water Central.” Virginia Water Resources Research Center. Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- Virginia Water Resources Research Center. Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs*. Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States*. U.S. Geological Survey. <http://water.usgs.gov/>.

### **Answer Key for Inquiry Graphic Organizer**

- OBSERVATION: *Heat makes ice melt into liquid water and makes liquid water become steam.*
- RELEVANT THEORY OR RULE: *Heat causes water to evaporate. When cooled, water vapor condenses and precipitation forms.*
- POSSIBLE EXPLANATION: *The addition of heat causes an increase in water temperature. Heat causes molecules to move faster and spread apart.*
- HYPOTHESIS: *When ice is heated, the temperature will increase and the ice will become liquid water. When liquid water is heated, the temperature will continue to increase and the water will become water vapor.*
- ACTIVITY OR EXPERIMENT:
  1. *Place ice in a beaker, measure temperature, and record temperature.*
  2. *Place beaker on hot plate and turn on heat.*
  3. *Record temperature every minute until ice is melted.*

4. *Continue heating the liquid water.*
5. *Record temperature every minute until liquid water becomes steam.*

# Inquiry Graphic Organizer

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

**OBSERVATION:** What are the effects of heat on the states of water?



**RELEVANT FACTS OR RULE:** What is heat's role in the water cycle?



**POSSIBLE EXPLANATION:** How might you explain heat's role in the water cycle and in changing the states of water?



**HYPOTHESIS:**



**ACTIVITY OR EXPERIMENT (list steps):** How could you design an investigation to show the effects of heat on the states of water?



**RESULTS:**



**Reflection**

1. What are the effects of heat on the states of water?  
\_\_\_\_\_
2. Put on your imaginary molecular glasses. What does heat do to water at the molecular level?  
\_\_\_\_\_
3. What happened to the temperature as ice was changing to liquid and as liquid was changing to gas?  
\_\_\_\_\_
4. What was the temperature range of water in the liquid state? \_\_\_\_\_
5. How could you explain the transfer of heat energy in the changing states of water?  
\_\_\_\_\_  
\_\_\_\_\_
6. What happens to water vapor as it cools?  
\_\_\_\_\_

**Conclusion**

1. What was your hypothesis? \_\_\_\_\_
2. Do the results of your experiment support your hypothesis? \_\_\_\_\_
3. Was your hypothesis correct or incorrect? \_\_\_\_\_
4. What happened in the investigation?  
\_\_\_\_\_
5. Use the average data and your answers to the Reflection questions to summarize the results. Explain why the results happened as they did, and include all discoveries you made. Make an inference based on what you now know.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## How Dense Can It Be?

**Organizing Topic** Investigating Water

**Overview** Students investigate some of the unique properties of water and see that water is one of the few types of matter that expands when it freezes.

**Related Standards of Learning** 6.5b

### Objectives

The students should be able to

- design an investigation to determine the relative density of liquid and solid water at various temperatures;
- compare the relative density of liquid and solid water;
- model and explain why ice is less dense than liquid water.

### Materials needed

- Two beakers
- Water
- Food coloring
- Eyedropper
- Graduated cylinders
- Water
- Triple beam balances
- Freezer
- Plastic wrap
- Rubber bands
- Copies of the attached handout

### Instructional activity

#### *Content/Teacher Notes*

Additional properties of water are its high surface tension and the large range of temperature (0–100°C) in which it can be found in the liquid state. Another remarkable property is that unlike other substances, it *expands* when it freezes; thus, ice is less dense than water.

Ice forms rigid clusters of hexagonal patterns, with a hydrogen atom from one molecule forming a hydrogen bond with an oxygen atom of another molecule. This leaves plenty of space between the oxygen atoms from one water molecule to the next, making ice less dense than liquid water. Liquid water is not so orderly, and water molecules are able to pack together more tightly. Water is most dense at 4°C.

Hydrogen bonding (a strong form of molecular bonding) in liquid causes water to change its shape. As the temperature decreases and the water molecules move together, they position themselves by twisting and turning so that they remain adequately far apart. The distance between the molecules depends on the temperature. but the molecules never move so close as to touch each other because there is repulsion on the negative oxygen atoms similar to the repulsion between two magnets.

#### *Introduction*

1. Perform the following demonstration. Place 200 mL of chilled water in a beaker or container, and allow it to settle for one minute.
2. Add 5 drops of food coloring to 30 mL of hot water. The temperature difference between the cold and hot water should be as great as possible. Allow coloring to spread throughout the water.
3. Ask, “What makes the coloring spread?” (*The relatively faster motion of its molecules*)
4. Using an eyedropper, slowly place several milliliters of the hot colored water onto the bottom of the beaker of cold water, trying to disturb the hot water as little as possible.

5. Instruct students to observe the beaker. Ask, “How does the hot water behave in the cold water?” (*Hot water rises to the top of the cold water.*) “Why does the hot water float to the top?” (*Hot water is less dense than cold water.*) “What does it mean that hot water is less dense than cold water?” (*Hot water molecules are moving around more and are therefore spread out more than cold water molecules.*)
6. After several minutes, have students make observations again. Ask, “What change do you notice?” (*The colored water is cooling, sinking, and spreading out.*) “What are the hot molecules doing now? (*Hot molecules are slowing down and moving closer together, making the colored water more dense.*) How does the density of liquid water relate to temperature? (*The hotter the water, the less dense it is; the colder the water, the denser it is, until it reaches 4°C.*)

### **Procedure**

1. Ask students the following questions, giving them time to ponder each question:
  - What is density? (*How tightly matter in an object is packed together*)
  - What do we have to know to calculate the density of an object? (*Mass and volume of the object*)
  - Which would be denser, liquid water or solid water?
  - How could you show which is denser?
  - How could we determine the density of liquid water and solid water?
  - How can we measure the mass and volume of ice and be sure that we do not lose any molecules during the change to liquid?
2. Pass out copies of the attached “How Dense Can It Be?” lab sheet, and have students read the steps and determine the independent and dependent variables. Also, have them write the purpose and form a hypothesis.
3. Have the students conduct the experiment, as directed on the lab sheet.

### **Observations and Conclusions**

1. Have students complete the lab sheet and Reflection questions on their own. Allow them to check their answers with a neighbor before having a class discussion of the results. Then ask, “Which is denser, liquid water or solid water? What happens to the molecules of water when it freezes? What would happen if ice didn’t float?” (*It would sink to the bottom of cold oceans.*) “Why is this property of water essential for life?” (*It prevents Earth from getting too cold for life to exist. If ice did not float in water, when water froze during ice ages in prehistoric times, it would have sunk to the bottom of the oceans. When warm weather returned to the Earth, it may not have been warm enough to melt all of the ice at the bottom of the seas, since there would have been very cold water in between the ice and the warm water, acting to insulate the ice. During the next freeze, a layer of ice would have formed on top of the existing ice, making more ice that would need to melt during the next warm period. Over time, the sea would have eventually frozen from the bottom up, and animals would not have been able to survive. Except for oceans near the equator, the vast majority of the oceans would have been completely frozen. )*
2. Organize students into groups of three each in order to model water molecules. Have each group stand together and decide who will be the two hydrogen atoms and who will be the oxygen atom. Have all the groups demonstrate liquid water molecules by moving close together in no particular pattern. Then tell them to demonstrate ice by moving into a pattern with the hydrogen atoms loosely bonding with an oxygen atom from another molecule.
3. Exit Ticket: Have students draw a picture of water molecules in liquid and solid states. Have them explain why ice is less dense than liquid water. Tell students this is their Exit Ticket to leave the classroom.

### Sample assessment

- Use the completed lab sheets and/or the Exit Tickets for assessment.

### Follow-up/extension

- Have students design and conduct an experiment that uses the same steps but a different liquid. Discuss the results.

### Resources

- *Natural Resource Education Guide: Virginia's Water Resources.* Virginia Naturally. <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
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- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

# How Dense Can It Be?

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Purpose

\_\_\_\_\_

## Hypothesis

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## Materials

Celsius thermometer, small graduated cylinder, triple-beam balance, water, freezer, plastic wrap, rubber band

## Procedure

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Constants: \_\_\_\_\_

## Steps

1. Measure the mass of the graduated cylinder, and record. \_\_\_\_\_
2. Pour 15 mL of room-temperature water into the graduated cylinder. Measure the mass of the graduated cylinder and water, and record. \_\_\_\_\_
3. Subtract the mass of graduated cylinder from the combined mass to determine the mass of the water only. Record. \_\_\_\_\_
4. Place plastic wrap over the top of the graduated cylinder, and secure with a rubber band.
5. Place the graduated cylinder in the freezer overnight.
6. Calculate the density of water by dividing the mass of the water by the volume of the water. Record. \_\_\_\_\_
7. On the next day, measure the volume and mass of the ice. Subtract the mass of the graduated cylinder, and record. \_\_\_\_\_
8. Calculate the density of the ice, and record. \_\_\_\_\_

## Qualitative Observations

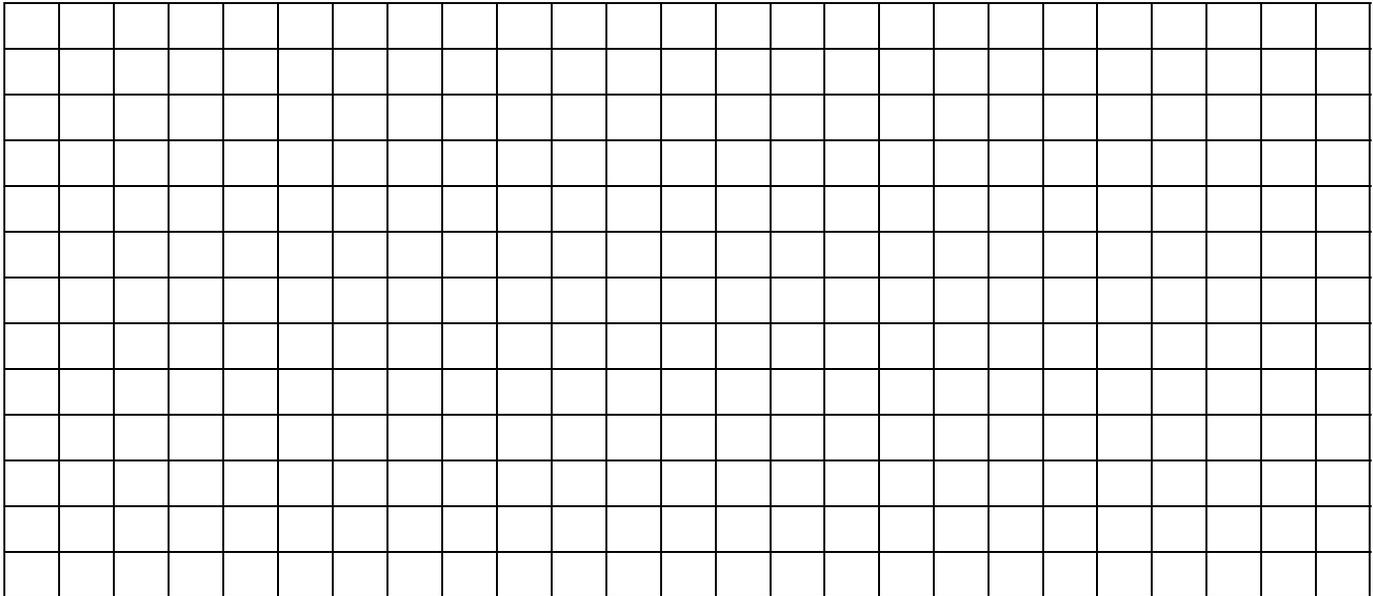
Water: \_\_\_\_\_

Ice: \_\_\_\_\_

**Data Table**

Independent Variable (IV)	Dependent Variable (DV)		
	Mass of water (g)	Volume of water (mL)	Density (mass/volume) (g/mL)
Water			
Ice			

**Graph**



**Reflection**

- Did the volume of the water change when it froze? \_\_\_\_\_ If so, how did it change?  
\_\_\_\_\_
- Calculate how much the volume changed as a percentage of the original volume. Do this by dividing the frozen volume by the liquid volume and then multiplying by 100. The frozen volume should be greater than 100% of the liquid volume. What is the percent? \_\_\_\_\_
- Since you know that ice is less dense than water, what do you think happens to the water molecules when water freezes?  
\_\_\_\_\_
- If ice were denser than water, what would happen when ice forms on the surface of a lake?  
\_\_\_\_\_ What would happen to water creatures in this scenario? \_\_\_\_\_
- Try this experiment with other liquids, such as syrup, vegetable oil, soda, salt water, and melted butter. Do you think you'll get the same results? \_\_\_\_\_ Why, or why not?  
\_\_\_\_\_

**Conclusion**

1. What was your hypothesis? \_\_\_\_\_
2. Do the results of your experiment support your hypothesis? \_\_\_\_\_
3. Was your hypothesis correct or incorrect? \_\_\_\_\_
4. What happened in the investigation?  
\_\_\_\_\_

5. Use the average data and your answers to the Reflection questions to summarize the results. Explain why the results happened as they did, and include all discoveries you made. Make an inference based on what you now know.

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## ***Physical or Chemical Weathering?***

**Organizing Topic** Investigating Water

**Overview** Students observe the effects of water and acid rain on the environment and classify the effects as physical weathering or chemical weathering.

**Related Standards of Learning** 6.5c

### **Objectives**

The students should be able to

- design an investigation to model the action of freezing water on rock material;
- design an investigation to model the action of acidified water on building material such as concrete, limestone, or marble;
- chart, record, and describe evidence of chemical weathering in the local environment.

### **Materials needed**

- |                          |                |                                  |
|--------------------------|----------------|----------------------------------|
| • Eggshell               | • Eyedroppers  | • pH paper                       |
| • Paper clips            | • Beakers      | • Goggles                        |
| • Several leaves         | • Water        | • Diatomaceous earth             |
| • Collected rock samples | • Rulers       | • Two spoons                     |
| • Milk cartons           | • Plastic bags | • Lamp with 100-watt bulb        |
| • Markers                | • Chalk        | • Three pieces of steel wool     |
| • Freezer                | • Long nail    | • Two zip-top plastic bags       |
| • Hand lenses            | • Vinegar      | • Copies of the attached handout |

### **Instructional activity**

#### ***Content/Teacher Notes***

Water (rain, ice, snow) has shaped our environment by physically and chemically weathering rock and soil and transporting sediments. Freezing water can break rock without any change in the minerals that form the rock (physical weathering). This usually produces small particles and sand. Water with dissolved gases and other chemicals in it causes the minerals in rocks to be changed, leading to the deterioration of the rock (chemical weathering).

Prepare for this lab in advance. The day before the lab, place a large piece of eggshell, a paper clip, and a leaf in a jar of vinegar and the same kinds of items in a jar of water. Do not label them. Collect small rocks that have small cracks in them, and collect milk cartons. Gather three small pieces of steel wool and three zip-top plastic bags, and place one piece in one of the bags. Soak another piece of steel wool in vinegar and the third piece in water for 10 minutes, and then place these pieces in zip-top bags and seal. Set up two locations for each station with the materials listed on the handout.

#### ***Introduction***

1. Discuss with students the difference between physical changes and chemical changes. Then, ask students, “What do you think would be the difference between physical weathering and chemical weathering. Can you think of any examples of physical or chemical weathering?”
2. Show the students the two jars you set up the day before. Tell them that you put identical items in each jar. Have student make observations. Ask, “Why do you think the items look so different?” Some students may guess correctly, but do not tell them whether they are right at this time. Tell

them that they are going to do a series of activities that will show either physical or chemical weathering. Based on what they do in the lab activities, they are to figure out what happened to these items in the jar.

### ***Procedure***

1. Hand out copies of the “Physical or Chemical Weathering?” lab sheet, and have the students read it over.
2. Explain the procedure at each lab station. Emphasize that as students move in teams from station to station, they will need to reread the directions for each station and follow them carefully. Some station procedures will take two days.
3. Have students conduct the lab and complete their lab sheets.

### ***Observations and Conclusions***

1. Ask, “What can we do to prevent or inhibit the effects of acid rain?” Discuss student responses.

### **Sample assessment**

- Use the completed lab sheets for assessment.
- Assign students to record and describe on a data table over a period of one week evidence of chemical weathering that they find in the local environment. They should record the date, location, item, description of condition, and cause of weathering.

### **Follow-up/extension**

- Have students design an experiment to determine the effect of acid rain on plants. Plants will be sprayed with different concentrations of vinegar and water, while a control group will be sprayed with water only. This experiment will have to last several weeks with students making observations daily.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “*Virginia Water Central.*” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

# Physical or Chemical Weathering?

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Water is constantly shaping our environment by both physical weathering and chemical weathering. *Weathering* refers to destructive forces that change the physical and chemical characteristics of rocks and soil near the Earth's surface.

- *Physical weathering* is the breaking down of rock into smaller pieces. The rock's physical characteristics change, but the rock's minerals (chemical composition) do not change.
- *Chemical weathering* is the decomposition of rock from exposure to water with dissolved atmospheric gases and other chemicals. As rock deteriorates, the minerals in the rock change, and new chemical compounds are formed.

These lab activities will introduce you to examples of physical and chemical weathering.

## STATION 1: ROCK FREEZE

### Materials

Rocks, hand lens, eyedropper, beaker of water, ruler, marker, plastic bag, freezer, milk carton

### Procedure

#### Day 1

1. Choose one rock from the pile, and examine it. Use the hand lens. Measure the rock and the crack(s). What makes this rock unique from all the other rocks? Record your observations:

\_\_\_\_\_  
\_\_\_\_\_

2. Turn the rock so that a crack in it will hold water. Using the eyedropper, put water in the crack, and count and record the number of drops that will fit in the crack: \_\_\_\_\_
3. Use a marker to label a plastic bag with your group number. Place the rock, crack side up (Don't let the water spill out!) in the plastic bag. Carefully place bag and rock in a milk carton so that the water does not spill out. Your teacher will place the carton in the freezer at the end of the class.
4. Form a hypothesis based on what you did in the experiment. What will happen?

HYPOTHESIS: \_\_\_\_\_

#### Day 2

5. After your rock has been out of the freezer for a while and the ice has melted, take the rock out of the plastic bag, and examine it as you did yesterday. Is it different in any way? \_\_\_\_\_ Record your observations: \_\_\_\_\_

\_\_\_\_\_

6. Using the eyedropper, put water in the crack again. Count and record the drops: \_\_\_\_\_ Does the rock hold more drops today than it did yesterday? \_\_\_\_\_ Why, or why not?

\_\_\_\_\_

7. Place the rock in the bag and milk carton again so it can be frozen one more time.

**Day 3**

8. Take the rock out of the bag once again, and examine it as you did yesterday. Is it different in any way? \_\_\_\_\_ Record your observations: \_\_\_\_\_  
\_\_\_\_\_

9. Using the eyedropper, put water in the crack again. Count and record the drops: \_\_\_\_\_ Does the rock hold more drops today than it did yesterday? \_\_\_\_\_ Why, or why not?  
\_\_\_\_\_

10. What type of weathering is this, physical or chemical? \_\_\_\_\_

11. Was your hypothesis correct? \_\_\_\_\_ Write a conclusion.

CONCLUSION: \_\_\_\_\_  
\_\_\_\_\_

## STATION 2: IT'S RAINING

### Materials

Chalk, long nail, beaker of vinegar, empty beaker, eyedropper, pH paper, goggles

### Procedure

1. Vinegar is an acid of similar strength to the acid in "acid rain." Use the pH paper to determine the pH of the vinegar, and record. \_\_\_\_\_
2. Chalk is limestone. Use the nail to carve a design in or a small statue out of the chalk.
3. Form a hypothesis based on what you know. What will vinegar do to the limestone?

HYPOTHESIS: \_\_\_\_\_

4. Use the eyedropper to drop single drops of vinegar ("acid rain") on the chalk. Record your observations as you continue to add drops of acid rain:

\_\_\_\_\_  
\_\_\_\_\_

5. What type of weathering is this, physical or chemical? \_\_\_\_\_

6. Was your hypothesis correct? \_\_\_\_\_ Write a conclusion.

CONCLUSION: \_\_\_\_\_

\_\_\_\_\_

7. How might acid rain affect buildings made of limestone having limestone on the exterior?

\_\_\_\_\_

8. What is the cause of acid rain?

\_\_\_\_\_

9. Why should we be concerned about acid rain?

\_\_\_\_\_

10. What can we do to inhibit the effects of acid rain?

\_\_\_\_\_

### STATION 3: THE GROUND UNDER OUR FEET

#### Materials

Two milk cartons per group, diatomaceous earth, small beaker of water, two spoons, marker, large beaker, freezer, lamp with 100-watt bulb, goggles

#### Procedure

##### Day 1

1. Label both milk cartons with your group number.
2. Carefully place diatomaceous earth in each milk carton. While stirring, slowly add just enough water to form a paste or clay. Don't let it get soggy.
3. If the mixture is soggy and has standing water on top, pour the extra water into a large beaker. Your teacher will dispose of it.
4. Record your observations of both cartons.

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5. Place one carton under the light. Your teacher will place the other carton in the freezer.
6. Form a hypothesis based on what you know. What will happen to each carton of earth?

HYPOTHESIS: \_\_\_\_\_

##### Day 2

7. Tear away each of the cartons, revealing the earth. How has it changed? Write your observations of each.

---

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8. If the earth from the freezer is still frozen or moist, mark the side of it, and place it under the light. Check it at the end of the bell or tomorrow.
9. What type of weathering is this, physical or chemical? \_\_\_\_\_
10. Was your hypothesis correct? \_\_\_\_\_ Write a conclusion.

CONCLUSION: \_\_\_\_\_

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## STATION 4: WHAT "WOOL" IT DO?

### Materials

One dry piece of steel wool in a zip-top bag, one water-wet piece of steel wool in a bag, one vinegar-wet piece of steel wool in a bag

### Procedure

1. Each piece of steel wool has been in its bag for the same length of time. Examine each bag with steel wool, and record your observations.

Dry: \_\_\_\_\_

Water-wet: \_\_\_\_\_

Vinegar-wet: \_\_\_\_\_

2. What effect did the water have on the steel wool? \_\_\_\_\_
3. What effect did the vinegar have on the steel wool? \_\_\_\_\_
4. If vinegar represents acid rain, what does this tell you about acid rain?  
\_\_\_\_\_  
\_\_\_\_\_

5. What type of weathering is this, physical or chemical? \_\_\_\_\_

6. Was your hypothesis correct? \_\_\_\_\_ Write a conclusion.

CONCLUSION: \_\_\_\_\_

\_\_\_\_\_

# Hydroelectric Power

**Organizing Topic** Investigating Water

**Overview** Students develop a presentation on the generation of electricity from waterpower, including the process, the cost, and the advantages and disadvantages. They also analyze the history of hydroelectric power.

**Related Standards of Learning** 6.5f

## Objectives

The students should be able to

- explain the role of water in power generation.

## Materials needed

- Resource materials on hydroelectric power generation
- Internet access
- Presentation software
- Poster paper
- Markers
- Copies of the attached handout

## Instructional activity

### *Content/Teacher Notes*

The first human settlements were established near springs, rivers, and lakes. Reliable fresh water sources and irrigation systems allowed civilizations to grow and flourish. As cities grew, different strategies, such as tunnels, aqueducts, wells, cisterns, pumps, and reservoirs, were employed to collect and store water.

Water is an important resource used in electric power generation. Hydroelectric power plants make use of the kinetic energy of water as it flows through turbines. Also, water is heated in some power plants and turned to steam, which is used to turn turbines to generate electricity.

### *Introduction*

1. Pre-assess students' knowledge of waterpower, using the following questions:
  - Where did early Americans establish their first settlements? Hint: Think of Jamestown. (*On rivers, lakes, and oceans*)
  - Why were the first settlements established near waterways? (*Supply of water; transportation*)
  - During the Industrial Revolution, how did Americans use water? (*For power*)
  - How did they harness the power of moving water to meet their industrial needs? (*Water wheels*)

### *Procedure*

1. Organize the class into teams of four or five students each, and pose the following scenario:

The rising cost of fuels (oil and gas) has astounded the people of Virginia. They are concerned about the risk of expending our supply of nonrenewable fossil fuels and becoming even more dependent on other countries for this crucial source of energy. The burning of fossil fuels is also polluting the atmosphere by putting excess carbon dioxide gas into the air.

This adds to the Greenhouse Effect and may increase global warming throughout the world. The people of Virginia are demanding change.

In response to the people, the governor has asked the Department of Energy to develop a plan to establish an alternative source of energy in Virginia. To help the Department of Energy, the governor is asking students across the state to research alternative sources of energy. Our class has been assigned the task of researching the use of water to generate electric power.

2. Have each team work together to develop a presentation on hydroelectric power generation. The presentation should include the history of waterpower usage, a description of the hydroelectric power process, a summary of the possibilities for using tidal energy, information about the costs involved, and a list of advantages and disadvantages. Each student should focus on a different aspect of the topic and become an “expert” on that aspect. The presentation should include a written report as well as visual images (e.g., posters, flowcharts, PowerPoint presentations, and graphs).
3. On day 1, have teams work on research.
4. On day 2, instruct the teams to organize their presentations.
5. On day 3, allow the teams to present their presentations. Each “expert” should present his/her own topic.

### ***Observations and Conclusions***

1. Have students discuss hydroelectric power generation.
2. Have students draw a picture of the process of hydroelectric power generation and write a brief summary of it. Have them complete the “Hydroelectric Power Flowchart” or create their own.

### **Sample assessment**

- Assess the students’ presentations.
- Assess the completed flowcharts.

