Activities/ Resources for Outcomes

Outcome #1

Think Like a Scientist

As you read the information below, underline important facts or definitions with your pencil or highlighter so you can find it for the written activity after the lesson.

Although you may not know it, you think like a scientist every day. Questions come up, and you try to answer them. For example, has something happened today that you did not understand or wanted to know more about? Maybe it was a math question; maybe you wanted to know what they weather could be so you could decide what to wear to school. Think about this question for a minute and then with your teacher's approval share it with a partner.

When you try to answer questions and solve problems, you are using many of the same skills that scientists use in their jobs. Read more details about these important skills below.

Observing

When you use one or more of your five senses to gather information, you are observing. When you hear a dog bark, count twelve green seeds, or smell smoke, you are making observations. Scientists are fortunate because they can sometimes use special tools to enhance their senses. Microscopes, telescopes, and other special instruments help them make more detailed observations than they could make with their senses alone. A microscope, for example, can make your vision powerful enough to see tiny hairs on a caterpillar that you could never see without assistance.

The key to observation, though, is that it must be accurate and factual. It cannot be made up in order to help solve a problem. It must be exact, and to do this you must keep careful records of your observations in science class. You can do this by writing or drawing on paper or in a notebook. This information that you collect is sometimes called evidence, data, or feedback.

Inferring

After you see or observe something in the world, you try to interpret it or make a prediction about what it is based on the details you observe. This interpretation or explanation is not necessarily correct; it is an educated guess. Scientists call such educated guesses inferences. You are inferring when you draw a conclusion based only on what is observed and what you already know, without searching for additional information. For example, if you hear a rooster crowing while you are partially asleep in bed, you would infer that the sun has come up and it is early morning. To make this inference, you combine the evidence – the crowing rooster – and your experience or knowledge of sunrise. You know from early elementary school that roosters typically crow in the morning at sunrise. To infer without looking that it is morning and sunrise is logical.

Remember though, that an inference is not a fact; it is only one of many possible reasons or explanations. For example, the rooster could be crowing because there is an intruder in his pen or because he is injured. An inference may turn out to be incorrect even if it is based on accurate observations. The only way to confirm whether an inference is true or false is to conduct a deeper investigation.

Predicting

Do you watch or listen to weather forecasts? Even if you do not, you probably know that weather forecasts are predictions about what the weather will be like later today, tomorrow, or next week. Weather forecasts may predict the amount of rain that will fall, wind speeds, paths of hurricanes, or whether there will be a snowstorm that keeps you out of school! In order to make these predictions, weather forecasters -- also called meteorologists -- observe the weather and use their observations and their knowledge of weather patterns to predict what will happen. The skill of predicting involves making an inference about a future event based on current evidence and past experience.

Classifying

Every year your picture is taken and placed in your school's yearbook. You find your picture in the yearbook by looking first for your class by grade and then for your name alphabetically. Can you imagine if your picture was just placed randomly in the book? It would take you a long time to find your picture! Organization or grouping by similarities is called classifying. You are grouped onto a certain page with your classmates because you are in the same grade and class. You can classify items in all kinds of ways, using size, shape, purpose, color, and so on. Scientists use this skill to organize information and objects. As a scientist solving a problem you are collecting data, and when you group similar data together, it is easier for you to understand how they relate or connect.

Making models

Have you ever played the game where you draw a picture and another person guesses what you are drawing without talking? If so, you were drawing a type of model. You use and make models all the time – a hand-drawn sketch, a diagram or illustration in a textbook, or a three-dimensional, physical object that is smaller than the object it represents. A good model can help you to understand something very complex in a simpler way. For example, if you read a description of the solar system, your might have trouble understanding how the planets rotate around the sun. A diagram of the solar system or a three-dimensional model that you could touch would make the concept easier for you to understand. Another example is putting a toy together. Often the instructions include pictures as well as words to help the person who buys the toy understand the process step-by-step. Scientists also use models to help them simplify complicated information and ideas. Scientists' models are often generated by computers, and sometimes they are only mental models made up of mathematical equations, but these models, like the ones you use, help scientists to simplify and make sense of complicated processes.

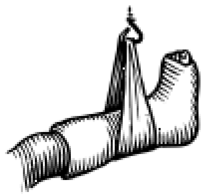
Communicating

Every day you talk to friends, listen to what other people have to say, and write messages or even letters. Reading, writing, speaking, and listening are all part of communicating. Communication is simply sharing ideas and information with other people. Scientists communicate to share information, data, results, and opinions. They often use formal methods of communication such as meetings, reports, and the Internet. By communicating, they can help one another find answers to questions and problems.

Outcome #1 Activity 1 Think Like a Scientist

Name: ________________________________

There are three pictures below. Look at them together and with a partner answer the questions below in the space provided.

(Observing) 1. List 3 observations.

(Inferring) 2. Use your observations to make an inference about what has happened. What experience or knowledge did you use to make the inference?

(Predicting) 3. Predict what will happen next. On what evidence did you use to make the inference?

Write answers in this space. Number each answer.

____

____

____

____

____

____

____

____

Outcome #1

Think Like a Scientist

Activity #2: Communicating

In the space provided, write out clear, specific directions on how to tie your shoe. Then, exchange your paper with a partner. See if you can follow your partner's directions by doing them exactly as they are written. Were you both successful? Could either you or your partner have written the directions more clearly? (Answer these questions below your directions.)

Directions:

____
____
____
____

Answers to Questions:

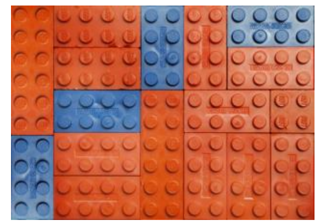
____
____
____
____

Outcome #1 Extension Activity

Communication in Action

This activity utilizes Lego® building pieces as the point of departure to help develop communication and improve verbal communication.

Objectives: In this lesson, the participants will:



1. Recognize the importance of communication skills.
2. Demonstrate good communication skills.
3. Become aware of the pitfalls of poor communicating.

Session Time: 30 minutes

Materials: Baggies with Legos® or Knex® in them.

Methods: Interactive participation and guided discussion.

Procedure:

1. Divide the class into pairs. Have the partners sit back to back so that they are looking different directions.

2. Give each group two small bags with identical six assorted Lego® building pieces in it (assorted shapes and colors work best). It works best if each group has different pieces in their bag.

3. Have one person in the pair construct an object using all six of the Lego® pieces without the partner seeing it.

4. The partner that constructed the object now verbally gives step-by-step instructions to the other partner on how to recreate the object that was constructed. The partner receiving the verbal instructions can NOT talk or ask questions. This means that partner giving the instructions must be very precise!

5. When the construction is complete, have the partners compare their creations to see how closely the re-creation resembles the original creation. Debrief on what happened.
    - Did partners that had the same color Legos® have an easier time or more difficult time communicating than the partners who had several different color Legos?
    - Discuss ways that communication could have been improved.
    - What kind of instructions did the partners that communicated well use?

NOTE: You can add more Lego® pieces to the bags to make it more challenging.

Outcome #1 Activity 3: Who else in the real world thinks like a scientist?

Answer this question by reviewing with a partner the 12 jobs below and classifying the skills in each job.

Group Assignment: For each of the skills in the reading, identify two careers from the list below that most use the skill to perform the job.

Architect: licensed to design and build buildings, complexes, towns, and more.

Veterinarian: treats and cares for pets, livestock, and other animals.

Teacher: helps students of a specific age to learn and apply concepts in subjects such as math, science, and art.

Weathercaster: gathers information, prepares reports, and broadcasts information about the weather.

Child Care Worker: nurtures and teaches children of all ages.

Sales Clerk in Music Store: interests customers in their music in order to sell their products.

Automobile Designer: combines knowledge of how cars work with a desire to create into a plan for a new product or idea, then creates a prototype of the design.

Artist: creates works of art to express ideas, thoughts, or feelings.

Stock Clerk: receives, unpacks, checks, stores, and tracks merchandise and materials.

Chief Executive Officer: establishes corporation's goals and policies. Ensures that operations are conducted in accordance with these policies.

Stock Broker: helps investors in the stock market place orders to a securities exchange.

Documentary Film Producer: oversees the business and financial decisions of a movie that documents facts about a person, place, or event.

OBSERVING

CLASSIFYING

INFERRING

MAKING MODELS

PREDICTING

COMMUNICATING

Closure

Questions for class discussion: Be ready to discuss with the class at the end. You or your partner might be called upon to answer! Written answers are not required but are recommended in order to help you answer during oral review. Talk about the answers with your partner after all activities are complete.

