LITTLE ENGINEERS CAN DO!

Yesterday, Today + Tomorrow
Teacher Guide

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THE NATIONAL WWII MUSEUM
NEW ORLEANS

ACKNOWLEDGMENTS

LITTLE ENGINEERS: Yesterday, Today + Tomorrow

Teacher Guide

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The Museum wishes to thank the Beoing for their generous support of Little Engineers.

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CAN DO!

INTRODUCTION

Children follow a US Soldier up a street in Italy, 1945. *(Image: The National WWII Museum, 2011.160.037.)*

A LETTER FROM THE PRESIDENT & CEO

STEPHEN J. WATSON

(Image: The National WWII Museum.)

Dear Educators,

People sometimes ask me why we have STEM (Science, Technology, Engineering, and Mathematics) programs at The National WWII Museum since we are a history museum. When this question comes up, I take them to the US Freedom Pavilion: The Boeing Center to see our B-17 Flying Fortress and six other meticulously restored warbirds soaring overhead. Or, to the Louisiana Memorial Pavilion to see our LCVP prominently featured along with an exhibit on businessman Andrew Jackson Higgins, whose unique boat designs were critical in shaping the Allied war strategy. Or, to our STEM Innovation Gallery in the Kushner Restoration Pavilion that showcases a few examples of the countless ways in which innovation and ingenuity solved significant problems in World War II.

The National WWII Museum tells the story of the American experience in *the war that changed the world* — why it was fought, how it was won, and what it means today — so that all generations will understand the price of freedom and be inspired by what they learn. Here at the Museum, we firmly believe that the story of World War II must include the story of STEM professionals and the innovations they made possible. To students, we say that during World War II, people solved really big problems — seemingly impossible challenges — to secure victory. To solve the problems of today and the future, young people can learn from the solutions and approaches of the STEM professionals of the WWII generation.

On our New Orleans campus, The National WWII Museum brings the story of wartime STEM innovations to students through our annual Robotics Challenge, summer camps, field trips, special events, and more. Across the country, we bring this story into classrooms through our Real World Science curriculum and teacher training program, which includes virtual and in-person workshops as well as a weeklong summer seminar at the Museum.

Little Engineers teaches science that elementary school students need to know by connecting it to stories from World War II. Within the units in this curriculum are topics in Physical Science, Life Science, and Earth Science woven together with literacy skills and lessons of how real-life scientists and engineers work.

Thank you to Boeing for their support of our Little Engineers curriculum and other teacher workshops.

Our hope is that Real World Science helps prepare students to solve big problems with STEM, just like ordinary and extraordinary people did during World War II.

Sincerely,

Stephen J. Watson
President & CEO, The National WWII Museum

INTRODUCTION AND HOW TO USE THIS BOOK

As teachers are already aware, the youngest students often make the most natural scientists. These students have boundless curiosity and innate skills of questioning and wondering. The best practices of science education take advantage of those attributes and provide opportunities for elementary school children to build concepts and practices that will make them the great scientists and engineers of the future.

This collection of essays, lesson plans, and activities is designed for these budding scientists and their teachers. In the collection, students will investigate the thickness of bubbles, will engineer an oven from a pizza box, and will discover the magic of germination. Every activity begins with a story from World War II—an era of uncertainty and danger, but also of great innovation and resilience. In those difficult times, people from every walk of life, many working within the fields of science, helped to win the war and secure the peace.

Each activity is aligned to the Next Generation Science Standards (NGSS). These standards have been adopted as written or have been adapted to the needs of individual states. These standards also have natural connections to the literacy and mathematics standards in the Common Core State Standards (CCSS). The relevant CCSS are highlighted in each activity. To use the activities, start with leading students through the stories from the WWII era. Depending upon your students' ages and reading abilities, you might read the selection to them, or you may have them read the selection within groups. The readings will provoke their natural curiosity and lead them into the investigations that follow.

The investigations all use simple and easy-to-find materials. The activities are easy to carry out while still challenging students to predict, observe, and then record and discuss their findings. There are investigations into all the areas of science that elementary students learn: **Physical Science, Life Science, and Earth Science.**

The Teacher Notes sections include discussions of the relevant standards, instructions for implementation, and resources for conducting and continuing the investigations.

A Dodge WC54 Ambulance located in The National WWII Museum's STEM Innovation Gallery.

We hope that you find these resources useful, and we ask that you pass them along to other educators as well.

If you have further questions relating to these materials, or if you would like to give us feedback about the lessons or participate in training or professional development, please contact us at **littleengineers@nationalww2museum.org**

LITTLE ENGINEERS

CAN DO!

LESSON PLANS, READINGS & ACTIVITIES

PHYSICAL SCIENCE

PHYSICAL SCIENCE

FREAKY FRICTION

GRADE LEVEL: 2 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Children learn science more effectively when they work like scientists to collaboratively explain what they experience. By connecting what they are doing today with the work of scientists and engineers in the past, they begin to understand the value of investigations and the power in the investigative process itself.

The following activity asks students to investigate properties of materials and friction. In most states, students in the second grade are expected to be able to explain phenomena regarding friction and the basic properties of materials. In order to prepare students, appropriate scaffolding experiences should be provided in kindergarten and first grade.

OBJECTIVE

Students will first listen to a story about tanks from World War II getting stuck in mud and will then investigate the properties of friction by packing rice and other materials around an object in a bottle. By modifying variables, discussing their observations, and coming to conclusions, they will learn about friction and how to work like a scientist.

STANDARDS

NGSS DCI PS1A
Structure of matter.

NGSS SEP
Planning and carrying out investigations.

NGSS CCC
Cause and Effect.

CCSS RI.2.8
Describe how reasons support specific points the author makes in a text.

CCSS W.2.7
Participate in shared research and writing projects.

CCSS MP.2
Reason abstractly and quantitatively.

PERFORMANCE EXPECTATIONS

NGSS 2-PS1-2
Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

HOW TO USE THIS RESOURCE

After reading the story about a real WWII situation with students and discussing it with them to ensure their understanding, lead them through the following investigation of friction.

Materials (per group or station)

- Plastic bottle (like a used sport drink bottle)
- Chopstick or long pencil
- Uncooked rice, sand, or dirt

Throughout the investigation, have students make predictions before making observations. Have students draw pictures of what they are doing and observing. Have students discuss their ideas and explanations. Record student observations in a place where the whole class can see and discuss them.

Instructions

1. Fill your plastic bottle with uncooked rice, sand, or dirt.

2. Insert a pencil or chopstick into the mouth of the bottle so that it enters the material you filled your bottle with. Lift up on the pencil or chopstick. Observe how the pencil or chopstick just slides out with no resistance.

3. Now tap the bottle against a table or desk so that the material inside settles and becomes more tightly packed.

4. Insert the pencil or chopstick into the bottle of material again, pushing it as far down as you can. Now pull up on it. The material should be so tightly packed against the pencil or chopstick that the friction will prevent it from coming out of the bottle and allow you to lift the bottle using just the pencil or chopstick.

5. Further investigation: Would this work with other substances? What kinds? What about sand? Would it work with tools other than a pencil or chopstick?

To discuss with students

WHAT IS FRICTION?

Friction is a force that exists between two objects rubbing together. Friction slows the movement of each object as they slide against each other. Many times, such as in flight, people try to design things that reduce friction. However, sometimes we want to increase friction and get it to work for us. Without friction, we wouldn't be able to walk or drive in a controlled or safe way. The friction between your shoes and the ground allows you to stay upright. Without that friction, walking, or even standing, would become very difficult. That's why walking on ice is very difficult—there is very little friction.

