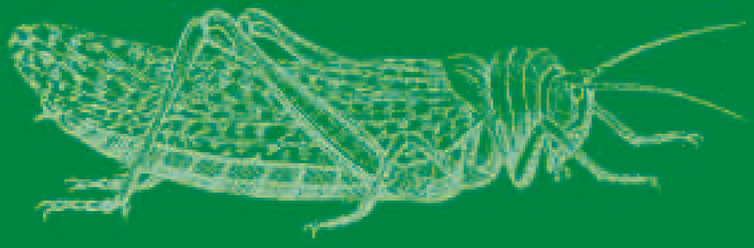

Math & Science Collaborative

Science Standards

A Parent's Handbook

Grades 6–8

What should my child be learning?

This handbook describes the science standards for sixth through eighth grades used in area school districts. These standards are based on the National Science Education Standards (developed by the National Research Council) and on Pennsylvania's Academic Standards for Science and Technology and Environment and Ecology. Because science topics are taught at different grade levels depending on which curriculum program your district has selected, the handbook is organized by area of science rather than by grade levels: **life science, earth and space science**, and **physical science.**

The standards—goals and expectations for your child—are intended to represent the important ideas of science. For example, an important idea in life science is that all organisms are composed of cells and that cells are the building blocks of life. An important idea in earth science is that the movement of "tectonic plates" (segments of the earth's crust) has changed the earth's surface over time. An important idea in physical science is that when substances change their form—from a liquid to a gas, for example—their mass (amount of matter) remains the same.


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The standards and classroom learning

In the classroom, children approach such concepts through the entry point of their own questions about the living things, objects and events in their world. Current methods of teaching science in the middle grades are designed to capitalize on children's natural curiosity by engaging them in the kinds of activities that adult scientists do. Like adult scientists, students begin by observing and exploring. For example, they might observe that the moon can sometimes be seen in the daytime. They might notice that a red-haired classmate has a red-haired mother. They might see that one kind of powder dissolves in water but another kind doesn't dissolve. These observations lead to questions. "Why don't I always see the moon in the daytime?" "How do people get their hair color?" "Why do some things dissolve in water but others don't?"

After the class discusses students' initial questions and new questions that arise during their discussion, students investigate further to find answers: using tools to observe more closely, conducting tests and experiments, and constructing models. For example, students might observe bread mold through a microscope, test the effects of heating various substances, selectively breed plants, and construct models to understand the earth's relationships with the moon and the sun.

Teachers then push students to form explanations for what they found, to test their explanations, and to change them if necessary. "How do your results compare to someone else's?" the teacher might ask. "If you tried that again, would the same thing happen?" "What if you changed one thing?" "Can you design another investigation that might tell you more?" Students further test their explanations by applying what they've learned to real-life situations, such as creating a brochure about earthquakes for residents of quake-prone communities, designing circuitry for a solar-powered car alarm, or researching and reporting on a threatened ecosystem.

Like adult scientists, students work in pairs or teams for many of these activities. Small groups conduct investigations and share their findings with the class, or they may become experts on one aspect of a whole-class project. As scientific knowledge in the adult world moves forward through teamwork—collaborating, critiquing others' conclusions, and testing results—so does learning in middle grades science classrooms.

"Inquiry" in science learning

Through active participation in investigations, students learn important skills for doing science: using a microscope, designing and conducting experiments, taking measurements, and so on.

But students don't simply follow steps the teacher has laid out for them. In an approach called "inquiry learning," teachers encourage students to think about what they are doing and why. "What kind of experiment is likely to answer our question?" the teacher might ask. "When is it useful to build a model?" "Why is it important to check and re-check our results?" Reflecting on the process in this way helps students find strategies for answering their own questions, in and out of the classroom. And through these experiences, students learn how adult scientists do their work.

During their investigations, students develop a range of process skills and inquiry abilities, including:

- **Posing questions.** Students learn to recognize questions that can be fully or partially answered through scientific investigation, and to adapt their questions if necessary. For example, the question "Why does salt melt ice?" could be adapted to "Which type of salt melts ice most effectively at -10º C?"
- **Observing.** Students use sight, hearing, touch, smell and sometimes taste for close observations of things and events. They use tools to "extend their senses," such as magnifying lenses, rulers, scales and thermometers. They notice changes, patterns, and differences.
- **Describing.** Students carefully describe things and events, using precise language. ("I will fill the beakers with 100 mL of sand.")
- **Grouping and identifying.** Students compare and group living things and materials to identify and understand them. For example, students might compare rock samples that formed under different processes. They might group mineral samples according to whether or not they stick to a magnet.
- **Predicting.** Students predict the answers to their questions—they "hypothesize"—as a way to organize their thinking. [See the sample of student work on page 12. The student was asked to state the "Question I am trying to answer" and "What I think will happen."]
- **Designing experiments.** Students think about how to set up experiments that can tell them what they want to know. They consider whether or not it is a "controlled experiment" (a test in which only one variable at a time is changed so that effects can be tied to causes). They reason about what kinds of information will be "evidence" of what they're looking for.
- **Constructing models.** Students build models, conduct tests using models, and consider the uses and limitations of models.
- **Gathering evidence.** Students record observations, measurements, results of tests, and other kinds of information (data) in notes, lists, and charts. They make judgments about which data are relevant to their investigation. They learn to respect evidence even when it's unexpected or confusing. ("Almost every day I observed the moon it appeared to look different.")
- **Using math.** Students perform calculations; create tables and graphs; and take measurements, including volume, weight, mass and density; to help them make sense of their data.
- **Explaining results.** Students reason about the evidence they've gathered, relate new information to what they already know, consider cause and effect, and look for patterns, as part of the process of finding explanations for their results. They consider alternate explanations, including whether or not there were flaws in the design of their investigation or in how they carried it out. They conduct research and compare their results to others' results—both their classmates' and adult scientists'.
- **Communicating.** Students create scientific drawings, demonstrations, models, written descriptions, and graphs to present their conclusions to their classmates. They describe their procedures and show evidence to back up their conclusions, using precise language.
- **Evaluating others' conclusions.** Students listen carefully to their classmates' discoveries, consider evidence presented, ask questions, and share their opinions.

In this handbook:

Life Science 5
Earth and Space Science 8
Physical Science 12

Assessment

Parents may wonder how teachers in inquiry-based classrooms assess what students are learning. How do teachers know if students understand what they're doing when they work with living things and materials, or what they're thinking when they observe events? How can teachers tell whether students have learned important concepts from the process of carrying out an investigation?

Teachers have a range of methods for assessing the learning that is going on while students are engaged in activities. A teacher may observe a pair of students as they set up an experiment, then ask what they plan to try next if the first experiment fails, to see if they understand what they are going to compare or measure. Later, he/she may ask them to explain their results in writing, drawn pictures, or diagrams. Such classroom "evidence" can show a teacher whether students' explanations are based on the information they gathered, whether that information is relevant to the question they asked, and whether they can relate their findings to scientific concepts.