### **Follow-up/extension**

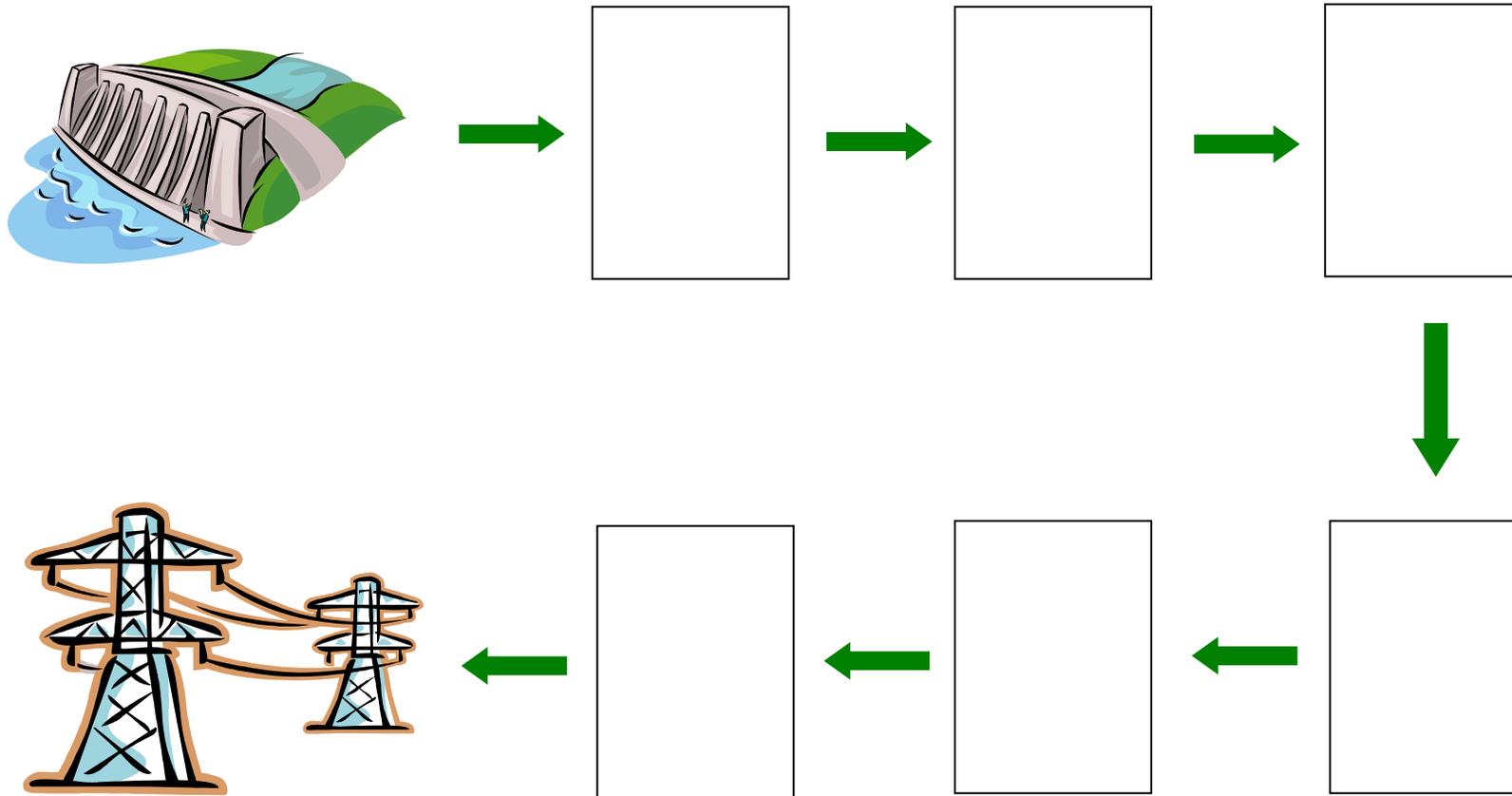
- Have each team of students research a different source of energy in the same way.
- Have students write the governor or president a letter that makes reasonable arguments for change in the primary source of energy used by Virginians or by all Americans.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “Virginia Water Central.” *Virginia Water Resources Research Center. Virginia Tech.* <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center. Virginia Tech.* <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs. Virginia Department of Environmental Quality.* <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States. U.S. Geological Survey.* <http://water.usgs.gov/>.

# Hydroelectric Power Flowchart

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_



# ***The Ocean’s Effect on Climate, 1***

**Organizing Topic** Investigating Water

**Overview** Students examine the fact that water heats and cools more slowly than air. They see that because water retains heat better than air, coastal communities generally experience more moderate temperatures than inland communities.

**Related Standards of Learning** 6.5d

## **Objectives**

The students should be able to

- analyze and explain the difference between average winter temperatures in central and western Virginia and those in areas along the Chesapeake Bay and Atlantic coast.

## **Materials needed**

- Identical containers with lids
- Celsius thermometers
- Copies of the attached handout
- Water
- Paper towels
- Lamps with 100-watt bulbs
- Hot plate
- Aluminum pie pan
- Food coloring

## **Instructional activity**

### ***Content/Teacher Notes***

Due to its high specific heat, water is able to absorb large amounts of thermal energy without showing a significant change in temperature. Therefore, large bodies of water act to moderate the climate of surrounding land areas by absorbing a large amount of the sun’s thermal energy in summer and slowly releasing that thermal energy in the winter. For this reason, the climate of land areas near large bodies of water is generally slightly milder than the climate of areas without any large bodies of water nearby.

If your class period is not long enough to accommodate this lab activity, which will last longer than 60 minutes, set up and start the activity before students come into the classroom. Record the starting temperature, and turn on the light. As the students arrive, have them examine the set up and identify the independent and dependent variables and constants.

### ***Introduction***

1. Discuss the difference between weather and climate, using the following questions:
  - What is weather?
  - What conditions create our weather?
  - Why is the atmosphere so important?
  - Why does the Northern Hemisphere experience summer while the Southern Hemisphere has winter?
  - How does the sun influence weather?
  - What is climate?
  - What is the difference between weather and climate?
  - What are some different climates that occur around the planet?

### ***Procedure***

1. Organize students into lab teams of four or five students each. Distribute “The Ocean’s Effect on Climate, 1” lab sheets, and tell students to read over the steps and identify the variables. Then, have them form their statements of purpose and hypotheses.
2. Have students conduct the experiment as directed on the lab sheet. Designate one student from each team to keep track of the time and to check the temperature every 10 minutes.
3. Perform the following activity while students are waiting between 10-minute intervals. Display a globe or large world map. Have students observe that all the oceans are connected. Ask, “Where do you think the water would be warmer? Why? Where would the water be colder? Why?”
4. Perform a demonstration (or have each team do an experiment) to show how the colder water near the poles and the warmer water near the equator move, thus creating ocean currents:
  - Place an aluminum pie pan on a burner or hot plate.
  - Fill pan half full with water and heat water for two to three minutes.
  - Put a drop of food coloring in the water at the edge of the pan. Tell students to observe the path the food coloring takes. They should observe that the coloring (representing cold water) moves along the bottom of the pan to the warm center. Once the coloring reaches the center of the pan, it begins to heat up and rises to the surface, where it curls back toward the edge.
  - Ask, “What does the cold food coloring do? What happens to the food coloring as it warms near the center? What type of heat transfer is this? (*convection*) How might this relate to ocean currents?”

### ***Observations and Conclusions***

1. Examine as a class the data from the lab, and have students complete the line graphs. The data should show that the air increased in temperature rapidly while the light was on, and it also decreased rapidly when the light went off. The water was slower to increase in temperature, and it retained the heat much longer so that it cooled off more slowly.
2. Use these results to discuss ocean currents and their effect on coastal climates. Guide the discussion by using the Reflection questions, such as, “In addition to the difference in elevation, what is another factor that causes the average winter temperatures in coastal Virginia to be more mild than the average winter temperatures in central and western Virginia?”

### **Sample assessment**

- Assess the completed “The Ocean’s Effect on Climate” lab report.

### **Follow-up/extension**

- Extend the lab activity to include a container of soil. Use the lab activity to lead into a lesson on land breezes and sea breezes. Soil also increases and decreases in temperature more rapidly than water. Since land heats faster than water during the day, warmer air over land rises and cooler air over the nearby sea moves in over the land to take its place — i.e., a sea breeze. At night, land cools faster than water, so cooler air from land moves out over the sea to push the warmer sea air up — i.e., a land breeze.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.*  
<http://www.vanaturally.com/guide/water.html>.

- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “*Virginia Water Central.*” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States.* U.S. Geological Survey. <http://water.usgs.gov/>.

# The Ocean's Effect On Climate, 1

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

**Purpose**

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**Hypothesis**

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**Materials**

Two identical containers with lids, two Celsius thermometers, water, paper towels, lamp with 100-watt bulb

**Procedure**

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Constants: \_\_\_\_\_

**Steps**

1. Put a hole in the lid of each container so that a thermometer will fit through.
2. Pour room-temperature water into one of the containers until it is high enough to cover the bulb of one of the thermometers.
3. Place the lid on each container, and gently put a thermometer through the hole in each of the container lids. Be sure the bulb of the thermometer in the jar with the water is below the surface of the water. **CAUTION:** Be very careful! If the thermometer breaks, do not touch the glass. Tell your teacher immediately.
4. After a few minutes have passed, read the initial temperature in each container, and record these temperatures in the data table below.
5. Place the containers side by side under the light and turn it on.
6. Observe and record temperature every 10 minutes for 30 minutes.
7. Turn the light off, and continue to observe and record temperature for 30 more minutes.

**Data Table**

Independent Variable (IV)	Dependent Variable (DV)							
	0 min	10 min	20 min	30 min	Light out	10 min	20 min	30 min
Air								
Water								



# ***Universal Solvent***

**Organizing Topic** Investigating Water

**Overview** Students investigate water as the universal solvent by comparing the solubility of certain solids in water, alcohol, and vegetable oil.

**Related Standards of Learning** 6.5a

## **Objectives**

The students should be able to

- design an investigation to demonstrate the ability of water to dissolve materials.

## **Materials needed**

- Beakers
- Water
- Measuring spoons
- Sugar
- Salt
- Sand
- Vegetable oil
- Rubbing alcohol
- Copies of the attached handout
- Test tubes
- Test tube rack
- Graduated cylinder
- Margarine
- Goggles

## **Instructional activity**

### ***Content/Teacher Notes***

One of the most remarkable properties of water is its ability to dissolve a large number of substances. For this reason, water is called the *universal solvent*. Since water molecules are *polar* molecules, meaning they have a positive and a negative side, the charges attract the opposite charges of other substances. *Adhesion* is the term used to describe the attraction of the molecules to different substances. The strong charges of water molecules cause many substances to easily dissolve in water.

The substance doing the dissolving (water) or breaking apart of another substance is called the *solvent*. It is not changed chemically when it does this, and it can be recovered for reuse after all dissolved substances are removed. The substance that is dissolved is called the *solute*. The homogeneous mixture of the solute and the solvent is called a *solution*. Most water on the Earth is actually a solution. Polar solvent dissolves polar solutes, and nonpolar solvent dissolves nonpolar solutes.

### ***Introduction***

1. Pass out copies of the attached “Inquiry Graphic Organizer” handout.
2. Put 50 mL of water in each of three beakers. Place 1 tsp. salt in one of the beakers, 1 tsp. sugar in another, and 1 tsp. sand in the third. Stir all three vigorously. Tell students to make observations and to list them on the graphic organizer. Ask students which mixtures formed solutions. Have them explain their answers. Ask them which substance in each beaker is the solvent (*water*) and which is the solute (*sugar, salt*).
3. Put 50 mL of water in each of two clean beakers. Add 50 mL of oil to one of the beakers and 50 mL of rubbing alcohol to the other. Ask students to make observations and to list these also on the graphic organizer. Ask students which mixture formed a solution, based on their observations. Have them explain their answers and write them on the graphic organizer. Ask them which substance is the solvent and which is the solute.
4. Have students develop class definitions for *solution, solvent, and solute*.

### ***Procedure***

1. Organize students into lab teams of four or five students each. List materials on the board, and ask, “How could you use all or some of these materials to design an investigation to demonstrate the ability of water to dissolve materials?” Give teams time to brainstorm, and allow them time to fill out the graphic organizer and come up with an experimental design. (A sample lab investigation is included: the “Universal Solvent” lab sheet.)
2. Instruct the teams to write up their lab design and get your approval before proceeding with the investigation.
3. Allow the teams to conduct their experiment.

### ***Observations and Conclusions***

1. Have the lab teams complete their lab report.
2. Ask, “Which solvent dissolved the most solute? What gives water the ability to dissolve so many solutes? How does the ability of water to dissolve materials aid in life processes?” Discuss responses.

### **Sample assessment**

- Assess the completed lab reports.

### **Follow-up/extension**

- Have students try different amounts of solute in water and vary the temperature.

### **Resources**

- *Natural Resource Education Guide: Virginia's Water Resources*. Virginia Naturally. <http://www.vanaturally.com/guide/water.html>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- “Virginia Water Central.” *Virginia Water Resources Research Center*. Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center’s homepage (see below).
- *Virginia Water Resources Research Center*. Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Water Resources Management Programs*. Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/waterresources/>.
- *Water Resources of the United States*. U.S. Geological Survey. <http://water.usgs.gov/>.

### **Answer Key for Inquiry Graphic Organizer**

- **OBSERVATION:** *Sugar and salt dissolved in water, but sand did not. Rubbing alcohol mixed completely in water, but oil did not.*
- **POSSIBLE EXPLANATION:** *A solution forms when one substance mixes into another liquid substance. More substances will dissolve in water than in other liquids.*
- **HYPOTHESIS:** *If sugar, salt, and margarine are mixed in water, rubbing alcohol, and oil, then sugar and salt will dissolve in water and alcohol, but not in oil.*

- **ACTIVITY OR EXPERIMENT:**

1. *Number the test tubes 1-9.*
2. *Pour 10 mL water into test tubes 1-3. Pour 10 mL alcohol into test tubes 4-6. Pour 10 mL vegetable oil into test tubes 7-9.*
3. *Place ½ teaspoon sugar into test tubes 1, 4, and 7. Place ½ teaspoon salt into test tubes 2, 5, and 8. Place a small piece of margarine into test tubes 3, 6, and 9.*
4. *Cover each test tube with your thumb and shake vigorously. Observe each test tube and record observations.*

# Inquiry Graphic Organizer

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

**OBSERVATION:**



**RELEVANT FACTS OR RULES:**

- Water is the universal solvent.
- Polar solvent dissolves polar solutes, and nonpolar solvent dissolves nonpolar solutes.



**POSSIBLE EXPLANATION:**



**HYPOTHESIS:**



**ACTIVITY OR EXPERIMENT (list steps):**



**RESULTS:**

# Universal Solvent

## Sample Lab Design

### Purpose

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### Hypothesis

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### Materials

Graduated cylinder, nine test tubes, test tube rack, water, rubbing alcohol, vegetable oil, salt, sugar, margarine, goggles

### Procedure

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Constants: \_\_\_\_\_

### Steps

1. Number the test tubes 1-9.
2. Pour 10 mL water into test tubes 1-3. Pour 10 mL alcohol into test tubes 4-6. Pour 10 mL vegetable oil into test tubes 7-9.
3. Place  $\frac{1}{2}$  teaspoon sugar into test tubes 1, 4, and 7. Place  $\frac{1}{2}$  teaspoon salt into test tubes 2, 5, and 8. Place a small piece of margarine into test tubes 3, 6, and 9.
4. Cover each test tube with your thumb and shake vigorously.
5. Observe each test tube, and record observations.

### Data Table

Fill in the table, using numbers to indicate the degree of dissolving, as follows:

3 = 100% dissolved      2 or 1 = partially dissolved      0 = undissolved

SOLVENT	SOLUTE		
	Sugar	Salt	Margarine
Water			
Alcohol			
Vegetable Oil			

### Reflection

1. Which solvent dissolved the most solute? \_\_\_\_\_
2. What gives water the ability to dissolve so many solutes? \_\_\_\_\_  
\_\_\_\_\_
3. How might the fact that water can dissolve so many other substances be essential for life? What would this help living organisms do?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### Conclusion

1. What was your hypothesis? \_\_\_\_\_  
\_\_\_\_\_
2. Do the results support your hypothesis? \_\_\_\_\_
3. Was your hypothesis correct or incorrect? \_\_\_\_\_
4. What happened in the investigation?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
5. Use the average data and your answers to the Reflection questions to summarize the results. Explain why the results happened as they did, and include all discoveries you made. Make an inference based on what you know.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## **Organizing Topic — Investigating the Atmosphere and Weather**

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### **Standards of Learning**

- 6.1 The student will plan and conduct investigations in which
- observations are made involving fine discrimination between similar objects and organisms;
  - a classification system is developed based on multiple attributes;
  - precise and approximate measurements are recorded;
  - scale models are used to estimate distance, volume, and quantity;
  - hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - a method is devised to test the validity of predictions and inferences;
  - one variable is manipulated over time, using many repeated trials;
  - data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - models are designed to explain a sequence; and
  - an understanding of the nature of science is developed and reinforced.
- 6.3 The student will investigate and understand the role of solar energy in driving most natural processes within the atmosphere, the hydrosphere, and on the Earth’s surface. Key concepts include
- the Earth’s energy budget;
  - the role of radiation and convection in the distribution of energy;
  - the motion of the atmosphere and the oceans;
  - cloud formation; and
  - the role of heat energy in weather-related phenomena including thunderstorms and hurricanes.
- 6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include
- the ability of large bodies of water to store heat and moderate climate.
- 6.6 The student will investigate and understand the properties of air and the structure and dynamics of the Earth’s atmosphere. Key concepts include
- air as a mixture of gaseous elements and compounds;
  - air pressure, temperature, and humidity;
  - how the atmosphere changes with altitude;
  - natural and human-caused changes to the atmosphere;
  - the relationship of atmospheric measures and weather conditions;
  - basic information from weather maps, including fronts, systems, and basic measurements; and
  - the importance of protecting and maintaining air quality.



- analyze and explain how convection currents occur, and how they distribute heat energy in the atmosphere and oceans.
-

## ***Layers of the Atmosphere***

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students complete a matrix on the layers of the atmosphere and make a model to represent the relative thickness of each layer.

**Related Standards of Learning** 6.1j; 6.6a; 6.6c

### **Objectives**

The students should be able to

- identify the composition and physical characteristics of the atmosphere;
- analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure.

### **Materials needed**

- Newsprint or large poster paper
- Construction paper or large sticky notes
- Resource materials with information pertaining to the layers of the atmosphere
- Copies of the attached handout
- Model-making materials (colored sand, apples, construction paper, dried beans, graph paper, various concentrations of colored water, clear plastic straws, other items requested by students)

### **Instructional activity**

#### ***Content/Teacher Notes***

Earth's atmosphere is a relatively thin layer of gases that protects the planet and allows life to exist. If Earth were compared to an apple, the atmosphere would be the thickness of the peel. The atmosphere is made up of five layers:

- The **troposphere** is the layer that is closest to Earth's surface, starting at the surface and rising to between 8 and 14.5 km high. It is the only layer in which life exists and virtually all weather occurs. It contains 99 percent of the water vapor in the atmosphere. Due to Earth's gravitational pull, most of the air molecules that make up the atmosphere are found in the troposphere; therefore, atmospheric pressure is highest in the troposphere. As altitude increases, atmospheric pressure *decreases* because fewer and fewer molecules are present. Temperature in the troposphere also *decreases* as altitude increases.
- The **stratosphere** starts just above the troposphere and rises to about 50 km above Earth's surface. The stratosphere is dry and much less dense than the troposphere. The ozone layer, which absorbs and scatters solar ultraviolet radiation, is in this layer. Temperature in the stratosphere generally *increases* as altitude increases, due to increasing absorption of ultraviolet radiation. The troposphere and stratosphere together contain 99 percent of the air molecules in the atmosphere.
- The **mesosphere** starts just above the stratosphere and extends to about 85 km above Earth's surface. Temperature in this layer *decreases* to as low as  $-93^{\circ}\text{C}$  as altitude increases. Molecules here are in an excited state as they absorb energy from the sun.
- The **thermosphere** starts just above the mesosphere and extends to around 500 km above Earth's surface. Temperature in this layer can soar to as high as  $1,727^{\circ}\text{C}$  due to solar activity. The thermosphere and the upper mesosphere contain the ionosphere, which is a large number of

electrically-charged particles (ions). Chemical reactions occur much more quickly here than on the Earth. Light displays, called *auroras*, occur here.

- The **exosphere** starts at the top of the thermosphere and continues upward until it merges with outer space. In this layer, hydrogen and helium are the main gases present.

### ***Introduction***

1. Conduct a short demonstration to assess students' knowledge about the Earth's atmosphere, to set the stage for student research, and to provide questions to focus inquiry. Begin by drawing a large half circle on the lower part of the board to represent the Earth. Ask students to work in groups to formulate answers to the following questions and/or formulate additional questions about the atmosphere.
  - What do you already know about the atmosphere?
  - How might the atmosphere protect living things and make life possible on Earth?
  - How far out into space do you think the atmosphere extends?
  - Are the characteristics of the atmosphere the same near the surface of the Earth as they are at its higher levels? Why, or why not?
2. Provide time for the groups to share with one another in class discussion. Record student answers, questions, and other information on newsprint or large poster paper. Inform students that they will return to these questions at the conclusion of the activity and modify the information on these sheets based on their research.

### ***Procedure***

1. Organize students into groups of five each. Have students in each group count off from 1 to 5, and then have the students arrange themselves into new groups based on these numbers. Explain that the "ones" will investigate the troposphere and become an "expert" group on it, the "twos" will become experts on the stratosphere, the "threes" on the mesosphere, the "fours" on the thermosphere, and the "fives" on the exosphere. In addition, each group will gather information to answer the questions posed during the opening of the activity.
2. Distribute research materials and the "Layers of the Atmosphere" matrix. Materials should contain descriptions of the atmospheric layers, data on the mixture of gases in the layers, and variations of air pressure and temperature due to altitude.
3. While groups are conducting research, circulate to ask them probing questions to prompt thought and additional exploration and research, to ensure that all students are participating, and to make certain that information being gathered is accurate and complete.
4. Once the expert groups have completed their research on their specific atmosphere layer, have all the students reform their original groups, each of which now contains an expert on one of the five atmospheric layers. Starting with the troposphere experts, have each expert present his/her information to the other members of the group, who use the information to complete the matrix.
5. Once their matrix is completed, each group should review the questions posed at the beginning of the activity to determine whether further research is needed to fully answer them. Have students post their group's answers to all the questions in order to provide a visual reference for the other students (and a formative assessment for the teacher).
6. Have students extend and apply their learning by creating a unique model of the Earth's atmospheric layers, using some of the materials mentioned under Materials above. It is important for students to choose for themselves the materials to use to represent what they have learned about the layers of the atmosphere. All models should be different.

### ***Observations and Conclusions***

1. Revisit the sheets of newsprint or large poster paper on which answers to the question were recorded during the introduction to the activity. Hold a class discussion to modify the information on these sheets based on what the students have learned. Make entirely new sheets, if necessary.

### **Sample assessment**

- Use the answers to the initial questions, the student models, and answers to the following questions to assess students' understanding of the main ideas of the lesson:
  - What have you learned about the atmosphere?
  - How does the atmosphere protect living things and make life possible on Earth?
  - How far out into space does the atmosphere extend?
  - What are the atmospheric layers? What are the characteristics of these layers?
  - What are the differences and similarities among the atmospheric layers?
- Given a data table, create a bar graph of the relative thickness (in kilometers) and temperature (in degrees Celsius) for each layer of the atmosphere.

### **Follow-up/extension**

- As a follow-up, or if reinforcement is needed, have students draw the layers of the atmosphere as a series of six semicircles, starting with Earth at the bottom and making each layer's thickness proportional to its actual thickness. Students should draw and label key characteristics for each layer. For example, they might draw gases, clouds, and weather in the troposphere; the ozone layer in the stratosphere; shooting stars in the mesosphere; auroras or the ionosphere in the thermosphere; and satellites or the space shuttle in the exosphere. Extend this by having students draw the sun at the very top and show what happens to solar radiation that enters the atmosphere.

### **Resources**

- *The Ceres S'COOL Project*. NASA. <http://asd-www.larc.nasa.gov/SCOOL/>. Includes activities related to clouds and cloud types.
- *Earth's Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).
- *The Globe Program*. [http://www.globe.gov/globe\\_flash.html](http://www.globe.gov/globe_flash.html). NASA-related program with weather-related investigations and real-time data. GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on, primary- and secondary-school-based education and science program.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>.

# Layers of the Atmosphere

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Layer	Mass of Air	Altitude	Air Pressure	Temperature	Description
Troposphere					
Stratosphere					
Mesosphere					
Thermosphere					
Exosphere					
Other Information					

# Layers of the Atmosphere

## Answer Key

Layer	Mass of Air	Altitude	Air Pressure	Temperature	Description
<b>Troposphere</b>	75% of atmosphere	8 to 14.5 km thickness, depending on the season	Highest pressure in the atmosphere, due to gravity: 100 to 1,000mb	<i>Decreases</i> as altitude increases; range: 17° to -52°C	Weather occurs here Densest layer—most gases Layer where life exists Contains 99% of the water vapor in atmosphere
<b>Stratosphere</b>	24% of atmosphere	14.5 to 50 km (31 mi.) high	Low pressure: 1 to 100mb	<i>Increases</i> as altitude increases; range: -52°C to -3°C, due to absorption of ultraviolet radiation	Contains ozone layer, which absorbs ultraviolet radiation Dry and less dense than troposphere
<b>Mesosphere</b>	A few molecules	50 to 85 km (53 mi.) high	Low pressure: 0.01 to -1mb	<i>Decreases</i> as altitude increases; range: -3°C to -93°C	Shooting stars burn up here
<b>Thermosphere</b>	Very few molecules	85 to 500 km (372 mi.) high	Very low pressure	-93°C to as high as 1,727°C due to the activity of the sun	Contains ionosphere—large number of electrically charged particles (ions) Light displays, called <i>auroras</i> , over poles (Northern lights)
<b>Exosphere</b>	Only helium and hydrogen molecules at very low density	500 to 800 km (372 to 500 mi.) high; merges with space	Extremely low pressure; very few molecules	1,100°C to 270°C	Satellites, Hubble telescope, and space shuttle orbit here Merges with vacuum of outer space
<b>Other Information</b>					

## ***The Ocean’s Effect on Climate, 2***

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students collect experimental data on the heating and cooling rates of land and water. From this data, they learn that water retains thermal energy longer than does land, and they use this fact to explain why the climate of coastal communities is generally warmer in winter than that of land areas with no nearby, large bodies of water.

**Related Standards of Learning** 6.1c, e, g, h, i; 6.3b; 6.5d; 6.6e

### **Objectives**

The students should be able to

- analyze experimental data to explain the effect of the presence (or absence) of large bodies of water on the difference between average winter temperatures in central and western Virginia and those in areas along the Chesapeake Bay and Atlantic coast.

### **Materials needed**

- Identical 1-liter containers with lids
- Celsius thermometers or temperature probes
- Water
- Dry soil/sand
- Paper towels
- Lamps with 100-watt bulbs
- Graph paper
- Copies of the attached handouts

### **Instructional activity**

#### ***Content/Teacher Notes***

Due to its high specific heat, water is able to absorb large amounts of thermal energy without showing a significant change in temperature. Therefore, large bodies of water act to moderate the climate of surrounding land areas by absorbing a large amount of the sun’s thermal energy in summer and slowly releasing that thermal energy in the winter. For this reason, the climate of land areas near large bodies of water is generally slightly milder than the climate of areas without any large bodies of water nearby.

The difference in heating and cooling rates of water and land also accounts for atmospheric convection currents, which produce landward and seaward wind patterns in coastal areas. During the day, the land and the air above it heat up much faster than the adjacent body of water and the air above it. As the air above the land gains thermal energy, it becomes less dense and begins to rise. By contrast, the water absorbs a large amount of the incoming thermal energy from the sun, leaving the air above it cooler and, therefore, denser. As the air over the land rises, the cooler, denser air over the water flows along the surface to take its place over the land, causing a landward breeze. This explains why sea breezes are directed landward during the day.

At night, the land and the air above it cool much faster than the water and the air above it. As the water slowly radiates the thermal energy it has absorbed during the day, it causes the air above it to become warmer, which causes it to become less dense and to rise. The cooler, denser, air over the land flows along the surface away from the land to displace the rising air over the water. This explains why sea breezes are directed seaward at night.

Before beginning the activity, review with students the components of an experiment and the process of completing an experimental design diagram to formulate a hypothesis and identify the independent and dependent variables and constants.

Students must be able to define and distinguish between the terms *thermal energy*, *temperature*, and *heat*:

- **thermal energy.** The energy of a substance, including both its average kinetic energy (temperature) and the number of molecules in the substance (mass).
- **temperature.** A measure of the average kinetic energy of the molecules in a substance.
- **heat.** The transfer of kinetic energy from molecules with more kinetic energy to molecules with less kinetic energy.

Therefore, thermal energy can be transferred, but heat cannot be transferred because *heat* is the term that describes the transfer of thermal energy from one substance to another due to a difference in temperature. Heat is a process, not a thing. The expression “transfer of heat” harkens back to the days when heat was thought to be a thing (caloric) that could flow between objects.