In the Freaky Friction activity, the pencil or chopstick is able to lift the bottle full of material because of friction. Because the material is tightly packed in the bottle when the pencil or chopstick is inserted, the friction of the grains of material push against the pencil or chopstick and prevent it from sliding out. However, when the material is loose in the bottle, the force of the friction is less than the weight of the material; thus, the pencil or chopstick slides out. Particles of different sizes and shapes will pack differently and create varying amounts of friction.

FURTHER READING

+ *Sheep In a Jeep*, by Nancy E. Shaw

A rhyming picture book in which talking pigs and sheep investigate forces such as friction while trying to travel together in an old Jeep.

READING
FREAKY FRICTION

Have you ever been in a car that got stuck in the mud or that was slipping on the road because of snow or ice? Situations like this happen due to a lack of friction. Friction is the force between two objects rubbing together. How could you make or design a vehicle that would travel better on wet and sticky roads or across slippery surfaces?

In World War II, soldiers often had to travel over bad roads or sometimes even off-road. Some soldiers traveled in vehicles called tanks. Tanks are made to be strong for protection, but they have another special feature too. Instead of wheels like a car, they use tracks like a bulldozer. The tracks provide more area for the tank to push against the ground and spread its weight across more of the ground so that it avoids getting stuck.

The tracks on a tank help it move over beaches and muddy ground. Many times, soldiers in World War II had to land on jungle islands with wet sandy beaches. The tank tracks pushed against the beach sand better than wheels. As a result, though the tanks went slower than they would if they had wheels, their tracks helped the tanks get across the beach sand where a car or truck with wheels would get stuck. The tracks also helped when the soldiers had to move through the jungles. In the jungles, there were no roads, and the ground was covered with plants and sticky mud. Normal tires would get stuck in holes or between logs and sink into deep mud. The tracks helped the tanks roll right over the holes and logs, and they didn't sink into the mud as much.

At other times, soldiers in World War II had to go over mountains. Sometimes in the mountains, ice and snow would cover all the roads. The tank tracks kept the tanks from sliding down the icy roads and crashing. If the ice was very hard and snow was very deep, there would be no way a vehicle with wheels could get through. Using their tracks, the tanks could roll over ice and get through deep snow.

Soldiers pushing Jeep stuck in mud, Italy, November 1943.
(Image: The National WWII Museum, 2002.337.244.)

NAME: **DATE:**

During World War II, soldiers were able to use friction to help them move over slippery and muddy roads and surfaces. Let's investigate how!

Your teacher will give you directions and supplies for your investigation. You will be given material, like sand, dirt, or rice. When these small objects are pushed together, something interesting happens.

2 1/2 ton Army truck stuck in the mud in Italy, November 1943.
(Image: The National WWII Museum, 2002.337.269.)

Sherman tanks on the sandy beach of Kwajalein island, February 1944.
(Image: The National WWII Museum, 2002.075.022.)

Follow the instructions. Be careful with the materials.

Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening, and try to explain it out loud or written down.

PHYSICAL SCIENCE

SECRET SOUNDS

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

This activity allows students to investigate how sounds and vibrations are related. Students learn about waves as mechanical phenomena throughout elementary school, and they connect patterns of motion to waves. Students can start this development as early as kindergarten and further develop the ideas through the first and second grades.

OBJECTIVE

Students will learn about noisemaking 'crickets' that some soldiers carried to communicate during World War II. Using this as a launch point, they will investigate how sound moves through materials. Thus, they will learn about waves, about conducting their own investigations, and about collaborating to come to a consensus explanation.

STANDARDS

NGSS DCI PS4
Wave Properties.

NGSS SEP
Constructing explanations (for science) and designing solutions (for engineering).

NGSS CCC
Cause and Effect.

CCSS SL.1.1
Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

CCSS W.1.7
Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

CCSS MP.5
Use appropriate tools strategically.

PERFORMANCE EXPECTATIONS

NGSS 1-PS4-1.
Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

HOW TO USE THIS RESOURCE

Read the story about a real WWII situation with students and discuss it with them to ensure their understanding, and then lead them through an investigation about sound waves.

Materials (per group or station)

- String, cut to a length of 3 feet
- Large metal utensils (the utensils that carry sound waves must be ONLY metal, for example no plastic or wooden handles.) You can use utensils of other materials for comparison.

Have students make predictions before making observations. Have students draw pictures of what they are doing and observing. Have students discuss their ideas and explanations. Record their observations and conclusions for all the class to see and discuss.

Instructions

1. Cut a piece of string about 3 feet in length.

2. Create a loop in the middle of the string and tighten the loop around one end of a metal spoon or spatula.

3. Wrap both ends of the string around each of your index fingers and hold the string so that the utensil is swinging freely in the air.

4. Swing the utensil so that it knocks against the edge of a desk or table. Ask "What do you hear?"

5. Next, lift the ends of the string to your ears as though you're going to plug your ears. You don't need to shove the string inside your ears, just hold them against your ears.

6. Now, lean forward and swing the utensil against the desk or table again. What did you hear this time? You should have heard something more like a church bell or a gong vibrating through the string by your ear.

For extra experimentation, you could also try this investigation with wood or plastic utensils to see if the same thing happens or if students hear something different.

To discuss with students

HOW DO SOUNDS TRAVEL?

What materials carried the sound well? What materials didn't? Sound travels in waves as the particles in air or water or metal vibrate. Things made of wood or rubber or other soft substances tend to absorb the vibrations and not pass them along. Stiff materials like metal pass the vibrations along well.

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *What Makes Different Sounds? I Wonder Why,* by Lawrence Lowery

You can get a replica cricket from the National WWII Museum store here: store.nationalww2museum.org/replica-wwii-clicker-d-day-cricket/

READING
SECRET SOUNDS

In the middle of the night, 13,000 young men were on board hundreds of planes over France, a country in Europe. It was June 6, 1944, and these men, who were part of the huge effort to free France from enemy Nazi forces, were about to jump out of the planes using parachutes to land on the ground in the dark.

After they landed, the men had to find each other. Because it was in the middle of the night, the men had all landed in different places in the fields and forests of France, and it was hard to meet up. They couldn't use flashlights or call out to each other because enemy soldiers might hear them. Radios back then were big and heavy and not everyone had one. So how could the men find each other safely and quietly?

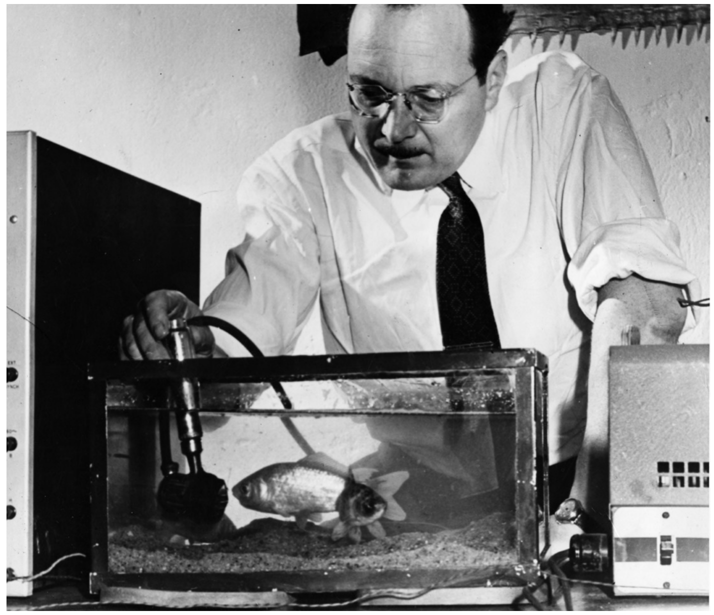
Some of the men who jumped from the planes were supplied with a small piece of metal called a cricket. When the men pressed down on the cricket, it made a clicking sound. Just as real crickets can use sound to find each other in the dark of night, the soldiers used their crickets and followed the sounds of each other's clicks to signal and to find each other in the darkness.

