Biomimicry Design Challenge

Lesson 5: Creating Nature-Inspired Ideas

Credit: Getty Images 83170683: sot: The hemisphere that trees come out

SUMMARY

In this three-part lesson, students begin to generate design ideas from the biological strategies and patterns they discovered in previous lessons. In the first session, they learn how to translate biological strategies from their research into biomimetic design strategies that can be applied to a design problem. In the next session, they participate in a biomimicry brainstorming activity to generate many diverse design ideas for applying those design strategies. In the final session, they assess those ideas more closely for relevance and feasibility and select the strongest idea to carry forward in the design process.

STANDARDS

COMMON CORE STATE STANDARDS (CCSS):
Grades 9–10: RI.9–10.1, W.9–10.1a–e, W.9–10.2a–f, W.9–10.4–8, SL.9–10.1a–d, SL.9–10.2–6, L.9–10.1b–d, L.9–10.2a–c, L.9–10.3a, L.9–10.4a–d, L.9–10.5a–c, L.9–10.6, WHST.9–10.1a–e, WHST.9–10.2a–f, WHST.9–10.4–8, WHST.9–10.10
Grades 11–12: RI.11-12.1, W.11–12.1a–e, W.11–12.2a–f, W.11–12.4–8, SL.11–12.1a–d, SL.11–12.2–6, L.11–12.1b–c, L.11–12.2a–c, L.11–12.3a, L.11–12.4a–d, L.11–12.5a–c, L.11–12.6, WHST.11-12.1.a–e, WHST.11-12.2.a–e, WHST.11-12.4–8, WHST.11-12.10

NEXT GENERATION SCIENCE STANDARDS (NGSS):
High School
Biological Evolution: Unity and Diversity: HS-LS4-2
Engineering, Technology, and Applications of Science: HS-ETS1-1, HS-ETS1-2, HS-ETS1-3

CLOUD EDUCATION FOR SUSTAINABILITY (EFS) STANDARDS & PERFORMANCE INDICATORS:
Grades 3–12: B9, C1, C3, C4, C6–12, C37, D2, F7b,i, G1, G4–7, H5, H6, I37, I38

TEXAS ESSENTIAL KNOWLEDGE & SKILLS (TEKS):
Biology: §112.34.c.3.A,D, §112.34.c.11.A.B, §112.34.c.12.B.D
Environmental Systems: §112.37.c.3.A, D, §112.37.c.5.C

OBJECTIVES

Students will be able to …

- ✓ Identify the design insights embodied in biological strategies.
- ✓ Develop nature-inspired design ideas.
- ✓ Use a variety of brainstorming and creative-thinking strategies.
- ✓ Evaluate design ideas for relevance and feasibility and select the strongest ideas.

ESTIMATED TIME NEEDED

Three 55-minute sessions plus group work outside of class

KEY VOCABULARY

Biomimicry, biomimetic, design, sustainability, design strategy, biological strategy, brainstorming, bio-inspired

TOPIC TAGS

Biomimicry, design, design in nature, challenge, project, sustainability, design strategy, biological strategy, bio-inspired

PREVIOUS SKILLS NEEDED

Completion of Biomimicry Design Challenge Lessons 1–4

ATTACHMENTS

- From Inspiration to Application Presentation
- From Inspiration to Application Presentation Teacher's Notes
- From Inspiration to Application Student Notes
- From Inspiration to Application Student Notes Sample Answers
- Developing Design Strategies Worksheet

MATERIALS

SESSION 1: FROM INSPIRATION TO APPLICATION

None

SESSION 2: BIO-INSPIRED IDEAS

Per group:

- ☐ Large piece of paper (e.g., flip chart paper or butcher paper)
- ☐ Index cards (10.16 x 15.24 cm/4 x 6 in. or larger)
- ☐ Sticky notes
- ☐ Colored markers

SESSION 3: SELECTING A DESIGN DIRECTION

- ☐ Large piece of paper (e.g., flip chart paper or butcher paper)
- ☐ Sticky notes
- ☐ Colored markers
- ☐ Dot stickers/labels in three different colors (e.g., green, yellow, red)

