BIOMIMICRY
YOUTH DESIGN CHALLENGE

INVESTIGATE

M MOTIVATE

I INVESTIGATE

M MATCH

I INNOVATE

C COMMUNICATE

BIOMIMICRY INSTITUTE

INVESTIGATE

The Investigate section of the Biomimicry Institute's Youth Design Challenge (YDC) begins with students understanding human impact and further investigating the causes and effects of the problem they would like to solve using biomimicry.

- Students continue to narrow broad issues and goals presented in the **UN Sustainable Design Goals (SDGs)**. The educator/coach has the option of selecting one or more SDGs (aligned with the Next Generation Science Standards) for students to work with, or letting students choose their own SDG.
    - *The modeled activity uses climate change, however, educators are encouraged to select a goal that resonates with students and is aligned with instructional goals.*
- Teachers guide students in a deeper investigation of their chosen problem, in preparation for asking how nature solves similar problems in the upcoming Match section.
- Investigate wraps up with learners considering what their designs would need to do to solve the problem and describing the design project's criteria and contraints.

Goal: Investigate, identify, and define the problem to be solved sustainably using nature as a mentor.

Question Aligned to the Storyline: To solve our selected problem, what does our design need to be able to do, and what are the criteria and constraints for success?

5E Instructional Model—Explore: In Investigate, we focus on the Explore component, and the activities are designed to introduce students with an experience that helps prepare them for later introductions to scientific and technological explanations of how biological strategies function to better inform design. They will have time to investigate the problem chosen in alignment with the Sustainable Development Goals (SDGs). Teachers are encouraged to ask probing questions and promote student-to-student interaction.

Investigate Questions

Part 1: How might we use SDGs to identify design opportunities related to human impact?

Part 2: How will we decide which specific problem will be the focus of our design challenge, and who might be impacted by our designs?

Part 3: Which SDG will we focus on, and why is it important?

Part 4: What does our design need to be able to do to solve the specific problem, and what are its limitations?

Procedure Part 1

How might we use SDGs to identify design opportunities related to human impact?

1. Share with students that humans can make impacts to the environment with design in many different ways, including water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land). These impacts can be linked to several **SDGs**. Invite them to think of some ways that human impact is made worse when we don't think about the consequences of our choices of the products we design.

2. Reminds students that the **SDGs** have the word "sustainable" in them, because sustainability is critical to lessen negative human impacts and move toward positive ones. Tell students that sustainability means meeting our own needs without compromising the ability of future generations to meet their own needs.

- Also tell students that environmental sciences and environmental engineering focus on the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance.

3. Revisit the **Design Brief**, and ask students to explore what they will need to know before designing ("What do you need to know before designing?"). Make a list of their questions that can be referred back to as the class works their way through MIMIC.

- Consider the context (climate, temperature constraints, location, and other factors affecting how and where the design is used, and by whom), as well as other limitations and constraints to be mindful of in deciding what needs to be known before designing.

4. Tell students that researching how to design, and investigating who might be impacted by our designs, is part of the process. Then we will look to nature to learn how there are strategies to solve these problems all around us.

Teacher Resources:

- Review ESS3.C Human Impacts on Earth Systems in **A Framework for K-12 Science Education: Practice, Crosscutting Concepts, and Core Ideas**.
- **Chapter 7: Dimensions 3: DCI-Earth and Space Sciences** (p. 194) to understand the goals of sustainability.

Procedure Part 2

How will we decide which specific problem will be the focus of our design challenge, and who might be impacted by our designs?

1. Do the modeled activity below with your whole class (as needed) for students to understand the process of identifying a specific SDG to be addressed, the context, criteria, and constraints, and proceed to the parts that follow in this procedure.

Modeled SDG Activity—on #13 Climate Change

- **SDG #13** focuses on action to mitigate climate change. Show the overview section to the whole group. Use this infographic to discuss the information on the page with focused attention on the bottom portion that states: *Rising global temperatures continue unabated, leading to more extreme weather.*