Parachuting soldiers drop from the air into Holland, September 1944.
(Image: The National WWII Museum, 2004.311.089.)

NAME: **DATE:**

We just learned about how soldiers during World War II used secret sounds to find each other in enemy territory by using a metal tool called a "cricket." So why does a piece of metal rubbing on another piece of metal make a sound? What carried that sound across the fields and forests in France? How can the type of material used affect the sound and how far it will carry? Let's investigate to find out.

A military band entertains fellow troops on an Air Base in Texas, 1944. *(Image: The National WWII Museum, 2009.353.003.)*



A scientist demonstrates apparatus to record the underwater sounds of fish, New York, NY, June 1945. *(Image: The National WWII Museum, 2012.019.607.)*

Your teacher will give you information about how sound is made, and how sound travels. You will investigate these ideas using different materials and methods of making and receiving sound waves.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

PHYSICAL SCIENCE

SOLAR OVENS

GRADE LEVEL: K | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Students in the earliest grades develop understanding about the concept of energy. A great introductory example is heat energy, or warmth. It is natural for students to connect heat energy to the sun. In this activity, students connect sunlight to electromagnetic energy and build a device to store and use solar energy.

OBJECTIVE

In this activity students will learn about waves that travel in a different way—light waves and other electromagnetic waves. They will read about the invention of RADAR that uses waves kind of like radios. Observations during the development of RADAR led to the invention of the microwave oven. Using a different form of waves to heat food, the students will build a solar oven. This exercise, an engineering design project, will show students how engineers work to improve things by tinkering and modifying their designs.

STANDARDS

NGSS DCI PS3.D
Energy in chemical processes and everyday life.

NGSS SEP
Analyzing and interpreting data.

NGSS CCC
Cause and effect.

CCSS K.MD.A.2
Directly comparing two objects with a measurable attribute in common to see which object has “more of”/”less of” the attribute, and then describing the difference.

CCSS W.K.7
Participating in shared research and writing projects.

PERFORMANCE EXPECTATIONS

NGSS K-PS3-1
Making observations to determine the effect of sunlight on Earth’s surface.

HOW TO USE THIS RESOURCE

Read the story about a real WWII situation with students and discuss it with them to ensure their understanding, and then lead them through an investigation about electromagnetic waves.

Materials (per group or station)

- Pizza box (clean unused)
- Pencils
- Ruler
- Utility knife (for adult to use
- Scissors
- Aluminum foil
- Glue
- Plastic wrap
- Tape
- A sheet of black paper
- Wooden dowels
- S'mores supplies (graham crackers, chocolate, marshmallows) or some

Instructions

1. On the top of the pizza box lid, draw a square that is about one inch inward from each edge. You could modify these instructions and use shoeboxes or other boxes as well.

2. Cut along each side of the square you just drew except for the side that runs along the hinge of the box. Cut all the way through the cardboard on those three sides of the square. Then fold the flap back slightly along the attached side.

3. Line the inside of the cardboard flap with aluminum foil. Fold the edges of the foil over the flap to help hold the foil in place and glue the foil onto the flap. Keep the foil as smooth as possible. Ask the students, What do you think is the purpose of this foil?

4. Cover the opening made by the flap (in the lid) with a layer of plastic wrap. Using shipping tape or black electrical tape, attach the plastic wrap to the edges of the opening. Make sure there are no holes in the plastic wrap and that all of its edges are completely attached to the lid. Ask the students, Why do you think it's important to make sure the plastic wrap completely seals the opening of the lid?

5. Line the inside of the box with aluminum foil also so that when the box is shut the entire interior is coated with foil. It is easiest to do this by covering the bottom of the box with foil and then covering the inside part of the lid (going around the plastic-covered opening) with foil as well. Secure the foil in place with glue. Ask the students, Why do you think we coated the inside of the box with foil like this?

6. Glue or tape a sheet of black paper to the bottom of the box, centering it there. This will act as your solar oven's heat sink. Ask the students, How do you think something like this pizza box could help heat or cook your food?

7. Lastly, use a wooden skewer or pencil (and some tape) to hold the lid of the solar oven upright, at about a 90-degree angle from the rest of the box.

8. If you want to use the solar oven to heat or cook something, a S'more is the easiest and fastest item to use. To make a S'more, break a graham cracker in half and place a marshmallow and small piece of chocolate between the cracker halves. The chocolate will melt long before the marshmallow so it may be best to save the chocolate until after the marshmallow has melted.

9. Place the prepared S'more or item you wish to warm or try to cook on a small square of aluminum foil that is slightly larger than the S'more—this will serve as its tray—and place it in your solar oven on top of the black sheet of paper.

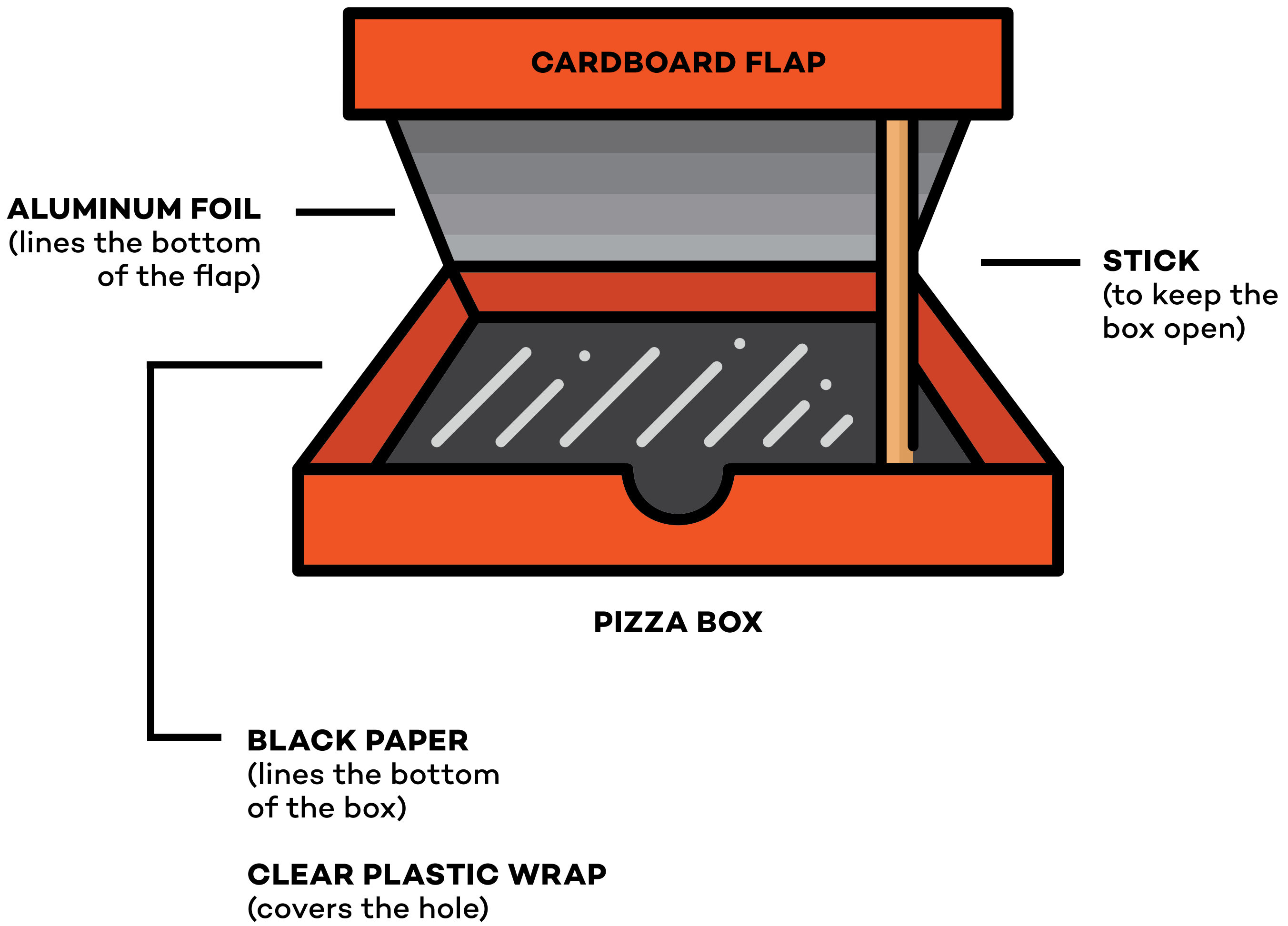
10. Place the solar oven outside where it will get full, direct sunlight for at least 30 minutes, and keep it turned so that the flap faces the sun. How long it needs will depend a lot on the outside temperature and how sunny it is. You could put them outside in the morning and then come back later in the day. When the marshmallow is soft, your S'more should be ready to eat and enjoy! Ask the students, How long does it take to cook the S'more in your solar oven?

