Physical Science:
Properties of Matter,
Heating and Cooling Substances

Washington University in St. Louis
Institute for School Partnership

Unit 11: Teacher Guide

A Home for a Penguin

mySci
inspiring the next generation of scientists

Bayer Fund

Teacher Background Information

In this unit, students will explore the scientific method and the engineering design cycle to create a prototype zoo habitat for penguins. In order to design a habitat that meets the needs of both penguins and humans, students will learn about the states of matter, changes of matter, heat transfer, and insulation.

SCIENCE AND ENGINEERING

SCIENCE

Science is the study of the natural and physical world through observation and experimentation. Scientists make observations and follow the scientific method to figure out how things work and why they work the way they do. Scientists conduct the same experiment many times until they have gotten the same results and they can be confident they have gotten the true explanation. There are many different branches of science. Chemistry is the study of matter and energy and how they interact. Biology is the study of living things. Physics is the study of matter and motion. These are only a few of the types of scientists who work to explain the laws of nature.

ENGINEERING

Engineering is the application of scientific and mathematical principles to solve real-world problems. There are engineers working in nearly every profession and career field to develop new technology. Technology is the development and application of tools and techniques to solve problems and complete tasks. Computer engineers develop new computer systems, hardware, software, programs and applications, Civil engineers plan and build roads, bridges and highways. Mechanical engineers develop machinery, automobiles, and industrial equipment. Biomedical engineers design and create medical devices and equipment to be used in hospitals, doctor's offices and people's homes. These are only a few of the types of engineers who work to create a better society and make people's lives easier.

STATE OF MATTER

All matter is made up of microscopic particles called atoms. The arrangement of the atoms and the amount of energy the atoms have determines how the matter appears physically. There are three primary states of matter - solid, liquid and gas. Matter can change from one state of matter to another by adding or taking away energy.

SOLID

In a solid, the atoms are very tightly arranged. Because they don't have much energy, the atoms aren't able to break out of this tight arrangement or slide past each other. Solids have a rigid shape without being held together by a container. There are many examples of solids including plastic, metal, wood and brick.

LIQUID

The atoms in a liquid have more energy than those in a solid so their arrangement is not as rigid. Liquids are able to flow because the atoms are able to slide past each other. This tendency to flow and move means that liquids don't have a fixed shape and instead take the shape of their container. The most common example of a liquid is water. Other liquids include gasoline, cooking oils, juice and honey.

GAS

The atoms in a gas have more energy than either solids or liquids. Gases have so much energy that the atoms are very far apart and easily move past each other. Like liquids, gases take the shape of their container, but all of the space between atoms allows gases to be compressed under pressure. The ability to be compressed means that it is possible to change the volume of a gas by either reducing or increasing the pressure of the container. Gases will spread out indefinitely if they are not held inside a container. Although they can be hard to see, gases are very plentiful on Earth. Common gases include oxygen, helium, nitrogen and hydrogen.

CHANGES OF MATTER

For many substances, it is possible to change between the states of matter by either adding or taking away heat. The best example of this phenomenon is water. In its most common form, water is a liquid. However, if heat is added to water, the atoms speed up and move farther and farther apart. If enough heat is added, the liquid water will turn into a gas (water vapor). The temperature at which a liquid becomes a gas is called the boiling point. The boiling point of water is 212°F (100°C). It is possible to reverse this change by lowering the temperature. As the temperature drops below the boiling point, the atoms in the water vapor will slow down and turn back into a liquid.

It is also possible to turn liquid water into a solid (ice). If heat is taken away from the liquid water, the atoms will have less energy and they will slow down and begin taking on a more organized arrangement. This arrangement of atoms gives the water a rigid structure and it becomes ice. The temperature at which a liquid becomes a solid is called the freezing point. The freezing point of water is 32°F (0°C). It is possible to reverse this change by increasing the temperature. As the temperature increases above the freezing point, the atoms in the water will speed up and move past each other and the ice will turn back into water.

Not all substances are able to undergo reversible changes. A change that cannot be undone is called an irreversible change. Cooking is a perfect example of an irreversible change. If heat is added to a raw steak, the steak becomes cooked. Once the steak is cooked it cannot be changed back to raw. Irreversible changes create new substances while reversible changes only change the appearance of a substance. Burning is another example of an irreversible change. For example, if wood is burned in a fireplace many new substances, including ash and smoke, are produced.

HEAT TRANSFER

Heat transfer occurs when two objects or substances are at different temperatures. Heat always flows from warmer objects to cooler objects until both objects are at the same temperature. Heat transfer occurs in one of three ways - conduction, convection and radiation. Conduction occurs when heat is transferred from one atom to another as they bump into each other as they vibrate in place. The heat energy possessed by the warmer object causes the atoms to vibrate slightly faster. These vibrations cause atoms to bump into each other and slowly transfer the heat from one atom to the next until both objects are at the same temperature. A hot plate transfers heat through conduction. Convection uses a flowing substance (usually water or air) to transfer heat from an area with high temperature to an area with low temperature. A convection oven helps warm or bake food because a fan circulates the warm air in the oven. Radiation transfers heat over a distance through electromagnetic waves. The sun warms the Earth through radiation.

INSULATION

Insulation helps keep substances and objects at a desired temperature by preventing heat transfer. Some insulation is designed to keep cold objects cold while other insulation is designed to keep hot objects hot. Insulation works best when the atoms in the insulating material are far apart because the extra space between atoms inhibits heat transfer. For this reason, gases generally make the best insulators while solids make the worst insulators.

Insulation is also designed to inhibit a particular type of heat transfer. Insulation to protect against convection physically separates the two substances with a barrier layer made of a poor conductor. Can koozies are a form of conduction insulation because they physically inhibit the flow of warm body heat into a cold drink. Insulation to protect against convection is designed to inhibit the fluid (either water or air) from flowing, thereby preventing heat transfer. Many common types of household insulation, including weatherstripping and caulking, protect against convection heat transfer because they decrease airflow through the house. Insulation against radiation is typically a shiny material that reflects electromagnetic waves away from the substance being protected. Many types of aircraft and spacecraft are covered with a layer of radiant insulation to reflect heat and light away from their interior.

FURTHER READINGS AND RESOURCES

What is Engineering?
http://www.livescience.com/47499-what-is-engineering.html

Science vs. Engineering:
http://www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method.shtml

States of Matter:
https://www.chem.purdue.edu/gchelp/atoms/states.html
http://www.livescience.com/46506-states-of-matter.html

Reversible Changes:
http://k8schoollessons.com/reversible-changes/

Heat Transfer:
http://www.physicsclassroom.com/class/thermalP/Lesson-1/Methods-of-Heat-Transfer

Insulation:
https://www.energy.gov/energysaver/insulation#:~:text=Most%20common%20insulation%20materials%20work,by%20reducing%20radiant%20heat%20gain.
http://www.school-for-champions.com/science/thermal_insulation.htm#.V6ar1bgrLIU

Additional Teacher Resources

Books

Tacky the Penguin

Bread, Bread, Bread, by Ann Morris

Sun Bread, by Elisa Kleven

Loaves of Fun, by Elizabeth Harbison

Bread Comes to Life, by George Levenson

Penguins; Birds that Swim, by Benjamin Pernick

Whose Feet Are These? by Wayne Lynch

Pierre the Penguin; A True Story, by (NSTA) Jean Marzollo

*Count the Animals**, by Terry O' Brady

*The Penguin Chick**, by Marilyn Woolley

Online Sources

"Who Invented Earmuffs?"
http://www.readworks.org/passages/who-invented-earmuffs

"The Silk Mystery"
http://www.readworks.org/passages/silk-mystery

"Steps To Inventing"
http://www.readworks.org/passages/steps-inventing

Discovery ED (Subscription Required)

Polar Ice:
http://bit.ly/1GwR4tS (9:07)
Tips: Penguin Habitat

Chilling With the Penguins:
http://bit.ly/1B3xAL7
Tips: Penguin's Exhibit to duplicate natural environment.

Emperor Penguins Raising Young:
http://bit.ly/1JGPwg6
Tips: Raising Young Penguins in cold Habitat

Career Connection

A designer and artist makes a snake habitat:
https://www.youtube.com/watch?v=HGm5bIr5u58

Design portfolio of a zoo architecture firm:
http://www.clrdesign.com/our-work

Five Materials Engineers tell their stories:
https://www.careergirls.org/careers/materials-engineer/

Zookeeper:
https://www.cnbc.com/2015/05/21/i-get-paid-to-be-a-zookeeper.html

Field Trip Connections

Bricks4Kidz:
http://www.bricks4kidz.com/missouri-ballwin-chesterfield/

Magic House:
http://www.magichouse.org/

Saint Louis Zoo Penguin & Puffin Coast:
https://www.stlzoo.org/visit/thingstoseeanddo/thewild/penguinpuffincoast/

Quizlet

MySci Unit 11 on Quizlet:
https://quizlet.com/_2s54e7

Unit 11 Overview

DESIGN CHALLENGE:

How can we design, test and improve our prototype of a penguin habitat?

ANCHORING PHENOMENON:

A penguin can live in the St. Louis Zoo, which can be very hot in the summer.

STORYLINE

In this unit, students learn how scientists and engineers work together to solve problems as they engage in the Science and Engineering Practices. The project for this unit is to design a new zoo habitat for emperor penguins that will meet the needs of the penguins and the zoo visitors. The activities in the unit also emphasize the Crosscutting Concepts of Patterns, Cause and Effect, and Energy and Matter.

First, students learn about the needs of penguins by reading a book and watching habitat webcams. Then, they learn about the work of scientists and engineers as they prepare to take on the role of scientist and engineer to design their penguin habitat.

Next, students take on the role of scientist as they study material properties and determine the best uses for materials based on those properties. They perform several investigations to discover how heat can change materials and determine which materials make the best insulation. Students consider how matter changes and figure out how insulation is made from sand and recycled glass.

Finally, students take on the role of engineer as they use the scientific knowledge gained in the previous lessons to select materials and create a design for their habitats. They work in teams to build and test a prototype of the habitat and use the results of testing to inform their redesign. Once they are finished with the project, they disassemble their habitat and use the materials to make something new.

OVERVIEW

Section 1 *What do we need to know to design a zoo habitat?*	**Section 2** *How do we discover the best materials for our habitat?*	**Section 3** *How can we design, test and improve our prototype of a penguin habitat?*
Total Time: 5 days LESSON 1 What animal will live in our habitat and what do these animals need? LESSON 2 How do scientists and engineers work together to solve problems?	Total Time: 10 days LESSON 3 How do we describe material properties and use properties to make decisions? LESSON 4 What makes matter change? LESSON 5 How can we make sure that solid ice doesn't melt in our habitat?	Total Time: 10 days LESSON 6 How do we combine our knowledge about penguins' needs and the materials we have to design and build the best habitat? LESSON 7 How do we test our habitat and use the results of testing to improve our design? LESSON 8 How can we use old materials to make something different?

Teacher Prep List – Section 1

	Inside mySci kit, you'll find:	Items you must supply:	Prep and copies:
Lesson 1 *(3 days)*	*Where is Home, Little Pip?* by Karma Wilson and Jane Chapman	Chart paper	Review MySci Safety Guidelines Quizlet Link Copy and administer pre-assessment NOTE: Decide if you will use individual handouts or if you will create Student Science Journals for each student. Copies of Student Pages 2-3 or Student Science Journals Teacher Page 2 Send home parent/guardian letter (Partner Resource Page 5)
Lesson 2 *(2 days)*		Post-its Chart paper	Copies of Student Pages 4-7 or Student Science Journals Teacher Pages 3-6 ***VIRTUAL RESOURCES:*** How Do Scientists and Engineers Work Together to Solve Problems? Mini-Lesson

SECTION 1: *What do we need to know to design a zoo habitat?*

LESSON 1: *What animal will live in our habitat and what do these animals need?*

LEARNING TARGETS
Ask questions and make observations about the problem we want to solve.

VOCABULARY
design habitat problem criteria

SUMMARY
ESTIMATED NUMBER OF DAYS: 3
Students may come with varied abilities to describe the properties (color, texture, strength) of different objects and what purpose the objects are made for. Some students may also know that objects can change when the object is heated or cooled.

In this lesson, students will ask questions about what penguins need in order to define their engineering problem that is the design challenge for this unit. Students gather information through a read aloud, readings, and observations of penguins in their natural habitat and at zoos. Students also ask questions about what zoo visitors need. **Students figure out that engineers ask questions, make observations, and gather information in order to define problems and develop possible solutions.** Students use a scientific drawing rubric to evaluate a drawing of their initial design ideas.

In the next lesson, students are introduced to the ways that scientists learn about the world around them and engineers apply scientific ideas to solve problems. This sets the stage for the learning in this unit, as students use the scientific process to gather information about properties of materials and investigate changes in matter in order to apply this knowledge to the design of a penguin habitat.

FRAMING THE UNIT
Introduce students to the unit phenomenon by showing a picture of emperor penguins in their natural habitat (from Pixabay). Then show a picture of the St. Louis zoo in the summer. Ask students: *What do you notice about these two photos? How would you describe the environment in these two photos?* Have students come up with a list of descriptive words for each photo and then compare the words they came up with when describing each photo.

MYSCI MATERIALS:

Where is Home, Little Pip? by Karma Wilson and Jane Chapman

TEACHER PROVIDES:

Copies of Student Pages 2-3 or Student Science Journals

Chart paper

Copy and administer pre-assessment

Teacher Page 2

Parent/guardian letter (Partner Resource Page 5)

Teaching Tip: This icon highlights an opportunity to check for understanding through a formal or informal assessment.

Now show students a picture of king [penguins at the St. Louis Zoo](). Ask students: *What questions do you have about this?*

Tell students: *In this unit, you will take on the role of scientist and engineer in order to study the needs of emperor penguins and the properties of materials. This unit is all about properties of materials, changes in materials caused by heating and cooling, and engineering. This knowledge will help you answer the question, 'How can we design, test, and improve our prototype of an emperor penguin habitat?' What do you think we need to know in order to be able to meet this design challenge? What questions do you have about this design challenge? Ask students to turn and talk to a partner, then to share out some answers to the whole class.* You may want to write some of their ideas and questions on a piece of chart paper to revisit throughout the unit.

ENGAGE

Ask the class: *Have any of you ever been to the zoo? What kinds of animals did you see there? If you haven't been to the zoo, what kinds of animals might you expect to see there?* Take student responses.

Ask students: *Do all of the animals at the zoo live in the same kind of habitat?* Discuss as a class.

The zoo needs help designing a habitat for their emperor penguins. What questions should we ask about the habitat that we will design? Give students a chance to discuss with a partner or small group before taking ideas from the class. Have students share the questions they have about penguins or their habitat and record them on a class chart paper.

Throughout the unit, keep adding to this list and checking off the questions that are answered as you work.

EXPLORE

Tell the students: *The first big question that we have to answer is what is important to emperor penguins?* Give students a moment to think silently before sharing ideas with a partner, then with a small group (think, pair, share). Finally, take ideas as a whole class.

We are going to read a book about one penguin family to see if we can learn what they need to have in their habitat. Read *Where is Home, Little Pip* to the class. There is a read aloud for this book on the Teacher Page 2. Ask students to pay attention to anything they see in the habitat that they can include in their design.

✓ **EXPLAIN**

Direct students to "Defining the Problem" (Student Page 2). Explain that

NGSS/MLS Connections:
K-2-ETS1-1 (2.ETS)
K-2-ETS1-2 (2.ETS)

ELA Connections:
https://learning.ccsso.org/wp-content/uploads/2022/11/ADA-Compliant-ELA-Standards.pdf
MLS 2.R.1.A.a
MLS 2.R.1.A.b

the first thing engineers do is define the problem they want to solve. Ask students: *Based on what we know about St. Louis in the summer, what is the problem we have to solve if we want to have emperor penguins at the St. Louis Zoo?* Have students share their ideas.

Then tell students that one part of defining the problem is figuring out the criteria or standards that the design must meet. Engineers use criteria to help them come up with solutions to problems. One thing they need to know in order to design the habitat is what is important to penguins.

Show the video Emperor Penguins (4:14) from BBC Earth to learn more about these animals.

Then have students write down things they learned that are important to emperor penguins on Student Page 2 (open ice, other penguins, cold temperatures).

ELABORATE

Tell students: *Now we are going to observe penguins in zoos to get an idea of what other people have done to solve this problem. Make sure to notice what is in each habitat.*

Click on the following links to view examples of Antarctic penguins at zoos in the United States:

Polk Penguin Conservation Center, Detroit, MI (1:36) from MLive

SeaWorld San Diego (1:08) from SeaWorld Parks and Entertainment

Penguin Beach, Long Beach, CA (Live Cam) from Explore

Ask students: *What did you notice about the penguin habitats at these zoos? What did their habitat include to keep the penguins happy and healthy? What features were put in place to make sure that zoo visitors were happy, too?*

Give students a moment to think silently before sharing ideas with a partner, then with a small group (think, pair, share). Finally, take ideas as a whole class. Hopefully, students come up with the idea that zoo visitors want to see the penguins. They may also come up with answers like being safe from the zoo animals, keeping the zoo animals safe from people, etc.

Direct students back to Student Page 2. Remind students that part of defining the problem is figuring out the criteria for their habitat design. Besides keeping penguins happy and healthy, the design must also be able to meet the needs of people who visit the zoo. Have students record what is important to zoo visitors. They can also add additional ideas under what is important to penguins at this time.