### ***Introduction***

1. Provide students with a map of Virginia showing the cities of Norfolk, Virginia Beach, Lynchburg, and Staunton, and distribute copies of the “Average Annual Temperatures in Virginia Cities” handout. Allow students time to analyze the data and note the general differences between the average winter temperatures in coastal areas and those in inland areas of Virginia. Activate students’ background knowledge, and engage them in the learning task by posing the following questions for class discussion.
  - What is the relationship between weather and climate?
  - In addition to the difference in elevation, what factors might explain the difference between average winter temperatures in coastal areas and average winter temperatures in inland areas of Virginia?
  - How does the heating of land and water produce wind patterns?

### ***Procedure***

1. Distribute copies of the “Experimental Design Diagram,” and lead students in reading over the steps for the investigation and identifying the experiment’s components.
2. Have pairs of students conduct the experiment, one partner conducting the experiment to collect data on the heating and cooling rate of water, and the other conducting the same experiment on soil/sand.
3. Have the partners pool their data and graph the results. Then, allow each pair to compare their graphs to the graphs of another pair.
4. Instruct each group of four to use their graphs to formulate a conclusion and to infer the effect of large bodies of water, such as oceans or very large lakes, on the climate of neighboring land areas.

### ***Observations and Conclusions***

1. Student data should show that while land (soil/sand) increased in temperature rapidly while the light was on, it also decreased rapidly when the light was turned off. The water was slower to increase in temperature, and it retained the thermal energy much longer. Use these results to discuss convection currents and resulting wind patterns and their effect on coastal climates. Return to the questions listed under Introduction for class discussion.

### **Sample assessment**

- Have students draw and label a diagram of an area where land and ocean meet, showing the temperature changes due to absorption of thermal energy during the day and radiation of thermal energy at night. Have students indicate the convection currents produced in the atmosphere and the direction the wind will flow.

## Follow-up/extension

- Extend the concepts highlighted in the lab activity to explain the movement of cold fronts (dense air masses) and warm fronts (less dense air masses) or the movement of ocean currents across the planet. These phenomena can be explained by connecting the heating and cooling of air (or water) masses and the convection currents which result.
- Another good connection is to have students explain how the tilt of the Earth on its axis and the consequent amount of solar radiation received (SOL 6.8g) affect global patterns of wind, weather, and ocean currents. Ask students to explain why the climates of the North and South Poles are never warm even though they are covered or surrounded by oceans.

## Resources

- *The Globe Program*. [http://www.globe.gov/globe\\_flash.html](http://www.globe.gov/globe_flash.html). NASA-related program with weather-related investigations and real-time data. GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on, primary- and secondary-school-based education and science program.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.
- *Virginia Naturally. Expanded Curriculum Framework*. <http://www.vanaturally.com/sixthgrade/framework.html>. Offers background information on the sixth-grade standards.
- *Virginia Weather*. <http://countrystudies.us/united-states/weather/virginia/>. Offers links to cities, towns, and counties throughout Virginia.
- *U.S. Environmental Protection Agency (EPA)*. <http://www.epa.gov/>.

# Experimental Design Diagram

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Title:	
Hypothesis:	
Independent Variable (IV):	
Levels of the IV: (Label the level that will act as <b>control</b> , if there is one.)	
Repeated Trials:	
Dependent Variable (DV):	
Constants: (Be sure to include measurements where needed.)	

## Materials

Two identical 1-liter containers with lids, two Celsius thermometers or temperature probes, water, dry soil or sand, paper towels, two lamps with 100-watt bulbs, graph paper

## Procedure

1. Pour about 250 mL of water into one of the containers — enough to cover the bulb of a thermometer. Pour the same amount of soil/sand into the other container.
2. Put a hole in the lid of each container so that a thermometer will fit through. Place the lid on each container, gently put a thermometer through the hole in each of the container lids, and position the thermometers so the bulbs are covered by the substances in the containers.  
**CAUTION:** Be very careful! If a thermometer breaks, do not touch the glass. Tell your teacher immediately.
3. After a few minutes, read the initial temperatures of the substances (water and soil/sand) and record these temperatures on the data table on the next page.
4. Place the containers near the lights in such a way that when the lights are turned on, each container will receive light of the same intensity and direction (i.e., same angle). Turn on the lights.
5. Measure and record temperatures every 5 minutes for 30 minutes.
6. Turn the lights off and continue to measure and record temperature every 5 minutes for 30 more minutes.

**Data Table**

TIME (min.)	TEMPERATURE (°C)			
	Water	Water	Soil/Sand	Soil/Sand
0				
5				
10				
15				
20				
25				
30				
35				
40				
45				
50				
55				
60				
Change between initial and final temperature				

**Graph**

Use graph paper and your data to construct a double-line graph of the heating and cooling rates of water and a similar graph of the heating and cooling rates of soil/sand. Label the *x*-axis "Time (min.);" and the *y*-axis "Temperature (°C)." Note that the total time on the *x*-axis should be 60 minutes. If you wish, use two colors for each substance — one to show the heating rate and one to show the cooling rate. Make a key to indicate which colors represent the heating and cooling rates of water and which colors represent the heating and cooling rates of soil/sand. Write a descriptive title for your graph.

**Data Analysis and Conclusion**

- Both substances (water and soil/sand) received the same amount of thermal energy from the lamp. Which substance showed the greatest temperature change while the light was on? Use data from your experiment to support your answer.  
\_\_\_\_\_
- Which substance showed the greatest temperature change after the light was turned off? Use data from your experiment to support your answer.  
\_\_\_\_\_
- Which substance retained the greatest amount of thermal energy? Use data from your experiment to support your answer.  
\_\_\_\_\_
- As the water and soil/sand cooled, which would have made the air above its surface the warmest?  
\_\_\_\_\_

**Application**

1. Use your data and analysis to help explain why there is a difference between the average winter temperatures in western Virginia (6-7 °C or 42-44°F) and the average winter temperatures in more moderate coastal Virginia areas (8-9 °C or 47-48°F).

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2. How does the unequal heating and cooling of land and water produce convection currents (i.e., wind) in areas near bodies of water?

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Draw a simple diagram to accompany your answer.

3. How do the concepts you learned in this activity connect to what you have learned about the Earth's energy budget?

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# Average Annual Temperatures in Virginia Cities

## Norfolk (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	47	48	57	66	75	82	86	85	78	68	61	52
<b>Avg. Low</b>	30	32	38	47	56	65	70	68	64	52	44	35
<b>Mean</b>	38	41	48	57	66	74	78	77	72	61	54	44

## Virginia Beach (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	48	50	58	66	74	82	85	85	80	71	62	54
<b>Avg. Low</b>	32	34	40	47	56	65	70	68	65	55	45	36
<b>Mean</b>	41	42	48	57	65	74	78	78	74	64	54	45

## Lynchburg (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	44	47	57	67	75	82	86	84	78	68	58	47
<b>Avg. Low</b>	24	27	35	44	52	60	65	64	57	45	37	28
<b>Mean</b>	34	37	46	56	64	72	76	75	68	57	48	38

## Staunton (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	42	44	54	64	74	81	84	84	77	66	56	46
<b>Avg. Low</b>	18	21	30	38	48	56	60	58	51	38	31	24
<b>Mean</b>	31	34	44	52	61	68	74	71	64	54	44	35

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## Norfolk (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	8	9	14	19	24	28	30	29	26	20	16	11
<b>Avg. Low</b>	-1	0	3	8	13	18	21	20	18	11	7	2
<b>Mean</b>	4	5	9	14	19	23	26	25	22	16	12	7

## Virginia Beach (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	9	10	14	19	23	28	29	29	27	22	17	12
<b>Avg. Low</b>	0	1	4	8	13	18	21	20	18	13	7	2
<b>Mean</b>	5	6	9	14	18	23	25	25	23	18	12	7

## Lynchburg (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	7	8	14	19	24	28	30	29	26	20	14	8
<b>Avg. Low</b>	-4	-3	2	7	11	16	18	18	14	7	3	-2
<b>Mean</b>	2	3	8	13	18	22	24	24	20	14	4	3

## Staunton (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Avg. High</b>	6	7	12	18	23	27	29	29	25	19	13	8
<b>Avg. Low</b>	-7	-6	-1	3	9	13	16	14	11	3	-1	-4
<b>Mean</b>	-1	1	6	11	13	20	23	22	18	11	6	2

# The Pressure's On

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students create and interpret graphs that show the relationship between altitude and pressure and between altitude and temperature in the Earth's atmosphere.

**Related Standards of Learning** 6.1h, i; 6.6a, b, c

## Objectives

The students should be able to

- identify the composition and physical characteristics of the Earth's atmosphere;
- analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure;
- identify the relationship between the temperature and pressure of a gas and its density.

## Materials needed

- Large plastic syringes
- Modeling clay
- Hot water baths
- Cold water baths
- Metric rulers
- Graph paper
- Colored pencils
- Pressure sensors
- Copies of the attached handouts

## Instructional activity

### Content/Teacher Notes

The *pressure* of a gas is related to the number of molecules of gas per unit of volume — i.e., *density*. As the density increases, so does the pressure that the gas molecules exert on their surroundings. The density and, therefore, pressure of atmospheric gases are related to their temperature. As temperature increases, gas molecules move faster and occupy a greater volume. This reduces their density which, in turn, reduces their pressure. Warm gases in the atmosphere are less dense than cold gases in the atmosphere.

Cold, dense gases in the atmosphere tend to sink toward the Earth's surface and are called *cold fronts*. Warm, less dense gases in the atmosphere tend to rise upward away from the Earth's surface and are called *warm fronts*.

The pull of the Earth's gravity is related to the distance from the Earth's center. Gases that are far from the Earth's surface are held together less tightly by gravity than gases that are near the Earth's surface. For this reason, density of gases decreases as distance from Earth's surface increases. Put another way, air pressure (i.e., density) decreases as altitude increases.

Temperature varies with altitude, as follows:

- In the **troposphere**, temperature *decreases* as altitude increases.
- In the **stratosphere**, temperature generally *increases* as altitude increases due to the increasing absorption of ultraviolet radiation by the ozone layer.
- In the **mesosphere**, temperature *decreases* as altitude increases, to as low as  $-93^{\circ}\text{C}$ .
- In the **thermosphere**, temperature *increases* as altitude increases, to as high as  $1,727^{\circ}\text{C}$ .

### Introduction

1. Assess students' background knowledge of pressure and density. Ask them to relate how diving to the bottom of a swimming pool feels in terms of the pressure of the water on their body, especially their ears. If any students scuba dive, have them extend the discussion by talking about the ever-

increasing pressure as one descends to greater depths. Ask students to think about a time when they went to the top of a very tall mountain. Ask, “How did the pressure of the air compare to that at the base of the mountain? Why did your ears “pop” as you went up? Why did your ears “close up” as you came down?” Make sure students relate decrease of air pressure with increase of altitude.

- Engage students’ interest in the activity by performing several simple demonstrations that show the effects of air pressure. Possible demonstrations might include filling an empty soda can with very hot water, emptying the can, and then quickly submerging it in a container of ice water (can collapses), or filling a glass with water to the rim, placing an index card over the top of the glass, and then quickly turning it upside down (water stays inside the glass). Ask students to think about the force which can crush the can *and* keep the water inside the upside-down glass. Discuss whether this force (i.e., air pressure) is the same at all levels of the Earth’s atmosphere.

### ***Procedure***

- Distribute the “The Pressure’s On!” lab sheets, and have students read through all the steps and questions for understanding. Go over any parts of the activity that need clarification.
- Have students conduct the experiment in order to discern patterns in the Earth’s atmosphere. Assist students in setting up the axes of each of the two graphs in step 7. The y-axis should be labeled “Altitude in kilometers” and numbered in increments of 20 km (or in increments of 100 km on every fifth line). Have students use a different colored pencil to lightly color each atmospheric layer on their graph and make a key for this shading.
- For the Altitude and Pressure Graph, explain that the x-axis represents air pressure in millibars and will be labeled “Air Pressure (mb).” Values will range from 0.0001mb to 1,000mb. The first line on the far left of the x-axis will be 0.0001mb, and every 4<sup>th</sup> line will be labeled as follows: 0.001, 0.01, 0.1, 1, 10, 100, and 1,000. (Note: The data are approximate.)
- For the Altitude and Temperature Graph, explain that the x-axis will be labeled “Temperature.” Numbering will not be regular due to the wide range of temperatures in the atmosphere. Show students how to make a zigzag line between numbers on the x-axis to show compression of the numbering. Zigzags can show compression of the following ranges: –100°C to –60°C; 20°C to 200°C; and 400°C to 1,500°C. The x-axis range will go from –100°C on the left up to 1,750°C on the right. Students should graph the first temperature at the lowest altitude of an atmospheric layer and then the second temperature at the highest altitude of that atmospheric layer. See the attached NASA graph for an example of what the graph will look like.
- For both graphs, have students connect the dots to create a smooth curve (line of best fit) through the data points. The pressure graph can be turned on its side with air pressure on the right so that students can more easily visualize what happens to the pressure in each layer of the atmosphere. Likewise, the temperature graph can be turned on its side with temperature on the right so that they can visualize what happens to the temperature in each layer of the atmosphere.

### ***Observations and Conclusions***

- Use the following questions to prompt conclusions:
  - What is the relationship between altitude and air pressure? (*The higher the altitude, the lower the air pressure.*)
  - Why is air pressure less in the upper atmosphere? (*There are fewer molecules of air.*)
  - Why is air pressure greater in the lower layer of the atmosphere than the upper layers? (*There are more molecules in lower layers; 75% of atmospheric gases are in the troposphere.*)
  - What causes the gases to remain closer to Earth? (*Gravity; gas has mass, and anything that has mass is affected by gravity.*)

- What is the relationship between altitude and temperature in the troposphere? (*Inverse—as the altitude increases, the temperature decreases.*)
- Why does the temperature increase in the stratosphere? (*Because of absorption of solar radiation by the ozone layer*)
- Which layer has the greatest range of temperatures? (*The thermosphere*)

### Sample assessment

- Assess students' answers to the following questions:
  - What is air pressure?
  - What is the relationship between altitude and pressure?
  - Why is the air pressure less in the upper atmosphere?
  - What happens to the temperature in the troposphere as altitude increases?

### Follow-up/extension

- Ask students to summarize what they have learned about pressure and density and about temperature and density. They can create a web, diagram, or story to demonstrate their learning.
- Ask students to apply what they have learned about temperature, pressure, and density to explain the phenomena observed in the opening demonstrations. For example, have them use what they learned about temperature, pressure, and density to explain why the can collapsed in the demonstration. (*When the can was placed in the cold water, the air in the can cooled. The molecules cooled, moved together, and exerted less pressure on the can's inside walls. The greater pressure on the can's outside walls made the can collapse.*)
- Have students draw a sun at the top of the page containing their temperature graph and then draw electromagnetic waves coming down through the atmosphere. They should show what happens to the solar radiation as it moves through the atmosphere.

### Resources

- *The Earth Observing System*. NASA. [http://eosps0.gsfc.nasa.gov/eos\\_homepage/for\\_educators/eos\\_posters/](http://eosps0.gsfc.nasa.gov/eos_homepage/for_educators/eos_posters/). Offers posters, PowerPoint versions of posters, and background information on the atmosphere.
- *Earth's Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.

# The Pressure's On!

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## The Effect of Pressure on Density

### Observations

1. Pull the plunger out of the syringe, and then carefully reinsert it. Do not press on the plunger at this time.
  - a. What makes up the air around us? \_\_\_\_\_
  - b. What is inside the syringe? \_\_\_\_\_
  - c. Draw a simple diagram to illustrate the contents of the syringe.
  
2. Place a finger over the end of syringe, and push in plunger in as far as it will go.
  - a. What happened to the number of air molecules inside the syringe?  
\_\_\_\_\_
  - b. What happened to the amount of space the air molecules occupy?  
\_\_\_\_\_
  - c. What effect did pushing in the plunger have on the density of the gas molecules inside the syringe? \_\_\_\_\_
  - d. Draw a simple diagram to illustrate the contents of the syringe now.
  
3. Release your hand's pressure on the plunger and observe what happens to the volume of gas inside the syringe. Why did this occur? \_\_\_\_\_  
\_\_\_\_\_
  
4. Depress the plunger about halfway. Place your finger over the end of the syringe and gently pull the plunger out as far as it will go.
  - a. How would you describe the density of the gas molecules inside the syringe now?  
\_\_\_\_\_
  - b. Draw a simple diagram to illustrate the contents of the syringe now.

## The Effect of Temperature on Density

5. Depress the plunger about halfway, and then stopper the end of the syringe with a small piece of modeling clay. Place the syringe, plunger end up, into a hot water bath. After several minutes, record your observations below.
  - a. What happened to the volume of gas inside the syringe? \_\_\_\_\_
  - b. What can you infer about the density of the gas molecules inside the syringe when it was heated? \_\_\_\_\_

6. Place the same syringe into a cold water bath. After several minutes, record your observations below.
  - a. What happened to the volume of gas inside the syringe? \_\_\_\_\_
  - b. What can you infer about the density of the gas molecules inside the syringe when it was cooled? \_\_\_\_\_

**Effect of Altitude and Temperature on Atmospheric Pressure**

7. Using data shown in the table below, do the following:
  - a. Create a graph of altitude (*y*-axis) versus atmospheric pressure (*x*-axis).
  - b. Create a graph of temperature (*y*-axis) versus atmospheric pressure (*x*-axis)
8. Using the graphs you have made, describe the relationship between altitude and air pressure.  
\_\_\_\_\_
9. Why is air pressure less in the upper atmosphere?  
\_\_\_\_\_
10. The pull of gravity is greatest near the surface of the Earth. How might the pull of gravity affect the density of gas molecules in the troposphere and the exosphere?  
\_\_\_\_\_
11. Describe what your graph shows with respect to altitude and temperature:  
\_\_\_\_\_  
\_\_\_\_\_

**Data for Graphs**

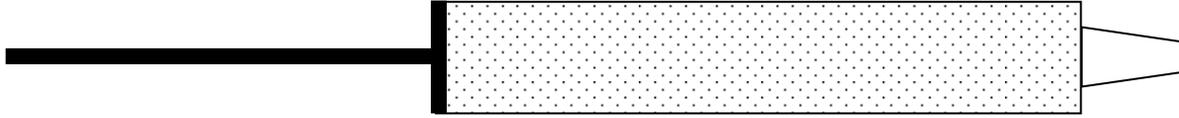
Both Graphs	Altitude and Pressure Graph	Altitude and Temperature Graph
Troposphere = 14.5 km Stratosphere = 50 km Mesosphere = 85 km Thermosphere = 500 km Exosphere = blends with outer space	0 km = 1000mb (equivalent to 14.5 pounds per square inch) 16 km = 100mb 32 km = 10mb 48 km = 1mb 64 km = 0.1mb 80 km = 0.01mb 96.6 km = 0.001mb 112 km = 0.0001mb	Troposphere = 17°C to -52°C Stratosphere = -52°C to -3°C Mesosphere = -3°C to -93°C Thermosphere = -93°C to 1,727°C Exosphere = Temperatures are very high

# The Pressure's On!

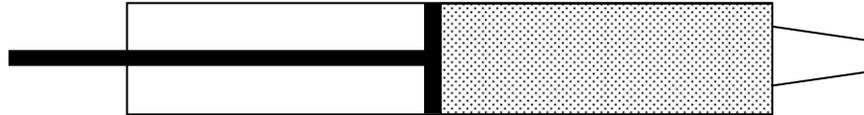
## Answer Key

### The Effect of Pressure on Density

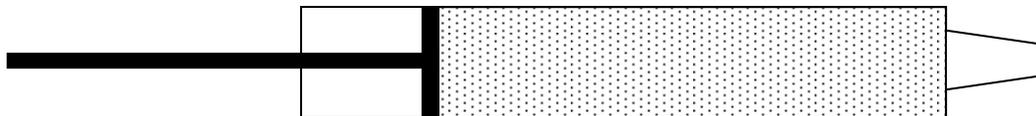
- 1a. What makes up the air around us? (*A mixture of gases, including nitrogen, oxygen, and carbon dioxide*)
- 1b. What is inside the syringe? (*Air – a mixture of gases*)
- 1c. Draw a simple diagram to illustrate the contents of the syringe.



- 2a. What happened to the number of air molecules inside the syringe? (*They stayed the same.*)
- 2b. What happened to the amount of space the air molecules occupy? (*It decreased.*)
- 2c. What effect did pushing in the plunger have on the density of the gas molecules inside the syringe? (*The density increased; there were more molecules in a smaller volume.*)
- 2d. Draw a simple diagram to illustrate the contents of the syringe now.



3. Why did this occur? (*The plunger moved to its original position. The pressure of the compressed gas molecules pushed the plunger back to its original position.*)
- 4a. How would you describe the density of the gas molecules inside the syringe? (*The density decreased; the same number of molecules now takes up a larger volume.*)
- 4b. Draw a simple diagram to illustrate the contents of the syringe now.



### The Effect of Temperature on Density

- 5a. What happened to the volume of gas inside the syringe? (*The volume increased.*)
- 5b. What can you infer about the density of the gas molecules inside the syringe when it was heated? (*The density decreased when it was heated.*)
- 6a. What happened to the volume of gas inside the syringe? (*The volume decreased.*)
- 6b. What can you infer about the density of the gas molecules inside the syringe when it was cooled? (*The density increased when it was cooled.*)

### The Effect of Altitude and Temperature on Atmospheric Pressure

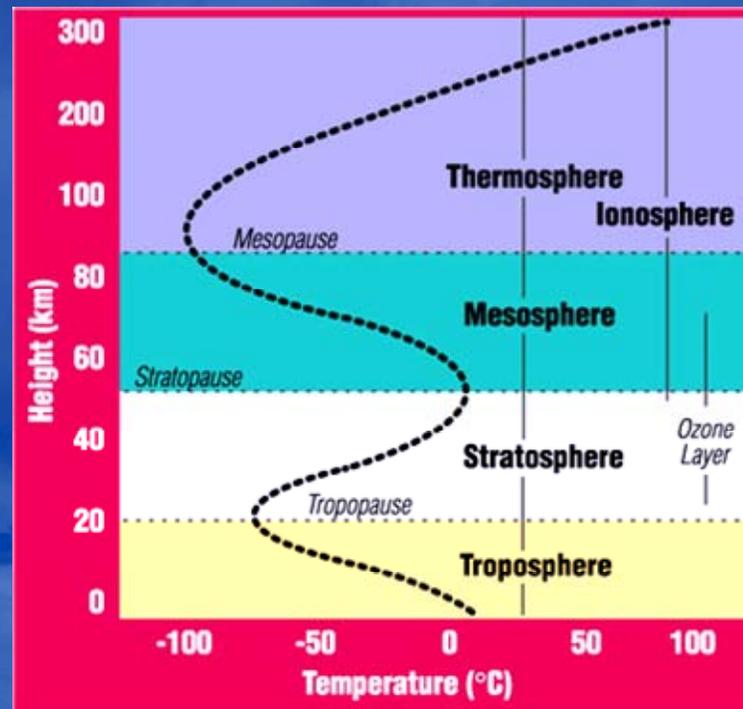
8. Using the graphs you have made, describe the relationship between altitude and air pressure. (*As altitude increases, air pressure decreases.*)
9. Why is air pressure less in the upper atmosphere? (*The molecules of air are more widely spaced – i.e., the atmosphere has a lower density.*)
10. How might the pull of gravity affect the density of gas molecules in the troposphere and the exosphere? (*The pull of gravity creates a greater density of gas molecules in the troposphere, which is near the surface of the Earth, than it does in the exosphere, which is farthest from the surface.*)
11. Describe what your graph shows with respect to altitude and temperature: (*The temperature varies throughout the layers but generally decreases from the troposphere throughout the mesosphere; then, the temperature increases.*)

## Layers of the Atmosphere

# Air *Our Atmosphere*

### Layers of the Atmosphere

The troposphere is the lowest layer of the Earth's atmosphere, extending to a height of 8-15 kilometers (about 5-9 miles), depending on latitude. The stratosphere, warmer than the upper troposphere, is the next layer and rises to a height of about 50 kilometers (about 31 miles). Temperatures in the mesosphere, 50 to 80 kilometers (31 to 50 miles) above the Earth, decline with altitude to  $-70^{\circ}$  to  $-140^{\circ}\text{C}$  ( $-94^{\circ}$  to  $-220^{\circ}\text{F}$ ), depending upon latitude and season. Temperatures increase again with altitude in the thermosphere, which begins about 80 kilometers (50 miles) above the Earth. They can rise to  $2,000^{\circ}\text{C}$  (about  $3600^{\circ}\text{F}$ ). The exosphere begins at 500 to 1,000 kilometers (about 310-621 miles) and the few particles of gas there can reach  $2,500^{\circ}\text{C}$  (about  $4500^{\circ}\text{F}$ ) during the day.



NASA's Earth Science Enterprise 

From *Earth's Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm). Used by permission.

## Cloud Formation

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students examine the effects of solar radiation on the heating and cooling of Earth’s land and water surfaces and how this heating and cooling affects the water cycle and the formation of clouds.

**Related Standards of Learning** 6.3d; 6.6e

### Objectives

The students should be able to

- compare and contrast cloud types, and relate cloud types to weather conditions;
- analyze the role of heating and cooling in the formation of clouds;
- order the sequence of events that takes place in the formation of a cloud.

### Materials needed

- Clear, 1-liter plastic bottles with caps
- Cold and hot water
- Beakers for measuring
- Matches
- Zip-top plastic bags
- Ice
- Copies of the attached handouts
- Resource materials on cloud types

### Instructional activity

#### *Content/Teacher Notes*

The water cycle plays an important role in determining climate patterns. Water evaporates from the surface of the Earth, rises, cools, condenses into rain, sleet, hail, or snow, and falls again to the surface.

Clouds are important indicators of atmospheric conditions. Clouds form from warm, moist air that rises from the Earth’s surface as it is heated. The warm, moist air is less dense than cold, dry air, so it rises relative to colder, drier air. As warm, moist air rises, it gives off some heat energy and cools. When it cools, the water vapor changes into droplets of water or crystals of ice. These droplets collect around tiny bits of dust floating in the air. As the drops condense, a cloud is formed. Clouds are not gaseous water vapor; rather, they are minute, condensed water particles. When the water droplets or ice crystals become too heavy to remain suspended, they fall to the ground in the form of precipitation.

Clouds are found at various levels within the troposphere. Three major types of clouds are **stratus**, **cumulus**, and **cirrus**, which are recognized by their shape and height. Stratus clouds form a layer or sheet across the sky. They are found at low levels in the troposphere and often produce light rain and drizzle. Cumulus clouds are found at different heights within the troposphere. They are individual, rounded clouds with fairly flat bases. They are often seen on dry, sunny days. Cirrus clouds are high-level clouds, usually found above 6,000 meters. They are made up of ice crystals and have a feathery, wispy appearance.

Many different combinations of cloud types may exist in the sky at the same time. Their names refer to the height at which the cloud is found and the type of cloud. For instance, the syllable *alto* in a cloud name indicates that the clouds are middle-level clouds, found between 3,000 and 5,000 meters. *Stratus* means layered, and *nimbus* indicates rain or snow is falling from the cloud. So a *nimbostratus* cloud is a low-level, layered cloud with rain. For more information on cloud types and names, go to <http://asd-www.larc.nasa.gov/SCOOL/tutorial/clouds/cloudtypes.html>.