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *Let's Ride a Wave!: Diving into the Science of Light and Sound Waves with Physics*, by Chriss Ferrie

SOLAR OVEN

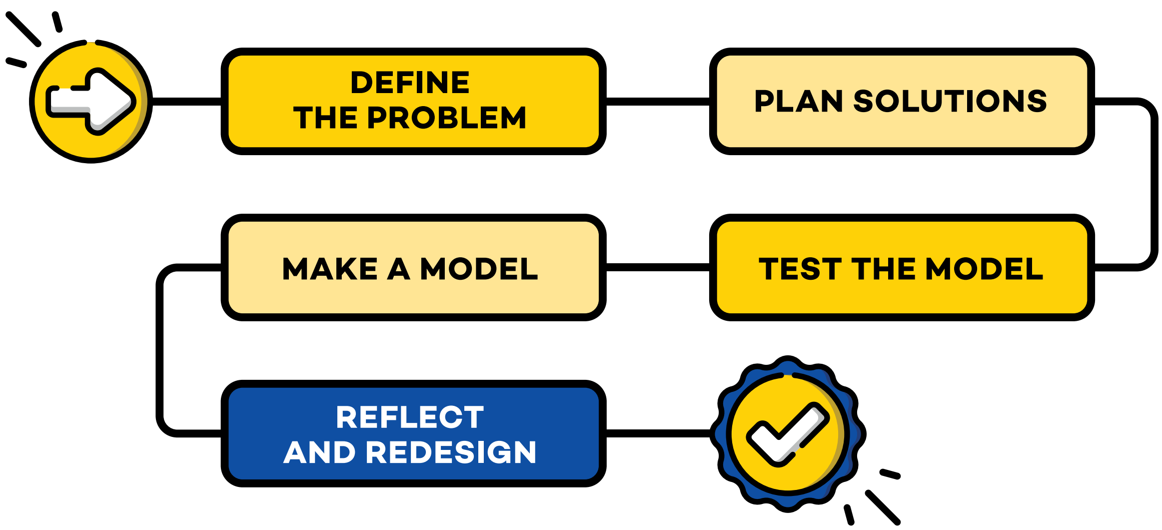

CARDBOARD FLAP
ALUMINUM FOIL
(lines the bottom
of the flap)
STICK
(to keep the
box open)
PIZZA BOX
BLACK PAPER
(lines the bottom
of the box)
CLEAR PLASTIC WRAP
(covers the hole)

To discuss with students

HOW DO ENGINEERS IMPROVE THEIR SOLUTIONS?

Engineers are always trying to improve their solutions to problems. They make something, test it, change it, and then they test it again. There are many variables that you can try to tweak to improve your oven design. What would make your oven heat food faster? What if we change the angle of the reflecting top? What if we insulate it with other material? What if we change its shape or size?

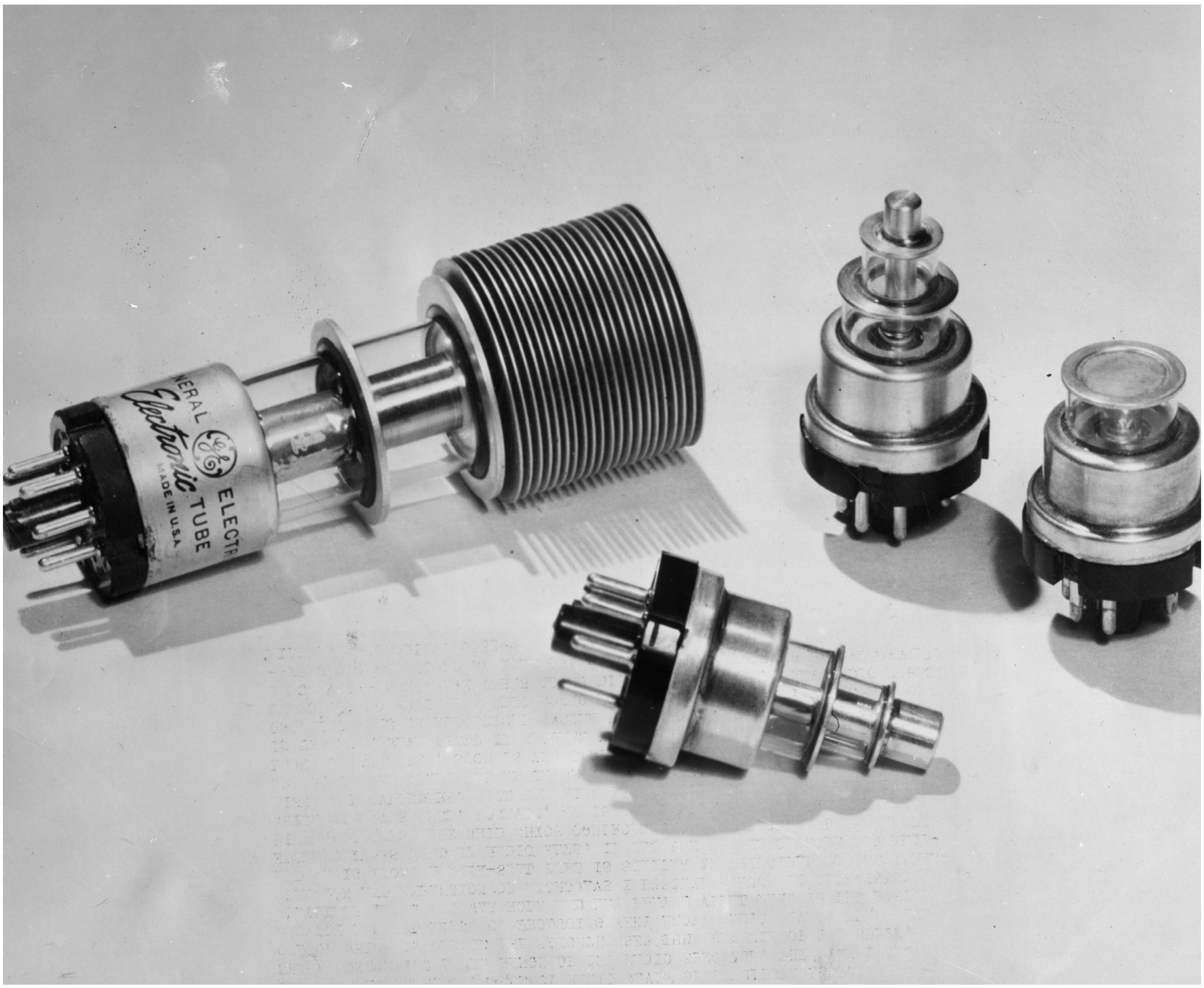
ENGINEERING DESIGN PROCESS



READING
SOLAR OVENS

During World War II, the first microwave was invented, but it was not made to cook food. At that time, scientists were working on an invention that would give off electromagnetic waves, like the sun and stars. The purpose of this invention was to figure out how to find objects, like ships or planes, that were far away or were moving in the dark of the night. While one of the scientists was working on the invention, he had a bar of peanut butter in his pocket. Because chocolate was rationed during World War II, getting chocolate bars was difficult to do. He noticed that the peanut butter bar started to melt when he was working on the invention. He realized that this invention could be used to heat food. After World War II, the invention was sold as the first microwave ovens. Much bigger than microwaves today, the first microwaves sold in stores was over six feet tall!

