Plant Biomimicry

Middle School
NGSS: MS-ETS1-1, MS-LS4-4

Lesson Description

In this lesson students will investigate the engineering concept of biomimicry - taking inspiration from nature to solve human problems. Students will then apply what they've learned about biomimicry by utilizing the engineering design process to solve an everyday problem in their own lives with inspiration from nature.

Driving Phenomenon

Biomimicry is an engineering concept about looking to nature for ideas. Engineers are able to solve problems by mimicking natural solutions - e.g: Velcro as a reusable adhesive inspired by burrs that stick to animals' fur.

One of the reasons that this approach works so well is that natural processes have evolved to work effectively and efficiently. Additionally, biomimicked solutions are often environmentally safe because they are copied from the natural environment, which is an important factor in today's world.

Driving Questions

- How can we use plants to help solve real world problems?

Learning Objectives

- Students will demonstrate their understanding of biomimicry by planning and designing a solution to a human problem using plant inspired ideas

Time Requirements

- Three- 45 minute work sessions

Prerequisite Knowledge

- Engineering design process
- Basic plant anatomy
- Basic understanding of structure and function

Teacher Resources

1. Kingfisher and Bullet Train Images
2. Mimicry Sorting, Plant or Animal?
3. Biomimicry examples

Student Resources

1. Engineering Design Process
2. Engineering Design Planning Document

Plant Biomimicry

Full lesson procedures begin on the next page

Engage | 15 minutes

Students compare images of a kingfisher vs. a train. They share out their comparisons and learn the definition of biomimicry.	Notes
Teacher Resource 1.0	

Explore | 15 minutes

Students will sort and pair human inventions to their nature inspirations. Once they have completed the activity, they will discuss potential benefits of taking inspiration from nature	Notes
Teacher Resource 2.0, 3.0	

Explain | 20 minutes

Students review the Engineering Design process. They then brainstorm challenges in their daily lives and choose one to solve with biomimicry.	Notes
Student Resource 1.0	

Elaborate | 60 minutes

Students research, design, and build their solutions to the chosen problem. They'll record their work in the planning document.	Notes
Student Resource 2.0	

Evaluate | 15 minutes

Students will display and provide each other with critical feedback on their design and inventions.	Notes

Pre-lesson Preparation

Materials

- projector or SmartBoard for showing students images
- computers, books, tablets for student research and investigation
- chart paper
- materials for posting or displaying student work
- building materials for engineering design

Lesson Enrichment Ideas

INVESTIGATE

Biomimicry Institute

Education is the root of change-and at the heart of everything we do.
Whether you are a leaner, a teacher, or an organization, we offer many
opportunities to learn and grow with biomimicry. www.biomimicry. org

Harris Learning Collection
Rent real specimens, and bring them to your classroom. If you live in the Chicago
area, the *N. W. Harris Learning Collection* at the Field Museum offers numerous
specimens that can be rented for study in the classroom.

READ

Biomimicry: Inventions Inspired by Nature
by Dora Lee and Margot Thompson
A fascinating homage to Mother Nature's genius, anchored by solid science and
a strong environmental message.
http://www.worldcat.org/oclc/1048057032

Wild Buildings and Bridges: Architecture Inspired by Nature
by Etta Kaner & Carl Wiens
From cactuses to birds' wings, termite towers to honeycombs, this book
celebrates more than thirty examples of nature's influence on building and
bridge designs all over the world. In some instances, architects looked to nature
to solve structural problems, like creating an earthquake-proof bridge by
mimicking the long roots of a type of grass known for stabilizing riverbanks.
http://www.worldcat.org/oclc/1023493052

WATCH

**Ted Talk: The Secret of Nature's Grosses Creatures Channeled into
Robots**
How can robots learn to stabilize on rough terrain, walk upside down, do
gymnastic maneuvers in air and run into walls without harming themselves?
Robert Full takes a look at the incredible body of the cockroach to show what it
can teach robotics engineers. https://youtu.be/ekUh9AW1hKg

How can we use plants to help solve real world problems?