EVALUATE

We have a lot more work to do to design our habitats, but I'm sure you already have some ideas about what you would like to design. One way we share our design ideas is with a sketch. But this isn't just a normal sketch. We want to make a sketch that shares our science and engineering ideas. This is called a Scientific Drawing.

Direct students to the Scientific Drawing Rubric (Student Page 3) and go over the rubric as a class to make sure students understand each category.

✓ Ask students to draw a scientific drawing of their design ideas on the bottom of Student Page 2. Be sure that their design meets the criteria identified in this lesson. Students can then share their design sketch with a partner and use the rubric to evaluate each other's designs.

EXTEND (OPTIONAL)

To extend this lesson with more life sciences connections, choose different animals and ask students to list what an artificial habitat would have to include for that animal. Examples include:

Fish	Lion	Eagle	Ants
Frog	Monkey	Hummingbird	

Students could also choose their own animal. Student responses should take into consideration the temperature the animal likes to live in, the types of exercise the animal may need (running, swimming, flying), where the animal builds its home or nest (in a tree, in the ground, etc). They should also consider what zoo visitors want (good views) and need (safety from some animals) as well!

NGSS/MLS Connections:

NGSS K-2-ETS1-1 (MLS 2.ETS1.A.1)

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Science & Engineering Practices in lesson:

- [x] Asking questions and defining problems
- [ ] Developing and using models
- [ ] Planning and carrying out investigations
- [ ] Analyzing and interpreting data
- [x] Constructing explanations and designing solutions
- [ ] Engaging in argument from evidence
- [ ] Using mathematics and computational thinking
- [x] Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- [x] Patterns
- [ ] Cause and effect
- [x] Structure and function
- [ ] Scale, proportion and quantity
- [ ] Stability and change of systems
- [x] Systems and models
- [ ] Energy and matter in systems

S1- L1 Defining the Problem

EXPLAIN: What is important to penguins?

ELABORATE: What is important to zoo visitors?

EVALUATE: Draw a sketch of the habitat that you would like to design. Be sure to use labels!

S1- L1

Scientific Drawing Rubric

	NO	SOMEWHAT	YES
Did I draw everything I saw?			
Did I label the parts of my drawing?			
Did I give my drawing a title?			
Is my drawing big enough and clear enough to see everything?			
Is my drawing realistic?			

Teacher Page – S1-L1 Read-Aloud Guide: *Where is home, Little Pip?*

Read the title, author, and illustrator to students. Remind students that they have talked about making a habitat for an animal at the zoo. Explain to students, "*As we read, I want you to think about what you learn about Pip's problem and the solution to that problem. I also want you to pay close attention to the different animal's habitats (where they live).* "

This book has no page numbers. We will count from the first page because there are important pictures for the students to get information about a penguin's environment.

Pages 1-2 (Inside cover of the book)- *Look at this landscape! This is the habitat, or environment, where penguins live. What do you see? What do you think the temperature is there? Hot or cold? How can you tell? Can you see any trees in this picture?*

Pages 7-8 Read as is. *Who can describe the environment this penguin family lives in. What do you see and what don't you see? (*See water, rocks, don't see trees or grass.) You may want to show where Antarctica is on a map.

Pages 9-10 Read as is.

Page 11-12 Sing the song on page 12. Think aloud: "*This song describes the habitat that we just described.*"

Pages 13-14 After reading page 13, ask: "*What warning did Mama and Papa give Pip?*" (Not to wander-or go-far from home). *Why do you think they told her this?* (To keep her safe)

Page 15-16 Read as is. *Let's make a prediction, what do you think will happen?*

Pages 17- 18 *Uh-oh! What is Pip's problem?* (She is lost!)

Pages 19-20 After singing the song on page 20, ask: "*What do we learn about the habitat, or home, of the whale? Is this the same as Pip's home?*"

Page 21-22 Read as is.

Page 23-24 After singing the song on page 23, ask: "*What do we learn about the habitat of the bird? Is this the same as Pip's home?*"

Page 25-31 Read as is. Continue to point out different aspects of the environment.

Page 32 *What do you think she heard?*

Page 33-end Read as is. *How did Pip solve her problem? (*She sang the song about home and her parents heard her.) *How do you know she's home?* (See that it's snowy, cold, etc.)

SECTION 1: *What do we need to know to design a zoo habitat?*

LESSON 2: *How do scientists and engineers work together to solve problems?*

LEARNING TARGETS
Explain the similarities and differences between the work of scientists and engineers.

VOCABULARY
brainstorm data hypothesis conclusion engineer prototype

SUMMARY
ESTIMATED NUMBER OF DAYS: 2
In the previous lesson students were introduced to the engineering design challenge in this unit.

In this lesson, students explore ideas about scientists and engineers as they prepare to take on the role of scientist and engineer throughout the rest of this unit. **Students figure out that the work of scientists and engineers are similar in some ways but differ in that scientists ask questions in order to explain the world around them and engineers define problems in order to design solutions.**

In the next section, students take on the role of a scientist first, in order to learn more about properties of materials and changes in matter that will help inform the design of their penguin habitat in Section 3.

ENGAGE
Say: *Today we are going to learn how scientists and engineers work together so that we can be both scientists and engineers in our habitat design project. What have you heard before about scientists and engineers? What do scientists do? What do engineers do? How would you explain science and engineering to someone who hadn't heard of them before?*

Allow each student to write down one idea about a scientist on a Post-it and another idea about an engineer on another Post-it. Have students put their ideas on chart paper labeled: "Scientist" and "Engineer." Find patterns in their answers and have a discussion about common ideas students have about scientists and engineers. Point out any similarities and differences that appear.

EXPLORE
Say: *Let's hear how other students think about science and engineering!*

TEACHER PROVIDES:
Chart Paper

Copies of Student Pages 4-7 or Student Science Journals

Teacher Pages 3-6

Copies of readings (No Problem and What Does an Engineer Do?)

VIRTUAL RESOURCES:
How Do Scientists and Engineers Work Together to Solve Problems? Mini-Lesson

Show the following videos:

What do you think a scientist does? (1:24) from Nova's Secret Life of Scientists and Engineers

Kid Engineer- The Design Process *(6:00) from PBS*

Ask students: *How are engineers and scientists similar? How are they different?*

Then show this PBS video about the design of a penguin habitat at SeaWorld in San Diego (1:00).

In this video, we saw a scientist AND an engineer talking about a penguin habitat project. Can you tell who is the scientist and who is the engineer?

Allow students to turn and talk with a partner and then share out a few ideas. They should notice that the scientist in this video was the one talking about the needs of penguin (like the kind of rocks they like) and the engineer was talking about the design of the habitat.

EXPLAIN

Have students read No Problem and What Does an Engineer Do? from Readworks. Use the questions under the "question set" tab to ensure student's comprehension of the passages.

Then direct students to the "Scientific Process" and "Engineering Design Cycle" posters (Student Pages 4-5). Go over the posters together as a class, ensuring that students understand the vocabulary of each step including hypothesis, data, and conclusion in the Scientific Process and brainstorm and prototype in the Engineering Design Cycle. Then allow students to work in small groups to discuss these questions:

1. How is the work of scientists and engineers the same?
2. How is the work different?

Allow students time to discuss in their groups before sharing out as a class.

ELABORATE

✓ *Big projects like our habitat project need both scientists and engineers.* Ask students to decide if they would like to be a scientist or an engineer. Divide the class into these two groups and ask them to share with their group why they made their choice. Prompt students to use the Scientific Process Poster, Engineering Design cycle, ideas from the videos and readings, as well as their previous experiences to come up with reasons why they prefer being a scientist or an engineer.

After each group has had a chance to discuss their idea, have the two groups share out their reasons to the whole class. After both groups have shared, ask if any students changed their mind and want to switch from scientist to engineer.

ELA Connections:
https://learning.ccsso.org/wp-content/uploads/2022/11/ADA-Compliant-ELA-Standards.pdf

Teaching Tip:
Print and cut strips for students from Teacher Pages 4-5. Prepare a chart in the classroom to match Student Page 7.

✓ *As we have said, we will need both scientists and engineers for our project. Both will be very important to our success!* Direct students to "Our Work as Scientists and Engineers" (Student Page 6) and ask them to complete the activity. Guidance for this is provided on Teacher Page 3.

Go over student answers after students have had a chance to complete the activity.

Our habitat design project is going to start off with doing the work of scientists. After the scientific work is finished, then we will do the work of engineers!

✓ **EVALUATE**

Revisit the phenomenon of the emperor penguins in their natural habitat (Pixabay), the St. Louis zoo in the summer, and the king penguins at the St. Louis Zoo. Ask students: *How do you think scientists helped create a safe habitat for the penguins in St. Louis? How do you think engineers helped create a safe habitat for the penguins in St. Louis?*

Pass out one strip to every two students from Teacher Pages 4-5. Ask students: *Do you think this activity is the work of scientists, engineers or both? What makes you think that?* Have students talk with their partner to come up with their claim and evidence. Then allow students to bring the strip up and tape it. Have students provide evidence based on the readings, videos, or posters for their decision. Direct students to Scientists and Engineers Comparison (Student Page 7). At this point, they can complete this activity individually or in pairs. Teacher guidance is provided on Teacher Page 6.

EXTEND (OPTIONAL)

This is an opportunity to talk more about collaboration and teamwork! Have students watch this video about a special team composing music.

Vittorio Montis Csardas by the Kanneh Mason Family (2:10) from The Kids Should See This

Ask: *Is everyone on this team doing the exact same job? Is everyone's job necessary to complete the goal?* (Everyone has their own job (instrument) in this musical team, but they are working together on the same task (song).)

Ask students to brainstorm teams that they have been on and figure out the different jobs of the individuals on the team. Ask students: *How does this relate to science and engineering? (*Whether you are making beautiful music, playing a sport or solving a problem, teams are important! Scientists and engineers almost always work in teams to make discoveries and solve problems.)

NGSS/MLS Connections:

NGSS K-2-ETS1-1 (MLS 2.ETS)

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

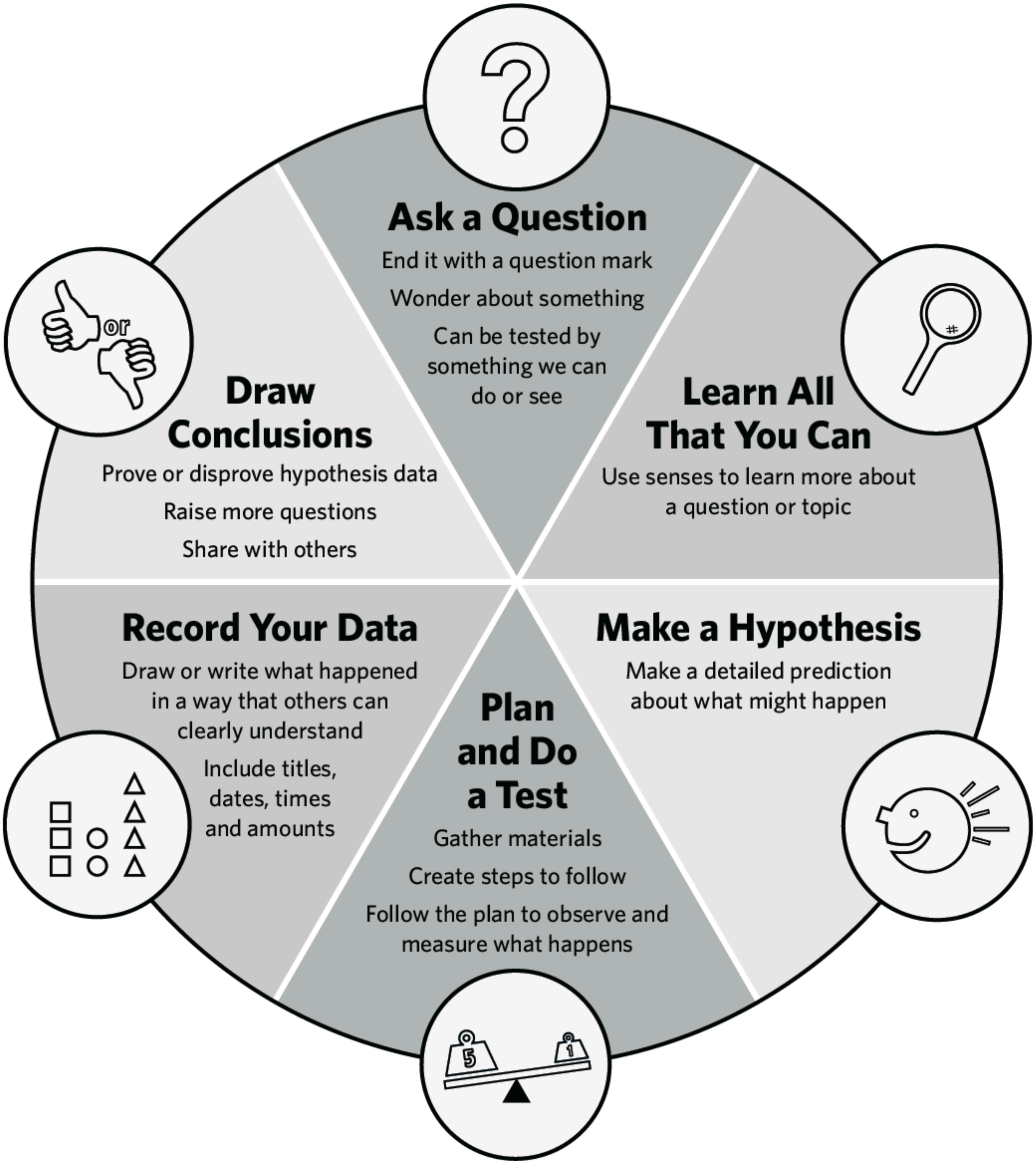
Science & Engineering Practices in lesson:

- ☐ Asking questions and defining problems
- ☐ Developing and using models
- ☐ Planning and carrying out investigations
- ☐ Analyzing and interpreting data
- ☐ Constructing explanations and designing solutions
- ☑ Engaging in argument from evidence
- ☐ Using mathematics and computational thinking
- ☑ Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- ☐ Patterns
- ☐ Cause and effect
- ☐ Structure and function
- ☐ Scale, proportion and quantity
- ☐ Stability and change of systems
- ☑ Systems and models
- ☐ Energy and matter in systems

S1- L2 Scientific Process

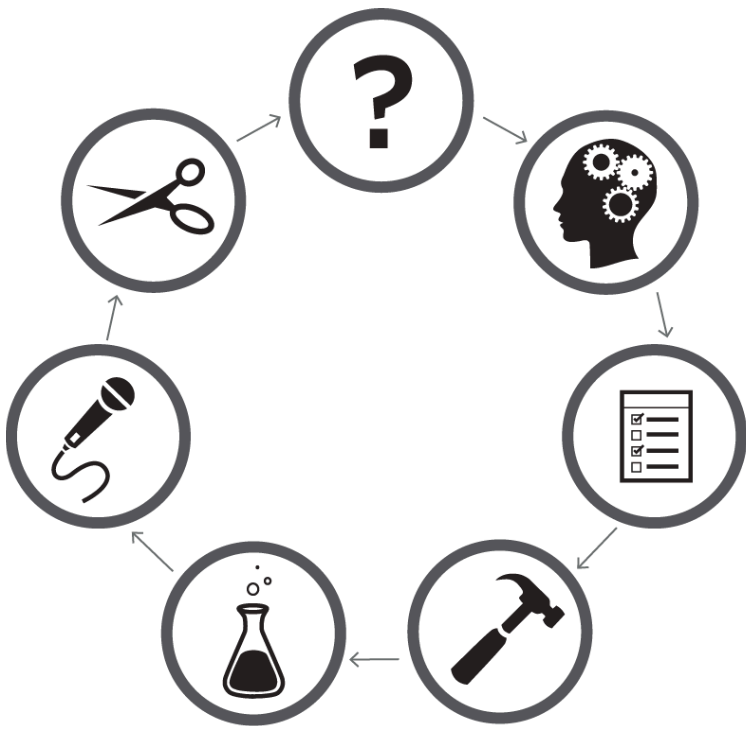


S1- L2 Engineering Design Cycle

1. Identify Need/Problem

7. Redesign

2. Research & Brainstorm



6. Communicate

3. Choose Best Ideas

5. Test & Evaluate

4. Construct Prototype

S1- L2 # Our Work as Scientists and Engineers

Read these tasks that we will have to do to make our habitat.

Design and sketch the habitat.	Test the prototype and decide how to make it better.	Study penguins and learn what they need.	Build a prototype of our habitat.	Do experiments to discover which materials will work best.

Put these tasks in order by copying them here, starting with the first task we need to do.
Then, write if you think a scientist or engineer will do each task.

TASKS	SCIENTIST OR ENGINEER?
1.	
2.	
3.	
4.	
5.	

S1- L2 # Scientists and Engineers Comparison

SCIENTISTS ...	BOTH SCIENTISTS AND ENGINEERS ...	ENGINEERS ...

PHRASE BANK

A. collect data

B. make a hypothesis (a guess)

C. brainstorm many ways to solve the problem

D. ask questions

E. build, test, rebuild prototype

F. compare result with hypothesis

G. define the problem

H. observe nature

I. communicate results

J. record results of experiment

K. design new things

L. do research

M. start with asking a question

N. start with a problem to solve

We Need Scientists and Engineers Guide

Read these tasks that we will have to do to make our habitat.

Design and sketch the habitat.	Test the prototype and decide how to make it better.	Study penguins and learn what they need.	Build a prototype of our habitat.	Do experiments to discover which materials will work best.

Put these tasks in order by copying them here, starting with the first task we need to do. Then, write if you think a scientist or engineer will do each task.