- Ask students to investigate some of the existing solutions that have been designed to mitigate the acceleration of climate change that have caused global rising temperatures, such as using renewable energy through solar and wind or changing diet to eat less carbon-intensive foods. After they have had the chance to search and share, have them discuss some ideas with the group. ***Optional Resource:*** **Project Drawdown Solutions**
- Explain how these solutions have made positive impacts toward climate action, and how even existing solutions can be improved with biomimicry, because nature is full of sustainable designs.
    - **Example:** **This YDC Team** looked to nature to improve wind turbines by decreasing frost build-up on turbine blades, which can negatively impact performance. Inspired by mint and lotus leaves, the team came up with a solution that could prevent drag-inducing frost from building up on wind turbine blades, thereby improving their efficiency and reliability in cold climates, without the use of chemical deicing agents. It is designed as an add-on to exisiting turbines to improve the overall performance and decrease risk of damage.
        - Takeaway: The turbine blade needs to keep ice from building up on the surface. The mint plant prevents frost from forming due to ridges, and lotus plants have a bumpy surface with wax crystals making it super hydrophobic. These biological strategies inspired the design.

2. Once you have completed the activity on climate change, decide whether the class will all be addressing SDG #13 or another one. Explore with students how to make the chosen goal more personal and tangible, aligning back to a specific problem they can solve that helps reach the goal.

- Use the modeled activity above to unpack the other SDGs in a similar way as needed, then use the **Reframing Problems Activity** to redescribe the challenge into possible areas of action.
    - The emphasis here is on what the solution does, not the exact details of what the solution is or how it might work. It's important not to get too far down the road of designing a solution, because that is where nature's creative lessons will offer a new lens for us to peer through.
- You may find the need to focus on a limited number of the SDGs for classroom YDC participation, or might also choose to do each of the 17 SDGs in this modeled format to support students with reframed statements.
- The following document can be used to further align science instruction around specific SDGs: **Aligning NGSS to SDGs**.
    - Students might also benefit from exploring the **"Why it Matters"** sheets for each SDG for the purpose of defining problems to solve.

3. Continue deeper into this process with your students, telling them that biomimicry designers define the challenge prior to taking action. They will not be able to create an effective solution to a problem that they have not properly defined. This is an opportunity to refine clarity.

- Use the worksheet **Define the Challenge** to take student SDG information through the process and to reframe the challenge into a design question.
    - Tell students that identifying the functions of these designs is important for the next step in the process during Match, where they will begin looking for biological models in nature that have these same functions.

4. Tell students that one way that designers attempt to make sure they are designing with sustainability in mind is to perform an empathy interview. Empathy interviews are a type of research done in an interview format with people who are affected by the problem we want to solve and might be impacted by our designs. For SDG #13 on climate change in our modeled example, if our goal were to mitigate impacts of

extreme weather, we might perform an interview with people in areas that are prone to wildfires, drought, hurricanes, or floods.

5. Consider working with local social organizations, businesses, colleagues on campus, administration, or parent groups to assess who might be available for a 30-minute empathy interview.

- Please note that district policy on adult guest speakers might need to be reviewed. Researching online first person accounts is an alternative approach.

6. Teach students about conducting interviews with people who might be impacted by what they design. Use the **Empathy Interview Tool** to become familiar with the process and goals of empathy interviews. This tool has been used by high school teachers to improve the student online learning experience. If the linked tool is inaccessible to your students (due to age or other considerations), consider having a student use the following format:

- Thank the person for their time.
- Introduce yourself.
- Introduce the SDG that was selected as the reason for the discussion.
- Ask the following questions:
  - How might these issues be impacting your/our community?
  - Who else might be negatively impacted by this issue?
  - What do you feel is most important for others to know about how this SDG works?
- Thank the person again for their time.

Procedure Part 3

Which SDG will we focus on, and why it is important?

1. Tell students that they will now select a specific SDG and problem to explore for the purpose of creating a design that has considered criteria and constraints. The process will be the same as with the modeled process of using SDG #13 (in Part 2 of this lesson).

- The SDG that students explore might be the same one that was identified in the Motivate section, or it might be another SDG that feels relevant to their lives.
- Encourage students to work together in pairs or small groups if they have selected/are unpacking the same SDG.
- Ask students to explore the "Targets and Indicators" and "Progress and Info" tab sections of their **SDG** to ensure that they understand the goals.

2. Explain to students that science and design (and engineering) are closely connected. Scientific observations can help to inform their designs.