1. Explain why you chose to put each career with a specific skill. Give an example.

2. How were your answers different from those of your partner?

3. List at least one additional skill needed for each career.

4. What characteristics were most important when you made your groups?

Outcome #2 Career Cards

Newspaper Reporter
Landscape Architect
Topographer
Police Officer
Building Inspector
Firefighter
Meteorologist
Photographer

Paramedic/EMT
Seismologist
Geologist
Electrician
Rescue Worker
Construction Worker
Nurse
Paralegal
Interpreter
Radio Announcer

Outcome #2

Problem Statement Sheet

Problem Statement:

Almost half of the earthquakes in the United States occur in California. You have recently moved to southern California. Yesterday a major earthquake has just occurred along the San Andreas Fault. The earthquake caused seismic waves to travel through the Earth's crust. Due to the energy from the seismic waves many buildings were destroyed and the community is still feeling aftershocks. The total death count is unknown, although, many people are dead and others are injured. The city is a disaster area in need of much work over a long period of time. Use the career cards on your table to establish your role in the recent earthquake. Look up career information about your job in the Occupational Outlook Handbook. On the worksheet provided you are responsible for explaining your role in the recent earthquake that took place in southern California. You will be asked to share your ideas with the class at the end of the activity. Be sure to use a loud public speaking voice.

Occupational Outlook Handbook:

http://www.bls.gov/ooh/

Outcome #2 Earthquake Job Information Sheet

Directions: Complete this page with your partner, exchanging careers with the other group at your table when you finish the first career.

Career Title:

Daily duties of this career after the earthquake:

Education/Training needed to perform your job:

Special experience needed:

Employment Outlook for the next ten years:

Salary for your work:

Previous interests that lead you to your career:

Why would this career be vital to the success of the city after the recent earthquake?

Outcome #3 Uses of Rocks and Minerals

Name: ___________________________________

Directions: Is this material composed of rocks & minerals? For each material, write Yes or No. Complete only the Hypothesis column until instructed otherwise by your teacher.

Material	Hypothesis	Actual	Components
Diamond Ring			
Camera			
Soda water			
Hammer and nail			
Eye glasses			
Toilet bowl			
Cosmetics			
Lightbulb			
Soap			

Outcome #3 Procedure: Look at the two charts below. One chart will be used for your rock/mineral and the other chart is for your career.

Rock/mineral directions: Find three classmates with different careers that would make use of your rock/mineral. Complete the chart below for each career. Do not duplicate information.

Assigned rock/mineral: ___________________________________

Uses: ____

Career	How career uses your assigned rock/mineral

Career directions: Find three classmates with different rocks/minerals that you could use with your career. Complete the chart below for each rock/mineral. Do not duplicate information.

Assigned career: ____

Job description:____

Rock/mineral	How rock/mineral is used in your career

Answer Keys for Outcome #3

Uses of Rocks and Minerals—Answers Page

Directions: Is this material composed of rocks & minerals? For each material write yes or no.

Material	Hypothesis	Actual	Components
Diamond engagement ring		YES	Diamonds, gold/platinum/silver
Camera		YES	Film has silver in it, flash has magnesium alloy wires, glass, plastic, metals
Soda water		YES	Water, salts, carbon dioxide
Hammer and nail		YES	steel
Eye glasses		YES	Glass, nickel and silver reinforced frames, plastic frames, metal hinges
Toliet Bowl		YES	Porcelain, steel, plastic
Cosmetics		YES	Talc, iron oxides, chrome oxides, manganese violet, lapis lazuli, kaolin, soda ash, and charcoal for colors; mica for luster
Light Bulb		YES	Glass, aluminum, tungsten
Soap		YES	Potash, salts

Rock/Mineral Uses Resource Pages
http://www.learnnc.org/lp/media/uploads/2008/01/4mineral_teacher_pages.pdf

Asbestos	Asbestos is used in fireproof fabrics, yarn, cloth, paper, paint filler, gaskets, roofing composition, as a reinforcing agent in rubber and plastics, brake linings, tiles, electrical and heat insulation, cement, and chemical filters.
Bauxite	The main source of aluminum. Aluminum is used in the United States in packaging, transportation, and building
Stibnite	Antimony metal is extracted from stibnite and other minerals. Antimony is used as a hardening alloy for lead, especially storage batteries and cable sheaths, also used in bearing metal, type metal, solder, collapsible tubes and foil, sheet and pipes, and semiconductor technology. Stibnite is used for metal fireworks. Antimony salts are used in the rubber and textile industries, in medicine, and glassmaking.
Barium	Used as a heavy additive in oil-well-drilling mud, in the paper and rubber industries, as a filler or extender in cloth, ink, and plastics products, in radiography, as alloys in vacuum tubes, deoxidizer for copper, lubricant in X-ray tubes, spark-plug alloys. Also used to make an expensive white pigment.
Beryllium	Beryllium alloys are used mostly in applications in aerospace, automobiles, computers, oil and gas drilling equipment, and telecommunications. Beryllium salts are used in fluorescent lamps, in X-ray tubes, and as a deoxidizer in bronze metallurgy. Beryl is the source of the gemstones emerald and aquamarine.
Coal	One of the world’s major sources of energy. More than half of all the electrical energy that is generated and used in the United States comes from coal.
Cobalt	Used in super alloys for jet engines, chemical paint driers, pigments, rechargeable batteries, magnets, and cemented carbides for cutting tools.
Cooper	Used in electric cables and wires, switches, plumbing, heating, roofing and building construction, chemical and pharmaceutical machinery, electroplated protective coatings and cooking utensils
Feldspar	A rock-forming mineral, industrially important in glass and ceramic industries, pottery and enamelware, soaps, abrasives, bond for abrasive wheels, cements and concretes, insulating compositions, fertilizer, poultry grit, tarred roofing materials, and in textiles and paper production.
Fluorite	Used in production of hydrofluoric acid, which is used in the electroplating, stainless steel, refrigerant, and plastics industries, in production of aluminum fluoride, which is used in aluminum smelting, as a flux in ceramics and glass, in steel furnaces, and in emery wheels, optics, and welding rods. Used in drinking water and toothpaste.
Gold	Used in dentistry and medicine, in jewelry and arts, in medallions and coins, in ingots as a store of value, for scientific and electronic instruments, as an electrolyte in the electro-plating industry.

Gypsum	Processed and used as prefabricated wallboard or as industrial or building plaster, used in cement manufacture, and agriculture.
Halite (Salt)	Used in human and animal diet, food seasoning and food preservation, used to prepare sodium hydroxide, soda ash, caustic soda, hydrochloric acid, chlorine, metallic sodium, used in ceramic glazes, metallurgy, curing of hides, mineral waters, soap manufacture, home water softeners, highway de-icing, photography, herbicide, fire extinguishing, nuclear reactors, mouthwash, medicine, in scientific equipment for optical parts. Single crystals used for spectroscopy, ultraviolet and infrared transmission.
Lead	Used in lead batteries, gasoline tanks and solders, seals or bearings, used in electrical and electronic applications, TV tubes, TV glass, construction, communications, protective coatings, in ballast or weights, ceramics or crystal glass, tubes or containers, type metal, foil or wire, Xray and gamma radiation shielding, soundproofing material in the construction industry, and ammunition.
Limestone	Limestone is used in the construction industry and is the main ingredient from which aggregate, cement, lime, and building stone are made. As a source for lime, it is used to make paper, plastics, glass, paint, steel, cement, and carpets. Used in water treatment and purification plants, and in the processing of various foods and household items (including medicines).
Lithium	Lithium compounds are used in ceramics and glass, in primary aluminum production, in the manufacture of lubricants and greases, rocket propellants, vitamin A synthesis, silver solders, underwater buoyancy devices, and batteries.
Mica	Mica is used in electronic insulators, ground in paint, as joint cement, as a dusting agent, in well-drilling muds, and in plastics, roofing, rubber, and welding rods.
Platinum	Platinum is used principally as a catalyst for the control of automobile and industrial plant emissions, and as a catalyst to produce acids, organic chemicals, and pharmaceuticals. Also used in bushings for making glass fibers used in fiber-reinforced plastic and other advanced materials, in electrical contacts, in capacitors, in conductive and resistive films used in electronic circuits, in dental alloys used for making crowns and bridges, and in jewelry
Potash	Used as a fertilizer, in medicine, in the chemical industry, and to produce decorative color effects on brass, bronze, and nickel. Is an essential mineral for vegetable and animal life.
Quartz	As a crystal, quartz is used as a semiprecious gemstone (agate, jasper, onyx, amethyst, citrine, rose quartz, smoky quartz, etc.) Because of its properties quartz is used for pressure gauges, oscillators, resonators, and wave stabilizers; heat-ray lamps; and in prism and spectrographic lenses. Used in the manufacture of glass, paints, abrasives, refractories, and precision instruments.

