BIOMIMICRY
YOUTH DESIGN CHALLENGE

INNOVATE

M MOTIVATE

I INVESTIGATE

M MATCH

I INNOVATE

C COMMUNICATE

BIOMIMICRY INSTITUTE

INNOVATE

The Innovate section of the Biomimicry Institute's Youth Design Challenge (YDC) begins with students brainstorming potential applications using their abstracted design strategies, and then they will create and construct a prototype design. They will refine that design through several emulation and evaluation phases to reach their final solution.

- During this iterative process, students will create a visual representation that communicates how their biomimicry design solution addresses the selected problem and assists in reaching the chosen SDG.
- As the Innovate section wraps up, students evaluate the design's ability to provide a solution to the local problem. This is an important step in the design process as students will need multiple opportunities to improve their designs.
- Students should continue taking photos and documenting their design process to show the improvements and explain why those changes were made.

Goal: Create and refine a nature-inspired solution to effectively address an identified problem and evaluate how well the solution will function.

Question Aligned to the Storyline: How can we, as biomimicry designers, apply our translated strategies to create a design that addresses our identified problem?

5E Instructional Model—Elaborate: In Innovate, we focus on the Elaborate component. Now that students have constructed explanations of how nature solves certain functional problems, and students have abstracted design strategies using these phenomena, they will have the opportunity to further their experience to apply these strategies in creating a design solution for their chosen problem.

Innovate Questions

Part 1: How do we apply abstracted design strategies to create a sustainable design?

Part 2: What might be some patterns or relationships that arise from the abstracted design strategies, and how could they be used to create an innovation?

Part 3: How will we refine our biomimetic design concept to improve its effectiveness in solving the identified problem?

Part 4: How will we ensure that our biomimetic design appropriately addressed the identified problem?

Part 5: How did this process help us better understand and connect to nature?

Procedure Part 1

How do we apply abstracted design strategies to create a sustainable design?

1. Remind students that they've now discovered and translated several design strategies from nature. They will now begin to capture the essence of the various strategies and mechanisms, through the **Emulate** phase, to determine whether using one or more strategies could help fulfill the **Design Brief**.

2. Tell students that they will now continue on their work of creating biomimetic designs using the Biomimicry Design Process with a focus on **Emulate** and **Evaluate**.

3. Elaborate on how during the **Emulate** phase of the design process, they will look for patterns and relationships among the strategies that were abstracted from biological models. They will also brainstorm application ideas for how one or more of their design strategies can be used to create a sustainable product, process, or system. And finally, they will create a solution!

4. During the **Evaluate** phase of the Biomimicry Design Process, the goal will be to assess how well the design concept meets the **Design Brief**, while adhering to the criteria and constraints of the selected challenge. Another very important evaluation will be on whether the design is furthering sustainable goals, observing some of the patterns found in nature (like using only abundant resources, using low energy, conserving water, etc.), and considering any unintended consequences their designs might have on the environment. Considering how the solution also meets the goals of (Re)Connect and Ethos will be important as well.

Procedure Part 2

What might be some patterns or relationships that arise from the abstracted design strategies, and how could they be used to create an innovation?

1. Invite students to explore some of the patterns seen between the abstracted design strategies they have focused on.

- Use the **Uncover Patterns** resource from the Biomimicry Toolbox to help with this process.
- Ask students to compare their abstracted design strategies side-by-side, looking for central ideas or unifying concepts that could summarize the strategy and be used for design.
- It may be helpful to have students work in pairs or small groups on each of their strategies.

2. Once the patterns or relationships have been identified from the various statements, have students brainstorm potential application ideas:

- One abstracted design strategy may provide the strategy needed to solve the design problem, but students can also combine multiple abstracted strategies to solve the problem.
  - **Note:** during the YDC judging process, some teams have received higher scores in years' past, because of their creative implementation of more than one biological model—however, that does not mean a very well-delivered design based on learning from a single organism would be overlooked.
- Have students elaborate on how this new strategy might be used to solve their selected problem. Tell them to consider each of their abstracted design strategies in relation to the original design question or problem they identified in the **Define** step.
  - "How can this strategy inform our design solution?"
  - Have students write down all of their ideas and then analyze them.
  - The **Biomimicry Brainstorming Activity** provides one way of doing this.

- Assist teams as they work. After about 20 minutes, or when students have explored all of the potential application ideas in the brainstorm, instruct students to study the collection of ideas they captured. Ask students: "Do any of the ideas seem to fit together?" and "Can you recombine or mix them to arrive at new ideas?"
- Have students draw lines, arrows, and add notes as needed to capture their observations and additional ideas. Give students approximately 15 minutes for this part of the activity.
- Check in with teams as they work to monitor their progress and answer questions.

3. Remind students of the path that they have taken:

- Students were given a Design Brief that asked them to identify and solve a problem connected to a local and/or global issue. **(Define)**
- Students were introduced to biomimicry as a way to create sustainable designs.
- Students were shown how organisms have lessons to teach us about solving problems.
- Students were asked to match their design needs with several organisms' strategies. **(Biologize** and **Discover)**
- Students were shown how to translate these strategies for use in design and brainstorm application ideas. **(Abstract Design Strategies)**
- Students are now asked to design and create their innovation based on their research **(Emulate)** and after that they will **Evaluate** how well the solution meets the defined problem.

