Pillbots

Description

After making observations of pill bugs, students are challenged to solve a human problem through biomimicry, the design of technologies that are modeled on living things. They read about some pill bug–inspired technologies as well as some other examples of biomimicry, and then design a device that mimics a pill bug's structures and behaviors.

Suggested Grade Levels: K–2

LESSON OBJECTIVES Connecting to the *Framework*		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concept**
Developing and Using Models Constructing Explanations and Designing Solutions	**LS1.A:** Structure and Function **ETS1.B:** Developing Possible Solutions **ETS2.B:** Influence of Engineering, Technology, and Science on Society and the Natural World	Structure and Function

Featured Picture Books

TITLE: ***Next Time You See a Pill Bug***
AUTHOR: **Emily Morgan**
PUBLISHER: **NSTA Kids**
YEAR: **2013**
GENRE: **Non-Narrative Information**
SUMMARY: *This book invites children and adults to interact with these fascinating animals and learn about their extraordinary features.*

TITLE: ***National Geographic Kids: Robots***
AUTHOR: **Melissa Stewart**
PUBLISHER: **National Geographic Children's Books**
YEAR: **2014**
GENRE: **Non-Narrative Information**
SUMMARY: *Young readers will learn about the most fascinating robots of today and tomorrow in this colorful, photo-packed book.*

Chapter 17

Time Needed

This lesson will take several class periods. Suggested scheduling is as follows:

Day 1: **Engage** with *Next Time You See a Pill Bug* Introduction **Explore** with Pill Bug Observations, and **Explain** with *Next Time You See a Pill Bug* Read-Aloud

Day 2: **Explain** with Biomimicry: Pillbot Video and *Robots* Read-Aloud

Day 3: **Elaborate** with Pillbot Designs and **Evaluate** with My Pillbot

Materials

For Pill Bug Observations (per student)

- Pill bugs
- Clear plastic container (with sides high enough to contain the pill bugs, or use a lid with tiny air holes punched through it)
- Piece of paper towel small enough to cover ½ of container bottom, dampened with water from a clean spray bottle
- Hand lens

SAFETY

- Wash hands with soap and water after completing this activity.
- Ensure that pill bugs do not become dehydrated, are not too hot or cold, and are not handled roughly.
- Remind students that all living things should be handled gently.

Student Pages

- Let's Learn About Pill Bugs
- Pill Bug Observations
- My Pillbot
- STEM at Home

Background for Teachers

Turn over a rock or rotting log nearly anywhere in the United States, and (if it is above freezing) you are likely to find a pill bug! Pill bugs, also called *roly-polies,* are small terrestrial isopods abundant in temperate areas throughout the world. Because they are engaging, harmless, and easily collected, they provide an excellent opportunity for children to learn about invertebrate body parts and behaviors. In this lesson, students also learn how studying common pill bugs has led roboticists to some exciting technologies that mimic their structures and functions.

Although many students might think of pill bugs as bugs or insects, they are neither. Pill bugs are actually crustaceans, like lobsters, shrimp, and crabs. But pill bugs are unusual crustaceans because they live their entire lives on land. Like all crustaceans, pill bugs breathe through gills. Their gills must be moist for them to breathe. However, pill bugs are not able to breathe underwater like their crustacean relatives, so it is important to store them in a place that is damp, but not too wet. A small aquarium or plastic container with moist soil is all you need to store them safely in the classroom. Pill bugs have 14 legs, 2 antennae, and 2 eyes, and their exoskeletons are divided into many segments. The most notable behavior of the pill bug is its ability to roll into a ball when it feels threatened.

Researchers in South Korea and Germany have developed technologies that mimic the structures and behaviors of pill bugs to solve human problems. German researchers have created a prototype for the OLE (pronounced "oh-luh") pill bug to detect and fight forest fires. They have scaled up the pill bug's form to the size of a St. Bernard. But instead of having 14 legs like a pill bug, OLE only has 6. These enormous, 200 lb. robots scuttle around the forest floor at speeds of 6–12 miles per hour and use infrared "biosensors" to detect fire sources. To protect itself, the OLE has a segmented shell that allows it to curl into a ball just like a real pill bug. This ceramic-fiber compound shell can withstand temperatures of more than 2300°F! According to researchers, 30 OLEs could protect a forest as large as 2,700 square miles.