Silver	Used in photography, jewelry, and electronics. Used as currency, in lining vats and other equipment for chemical reaction vessels, water distillation, mirrors, electric conductors, batteries, silver plating, table cutlery, dental, medical, and scientific equipment, electrical contacts, and bearing metal.
Sodium Carbonate	Used in glass container manufacture, in fiberglass and specialty glass. Also used in production of flat glass, in powdered detergents, in medicine, as a food additive, photography, cleaning and boiler compounds, and for pH control of water.
Sulfur	Used in glass container manufacture, in fiberglass and specialty glass. Also used in production of flat glass, in powdered detergents, in medicine, as a food additive, photography, cleaning and boiler compounds, and for pH control of water
Tantalum	Used mostly in the production of electronic components. Alloyed with other metals, it is also used in making carbide tools for metalworking equipment, and in the production of super alloys for jet engine components.
Titanium	Titanium is a strong, lightweight metal often used in airplanes, and as a brilliant white pigment used in paint, paper, and plastics
Tungsten	Used in metalworking, construction and electrical machinery and equipment, in transportation equipment, as filament in light bulbs, as a carbide in drilling equipment, in heat and radiation shielding, textile dyes, enamels, paints, and for coloring glass.
Zeolites	Used in aquaculture (fish hatcheries for removing ammonia from the water), water softener, in catalysts, cat litter, odor control, and for removing radioactive ions from nuclear plant waste.
Zinc	Used as a protective coating on steel, with copper to make brass, and as chemical compounds in rubber and paints, used as a sheet zinc and for galvanizing iron, electroplating, metal spraying, automotive parts, electrical fuses, anodes, dry cell batteries, fungicides, nutrition (essential growth element), chemicals, roof gutter, engravers' plates, cable wrappings, organ pipes, in pennies, primers, paints, to protect ship hulls, in lubricating oils and greases. Zinc oxide is used in medicine, paints, as an electrostatic and photoconductive agent in photocopying.
Clay	Used to coat the pages of newspaper, magazines, stationery, brochures, and boxes so that the ink used in printing on them will be bright and will not run. Also used as a brightener and abrasive in toothpaste, and in medicines to provide a smooth coating for the stomach.
Chromite	Used in making steel, “chromed” parts for automobiles and appliances and in the manufacture of chromic acid which is used to tan much of the leather used in making shoes, belts, purses, jackets, gloves, etc.
Hematite	Hematite is processed to produce iron, which is used to make steel. Steel, in turn, is used in everything from automobiles to flatware to the machinery used in most manufacturing. Steel is used in the manufacture of such things as kitchen appliances, furniture, tools, bridges, buildings, construction equipment, highway construction, shipbuilding, and trains

	and railroads. Powdered iron is used in magnets, high-frequency cores, auto parts, and as a catalyst. Radioactive iron is used in medicine and as a tracer element in biochemical and metallurgical research. Iron blue is used in paints, printing inks, plastics, cosmetics, and paper dyeing. Black iron oxide is used as a pigment and in polishing compounds, medicines, and magnetic inks.
Gilsonite	Gilsonite is used in the manufacture of wire insulation, paints and varnishes, construction materials, asphalt, printing ink, oil well drilling, and in foundry casting
Kaolinite	Kaolinite is a very fine white clay used as a filler in many products, for coating pages in magazines and newspapers to prevent ink from running, and as a whitener and abrasive in toothpaste.
Magnetite	Magnetite is processed to produce iron which is used in making steel. Steel is used to make nails, kitchen appliances, furniture, tools, bridges, buildings, automobiles, construction equipment, manufacturing machinery, and in highway construction, shipbuilding, trains, and railroads. Powdered iron is used in magnets, high-frequency cores, auto parts, and as a catalyst. Radioactive iron is used in medicine and as a tracer element in biochemical and metallurgical research. Iron blue is used in paints, printing inks, plastics, cosmetics, and paper dyeing. Black iron oxide is used as a pigment and in polishing compounds, medicines, and magnetic inks.

Rock/Mineral Careers Resource Page
http://www.learnnc.org/lp/media/uploads/2008/01/4mineral_teacher_pages.pdf

Textile machine operator	You are responsible for running machines that make textile products from fibers. Products made from fibers include towels, socks, tires, roofing materials, and just about all clothing. You learned this skill in a vocational training program after high school.
Tile installer	You are responsible for applying hard tile (such as ceramic and marble) to floors, walls, ceilings, and roof decks. You learned this skill on the job during summers while going to high school, working as a helper to a more experienced tilesetter.
Insulation worker	You are responsible for properly insulating buildings to reduce energy tanks, vessels, boilers, and pipes. You learned this skill just after high school with on-the-job training.
Packer	You are responsible for manually packaging a variety of materials. You also inspect items for defects, label cartons, stamp information on products, keep records of items packed, and stack your packages on a loading dock. You learned this skill at the age of 18 with on-the-job training.
Metallurgical engineer	You are responsible for removing metals from ores and making them suitable for industrial processes by refining and alloying. You learned this skill in a four-year program at college.
Metalworking machine operator	You are responsible for producing products made of metal. Metalworking industries produce most of the consumer products on which we rely daily. You learned this skill on the job after high school.
Transportation inspector	You are responsible for inspecting equipment in connection with the safe transportation of cargo or people. You have inspected trucks, airplanes, and automobiles. You learned this skill working in a related occupation after high school.
Logistics	You are responsible for planning, directing, and coordinating transportation, storage, and distribution of goods for a paper manufacturer. You must follow governmental policies and regulation. You learned this skill working in a related occupation after high school
Solderer	You are responsible for using molten metal to join two pieces of metal together (similar to welding). You commonly join electrical, electronic, and other small metal parts together. You learned this skill during high school in a vocation-training program.
Painter	You are responsible for communicating ideas, thoughts, or feelings through art. You use shading, perspective, and color to produce realistic scenes or abstractions. You learned this skill while earning a masters degree in fine art at a college.
Electrician	You are responsible for installing, connecting, testing, and maintaining electrical systems. You learned this skill by completing an apprenticeship program lasting 3-5 years.

Driller	You are responsible for operating rotary, churn, and pneumatic drills to tap subsurface water and salt deposits. You have also drilled to remove core samples during mineral exploration or soil testing. On occasion you have had to drill in order to use explosives for mining or construction. You learned this skill after a moderate amount of on-the-job training after high school.
Printing machine operator	You are responsible for preparing, operating, and maintaining the printing presses in a pressroom. You ink the presses, load the paper, adjust the pressure and flow of ink, feed the paper through the press cylinder, and adjust the feed and tension cords. You learned this skill through a formal apprenticeship after high school.
Mine cutter	You are responsible for operating machinery to allow access to coal deposits, stone quarries, or other mining areas. You also facilitate blasting, separating, or removing minerals or materials from mines. You learned this skill after a moderate amount of onthe-job training after high school.
Dental hygienist	You are responsible for helping patients develop and maintain good oral health. You clean teeth, examine patients for oral diseases, and teach your patients about good oral health. You learned this skill in college and had to be licensed by the state
Chemist	You are responsible for searching for and using new knowledge about chemicals. This knowledge leads to the discovery and development of new fibers, paints, adhesives, drugs, cosmetics, electronics, lubricants, and thousands of other products. You leaned this skill in a masters program at college.
Dietician	You are responsible for managing food service systems for institutions, promoting sound eating habits through education, and conducting research. You learned this skill in a four-year program at college, and then received a license from the state
Concrete finisher	You are responsible for placing and finishing the concrete used in building. Concrete is a mixture of cement, sand, gravel, and water. You can create walls, sidewalks, beams, columns, and panels. You learned this skill with on-the-job training after high school.
Jeweler	You are responsible for designing and manufacturing new pieces of jewelry. You cut, set, and polish gemstones, and repair or adjust jewelry. You learned this skill at a technical school after high school.
Desktop Publisher	You are responsible for using computer software to format and combine text, numerical data, photographs, charts, and other visual graphic elements to produce publication-ready materials as brochures, advertisements, and newsletters. You learned this skill by completing a certificate program after high school
Glazier	You are responsible for selecting, cutting, installing, replacing, and removing all types of glass. You learned this skill after high school with on-the-job training.

Agricultural scientist	You are responsible for studying farm crops and animals, and developing ways to improve the quantity and quality of food. To do this you must control labor costs, pests, and weeds. You also work to conserve soil and water. You earned a doctoral degree in order to do research in this area
Plasterer	You are responsible for applying and repairing plaster to interior walls and ceilings. You specialize in plastering over concrete. To do this you apply a gypsum plaster layer onto a supportive steel wire mesh. You follow this with a finished lime plaster layer. You learned this skill through a 2-3 year apprenticeship.
Home appliance repairer	You are responsible for keeping home appliances working and helping prevent unwanted breakdowns. You can work on refrigerators, dishwashers, water softeners, washers, and dryers. You learned this skill at a trade school after you finished high school.
Accounting clerk	You are responsible for organizing an organization's financial record-keepers. You update and maintain the accounting records for your organization. You often use computers to store information. You learned this skill in college.
Construction laborer	You are responsible for performing many physically demanding tasks including cleaning and preparing construction sites, digging trenches, mixing concrete, and setting braces. You also do a lot of loading and unloading of materials. You learned this skill on the job during high school.
Animal breeder	You are responsible for breeding animals according to their genealogy, characteristics, and offspring. You need to keep your animals healthy and clean. You use your computer to keep excellent records. You learned this skill from on-the-job training
Photographic process worker	You are responsible for retouching photographic negatives and prints to emphasize or correct specific features. You learned this skill with on-the-job training.