Engage

1   Have students look at the images of the kingfisher and the Japanese bullet train ([Teacher Resource 1.0](#)) and compare them independently.

2   Give students the following prompts and have them record their answers in a notebook: **What do you notice? What do they have in common? How are they different?**

3   Have students share out their observations as a class or in small groups.

4   Once they have shared out, tell students that the bullet train was built to look like the kingfisher. The kingfisher's shape allows it to fly very quickly without using a lot of energy. When humans find solutions to problems based on things they see in nature that is called biomimicry.

5   Write biomimicry and its definition somewhere in the room where students can reference it.

Explore

1   Have students investigate the different ways other species have used mimicry to help with their survival ([Teacher Resource 2.0](#)). Distribute mimicry cards to groups of three to four students. Have students sort these images into categories, plant or animal.

2   After all the groups have finished sorting, have the students discuss which category each image belongs in as a whole class (Answers: examples #1 and 4 are animals, examples #2 and 3 are plants). Ask the following questions: **Why would these animals want to mimic plant? What kinds of benefits do these animals gain from mimicking their environment?** Answer as a class.

3   Have students discuss how humans can benefit from taking inspiration from nature, use [Teacher Resource 3.0](#) to help facilitate this discussion, if necessary. Have students discuss biomimicry and how nature has survived millions of years with its designs and mechanisms.

Explore| Helpful Links

Have students read this Washington Post article to learn more about engineering and biomimicry:

https://www.washingtonpost.com/news/speaking-of-science/wp/2016/06/07/moss-is-a-master-of-mechanical-engineering/

Watch this cool video about a stick insect:

https://youtu.be/vZPVeJhld_I

Explain

1   Remind students of the engineering design process. If your students are new to the engineering design process, you will want to take time to allow them to engage in this process before entering this activity. You will find the Engineering Design Process handout (Student Resource 1.0, 2.0) with steps, descriptions, and suggested questions to answer.

2   Have students brainstorm problems in their daily lives. Record their ideas on the board or chart paper for the class to be able to reference. You can either vote on the problem you want to solve as a class or break students into groups or pairs and allow them to choose a problem from the brainstorm list.

3   Once students have chosen the problem they would like to solve, have them research solutions others have already invented for their problem. You may want to review best practices for find quality sources if your class or schools has these guidelines. Students should record their research in the Engineering Design Planning Document (Student Resources 2.0).

Elaborate

1   Once students have researched prior inventions to solve their chosen problem or challenge it's time to create a plan for their invention. For this engineering design challenge, students will be required to take inspiration from plants. Students should investigate plants and their mechanisms for survival. Once they have done this, they should record their findings as well as their plan into the project checklist and planning document. After students have completed the design phase of their project, they should begin to build a prototype of their idea. You may use any materials you have or that students find inspiration from and are easily obtained. See Digital Option (right) for a wasteless build option.

2   Have students test their inventions if possible. Students should test their designs multiple times (trials) and record the outcomes in their checklist and planning document. **Note**: If students are unable to test their biomimicry inventions, students can provide feedback to each other by completing a gallery walk or student presentations.

Evaluate

1   Have students iterate or improve their designs based on test results or student feedback. Students can write their revisions down on their planning document or add the revisions to their prototypes. Encourage students to be specific in their improvements and provide reasoning and evidence for their changes.

In the Student Resource

Explain | Engineering Design

Process
- Identify the Problem
- Explore
- Design
- Create
- Test it Out
- Make it Better

Procedures

Suggested Materials

Elaborate | Step 1
- paper or card stock
- cardboard (all kinds!)
- cutting tools
- adhesives
- inexpensive paintbrushes
- post-it notes and pencils
- felt or foam

Digital Option | Step 1

SolidWorks Apps for Kids

SolidWorks provides kid-friendly CAD design. Teachers can sign up for a classroom account, students can design on tablets, and print on 2D or 3D printers.

Engage: The Kingfisher and the Bullet Train

Teacher Resource 1.0

Explore: Mimicry Sorting, Plant or Animal?