A PILL BUG

Roboticists in South Korea have designed a robot called the Pillbot that mimics a pill bug. This robot is about the size of a softball, and it has two modes: protection and locomotion. In protection mode, the Pillbot rolls into a ball and can be "bowled" into a location that is too dangerous for humans. Once it reaches the target, it unrolls into locomotion mode and can then move around and collect information in this dangerous area. See the "Websites" section at the end of this lesson for more information about these pill bug–inspired robots.

OLE and the Pillbot are examples of *biomimicry*, which is the design and production of materials, structures, and systems modeled on living things. This field of science is known as *biomimetics*. Scientists and engineers study nature and use its solutions to solve human problems. One of the most well-known examples of biomimicry is the invention of Velcro (see Biomimicry Photo Gallery in "Websites" section). Swiss inventor George de Mestral noticed how strongly cockleburs stuck to his pants after a walk through the woods, so he decided to look closely at them under a microscope. He observed that the burs were covered in small hooks and that the hooks caught the loops in the fabric of his pants. This observation inspired him to design a loop-and-hook fastening system, which we now know as Velcro. Olympians wear swimsuits that mimic sharkskin, underwater communication devices mimic the sounds that dolphins send through the water, NASA has suggested the development of aircraft that are modeled on the shape of twirling maple seeds, and the list goes on and on.

In this lesson, students begin by observing the structures and behaviors of a familiar animal, the pill bug. They read about some pill bug–inspired technologies as well as some other examples of biomimicry. Then, they are challenged to design a pillbot to solve a human problem. Students share their designs through sketches and drawings. These activities allow students to experience the science and engineering practice of developing models, while addressing the crosscutting concept of structure and function.

engage

Next Time You See a Pill Bug Introduction

Making Connections: Text to Self

Show students the cover of *Next Time You See a Pill Bug* and introduce the author, Emily Morgan. Tell them that as a child, the author enjoyed exploring the outdoors, looking under rocks and logs to see what was living there. Now, she and her young son like to explore the woods in their backyard together, collecting pill bugs and other living things to observe. Ask students if they have ever collected pill bugs or played with them. If so, where did they find them? What did they do with them? Read aloud only pages 6–7, which encourage students to pick up a pill bug and let it crawl around on their hands, observe it closely, and describe it.

Observing a pill bug

Tell students that, later, they are going to have an opportunity to do just that!

Anticipation Guide

Project a copy of the Let's Learn About Pill Bugs student page. Preassess the students' understandings about pill bugs by having them signal (thumbs-up or thumbs-down) to indicate whether they agree or disagree with each of the following statements (they should also write *T* or *F* in the left-hand column of the student page):

1. Pill bugs have 14 legs.
2. Pill bugs are insects.
3. Pill bugs hatch from eggs.
4. Pill bugs roll into a ball when they feel threatened or scared.
5. Pill bugs prefer very dry places.

Tell them that after observing pill bugs and reading the rest of the book, they will be revisiting the student page to see if their guesses were correct.

explore

Pill Bug Observations

In advance, collect some live pill bugs from the local environment (one per student), and keep them in a temporary habitat containing some damp paper towels or damp leaf litter. Make sure the sides of the container are high enough that the pill bugs cannot escape (or use a lid with tiny air holes punched through). You can also have your students collect the pill bugs for homework and bring them to class for this activity.

Give each student a Pill Bug Observations student page and a hand lens. Tell them that they will be closely observing pill bugs to learn more about their body parts and behaviors. Remind them to treat the pill bugs gently, then give each student a pill bug in a clear plastic container with half of the bottom covered with a piece of damp paper towel. (Students will be observing whether the pill bugs seem to prefer damp or dry places, so it is important not to cover the entire container bottom with the damp paper towel.) Review how to use a magnifier properly: Put your eye close to the lens, shut the other eye, and move the hand lens close to the pill bug until it comes into focus. Students will observe the pill bug; make a detailed, labeled sketch of it on the student page; and describe its body parts and behaviors. Next, they will observe and record the pill bug's reactions to different stimuli in a chart.

explain

Next Time You See a Pill Bug Read-Aloud

Turn and Talk

Have students explain what they have observed by sharing their drawings and observations with a partner. Then, *ask*

? What did you notice about your pill bug's body parts? Did you see segments, feet, or antennae? (Answers will vary.)

? What did you notice about your pill bug's behavior in response to your actions? Did it move away from touch, flip itself back over, roll into a ball, and move back to the damp paper towel? (Answers will vary.)

? Why do you think your pill bug reacted that way? (Answers will vary.)

