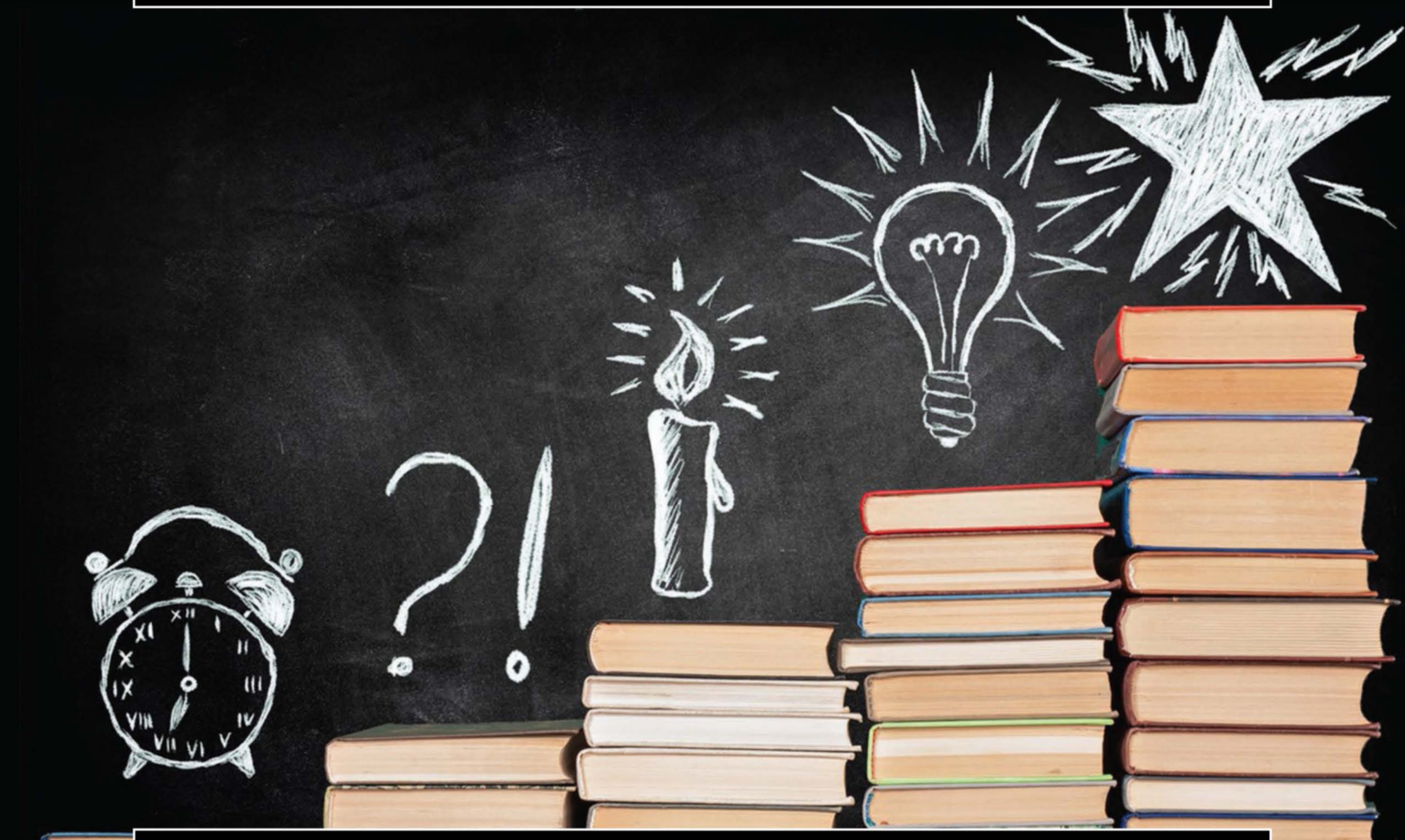
STEPS to STEM

A Science Curriculum Supplement for Upper Elementary and Middle School Grades – Teacher's Edition

Aaron D. Isabelle and Gilbert A. Zinn

Aligned with the Next Generation Science Standards (NGSS)



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PREFACE

A science program that ignores process skills development is like a reading program that ignores the basics of reading and writing.

– Colvill & Pattie

Welcome to *STEPS (Science Tasks Enhance Process Skills) to STEM (Science, Technology, Engineering, Mathematics)*, an inquiry-based science curriculum supplement focused on the development of students' science process skills and problem-solving skills. This program has been created in response to the high-stakes testing environment in schools across the United States in which there has been a departure and de-emphasis on science instruction. We specifically designed this science program to allow your students to learn key science concepts while gaining experience with the basic science process skills through "structured inquiry" STEP activities. Furthermore, with the increased emphasis on STEM (Science, Technology, Engineering, Mathematics) experiences as illustrated in the *Next Generation Science Standards (NGSS)* (Lead States, 2013), students not only need to have a strong foundational understanding of the "big ideas" in science, but also need to be expert critical thinkers and problem solvers prior to the high school years. *STEPS to STEM* will provide your students with these valuable and essential experiences in science.

The vast majority of inquiry-based science curricula used in Elementary and Middle Schools are referred to as "skills-based" curricula. Science process skills or abilities reflective of the behavior of scientists and engineers (e.g. observing, inferring, predicting, measuring, etc.) are used while students are engaged in the active exploration of science concepts. The use of science process skills and the learning of science concepts become inseparable when a skills-based curriculum is implemented. Colvill & Pattie (2002) state that a "skills-based" science program is necessary if teachers base their lessons on problem-solving or inquiry-based learning experiences; "nothing can be more frustrating in a problem-solving program if the work is held up by a lack of skill in the basic processes" (pp. 20–21). Problem-solving activities require scientific reasoning and critical thinking abilities which, in-turn, require proper use of the basic science process skills. Therefore, teachers must not take for granted that students have adequately developed these skills; rather, "we must be deliberate in how we instruct students and encourage their development of these skills" (Froschauer, 2010, p. 6). Providing students with a wide range of meaningful, hands-on science experiences to develop their process skills should be a primary objective for all science teachers. Accordingly, *STEPS to STEM* has been specifically designed to nurture the use of the science process skills while students actively participate in meaningful and engaging science activities. Throughout the program, students *Investigate* everyday materials, develop *Hypotheses*, and then *Test* their ideas related to a particular science concept; this occurs in STEP 1 (Investigate–Hypothesize-Test). In STEP 2, students extend their learning from STEP 1 when they *Observe* a new but related set of materials, *Record* ideas, and then make a *Prediction* (Observe-Record-Predict). In STEP 3 students *Gather* additional everyday materials to *Make* an experimental set-up which will allow them to *Try* out their ideas (Gather-Make-Try) (Note: meaningful connections to *Mathematics* are commonly made during the STEPS either using measurement or mathematical calculations). Lastly, students are ready to engage in a *STEM Center* where they will be more fully focused on problem-solving and/or engineering practices; students extend what they learned in the previous STEPS by focusing on a problem to solve (i.e. a team challenge). Students first conduct *Research* using *Technology* to gain more background information and facts about the problem (as well as information about scientists/inventors who worked on a similar problem); work together to devise a *Plan* to solve the problem (Note: this will include discussion, preliminary designs, sketches, or building models); and then try to *Solve* the problem by testing their design/solution. This sequence can certainly be followed by re-design and re-testing if necessary. This three-phase format of the program will help your students develop a genuine understanding of each science concept while nurturing their process skills and problem-solving abilities. Students will learn to think and act not only like scientists, but also like engineers.

STEPS to STEM combines both "structured" and "guided" experiences for your students. After a set of "structured" STEP activities is completed (which will help students learn prerequisite content knowledge and skills), your students will be engaged in *STEM Centers* which are "guided" problem-solving experiences. These center-based experiences <u>focused on a problem</u> will allow your students to not only practice and refine their problem-solving skills, but also explore their own ideas while thinking/acting like engineers. Using a STEM Center approach, you will be able to actively support and assess students' understanding and use of science and engineering skills, while nurturing students' problem-solving abilities. This, in-turn, will help to inform you about your students' readiness to advance to the next science concept in your curriculum.

Lastly, students are asked to identify which *NGSS* Science & Engineering Practices were utilized during the problem-solving process. This type of self-reflection will further emphasize that the students are using key practices that reflect the behavior of both scientists and engineers.

We firmly believe that quality science instruction, characterized by building process skills in the context of learning big ideas in science, is critical for students' academic development. On the one hand, the use of process skills is not limited to science; rather they will assist students in all academic areas. On the other hand, we live in a highly technological, democratic society which demands that individuals be independent, critical thinkers who are able to make good decisions while working collaboratively with others. As stated by White & Harrison (2012), these skills are not confined to the science classroom, but can be learned and used in other disciplines, as well as transferred to real-world situations; they serve as the foundation for helping students to become effective and responsible citizens capable of making informed decisions on a variety of important issues. Therefore, teachers need to make it a top priority to nurture the development of these practices—not just in the science classroom, but across the curriculum. *STEPS to STEM* will help you to prepare your students for the real-world by first stimulating their interest and curiosity about the world around them. Once students realize that science (and engineering) is all around them, you will have taken the first step to help them develop into life-long learners, a fundamental disposition for success in our global and highly technology society.

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INTRODUCTION

Teacher's Guide for STEPS to STEM

The learning experiences in *STEPS to STEM* are specifically designed to stimulate the interest of your students and enable them to explore specific areas of science at their own pace. Each activity provides opportunities for the students to develop the skills of observation and an understanding of the basic science process skills characteristic of how scientists think and act. Through these activities, students gain experience in manipulating materials, observing changes, measuring objects, recording results, predicting effects, inferring causes, and communicating ideas.

Once students have completed a set of three (3) STEPS focused on a "big idea" in science, students are ready to collaborate using an STEM Center Approach. STEM Centers provide students with the opportunity for extended investigations focused on a single problem. They not only practice their science process skills, but also move beyond these skills as they use critical thinking and problem-solving skills. Although each STEM Center is guided by a particular problem or task, students should be allowed to develop their own questions and problems which derive from their curiosity and interest in the topic.

The program is flexible and therefore adaptable as an individualized or whole-class program that will fit easily into any science curriculum. Only simple, readily available materials are needed for most of the activities.

FEATURES OF THE PROGRAM

STEP Activities

Each chapter includes STEP activities focused on one of seven (7) "big ideas" in science at the elementary and middle school grade levels: Electricity and Magnetism; Air and Flight; Water and Weather; Plants and Animals; Earth and Space; Matter and Motion; Light and Sound. Each activity is correlated with the *Next Generation Science Standards (NGSS)*. Once students successfully complete three (3) STEP activities, they are ready for a STEM Center which makes use of the knowledge and skills learned in the previous STEPS. Each STEP activity and STEM Center utilizes a different set of skills and processes in the development of science concepts. The structure of the individual steps for each area is as follows:

STEP 1	Investigate – Hypothesis – Test
STEP 2	Observe – Record – Predict
STEP 3	Gather – Make – Try
STEM Center	Research – Plan – Solve

The content of the activities has been chosen to satisfy a wide range of interests among your students, in correlation with content of the *NGSS*. In general, the activities are independent of one another and may be performed in any sequence that fits the objectives of your district's science program.

STEM Centers

After each set of STEP activities is completed, students work in small, cooperative groups or teams to complete a STEM Center. STEM Centers are guided centers in which students are able to make decisions, problem-solve, and use critical thinking skills. Each STEM Center is guided by a task or problem; however, as students advance in this program and gain proficiency with the science and engineering skills, students should be encouraged to develop and solve their own problems/tasks.

While using STEM Centers, the teacher should serve as a facilitator of the learning experience, monitor and assess students' progress, and offer assistance as needed. Using STEM Centers, students are given the opportunity to think/act as scientists and engineers. It is also essential for students to share their work and their thinking with their classmates after a STEM Center has been completed. (Note: based upon the readiness of the students, as well as the complexity of the task, a STEM Center may take 2–3 class periods.) In doing so, a sense of classroom community focused on STEM will be nurtured.

Practices versus Process Skills

As stated in the National Research Council (NRC) Framework (2012), the term "practices" are used in the *NGSS*, rather than "science processes" or "inquiry" skills for a specific reason: "We use the term 'practices' instead of a term such as 'skills' to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" (NRC Framework, 2012, p. 30).

The following eight (8) Science & Engineering Practices are utilized throughout the *NGSS* and are an integral part of the problem-solving process:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

To encourage self-reflection and emphasis of these practices, after each STEM Center is complete, students are asked to identify which Science & Engineering Practices they feel that they used to solve the STEM Center team challenge. Teachers are encouraged to engage students in discussion about their thinking both during and after the STEM Center has been completed, and to help make them aware that certain key practices were utilized. Students are also encouraged to reflect along with their team members.

STEM Center Tips:

1. Give each team of 3-4 students ample space to spread out the materials. You may consider placing a large piece of chart paper on the table/desks not only to serve as a focal point, but also to make the clean-up process easier. Access to a computer or laptop is essential since students need to conduct background research on the topic.
2. Review safety procedures and the importance of using all materials appropriately.
3. After research has been conducted, instruct each team to develop a plan to solve the problem (Note: you should review each team's plan before they begin. Also, because students may need to bring in additional materials the next day to complete their design, it is suggested to devote one full class period to "solve the problem.")
4. Emphasize that although each team will be working cooperatively, each student is responsible for completing his/her own Sci-Book (see next section).
5. Allow students to work for 30-40 minutes at a time, but always leave time for each group to briefly share their findings with the whole class to promote a community of scientists/engineers.
6. After completing each STEM Center, ask the students to share questions or anything new that they wonder about. Keep track of students' questions and problems on a "question/problem" or "wonder" wall and allow the students to revisit these ideas whenever possible.
7. Once students share what they learned and what questions they have, be sure to infuse and re-emphasize the key science ideas which you want them to learn from the previous STEP activities, as well as the STEM Center experience.

Sci-Book

A science notebook or Sci-Book serves as a companion to this program. Using the Sci-Book, students maintain a record of their completed activities which can serve as a form of authentic or performance-based assessment. Recording ideas, plans, sketches, and questions are especially critical during STEM Center experiences so that students can look back on their work, view their progress, and share their thinking with classmates and with the teacher. This will also help to instill a sense of purpose and pride in using and maintaining the Sci-Book.

Teacher Notes

Each STEP activity contains a copy of the student activity sheet, along with notes and background information for the teacher. This material will help you anticipate and answer any questions that may arise in the course of the activity. You may also elect to transmit some of the background information to the students if you feel it is appropriate; however, each activity should be thought of as a supplementary experience, not specifically intended to teach a concept in depth.

Sci-Terms

Key science terms (language demands) or Sci-Terms are listed after each STEP activity. In the spirit of inquiry-based science, it is suggested that these terms be formally introduced to students in the context of their experiences rather than at the beginning of a particular STEP activity. In doing so, the academic language will be more meaningful to the students because they will be based upon their personal investigations. Students can be given the definitions or they can look up the terms on their own using a science dictionary. In addition, students should be encouraged to add additional ideas from their own experiences to create a working definition for each term.

About Metric Units of Measurement

The use of metric units is steadily increasing in the United States and is the common system of measurement used within the scientific community. It is therefore important to familiarize students with the metric system and to make them as much at ease with it as with the customary English system.

It is generally agreed that this goal is best achieved by avoiding "conversions" about different units and simply using metric units naturally and independently. For this reason, we have adopted a policy in these activities of sometimes using metric units and sometimes using English units. In any given activity, only one system or the other is used throughout. In this way, the students will learn through experience the magnitudes of lengths, volumes, and weights expressed either way. They will learn, for example, about how long 10 centimeters is, just as they have already learned about how long 1 foot or 12 inches is.

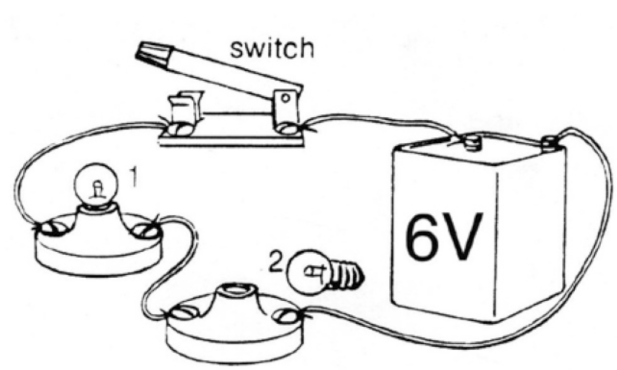
CONCLUSION

STEPS to STEM is a science curriculum supplement and resource designed to help your students find enjoyment in science and in the process of problem-solving. There are things to do, discoveries to be made, and problems to solve for each individual student in your class. Your students will enjoy the success of finishing each set of STEPS and the accompanying STEM Center, and in many cases, will be left with something tangible to show for their efforts. These rewarding experiences will help to keep students' interest high. Ideally, they will lead to more explorations, curiosity, and observations of the world around them.

ELECTRICITY & MAGNETISM

Step 1: Series Circuits

A. Investigate



1. Set up the electric circuit as shown in diagram. This is a series circuit.

2. Close the switch by pulling the blade down. What happens?

With the blade of the switch pulled down, the circuit is complete. Both bulbs will light.

3. Take out bulb #1. What happens?

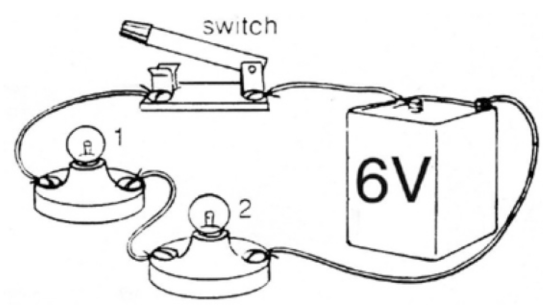
When one bulb is removed, the other bulb does not light.

4. Replace bulb #1. What happens?

____

____

B. Hypothesis



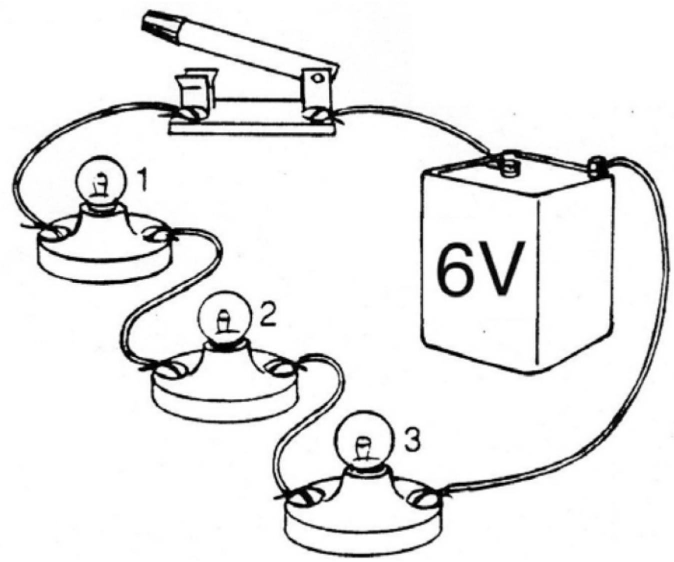
1. In a series circuit, there is:

   __*a*__ a) only one path for the current.
   ______ b) more than one path for the current.

2. When any part of a series of a circuit is disconnected:

   __*a*__ a) the current stops flowing.
   ______ b) the current flows through the other parts.

C. Test



1. Add bulb #3 to the series circuit.

2. Close the switch.
   What happens?

   ____

   ____

   ____

3. Remove one of the bulbs. What happens?

When one bulb is removed the other two will not light.

4. Replace the bulb and remove another. What happens?

As bulbs are added in a series circuit, the brightness of each is decreased.

Teacher Notes:

A. Use any miniature bulb rated at 1.5 volts.

Background Information:

An electric current is a flow of electrons. Electrons are particles with a negative electric charge that are present in all atoms. In metals, some of the electrons move easily from one atom to the next.

The "push" that causes electrons to move through a metal wire is called voltage. A dry cell produces voltage by chemical reactions. The positive terminal of the dry cell attracts electrons. The negative terminal repels electrons. When a metal wire is connected to the terminals of a dry cell, electrons flow into the wire from the negative terminal and flow out of the wire into the positive terminal. Electrons are pushed along the wire from the negative end toward the positive end. This is an electric current.
An electric current cannot flow unless it has a continuous conducting path. If a series circuit is broken at any point, the entire current stops flowing.

An electric current carries energy. This energy is turned into heat and light when the current flows through the metal filament of the light bulb. When more bulbs are added in the series, their total resistance to the flow of current increases. Less current flows and the bulbs shine less brightly. If dry cells are added in series, their total voltage is increased. This causes more current to flow in a circuit.

Sci-Terms:

Series circuit
Electric current
Electricity
Resistance
Electrons
Dry cell
Voltage
Switch

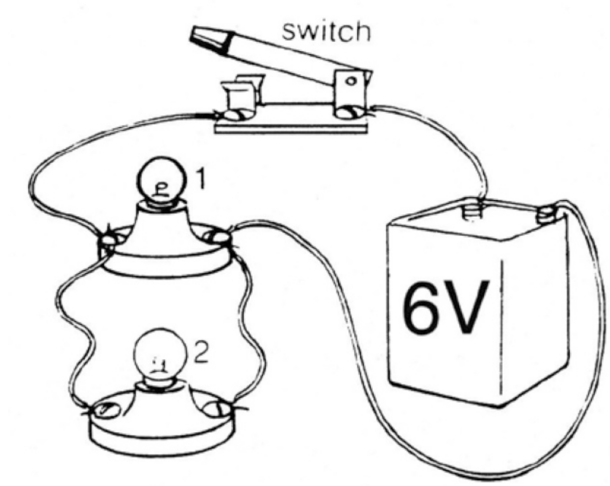
Connections to the *Next Generation Science Standards* (NGSS):

Standard: 4.PS3 Energy (p. 35)
Performance Expectation: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. (p. 35)
Disciplinary Core Ideas:

- PS3.A: Definitions of Energy. Energy can be moved from place to place by moving objects or through sound, light, or electrical currents (p. 35)
- PS3.B: Conservation of Energy and Energy Transfer: Energy can also be transferred from place to place by electrical currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (p. 35)

Step 2: Parallel Circuits

A. Observe



1. Set up the circuit as shown in the diagram. The two bulbs are connected in parallel.

2. Close the switch. What happens?

In a parallel circuit, each bulb is connected independently to the source of energy--the dry cell. When the circuit is complete, after the blade of the switch is pulled down, both bulbs will light.

3. Remove bulb #1. What happens to bulb #2?

When either bulb is removed, electricity can still flow through the other lamp and return to the dry cell.

4. Replace bulb #1. Remove bulb #2. What happens to bulb #1?

____

____

B. Record

1. Connect 1 bulb, a switch, and a battery in a series circuit.

2. Close the switch. Observe how bright the bulb is. Call this brightness NORMAL.

3. Observe the brightness of the bulbs in each of the following circuits:

   a) 2 bulbs in series with a battery
   b) 2 bulbs in parallel with a battery

4. In the chart, record whether the bulbs are NORMAL, DIMMER, or BRIGHTER.

Kind of Circuit	Brightness
1 bulb in series	NORMAL
2 bulbs in series	***DIMMER***
2 bulbs in parallel	***NORMAL***

C. Predict

1. With two bulbs in parallel, open the switch.

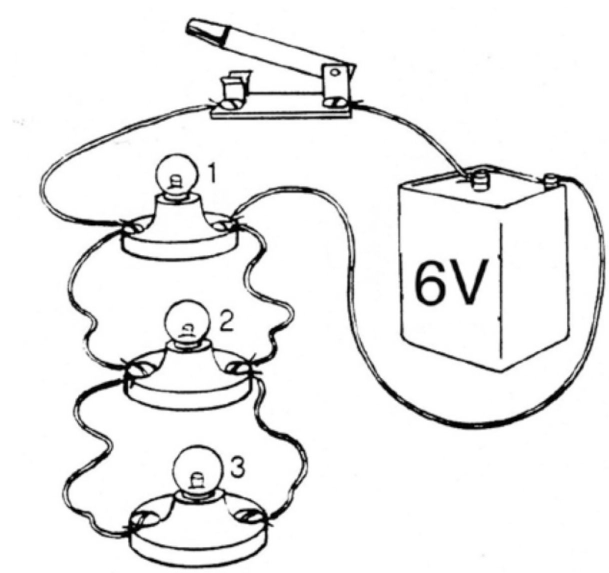
2. Add a third bulb in parallel with the other two.

3. Predict whether the bulbs will be NORMAL, DIMMER, or BRIGHTER when you close the switch.

____

4. Test your prediction. Was your prediction correct? Explain your thinking.

The brightness remains the same-normal--when additional bulbs are added to a parallel circuit.



Background Information:

In a parallel circuit, each branch receives the full voltage of the source of current, making a complete circuit by itself. Therefore, one branch is not affected by opening or closing the circuit of any other branch. Also, the amount of current in each branch remains the same, no matter how many other branches are connected in parallel. Therefore, the brightness of the bulbs remains the same.

However, the source of current must supply a separate current for each branch. If there are many branches, the current drain on a dry cell becomes greater and the cell becomes used up faster. This can be offset by connecting several dry cells together in parallel--positive to positive and negative to negative. This forms a battery. A battery of cells in parallel has the same voltage as a single cell, but it can supply current for a longer time before it wears out. Dry cells in parallel will not make a bulb brighter, because the voltage remains the same.

Sci-Terms:

Parallel circuit
Branch
Electric current
Resistance
Dry cell
Battery
Voltage

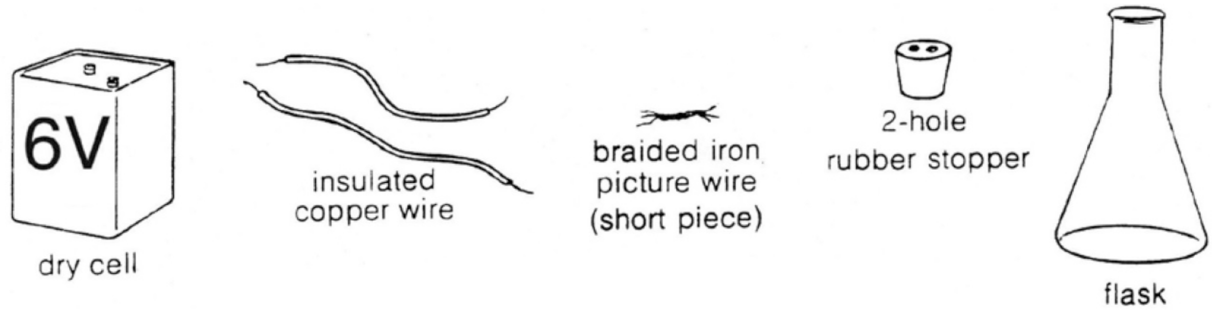
Connections to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 4.PS3 Energy (p. 35)
<u>Performance Expectation</u>: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. (p. 35)
<u>Disciplinary Core Ideas</u>:

- PS3.A: Definitions of Energy. Energy can be moved from place to place by moving objects or through sound, light, or electrical currents (p. 35)
- PS3.B: Conservation of Energy and Energy Transfer: Energy can also be transferred from place to place by electrical currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (p. 35)

Step 3: Electricity and Heat

A. Gather



1. Strip ½ inch of the insulation from each end of the copper wires.

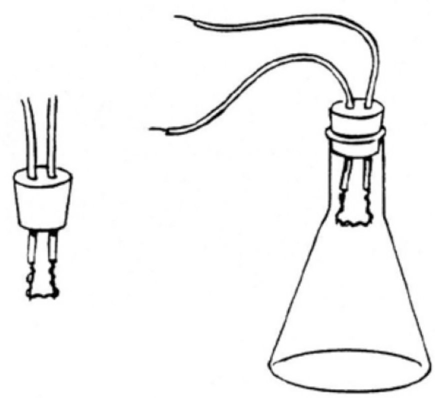
2. Unravel the iron picture wire (this will be the light bulb filament).

B. Make

1. Put a copper wire through each of the holes in the stopper.

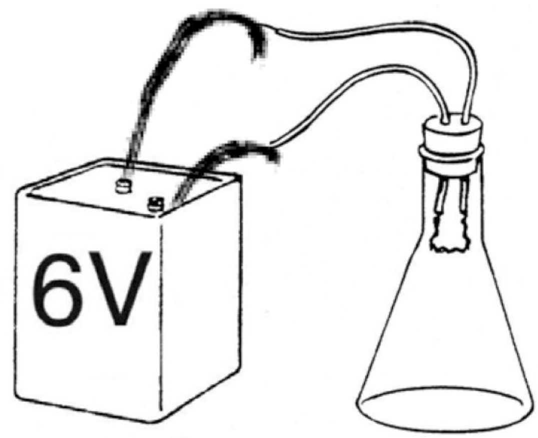
2. Attach one strand of the iron picture wire to the two bare ends of the copper wire.

3. Put the stopper into the flask.



C. Try

1. Connect the outside ends of the copper wire to the dry cell.



2. What happens to the iron wire (filament)?

The iron wire begins to glow.

3. How does the flask feel?

The flask may soon feel warm due to the heat produced.

4. Darken the classroom. What do you observe?

Light is also produced by the glowing wire.

5. Use 2 batteries in series instead of 1. What happens to the wire?

With more voltage, there will be more current; the wire will get red hot and may melt.

6. Where else can you find electricity being used in this way?

Hot plates, toasters, and electric blankets turn electricity into heat energy.

Teacher Notes:

A. A cork or a piece of clay, with a bottle, can be used instead of the 2-hole stopper and the flask.

B. Be sure to twist the bare ends of the copper wire and the iron wire together.

Background Information:

Iron wire does not conduct electricity as well as copper wire. This “resistance” to the flow of electrons in the iron wire will cause it to get hot and glow. The same thing happens in a light bulb.

Electric light bulbs use tungsten wire or alloys which include tungsten to produce the desired amount of light. Tungsten has a very high melting point and a good resistance to electrical current. Light bulbs do not contain ordinary air. If they did, the tungsten wire (filament) would quickly burn up because of the oxygen in the air. Light bulbs are filled with a mixture of nitrogen and argon gases. Light bulbs eventually burn out because the great heat of the filament causes it to slowly evaporate. The dark area inside the glass of an old bulb is formed by tungsten atoms that evaporated from the wire and condensed on the glass.

During the STEM Center experience, students can use wires (filaments) with different thicknesses, then try different kinds of metal. In addition to using iron, copper, or other metals, students might also try using different thicknesses of graphite used in mechanical pencils to achieve the brightest glow.

Sci-Terms:

Incandescent light bulb
Filament
Current
Resistance
Heat energy
Light energy

Connections to the *Next Generation Science Standards* (NGSS):

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STEM Center 1.1

Team Challenge: *How can your team make a light bulb filament glow the longest and the brightest?* [NGSS 4-PS3-3. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on light bulbs and filaments that will help you solve the problem [e.g. what makes a light bulb filament glow? What kinds of materials were used for filaments in early light bulbs? What materials are used for filaments in modern day incandescent light bulbs?].