### **Introduction**

1. Review the water cycle, using the following questions:
  - If water absorbs radiant energy and increases in temperature, what happens to the water molecules near the surface? (*The liquid water molecules gain energy, causing them to move from the liquid phase into the gas phase as they break free of other water molecules due to the increase in energy.*)
  - What do we call it when a liquid becomes a gas? (*Evaporation*)
  - What does the warm water vapor do? (*It rises.*)
  - What happens to the water vapor as it rises higher in the atmosphere? (*It begins to cool.*)
  - What happens when the water vapor cools? (*The molecules move together to form droplets.*)
  - What do we call the process of water vapor becoming a liquid? (*Condensation*)
  - What occurs due to condensation? (*Clouds form.*)
  - What happens when the droplets get too large? (*Precipitation happens: it rains.*)
  - What forms does precipitation take? (*Rain, sleet, snow, hail*)
  - What states of water are present in the water cycle? (*Solid, liquid, and gas*)
2. Use the following “cubing” activity to facilitate a discussion regarding the water cycle. “Cubing” asks you to probe your topic from six different perspectives, as follows: First, select a topic ( an issue, person, idea, event, problem, object, or scene), and write it at the top of your page to help you keep it firmly in mind. Then, give yourself three to five minutes to write from each of the perspectives listed below. Start from what you know, but do not limit yourself; give yourself permission to identify those areas that will need further thought or research, and speculate about where you will discover this information. Try not to sabotage yourself; that is, keep going until you have written about your topic from all six perspectives. As in freewriting, it is important to reread what you have written. Look for surprises, unexpected insight, and momentum.
  - a. **Describing:** Physically describe your topic. What does it look like? What color, shape, texture, size is it? Identify its parts. This would work nicely for the water cycle.
  - b. **Comparing:** How is your topic similar to other topics/things? How is it different? How is the water cycle similar to other cycles?
  - c. **Associating:** What other topic/thing does your topic make you think of? Can you compare it to anything else in your experience? Don’t be afraid to be creative here; include everything that comes to mind. How does the water cycle relate to you and your life?
  - d. **Analyzing:** Look at your topic’s components. How are these parts related? How is it put together? Where did it come from? Where is it going? How are the parts of the water cycle related? What are the stages in the water cycle?
  - e. **Applying:** What can you do with your topic? What uses does it have? How is the water cycle useful to humans? To nature?
  - f. **Arguing:** What arguments can you make for or against your topic? Present a scenario, and argue for or against the scenario being a part of the water cycle. For example, talk about a snowy day, and say that this represents the stage in the water cycle in which water molecules are evaporating. Others will have to argue against this idea and provide ideas to substantiate their views.

### **Procedure**

1. Organize students into groups of four each, and distribute the “Cloud Investigation” sheets and materials to each group.
2. Ask students to respond to the following question: “What conditions would need to be present in a bottle half-filled with water in order for a cloud to form in the bottle?” List on the board all

reasonable answers, and create a class list of these independent variables they propose. Possible answers may include hot water, cold water, warm air, cold air. Through class discussion, help students understand that the temperature of the water will affect the temperature of the water vapor in the bottle. For example, they could not have hot water in the bottle and cool water vapor at the same time.

3. Instruct students to write a hypothesis to answer the question posed in step 2, for example, “If water is cooled, then the vapor inside the bottle will also cool, and a cloud will form.”
4. Review directions for the experiment. Explain to students that only you may handle the matches. Also, explain that as soon as the match is extinguished and dropped into the bottle, the cap must be replaced immediately to trap the smoke.
5. Have students conduct the experiment and record their observations.

### ***Observations and Conclusions***

1. Use the following reflection questions and student responses as a basis for class discussion:
  - Why was it necessary to shake the bottle? (*To saturate the air inside the bottle*)
  - What did squeezing the bottle do? (*Increased the air pressure inside the bottle, which increased the air temperature. With the air heated, more water moved into the air, saturating it.*)
  - What did releasing the bottle do? (*Decreased the air pressure, lowered the temperature, and caused condensation in the bottle*)
  - Why was smoke added to the bottle? (*To give the water something upon which to condense*)
  - How did hot water affect the cloud formation? Explain: (*Hot water heated the atmosphere inside the bottle. When saturation is reached, more water condenses, and a larger cloud forms.*)

### **Sample assessment**

- Have students describe in their own words how a cloud is formed.

### **Resources**

- *The Ceres S’COOL Project*. NASA. <http://asd-www.larc.nasa.gov/SCOOL/>. Includes activities related to clouds and cloud types.
- *Earth’s Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).
- *The Globe Program*. [http://www.globe.gov/globe\\_flash.html](http://www.globe.gov/globe_flash.html). NASA-related program with weather-related investigations and real-time data. GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on, primary- and secondary-school-based education and science program.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.
- *U.S. Environmental Protection Agency (EPA)*. <http://www.epa.gov/>.

# Cloud Investigation

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Hypothesis

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## Materials

One-liter clear plastic bottle with cap, beaker for measuring, cold and hot water, matches, zip-top plastic bag, ice

## Procedure

1. Pour 100 mL of *cold* tap water into the clear plastic bottle, and put the cap on tightly. Put ice into the zip-top bag, and seal.
2. Shake the bottle for 30 seconds, and set it on a table.
3. Squeeze the bottle, and then release it slowly; repeat this process several times. Hold the ice bag around the top of the bottle.
  - a. Do you notice anything different about the bottle? \_\_\_\_\_ If so, describe:  
\_\_\_\_\_
  - b. Do you notice anything different inside the bottle? \_\_\_\_\_ If so, describe:  
\_\_\_\_\_
4. Remove the cap from the bottle.
5. With your teacher or another adult helping you, hold a burning match in the bottle's mouth.
6. Quickly squeeze and release the bottle to blow out the match and draw in the smoke.
7. Drop the match into the bottle and quickly replace the lid.
8. Squeeze and release the bottle several times, holding ice around the top of the bottle.
  - a. What is different about the bottle now?  
\_\_\_\_\_
  - b. Did a cloud form in the bottle? \_\_\_\_\_
  - c. If a cloud did form, why did it form after you added smoke?  
\_\_\_\_\_
9. Clean out the bottle thoroughly.
10. Pour 100 mL of *hot* tap water into the bottle.
11. Repeat steps 2-8, using hot water.
  - a. What happened differently this time?  
\_\_\_\_\_

- b. Was there a bigger cloud than before? \_\_\_\_\_
- c. If it was bigger, what do you think was the reason?  
\_\_\_\_\_

**Reflection**

- 1. Why was it necessary to shake the bottle?  
\_\_\_\_\_  
\_\_\_\_\_
- 2. What did squeezing the bottle do?  
\_\_\_\_\_  
\_\_\_\_\_
- 3. What did releasing the bottle do?  
\_\_\_\_\_  
\_\_\_\_\_
- 4. Why was smoke added to the bottle?  
\_\_\_\_\_  
\_\_\_\_\_
- 5. How did hot water affect cloud formation? Explain:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# Cloud Investigation

## Answer Key

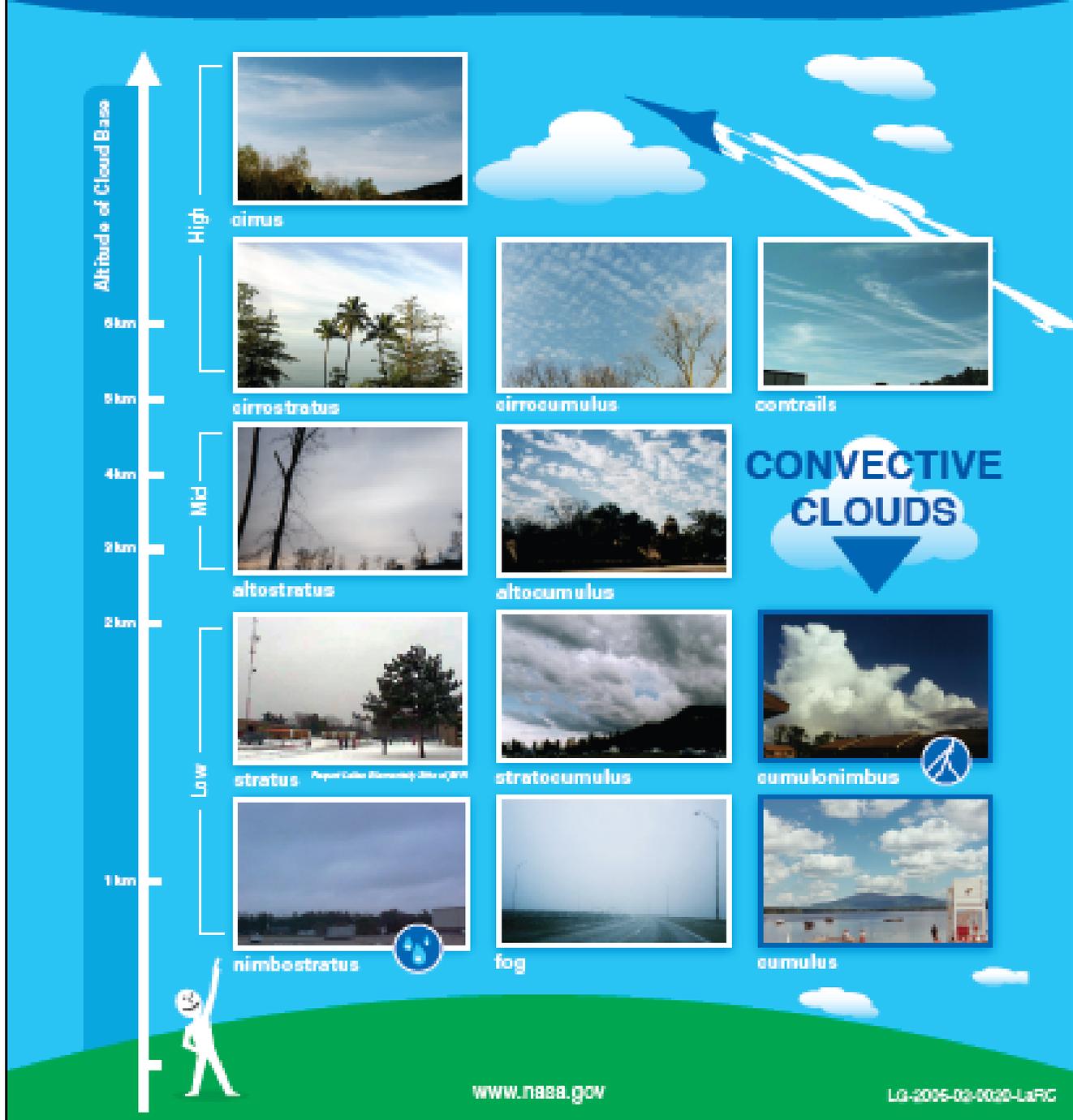
### Reflection

1. Why was it necessary to shake the bottle?  
To saturate the atmosphere inside the bottle
2. What did squeezing the bottle do?  
Squeezing the bottle increased the air pressure inside the bottle, which increased the air temperature. With the air heated, more water moved into the air, saturating it.
3. What did releasing the bottle do?  
Releasing the bottle decreased the air pressure, lowered the temperature, and caused condensation in the bottle.
4. Why was smoke added to the bottle?  
Smoke gave the water something to condense upon.
5. How did hot water affect cloud formation? Explain:  
Hot water heated the atmosphere inside the bottle. When saturation was reached, more water condensed and a larger cloud formed.

National Aeronautics and Space Administration



# S'COOL Cloud Identification Chart



www.nasa.gov

LG-2005-02-0020-JaPC

From *The Ceres S'COOL Project*. NASA. [http://asd-www.larc.nasa.gov/SCOOL/PDF/Cloud\\_ID.pdf](http://asd-www.larc.nasa.gov/SCOOL/PDF/Cloud_ID.pdf). Used with permission.

## Convection Currents

(Adapted from an activity, “Things Are Heating Up!” included in the Educator’s Guide for the NASA SciFiles™ video program “The Case of the Phenomenal Weather.” Used by permission.)

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students investigate how convection currents are formed and how they relate to high-pressure and low-pressure systems.

**Related Standards of Learning** 6.3b

### Objectives

The students should be able to

- analyze and explain how convection currents occur, and how they distribute heat energy in the atmosphere and oceans.

### Materials needed

- Small latex balloon
- Rubber bands
- Large salad dressing bottle
- Hot water
- Large rectangular pan (about 33 x 23 cm)
- Science journals

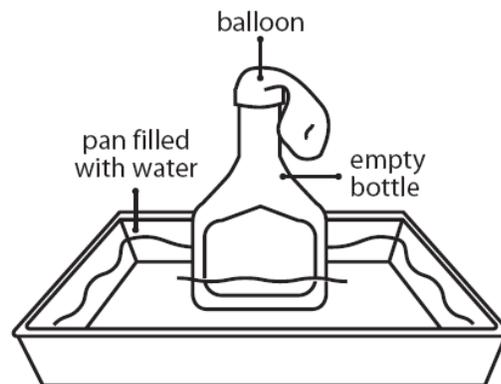
### Instructional activity

#### Content/Teacher Notes

Both high-pressure and low-pressure systems start with the sun. Heat causes air to expand and become less dense. It then rises, leaving an area of low pressure. Because the cooler air higher in the atmosphere is denser, it then sinks, replacing the air that has risen and creating an area of high pressure. When this dense air sinks toward Earth, it is eventually warmed, and the cycle continues. The replacement of the warmer (less dense) air by cooler (more dense) air is called a *convection current*.

#### Procedure

1. Attach the mouth of the balloon to the top of the bottle.
2. Place rubber bands over the balloon on the neck of the bottle to ensure a tight fit.
3. Pour the hot water into the pan to a depth of about 2.5 cm from the top.
4. *Carefully* place the bottle in the hot water. It may be necessary to hold the bottle down.
5. Observe and record your observations.
6. *Carefully* place the bottle and balloon in a refrigerator or a tub of ice for 10 to 15 minutes.
7. Observe and record your observations.



#### Observations and Conclusions

1. Use the following questions and student responses as a basis for class discussion:
  - What happens to the air in the bottle? (*The air in the bottle was heated by the hot water. As the molecules got hot, they moved farther away from each other. Therefore, the air expanded.*)

- How do you know that is what happened? (*Because the balloon began to inflate*)
- How did what happened demonstrate convection? (*In convection, the air is heated at the surface of the Earth, which causes the molecules to move away from each other, creating less dense air. Now that the air is less dense, it begins to rise. As the air rises, it begins to cool. As it cools, the molecules move closer together and the air becomes denser. The air then begins to fall again back toward the Earth. The cycle of convection was demonstrated when the balloon increased in size as the air warmed and then became smaller as the air cooled.*)
- How are low-pressure systems formed? (*When the air near the surface of the Earth is heated, the air molecules spread out so there are fewer air molecules in the same space. Warm air weighs less than cool air, which means that warm air presses down on Earth less than cool air does. A mass of warming air is an area of low pressure.*)
- How are high-pressure systems formed? (*When air cools, the air molecules come closer together, so there are more air molecules in the same space. The air mass becomes heavier and sinks toward the Earth, creating an area of high pressure.*)

### Sample assessment

- Have students describe in their own words how convection currents affect the weather.

### Resources

- *Air Pollution: What's the Solution?* The Center for Innovation in Engineering and Science Education (CIESE). <http://www.k12science.org/curriculum/airproj/>.
- “The Case of the Phenomenal Weather.” *NASA SciFiles™*. <http://scifiles.larc.nasa.gov/educators/index.html?p=episodes/guides>. Click “Archives” — “2001–2002 Season” — “The Case of the Phenomenal Weather” — “Download the Full Guide.”
- *Earth's Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).
- *Energy Information Administration: Official Energy Statistics from the U.S. Government*. National Energy Information Center (NEIC). <http://www.eia.doe.gov/>.
- *Global Warming – Emissions*. U.S. Environmental Protection Agency. <http://yosemite.epa.gov/oar/globalwarming.nsf/content/Emissions.html>. Offers information about greenhouse gases.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.
- *U.S. Environmental Protection Agency (EPA)*. <http://www.epa.gov/>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *What Are Greenhouse Gases?* National Energy Information Center (NEIC). <http://www.eia.doe.gov/oiaf/1605/ggcebro/chapter1.html>.

## ***What Is Weather?***

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students use scientific instruments to measure and record the current conditions of the atmosphere.

**Related Standards of Learning** 6.6a, b

### **Objectives**

The students should be able to

- comprehend and apply basic terminology related to air and the atmosphere;
- measure and record air temperature, air pressure, and humidity, using appropriate units of measurement and tools.

### **Materials needed**

- Barometers
- Compasses
- Anemometers
- Celsius thermometers
- Hygrometers
- Class weather chart
- Resource materials for weather (newspaper, Internet, books)
- Copies of the attached handouts

### **Instructional activity**

#### ***Content/Teacher Notes***

Observations of the atmosphere have been made for centuries and were used as the starting point in an effort to understand and predict the atmosphere's behavior. In the past, most observations were made from the ground level at stations equipped with instruments that measured pressure (barometer), temperature (thermometer), humidity (hygrometer), wind speed (anemometer), and wind direction (wind vane or wind compass). Today, hi-tech devices, which are sent up in weather balloons, electronically transmit data on wind and atmospheric pressure, temperature, humidity, and wind back to receivers on the ground. This data provides *meteorologists* (scientists who study weather) with basic information about what is happening at higher levels of the atmosphere than was previously possible with land-based observatories.

#### ***Introduction***

1. Organize students into teams of four students each.
2. Quick Write: Give students five minutes to write everything they can think of that relates to the following questions:
  - What is weather?
  - What information does a meteorologist need to know to forecast the weather accurately?
  - How would you describe today's weather? How would you describe it if you were a meteorologist?
3. Have the students share what they wrote with their team members. Then, have each team share with the class some of the important thoughts of his/her team. As students share, list key weather words (e.g., *precipitation, pressure, humidity, front*) on the board or overhead.
4. Use these student-generated words to lead into a discussion and form a definition of *weather*. Make sure that students understand that weather is the condition of the atmosphere at a specific time and place.

5. Show students a photocopy or transparency of a current weather report. Prompt them to underline any words in the report that appeared on the class list of keywords. Keep this for assessment at the end of the activity.

### ***Procedure***

1. Show each weather instrument, describe it, and pass it around. Allow students time to examine the tools and practice reading the scale on each device.
2. If possible, take students outside to measure the current weather conditions with the instruments. Remind students that it will take about five minutes for the instruments to adjust to the conditions, so readings should not be taken immediately. Alternatively, take a small group of students outside each day to measure the weather conditions until every student has had an opportunity to use the instruments. If this is not possible, obtain daily weather conditions from the Internet or local newspaper.
3. Record daily weather conditions on a class “Weather Chart” similar to the attached chart.
4. Distribute the “Weather Basics Matrix” to each student and various resource materials to each team. Jigsaw this activity by assigning each team a different weather term on which to become “experts.” Have each team search for information on their term and complete their part of the matrix.
5. Have students move into new groups in which there is an “expert” for each term. Have each expert report findings to the new team members so that each student can complete his/her matrix.
6. Discuss the findings as a class. Make a class “Weather Basics Matrix” with the best of the gathered data, and have the students correct their own matrix as necessary. The answer key provided shows a possible way to complete the chart. You may choose to use less detail.

### ***Observations and Conclusions***

1. Have students write weather reports based on one day’s weather conditions. You may wish to give students a copy of one from the newspaper as an example of the format and type of information included in a typical weather report. Have volunteers present their weather report to the class.

### **Sample assessment**

- Have students name and identify the unit of measure of the instruments used to measure each of the following weather conditions: air pressure, temperature, humidity, wind speed, and wind direction.
- Refer back to the weather report in which students underlined words at the beginning of the lesson. Ask students to explain what each term means, and then move on to defining any other terms found in the report.

### **Follow-up/extension**

- Have students use the collected data to plot weather maps over a number of consecutive days. They should include fronts and pressure systems, which can be obtained from TV, newspaper, or the Internet. Use this activity to lead into reading a weather map and making a forecast.

### **Resources**

- *The Globe Program*. [http://www.globe.gov/globe\\_flash.html](http://www.globe.gov/globe_flash.html). NASA-related program with weather-related investigations and real-time data. GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on, primary- and secondary-school-based education and science program.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.



# Weather Basics Matrix

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Weather is \_\_\_\_\_.

Weather is the result of \_\_\_\_\_.

<b>Weather Factors</b>	<b>Definition</b>	<b>Factors That Affect</b>	<b>Measurement</b>
<b>Air Temperature</b>			
<b>Air or Atmospheric Pressure</b>			
<b>Wind</b>			
<b>Moisture,</b>  <b>including:</b> <b>Humidity</b>  <b>Relative Humidity</b>  <b>Cloud Formation and Cloud Types</b>  <b>Precipitation</b>			

# Weather Basics Matrix

## Answer Key

Weather is the state of the atmosphere at a specific time and place.

Weather is the result of heat from the sun and Earth's air and water.

Weather Factors	Definition	Factors That Affect	Measurement
<b>Air Temperature</b>	Measure of the amount of heat (average amount of motion, or kinetic energy, of molecules) in the air	<ul style="list-style-type: none"> <li>Location on Earth — how directly the sun's rays strike the area.</li> <li>Amount of radiation from the sun</li> </ul>	<b>Thermometer</b> ; in degrees Celsius (°C)
<b>Air or Atmospheric Pressure</b>	The force of air exerted on an area on Earth from all directions, including directly down	<ul style="list-style-type: none"> <li>Gravity pulling on air</li> <li>Altitude</li> <li>Density of air</li> <li>Temperature of air</li> </ul>	<b>Barometer</b> ; average pressure of atmosphere at sea level = 1 bar; unit for reporting air pressure is millibar (1/1000 of a bar)
<b>Wind</b>	Movement of air from an area of high pressure to an area of low pressure; described by <i>direction</i> and <i>speed</i>	<ul style="list-style-type: none"> <li>Differences in the amount of solar radiation received</li> <li>Coriolis effect — rotation of the Earth</li> </ul>	<p><b>Wind vane</b>; measures wind <i>direction</i>; arrow points in direction <u>from which</u> the wind is blowing; a compass point may also be used.</p> <p><b>Anemometer</b>; measures wind <i>speed</i> in kilometers (or miles) per hour</p>
<b>Moisture,</b> <b>including:</b> <b>Humidity</b>  <b>Relative Humidity</b>  <b>Cloud Formation and Cloud Types</b>  <b>Precipitation</b>	<p>Water in the atmosphere; transitions between any of water's three states in Earth's normal temperature range</p> <p>Amount of water vapor in the air</p> <p>Amount of water vapor in a volume of air compared to the maximum amount the air can hold (saturation) at a given temperature</p> <p>Warm air moves upward, expands, and cools; when air is saturated, water vapor condenses around small, air-borne particles, such as dust or salt.</p> <p>Water falling from clouds</p>	<ul style="list-style-type: none"> <li>Air temperature</li> <li>Air temperature — heat from sun evaporates water</li> <li>Humidity</li> <li>Air volume</li> <li>Temperature</li> <li>Temperature</li> <li>Air pressure</li> <li>Humidity</li> <li>Air temperature — causes either rain, snow, sleet, or hail</li> </ul>	<p>Measured as humidity (see below)</p> <p><b>Hygrometer</b>; in percent</p> <p><b>Psychrometer</b>; in percent; can range from 0% to 100%</p> <p>Shape and height:</p> <ul style="list-style-type: none"> <li>Stratus — smooth layers at low elevation</li> <li>Cumulus — puffy, white</li> <li>Cirrus — high, thin, white, feathery</li> </ul> <p><b>Rain gauge</b>; in centimeters or inches</p>

# Weather Forecasting

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students use weather maps to forecast the weather for a particular area.

**Related Standards of Learning** 6.6e, f

## Objectives

The students should be able to

- map the movement of cold and warm fronts, and interpret the effects of the fronts on observable weather conditions;
- interpret basic weather maps, and make forecasts based on the information presented.

## Materials needed

- U.S. maps (regional or national)
- Collection of weather reports from newspaper or Internet covering four consecutive days

## Instructional activity

### *Content/Teacher Notes*

Weather maps provide a valuable way to visualize data in order to predict the weather. Weather maps use special symbols that stand for the various pressure areas and fronts and their boundaries. The curved lines on a weather map show areas of equal air pressure (isobars) and temperature (isotherms).

- An *isobar* is a line connecting locations with equal barometric pressures. Isobar maps show where pressures are relatively high and low and where pressure changes are gradual or dramatic over a distance.
- An *isotherm* is a line connecting locations with equal temperatures. Isotherm maps show where temperatures are relatively high and low and where temperature changes are gradual or dramatic over a distance. There are examples of maps with isobars and isotherms included at the end of this lesson.

When forecasters say that a *low-pressure area or system* is moving toward your region, this usually means that cloudy weather and precipitation are coming. Low-pressure systems have different intensities, with some producing a gentle rain and others producing strong winds and heavy rain. The centers of all storms are areas of low air pressure. Air rises near low-pressure areas. As air rises, it cools and often condenses into clouds and precipitation. In the Northern Hemisphere, low-pressure area winds circulate in a counterclockwise direction. Cold air will likely be found north and west of the low-pressure area, while warm air is found south and east of the system.

When you hear a weather forecaster say that a *high-pressure area or system* will dominate the weather, it usually means your region has several partly to mostly sunny days in store with little or no precipitation. Air tends to sink near high-pressure centers, inhibiting precipitation and cloud formation. This is why high-pressure systems tend to bring sunny days with calm weather. Air flows clockwise around a high-pressure system in the Northern Hemisphere.

A *warm front* is the boundary between warm and cool or cold air, where the warm air is replacing the cold air. Warm fronts often form to the east of low-pressure centers as warm air from the south is pushed northward by counterclockwise winds. As warm, light air advances northward, it rides over the cold, heavy air ahead of it. The warm water vapor in the air rises, cools, and condenses into clouds that

typically produce long periods of precipitation as the cold air below it slows the progress of the warm front. On a weather map, the warm front marks the boundary between warm and cold air at the Earth's surface. It is shown as a red line with curved half-circles that point in the direction the warm front is moving.

A *cold front* is the boundary between warm and cold air, where the cold air is replacing the warm air. Showers and thunderstorms often develop ahead of a cold front in the warm, unstable air ahead of the front. Winter cold fronts often bring frigid air, while summer cold fronts often bring dry air. As a cold front moves into an area, the heavier, cool air pushes under the lighter, warm air it is replacing. The warm air cools as it rises. If the rising air is humid enough, water vapor will condense into clouds and may bring precipitation. In summer, a cold front could trigger thunderstorms with hail and damaging winds and even tornadoes. On a weather map, the cold front is shown as a blue line with triangles that point in the direction the cold front is moving.