TASKS	SCIENTIST OR ENGINEER?
1. Study penguins and learn what they need.	Scientist
2. Do experiments to discover which materials will work best.	Scientist
3. Make a sketch of our habitat design.	Engineer
4. Build a prototype of our habitat.	Engineer
5. Test the prototype and decide how to make it better.	Engineer

Scientists and Engineers Comparison Strips

A. collect data

B. make a hypothesis

C. brainstorm many ways to solve the problem

D. ask questions

E. build, test, rebuild prototype

F. compare result with hypothesis

G. define the problem

H. observe nature

I. communicate results

J. record results of experiment

K. design new things

L. do research

M. start with asking a question

N. start with a problem to solve

Scientists and Engineers Comparison Guide

✓

SCIENTISTS ...	BOTH SCIENTISTS AND ENGINEERS ...	ENGINEERS ...
B. make a hypothesis F. compare results with hypothesis H. observe nature J. record results of experiment M. start with asking a question	A. collect data D. ask questions I. communicate results L. do research	C. brainstorm many ways to solve the problem E. build, test, rebuild prototype G. define the problem K. design new things N. start with a problem to solve

PHRASE BANK

A. collect data
B. make a hypothesis
C. brainstorm many ways to solve the problem
D. ask questions
E. build, test, rebuild prototype
F. compare result with hypothesis
G. define the problem
H. observe nature
I. communicate results
J. record results of experiment
K. design new things
L. do research
M. start with asking a question
N. start with a problem to solve

Teacher Prep List – Section 2

	Inside mySci kit, you'll find:	Items you must supply:	Prep and copies:
Lesson 3 *(3 days)*	6 baggies, each with: 1 wooden block, 1 pink eraser, 1 brass fastener, 1 small cup/lid, 3 Q-tips 1 small bottle of yellow paint 6 graphite sticks 6 yellow pencils 30 packing peanuts 30 paper clips	White paper for each group	Copies of Student Pages 3, 8-11 or Student Science Journals Teacher Pages 7-10 Make ice cubes for the next lesson ***VIRTUAL RESOURCES:*** Choosing the Best Material (Student Science Journal page 11) virtual adaptation How Can We Choose the Best Materials to Solve a Problem? Mini-Lesson
Lesson 4 *(5 days)*	6 tea light candles Small box of matches Half a petri dish Heat lamp Penguin ice cube tray 2 thermometers Petri dish 7 small graduated cups 6 pipettes *All About Matter*, by Mari Schuh and Gail Saunders-Smith	Ice cubes Timer Optional Extend: Hot plate and foil pan Various materials with different melting points (chocolate chips, butter, Vaseline, crayons, glue stick, etc).	Copies of Student Pages 4, 12-15 or Student Science Journals Teacher Page 11 ***VIRTUAL RESOURCES:*** What Makes Matter Change? Mini-Lesson
Lesson 5 *(2 days)*	6 sheets of felt 6 sheets of bubble wrap 6 small black garbage bags 6 foam sheets Aluminum foil Plastic wrap 5 thermometers plus 2 thermometers (from Lesson 4) Heat lamp (from Lesson 4)	Timer	Copies of Student Pages 16-18 or Student Science Journals Teacher Pages 12-13 Make ice cubes for the next lesson

SECTION 2: How do we discover the best materials for our habitat?

LESSON 3: *How do we describe material properties and use properties to make decisions?*

LEARNING TARGETS

Examine, describe and classify materials based on their observable properties.

Relate properties of a material to its functions and uses.

VOCABULARY

flexibility observation texture material property transparent

SUMMARY

ESTIMATED NUMBER OF DAYS: 3

In the last section students were introduced to the design challenge - creating a habitat for an emperor penguin. They also learned about the role of scientists and engineers.

In this lesson, students will work in groups to examine and describe several materials. **Students will figure out that matter can be described and classified by its observable (physical) properties and connect the properties of those materials to their purpose.** Students will connect this learning to the design challenge by selecting common building materials based on how they will be used in animal habitats.

In the next lesson, students explore changes in matter to observe how adding heat can change materials in order to consider this in their habitat design.

ENGAGE

Display picture of a sweater and a pile of rocks using Slide 1 of this link or the Google Slideshow for Unit 11. Ask students: *How would you describe the sweater to someone who couldn't see or touch it? How would you describe the rocks to someone who couldn't see or touch them?*

Allow students to think about their answer for a moment, then share with a partner, then with a small group. Then discuss as a class. Allow each student who shares to say one word or phrase without saying which object they are talking about. Can the other students identify the object the student is describing?

- *Which is better, the sweater or the rocks? Why? What might you use*

MYSCI MATERIALS:

6 baggies, each with: 1 wooden block, 1 pink eraser, 1 brass fastener, 1 small cup/lid, 3 Q-tips

1 small bottle of yellow paint

6 graphite sticks

6 yellow pencils

30 packing peanuts

30 paper clips

TEACHER PROVIDES:

Copies of Student Pages 3, 8-11 or Student Science Journals

Teacher Pages 7-10

White paper for each group

VIRTUAL RESOURCES:

Choosing the Best Material (Student Science Journal page 11) virtual adaptation

How Can We Choose the Best Materials to Solve a Problem? Mini-Lesson

Teaching Tip:

Make penguin ice cubes for the next lesson!

Tech Tip:

On the Google Presentations, hit the "present" button to be able to show the pictures full screen.

each one for? Why?

- *What does this have to do with our habitat project?*

Display Slide 2 of a penguin habitat. Ask students to notice materials used in the habitat. Explain to students that we need to learn about different materials so that we can make good decisions about our habitat design. Say: *Today we are going to learn how scientists describe materials and use properties of materials to design things for a particular purpose.*

EXPLORE

Direct students to Material Properties Exploration (Student Page 8) and go through the row titles to make sure that the students understand what they are looking for. Don't worry about the blanks; we will fill them in later.

Put students into six groups and give each group the materials for this activity (1 wooden block, 1 pink eraser, 1 brass fastener, 1 small cup/lid to hold paint, 3 Q-tips). Then give each group a graphite stick and a small bit of paint to test. IMPORTANT NOTE! Do not give out the pencils yet (they will use these during the Explain).

Instruct students to observe each material and record what they find on their sheet. Teacher guidance for student answers is provided on Teacher Page 7.

When groups have finished, allow each group to share out one row of the chart. Discuss as a class if there are disagreements.

EXPLAIN

Direct students to the title on the table they have just filled out. Ask students: *What is a material? What is a property?*

Have students read the overview of Material Properties from the BBC or read it aloud.

Have students fill in "flexibility" and "texture" in the appropriate spots in the first column of Student Page 8. (See Teacher Page 7 for guidance)

Ask students: *Did the reading give us any other ideas of what we could record about our materials?* Take student responses. Besides listing examples from the text, students might also say that description could include measurements such as length, weight or volume. If desired, continue this conversation with mentioning what kinds of scientific tools they would use to measure (rulers, scales, measuring cups, etc).

Give each group a pencil. Ask students: *What is a pencil used for? How do scientists and engineers use pencils to do their job?* (Scientists and engineers use pencils to record observations and data.)

Next ask students: *How does this pencil relate to the materials we observed (wood, graphite, paint, brass, rubber)?*

Allow students to discuss with a partner. Then, direct them to the second part of the Material Properties Exploration (Student Page 9). Remind them of the Scientific Drawing Rubric (Student Page 3) and ask them to draw their pencil in the first box. Then, they should work as a group to fill in the chart at the bottom. Teacher Guidance is provided on Teacher Page 8.

ELABORATE

Ask students: *Why do materials work in different ways?*

Display this article from BBC Bite Size. Be sure to explain the properties of the materials and why they are best for the job.

Give each student a piece of foam and a paperclip. Direct them to Material Properties Practice (Student Page 10). Make sure that they understand the data table and ask them to complete the activity individually or in pairs before discussing as a class. Teacher Guidance is provided on Teacher Page 9.

Then, ask students: *How might knowing about properties of materials help us as we design our penguin habitat?*

Show students some of the materials they will use in their design from Lesson 5 (bubble wrap, felt, foil, etc.). Ask students: *What do you want to know about these materials? Why might we need to know the properties of these materials to design our habitat?* Have students think, pair, share their ideas.

EVALUATE

Say: *If we are going to design a zoo habitat to keep penguins and people happy, we will need many different materials. Today, we took on the role of scientist to learn about properties of materials and figure out the ways materials are used for different purposes.*

Ask students: *How can we show our understanding to make recommendations for other zoo habitats?* Direct students to Choosing the Best Material (Student Page 11). Explain to students that they are going to apply their knowledge to make recommendations for a habitat for fish and mice. On the top part of the page, students will pick the material and properties for a fish tank. On the bottom, they will pick the material and properties for baby mice inside of a cage. A word bank is provided for them. Teacher guidance for this activity can be found on Teacher Page 10.

EXTEND (OPTIONAL)

Do you think that wood, graphite, paint, brass and rubber have any other uses? Can you think of any? Take student responses. Then display the following photos using this link or from the Google Slideshow for Unit 11. Ask students

NGSS/MLS Connections:

NGSS 2-PS1-1 (MLS 2.PS)

Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

NGSS 2-PS1-2 (MLS 2.PS)

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

NGSS K-2-ETS1-1 (MLS 2.ETS)

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Science & Engineering Practices in lesson:

- [ ] Asking questions and defining

to identify the materials we just studied and how they are used in each picture.

You can further extend this activity by giving students samples of any other material and asking them to observe and describe the material and determine what it could be used for OR have them find objects in the classroom and identify the materials the object is composed of and what each material is used for.

problems

- [ ] Developing and using models
- [x] Planning and carrying out investigations
- [ ] Analyzing and interpreting data
- [ ] Constructing explanations and designing solutions
- [x] Engaging in argument from evidence
- [ ] Using mathematics and computational thinking
- [x] Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- [ ] Patterns
- [ ] Cause and effect
- [ ] Structure and function
- [ ] Scale, proportion and quantity
- [ ] Stability and change of systems
- [x] Systems and models
- [x] Energy and matter in systems

S2- L3 # Material Properties Exploration

	WOOD	GRAPHITE	PAINT	BRASS	ERASER
What color is it?					
What shape is it?					
Can you bend it? ___________					
Can you break it with your hands?					
What does it feel like in your hands? ___________					
What happens when you rub it on paper?					

Material Properties Exploration *continued*

Make a drawing of the object here, using labels for each material. Use the Scientific Drawing Rubric as a guide.

	WOOD	GRAPHITE	PAINT	BRASS	ERASER
What is it used for in our object?					
Why? What properties make it good for that use?					

S2- L3 Material Properties Practice

	PAPER CLIP	FOAM
Is it solid or liquid?		
What is color is it?		
What shape is it?		
Can you bend it? (flexible)		
Can you break it with your hands?		
What does it feel like in your hands? (texture)		
Which one of these is it most similar to and why? Circle one and explain.	Wood Brass Paint Eraser Graphite	Wood Brass Paint Eraser Graphite

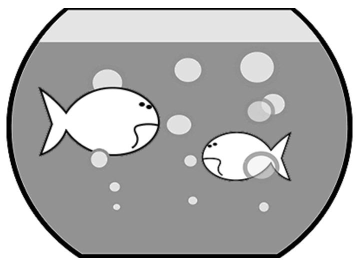
S2- L3 Choosing the Best Material

Materials to choose for your **claim** (blank 1):

Glass Plastic Wool Rocks

Properties to choose for your **evidence** (blanks 2, 3, and 4):

See-through Flexible Soft Warm Liquid



I would choose 1. ______________________ to make a fish tank walls for the zoo's fish because fish tank walls need to be 2. ______________________ and the material I chose has this property.

I would choose 1. ______________________ to make nests for the zoo's baby mice because nests need to be 3. ______________________ and 4. ______________________ and the material I chose has these properties.

Material Properties Exploration Guide

	WOOD	GRAPHITE	PAINT	BRASS	ERASER
What color is it?	Brown or tan	Black or gray	Yellow	Gold	Pink
What shape is it?	Round with flat ends	Square or rectangle	No shape	Round top with two flat parts	Square
Can you bend it? flexibility	No	No	No	Yes	No
Can you break it with your hands?	No	Yes	No	No	No
What does it feel like in your hands? texture	Smooth on the sides and rough on the ends	Smooth	Slippery	Smooth and cold	Rough
What happens when you rub it on paper?	Nothing happens OR it tears the paper	It leaves a black mark	It leaves a yellow mark	Nothing	Little pink pieces come off

Material Properties Exploration Guide *continued*

Make a drawing of the object here, using labels for each material. Use the Scientific Drawing Rubric as a guide.

Students should have a realistic drawing of a pencil and have the materials labeled (wood, graphite, yellow paint, brass, eraser)

	WOOD	GRAPHITE	PAINT	BRASS	ERASER
What is it used for in our object?	The wood is like the “handle” for the pendil. It holds the graphite stick.	The graphite is what makes the marks on the paper. It is inside the wood.	The paint is on the wood. This makes the wood a nice color and keeps people safe from splinters.	The brass holds the eraser onto the end of the pencil.	It is on the end of the pencil to fix mistakes.
Why? What properties make it good for that use?	Wood is strong and protects the graphite from breaking, because graphite is easy to break.	Graphite makes black marks on paper, so we need it for writing.	The paint is a nice color and it is very smooth when it dries. This makes the pencil nice to look at and safe to write with.	Brass is good for this because it is flexible and strong.	The pencil can remove the marks from the graphite. It is soft and doesn’t hurt the paper when it is rubbed on the paper.

 Material Properties Evaluation Guide

	PAPER CLIP	FOAM
Is it solid or liquid?	Solid	Solid
What is color is it?	Gray or silver	Green
What shape is it?	A long, thin wire bent into two loops	Small rectangle
Can you bend it? (flexible)	Yes	Yes
Can you break it with your hands?	Students may be able to break the paperclip if they repeatedly bend it back and forth; otherwise, they will not be able to break it.	Yes
What does it feel like in your hands? (texture)	Smooth and cold	Rough
Which one of these is it most similar to and why? Circle one and explain.	Wood Brass Paint Eraser Graphite Student answers will vary and any answer is OK as long as it is justified. Most students will probably say brass and metal because they are both shine and metal and cannot be bent	Wood Brass Paint Eraser Graphite Student answers will vary and any answer is OK as long as it is justified. Students may say the eraser and graphite because they are both very soft.

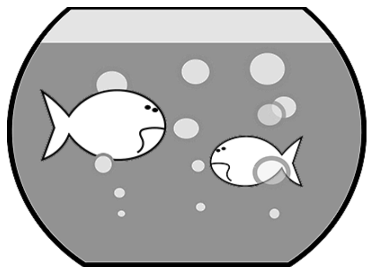
 Choosing the Best Material Guide

Materials to choose for your **claim** (blank 1):

Glass Plastic Wool Rocks

Properties to choose for your **evidence** (blanks 2 and 3):

See-through/transparent Flexible Soft Warm Liquid



I would choose 1. glass to make a fish tank walls for the zoo's fish because fish tank walls need to be 2. see-through/transparent and the material I chose has this property.

I would choose 1. wool to make nests for the zoo's baby mice because nests need to be 3. soft and 4. warm and the material I chose has these properties.

SECTION 2: *How do we discover the best materials for our habitat?*

LESSON 4: *What makes matter change?*

LEARNING TARGETS

Apply the scientific process to experiments involving heat and change of state.

Explain that some changes in matter are reversible while others are not.

VOCABULARY

matter solid liquid freeze melt reversible experiment temperature volume

SUMMARY

ESTIMATED NUMBER OF DAYS: 5

In the last lesson, students were introduced to properties of materials in order to describe how the properties of a material makes it well suited for a particular purpose.

In this lesson, students are introduced to matter and how it changes. Students observe a small candle and use what they have learned about material properties to describe the parts of the candle. **Then, students apply the scientific process to investigate changes to the candle after adding heat and figure out that some changes are reversible and others are not.** Students then apply this knowledge to their penguin habitat design challenge as they investigate changes in ice cubes that occur in different temperatures. Students figure out that ice can change into water and then back into ice again, if the temperature is low enough.

In the next lesson, students investigate properties of materials in order to determine how these materials change when heat is added and which materials will work best for different jobs in their habitat design.

ENGAGE

So far, we have talked about materials and their properties. What are some of the properties we have discussed? (Review properties: texture, color, flexibility, etc.)

Put students into six groups.

Today we are going to learn about some ways that materials can change. First, we are going to look at these (hold up candles). Who knows what these

MYSCI MATERIALS:

6 tea light candles

Small box of matches

Half a petri dish

Heat lamp

Penguin ice cube tray

2 thermometers

Petri dish

7 small graduated cups

6 pipettes

All About Matter, by Mari Schuh and Gail Saunders-Smith

TEACHER PROVIDES:

Copies of Student Pages 4, 12-15 or Student Science Journals

Teacher Page 11

Timer

Ice cubes

Optional Extend:

Hot plate and foil pan

Various materials with different melting points (chocolate chips, butter, Vaseline, crayons, glue stick, etc).

VIRTUAL RESOURCES:

What Makes Matter Change? Mini-Lesson

Teaching Tip:

CAUTION! The heat lamp bulb and silver lampshade can become VERY hot!

are? Take student responses. *Today we are going to do a scientific investigation with these candles. You will work with your group. First, let's remind ourselves about the Scientific Process.* Direct students to the Scientific Process poster (Student Page 4) and review each step with the class.