BACKGROUND INFORMATION

When we think of what designers do, it is probably the brainstorming, creative thinking, and solution development that come most quickly to mind. These activities are captured in the Create step of the design process along with another preparatory activity that is unique to the practice of biomimicry: translating biological strategies into applicable design strategies. That is, once a design team has assembled a variety of natural models for inspiration, they must analyze and extract the key insights from each biological strategy so that those strategies can inform potential design solutions. The experience of doing this merges science literacy with creative problem solving as teams interpret their research findings, brainstorm dozens of applications for what they've learned, and select their best ideas for further refinement in the design process.

Credit: Getty Images sb10064500w-001: Bob Stefko: Jackrabbit (Lepus californicus) sitting in grass

IN ADVANCE

SESSION 1: FROM INSPIRATION TO APPLICATION

Make sure students come to class prepared with their biological strategy research from previous lessons and Natural Strategies Research Documentation Worksheet from Lesson 3. Review the From Inspiration to Application Presentation and corresponding Teacher's Notes. Set up and test the equipment needed to share the presentation. Print one or more copies of the Design Strategy Worksheet for each student.

SESSION 2: BIO-INSPIRED IDEAS

Make sure student design teams come to class prepared with their completed Design Strategy Worksheets and several design strategies ready to apply to their design challenge. Review the Bio-Brainstorming Activity in advance and collect the needed supplies.

SESSION 3: SELECTING A DESIGN DIRECTION

Make sure student design teams come to class prepared with several design ideas generated by the previous session's brainstorming activities. It is particularly helpful for students to refer back to their Build-the-Box Activity from Challenge Lesson 2 when completing this activity, so ask students to find the graphics they created then and refer back to them now. Review the Dot Democracy and BOP Quiz activities in advance, and collect the needed supplies.

ACTIVITY BREAKDOWN, SESSION 1: FROM INSPIRATION TO APPLICATION

Time	Exercise	Description
5 min.	Introduction	Recap learning to date and introduce the Create step, the focus of this session.
20 min.	Presentation	Share the From Inspiration to Application Presentation while students participate and take notes on the corresponding Student Notes worksheet.
25 min.	Group Work	Teams work together to complete the Design Strategy Worksheet.
5 min.	Wrap-Up	Facilitate a final synthesizing discussion and share with students their homework assignment.
Homework	Design Strategies	Teams finish their Developing Design Strategies Worksheets as homework.

ACTIVITY BREAKDOWN, SESSION 2: BIO-INSPIRED IDEAS

Time	Exercise	Description
5 min.	Introduction	Recap what students learned in the previous lesson and introduce the objective for the day.
45 min.	Activity	Students work in their teams to complete the Bio-Brainstorming activity.
5 min.	Wrap-Up	Facilitate a final synthesizing discussion and share with students their homework assignment.
Homework	Optional Assignment	Teams continue brainstorming design ideas or refine/recombine the ideas they generated in class.

ACTIVITY BREAKDOWN, SESSION 3: SELECTING A DESIGN IDEA

Time	Exercise	Description
5 min.	Introduction	Check in with students about their progress to date and introduce the objective for the day.
20 min.	Activity 1	Students use the Dot Democracy Activity to narrow ideas.
25 min.	Activity 2	Students analyze their preferred ideas using a BOP Quiz.
5 min.	Wrap-Up	Lead a final synthesizing discussion, and answer any lingering questions students may have.
Homework	Refine Design Directon	Teams continue to select a design direction based on their analysis of which design idea (or ideas) holds the most promise and to develop that idea further.

IMPLEMENTATION, SESSION 1: FROM INSPIRATION TO APPLICATION

1. **Introduction**: Give students an opportunity to share how their Design Challenge is going so far. Encourage them to recall what they discussed in the previous lesson (how to observe strategies and patterns in nature) and discuss whether they have had any luck noting patterns in their group research. Remind students that the previous lesson was part of the Explore phase of the design process they are using for this challenge. Tell students that today they are going to learn about the next step in the design process: Create.