More formal assessments, such as end-of-unit tests, may involve challenging students to design an investigation that can answer a particular question. (Although students may be directed to work in pairs or groups, the teacher judges each student's work individually.) Such assessments ask students to use a broader range of skills and knowledge than can be shown on a traditional "paper and pencil" test.

Students with special needs

All students have the right to participate in the learning activities of the science curriculum. Some students may be able to participate fully with the help of special technology or a facilitator; for others, activities may need to be modified. All children should be able to participate in at least some aspects of the program. The teacher's guide for the program used in your child's school may include suggestions for adapting or modifying lessons. Ask your child's teacher for more information.

The teacher's role in an inquiry-based classroom

Teachers support inquiry learning by:

- Involving students in creating the learning environment (students set up experiments, care for living things, maintain tools...)
- Pushing students to explore further ("Have you tried changing the direction of the electric current?")
- Asking students to make predictions ("What do you think is going to happen to the shape of the moon tomorrow?...at the end of the month?")
- Encouraging students to question their findings and to re-do steps of an experiment if necessary
- Helping students feel comfortable in defending their results and explanations to their classmates, and in acknowledging their own mistakes and misconceptions
- Encouraging students to question their classmates' results and explanations
- Modeling a scientific mindset: expressing curiosity, skepticism, and wonder

Questions parents can ask their children

Parents can support inquiry learning when they discuss homework or classwork with their children. You might ask your child:

- "What specific question were you trying to answer? Is that the question you started with or did you change it?"
- "What did you do to find the answer?"
- "How did you decide to do that? What else did you try, or think of trying?"
- "What would you do differently next time?"
- "After doing this investigation, what new questions do you have?"
- "How can you use what you found out in your everyday life?"

For more information

The activities described in this handbook reflect these curriculum programs:

- Event-Based Science: **www.phschool.com/ebs/**
- FOSS (Full Option Science System): **www.fossweb.com**
- Investigating Earth Systems: **www.its-about-time.com/htmls/ies.html**
- Science and Technology Concepts for Middle Schools: **www.nsrconline.org/curriculum_resources/middle_school.html**
- SEPUP (Science Education for Public Understanding Program): **www.sepup.com**

All five programs consist of a group of modules or units.

This handbook is only an outline. For more detailed information, ask a teacher or the principal which curriculum your district uses, then which modules or units are used at your child's grade level. Some programs have materials written specifically for parents that you can request.

Note: Activities given as examples in this handbook are intended to provide information for parents about how science standards are taught. They are *not* intended to be examples of activities that children and parents can do at home. In classrooms, such activities take place under controlled conditions and within specific safety guidelines. For information about home science activities, ask your child's teacher.

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Classroom photographs were taken at Dorseyville Middle School and Rogers Creative and Performing Arts Middle School in Pittsburgh, Pennsylvania.

aiu3 Allegheny Intermediate Unit

Life Science

The Structure of Life

Through experiments, discover that micro-organisms (living things that are too small to see without magnification) are alive. Understand that micro-organisms—like other living things—grow, take in food, produce waste, exchange gases (such as oxygen and carbon dioxide), respond to changes in their environment, reproduce, and need the right conditions to survive.

- Use a hand lens and a microscope to observe micro-organisms and other simple organisms (living things) moving.
- Observe, measure and graph the growth of bacteria and fungi (for example, on bread).
- Understand the role of micro-organisms in food production and disease.

Understand that the cell is the basic building block of life. Recognize that human beings are made up of cells.

Observe organisms that have only one cell. Identify and draw to scale the parts of the cell's structure (cell wall, cell membrane...). Model how a cell takes in food.

Understand that organisms grow and reproduce by cells dividing. Use models to show the stages a cell undergoes when it divides.

Recognize that cells have different structures and functions.

- Compare the cells of animals, plants and bacteria.
- Experiment with a plant's system for drawing water into its stem and leaves.
- Dissect seeds to examine and compare their structures.
- Observe the structure and behavior of an insect (for example, experiment to discover its food preferences) and relate its behavior to its structure.

Understand that organisms can be grouped by their structures.

- Classify organisms as "eukaryotes" (organisms that have cells which contain a "nucleus"—a specialized part that directs some of the cell's functions) or "prokaryotes" (single-celled organisms with no nucleus). For example, eukaryotes include the kingdoms *Animalia* (animals, including human beings), *Plantae* (plants), *Fungi* (mushrooms, molds, yeasts), and *Protista* (a wide variety of single-celled organisms), while prokaryotes include the kingdom *Monera* (organisms such as bacteria).
- Group organisms using a "dichotomous key" (a way of classifying organisms by posing questions to narrow the options).

Recognize that in organisms with more than one cell, cells work together so the organism can function as a whole.

The Human Body

Note: These topics may be taught in health or wellness classes in your school district rather than in science classes.

Explore the human body's mechanism for taking in nutrients and eliminating waste: the digestive system.

- Conduct chemical tests to investigate digestion.
- Demonstrate digestive processes with models (such as a model of food traveling through the intestines).
- Conduct tests and use models to understand how nutrients are absorbed into the body during the process of digestion.
- Relate the function of cells in the body to the digestive system.

Explore the human body's mechanisms for carrying nutrients and oxygen to cells, and carbon dioxide and other waste products away from cells: the respiratory and circulatory systems.

- Conduct tests and use models to understand how gases (such as oxygen and carbon dioxide) are exchanged and to understand the function of the lungs.
- Conduct tests and use models to understand how nutrients combine with oxygen to provide energy for the body.
- Model the pumping action of the heart. Explore factors that affect heart rate (such as exercise). Measure own heart rate and find average ranges for the class.

Sample of student work

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Students constructed pond and meadow ecosystems in containers, then observed and analyzed the interactions between plants and animals over several weeks.

- Relate the function of cells in the body to the respiratory and circulatory systems.

Explore the mechanisms that allow the human body to stand upright and move: the muscular-skeletal system.

- Perform exercises and record how muscles respond. Investigate muscle size and strength, and muscle fatigue (tiring).
- Use models to show how muscles, joints and bones work together.

