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| **Biomimicry in Action** |
| **Unit Overview**  |
| **Target Audience:** 6 - 7th grade | **Est. Time:** 55-minute class periods | **Content Area(s):** Environmental Science and Engineering  |
| **Abstract:**This mini-unit aims to introduce students to the scientific topic of biomimicry. The unit will begin with an introduction to the concept of biomimicry through discussion and a hands-on activity. The students will then be presented with two examples of biomimicry used today, first by comparing spider silk's strength to steel. It shows how spider silk is stronger than steel in many ways and how scientists are trying to replicate spiders' characteristics naturally in fabrics and architecture. Next, show how sharks' skin helps them to swim effortlessly through the water and have students start to develop ideas of inventions based on the concept. The students use all of the information they have gained to identify a problem in their own lives where animals, bugs, and plants might have already found a solution. To end the unit students prove they have mastered the concept of biomimicry by designing a prototype of a solution to their identified problem inspired by a species in nature. This integrated unit focuses on how natural resources and species are connected to the Indiana State Standards of Engineering and Technology middle school.  |
| **Unit Goals/Objectives:**Students will be able to….* Describe the concept of biomimicry
* Identify current examples of biomimicry
* Recognize the practical application of biomimicry
* Design solutions to problems based on biomimicry
* Apply the concept of biomimicry in their future classes and design
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| **Lesson Summaries:**Lesson 1: Introduction to Biomimicry1. Students will be able to describe the concept of biomimicry and provide real-world context.
2. Students will be able to describe how biomimicry can be used to improve the sustainability of innovations.
3. Students will be able to identify some examples of biomimicry

Lesson 2: Spiders: Creepy Crawlers and Construction Crews 1. Students will be able to identify that spider silk is stronger than steel in some ways
2. Students will be able to explain why spider silk is so strong; including its structure and physical properties
3. Students will be able to recognize potential possibilities of biomimicry that are based on spider silk

Lesson 3: Sharks: Stealthy Innovators1. Students will be able to list the aspects of shark skin that improve a shark’s speed
2. Students will be able to explain the micro-structure of shark skin and why it allows the shark to move fast
3. Students will be able to describe how engineers have utilized the design of shark skin to create various innovations

Lesson 4: Nature’s Champions to the Rescue1. Students will be able to recognize the practical purposes of biomimicry in everyday life
2. Students will be able to apply the steps of the engineering design process
3. Students will be able to invent ideas using the concept of biomimicry

Lesson 5: From Imagination to Innovation! Design Your Solutions1. Students will be able to demonstrate the principles of biomimicry through a hands-on activity.
2. Students will be able to solve a problem using the principles of biomimicry
3. Students will be able to utilize the principles of design to solve a real-world problem
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| **Lesson Timeline:**Lesson 1: Introduction to Biomimicry * Introduction: *5 minutes*
* Pre-assessment notecards: *5 minutes*
* Discussion with video: *20 minutes*
* PowerPoint Presentation: *15 minutes*
* 3-2-1 Notecards and wrap-up: *5 minutes*

Lesson 2: Spiders: Creepy Crawlers and Construction Crews * Introduction: *5 minutes*
* Review: *5 minutes*
* Spider Silk Versus Steel the Big Show Down Activity: 20 minutes
* Amazing Answer and Engineering Potential: 20 minutes
* Post Assessment Quiz: *5 minutes*

Lesson 3: Sharks: Stealthy Innovators * Introduction & Review: *5 minutes*
* PowerPoint Presentation and Discussion: *15 minutes*
* Activity: *20 minutes*
* Quiz and Wrap-up: *10 minutes*

Lesson 4: Nature’s Champions to the Rescue * Introduction: *5 minutes*
* Review: *5 minutes*
* Nature’s Champion Activity: *45 minutes*
* Think-Pair-Share (during Nature’s Champion Activity)