2. Ask for a volunteer to remind the class about the purpose of the Create step. Encourage students to look at their notes or their A Biomimicry Design Thinking Process handout (from Challenge Lesson 1) as necessary. Remind students that in this step we "Develop design ideas that emulate nature's strategies" and that a critical part of this step is to extract the key design insights from the biological strategies they identified so that they can apply those insights to their designs. Tell students that they will be practicing this part of the Create step today.

3. **Presentation**: Share the From Inspiration to Application Presentation with students, using the corresponding Teacher's Notes to guide discussion. To help students organize and summarize their learning, give each student a copy of the From Inspiration to Application Student Notes, and ask them to complete it as they view the presentation.

4. After the presentation, answer any questions students may have.

5. **Group Work:** Hand out a copy of the Design Strategy Worksheet to each student. Tell students to get out their Natural Strategies Research Documentation Worksheet from Lesson 3, and sit together in their design teams.

6. Instruct teams to work together to translate their biological strategies into design strategies, using the method described in the presentation and the Design Strategy Worksheet. Give students 25 minutes to work together.

7. Individually check in with teams as they work to monitor progress and answer any questions they may have. Translating biological strategies into design strategies and concepts is one of the most unique and challenging parts of practicing biomimicry. When writing design strategies, students may jump to conclusions regarding how a biological strategy actually works. Encourage students to create simple drawings (or find existing diagrams or illustrations) to aid their understanding of the biology and encourage faithful emulation of the strategy in their design. Also encourage students to be mindful of the role scale and context play in their strategies and to be sure not to lose these details in translation. (For example, some strategies may work only under certain conditions and cannot be generalized and applied in other situations.) When selecting biological strategies to develop into design strategies, students may be tempted to focus on those strategies that fit a design solution they already have in mind. Try to discourage this practice and instead have students focus on strategies that best match the *context* and what it is the team wants their design to do (*function*).

IMPLEMENTATION, SESSION 1: FROM INSPIRATION TO APPLICATION, continued

8. **Wrap-Up**: Use the Reflection Questions on page 10 to stimulate a final synthesizing discussion and answer any remaining questions students may have.

9. **Homework:** Instruct students to keep working on their design strategies. Suggest teams divide the remaining strategies among their members, work independently to complete them, and then reconvene to discuss and refine as a group. Tell students that they will need to have their design strategies completed by the next class session, as they will be using them to brainstorm biomimetic designs. You may wish to collect and review students' strategies before they begin the next lesson to ensure that students have effectively translated the biological terms into more general terms.

IMPLEMENTATION, SESSION 2: BIO-INSPIRED IDEAS

1. **Introduction**: Ask students to recap what they learned in the previous lesson about translating biological strategies into bio-inspired design strategies. Tell them that now they will take their design strategies and use them to brainstorm bio-inspired design solutions to their design challenge.

2. Write the following quote on the board: *"The difficulty lies not so much in developing new ideas as in escaping from old ones."* —John Maynard Keynes, economist

3. Engage students in a conversation about what Keynes might have meant with this statement. *(Creativity can be limited by an attachment to, or familiarity with, how things have been done in the past.)* Tell students that this concept is important to keep in mind as they begin the creative part of the design process. Explain that one benefit of biomimicry is that it helps us to re-think how things can be done by looking for solutions in seemingly unusual places. Still, it takes creativity to apply nature's strategies in innovative ways. Brainstorming and other creative-thinking tools can help get your design team to think differently, "escape" old ideas, and move beyond obvious applications.

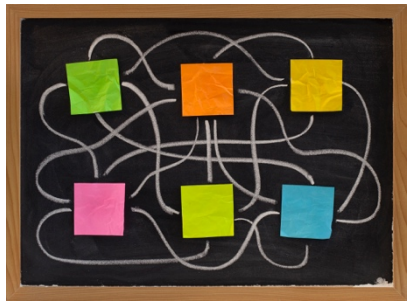
4. **Bio-Brainstorming Activity**: Have students sit together in their design teams. Give each team a large sheet of paper, markers, sticky notes, and index cards.