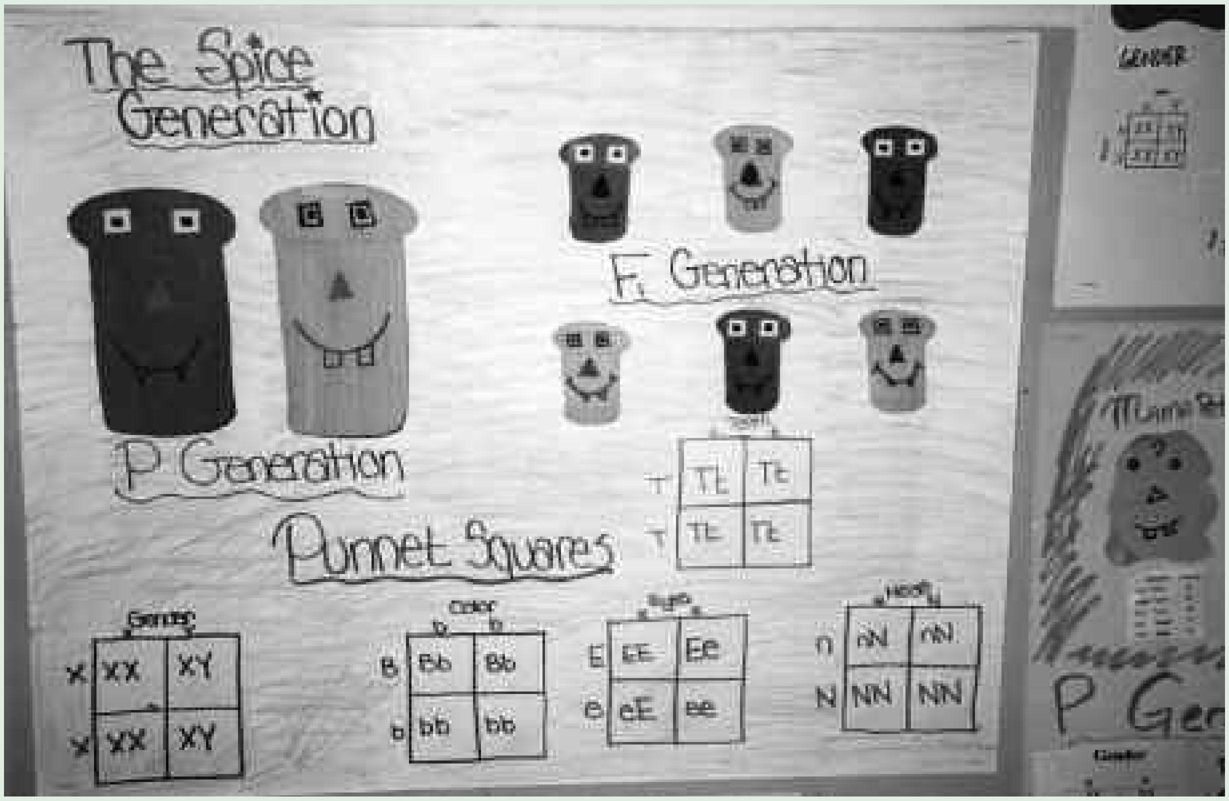
Explore how the brain receives information from the senses (sight, hearing, touch, smell, taste).

- Experiment with learning and memory tasks to begin to relate learning to the function of the brain and the senses.
- Study scanned images of the brain and construct a model showing the brain's major parts (cerebrum, cerebellum, and brain stem).
- Investigate the structure of a sensory organ and demonstrate how it responds. For example, experiment to discover how the pupil of the eye responds to light; construct a model of the eye.
- Explore how the brain creates meaning from sensory perceptions. For example, experiment with depth perception and explain how optical illusions work.
- Discover that messages from the senses physically travel to the brain. For example, experiment with reaction time (how long it takes to respond to an image, sound, or another kind of stimulus). Demonstrate how a message passes from one of the senses to the brain.

Explain ways that the systems of the body work together. Understand that physical health requires the smooth functioning of body systems.

Understand disease as the breakdown of the structure or function of a part of the body.

Sample of student work



GABRIELA ROSE

Students modeled how traits are inherited using imaginary creatures. "P Generation" refers to parents; "F_1 Generation" refers to offspring. A "Punnett square" is a diagram used to show how genes are passed from parents to offspring.

Reproduction and Genetics

Explore reproduction by observing insects and experimenting with flowering plants.

- Observe the behavior of insects throughout a life cycle and through several generations, including reproductive behavior (mating, hatching young).
- Dissect a flower, identify the parts used in reproduction (the process of forming a seed), observe them under a microscope, and sketch them. Relate each part to its function.
- "Cross-pollinate" flowers in the classroom (transfer pollen from one flower to another to promote fertilization). Recognize that pollination is necessary for flowering plants to produce seeds.
- Compare reproduction in flowering plants (sexual reproduction) to reproduction in one-celled organisms by cells dividing ("asexual" reproduction).

Understand the difference between a "biological feature" of an organism (such as hair on a cat) and a "trait" (such as white hair on a cat).

Experiment with seedlings to discover how traits are passed on—through genes from each of an organism's parents.

- Cross-pollinate plants, harvest their seeds and grow seedlings. Compare seedlings' traits (such as color) to their "parent" plants' traits.
- Understand that pairs of genes are necessary for a trait to be passed on. Based on data (information) from experiments,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Students were challenged to separate the components of rock salt. After determining that rock salt has soluble and insoluble parts, they added water and filtered out the insoluble materials.

recognize that some traits are "dominant" (they supercede other traits) and some are "recessive" (they don't supercede other traits). Chart possible pairings of dominant and recessive plant genes.

Understand that genes are located in chromosomes within an organism's cells.

Model and chart possible pairings of human genes. Determine how specific traits are passed on.

Ecosystems

Understand the difference between a population (all the individual organisms in one species in a given area), a community (all the populations that interact in a given area), and an "ecosystem" (all the organisms that interact in a given area, plus all the nonliving elements and factors, including resources such as soil and conditions such as air temperature).

Set up an ecosystem (such as a terrarium and an aquarium). Observe the behavior of organisms and monitor conditions and resources (air, sunlight, water, soil...). Predict, observe, document and analyze interactions (such as one organism feeding on another) and changes (such as dead organisms, or the presence of eggs).

Recognize that organisms can be classified as "producers" (creating their own source of energy, such as plants), "consumers" (eating producers or other consumers, such as a fish or a fox) and/or "decomposers" (breaking down dead producers and consumers, such as bacteria or fungi). Construct a "food web" (a method of diagramming feeding relationships) for a particular ecosystem. Trace the flow of energy through a food web.

Demonstrate that a food sample contains energy by burning it and measuring the heat it produces (using it as fuel to heat water, for example).

Explore how plants grow by producing their own source of chemical energy. For example, grow plants from seed under varying conditions, then compare the weights of the seeds to the weights of the harvested plants. Begin to understand "photosynthesis" (the process by which plants use sunlight, carbon dioxide and water to produce their own source of chemical energy).

Recognize that energy flows through an ecosystem and some is lost, but that matter is recycled through an ecosystem (a tree trunk decays into soil, for example).

Explore factors that limit population size, including the availability of resources (such as food) and natural events (such as a forest fire). Recognize that biodiversity is a characteristic of a healthy ecosystem.

Research an ecosystem and compare and contrast it with others. Discuss particular challenges to its survival, including threats posed by human populations.

Genetics and Evolution

Explore the concept of an "adaptation"—a structure or behavior that increases an organism's ability to survive and reproduce in a given environment (such as fur markings that help an animal blend in with its surroundings or a plant's mechanism for dispersing its seeds).