Lesson 5: From Imagination to Innovation! Design Your Solutions * Introduction: *5 minutes*
* Review: *5 minutes*
* Design Your Solution Activity: *35 min*
* Discuss and Share: *5 min*
* Swap and evaluate: *5 min*
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| **Standards:****Standards for Technology and Engineering Literacy (Grades 6-7)****ETE – 2.2** Apply knowledge and skills learned in science, mathematics, language arts, fine arts, and social studies classes when completing engineering and technology-based assignments.**ETE – 3.2** Investigate inventions and innovations of products, processes, materials, and tools. **ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to meet the criteria for success better.**ETE – 1.1** Illustrate the purpose of engineering and technology in society. **ETE – 4.1** Apply the steps of the design process.**ETE – 4.2** Use the design process to create a product that addresses a real-world problem. |

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| **Lesson 1: Introduction to Biomimicry** |
| **Est. Time:** 55 minutes |
| **Lesson Learning Goals/Objectives:**1. Describe the concept of biomimicry and provide real-world context
2. Describe how biomimicry can be used to improve the sustainability of innovations
3. Identify some examples of biomimicry
 | **Learning Standards: Standards for Technology and Engineering Literacy (Grades 6-7).**ETE – 2.2 Apply knowledge and skills learned in science, mathematics, language arts, fine arts, and social studies classes when completing engineering and technology-based assignments.ETE – 1.1 Illustrate the purpose of engineering and technology in society.  |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***5 minutes* | Discuss lesson plan and objectives |  |
| Pre-assessment notecards ***5 minutes*** | Pre-assessment notecards:* Show the word “Biomimicry” to the class
* Side 1: Write “yes” or “no” to the question: have you ever heard of biomimicry?
* Side 2: Write what you think the word “biomimicry” means

Be sure to mention that bio means life and mimic means copying/creating | Notecards Pencils  |
| Discussion ***20 minutes*** | Ask students:* To share their note card, answer with a partner
* To share their note card, answer with the class

Watch the Introduction to Biomimicry video: <https://www.youtube.com/watch?v=iMtXqTmfta0&t=188s>Ask students:* Question students about if they understood certain key points
* Have you seen any other examples of biomimicry?

Ask students if they have any questions about the video | Computer Projector Internet Speakers |
| PowerPoint Presentation***15 minutes*** | 1. [Lesson 1: Introduction to Biomimicry](https://docs.google.com/presentation/d/1jgwtyTQJ32dW7u2jfNvh0wPlRospdUu2LTfPxeS2QD8/edit?usp=sharing)
2. Definition of biomimicry
3. The relation between evolution and design
4. Nature as a model, nature as a measure, nature as a mentor
5. Principles of biomimicry
* Nature runs on sunlight
* Nature uses only the energy it needs
* Nature fits form to function
* Nature recycles everything
* Nature rewards cooperation
* Nature banks on diversity
* Nature demands local expertise
* Nature seeks balance
* Nature taps the power of limits
1. Where can biomimicry be used? Anywhere!
2. More examples of biomimicry with visuals
* Gecko example video: [Harnessing the Power of Gecko Feet | ScienceTake](https://www.youtube.com/watch?v=fEb9Z6VdoS8)
1. How biomimicry designers think

Discussion about biomimicry and sustainability | Computer Projector PowerPoint  |
| 3-2-1 Notecards and wrap-up ***10 minutes*** | Post-assessment 3-2-1 notecards:* Side 1: 3 things they learned
* Side 2: 2 things they thought were interesting and 1 question they still have
 | Notecards Pencils |
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| **Resources:**Video: [The world is poorly designed. But copying nature helps.](https://www.youtube.com/watch?v=iMtXqTmfta0&t=188s) Video: [Harnessing the Power of Gecko Feet | ScienceTake](https://www.youtube.com/watch?v=fEb9Z6VdoS8) PowerPoint: [Lesson 1: Introduction to Biomimicry](https://docs.google.com/presentation/d/1jgwtyTQJ32dW7u2jfNvh0wPlRospdUu2LTfPxeS2QD8/edit?usp=sharing)Formative Assessments:Pre-assessment notecards: method of assessing students’ prior knowledge about the subject.3-2-1 notecards: used to determine how well the students understood the material in lesson one. |

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| **Lesson 2: *Spiders: Creepy Crawlers and Construction Crews*** |
| **Est. Time:** 45 minutes |
| **Lesson Learning Goals/Objectives:**1. Explain why spider silk is so strong; including its structure and physical properties.
2. Recognize potential possibilities of biomimicry that are based on spider silk.
 | **Indiana State Standards: Standards for Technology and Engineering Literacy (Grades 6-7)*** ETE – 2.2 Apply knowledge and skills learned in science, mathematics, language arts, fine arts, and social studies classes when completing engineering and technology-based assignments.
* ETE – 3.2 Investigate inventions and innovations of products, processes, materials, and tools.
* 6-8. ETS 1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to meet the criteria for success better.