Fact 1:

Fact 2:

Fact 3:

Find two scientists who were involved in the development of light bulbs through the years and identify at least one way that the use of light bulbs has impacted our everyday lives.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

During your work in the STEM Center, you used certain key “practices” similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 4: Static Electricity

A. Investigate

1. Cut a strip of paper about 25 cm long and 2 cm wide.

2. Tape the ends together to form a hoop.

3. Rub or comb your hair briskly with the comb.

4. Place the comb just in front of the hoop. Move the comb slowly away.

5. What happens to the hoop?

The hoop moves towards the comb (attraction). The stream of water is also attracted to the charged comb.

6. Rub the comb through your hair again.

7. Hold it near a fine stream of water.

8. What happens?

____

____

B. Hypothesis

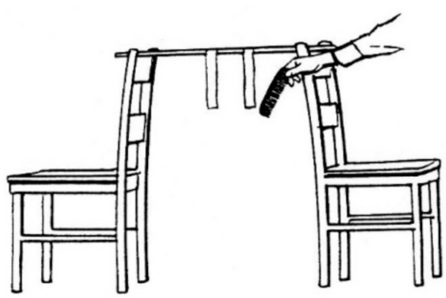
When certain materials are rubbed with other materials, they get an electric charge. Which one of these statements do you think is true?

__**a**__ a. A charged object always attracts other things.

__**b**__ b. A charged object sometimes pushes another charged object away from it.

C. Test.

1. Cut two strips of paper about 15cm long and 2 cm wide.



2. Tape their ends to a meter stick and hang them up as shown in the drawing.

3. Charge the comb as before, and bring it near each strip of paper in turn. What happens to each strip of paper?

The charged comb attracts the strips of paper.

4. Rub the strip of paper several times with your fingers or with a piece of fur.

5. Bring the charged comb near the paper you rubbed. What happens?

The comb repels the paper that was rubbed. (It still attracts the other strip, which was not rubbed.)

6. Do charged objects always attract other things? Explain.

Charged objects do not always attract other things. (They sometimes repel other charged things.)

Teacher Notes:

A. (Important: All these activities work best on cool, dry days.).

B. On the basis of the investigation thus far, hypothesis "a" is reasonable, but hypothesis "b" is still possible. Further testing is necessary.

Background Information:

Static electricity is a phenomenon of matter that causes bodies of matter to attract or repel each other. Magnetism is a similar phenomenon, but it acts only on certain "magnetic" materials, such as iron. Any material can acquire static electricity, or electric charge. It usually appears as the result of rubbing two materials together. According to modern atomic theory, atoms contain protons, which have a positive electric charge, and electrons, which have a negative electric charge. Normally, these charges balance. But when two different materials are rubbed together, electrons may move from one to the other. The material that loses electrons is left with an excess positive charge, while the other acquires an excess negative charge.

Objects with opposite charges attract each other; objects with the same charge repel each other. However, a charged object may attract an uncharged one (as in Part A). In this case, the charged object causes the electrons and protons in the other material to shift positions, resulting in a net force of attraction.

Sci-Terms:

Electric charge
Static electricity
Repels
Attracts

Connection to the *Next Generation Science Standards* (NGSS):

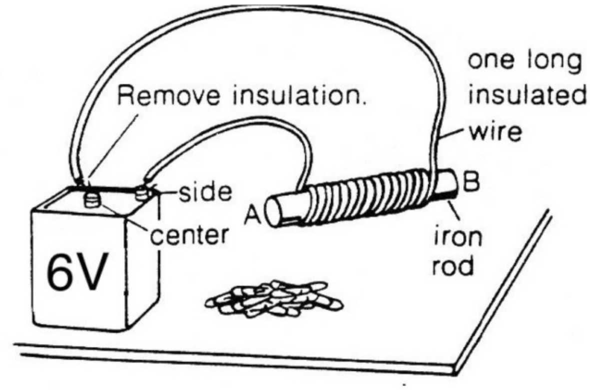
Standard: MS-PS2 Motion and Stability: Forces and Interactions (p. 59)
Performance Expectations: MS-PS 2-3: Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. (p. 59)
Disciplinary Core Ideas: Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (p. 60)

Step 5: Electromagnetic Poles

A. Observe

1. Use the materials shown in the diagram to make an electromagnet.

2. Test the electromagnet to see if it is working. Use it to pick up and drop some paperclips.



B. Report

1. Bring the North Pole of a compass needle close to the A end of the electromagnet. See what happens.

2. Record your findings on the chart.

3. Bring the North Pole of a compass needle close to the b end of the electromagnet. See what happens.

4. Record your findings on the chart.

5. Study the chart; then answer this question

    Do electromagnets have poles? ____**Yes**____
    A is a ____**North**____ pole.
    B is a ____**South**____ pole.

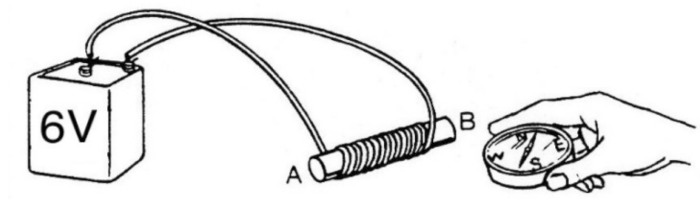
6. Test both ends of the electromagnet with the South Pole of the compass needle. Record your findings on the chart. Were your original conclusions correct?

"A" Wire Connected to Side Terminal
"B" Wire Connected to Center Terminal

Pole of Compass	Ends of Electromagnet	
	A	B
North Pole		
South Pole		

C. Predict

1. Switch the A wire to the central terminal of the dry cell.



2. Switch the B wire to the side terminal.
3. Do you think the poles of the electromagnet will remain the same?
4. Test the poles to find out.
5. Use the chart to record your findings.

"A" Wire Connected to the Center Terminal
"B" Wire Connected to Side Terminal

Pole of Compass	Ends of Electromagnet	
	A	B
North Pole		
South Pole		

Teacher Notes:

A. The electromagnet attracts paper clips only when current is flowing through the wire.

B. By the "law of magnetic poles," the end of the electromagnet that attracts the N pole of the compass is an S pole. It will repel the other compass pole. The other end of the electromagnet will act oppositely; it is an N pole.

C. It will be observed that switching the wires reverses the polarity of the magnet.

Background Information:

An electric current is a flow of electric charge (usually electrons). An electric current in a wire has a magnetic field around it; that is, it acts like a magnet. Winding the wire to make a coil can increase the strength of the magnet, and it can be made very much stronger by putting an iron rod inside the coil. (An ordinary bolt from a hardware store makes a good "core" for the electromagnet.) The polarity of the magnet depends on the direction of the current through the coil. Reversing the connections to the dry cell reverses the direction of the current and therefore reverses the polarity.

Sci-Terms:

Electromagnet
Insulation
Terminal
Compass
Poles (North and South)
Dry Cell

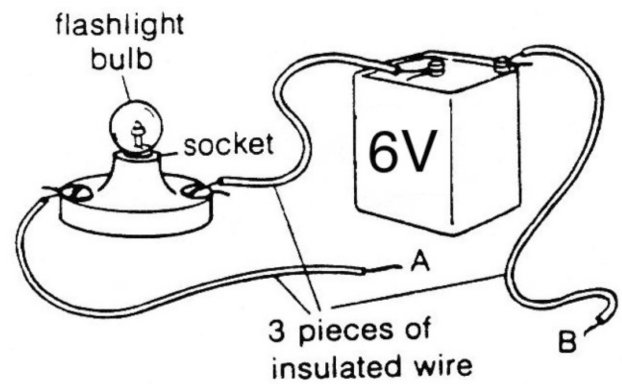
Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: MS-PS2 Motion and Stability: Forces and Interactions (p. 59)
<u>Performance Expectations</u>: MS-PS-2: Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. (p. 59)
<u>Disciplinary Core Ideas</u>: Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and tier sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (p. 60)

Step 6: How Steady is Your Hand?

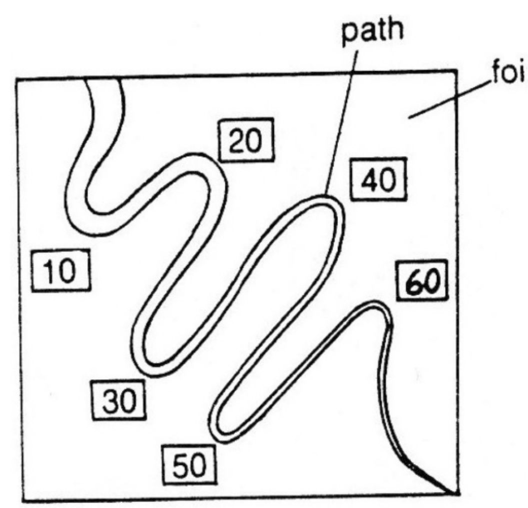
A. Gather

1. Remove 2 cm of insulation from the ends of each wire.
2. Attach the wires as shown in the diagram.
3. Touch the bare ends of wires A and B together. If the bulb lights, the circuit is working.



B. Make

1. Wrap aluminum foil around a piece of cardboard that is about 20 cm square.
2. Draw a path on the aluminum foil. Use a dull pencil and do not press hard. The starting point of the path should be 1 ½ cm wide. The path should get narrower until it is less than ½ cm wide when it ends.
3. Cut out the path.
4. Tape points-10, 20, 30, etc. after each bend in the path.
5. Tape the wire that comes from the dry cell to the underside of the foil.



C. Try

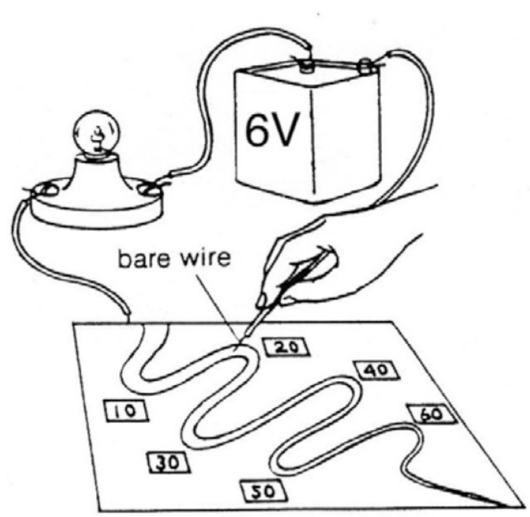
1. The wire from the socket is a pointer. What happens when you touch the pointer to the aluminum foil?

<u>If the pointer touches the side of the path, the light will go on. The farther along the path you go, the higher the score.</u>

2. See how far along the path you can move the pointer without touching the sides.

3. Keep score. Your score is the number of points just before the bulb went on.

4. Have a "steady hand" contest with your classmates.



Teacher Notes:

A. Make certain the circuit is working properly before going on.

B. Aluminum foil acts as a good conductor of electricity. Neatly tuck under any jagged pieces of foil all along the pathway.

Background Information:

A complete circuit is made each time the pointer "C" touches the aluminum foil. This game will provide interest in electricity while providing experience for improving hand and eye coordination.

Sci-Terms:

Socket
Insulation
Circuit
Conductor
Dry Cell

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 4.PS3 Energy (p. 35)
<u>Performance Expectation</u>: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. (p. 35)
<u>Disciplinary Core Ideas</u>: PS3.B: Conservation of Energy and Energy Transfer: Energy can also be transferred from place to place by electrical currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (p. 35)

STEM Center 1.2

Team Challenge: **How can your team make a strong electromagnet? How can you prove that your team's electromagnet is stronger than the other teams' electromagnet?** [NGSS MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on electromagnets that will help you solve the problem [e.g. what materials are used to create electromagnets? How is a basic electromagnet created? What is the best shape for an electromagnet?].

Fact 1:

____

____

____

Fact 2:

____

____

____

Fact 3:

____

____

____

Find two scientists who were involved in the understanding of electromagnetism and identify at least one way that electromagnets are used in our everyday lives.

____

____

____

____

____

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 7: Charged Balloons

Balloons

A. Investigate

1. Blow up two balloons and tie their necks closed so air cannot escape.

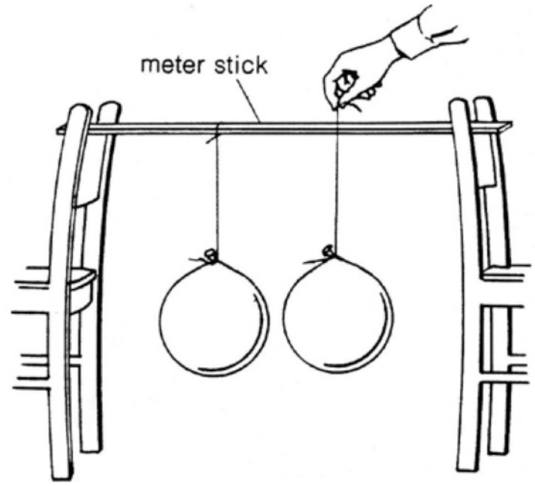
2. Attach a string to each balloon.

3. Hang one balloon from a support.

4. Rub the hanging balloon with a piece of fur or woolen cloth.

5. Rub the other balloon with the same cloth.

6. Hold the second balloon by the string and bring it near the hanging balloon. What happens? ***The two balloons repel each other.***



B. Hypothesis

When certain materials are rubbed with other materials, they get an electric charge. Which of these statements do you think are true?

1. Electric charges attract each other if
______ a. they are the same kind.
__**b**__ b. they are different kinds.

2. Electric charges repel each other if
__**a**__ a. they are the same kind.
______ b. they are different kinds.

C. Test

1. Charge the hanging balloon by rubbing it with fur or with a wool cloth.

2. Charge the glass rod by rubbing it with fur.

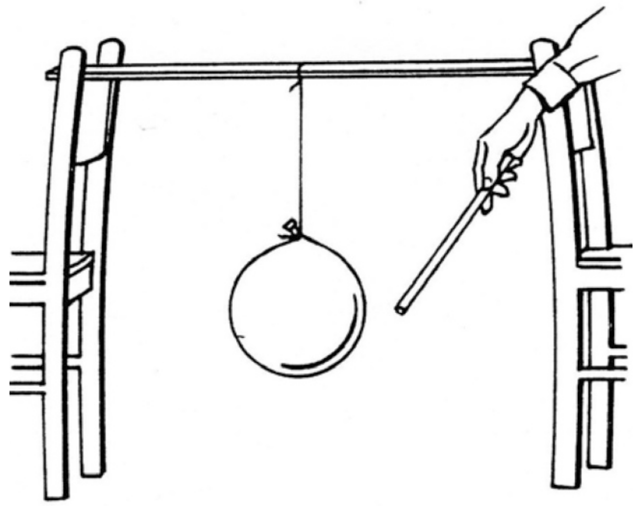
3. Bring the glass rod near the balloon. What happens?

Glass rubbed with fur repels the Balloon.

4. Now, charge the glass rod by rubbing it with silk.

5. Bring the glass rod near the balloon. What happens?

Glass rubbed with silk attracts the balloon.



Teacher Notes:

B. Since the balloons were treated alike, their charges are alike. Since they repel each other, a good hypothesis is that charges of the same kind repel, and opposite charges attract.

C. A good way to remove charges from the glass between trials is by wiping it with aluminum foil.

Background Information:

Atoms of matter normally have equal amounts of positive and negative charge. The positive charge is on the protons in the atomic nucleus. The negative charge is on the electrons that circle around the nucleus. When certain materials are brought into close contact (such as by rubbing them together), electrons (negative charge) move from one material to the other. The material that loses electrons is left with a positive charge. The material that gains electrons acquires a negative charge.

Rubber easily acquires negative charge when rubbed with almost any nonmetallic material. Since objects with the same charge repel each other, two charged balloons repel each other. Most other materials tend to acquire positive charges and therefore attract the balloons. Glass can usually be given a negative charge (same as the rubber) if rubbed with fur, and it will then repel the balloon. If the glass tends to remain positive, use a hard rubber (ebonite) rod instead.

Sci-Terms:

Electric charge
Attract
Repel
Charge

Connections to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2 Motion and Stability: Forces and Interactions (p. 59)
Performance Expectations: MS-PS 2-3: Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. (p. 59)
Disciplinary Core Ideas: Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and tier sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (p. 60)

Step 8: Making Magnets

A. Observe

1. Cut a 5-inch section from the paper tube found on some wire hangers.

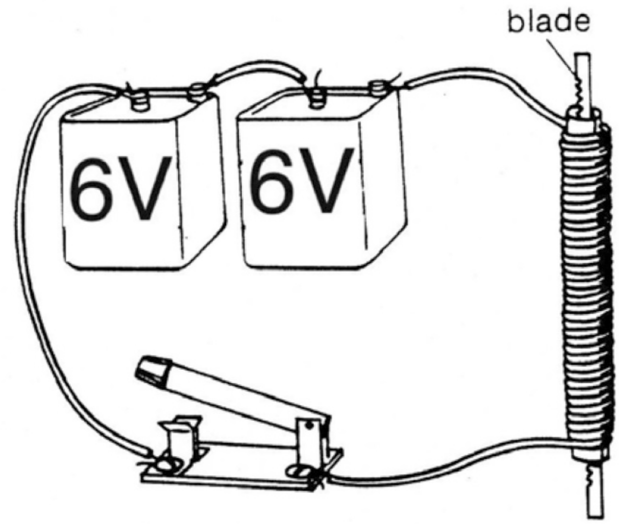
2. Wrap 150 turns of insulted wire around the tube.

3. Connect the wire to two dry cells and a switch in series.

4. Get a thin, used coping saw blade that is 6 inches long.

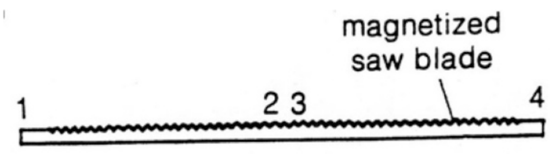
5. Put the saw into the tube, close the switch, and let the current flow for 10 seconds.

6. Remove the blade from the tube. Test the blade with a paper clip. Did it become a magnet? ______________________________



B. Record

1. See how many paper clips can be picked up at each of the four points numbered 1, 2, 3, and 4 in the drawing.



2. Record your observations on the chart below.

The ends will attract the clips, not the center of the blade. If #1 is a N pole, then #4 is a S pole.

3. Where are the poles of your magnetized saw blade?

At points 1 and 4.

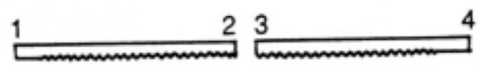
4. Use a compass to find the North and South poles of the saw blade. The colored end of the compass needle is usually a North Pole. Remember that like poles repel, and unlike poles attract.

5. Label the poles on the drawing.

Points	**Number of Paper Clips**
1	
2	0
3	0
4	

C. Predict

1. Use a pair of pliers to bend the saw blade back and forth between points 2 and 3 until it breaks in half.



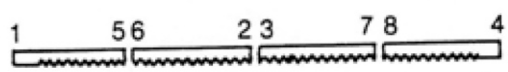
2. What do you predict will happen at point 2? ______________________________

3. What do you predict will happen at point 3? ______________________________

4. Test these points as you did in part B-Record. What happens to points 2 and 3? ______________________________

5. Break the saws in half again. Predict what will happen to points 5, 6, 7, and 8 with regard to the formation of magnetic poles.

<u>If #1 is N, then #2 is S, #3 is N, #5 is S, #6 is N, #7 is S, #8 is N.</u>



Teacher Notes:

A. A coil of wire, without an iron core, is called a "solenoid." With the electric current flowing, the blade seems to be lifted into the solenoid. The blade is now a magnet and it will pick up the paper clips.

Background Information:

It is generally assumed today that each molecule of a magnet is a magnet itself, having its own N and S poles. Most molecules line up facing the same way- north poles facing one way while the south poles are turned in the opposite direction. The more molecules within the magnet facing the same way, the stronger the magnet.

Sci-Terms:

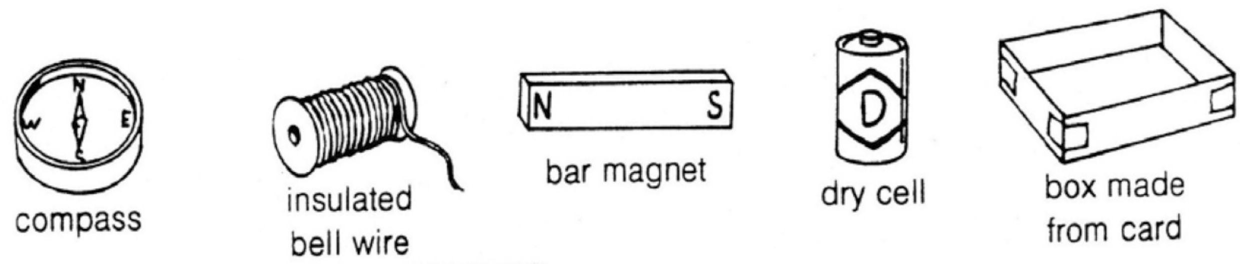
Insulated
Coping saw
Current
Poles (N and S)
Solenoid

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2 Motion and Stability: Forces and Interactions (p. 59)
Performance Expectations: MS-PS 2-3: Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. (p. 59)
Disciplinary Core Ideas: Electrical and magnetic (electromagnetic) forces can be attractive or repulsive, and tier sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (p. 60)

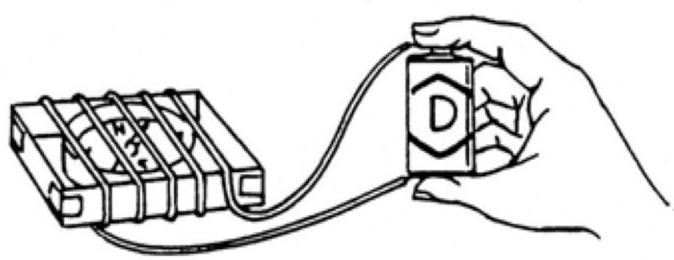
Step 9: Magnetism and Electricity

A. Gather



B. Make

1. Fold up the sides of the card and tape them together to make a box.



2. Put the compass into the box.

3. Wrap 5 turns of wire around the box and the compass.

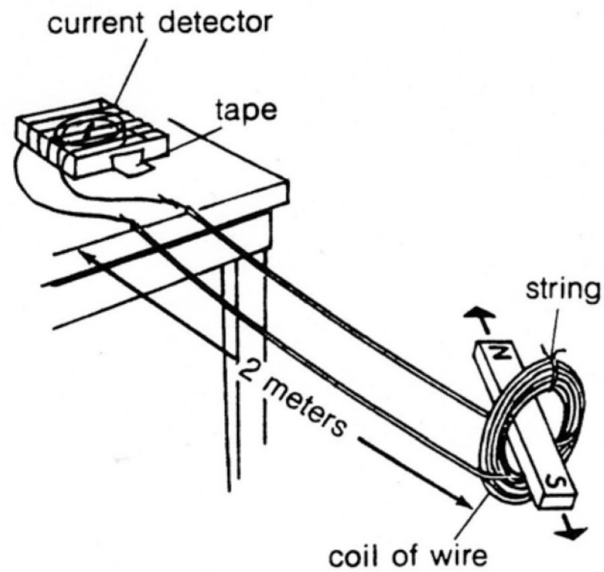
4. Connect the ends of the wire to the dry cell.

5. What happens to the compass needle?

The compass needle will turn at right angles to the coils of wire when a current is passing through the wire. Reversing the wires to the battery will cause the needle to deflect in the opposite directions.

You have made a current detector. The compass needle will move when current is flowing in the wire.

C. Try



1. Make a coil of wire by wrapping about 50 turns of wire around a small jar. Leave about 2 meters of straight wire at eachend of the coil.

2. Slide the coil off the jar and tie it with string to hold it together.

3. Connect the ends of the coil to your current detector.

4. Tape the current detector to a tabletop. Make sure you can see the needle and that it can move freely.

5. Hold the coil as far from the current detector as you can. Move the magnet in and out of the coil very rapidly. Have another person observe the compass needle as you do this.

6. What happens to the needle when you move the magnet in and out of the coil?

<u>As the magnet is moved rapidly within the coil, the compass needle will be deflected slightly, indicating a current has been produced.</u>

7. What does this show? ______________________________

8. Hold the magnet still inside the coil. Does the needle move? ______________________________

9. When does a magnet make current flow in a coil? ______________________________

____

Teacher Notes:

A. The box is a convenient way to wrap the wire around the compass. Remember to remove the insulation from the ends of the wire.

Background Information:

A flow of electricity from a battery through a coil of wire produces a magnetic field around the wire, as indicted by the movement of the compass needle. This current-detecting instrument is a galvanometer. A magnetic field that moves across a coil of wire can generate electricity. This is a simple generator. In some generators the magnets are stationary while the coils of wire move. The compass needle swings only when the magnet is in motion through the coil. A wire and a magnet that are not in relative motion will not produce a current.

Sci-Terms:

Bar magnet
Current detector
Galvanometer
Generator

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 4.PS3 Energy (p. 35)
<u>Performance Expectation</u>: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. (p. 35)
<u>Disciplinary Core Ideas</u>: PS3.B: Conservation of Energy and Energy Transfer: Energy can also be transferred from place to place by electrical currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (p. 35)

STEM Center 1.3

Team Challenge: **How can your team make a simple generator? How can you prove that your team's generator is more powerful than the other teams' generators?** [NGSS MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on generators that will help you solve the problem [e.g. what is the function of a generator? What materials are used to create simple generators? How have generators changed over time?].

Fact 1:

Fact 2:

Fact 3:

Find two scientists who were involved in the development of the generator and identify at least one way that the use of generators has affected our everyday lives.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

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1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

AIR & FLIGHT

Step 1: Air Pressure

A. Investigate

1. Get two plungers that are the same size.

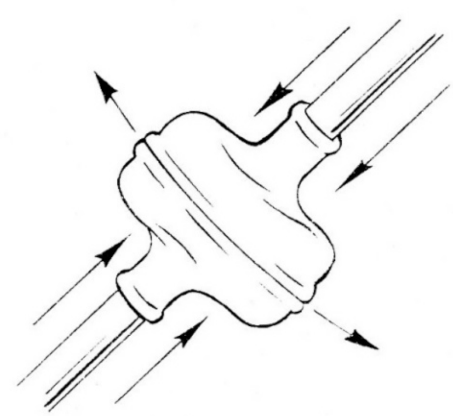
2. Wet the rim of each plunger.

3. Have a friend help you press the two plungers together very hard.

4. Try to pull them apart. Is it easy to do? ____

B. Hypothesis

You forced most of the air out from between the plungers.

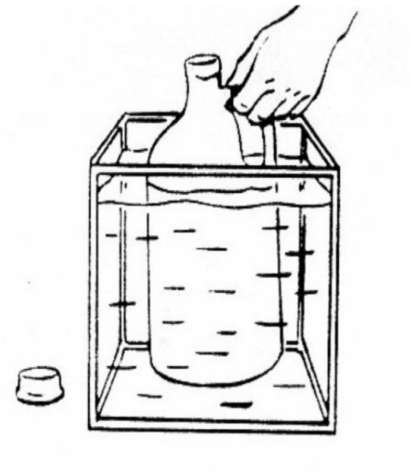


1. When you tried to pull the plungers apart the air pressure inside the plungers became
   _____ a) greater.
   __*b*__ b) smaller.

2. The air pressure outside the plungers stayed the same. The air pressure outside the plungers was
   _____ a) the same as the pressure inside.
   __*b*__ b) greater than the pressure inside.
   _____ c) less than the pressure inside.

A slight lifting of the rim will allow air to enter. The pressure both inside and out become equal and the plungers are easily pulled apart.

C. Test



1. Get a round plastic bottle. Remove the cap.

2. Place the bottle upright in *very hot* water for 2 minutes. (Do not let water into the bottle.)

3. How does this force air out?

The hot water heats the air inside the bottle causing the air to expand and some air leaves the bottle through the open neck.

4. Put the cap on the bottle.

5. Remove the bottle from the water. Quickly rinse it in cold water.

6. What happens to the bottle?

When the capped bottle is cooled, the remaining air inside it tends to contract to a smaller volume. This lowers the pressure inside the bottle. The air pressure outside the bottle is now greater than inside, and the sides are pushed in by this greater pressure.

7. Where has the air pressure been lowered?

Inside the bottle.

8. Where is the air pressure greater?

Outside the bottle.

Draw what happens to the bottle after it has been heated and cooled.

Teacher Notes:

A. Plungers are commonly called "plumber's helpers."

Background Information:

There are two ways that the pressure of a gas, such as air, can be changed: (1) If the gas is in a closed, rigid container, so its volume cannot change, its pressure will increase when it is heated and decrease when it is cooled. (2) If the temperature of a gas stays the same, its pressure will increase if it is squeezed into a smaller space and decrease if it is allowed to spread into a larger space. However, the pressure of a gas will not change if it can enter or leave the container freely. These relationships are known as "Gas Laws."

In A, some air leaves the plungers when they are pressed together. When the plungers are pulled back, the volume inside becomes larger. The air inside spreads out through the larger volume and its pressure decreases. (Air cannot get into the plungers from outside because the outside pressure keeps them tightly pressed together in an airtight seal.)

In C, heated air leaves the bottle. Its pressure does not change. When the bottle is stoppered and then cooled, the pressure decreases. (If the cap had been left off during the cooling, the pressure would not change, because air could flow back in.)

Sci-Terms:

Gas Laws
Air pressure
Temperature
Volume

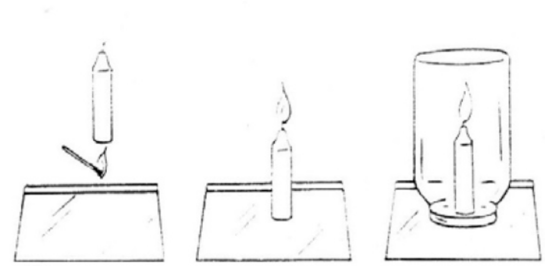
Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS1-Matter and Its Interactions (p. 56)
Performance Expectation: MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (p. 56)
Disciplinary Core Idea: PS1.A: Structure and Properties of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (p. 56)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (p. 57)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (p. 57)

Step 2: Out Goes the Candle

A. Observe



1. Melt the bottom of a candle with a match.
2. Press the candle bottom to a cookie tray.
3. Light the wick.
4. Place a pint mayonnaise jar over the candle.
5. What happens to the flame?

In a short while, the flame will go out.

6. Why?

There isn't a sufficient amount of oxygen left in the jar to support the burning of a candle flame.

B. Record

1. Gather a watch with a sweep-second hand or a stopwatch.
2. Again, cover the lighted candle with the jar.
3. Time how long it takes for the flame to go out.
4. Do this 3 times. Record each trial on the chart.
5. After each trial, lift the jar to allow the gases to get out. Wipe the jar dry with a paper towel.
6. Complete the chart for the pint jar.
7. Repeat the experiment with a quart size mayonnaise jar.