Recognize that slight differences in organisms' traits (such as darker fur, or later seed production) help to ensure a population's survival over time, despite changing conditions (flexibility in the population means that some organisms will survive under new conditions).

Simulate the process of "natural selection" (organisms that are better suited to conditions survive and reproduce, passing on their traits). For example, show the effect of environmental changes or a new predator on successive generations of a certain population.

Understand that new species emerge over short or long time spans ("biological evolution") through the process of natural selection.

Earth and Space Science

Earth Materials

Explore the formation and properties (defining characteristics) of rocks.

- Understand that rocks formed by the cooling of hot magma or lava are called "igneous," rocks formed by the settling of materials (such as sand or soil) are called "sedimentary," and rocks changed into new forms by pressure are called "metamorphic."
- Know that one form can change to another through heat and pressure or through weathering, in an ongoing process called "the rock cycle."

Explore the formation of minerals by investigating crystals.

Conduct tests to discover the physical properties of a range of mineral samples—for example, density (the amount of mass per volume) and magnetism.

Compare rocks to minerals and conduct tests to identify some of the components of rock samples.

Recognize that minerals are important resources for human beings. Research the distribution of mineral resources in the U.S. Understand the term "mineral deposit."

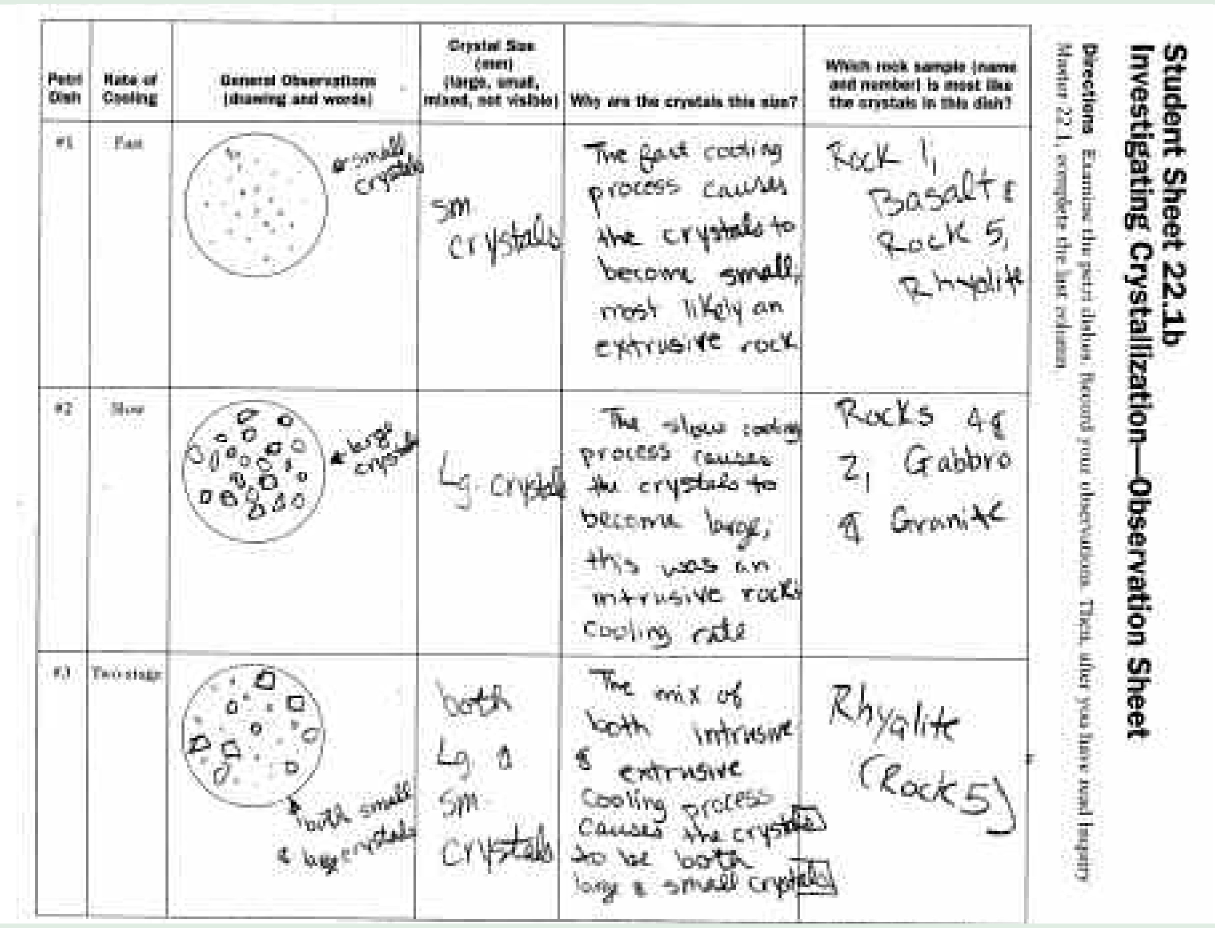
Explore the mining process.

- Use models to understand various processes for mineral exploration and for mining.
- Use models and tests to understand various physical and chemical processes for extracting minerals (separating them from unwanted materials). Discover how a mineral's properties (such as magnetism) relate to extraction methods.

Research common objects to determine the substances they were made from, identify whether or not those substances were mined, and show how the properties of minerals relate to the objects' uses.

Explore environmental, economic and global issues related to the mining industry and the management of mineral resources.

Sample of student work



Student Sheet 22.1b
Investigating Crystallization—Observation Sheet

Directions Examine the petri dishes. Record your observations. Then, after you have read Inquiry Master 22.1, complete the last column.

Petri Dish	Rate of Cooling	General Observations (drawing and words)	Crystal Size (mm) (large, small, mixed, not visible)	Why are the crystals this size?	Which rock sample (name and number) is most like the crystals in this dish?
#1	Fast	← small crystals	sm crystals	The fast cooling process causes the crystals to become small, most likely an extrusive rock	Rock 1, Basalt & Rock 5, Rhyolite
#2	Slow	← large crystals	Lg. crystals	The slow cooling process causes the crystals to become large, this was an intrusive rock cooling rate	Rocks 4 & 2, Gabbro & Granite
#3	Two stage	both small & large crystals	both Lg & sm crystals	The mix of both intrusive & extrusive cooling process causes the crystals to be both large & small crystals	Rhyalite (Rock 5)

In this assignment, from the Science and Technology Concepts for Middle Schools™ *Catastrophic Events* unit, students cooled heated solutions at varying rates, observed the crystals that formed during the cooling process, and compared their observations to samples of "igneous" rocks (rocks formed by the cooling of hot magma or lava) they had examined under a microscope.

Earth's Surface and Interior

Identify the layers of the earth's surface and interior: "crust," "mantle," and outer and inner core. Understand that the mantle (the layer below the crust) is fluid.