As a class, discuss whether students have evidence that any of the statements on the Let's Learn About Pill Bug's student page are true or false. They will most likely have evidence to show that statement 1 is true ("Pill bugs have 14 legs"), statement 4 is true ("Pill bugs roll into a ball when they feel threatened or scared"), and statement 5 is false ("Pill bugs prefer very dry places").

Connecting to the Common Core
Reading: Informational Text
Key Ideas and Details: K.1, 1.1, 2.1

Determining Importance

Now, tell students that you are going to share the rest of the book *Next Time You See a Pill Bug* and that this book will provide more evidence about the statements on the anticipation guide. It might also help them understand some of the pill bug behaviors they observed earlier. Have students signal when they hear evidence from the text for or against any of the five statements. Stop and discuss each one as you read the book aloud. Students should record the correct answers in the right-hand column of the student page. The correct answers are as follows:

1. Pill bugs have 14 legs. (true, p. 9)
2. Pill bugs are insects. (false, pp. 9–11; they are crustaceans)
3. Pill bugs hatch from eggs. (true, p. 13)
4. Pill bugs roll into a ball when they feel threatened or scared. (true, p. 15)
5. Pill bugs prefer very dry places. (false, pp. 23–25; pill bugs need moisture)

After reading, *ask*

? If your pill bug moved back to the damp paper towel when you moved it to a dry place, why do you think it did so? (Pill bugs need to stay in damp or moist areas so they can breathe through their gills.)

? If your pill bug rolled up when you touched it or turned it over, why do you think it did so? (It felt threatened or scared.)

? What body parts help the pill bug roll up? (its segments or its segmented exoskeleton)

Revisit page 15 of the book, which shows a pill bug flattened out and then rolled up into a ball to protect itself. Students should be able to see from the pictures how the exoskeleton protects the inner, softer part of its body. Explain that this defense mechanism is so unique and special that *roboticists,* or engineers who design robots, have actually tried to copy it!

Biomimicry: Pillbot Video

Making Connections: Text to World

Tell students that a team of roboticists in South Korea have created a working robot called the Pillbot. The Pillbot is based on many of the structures and abilities of real pill bugs. Show students the video of the Pillbot (see "Websites" section), and *ask*

? How does the Pillbot compare to a real pill bug? (It crawls over obstacles, it rolls into a ball, it has a hard exoskeleton, etc.)

? What do you think a robotic pill bug might be used for? (Answers will vary.)

Explain that this little robot is about the size of a softball and can be rolled up and "bowled" into a location that is too dangerous for humans. Once it reaches the target point, it unrolls and then crawls around and collects information. Roboticists in Germany are working on another type of pillbot—the OLE (pronounced "oh-luh") pill bug, which could someday be used to fight forest fires. It carries water and fire extinguishers and has a fireproof exoskeleton. Explain that engineers often look to nature for ideas. Imitating living things to solve a human problem is called *biomimicry*. Explain that the prefix *bio* means "life" and the word *mimic* means "to

imitate." So the invention of robotic pillbots is an example of biomimicry—"imitating life."

Robots Read-Aloud

Connecting to the Common Core
Reading: Informational Text
Key Ideas and Details: K.1, 1.1, 2.1

Chunking

Show students the cover of the book *National Geographic Kids: Robots*, and ask if they know what a robot is. You will likely get a wide variety of responses. In fact, engineers themselves don't always agree on the definition of *robot*. Explain that because the book is nonfiction, you can enter the text at any point. You don't have to read the book from cover to cover if you are looking for specific information. Tell students that you will be reading the parts of the book that explain how engineers sometimes look to nature for inspiration. Read and discuss pages 4–7, which describe these characteristics of a robot:

- Has movable parts
- Can make decisions
- Is designed by people to do a job by itself
- Collects information from its surroundings
- Processes the information and figures out what to do next
- Does only things it is programmed to do

Questioning

Then, *ask*

? What makes a Pillbot a robot? (It has movable parts, it is designed to do a job by itself, it collects information, etc.)

Tell students to listen carefully as you read another section of the book. This section gives more examples of biomimicry—robots inspired by nature. Have students listen for the different kinds of animals that roboticists study as they design robots. Read aloud pages 16–21 of *Robots,* making sure to share the photographs and insets as you read. Then, share another example of biomimicry by reading about the Robotuna pictured on page 13.

After reading, *ask*

? What is the branch of science called that uses *biomimicry* (borrowing ideas from nature)? (biomimetics)

? What kinds of animals did roboticists study to design the robots you learned about? (ladybugs, geckos, dogs, jellyfish, snakes, fish)

? Why do roboticists study animals? (to get ideas for solving design problems)

? Can you guess what animal roboticists have studied more than any other animal in the world? (humans!)