3. Share that they will be creating a poster (or Google Slide/digital interface) of their selected SDG for sharing. The SDG that is selected to share in class may be the SDG that is submitted to the YDC, or students may decide to select another SDG based on feedback. The following should be on each poster:

- SDG number and title on the top, along with group member names
- What are the causes of this SDG? (causes)
- How is the earth impacted by not accomplishing or achieving the SDG? (What's the science?)
- Why are the people concerned about meeting the SDG? (effects)

- What are people doing to slow the negative effects identified in the SDG? (mitigation solutions)
- What are people doing to lessen the harm identified in the SDG? (current solutions)
- A summary sentence on the information gathered.

4. Tell students to continue recording all information from the poster into their Biomimicry Notebooks. A picture taken of the poster might also be logged in a digitial format.

5. Host a classroom gallery walk. Have students practice scanning each other's posters for the purpose of providing feedback on what they have selected to display. Conduct a student gallery walk of the posters with feedback sessions as appropriate to the classroom goals.

6. Tell students that in the next phase of MIMIC, they will have an opportunity to use the information that was gathered while outside and/or information gathered from **AskNature.org** (the world's largest database of biological strategies for sustainable innovation) to begin identifying biological strategies that could inform their biomimetic design.

7. Use student posters (assigning points for each bullet point of poster content) to evaluate student learning.

Procedure Part 4

What does our design need to be able to do to solve the specific problem, and what are its limitations?

1. Tell students that you are going to revisit the answers to "What do you need to know before designing?" (in Part 1 of this section). Separate the list into possible criteria, or what the design has to do, context considerations, and possible constraints or limitations of resources.

- Remind students that design problems have their own unique criteria and constraints.
    - If the whole class is working on one problem, they will be able to identify criteria and constraints together.
    - If there are groups in class working on a variety of problems, then each group will have to identify the criteria and constraints specific to their problem.

2. Explain that criteria, which typically reflect the context of the how and where the design will be used, and needs of the expected end-user of a technology or process, address such things as how the product or system will function (what job it will perform and how), its durability, and its cost. Sustainability criteria should also be included. Criteria should be quantifiable, whenever possible, and stated so that one can tell if a given design meets them, with focused attention give to sustainability.

- Context can include many factors, but it's essential to identify the needs of stakeholders (those who will be impacted) and the location or setting in which the design will be used. Without this context, a design challenge is often too broad to be addressed successfully. On the other hand, remind students to be careful not to define the context too narrowly.

3. Let students know that constraints, which frame the most important conditions under which the problem must be solved, may be physical, economic, legal, political, social, ethical, aesthetic, or temporal (related to time and place). In terms of quantitative measurements, constraints may include limits on cost, size, weight, or performance, for example. This also includes sustainably-minded constraints, such as not wasting fresh water or emitting pollution.

- Explain that applying too many constraints before beginning the design process can limit the number and variety of potential solutions. Asking the right question at the beginning of the project will guide them in their research and offer a better chance of arriving at an innovative and impactful solution.

4. Invite students to explore the patterns they have witnessed so far in learning what nature does well, such as using locally available materials, minimizing energy use, and using life-friendly chemistry. These are valuable considerations that can be introduced as aspirational ideals that we can return to in the final evaluation of how well the design functions. This is also a key component of the Ethos component of biomimicry.

- Remember that these resources are available for deeper exploration of patterns found in nature: **Nature's Unifying Patterns** and **Biomimicry Life's Principles**.

5. Revisit the list of questions and categorize them as criteria, constraints, or unknown.

6. Once the list has been categorized and reviewed together by the group, invite students to phrase their selected challenge as a question that begins with, "How might we...?"

- Their question should give a sense for the criteria and context in which they are designing, as well as the impact they want to have and what/whom it benefits. If it doesn't, it may be too broad.
- Their question should also be somewhat open-ended to ensure they haven't jumped to conclusions about what they are designing. If the question is very specific, it may be too narrow.
- Try a few variations. Then circle the one that is not too broad or too narrow, but just right for the chosen design challenge.

Investigate: New Vocabulary

Climate
Constraints
Criteria
Ecological
Empathy Interviews
Human impact
Scientific observations

Additional Teacher Resources

- **Our Climate, Our Future Videos** (2-5 minutes)
- **The Emergent Pattern of Climate Change** (12 minutes)
- **Before the Flood** (Documentary; 96 minutes)
- **Climate Change Resources from Previous YDC Program Cycles**
- **Global Climate Change: Vital Signs of a Planet**, NASA
- **Climate Literacy and Energy Awareness Network**, CLEAN
- **A Student's Guide to Global Climate Change**, EPA