Teacher reference page—Minerals listed by career

NOTE: Additional correlations apply. Four are listed here as a reference.
http://www.learnnc.org/lp/media/uploads/2008/01/4mineral_teacher_pages.pdf

Career	Rock/Mineral
Textile machine operator	Asbestos Feldspar Tungsten Stibnite
Tile installer	Asbestos Halite Feldspar Lithium
Insulation worker	Asbestos Copper Stibnite Feldspar
Packer	Clay Barium Tungsten Kaolinite
Metallurgical engineer	Bauxite Stibnite Lead Lithium
Metalworking machine operator	Bauxite Copper Zinc Magnetite
Transportation inspector	Bauxite Magnetite Lead Platinum
Logistics manager	Bauxite Asbestos Limestone Clay
Solderer	Stibnite Copper Gold Lead
Painter	Barium Hematite Magnetite Limestone

Driller	Barium Coal Gold Silver
Printing machine operator	Barium Cobalt Feldspar Clay
Mine cutter	Coal Gold Silver Cobalt
Electrician	Coal Copper Lead Silver
Dental hygienist	Kaolinite Clay Halite Platinum
Dietitian	Halite Limestone Lithium Zinc
Concrete finisher	Limestone Tungsten Zinc Magnetite
Jeweler	Silver Copper Beryllium Gold
Desktop publisher	Clay Kaolinite Beryllium Barium
Plasterer	Gypsum Limestone Tungsten Chromite
Glazier	Quartz Sodium carbonate Lead Lithium

Home appliance repairer	Zeolites Chromite Tungsten Halite
Accounting Clerk	Clay Beryllium Silver Lead
Photographic process worker	Halite Silver Sodium carbonate Gilsonite
Animal breeder	Potash Halite Beryllium Sodium carbonate
Construction laborer	Limestone Tungsten Magnetite

Outcome #5 pH worksheet

<u>What is pH?</u>

pH is a measurement of how acidic or how basic a solution is. The pH scale starts at 0 and goes up to 14. Halfway between 0 and 14 is 7, which is neutral. Compounds are acidic if they have a pH lower than 7. Compounds with a pH higher than 7 are said to be basic or alkaline.

<u>Exactly what makes a compound an acid or a base?</u>

To understand this you must understand water. Water is a molecule made up of three atoms covalently bonded together. Think of water as HOH.

Some compounds can cause water molecules to break apart into H+ and OH- ions. The H+ ion is called a hydrogen ion. It is actually a proton with no electrons. The OH- ion is called a hydroxide ion.

If you mixed hydroxide and hydrogen ions together, they would immediately pair up and make water molecules.

H^{+} + H^{-} ------------> HOH ----> $H_2 0$

This is called a neutralization reaction. Hydroxide ions neutralize hydrogen ions.

If, after the neutralization reaction is complete, there are H^{+} ions left over, then the solution is acidic.

If, after the neutralization reaction is complete, their are OH^{-} ions left over, then the solution is basic.

<u>Why is pH important to biology?</u>

Most cells can only survive within a certain range of pH. For example, human blood has a pH of about 7.2, which is slightly basic. Any higher or lower and the blood cells would be injured or killed. So you could say that a healthy person's blood has a pH range or 7.2 to 6.9.

Acids denature, or change the shape of proteins in much the same way heat does. As a matter of fact, strong acids like vinegar and lemon juice can be used to actually cook meats like fish and eggs. Seviche is a dish made by mixing raw fish and lime juice and letting it sit for a few hours. Acids are used by your digestive system to break down food molecules into simpler monomers (a molecule that can be bonded to other identical molecules to form a polymer).

Bases cause oils and fats to fall apart. Your digestive system uses bile, a basic compound to help in the digestion of fats and grease. Oven cleaners and drain cleaners contain lye, a strong base that dissolves baked on grease and burned fats.

Questions

1. A student mixes strawberry Koolaid® and water. A pH meter is used to measure pH of 5.4. What kind of solution is strawberry Koolaid®?

2. In the Koolaid® mixture, what must there be more of, hydrogen ions or hydroxide ions?

3. A student adds an Alka-Seltzer® to the Koolaid® and stirs. The pH meter now reads 8.3. What was released by the Alka-Seltzer® tablet to cause this change?

4. Baking soda is a weak base. Hydrochloric acid is a strong acid. What would happen if these two were mixed?

5. Bromthymol blue is a chemical indicator that is blue in basic and neutral solutions, and turns greenish and then yellow as the solution becomes more and more acidic. Fill in what color you think bromthymol blue would be in each of the situations in the chart.

Situation	pH	Bromthymol blue indicator
Water directly out of tap	pH =7.2	
pH after exhaled air is blown through a straw into water for 5 min.	pH=5.1	
pH after a snail has lived in water for three days	pH=5.8	
pH with 2mL of bleach added to the water	pH=9.4	
pH with instant coffee added to the water	pH=5.0	
pH after an aquatic plant is grown in water for three days in bright sunlight	pH=7.7	

What effect does carbon dioxide have on tap water?

Is bleach an acid or a base?

Is coffee an acid or a base?

Answer Key for Outcome #5

1. A student mixes strawberry Koolaid® and water. A pH meter is used to measure pH of 5.4. What kind of solution is strawberry Koolaid®? ACID

2. In the Koolaid® mixture, what must there be more of, hydrogen ions or hydroxide ions? Hydrogen / H+

3. A student adds an Alka-Seltzer® to the Koolaid® and stirs. The pH meter now reads 8.3. What was released by the Alka-Seltzer® tablet to cause this change? Hydroxide ions /OH-

4. Baking soda is a weak base. Hydrochloric acid is a strong acid. What would happen if these two were mixed? The acid would become a weaker acid with a higher pH than before

5. Bromthymol blue is a chemical indicator that is blue in basic and neutral solutions, and turns greenish and then yellow as the solution becomes more and more acidic. Fill in what color you think bromthymol blue would be in each of the situations in the chart.

Situation	pH	Bromthymol blue indicator
Water directly out of tap	pH =7.2	Blue
pH after exhaled air is blown through a straw into water for 5 min.	pH=5.1	yellow
pH after a snail has lived in water for three days	pH=5.8	greenish
pH with 2mL of bleach added to the water	pH=9.4	blue
pH with instant coffee added to the water	pH=5.0	yellow
pH after an aquatic plant is grown in water for three days in bright sunlight	pH=7.7	blue

What effect does carbon dioxide have on tap water? Adding pressurized CO2 to water (carbonation) makes the water fizzy, such as in soda pop. CO2 also makes the water slightly acidic.

Is bleach an acid or a base? base

Is coffee an acid or a base? acidic

Outcome #5: Breathing Bubbles Experiment Directions

Provide students with pH worksheet to give basic understanding of pH before beginning. After this activity, students should be able to:

- Describe the effects of cellular respiration on pH.
- Explain how engineers use pH to measure cellular respiration in bioremediation of contaminated soils.

Materials List

Each group needs:

- 4 small clear plastic cups
- 2 straws
- 1 spoon
- Breathing Bubbles Worksheet

To share with the entire class:

- water
- red cabbage indicator solution (Instructions: Chop a cabbage into small pieces and steep in boiling water for at least 10 minutes. Then, filter out the cabbage pieces using a coffee filter or tea strainer. You should be left with a bluish/purple solution at neutral pH.)
- 4 clear different solutions to measure pH (examples: diluted lemon juice and/or vinegar, baking soda mixed with water, water, soda pop, etc.)
- pH meter (if available) or pH paper strips (optional)
- plastic gloves (optional)

Introduction/Motivation

What do you know about *pH*? The pH of a solution is a measure of how much *acid* or *base* is in a solution. A low pH corresponds to an acidic solution, and a high pH corresponds to a basic solution. As a point of reference, a neutral pH would be 7. What is an example of a solution with a low pH? This would be anything acidic, such as citrus fruit or vinegar (remember: low pH equals high acidity). What solution has a neutral pH? Distilled water is a solution that has a perfectly neutral pH. What is an example of a solution that has a high pH, or is basic? Basic solutions would include baking soda, ammonia and bleach (remember: high pH equals low acidity, or is basic). pH measures the amount of hydrogen ions in a solution. Lots of hydrogen ions form an acidic solution, and fewer hydrogen ions form a basic solution.

Did you know that cellular respiration has a pH value? When a cell goes through cellular respiration, it consumes oxygen and produces CO_2 which lowers the pH of water (forming an acidic solution). On the other hand, when cells go through photosynthesis, they produce oxygen, which raises the pH of water (forming a basic solution).

Bioremediation is a process whereby engineers use something living, like a microorganism, fungus or green plant, to return a polluted environment back to its original state. During bioremediation, some cells can use certain types of pollution as food for cellular respiration, to create energy for growth, life and reproduction. How do you think engineers can use pH to measure bioremediation? Well, pH tells us about the chemistry of water and soil. Engineers can test the pH of an area to determine if bacteria or other cells are growing and performing cellular respiration in the area. If the pH is very acidic, then cellular respiration may be occurring (or the water may be acidic due to the presence of inorganic acids). The organisms that engineers use for bioremediation are microscopic. So, it is hard to detect them directly. It is much less expensive and faster for engineers to measure the pH that bacteria cells produce when they grow and reproduce in the environment than to develop complex equipment to detect their presence. If you measure the pH of a polluted system and then add microorganisms in order to eat up the pollution, the pH of the system should decrease over time as the microbes do their job. This decrease in pH provides evidence that the bioremediation is proceeding as it should.