[All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.](http://www.nap.edu/openbook.php?record_id=13165&page=96)[The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.](http://www.nap.edu/openbook.php?record_id=13165&page=96) |
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| **Lesson Component** | **Instructions** | **Materials** |
| Introduction ***5 minutes*** | Discuss the plan and objectives for the lesson |  |
| Review ***5 minutes*** | Review what students learned in lesson 1, Ask: * Who can tell me the definition of biomimicry that we reviewed in Lesson 1?
* What are some examples of biomimicry that we saw in lesson 1?
* What questions did we still have at the end of lesson 1?
* Pretest
* [Spiders: Creepy Crawlers and Construction Crews Pretest](https://docs.google.com/document/d/1r0wjlZ3CHzVgRp26mw3_PItQBHoCk0Kl7za52a227n0/edit)
 | Paper PrinterPencils |
| Spider Silk Versus Steel the Big Showdown Activity ***20 minutes*** | Introduce activity: * Ask students what they believe is the strongest: steel, concrete, wood, or spider silk
* Have students vote whether steel or spider silk is stronger. Ask them why they voted either way.
* Explain to students that they are going to watch a video about how much weight a spider dragline can hold and how much weight a steel wire can hold. Have them vote on how many weights the spider dragline can hold and how many the steel wire can hold.

[Is Spider Silk Stronger Than Steel?](https://www.youtube.com/watch?v=IbDDhycZ2uM) * Ask students what theories they have for why the spider dragline could hold so much more.
 | Computer Projector  |
| Amazing Answer and Engineering Potential***20 minutes*** | * Show students a video explaining how spider silk is so strong.
* After the video ask students what the big reasons are and make sure to review key points

[Why Spider Silk is Stronger than Silk](https://www.youtube.com/watch?v=UGcOKR-Aojs) * Explain to students what tensile strength is and strength-to-density ratio.
* Have a group discussion on what they mean and how they relate to spider silk and steel wire
* Ask students what scenarios each of the properties is good for
* Ask students what are possible things that humans could use the amazing properties of spider silk for. (Biomimicry)
* Show them real-life examples: Bridges, body armor, and fishing nets

[Spiders: Creepy Crawlers and Construction Crews](https://docs.google.com/presentation/d/11_j1fx29AkqC-rjE3hZ90p9Fk0Ua0HHQY4FuddzXIGY/edit#slide=id.g23a599f39e8_0_62) | Computer Projector PhotosPaper  Pencils |
| Quiz and wrap-up ***5 minutes*** | * Post-assessment Quiz
* Post-test

[Spiders: Creepy Crawlers and Construction Crews Posttest](https://docs.google.com/document/d/1PpaVjDJVz9t8AX2zKdHmcwytlGbMoUrcOdYJe9Yy5bs/edit) | Paper PrinterPencils |
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| **Resources:** * Video: [Is Spider Silk Stronger Than Steel?](https://www.youtube.com/watch?v=IbDDhycZ2uM)
* Video: [Why Spider Silk is Stronger than Silk](https://www.youtube.com/watch?v=UGcOKR-Aojs)
* PowerPoint: [Spiders: Creepy Crawlers and Construction Crews](https://docs.google.com/presentation/d/11_j1fx29AkqC-rjE3hZ90p9Fk0Ua0HHQY4FuddzXIGY/edit#slide=id.g23a599f39e8_0_62)
* Pretest: [Spiders: Creepy Crawlers and Construction Crews Pretest](https://docs.google.com/document/d/1r0wjlZ3CHzVgRp26mw3_PItQBHoCk0Kl7za52a227n0/edit)
* Posttest: [Spiders: Creepy Crawlers and Construction Crews Posttest](https://docs.google.com/document/d/1PpaVjDJVz9t8AX2zKdHmcwytlGbMoUrcOdYJe9Yy5bs/edit)

 Summative Assessments:* Pretest: five multiple-choice, true false, and fill-in-the-blank questions to gauge students' starting points.
* Posttest: the same five questions as the pretest with an additional open-ended question to assess knowledge gained.