There are lots of different kinds of electromagnetic waves, and microwaves are just one kind. All waves have one thing in common: they carry energy from one place to another.



Electrical tubes designed to generate microwaves, high energy electromagnetic waves. June 1945.
(Image: The National WWII Museum, 2012.019.602.)

NAME: **DATE:**

Light is the most common form of electromagnetic wave. We can see light everyday shining from the sun. What ways do we use light? Solar energy (light from the sun) is a renewable energy resource. Using solar energy helps us protect and save resources and prevent pollution. Saving energy was important during World War II. One of the ways kids helped out with the war effort was to take part in energy-saving activities. Let's investigate and see what we can do with solar energy.

During World War II, scientists were experimenting with microwaves to detect ships and planes in the dark. However, they found that their invention had a completely different use—to cook food. Your teacher will give you the tools you need to investigate the methods for collecting solar energy to cook or heat food.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

PHYSICAL SCIENCE

BUBBLE VIEWER

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Students investigate electromagnetic waves in the form of light throughout elementary school. One of the first things students should investigate is how light interacts with different materials. Is light absorbed, reflected or refracted? In this lesson, students will first examine light as it passes through bubbles, and then they will use the light's refraction in order to estimate the thickness of the bubbles.

OBJECTIVE

Students will read about the research conducted by a scientist during World War II and then will conduct an investigation similar to hers. Students will thus learn about electromagnetic waves (light, in this case) and how the waves interact with matter. At the same time, they will work through investigations and observations like scientists.

STANDARDS

NGSS DCI PS4B
Electromagnetic radiation.

NGSS SEP
Constructing explanations (for science) and designing solutions (for engineering).

NGSS CCC
Cause and effect.

CCSS MP.4
Modeling with mathematics.

PERFORMANCE EXPECTATIONS

NGSS 1-PS4-3
Planning and conducting an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.

HOW TO USE THIS RESOURCE

Read the story about a real World War II situation with students. After discussing the story with them to ensure their understanding, lead them through an investigation about electromagnetic waves and how light bends and refracts as it passes through substances.

Materials (per group or station)

- Flashlight
- Clear plastic lid, like from a Pringles or yogurt container
- Clear packing tape
- Cup
- Dish soap mixed with water in 1:1 ratio
- Straw

Instructions

1. Tape the clear plastic lid to the top of your flashlight. Make sure the rim of the lid is facing out.

2. In a cup, mix together dish soap and water. Use a ratio of 1:1.

3. Turn on the flashlight and dim the lights in the room. The bubble viewer works best in darkness.

4. Carefully pour a teaspoon or so of your dish soap/water mixture onto the plastic lid "platform."

5. Dip one end of your straw into the soap mixture and blow gently into the other end to blow a bubble on top of your flashlight. Carefully remove the straw so that the bubble remains intact on top of the lid. Ask the students, Can you determine how thick our bubble is based on the colors we see in it? Can you tell when it's about to pop?

To discuss with students

WHAT CAN WE PREDICT FROM BUBBLE COLORS?

Can you see the colors on the surface of the bubble? Do the colors change as the bubble gets bigger? Can you tell how thick our bubble is based on the colors we see in it? Can you tell when it's about to pop? Why do we see colors when the flashlight is white light?

ADDITIONAL RESOURCES

To accompany this lesson, try this book:

+ *Let's Ride a Wave!: Diving into the Science of Light and Sound Waves with Physics* by Chriss Ferrie

READING

BUBBLE VIEWER

Do you think you could measure the thickness of a bubble? Katharine Burr Blodgett, a scientist during World War II, figured out how to do it, and she didn't use a ruler.

Dr. Blodgett was working as a physicist for the General Electric company. Her job was to make the lenses on cameras clearer. She did this by coating the glass lenses so that they would be less reflective. Some of Dr. Blodgett's inventions were used in World War II for periscopes in order for submarines to be able to see underwater. Her inventions were also used in the lenses of cameras in airplanes.

While she was investigating the coatings on lenses, Dr. Blodgett noticed something interesting. When light passed through glass, some of the light bent or curved. When light bends, it splits into colors, much like a rainbow. The amount that light is bent determines the colors we see. Blodgett realized that because of this she could tell the thickness of the liquid coating on the glass to a millionth of an inch just by looking at the color. Not only was her invention simple and cheap, it was also very accurate.

The "invisible glass" she invented had very little reflection and is still used today on computer screens, car windshields, eyeglasses, and other things.

Air crewman, in leather flight suit and hat, carrying an airplane camera.
(Image: The National WWII Museum, 2009.278.510.)

NAME: **DATE:**

Dr. Katharine Blodgett's experiments with trying to create glass lenses that were clearer led her to a discovery on light refraction—the bending of light. She learned how to measure how much liquid was on glass by the colors created from light when it hit the glass surface. Do you think you can estimate how thick a liquid is by using colors that you see? Can you find out how thick a bubble is using the same method as Dr. Blodgett?

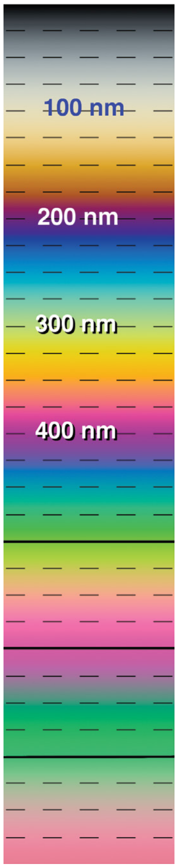
Your teacher will give you the materials you need to investigate the thickness of bubbles based on the color of light that passes through them.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

Use the line of numbered colors below as your bubble thickness color gauge. Matching the colors in your bubbles to the colors and numbers on this gauge will help you determine how thick your bubble is (and when it's about to pop). The colors of your bubbles may not totally match those on the color gauge because the exact color of your bubble will depend on the angle of the light, the type of soap you use, and other factors.

This gauge shown on the right uses nanometers as the unit of measure. A nanometer is 1 millionth of a millimeter. Think about the hair on your head. One hair is 75,000 nanometers thick. A human red blood cell is between 6,000 and 8,000 nanometers. Katharine Burr Blodgett's gauge wasn't good enough to measure objects that thin, but it was the best and least expensive method of the time. Before her discovery, people could only measure up to 1000th of an inch. Blodgett came up with a method that was a thousand times better and didn't require any fancy equipment. The color gauge goes from thin to thick and cycles through the rainbow spectrum. When the bubble gets dark around the edges, that means it's about to pop.

US airmen hold an aircraft camera used to take surveillance photos.
(Image: The National WWII Museum, 2009.278.329.)



LITTLE ENGINEERS

CAN DO!

LESSON PLANS, READINGS & ACTIVITIES

EARTH SCIENCE

EARTH SCIENCE

SUNDIALS

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

The motions and patterns of the sun and the moon in the sky and the changing of shadows through the day and across the seasons are some of the first things young student scientists notice. Throughout elementary school, students will use their science practices to investigate and make sense of these patterns.

OBJECTIVE

In this lesson, students will use simple tools to notice the patterns of shadows that indicate the motion of the sun and will evaluate the regularity of this pattern. The motion of the sun, the patterns between the length of shadows, and the angles between objects are phenomena students should understand. In this engineering design project, they will apply their knowledge.