Use models to explore how "seismic waves" (waves of energy caused by earthquakes) can provide information about the structure and composition of the earth's interior.

- Identify and model different forms of seismic waves.
- Observe, measure and change

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Students set up circuits using various components (switch, resistor, lamp…) and measured the voltage for each component (see page 14 for more information).

the speed of waves traveling through water and through a coiled spring.

- Experiment to discover that waves change speed and direction (“refract”) when they encounter a new material.

Explore “convection” (the motion of a fluid when it is cooled from above and heated from below).

- Observe convection in fluids and other materials that simulate flowing rock.
- Relate convection to ongoing processes of change in the earth’s interior.

Use models to understand “tectonic plates” (segments of the earth’s crust and upper mantle). Identify plate movements: toward, away from, or sliding along another plate. Model two plates moving toward each other (“convergence”) and show how differences in plate density produce different results.

Explain ways that plate movements have shaped and continue to shape the earth’s features, including mountains formed by “folding” (the result of one plate pushing into another), volcanoes (some are formed by plate convergence), and “faults” (fractures in the earth’s surface caused by adjacent plates moving with respect to each other).

Locate major mountain ranges on a map. Compare their locations with the locations of recent earthquakes and volcanic eruptions.

Consider the evidence that present-day continents were once joined (“continental drift” theory).

Research some of the effects of earthquakes and volcanoes and ways that communities can prepare for them.

Weather and Climate

Explore the causes of weather.

- Experiment to discover that air has mass (an amount of matter that can be measured) and that air (and other gases) can be compressed.
- Relate winds to differences in air pressure.
- Experiment with differences in the densities of liquids to understand convection in the context of weather. Test the effect of heating and cooling air (in balloons, for example) on air density.
- Understand how heat causes materials to expand (heating matter sets its atoms or molecules in motion, causing expansion). Model heat transfer through “conduction” (direct contact between a colder material and a warmer material) and radiation (the sun’s rays falling on the earth, for example).
- Heat materials (such as water, sand, soil and air), measure how rapidly they cool, and graph and compare the results, to discover the sun’s differing effects on earth materials.
- Understand the water cycle: evaporation draws water from the earth into the atmosphere as water vapor, water vapor condenses and returns to the earth as precipitation (rain, snow, hail, sleet). Relate the redistribution of water through the water cycle to weather.
- Model the cooling effect of evaporation. For example, wet surfaces, expose them to a fan, and measure temperature changes.
- Find the “dew point” (the temperature at which air saturated with water vapor begins to condense: a measure of humidity). For example, cool a cup of water until condensation forms.
- Simulate cloud formation (for example, by breathing into a container of chilled air). Understand that clouds form when water vapor in the air condenses on the surface of air-borne specks of matter.

Understand the behavior of a “front” (the boundary between masses of warm and cool air) and the relationship of different fronts to regional weather changes.

Explore storms and storm systems, such as hurricanes.

- Simulate the vortex of a storm (the spiraling motion)—for example, by swirling liquids and other materials in plastic bottles.
- Plot the path of a hurricane on a map using tracking data (information), including latitude, longitude, and maximum wind speed.

Research some of the effects of severe weather (such as hurricanes) and ways that communities can prepare for them.

Explore weather monitoring.

- Research the instruments used to measure the atmosphere (thermometer, barometer, radar...) and explain how they work.
- Observe weather; use instruments to measure and record weather data.

Explore and analyze weather reporting and explain weather data.

- Understand symbols and terms used on weather maps and in reports.
- Compare weather reports and predict their accuracy.
- Recognize patterns in weather predictions.
- Compare air temperatures for different altitudes using data gathered by weather balloons. Recognize "inversions" (when the air temperature near the ground is cooler than the air temperature higher in the atmosphere).
- Compare satellite images of cloud locations and movement, identify patterns, and compare them to relevant precipitation data gathered by radar.
- Write a weather report.

Distinguish between weather (daily or short-term conditions in the atmosphere over an area) and climate (the long-term average of weather in a region).

Understand factors that influence climate.

- Model the varying effects of the sun's rays on the earth.
- Use models to understand that the tilt of the earth's axis is responsible for the seasons.
- Relate a region's closeness to a large body of water (such as an ocean) to its climate.

Consider historical evidence of significant climate change, such as fossil locations (the remains of marine animals found far from a present-day ocean, for example).

Gather and analyze current evidence of climate change and predict future climate change. For example, investigate the concentration of "greenhouse gases" in the atmosphere (certain gases that trap heat), consider evidence of global warming, and predict the effect of global warming on a region's water supply.

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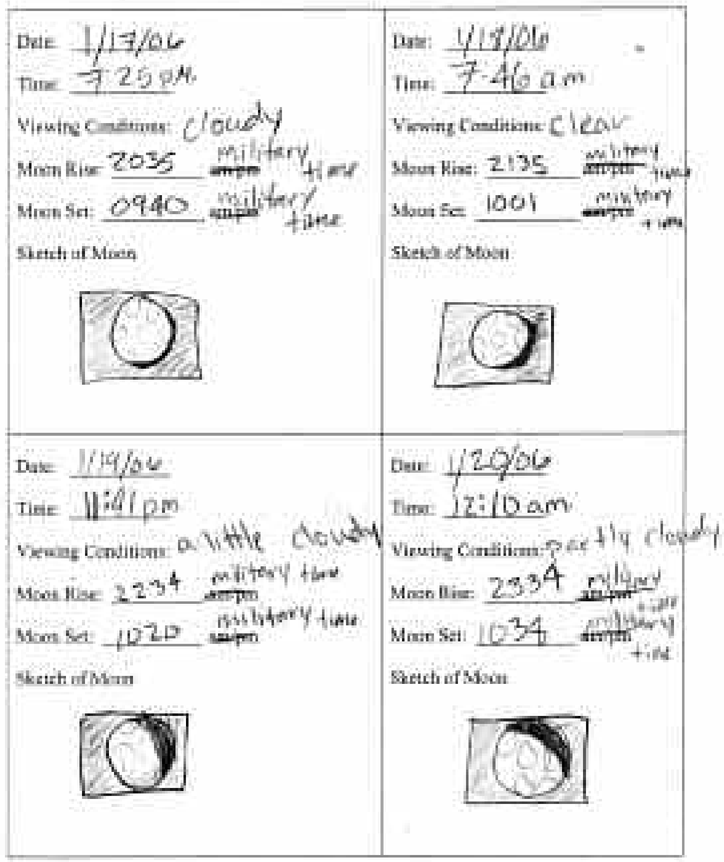
Space

Explore characteristics of the earth, the moon, and the sun, and investigate their relative positions.