Today we are going to measure the pH of a variety of solutions and then measure how much CO_2 we breathe out when we are resting and when we are exercising. First, we are going to test our pH indicator on four different solutions by adding a few drops of the indicator to each solution. Once we have determined which solutions are acidic, basic or neutral, we will try to identify the solutions as a class. Next, we will measure how much CO_2 we produce when we are resting and exercising, using the same indicator we used to determine the identity of the four solutions. Lastly, we will think about how we can use pH to help engineers optimize bioremediation.

- Gather materials and make copies of the Breathing Bubbles Worksheet.
- Make the red cabbage indicator solution the day before. (See instructions in Materials List section)

With the Students

1. Pass out materials to students. Have them line up their four cups to receive the "unknown" solutions.
2. Pour samples of four unlabeled solutions, one in each cup, to each team of students. Have students use the indicator to assign identities to four clear solutions by adding a spoonful of indicator into the solution until it turns color. For acidic solutions, the indicator should turn red, and for basic solutions the indicator should turn blue. Have students record their observations on their worksheets.
3. Next, have students thoroughly rinse their cups. Pour cabbage juice indicator into all four of the cups, about halfway full.

4. Remind students that CO_2 is produced during cellular respiration and O_2 is consumed. This results in an acidic solution being created. Have students record on their worksheets the color of the cabbage juice indicator before the experiment begins.
5. Next have each student breathe into one cup of the indicator solution through the straw, remembering not to drink the indicator but blow into it. Record the number of breaths that it takes to turn the indicator to an acidic pH.
6. Next, have students sprint, briskly walk up and down stairs, or do some jumping jacks.
7. Have the students repeat the process of breathing into the indicator solution through the straw, and record how many breaths it takes to turn the solution to an acidic color after exercising.
8. Have students report their results to the class and record the results on the board.
9. Next, have students answer the results and engineering questions on their worksheets.
10. As a class, discuss how engineers can use a similar technique to measure the amount of microbial activity in the water or in the soil where a toxic spill has occurred. Engineers can save time and money by measuring changes in pH after they have added bacterial cells or plants to a bioremediation site instead of trying to culture organisms in the lab.

Outcome #5: Breathing Bubbles Worksheet

Observations

Record the pH colors of the **four unknown solutions**. What do you think each solution is?

Solution #1: color of indicator: _______________ What is it? __________________

Solution #2: color of indicator: _______________ What is it? __________________

Solution #3: color of indicator: _______________ What is it? __________________

Solution #4: color of indicator: _______________ What is it? __________________

What is the color of the indicator *before breathing into it*? _______________

Record **how many breaths** it takes to change the indicator color (list results in table below):

	Number of Breaths	
	At rest…	**After exercising…**
Trial 1 (partner #1)		
Trial 2 (partner #2)		

Results

What color did the indicator change? Why?

____

____

Did the indicator change more quickly after exercising or at rest? Why?

____

____

Did the indicator change more quickly depending on which partner was blowing in the straw? Why?

____

____

Outcome #5: Optional Post-Activity Discussion (Breathing Bubbles)

Engineering and Bioremediation Costs: Bioremediation has many cost and efficiency benefits. Have students think about how the expense and resources put into bioremediation might be different than developing tools and equipment to remove contaminants from soils and water. Have them write a paragraph or hold a class discussion comparing bioremediation vs. land removal in contamination cleanup. Use the following questions to frame the advantages and disadvantages of the two remediation options systematically:

- What materials are needed for land removal? (Excavation equipment, usually a backhoe to dig out the soil, a giant bin to store the excavated soil, and a large truck to transport the excavated soil to the appropriate disposal facility.)
- Which remediation option (bioremediation or land removal) do you expect to be less expensive? (There are fewer costs associated with bioremediation because biodegradation is a naturally occurring process. Engineers harness the ability of microbes or larger organisms such as plants to degrade contaminants during bioremediation.)
- Can we use bioremediation at any contaminated site? What conditions must be present for bioremediation to be effective? (Microbes must be present at the contaminated site in order for bioremediation to be possible. Alternatively, microbes can be introduced to the site, but the success rates with non-native microbes are much lower.)
- Which remediation option has a higher likelihood of failure? (There are more variables influencing the success of bioremediation; for example, if the soil conditions and the contaminant are not conducive to microbial growth, then bioremediation will not work. Land removal is more straightforward and predictable because to eliminate the contaminant, all you have to do is excavate the soil.)

Engineering Recommendations: Have students pretend to be consultants for an engineering firm for one of the following scenarios. Ask the students to make recommendations about how to monitor the bioremediation of the area based on what they learned during this activity.

- A piece of land contaminated with heavy metals and oils from an old industrial factory.
- A former shipyard that has leaking barrels of oil in one area.
- A piece of farmland that has been previously treated with several harmful pesticides.
- A piece of land that has been contaminated with soaps and solvents used by a dry cleaning company.
- A nuclear waste site that has very high amounts of radioactive materials leeching into the soil and groundwater.

Outcome #6 Earthworm Problem Statement

You are now an earthworm. You live in Illinois. You have many questions about your life as an earthworm. Develop as many questions as you can to ask your teacher. You will record these questions on the student earthworm sheet. The questions require a yes or no response. If you ask a question that is not a yes or no question the teacher will ask you to restate the question. After the teacher answers the question you will circle either the yes or no response.

Example: 1. Do I eat leaves? Answer: yes

Outcome #6 Earthworm Student Sheet

Name: ______________________

Directions: Your job is to develop questions you need to know about earthworms to obtain more information. Write your questions under the student question column. Your instructor is only allowed to answer yes, no, or that you need to restate the question. When your instructor answers your question you will circle the response yes or no. The challenge is to ask good yes or no questions pertaining to earthworms. You need to get as much information as possible on your own.

Student Questions	**Teacher Response**
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No
	Yes or No

Outcome #7 Making Muscles Move

Name: ______________________ Date: ________________

Making Muscles Move Part A:

In this activity, you'll make models of your arm muscles and explore how they work.

Materials:

- Two cardboard strips, 2 inches by 6 inches (cereal boxes work well for this)
- Two paper fasteners
- Tape
- A hole puncher
- A red balloon and a blue balloon

Methods:

1. Punch a hole in each cardboard strip, about 1.5 inches from the end, and in both ends of each balloon.

2. Tape the two strips together end to end so that the holes are about 3 inches apart. The strips will bend like a joint on the taped side. (One strip represents the upper arm; the other represents the lower arm; the joint represents the elbow.)

3. With a paper fastener, attach the two balloons to opposite sides of the "upper arm," with the red balloon on the taped side. Attach the other end of each balloon to the "lower arm" in the same way.

4. Bend the "arm" at the "elbow," noticing what happens to the balloons.

Conclusion Questions

1. What happens to the red balloon when the blue one contracts? What happens to the red balloon when the blue one relaxes?

2. How does this model how muscles work together?

3. How does this model show how muscles move bones?

4. What type of simple machine have you made?

Name: ____________________ Date: _______________

Making Muscles Move Part B:

In this activity, you'll stretch your muscles. As you do the stretches, focus on which muscle(s) are being stretched. When you have finished each stretch, write down the name of the muscle you stretched beside the description of the stretch.

Stretch 1:____________________

Hold your arm out in front of you and grasp something that is at your shoulder height. Turn your body away from what you have grasped. Where do you feel the stretch? Switch arms.

Stretch 2:___________________

While sitting on the floor with your legs in front of you reach for your toes. Go as far as you can until you start to feel a pull. What muscle is pulling?

Stretch 3:___________________

Have a partner hold your wrists and slowly bring your hands together behind you until you say stop. What muscles are being stretched?

Stretch 4:___________________

While standing on one foot, bring the other foot up to hold one ankle in your hand pointing your knee to the ground. Switch legs. What muscle are you stretching?

Stretch 5:___________________

Lift your arm and place your hand on the middle of your back. Your elbow should be facing upward towards the ceiling. Pull on your elbow to feel the stretch. Switch arms. In what muscle do you feel the stretch?

Stretch 6: ___________________

Go to your hands and knees and round your back like you might see a kitten do when it is stretching after a nap. What muscles are being stretched?

For reference: An interactive site describing each of the human muscles and what they do: http://www.innerbody.com/image/musfov.html

Outcome #8 International Space Station worksheet

Name: ___________________________________

Procedure 1: Use either the Occupational Outlook Handbook website (http://www.bls.gov/oco) or the NASA Astroventure website (http://astroventure.arc.nasa.gov) to learn about your assigned career.

Fill in the information about your career below.

Career: ____

Salary Range:____

Summary of Job Description: ____
____

Educational Requirements: ____
____

Procedure 2: Now that you have learned about your career you need to learn about the International Space Station (ISS). Use the following sites to help you answer the individual questions.