First, you will work with your group on the Question, Observations and Hypothesis. Direct students to Candle Changes (Student Pages 12-13), and give them time to work in their groups to describe the materials that make up the candle and predict how each will change (Learn All You Can and Hypothesis steps). Share predictions as a class after students have finished.

EXPLORE

Collect the candles from students and gather them around so that they can all see. You can also place a candle under your document camera to display to the class. Direct students to Student Page 13 so that they are ready to draw what they see.

Ask students: *What do you think will happen if I add heat to the candle? What will happen to the metal, the wick, and the wax?*

Light one or more candles. Allow the candles to burn until at least half of the wax is a liquid.

Blow out the candles and pour a little bit of the wax into the petri dish so that students can see that it is liquid.

Ask students: *Was your hypothesis correct about what would change? Did any of the changes surprise you?* As a class, discuss the conclusions from this experiment and compare them to the hypotheses that students made. Record conclusions on Student Page 13.

EXPLAIN

Ask students: *How did the wax change? Why did the wax change? Why didn't the metal change? What happened to the wick?* (The wax, the wick, and the metal all started out as solids. The metal did not change, the wax turned into a liquid, and the wick turned black or "disappeared.")

Say: *The wax, the wick, and the metal are all matter! They changed in different ways when heat was added.*

Look back at the candle wax that you melted and poured into a petri dish. Pass the dish around so that the students can see that the wax is now solid. Discuss this phenomenon with your students. *When we started with this wax, was it solid or liquid?* (Solid) *What happened when we lit the candle?* (it became liquid, melted) *Look at it now, is it solid or liquid?* (SOLID! It "froze" again!) *Why?* Students should gain an understanding that it took the heat from the flame to melt the wax, but that it is cooler now at room temperature so it became a solid again. Some objects' state of matter

Do not touch them when the lamp is on and allow time to cool after you turn the lamp off.

Tech Tip:

If you are not permitted to light a candle in your classroom, you can watch a video instead. One option is this Timelapse Video of a candle burning (00:15) from XO.

changes are reversible, meaning they can go back and forth.

Ask students: *What other things can turn from a solid to a liquid and back to a solid because of temperature?*

Read *All About Matter* to the class. There is a read aloud guide for this book on Teacher Page 11.

Then, show the video What's the Matter? (1:39) from PBS. You may also wish to provide copies of States of Matter and Solids and Liquids from ReadWorks.

✓ Ask students to provide descriptions of properties of solids and liquids. Create an anchor chart to describe the states of matter and properties of matter in these states.

Read Reversible and Irreversible Changes (pages 1-3) from the BBC. Ask students: *How can heat change matter? What are some changes that are reversible? What are some irreversible changes?* See if students can identify and label on their drawing of the candle things that changed with heat (wax and wick) and then which change was reversible (melting of the wax) and which was irreversible (burning of the wick).

ELABORATE

Say: *Let's apply this knowledge to our penguin habitat. Penguins from Antarctica like cold water and ice! We are going to do another experiment about changes in matter by looking at how adding heat can change ice.*

Show students the thermometer, ice cube, pipette, measuring cup, and penguin ice cube.

Ask students: *How can we investigate how this ice cube will change when we add heat? What questions could we ask? What could we measure?*

Say: *One important thing that we need to measure is the temperature. Does anyone know how we measure temperature?* (Explain to students how to use the thermometer to measure temperature changes). *The other important thing that we need to measure is how much liquid we have. Does anyone remember what we call that? How can we measure volume?* Take student ideas.

Set up the heat lamp; one option is to clamp it to the side of your MySci crate. Do not turn the lamp on yet, but put a petri dish and thermometer under the lamp and another petri dish and thermometer in a nearby location that is not under the lamp. Tell students you will place an ice cube in each petri dish. Ask students: *What do you think this represents?* Explain to students that the petri dish under the lamp represents a penguin habitat under the St. Louis sun, while the petri dish away from the lamp represents

ELA Connections

MLS 2.R.1.A.b.

MLS 2.R.3.A.b.

https://learning.ccsso.org/wp-content/uploads/2022/11/ADA-Compliant-ELA-Standards.pdf

Teaching Tip:
Direct students to further explore reversible and irreversible changes through this simulation.

Teaching Tip:

If your students have not learned how to read a thermometer, you can use the following resources to teach them how.

- Reading a Thermometer Video (1:23)
- Practice Worksheet

Teaching Tip:
Allow students to explore this simulation - Solids and Liquids to investigate the effects of heating and cooling different materials.

a penguin in its natural habitat.

Ask students: *What do you think will happen? What is your hypothesis?* Direct students to Water Changes (Student Pages 14-15). Go over the question and ask students to record their hypotheses. Then place an ice cube in each petri dish and set a timer for 10 minutes.

As you are waiting, show the video: Changing Water (5:08) from South East Water. Ask students: *How does water change? Are these changes reversible or not? Explain your thinking.*

After 10 minutes, direct students back to the heat lamp experiment. Ask students to draw what they see on their Water Changes sheet (Student Page 14-15). Measure and record the temperature under the heat lamp and the temperature away from the heat lamp and ask students to record that data as well. Finally, use the pipette to measure the volume of water from ice that melted in each petri dish. Students should also record this data.

Discuss the results of the experiment with the class and compare the results to the original prediction. Students should record their conclusions.

Ask students: *What will happen to the water if we turn off the lamp? Will the water go back to being solid like the wax did? Why do you think that?* Give students time to think about this on their own before discussing ideas with a partner or small group. Share out ideas with the class. You may wish to allow the water to sit in the dish overnight to prove to students that it will not return to a solid state.

Ask students: *Why did the wax change back to a solid but the water did not? Is there a way to change the water back into ice?* Students should use evidence from their investigations to support the claim that materials become solids and liquids at different temperatures and suggest that putting the water back in the freezer could change the water back to ice.

EVALUATE

Ask students: *How can we use this knowledge to think about the materials in our penguin habitat?*

Direct students to the "Evaluate" portion of Water Changes (Student Page 15). Ask students to draw and label what will happen to different materials in the habitat if they get too warm. They should pay attention to things in the habitat that will change when heat is added and things that will not. Be sure that students consider the glass, rocks, ice, snow, and water in the picture.

EXTEND (OPTIONAL)

You can extend this lesson by repeating the experiment from the "Elaborate" portion of this lesson with a more intense heat source. This will require a hot plate and various materials that you choose. Material ideas include: Chocolate chips, butter, glue stick, vaseline, plant or grass leaf, lump of clay, etc.

You should also choose some materials that will not melt, like the wood blocks from Lesson 3.

Show the students the materials that you have brought for testing and ask them to predict which ones will melt and which ones will not melt. Put each object into a foil pan. Ask students to describe the objects.

Ask: *Are these items solids or liquids?* (They are all solids). *But, what will happen if we heat these items up?* Have students make predictions about what will happen to each item. Record student predictions and run the experiment. Then ask: *What will happen if we let all of these things sit here NOT under the lamp? Will they go back to how they were before? Record predictions.*

Check on the items the next day. *What did they look like before we heated them? What happened when we heated them? What do they look like now?*

NGSS/MLS Connections:

NGSS 2-PS1-4 (MLS 3.PS)

Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

(MLS 3.PS)

Predict and investigate that water can change from a liquid to a solid (freeze), and back again (melt), or from a liquid to a gas (evaporation), and back again (condensation) as the result of temperature changes.

Science & Engineering Practices in lesson:

- ☐ Asking questions and defining problems
- ☐ Developing and using models
- ☑ Planning and carrying out investigations
- ☑ Analyzing and interpreting data
- ☑ Constructing explanations and designing solutions
- ☐ Engaging in argument from evidence
- ☐ Using mathematics and computational thinking
- ☐ Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- ☐ Patterns
- ☑ Cause and effect
- ☐ Structure and function
- ☑ Scale, proportion and quantity
- ☑ Stability and change of systems
- ☐ Systems and models
- ☑ Energy and matter in systems

S2- L4 # Candle Changes

QUESTION: How will the materials change when we light the candle?

LEARN ALL YOU CAN: Observe and describe the three different materials that make up the tea light?

METAL	WAX	STRING

HYPOTHESIS: How do you think the materials will change?

When we light the candle,

I think the metal will ______________________________

____

I think the wax will ______________________________

____

I think the string will ______________________________

____

S2- L4 Candle Changes *continued*

DATA AND DRAWING: Observe, describe and draw a model to show the changes in materials when you light a candle. Be sure to include all three materials in your model.

Before Heating	After Heating

CONCLUSION: How did the materials change?

When we lit the candle,

the metal ______________________________

____

the wax ______________________________

____

the string ______________________________

____

S2- L4 # Water Changes

QUESTION: Will the heat lamp affect how fast the ice melts?

HYPOTHESIS: How will the heat lamp affect how fast the ice melts?

a. I think the two ice cubes will melt at the same rate.

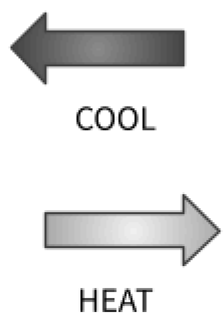
b. I think the ice cube under the heat lamp will melt faster.

c. I think the ice cube away from the heat lamp will melt faster.

LEARN ALL YOU CAN: Observe and draw a model of the changes to the ice cube.

NO HEAT LAMP

HEAT LAMP



S2- L4 # Water Changes *continued*

DATA: Measure and record the data after 10 minutes.

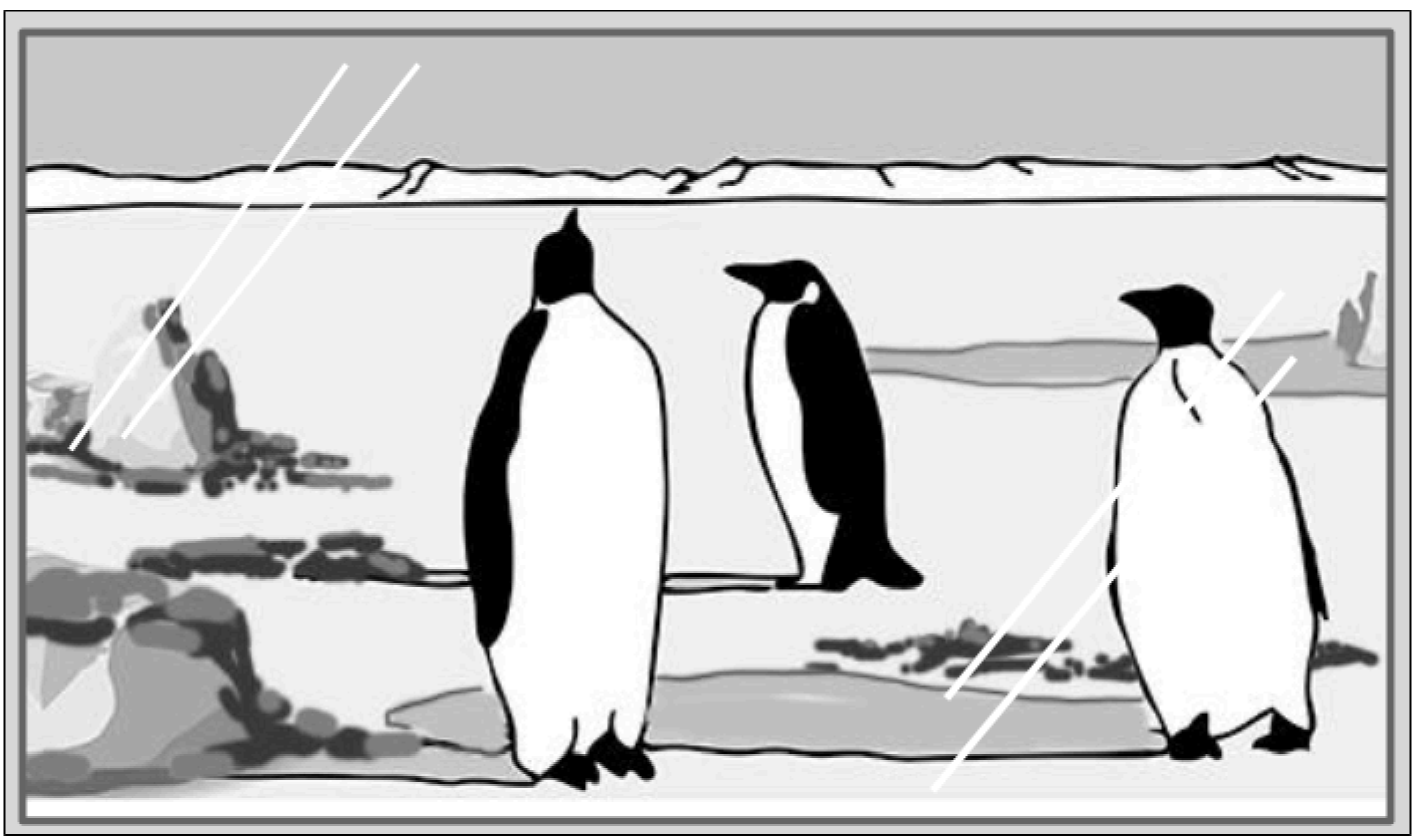
HEAT LAMP	NO HEAT LAMP
Temperature:	Temperature:
Volume:	Volume:

CONCLUSION: How did the heat lamp affect the ice melting?

The ice under the heat lamp melted ______________________________

compared to the ice not under the heat lamp.

EVALUATE: What will happen if it gets too warm in our penguin habitat? Use labels to describe what might happen on the drawing.



Read-Aloud Guide: *All About Matter,* Mari Schuh

Hold up the book and show students the cover. *So far we have been talking about properties of matter with liquids and solids. Think about the activity we just did with the candle. What parts of the candle were solid? What parts were liquid? (*The wax, once it melted).

Do a picture walk through the book. *Is this book a fiction or nonfiction book? How do you know?* Point out the informational book text-features such as the Table of Contents, Headings, and Glossary. Say: *This book is going to help us learn more about different types of matter.*

Table of Contents Review with student that the Table of Contents help us know where to find different pieces of information in the book.

Pages 4-5 Read as is.

Pages 6-7 Read as is. *What do you see in this picture that is a solid?* (the ice) *What is liquid?* (the water) *What is a gas?* (the air)

Pages 8-9 Read as is. *What else do you see in this picture that is a solid? Turn and talk to your partner and name items in this classroom that are also solid.*

Pages 10-11 Read as is. *What are some other examples of liquids?*

Pages 12-13 Read as is. Ask students: *What is inside a balloon? Is that a solid/liquid/gas?* Explain that the balloon itself is a solid, but it is filled with air (a gas).

Page 14-15 Read as is. Think aloud: *"This page taught me that matter can change forms. I can see in this picture that the ice-cream was a solid, but it has started to melt and is turning into a liquid. I bet it is hot outside!"* Ask students, "*Can you think of anything else that can change from a solid to a liquid?"*

Page 16-17 Read as is. Ask students if they have ever made ice cubes before. Have them share what happens. *Can you think of anything else that can change from a liquid to a solid?*

Page 18-19 Read as is. You can explain that steam produced by boiling water is a gas.

Page 20-21 Read as is.

Page 22 You can use the glossary to play a quick quiz game. Read the definition and have students call out the term (matter, solid, liquid, gas).

SECTION 2: *How do we discover the best materials for our habitat?*

LESSON 5: *How can we make sure that solid ice doesn't melt in our habitat?*

LEARNING TARGETS

Describe observable properties of various materials.

Conduct an experiment to determine the insulating properties of various materials.

VOCABULARY

insulate   insulation

SUMMARY

ESTIMATED NUMBER OF DAYS: 2

In the last lesson, students explored changes in matter, including changes that are reversible and those that are not.

In this lesson, students will describe the properties of six potential insulating materials to use in their habitat design. They will describe how reversible and irreversible changes are used to create materials. **Then they will design and conduct an experiment to figure out which materials are the best insulators for the penguin habitat and which materials will allow people to see the penguins.**

In the next lesson, students will apply their scientific findings from the lessons in Section 2 as they take on the role of engineer to design their penguin habitat.

ENGAGE

Ask students: *How can we make sure that solid ice doesn't melt in our penguin habitat?*

In this lesson, students will investigate properties of materials in order to identify materials they might use in their habitat design.

Ask students: *How do you keep warm in the cold of winter? Why do you wear layers of warm clothes in the winter? Have you ever put on a coat or gloves that were laying around outside? Are they warm or cold? (*They do not become warm until the heat from your body is trapped by the layers of clothes. Then they keep you warm. Its works the same way for keeping things cold, too.) *When you go on a picnic or camping, what do you put your cold drinks in?* (A cooler) *The cold from the drinks or ice in the cooler is trapped by the plastic foam that the cooler is made from. Keeping hot or cold*

MYSCI MATERIALS:

6 sheets of felt

6 sheets of bubble wrap

6 small black garbage bags

6 foam sheets

Aluminum foil

Plastic wrap

5 thermometers plus 2 thermometers (from Lesson 4)

Heat lamp (from Lesson 4)

TEACHER PROVIDES:

Copies of Student Pages 16-18 or Student Science Journals

Teacher Pages 12-13

Timer

Teaching Tip:

CAUTION! The heat lamp bulb and silver lampshade can become VERY hot! Do not touch them when the lamp is on and allow time to cool after you turn the lamp off.

air trapped is called insulation.

Today we are going to learn more about how some materials are better than others at insulating. We have six materials to choose from to try and insulate our habitat.

EXPLORE

Direct students to Insulating Materials Experiment (Student Pages 16-17). Put students into six groups and give each group one of the materials to examine or one piece of each material. They should be careful not to destroy the materials because we will need them later. Go over the question together and then ask students to fill out the observation section, passing the materials on to another group when they have finished.