5. Direct students to write their original *design question* ("How might we…") across the top of the large paper. Then have them select 10–12 of their most interesting and inspiring bio-inspired *design strategies* (from the previous session/homework) and write them on the index cards (one strategy per card). Have students place the completed index cards in a pile in the center of the table.

Credit: Getty Images 519957352: genyuan huang: Grass

IMPLEMENTATION, SESSION 2: BIO-INSPIRED IDEAS, continued

6. Tell students that in this activity they will be brainstorming ways to apply their design strategies to their design problem/question. Explain that the point of brainstorming is to generate a large number of potential solutions to a problem and foster new ways of thinking. So, it is important to keep an open mind and encourage all ideas—even if they don't seem realistic at first. Encourage students to be generous with their ideas and withhold criticism of ideas offered by their teammates. Every idea is creative currency that may pay off later in the process!



Credit: Getty Images 101361836: Marek Uliasz

7. Instruct students to take turns reading the design strategies aloud to their team. After each strategy is read, the team should spend a few minutes brainstorming an answer to the question "How can this strategy help solve our design problem?" Tell them to record all of their ideas on sticky notes and attach them to the large paper. They can do this either by designating a "team scribe" or by providing enough markers and sticky notes for each student to write down his or her own ideas. Encourage students to capture their ideas as doodles, sketches, or short statements. It's OK if ideas are incomplete or in the form of questions; each note may represent only a single component or elements of a larger possible solution.

8. Walk around to assist teams as they work. When selecting design strategies for the Bio-Brainstorming Activity, students may again be tempted to focus on strategies that fit a design solution they already have in mind. Again, discourage this way of thinking and instead have students focus on strategies that best match the *context* and what it is the team wants their design to do (*function*). Insights gleaned from evaluating strategies for patterns can also inform selection.

9. After about 30 minutes or when students have explored all of the design strategy cards, instruct design teams to study the collection of ideas they captured and cluster them by moving the sticky notes around. Tell them to look for patterns and relationships between the ideas and clusters. Ask students: Do any of the ideas seem to fit together? Can you recombine or mix them to arrive at new ideas? Draw lines, arrows, and add notes as needed to capture your observations and additional ideas. Give students approximately 15 minutes for this part of the activity.

10. Again, check in with teams as they work to monitor their progress and answer questions.

11. **Wrap-Up**: When the class period is nearly over, instruct students to hang their brainstorming papers on the wall or provide a safe place in the classroom for teams to store their papers until the next class session. (Students may also want to save a copy as a photo, if they have a camera or smartphone.)

12. Use the Reflection Questions on page 10 to lead students in a final synthesizing discussion. Answer any remaining questions they have.

13. **Homework (optional):** You may wish to instruct students to spend additional time with their design teams outside of class to continue brainstorming design ideas or to refine/recombine the ideas they generated in class.

IMPLEMENTATION, SESSION 3: SELECTING A DESIGN DIRECTION

1. **Introduction**: Check in with the design teams on their progress since the last session. Did the activities spark some interesting ideas? Did the creative juices keep flowing after class? Sometimes letting ideas simmer "on the back burner" can result in surprising insights later on!

2. Tell students that today they are going to work in their teams to determine their strongest design idea—the one that they will continue to develop into a final design concept for their Challenge project. Direct students to gather together in their design teams and get out the brainstorming paper from the last session as well as any new ideas they generated since the last class. Explain that they will be doing two activities today to help them analyze their design ideas. Give each team another large piece of paper, a selection of markers, sticky notes, and colored dot stickers.

3. **Dot Democracy Activity**: Instruct students to review the clusters and notes they made during the last session and make any necessary adjustments to reflect additional work or new thinking since then. The goal is to create an arrangement on the paper that reflects all of the ideas currently "on the table."

4. Next, tell students that they will use the dot stickers to vote individually on the design ideas they think are the strongest. The three colors of dot stickers represent their first, second, and third choices (e.g., green = 1st; yellow = 2nd; and red = 3rd). Tell each student to get one sticker of each color and place those stickers on the three ideas they think are the best. Direct students to focus on the ideas that have the greatest potential to solve the team's design problem and that correctly apply a bio-inspired design strategy.