4. Have students make concept models of their design ideas. Note the difference between a biological model and a concept model explored here. These models might be drawings, diagrams, or physical replicas/prototypes of the design concept. The important point to remember is that the model is clearly understandable to others and communicates the key features and purposes of their design.

- Encourage students to think about and incorporate details into their designs. Here are some questions you might ask:
  - What are the dimensions? How much space does it need?
  - What is my design made of? Are the materials sustainable or sustainably-sourced?
  - How does my design fit into the environment in which it is designed for?

Procedure Part 3

How will we refine our biomimetic design concept to improve its effectiveness in solving the identified problem?

1. Tell students that design requires multiple concepts and ideas to be analyzed and explored through various iterations before settling on a design solution in the **Emulate** phase of the Biomimicry Design Process.

- If possible, talk with the stakeholders affected by the problem or experts from students' empathy interviews. They can ask for feedback on the strongest idea(s) they think are worthy of pursuing.
- Solutions have strengths and weaknesses. It is important to consider how the solutions will work not only for performance capabilities and for solving the problem being addressed, but also for whether they are offering true sustainable solutions and not unintentionally doing more harm.

2. Refine the list of brainstormed application ideas to pursue the strongest potential solution that they will want to develop for their biomimetic design.

3. Encourage students to create two- and three-dimensional models that highlight the abstracted design strategy for their design concept.

- Consider having students use homemade sculpting clay or scrap materials from a junk drawer as a way to increase their awareness of the design features.
- Free, online websites and resources like TinkerCAD or 3D Slash can be easy introductions to 3D modeling and design, as well.
- If resources are limited, sketching, illustrations, and written explanations will suffice.

4. Tell students that the model that is created and based on their abstracted design strategies might require several versions before it is complete. Use class time for students to continue working on their biomimetic designs for however long seems reasonable.

- **Note:** Ideally, students would iterate 2-3 times before arriving at their final submitted work—each time refining their design based on data/evidence and justifying their design decisions in the light of their identified problem.

Procedure Part 4

How will we ensure that our biomimetic design appropriately addresses the identified problem?

1. Have students review the strategies and mechanisms that informed their final design. Ask them to think about how the strategies and design concepts they are working with relate to patterns also seen in nature that were explored in the previous lesson (i.e. using multifunctional design, building with modular and nested components, etc.).

- Remind students that biological strategies should not have simply been "an attachment" to their design, but should have been the main component, so that should be the same for their abstracted design strategy.
- For example: jackrabbit ears cool through their large surface area that dissipates heat. A design solution for a cooling tower should not then be to add "rabbit ears" to a standard cooling tower model.

2. Have students **Evaluate** the design concept(s) for how well they meet the criteria and constraints of the design challenge. Refine and revisit previous steps as needed to produce a viable solution.

- These next few steps are all about assessment. Students will examine the design concepts they have developed for how well they solve the selected design challenge in a life-friendly way and for how feasible the designs could be in real-world application.
- Although **Evaluate** is shown as the "last" step in the Biomimicry Design Process, evaluation should occur multiple times throughout the design process and with increasing rigor.

3. Ask students to consider potential barriers or limitations that their design concept might face (i.e. technology, cost, matierals, regulations, culture) and how the solution could be deployed in the real world. Is implementation/adoption of their idea feasible? What are the next steps it would take to achieve their goals?

4. Help students assess and explain how their final design helps solve their problems by reviewing the **Design Brief**. If the design did not clearly solve the problem, have students describe why and propose changes to the design to make the design a more effective solution to the problem.

5. Elaborate on the Ethos component of biomimicry and how the **Evaluate** phase includes reflection on the aspirational ideals we have set for how well the design supports life (i.e. is sustainable). Others goals could be aiming for zero waste, modular design, life-friendly materials, multifunctionality, and cooperative relationship opportunities. Solutions should also evaluate the (Re)Connect component: how have the students' design solution help humans better reconnect with nature?

- Communicating the value of the design, considering its ability to solve the problem, and explaining how the design matches nature's sustainability is an essential part of the evaluation process for biomimicry.
- Communicating scientific and engineering discoveries is also essential to help stakeholders understand the importance of the project.

6. In small groups, have students create a visual representation of how their bio-inspired design solution for the local problem contributes to reaching their chosen SDG.

Procedure 5

How did this process help us better understand and connect with nature?

1. Begin by asking students to reflect on their own whether they feel more connected to the natural world after this experience. Ask questions like, "How has your relationship to being outside changed?" and "How has your perspective about organisms, ecosystems, human impact, or design changed since beginning this project?" Invite them to also consider how the community in which they are solving their challenge might change for the better if more people were more deeply connected to nature in this way.

2. Have students get into groups to share their reflections and come up with a list of ways this process surprised them both in learning from the natural world and how we can create better designs that are helpful to the environment and to us as a society.

3. Come back together as a group and share ideas.

4. Invite students to consider the practice of gratitude. Thanking nature for the guidance to solve these problems helps strengthen the Ethos element of biomimicry.

Innovate: New Vocabulary

Evaluate Model Protype

Additional Teacher Resources

- Next Generation Science Standard: Appendix G - Crosscutting Concepts
- Bozeman Science Patterns Video (7 minutes)
- Rapid Prototyping, IDEO
- Homemade Sculpting Clay (6 minutes)
- 3 Ways to Practice Gratitude, Nemours TeenHealth