Trials	Pint jar	Quart jar
1st		
2nd		
3rd		
Average time		

C. Predict

1. Study the chart in part B. How long do you think the flame will burn if you use a wide-mouth gallon jar?

Since there are 4 quarts in a gallon, there is 4 times as much air within the bottle. The candle should burn about 4 times as long as in the quart jar (about 40 seconds in a typical case).

2. See if you are right. Make 3 trials.

   a. ___________________________

   b. ___________________________

   c. ___________________________

   Average: ____________________

Teacher Notes:

A. Birthday candles will work well because they burn slowly.

B. Approximate average time:

   Pint - 6 seconds
   Quart - 11 seconds

Background Information:

Measuring elapsed time, recording trial attempts, and computing averages of these observations provide experiences in some of the basic skills of science. Comparing the size of the containers to the length of burning time helps the child to understand and be capable of making logical predictions. This could serve as a good introduction to the use of graphs in science.

Sci-Terms:

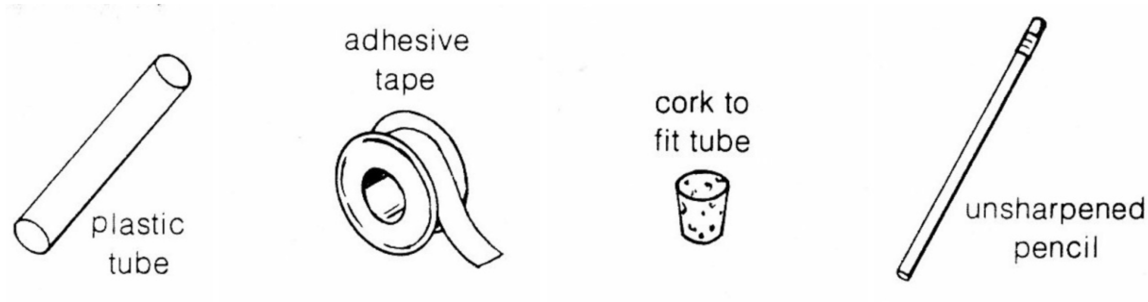
Oxygen
Burning
Chemical Reaction

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS1: Matter and Its Interactions (p. 43)
Performance Expectation: 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
Disciplinary Core Idea: PS1.A: Structure and Properties of Matter- Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)

Step 3: Pop!

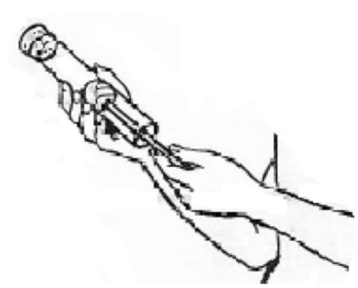
A. Gather



B. Make

1. Wrap the adhesive tape around the graphite end of the unsharpened pencil.
2. Continue wrapping the tape until the pencil just fits into the tube.
3. Place the cork into the other end of the tube. Do not push the cork in tightly.

C. Try



1. Point the cork end away from you. (Do not aim it at anyone.)
2. Plunge the pencil in quickly.
3. The air in the tube is pushed into a smaller space. It is being compressed. What does this do to the cork?

   The compressed air pushes with enough force to make the cork fly out.

4. How does compressed air help us in other ways?

   Compressed air is used to fill bicycle tires and automobile tires. Jackhammers use the force of compressed air to break up a roadway.

Teacher Notes:

A. Plastic tubes can be made from bead containers or cigar tubes by cutting off the closed end.

B. The pencil becomes a piston within the plastic cylinder.

Background Information:

The pressure of a gas is the result of the impacts of its molecules against a surface. When there are more molecules in the same space, the number of impacts is greater, thus causing a greater pressure. Or if the temperature of a gas is increased, its molecules move faster and exert greater force at each impact; therefore, the pressure of a heated gas inside a container is greater than that of the same amount of gas at a lower temperature. These two factors -density of the gas and temperature - act independently to determine the pressure of a gas. They are not related.

In this activity, temperature is not involved. When the pencil piston is pushed into the tube, the air is compressed (squeezed) into a smaller space. There are more molecules in that space than there were before, so the pressure is greater. This is known as Boyle's Law.

Sci-Terms:

Piston
Gas
Pressure
Volume
Boyle's Law

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS1-Matter and Its Interactions (p. 43)
Performance Expectation: 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
Disciplinary Core Idea: PS1.A: Structure and Properties of Matter-Matter of any type can be subdivided into particles too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)

STEM Center 2.1

Team Challenge: **What design will make a Balloon Rocket travel the farthest distance possible?** [*NGSS 5-PS1-1*: Develop a model to describe that matter is made of particles too small to be seen.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on how balloon rockets that will help you solve the problem [e.g. what is the science behind propelling a rocket? How is a balloon rocket propelled? What materials are used in the design of a balloon rocket and what is a good design?].

Fact 1:

Fact 2:

Fact 3:

Find two scientists who were involved in the study of rockets.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

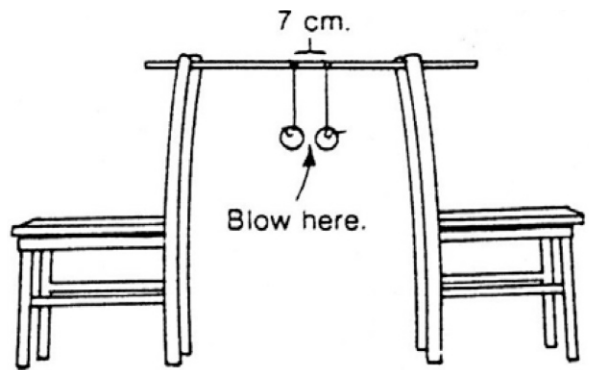
Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 4: Which Way?

A. Investigate



1. Tape two strings to two Ping-Pong balls.

2. Tape the other ends of the strings to a meter stick. The strings should be about 7 cm apart.

3. Hang the meter stick between two chairs.

4. Blow hard between the Ping-Pong balls.

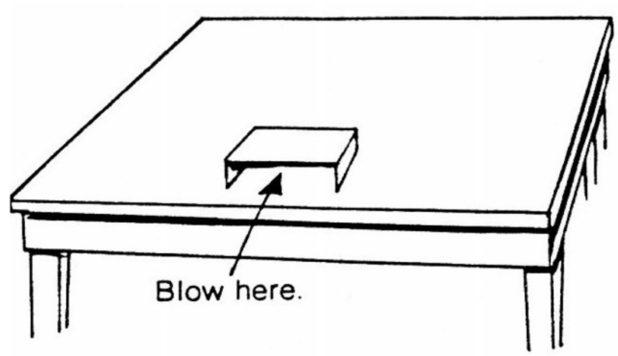
5. Which way did the balls move?

Children will expect the Ping-Pong balls to fly apart. Actually, they are pushed together.

B. Hypothesis

Moving air causes differences in air pressure. When air moves faster, the pressure at its sides becomes lower.

1. Fold down the ends of a piece of paper, about 8cm × 15cm, as shown in the diagram.



2. Place the paper on a table. Blow some air under it. What happens?

<u>The middle of the paper is pushed down.</u>

3. The air moving under the paper is moving fast. Therefore, the pressure on the underside of the paper ***<u>is lowered.</u>*** The normal air pressure above is now greater.

4. The air above the paper is not moving. Therefore, the air pressure on top of the paper ***<u>is now greater (i.e. the normal air pressure)</u>*** than it is under the paper.

C. Test

1. Hold an empty soda bottle on its side.

2. Put a small wad of paper into the neck of the bottle.

3. In which direction do you think the paper will move if you blow across the opening in the bottle?

   __*a*__ a. toward the opening

   ______ b. toward the bottom of the bottle

   ______ c. straight up

4. Try it.

5. Which way did the paper move? Explain.

   Air pressure at the opening is lower than inside the bottle, so the paper is pushed outward (toward the opening) and into the stream of wind.

Background Information:

The importance of this investigation lies in its demonstration that things in the physical world don't always act the way we expect them to. When this happens, we have a puzzle for scientists to explain. The explanation in this case is not easy to understand, but it depends on the fact that a gas exerts pressure because of the energy of its molecules, which ordinarily are moving in all directions. However, when a mass of gas is moving rapidly in one direction (as in a wind), more of the energy of the molecules is directed forward and less to the sides. Therefore, the sidewise pressure is reduced. Normal pressure of the air at rest now accounts for the pushing effect noted in each activity. This is known as Bernoulli's Principle.

Sci-Terms:

Pressure
Bernoulli's Principle

Connections to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2: Motion and Stability: forces and Interactions (p. 59)
Performance Expectation: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
Disciplinary Core Idea: PS2.A: Forces and Motion- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the ass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

Step 5: Particles in the Air

A. Observe

1. Get 4 glass microscope slides.
2. Coat one side of each slide with petroleum jelly (Vaseline).
3. Place the slides in various locations around your home (jelly side up).
4. Secure them with tape so they will not move.
5. Look at the slides. What do you see? Record your findings on the chart below.

<u>The slides will become dirty. Particles in the air will stick to the Vaseline.</u>

B. Record

Location	1 Day Later	3 Days Later	5 Days Later

1. Where did you find the dirtiest slide?

____

2. Where did you find the cleanest slide?

____

C. Predict

1. Get 6 glass microscope slides. Put petroleum jelly on one side.
2. Put the slides in the locations shown on the chart below.
3. Predict which of the two slides in each case will be dirtier in 1 day.
4. Do the experiments and record your findings on the chart.
5. Use a magnifying glass to help you discover what the particles are.
6. Check which of the 2 slides in each case was dirtier.

<table>
<tr><th colspan="2">Location</th><th>Prediction</th><th>Kinds of Particles</th><th>Dirtier</th></tr>
<tr><td rowspan="2">Air Conditioner</td><td>Outdoors</td><td></td><td></td><td></td></tr>
<tr><td>Indoors</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Automobile (outdoors)</td><td>Front</td><td></td><td></td><td></td></tr>
<tr><td>Rear</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Tree</td><td>Bottom</td><td></td><td></td><td></td></tr>
<tr><td>High up</td><td></td><td></td><td></td></tr>
</table>

The slides should be dirtier…
- ***On the outside of the air conditioner***
- ***At the rear of the car***
- ***At the base of the tree***

Teacher Notes:

B. The chart will vary according to the location of the slides, time of the year, weather, etc.
C. Encourage comparisons and discussion of observations.

Teacher Background Information:

The chief causes of air pollution are motor vehicles, factories, furnaces, and power plants. Particles of soot, exhaust gases, garbage burnings, etc., enter our atmosphere and can cause a great deal of damage and personal harm. These particles affect the respiratory system and the eyes of millions of people. Natural pollutants of dust, pollen, bacteria, and spores also affect our lives. In addition, man-made and natural pollutants cause considerable damage to crops, livestock, and building structures.

Sci-Terms:

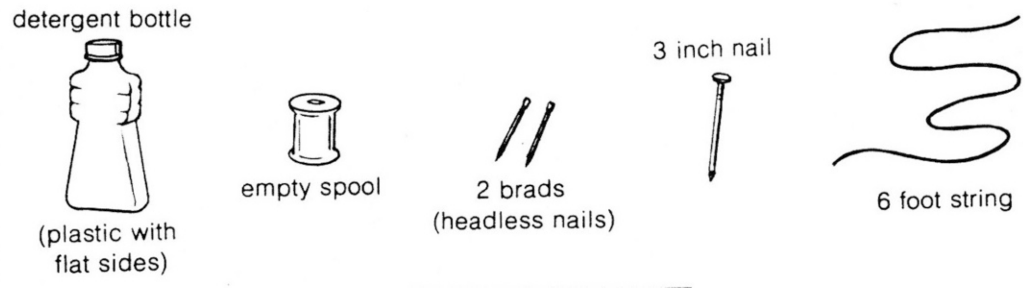
Petroleum jelly
Particles
Microscope slides

Connections to the *Next Generation Science Standards* (NGSS):

Standard: 5-ESS3-Earth and Human Activity (p. 51)
Performance Expectation: 5-ESS3-1-Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (p. 51)
Disciplinary Core Idea: ESS3.C: Human Impacts on Earth Systems- Human activities in agriculture, industry, and everyday life have had major effects on land, vegetation, streams, oceans, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (p. 51)

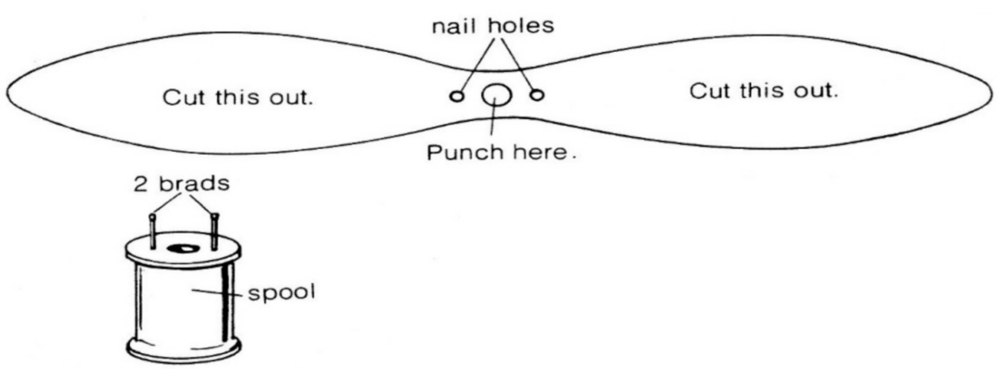
Step 6: Propeller Flights

A. Gather



B. Make

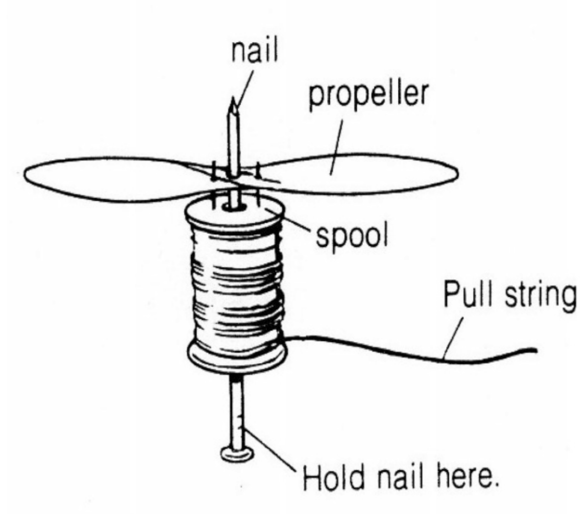
1. Cut out the propeller pattern.



2. Trace the pattern onto the flat side of the plastic bottle. Place marks where the holes will be.
3. Carefully cut out the propeller.
4. Use a paper punch and a nail to make the 3 holes.
5. Drive 2 brads or headless nails into the top of the spool.

C. Try

1. Wind the string around the spool.
2. Bend the propeller blades slightly in opposite directions.
3. Place the propeller over the 2 nails.
4. Set the spool and propeller on a 3-inch nail.
5. Hold the nail in one hand and the string in the other.
6. Pull the string hard to unwind it.
7. What happens to the propeller?



<u>The propeller will lift off when it is spun around only if its "leading edges" are bent upward. The pressure below the blades is then greater than above the blades.</u>

Teacher Notes:

B. Cut the plastic as smoothly and evenly as possible.

C. IF the blades are bent the wrong way, they can be bent back the other way, or the string can be wound around the spool the other way to reverse the direction of spin. (Turning the propeller over will not help!)

Background Information:

This propeller acts like a mini-helicopter. A propeller on an airplane acts like a screw being turned by a screwdriver. The propeller has a shape similar to the wings of an airplane. As the blade whirls through the air, the air pressure in the front becomes lower than the air behind the propeller. The airplane moves forward towards the place of lower pressure.

Sci-Terms:

Brads
Propeller

Connections to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: MS-PS2-Motion and Stability: Forces and Interactions (p. 59)
<u>Performance Expectation</u>: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
<u>Disciplinary Core Idea</u>: PS2.A: Forces and Motion-The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

STEM Center 2.2

Team Challenge: **Make a simple atomizer that can perform a useful function in the classroom**. [*NGSS 5-PS1-1*: Develop a model to describe that matter is made of particles too small to be seen.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on atomizers that will help you solve the problem [e.g. what is an atomizer? What are some ways to make a simple atomizer? Explain how an atomizer works by using Bernoulli's principle of air pressure].

Fact 1:

Fact 2:

Fact 3:

In addition to Bernoulli, what other scientists/inventors contributed to the study of air pressure?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

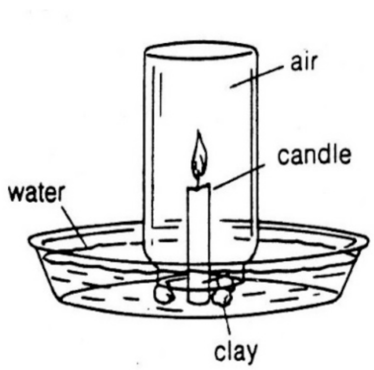
Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 7: Oxygen and Burning

A. Investigate



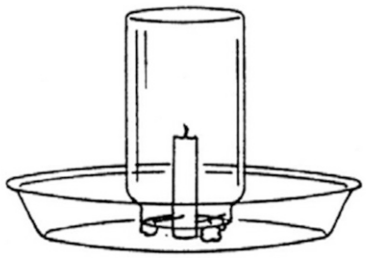
1. Heat the bottom of a candle and attach it to a dry cake pan.
2. Stick three small pieces of clay to the rim of a jar.
3. Fill the pan with water.
4. Light the candle.
5. Put the jar over the candle, so it rests on the clay supports.
6. What happens to the candle?

After a few seconds of burning, the candle goes out.

7. What happens to the water?

The water rises into the jar to about 1/5 of its height.

B. Hypothesis



Draw the water level in the jar.

1. What caused the flame to go out?

______ a. All the air was used up

______ b. All the oxygen in the air was used up.

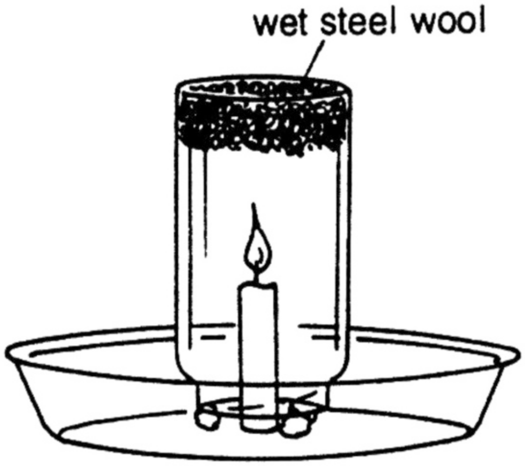
__*c*__c. Some of the oxygen was used up.

2. What caused the water to go into the jar?

__*a*__a. Air pressure on the outside of the jar was greater than on the inside.

______ b. Air pressure on the inside of the jar was greater than on the outside.

C. Test



After 2 days, draw the water level.

1. Do steps 1–4 in Part A again.
2. Wedge some moist steel wool into the jar.
3. Put the jar over the candle.
4. Leave the jar in place for 2 days after the candle goes out.
5. What happens to the water level now?

The water level continues to rise in the jar.

6. What happened to the steel wool?

The steel wool becomes rusty.

7. What does this show?

This proves that there was still oxygen left in the jar after the candle goes out because oxygen is necessary for the steel wool to rust.

Background Information:

Burning is a chemical combination with the oxygen in the air (about 21% of the volume of air) in which light and heat are given off. A candle will stop burning in air before all the oxygen is used up. Rusting is slow oxidation (combination with oxygen) in which no noticeable light or heat is given off. It can occur at much lower concentrations of oxygen than are required for burning.

As oxygen is removed from the air by burning or rusting, the pressure of the remaining gases (mostly nitrogen) becomes less. The normal air pressure outside the jar forces water into the jar until the pressures are balanced.

The burning of a candle produces the gas carbon dioxide, which partly replaces the oxygen removed from the air, but the carbon dioxide gradually dissolves in the water. The rusting iron removes almost all the remaining oxygen, and the bottle fills with water to about 20% its volume (replacing the lost oxygen).

Sci-Terms:

Steel wool
Rusting
Oxidation

Connections with the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2-Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
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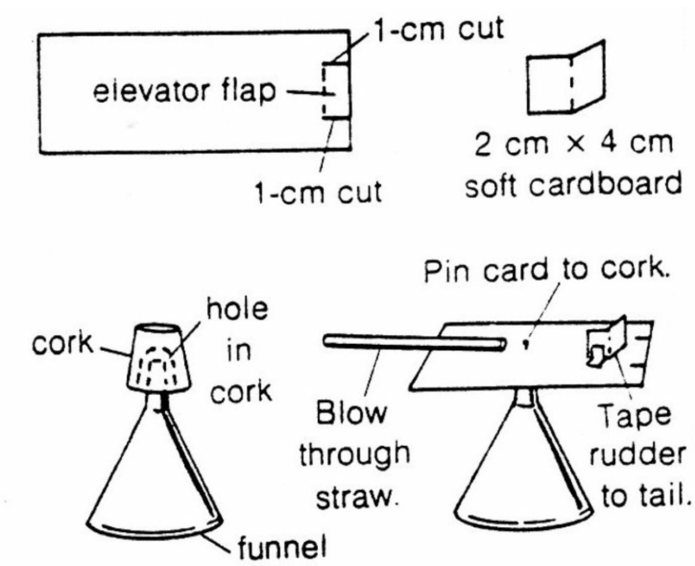
Step 8: Control of Flight

A. Observe



1. Get a model airplane. Observe the rudder and elevator of the plane. The rudder helps the plane to change direction.

2. Make a paper model of an airplane tail as shown in the diagram.

3. Use a straw to produce an air stream. Direct a stream of air at the rudder.

4. See how changing the angle of the rudder changes movement of the airplane. Record your observations on the chart.

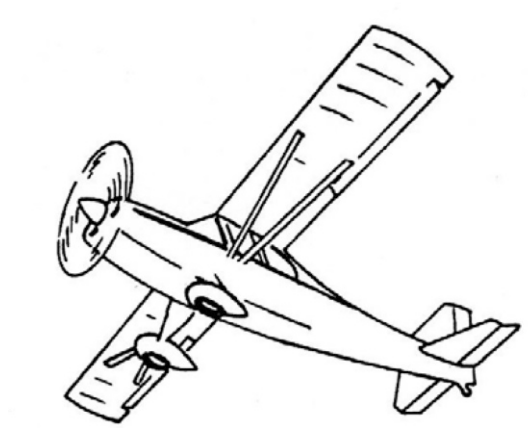
B. Record

Directions	Direction of Plane's Movement
Fold the rudder to the pilot's left. Keep the elevator level. Blow air through the straw.	
Fold the rudder to the pilot's right. Keep the elevator level. Blow air through the straw.	
Tape the rudder together. Fold the elevator up. Blow air through the straw.	
With the rudder taped together, fold the elevator down. Blow through the straw on the underside of the card.	

Left and Right refers to the plane's left and right as it would be in flight.

1. Tail moves to the right – Front of plane moves to the left
2. Tail moves to the left – Front of plane moves to the right
3. Tail moves down – Front of plane moves up
4. Tail moves up – Front of plane moves down.

C. Predict



1. What folds would you make in the elevator and rudder to move the front end…
   (choose from “up,” “down,” “left,” “right.”)

   a. up and to the right?

      Rudder ***- right***

      Elevator ***- up***

   b. down and to the left?

      Rudder ***- left***

      Elevator ***- down***

2. Try it. Were your predictions correct?

___

___

Teacher Notes

A. Tape the small piece of card, acting as the rudder, vertically to the rest of the tail section. The funnel set-up is merely used for stability.

Background Information:

The pilot of an airplane controls the rudder with a pair of pedals. When he pushes down on his left pedal, the rudder turns to his left. The tail end is pushed to his right while the front end turns to the left. Pushing down on the right pedal will turn the plane to the right. A control stick is pulled back to make the elevators go up and the plane up. A push forward allows the elevators to go down which makes the tail section go upwards and the plane heads down.

Sci-Terms:

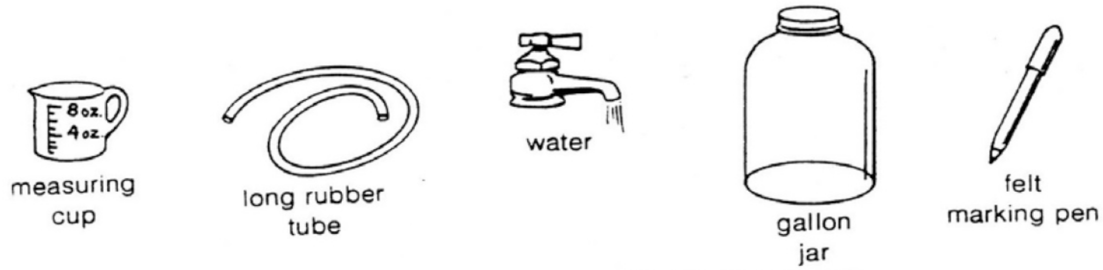
Rudder
Elevator
Funnel

Connections to the *Next Generation Science Standards* (NGSS):

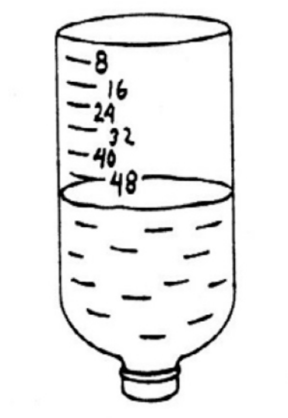
Standard: MS-PS2-Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
Disciplinary Core Idea: PS2.A: Forces and Motion- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

Step 9: Air in Your Lungs

A. Gather

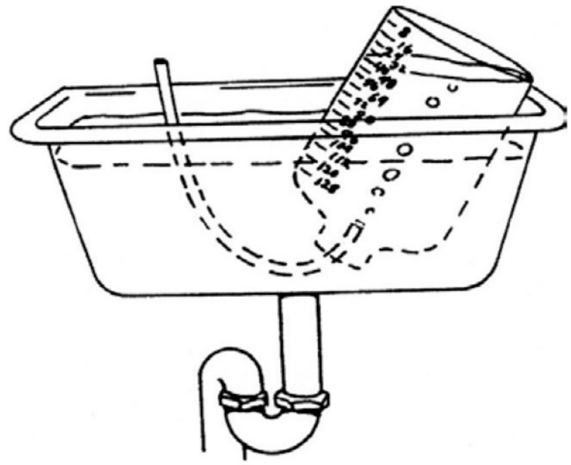


B. Make



1. Fill the jar with water.
2. Pour 8 ounces of water from the jar into the cup.
3. Replace the cap on the jar. Turn the jar over. On the outside of the jar, mark the level of the water with the number 8.
4. Empty the cup.
5. Pour another 8 ounces of water from the jar into the cup.
6. Repeat steps 3 and 4. Mark the level 16.

C. Try



1. Fill the jar completely with water.
   Put the cap on the jar.

2. Fill a sink with water.

3. Turn the jar over in the sink.
   Be sure the jar is under water (And be sure the opening of the jar is under the water.)

4. Unscrew the cap while the jar is under water.

5. Tip the jar slightly.

6. Place one end of the rubber tubing into the mouth of the jar.

7. Place the other end of the rubber tubing above the water level.

8. Take a deep breath and exhale steadily into the rubber tubing until you empty your lungs.

9. Record how much water is forced out of the jar by your breath. Do this 3 times. Then find your average lung capacity.

   1st Try _______________ oz
   2nd Try _______________ oz
   3rd Try _______________ oz

   Average lung capacity _____________ oz

Teacher Notes:

A. Use a marking pen that will write directly on the glass jar.

B. The scale is very important. The entering air forces out the water in an equal amount. (Two things cannot be in the same place at the same time.)

C. The actual amounts will vary according to age, sex, and body type.

Background Information:

An adult usually exhales about 1 pint of air with each breath. This "tidal air" is only about 1/7 of all the air available ("vital capacity") of the lungs. Oxygen of the air enters the air sacs, which are surrounded by capillaries. The oxygen passes into the blood and is carried to all the cells of the body. Here it combines with the food, and energy is released. Carbon dioxide and water vapor are waste products that enter the blood, exchanged in the lungs, and eliminated when we exhale.

Sci-Terms:

Ounces
Exhale
Lung capacity

Connections to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 5-PS1-Matter and Its Interactions (p. 43)
<u>Performance Expectation</u>: 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
<u>Disciplinary Core Idea</u>: PS1.A: Structure and Properties of Matter-Matter of any type can be subdivided into particles too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)

STEM Center 2.3

Team Challenge: **How can you incorporate the principles learned in STEP 8 to make a paper airplane fly in a particular direction (up, down, left, right)?** [*NGSS MS-PS2-2*: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on the moving parts of airplanes that will help you solve the problem [e.g. what are the moving parts on airplanes? How do these parts help planes maneuver and change direction? Did early airplanes have these moving parts?].

Fact 1:

Fact 2:

Fact 3:

What early inventors worked to help maneuver and control an airplane in flight?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

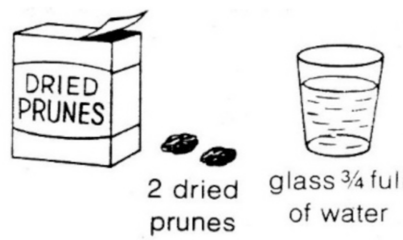
During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

WATER & WEATHER

Step 1: Water to the Rescue

A. Investigate

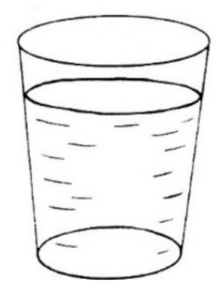


1. Place a dried prune into a glass ¾ full of water.

2. Let it stand overnight.

The prune swells and becomes a bit smoother.

B. Hypothesis



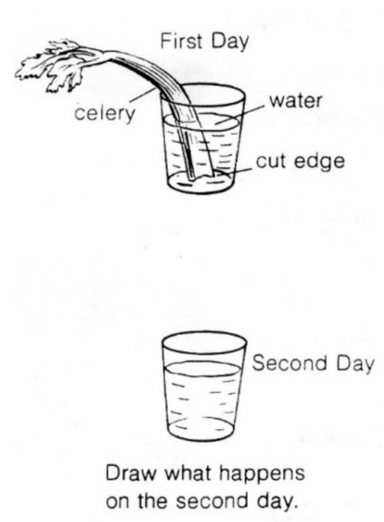
1. Draw what happened to the prune.

The prune loses its wrinkled characteristic, becoming plumper as water moves into it.

2. Which hypothesis explains what happened?

__*a*__ a. Water moves into dried fruits and vegetables.
_____ b. Water moves out of dried fruits and vegetables.
_____ c. Water does not move into or out of dried fruits and vegetables.