• Building the ISS - European Space Agency (ESA)
http://www.esa.int/esaHS/ESARW78708D_iss_0.html

• ISS History - Canadian Space Agency (CSA)
http://www.space.gc.ca/asc/eng/iss/default.asp

• Living in Space - National Aeronautics and Space Administration (NASA)
http://spaceflight.nasa.gov/living/index.htm

• ISS - (NASA) http://www.nasa.gov/mission_pages/station/main/index.html

• ISS Space Lab - Japan Aerospace Exploration Agency (JAXA)
http://www.jaxa.jp/missions/projects/iss_human/index_e.html and
http://www.jaxa.jp/missions/projects/iss_human/iss/index_e.html

Outcome #8 Individual Questions

1. What is the International Space Station and who built it?

2. How is your career related to the International Space Station? Remember the space station had to be planned, then built, and sent to space and assembled before we could use it as we do today.

3. Name two things that make living in space difficult. How do the astronauts on the International Space Station deal with these challenges?

4. You hear a neighbor say, “The government spends too much money on space exploration!”

a. What would you say to this? Explain your point of view using specific examples.

b. If we did not spend this money to explore space, what do you think would happen to all the people who work for, sell to, or deliver equipment to NASA? Explain your point of view using specific examples.

Outcome #8: INTERNATIONAL SPACE STATION CAREERS

Food Scientist	Computer Programmer
Industrial Engineer	Carpenter
Psychologist	Journalist
Astronaut	Pilot Mechanic
Astronaut	Astronomer
Construction Engineer	Banker
Water Conservationist	Plumber
Physician	Electrician
Interior Designer	Photographer
Biochemist	Publisher
Nutritionist	Physical Fitness Trainer
Atmospheric Chemist	Astrophysicist
Botanist	Aerospace Engineer
Software Engineer	Human Factors Researcher
Project Manager	Executive Manager
Meteorologist	Microbiologist
Occupational Therapist	Satellite Manufacturers
Satellite Operators	Facility Operations
Flight Controller	Safety Engineer
Security	Insurance Agent

Outcome #8

The Slinky®

It was a mistake. A goof-up. An invention that didn't work. A flop; that's what the Slinky® was, at least in the beginning.

In 1945, an engineer by the name of Richard James was hard at work in a Philadelphia shipyard. The U.S. Navy had hired him to invent a stabilizing device for its ships. When a ship is plowing through the waves at sea, it pitches and plunges and rocks every which way. And its navigational instruments do, too. Richard's job was to come up with something that would counterbalance the instruments so that they would be level at all times. Springs! Richard believed that some sort of arrangement of springs would do the trick. He tried all different types and sizes, and put them together in every conceivable way. For weeks he toiled, making dozens of different devices. But none of them worked. In fact, he never did come up with the item the Navy had hired him to invent.

But one day Richard accidentally knocked a large experimental spring off a shelf. It should have just plopped to the floor. Instead, it walked down. Crawled, really. Coil by coil, end over end, it descended onto a stack of books…then down to a desktop…down to a chair…and from there to the floor, where it gathered itself back together.

He tried it again and again. Each time, the same thing happened.

As soon as the workday was over, Richard hurried home. Fascinated with the strange spring, he showed his wife, Betty, what it could do. Together, they tried it out in all sorts of ways and in all sorts of places. It was especially good at walking down stairs.

A toy?

Richard didn't think of it that way. Betty did. She was the one who realized that what her husband had invented was a terrific toy. Betty was also the one who named it.

At first, all sorts of names came to mind, but none seemed quite right. For the next two days she thumbed through a dictionary, keeping a list of some of the best possibilities. Finally, she came upon what she believed was the perfect word to describe the toy: slinky.

Slinky® Tidbits

- Betty James, CEO of James Industries and widow of Slinky inventor Richard James, named the famous toy. She scanned the dictionary for ideas and knew she'd found the perfect name with "Slinky," which is Swedish and means stealthy, sleek, sinuous.
- Some very innovative uses have been found for the Slinky. It has been used in pecan-picking devices in Texas and Alabama; on lighting fixtures in Harrah's Casino in Las Vegas because of the unusual shadows it casts; and as table decorations, drapery holders, bird repellers, mail holders, therapeutic devices, wave motion coils, gutter protectors, and in numerous other ways. Also, the Slinky sometimes is prescribed by physical therapists for coordination development.
- During the Vietnam War (early 1960s-1975) the Slinky reverted to its original role. First intended for the military, the toy ended up on the battlefield. Carried by radioman in the jungles of Vietnam, Slinkys were tossed over high tree branches as make-shift antennas.
- The amount of wire used since 1943 to make Slinkys could wrap around the Earth 126 times.
- Fifty years after its invention, the Slinky sells for only about twice the one dollar it originally cost.
- The Slinky has appeared in several movies, including *Ace Ventura: When Nature Calls*, *Demolition Man*, *Other People's Money*, and *Hairspray*, and the Slinky® Dog played in *Toy Story.*
- There are about eighty feet of wire in a standard-sized Slinky.
- It takes approximately ten seconds to manufacture one Slinky.
- Slinky's most recent accomplishment was in outer space. Bunches have gone aboard space shuttles. The purpose: to test the effects of zero gravity on springs.

From <u>Toys! Amazing Stories Behind Some Great Inventions</u> by Don Wulffson

Slinky Classroom Exercises

In addition to being a terrific toy, the Slinky is an excellent device for demonstrating various properties of physics.

The Slinky, like all objects, tends to resist change in its motion. Because of this *inertia*, if placed at the top of stairs it stays at rest. At this point it has *potential or stored energy*. But once it is started down the stairs and *gravity* affects it, the potential energy is converted to the *energy of motion or kinetic energy* and the Slinky gracefully tumbles coil by coil down the stairs.

Physical properties of the Slinky determine how quickly it moves under the influence of *gravity*. Although its movement may look simple, from a scientific point of view the motion is quite complex.

Exercise #1: Racing Slinkys

In this activity, inertia, gravity, potential energy, kinetic energy, and longitudinal waves are demonstrated when the Slinky "walks" down stairs or an incline.

Materials:

- A large slinky
- A small slinky
- Stairs or books stacked

Procedure:

1. Show the class two Slinkys of different sizes and ask which one they think will win a race down stairs or an incline. (Graduated stacks of books work well; also any board or table top with a non-slip surface will do. Slope surface so rise equals about 1 foot for every 4-foot length.)

2. Place both Slinkys on the top stair or top of a ramp. Ask why the Slinkys remain motionless. What will it take to get them in motion? (Newton's first law of motion: *A body at rest will remain at rest unless an external force acts upon it. A body in motion will remain in motion in a straight line at a steady speed unless an external force acts upon it.*)

3. Grip a coil of each Slinky at the top and flip it over toward the middle of the next lower step, releasing your hold (with this action, potential energy is converted to kinetic energy). The Slinkys race downward all by themselves.

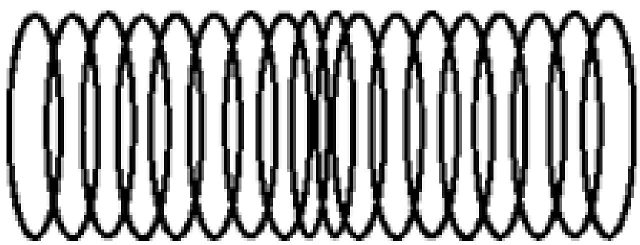
4. After the race, ask why the smaller Slinky won. (As the Slinky moves down the steps, energy is transferred along its length in a longitudinal or compressional wave which resembles a sound wave that travels through a substance by transferring a pulse of energy to the next molecule. How quickly the wave moves through the Slinky depends on the tension and mass of the coil. The smaller the mass, the tighter the tension; the tighter the tension, the faster the wave speed. So, the wave moves faster through the smaller Slinky.)

Exercise #2: Slinky Waves

A Slinky can easily demonstrate the two basic types of waves, *longitudinal* and *transverse*, as well as several others. A longitudinal wave vibrates parallel to (in the same direction of) wave travel (sound waves are a good example). A transverse wave vibrates perpendicular (at right angles) to the wave travel (water waves are a good example).

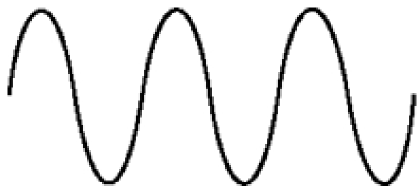
To demonstrate the types of waves:
Have two students each take one end of a Slinky and stretch it out along the floor (the waves will be more apparent this way).

Longitudinal Waves. Have one student grasp and draw toward himself or herself several coils of a stretched <u>metal</u> Slinky and then release the coils. The other student must hold his or her end of the Slinky still. A longitudinal wave pulse will be generated and travel downs the length of the Slinky.

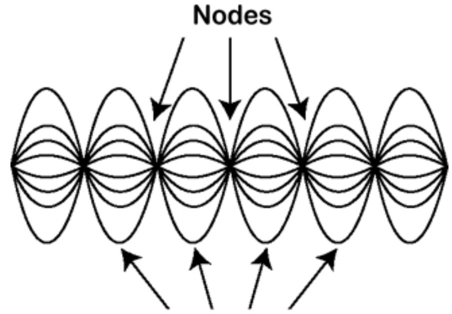


Longitudinal Waves

Transverse Waves. Have one student move his or her end of a plastic or metal Slinky back and forth (left and right, like a snake crawling), perpendicular to its stretched length. The other student must hold his or her end of the Slinky still. A series of transverse waves will be generated.