STANDARDS

NGSS DCI ESS1 A&B
The universe and its stars; Earth and the solar system.

NGSS SEP
Analyzing and interpreting data

NGSS CCC
Patterns.

CCSS W.1.7
Participating in shared research and writing projects.

CCSS MP.4
Modeling with mathematics.

PERFORMANCE EXPECTATIONS

1-ESS1-1
Using observations of the sun, moon, and stars to describe patterns that can be predicted.

HOW TO USE THIS RESOURCE

After reading the story about a real World War II situation with students and discussing it with them to ensure their understanding, lead them through an investigation of the patterns of shadows made by the movement of the sun throughout the day.

Materials (to be done as a whole class)

- Meter stick or other straight measuring stick of about the same size
- Eight stones (to mark shadow points) with the numbers 1, 2, 3, 8, 9, 10, 11, and 12 written on them in paint, chalk or marker
- Data table to record results

Instructions

1. Find a consistently sunny spot in the school yard, and bury the end of the meter stick so that the stick points straight up. You might need a small spade or trowel to help dig a hole to keep the measuring stick in place.

2. Place a stone at the spot where you see the tip of the stick's shadow. Check the time and use that stone with the number that corresponds to the appropriate hour.

3. Come back throughout the day, and the next day if necessary, to place the appropriate stone for the other hours until you have all 12 hours accounted for. Be sure to carefully place each stone right at the tip of the stick's shadow.

4. Check the shadows over the next few days or weeks. Ask your students, Are the shadows of the stick in the same place every day? Do you think the shadows will be in the same place forever or will they change throughout the year?

Further Discovery

If you have time, you could keep checking the pattern of the shadows throughout the year. You could also make a more permanent sundial, or alternately you could make smaller, more portable sundials using paper plates and a pencil or similar stick in place of the measuring stick.

To discuss with students

HOW DID PEOPLE TELL TIME BEFORE THERE WERE CLOCKS?

Have you noticed how the sun moves through the sky during the day? Is it always in the same position in the sky? Is there a pattern to how it moves? Have you looked and the shadows of trees and buildings in the morning, at noon, and in the evening? Is there a pattern to how long they are?

ADDITIONAL RESOURCES

To accompany this lesson, try these books:

+ *The Magic School Bus Lost in the Solar System*, by Joanna Cole

+ *The Next Time You See a Sunset*, by Emily Morgan

READING
SUNDIALS

In December 1941, Ned Nye was on Wake Island, a small island in the middle of the Pacific Ocean. Although Ned was not in the military, he worked for the Navy at a base there. Beginning December 8, 1941, Japanese forces began bombing and trying to take over Wake Island. Ned Nye and the other civilians on the island were quickly asked to join the Navy. Ned fought with the others on the island against the Japanese. On December 23, 1941, even though Ned and his friends fought hard and bravely, the Japanese captured the island. Ned Nye and the other survivors were taken prisoner and sent away to camps in China. Ned spent the war in very bad conditions at a camp near Shanghai, China.

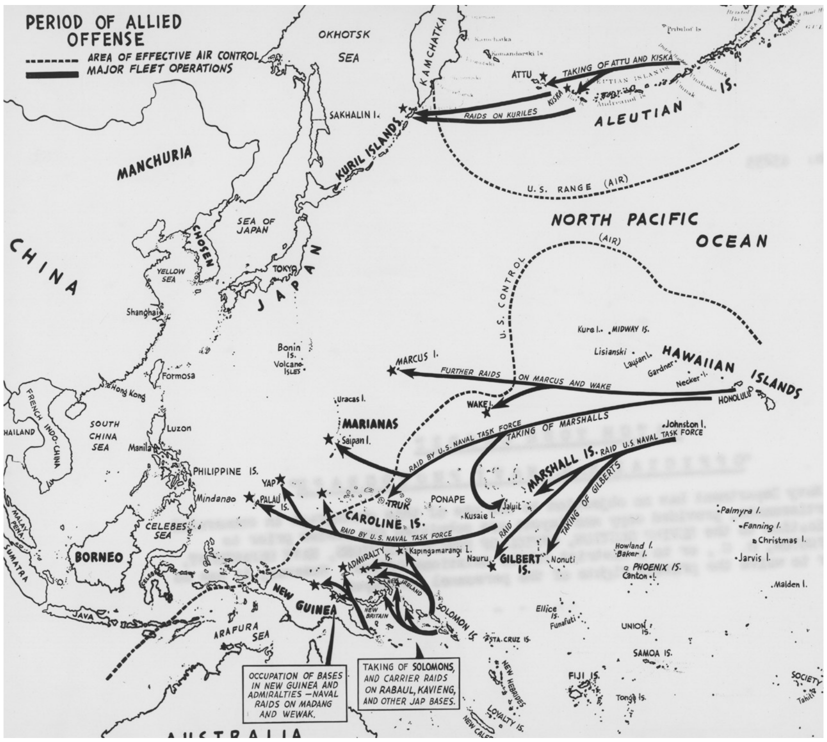
Ned Nye had a love for tinkering and for science. Using sticks and stones, Ned built sundials outside the building where he slept. With the sundials, he could tell the time of day and could figure out where he was in the world. Also, with the sundials, Ned could follow the seasons.

When World War II ended in August 1945, Ned Nye and the other prisoners were freed, and Ned was sent home to Baltimore, Maryland. In December 1945, he married Jacqueline Jenkins, whom he had known from before the war. Jacqueline had spent the war as a code breaker for the Navy. In 1955, the couple had a son, William Nye. William grew up influenced by his parents' love of math and science and became an engineer. William is better known today as "Bill Nye the Science Guy." Ned Nye died in 1997 and is buried in Arlington National Cemetery. His son William's interest in sundials continued through the years and even resulted in a sundial that was used on a mission to explore Mars.

A Coast Guardsman finding his ship's position with a sextant, which uses the position of the sun to navigate.
(Image: The National WWII Museum, 2015.063.091.)

NAME: **DATE:**

Ned Nye was able to use his knowledge of science in order to create a way to keep track of time while a prisoner during World War II. Using found objects in nature, Ned assembled a sundial to help him tell time and navigate the seasons. Try your hand at creating and using a sundial to see if you can track the time of the day and seasons like Ned Nye did!



Official U. S. Navy Map of Western Pacific, and troop travels.
(Image: The National WWII Museum, 2011.102.437.)

Your teacher will give you materials and directions. You will investigate the patterns of shadows the sun makes over a day.

Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down.

EARTH SCIENCE

CONSTELLATION LANTERN

GRADE LEVEL: 1 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Students are naturally curious about the stars and planets that can be seen in the night sky. These observations of night-time objects in the sky can help them understand the relative place of Earth in the solar system and the universe.

OBJECTIVE

In this activity, students will learn to identify constellations and make themselves a night light that imitates the night sky. Students will learn about how sextants were used for navigation during World War II and will then make models of constellations from the night sky. This activity will engage them in modeling and in noticing the patterns in nature.

STANDARDS

NGSS DCI ESS1 A&B
The universe and its stars; Earth and the solar system.

NGSS SEP
Constructing explanations (for science) and designing solutions (for engineering).

NGSS CCC
Patterns.

CCSS W.1.7
Participating in shared research and writing projects (for example, exploring a number of "how-to" books on a given topic and using them to write a sequence of instructions).

CCSS SL.1.1
Participating in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

PERFORMANCE EXPECTATIONS

1-ESS1-1
Using observations of the sun, moon, and stars to describe patterns that can be predicted.

HOW TO USE THIS RESOURCE

After reading the story about a real WWII situation with students and discussing it with them to ensure their understanding, lead them through observations of the patterns of the stars in the sky.