### **Introduction**

1. Activate students' background knowledge, and engage them in the learning task by posing the questions: "What is a meteorologist? (*A scientist who studies weather*)" "Where do meteorologists get information to develop a weather report?" (*From instruments that measure temperature, air pressure, winds, humidity, and precipitation*) Record student answers.
2. Explain to students that the weather instruments they have in the classroom are for local weather and are good only for measuring current conditions. Ask the following questions:
  - How do meteorologists get the information necessary to make an accurate five-day forecast? (*The National Weather Service collects data from around the country. Data are collected from the upper atmosphere and from the Earth's surface by using weather satellites, Doppler radar, and instruments attached to weather balloons.*)
  - What do meteorologists do with this data? (*They use computers to process this data into "predictor models." They use this information to predict the weather.*)
  - How do meteorologists display the data for the public? (*They use weather maps and long-range charts.*)

### **Procedure**

1. Organize students into teams of four each.
2. Give each team two weather maps (similar to the one on p. 162), showing the weather on two consecutive days. Also, give them two weather reports for the same days. Allow students time to examine maps and make discoveries. Ask the following questions:
  - What information do you find on the weather maps?
  - What other information is in the weather report?
  - What patterns do you notice on your two maps?
  - Are there any fronts on your maps?
  - How did the fronts move? How far did they travel from one day to the next?
  - As the fronts approached, what changes in the sky conditions probably occurred?
  - Was there any precipitation associated with these fronts?
  - What changes in wind direction and temperature probably accompanied these fronts?
  - Are there any high-pressure or low-pressure systems?
  - How did the pressure systems move? How far did they travel from one day to the next?
  - What weather conditions (such as clouds, precipitation, temperature changes) are to be expected with each pressure system?
3. Locate weather maps for four recent consecutive days. Copy and pass out the maps for days 1 and 2. Also, pass out two maps of exactly the same territory but containing no weather data.

4. Tell the students that they will model the work of meteorologists as they track weather patterns over a period of two days and make a weather report forecasting weather conditions for the following two days. They have the first two days' of weather data with which to create a four-day sequence. Tell the teams to use what they learned from the weather maps to study the weather patterns set up on days 1 and 2 in order to make a prediction of the weather for days 3 and 4. Have them draw their forecasts on the blank maps.
5. Explain that a weather reporter needs to be able to explain his/her weather report to the general public. Have students write a weather report that explains their forecast. They should discuss pressure, temperature, wind direction, wind speed, sky condition, and precipitation, if any, as they explain what weather is coming.

### ***Observations and Conclusions***

1. Remind students that meteorologists are not always correct in their forecasts even though they use all available data, past and present, to make them. Discuss why this is true.
2. Once students have completed their weather reports and forecasts in step 5 above, pass out copies of the actual weather maps for days 3 and 4. Have students check their maps and predictions against the actual ones. Ask students what variables might have resulted in inaccurate forecasts. These variables could include the jet stream, high-pressure or low-pressure front movements, mountain ranges, and/or large bodies of water.
3. Ask students, "Why are weather forecasts important?" List their responses, and continue brainstorming reasons that knowing what the weather will be for the rest of the day, or tomorrow, or beyond is frequently very important to people. Ask, "How would our lives be different if all weather forecasts were incorrect? How would life change if there were no weather forecasts?"

### **Sample assessment**

- Distribute a weather map, and have students write a weather report for the next day, based on the conditions that are presented on the map.
- Students use the weather data collected by the class to make a weather map for any given day.

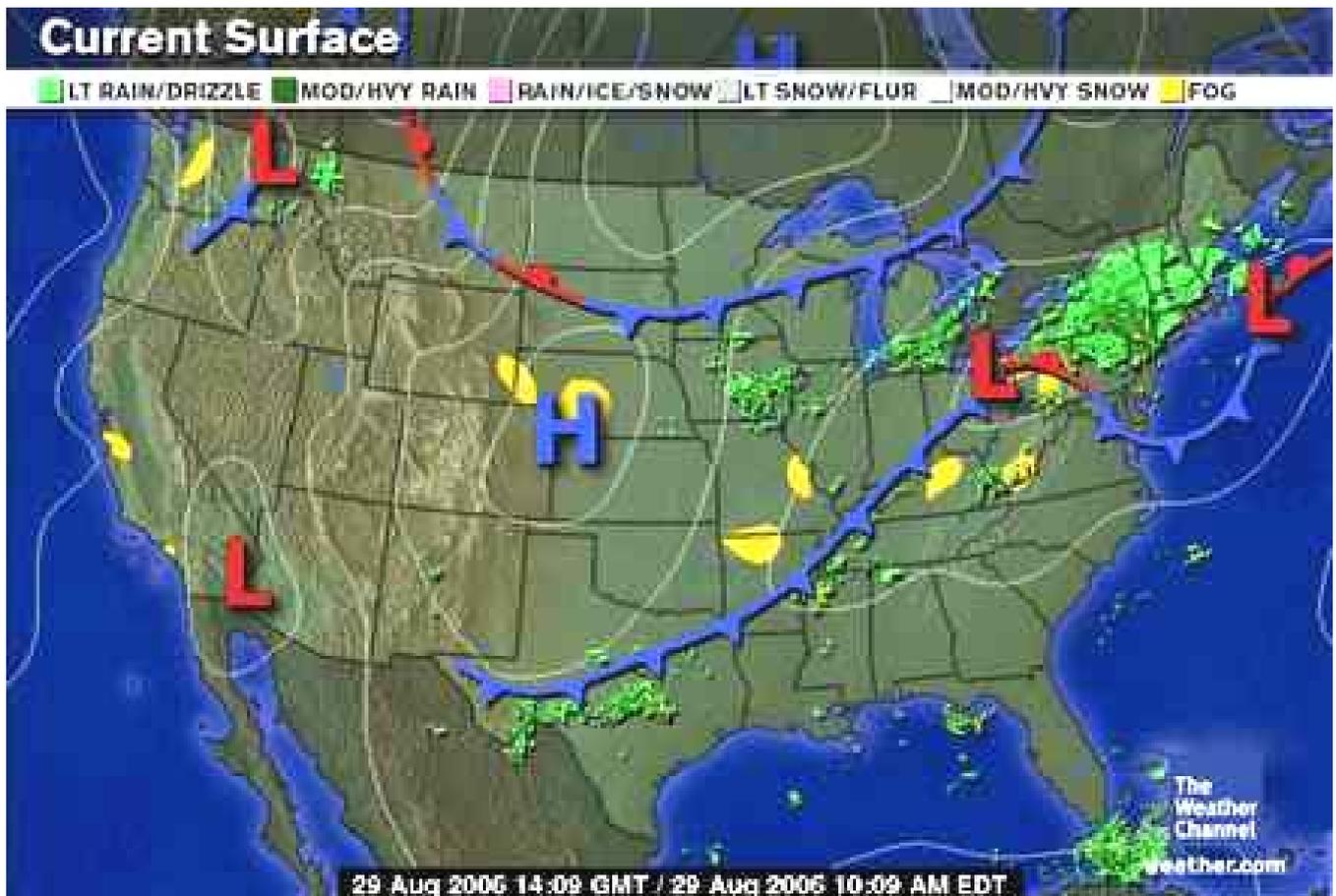
### **Follow-up/extension**

- Remind students that technology has helped to produce better, more reliable weather forecasts. This improved technology has allowed meteorologists to predict violent weather more accurately and has helped people to prepare for dangerous weather events such as hurricanes, severe thunderstorms, tornados, and blizzards. Have students research and prepare an interesting presentation to the class about the current technology (e.g., satellites, radar, computer modeling, instrumental aircraft) used by meteorologists to make weather predictions accurate.
- Have the class become part of the "GLOBE Program" to record and report a variety of weather and other data to the GLOBE database, which is accessible worldwide. (See Resources below.)
- Have students collect weather-related data over an extended period of time and enter that data into ArcView (desktop GIS for mapping, data integration, and analysis) to display color-coded GIS maps of their data.

### **Resources**

- *The Ceres S'COOL Project*. NASA. <http://asd-www.larc.nasa.gov/SCOOL/>. Includes activities related to clouds and cloud types.
- *Earth's Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).

- *The Globe Program.* [http://www.globe.gov/globe\\_flash.html](http://www.globe.gov/globe_flash.html). NASA-related program with weather-related investigations and real-time data. GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide, hands-on, primary- and secondary-school-based education and science program.
- *National Oceanic & Atmospheric Administration (NOAA).* U.S. Department of Commerce. <http://www.noaa.gov/>.
- *Printable Maps.* Nationalatlas.gov. <http://www-atlas.usgs.gov/printable.html>.
- *The Weather Channel.* <http://www.weather.com/>.
- *U.S. Surface Weather Features.* USA Today. <http://www.usatoday.com/weather/fronts/latest-fronts-systems.htm>. Offers weather maps.
- *Water Vapor Satellite Images.* Unisys Weather Satellite. Unisys Corp. [http://weather.unisys.com/satellite/water\\_vapor.html](http://weather.unisys.com/satellite/water_vapor.html).



From: *U.S. Surface Weather Features.* USA Today. <http://www.usatoday.com/weather/fronts/latest-fronts-systems.htm>. Used by permission.

## ***Air Quality***

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students investigate how human activities and natural events change the atmosphere. They examine the consequences that these changes have on quality of life, the weather, and climate. Finally, they evaluate their own role in protecting air quality.

**Related Standards of Learning** 6.6d, g

### **Objectives**

The students should be able to

- analyze and explain some of the effects that natural events and human activities may have on weather, atmosphere, and climate;
- evaluate their own roles in protecting air quality;
- analyze and interpret a chart or diagram showing the Earth’s energy budget;
- analyze, model, and explain the Greenhouse Effect in terms of the energy entering and leaving the atmosphere.

### **Materials needed**

- 8½ x 11 paper for air-quality brochure
- Sample air-quality brochure
- Resource materials (e.g., textbooks, trade books, encyclopedias, Internet access)
- Copies of the attached handout

### **Instructional activity**

#### ***Content/Teacher Notes***

Forest fires and volcanic eruptions are two natural processes that pollute the Earth’s atmosphere, but many gaseous compounds and particles are released into the atmosphere as a result of human activities, such as burning fossil fuels and releasing chlorofluorocarbons (CFCs). The effects of these compounds on the atmosphere are not yet fully understood, but evidence that they are damaging is mounting.

Ozone, a compound formed when three atoms of oxygen combine, can form near the surface of the Earth when vehicle exhaust pollutants react with sunlight. This type of ozone pollution can cause health problems. (This should not be confused with naturally occurring ozone found in the upper atmosphere, which is beneficial in shielding the Earth from ultraviolet radiation.)

Life on Earth is supported by energy from the sun. The Earth’s *energy budget* is a balance between the amount of energy that reaches the Earth’s surface versus the amount of energy that is radiated back into space. Radiation with a short wavelength, mainly ultraviolet, is received from the sun and absorbed and scattered by the atmosphere, clouds, and the Earth’s surface. Long-wave radiation, known as infrared, is reflected back into space. *Heat* is the transfer of thermal energy between substances. Infrared radiation “heats” other substances by causing their molecules to gain energy and move faster. The so-called “Greenhouse Effect” occurs when thermal energy is trapped within the atmospheric layers. The accumulation of thermal energy causes an abnormal rise in atmospheric temperature (global warming), which endangers the delicate balance that keeps the Earth’s fragile ecosystem in equilibrium.

Energy received from the sun drives the Earth’s weather and climate and heats the Earth’s surface; in turn, the Earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon

dioxide, and other gases) trap some of the outgoing energy, retaining thermal energy somewhat like the glass panels of a greenhouse. Without this natural Greenhouse Effect, temperatures on Earth would be much lower than they are, and life would not be possible. Thanks to greenhouse gases, the Earth's average temperature is a more hospitable 15°C. However, problems may arise when the atmospheric concentration of greenhouse gases increases.

Since the beginning of the industrial revolution, the amount of carbon dioxide (CO<sub>2</sub>) in the atmosphere has increased nearly 30%, methane (CH<sub>4</sub>) has more than doubled, and nitrous oxide (N<sub>2</sub>O) has risen by about 15%. Why are such gas concentrations increasing? Scientists have data to support the hypothesis that the burning of fossil fuels and other human activities are the primary reason for the increased amount of carbon dioxide in the atmosphere. There has always been a natural release of carbon dioxide into the atmosphere, but these releases have generally been in balance during the centuries leading up to the industrial revolution. During this time, carbon dioxide was recycled by plants and the oceans.

Fossil fuels burned to run vehicles, heat homes and businesses, and power factories are responsible for about 98% of U.S. carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions. Increased agriculture, deforestation, landfills, and mining also contribute a significant share of emissions. In 1997, the United States produced about one-fifth of total global greenhouse gases emitted into the atmosphere.

### ***Introduction***

1. Ask students to brainstorm all the things they already know about the atmosphere, greenhouse gases, the Greenhouse Effect, and global warming. As they mention their ideas, make a concept web on newsprint showing the connection between these ideas.
2. Inform students that the goal of this lesson is to help them explore the connection between the Greenhouse Effect and global warming and to examine their own role in protecting the quality of Earth's atmosphere.

### ***Procedure***

1. Organize students into five teams in order to work on air-quality brochures. Inform the teams that the information contained in their brochure will be used to design a whole-group activity. Assign each team one of the following five topics on which to become an "expert":
  - Causes of Air Pollution: Human Activities and Natural Events
  - Major Pollutants in the Air and Their Sources
  - Effects of Air Pollution on Humans and Other Organisms
  - Climatic Changes Due to Pollution
  - Possible Solutions to Air Pollution.
2. Have students in each team use resource materials to gather information on their assigned topic and share that information with their team members. Be sure to have students include information on how their topic affects Earth's energy budget (see diagram on p. 168).
3. Once each team has completed their research, have them create a simple brochure on their assigned topic.
4. When these brochures are finished, place students into reporting groups with at least one student from each expert team per group. Students report their finding to their new group, and all students add information to the brochures so that each brochure now covers all five topics.
5. Have all students work collaboratively, using their research, to design an activity to illustrate the relationship between human actions (both positive and negative), natural events, and the Earth's temperature. Many activity scenarios are possible as long as they reflect the students' creativity and knowledge about the concepts around which the lesson was developed. One possible activity would

be to have students write “situation” cards in which such human actions and natural events are described. Situations could include things like burning trash, planting trees, volcanic eruption, and buying hybrid automobiles. Creating the situation cards will allow students not only to summarize what they have learned, but also to evaluate the *effect* of each situation on the amount of CO<sub>2</sub> in the atmosphere and its consequent *effect* on the Earth’s temperature.

6. Finally, the class could enact the activity they have designed in step 5. For example, enacting the situations could happen as follows: Appoint a group of students to act as CO<sub>2</sub> molecules in the atmosphere and another group to be the situation-card group. Give each student in the latter group one situation card to read aloud. As each card is read, the CO<sub>2</sub> group must decide if a CO<sub>2</sub> molecule in the atmosphere is saved (i.e., joins the situation-card group) or if more CO<sub>2</sub> is created. If CO<sub>2</sub> increases, then the card’s reader must join the CO<sub>2</sub> group.

### ***Observations and Conclusions***

1. Discuss the effect of air pollution on the environment, particularly the effects on the weather, atmosphere, and climate. Discuss how these changes affect each of us, and ask what we can do to protect and improve the quality of the atmosphere.
2. Ask students to work together in groups of four to summarize the things they now know about the atmosphere, greenhouse gases, the Greenhouse Effect, and global warming. Instruct each group to come up with some concepts to add to the concept web created at the beginning of the lesson. These concepts should show additional connections between these ideas. Challenge each group to share one or two ideas that are new (or newly clarified) to add to the web.

### **Sample assessment**

- Have students develop a cartoon strip that shows at least five things that they can do to protect and/or improve air quality.
- Use the completed air-quality brochures for assessment.

### **Follow-up/extension**

- Have students research the positive effect that worldwide restriction of chlorofluorocarbons (CFCs) has had and is now having on the polar holes in the ozone layer. Point to this as an example of humans correcting an air-pollution problem that they caused.
- Have students research how much CO<sub>2</sub> their whole family produces in a year.

### **Resources**

- *Air Pollution: What’s the Solution?* The Center for Innovation in Engineering and Science Education (CIESE). <http://www.k12science.org/curriculum/airproj/>.
- *Earth’s Atmospheric Layers and Temperature Variations*. NASA. [http://science.nasa.gov/newhome/essd/atmos\\_layers.htm](http://science.nasa.gov/newhome/essd/atmos_layers.htm).
- *Energy Information Administration: Official Energy Statistics from the U.S. Government*. National Energy Information Center (NEIC). <http://www.eia.doe.gov/>.
- *Global Warming – Emissions*. U.S. Environmental Protection Agency. <http://yosemite.epa.gov/oar/globalwarming.nsf/content/Emissions.html>. Offers information about greenhouse gases.
- *National Oceanic & Atmospheric Administration (NOAA)*. U.S. Department of Commerce. <http://www.noaa.gov/>.
- *U.S. Environmental Protection Agency (EPA)*. <http://www.epa.gov/>.

- *Virginia Naturally: Sixth Grade Science Resources.*  
<http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *What Are Greenhouse Gases?* National Energy Information Center (NEIC).  
<http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html>.

## Causes and Effects of Air Pollution

### Causes of Air Pollution: Natural Events

- Volcanic eruptions (ash, toxic gases)
- Forest fires (smoke)

### Causes of Air Pollution: Human Activities

- Vehicle exhaust — photochemical smog (nitrogen compounds that react with sunlight to form ozone)
- Industry/factories — acid rain
- Construction — particulate matter (e.g., smoke, soot, dust)
- Power plants — toxic air pollutants (e.g., carbon monoxide)
- Burning fossil fuels for heat, generating electricity, running vehicles — smog, particulate matter, toxic air pollutants
- Air conditioners, refrigerators, aerosol sprays — chlorofluorocarbons (CFCs), which damage the ozone layer

### Effects of Air Pollution on Humans

- Respiratory (breathing/lung) problems
- Allergies
- Watery eyes, other vision problems
- Nerve damage
- Reproductive disorders
- Cancer
- Heart disease
- UV ray skin cancer, cataracts

### Effects of Air Pollution on Other Organisms

- Reduces phytoplankton's ability to make food
- Decreases plants' abilities to fight diseases and pests
- Spreads pollutants' effect through the food chain when polluted organisms are eaten by other animals

### Effects of Air Pollution on Materials and Structures

- Corrodes metals
- Deteriorates stone and paint

### Climate Changes from Natural Events

- Meteorite collisions, volcanic eruptions, fires, and wind erosion put particles and liquid droplets into atmosphere, blocking solar radiation, increasing cloud cover, and cooling the planet
- Changes in solar output (energy given off by sun), such as sunspots
- Changes in Earth's movement in space (changes in tilt and orbit) change amount of energy reaching parts of Earth

### Climate Changes from Human Activities

- Climate changes from burning fossil fuels, thereby putting harmful pollutants (automobile exhaust, smoke-stack emissions) into the air
- Climate changes from deforestation (cutting down trees and other vegetation without replacing them), thereby reducing the amount of  $CO_2$  that will be removed from the atmosphere

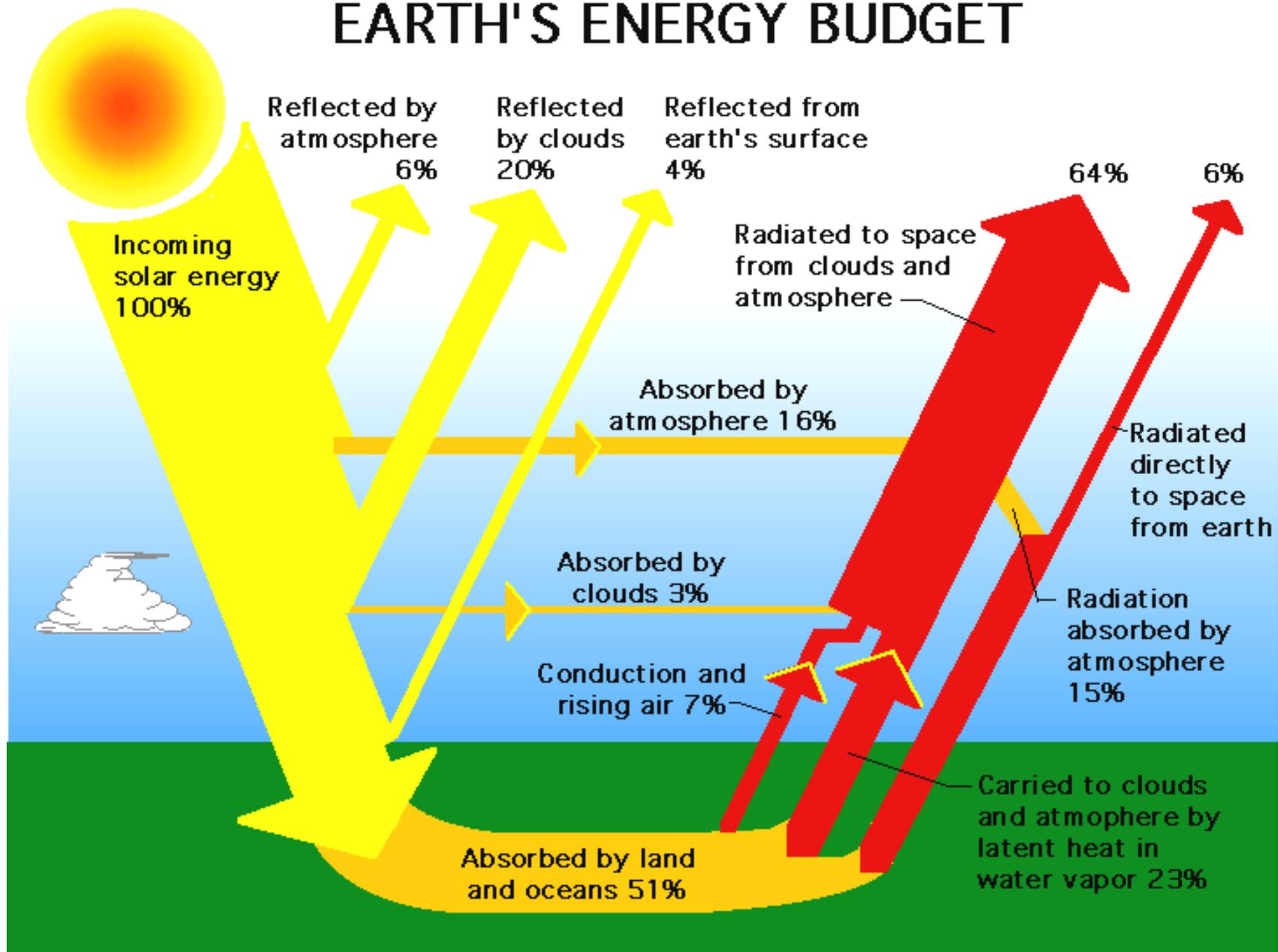
### Greenhouse Effect

- Natural atmospheric heating when gases ( $H_2O$ ,  $CO_2$ ) trap heat. Without these gases, Earth would be too cold for life to exist. However, air pollution increases the levels of  $CO_2$ , too much heat is trapped, Earth becomes warmer and warmer, and fragile ecosystems are disrupted. This is called "global warming."

### Solutions to Air Pollution Problems

- Clean Air Act — federal government laws that regulate air pollution
- Investigating and using alternative, non-polluting power sources (solar, wind, water)
- Conserving electricity (turning off lights and TV; opening windows instead of using air conditioners)
- Decreasing use of car (carpooling, using public transportation, riding bikes, walking)
- Planting trees and vegetation to help remove carbon dioxide
- Using catalytic converter on car to change harmful exhaust gases into less harmful ones

# EARTH'S ENERGY BUDGET



## ***Blue Skies and Red Sunsets***

**Organizing Topic** Investigating the Atmosphere and Weather

**Overview** Students investigate how some wavelengths of light are scattered more than others, producing blue skies and red sunsets.

**Related Standards of Learning** 6.3a

### **Objectives**

The students should be able to

- comprehend and apply basic terminology related to solar energy, including *wavelength*, *ultraviolet radiation*, *infrared radiation*, *visible light*, *reflection*, *refraction*, and *absorption*.

### **Materials needed**

- Piece of yarn or rope, or a long slinky
- Water
- Drinking straws
- Tall, clear glasses or bottles
- Whole milk
- Flashlights

### **Instructional activity**

#### ***Content/Teacher Notes***

Sunlight is composed of the full spectrum of colors: red, orange, yellow, green, blue, indigo, and violet. Nonetheless, *visible light* is a tiny part of the electromagnetic spectrum. Colors toward the red end of the spectrum have longer wavelengths, while colors near the violet end of the spectrum have shorter wavelengths. Like all electromagnetic radiation, light carries energy in waves. Light waves can transfer energy when they interact with matter.

When light hits an object, it can be *transmitted* (pass straight through), be *refracted* (be slightly bent), be *reflected* (bounce off), or be *absorbed*. The molecules and other particles in Earth’s atmosphere refract or reflect some wavelengths of light more easily than others. The shorter wavelengths, such as violet and blue are more readily scattered. The sky looks blue because our eyes are not very sensitive to violet light, and, therefore, our eyes detect more of the blue than the violet color.

When the sun is low in the sky, sunlight travels through a much greater thickness of atmosphere before it reaches our eyes than it does when it is overhead. Through this greater thickness, more wavelengths of light are scattered, including longer wavelengths like green, yellow and orange. Primarily the red wavelength comes through to our eyes, so the setting sun appears to be red.

In this activity, the suspended particles of milk in the water scatter light in the same way that molecules and other particles in Earth’s atmosphere scatter light. Where the light has traveled through only the top layer of the liquid, the light appears light blue. Where it has traveled through most of the liquid, it appears yellow, orange, or red. If you add too much milk to the water, the liquid will have a yellowish hue just like the atmosphere on a smoggy day.

#### ***Introduction***

1. Demonstrate for students the concept of wavelength by waving a rope or slinky back and forth on a large flat surface. Ask student volunteers to model a long wavelength and short wavelength. Using the rope or slinky, ask students to model an ultraviolet wave (short wavelength), an infrared wave (long wavelength), and the way a wave behaves when it strikes an object and is reflected or absorbed.

2. Some of these concepts should be a review from fifth grade science. Be sure to relate them to solar energy.

### ***Procedure***

1. Have students fill a tall, clear glass or bottle with water, and place a sheet of white paper on the back side of the glass so that when they look through the water, they do not see any colors.
2. Darken the room, and have the students shine a flashlight vertically down through the top of their glass of water.
3. Ask students to observe and record (a) the color of the light coming from the flashlight, (b) the color of light as it travels through the water, and (c) the color of the water at the bottom of the glass.
4. Turn on the lights. Instruct students to fill their straw with about 3 cm of milk, add it to the glass of water, and mix. (If they are using soda bottles, they will need to use more milk.)
5. Turn off the lights, and again instruct students to shine a flashlight down through the top of their glass of water-milk and make the same observations. If students cannot see any variations of color, instruct them to add a few more drops of milk to the mixture and try again. The light should look blue where it has traveled a short distance through milky water. At the bottom of the container, where the light has traveled a greater distance through the milky water, the light should look yellow, orange, or red.

### ***Observations and Conclusions***

1. Discuss with students what data they were able to record, and help them generate explanations from their evidence as to the wavelengths of light that are being reflected in each part of the liquid. In which part were long wavelengths being reflected? In which part were short wavelengths being reflected? Why is this so? Instruct students to use the terms in the introduction to help them explain what they observed. You might wish them to make a drawing to accompany their explanation.
2. Have students extend what they have learned in order to explain real-life situations involving color variations. Be sure the discussion includes the reason why the sun appears to be yellow-white during the day and quite red at sunset. Also, guide students in understanding why the sky appears fairly dark blue on a very cool, crisp winter day and much less blue or even slightly green or yellow on sultry, humid days.

### **Sample assessment**

- Have students describe why different colors were observed in their investigation.

### **Follow-up/extension**

- Do the same investigation, but use a liquid of another color to see if the results are the same.

