Dear Educators,

The Biomimicry Youth Design Challenge (YDC) is an authentic STEM learning experience that empowers learners to pursue project-based-learning skills needed to solve real-world problems. Working with an adult coach, learners explore biomimicry and apply their new understanding to create biomimicry solutions to global and local sustainability problems. For additional details, visit the Youth Challenge Home Page.

Designing a nature inspired solution to a sustainability problem requires students to connect:
• Biomimicry  
• Sustainability Problem  
• Designed Solutions

The YDC guides learners through the creation of a biomimetic design using the MIMIC Instructional Approach. Each 5E instructional segment is one in the five phased MIMIC series.

![MIMIC Instructional Approach Diagram]

**MOTIVATE** Get inspired! Motivate your team by exploring biomimicry. Discover how the unique abilities of organisms help them to survive and thrive, and how people have been inspired by them to design solutions to challenging problems.

**INVESTIGATE** Investigate the causes and effects of a sustainability problem you would like to solve. Identify the impact your solution will need to have to address the problem effectively.

**MATCH** Explore how nature has solved problems similar to yours by matching what you need your design to do with organisms that have similar abilities. Examine the features of these organisms and why they have those abilities, and determine which organisms could inspire your solution.

**INNOVATE** Create a biomimicry innovation that would help solve your selected problem. Refine your innovation after evaluating its strengths and weaknesses.

**COMMUNICATE** Use evidence to explain how your biomimicry design solves the selected problem and how nature has inspired it.

Youth Education at the Biomimicry Institute
YOUTH DESIGN CHALLENGE STORYLINE

The Earth is facing a number of large, shared ecologic and economic problems. The UN has established 17 sustainability goals that will help the people of the planet move towards a better future. As we look for solutions to the problems we face, people can leverage the strength of nature’s designs. When we study and use nature as inspiration in our solutions, we are doing biomimicry. Using biomimicry to address human problems is not a new idea. Indigenous cultures and current businesses have used biomimicry to find creative ways to solve the problems they have been faced with. These problems might be world-scale issues or local issues. Some biological structures or behaviors can be more helpful than others when solving specific problems. To derive the best solution to a problem, the structures of many natural systems should be investigated and the most useful ones should be incorporated into the design of the solution. Solutions have strengths and weaknesses. It is important to test the solutions, and iterate them in order to increase the likelihood of their success. By implementing successful local solutions, we can contribute to the UN sustainability goals for the planet.

- **Anchor Phenomenon:** Nature solves its problems with well-adapted designs, life friendly chemistry and smart material and energy use.
- **Driving Question:** How can learning from nature help us solve local and global sustainability problems?

Science Standards

Forty-four states (representing 71% of U.S. students) have education standards influenced by the Framework for K-12 Science Education and/or the Next Generation Science Standards.

Foundational biomimicry, climate change, and design challenge alignments are shown in the table below. Alignment strength will depend on lesson choice, depth of instruction, and problem choice. Additional specific physical, earth, and life science standards can be selected by choosing a particular Sustainable Development Goal as the focus for the design challenge.
The foundational biomimicry, climate change, and design challenge alignments are shown in the table below. Alignment strength will depend on lesson choice, depth of instruction, and problem choice. Additional specific physical, earth, and life science standards can be selected by choosing a particular Sustainable Development Goal as the focus for the design challenge.

<table>
<thead>
<tr>
<th>DISCIPLINARY CORE IDEAS (DCI)</th>
<th>SCIENCE &amp; ENGINEERING PRACTICES (SEP)</th>
<th>CROSSCUTTING CONCEPTS (CCC)</th>
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<tr>
<td><strong>BIOMIMICRY</strong></td>
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<td>MS, HS - LS1.A: Structure and Function&lt;br&gt;MS, HS - LS4.C: Adaptation</td>
<td>• Developing and Using Models&lt;br&gt;• Engaging in Argument from Evidence&lt;br&gt;• Constructing Explanations and Designing Solutions</td>
<td>• Structure &amp; Function&lt;br&gt;• Patterns&lt;br&gt;• Systems &amp; System Models</td>
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<td><strong>ENGINEERING DESIGN</strong></td>
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<td>MS, HS - ETS1.A: Defining and Delimiting Engineering Problems&lt;br&gt;MS, HS - ETS1.B: Developing Possible Solutions&lt;br&gt;MS, HS - ETS1.C: Optimizing the Design Solution</td>
<td>• Asking Questions and Defining Problems&lt;br&gt;• Developing and Using Models&lt;br&gt;• Analyzing and Interpreting Data&lt;br&gt;• Constructing Explanations and Designing Solutions&lt;br&gt;• Engaging in Argument from Evidence&lt;br&gt;• Obtaining, Evaluating, and Communicating Information</td>
<td>• Systems &amp; System Models&lt;br&gt;• Influence of Science, Engineering, &amp; Technology on Society and the Natural World&lt;br&gt;• Structure and Function</td>
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<td>MS, HS - ESS3.D: Global Climate Change&lt;br&gt;MS, HS - ESS3.C: Human Impacts on Earth Systems</td>
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<td>• Cause &amp; Effect&lt;br&gt;• Stability &amp; Change</td>
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**ADDITIONAL PHYSICAL, EARTH, AND LIFE SCIENCE STANDARDS**