C. Test



1. Get a limp celery stick.
2. Cut a slice from the bottom.
3. Place the celery stalk into a glass of blue, green, or red colored water.
4. Let it stand overnight.
5. Did the water move?
6. How do you know?

Cutting the end allows water to enter into the water-conducting tubes. The celery becomes firm and crisp while the leaves become the color of the dye in the water

7. Find other fruits or vegetables to test your hypothesis.

Background Information:

A prune is a sweet plum that has been dried. During the process it acquires its characteristic wrinkled appearance. When the prune is placed in water, the processes of diffusion and osmosis take place. Water moves from an area of high concentration (outside the prune) to an area of lower concentration (inside the prune) and across cell membranes of the prune.

Sci-Terms:

osmosis
diffusion

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-LS1- From Molecules to Organisms: Structures and Processes (p. 38)
Performance Expectation: 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (p. 38)
Disciplinary Core Idea: LS1.A: Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (p. 38)

Step 2: Ice Cubes

A. Observe

1. Fill a tall, narrow glass about ¾ full of water.
2. Place a large ice cube into the glass.
3. Put a rubber band around the glass at the water level.
4. Let the ice cube melt.
5. Is the water level higher or lower than the rubber band?

No noticeable change in water level occurs.

B. Record

Fresh Water

Contents of Glass	Temp	Time
All ice		
Mostly water, some ice		
Mostly ice, some water		
All water		

1. Fill a drinking glass with cracked ice cubes.
2. Put a thermometer into the glass.
3. Record the temperature at the start.
4. Watch the temperature as the ice melts.
5. See how long it takes to melt.
6. Record your observations on the chart.

C. Predict

1. What do you predict will happen to the temperature if you add salt to the ice?

____

2. Add 2 tablespoons of salt to a glass of cracked ice cubes.

3. Place a thermometer inside the glass.

4. Complete the chart.

5. What does salt do to the melting point of ice?

In the presence of salt, ice melts at a lower temperature. The temperature of the ice and salt water mixture will be a few degrees below the normal freezing point: 26 degrees to 28 degrees Fahrenheit, or -2 degrees to -3 degrees Celsius.

Salt Water

Contents of Glass	**Temp**	**Time**
All ice		
Mostly water, some ice		
Mostly ice, some water		
All water		

Try this on your friends:

1. Dip one end of a string in water.
2. Lay the wet end across an ice cube.
3. Sprinkle salt along both sides of the string.
4. Wait a minute. Lift the dry end of the string.
5. What happened to the ice cube?

____

____

Teacher Notes:

B. Temperature shown by the thermometer will be somewhat above the melting point (32 degrees Fahrenheit, 0 degrees Celsius). The reading will remain the same (or may rise slightly) as long as there is any un-melted ice. When it is all water, the temperature will then begin to rise rapidly toward room temperature (See background information.)

Background Information:

Most materials contract when they freeze from liquid to solid. This makes the solid more dense than the liquid. Water is an exception. It expands when it freezes, and becomes less dense than water. Any object that is less dense than water (has less weight than the same volume of water) will float in water. A floating object displaces its own weight of water.

When the ice cube melts, it turns into the same weight of water, which is exactly the amount of water that it is displacing. This water just fills the "hole" that the ice is making in the water. So the water level doesn't change. You will observe the same thing in a glass full of an iced drink. No matter how much ice is in the glass, the liquid level stays the same as the ice melts.

Theoretically, a melting solid stays at a constant temperature while it is melting. In an actual experiment with ice and water, it is very hard to spread the heat uniformly. Parts of the liquid near the container and near the air surface will always be a little warmer than the parts near the ice. The thermometer will therefore read a little higher than the theory predicts.

Salt lowers the melting point of ice. If you have pure ice at 0 degrees C, and you sprinkle it with salt, the ice can't remain ice at this temperature. It is too warm. So it melts. However, if the surroundings are cold, the melted ice may cool down and freeze again below 0 degrees C.

Sci-Terms:

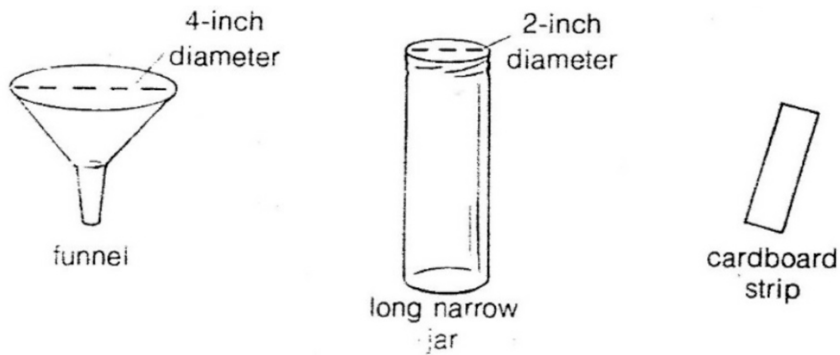
Density
Expands/Expansion
Melting Point
Freezing Point

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 5-PS1- Matter and Its Interactions (p. 43)
<u>Performance Expectation(s)</u>:
5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
5-PS1-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating cooling, or mixing substances, the total weight of matter is conserved. (p. 43)
5-PS1-3: Make observations and measurements to identify materials based on their properties. (p. 43)
<u>Disciplinary Core Idea(s)</u>:
PS1.A: Structure and Properties of Matter: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving feely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)
PS1.A: Structure and Properties of Matter: The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (p. 43).

Step 3: Measuring Rainfall

A. Gather



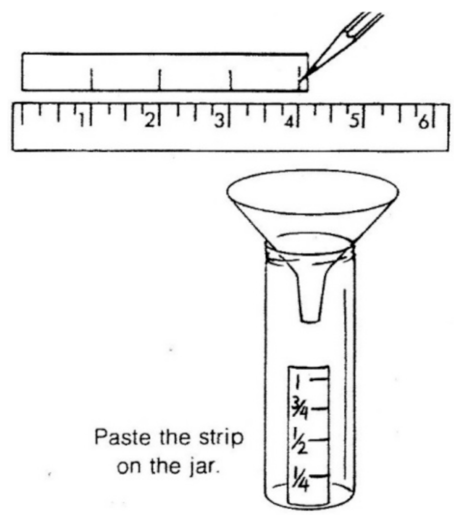
B. Make

1. Place the funnel into the jar.

2. With a ruler, mark off the cardboard strip in inches.

3. Next to the first mark, write ¼; next to the second mark, write ½, and so on. (Use a permanent marker.)

4. Paste the strip onto the jar so you will be able to read the scale.



C. Try

1. Wait for the beginning of the next rainfall. Place your rain gauge in an open place. Leave it there until the rain stops.

2. After the rain has stopped, look at the water level in the jar.

3. Read the gauge. How much rain fell? ____

4. Empty the jar.

5. See how much rain falls during the next four rainy days. Record your observations on the chart.

Date	Amount of Rainfall

Teacher Notes:

B. The area of a circle is πr2. This means that the funnel will collect water from four times the area that the jar alone could.

C. The amounts will vary according to day, place, and other local conditions.

Background Information:

The rain gauge is an important tool used by meteorologists (weather scientists) to measure total rainfall or rainfall per hour. The official Weather Bureau uses a gauge consisting of a funnel and tube with a 10:1 ratio for easy reading. Also, meteorologists are concerned with all kinds of precipitation: snow, sleet, hail.

Sci-Terms:

Diameter
Funnel
Rain gauge
Meteorologist

Connections to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 3-ESS2: Earth's Systems (p. 32)
<u>Performance Expectation</u>: 3-ESS2-1- Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. (p. 32)
<u>Disciplinary Core Idea</u>: ESS2.D: Weather and Climate: Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.

STEM Center 3.1

Team Challenge: **What different materials could be added to water to allow 4 identical objects to float at different levels in a tall glass cylinder?** [*NGSS 5-PS1-3*. Make observations and measurements to identify materials based on their properties.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on changing the density of water that will help you solve the problem [e.g. how can we change the density of water? What are the interrelationships between glaciers, icebergs, ocean level, and temperature? What could be the anticipated effects of climate change upon these same factors?].

Fact 1:

Fact 2:

Fact 3:

What are current scientists finding out about climate change and the world's oceans?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

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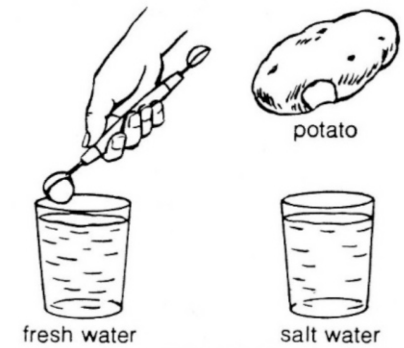
Step 4: A Bathysphere

A. Investigate



1. Use a kitchen scoop to make a small ball from a raw white potato.

2. Place the ball into a glass full of cold water.

3. Draw what happens to the potato bathysphere.

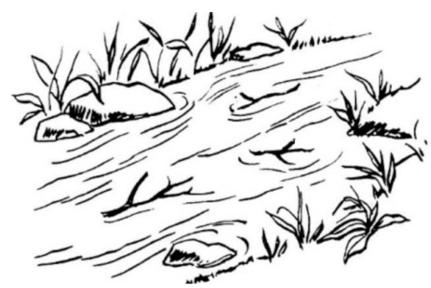
The potato ball with sink to the bottom of the glass of fresh water.

4. Add 3 tablespoons of salt to the water. Stir it.

5. What happens to the bathysphere?

When salt is added, the potato ball will float at the surface.

B. Hypothesis



Which statements explain what happened?

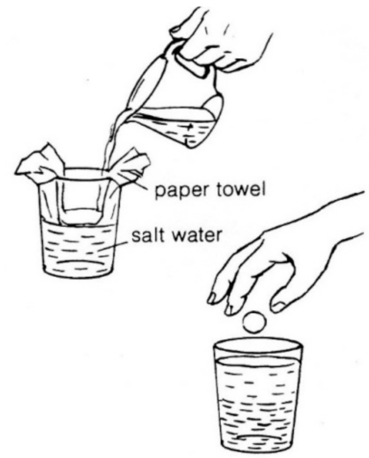
__*a*__ a. Salt makes the water get heavier.

______ b. Salt makes the water get lighter.

______ c. An object floats if it is heavier than the water it pushes aside.

__*d*__ d. An object floats if it is lighter than the water it pushes aside.

C. Test



1. Remove the potato ball.

2. Pour out half the salt water.

3. Place a piece of paper towel into the glass over the salt water.

4. Carefully pour fresh water into the remaining half of the glass. Do it so gently that the fresh water does not mix with the salt water.

5. Carefully remove the paper towel, keeping the fresh water on top.

6. Place the potato bathysphere into the glass.

7. Where does the bathysphere settle?

The salt water and fresh water have different densities, and if done gently, two distinct layers will be found. The bathysphere will float on the top of the salt water, where the density is greater.

Background Information:

The early bathysphere was used to study the ocean floor. The steel ball had thick quartz windows for the oceanographer to observe the life and conditions existing about 3,000 feet below the surface. A revolutionary observation-type diving ship, called the "bathyscaphe," was used to descend to the deepest ocean trench at 35,000 feet below sea level in 1960. Modern-day deep-diving submarines or deep submergence vehicles (DSVs), such as Alvin, use different buoyant materials to help explore the ocean depths.

Sci-Terms:

Bathysphere
Density

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2 Motion and Stability (p. 59)
Performance Expectation: MS-PS2-2- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. p. 59)
Disciplinary Core Idea: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

Step 5: Crystal Shapes

A. Observe

1. Put ¼ cup of water into a pot and bring it to a boil.
2. Add ¼ cup of Epsom salts to the water. Stir.
3. What happens to the Epsom salts?

The Epsom salts will dissolve readily in hot water.

4. Pour the solution into a glass.

B. Record

1. Use a medicine dropper to put one drop of the solution on a clean glass microscope slide.
2. Leave the rest of the solution in the glass. Cover the glass with a sheet of paper.
3. Wait a few minutes until the solution evaporates. Then examine the liquid on the slide with a magnifying glass.
4. Draw a picture of what you see. Use the space below.
5. Wait a day. Then examine the glass containing the Epsom salts solution.
6. Draw a picture of what you see. Use the space below.

On an exposed glass slide the water evaporates quickly and there is rapid crystallization. They appear flat. When allowed to crystallize slowly in the glass, the shape of the crystals will be needle-like and 4-sided.

C. Predict

Do you think all crystals have the same shape? Do this to find out:

1. Do part A again, but use 2–3 teaspoons of table salt instead of the Epsom salts.
2. Put a drop of the solution on a glass microscope slide. Examine it with a magnifying glass after a few minutes (after evaporation occurs).
3. After a few days, examine the solution in the glass with a magnifying glass.
4. Draw pictures of what you see. Use the space below.

5. Do the table salt crystals look like Epsom salt crystals? ______________________________
6. How many sides do the table salt crystals have?

Crystal shape varies. Table salt forms a 6-sided cube.

7. Was your prediction correct? ______________________________

Background Information:

Dissolving occurs when a solid placed in water breaks down into extremely small particles, which may be molecules or even smaller particles called ions. Different salts will dissolve in water to different extents. When water has as much of a dissolved salt as it can hold, the solution is saturated. As water evaporates from a saturated solution, the excess dissolved salt must come out of a solution. It does this by forming a small crystal and then adding on to the outside of the crystal, layer by layer, but always keeping its own particular shape. There are many different geometric shapes that crystals may have, depending on the arrangement of the atoms in the particular salt.

Sci-Terms:

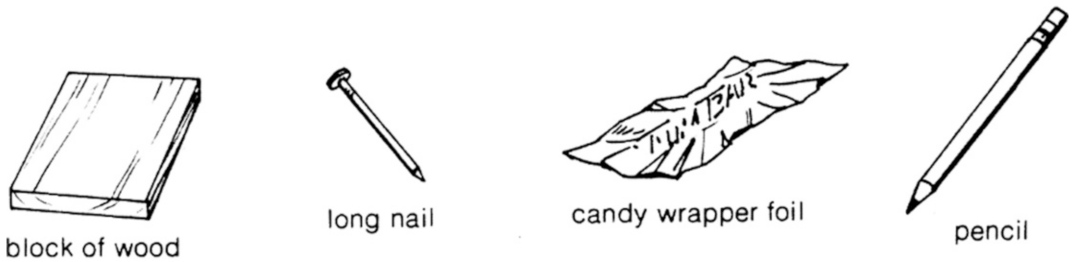
Epsom salts
Solution
Crystals

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: MS-PS1-1 Matter and Its Interactions (p. 56)
<u>Performance Expectation</u>: MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. (p. 56)
<u>Disciplinary Core Idea</u>: PS1.A: Structure and Properties of Matter
Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (p. 57)

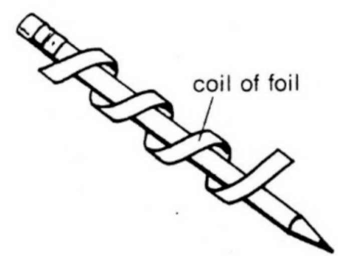
Step 6: Candy Wrapper Hygrometer

A. Gather



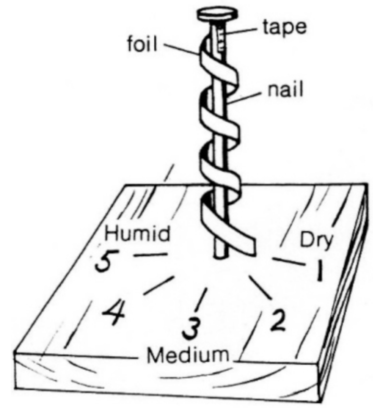
The candy wrapper must have foil on one side and paper on the other.

B. Make



1. Cut a strip about 15 cm × ½ cm from the candy wrsapper.
2. Wind it, with the foil side facing out, around a pencil.
3. Remove the coil of paper. Slip it around the nail. Tape one end to the top of the nail.
4. Drive the nail into the block of wood.

C. Try



1. Put your hygrometer in a cool, dry place. Mark a line where the end of the coil is pointing. Label it DRY.

2. During the next rain, place your hygrometer outdoors, but in a place where it will not get wet.

3. What happens to the foil?

<u>The paper absorbs the water better than the foil. This produces a bending, which in turn makes the coil unwind.</u>

4. Mark a line where the end now points. Label it HUMID.

5. Divide the space between the two marks. Look at the drawing to see how it is done.

6. Check the moisture in the air with your hygrometer.

Teacher Notes:

A. Some cereals use a paper and foil inner bag. This works fine, too!

B. Keep the coil evenly spaced with the end free.

Background Information:

A hygrometer is an instrument used to measure the amount of water vapor in the air. This amount, compared to the amount that the air could possibly hold at the particular temperature, determines the “relative humidity” of the air at that time.

Sci-Terms:

Hygrometer
Humid/humidity
Relative humidity

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: MS-ESS2-Earth’s Systems (p. 80)
<u>Performance Expectation</u>: MS-ESS2-5- Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. (p. 80)
<u>Disciplinary Core Idea</u>: ESS2.C: The Roles of Water in Earth’s Surface Properties: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landform, and ocean temperatures and currents, are major determinants of local weather patterns. (p. 81)

STEM Center 3.2

Team Challenge: **How can you grow the longest crystal? Which team can grow the most colorful crystal?** [*NGSS MS-PS1-1.* Develop models to describe the atomic composition of simple molecules and extended structures.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on how crystals form that will help you solve the problem [e.g. how do crystals form? What factors contribute to the size, length or shape of a crystal? What factors contribute to the color of a crystal?]

Fact 1:

Fact 2:

Fact 3:

What scientists have helped to identify different crystals? How can the use of crystals be helpful in a forensic crime investigation?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

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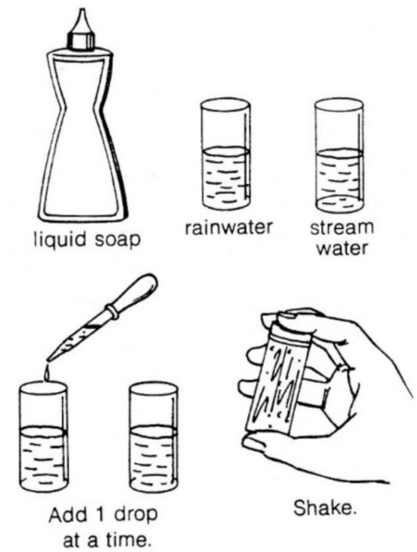
Step 7: Hard and Soft Water

A. Investigate



1. Use a small jar and a wide funnel to collect some rainwater.

2. In another jar, collect some clear water from a stream.

3. Put equal amounts of rainwater and stream water in separate vials.

4. Add liquid soap to each vial, 1 drop at a time. Cover the vials. Shake after each drop.

5. How many drops did you need to make ½-inch of suds?

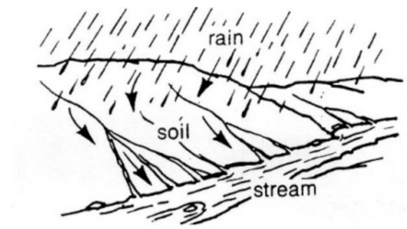
   Rainwater ______________ Stream water _______________

Water that makes suds with little soap is called soft water. Water that needs much soap to make suds is called hard water.

6. Which water sample was soft? ___________________________________

   Which water sample was hard? __________________________________

B. Hypothesis



Chemicals dissolve in rainwater as it flows over or through the soil. Dissolved chemicals make water hard.

Which do you think is correct?

_____ a. All chemicals make water hard.

__*b*__ b. Only certain chemicals make water hard.

C. Test

1. Put equal amounts of soft water in four vials.

2. Add 1 teaspoon of table salt to one vial; 1 teaspoon of Epsom salts to a second vial; and 1 teaspoon of washing soda to a third vial. Do not add anything to the fourth vial.

3. Shake the vials to dissolve the chemicals.

4. Test each vial with liquid soap. Record the number of drops needed to make ½-inch of suds in each vial.

Kinds of Water	No. of Drops of Soap
Pure soft water	
Soft Water + Table Salt	
Soft Water + Epsom Salts	
Soft Water + Washing Soda	

5. Which of the chemicals made the water hard?

Salt may or may not have a noticeable effect. Washing soda may have somewhat more noticeable effect. Epsom salts will have a marked effect in making the water hard.

Teacher Notes:

A. Tap water in many communities is soft enough for use in this activity, if not enough rain water can be collected. Distilled water may also be used. If natural stream water in your locality is not available or not hard enough, you can make “hard water” with Epsom salts.
The liquid soap should be true soap, not a detergent. Detergents are not affected much by hardness in water. Liquid shampoos are usually soaps.
One drop of soap will probably be enough in a vial of soft water; two or three drops may be needed for the natural hard water.

C. Washing soda or sodium carbonate is often difficult to find, so you can make your own… Use a deep cookie sheet. Set your oven to 400 degrees F. Spread a thin layer of baking soda in cookie sheet and bake for about an hour. Mix it, then bake for another hour until you feel tiny granules, unlike baking soda).

Background Information:

Hardness in water is caused by the presence of compounds of certain metals dissolved in the water. Calcium and magnesium are the most common causes of hardness. These metals react chemically with soap and form insoluble compounds that settle on clothes, while interfering with the cleaning action of the soap. Epsom salts contain magnesium sulfate, and simulates the presence of natural magnesium compounds in water supplies.

Sodium compounds do not make water hard. Washing soda, which is sodium carbonate, is an example. (Ordinary salt would not make water hard, but most commercial salt has other compounds added to it, which do cause hardness.)

Hardness in water can be corrected by removing the troublesome metal. This can be done by causing the metal to form an insoluble compound that will settle out of the water before the water is used. If the hardness is caused by calcium bicarbonate (common in limestone regions), it can be overcome by boiling the water. The bicarbonate changes to the insoluble calcium carbonate. Otherwise, washing soda can be added to the water to form insoluble carbonates of the calcium or magnesium.

Sci-Terms:

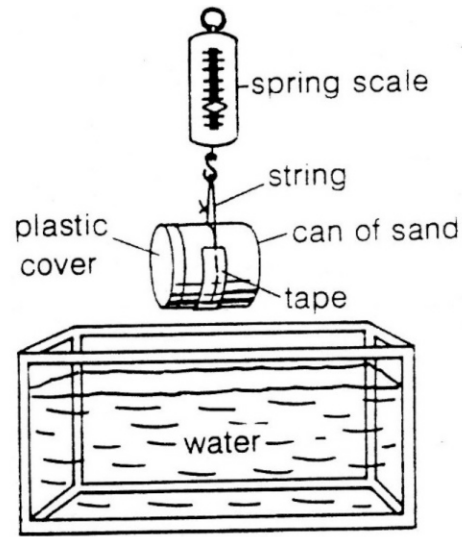
Vial
Suds
Hard water
Soft water
Epsom salts
Washing soda
Compounds

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 5-ESS2- Earth’s Systems (p. 50)
<u>Performance Expectation</u>: 5-ESS2-1- Develop a model using an example to describe ways in which the geosphere, biosphere, and/or atmosphere interact. (p. 50)
<u>Disciplinary Core Idea</u>: ESS2.A: Earth Materials and Systems: Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (p. 50)

Step 8: Water and Weight

A. Observe



1. Fill a small peanut can with sand.
2. Replace the plastic cover. Seal the can with masking tape so that water cannot get in.
3. Fasten a string around the middle of the can with tape.
4. Use a spring scale to weigh the can in the air.
5. Lower the can into a tank of water and read the scale again.

There will be a "loss of weight" when the can is placed in the water.

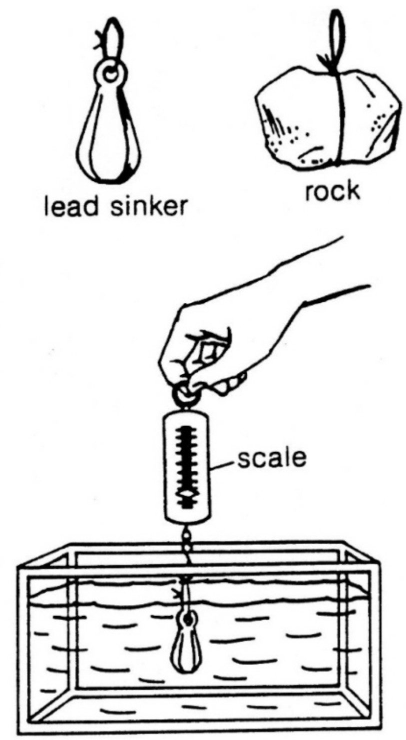
B. Record

1. On the chart below, record the weight of the can in air and in water.
2. Tie a string around a medium-sized rock. Weigh the rock in air and in water. Record your observations on the chart.
3. Is there a difference between the weight of an object in air and its weight in water?

Item	Weight	
	In Air	In Water
Can of Sand		
Rock		

Both the rock and the can apparently "lose weight" in water.

C. Predict



1. Obtain a small, heavy sinker.

2. Measure its weight.

3. Find a rock that has the same weight as the sinker.

4. Predict which object will seem to lose more weight in water.

5. Weigh both objects in water.

   Weight of sinker _______________

   Weight of rock _______________

6. Did one object lose more weight than the other? Explain why.

<u>The rock will appear to lose more weight than the sinker. In this experiment, the rock has less density than the lead sinker, which means it has more volume for the same weight. Therefore, the rock displaces more water than the sinker, and it is buoyed up by a greater force.</u>

Teacher Notes:

B. The scale may be calibrated in ounces or grams. Use the same scale throughout.

Background Information:

Archimedes, a Greek mathematician and scientist who lived around 250 B.C., discovered the principle of buoyancy: an object placed in a liquid is buoyed up by a force equal to the weight of the liquid it displaces. The greater the volume of the object, the greater the buoyant force, and the greater the amount of weight the object appears to lose. If the buoyant force is greater than the object's weight, the object will float.

Sci-Terms:

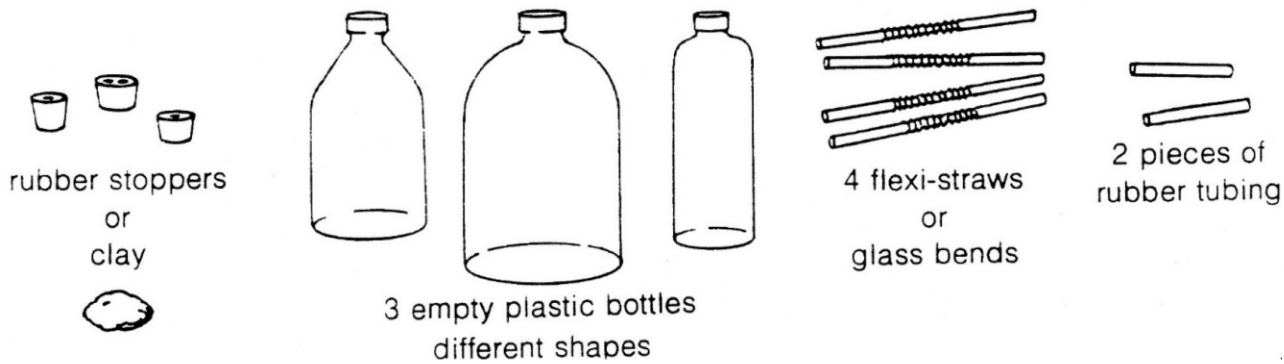
Density
Buoyancy
Spring scale
Weight
Mass
Volume

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2- Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation: MS-PS2-2- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
Disciplinary Core Idea: PS2.A: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

Step 9: Water Finds Its Level

A. Gather

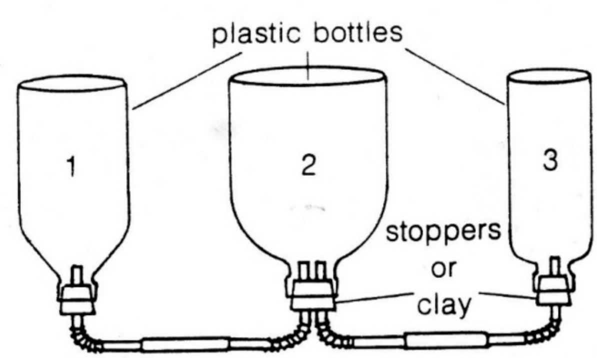


B. Make

1. Cut the bottom off each bottle so they will all be the same height.

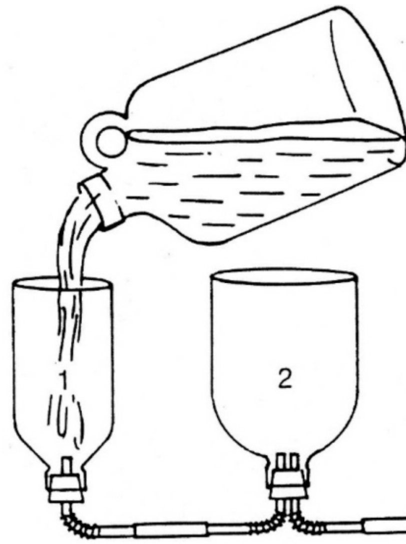
2. Assemble the three bottles as shown in the diagram.

3. Set them upright in a sink. Add water to the bottles and check for leaks.



C. Try

1. Add some food coloring to a jar of water.
2. Pour some of the water into bottle #1.
3. What happens in bottles #2 and #3?



4. Empty the bottles.
5. Pour some colored water into bottle #2.
6. What happens in bottles #1 and #3?

The food coloring is added just to see the water level better. Water flows from one bottle to the other two to maintain the same level in each, regardless of which one gets the water first.

Teacher Notes:

A. If glass tubing bent to a right angle, rubber stoppers, and rubber tubing are available, they could be used and some leakage may be avoided.

B. It may be necessary to prop the bottles upright in the sink.

Background Information:

Water exerts its pressure equally in all directions. This force of water is dependent only upon the depth of the water, not the quantity. Water pressure one foot below the surface in a bathtub would be the same as the pressure of water 1 foot below the surface of a large lake.

Sci-Terms:

Pressure/Water Pressure
Depth

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-ESS2: Earth's Systems (p. 50)
Performance Expectation: 5-ESS2-1: Develop a model suing an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact. (p. 50)
Disciplinary Core Idea: ESS2.A: Earth Materials and Systems- Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (p. 50)

STEM Center 3.3

Team Challenge: **How is water able to flow evenly to the 21st level of a 30 floor building? In other words, how does water get to the 21st level without losing pressure before getting to the higher levels? Can you make a model to show how this works?** [*NGSS 5-ESS2-1*: Develop a model suing an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on water pressure and transportation of water that will help you solve the problem [e.g. where does your community get its water from? How does it reach your school? How does water reach different floors in tall buildings and skyscrapers?]