Teaching Tip:
You might choose to prepare in advance six bins with a sample of each of the six materials so students can explore all materials with their group.

After all groups have seen all materials, go over the material descriptions for each item. Did students include things we have talked about, like color and texture? After discussing the materials, ask each group to make a hypothesis and record it on their sheet.

Now we have to figure out how to test these materials to see which one will keep our habitat the coolest. How do you think we might do that? Take student ideas.

If no student comes up with the idea of using thermometers, mention it to students. Take six thermometers and wrap one bulb end of a thermometer with each material. Use only one layer of the material to be consistent among thermometers. The seventh thermometer should be left bare. Place the seven thermometers under the heat lamp, close together. Before you turn the lamp on, read the temperature on the thermometer that has no wrapping. Direct students to record this temperature. Then turn the lamp on and wait 10 minutes. While you wait, students can watch penguin webcams from Lesson 1 or discuss their hypotheses with other teams. After 10 minutes, read all of the thermometers, recording the data on Student Page 17. Turn off the heat lamp.

Teaching Tip:
Students might suggest putting an ice cube in cups covered with each of the materials. You may choose this option and measure the amount of ice that has melted after 10 minutes instead or in addition to using the thermometer as described in the Explore section.

EXPLAIN

Now we have to look at our data to see if it helps us answer our question. Review the initial question that students asked. Then review the data. *What kind of data would show that a material was very good at insulating the thermometer? Do we want the temperature reading to be higher or lower?* Take student ideas. Hopefully they understand that a lower temperature reading is better because it demonstrates that the material keeps the temperature cooler.

Ask teams to fill in the conclusion on Student Page 17 and check it against the hypothesis.

Direct students to this website - Testing Insulators: Ice Cube in a Box (5:00) from PBS- or show it on your SmartBoard.

✓ Ask students: *Which materials in our experiment were the best insulators? What is an insulator?* Have students turn and talk, then take a few student responses. Be sure students use evidence from the experiment to support their claim.

ELABORATE

Ask students: *What materials are used in penguin habitats? What materials are used as insulation? What about materials used to create glaciers and rocks?*

Display the following articles - summarize the main ideas and point out important images that show materials used in penguin habitat designs. There is also a read-aloud guide on Teacher Page 12.

World's Largest Penguin Playground Opens at Detroit Zoo with Help of Insulation from Insulation Outlook

OTL to Build Natural Habitat for Detroit Zoo's Penguin Exhibit (Video included, 1:50) from Outside the Lines

Zoo Displays: Penguin Pools from Aquarium Technology Ltd.

Ask students: *How are these materials created?*

Show How It's Made: Acrylic Windows (2:20) from Science Channel and The Nature of Insulation (2:32) by E.ON Energy UK.

Ask students: *What changes did you notice?* (Chemicals were dissolved in liquid, acrylic changed from liquid to solid; sand was changed to glass, glass and other materials were changed to fiberglass insulation) *Are these changes reversible like the melting and freezing of water?* (No. Once you have acrylic, you cannot get the dissolved chemicals back; Once you have fiberglass you cannot get sand)

✓ **EVALUATE**

Materials science is a very important part of designing our penguin habitat. Remind students of the criteria for their penguin habitat (e.g., it must keep penguins cool and it must allow people to view penguins safely). Direct students to Meeting the Needs of Penguins and People (Student Page 18) and ask them to complete the activity based on the materials they investigated today. Teacher guidance is provided on Teacher Page 13.

EXTEND (OPTIONAL)

Ask students: *Which materials do you think would work best together to keep ice from melting? Do you think extra layers of material will help provide more* *insulation? What if we combine more than one material on the same thermometer? How do you think the data will compare to the single material test?*

Repeat the experiment in this lesson with multiple layers of each material and/or by combining different materials on the same thermometer. Analyze data in the same manner as described in the lesson.

What does this test tell you about the best way to keep our penguin habitat cool?

NGSS/MLS Connections:

NGSS 2-PS1-1 (MLS 2.PS)

Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

NGSS 2-PS1-2 (MLS 2.PS)

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

Science & Engineering Practices in lesson:

- ☑ Asking questions and defining problems
- ☐ Developing and using models
- ☑ Planning and carrying out investigations
- ☑ Analyzing and interpreting data
- ☐ Constructing explanations and designing solutions
- ☐ Engaging in argument from evidence
- ☐ Using mathematics and computational thinking
- ☐ Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- ☐ Patterns
- ☑ Cause and effect
- ☐ Structure and function
- ☑ Scale, proportion and quantity
- ☑ Stability and change of systems
- ☐ Systems and models
- ☐ Energy and matter in systems

S2- L5 # Insulating Materials Experiment

QUESTION: Which material will work best to keep our penguin habitat cool?

LEARN ALL YOU CAN: Observe and describe the properties of the materials we have to work with.

MATERIAL	DESCRIBE THE MATERIAL PROPERTIES
Felt	
Bubble Wrap	
Aluminum Foil	
Garbage Bag	
Foam Sheet	
Plastic Wrap	

HYPOTHESIS: Which material will work best to keep our penguin habitat cool?

I think that the ______________________________

will work best to keep our penguin habitat cool.

S2- L5 # Insulating Materials Experiment *continued*

DATA: Temperature with the lamp off is ____________________

MATERIAL	TEMPERATURE AFTER 10 MINUTES UNDER THE HEAT LAMP
Plain Thermometer	
Felt	
Bubble Wrap	
Aluminum Foil	
Garbage Bag	
Foam Sheet	
Plastic Wrap	

CONCLUSION: Which material will work best to keep our penguin habitat cool?

I think the ______________________________ will work best.

I think this because ______________________________

____

____

S2- L5 # Meeting Needs of Penguins and People

Here is a list of the materials we tested. Choose the best material for the jobs below and explain why you are choosing that material.

Felt	**Aluminum Foil**	**Foam Sheet**
Bubble Wrap	**Garbage Bag**	**Plastic Wrap**

The penguins need to keep cool in their habitat.

The material that will help me with this is: ______________________________

Because: ____

____

The people at the zoo need to see the penguins in the habitat.

The material that will help me with this is: ______________________________

Because: ____

____

Read Aloud Guide for Articles

1. "World's Largest Penguin Playground Opens at Detroit Zoo with Help of Insulation" by Dale McGlothlin

Teacher Note: This article is well-above student's reading level. We suggest reading it outloud and keeping the focus on habitat design.

Paragraph 1 Say, "*In this first paragraph, we learn that the Detroit Zoo uses three main types of insulators: fiberglass, elastomeric, and spray foam insulation. What is the purpose of insulators?*" (Insulation keeps the penguins cold). Think aloud: "*Wow, they use three different materials to insulate the habitat to make sure the penguins stay cold!*"

Show pictures of engineers constructing the habitat.

Paragraph 2 Skip

Paragraph 3 Read the last sentence ("Visitors can also make…") and show picture.

Paragraph 4 Read as is. *How do you think it is possible that it is 70 degrees where the people walk and 37 degrees where the penguins are?* (The insulation keeps the penguins very cold). *Why do you think it's important that it is colder for the penguins than for the zoo visitors?*

Paragraph 5 Skip.

Paragraphs 6-7 Read as is. Think aloud: "*Here we learn about the specific type of insulation, called spray polyurethane foam, that the engineers used to create the habitat.*"

Paragraph 8 skip.

Paragraph 9 Read as is.

2. "OTL to Build Natural Habitat for Detroit Zoo's Penguin Exhibit"
   Posted in News, Press - Nov 15, 2014

Read **Paragraphs 1**, **4-7**. Ask students, "*Why do you think that teams made multiple trips to Antarctica (where Penguins live) to do research? Why do you think that this project took two years to plan and design?* "

3. Zoo Displays (https://www.aquariumtechnology.com/zoo-displays/nggallery/page/2)

Teacher Note: Scroll down to the "Penguin Pool" section

What type of windows do zoos use for their penguin displays? (Acrylic) *We are going to learn more about Acrylic windows in a video!*

What do you notice about the Penguin habitats in these pictures?

✓ Here is a list of the materials we tested. Choose the best material for the jobs below and explain why you are choosing that material.

Felt	**Aluminum Foil**	**Foam Sheet**
Bubble Wrap	**Garbage Bag**	**Plastic Wrap**

The penguins need to keep cool in their habitat.

The material that will help me with this is: Answers will vary based on the results of your testing

Because: Look for answers that indicate we tested each material and the chosen material kept the temperature the lowest.

The people at the zoo need to see the penguins in the habitat.

The material that will help me with this is: Plastic wrap

Because: It is the only material that is really see-through (Note: students may choose bubble wrap because you can somewhat see through it, but the view will not be as good!)

Teacher Prep List – Section 3

	Inside mySci kit, you'll find:	Items you must supply:	Prep and copies:
Lesson 6 *(3 days)*	6 cardboard boxes 3 petri dishes (plus one from Lesson 4) Felt, bubble wrap, garbage bags, foam sheets, aluminum foil, and plastic wrap (from Lesson 5) Rubber bands (30)	Penguin ice cubes (Prepare for Lesson 7)	Copies of Student Pages 2, 3, 5, 19-20 or Student Science Journals Make ice cubes for the next lesson ***VIRTUAL RESOURCES:*** How Can We Design, Test, and Improve Our Penguin Habitat? Mini-Lesson
Lesson 7 *(5 days)*	7 small graduated cups (from Lesson 4) Heat lamp (from Lesson 4) Thermometers (from Lesson 5) All materials (from Lesson 6)	Penguin ice cubes Timer	Copies of Student Pages 3, 5, 21-22 or Student Science Journals ***VIRTUAL RESOURCES:*** How Can We Design, Test, and Improve Our Penguin Habitat? Mini-Lesson
Lesson 8 *(2 days)*	*Changes, Changes*, by Pat Hutchins Habitat materials (from previous lessons)		Copies of Student Page 23 or Student Science Journals Teacher Page 14 Copy and administer post-assessment

SECTION 3: *How can we design, test and improve our prototype of a penguin habitat?*

LESSON 6: *How do we combine our knowledge about penguins' needs and the materials we have to design and build the best habitat?*

LEARNING TARGETS

Work with a team to apply scientific findings to the engineering design process in order to solve a problem.

Plan and build a prototype to meet criteria of the design challenge.

VOCABULARY

No new vocabulary

SUMMARY

ESTIMATED NUMBER OF DAYS: 3

In the last lesson, students took on the role of materials scientist to investigate the properties of materials, especially their ability to provide insulation.

In this lesson, students will review what they have learned so far that will help in their habitat designs. Then they will learn about the materials they can have to build their prototypes. Students will revisit the Engineering Design Cycle and then begin to work in teams to plan, sketch and build their prototypes. **Students figure out that designs can be conveyed through sketches, drawings, or physical models and that these representations are useful in communicating ideas for a problem's solutions to other people.**

In the next lesson, each group will test their prototype to see how well it meets the criteria and compare how well the designs worked to solve the problem.

ENGAGE

What have scientists helped us learn so far….

- *About penguins and what they need?*
- *About describing material properties?*
- *About insulation?*

We are all going to use the same materials that we have tested but each team can decide to put them together in different ways. Now, it is time to do some engineering!

MYSCI MATERIALS:

6 cardboard boxes

3 petri dishes (plus one from Lesson 4)

Rubber bands (30)

Felt, bubble wrap, garbage bags, foam sheets, aluminum foil, and plastic wrap (from Lesson 5)

TEACHER PROVIDES:

Copies of Student Pages 2,3,5,19-20 or Student Science Journals

Prepare penguin ice cubes for next lesson

VIRTUAL RESOURCES:

How Can We Design, Test, and Improve Our Penguin Habitat? Mini-Lesson

Teaching Tip:

CAUTION! The heat lamp bulb and silver lampshade can become VERY hot! Do not touch them when the lamp is on and allow time to cool after you turn the lamp off.

Here is a short video of one materials engineer describing her job. Just watch the first 50 seconds of this segment: [Materials Engineer] (0:50) from Career Girls.

EXPLORE

Ask students: *Why can't we test our habitat with real penguins?* Give students a chance to turn and talk with a partner, then take several different student responses. Students should say things such as we don't have enough materials, it would cost too much money, we don't know if it is going to work, it might hurt the penguins, etc.

Say: *Scientists and engineers build models of things first, on a smaller scale to save money and time and to make sure it will work! Those models are called prototypes. We are going to make a prototype of our habitats first. Engineers make prototypes to test their designs before building the real design.*

Show the materials that they have available, including the materials we tested in Lesson 5, the small boxes, and rubber bands. Teams can choose only two of the materials from Lesson 5 and each team will get a box and five rubber bands. Show students how the rubber bands can fit around the boxes to hold the materials in place. For testing, each team will get one penguin ice cube in a petri dish. Describe how teams must include a way to open the habitat, put in the penguin, and close it up again.

How will you decide which materials to use? Remember, we have to keep penguins and people happy. What did we learn as scientists to help us choose the best materials? Allow students to discuss with a partner before sharing out with the class.

EXPLAIN

Direct students back to their original sketch for their habitat (Student Page 2). *Has anything we have learned given you new ideas about your habitat?*

Direct students to the Engineering Design Cycle (Student Page 5). *What have we done so far and what do we still need to do?* Discuss as a class. The class has identified the problem (Step 1) and completed research (part of Step 2). Now students have to brainstorm some possible solutions.

Direct students to make a new sketch on Student Page 19 and use the Scientific Drawing Rubric on Student Page 3 to guide their work. Remind students of the criteria (it must keep penguin cool and allow people to view penguins safely) and constraints (the available materials and time) for this design.

ELABORATE

Put students into six teams and instruct them to share their individually brainstormed design ideas with their teams. Students should describe how

Teaching Tip:

Set up the "Zoo habitat" by lining the crate with foil, putting the black paper down on the bottom and then attaching the heat lamp. Plug in and turn on the heat lamp before testing to warm up the "penguin house". Place the thermometer in the bottom.

NGSS/MLS Connections:

NGSS [2-PS1-2] (MLS [2.PS])

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

NGSS [K-2-ETS1-1] (MLS [2.ETS])

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

NGSS [K-2-ETS1-2] (MLS [2.ETS])

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

their design meets the criteria and constraints of the design challenge. The team should then choose the best idea (Step 3).

Direct students to Team Design Ideas (Student Page 20) and the Scientific Drawing Rubric (Student Page 3). Ask them to draw a sketch of their team's design and label it. After students have drawn their design, they should pair with another team to explain how the design will solve problems for people and penguins at the zoo.

EVALUATE

Examine each team's drawing and evaluate it with the Scientific Drawing Rubric (Student Page 3). Make sure all materials that they need are labeled on the diagram and that it is clear what they will do. If necessary, require drawing revisions.

Once drawings are acceptable, students should begin to build their prototypes. Give them the materials shown on their drawing so that they can construct their prototype (Step 4). Give them time to build their prototype and circulate to ask questions about how their prototype will meet the design criteria, including having a way to open the habitat to put the penguin inside, keeping the penguin cool, and making sure zoo visitors can safely view the penguins.

Teacher Tip: Prepare penguin ice cubes for the following lesson.

EXTEND (OPTIONAL)

Give a dollar amount to each material and then have students calculate the price of their habitat design. They can then compare which one cost the most and which one was most cost effective. You might also provide a constraint by only giving students a certain budget to work with to redesign their habitat.

Science & Engineering Practices in lesson:

- [ ] Asking questions and defining problems
- [x] Developing and using models
- [x] Planning and carrying out investigations
- [x] Analyzing and interpreting data
- [ ] Constructing explanations and designing solutions
- [x] Engaging in argument from evidence
- [x] Using mathematics and computational thinking
- [ ] Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- [ ] Patterns
- [ ] Cause and effect
- [ ] Structure and function
- [ ] Scale, proportion and quantity
- [ ] Stability and change of systems
- [x] Systems and models
- [ ] Energy and matter in systems

S3- L6 My Design Ideas

Sketch your ideas for your habitat here. Be sure to use labels.

S3- L6

Team Design Ideas

Sketch your team's prototype here. Be sure to use labels.

How will your prototype solve problems for penguins and people?

SECTION 3: *How can we design, test and improve our prototype of a penguin habitat?*

LESSON 7: *How do we test our habitat and use the results of testing to improve our design?*

LEARNING TARGETS
Test and evaluate engineering prototypes based on the results of testing.

VOCABULARY
No new vocabulary

SUMMARY
ESTIMATED NUMBER OF DAYS: 5
In the last lesson, students applied their knowledge of science to Steps 1-4 of the Engineering Design Cycle and created a prototype of their penguin habitat.

In this lesson, student groups will test their penguin habitats under the heat lamp and examine the results of testing. **Students will analyze data from the tests of different habitat designs and figure out that because there is always more than one possible solution to a problem, it is useful to compare and test designs.** Based on test results, students will make a plan to redesign their penguin habitats.

In the last lesson, students consider how the same materials used in their penguin habitat could be repurposed for another job.

ENGAGE
Show this image. Ask students: *What do you notice about this zoo exhibit? Do you think zoo visitors would enjoy this exhibit?*

Direct students to Penguin Habitat Prototype Testing (Student Page 21) and explain that we will first see if the habitat meets the needs of zoo visitors. Allow each team to show their habitat and explain what they did. The other students should mark whether or not they will be able to see penguins in the habitat and if the habitat design will keep the people and penguins safe.