Teacher Resource 2.0

Example #1	**Example #2**
Photo courtesy Robert Lucking	Image credit Flickr user fturmog
Example #3	**Example #4**
Photo by Kew Gardens	Photo courtesy Robert Lucking
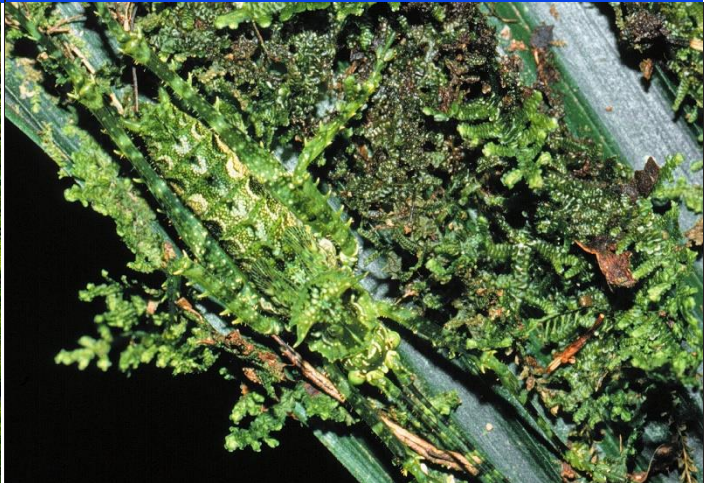
Biomimicry Examples

Teacher Resource 3.0

Burr | Attaches to clothing and fur	**Velcro |** Materials that stick together
Copyright by MaxPixel	Alexander Klink [CC BY 3.0 (https://creativecommons.org/licenses/by/3.0)]
Leaf | Uses sunlight to make food (energy)	**Solar Panel |** Uses sun rays to make electrical energy
By Rowan Heuvel insolitus - https://unsplash.com/photos/KJwc8w_ANIAarchive copy	Pixabay

Teacher Resource

Teacher Resource 3.0 Biomimicry Cards

Fiddlehead Fern |
Uncurls from a spiral to minimize drag

Wingchi Poon [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)]at the

Mixer Blade |
Spiral shape helps it to mix liquids easily

PAX Scientific, Inc.

Mangrove Tree |
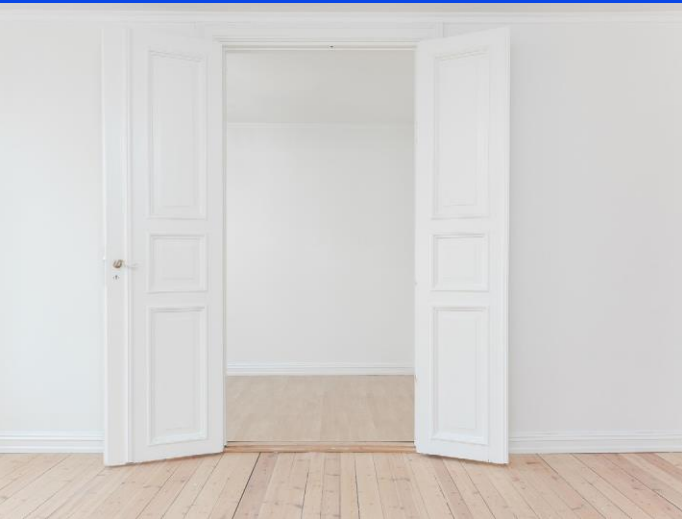One of few trees that can live in saltwater