## Organizing Topic — Investigating Watersheds

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### Standards of Learning

- 6.1 The student will plan and conduct investigations in which
- observations are made involving fine discrimination between similar objects and organisms;
  - a classification system is developed based on multiple attributes;
  - precise and approximate measurements are recorded;
  - scale models are used to estimate distance, volume, and quantity;
  - hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables;
  - a method is devised to test the validity of predictions and inferences;
  - one variable is manipulated over time, using many repeated trials;
  - data are collected, recorded, analyzed, and reported using appropriate metric measurements;
  - data are organized and communicated through graphical representation (graphs, charts, and diagrams);
  - models are designed to explain a sequence; and
  - an understanding of the nature of science is developed and reinforced.
- 6.5 The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include
- the importance of protecting and maintaining water resources.
- 6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include
- the health of ecosystems and the abiotic factors of a watershed;
  - the location and structure of Virginia’s regional watershed systems;
  - divides, tributaries, river systems, and river and stream processes;
  - wetlands;
  - estuaries;
  - major conservation, health, and safety issues associated with watersheds; and
  - water monitoring and analysis using field equipment including hand-held technology.
- 6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include
- the mitigation of land-use and environmental hazards through preventive measures; and
  - cost/benefit tradeoffs in conservation policies.

### Essential Understandings, Knowledge, and Skills

### Correlation to Textbooks and Other Instructional Materials

The students should be able to

- comprehend and apply basic terminology related to watersheds;
- use topographic maps to determine the location and size of Virginia’s regional watershed systems;
- locate the local watershed and the rivers and streams associated with it;

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## ***Where Are Virginia’s Watershed Systems?***

**Organizing Topic** Investigating Watersheds

**Overview** Students identify the watershed in which they live and locate other watersheds throughout the state of Virginia.

**Related Standards of Learning** 6.7a, b, c

### **Objectives**

The students should be able to

- comprehend and apply basic terminology related to watersheds;
- use topographic maps to determine the location and size of Virginia’s regional watershed systems;
- locate their own local watershed and the rivers and streams associated with it.

### **Materials needed**

- Virginia state map showing rivers and tributaries (see Resources)
- Colored pencils
- Science journals

### **Instructional activity**

#### ***Content/Teacher Notes***

A *watershed* is the land that water flows across, under, or through on its way to a stream, river, lake, wetland, or other body of water. Small watersheds encompass small land areas and typically drain into small bodies of water. The runoff from small watersheds characteristically joins together with that from other small watersheds to form a larger watershed. Usually, the larger the body of water, the larger its watershed. Areas of higher elevations, such as ridgelines and divides, separate watersheds.

The Virginia Department of Game and Inland Fisheries defines 12 major watersheds in Virginia (see Resources). The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina sounds, or the Gulf of Mexico. Sixty percent of Virginia is part of the Chesapeake Bay watershed, which covers 64,000 square miles in six states. This includes five watersheds in Virginia: the James River, York River, Rappahannock River, Potomac and Shenandoah Rivers, and the Eastern Shore. Two of Virginia’s watersheds empty into the Albemarle Sound in North Carolina; they include the Chowan River (containing the southern portion of Virginia Beach and Chesapeake) and the Roanoke River. The Big Sandy River and the New River eventually empty into the Ohio River. The Clinch, Powell, and Holston Rivers empty into the Tennessee River, which meets the Ohio River just before it empties into the Mississippi River.

River systems are made up of tributaries of smaller streams that join along their courses. Rivers and streams generally have wide, flat, border areas, called *flood plains*, onto which water spills out at times of high flow. Virginia has 497 sub-watersheds, which are made up of small creeks and streams that filter into larger ones before merging into rivers.

Rivers and streams carry and deposit sediment. As water flow decreases in speed, the size of the sediment it carries decreases.

### ***Introduction***

1. Introduce the concept of watersheds by using the following questions to stimulate class discussion:

- Have you ever wondered where rain goes when it falls? (*It soaks into the ground and becomes ground water; it becomes runoff and goes into storm drains; it evaporates.*)
  - Does the water on streets or lawns end up in our drinking water? (*Yes*)
  - What natural process keeps water clean? (*Land areas filter the water naturally as it passes through the ground and along the surface.*)
  - Into what nearby bodies of water might our rainwater flow? (*Students should be able to name nearby rivers and lakes.*)
2. Tell students that quite a bit of rainwater runs off the land, trickles down a drain or into a creek or culvert, flows into a stream, and then flows to a larger river, lake, or other body of water. The whole area of land that water drains across or through to get to a particular body of water is called a *watershed*.
  3. Have students define *watershed* in their own words, and write these definitions on the board. Use these definitions to construct a class definition, and have the students record the definition in their journals.

### **Procedure**

1. Distribute copies of a Virginia map showing the state's watersheds. (See <http://www.dgif.state.va.us/education/watersheds.html>.)
2. Have students use a colored pencil to trace
  - the city/town/community in which you live
  - the tributaries that carries the water in your watershed to the nearby major river
  - the nearby major river or other waterway that carries your water to the larger body of water
  - the larger body of water into which your watershed flows (see Follow up/extension on next page).
3. Have students locate all the land that drains into the same major river. Have students use the same colored pencil to trace other tributaries in the region that flow into the same major river. Then, have them use the same colored pencil to draw a general boundary around the entire watershed area and shade it lightly with the same color. Tell students that the watershed is named after the major river that drains the area. Ask, "What is the name of our watershed area?"
4. Have students locate the other major rivers in Virginia and trace each of these rivers and its tributaries in a different color. As in step 3, have them use the matching colored pencil to outline and shade the watershed area surrounding each river system. Students should note the large bodies of water into which the rivers empty, and they should name the watershed after the major river that drains the area. Tell students that the four major rivers in Virginia that flow into the Chesapeake Bay are part of the larger Chesapeake Bay watershed.

### **Observations and Conclusions**

1. Have the students list the names of tributaries, rivers, major lakes, and other bodies of water in your area.

### **Sample assessment**

- Have students define *watershed*.
- Have students identify the watershed in which they live
- Have students list the Virginia watersheds that are part of the Chesapeake Bay watershed.

## Follow-up/extension

- Teachers in the western part of the state (New River, Big Sandy River, Holston River, and Clinch River) may want to give students a map of the eastern U.S. and have them trace their watershed to the Mississippi River and then on to the Gulf of Mexico.
- Teachers in the Chesapeake Bay watershed may want to give students a map showing the entire watershed area and have them trace all the major rivers that flow into the bay.
- Teachers in the Roanoke and Chowan areas may want to give students a map showing that entire watershed area and have them trace all the major rivers that flow into the Albemarle Sound in North Carolina.

## Resources

- *Chesapeake Bay Program: America's Premier Watershed Restoration Partnership.* <http://www.chesapeakebay.net>.
- *Mapping the Chesapeake. Chesapeake Bay Program.* <http://www.chesapeakebay.net/maps.htm>. Offers a variety of maps, including Chesapeake Bay watershed maps.
- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Project WET: Water Education for Teachers.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/education/wet.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Save Our Streams Chapter of the Izaak Walton League of America.* <http://www.sosva.com/vasoschapterinvitation.htm>.
- “Virginia Water Central.” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center's homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Virginia Watersheds.* Virginia Department of Game and Inland Fisheries. <http://www.dgif.state.va.us/education/watersheds.html>. Offers watershed maps of Virginia.
- *Watersheds. Chesapeake Bay Program.* <http://www.chesapeakebay.net/wshed.htm>.

# ***Estuaries***

**Organizing Topic** Investigating Watersheds

**Overview** Students learn the function and importance of estuaries. They make graphics (maps and flow charts) to illustrate how watersheds, wetlands, and estuaries are related and how the destruction of one affects the others.

**Related Standards of Learning** 6.7e

## **Objectives**

The students should be able to

- explain what an estuary is and why it is important to people.

## **Materials needed**

- Copies of the attached handouts
- Colored pencils
- Map of the Virginia Chesapeake Bay watershed
- Map of Virginia Chesapeake Bay wetlands

## **Instructional activity**

### ***Content/Teacher Notes***

*Estuaries* are partially enclosed bodies of water where freshwater from streams and rivers meets salty ocean water. Bays, lagoons, harbors, inlets, and sounds are examples of estuaries. Estuaries perform important functions, such as providing habitat for many organisms and serving as nurseries for their young. A very large number of fish that are used commercially return from the ocean to spawn in the protective waters of estuaries. Seventy-five percent of commercial fish catch and 80 percent of recreational fish catch make their home in estuaries. Oysters, clams, and crabs thrive in the bays and inlets. Estuaries provide a habitat for endangered and threatened birds.

People depend on estuaries for trade, food, and shelter from violent open ocean water. Among other benefits, estuaries provide recreation in the form of swimming, boating, fishing, surfing, and bird watching. Estuaries act as a natural laboratory for scientists and students. The economy of many coastal communities is directly linked to the aesthetic beauty of the estuary nearby.

Like our rivers and streams, estuaries are in danger as a result of human activity. Much trash and sediment from upriver are carried into the estuary. Chemical contamination in an estuary can linger for years and close down fishing in those areas. Silt and other sediment caused by erosion can suffocate bottom-dwelling plants and animals. Nutrients from upstream make their way into the estuary and cause over-enrichment of the water and oxygen depletion. Altering the natural water flow primarily by dredging and filling wetlands for development purposes has devastating effects on the estuary. Wetlands act as a buffer zone to the estuary by filtering and breaking down nutrients.

The Chesapeake Bay is an estuary where fresh and salt water meet and are mixed by tides. It is the largest estuary in the contiguous United States and one of the most productive. However, the population around the Chesapeake Bay has reached 15 million people and the bay's natural resources are being threatened.

### ***Introduction***

1. Distribute copies of the attached “Watershed Brain Drain” handout.

2. Tell students they have three minutes (adjust the time as desired) to list as many facts about watersheds as they can think of. Give hints if students seem stuck: for example, “What are the parts of a watershed? What do watersheds carry?”
3. Call time at the end of three minutes, and ask students to share their brain drain with a partner. Allow students to add facts to their charts if they know the facts to be true. Students may add other branches to the brain.
4. Have students share their ideas as a class. Make a brain drain on the board to list their ideas.
5. Define *estuary* as a body of water where freshwater meets salty ocean water. Have students name some well-known estuaries in Virginia and elsewhere.
6. Ask students whether wetlands and estuaries are parts of a watershed. Discuss why they *are* parts of a watershed and why they are important. Have students add these facts to their brain drain, and add them to the class brain drain. Then, tell students that you will come back to the brain drain later in the lesson.

### **Procedure**

1. Pass out maps of the Virginia Chesapeake Bay watershed to students. (See <http://www.dgif.state.va.us/education/watersheds.html>.)
2. Remind students that the Chesapeake Bay is an estuary. Lead a discussion about salinity by asking students to describe and compare how they think water would taste upriver, in the Atlantic Ocean, and in the Chesapeake Bay.
3. Have students color the water on the map according to salinity levels, reminding them that river water is fresh, water in the Bay is brackish, and water in the ocean is salty. Tell students to make a key on their maps for these three salinity levels.
4. Now that they know where the estuary is located, ask students where they think the wetlands are located. Show a map of the bay’s wetlands, and have students add the wetlands to their maps. Ask students, “What are the benefits of the wetlands? How do the wetlands help the estuary?”
5. Have students return to their brain drains, and tell them that they are going to organize the information on a flow chart. Hand out copies of the “Watershed Flow Chart,” and explain that the completed chart will show them how waterways, wetlands, and estuaries all work together to make up the watershed.
  - On their brain drain, have students underline in one color all the facts that pertain to the *waterways*. These may be things that go into the water, such as runoff, pollutants, and nutrients. Have students place these facts on the first oval of the flow chart, labeled “CREEKS, STREAMS, LAKES, and MAJOR RIVERS.”
  - Have students use another color to circle everything on the brain drain that has something to do with *wetlands*. Then, have them add these items to the rectangle on the flow chart, labeled “WETLANDS.”
  - Have students use a third color to put a check mark next to any fact on the brain drain that tells about an *estuary*. These items should be added to the second oval, labeled “ESTUARY.”

### **Observations and Conclusions**

1. Hold a class discussion on estuaries, using the following facts:
  - The population in the Chesapeake Bay watershed has grown to over 15 million people.
  - The Chesapeake Bay’s health and productivity has declined in the last several decades.
  - One reason for the decline is increasing land-use development. As population increases, people look for more and more places to develop land.
  - Increased land-use development has resulted in increased pollution of the bay.
  - Wetlands have been drained and filled to make room for housing and industries.

2. Have students look at their flow chart, covering up with another piece of paper the section that has to do with wetlands. Have them answer the question, “What effect does the destruction of wetlands have on the estuary?”

### Sample assessment

- Have students define *estuary*.
- Have students explain the importance of estuaries to people and other animals.

### Follow-up/extension

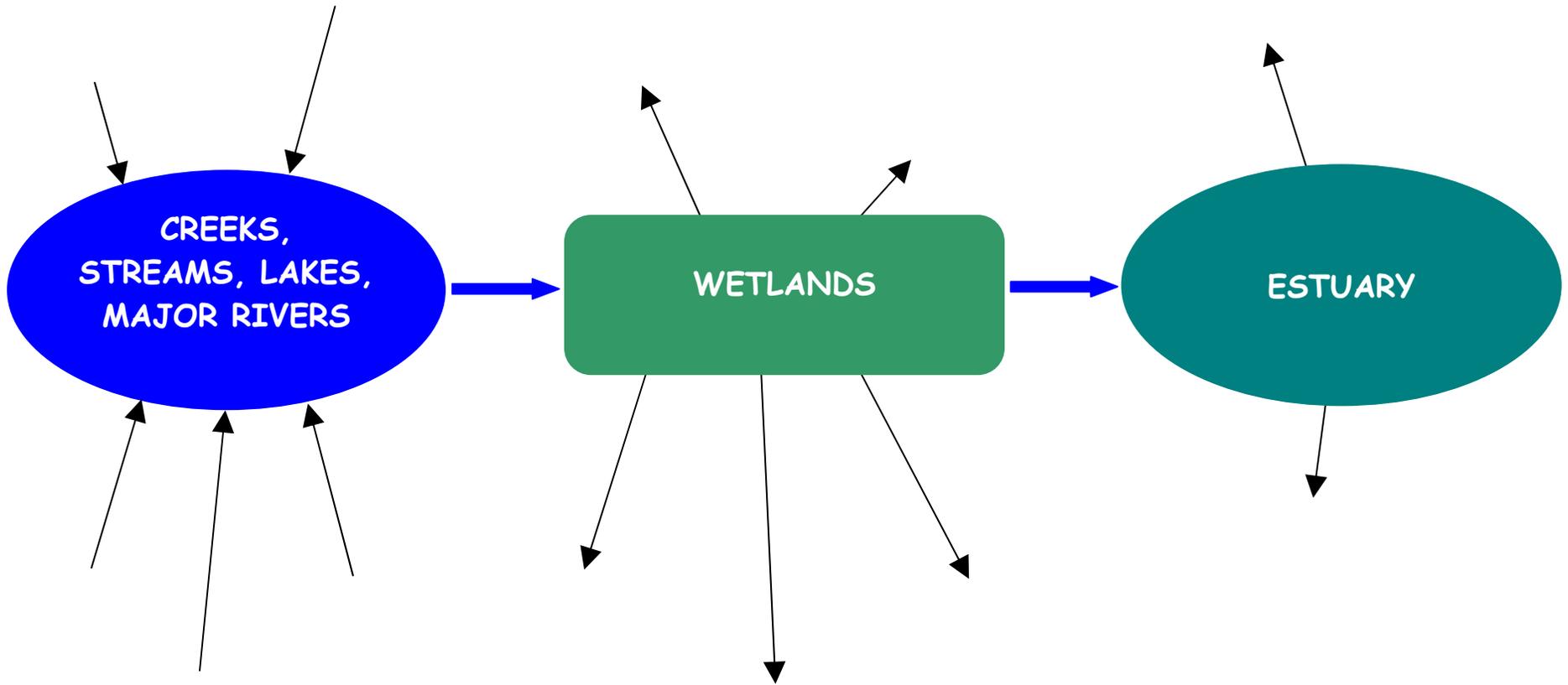
- Have students research and write a brief report on an animal or plant that lives in the Chesapeake Bay watershed. They should include an illustration that can be mounted in the classroom.

### Resources

- *Chesapeake Bay Program: America’s Premier Watershed Restoration Partnership.* <http://www.chesapeakebay.net>.
- *Mapping the Chesapeake. Chesapeake Bay Program.* <http://www.chesapeakebay.net/maps.htm>. Offers a variety of maps, including Chesapeake Bay watershed maps.
- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Project WET: Water Education for Teachers.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/education/wet.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Save Our Streams Chapter of the Izaak Walton League of America.* <http://www.sosva.com/vasoschapterinvitation.htm>.
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- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrcc.vt.edu/>.
- *Virginia Watersheds.* Virginia Department of Game and Inland Fisheries. <http://www.dgif.state.va.us/education/watersheds.html>. Offers watershed maps of Virginia.
- *Watersheds. Chesapeake Bay Program.* <http://www.chesapeakebay.net/wshed.htm>.

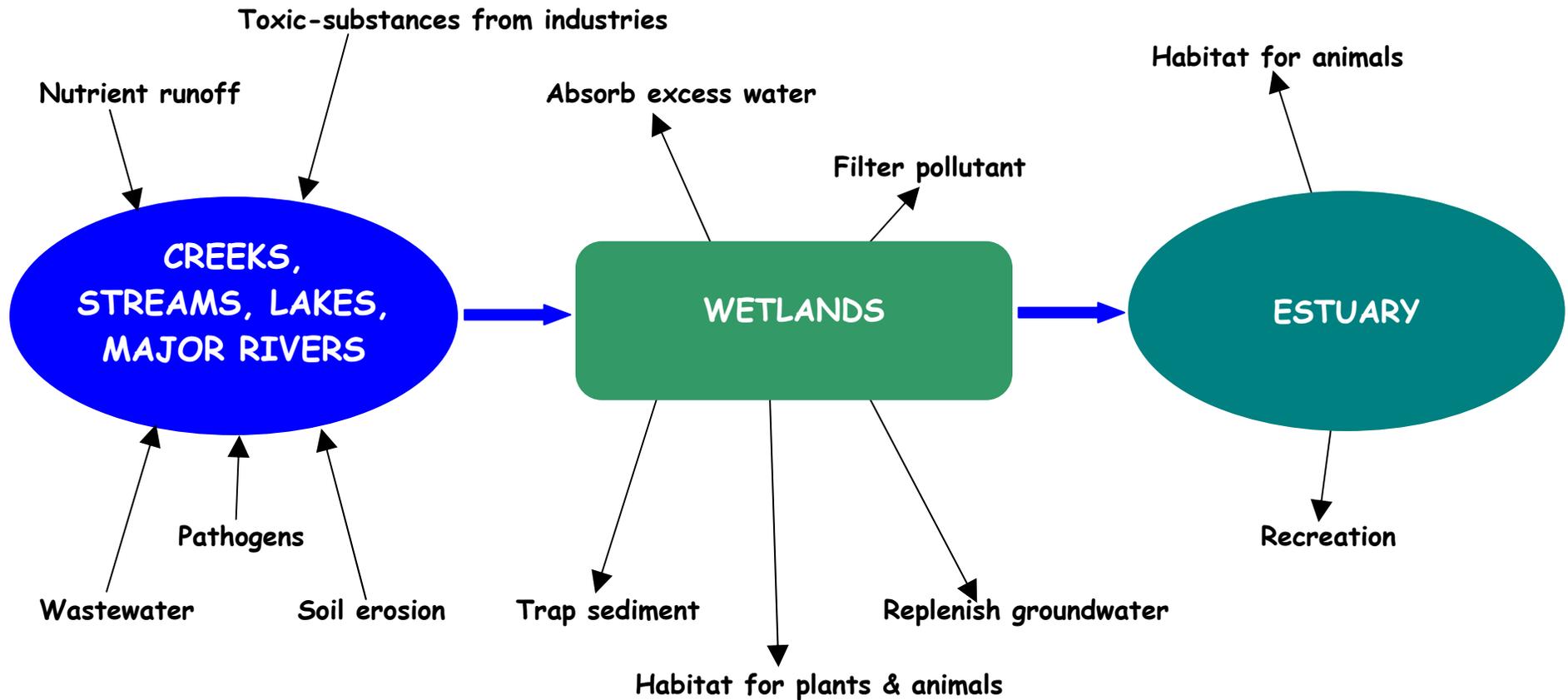
# Watershed Flow Chart

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_



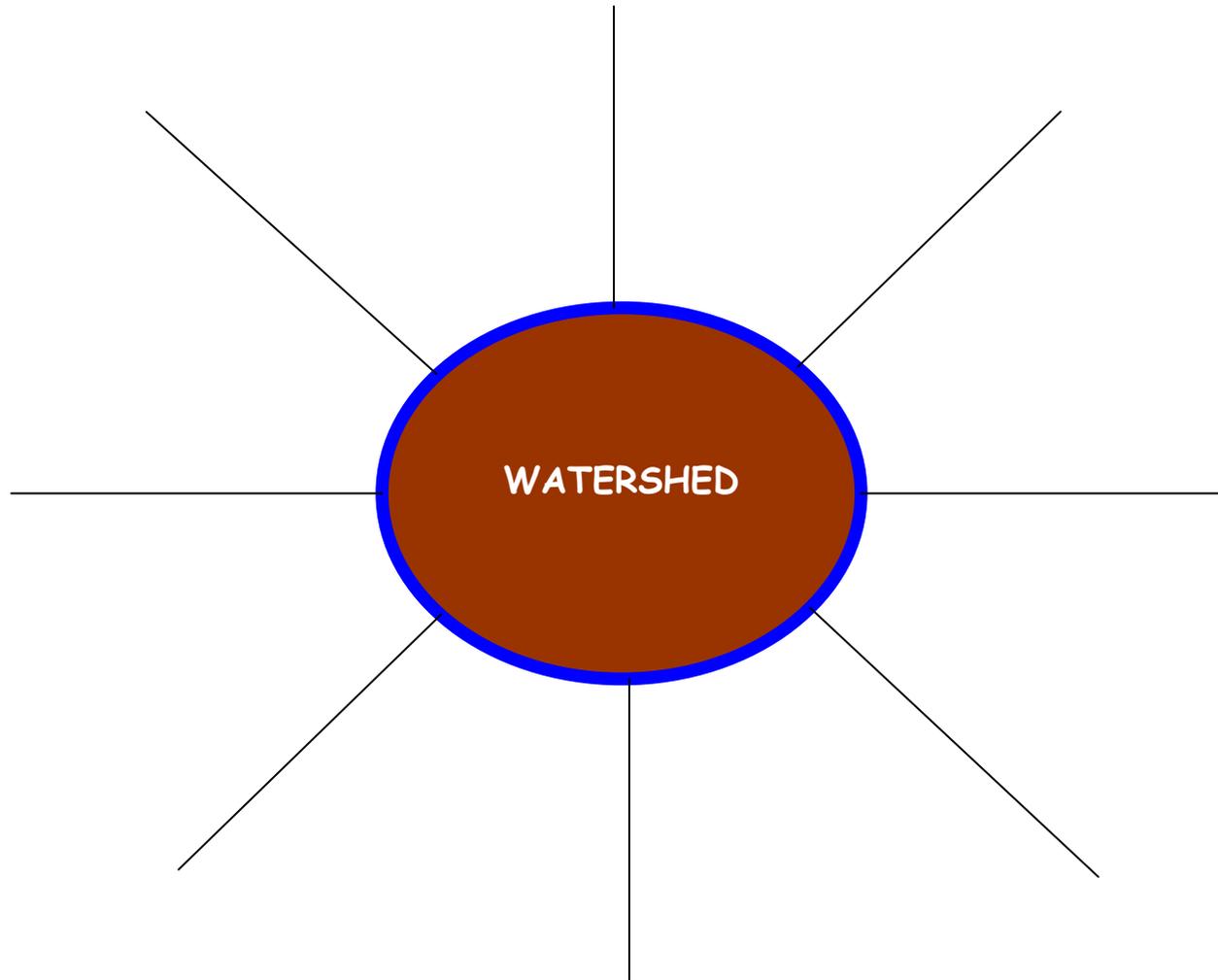
# Watershed Flow Chart

## Answer Key



# Watershed Brain Drain

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_



# Wetlands

**Organizing Topic** Investigating Watersheds

**Overview** Students learn the function and benefits of wetlands while delving into the issue of commercial development versus wetland preservation.

**Related Standards of Learning** 6.7d

## Objectives

The students should be able to

- analyze and explain the functioning of wetlands, and appraise the value of wetlands to humans;
- describe a wetland;
- argue for and against commercially developing a parcel of land containing a large wetland area;
- design and defend a land-use model that minimizes negative impact.

## Materials needed

- Two paint trays
- Rocks or other small objects
- Aluminum foil
- Sponges
- Cinnamon
- Powdered drink mix
- Water
- Spray bottle
- Large bowl
- Small bowl to fit inside large bowl
- Beaker
- Modeling clay or rocks
- Peat moss
- Chart paper or other large paper
- Copies of the attached handout

## Instructional activity

### *Content/Teacher Notes*

Wetlands form the transition zone between dry land and bodies of water, such as rivers, lakes, or bays. Both estuarine (salty or brackish water) and palustrine (freshwater) wetlands perform important functions, including regulating runoff by storing flood waters; reducing erosion by slowing down runoff; purifying water by filtering sediments, trapping nutrients, and breaking down pollutants; and recharging groundwater. They also provide food and shelter for fish and other aquatic life and nesting and resting areas for migratory birds.

Other names for wetlands include swamps, marshes, and bogs, which are characterized primarily by their vegetation:

- **Swamps** are wetlands where the most common plant types are trees (cypresses, willows, oaks), vines (poison ivy), and shrubs. They occur in low-lying areas near slow-moving rivers and need a steady supply of water in order for trees to grow.
- **Marshes** are treeless wetlands sometimes called *wet meadows*. Grasses, reeds, cattails, and nonwoody plants called *rushes* and *sedges* are common marsh plants. Marshes often form on floodplains where rivers overflow their banks.
- **Bogs** are characterized by low to medium-height woody plants. The only source of freshwater in a bog is rain. Since no streams carrying nutrients flow into bogs, plants, such as the Venus flytrap, get nutrients from insects. Because water does not drain from a bog, dead plant material builds up and sinks to the bottom. Eventually a substance called *peat* is formed. Gardeners use peat from a plant called *sphagnum moss*, which, when dried, can hold up to 20 times its weight in water.

At one time, wetlands were thought to be useless, disease-ridden, mosquito-breeding wastelands that should be improved. Many were drained, filled, and destroyed to make room for residential and commercial developments. It is only recently that people have begun to understand the importance of these valuable areas. As people become more educated about their natural benefits, public support for protection and restoration of wetlands increases.

Before undertaking the activity, make two “wetlands” models, as follows: place small rocks or other small objects on two sloping paint trays, and cover the trays and objects with aluminum foil to make the surface look like a watershed with hills and valleys. Put water in the bottom part of each tray to a depth of about one inch to represent a lake or river. Place a line of wet sponges across one tray bridging the boundary between the water and the dry slope to represent wetlands that help keep water clean and prevent flooding.