EXPLORE
Ask students: *Do we want our ice penguins to melt? No! How long do you think your ice cube penguin can survive in your habitat?*

We are going to test your habitats as if it is a very hot day at the zoo. We will put your penguins inside your habitats and wait for 15 minutes. Then we will

MYSCI MATERIALS:

7 small graduated cups (from Lesson 4)

Heat lamp (from Lesson 4)

Pipettes (from Lesson 4)

Thermometers (from Lesson 5)

All materials from Lesson 6

TEACHER PROVIDES:

Copies of Student Pages 3,5, 21-22 or Student Science Journals

Penguin ice cubes

Timer

VIRTUAL RESOURCES:

How Can We Design, Test, and Improve Our Penguin Habitat? Mini-Lesson *see how much each penguin melted. We will also have one penguin that isn't in a habitat to compare.*

Set up the testing environment (See Teaching Tip in lesson 6). Have each team open their habitat and place their penguin in a petri dish in the habitat at the same time. Place all of the habitats inside the crate (along with an extra penguin ice cube in a petri dish) and turn on the heat lamp. Set a timer for 15 minutes.

While you wait, watch these videos of things melting:
[Snowman Melting Time Lapse] 2 (0:11) from Kyle Spradley
[Ice Melting] (1:57) from Jim R.

What caused the snowman and ice to melt? How long do you think it took? Why do you think that? You could also spend this time watching penguin webcam videos using the links provided in Lesson 1.

EXPLAIN
When the timer goes off, turn off the heat lamp. Quickly take out the penguins and remove any unmelted ice from the petri dishes. Then measure how much melted from each team's penguin and the penguin that wasn't in a habitat using the measuring cups or pipettes from Lesson 4. Record the data on Penguin Habitat Prototype Testing (Student Page 21).

One important thing that engineers do is share and compare results of different ideas. Discuss the results of the testing. Direct students to answer the questions below the data table and discuss them as a class.

ELABORATE
Now that we have done one test, where are we in the Engineering Design Cycle? Direct students to the Engineering Design Cycle (Student Page 5) and talk about each step. *We have done everything except redesign. What do you think you could change to make your habitat even better?* Give students an opportunity to discuss their redesign.

EVALUATE
Allow time for students to work in their teams and discuss how they could change their design. Direct students to Ideas for Redesign (Student Page 22). Evaluate student sketches based on the Scientific Drawing Rubric (Student Page 3) as well as students ability to defend the changes they made to their design by using evidence from the tests of the prototypes.

EXTEND (OPTIONAL)
If you have time, allow students time to rebuild and retest their habitats. They can try adding more layers of insulation or adding a new kind of insulation.

NGSS/MLS Connections:

NGSS 2-PS1-2 (MLS 2.PS)

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

NGSS K-2-ETS1-2 (MLS 2.ETS)

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

NGSS K-2-ETS1-3 (MLS 2.ETS)

Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Science & Engineering Practices in lesson:

- ☐ Asking questions and defining problems
- ☑ Developing and using models
- ☐ Planning and carrying out investigations
- ☐ Analyzing and interpreting data
- ☑ Constructing explanations and designing solutions
- ☐ Engaging in argument from evidence
- ☐ Using mathematics and computational thinking
- ☑ Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- ☐ Patterns
- ☐ Cause and effect
- ☑ Structure and function
- ☐ Scale, proportion and quantity
- ☐ Stability and change of systems
- ☑ Systems and models
- ☐ Energy and matter in systems

S3- L7 # Penguin Habitat Prototype Testing

PROTOTYPE TEST DATA

TEAM	CAN YOU SEE THE PENGUIN?	HOW MUCH LIQUID MELTED?	NOTES
1	Yes No Some		
2	Yes No Some		
3	Yes No Some		
4	Yes No Some		
5	Yes No Some		
6	Yes No Some		

Which team's habitat was best for making people happy? Why?

___

___

___

Which team's habitat was best for making penguins happy? Why?

___

___

___

___

S3- L7 # Ideas for Redesign

Sketch and label your ideas for redesigning your habitat.

SECTION 3: *How can we design, test and improve our prototype of a penguin habitat?*

LESSON 8: *How can we use old materials to make something different?*

LEARNING TARGETS

Describe how an object can be disassembled and reassembled to make a new object with new functions.

Plan and build a new object using their old prototype.

VOCABULARY

disassemble   reassemble

SUMMARY

ESTIMATED NUMBER OF DAYS: 2

In the last lesson, students tested their penguin prototypes and compared data from the test of different designs.

In this lesson, students consider how properties of materials can allow them to be used for different purposes. First, students observe a wordless story involving a set of blocks that is made into many different objects and track a given block through the story. Then, students plan and create a new object using their old penguin habitats. **Students figure out that objects can be disassembled and reassembled to make a new object with different functions.**

This unit sets the stage for deeper learning in grades 3-5 on properties of matter, physical and chemical changes, and conservation of matter.

MYSCI MATERIALS:

Changes, Changes, by Pat Hutchins

Habitat materials (from previous lessons)

TEACHER PROVIDES:

Copies of Student Pages 3, 23 or Student Science Journals

Teacher Page 14

Copy and administer post-assessment

ENGAGE

Say to students: *Today we are going to "read" a special kind of story called Changes, Changes.* There is a Read-Aloud guide for this book on Teacher Page 14.

EXPLORE

What did the family in the book have as their materials? Did the materials change throughout the story? Take student responses. Some may say that the materials changed while others may disagree.

Let's look at the book again. This time, I am going to ask each of you to look for your block on each page.

There are 10 kinds of blocks (27 blocks total) on each page. Assign each pair or small group of students a type of block to track. Tell the students that you will track the large yellow arch. Use the first two pages of the book, which show the couple and all of the blocks before building, to make sure that students know what their block looks like. The other 9 block types are:

- 1 red triangle
- 1 yellow rectangle
- 7 long orange rectangles
- 3 short orange rectangles
- 2 small yellow arches
- 4 tall green cylinders
- 4 short green cylinders
- 2 small orange arcs
- 2 red rectangles with arches

Go through the book again, allowing each student time to find their block on each finished structure (house, fire truck, boat, truck, train and house). You will notice that the large yellow arch does not appear after the first house. Ask students why it does not appear. It burned away.

Let's go back to our original questions. What did the family in the book have as their materials? (They only had blocks). *Did the materials change throughout the story?* (No, they had the same materials except the large yellow arch, which burned away.) Take student responses.

EXPLAIN

If you are given materials, you can build many things out of the same set of materials. Building blocks are one example of this, but so are the materials that we have worked with to make our penguin habitat. What might we be able to make out of the materials that we used to make our penguin habitats?

Allow students time to discuss this question with their groups. If students are struggling with ideas, you may supply them a list to get started, such as a hat, a purse, a toy, a pencil holder, a cup insulator, etc.

Direct students to " Take Apart and Put Together" (Student Page 23). Ask them to draw and label a sketch of their penguin habitat and the new item they will build. They should use the Scientific Drawing Rubric (Student Page 3) to evaluate their own work.

ELABORATE

Give students time to disassemble and reassemble their materials. When they are finished building, they should go back to their drawing on Student Page 23 and see if it needs to be changed or updated to look more like the object they built.

Teaching Tip:

If your students are stuck and cannot come up with any ideas of what to make with their habitat materials, you can give them a possible list of things to choose from, such as: a hat, a purse, etc.

EVALUATE

Have each group share their new creation with the class, describing how they used each material in the original penguin habitat and in the new object.

EXTEND (OPTIONAL)

If you have Legos or blocks in your classroom, have students select a set of 20-30 blocks and work in small groups to create a story like *Changes, Changes.* They can illustrate their own short story or take photos of their blocks in the different arrangements.

NGSS/MLS Connections:

NGSS 2-PS1-3

Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

NGSS 2-PS1-2 (MLS 2.PS)

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

Science & Engineering Practices in lesson:

- [ ] Asking questions and defining problems
- [ ] Developing and using models
- [ ] Planning and carrying out investigations
- [ ] Analyzing and interpreting data
- [ ] Constructing explanations and designing solutions
- [x] Engaging in argument from evidence
- [ ] Using mathematics and computational thinking
- [ ] Obtaining, evaluating and communicating information

Crosscutting Concepts in lesson:

- [ ] Patterns
- [ ] Cause and effect
- [ ] Structure and function
- [ ] Scale, proportion and quantity
- [x] Stability and change of systems
- [ ] Systems and models
- [x] Energy and matter in systems

S3- L8 # Take Apart and Put Together

PENGUIN HABITAT

Draw and label the materials in your penguin habitat.

NEW ITEM: We will build: ______________________________

Draw and label your new item.

Teacher Page – S3-L8 Read-Aloud Guide: *Changes, Changes,* Pat Hutchins

Hold up the book and show the cover. Say: *I am going to quickly flip through this book. Think about if you notice anything special about this book!* Quickly flip through the book and have students share what they notice. (There are no words!)

How will we read this book if there are no words? Take student responses.

Teacher Note: These pages aren't numbered. Page 1 begins with Title Page (contains no pictures)

Pages 1-5 Read title page and then skip.

Pages 6-7 *Turn to a partner and describe what you see on these two pages*. Students should point out that there are different colored blocks, a toy man, and a toy woman.

Pages 8-9 *What do you think they are building?* Allow students to share out their answers.

Page 10 Show this page without showing page 11 yet. *What did they make?*

Page 11 *Uh-oh! Turn to your partner and create dialogue for this page.* Invite a few students to share out their responses.

Pages 12-13 Think aloud: *"Hum, I wonder what they are doing here? How are they going to put out the fire?"*

Page 14 Show this page without showing page 15 yet. *It looks like they are building something else. Let's make a prediction, what do you think they are building?*

Page 15 *What did they make? Was your prediction correct?*

Pages 16-17 *Turn to a partner and create dialogue for these two pages.* Invite a few students to share out their responses.

Pages 18-19 *What did they build? Did they use the same materials?*

Pages 20-21 *I see that they are disassembling their blocks again. What do you think they are going to do with them?*

Page 22-23 *Was your prediction correct? What did they build this time?*

Page 24 *Uh-oh! What happened here? What do you think they might do?*

Pages 25-27 Show pages and have students predict what they are building this time.

Page 28-29 *They built a train!*

Page 30-31 *It looks like they are building one more thing. What could it be?*

Page 32 Show page

Teacher Note: This book could also make a good writing activity as an extension. Students could write captions for each page of the book.

Name: ______________________ Date: ______________________

ASSESSMENT CHECKLIST ***Unit 11: A Home for a Penguin***

Materials Needed: Teacher pages, student science journals, provided MySci materials

LESSON		1 - BEGINNING	2 - DEVELOPING	3 - PROFICIENT
1	Student is able draw a scientific drawing of their penguin habitat design ideas (Student Page 2). Completed individually during Evaluate.			
2	Student is able to compare and contrast the work of scientists and engineers (Student Page 7). Completed in pairs during Evaluate.			
3	Student chooses the best material based off of properties for fish and mice habitats (Student Page 11). Completed individually during Evaluate.			
4	Student can use their knowledge of water changes to show what would happen if a penguin habitat got too warm (Student Page 15). Completed individually during Evaluate.			
5	Student chooses the best materials for penguins and people based off the results of their investigation (Student Page 18). Completed individually during Evaluate.			
6	Student designs a prototype for their penguin habitat (Student Page 20). Completed in groups during Evaluate.			
7	Student redesigns their prototype based off of the results of their tests (Student Page 22). Completed in groups during Evaluate.			
8	Student is able to create a new object using the same materials they used for their penguin habit. They are then able to share their ideas with the class.			

ASSESSMENT CHECKLIST *Unit 11: A Home for a Penguin*

Materials Needed: Teacher pages, student science journals, provided MySci materials

LESSON & OBJECTIVE	**STUDENT NAMES**																									
	STUDENT SCORES: 1 - BEGINNING 2 - DEVELOPING 3 - PROFICIENT																									
LESSON 1: Student is able draw a scientific drawing of their penguin habitat design ideas (Student Page 2). Completed individually during Evaluate.																										
LESSON 2: Student is able to compare and contrast the work of scientists and engineers (Student Page 7). Completed in pairs during Evaluate.																										
LESSON 3: Student chooses the best material based off of properties for fish and mice habitats (Student Page 11). Completed individually during Evaluate.																										

LESSON & OBJECTIVE	**STUDENT NAMES**																									
	STUDENT SCORES: 1 - BEGINNING 2 - DEVELOPING 3 - PROFICIENT																									
LESSON 4: Student can use their knowledge of water changes to show what would happen if a penguin habitat got too warm (Student Page 15). Completed individually during Evaluate.																										
LESSON 5: Student chooses the best materials for penguins and people based off the results of their investigation (Student Page 18). Completed individually during Evaluate.																										
LESSON 6: Student designs a prototype for their penguin habitat (Student Page 20). Completed in groups during Evaluate.																										

LESSON & OBJECTIVE	**STUDENT NAMES**																									
	STUDENT SCORES: 1 - BEGINNING 2 - DEVELOPING 3 - PROFICIENT																									
LESSON 7: Student redesigns their prototype based off of the results of their tests (Student Page 22). Completed in groups during Evaluate.																										
LESSON 8: Student is able to create a new object using the same materials they used for their penguin habit. They are then able to share their ideas with the class.																										

Section 1 Pre/Post Assessment

Unit 11 | Section 1: What do we need to know to design a zoo habitat?

Name: ____ Date: ____________________

1. Draw a line to match the <u>action</u> with the <u>person</u> most likely to do this.

<u>PERSON ACTION</u>

Design and construct a prototype

Scientist

Study something to learn all you can

Make a hypothesis

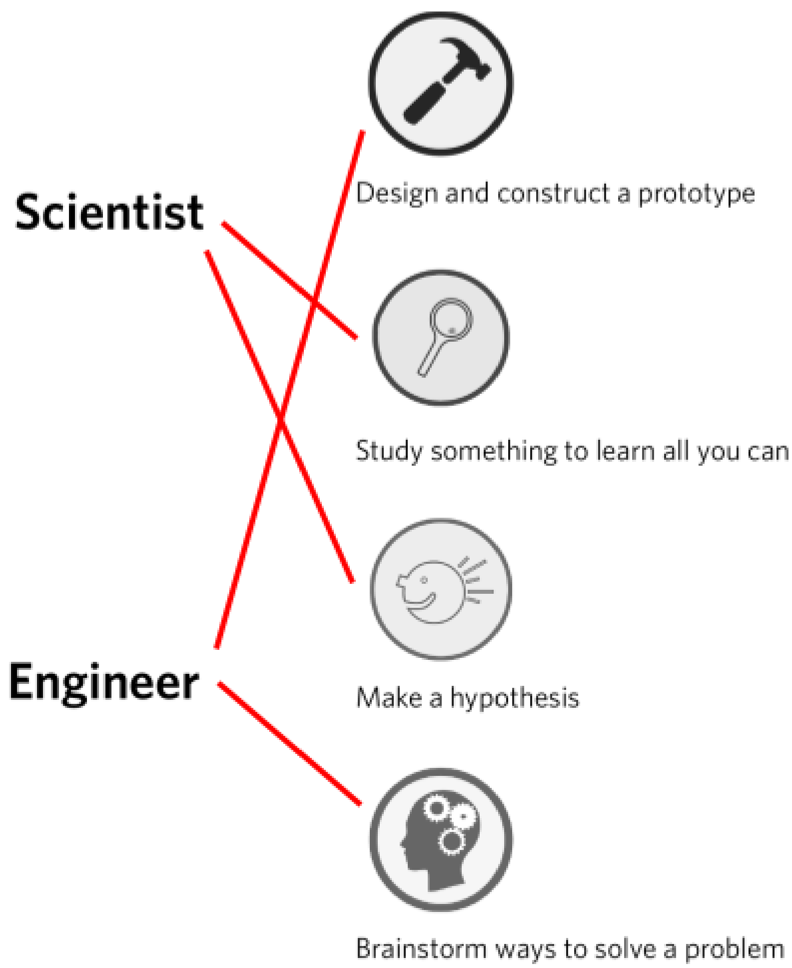
Engineer

Brainstorm ways to solve a problem

Section 1 Pre/Post Assessment Answer Key 4 pts
Unit 11 | Section 1: What do we need to know to design a zoo habitat?

1. Draw a line to match the action with the person most likely to do this. **4 POINTS.**
   1 point for each correct match.

PERSON ACTION



Unit 11 | Section 1 Assessment Standards Breakdown

STANDARDS ADDRESSED IN QUESTION 1: (Lesson 2)
ETS1.A.Defining and Delimiting Engineering Problems ETS1.B. Developing Possible Solutions ETS1.C. Optimizing the Design Solution Planning and Carrying Out Investigations

Section 2 Pre/Post Assessment

Unit 11 | Section 2: How do we discover the best materials for our habitat?

Name: ______________________________ Date: ________________

1. The data table below shows two properties of different objects.

OBJECT	**PROPERTY A:** __________	**PROPERTY B: TEXTURE** (What something feels like)
Plastic shoebox	White	Smooth
Felt	Black	Fuzzy
Bubble wrap	Green	Bumpy
Garbage bag	Black	Smooth

A. Identify Property A: ______________________________

B. Which objects are black?

____

____

____

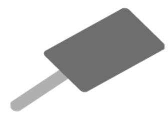
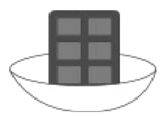
C. What do a garbage bag and a plastic shoebox have in common?

a. They are both black

b. They are both smooth

c. They are both bumpy

2. Lawrence and Latasha are conducting an investigation to see the effects of heating and cooling. The results they get are summarized below:

MATERIAL	**BEFORE** ADDING HEAT	**AFTER** ADDING HEAT
PAPER		
POPSICLE		
CHOCOLATE		
EGG		

Using the data above, complete the claim and evidence statements by circling the best answer.

