Lesson 4.1
Cockroach Robots
Lesson Overview

In this lesson, students are briefly introduced to their next design task and then read and discuss the book *Cockroach Robots*. To begin, the class receives a message from the engineering firm introducing the class’s next project: to design something inspired by the traits of giraffes. Students are then introduced to the Chapter 4 Question: *How can engineers use what they learn from organisms’ traits to design solutions?* and the new Investigation Question: *How do engineers learn, plan, make, and test their designs?* Partners read *Cockroach Robots*, which describes a group of engineers who design solutions to problems based on inspiration from observing the traits of organisms. After reading, students reflect on how the engineers in the book used the design cycle to guide their work. The purpose of this lesson is to introduce students to an example of a real-life engineering team that gathers inspiration for designs from the traits of living organisms. This will help prepare students for the remainder of the chapter when they will be engaging in the design cycle themselves.

**Design Problem:** Design a robot that can remove and grind up invasive plants.

**Students learn:**

- Organisms such as cockroaches have traits that engineers use to inspire their designs.
- Scientists and engineers can work together to create designs inspired by real organisms.
- Engineers use each part of the design cycle to help them design and refine solutions.
- Scientists use tools and technologies to make accurate measurements and observations.
- People from all cultures and backgrounds choose careers as scientists and engineers.
- Most scientists and engineers work in teams.
- Science affects everyday life.
Reading: Cockroach Robots

Students are introduced to *Cockroach Robots* and the purpose for reading. Then, partners read the book.

Instructional Guide

1. **Project Design Cycle.** Remind students that when they used the traits of grove snails to get ideas for a design, they made a drawing of their design.

   ![Design Cycle Diagram]

   Previously, you engaged in the Learn and Plan parts of the design cycle. You learned about grove snails. Then, you planned what your design would look like, what it would be made out of, and how it would solve a problem. However, you didn’t get to make or test your design.

2. **Introduce the Investigation Question.**

   In order to prepare for our next project, we need to learn more about how biomimicry engineers follow each part of the design cycle to help them make their designs.

   We will investigate this question: *How do engineers learn, plan, make, and test their designs?*
3. **Introduce the book *Cockroach Robots***. Hold up a copy of the book.

You will read about a team of real biomimicry engineers who observe organisms so they can get ideas for designs. This book is about how and why these engineers used ideas from cockroaches to make a robot to help rescue people from fallen buildings.

Just as we used our creativity and imaginations when we used grove snail traits to inspire designs, you’ll see that the biomimicry engineers in *Cockroach Robots* use creativity and imagination to come up with their cockroach-inspired designs.

Creativity and imagination are an important part of science and engineering.

The biomimicry engineers in this book created a design that helps people in everyday life. Can you think of other engineering designs or science ideas that affect everyday life?

4. **Remind students about making inferences**. Remind students that making inferences as they read can help them understand the book.

5. **Distribute books**. Distribute one copy of *Cockroach Robots* to each pair of students. Encourage students to think about how the design cycle helps the biomimicry engineers make a design that solves a problem.

6. **Partners read**. Circulate and offer support as needed.

7. **Discuss inferences students made while reading**. Have students share an inference they made as they read and, if possible, explain how it helped them understand the text.

**Teacher Support**

**Background**

**About the Book: *Cockroach Robots***

*Cockroach Robots* is about the work of Bob Full and his team of biomimicry engineers who build robots inspired by the traits of organisms. This book follows the process of designing a many-legged robot that can run fast through tiny spaces, just like a cockroach can. Full and his team carefully observe the cockroach and its traits, and then they design a robot that can also move quickly over and around obstacles. They test the robot, which is intended to enter buildings in the case of a disaster such as an earthquake, to see if it is safe for people to enter the buildings. After testing the robot, Full and his team revise the robot to better meet their design criteria. This book models the practices of observation, investigation, design, testing, and more that engineers engage in when they work.

**Crosscutting Concept: Structure and Function Throughout Chapter 4**

Throughout Chapter 4, students have numerous opportunities to engage with the crosscutting concept of Structure and Function. Students read the book *Cockroach Robots* and learn how engineers observe the structure and function of organisms’ parts in order to get ideas for their own designs. Students are presented with design criteria highlighting the
specialized function of aspects of the robot they are to design. Students then read about the structures in giraffe necks and mouths that allow giraffes to reach plants at different heights and to cut and grind food. Students use what they read about giraffe structures to design and make a robot neck and teeth that serves the same function as those of the giraffe. Students engage in the design cycle a few times, testing their designs to confirm whether the neck and teeth serve the functions they are designed to serve—whether they meet the criteria. If not, students have the opportunity to further refine the structures in their robots in order to meet the criteria.

Rationale

Literacy Note: Making Inferences
In Chapters 1–3, you modeled making an inference when reading and guided students in making their own inferences. Students recorded their inferences as they read and then had the opportunity to discuss one of the inferences they made. In this lesson, students are reminded of the sense-making strategy of making inferences, but it is not a focus of the lesson. Since this is the last book in the unit, students have the opportunity to practice the strategy of making inferences as independently as possible.