### ***Procedure***

#### Activity 1: Wetlands in a Tray

1. Tell students they are going to see a demonstration of the effects of wetlands. Show students the tray without the sponges, tell them that this is a model of a watershed with no wetlands, and instruct them to observe what happens in the watershed when it “rains.” Spray the watershed with water from a spray bottle to represent rain, and ask students to make observations about the runoff. Ask, “Where does it all end up? Does anything hinder it?”
2. Sprinkle some cinnamon over the watershed to represent soil. Repeat the rain demonstration, and ask students to make observations. Ask, “What happens to the loose soil? In real life, what things could help to stop the soil from eroding?”
3. Sprinkle some colored powdered drink mix over one part of the watershed to represent pollution. Tell students that this polluting substance is like fertilizer applied to a farm field or like industrial waste from a factory. Repeat the rain demonstration, and have students make observations of how pollutants flow through the watershed. You may want to have a student time how quickly the water moves through the watershed. What happens to the freshwater in the lake?
4. Now, repeat steps 1–3 with the tray containing the sponges. Students should observe that the sponges absorb and/or filter out the pollutants and prevent flooding by soaking up excess rain.
5. Hold a class discussion about watersheds and wetlands, using the following questions:
  - How did water travel through the system?
  - What changes did you observe in the watersheds as the water flowed through it?
  - Where did erosion occur?
  - How would the flow of water through the watershed affect people’s choice of building sites?
  - What happened to the pollutants? Where did they end up?
  - What factors may lead to increased pollution in the form of runoff containing sediment, industrial waste, fertilizers, pesticides, and other harmful substances?
  - What are some ways to prevent or reduce pollution?
  - What helped reduce the amount of pollutants entering the body of water?
6. Summarize the demonstration by telling students that the sponges did the job that wetlands do in real life — (1) filter out pollutants, (2) absorb quite a bit of water, thereby helping to prevent flooding, and (3) allow water to seep into the ground to replenish the underground water supply.

#### Activity 2: To Flood or Not to Flood

1. Organize students into groups of four or five each.
2. Pass out a copy of the attached “To Flood or Not to Flood” handout to each student.

3. Go over the activity, emphasizing that the purpose is to determine the effects of wetlands on flood control.
4. Monitor groups as they work through the activity.
5. Upon completion of the activity, have students work in groups to answer the analysis questions.

### ***Observations and Conclusions***

1. Pose the following analysis questions, and discuss student responses:
  - What type of environment did the bowl filled with clay or rocks represent? (*Non-wetland area*)
  - What type of environment did the bowl filled with peat moss represent? (*Wetland*)
  - What did the large bowl that caught the overflow represent? (*Town*)
  - How do wetlands help control flooding and reduce erosion? (*Wetlands act like a sponge and soak up excess water from rain, melting snow, and floods. Wetland plants hold soil in place and slow the flow of water to reduce erosion.*)
  - How can wetland areas improve water quality? (*Wetlands absorb excess nutrients and reduce sedimentation from erosion. Wetlands are so effective at reducing nutrients that they are sometimes created at sewage-treatment plants to remove sewage from water.*)
2. Have student research the controversial issue of commercial development vs. wetland preservation, focusing, if possible, on an actual area in your region. Then, have each student write a persuasive paragraph about the issue. After students have finished their persuasive paragraphs, hold a mock council meeting, and let students have one minute each to present their opinions. If students take only the environmentalists' side, you can take the side of business and industry leaders. After the presentations, let the "council" (class) debate the issue.

### **Sample assessment**

- Use the students' completed analysis questions and persuasive paragraphs for assessment.
- Have students define *wetland* and describe the reasons wetlands are important to preserve and protect the land we live on.

### **Follow-up/extension**

- Working toward the resolution of conflicting land-use goals so that everyone benefits is an important lesson for students. Wetlands, with all their important advantages, often stand in the way of development. Since wetlands can easily be changed or completely destroyed as a result of land-use decisions, giving students the opportunity to develop a land-use model is an important activity related to real-life. The goal is to find a balance that meets all the needs of the people and protects the environment and wildlife. This is quite a challenge to landowners, city planners, and homeowners.
  - Divide the class into small teams. Give each team various-sized squares of colored paper labeled to represent things found throughout your community, e.g., stores, restaurants, malls, gas stations, factories, houses, apartment complexes, high rise buildings, fire station, police station, farmland, parks, highways, school and schoolyard with ball fields, pastureland, city hall and courthouse, grassland, forest, and military facility.
  - Give each team a large sheet of paper, and have them draw an irregularly-shaped lake with streams flowing in and out of it and a marsh next to it with water grasses and cattails. Have students name their lake and streams.
  - Assign each team a different special interest group whose point of view they will represent. Examples of special interest groups should include the following:
    - Residents of this land

- Farmers who need the land to raise livestock and grow corn
  - Business people who want to develop the land for commerce
  - People who want to use the land for recreational purposes
  - People who want more and better roads and transportation products
  - Gas station owners who want to build service stations for auto repair
  - Conservationists who want to build a habitat for wildlife that has already been displaced by development.
- Have teams arrange their land-use squares on their large sheet of paper based on the priorities of their special interest group and according to the following rules:
    - All land-use squares must be used.
    - Squares may touch, but they may not overlap.
    - Wildlife habitat must be protected.
    - Everyone in the group must agree on the use of the land.
  - Tell students to think logically about what structures or land uses should border each other as they move the squares around. Once they have made up their minds, teams should glue or tape down the squares.
  - Instruct teams to prepare to display and present their project to the class. They need to discuss the advantages and disadvantages of the land use based on their special interests.
  - Once teams have presented their land-use projects, place one of the plans on the wall, and make the streams lead to a major river or estuary. Discuss how the activities around the lake might influence water quality downstream. Have students predict possible problems that might arise within the watershed system that you created.
  - Ask students to think of ways in which special interest groups could work together to resolve conflict and minimize negative impact on people and wildlife.

## Resources

- *Chesapeake Bay Program: America's Premier Watershed Restoration Partnership.* <http://www.chesapeakebay.net>.
- *Mapping the Chesapeake. Chesapeake Bay Program.* <http://www.chesapeakebay.net/maps.htm>. Offers a variety of maps, including Chesapeake Bay watershed maps.
- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Project WET: Water Education for Teachers.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/education/wet.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Save Our Streams Chapter of the Izaak Walton League of America.* <http://www.sosva.com/vasoschapterinvitation.htm>.
- "Virginia Water Central." *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center's homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Virginia Watersheds.* Virginia Department of Game and Inland Fisheries. <http://www.dgif.state.va.us/education/watersheds.html>. Offers watershed maps of Virginia.
- *Watersheds. Chesapeake Bay Program.* <http://www.chesapeakebay.net/wshed.htm>.

# To Flood or Not to Flood

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Materials

Large bowl, small bowl that fits inside large bowl, beaker, rocks or modeling clay, peat moss, water

## Procedure

1. Fill the large bowl  $\frac{3}{4}$  full with water.
2. Pour the water from the bowl into the beaker.
3. Place the small bowl inside the large bowl.
4. Fill the small bowl  $\frac{1}{4}$  full with rocks or clay.
5. Pour all the water from the beaker into small bowl, allowing it to overflow into large bowl.  
Record observations: \_\_\_\_\_
6. Measure and record amount of water that overflows into the large bowl: \_\_\_\_\_
7. Pour all water from both bowls back into the beaker.
8. Remove rocks or clay from the small bowl.
9. Fill the small bowl  $\frac{1}{4}$  full with peat moss to the same height as the earlier rocks.
10. *Slowly* pour all the water from the beaker into small bowl, allowing it to overflow into large bowl. Record observations: \_\_\_\_\_
11. Measure and record amount of water that overflows into the large bowl: \_\_\_\_\_

## Analysis Questions

1. What type of environment did the bowl filled with clay or rocks represent?  
\_\_\_\_\_
2. What type of environment did the bowl filled with peat moss represent?  
\_\_\_\_\_
3. What did the large bowl that caught the overflow represent?  
\_\_\_\_\_
4. How do wetlands help control flooding and reduce erosion?  
\_\_\_\_\_  
\_\_\_\_\_
5. How can wetland areas improve water quality?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



## **Water Quality**

**Organizing Topic** Investigating Watersheds

**Overview** Students research indicators relating to water quality and water pollution.

**Related Standards of Learning** 6.5g; 6.7g

### **Objectives**

The students should be able to

- propose ways to maintain water quality within a watershed;
- explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem;
- forecast potential water-related issues that may become important in the future;
- locate and critique a media article or editorial (print or electronic) concerning water use or water quality, and analyze and evaluate the science concepts involved;
- measure, record, and analyze a variety of water-quality indicators and describe what they mean.

### **Materials needed**

- Water-quality field-test kit
- Copies of the attached handouts
- Resource materials (library books, Internet access)

### **Instructional activity**

#### ***Content/Teacher Notes***

An *ecosystem* is made up of the living community and the nonliving factors that affect the organisms living in it. The nonliving, physical features of the environment are the *abiotic* factors, which determine ecosystem type and its distribution of plants and animals. Abiotic factors include water quality, topography, landforms, geology, climate, soil types, amount of sunlight, and air quality or oxygen availability. The health of an ecosystem is directly related to its water quality.

One thing that all watersheds have in common is people. Human activity can alter abiotic factors and thus accelerate or decelerate natural processes. Human activity can affect water quality in two ways: by changing the ecological processes that naturally purify water, and by adding pollutants. For example, people can affect the rate of natural erosion one way or the other. Plowing cropland can cause greater erosion, while planting trees can lessen it. Preserving or destroying wetlands is another example, because wetlands regulate runoff, reduce erosion, purify water by filtering it, and recharge groundwater.

Land-use changes upstream can cause runoff pollution problems for people, plants, and animals downstream that depend on clean, usable water. This form of pollution is called *non-point-source* pollution (NPS), because the pollution does not come from a single source, such as the discharge from a sewage treatment plant or a factory. NPS pollution is caused mainly by storm-water runoff. When it rains hard, water runs off farmland, city streets, construction sites, lawns, and driveways, carrying sediment, nutrients, pesticides, oil and gasoline, bacteria, and other pollutants with it. One of water's unique properties is its ability to dissolve a wide variety of compounds. Thus, water-soluble materials easily pollute water, which then carries these harmful substances into our waterways and other bodies of water.

The four primary NPS pollutants are sediment, nutrients, toxic chemicals, and disease-causing pathogens.

- **Sediment** is soil carried by rainwater into streams, rivers, and lakes. It cuts light needed by aquatic plants, blocks up waterways, and covers up aquatic habitat. Often the sediment from farmland also carries pesticides and nutrients.
- **Toxic chemicals**, such as pesticides, herbicides, and oil and gasoline, can damage and/or kill aquatic animal and plant life.
- **Nutrients**, particularly nitrogen and phosphorus, over-enrich bodies of water, causing excessive growth of algae. When algae die, bacteria decompose it, decreasing the water’s dissolved oxygen level in the process. Low oxygen can kill or cause distress to aquatic animals. Algae also cloud the water and block much-needed sunlight.
- **Pathogens** enter bodies of water primarily through human or animal waste.

Water-quality monitoring is the collection of water samples in order to analyze chemical and/or biological parameters. Simple parameters include pH, temperature, salinity, dissolved oxygen, turbidity, and the presence of macro-invertebrate organisms.

In the past, streams and rivers were often used to dispose of human waste, and open sewers were common. During the mid-1800s, public health officials recognized the connection between disease outbreaks and contamination of public wells and drinking water. Advances in water treatment and sanitary sewers have helped eliminate diseases associated with human waste.

### **Introduction**

1. Introduce the activity by asking students the following questions: “What happens to water that runs off our streets and lawns? Where does it go? What are some ways that water can become polluted or contaminated?” List their ideas on the board in two columns: “Point-Source Pollutants” and “Non-Point-Source (NPS) Pollutants.” Lead students into a discussion on point-source pollutants (e.g., sewage, industrial discharge) and NPS pollutants (e.g., runoff).
2. Ask students, “How do we know if our water is safe to drink?” (*Test the water.*) Show students a water-quality test kit and equipment. Tell students that before they may use the equipment, they need to learn about the different types of pollutants, what the different tests are, and why they are used.

### **Procedure**

1. Distribute copies of the “Water-quality Monitoring” and “Water Pollutants” handouts.
2. Organize students into “base teams” of four students each, and assign two students from each base team to work on water-quality monitoring and the other two to work on water pollutants.
3. Next, have all “water-quality monitoring” students group together into an “expert group” and all “water pollutants” students group together into another “expert group” in order to complete their assigned matrix. Assign each base team pair in each large expert group a different task.
4. Have expert pairs complete their research and then report back to their expert group. Monitor the sharing of information to ensure that it is correct.
5. Once all expert pairs have completed their matrix, tell students to return to their base teams and report back all information that was gathered. Go over the matrix to ensure students have correct information.
6. Have students choose an article from the *Virginia’s Water Resources* (available at <http://www.vanaturally.com/guide/water.html>) to summarize. As an alternative to summarizing, you may wish to have students use one of the reading strategies from the English Enhanced Scope

and Sequence (at <http://www.pen.k12.va.us/VDOE/EnhancedSandS/english6-8.pdf>). Students can complete this for homework.

7. As an introduction for the next day’s class, have several students report on different articles that they read.

### ***Observations and Conclusions***

1. Have students report on their findings from the matrices and magazine articles. Discuss these findings with the class.

### **Sample assessment**

- Student matrices
- Article summary

### **Follow-up/extension**

- Follow this lesson with the next one, entitled “Water Testing.”

### **Resources**

- *Chessie: Chesapeake Science on the Internet for Educators*. Mid-Atlantic Marine Education Association (MAMEA). <http://www.bayeducation.net/>.
- *Lessons from the Bay*. Virginia Department of Education. <http://www.pen.k12.va.us/VDOE/LFB/>.
- *VA Save Our Streams: Protecting Virginia’s Natural Resources Since 1989*. <http://www.sosva.com/>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Naturally.... Virginia’s gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

# Water-Quality Monitoring

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Test	What and/or Why	Method
pH		
Temperature		
Salinity		
Dissolved Oxygen		
Turbidity		
Macro-invertebrates		
Nutrients		

## Water-Quality Monitoring

### Answer Key

Test	What and/or Why	Method
<b>pH</b>	Measures how acidic or basic a solution is. Most organisms are adapted to a specific pH level and are highly susceptible to changes.	Test kits or probes. In U.S., pH in most natural water systems is 6.5-8.5.
<b>Temperature</b>	Can influence biological activities and chemical processes of organisms living in water. Can change dissolved oxygen levels.	Thermometers or probes.
<b>Salinity</b>	The amount of dissolved salts in water. Controls the types of plants and animals that can live in the water.	Physical methods: density (hydrometer), conductivity, or refractivity. Chemical method: chloride concentration with test kit.
<b>Dissolved Oxygen</b>	Best indicator of water's health. Decrease in level can cause changes in type and number of macro-invertebrates.	Field-test kits with five chemicals that are added to water in prescribed order.
<b>Turbidity</b>	Clarity or transparency of water. Suspended particles clog gills of fish, reduce photosynthesis, and impair filter-feeding system of many aquatic animals.	Black-and-white weighted disk (Secchi disk) on measured rope is lowered on shady side of boat, and depth at which it disappears is measured and recorded.
<b>Macro-invertebrates</b>	Bottom-dwelling organisms. Presence or absence of organisms is indicator of water quality.	Kick net or dip net scoop sample from the bottom of stream bed. Net is spread out on white plastic to examine specimens.
<b>Nutrients</b>	Main cause of Chesapeake Bay's poor water quality. Excessive amounts cause algae to grow. Bacteria decompose algae, a process that decreases water's dissolved oxygen level.	Field-test kits measure concentration of nitrates and phosphorus in water.

# Water Pollutants

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Category	Sources & Examples	Impact	Tests
<b>Sediment Pollution</b>			
<b>Nutrient Pollution</b>			
<b>Toxic Pollution</b>			
<b>Pathogen Pollution</b>			
<b>Thermal Pollution</b>			

# Water Pollutants

## Answer Key

Category	Examples & Sources	Impact	Tests
<b>Sediment Pollution</b>	Insoluble particles suspended in water. Soil eroded from farmland, lawns, construction sites, and other places.	Clogs gills of fish, blocks up waterways, covers up aquatic habitat and disrupts food web, clouds water and inhibits photosynthesis.	Turbidity test: Secchi disk. Macro-invertebrate population.
<b>Nutrient Pollution</b>	Primarily nitrates and phosphorus. Industrial discharge, fertilizer runoff, vehicle exhaust, animal and human waste.	Causes over-growth of plant life, decreases dissolved oxygen level, increases temperature.	Chemical field-test kits. Dissolved oxygen.
<b>Toxic Pollution</b>	Gasoline, oil, pesticides. Industrial discharge, runoff from streets and other impervious surfaces.	Threatens human health, harms aquatic organisms.	Visual observations of oil spills. Macro-invertebrate population.
<b>Pathogen Pollution</b>	Mostly bacteria. Sewage carrying human and animal waste.	Spreads disease causing micro-organisms that typically cause gastrointestinal problems.	Total coliform test or fecal coliform test.
<b>Thermal Pollution</b>	Hot water. Water used to cool industrial and power plants; water runoff from extremely hot, paved surfaces.	Decreases dissolved oxygen level, influences survival of aquatic organisms, increases rate of bacteria growth.	Thermometer. Macro-invertebrate population. Dissolved oxygen.

## **Water Testing**

**Organizing Topic** Investigating Watersheds

**Overview** Students investigate the water quality of a stream or other body of water, using several indicators. This lesson should follow the previous lesson, “Water Quality.”

**Related Standards of Learning** 6.5g; 6.7g

### **Objectives**

The students should be able to

- propose ways to maintain water quality within a watershed;
- explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem;
- measure, record, and analyze a variety of water-quality indicators and describe what they mean.

### **Materials needed**

- Water-quality field-test kit
- Test collection equipment
- Wastewater container
- Handheld technology for data collection
- Copies of the attached handout (The exact parameters being tested will change, depending on the parameters in your water-quality test kit. Change data sheet as needed.)

### **Instructional activity**

#### ***Content/Teacher Notes***

For background information on water-quality indicators, see Chapter 5 of the resource *Virginia’s Water Resources: A Tool for Teachers* (available for download at [www.vanaturally.com](http://www.vanaturally.com)). This resource provides an excellent background for water-quality indicators. You may want to copy portions for your students to use as a resource, or you might summarize the information for your students in a chart.

Prior to starting this lesson, students should have completed the previous lesson, “Water Quality,” which will provide them with background information necessary to complete this activity. This lesson focuses on actual testing of water for various indicators of pollutants. The next lesson will focus on using macroinvertebrates as indicators to help determine water quality. Both of these lessons will require students to be out in the field, collecting data from a local stream or other body of water. This can be done at the same time, perhaps with one group of students collecting data on pollutants and another group collecting data on macroinvertebrates. Accessibility to a body of water and time constraints will determine the amount of time you allow students for data collection.

Water-quality test kits can be ordered from most science supply catalogs at a wide range of prices. There are many parameters to test for, and all are not necessary at this level. It is important to introduce students to different types of handheld technology that is used to measure water quality, so include some of these, if possible.

#### ***Introduction***

1. Have several students share their summary of an article they chose from the *Virginia’s Water Resources* magazine, if this was not done in the previous lesson.

2. Review the matrices students completed in the previous lesson. Have them focus on the water-quality indicators. Bring discussion around to the tests that you will be performing in the field.

### ***Procedure***

1. Show students the water-quality test kits. Review directions for each parameter you will be testing. You may wish to have students practice using the kits inside in the lab before going into the field.
2. Take students on a field trip to a nearby stream or other body of water to give them hands-on experience testing water samples. Have them collect data from at least three different areas of the water and record their data on the data sheet.
3. Have students observe the surrounding habitat, noting plants and animals that grow in or near the water and abiotic factors that might influence the living organisms. They should record this information in their notebook or on the data sheet.
4. Upon return to the classroom, have students work in their teams to write a summary of what they discovered about the area. Be sure to provide students with information regarding acceptable limits of the parameters they tested. Student should include the following:
  - Biotic and abiotic factors
  - Description of plant life in the water and near the water's edge
  - Description of any animals or insects in or near the water
  - Description of their first impression of the water: Did the water look dirty? Was there any litter around? What evidence was there that humans are affecting in the area?
5. Have the teams analyze the data collected. Have them decide if the body of water is a healthy one or not and explain their reasoning. Also, have them describe their impression of the water after having taken a close look at it.

### ***Observations and Conclusions***

1. Have students read their summaries to the class. Using the combined information from the summaries, discuss whether the body of water is healthy. If the water is deemed unhealthy, have each team develop an action plan that includes ideas for cleaning up the water and the reasons it is critical to do so.
2. As an alternative, have students complete part 5 of the lesson after they complete the macroinvertebrate portion of this group of lessons.

### **Sample assessment**

- Use the students' data sheets and summaries of water quality for assessment.
- Have students describe some of the causes of poor water quality (e.g., the types of things that may cause the pH of water to be out of balance or the dissolved oxygen level to be very low).

### **Follow-up/extension**

- This lesson should be followed by the "Macroinvertebrates" lesson.

### **Resources**

- *Chessie: Chesapeake Science on the Internet for Educators*. Mid-Atlantic Marine Education Association (MAMEA). <http://www.bayeducation.net/>.
- *Lessons from the Bay*. Virginia Department of Education. <http://www.pen.k12.va.us/VDOE/LFB/>.
- *VA Save Our Streams: Protecting Virginia's Natural Resources Since 1989*. <http://www.sosva.com/>.

- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Naturally.... Virginia's gateway to environmental information and resources.* Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.

# Water Data

**Name:** \_\_\_\_\_ **Date:** \_\_\_\_\_ **Class:** \_\_\_\_\_

Name of body of water: \_\_\_\_\_

Date(s) of tests: \_\_\_\_\_

Air temperature during tests: \_\_\_\_\_

Water Test	Location #1 _____	Location #2 _____	Location #3 _____	Average
Temperature				
pH				
Dissolved oxygen				
Nitrates				
Phosphates				
Turbidity				
Salinity				

Describe the biotic and abiotic factors that you observed in this area:

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## **Macroinvertebrates**

**Organizing Topic** Investigating Watersheds

**Overview** Students investigate the water quality of a stream or other body of water, using several indicators. This lesson should follow the previous lesson, “Water Testing.”

**Related Standards of Learning** 6.5g, 6.7g

### **Objectives**

The students should be able to

- propose ways to maintain water quality within a watershed;
- explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem;
- measure, record, and analyze a variety of water-quality indicators and describe what they mean.

### **Materials needed**

- Dip nets
- Kick nets
- White ice cube trays
- Forceps
- Magnifying glass
- Waders
- Digital camera
- Field guides
- Macroinvertebrate cards
- Copies of the attached handouts

### **Instructional activity**

#### ***Content/Teacher Notes***

There are several good resources for information about macroinvertebrates. *VA Save Our Streams* (at <http://www.sosva.com/>), a national program of citizen water monitoring, offers quite a bit. *Project WET* (at <http://www.deq.virginia.gov/education/wet.html>) has a section about macroinvertebrates, and *Lessons from the Bay* (at <http://www.pen.k12.va.us/VDOE/LFB/>) has a lesson on macroinvertebrates. Use these and other resources to become familiar with sampling techniques and the necessary materials before taking a group into the field for investigation.

If your time constraints and/or location do not permit an outside field exploration, an alternative to taking students to a stream or other body of water is to have students analyze macroinvertebrates in the classroom by using leaf packs. Information about this can be found at [www.stroudcenter.org/lpn](http://www.stroudcenter.org/lpn), and kits can be ordered from many science supply catalogs.

#### ***Introduction***

1. Review the information students collected in their matrices regarding macroinvertebrates. Provide each student with a “Macroinvertebrate Fact Sheet.”

#### ***Procedure***

1. Review the fact sheet with students. Use the resources above or other resources to supply students with pictures of each macroinvertebrate. There are also commercial identification cards available. You may want to laminate cards so students can take them into the field without damaging them.
2. Take students on a field investigation to a nearby stream or other body of water. Assign a student to document the area and findings with the digital camera. If available, use a GPS unit to mark the sampling location.

3. Give students hands-on experience collecting macroinvertebrate samples. Students should record their findings on the data sheet. Have them use white ice cube trays to hold specimens for further observations.
4. As in the water-testing activity, have students observe the surrounding habitat, noting plants and animals that grow in or near the water and abiotic factors that might influence the living organisms. They should record this information in their notebook or on the data sheet.
5. Upon return to the classroom, have students work in their teams to complete a field guide of specimens that they found. Each entry should include, among other things, name of specimen, location found, total number found, tolerability to pollution, and a sketch.

### ***Observations and Conclusions***

1. After they have completed their field guides, have students report their findings to the class.
2. Lead a class discussion concerning what the specimens indicate about the water quality.

### **Sample assessment**

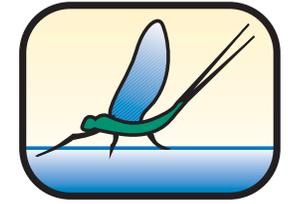
- Use students' data sheets and field guides for assessment.
- Have students describe how collecting macroinvertebrates can help a scientist determine the water quality of a body of water.

### **Follow-up/extension**

- If you sampled at the same location for both lessons, combine the results of the macroinvertebrate sampling with the water-quality testing, data and have students analyze both sets of data together. If you sampled at different locations, have students compare the quality of one body of water to the other.
- If you have convenient access to water year-round, have students collect data on a monthly basis and look for changes over time. If you do this each year, you can have students look at past data and discover how it has changed or stayed the same.

### **Resources**

- *Chessie: Chesapeake Science on the Internet for Educators*. Mid-Atlantic Marine Education Association (MAMEA). <http://www.bayeducation.net/>.
- *Lessons from the Bay*. Virginia Department of Education. <http://www.pen.k12.va.us/VDOE/LFB/>.
- *Project WET: Water Education for Teachers*. Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/education/wet.html>.
- *VA Save Our Streams: Protecting Virginia's Natural Resources Since 1989*. <http://www.sosva.com/>.
- *Virginia Naturally: Sixth Grade Science Resources*. <http://www.vanaturally.com/sixthgrade/homepage.html>. Resource for the sixth-grade water standards.
- *Virginia Naturally.... Virginia's gateway to environmental information and resources*. Virginia Department of Environmental Quality. <http://www.vanaturally.com/homepage.html>.