Then, read pages 32–33, about humanlike robots. Explain that studying how humans move and behave is also an example of biomimicry. For more examples of biomimicry, see the "Websites" section for a photo gallery.

elaborate

Pillbot Designs

Tell students they are going to have the opportunity to design their very own robot! They will be using biomimicry by studying the body parts and movements of pill bugs to invent a pillbot. The purpose of designing a pillbot is to solve a human problem or need. You may want to have students observe live pill bugs again to get inspiration for their pillbot designs. Alternately, you can view a video segment that gives a close-up view of the pill bug's body parts and behaviors, such as the one at *www.youtube.com/watch?v=DWW8Caur8Co*.

Begin the brainstorming process by discussing questions such as the following:

? What are some unique body parts you noticed when observing your pill bug? (14 legs, antennae, hard exoskeleton, segments, etc.)

- ? What are some unique movements or behaviors you noticed when observing your pill bugs? (They roll up when threatened, they crawl over things, they flip over when turned on their backs, etc.)
- ? What are some human problems that a pillbot might be able to solve? (Answers will vary.)
- ? Are there places that are unsafe for humans that a pillbot might be able to explore? (Answers will vary.)
- ? Are there jobs that a robotic pill bug could do that humans could not? (Answers will vary.)
- ? Are there toys or devices that could be inspired by a pill bug's movements or body parts? (Answers will vary.)

Then, brainstorm some pillbot ideas together. Examples might include an expandable backpack that automatically rolls up for storage when it is empty, a device that transports something by rolling up into a ball and then unrolling when it reaches its destination, a modified soccer ball that rolls up when it is kicked and then unrolls and moves by itself to make the game more fun and interesting, and so on.

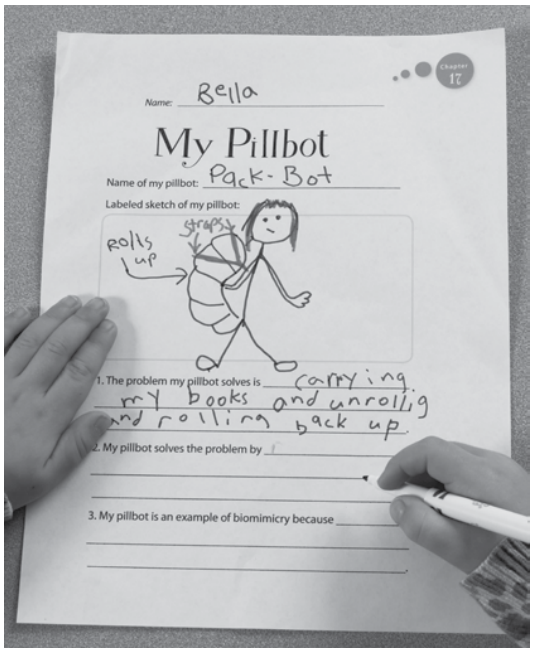
evaluate

My Pillbot

Connecting to the Common Core
Writing
Text Types and Purposes: K.3, 1.3, 2.3

Writing

Have each student select an idea from your brainstorming session or come up with an idea of his or her own. Give each student a copy of the My Pillbot student page, and have them begin designing their pillbots. Students should be able to make a simple, labeled sketch to illustrate how the features of the pillbot help it solve a human problem; describe the human problem the pillbot solves; and explain how the pillbot is an example of biomimicry.



My pillbot

STEM at Home

Have students complete the "I learned that …" and "My favorite part of the lesson was …" portions of the STEM at Home student page as a reflection on their learning. They may choose to do the following at-home activity with an adult helper and share their results with the class. If students do not have access to the internet or these materials at home, you may choose to have them complete this activity at school.

"At home, we can watch a video together called 'RoboSnail' about how roboticists, or engineers who design robots, are studying the movements of snails and slugs to invent a new kind of robot."

Search "RoboSnail" on pbslearningmedia.org *to find the video at* www.pbslearningmedia.org/resource/eng06.sci.engin.systems.robosnail/robosnail.

"After we watch the video, we can design our own robot based on a different animal!"