 Formative Assessments: Questions the instructor asks: several questions throughout the whole lesson to gauge if students understand what is happening in the lesson. Discussion over topics being introduced to keep the students engaged and connecting to the lesson. |

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| **Lesson 3: *Sharks: Stealthy Innovators*** |
| **Lesson Learning Objectives:** 1. List the aspects of shark skin that improve a shark’s speed
2. Explain the micro-structure of shark skin and why it allows the shark to move fast.
3. Describe how engineers have utilized the design of shark skin to create various innovations
 | **Learning Standards: Standards for Technology and Engineering Literacy (Grades 6-7).****ETE – 2.2** Apply knowledge and skills learned in science, mathematics, language arts, fine arts, and social studies classes when completing engineering and technology-based assignments.**ETE – 3.2** Investigate inventions and innovations of products, processes, materials, and tools. **ETE – 1.1** Illustrate the purpose of engineering and technology in society. **ETE – 4.1** Apply the steps of the design process.**ETE – 4.2** Use the design process to create a product that addresses a real-world problem. |
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| **Lesson Component** | **Instructions** | **Materials** |
| Introduction and Review***5 minutes*** | Discuss lesson plans and objectives, and review what students learned in lesson 1 and 2. |  |
| PowerPoint Presentation & Discussion1. ***minutes***
 | 1. [Lesson 3: Sharks: Stealthy Innovators](https://docs.google.com/presentation/d/1tCGkzFIHVCap7yz-cGQzQjcF_QfhJ0r_alCfDwYrePk/edit?usp=sharing)
2. Introduction to sharks and habitat
3. Introduction of sharks: discussion
	1. Ask students: have you ever swam in the ocean?
	2. Ask students: if you have swum in the ocean, were you afraid of sharks?
	3. Encourage students to share their experiences
4. Discuss the properties of sharks
	1. Ask students: what are some aspects of sharks? What makes a shark a shark?
	2. Discuss how sharks are able to stalk and catch prey
5. Discuss the properties of shark skin that make them move quickly in the water
6. Discuss the physical advantages of these shark skin properties
	1. Reduced drag
	2. Increased speed
7. Discuss biomimicry
	1. Ask the students: when we’re talking about biomimicry, what are some things that we use (products) that may require these physical advantages?
8. Explain how biomimicry engineers work to apply shark skin design to innovations
	1. Airplanes
	2. Wetsuits
	3. Swimsuits
9. Video: [3 Cool Materials That Mimic Shark Skin](https://www.youtube.com/watch?v=jHGTZmKWEnU)
10. Ask students to raise their hands if they know what is a blueprint
	1. Allow student who raised their hands to say their definitions for the class
11. Provide the definition of a blueprint
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| Activity***20 minutes*** | * Ask students to brainstorm a blueprint of an item that can be made utilizing shark skin properties
	1. If students are stuck, provide examples (e.g., anything that needs to move fast through water or air–airplanes, swimsuits, boats, etc.)
	2. The item can be one we discussed in class, a new idea, or something you have seen out in the world
* Students sketch a blueprint of their innovation
 | PaperPencils |
| Quiz and wrap-up ***15 minutes*** | Post-assessment quiz• Post-test (multiple choice and free answer) | PaperPrinterPencils |
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| **Resources:**Video: [3 Cool Materials That Mimic Shark Skin](https://www.youtube.com/watch?v=jHGTZmKWEnU)PowerPoint: [Lesson 3: Sharks: Stealthy Innovators](https://docs.google.com/presentation/d/1tCGkzFIHVCap7yz-cGQzQjcF_QfhJ0r_alCfDwYrePk/edit?usp=sharing)Summative Assessment:Post-assessment quiz: [Lesson 3: Post-Assessment Quiz](https://docs.google.com/document/d/1uM_bomXunxOcC8KsBiFDlsKSEJEcKTZGHS8jqSlErjs/edit?usp=sharing)Post-assessment quiz KEY: [Lesson 3: Post-Assessment Quiz KEY](https://docs.google.com/document/d/1Tn7dYCblPtDg5lGnlYKz1ljmhb8awP1xXVYuq9XWXAs/edit?usp=sharing)Formative Assessment: Questions and discussion throughout the lesson provide the instructor with information about how well their students are receiving the material. |