Fact 1:

Fact 2:

Fact 3:

What evidence do we have that ancient civilizations were able to store and supply their community with water?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

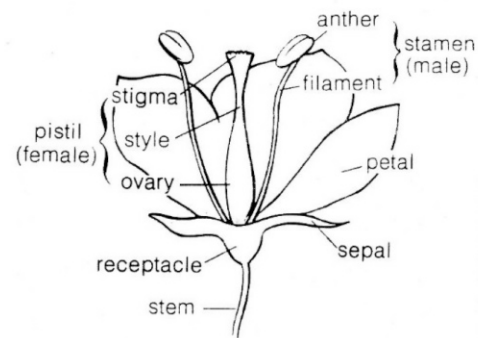
During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

PLANTS & ANIMALS

Step 1: Pollen Grains

A. Investigate



1. Collect several different kinds of flowers.
2. Identify the parts of the flower. Use the diagram at the right to help you.
3. Remove a stamen from one of the flowers.
4. Carefully cut open the anther.
5. Shake out the pollen grains over a piece of black paper.
6. Examine the pollen grains with a magnifying glass.
7. Follow steps 3–6 for several other kinds of flowers.
8. Are the pollen grains alike? If not, how do they differ from one another?

Pollen grains vary in size, shape, and color depending upon the type of flower.

B. Hypothesis

When pollen falls on the stigma of a flower, the flower becomes pollinated. After the pollen grains fall on the stigma, they will

______ a. dry up

______ b. stay at the top of the stigma

___***C***___ c. grow downward

C. Test

1. Put 2 teaspoons of water and 2 teaspoons of pancake syrup into a small saucer. Mix them.
2. Sprinkle some pollen grains on this sugary solution. (Pancake syrup is mostly sugar.)
3. Cover the saucer with plastic wrap.
4. Keep it in a warm place for 3–4 hours.
5. Use a magnifying glass or a microscope to examine the pollen grains.
6. Draw what you see.
7. Was your hypothesis correct?
8. Why?

The pollen grains split open and growth begins. A small "pollen tube" grows from each grain, using the energy of the sugary solution.

Teacher Notes:

A. Not all flowers will look like this. Some do not have the male and female organs in the same flower. Others may have the pistil higher than the stamens. Many flowers (chrysanthemums, zinnias, marigolds) are composites; the "flower" is really made up of many tiny flowers clustered together. The parts of such flowers are very hard to see.

Background Information:

In nature, pollination occurs within the flower or between flowers with the help of the wind, water, or insects. After landing on the stigma, the pollen tube grows down the style toward the ovary. Fertilization occurs when the male sex cell (in the pollen tube) unites with the female sex cell (in the ovule). The ovule becomes the seed containing the embryo-baby plant. The ovary ripens to become the fruit of the plant.

Sci-Terms:

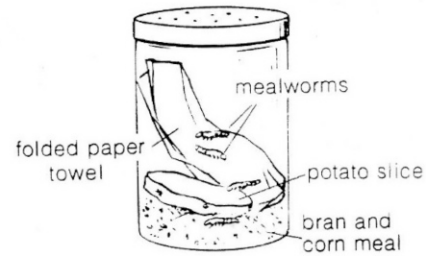
Stigma
Style
Ovary
Receptacle
Stem
Sepal
Petal
Filament
Anther
Stamen
Pollen

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-LS1: From Molecules to Organisms: Structures and Processes (p. 38)
PE: 4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (p. 38)
DCI: LS1.A: Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (p. 38)

Step 2: Mealworms

A. Observe



1. Get some mealworms from a pet shop.

2. Set up a home for them in a jar. Use the diagram to see how to do this.

3. Observe the behavior of the mealworms.

   a. How do they move? ______________________________

   b. How do they eat? ______________________________

B. Record

As each mealworm grows, it sheds its skin.

1. Mark four mealworms with a dot of food coloring. Use a different color for each mealworm.

2. Place each mealworm on a ruler to find its length. Record the length of each on the chart.

3. Examine the mealworms each day. See how many days it takes before the dot on each mealworm can no longer be seen. Record your observations on the chart.

4. Mark each mealworm again, with the same color as before.

5. Again, see how long it takes for each to shed its skin. Record your observations on the chart.

Color	Until 1st Shed		Until 2nd Shed	
	Size	Days	Size	Days
Blue				
Green				
Yellow				
Red				

The skin is shed every 10-14 days during the entire 4-5 month duration in the larva stage of development.

C. Predict

When there are sudden changes in the environment, mealworms react by moving.

1. Use light, touch, food, and noise to make changes in the environment of two of your mealworms.

2. Before doing each experiment, predict whether the mealworm will move toward or away from the change. Record your predictions on the chart as follows:

   + moves toward the change
   – moves away from the change
   0 no movement

3. Do each experiment, and record your observations on the chart.

Prediction

Mealworm	**Light**	**Touch**	**Food**	**Noise**

Test

Mealworm	**Light**	**Touch**	**Food**	**Noise**

<u>Mealworms tend to react negatively to most stimuli, except food. However, results may vary according to the methods each student uses.</u>

Teacher Notes:

A. Mealworms are inexpensive and can be purchased in pet shops that sell fish. They are insects that have six legs near the front end of their segmented bodies. Their mouthparts aid them in chewing their food.

B. The size of each mealworm will depend on its age at the start of the activity. The insects eat and grow until they become too big for their outer skins.

C. Have the students make up their own experiments using light, touch, food, and noise.

Background Information:

Mealworms are the larva stage of the darkling beetle. The darkling beetle is an insect that goes through a process of metamorphosis, or change, as it proceeds from egg to adult. In the case of the darkling beetle, mealworms hatch from the eggs about a week after the eggs are laid. The mealworms spend most of their time moving about and eating, in preparation for the pupa or resting stage. This stage lasts from 1-3 weeks, after which the adult insect emerges. Its color changes from white to brown and finally to black as it continues its life cycle. The adults live about 6-10 weeks until they reproduce.

Sci-Terms:

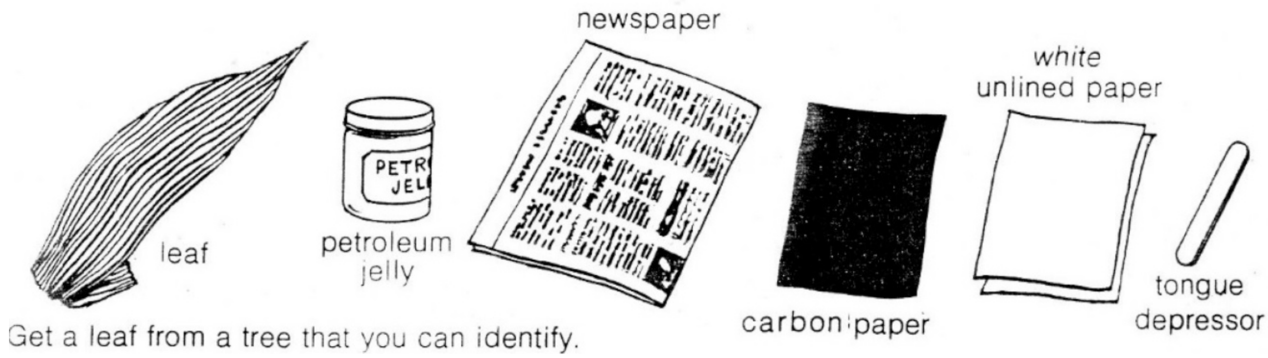
Environment
Mealworm
Larva stage

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-LS1 From Molecules to Organisms: Structures and Processes (p. 38)
PE: 4-LS1.1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (p. 38)
DCI: LS1.A: Structure and Function: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (p. 38)
LS1.D: Information Processing: Different sense receptors are specialized for particular kinds of information, which may then be processed by an animal's brain. Animals are able to use their perceptions and memories to guide their actions. (p. 38)

Step 3: Leaf Vein Patterns

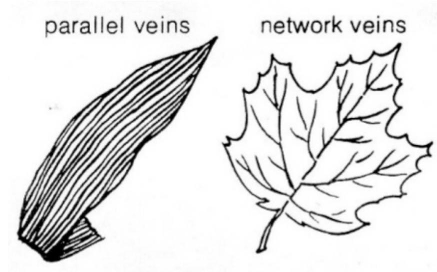
A. Gather



B. Make

1. Smear petroleum jelly lightly over the underside of the leaf (the side with the veins.)
2. Place the leaf, jelly side up, on folded newspaper.
3. Put the carbon paper, carbon side down, over the leaf.
4. Cover the carbon paper with a sheet of white paper.
5. Rub the side of the wood stick back and forth across the white paper.
6. Remove the carbon paper. Place it between 2 sheets of clean white paper.
7. Rub the paper with the stick. The leaf print will appear on one of the white sheets of paper.

C. Try



Leaves from different trees and plants have different vein patterns. Study the drawings to be familiar with parallel and network vein patterns. These patterns can help you identify the plants from which different leaves come.

1. Try making leaf vein prints from the leaves of other trees and plants.

2. Look for differences in the patterns the veins make. The drawings above will help you. These patterns can help you identify plants and trees. What did you observe?

Leaves of broad-leaf plants are classified as follows:
Parallel Veins-seeds with 1 part (monocotyledons) such as wheat corn, grasses, and grains.
Network Veins- seeds with 2 parts (dicotyledons) such as maple and oak.

Teacher Notes:

A. Select leaves with a thick set of veins.
B. Veins are found on the underside of most broad-leaf plants.

Background Information:

Veins help form the characteristic shape of the leaf. Actually, they are the vessels that carry water from the stem, through the leaf base and then into the leaf itself.

The water from the roots reacts with the carbon dioxide from the air in the presence of chlorophyll and sunlight to produce sugar during the process of photosynthesis.

Sci-Terms:

Veins
Parallel Veins
Network Veins

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-LS1 From Molecules to Organisms: Structures and Processes (p. 38)
PE: 4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (p. 38)
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STEM Center 4.1

Team Challenge: **What other methods and materials can be used to make a collection of leaf vein prints from trees surrounding the school and/or your home?** [*NGSS 4-LS1-1*: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about leaf veins [e.g. what is the purpose of veins in a leaf? What materials and/or methods are commonly used to create leaf vein prints? How can you use leaf vein patterns to help identify a tree?].

Fact 1:

____

____

____

Fact 2:

____

____

____

Fact 3:

____

____

____

What is the process of a tree losing its leaves and why does it occur each fall? Identify at least two (2) scientists who made significant discoveries about the structure of plants, trees, and leaves.

____

____

____

____

____

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

____

____

____

____

____

____

____

Write down any questions that you have and anything that you are curious about.

____

____

____

Science & Engineering Practices

During your work in the STEM Center, you used certain key “practices” similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 4: Root Hairs

A. Investigate

1. Place a layer of wet paper towel in an aluminum pie pan.

2. Sprinkle seeds of the following kinds onto the paper towel:

   a. mustard
   b. radish
   c. pea
   d. corn
   e. baby lima bean

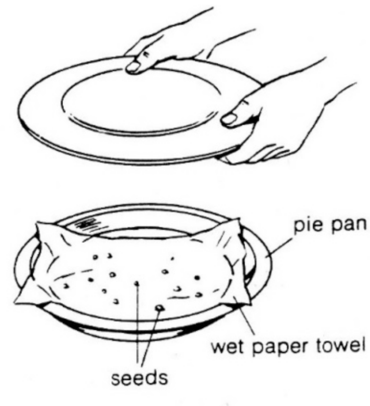
3. Cover the pie pan.

4. Add water when needed so the paper does not get dry.

5. Examine the seeds every day.

6. Which seed grew first? ***Mustard and radish seeds are usually fast starting.***

7. Which part of the young plant grew first? ***The root grows first.***



B. Hypothesis

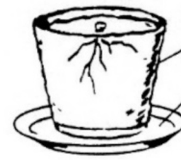
The white fuzz you see on the roots are root hairs. Root hairs…

_____ a. continue to grow all along the root as it grows in the soil.

_____ b. grow only near the tip of a growing root.

Either one is possible, although if the young roots are examined carefully, there may be evidence for hypothesis "b".

C. Test



1. Use a fine, colored felt pen to mark the area on the root where the root hairs first grow.

2. Plant a few of the young plants in small peat pots filled with vermiculite.

3. Keep them wet.

4. After 3 or 4 days, carefully remove a plant and examine it with a magnifying glass.

5. Is there any white fuzz at the marked area?

There will be few or no root hairs at the marked area.

6. Is there any white fuzz anywhere else?

Below it will be a new growth of root hairs.

7. Draw a picture in the space below to show where the root hairs are now.

Teacher Notes:

A. Soaking larger seeds overnight will make them grow from seed a little faster. Covering the seeds cuts down on evaporation.

Background Information:

"Root hairs" are not really hairs at all. They are delicate extensions of a single cell of the outer layer of a young rootlet. They are found just above the growing tip of the root. They grow, increase the surface area exposed to the soil, absorb water and minerals, and then shrivel up as the tiny rootlet continues its growth in the soil. New root hairs are constantly growing near the tip.

Sci-Terms:

Vermiculite
Root hairs
Roots

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-LS1. From Molecules to Organisms: Structures and Processes (p. 38)
PE: 4-LS1.1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (p. 38)
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Step 5: Growing Molds

A. Observe

1. Boil a white potato.
2. Cut the potato into 4 thin slices that are about the same size.
3. Place each potato slice on a separate piece of aluminum foil.
4. Wrap one slice completely in foil.
5. Put each slide in a different room of your home.
6. Leave them undisturbed for several days, but examine them each day.
7. Do not examine the wrapped slice. (The wrapped potato slice will serve as the "control.")

B. Record

Molds, which are tiny fungus plants, will probably grow on your potato slices.

1. Count the number of colonies (groups of molds). Record the number on the chart.

2. Record the color of the mold growths on the chart.

3. Are all molds alike? Explain.

No. There are many varieties of molds. They grow in colonies with distinct shape and color, and so each group can be counted.

4. Where did these molds come from?

Spores (reproductive cells of molds) are carried in the air.

5. After 6 days, uncover the wrapped potato slice. What do you observe about the control as compared to the other samples?

The control has no growth.

Room	**3rd Day**		**5th Day**	
	Colonies	Color	Colonies	Color

C. Predict

1. Prepare 4 potato slices as you did in Part A.

2. Rub each slice with any one of the following:
   a. dust from the floor
   b. dirty fingers
   c. flower pot soil
   d. soil from outdoors

3. Which do you predict will have the greatest mold growth? Why?

<u>Answers will vary according to location and conditions.</u>

4. Which do you predict will have the least mold growth? Why?

5. Record the colors of the molds on the chart. Also, which rank potato slices have the most to least amount of mold (1=most, 4=least).

Potato Slice	Color	Amount of Mold
Floor dust		
Dirty fingers		
Soil from a flower pot		
Soil from outdoors		

Teacher Notes:

C. Most common mold families are black, green, and blue in color.

Background Information:

Molds belong to a simple group of plants called fungi (singular, fungus) that have no true stems or roots and that do not contain any chlorophyll (the coloring matter of green plants). These plants cannot manufacture their own food (no photosynthesis can occur without chlorophyll). Many molds are specific and grow best on particular energy sources. When conditions are right, mold spores germinate, grow rapidly, and release new spores to start the growth cycle again.

Sci-Terms:

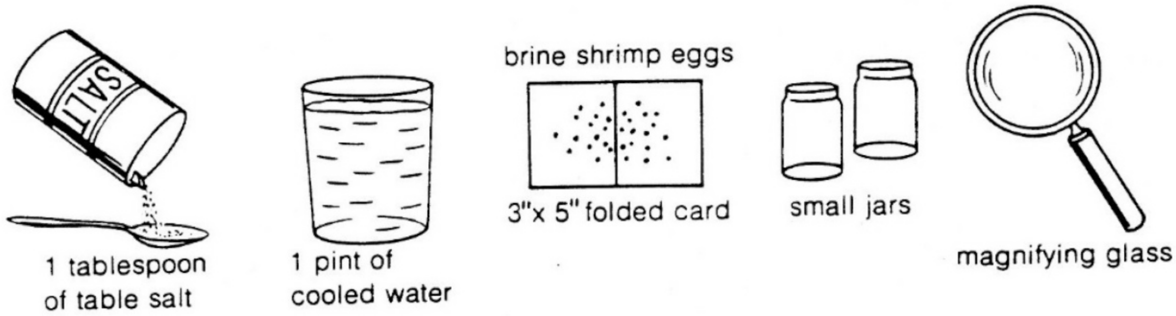
Mold
Colonies
Fungus

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 3-LS4: Biological Evolution: Unity and Diversity (p. 30)
PE: 3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. (p. 30)
DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (p. 30)

Step 6: Hatching Brine Shrimp

A. Gather



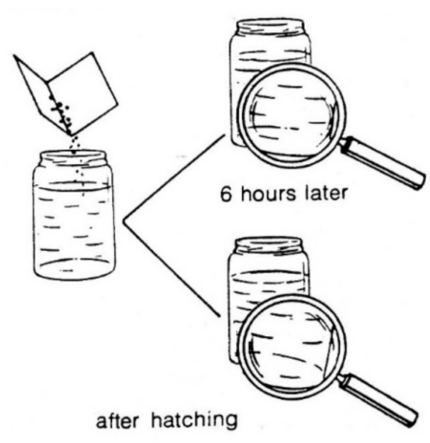
1. Boil the water, and let it cool.

2. Add the salt, and stir.

3. Sprinkle 20-30 brine shrimp eggs on the card. Observe them with a magnifying glass. What do they look like? Describe.

small, brown, spherical

B. Make



1. Pick up the creased card and carefully sprinkle the eggs into the jar of salt water.

2. Keep the jar in a warm spot (about 70-80 degrees F).

3. Look at the eggs after 6 hours. Do you see any difference in their shape?

The small, brown, spherical eggs soon swell when in water.

4. How many of your brine shrimp hatch after:

   1 day? ______ 2 days? ____ 3 days? ________

Hatching time will vary-just keep looking for the free-swimming organisms.

5. Add more boiled and cooled water to the jar to keep the water level the same.

C. Try

1. Make 3 more jars of salt water.

2. Add about 20-30 eggs to each jar.

3. See what the effect on the hatching rate is if the conditions are changed. Choose one: slightly alter the amount of salt in each jar OR store the jars in different locations- bright light, darkness, or a cool place.
   What are your results?

Condition	2 days	4 days

Teacher Notes:

A. Brine shrimp eggs are available in most pet shop and are inexpensive. Some kits contain ocean salts. If using the kits, follow the directions carefully. Boiling removes chlorine from the water. **Do not use iodized salt.**
B. Keep water level the same or it may get too salty.
C. Will vary according to actual conditions used.

Background Information:

Brine shrimp eggs can remain in the dormant stage for years at a time. When the proper conditions become available, they are capable of resuming growth. While used mainly for food for aquarium animals, these tiny crustaceans are interesting for study and experimentation. They eat, grow, shed their skins (molt) several times, and reproduce readily.

Sci-Terms:

Brine shrimp
Hatching rate
Magnifying glass

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 3-LS4: Biological Evolution: Unity and Diversity (p. 30)
PE: 3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. (p. 30)
DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (p. 30)

STEM Center 4.2

Team Challenge: **Can your team find any other small, available animal species that you can grow, investigate its life cycle, and test various living conditions?** [*NGSS 3-LS4-3*: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all].

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about the animal specimen that you have identified [e.g. what can you find out about its habitat? What are optimum conditions for growth and survival? What is its life cycle?].

Fact 1:

____

____

____

Fact 2:

____

____

____

Fact 3:

____

____

____

What is the history of the development of the microscope? How are modern day microscopes different from early instruments?

____

____

____

____

____

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

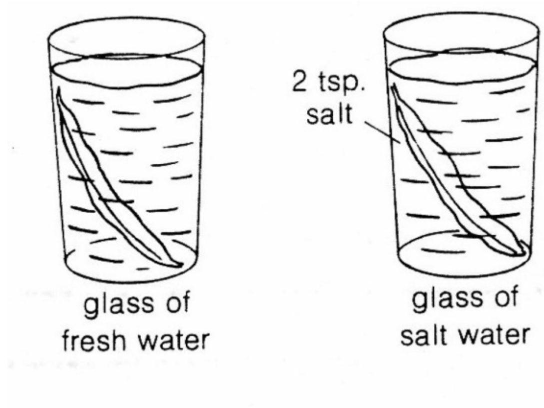
Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 7: Salt and Cells

A. Investigate



1. Place a fresh string bean into a glass of fresh water.
   Place a fresh string bean into a glass of salt water.

2. Leave the beans for one day.

3. Remove the beans from the water. Examine them and compare them.

4. What happened to the bean in fresh water?

The bean in fresh water will swell and get rigid.

5. What happened to the bean in salt water?

The bean in salt-water wilts and gets soft.

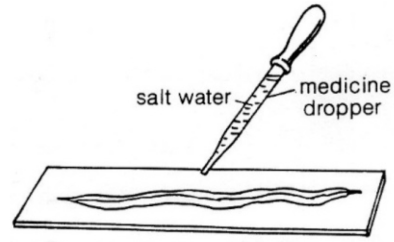
B. Hypothesis

What happened to the string bean that was placed in salt water?

__*a*__ a. Water moved from the living cells to the salt solution.

_____ b. Water moved from the salt solution to the living cells.

C. Test



1. Place a leaf from a fresh-water aquarium plant on a microscope slide.

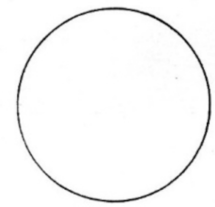
2. Examine the cells under a microscope.

3. Use a medicine dropper to place some salt solution on the leaf.

4. Observe the leaf through a microscope. What happens to the living cells?

_____ a. They swell with water that enters them.

__*b*__ b. They shrivel as water leaves them.



Draw what you observe in the space below:

Teacher Notes:

C. Elodea plants are usually available and the brick-shaped cells are large enough to view with a student microscope. The green dots are called chloroplasts. They are filled with chlorophyll needed for food making. (Note: A microscope with a magnification of at least 100x is needed for studying Elodea cells.)

Background Information:

Water moves in and out of living cells by the process of osmosis. The flow is always from an area of high concentration to an area of low concentration. Since there is more "fresh" water inside the cells the flow of water is from the cells to the salt solution. This was used as a basis for preserving food for hundreds of years. Food-spoiling microorganisms will also lose water when placed in a salt solution. This process kills these harmful cells, and food could thus be stored for a long time.

Sci-Terms:

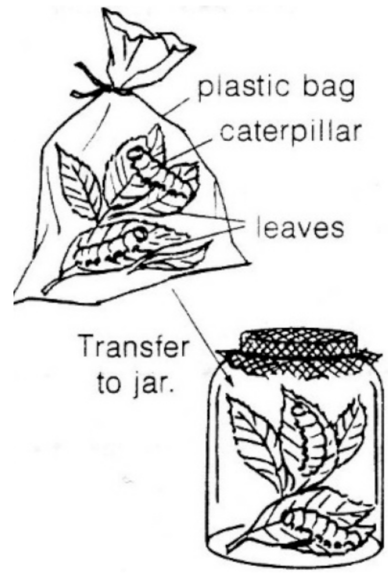
Salt solution
Osmosis
Cells

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 3-LS4: Biological Evolution: Unity and Diversity (p. 30)
PE: 3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. (p. 30)
DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (p. 30)
LS4.D: Biodiversity and Humans: Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (p. 31)

Step 8: Moth or Butterfly?

A. Observe



Caterpillars are the larva stage in the development of moths and butterflies.

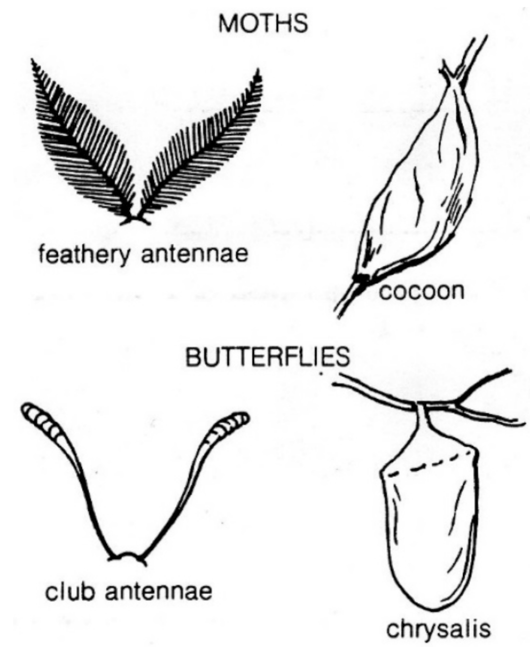
1. Find caterpillars that are feeding on leaves of different plants.
2. Collect at least two caterpillars of each kind. Put them into separate plastic bags with some of the leaves they were eating.
3. Place the insects and their food supply in large jars, one jar for each kind of insect. Cover the jars with screening or cloth.
4. Sprinkle some water into the jars every 3 days.
5. Add more leaves when necessary.
6. Watch the caterpillars eat and grow. Record your observations on the chart below.

B. Record

Caterpillar	Size	Color	Unusual Markings	# of Legs	Other Characteristics
#1					
#2					
#3					

C. Predict

Some of your caterpillars may become moths, and some may become butterflies. Use the pictures below to help you answer the questions.



1. Use a moth and butterfly identification book. Look at the pictures and try to predict whether your caterpillars will become moths or butterflies.

   #1____________ #2____________ #3____________

2. When a caterpillar grows large enough, it enters a pupa or resting state. The caterpillar spins a cocoon or a chrysalis. Which did your caterpillars spin?

   #1____________ #2____________ #3____________

3. How long did it take for the adult insect to come out?

   #1____________ #2____________ #3____________

4. Which kind of antennae does each insect have?

   #1____________ #2____________ #3____________

5. Find the names of your insects in an insect identification book.

   #1____________ #2____________ #3____________

Teacher Notes:

A. Be certain to take some leaves of the plant you find the caterpillar eating. Caterpillars have chewing mouthparts and eat several times their own weight daily. If kept healthy, they may <u>molt</u> or shed their skin while growing.

B. Chart will vary according to the actual specimens being collected and observed.

C. The larva of the moth spins a cocoon, while a chrysalis is formed by a caterpillar of a butterfly.

Background Information:

Moths and butterflies are insects with 6 legs, 3 body parts, and 2 pairs of scaly wings. Even the caterpillar stage has 6 true legs on thorax region (with 4-10 false legs on the abdomen). Many adult moths and butterflies are useful in the pollinating of different plants; however, the eggs they produce develop into the larvae that can become pests to our various crops. These insects show the 4 stages of development, known as complete metamorphosis.

Sci-Terms:

Metamorphosis
Larva stage
Antennae
Cocoon
Chrysalis
Pupa
Insect
Thorax
Abdomen

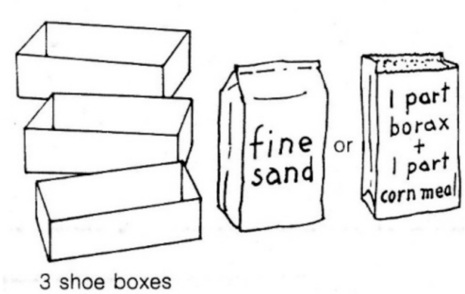
Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 3-LS1: From Molecules to Organisms: Structure and Processes (p. 27)
<u>PE</u>: 3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. (p. 27)
<u>DCI</u>: LS1.B: Growth and Development of Organisms: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (p. 27)

<u>Standard</u>: 3-LS3-Heredity: Inheritance and Variation of Traits (p. 29)
<u>PE</u>: 3-LS3-1: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these straits exists in a group of similar organisms. (p. 29)
<u>DCI</u>: LS3.B: Variation of Traits: Different organisms vary in how they look and function because they have different inherited information. (p. 29)

Step 9: Collecting and Preserving Flowers

A. Gather

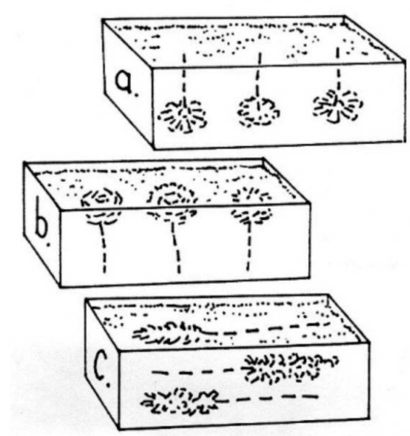


Collect a variety* of flowers. Follow these instructions when you pick them:

a. Pick in the late afternoon of a sunny day.
b. Pick at the peak of bloom.
c. Pick light-colored flowers (pink, yellow, orange). They dry best.

***Note:** See B.4 below for a variety of flowers to collect.

B. Make



1. Remove the leaves from the stems.

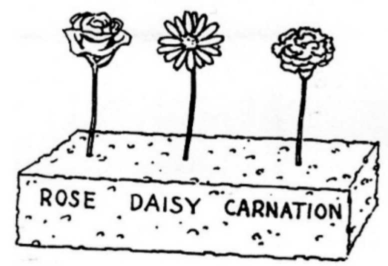
2. Use a tissue to blot up any surface moisture.

3. Put a 2cm layer of sand on the bottom of each box.

4. Place the flowers according to the following instructions:
   a. Flowers with ray-like petals (daisy, black-eyed Susan)-stem up, flower down.
   b. Flowers with thickly clustered petals (rose, carnation)-stem down, flower up.
   c. Flowers that grow along long stems (delphinium, snapdragon)-lengthwise in box.

5. Gently sift the sand over the flowers until they are completely covered.

C. Try



1. Keep the boxes undisturbed so the flowers dry properly.
2. Remove thick-centered flowers after 1 week. Hang them upside down in a dry, dim place for 2-3 weeks.
3. Most flowers dry in 10-14 days. Some may take up to 4 weeks.
4. After the flowers have dried, place their stems in a piece of Styrofoam.
5. Label and classify your preserved flowers.

Teacher Notes:

A. Suggest trying the local florist for some discarded flowers that can still be preserved.

B. Sand should be very clean and dry. If beach sand is not available, then the mixture of cornmeal and borax (1:1) can be used with good results.

C. Carefully dust off the sand (or powder) with a paintbrush. Arrange and classify the flowers you have preserved by type, color, families, or location of growth.

Background Information:

The old technique of hanging flowers upside down is still used for drying flowers. This method allows a larger variety of flowers to be preserved. Since flowers are all around us, they should be enjoyed. Through this activity of collecting, preserving, and classifying the flowers, the students will become more aware of their beauty, shape, color, and adaptation.