Pixabay License

Desalination Filter |
Removes salt out of seawater

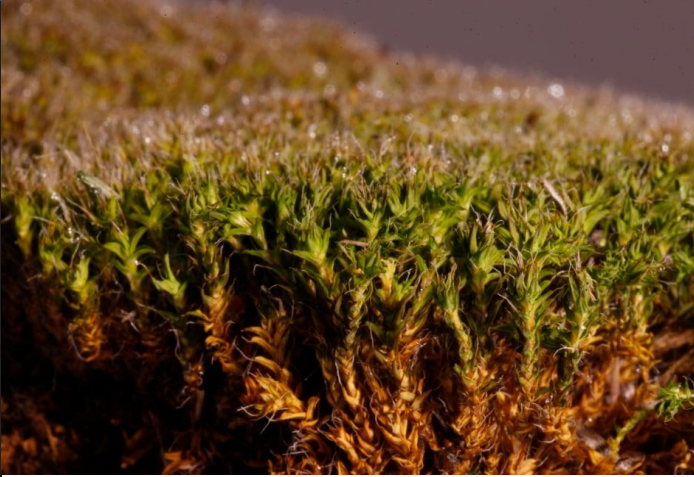

Cpl. Elize McKelvey [Public domain]

Teacher Resource 3.0 Biomimicry Cards

Moss |
Able to absorb large amounts of water

EQmagpro.com

Sponge |
Able to absorb large amounts of water.