For Further Exploration

This section is provided to help you encourage your students to use the science and engineering practices in a more student-directed format. This box lists questions and challenges related to the lesson that students may select to research, investigate, or innovate. Students may also use the questions as examples to help them generate their own questions. After selecting one of the questions in the box or formulating their own questions, students can individually or collaboratively make predictions, design investigations or surveys to test their predictions, collect evidence, devise explanations, design solutions, or examine related resources. They can communicate their findings through a science notebook, at a poster session or gallery walk, or by producing a media project.

Research

Have students brainstorm researchable questions:

- ? Where do pill bugs live?
- ? What are some other types of isopods, and where do they live?
- ? What are some other examples of biomimicry?

Investigate

Have students brainstorm testable questions to be solved through science or math:

- ? Do pill bugs prefer bright places or dark places?
- ? What types of food do pill bugs prefer?
- ? Can a pill bug find its way through a maze?

Innovate

Have students brainstorm problems to be solved through engineering:

- ? How could you use biomimicry to invent something that is based on how an elephant uses its trunk?
- ? How could you use biomimicry to invent something that is based on how a snake moves?
- ? How could you use biomimicry to invent something that is based on how a maple seed spins through the air?

Websites

Biomimicry Photo Gallery
http://inhabitat.com/finding-design-inspiration-in-nature-biomimicry-for-a-better-planet

"Pill Bug" (video)
www.youtube.com/watch?v=DWW8Caur8Co

"Firefighting Robot" (article)
Note: The pill bug is inaccurately referred to as an insect. *www.popsci.com/scitech/article/2008-03/firefighting-robot*

"OLE Pill Bug Robot" (article)
www.engadget.com/2007/08/12/ole-pill-bug-robot-concept-could-fight-forest-fires

"Pillbot" (video)
www.youtube.com/watch?v=-vi-5PisiDY

"RoboSnail" (video)
www.pbslearningmedia.org/resource/eng06.sci.engin.systems.robosnail/robosnail

More Books to Read

Becker, H. 2014. *Zoobots: Wild robots inspired by real animals.* Toronto: Kids Can Press.
Summary: This book for older readers (grades 3–6) explores the world of robo-animals, or zoobots. Twelve double-page spreads reveal vivid, Photoshop-rendered illustrations of robot prototypes such as the bacteria-inspired Nanobot, which can move through human blood vessels, and the OLE pill bug, which can fight fires. Each spread shows a smaller illustration of the animal on which the zoobot is based.

Hughes, M. 2004. *Pill bugs.* Chicago: Raintree.
Summary: Simple text and full-color, up-close photographs in this book for young readers describe pill bug anatomy, feeding, growth, reproduction, and hibernation.

Lee, D. 2011. *Biomimicry: Inventions inspired by nature.* Toronto: Kids Can Press.
Summary: This book for older readers (grades 3–6) examines the extraordinary innovations of the natural world and the human inventions they have inspired.

Chapter 17

Name: _____

Let's Learn About Pill Bugs

Before Reading True or False		**After Reading** True or False
_____	1. Pill bugs have 14 legs.	_____
_____	2. Pill bugs are insects.	_____
_____	3. Pill bugs hatch from eggs.	_____
_____	4. Pill bugs roll into a ball when they feel threatened or scared.	_____
_____	5. Pill bugs prefer very dry places.	_____

Name: _____

Pill Bug Observations

Make a labeled sketch of your pill bug in the box below.

How many legs does your pill bug have? _____

Observe your pill bug's body parts. What do you notice?_____

_____

_____

Observe your pill bug's reactions to different stimuli. What do you notice?

What I Do	What My Pill Bug Does
Gently touch it	
Gently turn it over	
Move it to a dry place in the container	

Name: _____

My Pillbot

Name of my pillbot: _____

Labeled sketch of my pillbot:

1. The problem my pillbot solves is _____

_____

_____

2. My pillbot solves the problem by _____

_____

_____

3. My pillbot is an example of **biomimicry** because _____

_____

_____

_____

Name: _____

STEM at Home

Dear _____,

At school, we have been learning about **pill bugs**—how they move, breathe, and defend themselves. We have also been learning about **biomimicry**—how engineers try to mimic, or copy, living things to design robots.

I learned that: _____

_____

My favorite part of the lesson was: _____

_____

_____

At home, we can watch a video together called "RoboSnail" about how roboticists, or engineers who design robots, are studying the movements of snails and slugs to invent a new kind of robot.

Search "RoboSnail" on *pbslearningmedia.org* to find the video at ***www.pbslearningmedia.org/resource/eng06.sci.engin.systems.robosnail/robosnail.***

After we watch the video, we can design our own robot based on a different animal!

Sketch of Real Animal	Sketch of Robot