Sci-Terms:

Preserved
Ray-like petals vs. Clustered petals

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-LS4. Biological Evolution: Unity & Diversity
PE: MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms (flowers) and between modern and fossil organisms to infer evolutionary relationships. (p. 74)
DCI: LS4.A: Evidence of Common Ancestry and Diversity
Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (p. 74)
Cross-cutting Concepts: Patterns

STEM Center 4.3

Team Challenge: **Can your team create a unique floral display of preserved flowers using a different technique to dry and preserve the flowers?** [*NGSS MS-LS4-2*. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms (flowers) and between modern and fossil organisms to infer evolutionary relationships.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on floral preservation, as well as modern day vs. primitive flowers [e.g. what are other methods of preserving flowers? Search for pictures of primitive flowers – Can you identify anatomical similarities and differences between your flowers and the primitive flowers?].

Fact 1:

____

____

____

Fact 2:

____

____

____

Fact 3:

____

____

____

How have scientists been able to identify and describe flowers that existed millions of years ago? How can you explain the anatomical similarities that exist between modern and primitive flowers?

____

____

____

____

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

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Science & Engineering Practices

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7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

-

Step 1: The Good Earth

A. Investigate

1. Collect some soil from the ground.
2. Examine it closely with a magnifying glass.
3. What non-living things can you identify?

____

____

4. What living things can you identify?

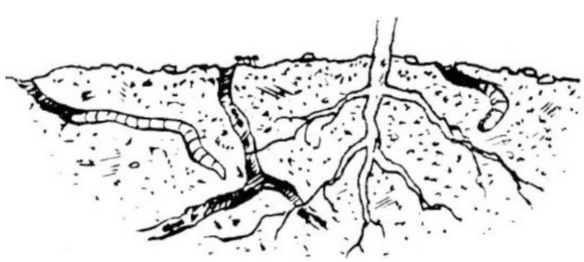
____

B. Hypothesis

Living things need air and water in order to survive.

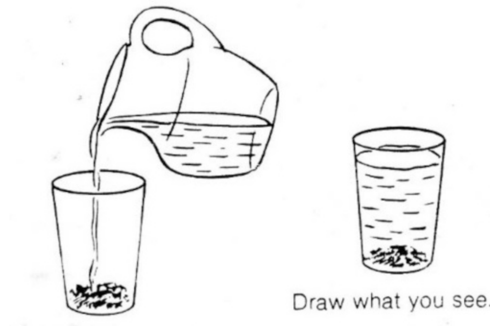
______ a. Soil does not contain these substances.

__*X*__ b. Soil does contain these substances.



C. Test

Part 1



1. Put some of the soil into an empty drinking glass.
   Fill the glass with water.

2. What do you see in the water?

Air bubbles

3. Where does this come from?

The bubbles rising in the water indicate that air is escaping from between the particles of soil.

4. How does it help living things in the soil?

The presence of air in soil ensures that particular soil organisms have the oxygen required for metabolism.

Part 2

1. Put some soil into a plastic bag. Tie the top tightly.

2. Put the bag in sunlight for an hour.

3. What appears on the inside of the bag?

Droplets of water appear on the plastic.

4. Where does it come from?

The sun's heat speeds up the evaporation of the water from the soil.

5. How does it help living things into the soil?

All living beings, whether they are animals or plants, need a definite amount of water present in their body to remain healthy.

Teacher Notes:

A. "Non-living" refers to things that never were alive, for example, rocks and metals. "Dead" means that the organisms were once alive-plants and animals. (Specific examples will vary according to locality.)

Background Information:

Soil is one of our most precious natural resources. A wide variety of living things make their home within the soil. One of the most beneficial is the earthworm. While digging for food, earthworms create channels for air and water to enter the soil. In addition, they bring some of the fertile subsoil to the surface. As plants and animals die, their remains add to the richness of the soil (humus) so that new plants can grow. In addition to what we are able to see, there are millions of microscopic plants and animals that are also present in the soil.

Sci-Terms:

Dead
Non-living
Living

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 5-LS2-Ecosystems: Interactions, Energy, and Dynamics (p. 48)
<u>Performance Expectation(s)</u>: 5-LS2-1-Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (p. 48)
<u>Disciplinary Core Idea(s)</u>: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment and release waste matter (gas, liquid, or solid) back into the environment. (p. 48)

Step 2: Surface Changes

A. Observe

Soil erosion caused by water and wind makes changes in the Earth's surface. You may walk past the same hillside or road cut every day. But how often do you observe the changes that take place at the surface? Some of these changes are man-made-construction, litter, digging, etc. Other changes are caused by nature. Changes in temperature, wind, and water affect the Earth's surface.

1. Choose a special place to observe once a week for a month. You might choose a hillside, a road cut, part of a farm, the banks of a stream, etc. See what changes occur.

2. Record your observations on the chart below.

B. Record

Month ____________________ Place______________________

Date	Change	Cause	
		Natural	Man-Made

C. Predict

Water causes many of the changes in Earth's surface. Rainfall, ice, and running water all can cause soil to wear away.

1. Fill two 8" × 8" cake pans with soil.
2. With a pencil, make 5 furrows in each pan. Place the pans on a cookie sheet.
3. Put blocks under one end of the pans to make an incline.
4. Predict which will show the greatest surface change after water is poured on it.

   ______ Pan A ______ Pan B

5. Gently sprinkle water over the pans. What surface changes took place?

Running water has the ability to pick up loose soil and carry it some distance away.

6. In which pan is the change greater?

Water running down the furrows (Pan A) will result in greater erosion than water running across the furrows (Pan B). In Pan B, the furrows prevent the water from gathering much speed and thus reduce erosion.

Teacher Notes:

A. People usually pass by these sites without much awareness of the changes taking place.

B. Where interest is high, encourage students to observe and record changes during the different times of the year.

C. Contour farming serves to prevent erosion.

Background Information:

While it may take hundreds of years to build up just one inch of valuable topsoil, this topsoil can be lost in a short period of time. Crop rotation, use of cover crops, contour plowing, and other valuable farming methods can help to conserve topsoil. Conservation of soil must also be taken into consideration in the development of land for new highways, housing, and industrial complexes. Land must be used in such a way as to preserve the topsoil of surrounding land.

Sci-Terms:

Erosion
Topsoil

Connection to the *Next Generation Science Standards* (NGSS):

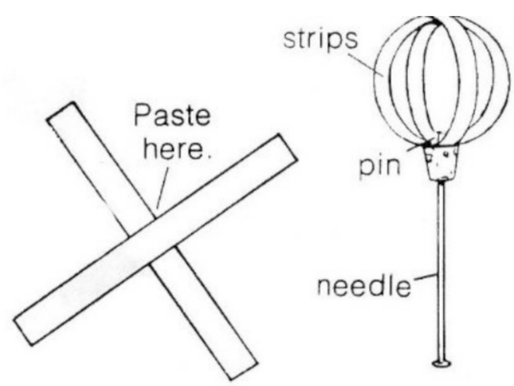
Standard: 4-ESS2-Earth's Systems (p. 40)
Performance Expectation(s): 4-ESS2-1- Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. (p. 40)
Disciplinary Core Idea(s): ESS2.A: Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils and sediments into smaller particles and move them around. (p. 40)

Step 3: The Earth's Shape

A. Gather

B. Make

1. Paste the two paper strips together at the center.
2. Bring the ends together so they form two loops. Paste them together.
3. Push the knitting needle into the cork.
4. Pin the strips to the top of the cork.



C. Try

1. Hold the knitting needle between your palms.

2. Move your hands back and forth to make the sphere spin.

3. What happens to the top and bottom of the sphere?

While spinning, the top and bottom of the strips will flatten slightly.

4. What happens at the middle?

There will also be a bulging effect around the center.

[All rotating spheres are affected in the same way. The Earth is a rotating sphere.]

5. What do you think happens to the Earth at the poles?

Our Earth spins around, making one rotation every 24 hours. This spinning causes a flattening at the poles.

6. What do you think happens to the earth at the equator?

This spinning causes a bulging at the equator.

Teacher Notes:

A. Strips of manila folder will work well.

B. You can staple the ends together as well.

C. Our Earth spins around, making one rotation every 24 hours. This spinning causes a flattening at the poles and bulging at the equator. The effect is actually very slight. This in-turn creates Earth's non-circular gravity field. This fact needs to be taken into consideration when designing space missions.

Background Information:

The distance around the Earth at the equator has been measured at 24,901 miles. The distance around the Earth at the poles is 24, 857 miles. The Earth's bulge occurs just a little south of the equator.

Because of its bulge, some people describe the Earth's shape as slightly pear-shaped instead of spherical.

Sci-Terms:

Sphere
Earth's poles

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS2 Motion and Stability: Forces and Interactions (p. 45)
Performance Expectation(s): 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down. (p. 45)
Disciplinary Core Idea(s): PS2.B: Types of Interactions
The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1). (p. 45)

STEM Center 5.1

Team Challenge: **How can your team construct a cross-section of soil formation in the area near your school and compare it to a different area some miles away?** [*NGSS 4-ESS2-1:* Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on soil sampling and how to create a cross-section of soil formation [e.g. how do scientists determine the depth of each layer that makes up the soil? What is a soil cross-section or soil profile?].

Fact 1:

Fact 2:

Fact 3:

What kinds of instruments have been developed for oil drilling, water drilling, and mineral excavation? Find two scientists who have contributed much to our geological knowledge.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

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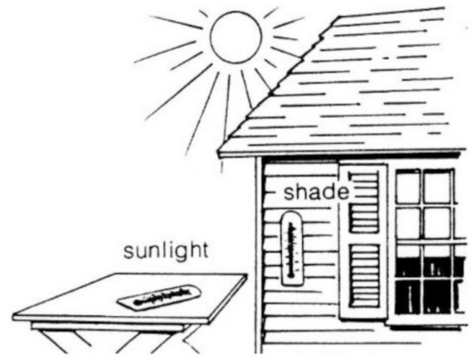
8. Obtaining, evaluating, and communicating information	

Step 4: Sunlight and Heat

A. Investigate



1. Place one thermometer outdoors in the shade.

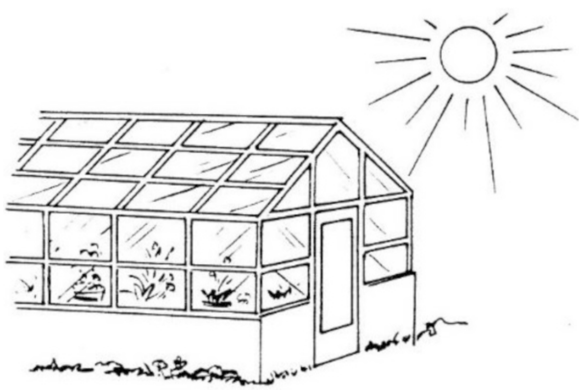
2. Place another thermometer outdoors in the sun.

3. Read both thermometers after 15 minutes.

   Thermometer in sun ______________°

   Thermometer in shade ____________°

B. Hypothesis

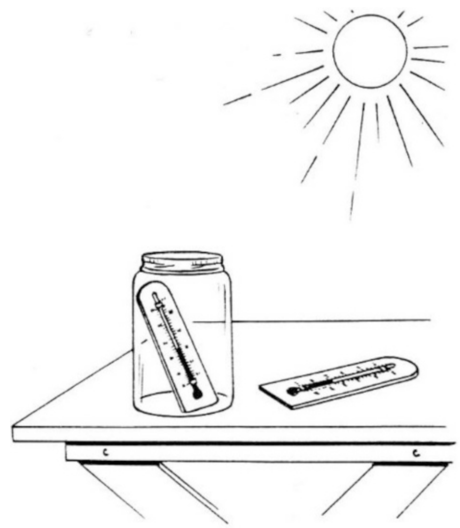


When an object absorbs energy from sunlight, the object becomes warmer.

a. The energy of sunlight (can, cannot) ________________ pass easily through glass.

b. Heat from a warm object (can, cannot) _______________ pass easily through glass.

C. Test



1. Put one thermometer inside a glass jar. Put the cover on the jar.

2. Put the jar and another thermometer side by side in the sun.

3. Read the thermometers every few minutes. Record your observations in the space below:

4. Which thermometer became warmer?

The thermometer inside the jar rises to a higher temperature.

5. Did energy from the sun pass into the glass jar?

This indicates that heat energy from the sun was able to pass through the glass into the jar.

6. Was heat from inside the jar able to escape easily?

Heat from inside the jar could not leave as readily.

7. What makes you think so?

Possible answers include "because the temperature went up so high in the jar" or "because the heat is trapped inside of the jar."

8. Do your observations support or change your hypothesis? ____

____

Teacher Notes:

A. Answers will vary according to location, time, and date, but the thermometer in the sun will how a higher reading (Note: measuring temperature in both degrees Celcius and degrees Fahrenheit will help students become more familiar with the Metric system of measurement).

B. Since there is no observational evidence as yet, either hypothesis is possible in each case.

C. The hypothesis in Part B may have to be changed accordingly.

Background Information:

Heat and light from the sun are forms of energy that reach us by the process of radiation. In this process, waves of energy travel through empty space. When matter is struck by those waves, some of the energy is absorbed. This causes the temperature of the matter to increase. Although warm objects radiate energy, their waves have longer wavelengths than radiant energy from very hot objects, such as the sun. These longer wavelengths cannot pass through glass very well, so their energy gets trapped inside the jar, or inside a greenhouse.

Sci-Terms:

Thermometer
Greenhouse/Greenhouse effect
Energy
Heat

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation(s): MS-PS4-2- Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (p. 63)
Disciplinary Core Idea(s): PS4.B: Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (p. 63)

Step 5: Limestone and Shale

A. Observe

1. Find an area near your home where rocks have formed in layers. These rocks were formed millions of years ago. They are called sedimentary rocks.

2. You may see 2 types of sedimentary rocks:
   a. Shale: fine-grained, gray, layered rock formed from particles of clay.
   b. Limestone: formed from the shells and skeletons of animals. Sometimes you can actually see the fossils of these creatures that were once alive.

B. Record

1. Collect some sedimentary rocks. Test the rocks to see if any are shale or limestone.

2. Perform the following tests.
   a. Scratch each rock with a nail (both can be scratched)
   b. Wet each rock and then smell it. (Shale will smell like clay.)
   c. Drop vinegar onto each rock. (Vinegar will react to form small bubbles on limestone easily seen with a magnifying glass.)

3. Record your observations in the chart below.

4. Which samples are limestone? ____

5. Which samples are shale? ____

Rock Sample	Scratch	Water	Vinegar
#1			
#2			
#3			
#4			

<u>Both are easily scratched, eliminating many rock samples. Shale originates from Mud; it is dark, smooth, and flat. Limestone is light, rough, and irregular. Drops of acid (vinegar) produce carbon dioxide gas.</u>

C. Predict

1. Get a piece of chalk, a building brick, and a piece of coral.

2. What do you think will happen if you test these materials with water and with vinegar? Predict the results. Record your predictions on the chart below.

3. Test the 3 materials with water and vinegar. Were your predictions correct?

Sample	Water	Vinegar
Chalk		
Brick		
Coral		

Coral/chalk-skeletal remains of sea animals that are now limestone. Brick is usually made with pieces of shale.

Teacher Notes:

A. While rocks are all around us, too few of us take the time to note their distinguishing characteristics. Sedimentary rocks are not always locally available. Ask an earth science teacher for advice about where to look for them.

Background Information:

Sedimentary rocks are formed in layers. Constant heat and pressure from materials in upper layers cause the lower ones to harden into rock. Limestone forms from the skeleton remains of billions of tiny sea creatures. Fast moving streams carrying tiny particles of mud and silt are the origins of shale. When rivers reach the ocean, they slow down, and these suspended particles settle to the bottom in layers. Upheavals and earthquakes have brought these rocks to the surface.

Sci-Terms:

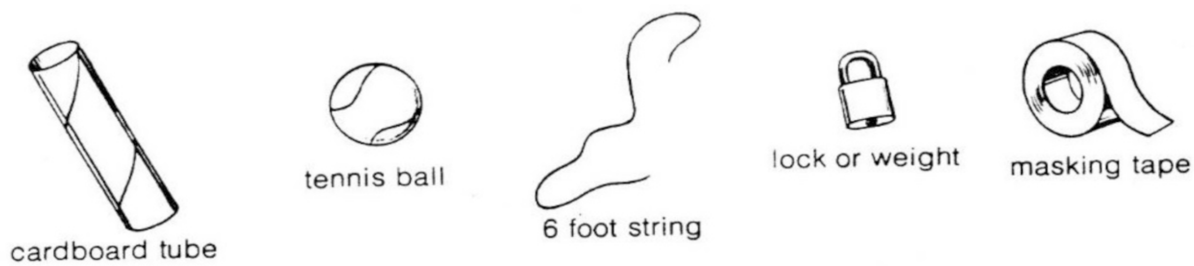
Sedimentary rocks
Limestone
Shale
Fossils
Coral

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-ESS1-Earth's Place in the Universe (p. 39)
Performance Expectation: 4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in landscape over time. (p. 39)
Disciplinary Core Idea: ESS1.C: The History of Planet Earth-Local, regional, and global patterns of rock formations reveal changes over time due to Earth's forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (p. 39)

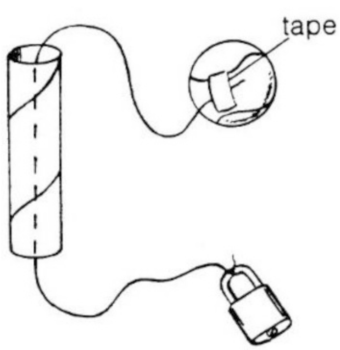
Step 6: Satellites in Orbit

A. Gather



Note: The lock or weight should be about 10 times heavier than the ball.

B. Make



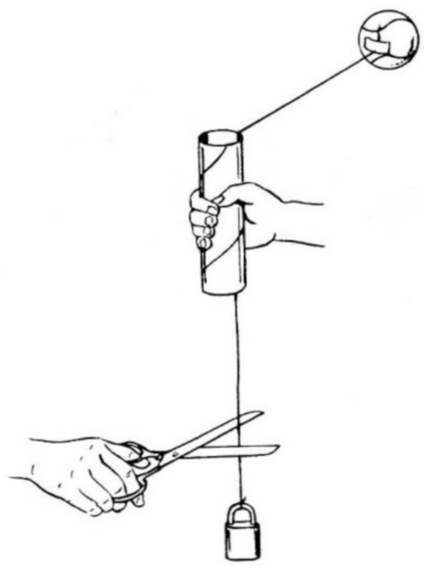
1. Use tape to attach the ball to one end of the string.
2. Drop the other end of the string through the tube.
3. Tie the locks or weight to this end of the string.

C. Try

1. Hold the tube in one hand with the ball just hanging over the edge of the tube. Start swinging the ball slowly in an orbit.

2. What happens to the weight?

As the ball gathers speed, the ball will eventually move outward into the circular path, thus pulling the weight upward.



3. Try slowing down the ball's speed.

4. What happens?

If the ball is then allowed to slow down, the weight will drop again.

5. Have someone cut the weight off while the ball is in orbit. Do this outdoors.

6. What happens to the ball?

When the weight is cut off, the ball flies away.

Teacher Notes:

A. Any weight easily secured to the string and much heavier than the ball, will do.

B. The ball will be at the top of the tube and the weight will be as far down as the string will allow.

C. With a little practice, the speed of the ball can be adjusted to hold the weight at any desired position.

Background Information:

To keep an object moving in a circular path, a force is needed. The weight provides this forces through the string. Satellites around the Earth are kept in their orbits by the force of the Earth's gravity. The closer the satellite is to the Earth, the faster it must move to balance the Earth's gravity and avoid being pulled down. Satellites about 300 miles above the ground go around once in about 75 minutes. The moon is kept in orbit around the Earth by gravity, but it is so far away that it takes a month to go once around the Earth.

Sci-Terms:

Satellite
Orbit
Gravity
Force

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 3-PS2-Motion and Stability: Forces and Interactions (p. 25)
Performance Expectation(s): 3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (p. 25)
3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (p. 25)
Disciplinary Core Idea(s): PS2.A: Forces and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative, addition of forces is used at this level.) (p. 25)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity are not introduced at this level, but the concept that some quantities needed both size and direction to be described is developed.) (p. 25)

STEM Center 5.2

Team Challenge: **Can your team construct an efficient device to dry a specified amount of fruit using only energy from the sun? [***NGSS MS-PS4-2:* Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on solar energy and the greenhouse effect [e.g. how can you construct a basic device to capture the sun's energy and retain heat energy? What are the best kinds of materials to use?].

Fact 1:

Fact 2:

Fact 3:

Trace the development of modern day solar panels and solar power units. Find two scientists/engineers/inventors who were involved in the research and development of solar panels and identify at least one way that the use of solar panels has impacted our everyday lives.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

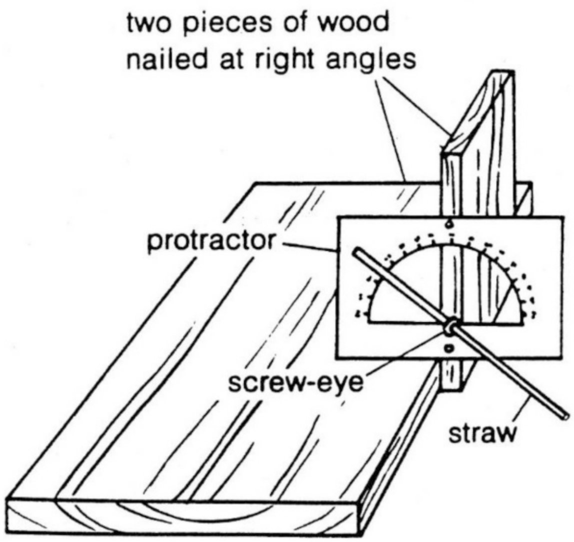
Science & Engineering Practices

During your work in the STEM Center, you used certain key “practices” similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 7: Star Sighting

A. Investigate



1. Make an astrolabe as shown in the drawing.

2. On a clear night, as soon as the stars can be seen, find Polaris, the North Star. (The Pointer Stars of the Big Dipper will help you.)

3. Place your astrolabe on a horizontal surface. Sight Polaris through the straw by turning the screw-eye.

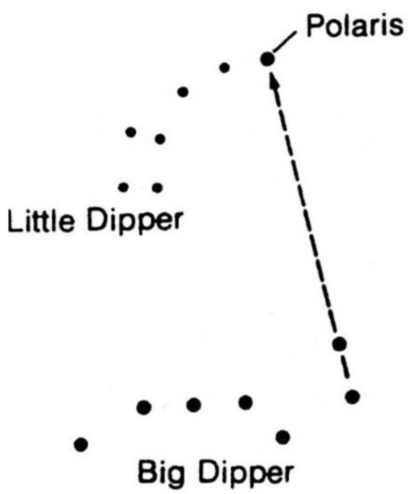
4. Read the angle that the straw makes with the horizontal surface. (A flashlight with colored plastic over the lens will help you see the protractor without dimming your night vision.)

5. What is the angle of Polaris? _____________°

6. According to the map, what is your latitude? _______________

7. Sight one of the Pointer Stars in the Big Dipper. What is its angle? ________°

B. Hypothesis



1. Later in the night, the angle of Polaris will be
   __*X*__ a. the same
   ______ b. different

2. Later in the night, the angle of the Pointer Star will be
   ______ a. the same
   __*X*__ b. different

3. During the night, the stars move
   ______ a. in straight lines from east to west.
   __*X*__ b. in circles around Polaris

C. Test

1. Wait 2 hours after your first sighting of the stars. Then sight Polaris again. What is its angle now? ____________°

2. What is the angle of the Pointer Star now? _________°

3. Do the Pointer Stars still point to Polaris? ________________________

4. What do you conclude about the motion of the stars?

The Pointers and the Big Dipper move counterclockwise around Polaris (the North Star) and the Little Dipper. The Pointers continue to point to Polaris.

Teacher Notes:

A. Be certain the board is set horizontally.

Background Information:

The stars appear to move because of the Earth's rotation. Since Polaris (the North Star) is almost directly above the Earth's North Pole, it does not seem to move. Polaris is not a very bright star. It can be found by locating the North Star and the Little Dipper.

Sci-Terms:

Astrolabe
Polaris
North Star
Little Dipper
Big Dipper
Latitude
Pointer Stars

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-ESS1-Earth's Place in the Universe (p. 49)
Performance Expectation(s): ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in the length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. (p. 49)
Disciplinary Core Idea(s): ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around the Earth, together with the rotation of Earth about an axis between its north and south poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (p. 49)

Step 8: Mineral Streak Test

A. Observe

1. Get samples of the following minerals: iron, pyrite, hematite, graphite, limonite, malachite, and galena (Note: you can substitute other minerals if one or more of the minerals listed above cannot be found; consult a mineral identification guide).

2. Put your samples in a suitable container such as an egg carton.

3. Observe the color of each of your samples. Record your observations on the chart below under "color."

B. Record

Sample #	Mineral	Color	Streak Test Color	
			Prediction	Actual Color
1	Pyrite	***light yellow***		***green-black***
2	Hematite	***silver gray***		***brownish-red***
3	Graphite	***black***		***black***
4	Limonite	***brown***		***yellow***
5	Malachite	***bright green***		***pale green***
6	Galena	***gray***		***lead gray***
7				
8				

C. Predict

1. Examine your samples. Try to predict the color of the mineral when it is ground to a powder. Record your prediction on the chart in Part B. You can perform a simple test to discover the color of the mineral color.

2. Get a piece of unglazed porcelain tile (also referred to as streak plate). White is the best. Use the unglazed side for the test.

3. Hold your mineral tightly and scrape across the tile. The mineral will leave a color streak. Test each of your mineral samples. Record your observations in the chart.

Teacher Notes:

A. There is usually at least one student in the class who has a commercial mineral collection. If not, borrow a set from the high school science teacher or buy a sample mineral kit online.

Background Information:

Minerals are either made of one element (a substance that cannot be broken down into simpler substances), or a compound (a substance consisting of 2 or more elements). There are many tests that should be made to positively identify an unknown mineral, in addition to the “streak test.” Students with real interest should be encouraged to observe luster, cleavage, reflection of light, and hardness.

Sci-Terms:

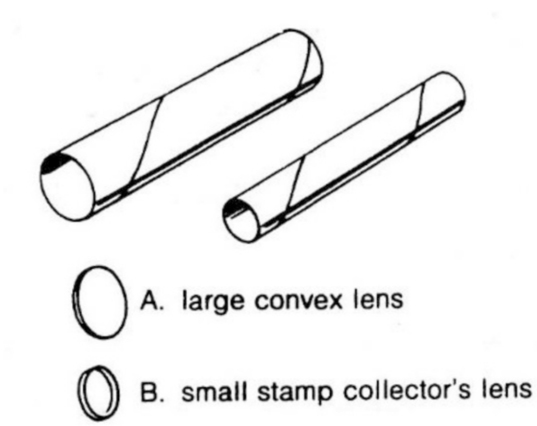
Minerals
Pyrite
Hematite
Graphite
Limonite
Malachite
Galena
Element
Compound

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS1- Matter and Its Interactions (p. 43)
Performance Expectation(s): 5-PS1-3: Make observations and measurements to identify materials based on their properties. (p. 43)
Disciplinary Core Idea(s): PS1.A: Structure and Properties of Matter: Measurements of a variety of properties can be used to identify materials. (p. 43)

Step 9: A Simple Telescope

A. Gather



TUBES

1. One tube should be slightly narrower than the other.

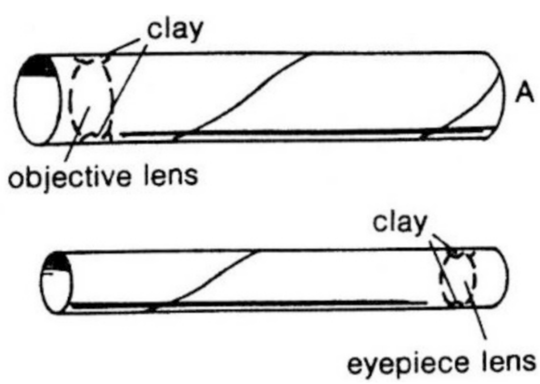
2. The lengths of the tubes may vary.

LENSES

A. The large lens, or objective lens, gathers the light and focuses it inside the tube.

B. The small lens, or eyepiece, magnifies the image from within the tube.

B. Make



1. Use clay or plasticine to fit the objective lens.

2. Fit the small eyepiece lens to one end of the narrow tube in a similar manner.

3. Insert the narrow tube into the wide tube at the point marked A.

C. Try

1. Look through the eyepiece end of your telescope.
2. Focus on a distant object by moving the narrow tube in and out.
3. If you cannot see clearly, you may have to cut the tubes down a bit or readjust the two lenses so they are in line.
4. Try looking at the moon with your telescope. Look at other objects in the night sky.
5. If the telescope is working properly, you may be able to see some of the moons of Jupiter.

NOTE: Never look at the Sun through this or any telescope!

Teacher Notes:

A. The large objective lens should have a focal length of about 8 inches (200mm). The small eyepiece lens should have a focal length of 1 inch (25 mm). Try your local optician for some discarded lenses.

B. Attach the lens to the clay neatly so it does not block the light.

C. Have patience adjusting the tubes and the lenses so your telescope can work properly.

Background Information:

The focal length of a lens is the distance from the lens to the point where parallel rays that enter the lens are brought together on the other side. This can be determined by using the lens to produce an image of a distant scene on a wall or white screen. Hold the lens parallel to the wall opposite a window on a bright day. Move the lens back and forth until a sharp image is seen on the wall. Then measure the distance from the lens to the wall. This is the focal length.

A lens used as a magnifying glass gives the greatest magnification when it is held just short of its focal length from the object being examined. This is another way to find focal length. (These statements apply only to convex lenses.)

In a telescope, the large lens (objective lens) forms an image inside the tube; the eyepiece lens is then used as a magnifier to see the image more clearly.

Sci-Terms:

Objective lens
Eyepiece lens

Connection to the Next Generation Science Standards (NGSS):

Standard: MS-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation(s): MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (p. 63)
Disciplinary Core Idea(s): PS4.B: Electromagnetic Radiation-The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g. air and water, air and glass) where the light path bends. (p. 63)

STEM Center 5.3

Team Challenge: **Can your team construct a "mini-planetarium" to show the positions of celestial bodies?** [*NGSS ESS1-2:* Represent data in graphical displays to reveal patterns of daily changes in the length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts on how to best construct a "mini-planetarium" and represent celestial objects in the night sky [e.g. what materials will you need? What celestial objects do you want to represent? How will you distinguish between a planet and a star?].

Fact 1:

Fact 2:

Fact 3:

Trace the history of development of the telescope including key scientists/inventors involved. What is the difference between a reflecting vs. a refracting telescope? What is the necessity of placing telescopes in space?

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

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1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

MATTER & MOTION

Step 1: Molecules in Motion

A. Investigate

All matter is made up of molecules. Molecules are always in motion.

1. Mix 2 drops each of red, yellow, blue, and green food coloring.

2. What color does the mixture become?

The mixing of the 4 colors produces a black color.