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| **Lesson 4: Nature’s Champions to the Rescue** |
| **Est. Time:** 55 minutes |
| **Lesson Learning Objectives:** 1. Recognize practical purposes of biomimicry in everyday life.
2. Apply the steps of the engineering design process.
3. Invent an idea using the concept of biomimicry
 | **Indiana State Standards: Standards for Technology and Engineering Literacy (Grades 6-7)****ETE – 1.1** Illustrate the purpose of engineering and technology in society. **ETE – 4.1** Apply the steps of the design process.**ETE – 4.2** Use the design process to create a product that addresses a real-world problem.NGSS**ETS1.A-** The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1) |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***5 minutes* | Discuss plan and objectives for lesson |  |
| **Review**5 *Minutes* | Review what students learned in lessons 1, 2, and 3 Ask: * What are some examples of biomimicry we have discussed before?
* Can you think of any other examples of biomimicry that we haven’t discussed yet?
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| **Nature Champion Activity**45 *Minutes* | * Have students placed in groups of 4-5. Adjust depending on class size.

**Introduce Activity:** * Aliens have come to Earth. They have deactivated all the current weapons on the planet and are extremely dangerous!! The aliens have three diverse types that each pose their own threats to humans. Each type of alien has evolved specifically for catching humans because humans are considered their biggest threat.
* [Natures Champions to the Rescue](https://docs.google.com/presentation/d/1E-fYO92ZYrwe14jxyHOle6Vs0UHsg70Q2aSWVo5dwpg/edit?usp=sharing)

**Individual Work:*** Each student designs anti-alien biomimicry inspired gear for each type of alien.
* For each species the students must pick a species they were inspired by, list the qualities they have that make them a good pick, and then sketch their design idea

**Partner Work:*** Have students pass their papers to the person next to them
* Instruct students to write on their partners papers any attributes that were missed for all three species and any ideas they have to further develop the biomimicry concepts
* Afterwards, students return papers to their original owner. Have them finalize all ideas once returned.

**Group work:*** Have every student list off their species and biomimicry concepts to their group.
* Have students compare and think critically about which species and biomimicry concept would be the most successful. Have each group pick one concept from all of them which they will work on within the lesson.
 | PaperPencils |
| Think-Pair-Share | Swapping of paper and group discussion during Problems and Nature’s Solutions Activity | PaperPencils |
| **Resources:** * PowerPoint: [Natures Champions to the Rescue](https://docs.google.com/presentation/d/1E-fYO92ZYrwe14jxyHOle6Vs0UHsg70Q2aSWVo5dwpg/edit?usp=sharing)
* Worksheet: [Antialien Gear Brainstorm Sheet](https://docs.google.com/document/d/1LFwjlPLvZwHnc5X10McorqDA75zfeQQtp2lUlhI8R6M/edit?usp=sharing)