Some changes caused by adding heat can be reversed and others cannot.

CLAIM: The change in the ___________________________ after adding heat **CAN** be reversed.

A. paper B. popsicle C. egg

EVIDENCE: I know this because if I cooled the object back down ______________________.

a. The material will go back to the same state (solid or liquid), but may be a different shape.

b. The material will not go back to the same state (solid or liquid).

c. The material will go back to the same state (solid or liquid) and will always be the same shape.

3. A student pours water from a faucet into a cup and places the cup in a freezer. After many hours, the water will change from:

a. Gas to liquid
b. Liquid to gas
c. Liquid to solid

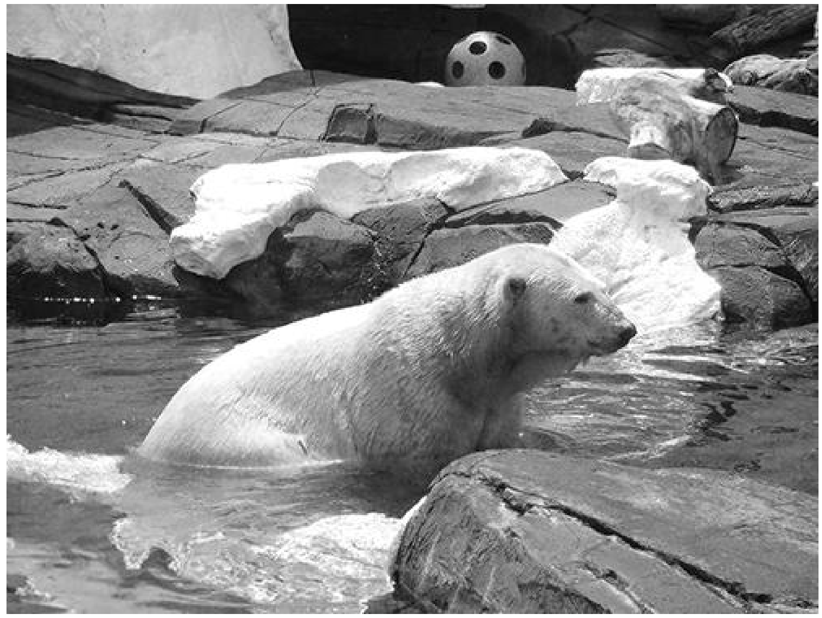
4a. Circle TWO ways that water changes when it goes from a liquid to a solid.

a. It gets colder
b. It gets warmer
c. It gets harder
d. It stays the same temperature
e. It flows more

4b. What could you do to make solid water change back into liquid water?

a. Increase the temperature
b. Decrease the temperature
c. Keep the temperature the same

5. The picture to the right shows a polar bear at the zoo.



A. Put an X on any material that will change form or shape if the habitat gets warmer.

B. Explain your reasoning.

Section 2 Pre/Post Assessment Answer Key 12 pts

Unit 11 | Section 2: How do we discover the best materials for our habitat?

1. The data table below shows two properties of different objects. **4 POINTS**

OBJECT	PROPERTY A: _________	PROPERTY B: TEXTURE (What something feels like)
Plastic shoebox	White	Smooth
Felt	Black	Fuzzy
Bubble wrap	Green	Bumpy
Garbage bag	Black	Smooth

A. Identify Property A: Color (1 point)

B. Which objects are black? 2 POINTS. 1 point for each item correctly identified as black.

The felt and garbage bag are both black.

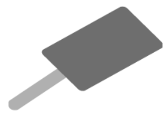
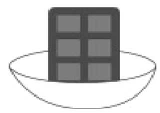
C. What do a garbage bag and a plastic shoebox have in common? 1 POINT

a. They are both black

b. They are both smooth

c. They are both flexible

2. Lawrence and Latasha are conducting an investigation to see the effects of heating and cooling. The results they get are summarized below:

MATERIAL	**BEFORE** ADDING HEAT	**AFTER** ADDING HEAT
PAPER		
POPSICLE		
CHOCOLATE		
EGG		

Using the data above, complete the claim and evidence statements by circling the best answer. **2 POINTS.** 1 point for selecting the correct claim. 1 point for selecting the correct evidence.

Some changes caused by adding heat can be reversed and others cannot.

CLAIM: The change in the ____________________________ after adding heat **CAN** be reversed.

A. paper B. popsicle C. egg

EVIDENCE: I know this because if I cooled the object back down ________________________.

a. The material will go back to the same state (solid or liquid), but may be a different shape.

b. The material will not go back to the same state (solid or liquid).

c. The material will go back to the same state (solid or liquid) and will always be the same shape.

3. A student pours water from a faucet into a cup and places the cup in a freezer. After many hours, the water will change from: 1 POINT

a. Gas to liquid
b. Liquid to gas
c. Liquid to solid

4a. Circle TWO ways that water changes when it goes from a liquid to a solid. 2 POINTS

a. It gets colder
b. It gets warmer
c. It gets harder
d. It stays the same temperature
e. It flows more

4b. What could you do to make solid water change back into liquid water? 1 POINT

a. Increase the temperature
b. Decrease the temperature
c. Keep the temperature the same

5. The picture to the right shows a polar bear at the zoo. **2 POINTS.**

A. Put an X on any material that will change form or shape if the habitat gets warmer. 1 POINT

B. Explain your reasoning. 1 POINT

The ice piles/snow piles will melt when heat is added and therefore get smaller and turn from solid to liquid.

Unit 11 | Section 2 Assessment Standards Breakdown

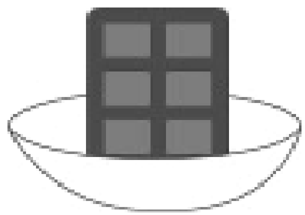
<table>
<tr><th colspan="3">STANDARDS ADDRESSED IN QUESTION 1: (Lesson 3)</th></tr>
<tr><td colspan="3">2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.</td></tr>
<tr><th>SCIENCE & ENGINEERING PRACTICES</th><th>DISCIPLINARY CORE IDEAS</th><th>CROSSCUTTING CONCEPTS</th></tr>
<tr><td>Analyzing and Interpreting Data
● Use data to serve as the basis for evidence to answer a question.</td><td>PS1.A: Structure and Properties of Matter
● Matter can be described and classified by its observable properties.</td><td>Patterns
● Patterns in the natural and human designed world can be observed.</td></tr>
<tr><th colspan="3">STANDARDS ADDRESSED IN QUESTION 2: (Lesson 4)</th></tr>
<tr><td colspan="3">2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.</td></tr>
<tr><th>SCIENCE & ENGINEERING PRACTICES</th><th>DISCIPLINARY CORE IDEAS</th><th>CROSSCUTTING CONCEPTS</th></tr>
<tr><td>Engaging in Argument from Evidence
● Construct an argument with evidence to support a claim.</td><td>PS1.B. Chemical Reactions
● Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.</td><td>Cause and Effect
● Events have causes that generate observable patterns.</td></tr>
<tr><th colspan="3">STANDARDS ADDRESSED IN QUESTION 3: (Lesson 4)</th></tr>
<tr><td colspan="3">PS1.A: Structure and Properties of Matter
Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature.</td></tr>
<tr><th colspan="3">STANDARDS ADDRESSED IN QUESTION 4: (Lesson 5)</th></tr>
<tr><td colspan="3">PS1.A: Structure and Properties of Matter
Different kinds of matter exist and many of them can be either solid or liquid, depending on the temperature</td></tr>
<tr><th colspan="3">STANDARDS ADDRESSED IN QUESTION 5: (Lesson 3)</th></tr>
<tr><td colspan="3">PS1.A: Structure and Properties of Matter
Different kinds of matter exist and many of them can be either solid or liquid, depending on the temperature
PS1.B: Chemical Reactions
Heating or cooling a substance may cause changes that can be observed.</td></tr>
</table>

Section 3 Pre/Post Assessment

Unit 11 | Section 3: How can we design, test and improve our prototype of a penguin habitat?

Name: ____ Date: ______________________

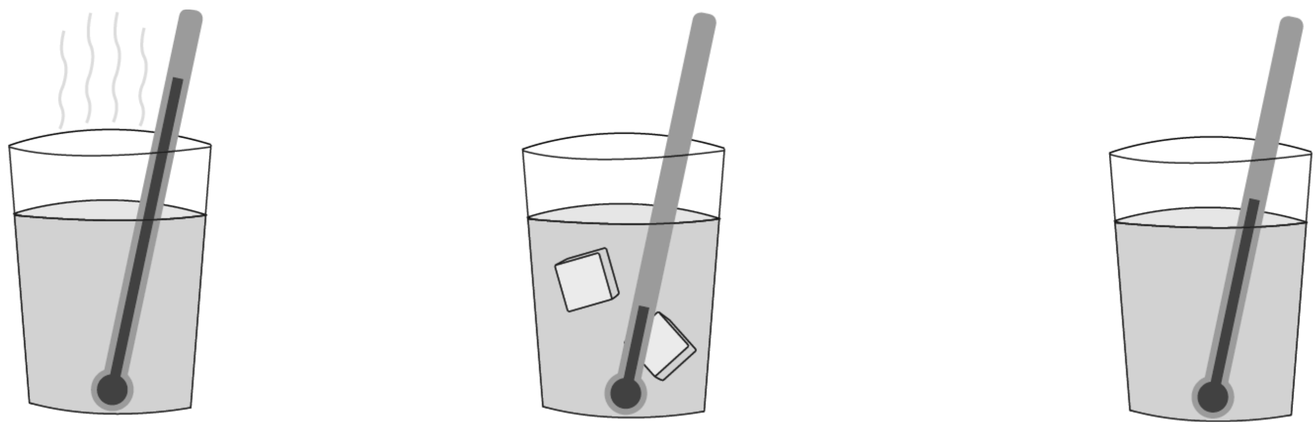
1.

SOLID CHOCOLATE	LIQUID CHOCOLATE
	

A. What do you think caused the chocolate to change from solid to liquid?

B. Suggest one solution for keeping the chocolate in solid form.

2. In designing your penguin habitat you need to choose the best material. You do the following test using cups made of different materials. The picture below shows the temperature of water after it has been in the sun for one hour.



Cup 1 **Cup 2** **Cup 3**

a. Which cup material would you use to keep the penguin the coldest?

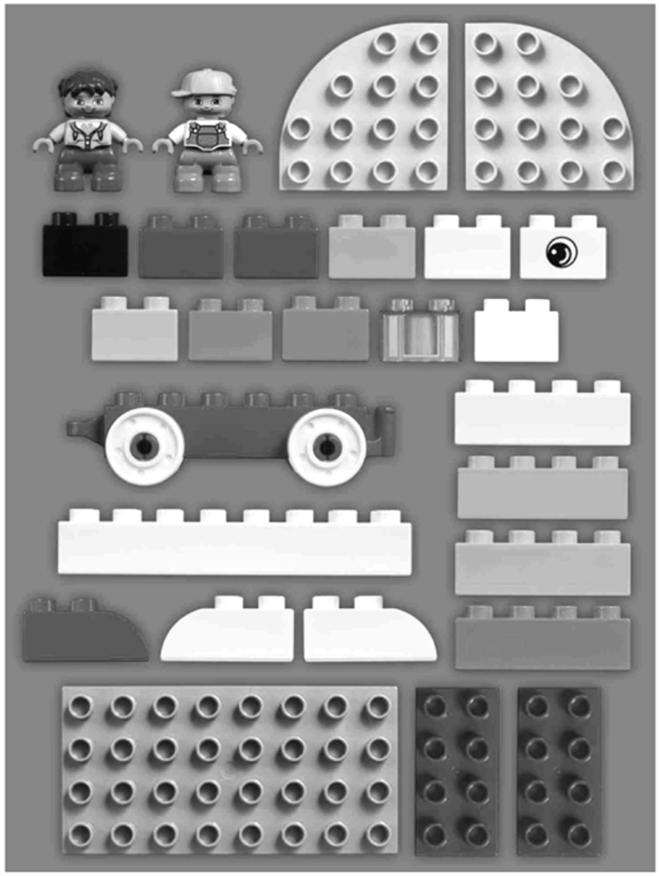
a. Cup 1

b. Cup 2

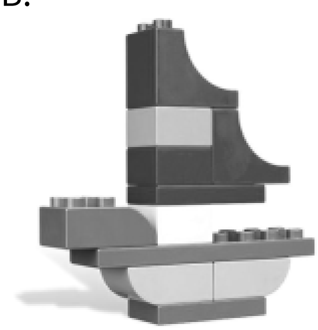
c. Cup 3

b. Explain why you chose that material.

3. The picture below shows Legos that came in a set.



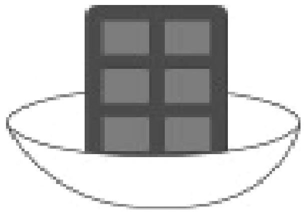
Which object was NOT made with the materials above?

A.	B.	C.
		

Section 3 Pre/Post Assessment Answer Key 10 pts

Unit 11 | Section 3: How can we design, test and improve our prototype of a penguin habitat?

1.

SOLID CHOCOLATE	LIQUID CHOCOLATE
	

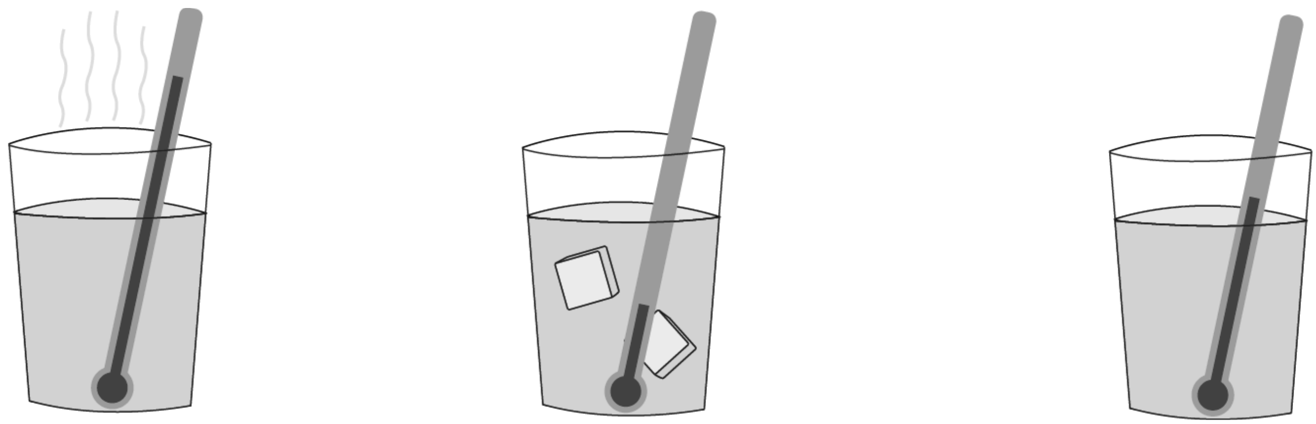
A. What do you think caused the chocolate to change from solid to liquid? 1 POINT

The student should be able to say that the chocolate was heated, or the temperature increased. This caused the chocolate to melt.

B. Suggest one solution for keeping the chocolate in solid form. 1 POINT

The student should be able to say that the chocolate could be placed in a container made of a material that protects it from the heat.

2. In designing the habitat you need to choose the best material. You do the following test using cups made of different materials. The picture below shows the temperature of water after it has been in the sun for one hour.



Cup 1 **Cup 2** **Cup 3**

A. Which cup material would you use to keep the polar bear the coldest? **1 POINT**

a. Cup 1

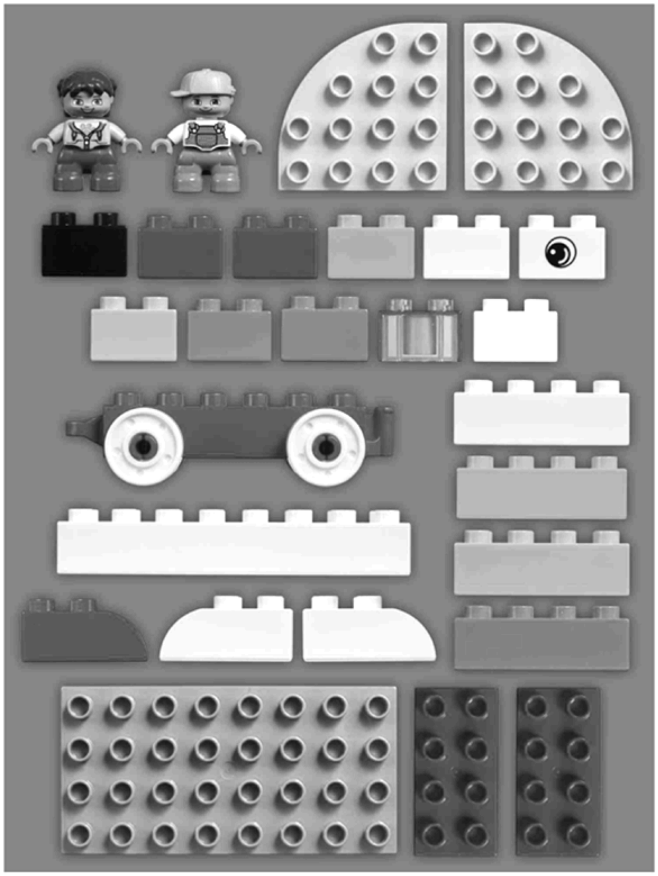
b. Cup 2

c. Cup 3

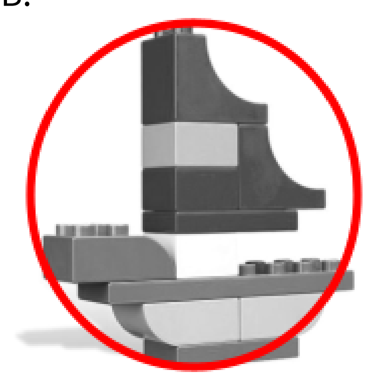
B. Explain why you chose that material. **2 POINTS.** 1 point for stating that cup 2 kept water coldest and 1 point for providing evidence.