Background

Science Note: Comparing Biomimicry Design to Organisms in Nature
The book *Cockroach Robots* addresses the differences between how engineers design by using organism traits and how traits help organisms survive. Students should understand that through the design process, engineers revise and improve an overall design, making choices about how to change its features and attempting to make it as successful as possible. In the natural world, organisms’ traits simply have to be good enough for the organisms to survive. Organisms cannot make decisions about changing their traits in order to be more fit for survival.

Rationale

Pedagogical Goals: Scientists from All Demographic Groups
It’s important for students to know that people from all demographic groups have made important contributions to society through science and technology. This diversity includes people of different ethnicities; people with disabilities; as well as lesbian, gay, bisexual, and transgender people. Because of pervasive representations of scientists as older, male, and largely white, students may assume that all scientists fall into those categories. In our curriculum we strive to present students with an array of diverse scientists so that they can see that the important ingredients for being a scientist are hard work, curiosity, and collaboration, and not age, skin color, gender, physical ability, or sexual orientation. You may want to have a conversation with your students about diversity in scientists. Noticing and discussing differences among people can help combat stereotypes more than ignoring these differences.

Rationale

Pedagogical Goals: Understanding the Nature of Science
One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS calls out eight understandings about the nature of science that are woven throughout the Amplify Science curriculum. This unit gives students an opportunity to experience two understandings about the nature of science: Scientific Knowledge Is Based on Empirical Evidence and Science Is a Human Endeavor. Specifically, the book *Cockroach Robots*, which describes the work of Bob Full and his team of scientists and engineers, illustrates the following ideas:

- Scientists use tools and technologies to make accurate measurements and observations.
• People from all cultures and backgrounds choose careers as scientists and engineers.
• Most scientists and engineers work in teams.
• Science affects everyday life.

In addition, as in *Biomimicry Handbook*, the book *Cockroach Robots* underscores the importance of creativity and imagination to science.
Reflecting on the Design Cycle

Directions:
1. Use examples from pages 8–12 in *Cockroach Robots* to help you complete the diagram below.
2. In the Learn box, record one example of how the team learned about cockroaches.
3. In the Plan box, record one example of how the team planned their designs.
4. In the Make box, record one example of how the team made their designs.
5. In the Test box, record one example of how the team tested their designs.

![Diagram of the Design Cycle with Learn, Plan, Test, and Make boxes]
Reading: Cockroach Robots

Students are introduced to *Cockroach Robots* and the purpose for reading. Then, partners read the book.

**Instructional Guide**

1. **Project Design Cycle.** Remind students that when they used the traits of grove snails to get ideas for a design, they made a drawing of their design.

2. **Introduce the Investigation Question.**

   Anteriormente participaron en las partes de Aprender y Planear del ciclo de diseño. Aprendieron acerca de los caracoles regineta. Luego planearon cómo sería su diseño, de qué estaría hecho y cómo resolvería un problema. Pero no llegaron a hacer el diseño ni a probarlo.

   Para prepararnos para nuestro próximo proyecto, tenemos que aprender más sobre cómo los ingenieros de biomimetismo siguen cada parte del ciclo de diseño para ayudarles a hacer sus diseños.

   Vamos a investigar esta pregunta: ¿Cómo aprenden, planean, crean y testean los ingenieros sus diseños?
3. **Introduce the book *Cockroach Robots***. Hold up a copy of the book.

Van a leer sobre un equipo real de ingenieros de biomimetismo, quienes observan organismos para poder sacar ideas para diseños. Este libro se trata de cómo y por qué estos ingenieros usaron ideas obtenidas de las cucarachas para hacer un robot que ayudara a rescatar gente en edificios caídos.

Igual como usamos nuestra creatividad e imaginación cuando usamos los rasgos de los caracoles regineta para inspirar diseños, verán que los ingenieros de biomimetismo en Robots cucaracha usan creatividad e imaginación para inventar sus diseños inspirados en las cucarachas.

Creatividad e imaginación son partes importantes de la ciencia y la ingeniería.

Los ingenieros de biomimetismo en este libro crearon un diseño que ayuda gente en la vida diaria. ¿Pueden pensar en otros diseños de ingeniería o ideas de ciencia que afecten la vida diaria?

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5. **Distribute books**. Distribute one copy of *Cockroach Robots* to each pair of students. Encourage students to think about how the design cycle helps the biomimicry engineers make a design that solves a problem.

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**Teacher Support**

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Nombre: ____________________________________  Fecha: ________________

Reflexionar sobre el ciclo de diseño

Instrucciones:
1. Usa ejemplos de las páginas 8 a 12 en Robots cucaracha para ayudarte a completar el diagrama debajo.
2. En el cuadro que dice “Aprender”, apunta un ejemplo de cómo el equipo aprendió sobre las cucarachas.
3. En el cuadro que dice “Planear”, apunta un ejemplo de cómo el equipo planeó sus diseños.
4. En el cuadro que dice “Crear”, apunta un ejemplo de cómo el equipo creó sus diseños.
5. En el cuadro que dice “Testear”, apunta un ejemplo de cómo el equipo testó sus diseños.