- Explore the concepts of relative size and "frame of reference" by drawing local maps and viewing aerial photographs (photographs taken from the sky).
- Construct a scale model of the earth, the moon, and the sun. Simulate the earth's revolution around the sun and the moon's revolution around the earth.
- Use models to demonstrate that half the earth is always lit by the sun and half is shadowed because the earth is a sphere. Compare day and night on the earth to day and night on the moon.
- Review historical evidence which persuaded observers that the earth is a sphere (ships appeared to sink over the horizon, the length of shadows at noon differed by location).
- Record the length and angle of shadows at different times of day, and analyze shadow data from different seasons, to discover evidence that the earth rotates on an axis and revolves around the sun.
- Model and explain eclipses of the sun (when the position of the moon blocks sunlight from reaching the earth) and eclipses of the moon (when the position of the earth blocks sunlight

Sample of student work

Sky Observation Journal



Almost everyday I observed the moon it appeared to look different. At the beginning of the project each night the moon became more and more illuminated until it was a full moon. After it became a full moon it began to lose some of it's light so you were only able to see less and less. The nights I couldn't observe the moon, and got my results off the internet, the shadow angle on the moon differed from when I observed the moon myself. As the project went on the rise and set times grew later and later. The amount of time the moon was out varied. It started out as being out for about 12 hours, then increased to being 13-15 hours, and ended the project on the 23rd with being out for 10 hours.

Observations over time help students understand the phases of the moon.

from reaching the moon).

- View pictures of sunspots to discover that the sun rotates on an axis.
- Track and document the moon's phases. Define "phase" as the shape of the illuminated part of the moon as it appears from the earth. Recognize that phase changes are predictable.

Begin to understand the effects of gravity (the force that attracts one mass to another), including gravity on or near the surface of a planet or a moon, and gravity that causes a body in space to orbit another body.

- Consider data about the weight of an object on the earth and the weight of the same object on other planets, to discover that gravity affects weight.
- Use a pan balance scale to determine an object's mass and a spring scale to determine an object's weight, to discover the difference between mass and weight (mass is a measure of the amount of matter; weight is a measure of the force of gravity on an object or body).
- Model the orbits of objects around other objects that have different masses.
- Consider data from one location about ocean tides, moonrise, moonset, and moon phases to explore the relationships among earth/moon/sun positions, gravity, and ocean tides.

Compare the surface features and composition of the moon and the planets to the earth's surface features and composition.

- Identify similarities between the earth and the other "inner" planets: Mercury, Mars and Venus (like the earth, they are composed mostly of rock).
- Identify differences between the earth and the "outer" planets: Jupiter, Uranus, Saturn and Neptune (unlike the earth, they are composed mostly of gas).
- Model "impact craters" (craters formed by the impact of small objects on other bodies).
- Relate processes that shape features on the earth to those that shape features on the moon and the other planets, such as wind erosion, the formation of volcanoes, "tectonics" (forces that cause changes in the crust), and impact craters.
- Investigate earth minerals that are similar to those found in moon rocks, and consider theories about the moon's origin.
- Compare the climate conditions that allow the earth to support life to climate conditions on other planets.

Compare types of debris in space, such as asteroids (rocky bodies, smaller than planets, that orbit the sun) and meteoroids (small asteroids that orbit the sun).

Explore fossil evidence that the earth's prehistoric climate changed because of large asteroids and/or comets striking it. Consider whether future strikes can be predicted.

Investigate some of the issues involved in space travel. Research a planet and plan a hypothetical space mission to visit it.

Physical Science

Note: Some aspects of Physical Science are covered in the Earth and Space Science section.

Properties of Matter

Test and observe a range of objects, describe their characteristics, and form a definition of matter (such as "the stuff that everything is made of").

Explore density (the amount of mass per volume of a substance) as a property (defining characteristic) of matter under stable conditions, such as temperature.

- Determine the density of different quantities of the same substance (such as water) to discover that the density of a substance is not affected by its quantity.
- Measure the mass and volume of different materials to determine their density; measure the volume of irregularly-shaped objects using "displacement" (submerging them in water and measuring the amount of water that is displaced).
- Construct a "density column" (layers of unmixable liquids that have different densities). Observe objects floating or sinking in the column depending on their relative densities.

Explore changes of state (when a material changes from a liquid to a gas, for example) and chemical reactions (when a material is chemically transformed).

- Heat various materials. Observe and record changes (such as a solid that becomes a liquid when heated and forms crystals when cooled).
- Relate changes of state to changes of temperature. For example, heat ice, record temperature changes, and identify the "melting point" of ice (the temperature at which ice melts) and the "boiling point" of water (the temperature at which water boils). Recognize that a change of state occurs when enough heat energy is absorbed by a material, or lost from a material.
- Discover that water's volume increases as it freezes, but its mass remains the same as a solid (ice) and as a liquid.
- Observe and describe chemical reactions. Identify and measure the "products" of the reaction (new materials that are formed, such as a gas and a solid material).
- Discover that the mass of the products of a chemical reaction equals the mass of the "reactants" (the original materials).

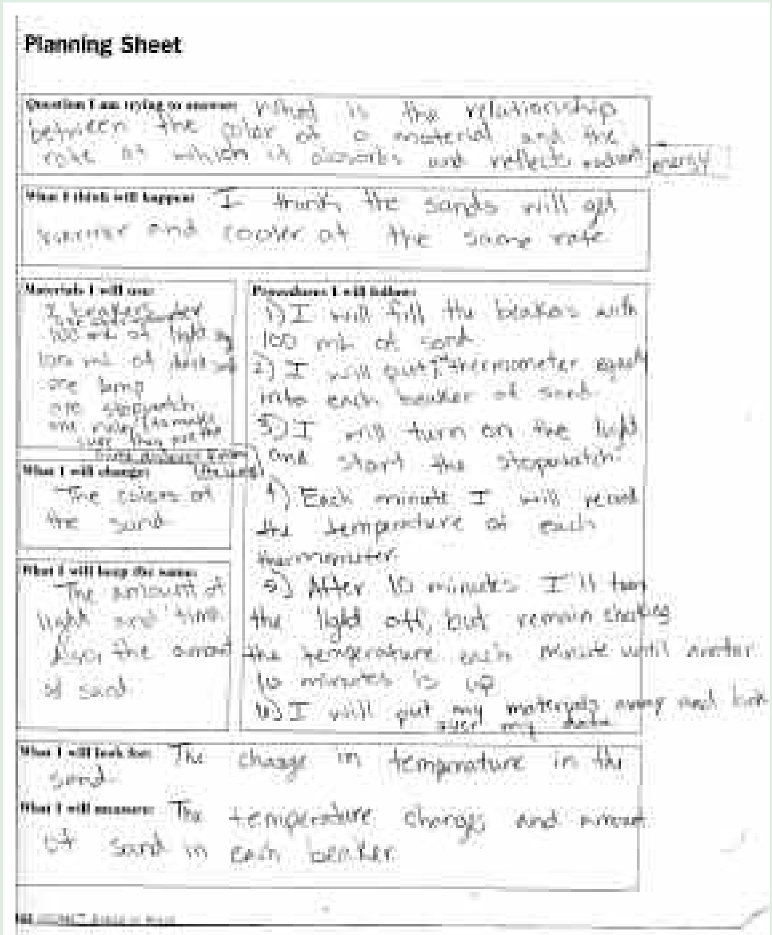
Explore the concept of a "pure substance" (matter that has constant physical and chemical properties, such as gold or water). Use knowledge of the properties of matter to develop tests for purity. For example, expose metal filings to a magnet to see if they separate into magnetic and nonmagnetic parts.