# Macroinvertebrate Fact Sheet

Information based on *A Guide to Common Freshwater Invertebrates* (see Resources)

Common Name	Scientific Name	Sensitivity to Pollution	What It Eats	Interesting Adaptations	Life Cycle Notes	Importance in Ecosystem
<b>Aquatic Worm</b>	Kingdom: <i>Animalia</i> Phylum: <i>Annelida</i> Class: <i>Oligochaeta</i>	Tolerant	Omnivore: Eats mud as it travels through and digests anything in the mud	<ul style="list-style-type: none"> <li>Does not need much oxygen</li> <li>Can regrow body part if it is severed</li> </ul>	<ul style="list-style-type: none"> <li>Lives a few weeks up to a few years</li> <li>Spends whole life in water</li> </ul>	<ul style="list-style-type: none"> <li>Eaten by fish</li> </ul>
<b>Case-making Caddis Fly</b>	Kingdom: <i>Animalia</i> Phylum: <i>Arthropoda</i> Subphylum: <i>Atelocerata</i> Class: <i>Hexapoda</i> SubClass: <i>Insecta</i> Order: <i>Trichoptera</i>	Sensitive	Omnivore: Collects particles, scrapes algae, shreds plants and decomposing plants, and eats small insects	<ul style="list-style-type: none"> <li>Builds its own home (case) by gluing stream pebbles or sticks together with a silk it makes; named after 15<sup>th</sup>-century ribbon (caddice) sellers, who pinned many ribbons to coat</li> <li>Soaks up oxygen all over its body</li> </ul>	<ul style="list-style-type: none"> <li>Lives 6 months to 2 years</li> <li>In water as egg, larva, and pupa</li> <li>Adult lives on land/air</li> <li>Female lays up to 800 eggs</li> </ul>	<ul style="list-style-type: none"> <li>Adults are eaten by birds.</li> <li>Larva are eaten by carnivorous stream macro-invertebrates.</li> <li>Their shredding helps break things down and makes small pieces for smaller animals.</li> </ul>
<b>Crayfish</b>	Kingdom: <i>Animalia</i> Phylum: <i>Arthropoda</i> Subphylum: <i>Crustacea</i> Class: <i>Malacostraca</i> Order: <i>Decapoda</i>	Somewhat sensitive	Omnivore: Shreds plants and decomposing plants, and eats snails, insects, small fish, and fish eggs	<ul style="list-style-type: none"> <li>Has large claws that are good for shredding food and for self-defense</li> <li>Can regrow a leg if it is severed.</li> <li>Has gills to take in oxygen</li> </ul>	<ul style="list-style-type: none"> <li>Lives 2-8 years</li> <li>Spends whole life in the water</li> <li>Molts (sheds skin) several times as it grows to make a bigger shell</li> </ul>	<ul style="list-style-type: none"> <li>Eaten by fish, snakes, raccoons, and people</li> <li>Their shredding helps break things down and makes small pieces for smaller animals.</li> </ul>
<b>Dragonfly</b>	Kingdom: <i>Animalia</i> Phylum: <i>Arthropoda</i> Subphylum: <i>Atelocerata</i> Class: <i>Hexapoda</i> Subclass: <i>Insecta</i> Order: <i>Odonata</i>	Somewhat sensitive	Carnivore: Stalks prey or lies in wait and ambushes; eats mayflies and other insects	<ul style="list-style-type: none"> <li>Has a lower lip like an arm with an elbow and sharp claw, which can be stretched out quickly to grab prey and bring the prey back to its mouth</li> <li>Has gills to take in oxygen</li> </ul>	<ul style="list-style-type: none"> <li>Lives 1-2 years</li> <li>Spends egg, larva, and pupa stage in water</li> <li>Crawls out of the water and sheds its skin to fly away as an adult</li> </ul>	<ul style="list-style-type: none"> <li>Eaten by ducks and other shorebirds</li> </ul>

Common Name	Scientific Name	Sensitivity to Pollution	What It Eats	Interesting Adaptations	Life Cycle Notes	Importance in Ecosystem
<b>Freshwater Clam</b>	Kingdom: <i>Animalia</i> Phylum: <i>Mollusca</i> Class: <i>Bivalvia</i>	Somewhat sensitive	Herbivore: Uses cilia (like moving hairs) to suck water in and filter out algae to eat	<ul style="list-style-type: none"> <li>• Has two shells hinged together and can open to eat, or close tightly for protection from predators</li> <li>• Has gills to take in oxygen</li> </ul>	<ul style="list-style-type: none"> <li>• Lives 1-4 years</li> <li>• Spends whole life in water</li> <li>• Female keeps hatched babies in her shell until they grow their own shells.</li> </ul>	<ul style="list-style-type: none"> <li>• Their filtering cleans the water to allow more sunlight to reach larger aquatic plants.</li> </ul>
<b>Gilled Snail</b>	Kingdom: <i>Animalia</i> Phylum: <i>Mollusca</i> Class: <i>Gastropoda</i>	Sensitive	Herbivore: Uses a sharp tongue on its foot to scrape algae off of plants or rocks	<ul style="list-style-type: none"> <li>• Has gills to take in oxygen</li> <li>• Clings to plants or rocks with its foot so it is not carried away by current</li> </ul>	<ul style="list-style-type: none"> <li>• Lives 2-5 years</li> <li>• Spends whole life in water</li> <li>• Female attaches eggs to aquatic plants.</li> </ul>	<ul style="list-style-type: none"> <li>• Eaten by fish, amphibians, birds, and crayfish</li> <li>• Scrapes algae off plants so they can get more sun</li> </ul>
<b>Leech</b>	Kingdom: <i>Animalia</i> Phylum: <i>Annelida</i> Class: <i>Hirudinea</i>	Tolerant	Carnivore: Sucks blood or body fluids out of prey, such as insect larvae, worms, snails, and sometimes fish or mammals	<ul style="list-style-type: none"> <li>• Soaks up oxygen all over its body</li> <li>• Has suckers to cling to rocks so it is not carried away by current</li> </ul>	<ul style="list-style-type: none"> <li>• Can live up to 15 years</li> <li>• Spends whole life in water</li> <li>• Hibernates in mud in winter</li> </ul>	<ul style="list-style-type: none"> <li>• Eaten by fish, newts, salamanders, snakes, and birds</li> </ul>
<b>Lunged Snail</b>	Kingdom: <i>Animalia</i> Phylum: <i>Mollusca</i> Class: <i>Gastropoda</i> Subclass: <i>Pulmonata</i>	Tolerant	Herbivore and detritivore: Scrapes algae from plants and collects decomposing plant particles	<ul style="list-style-type: none"> <li>• Has lungs instead of gills, so it comes to the surface and carries a bubble of air back down in its shell to breathe</li> </ul>	<ul style="list-style-type: none"> <li>• Lives 1 year</li> <li>• Spends whole life in water</li> </ul>	<ul style="list-style-type: none"> <li>• Eaten by fish, amphibians, birds, and crayfish</li> <li>• Scrapes algae off plants so they can get more sun</li> </ul>
<b>Mayfly</b>	Kingdom: <i>Animalia</i> Phylum: <i>Arthropoda</i> Subphylum: <i>Atelocerata</i> Class: <i>Hexapoda</i> Subclass: <i>Insecta</i> Order: <i>Ephemeroptera</i>	Sensitive	Herbivore and detritivore: Scrapes algae, collects and filters decomposing plant particles and algae	<ul style="list-style-type: none"> <li>• Has gills to get oxygen</li> <li>• After last molt in the water, it uses its shed skin as a raft to float on while its wings dry to fly.</li> </ul>	<ul style="list-style-type: none"> <li>• Lives for 1 year</li> <li>• Spends egg, larva, and pupa stage in water</li> <li>• Sheds skin (molts) many times – up to 27 times before it leaves the water</li> </ul>	<ul style="list-style-type: none"> <li>• Is a favorite food of fish</li> <li>• Eaten by carnivorous stream macro-invertebrates</li> </ul>
<b>Stonefly</b>	Kingdom: <i>Animalia</i> Phylum: <i>Arthropoda</i> Subphylum: <i>Atelocerata</i> Class: <i>Hexapoda</i> Subclass: <i>Insecta</i> Order: <i>Plecoptera</i>	Sensitive	Carnivore: Prey includes midges, mayflies, blackflies, caddis flies, beetles, moths, crustaceans, and other stoneflies.	<ul style="list-style-type: none"> <li>• Can do pushups to move water across its gills when it needs more oxygen</li> </ul>	<ul style="list-style-type: none"> <li>• Lives 1-3 years</li> <li>• Spends egg, larva, and pupa stage in water</li> </ul>	<ul style="list-style-type: none"> <li>• Eaten by ducks, fish, and carnivorous stream macro-invertebrates</li> </ul>



# Stream Flow and Slope

**Organizing Topic** Investigating Watersheds

**Overview** Students create their own watersheds and design an investigation to determine the effects of stream flow on various slopes. They also observe the effects of pollution in the watershed.

**Related Standards of Learning** 6.1a, b, e, f, g, h, i, j; 6.7c

## Objectives

The students should be able to

- design an investigation to model the effects of stream flow on various slopes.

## Materials needed

- Diatomaceous earth (found with swimming pool supplies)
- Water
- Large rectangular plastic tubs with 5 inch sides
- Plastic coffee stirrers
- Thin wire
- Small plastic cups (5 oz.)
- Goggles
- Disposable dust mask
- Copies of the attached handouts
- Modeling clay
- Wax paper
- Spray bottles
- Flavored drink mix

## Instructional activity

### *Content/Teacher Notes*

River systems are made up of tributaries of smaller streams that join together along their courses. Rivers and streams generally have wide, flat, border areas, called *flood plains*, onto which water spills out at times of high flow. Rivers and streams carry and deposit sediment. As water flow decreases in speed, the size of the sediment it carries also decreases.

Before doing this activity, set up a demonstration model of a watershed for students to observe, using the steps given on the attached “Watershed Investigation” handout. Diatomaceous earth can be used over and over again for years if you allow all the water to evaporate before storing it.

### *Introduction*

1. Have students locate the local watershed on a state map. Ask them to identify the source of water and into what body of water the river or streams empty.
2. Tell students that you are going to demonstrate the formation of a river system and watershed. Have students observe as you start your river flow. Students should describe what they see. (*The water flows from higher to lower elevation, forming waterfalls, shallow lakes, canyons, shoreline, floodplains, smaller creeks, and tributaries.*)
3. After they have observed for a few minutes, ask them if there is anything that they could change that would affect the formation of the river. (*The slope, rate of stream flow, length of time water flows, landscape around the watershed, the amount of impervious surfaces, the amount of peat moss representing wetlands*)

### ***Procedure***

1. Organize students into teams of four or five each. Tell students that each team is going to create its own watershed, test it, and change something with each trial.
2. Hand out the “Four Questions about Watershed Models” worksheet, and lead students through the Four-Questions strategy. You may decide to have each group do something different or have each team do a different level of the same independent variable. For example, if the independent variable is stream flow, each team could have their water flow at a different rate. Since it will be difficult to control all variables (such as slope) in this experiment, it is recommended that teams observe each other’s watersheds.
3. Once teams have prepared their lab reports, lead them through the setup of the experiment. It is advisable to have placed the diatomaceous earth in each tub beforehand. Caution students to pour water slowly and close to the powder so that the powder does not fly up in their faces. Students should wear goggles.
4. When teams are ready to begin, remind them to make careful observations. Tell them to list the level of the independent variable in the left-hand margin next to the drawing of the watershed. Have each team do the experiment three times.
5. Tell students to keep their streams flowing. They will have to make sure to keep the small plastic cup full of water. Have students rotate through the classroom to observe the other teams’ watersheds.
6. After teams have completed their experiments, have them flatten out an area along the major river. It should slope slightly toward the river. They may need to use modeling clay to accomplish this. Have them place a piece of wax paper or aluminum foil over part of this area. If necessary, have them use clay to hold down the edges. Tell students that this is an impervious area, like a parking lot. Then, have students use a spray bottle to make it “rain” over the flattened area. Ask students to note what the “rain” does. (*It soaks into the land, but runs off the impervious surface to the river.*) Ask, “What would be the effect if the entire land area of a watershed were paved?”
7. Sprinkle some flavored drink mix over the side of one watershed. Tell the students the powder represents pollution. Have them use the spray bottle again to create “rain” over the area and make observations. They should note that the pollution travels down through the watershed and contaminates the areas downstream. Discuss why pollution is a problem and what can be done to fix the problem.

### ***Observations and Conclusions***

1. Discuss results of the experiment with students, using the following questions:
  - What were the effects of stream flow on various slopes?
  - What happened as the speed of flow was increased?
  - What happened as the speed of flow was decreased?
  - What features appeared in your watershed?
  - We observed what happens to water on impervious surfaces. What other surfaces besides parking lots can cause excessive runoff? (*Construction sites, farmland, roofs of buildings, etc.*)
  - We witnessed what happens to chemicals in the watershed when it rains. What are some possible sources of watershed pollution in our community? (*Fertilizer, pesticides, sewage, oil, gasoline, industrial waste, etc.*)

### **Sample assessment**

- Completed lab reports

## Follow-up/extension

- Have students identify where the runoff from their lawns and driveways will end up. They should track the path of these pollutants to the large body of water into which their waterway flows.
- Use the lab setup to demonstrate the effects of wetlands. Use peat moss or sponges downstream to absorb water.

## Resources

- *Chesapeake Bay Program: America's Premier Watershed Restoration Partnership.* <http://www.chesapeakebay.net>.
- *Mapping the Chesapeake. Chesapeake Bay Program.* <http://www.chesapeakebay.net/maps.htm>. Offers a variety of maps, including Chesapeake Bay watershed maps.
- *Natural Resource Education Guide: Virginia's Water Resources. Virginia Naturally.* <http://www.vanaturally.com/guide/water.html>.
- *Project WET: Water Education for Teachers.* Virginia Department of Environmental Quality. <http://www.deq.virginia.gov/education/wet.html>.
- *Virginia Naturally: Sixth Grade Science Resources.* <http://www.longwood.edu/cleanva/teachersvawatercurriculum.htm>. Resource for the sixth-grade water standards.
- *Virginia Save Our Streams Chapter of the Izaak Walton League of America.* <http://www.sosva.com/vasoschapterinvitation.htm>.
- “Virginia Water Central.” *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/central/virginia.htm>. Offers online back issues of the *Virginia Water Central* newsletter. Current issues can be found at the Research Center's homepage (see below).
- *Virginia Water Resources Research Center.* Virginia Tech. <http://www.vwrrc.vt.edu/>.
- *Virginia Watersheds.* Virginia Department of Game and Inland Fisheries. <http://www.dgif.state.va.us/education/watersheds.html>. Offers watershed maps of Virginia.
- *Watersheds. Chesapeake Bay Program.* <http://www.chesapeakebay.net/wshed.htm>.

# Four Questions about Watershed Models

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

1. What does the watershed model do?

\_\_\_\_\_ INDIVIDUAL

GROUP \_\_\_\_\_

2. What materials are available for conducting an experiment with the watershed model?

\_\_\_\_\_ INDIVIDUAL

GROUP \_\_\_\_\_

3. What changes could you make to affect what the watershed model does?

\_\_\_\_\_ INDIVIDUAL

GROUP \_\_\_\_\_

4. How could you measure and/or describe the response of the watershed model to these changes?

\_\_\_\_\_ INDIVIDUAL

GROUP \_\_\_\_\_

# Experimental Design (ExD) Pre-Lab

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

Complete this ExD pre-lab before beginning the lab.

1. Experiment Title:

\_\_\_\_\_

2. What are you changing in your experiment (the "CAUSE")? Pick one item from question #3 of the "Four Questions". This is the *independent variable*, and it will be the "if" in your hypothesis.

\_\_\_\_\_

3. What is being measured in your experiment (the "EFFECT")? See question #4. This is the *dependent variable*. A prediction of how this experiment will turn out will be the "then" in your hypothesis.

\_\_\_\_\_

4. Hypothesis: (Use an "if...then..." format.)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. What must you *keep the same* in your experiment? These will be everything else from question #3, and they are the *constants* in the experiment.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. The purpose of this experiment is to determine the effect of

\_\_\_\_\_ on \_\_\_\_\_

(Independent Variable from question 2 above)

(Dependent Variable from question 3 above)

7. Get your teacher's approval before continuing.

# Watershed Investigation

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Purpose

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## Hypothesis

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## Materials

Diatomaceous earth, water, large, rectangular plastic tubs with 5-inch sides, plastic coffee stirrers, thin wire, small plastic cups, goggles, disposable dust mask

## Procedure

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Constants: \_\_\_\_\_

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## Steps

1. Pour 2 to 3 liters of diatomaceous earth into a plastic tub. Add 1 liter of water at a time, and mix with your hands. It should be mushy but have no puddles. Add more water if necessary.
2. Form a slope at one end of the plastic tub. Flatten the top of the slope slightly to create a "ridge."
3. Insert wire into the coffee stirrer, and bend the stirrer into an arch. Try to avoid making any crimps in the stirrer that will disrupt water flow. This will be your siphon. Carefully remove the wire, leaving the stirrer in the arch shape.
4. Cut a small v-shaped notch in the top rim of the paper cup. Fill the cup with water, and rest the cup at the top of the slope.
5. To create a siphon in the stirrer, stick one end of the stirrer into a beaker of water. Turn the stirrer until it is completely under and filled with water. You may need to flick the end of the stirrer while under water to remove water bubbles. Remove stirrer from beaker.
6. Turn the stirrer over quickly, placing one end in the cup of water and resting it in the notch of the plastic cup. The other end of the stirrer should drip water over the slope. You can adjust the flow by moving the stirrer up or down in the plastic cup. This is the most difficult part of the experiment and may take several attempts to get it right.

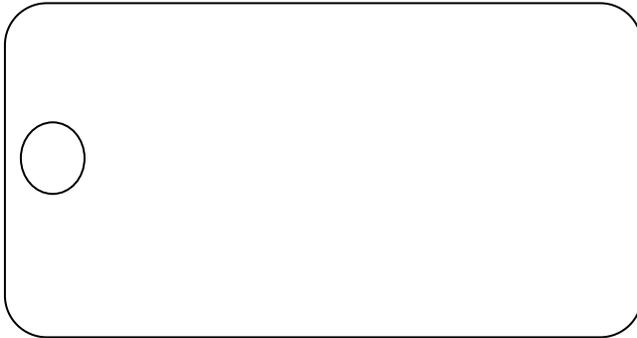
7. Allow water to flow for 5 minutes, forming a "river system." Record observations by drawing your watershed and listing any features that are formed.
8. Repeat twice for a total of three trials. The setup can be used over and over again by tilting the tub back and forth so that the runoff sediment can fill in the river and then pouring off excess water before each trial.

**Observations**

**Drawings of Watershed**  
(The circle is the plastic cup.)

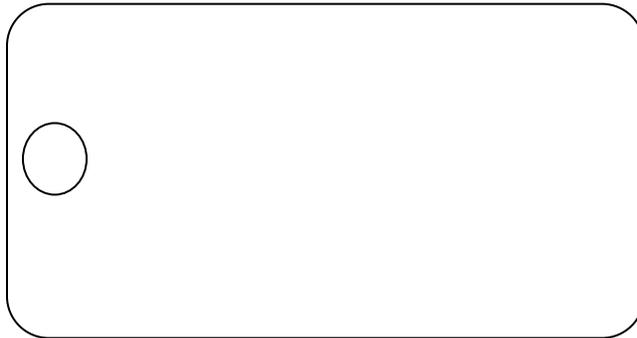
**Features Formed**

Trial 1



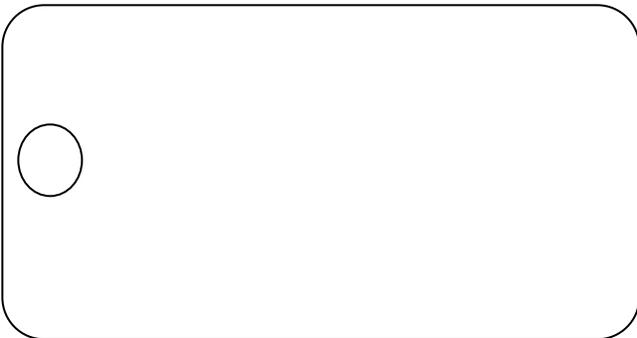
1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

Trial 2



1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

Trial 3



1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

**Conclusion**

1. What was your hypothesis?

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2. Do the results support your hypothesis? \_\_\_\_\_
3. Was your hypothesis correct or incorrect? \_\_\_\_\_
4. What happened in the investigation?

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5. Use the average data and your answers to the questions to summarize the results. Explain why the results happened as they did, and include all discoveries you made. Make an inference based on what you know.

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**Analysis**

1. What was the effect of stream flow on various slopes in your watershed?

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2. What are some possible sources of watershed pollution in your community?

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3. What other surfaces, besides parking lots, cause excessive runoff?

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# Conservation

**Organizing Topic** Investigating Watersheds

**Overview** Students investigate how much water they use and waste daily and discover methods to conserve water.

**Related Standards of Learning** 6.7f, 6.9c, d

## Objectives

The students should be able to

- describe the importance of careful management of water resources;
- describe the role of local and state conservation professionals in managing natural resources, including those working in wildlife protection; forestry and waste management; and air, water, and soil conservation;
- evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment.

## Materials needed

- Gallon jug
- Graduated cylinder
- Blue food coloring
- Water
- Salt
- Measuring spoons
- Copies of the attached handout

## Instructional activity

### *Content/Teacher Notes*

All living organisms are dependent upon the availability of clean water and air and a healthy environment. While the supply of water seems limitless, water is not an infinite resource. Usable fresh water is actually quite limited and is scarce in some places.

Local, state, and federal governments have significant roles in managing and protecting air, water, plant, and wildlife resources. Regulations, incentives, and voluntary efforts help conserve resources and protect environmental quality.

Conservation of resources and environmental protection begin with the individual. Understanding the watershed is the first step in protecting water and other natural resources. What goes on upstream can make water downstream unfit to use, forcing downstream users to clean up the water before it can be used again.

Use of renewable and nonrenewable resources must be considered in terms of their cost/benefit tradeoffs. Preventive measures, such as pollution prevention or thoughtfully planned and enforced land-use restrictions, can reduce the impact of problems in the future. Pollution prevention and waste management are usually less costly than cleanup.

Renewable resources should be managed so that they produce continuously. Sustainable development makes decisions about long-term use of land and natural resources with concern for maximum community benefit for the longest time and with the least environmental damage.

The availability of fresh water may not be a problem in the United States today, but it is a problem in other parts of the world, such as the Middle East and northern Africa. The greatest influence on water

availability is the number of people competing for it. As population grows, fresh water becomes increasingly less available. China and Canada receive about the same amount of water due to precipitation. However, China’s population is over 40 times that of Canada. It is projected that by the year 2025, one-fourth of the world’s population will be in need of more water.

Besides higher populations, higher standards of living increase the demand for water. In the United States, for example, each individual uses approximately 250 liters of water each day, whereas in African nations, the average person uses only slightly more than 29 liters.

### ***Introduction***

1. Fill a clear, plastic gallon jug with water, and add a little blue food coloring. Tell students that this represents all the water on the Earth.
2. Pour 50 mL of the water into a graduated cylinder, and then add 6 tbsp. salt to the water left in the jug. Tell students that the water remaining in the jug represents all the ocean water on Earth, which is undrinkable because it is salty. Set the jug aside.
3. Hold up the graduated cylinder, and point out that the water in it represents all the freshwater on Earth. Of this amount, 70 percent is inaccessible to us because it is trapped in glaciers or is too deep in the ground to recover. Pour out 35 mL — i.e., 70 percent of the 50 mL in the beaker.
4. Now show students the amount left, and point out that this amount represents less than 1 percent of the total amount of water on Earth. This freshwater is all there is to support human needs for agriculture, drinking, and washing, as well as the needs of lake, river, stream, and other freshwater ecosystems. Ask the students, “Can we get more fresh water for our needs?” (*The amount of water on Earth is constant due to the water cycle. There will never be any more or less water than there is right now. Human activity, though, can create an imbalance in the supply of usable water.*) “How does human activity affect the balance in the supply of usable water?” (*Increasing population, standard of living, and industrial activity all put greater and greater demands on the supply of usable water.*)

### ***Procedure***

1. Pass out copies of the attached “Waste Not, Want Not” handout.
2. Have students calculate the amount of water their families use in one week, using the steps given on the handout.

### ***Observations and Conclusions***

1. Which category shows the most water usage? (*Most data shows that toilet flushing uses the most water per day, followed by showers and baths.*)
2. Use the following questions to lead a class discussion of ways to decrease water use:
  - What are three ways to reduce the amount of water you use?
  - If you practiced these three conservation measures for a week, how much water would you save?
  - Suppose everyone in your family joined you in your conservation effort for one week. How much water would then be saved?
3. Have another class discussion based on the following questions: “We’ve discussed ways that individuals can conserve resources and prevent pollutants from entering our watershed, but what should be the role of the government? What local, state, and federal conservation efforts are now in place? What conservation efforts should government put in place?”

### **Sample assessment**

- Assess the students' completed home project on water use.
- Have the students write a paragraph explaining three ways to decrease water use.

### **Follow-up/extension**

- Divide students into two groups, one representing a citizens' rights group and the other representing a group of environmentalists. Have the environmentalists propose a federal law that would make it a crime to use fertilizer on lawns because it could run off into the ground or surface water. Remind students that they must include justifications for the law and penalties for breaking it. Have the citizens' rights group prepare an argument against the law, contending that the law is unjust because it restricts their rights to private property. Have the two groups debate the issue.
- Have students predict events or circumstances that could negatively affect the supply of fresh water in your community. What would be the impact if the community's water source ran dry? How would people in your community compete for this resource? Would other communities be willing to share their water? Brainstorm ways that the community could work together to reduce its freshwater consumption.
- Describe the following scenario to students: "You live in the Middle East or in North Africa. Your country is classified as having a water shortage. Water shortages happen when demand exceeds supply, due to population growth, drought, or widespread practices that consume excessive amounts of water. That means that there are insufficient water resources to meet the water needs for the population, food production, industry, and environmental purposes. Due to restrictions on water use, you are permitted to use only one gallon of water per day. Since there is no plumbing in your region, you must walk a mile every day to get your gallon of freshwater." Have students try using only one gallon of water for one day. If this is too easy, challenge them to try it for a week. Discuss the value of that gallon of water.

# Waste Not, Want Not

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

## Purpose

The purpose of this experiment is to determine the amount of water used by a family each week and to develop ideas for conservation of this resource.

## Hypothesis

How much water does your family use in one week?

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## Materials

### Water Usage Data

Water Activity	Amount of Water Used (approximate)
Taking a bath	25 gallons
Taking a shower	5 gallon per minute
Brushing teeth and letting water run	3 gallons
Cleaning the house	8 gallons
Running dishwasher	14 gallons
Washing dishes by hand (3 times/day)	10 gallons
Flushing toilet	5 gallons per flush
Watering lawn	10 gallons per minute
Letting faucet drip	15 gallons per day
Running washing machine	40 gallons per load

## Steps

- Calculate how much water your family used for showers in one week.

$$\frac{\text{Number of showers per week}}{\text{Number of showers per week}} \times \frac{\text{Average number of minutes per shower}}{\text{Average number of minutes per shower}} = \frac{\text{Showering minutes per week}}{\text{Showering minutes per week}}$$

$$\frac{\text{Showering minutes per week}}{\text{Showering minutes per week}} \times \frac{\text{Gallons per minute}}{\text{Gallons per minute}} = \frac{\text{Total gallons used per week}}{\text{Total gallons used per week}}$$

2. Calculate the number of gallons used per week for the following activities:

Activity	Times/Week	Gallons/Activity	Gallons Used/Week
Brushing teeth			
Cleaning house			
Running dishwasher			
Flushing toilet			
Taking bath			
Watering lawn			
Doing laundry			
Leaking faucet			
Taking showers (Transfer number from step 1.)			
TOTAL GALLONS USED			

3. Assume water costs \$0.01 per gallon. How much money does your family spend for water in one week?

$$\frac{\text{_____}}{\text{Gallons used}} \times \$0.01 = \frac{\text{_____}}{\text{Cost of water for one week}}$$

**Analysis**

1. What are three ways that you could reduce the amount of water you use?

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2. How much water would you save if you practiced these three conservation measures for one week?

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3. How much water would your family save if they did the same?

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4. How would your life be affected if you turned the faucet on and no water came out?

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