Pixabay License

Lotus Flower |
Lotus leaves don't collect dirt or dust

Pixabay License
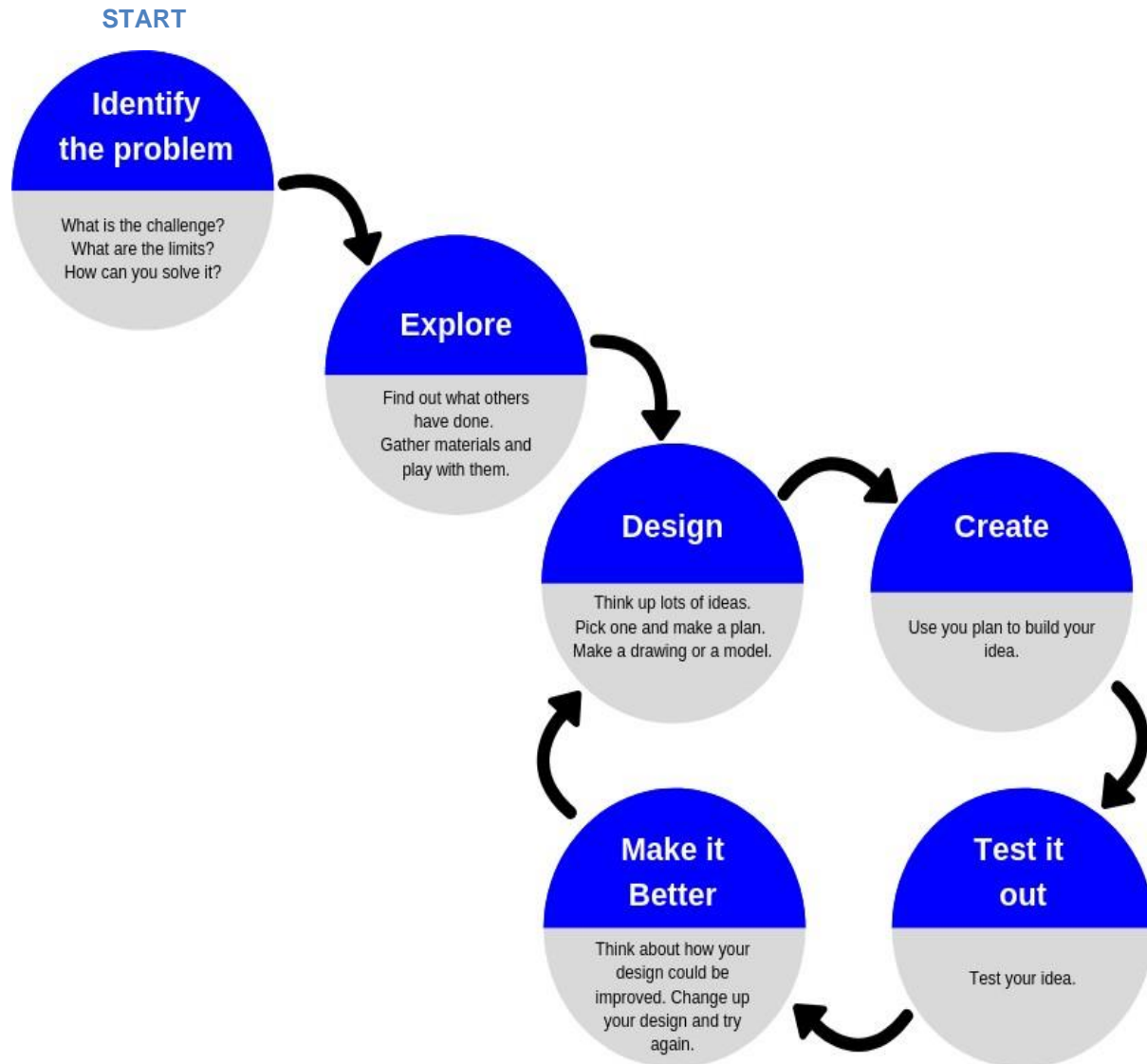

Paint |
This paint doesn't get dirty

Pixabay License

Teacher Resource 3.0 Biomimicry Cards

Liverwort elaters | Coiled tube used for spawning (reproduction) Photo by Ron Oldfield (https://www.nikonsmallworld.com/galleries/2005-photomicrography-competition/lepidozia-sp.-a-liverwort-spores-and-elaters)	**Metal spring |** Coiled metal used for flexibility and strength Pixabay License
Desert Moss | Uses "hairs" to collect water from the air Washington Post	**Fog nets |** Fine mesh that collects water from the air CNN.com

Engineering Design Process and Design Handout

Student Resource 1.0

Engineering Design Process

START

Identify the problem
What is the challenge?
What are the limits?
How can you solve it?

Explore
Find out what others have done. Gather materials and play with them.

Design
Think up lots of ideas. Pick one and make a plan. Make a drawing or a model.

Create
Use you plan to build your idea.

Make it Better
Think about how your design could be improved. Change up your design and try again.

Test it out
Test your idea.

Note: This is one version of the engineering design process, made to best serve this lesson.

Engineering Design Planning Document

Student Resource 2.0

Team Name:

Team Members:

Criteria	Constraints
• Your invention must solve a problem in everyday life	Your design must mimic nature. Ways you can mimic nature: 1. mimic how a plant **moves** 2. mimic the form or **shape** of a plant 3. mimic the **system** of a plant

Identify the Problem

What problem have you chosen to solve? Why is the problem important to you?

Explore
Find out what others have done.