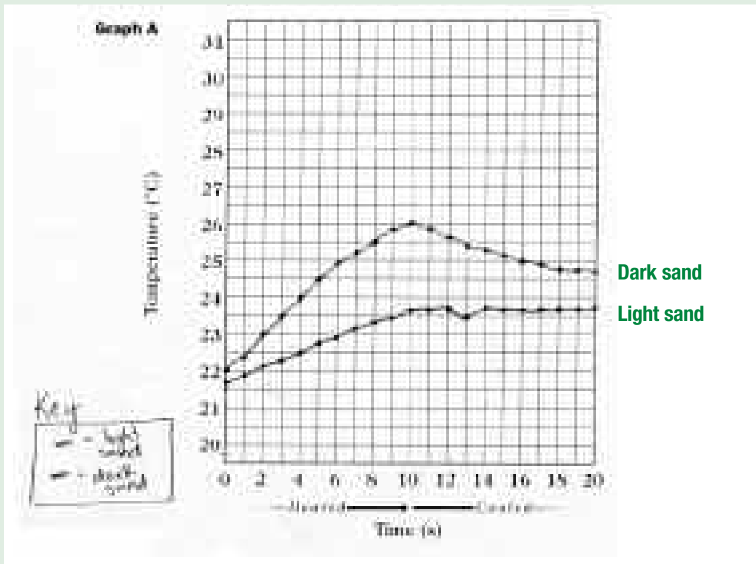
Understand the concept of a mixture (two or more substances that are physically combined and can be physically separated—for example, with a filter).

Sample of student work

The Relationship Between Sand Color and Heat Absorption

From the Science and Technology Concepts for Middle Schools™ *Catastrophic Events* unit





In this sample, the graph shows that the information the student gathered would have led her to a conclusion that differed from her hypothesis ("What I think will happen"). An unproven hypothesis often prompts ideas for further investigations.

Analyze mixtures. For example, identify the main components (parts) of a household cleanser and relate each component to its use.

Explore solutions (homogeneous mixtures of liquids, gases or solids—for example, salt water, air, and metal alloys).

- Observe a material dissolving in water to form a solution. Observe what happens when the water evaporates (in salt water, for example, salt reappears as crystals).
- Experiment with saturation—the point at which the "solute" (the material that dissolves, such as salt) no longer dissolves in the "solvent" (the part of a solution that dissolves another material, such as water).
- Understand "solubility" (the amount of a substance that will completely dissolve in a given solvent) as a property of matter.
- Discover that solubility can be used to separate a pure substance from a mixture. For example, add water to rock salt, filter out the impurities left in the water after the salt dissolves, and allow the water to evaporate (pure salt—the soluble part of rock salt—reappears).
- Test different concentrations of commonly used solutions. For example, dissolve varying amounts of bleach in water and test each solution's effectiveness at removing stains.
- Recognize that some materials which won't dissolve in water will dissolve in other solvents. For example, experiment with removing stains from cloth with solvents other than water.
- Discover that a solution of two or more pure substances can have physical properties that are different from those of the original substances. For example, add varying amounts of salt to water and observe changes in the temperatures of the freezing point and the boiling point.

Understand that some pure substances are "elements" (substances that can't be broken down into different components) and some are "compounds" (two or more elements chemically combined in fixed proportions, such as H_2O—water).

Identify and group elements by their properties. Classify elements into two important groups: metals and nonmetals.

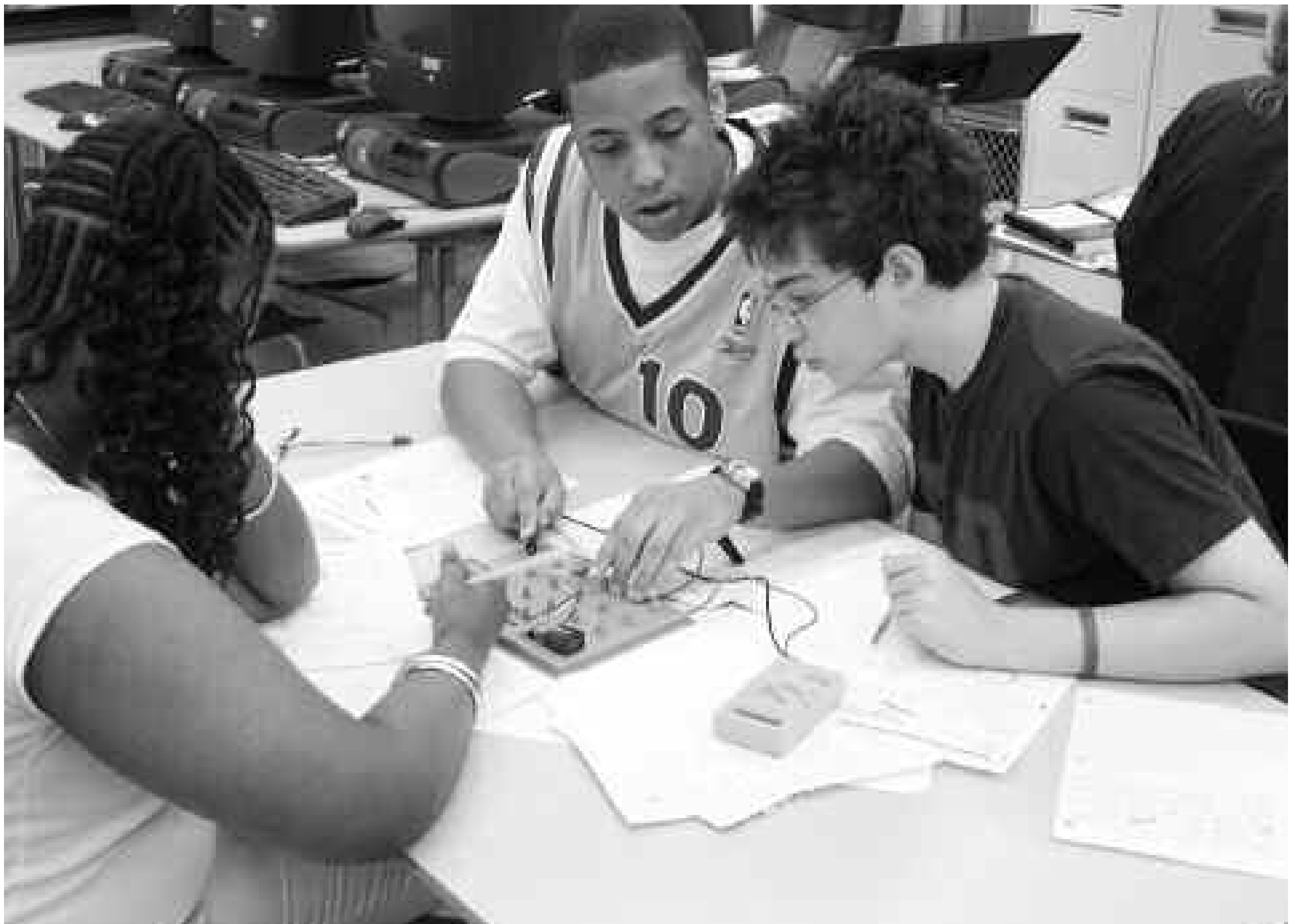
Research a manufactured object and identify the materials used to make it. Relate the properties of the materials to the object's function. [See the sample of student work on page 14.]