The material in Cup 2 was able to keep the water the coldest. You can see this because the thermometer reading is the lowest and there are still ice cubes in the cup after 1 hour.

3. The picture below shows Legos that came in a set.



Which object was NOT made with the materials above? **1 POINT**

A.	B.	C.
		

Unit 11 | Section 3 Assessment Standards Breakdown

STANDARDS ADDRESSED IN QUESTION 1: (Lesson 6)		
PS1.A: Structure and Properties of Matter Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature K-2-ETS1-2 (1.ETS1.B.1) Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.		
STANDARDS ADDRESSED IN QUESTION 2: (Lesson 7)		
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.		
SCIENCE & ENGINEERING PRACTICES	**DISCIPLINARY CORE IDEAS**	**CROSSCUTTING CONCEPTS**
Analyzing and Interpreting Data ● Analyze data from tests of an object or tool to determine if it works as intended.	PS1.A: Structure and Properties of Matter ● Different properties are suited to different purposes.	Cause and Effect ● Simple tests can be designed to gather evidence to support or refute student ideas about causes.
STANDARDS ADDRESSED IN QUESTION 3: (Lesson 8)		
2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.		
SCIENCE & ENGINEERING PRACTICES	**DISCIPLINARY CORE IDEAS**	**CROSSCUTTING CONCEPTS**
Constructing Explanations and Designing Solutions ● Make observations to construct an evidence-based account for natural phenomena.	PS1.A: Structure and Properties of Matter ● A great variety of objects can be built up from a small set of pieces.	● Energy and Matter Objects may break into smaller pieces and be put together into larger pieces, or change shapes.

Unit 11: *A Home for a Penguin*

NEXT GENERATION SCIENCE STANDARDS / MISSOURI LEARNING STANDARDS

NGSS codes begin with the grade level, then the Disciplinary Core Idea code, then a standard number.↓ MLS codes begin with the grade level, then the Disciplinary Idea code, followed by a letter and number.↓ The Disciplinary Core Ideas are:

Physical Sciences PS1: Matter and its interactions PS2: Motion and stability: Forces and interactions PS3: Energy PS4: Waves and their applications in technologies for information transfer **Life Sciences** LS1: From molecules to organisms: Structures and processes LS2: Ecosystems: Interactions, energy, and dynamics LS3: Heredity: Inheritance and variation of traits LS4: Biological evolution: Unity and diversity	**Earth and Space Sciences** ESS1: Earth's place in the universe ESS2: Earth's systems ESS3: Earth and human activity **Engineering, Technology, and Applications of Science** ETS1: Engineering design ETS2: Links among engineering, technology, science, and society

For more information about NGSS, visit http://www.nextgenscience.org/next-generation-science-standards
For more information about MLS, visit
https://dese.mo.gov/college-career-readiness/curriculum/missouri-learning-standards#mini-panel-mls-standards3

Note: The MLS codes are listed in parentheses in the table below.

PERFORMANCE EXPECTATIONS	CONNECTION TO UNIT ACTIVITIES
2-PS1-1. (2. PS1.A.1) Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.	Students examine and describe the materials used to make a pencil. Students plan and conduct investigations about how some materials change with temperature (wax, ice) and some do not (metal). Students observe and describe various materials that could be used for insulation.
2-PS1-2. (2.PS1.A.2) Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.	Students observe and test materials to determine why each was chosen to perform its function in a pencil. Students test several materials to determine which one has the best insulating properties. Students use the results of material testing to design their habitats to meet the needs of penguins and people.
2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.	Students examine the ways that the materials in a pencil are used in a wide variety of other objects and discuss how each material's properties have led to its uses. Students track the progress of "their" block to determine that the same materials are reused in novel ways throughout the story. Students use the materials from their penguin habitats to design and create a new object.

2-PS1-4. (3.PS1.B.1) Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.	Students observe that both ice and wax melt due to heat but that only wax goes back to a solid at room temperature. Students observe that a candle wick becomes black and falls apart when it is burnt and that this change is not reversible.
K-2-ETS1-1 (2.ETS1.A.1) Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.	Students use text and webcams to gather information about the habitat needs of penguins. Students use the results of material testing to design their habitats to meet the needs of penguins and people.
K-2-ETS1-2 (1.ETS1.B.1) Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	Students create drawings of their initial design ideas. Students examine their original habitat designs and create a new design based on evidence gathered during material testing.
K-2-ETS1-3 (2.ETS1.C.1) Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.	Students test their habitats and create a new design based on the results of testing.
(3.PS1.A.1) Predict and investigate that water can change from a liquid to a solid (freeze), and back again (melt), or from a liquid to a gas (evaporation), and back again (condensation) as the result of temperature changes.	Students conduct investigations on ice (solid) melting into water (liquid) and wax melting and then reforming as a solid as a result of temperature changes.
DISCIPLINARY CORE IDEAS	**CONNECTION TO UNIT ACTIVITIES**
PS1.A: Structure and Properties of Matter Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature.	Students examine both water and wax in both liquid and solid states.
PS1.A: Structure and Properties of Matter Matter can be described and classified by its observable properties.	Students examine and record properties of the materials that are used to make up a pencil. Students examine and record properties of various potential insulating materials.
PS1.A: Structure and Properties of Matter Different properties are suited to different purposes.	Students explain how each part of a pencil was made out of a particular material for reasons that relate to the material's properties. Students choose materials that will insulate their habitat and other materials to allow humans to see the penguins using the material properties they observe and measure. Students use the results of material testing to design their habitats to meet the needs of penguins and people.

PS1.A: Structure and Properties of Matter A great variety of objects can be built up from a small set of pieces.	Students learn how each component of a pencil can also be used for other objects. Students track the progress of “their” block to determine that the same materials are reused in novel ways throughout the story. Students use the materials from their penguin habitats to design and create a new object.
PS1.B: Chemical Reactions Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	Students plan and conduct investigations about how some materials change with temperature (wax, ice) and some do not (metal). Students observe liquid wax returning to a solid at room temperature while liquid water remains a liquid.
ETS1.A: Defining and Delimiting Engineering Problems A situation that people want to change or create can be approached as a problem to be solved through engineering.	Students begin their design project by thinking about the problem that needs to be solved and the needs of penguins and people. Students explain how the engineering design process is used to solve problems. Students design a habitat that meets the needs of penguins and people.
ETS1.A: Defining and Delimiting Engineering Problems Asking questions, making observations, and gathering information are helpful in thinking about problems.	Students will use text, videos, and prior experiences to define the problem to be solved. Students discover the roles that scientists and engineers play in solving complex problems. Students use information and data gathered from testing to select the best materials for their habitats.
ETS1.A: Defining and Delimiting Engineering Problems Before beginning to design a solution, it is important to clearly understand the problem.	Students define the needs of both penguins and people. Students explain how both scientist and engineers are needed to solve our problem Students select materials and design a habitat to meet the needs of both penguins and people.
ETS1.B: Developing Possible Solutions Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people.	Students make initial design drawings for their habitats. Students will examine their original habitat designs and create a new design based on evidence gathered during material testing. Students will create a new design for their habitats based on the results of habitat testing.
ETS1.C: Optimizing the Design Solution Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	Students use webcams to compare and contrast penguin habitats that others have built. Students will compare the habitat of each group based on how well each solution meets the needs of both penguins and people.

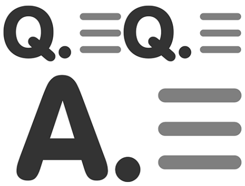
SCIENCE AND ENGINEERING PRACTICES (SEP)	CONNECTION TO UNIT ACTIVITIES
Asking Questions and Defining Problems	Students ask questions about the needs of animals and of zoo visitors to define the problem we will try to solve. Students ask questions about materials that will meet the needs of penguins and people (insulation, transparency, etc).
Developing and Using Models	Students use their conclusions from testing to create design drawings for their final penguin habitats. Students create prototype habitats using their design drawings. Students develop model habitats, present their habitat design to the class, and compare the designs from each group.
Planning and Carrying Out Investigations	Students investigate the properties of materials and record their findings. Students observe material properties of parts of a tea light, use those properties to make predictions, and then observe what happens to the materials when the tea light is lit. Students plan and conduct an investigation of the insulating properties of various materials. Students collect data to compare the insulating properties of materials with an uninsulated thermometer. Students examine materials and document material properties (including transparency) to determine if the materials will meet the needs of penguins and people. Students predict how well their habitat will protect their penguin and compare this prediction to actual results. Students conduct an investigation to determine how well their habitat meets the needs of penguins. Students collect and compare temperature and volume data to evaluate competing models.
Analyzing and Interpreting Data	Students measure and record temperature and volume data. Students compare their predictions of material changes to what actually happens when the tea light is lit and when ice cubes are placed in different locations. Students collect and analyze temperature data and compare the actual data with their predictions of which material will be the best insulator Students measure and record temperature and volume data and compare results to determine success.
Engaging in Argument from Evidence	Students use evidence from videos and diagrams to make and support claims about the work of scientists and engineers. Students support their choice of habitat materials based on observed material properties. Students use both quantitative (temperature) and qualitative (transparency) data to support claims about the best materials to meet the needs of penguins and people. Students evaluate the various habitat designs and argue from evidence about which one best meets the needs of both penguins and people. Students carefully track how their block changes throughout a story to support an argument about what changes and what stays the same.
Using Mathematics and Computational Thinking	Students use both qualitative (hot and cold) and quantitative data (temperature and volume) to describe test conditions and results. Students measure and compare temperatures to determine insulating properties of various materials. Students use both qualitative (viewing ability) and quantitative (temperature and volume) data to compare each team's habitat.
Constructing Explanations and Designing Solutions	Students compare and contrast a variety of constructed penguin habitats. Students use observations and collected data to determine how temperature changes affect matter. Students create prototype habitats that meet the needs of both penguins and people.

Obtaining, Evaluating, and Communicating Information	Students use text and webcam videos to determine the habitat needs of penguins. Students create drawings of initial design ideas for the habitat. Students use videos and diagrams to understand the work of scientists and engineers. Students examine photos of a small set of materials being used in a wide variety of ways and describe how the each material's properties make it well suited for each use. Students create design drawings for their habitats, including labels of materials used based on previous testing.

CROSSCUTTING CONCEPTS	CONNECTION TO UNIT ACTIVITIES
Patterns	Students use webcams to determine common design elements of other penguin habitats.
Cause and Effect: Mechanisms and Prediction	Students predict and observe changes to tea light materials caused by lighting the tea light. Students predict and observe changes to ice in various locations. Students conduct a simple experiment to determine which material will have the best insulating properties.
Scale, Proportion, and Quantity	Students use standard units to measure temperature and volume.
Systems and System Models	Students create drawings of habitat designs, including labels of the various parts. Students understand the work of both scientists and engineers using diagrams. Students examine a pencil as a system and explain how each part was chosen based on material properties and how these parts work together to allow the pencil to function. Students justify their choice of materials for the penguin habitats based on the way the materials will work together to meet various needs. Students present their habitat designs, including why they chose the materials to meet specific goals.
Structure and Function	Students create initial design drawings for a penguin habitat that meets the needs of penguins and people. Students explore and describe the properties of materials in order to determine how each material can be used. Students design penguin habitats based on their knowledge of what people and penguins need and on the results of previous testing.
Energy and Matter	Students combine their knowledge of material properties and images of how these materials are used in different ways to explain that a small number of materials can be used and combined in a large number of ways. Students observe the effects of heat energy on matter, including wax and ice. Students use the materials from their penguin habitats to create a new object.
Stability and Change	Students predict and observe changes to tea light materials caused by lighting the tea light. Students predict and observe changes to ice in two locations and compare the rate of change of the ice. Students perform an experiment to test which materials have the best insulating properties by determining which ones slow down the temperature change caused by a heat lamp. Students use the materials from their penguin habitats to create a new object.

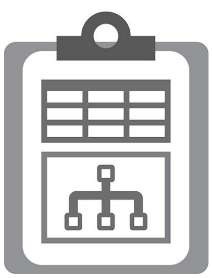
Unit 11 Vocabulary and Glossary

BRAINSTORM
a spontaneous production of ideas

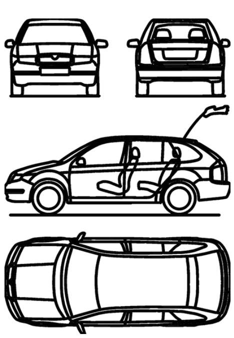


CONCLUSION
a statement that tells what an investigation showed, based on observations and data

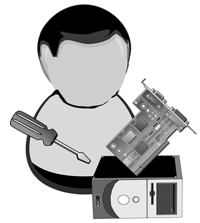
CRITERIA
standards that engineers should meet in designing a system or device



DATA
pieces of information collected in an investigation



DESIGN
the process of deciding how something will be made, including how it will work and what it will look like



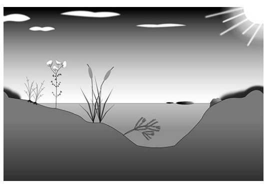
DISASSEMBLE
to take apart

ENGINEER
a person who uses math and science to design technology that solves problems

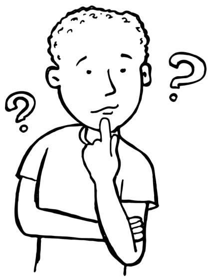
EXPERIMENT
a scientific investigation undertaken to make a discovery, test a hypothesis, or demonstrate a known fact

FLEXIBILITY
ability to be easily modified; quality of bending easily without breaking

FREEZE
to change from a liquid to a solid when temperature drops



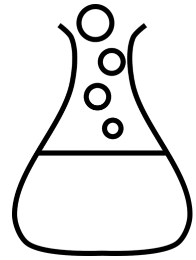
HABITAT
the natural home or environment of an animal, plant, or other organism



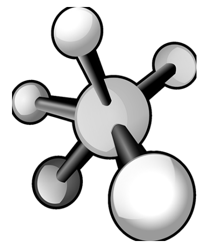
HYPOTHESIS
a detailed prediction about what might happen in an experiment or observation

INSULATE
material used to insulate something; with a material that reduces the passage of heat, electricity, or sound

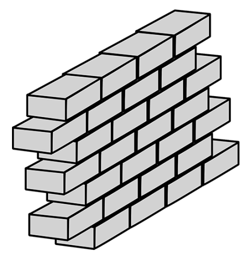
INSULATION
material used to insulate something; a material that does not let heat energy or electricity pass through easily



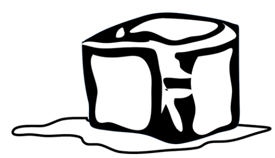
LIQUID
a state of matter in which the substance has a definite volume, but takes the shape of its container



MATTER
the material, or “stuff,” that everything is made of

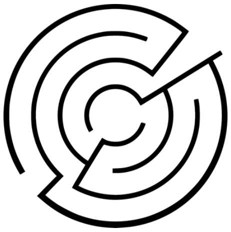


MATERIAL
the matter from which a thing is or can be made

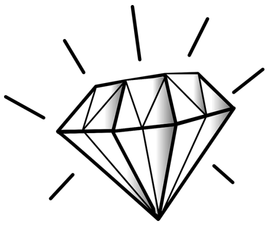


MELT
to change from a solid to a liquid when temperature rises

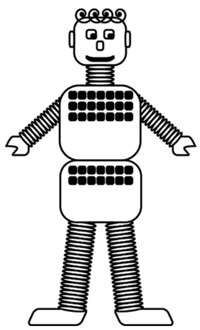
OBSERVATION
the action or process of noticing or watching something carefully in order to gain information



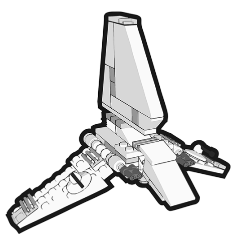
PROBLEM
something that needs to be solved or improved



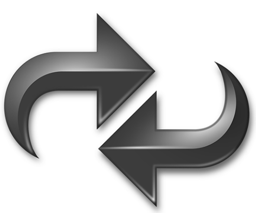
PROPERTY
a characteristic of something that can be observed



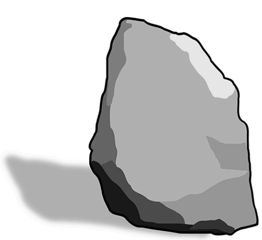
PROTOTYPE
a first or preliminary model of something



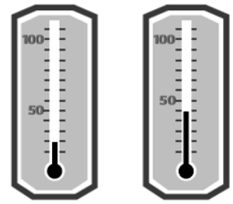
REASSEMBLE
put together again



REVERSIBLE
capable of changing between two states of matter



SOLID
a state of matter in which the substance has a definite shape and volume



TEMPERATURE
a degree of hotness or coldness that can be measured using a thermometer; a measure of how fast the particles of a substance are moving

TEXTURE
the feel and appearance of a surface or substance

TRANSPARENT
something clear or see through

VOLUME
the amount of space a substance or object occupies

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