SUSTAINABLE FUTURES

TEACHER-LED ACTIVITY | GRADE RANGE: 6–8

Biomimicry

OBJECTIVES

Students will:

- Define biomimicry.
- List examples of engineered products that were inspired by nature.
- Explain how engineers use biomimicry to design innovative cooling products.
- Use biomimicry to develop a design for a new product.

OVERVIEW

Students will learn about biomimicry and explore how engineers have long imitated nature when designing and innovating products. They will demonstrate their understanding by designing a new product based on what they know about animals and nature. Emphasis will be put on nature's ways of cooling and keeping cool.

Timing: 45–60 minutes

MATERIALS

- **Biomimicry and Engineering** display photos, one copy or displayed electronically
- **Natural Air-Conditioning Design cards**, one card per group
- **Biomimicry Prototype Design** student handout, one per group *or* one per student
- Rulers, one per group
- Colored Pencils, one set per group
- **Exit Ticket** student handout, one half-sheet per student

ESSENTIAL QUESTION

- What can animals teach me about staying cool?

PROCEDURE

Engage

1. Introduce students to the upcoming concept by displaying and discussing the following essential question:

   What can animals teach me about staying cool?

2. Write the term *biomimicry* on the board and take an informal poll to determine how many students are familiar with the term.

3. Display the **Biomimicry and Engineering** photos and ask if any volunteers can explain how each photo relates to biomimicry.

Learn

4. Explain to students that the word biomimicry is made up of two parts—*bio* (life) and *mimicry* (imitation). Biomimicry means to imitate life (or nature) when solving problems or creating new things. It is a way to learn from plants and animals. It is a way of mimicking their characteristics and behaviors to create a new product, process, or machine that helps people. Tell students that engineers have used *biomimicry* of plants and animals to design things like space rovers, artificial limbs, running shoes, and Velcro®.
5. Emphasize that while many inventions and innovations have come from observing plants (such as Velcro®, which was invented after George de Mestral observed prickly plants sticking to his pant legs), the focus of today's activity will be on ways we have and can continue to learn from animals when designing new products or trying to help people.
6. Ask volunteers to share things they can think of that were inspired by animals. If not shared by students or time is limited, provide the following examples:
    - Airplane wings are designed based on a bird's wings.
    - Adhesives are designed based on the sticky substance on geckos' feet.
    - Radar and sonar devices are designed based on a bat's echolocation.

Explore

7. Divide students into groups of four and distribute one **Natural Air-Conditioning Design card** to each group, distributing the four designs evenly[1]. Explain that all of the examples provided are of ways that nature has helped us stay cool.
8. Instruct groups to read and discuss their assigned biomimicry example.
9. Ask a volunteer from four of the groups, one for each design, to briefly explain to the class the innovation and how it is based on an animal. Give any other groups with that same design an opportunity to add to or clarify the first volunteer's information.

Challenge

10. Distribute one **Biomimicry Prototype Design** student handout, one ruler, and one set of colored pencils to each group.

- **Note:** *Alternatively, each student can complete this step independently.*

11. Explain to students that they will be brainstorming and designing an item based on biomimicry. As a group, they should think of a category that is interesting to all members. Examples include sports equipment, music, clothing, chores, cooking, etc.

1 https://www.nationalgeographic.com/science/article/130703-air-conditioning-biomimicry-natural-cooling

12. Give students approximately ten minutes to think of a characteristic or behavior of an animal that could be applied to their chosen topic. Encourage them to think of unique features and how those features could be useful in solving a problem or completing an action. Remind them that there are no wrong or "bad" ideas when brainstorming.
13. Instruct students to use the remaining work time to decide on an idea with which to move forward and use it to complete the **Biomimicry Prototype Design** student handout.

Discuss

14. Give students the opportunity to share their design ideas and drawings.

Reflect

15. Distribute an **Exit Ticket Student Handout** to each student and ask them to reflect upon the activity's essential question. Collect them as students leave and use responses to determine their level of understanding. Consider taking time in a future session to address misconceptions, highlight key takeaways, or share interesting insights brought up on the tickets.

EXTENSION IDEAS FOR EDUCATORS

- Provide time and materials for students to build physical prototype models to scale of their biomimicry designs. Work through the design and reiteration process.
- Have students role-play as if they represented engineering companies looking to manufacture new products. Students can present their designs and/or prototypes to receive and respond to feedback.