Electricity and Electronics

Understand that electricity is a form of energy.

- Observe an electric charge being transferred from one object to another without a power source ("static electricity"). For example, temporarily light a bulb using a charge from an object.
- Understand that matter is made of atoms that have positive and negative charges, and that similar charges repel (push away from each other) and opposite charges attract (are drawn together and stick to each other).
- Understand electric current as a flow of electrons (particles within atoms that are negatively charged and in constant motion).

Model electric current and voltage (the force that moves current, or has the potential to move current, such as the



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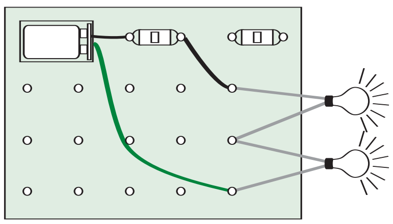
Students set up circuits using a variety of components (switch, resistor, lamp…) and measured the voltage for each component (see page 14 for more information).

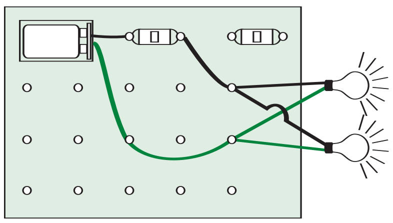
voltage in an unused battery). For example, observe water flowing from a container onto a water wheel and measure water pressure and rate of flow. Relate water pressure to voltage and water flow to the flow of electric current.

Experiment with creating circuits (pathways that connect a power source to a receiver).

- Build a "series circuit" (a circuit with all components on the same pathway) and a "parallel circuit" (a circuit with components on more than one pathway). [See illustration.]



Series circuit



Parallel circuit

- Reason about the difference in brightness when two bulbs are lit in a series circuit and in a parallel circuit.
- Build a circuit with two switches that will light a bulb and power a fan independently.
- Create a diagram of a circuit; build a circuit from a diagram.

Understand the concepts of a "conductor" (a material with freely moving electrons that facilitates the transfer of an electric charge, such as copper) and an "insulator" (a material without freely moving electrons that resists the transfer of an electric charge, such as rubber).

Explore the concept of "electrical resistance" (the tendency of all materials to resist electric current to a greater or lesser degree).

- Investigate the resistance in wires of different materials, lengths, and thickness.
- Test "resistors" (components that block or divert the flow of current) and measure their resistance.
- Discover that the property of electrical resistance allows the flow of current to be controlled. Understand some of the uses of resistors in appliances, such as volume control on a radio or varying speeds on a fan.

Use a "voltmeter" to measure voltage. Vary the resistance and the voltage in a circuit, measure the current, and graph and compare the results.

Explore common components of circuits.

- Construct a compound battery by connecting single D-cell batteries.
- Experiment with a "diode" (a component used to conduct and/or control the flow of current).
- Experiment with a "capacitor" (a component used to store and release electrical energy).
- Investigate a "solar cell" (a source of stored power, like a battery, that transforms energy from the sun into electrical energy).

Investigate common electronic devices, identify some of their components, and draw diagrams to show how their circuits work.

Investigate the amount of electrical energy used by home appliances.

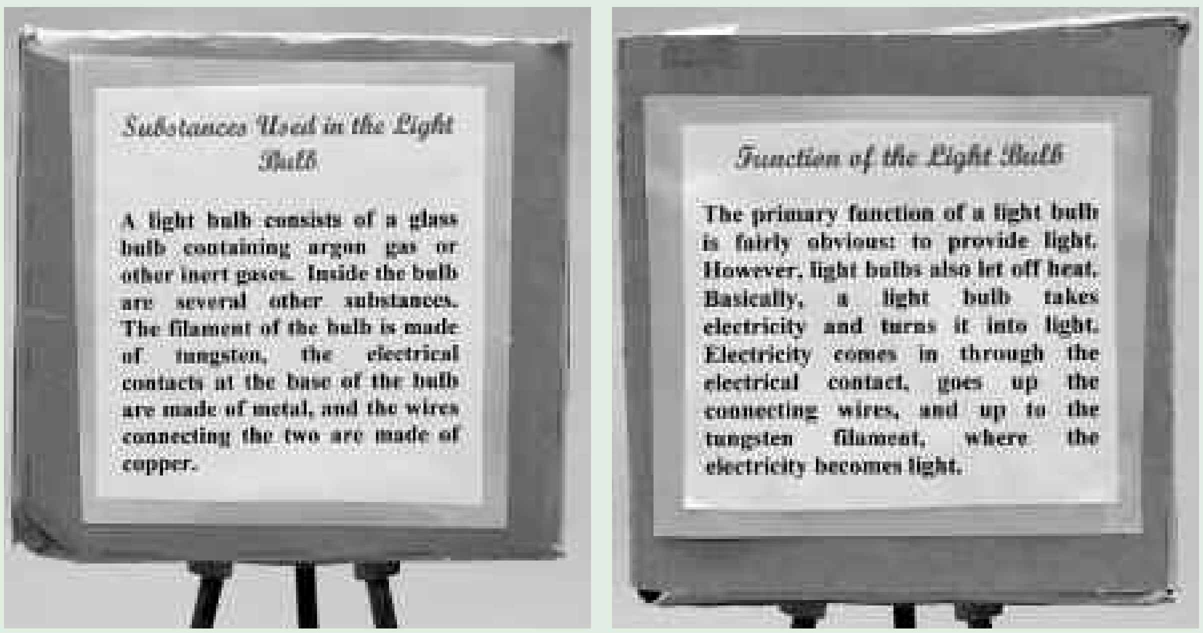
Experiment with automated electrical systems (systems that use sensors to regulate themselves—a "feedback mechanism"). For example, construct a circuit with a thermostat that turns a fan on or off depending on temperature.

Design an electrical system to perform a specific function.

Forces, Energy and Motion

Experiment with different forces (*force*: a push or pull on an object or body). For example, measure the elastic force in a rubber band (by measuring

Sample of student work



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Students researched a manufactured object, identified the materials used to make it, and discussed the relationship of the materials' properties to the object's function.

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