Standing Waves. When a series of wave pulses are sent through a medium and then reflected back upon themselves, *standing waves* can be generated, as demonstrated in the space shuttle footage in the video, *Slinky Scientific Shindig*. These distinctive waveforms have places where the medium does not vibrate at all, called *nodes*, and other places where the medium vibrates the most, called *antinodes*. When the students are demonstrating transverse waves, standing waves with varying numbers of nodes and antinodes can be generated by having the student moving the Slinky vary the rate at which he or she continually moves it back and forth.



Compressions and Rarefactions. Longitudinal waves can be composed of *compressions*, where the parts of the medium (coils of the Slinky) are closer together than normal, or *rarefactions*, where the parts of the medium are farther apart than normal. In the above demonstration, the students created compressional longitudinal waves. A rarefactional longitudinal wave can be produced by stretching a segment of the Slinky and then releasing it.

The stretched area (rarefaction) will then travel along the length of the Slinky.

Across the Curriculum Instruction Extensions

Science
- Discuss springs and where they are used and their purposes
- Find springs in items we use everyday
- Use simple machines to make daily tasks easier
- What else can Slinkys® be made of?
- Radio waves – what are they, how do they work
- Space – discuss Slinkys used in space and why
    - zero gravity
    - space shuttle
    - the solar system

Social Studies
- Patents – what are they and how do you get one, why do we have them?
- Vietnam War – Why was this war so controversial?
  Who was involved in it?
  When was it fought and what was the outcome?
  Vietnam Memorial – Where is it and what does it look like?

Math
- Math problems using the length of manufacturing time – how many could you make in a minute, an hour?
    - How many feet of wire would you need to make 10 Slinkys, etc.?
    - Production costs – you sell them for $2 a piece, it costs you $0.25 in materials, decide how much you think labor and marketing cost and how much money you make; How many do you have to manufacture and sell to make $1,000,000?

Reading
- Read the excerpt on Slinkys® and ask critical thinking questions.
- Read about any of the above topics in an effort to research additional information on any of these areas.
- Read about inventors and their inventions and patents. Especially focus on inventors who failed many times but persevered such as Thomas Edison and the lightbulb.

Writing
- Write about a time a situation didn't go as planned but some surprise good came of it.
- Write about an inventor after researching his/her life & report to the class.

Outcome #9

Student Study Guide: Nature of Sound, Properties of Sound, and Combining Sound Waves

The nature of sound:

Key points:

- Sound comes from a series of vibrations and travels through a medium (such as the air) in waves.

- The speed of sound depends on the elasticity, density, and temperature of the medium.

Vocabulary:

- Elasticity describes how quickly a medium's molecules return to their original positions after being disturbed by sound waves. Molecules that return to their original shape quickly are ready to move again more quickly. Therefore, they can vibrate at higher speeds. Sound can travel faster through mediums that vibrate faster.

- Density describes the mass of a substance per unit of volume. Sound waves travel faster in less dense materials than in more dense materials.

- Temperature refers to the heat of a medium. Molecules at higher temperatures have more energy, and therefore can vibrate faster. As a result, sound waves can travel more quickly through warmer mediums.

Properties of sound:

Key points:

- A sound wave with a higher intensity sounds louder than one with a lesser intensity. Loudness is measured in decibels.

- Pitch depends on the frequency of the sound wave.

Vocabulary:

- Intensity – the amount of energy a sound has over an area. The same sound is more intense if you hear it in a smaller area. In general, we call sounds with a higher intensity louder. Intensity is measured in decibels.

- Loudness cannot be assigned a specific number, but intensity can. The human ear is more sensitive to high sounds, so they may seem louder than a low noise of the same intensity.

- Decibels (dB) – The unit of measurement for the intensity of sound. A whisper is about 10 decibels while thunder is about 100 decibels.

- Pitch helps us distinguish between high and low sounds. Pitch depends on the frequency of a sound wave. (In music, we can see how four different properties affect the pitch of a stringed instrument: length, diameter, tension, and density. A string with a greater diameter – a thicker guitar string, for example – will produce a lower pitch than one with a lesser diameter.)

- Frequency – the number of wavelengths that fit into one unit of time. (Usually measured in number of vibrations per second.)

- Doppler effect – the principle that explains why we hear sounds differently when we, or the source of a sound, are moving.

- Ultrasound – sound waves with frequencies so high they are above the range we can normally hear.

- Infrasound – sound waves with frequencies so low they are below the range we can normally hear.

Combining sound waves:

- Musicians combine tones to create a desired effect in the listener (pleasure, sadness, etc.)

- Timbre is the quality of a sound that can't be described by its pitch or loudness. Musicians sometimes refer to timbre as the "color" of a sound.

Most information in this study guide is from the NDT Resource Center website "Introduction to Sound," copyright 2001 Iowa State University. http://www.ndt-ed.org/EducationResources/HighSchool/Sound/introsound.htm Courtesy of NDT Resource Center, Iowa State University.

Outcome #9

Musical Notes

Musical instruments produce sound by setting up standing waves. Those waves can be on a string or in a column of air. In this lab, you will see how you can use bottles to produce different musical notes, maybe enough to play a simple tune.

Problem: How can you produce different notes with bottles of water?

Methods: predicting, observing, inferring

Materials:
- 3 identical glass bottles
- Water
- Masking tape
- Marking pen
- Pencil

Procedure:

1. Label the bottles A, B, and C

2. Put water in each bottle so that bottle A is one-fourth full, bottle B is half full, and bottle C is three-fourths full.

3. Measure the distance from the top of each bottle to the surface of the water. Then measure the height of the water in each bottle. Record your measurements.

4. Predict the difference in pitch you will hear if you blow across the top of each bottle in turn. Give reasons for your predictions.

5. Test your prediction by blowing over the top of each bole. Listen to the sound you produce. Describe each sound in terms of its pitch—low, medium, or high. Record the pitch of each sound.

6. When you gently tap the side of a bottle with a pencil, you produce another sound. Do you think the sound will be similar to or different from the sound produced by blowing across the top to the bottle? Explain.

7. Test your prediction by tapping on the side of each bottle with a pencil. Record the pitch of each sound.

Outcome #9

Data recording worksheet

BOTTLE	LENGTH OF COLUMN OF AIR (cm)	HEIGHT OF WATER (cm)	PITCH PRODUCED BY BLOWING ACROSS TOP OF BOTTLE	PITCH PRODUCED BY TAPPING PENCIL ON SIDE OF BOTTLE
Bottle A				
Bottle B				
Bottle C				

1. Look at your data table. How does the length of the column of air affect the pitch?

2. Based on your observations in this lab, what statements can you make about the relationship between the sounds produced and the medium through which the sound travels?

3. Can your group figure out how to play a simple melody or create one of your own, like a musician or composer? Try with your group to create a beat of three or four notes that repeat with a pleasing sound. If you don’t think music is a future career for anyone in the group, cheat and see if you can sound out the notes to a simple children’s song like “Mary Had a Little Lamb,” “Twinkle, Twinkle Little Star,” or the ABCs.

Outcome #9

Analyze and Conclude

1. Describe how the sound is produced in Step 5. Which bottle produced the highest pitch? Which bottle produced the lowest pitch?
2. What caused the change in pitch from bottle to bottle?
3. Describe how the sound is produced in Step 7. Which bottle produced the highest pitch? Which bottle produced the lowest pitch?
4. What caused the change in pitch from bottle to bottle? What change in pitch can you produce by tapping on a different part of the bottle?
5. Compare the sounds you produced by blowing across the bottles with those produced by tapping on the bottles. What was the difference in pitch for each bottle? Explain your observations.
6. Look at your data table. How does the length of the column of air affect the pitch? How does the height of the water affect the pitch?

Think About It

Based on your observations in this lab, what statements can you make about the relationship between the sounds produced and the medium through which the sound travels?

Extension Activity

To play simple tunes, you will need eight notes. Set up a row of eight bottles, each with a different amount of water. Adjust the water level in each bottle until you can play a simple scale. Practice playing a simple tune on your bottles.

Adapted from a lesson at http://wsfcs.k12.nc.us/cms/lib/NC01001395/Centricity/Domain/2398/Lab%20Musical%20Notes.pdf

Outcome #10

Energy Transfer Relationships

Materials Needed:

- *Occupational Outlook Handbook* published by the U.S. Department of Labor
    - http://www.bls.gov/ooh/
- One sheet of white paper for each student
- For each student, one copy of each of the student handouts:
    - "Skateboard Scenario"
    - "A Bright Idea: Energy Conservation"
    - "Energy Job Information Sheet"
- Light bulb
- Pencils

Directions:

1. Instruct the students to make a foldable with the white paper. First, fold the paper hotdog style, then fold in half, and fold in half one last time.
2. Have students label the top of the boxes with the following vocabulary words: energy, kinetic energy, potential energy, mechanical energy, thermal energy, conversion, friction, law of conservation of energy.
3. Use the examples from the vocabulary teacher reference page to give the students notes on energy.
4. Instruct students to record their vocabulary definitions and examples on their foldable.
5. Show the class a light bulb and ask what career would relate to the light bulb and energy. (Electrician)
6. Using the sheet "A Bright Idea: Energy Conservation," lead the class in a discussion on energy conservation.
7. As you discuss energy conservation, instruct students to fill in key words on the student handout "A Bright Idea: Energy Conservation."
8. Have students look at the "Skateboard Scenario" student handout, and read the scenario to the class.
9. Put the students in groups of four or five.
10. Have students discuss the answer within their groups, and then check for understanding.
11. Assign one of the following careers to each student: automotive systems technician/race car performance, power plant operator, mechanical engineer, nuclear engineer, petroleum engineer, biomedical engineer, or hairdresser.
12. Instruct students to complete the "Energy Job Information Sheet" according to their assigned careers.