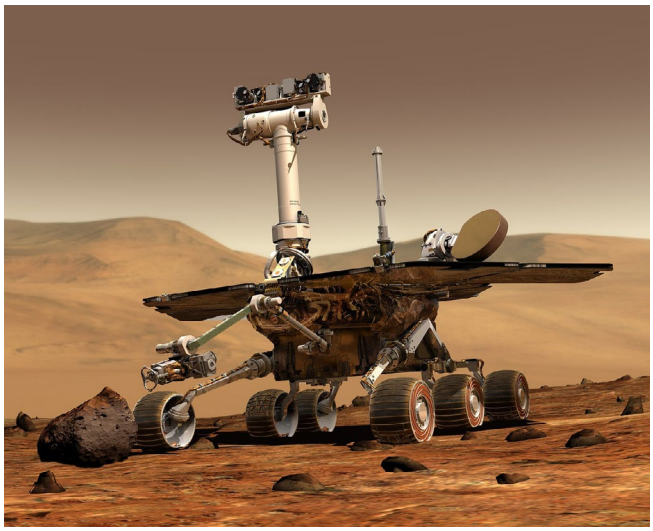
NATIONAL CONTENT STANDARDS

National Science Standards

- MS-LS1.2: Complex structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.
- MS-LS4.5: Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Science and Engineering Practices:

- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models

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Termites

Large termite hills can stay incredibly cool, even in the extreme heat of African deserts.

Termites keep their hills cool by managing the airflow within the hill instead of the breeze blowing over it from the outside. They do this by relying on the sunlight that heats air in different parts of the hill at different times. When the air cools in one section as a new section is being heated, it creates air movement.[2]

The Eastgate Centre is a shopping mall in Zimbabwe designed by architect Mick Pearce to mimic a termite hill. It is a "green building" that aims to learn from nature in order to be more sustainable. It is cooled with outside air and uses 35% less energy than similar buildings to keep cool![3]

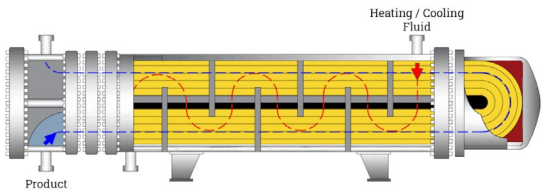
2 https://www.asme.org/topics-resources/content/what-termites-can-teach-engineers
3 https://www.mickpearce.com/Eastgate.html

Birds

Birds like ducks and penguins have veins and arteries in their feet that keep their core temperature warm and their surface temperature cool.

This happens because their feet have a countercurrent configuration, which means that the blood near the birds' hearts and the blood near their feet move in opposite directions. This ends up cooling the blood that is by their feet and wings. Keeping the cool blood closer to ice, snow, and water means that the animals lose less body heat.

Engineers use this natural phenomenon when they design shell and tube heat exchangers that are used in large chemical operations like oil refineries. These machines circulate hot liquid around a tube that contains a cooler liquid, mimicking blood flowing through veins.



Ticks

Brown dog ticks are able to survive for months without drinking water, because they absorb water vapor from the atmosphere. They secrete a hydrophilic solution from their mouths. If the humidity is above 41%, the solution absorbs the moisture from the air. Once the solution is saturated, the tick swallows the solution back up again.[4]

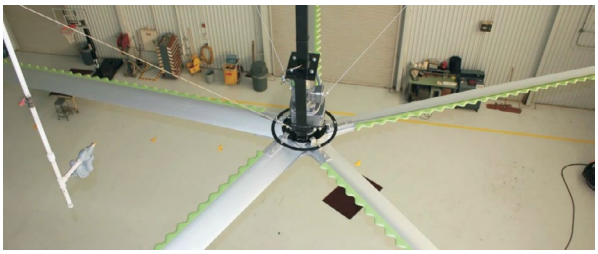
Engineers have designed the desiccant dehumidifier to operate based on the same principles. These machines use a liquid salt solution to draw moisture out of the air. When used to pull humidity out of the air inside buildings, these dehumidifiers can act to cool the air similar to a traditional air conditioner.

4 https://asknature.org/strategy/water-absorbed-from-humid-air/

Whales

Unlike other designs in nature and aerospace engineering that have smooth leading edges, the humpback whale's unique bumpy leading edge helps it survive by making its feeding more efficient. These bumps, called tubercles, allow the very large whales to make very tight turns and swim more efficiently. They help the whale maintain lift and decrease drag when chasing prey.

Engineers like the founders of WhalePower Corporation have taken this natural phenomenon and used it to create more efficient fan blades that create less drag and can tilt to up to 30° without stalling. They use less energy to cool large spaces in industrial and agricultural settings.[5] HVAC companies are working to apply this technology to smaller scale fan and air conditioner blades to increase efficiency and decrease energy consumption.



5 https://youtu.be/4Hh1YZRK3yw?si=lzU2V2t7WjoZVR3P

Biomimicry Prototype Design

STUDENT HANDOUT

Design Title:_____

What is the purpose of your design? What problem will it solve?

What animal characteristic or behavior inspired your design?

Sketch your design. Include labels.

What can animals teach me about staying cool?

What can animals teach me about staying cool?