Formative Assessment: * Worksheet: Students work on the same worksheet throughout the whole lesson. The instructor can check in with each student at any time throughout the lesson to see if they are understanding or if instructions need to be reexplained.
* Think-Pair-Share: Students swap their worksheets within the middle of the lesson. This gives another opportunity for the instructor to step in and here if students are following along with the concepts they are learning.
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| **Lesson 5: *From Imagination to Innovation: Design Your Own Solutions*** |
| **Est. Time:** Two 55-minute. |
| **Lesson Learning Goals/Objectives:**1. Demonstrate principles of biomimicry through a hands-on activity
2. Solve a problem using the principles of biomimicry
3. Apply the principles of design to solve a real-world problem
 | **Indiana State Standards: Standards for Technology and Engineering Literacy (Grades 6-7)****ETE – 2.2** Apply knowledge and skills learned in science, mathematics, language arts, fine arts, and social studies classes when completing engineering and technology-based assignments.**ETE – 3.2** Investigate inventions and innovations of products, processes, materials, and tools. **ETE – 1.1** Illustrate the purpose of engineering and technology in society. **ETE – 4.1** Apply the steps of the design process.**ETE – 4.2** Use the design process to create a product that addresses a real-world problem. |
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| **Lesson Component** | **Instructions** | **Materials** |
| **Introduction***5 minutes* | Discuss plan and objectives for lesson |  |
| Review ***5 minutes*** | Ask students to raise their hands and answer the question: • What did we learn so far? Review what students learned in lessons 1-4 |  |
| Design Your Own Solution Activity***35 minutes*** | Introduce activity: Place students in the same groups they were in for activity 4Provide a PowerPoint slide outlining the steps of the activity: [Lesson 5: Design Your Own Solutions!](https://docs.google.com/presentation/d/1IBAv2tHeIcmlFzejJ_S6nQ93siKHyd0NEnULcyG6Wtk/edit?usp=sharing)* Discuss the design process: Define, Ideate, Prototype, and Test
* Discuss what a blueprint is
* Ask students what they remember about blueprints from lesson 3
* Discuss what a prototype is (MINIATURE)
* Ask students if they know what a prototype is
* Tell students they will be creating prototypes that are…
* Scaled down in size
* Made from simple, inexpensive materials provided for them

 Create a blueprint of the prototype: * Ask students to work together to draw a blueprint of the prototype they have in mind and discuss the materials they will need to create their prototype.
* Students should keep in mind:
* What is the product’s purpose? (e.g., protection, camouflaging, transportation, etc.)
* What will it be made out of?
* Is it wearable, something you carry around, or a stationary item?
* What will it look like?
* How will it function?

 Create a prototype of the product:* Introduce the materials provided for the students
* Tell students to be mindful of how much material they are using and what types of materials they are using
* Students will work together to create a prototype of their product
* Monitor groups and ensure students are working collaboratively.
 | Popsicle sticksHot glue gunConstruction paper StringPaperclips Tape Markers Cotton ballsCardboard Scissors Pencils Fabrics Straws Plastic sheets Quick-dry tacky glueTin foil Glue sticks |
| Discuss and Share***5 minutes*** | Ask students if they would like to share and/or demonstrate their prototypes with the classAsk students: What they learned through this activityA challenge they had during this activity |  |
| Swap and Evaluate***5 minutes*** | Post-assessment swap and evaluation: [Lesson 5: Swap and Evaluate Worksheet](https://docs.google.com/document/d/1A71PuPjf0Xo7Xl48gbUPUmCZBnimfhs0-CBZxyBQAv0/edit?usp=sharing)Ask students to swap prototypes with another groupAsk each group to evaluate the prototype based on creativity, biomimicry utilization, and presentationEach group will fill out one swap and evaluate the worksheet | Notecards Pencils |
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| **Resources:** * PowerPoint: Lesson 5: Design Your Solutions.
* Swap and Evaluate Worksheet: [Lesson 5: Swap and Evaluate Worksheet](https://docs.google.com/document/d/1A71PuPjf0Xo7Xl48gbUPUmCZBnimfhs0-CBZxyBQAv0/edit?usp=sharing)

 Formative Assessment: * Worksheet: Students utilize the same worksheets they worked on during lesson 4. The instructor can check in with each student throughout the lesson to determine if students understand the lesson or if instructions need to be explained.
* Monitoring Group Work: Instructors can monitor groups as they work to create their blueprints and prototypes to determine how well they are working together and utilizing biomimicry principles learned in class.
* Student Assessment: The swap and evaluate worksheet is a way for to simultaneously gauge grades for students’ projects and provide inspiration and guidelines for students. By working with this loose rubric, students gain a better understanding of the teacher’s expectations on future projects.
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