A trip to a planetarium would be a really cool experience to plan along with this lesson. There are also many computer simulations and apps that can show the night sky and the movement of constellations as well.

Materials (per group or station)

- Glass or plastic jar, labels removed
- Electric tea light or headlamp
- Cardboard
- Tin Foil
- Toothpick or sharp pencil
- Constellation Guide (see additional materials)

Instructions

1. Cut a piece of tin foil that can wrap around the inside of your glass jar. You want a piece that will cover the glass completely so that very little extra light comes through.

2. Lay the tin foil flat on the table on top of a piece of cardboard.

3. See your constellation guide and choose 3-5 constellations you would like to copy onto your tin foil. Lay your constellation guide on top of your tin foil.

4. Using your sharp pencil or toothpick, make the holes in your tinfoil following along with your constellation guide. Try to keep your constellations away from the top or bottom of the tin foil so that they'll be easier to see.

5. Once you've added the constellations to your tinfoil, carefully roll up your tin foil and slide it into the jar. Put your hand into the jar and gently press the tin foil against the glass so the tin foil is as smooth as it can be.

6. Turn on your light source and carefully place it on the bottom of the jar then seal the lid.

7. Turn off the lights and enjoy your constellation lantern! Ask your students, can you identify the constellations you chose?

ADDITIONAL RESOURCES

To accompany this lesson, try these books:

+ *A Child's Introduction to the Night Sky (Revised and Updated): The Story of the Stars, Planets, and Constellations—and How You Can Find Them in the Sky*, by Michael Driscoll

+ *Find the Constellations*, by H. A. Rey.

  This is a charming older book. Rey and his wife were refugees from Germany during World War II before making the Curious George books.

READING
CONSTELLATION LANTERN

People have been watching the stars in the night sky for as long as there have been humans on Earth. There are thousands of stories and myths about the stars, about their locations and about their movements. Long ago, people noticed that they could use the stars to navigate or to find out in which direction they were going. Using stars for navigation was still important even during World War II. From smaller boats to large aircraft carriers, tools called sextants were used to find ways across the open waters of the ocean. A sextant measures the angles to and between different stars to find out exactly where you are on Earth.

Centuries of work went into making sextants and into observing stars and their patterns in the sky. At Harvard University before World War II, a team of women made important observations and discoveries about the stars. The scientists that ran the observatory there trained a group of women to take pictures of the night sky and to take notes on every detail of what they saw in their pictures. These women weren't paid as well as the men who were doing the same job and also weren't given official positions at Harvard, but their bosses gave them credit for their hard work and discoveries.

One of the first women to do this work was named Williamina Fleming. Williamina worked as a maid to the director of the observatory. When her boss noticed how careful and smart Williamina was, he taught her to take photographs using powerful telescopes. Starting in 1879, she classified more than 10,000 stars and discovered ten new stars. She even discovered other objects in space, like the Horsehead Nebula. Williamina also identified 300 stars as "variable," which means the light that they produce changes over short periods of time.

Another woman working at the observatory was named Cecelia Payne. She was a student at Harvard and became the first person to graduate with a PhD in astronomy. Using the kinds of light that came from the sun and other stars, she discovered that stars were made of mostly two gases called hydrogen and helium. Cecelia also discovered how to find out the temperature of different stars. Her ideas were not popular at first because they were very different from older ideas. Later, astronomers found out that Cecelia had been right all along.

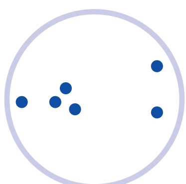
When you look up at the stars, think about all the information that light carries. The light that you see from stars has traveled many billions of miles to reach us. The light that you see in the sky today is actually the same light that the stars have been making for millions and millions of years.

NAME: **DATE:**

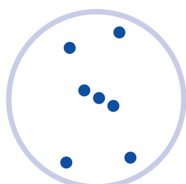
During World War II, navigators on aircraft and ships could use the constellations and their sextants so that they could stay on course and not get lost. Can you name and find some constellations in the sky? Let's try your hand as a navigator!

Your teacher will give you materials and directions. You will make a model of the night sky so that you can identify constellations and observe the patterns in the stars.

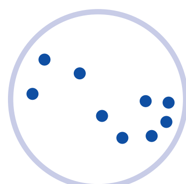
Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down. When you are done, you will be ready to watch the sky and make observations like Williamina and Cecelia.



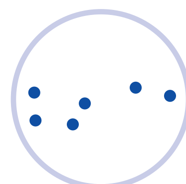
TAURUS
The Bull



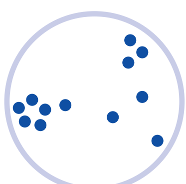
ORION
The Hunter



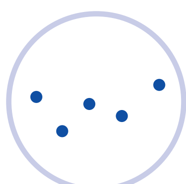
SCORPIUS
The Scorpion



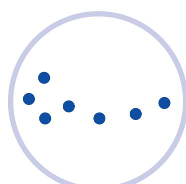
URSA MAJOR
The Great Bear



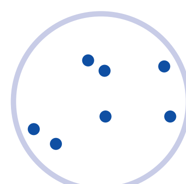
PISCES
The Fishes



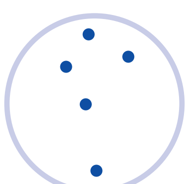
CASSIOPEIA
The Queen



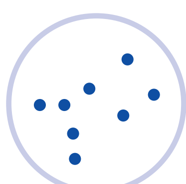
URSA MINOR
The Little Bear



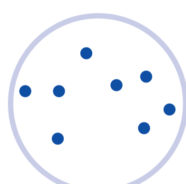
PEGASUS
The Flying Horse



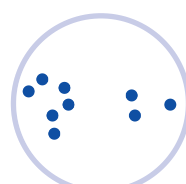
BOOTES
The Herdsman



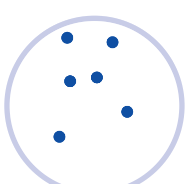
GEMINI
The Twins



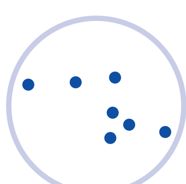
SAGITTARIUS
The Archer



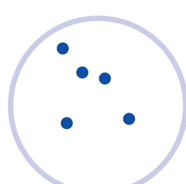
LEO
The Lion



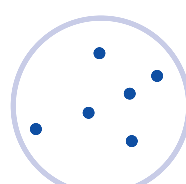
HERCULES



CANIS MAJOR
The Big Dog



PERSEUS



CYGNUS
The Swan

LITTLE ENGINEERS

CAN DO!

LESSON PLANS, READINGS & ACTIVITIES

LIFE SCIENCE

LIFE SCIENCE

SPROUTS

GRADE LEVEL: 3 | TIME REQUIREMENT: 1-2 HOURS

INTRODUCTION

Among the earliest things elementary science students learn is what is living and what is not. From there, students start to learn about life cycles and the reproduction of living things. Plant life cycles are more complex than those of many animals, and the concept of a seed being alive can be a challenging idea.

OBJECTIVE

In this activity, students will observe the germination of seeds. Using seeds of common foods, students will be presented with an intriguing case that connects the ideas of plant anatomy and structure to food and nutrition. By making their own observations and diagrams, students will be actively working like scientists as they learn the concepts.

STANDARDS

NGSS DCI LS1.B
Growth and development of organisms.

NGSS SEP
Developing and Using Models.

NGSS CCC
Patterns.

CCSS RI.3.7
Using information gained from illustrations.

PERFORMANCE EXPECTATIONS

3-LS1-1
Developing models to describe that organisms have unique and diverse life cycles but all also have in common birth, growth, reproduction, and death.

HOW TO USE THIS RESOURCE

After reading the story about a real WWII situation with students and discussing it with them to ensure their understanding, lead them through observations of seed germination.