3. Dip a corner of a paper towel into the mixture. What happens?

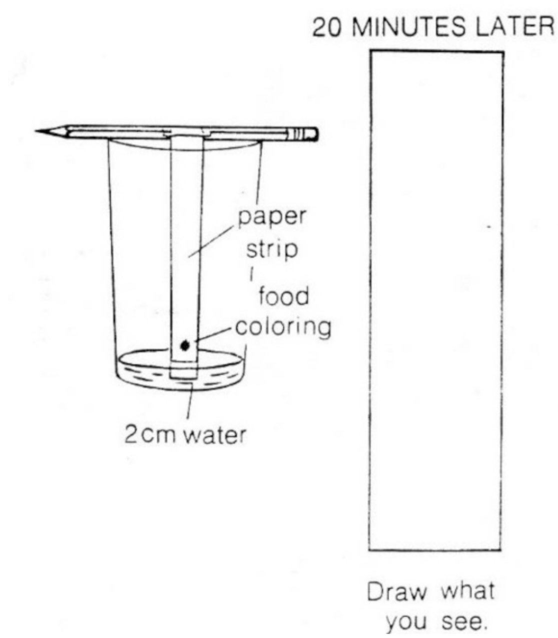
When the corner is dipped into the mixture, the liquid is absorbed by the towel and spreads quickly.

B. Hypothesis

What happened to the molecules of the red, yellow, blue, and green substances?

____ a. They changed.
____ b. They disappeared.
__*c*__ c. They are still there.

C. Test



1. Put 1cm of water into a tall glass.
2. Cut a strip of white paper towel or a white coffee filter (2cm × 20cm). Tape the strip to a pencil.
3. Place one small drop of the liquid about 2cm from the loose end.
4. Hang the strip as shown in the drawing.
5. What happens at first?

At first the black dot spreads considerably.

6. Wait 20 minutes. Then remove the paper.
7. Were the different molecules still in the mixture? Explain.

Yes. Soon, the 4 colors are seen once again in separate bands.

8. Did all molecules move at the same speed? ***No.***
9. Which moved fastest?

The molecules of blue and green are at the top.

10. Which moved slowest?

The molecules of the red and yellow molecules lag behind.

Background Information:

This method of separating out various chemicals from a single mixture is called "paper chromatography." Molecules of various materials move at different speeds, because of their particular size and weight, and because they have different degrees of attraction for the paper. In laboratories, more sophisticated methods of chromatography are used to identify various components of unknown mixtures of materials, especially complex organic compounds, such as amino acids in proteins.

Sci-Terms:

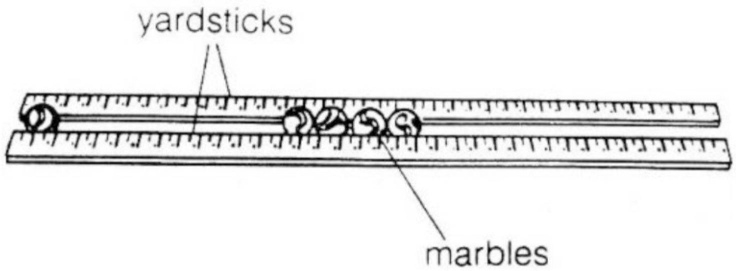
Paper chromatography
Matter
Molecules

Connection to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: 5-PS1 Matter and Its Interactions (p. 43)
<u>Performance Expectation</u>: 5-PS1-1-Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
<u>Disciplinary Core Idea</u>: PS1.A: Structure and Properties of Matter-Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)

Step 2: Objects at Rest

A. Observe



1. Make a track from two yardsticks or meter sticks. The track should be narrow enough for a marble to fit snugly on it.

2. Place 4 marbles in the middle of the track.

3. Gently roll another marble along the track toward the other 4 marbles.

4. What happens?

After the rolling marble hits the group in the track, the marble at the far end will move down the track.

B. Record

1. Try rolling 2 marbles together at the 4 marbles in the track. Record what happens on the chart below.

2. Roll 3 marbles together. Record your observations in the chart below.

Before Hitting		After Hitting	
Roll	In Track	In Track	Down the Track
●	●●●●	○○○○	○
●●	●●●●	○○○○	○○
●●●	●●●●	○○○○	○○○

C. Predict

1. Predict what will happen if the marbles are rolled with greater force.

<u>The greater the force with which the marble is rolled toward the group, the farther the marble at the other end will roll.</u>

2. Try it.

3. What did happen? ______________________________

4. Predict what will happen if one marble is rolled from the left at the same time that two are rolled from the right.

<u>Two marbles will move to the left and one will move to the right.</u>

5. Try it.

6. What did happen? ______________________________

Background Information:

A rolling marble contains energy of motion. When it is stopped by colliding with the stationary marbles, its energy can be passed along from marble to marble. When the energy reaches the last marble, it rolls away. Another principle, however, explains why the number of marbles that roll away always equals the number that strike the other end. This is the principle of momentum. The total momentum must stay the same. This can happen only if one marble rolls away for each marble that hits.

Sci-Terms:

Force
Momentum
Energy

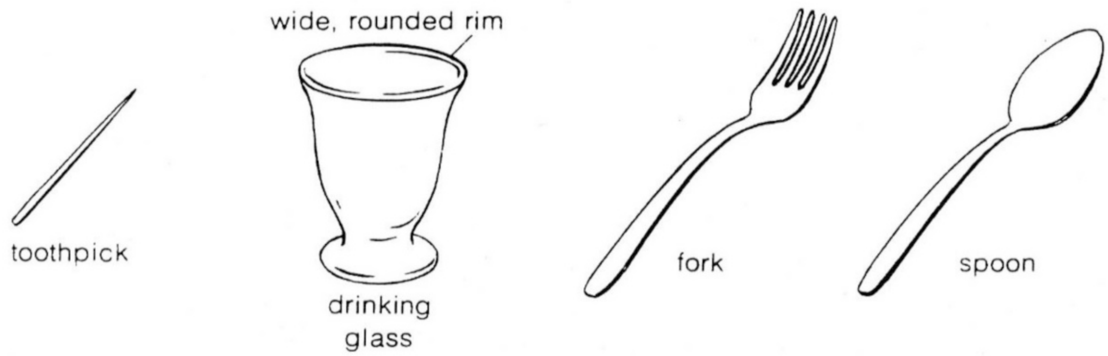
Connections to the *Next Generation Science Standards* (NGSS):

<u>Standard</u>: MS-PS2-Motion and Stability: Forces and Interactions (p. 59)
<u>Performance Expectation</u>: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
<u>Disciplinary Core Idea</u>: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

<u>Standard</u>: MS-PS3-Energy (p. 62)
<u>Performance Expectation</u>: MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (p. 61)
<u>Disciplinary Core Idea</u>: PS3.C: Relationship Between Energy and Forces-When two objects interact, each one exerts a force on the other than can cause energy to be transferred to or from the object. (p. 62)

Step 3: A Balancing Act

A. Gather

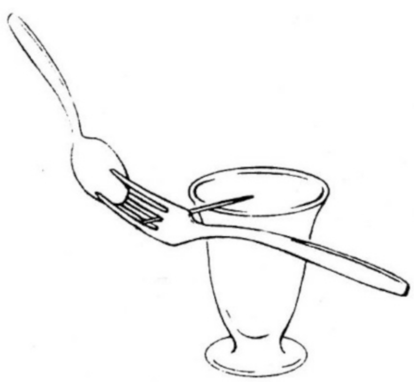


B. Make

1. Wedge the spoon into the fork.

2. Place one end of the toothpick between the center tines of the fork.

3. Place the other end of the toothpick on the rim of the glass. Get the objects to balance. You may have to move the three objects many times until they are balanced.



C. Try

1. Wait until there is no movement of the objects.

2. Hold a lighted match at the outside end of the toothpick (at the end that is not on the glass). **Your teacher will assist you with this task.**

3. What happens to the flame?

The toothpick burns until it reaches the metal utensils. The heat is conducted away and the flame goes out.

4. Hold a lighted match at the other end of the toothpick (the end on the rim of the glass).

5. What happens to the flame?

On the other side, it is the glass that absorbs the heat from the match.

6. What happens to the balanced objects after the toothpick stops burning?

After the toothpick stops burning, the objects should remain balanced.

Teacher Notes:

A. Use a fork and spoon that are similar in weight and can fit together easily.
B. Have patience! The balancing act may take a while to set up. You must find the right position for the different objects.
C. Do not disturb the glass while the toothpick is burning at either end. **Caution**: the children are to have no papers nearby while they light the match. Remind them to be careful as they light the ends of the toothpick. Sometimes this movement will cause the fork and spoon to fall from the glass, knocking the match out of the child's hand. [Note: teacher's assistance may be needed.]

Background Information:

Every object, or combination of objects, has a center of gravity. This is the point at which all the weight seems to be concentrated. If the center of gravity is kept below the point of support, the objects will remain in balance. In this balancing act the center of gravity must be directly below the point resting on the rim of the glass.

Sci-Terms:

Gravity
Center of gravity

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2- Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation(s):
MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. (p. 59)
MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
Disciplinary Core Idea(s): PS2.A: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction. (p. 59)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

STEM Center 6.1

Team Challenge: **Can your team put together three (3) different "balancing act" models using simple materials?** [*NGSS MS-PS2-2:* Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object – emphasis is on balanced vs. unbalanced forces.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about an object's center of gravity [e.g. What is the difference between an object's "center of gravity" versus an object's "center of mass"? What is the key to getting an object or a combination of objects to balance?]

Fact 1:

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Fact 2:

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Fact 3:

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Name at least one scientist who studied the concept of "center of gravity." What are some balancing acts that might be performed in a circus? Can you find some interesting examples of real-world balancing acts?

____

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B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

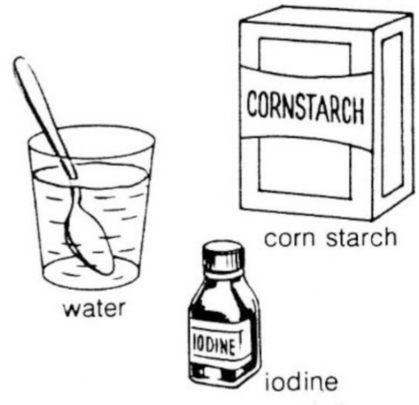
Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 4: Testing for Starch

A. Investigate



1. Add 2 drops of iodine to a fresh glass of water. Stir it. What happens to the mixture?

Iodine in water is brown in color.

2. Add a pinch of cornstarch to the mixture. Stir it. What happens to the mixture?

Add a pinch of cornstarch and the iodine will turn bluish.

3. Add about 1 teaspoon of cornstarch to the mixture. What happens now?

Larger amounts of starch and iodine will be almost black.

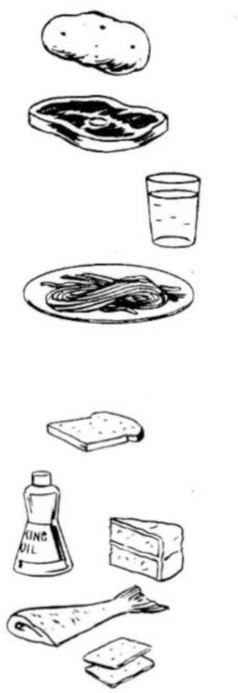
B. Hypothesis

Some foods contain starch. Iodine changes color when it comes into contact with starch. Therefore, iodine can be used to test for starch in foods. When iodine is added to a food,

____ a. it always turns blue.
__*b*__ b. it will turn a blue color if it contains a small amount of starch.
__*c*__ c. it will turn a black color if there is a great deal of starch.
__*d*__ d. no starch is present in the food if the iodine remains brown.

C. Test

Use 2 drops of iodine to test each of the following foods for the presence of starch.



Food	Starch		
	None	Some	Much
Potato			
Meat			
Orange juice			
Spaghetti			
Bread			
Cooking oil			
Cake			
Fish			
Cracker			

Meats, orange juice, oil, and fish show no evidence of starch. Potato, spaghetti, bread, cake, and crackers will show that starch is present.

Background Information:

Starch is just one of the nutrients that is included in a balanced diet (proteins, fats, minerals, and vitamins are others). Starch, a carbohydrate, is digested and changed to sugar, another form of carbohydrate. The sugar is oxidized in our cells and energy is derived by which we maintain our body temperature and can carry on all the life processes. Mixing iodine and starch results in a change of color which is a chemical reaction or change.

Sci-Terms:

Starch
Iodine
Chemical Change

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS1-Matter and Its Interactions (p. 43)
Performance Expectation: 5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen. (p. 43)
5-PS1-3: Make observations and measurements to identify materials based on their properties. (p. 43)
Disciplinary Core Idea: PS1.A: Structure and Properties of Matter: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model that shows gases are made from matter particles that are too small to see and that are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (p. 43)
PS1.A: Structure and Properties of Matter: Measurements of a variety of properties can be used to identify materials. (p. 43)

Step 5: Gears

A. Observe

1. Turn a one-speed bicycle upside down.

2. Put a chalk mark on the large pedal gear.

3. Put another chalk mark on the small rear gear.

4. Turn the pedal around once so the front gear will turn once. Watch the gear as you do this.

5. How many times did the gear turn?

Usually, one-speed bicycles have a 2:1 ratio of teeth. For each turn of the large gear, the smaller gear goes around twice.

B. Record

1. Get a hand eggbeater or a hand drill. It will have a large gear and a small gear.

2. Count the number of teeth on the large gear. Record that number on the table.

3. Count the number of teeth on the small gear. Record that number on the table.

4. Turn the large gear once. How many times around does the small gear move?

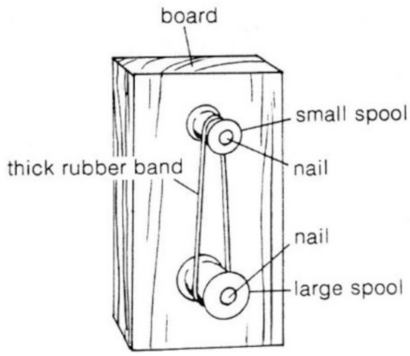
____

5. How much faster is the small gear moving?

Answers may vary. Example: A hand drill with 60 teeth on a large gear and 15 teeth on a smaller gear will increase speed by 4 times. (60 / 15 = 4)

Gear	Number of Teeth
Large	
Small	

C. Predict



1. Put together a belt system like the one in the diagram.

2. Make sure the rubber band fits tightly around the spools.

3. When you turn the large spool, which spool will turn faster?

Turn the large spool; the smaller spool will turn faster.

4. What will happen if you turn the small spool?

Turn the small spool; the larger spool will turn more slowly.

5. Try it.

Background Information:

Gears are used when we want a driving wheel to turn at a different speed than a driven wheel. Gears may mesh directly, or they may be connected through a chain, as in a bicycle. If the driven gear has fewer teeth (and therefore a smaller diameter) than the driving gear, the driven gear will turn faster. The reason is that the smaller gear has to make more turns to pass the same number of links in the chain. A belt system is like a gear-and-chain system, except that the belt relies on friction to transmit the turning force, and therefore a belt can slip. A gear-and-chain system and a small gear in contact with a larger gear are two examples of a simple machine.

In a bicycle, the driven wheel turns faster than the pedals. This gain in speed is offset by a loss of force. When greater force is needed-for example, in going uphill-many bicycles have “slow” or “low” gears that do not turn as fast as the pedals, but exert greater forces. Automobiles have different gear ratios for getting started and for going up steep hills than they have for cruising at high speed.

Sci-Terms:

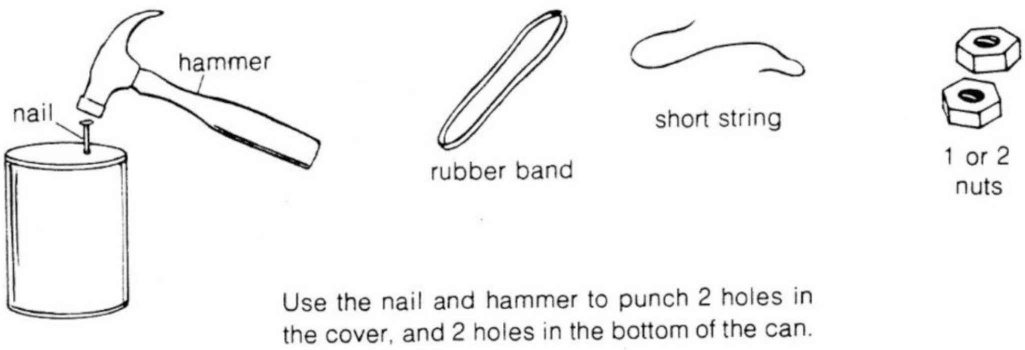
Gears
Simple machine
Teeth
Belt system
Driver gear
Driven gear

Connection to the *Next Generation Science Standards* (NGSS):

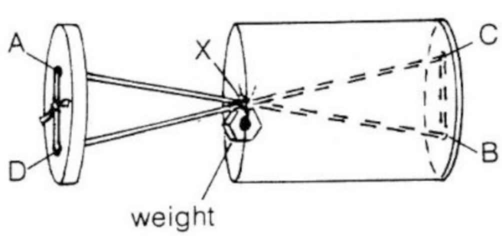
Standard: MS-PS2-Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation: MS-PS2-2: Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. (p. 59)
Disciplinary Core Idea: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

Step 6: Roll Back

A. Gather



B. Make



1. Cut the rubber band.
2. Push one end of the rubber band through hole A. Hold on to one end.
3. Then push the rubber band through hole B; then around the bottom of the can and through hole C; and then up through hole D. Tie the two ends of the rubber band together on top of the cover.
4. At X (where the rubber band crosses), tie the string and weight (nut) tightly. Replace the cover.
5. Paste construction paper over the top and bottom of the can to hide the holes and the rubber band.

C. Try

1. Gently roll the can away from you on a smooth floor.

2. How far does it go?

How far it rolls will depend on the force put into it and the surface of the floor.

3. Does it stop?

It will stop for an instant.

4. What happens after it rolls forward?

It will then roll back.

5. Where does it stop?

It will stop almost at the starting point.

A. A small (short) Pringles can works very well.

Background Information:

Energy is the ability to do work, or to make something move. The energy of your muscles is put into the can to start it rolling. The energy of this motion is called kinetic energy. This energy is then used to wind up and stretch the rubber bands. Gradually the kinetic energy is changed to stored energy in the rubber bands, called potential energy, and the rolling can comes to a stop. The potential energy of the rubber bands is then changed back to kinetic energy as they unwind and cause the can to roll back. Theoretically, the can should roll back and forth forever as the energy changes back and forth from kinetic to potential. But friction changes much of the energy to heat, which is lost to the surroundings, and the motion soon stops.

Sci-Terms:

Energy
Kinetic energy
Potential energy
Friction

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS3 Energy (p. 61)
Performance Expectation: MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (p. 61)
Disciplinary Core Ideas:
PS3.A: Definitions of Energy

- Motion energy is properly called kinetic energy (p. 61)
- A system of objects may also contain stored (potential) energy, depending on their relative positions. (p. 61)

PS3.B: Conservation of Energy and Energy Transfer

- When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (p. 62)

STEM Center 6.2

Team Challenge: **Can your team construct a device that can take an object from one place to another using at least six (6) different gear sizes?** [*NGSS MS-PS2-2:* Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about gears [e.g. Why is the combination of larger gears and smaller gears considered a simple machine? What combination of different size gears is most effective in moving an object? **Note:** there are a variety of plastic gear sets that can be ordered online.]

Fact 1:

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Fact 2:

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Fact 3:

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Can you find examples of how gears are used in various objects in or around your house? Explain how the gears work in these objects. Find an inventor who has contributed in the development of gears.

____

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B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

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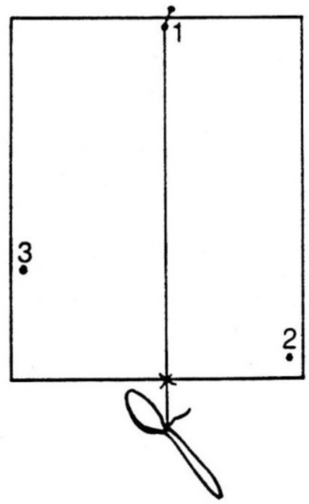
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

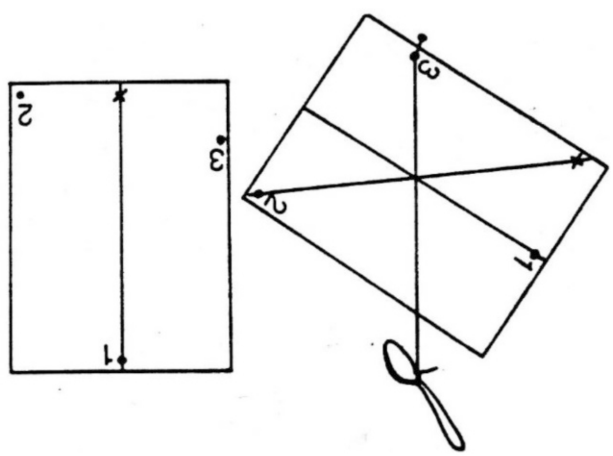
Step 7: Finding the Center

A. Investigate



1. Cut a rectangle from the large side of a cereal box.
2. Punch three small holes in it as shown in the diagram.
3. Put a pin through hole #1. Pin the cardboard to a bulletin board.
4. Attach a string with a weight to the pin.
5. Put a mark at point X where the string crosses the edge of the cardboard. Draw a straight line from hole #1 to point X on the cardboard.
6. Repeat this procedure at points #2 and #3 by hanging the string from point #2 and then from point #3, and then drawing straight lines.

B. Hypothesis



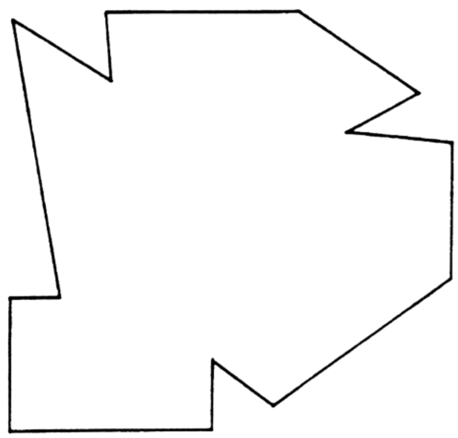
The three lines should cross at one point. Which of the following statements are true about this point?

___*X*___ a. the cardboard can be balanced on a pin at this point.

___*X*___ b. the cardboard will spin evenly when a pin is stuck through this point.

Both statements concerning the point are true, as this is the cardboard's "center of gravity."

C. Test



1. Draw a figure like the one at the left on another piece of cardboard. Cut it out.
2. Select any three points.
3. Repeat the same steps as you did in part A.
4. Locate the center.
5. How does this verify your answers in Part B?

____

____

Teacher Notes:

A. The string and the weight form a “plumb line.” The weight is pulled straight down towards the center of the earth by the pull of gravity.

C. Results may vary depending upon the actual figure the student cuts out; however, statements will still be true.

Background Information:

The “center of gravity” is that point in any object where the force of gravity seems to act. You can balance any object by supporting it at any point that is on a vertical line that passes through this center of gravity. The center of gravity is also the point at which all the weight seems to be.

Sci-Terms:

Center of gravity
Gravity

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS2 Motion and Stability: Forces and Interactions (p. 59)
Performance Expectation(s):
MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object (the focus is on balanced and unbalanced forces). (p. 59)
Disciplinary Core Idea(s):
PS2.A: Forces and Motion

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (p. 59)

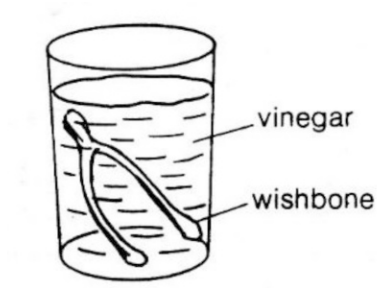
PS2.B. Types of Interactions

- Gravitation forces are always attractive. There is gravitational force between any two masses, but it is very small except when one or both of the objects have large mass (e.g. Earth and the Sun) (p. 60) (The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center, p. 45)

Step 8: Vinegar and Calcium

A. Observe

1. Clean the wishbone of a chicken.
2. Place it into a glass of vinegar.



3. Leave it undisturbed for a few days.
4. Remove the wishbone.
5. What has happened to it? What do you observe?

The wishbone will become soft and bendable.

B. Record

1. Put a small piece of chalk into some vinegar.
2. What happens to the chalk?

Chalk and bones both contain calcium. Vinegar is an acid. It makes the bones bend and the chalk fall apart.

Bubbles are produced and the chalk disintegrates.

3. Put other chicken bones, such as the wing bone and leg bone, into some vinegar. See how many days it takes before the vinegar makes the bones bend.
4. Record your observations on the chart below.

Bone	Number of Days
wish bone	
wing bone	
thigh bone	

The number of days it takes for different bones in the chicken to become soft and bendable depends upon the thickness and size of the bone.

C. Predict

1. What is an egg shell made of?

The egg shell is also made of calcium (calcium carbonate).

2. What do you think will happen to an egg if it is placed in a glass of vinegar?

It reacts with the vinegar. The chemical reaction dissolves the calcium carbonate egg shell.

3. Try it.

4. How long did it take for the reaction to take place?

It can take 12-24 hours before a good portion of the shell is dissolved. You may have to rinse it and replace with fresh vinegar to remove the outer shell completely.

5. Rinse off the egg. Now, put it into a glass of fresh water.

6. What do you predict will happen if it is left overnight?

____

____

7. What does happen?

When left in water, the egg swells.

8. Why?

The egg will swell as water passes through the membrane into the egg. There is no shell to stop this from happening.

Teacher Notes:

C. Have your students measure the mass of the egg (without the shell) *before and after* you soak the egg in a glass of fresh water to determine how much water passed into the egg.

Background Information:

An acid, such as vinegar, reacts with the calcium carbonate found in the chalk, bone, and egg shell. The chemical change produces the gas carbon dioxide and calcium acetate. The removal of the calcium leaves the bone with other materials that are pliable. Osmosis is the passage of a material from an area of high concentration to an area of lower concentration, through a selective membrane. This allows only the smaller molecules, like water, to pass through. Without the calcium to make the bone rigid, the only thing left behind is soft bone tissue (collagen).

Sci-Terms:

Calcium
Chemical Reaction
Osmosis
Acid

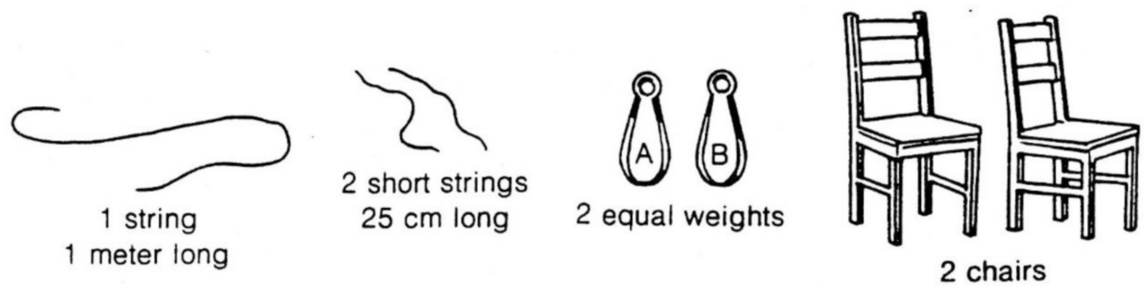
Connection to the *Next Generation Science Standards* (NGSS):

Standard: 5-PS1-Matter and Its Interactions (p. 43)
Performance Expectation: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (p. 43)
Disciplinary Core Idea: PS1.B: Chemical Reactions

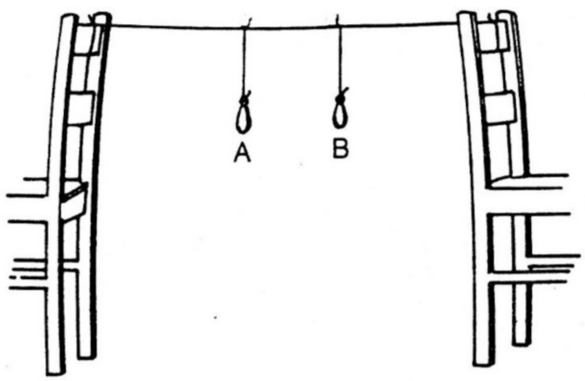
- When two or more different substances are mixed, a new substance with different properties may be formed. (p. 43)
- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (p. 43)

Step 9: Transfer of Energy

A. Gather



B. Make



1. Set up your materials as shown in the diagram. The short strings should be about 20-30cm apart.

2. Wait a few moments until the weights stop moving.

C. Try

1. Stand in front of the weights.
2. Pull weight A toward you. Then let it go so it swings as a pendulum.
3. After a few seconds, what happens to:

   Weight A? ***Weight A swings and then slows down and stops*.**

   Weight B? ***Weight B will move slowly and then swing rapidly*.**

4. In a short while, another change will happen. What happens to:

   Weight A? ***Weight A begins swinging once again*.**

   Weight B? ***Weight B begins to slow down*.**

Teacher Notes:

A. The string must be strong enough to support the weights, which need not be too heavy. Small fishing sinkers, or something similar, would be fine.
B. Do not allow the string to sag very much. Spread the chairs to keep the line as straight as possible.

Background Information:

A weight swinging on a string is a simple pendulum acted upon by the force of gravity. Each time weight A swings, it gives weight B a little push by giving up a little energy to the line. Soon weight A comes to a rest, while weight B has the energy to swing in full motion. This machine is called a coupled pendulum.

Sci-Terms:

Pendulum
Coupled Pendulum
Gravity
Energy
Transfer of Energy

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS3 Energy (p. 61)
Performance Expectations:

- MS-PS3-2-Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (p. 61)
- MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (p. 61)

Disciplinary Core Ideas:

- PS3.B. Conservation of Energy and Energy Transfer: When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (p. 62)
- PS3.C: Relationship Between Energy and Forces: When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (p. 62)

STEM Center 6.3

Team Challenge: **Can your team make a model using three (3) or more weighted, swinging objects to show a transfer of energy?** [*NGSS MS-PS3-2:* Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system forces on the object.]
(**Note:** experiment with different size weights and different length strings).

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about a pendulum [e.g. what is a pendulum and how does it work? How can a coupled pendulum cause a transfer of energy to occur? What types of energy are involved?]

Fact 1:

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____

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Fact 2:

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Fact 3:

____

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Describe the work of some notable scientists associated with pendulums. Where can pendulums be found in our everyday lives?