Engineering Design Planning Document
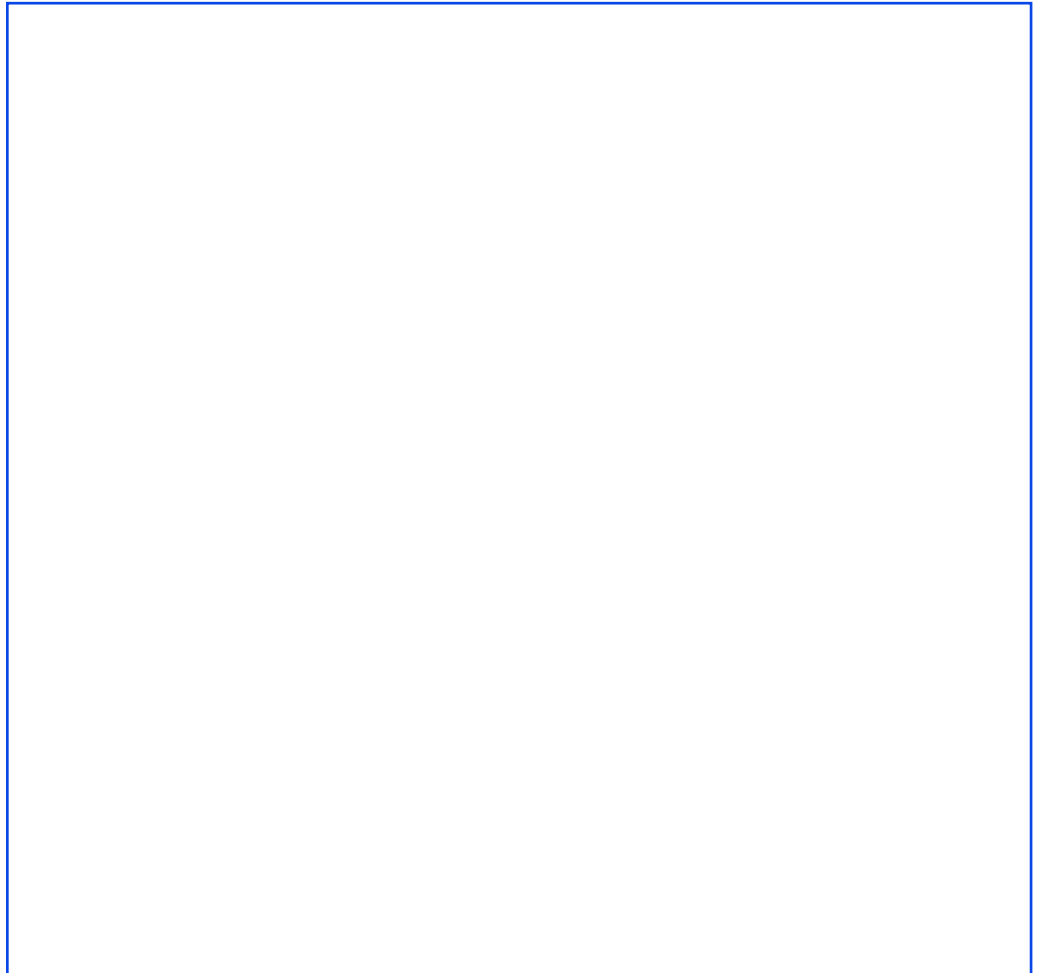
Design

Write down at least 3 ideas.

Pick one and make a plan.

Engineering Design Planning Document

Design

Create a model or drawing(s) of your plan. Make sure to Include labels and arrows.

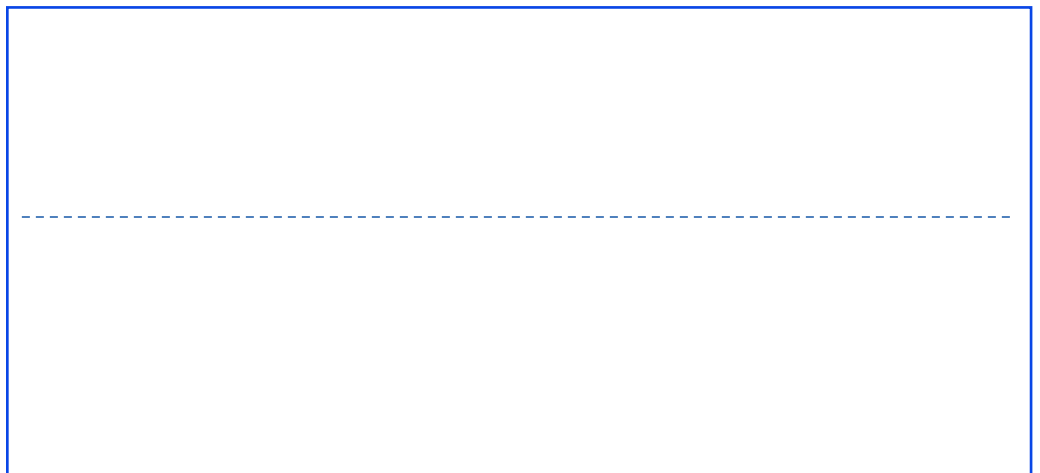**Create**

Use your plan to build your idea.

Check here after building your model.

Test

Test your idea. Write your observations from your test to the right.

What went well? What needs to be improved?

Engineering Design Planning Document

Gather Feedback from others

Record feedback you've received from your project here.

Make it Better

Think about what went well and what went less well. How are you going to improve your design?