Choose a Sustainable Development Goal that matches your class or program content as the focus for the design challenge. Refer to the document, UN Sustainable Development Goals Aligned to NGSS, for suggested alignments.
The Match section of The Biomimicry Institute’s Youth Design Challenge (YDC) begins with students using the biomimicry design process to biologize their design problems (translating the function and context into biological terms so that they can be searched on AskNature.org). Next, students identify multiple biological organisms to arrive at an abstraction—removing the biological terminology and distilling the essential principles of the strategy. Learners are encouraged to conduct research in nature (if possible) and may also use the AskNature online database as a valuable resource. Match wraps up the design process by having students assess how well their abstractions summarize the biological strategies on which they focused. Students are encouraged to take photos and make sketches to capture and document their design process.

### Goal

| Identify biological strategies aligned to the function of their design. |
| How can we use biological strategies found in nature to inspire a solution to the identified problem? |

### ENGAGE

**Engage Questions:**

- What is and isn’t biomimicry?

**PROCEDURE**

1. Have student answer the following statements with a “yes” or “no” for biomimicry:
   
   a. A person dissects a frog or grasshopper to see how it works? No
   b. A telephone pole that has branches so it looks like a tree? No
   c. A paint that uses the understanding of lotus leaves to rinse off quickly? Yes
   d. A person raises fish or butterflies in their classroom to see life cycles? No
   e. A solar panel that follows the sun like a flower? Yes

**Extension Activity:** Extend this assessment of biomimicry by instructing students to look for and think of more examples and non-examples, quizzing one another in small groups.

### EXPLORE

**Explore Questions:**

- How does biomimicry use biological strategies to design? (challenge to biology)

**PROCEDURE: PART 1**

1. Tell students that they’re going to use the information gathered in the *Exploring Functions in Nature* activity from the Motivate section. Remind students that biomimicry relies on deep observation of nature, specifically, to discover a trait that an organism has and the function or purpose of the trait.
2. Tell students that there are several ways to approach a design problem using biomimicry and today we’re going to learn about the Biomimicry Design Process. The steps in the process are:
   1) define 2) biologize 3) discover 4) abstract 5) emulate 6) evaluate

3. Define - Tell students that biomimicry designers define the challenge prior to taking action. You cannot create an effective solution to a problem that you have not defined. Use the worksheet **Define the Challenge** to take student SDG information through the process. Use the worksheet to reframe the challenge into a design question.

4. Biologize - This word means “to translate into biological terms/language”. Tell students that biomimicry designers must biologize the function(s) of their design to understand what to look for in nature. The goal is to reframe the functions of your design with biological terms and then “ask nature” for advice. Use the “How might we...?” information from the Define the Challenge worksheet to begin the **Biologize Function and Context** worksheet.

5. Discover - Tell students that during this time, they will look for natural models (from organisms, all the way up to ecosystems) that need to address the same functions and context as your design solution. Spending time outside will help you identify the strategies used that support their survival and success. This step was begun in Motivate, but now that students have a greater understanding of the essential elements of biomimicry, an additional session outdoors might support their learning goals. Remind students that the AskNature online database is also an excellent resource for finding biological strategies.

6. Abstract Design - To abstract something means to make a conceptual model of it. Tell students that this next part of the biomimicry design process will require them to study and understand a biological strategy, then communicate that idea by replacing the biological words with design terms—and this will take practice. We want to understand a biological strategy to be able to clearly communicate what the strategy does (its function) and how it is accomplished.
   a. Also tell students that several abstractions/interpretations of a biological strategy might all be correct if they are presenting their ideas through the evidence of what the organism does. This approach is connected to the Next Generation Science Standards, Science and Engineering Practice #7 - Engaging in Argument from Evidence.