____

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B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

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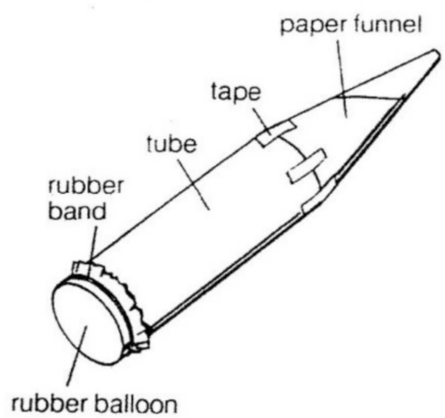
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

LIGHT & SOUND

Step 1: Vibrations and Sound

A. Investigate



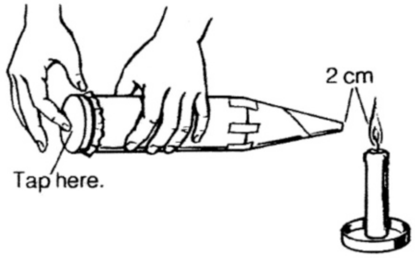
1. Stretch a piece of rubber balloon tightly over one end of a cardboard tube.
2. Attach it with a rubber band.
3. Roll up a sheet of paper (about 10cm × 15cm) like a funnel. Tape it to the other end of the tube.
4. Tap gently on the rubber membrane with your finger.
5. Is there any sound produced?

Make the membrane fit tightly on the tube so the slightest tap will produce a distant sound.

6. Place the small end of the funnel about 2 cm from a lighted candle.
7. Tap the membrane again. What happens to the flame?

The flame will flicker in unison with the tapping on the membrane.

B. Hypothesis



Which of the following must be vibrating?

_____ a. the cardboard tube
__*X*__ b. the rubber membrane
_____ c. the paper tube
__*X*__ d. the air inside the tube

C. Test

1. Use glue or tape to attach a small mirror to the rubber membrane.

2. Bounce the light of a flashlight from the mirror to the wall.

3. Make a sound into the paper end by blowing out with your tongue between your lips.

4. What happens to the light on the wall?

You see this vibrating by watching the moving light on the wall.

5. What two things must be vibrating?

The rubber membrane and the air inside the tube.

Teacher Notes:

B. The cone area concentrates the energy of the vibrating air enough to extinguish the flame.

C. Now the sound originates at the smaller end. The vibrations are still carried through the air in the tube to the large end with the membrane.

Background Information:

Sounds are produced by objects that are moving rapidly back and forth, or vibrating. When they vibrate in air, they cause waves of vibration to travel through the air in all directions. These waves in the air can cause membranes to vibrate in step with them. The eardrum is a membrane that is set vibrating by sound waves. This membrane sends its vibrations into the ear, where they cause nerve endings to send messages to the brain. These messages are interpreted by the brain as sounds. Different rates of vibration are heard as sounds of different pitch-the faster the vibration, the higher the pitch. Membranes can also produce sounds if they are set vibrating by being hit, as in a drum.

Sci-Terms:

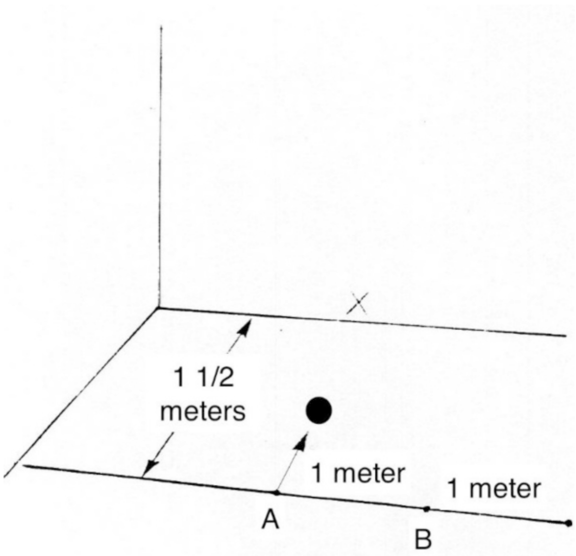
Membrane
Vibrations/vibrate

Connections to the *Next Generation Science Standards* (NGSS):

Standard: 1-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 10)
Performance Expectation: 1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (p. 10)
Disciplinary Core Idea: PS4.A: Wave Properties-Sounds can make matter vibrate, and vibrating matter can make sound. (p. 10)

Step 2: Watch the Rebound

A. Observe



1. Draw a chalk line on the floor 1.5 meters in front of a wall.

2. Mark an X on the wall close to the floor.

3. Mark point A on the chalk line directly in front of the X.

4. Roll a rubber ball from point A straight toward the X.

5. In what direction does the ball rebound?

Roll the ball with enough force so it rolls straight to the X and back across the line. From A it bounces directly back to A.

6. On the chalk line, mark point B, 1 meter to the right of point A.

7. Roll the ball from point B toward the X. Keep trying until the ball hits the X.

8. Have someone mark point C where the ball crosses the chalk line to the rebound.

9. Repeat steps 6 and 7 from point D, 2 meters to the right of point A. Mark point E where the ball crosses the chalk line on the rebound.

B. Record

1. Measure the distance from point A to point C and from point A to point E.

2. Record your observations on the chart.

Roll Point	**Distance from A**	**Rebound Point**	**Distance from A**
B	1 meter	C	1 meter
D	1 meter	E	2 meters

C. Predict

Light rebounds from a mirror the way a ball rebounds from the wall.

1. Tape a mirror to the wall above the X.

2. Predict where the light will rebound when you shine a flashlight toward the mirror from point A.

____

3. Predict where the light will rebound when you shine it from point B.

____

4. Try it. Have a friend "catch" the rebound on a sheet of paper.

5. Make the prediction for other points along the chalk line. Test your prediction each time.

Teacher Notes:

B. See filled-in chart.

C. Light reacts in the same way as the bouncing ball. You will find the reflected beam by holding the paper an equal distance to the left of A as the flashlight is to the right of A.

Background Information:

Light travels in a straight line when it bounces back, or is reflected, from a smooth surface. The angle at which the ray of light from the flashlight hits the mirror (angle of incidence) is equal to the angle at which the light ray bounces off (angle of reflection). The children should be able to discover this "law of reflection" by their own measurements.

Sci-Terms:
Angle of incidence
Angle of reflection
Law of reflection

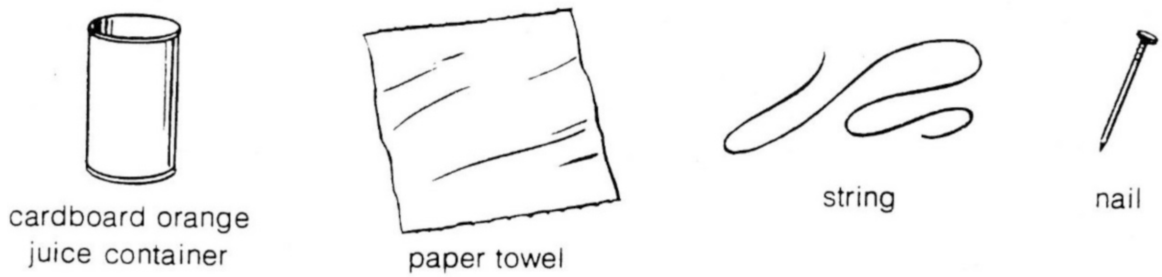
Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation: MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (p. 63)
Disciplinary Core Idea: PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (p. 63)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (p. 63)

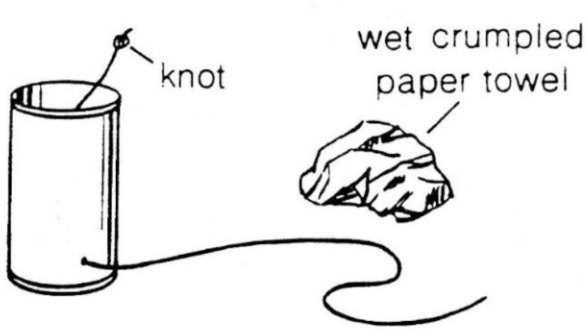
Step 3: Canned Sounds

A. Gather



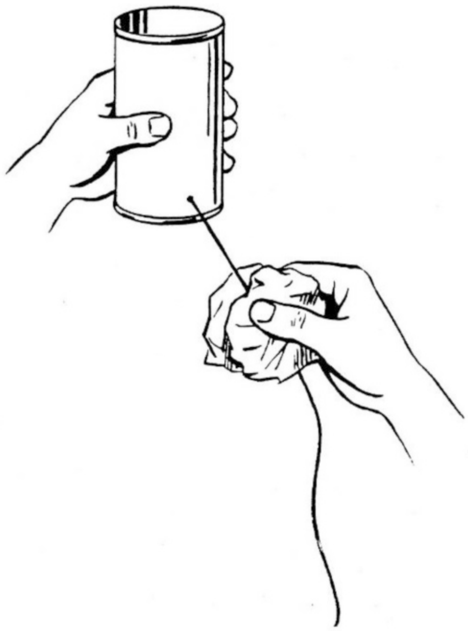
*clean the orange juice container by rinsing it with water.

B. Make



1. Make a hole near the bottom of the can.
2. Pull the string through the hole.
3. Tie a knot on the end of the string that goes inside the can.
4. Wet and crumple the paper towel.

C. Try



1. Hold the can in one hand.

2. Pull the wet paper along the string.

3. It makes a noise. What does the noise sound like to you?

____

4. Change how tightly you squeeze on the string with the paper. What does it sound like now?

____

5. Try making other "canned" sounds. Use:
   a. different sized containers
   b. wire instead of string
   c. different thickness of string or wire

6. What kinds of sounds did you make?

____

7. What causes the sounds? _______________________________

Teacher Notes:

A. Use the nail to make the right size hole in the can.

B. Have the children make the string just long enough so they can reach the end with one hand while holding the can with the other hand.

C. The sound produced might sound like a howling dog, depending on how taut the string is held. Answers will vary according to the other materials that are used.

Background Information:

The vibrations produced by the string are carried into the cup and made louder when the air inside vibrates. When sound vibrations of different rates or frequencies are mixed, sounds of many different qualities are produced. The strange sounds produced in this activity result from the fact that the rubbed string vibrates in many different ways as the wet paper is moved along it. The variety of sounds and their interpretations may stimulate an interest in sound on the part of the students.

Sci-Terms:

Vibrations
Frequencies

Connections to the *Next Generation Science Standards* (NGSS):

Standard: 1-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 10)
Performance Expectation: 1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (p. 10)
Disciplinary Core Idea: PS4.A: Wave Properties-Sounds can make matter vibrate, and vibrating matter can make sound. (p. 10)

STEM Center 7.1

Team Challenge: **Can your team write and produce a short play or skit that uses six (6) or more different "canned sound" effects?** [*NGSS 1-PS4-1:* Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about the vibrations of strings using a can [e.g. How do vibrations produce different sounds? How does the size of the can and the type and thickness of the string affect the type of sound produced?]

Fact 1:

Fact 2:

Fact 3:

Name at least one scientist who contributed to our understanding of the creation and transfer of sound. Briefly explain his/her discoveries.

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 4: Speed of Vibrations

A. Investigate

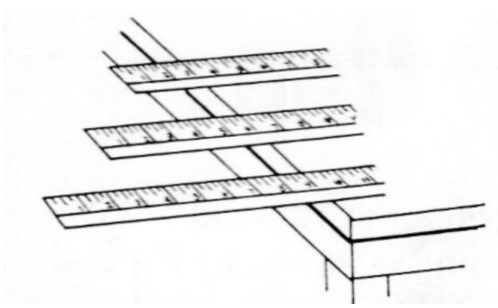
1. Get a thin plastic or metal 12-inch ruler.
2. Hold the ruler on a desk or table so that 3 inches of the ruler hangs over the edge.
3. Make the 3-inch part vibrate. Notice the speed at which it vibrates.
4. Listen to the sound made by the vibrations.
5. Do steps 2-4 at 6 inches and at 9 inches.
6. Which length vibrates the fastest?

The 3-inch part will vibrate the fastest and produce the highest sound.

7. Which length vibrates the slowest?

The 9-inch extension will vibrate the slowest and produce the lowest sound.

B. Hypothesis



If one object is longer than another, but otherwise they are alike (same material, width, and thickness), then the longer one will vibrate…

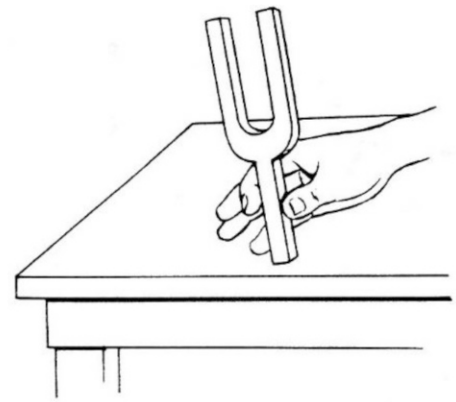
______ a. faster

__*b*__ b. slower

C. Test

1. Get three tuning forks from a set. Find the number printed on each one that tells you how many times per second it vibrates.

2. Write the numbers on the chart.



3. Measure the length of the prongs of each tuning fork. Write the lengths on the chart.

4. Strike each tuning fork with a rubber hammer, and quickly hold the handle against a wood surface. Listen to the sound each makes.

5. Which tuning fork makes…
   a. the highest sound? ___________
   b. the lowest sound? ___________

The shortest tuning fork vibrates the fastest and makes the highest sound.

No. of Vibrations/Second			
Length			

Teacher Notes:

A. Even a wood ruler can produce a satisfactory difference in sound.
C. Typical dimensions of a matched set of tuning forks
   8cm length-1024 vps (vibrations per second)
   11cm length- 512 vps
   12cm length- 480 vps
   16cm length-256 vps

Background Information:

The pitch of a sound is what we call its "highness" or "lowness"- a subjective sensation that cannot really be described, but only demonstrated. The pitch is determined by the rate at which the sounding body is vibrating-the greater the rate, the higher the pitch. The pitch of middle C corresponds to a rate of 256 vps. This is the note called "do" in the scale of C. A sound of twice this rate, or frequency-512 vps- will seem to be the same note, but with a higher pitch. It is also called "do", but it is one octave higher. Each octave doubles the frequency of the note one octave lower. (Note: the unit "hertz" is now used in place of vibrations or cycles per second. A frequency of 1,000 cycles per second would be called 1,000 hertz.)

Sci-Terms:

Tuning fork
Pitch
Octave
Frequency

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 1-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 10)
Performance Expectation: 1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (p. 10)
Disciplinary Core Idea: PS4.A: Wave Properties-Sounds can make matter vibrate, and vibrating matter can make sound. (p. 10)

Step 5: Seeing

A. Observe

Everyone has a blind spot.

1. Hold this paper at arm's length.

2. Close your left eye and stare at the dot with your right eye.

3. Are you able to see the square? ___________

4. Slowly bring the paper closer to you.

5. What happens to the square when the paper is about 10-12 inches away?

____

<u>The image of the square has fallen on the blind spot of your eye.</u>

B. Record

1. Keep both eyes open while you point to an object on the other side of the room.

2. Keep pointing while you close your right eye.

3. If the object seems to jump to the right, you are right-eyed. If the object stays in the same position, you are left-eyed.

4. Test other members of your family to see if they are right-eyed or left-eyed. Record your observations on the chart.

Family Member	**Right**	**Left**

C. Predict

1. The pupil of your eye opens and closes according to the light available.

2. Predict how it will be…
   a. in bright light _______
   b. in dim light ________

3. Stand in front of a mirror in a brightly lighted room. Observe the size of your pupils.

4. Cup your left hand over your left eye.

5. Keep your left eye open in the darkness of your hand for a minute.

6. Stare into the mirror. Remove your left hand.

7. What happens to the pupil of your left eye? ____

It gets larger in dim light and smaller in very bright light.

Teacher Notes:

A. The blind spot is an area in your eye where the optical nerve joins the retina. It is not sensitive to light. This is one form of an optical illusion.
B. Everyone has a stronger and a weaker eye. Finding yours will help you choose which to use while looking through a microscope or a telescope.
C. The pupil is the opening in the center of the colored iris. When muscles of the iris contract or relax, the pupil will change in size.

Background Information:

While the eye has the ability to form an image of objects, it is the brain that actually allows us to see. If a model of the eye is available, use it to show the path light rays take from the object, through the cornea, the aqueous humor, the pupil, the lens, and the vitreous humor to reach the retina. The light-sensitive cells here are stimulated and the messages are carried to the visual area in the back of the brain.

Sci-Terms:

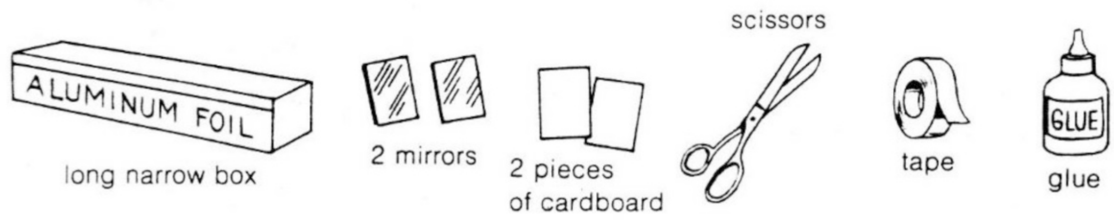
Blind spot
Pupil (as it relates to the eye)
Optical Illusion

Connection to the *Next Generation Science Standards* (NGSS):

Standard: 4-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 37)
Performance Expectation: 4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eyes allows objects to be seen. (p. 37)
Disciplinary Core Idea: PS4.B: Electromagnetic Radiation- An object can be seen when light reflected from its surface enters the eye. (p. 37)

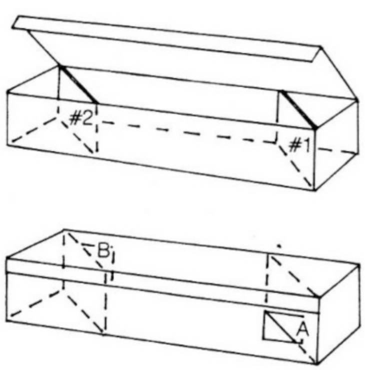
Step 6. Up Periscope

A. Gather



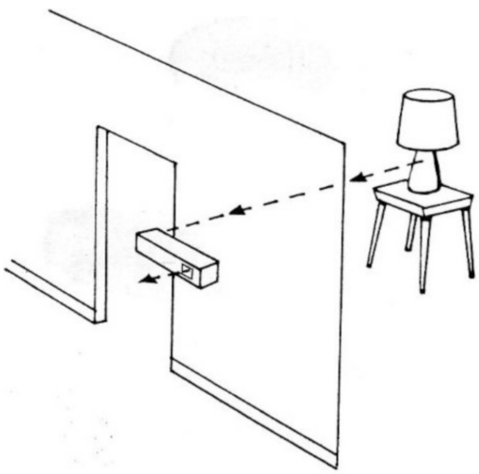
*pull the cutting edge off the box if there is one!

B. Make



1. Open the cover of the box.
2. Place mirror #1 in a corner at a 45° angle. The mirror must face the other corner.
3. Tape the mirror to the box. If the mirror does not reach the sides, tape it first to a piece of cardboard that will. Then tape the cardboard to the box.
4. Do the same with mirror #2 at the other corner. Mirror #1 should face mirror #2.
5. Cut a hole in the front of the box at A. You should be able to see mirror #1.
6. Do the same at the back for mirror #2.

C. Try



1. Stand behind a wall near a doorway. Hold your periscope so that one hole is facing into the next room.

2. Look through the other hole. What do you see?

The light travels in straight lines from the object to mirror #1. Here it is reflected at an angle to mirror #2, then to the eye.

Teacher Notes:

A. Rectangular mirrors can be wedged into the box at the desired angle are best.

B. Be neat with the tape so it does not block the view. The large holes need not be as large as the mirror.

Background Information:

Light travels in straight lines. Ordinarily, you cannot see something if there is an opaque screen between your eyes and the object you wish to see, because the light rays from the object cannot go through the screen to reach your eyes. Mirrors can be used to change the direction of light rays and make them go around obstacles. When light rays strike the smooth surface of a mirror, they are reflected, or bounced off, at the same angle to the mirror, but on the other side of a perpendicular line to the mirror. In this periscope, the rays strike the mirror at 45°, and bounce off at 45°, thus making a total change in the direction of 90°, or a right-angle turn, at each mirror.

Sci-Terms:

Periscope
Reflection

Connection to the *Next Generation Science Standards* (NGSS):

Standard MS-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation: MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (p. 63)
Disciplinary Core Idea: PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (p. 63)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (p. 63)

STEM Center 7.2

Team Challenge: **Can your team create a collection of unusual "optical illusions" to try out with other teams?** [*NGSS 4-PS4-2.* Develop a model to describe that light reflecting from objects and entering the eyes allows objects to be seen.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about optical illusions [e.g. What are some common optical illusions? What materials are needed to create them? What are the fundamental causes of seeing an "optical illusion?"].

Fact 1:

____

____

____

Fact 2:

____

____

____

Fact 3:

____

____

____

Which scientists have helped us understand how we see? Explain why it is said that we really "see with our brain."

____

____

____

B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

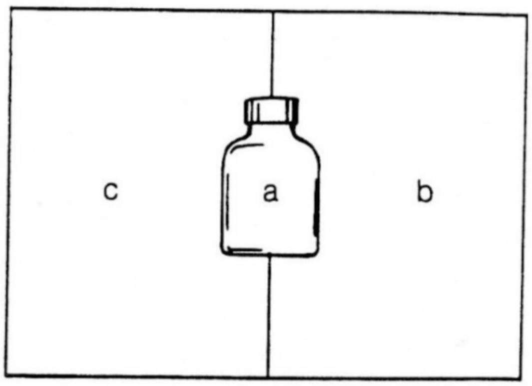
Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

Step 7: Light and Water

A. Investigate



1. Draw a line across a sheet of paper.
2. Fill a small, clear flat-sided bottle with water.
3. Cap the bottle and lay it down with the wide side over the line.
4. How does the line appear from the following positions?

a. From above: ***one line***

b. In front: ***broken line***

c. Behind: ***the line is broken, but this time is in the opposite direction***

B. Hypothesize

The line seems to appear in different places because

__*a*__ a. light changes direction as it passes through different materials.

____ b. light passes in a straight line through all materials.

C. Test

1. Place a quarter into a shallow saucepan or frying pan.

2. Place the pan on a table or desktop.

3. Step backward away from the pan until you can no longer see the quarter.

4. Look at the pan while a friend pours water into it.

5. Are you able to see the quarter again? Explain.

The quarter appears to rise, and it once more is in sight.

Background Information:

The bending of light as it passes at a slant from one medium (water) to another (air) is called refraction. This is the result of changes in the speed of light as it travels through various media. When the light ray is vertical, there is no change, as the entire ray of light is affected at the same time as it passes from the object through the water and air to the eye. However, at an angle, the part of the ray that reaches the refracting substance first is held back first, causing the ray to bend.

Sci-Terms:

Reflection
Refraction

Connection to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS4- Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation: MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (p. 63)
Disciplinary Core Idea: PS4.B: Electromagnetic Radiation- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (p. 63)

Step 8: Groovy Sounds

A. Observe

1. Look at an old 78 rpm (10 inch) vinyl record.

2. Do the grooves look the same all over the record? If you see any differences, tell what they are.

At a glance the grooves appear to be regular and smooth.

3. Look at the grooves through a strong magnifying glass.

4. What do you see?

With a powerful magnifier, irregular wavy lines will be seen.

B. Record

1. Put the record on a record player at 78 rpm. Let the record turn without placing the needle on it.

2. Place your fingernail into the record groove.

3. Observe what you feel and hear where the record looks rough, and where it looks smooth.

You feel your fingernail vibrating in the groove while the record revolves. The smooth regions will produce a low pitched sound. The more the fingernail wiggles, the higher the sounds produced.

4. Record your observations on the chart.

Record	Feel	Hear
Rough		
Smooth		

C. Predict

1. Hold a sewing needle in the record groove as the record turns.

2. What happens?

<u>The metal needle conducts the sound better than your fingernail.</u>

3. Roll a sheet of paper to form a horn.

4. Bend the narrow end back and stick the sewing needle through it.

5. Predict what this will do to the sound.

____

____

6. Hold the paper horn by the narrow end and place the needle into the groove of the turning record.

7. What happens?

<u>The sound is even louder when it can be directed out in just one direction through the paper horn.</u>

Background Information:

The grooves of the record contain many combinations of patterns-narrow, wide, deep, furrows, and shallow furrows. These were first made by the loudness and pitch of the sound as the record was cut. Now, as the needle passes in the groove, its vibrations are picked up in the cartridge, changed to an electric current, carried to the amplification system, and changed back to the original sounds during the recording session.

Sci-Terms:

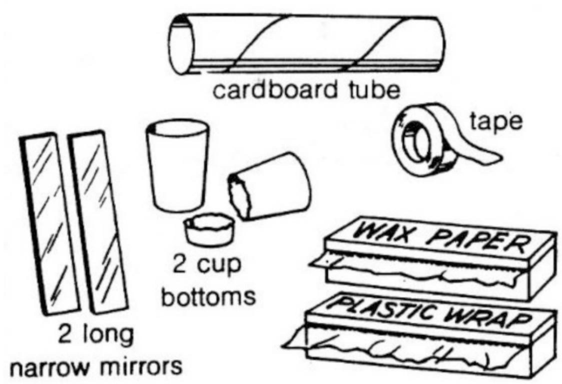
Furrows
Current
Amplification

Connections to the *Next Generation Science Standards* (NGSS):

Standard: 1-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 10)
Performance Expectation: 1-PS4-1: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (p. 10)
Disciplinary Core Idea: PS4.A: Wave Properties-Sounds can make matter vibrate, and vibrating matter can make sound. (p. 10)

Step 9: A Kaleidoscope

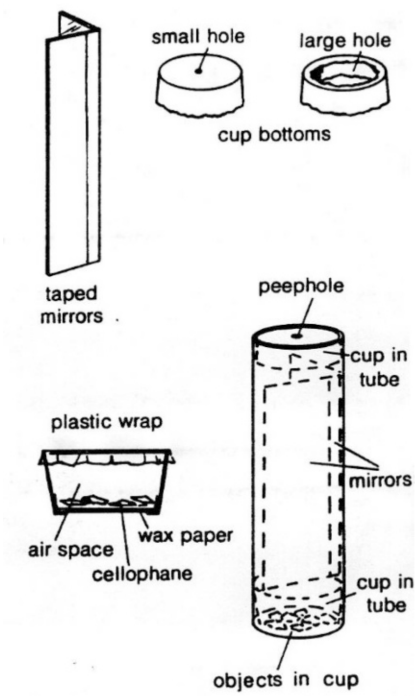
A. Gather



1. If you cannot get mirrors, use two pieces of glass that you have painted black on one side.
2. Tape the edges of the mirrors if they are rough.
3. The bottoms of the cups should fit into the tube.

*Note: you will also need pieces of colored plastic wrap or cellophane.

B. Make



1. Tape the two mirrors together at a 30 degree angle.
2. Wedge the mirrors inside the tube. If they are loose, tape them to the inside of the tube.
3. Poke a small hole in the center of one cup bottom to make a peephole.
4. Place it in one end of the tube.
5. Cut a large hole in the other cup bottom.
6. Place some wax paper in it and tape it down.
7. Put some colored pieces of cellophane on top of the wax paper.
8. Cover the top of the cup with clear plastic wrap. Leave enough room for the pieces of cellophane to move around. Tape the plastic wrap down.
9. Fit the cup bottom into the tube.

C. Try

1. Hold the kaleidoscope up to a light. Look through the peephole.
2. What do you see? ______________________________
3. Turn your kaleidoscope as you keep looking through the peephole.
4. What happens?

A variety of beautiful designs will be seen as it is turned.

Teacher Notes:

A. Most commercial kaleidoscopes made today use 2 shiny metal strips.

B. Be neat. Use tape only on the back portions of the mirrors. The wax paper is translucent and allows some light to pass through. The plastic wrap seals in the colored objects. It is transparent and lets all of the light pass through.

Background Information:

The kaleidoscope makes use of the principles of reflection of light. You see an image in each mirror. The image of the object in one mirror has an image in the other mirror. There are as many images of images of images as can fit your angle (30°) into the circle made by the tube (e.g. 12 images- each pair are back to back so it will look like 6 different groups of the object).

Sci-Terms:

kaleidoscope
reflection
angles

Connections to the *Next Generation Science Standards* (NGSS):

Standard: MS-PS4-Waves and Their Applications in Technologies for Information Transfer (p. 63)
Performance Expectation: MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials (p. 63)
Disciplinary Core Ideas: PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted though the object, depending on the object's material and the frequency (color) of the light. (p. 63)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (p. 63)

STEM Center 7.3

Team Challenge: **Can your team construct a more complex type of kaleidoscope?** [*NGSS MS-PS4-2:* Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.]

A. Team Research

Using the computer as a research tool, find at least three (3) new facts about kaleidoscopes [e.g. What principles of science are involved when you are using a kaleidoscope? What materials would you need to create a more complex kaleidoscope?]

Fact 1:

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Fact 2:

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Fact 3:

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What evidence can you find about the making of kaleidoscopes in centuries past?

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B. Team Plan

Where do we go from here to solve the problem? Discuss your ideas with your group members and devise a plan. Use the space below for notes and/or sketches of your design:

C. Team Results – Solve

What did you do to help find the solution to the problem? Describe what you did, what you observed, and explain your thinking. (Note: you can use both pictures and words in the space below.)

Write down any questions that you have and anything that you are curious about.

Science & Engineering Practices

During your work in the STEM Center, you used certain key "practices" similar to how scientists and engineers think and act. Identify which Science & Engineering Practices you feel that you were engaged in during the STEM Center problem-solving process. You are encouraged to talk with your team members about this and reflect upon your thinking process. Place a check in the right hand column next to each practice that you made use of:

1. Asking questions and defining problems	
2. Developing and using models	
3. Planning and carrying out investigations	
4. Analyzing and interpreting data	
5. Using mathematics and computational thinking	
6. Constructing explanations and designing solutions	
7. Engaging in argument from evidence	
8. Obtaining, evaluating, and communicating information	

CONCLUSION

It is our hope that *STEPS to STEM* has been a valuable asset and resource to you when teaching science. Rather than relying on rote memorization, reading from a textbook, or using teacher-led demonstrations, we strongly advocate for putting everyday materials into students' hands; creating authentic, inquiry-based learning environments; and allowing students to think and act like scientists/engineers and become genuine critical thinkers and problem-solvers. Realistically, our goal in creating *STEPS to STEM* was for you to be able to choose the topics and activities that best suit your needs, your students' needs, and your curriculum. By focusing on seven "big ideas" in science, *STEPS to STEM* offers a broad, teacher-friendly curriculum resource. By implementing one or more sets of *STEPS*, along with an accompanying STEM Center, we hope that you were able to spark your students' imaginations and enthusiasm while nurturing their science and engineering practices (skills). It is quite obvious that not all students will go into STEM careers; however, *all* students should have the requisite skills to succeed in a highly technological world that demands the use of "process skills," regardless of their career choice. Facilitating and fostering the development of these skills was our ultimate driving goal and intention in creating *STEPS to STEM*.