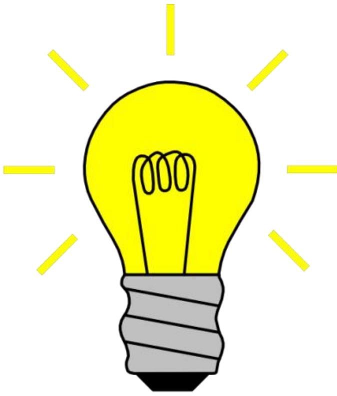
Outcome #10

Skateboard Scenario

You are in Glen Ellyn, Illinois, at the new skateboard park. As your left foot stays on the skateboard, you push your right foot off the payment. Next, you quickly jump on the skateboard and pick up speed going down the halfpipe. As you are moving on your skateboard, you are the source of the kinetic energy. When you reach the top of the half-pipe, your potential energy is at a maximum. How did you get so high up? What happens to the energy when you begin to speed down the bottom of the half-pipe? How does this relate to energy conversion?

Outcome #10 A Bright Idea: Energy Conservation

Name: ____



Some energy is converted into ________________________ energy. After awhile, this makes the lightbulb _______________________________.

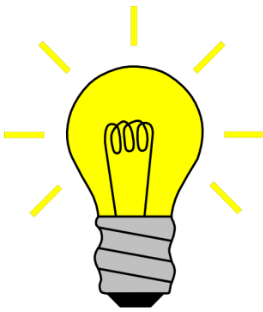
____________________________ energy is transmitted through the wire. Part of the energy is changed into _________________________ energy.

Only about ___________________________ of the energy is converted into ________________________________ energy.

Remember: The overall amount of energy in a closed system always remains the same. As in the lightbulb example, energy can change from one form to another form. All the different forms of energy in a system always add up to the same total amount of energy. It does not matter how many energy conversions occur.

Outcome #10 A Bright Idea Answer Key

Found in:http://www.learnnc.org/lp/media/uploads/2008/01/9energy_teacher_ref.pdf



Some energy is converted into thermal energy. After awhile, this makes the lightbulb hot.

Electrical energy is transmitted through the wire. Part of the energy is changed into thermal energy.

Only about one-tenth of the energy is converted into light energy.

Teacher Reference Pages

Critical vocabulary:

1. Energy: The ability to do work
2. Potential energy: The energy an object has because of its position
3. Kinetic energy: The energy of motion
4. Energy conversion: Change form one form of energy to another
5. Friction: The force that opposes motion between two surfaces that are touching each other
6. Law of conservation of energy: Energy cannot be created or destroyed, but only changed from one form into another
7. Mechanical energy: Total energy of motion and position of an object
8. Thermal energy: Internal kinetic energy due to the random motion of particles that make up an object

Relevant page numbers for the Occupational Outlook Handbook (or use resources form the website, http://www.bls.gov/oco)
[NOTE: The page numbers below refer to the 2004-2005 edition of the book.]

Career	Page number
Automotive systems technician/Race car performance	136.521.523.596
Power plant operator	582
Water transportation occupations	634
Mechanical engineer	136
Nuclear engineer	137
Petroleum engineer	138
Biomedical engineer	128
Hairdresser	368
Machinists	575
Water & liquid waste plant system operators	600
Forest conservation	478
Hazardous materials removal workers	507
Diesel service technicians and mechanics	541

Outcome #10 Energy Job Information Sheet

Career Title:

____

Daily duties of this career:

____
____
____
____
____
____

Education/Training needed to perform your job:

____
____
____
____

Special experience needed:

____
____
____

Employment outlook for the next ten years:

____
____

Salary for your work:

____
____

Previous interests that lead you to your career:

____
____

List three ways you use energy. What could you do to conserve electricity?

____
____
____

Outcome #11

What Is Your Lung Capacity?

Materials Needed:

- Computer with internet connection
- Multimedia projector
- Athletic trainer overview from the Bureau of Labor Statistics' *Occupational Outlook Handbook* **Optional:** If you don't have access to the internet or a multimedia projector, you may copy the athletic trainer information onto a transparency or make it into a handout.
- Meter sticks
- Round balloons (Be aware of any latex allergies.)
- String
- Scale (optional)
- Student handout: "What Is Your Lung Capacity?" activity directions, data sheet, and conclusion questions — one copy for each student

Activities

1. Project the information about athletic trainers (or pass it out to the class). Discuss the career with the class.
2. Explain what lung capacity is and why it is important. (The amount of air your lungs can hold or the combination of different lung volumes. An average pair of lungs can hold 6 liters of air, but only a small amount of that is used in normal breathing. Lung capacity enables your body to get oxygen when it is needed.)
3. Brainstorm professions where it would be extremely important to have good lung capacity. (Examples may include firefighters, athletes, fitness instructors, coaches, referees/umpires, chefs, day care workers, military careers, musicians, etc.)
4. Discuss what factors can affect lung capacity. (You could ask students to research this before the discussion takes place or you can have the class brainstorm. Examples of things that could affect lung capacity include a person's height, whether a person smokes, the altitude where a person lives, gender, athletic activity, diseases of the lungs, etc.)
5. Hand out the "What Is Your Lung Capacity?" activity directions and the data sheet. Have students work in groups to determine their lung capacity following the instructions on the activity sheet. It may be necessary for one or two students in each group to be subjects with other group members recording the data.

Outcome #11 What Is Your Lung Capacity?

Name: ___________________________ Date: ________________

Your lung capacity is the amount of air your lungs can hold or the combination of different lung volumes. This activity will address two different types of lung volumes: Tidal volume and vital capacity. Tidal volume is the amount of air you breathe in or out during a normal breath. Vital capacity is the amount of air that can be forced out of your lungs when you take a very deep breath. Your lung capacity allows you to provide your body with the oxygen it needs. In this activity, you'll examine your lung volumes at rest and after you have completed a set of exercises.

Materials Needed:

- Meter sticks
- Round balloons (be aware of any latex allergies)
- String Scale (optional)

Methods:

1. To measure tidal volume, take a normal-size breath and exhale it into the balloon. Do not force extra air into the balloon. Twist the balloon to keep the air in. Do not tie the balloon.
2. Take the string and use it to measure the diameter of the largest part of the balloon in centimeters. Record the number in the "resting" data table.
3. Repeat two more times, and average the tidal volume.
4. To measure vital capacity, inhale deeply taking in as much air as your lungs can hold and exhale it into the balloon. Twist the balloon to keep the air in. Do not tie the balloon.
5. Take the string and use it to measure the diameter of the largest part of the balloon in centimeters. Record in the "resting" data table.
6. Repeat two more times, and average the vital capacity.
7. Jog in place for two minutes.
8. To measure tidal volume, take a normal-size breath and exhale it into the balloon. Do not force extra air into the balloon. Twist the balloon to keep the air in. Do not tie the balloon.
9. Take the string and use it to measure the diameter of the largest part of the balloon in centimeters. Record in the "jogging" data table.
10. Repeat two more times, and average the tidal volume.
11. To measure vital capacity, inhale deeply taking in as much air as your lungs can hold and exhale it into the balloon. Twist the balloon to keep the air in. Do not tie the balloon.
12. Take the string and use it to measure the diameter of the largest part of the balloon in centimeters. Record in the "jogging" data table.
13. Repeat two more times, and average the vital capacity.
14. Convert the diameters and the averages you measured to volume using the graph and record in the data tables.
15. Answer the conclusion questions.

Outcome #11 Data Tables

Data Table: Resting

	Tidal Volume	**Tidal Volume**	**Vital Capacity**	**Vital Capacity**
Trial	Diameter in cm	Volume	Diameter in cm	Volume
1				
2				
3				
Average				

Data Table: Jogging

	Tidal Volume	**Tidal Volume**	**Vital Capacity**	**Vital Capacity**
Trial	Diameter in cm	Volume	Diameter in cm	Volume
1				
2				
3				
Average				

Outcome #11

Conclusion Questions:

1. How do your tidal volume and vital capacity compare to one another? Which is larger? Why?

2. Compare and contrast your tidal volume during resting and after jogging.

3. Compare and contrast your vital capacity during resting and after jogging.

4. How does your data compare to others in your class?

5. Why do some of your class members have similar data to you? Why do some of your class members have different data from you?

6. How could an athletic trainer help improve your lung capacity?

7. If you were to start an exercise routine, how would it affect your lung capacity?