7. Tell students that the rest of the biomimicry design (emulate and evaluate) will be explored during the next phase, the Innovate section of YDC.

**EXPLAIN** *(Vocabulary)*

<table>
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<th>Abstract</th>
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<th>Iterate</th>
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<tbody>
<tr>
<td>Biologize</td>
<td>Ethos</td>
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**Explain Question:**

- Which organisms have strategies for solving problems that are similar to the problem we want to solve?

**PROCEDURE: PART 1**

*What tools do we have available to help us gather information about biological strategies?*

1. Tell students that they may use the **Biomimicry Taxonomy** sheet to help them ask the design questions in a biological context. Students may move from the center outward or from the edges to the center in
order to help them understand how functions are grouped. Encourage students to examine the entire sheet.

2. Using the AskNature Biological Strategies pages, students will be able to select the phrases from the taxonomy to input into the website.

3. Students should find two-to-five biological models that all exhibit the function that is needed to solve their identified problem. Encourage students to document all of the strategies they researched. (This is a good place for citation skills practice.)

**PROCEDURE: PART 2**

How will we select the biological strategies that will become our models for a biomimicry solution?

*Abstract Design Steps*

1. Review the vocabulary terms “strategy” and “mechanism” with students. Emphasize that strategy focuses on WHAT the organism does and mechanism focuses on HOW the strategy is done. We will focus our attention on the function as it often includes the mechanism.

2. For each biological strategy, have students write a complete sentence using this sentence structure to summarize the biological strategy:
   a. Part of the organism, organism, the function (WHAT it does it), the mechanism (HOW it’s done).
      (Example: The antennae of the honeybee enable smooth landings by sensing landing distance and angle, signaling the body to orient appropriately).

3. Students then draw a sketch or concept diagram of the biological strategy to help clarify their understanding. In the drawings, label how each organism’s traits work to accomplish the needed function given the specific conditions and context (i.e., variables) in which the organism lives. Explain that the conditions and context pertain to the environment in which the organism is found (i.e., does it live in water?). For example: the honeybee flies through the air—it is an important context to consider.

4. Students go back to their sentences that describe the biological strategy and highlight or underline keywords or phrases that address the function (purpose/WHAT it does) and mechanism (HOW it’s done).

5. Replace the biological words with neutral synonyms—take the biological context away. (Example: “fur” is replaced with “fibers” and “skin” is replaced with “membrane”). Use this [Biology to Engineering thesaurus](#) to help students find possible terms to use.

6. Finally, students rewrite the biological strategy using the engineering/design words that were substituted for biological words from the thesaurus.

**Elaborate/Extend Question:**

- How can we ensure that our selected strategies meet the design challenge?

**PROCEDURE:**

1. Remind students that they’ve participated in a (re)connect activity if/when they went outside to observe nature, participated in an ethos activity when they did an empathy interview, and now are going to learn about how the abstract phase of the biomimicry design cycle is connected to the emulation of biological strategies.

2. Tell students that they will share their abstracted design ideas with peers to collect feedback on how
completely they have expressed the function of their proposed design. Encourage students to ask probing questions about a strategy to see how well their peers understand it, themselves.

**EVALUATE**

Evaluate Question:

- How effectively does each abstraction that I wrote translate to biological strategy?

**PROCEDURE:**

1. Tell students they will have an opportunity to argue from evidence (this is a Next Generation Science Standard Practice) as to why their discovered strategies are the best model for the design they have in mind.

2. Determine whether small groups or whole group would meet your students’ needs better, then ask them to share:
   - Sketches and summaries of the biological strategies;
   - Abstracted sentences of the design function;
   - Unifying design concept.

3. Tell students that they will be able to make iterations, or improvements, to their designs based on how well their peers understood the ideas presented. If necessary, allow students to review the Design Brief and Biomimicry Design Process for clarity on how to iterate on their design ideas.

**ADDITIONAL RESOURCES**

- [Ask a Biologist](#), Arizona State University
- [AskNature Collections](#), Biomimicry Institute
- [Pathful Connect](#) (platform for connecting industry experts to classrooms)
- [References for Biology Research (Biomimicry Toolbox)](#), Biomimicry Institute