Materials (per group or station)

- Glass canning jars or empty food jars (for example, pickles or pasta sauce, thoroughly rinsed)
- Cheesecloth, thin napkins, or paper towels
- Canning jar ring lids, or rubber bands
- Seeds (use dried beans, lentils, or seeds for gardening, or sprouting seeds)

Instructions

1. Place the seeds in the bottom of the glass jar. Use just enough seeds to cover the bottom of the jar.

2. Fill the jar with room temperature water and let sit overnight.

3. After the seeds have soaked overnight, cover the mouth of the jar with the cloth or paper, and then screw the ring lid onto the jar. You may also alternately use rubber bands to hold the cloth or paper onto the jar.

4. Open the jar and pour the water out, leaving the seeds inside.

5. Twice daily, morning and afternoon, fill the jar with water and swirl the seeds around before pouring the water out.

6. Observe the seeds daily to see what happens. Record the data in the table. Because not all types of seeds will sprout at the same rate, record the dates of any changes.

7. When the seeds begin to sprout, carefully take one or two of the sprouting seeds out. Have students draw a picture of the sprouts and label what they see.

If edible seeds begin to sprout, the students can taste them. You could bring sprouts or microgreens from the grocery store to show and compare with the sprouts that the students are growing.

ADDITIONAL RESOURCES

To accompany this lesson, try these books:

+ *From Fruit to Flower*, by Richard Konicek-Moran and Kathleen Konicek-Moran

+ *Notable Notebooks*, by Jessica Fries-Gaither

READING
SPROUTS

In many places during World War II, there was a shortage of many kinds of foods. Because the United States had to ship food to millions of its men and women in the military overseas, there was not always enough food for Americans who stayed at home. During the war, there were even limits on how much butter, meat, sugar, and even chocolate that families could buy.

The United States also had shortages of fuel and gas. Because some foods like vegetables had to be shipped from farms where they were grown to cities and grocery stores, there were sometimes shortages of vegetables too. Families were encouraged to grow Victory Gardens. These were gardens grown in extra space in yards or neighborhoods where people could grow their own food to eat. These activities were not something new to many Americans because they'd had to do something similar in the years leading up to World War II, years known as the Great Depression. The Great Depression was a time when many people were out of work, and food prices were high as a result of years of bad weather patterns. During this time, people often grew their own food gardens, so it made sense to ask families to plant Victory Gardens during World War II.

Would you and your family be able to grow some or all of your own food? Would you know how to grow your own food? There is a special kind of magic in eating something that you grew yourself. Though it may seem like magic, it's actually science!

NAME: **DATE:**

Victory Gardens were part of everyday life for Americans on the Home Front during World War II. Families in both rural areas and in cities used the extra spaces that they had available to create their own gardens to grow their own food. Knowing how and when to plant your seeds so that you could nurture sprouts into an adult plant was important. Have you ever sprouted seeds or grown anything before? Let's investigate the first steps in growing vegetables.

Your teacher will give you materials and directions. Follow the instructions. Be careful with the materials. Before you make observations, say or write down what you think will happen. Draw pictures of what you see. After the activity, decide if your predictions were correct or incorrect. Discuss with your classmates what is happening and try to explain it out loud or written down. Record your data neatly so that you can learn from your experience.

TYPE OF SEED	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5

LIFE SCIENCE

LOYAL FORCES

GRADE LEVEL: 1 | TIME REQUIREMENT: 2-3 HOURS

INTRODUCTION

This activity allows students to investigate how sounds In elementary school, students learn about the characteristics of different animals and how the special features of certain animals help them survive in their specific environments. Domesticated animals in the form of family pets are a specific example we can use to guide student learning about this idea. Humans have intentionally bred certain features into domesticated animals. Also, humans have taken wild animals and have selected the features that would help these animals in their roles working alongside people.

OBJECTIVE

In this activity, students will look at cases of animals that were used for different tasks during World War II. Noticing how the features of animals are useful for their survival and how these features might be useful to humans, students will apply what they know just as scientists and engineers do.

STANDARDS

NGSS DCI LS1A
Structure and function.

NGSS SEP
Engaging in argument from evidence.

NGSS CCC
Structure and function.

NCSS RI.1.10
With prompting and support, reading informational texts appropriately complex for their grade level.

NCSS W.1.7
Participating in shared research and writing projects.

PERFORMANCE EXPECTATIONS

1-LS1-1
Using materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

HOW TO USE THIS RESOURCE

Read the stories about a real WWII situation with students and discuss it with them to ensure their understanding. After students read the stories and look at the pictures, lead them to answer the questions in the data table. Students need to identify the relevant characteristics of the animals in the stories (for example: 1. pigeons can fly, 2. pigeons can find their way back to their home roost or nest, etc.) and need to be able to describe how these characteristics made the animals useful in the situation described.

Finally, have students think of other animals they know. What features do those animals possess that could make them useful? What jobs do people still use animals to help with today?

Materials (per group or station)

No materials other than the handouts below are needed, but photos of animals in service might help.

Instructions

1. Students will read the WWII story and will then fill out the table using information they know or look up.

ADDITIONAL RESOURCES

To accompany this lesson, try these books:

+ Loyal Forces, by Toni Kiser and Lindsey Barnes
+ *What would you do with a tail like this?* by Steve Jenkins and Robin Page

READING
LOYAL FORCES

On June 6, 1944, during World War WII, there was a large invasion from England to Normandy, France. June 6 was code-named D-Day. The very first news from the D-Day invasion of Normandy was carried back to England by Gustav. Gustav was a messenger pigeon brought to the battlefields in France by a news reporter. On the morning of June 6, 1944, Gustav flew 150 miles north from Normandy, then all the way across the English Channel to Portsmouth, England. It took Gustav five hours to fly back to England.

Man's best friend was also put to service during World War II. Rip was a stray dog that rescuers in England used to save people who where trapped under rubble when bombs destroyed buildings in London. Rip found trapped survivors and helped get them to safety. Jet was another rescue dog. She was so good at rescuing trapped people in London that soldiers took her to Germany to help to free trapped people there too after bombs were dropped.

Another four-legged service member was Bryn Awryn, a chestnut horse with a white patch on his nose. He carried soldiers into battle in the Philippines, and this was one of the last times the United States used horses in battle. The horses were good at traveling quickly in areas where jeeps and trucks couldn't go.

Animals have been helping humans with jobs, in peacetime and wartime, for thousands of years. Think about an animal you know. Now think of a job or task. What can these animals do that might make them useful for this task? Is there an animal that might be more useful or better at this job? Which animal would you pick to help you with each job?

This is Chick, a mule in service in the Army, working in China. 1945.
(Image: The National WWII Museum, 2002.210.022.)

NAME: **DATE:**

During World War II, soldiers and civilians used animals to help them with a wide range of jobs. Each animal had characteristics or skills that made certain jobs a natural fit for them when it came to assisting humans. Look at the animals listed below. Write down what abilities, skills or features the animal has and what makes those skills or features useful.

US soldier holds a carrier pigeon. It has a tube on its leg to carry tiny coded messages. Italy December 1943.
(Image: The National WWII Museum, 2021.337.283.)

US Soldier reads a message brought to him by Rex. Italy, November 1944.
(Image: The National WWII Museum, 2007.048.470.)

ANIMAL	WHAT THE ANIMAL HAS	HOW IT'S USEFUL
Horse/Mule		
Dog		
Pigeon		

1. How do these animals help people today? Do we still use them for the same kinds of jobs?

2. What are some other animals you know about? Pick an animal that you know about and explain how the animal helps people do or make something. What does the animal have that makes it good for that job?

Children pose in front of their community garden in what was then Palestine, and is now Israel. Taken in 1943 or 1944.
(Image: The National WWII Museum, 2013.608.013.)

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