5. When all students have voted, direct each team to tally the votes and determine which ideas emerged as the most popular. Ask students, was there a clear "winner," or were several ideas popular? Have them discuss why they think some ideas were more popular than others and if there are elements of the less popular ideas that are worth pursuing further.

6. **BOP Quiz Activity**: Tell students that in this activity they will analyze several of their most promising design ideas according to three criteria: To what degree is the idea **Beneficial**, **Original**, and **Probable**.

7. Direct students to write their design question across the top of the large blank sheet of paper. Beneath it, have them draw a chart with five columns (the left-most column should be wider than the others) and add the headings (left to right): Idea, Benefits, Originality, Probability, Total. Have students write 5–7 of their best ideas from the Bio-Brainstorming and Dot Democracy activities in the Idea column.

IMPLEMENTATION, SESSION 3: SELECTING A DESIGN DIRECTION, continued

8. Explain to students that they are to evaluate each of their design ideas based on the following criteria:

    a. Benefits: Is this idea useful? Does it make a big impact and create a real solution to the problem you identified? Any idea that benefits a lot of different stakeholders and is a long-lasting solution should score well.
    b. Originality: Is this a new solution or a new approach to the problem? Is it more innovative than similar ideas that have come before it? The newer and more unique the solution, the higher it will score.
    c. Probability: Is your design feasible? Can it actually be done with existing technology or is it "pie in the sky"? Can you identify the resources and skills required to implement it? Does the idea solve for the constraints you identified in the Identify step (e.g., Build-the-Box Activity from Challenge Lesson 2)? Elements and ideas that have the fewest barriers and require the least effort to implement will score higher here.

9. Instruct students to rate each idea on a scale from 1 to 10 (with 10 being the highest score) based on how well it meets (or could meet) each criterion. Have students consider each idea one-by-one, score each design idea with the same level of scrutiny, and then write the score in the appropriate column. After they have rated each idea on each criterion, have them add the number together to create a master score for each design idea. Write this number in the Total column. Then have students analyze and discuss the outcomes from the activity.

10. **Wrap-Up**: Debrief the activities as a group, asking teams to share some of their insights with the class. You can also use the Reflection Questions below to help students synthesize what they are learning.

11. **Homework**: Instruct students to continue working in their teams to select a design direction based on their analysis of which design idea (or ideas) holds the most promise, and to develop that idea further. (If students will be submitting their designs to the Biomimicry Global Design Challenge, also remind them to consider how their design ideas incorporate and/or respond to system-level patterns in nature, as described in Challenge Lesson 4.) Tell students that in the next lesson, they will be presenting their design concept to peers for constructive feedback.

Credit: Getty Images 105655598: GYRO PHOTOGRAPHY/amanaimagesRF: Sketch pad and color pencils

REFLECTION QUESTIONS

Use the following questions to prompt critical thinking and guide students to reflect about the lesson:

- In the first class session, did you find translating biological observations into design ideas challenging? If not, what made it easy for you? If so, what was the most challenging aspect? *(Sample answer: It was not easy for us. We found we really had to focus to understand the science of how our biological strategies worked, not just what they do. And it seems like there are so many things to keep in mind—like not jumping to conclusions about our solution and remembering scale. When we started sketching things out, we found the process a little easier.)*

- In the second class session, how did it feel asking: How can this strategy help solve our design problem? Did ideas come easily? Or was it difficult? *(Sample answer: We got lucky and seemed to have a very easy time bio-brainstorming. After we translated our biology research into design strategies, it became much easier to see how we could apply it to our challenge. We're shocked at the sheer volume of answers available to us from nature!)*

- Was it easy for you to see patterns or connections among your ideas? What techniques did you find helpful to keep the creative juices flowing? *(Sample answer: Several of us are very visual, so we seem to work best when we draw things. We used a lot of sticky notes to see how our ideas meshed, and it was very fruitful!)*

- In the third class session, were you able to improve your design ideas based on what you learned during the Dot Democracy and BOP activities? *(Sample answer: Yes! The Dot activity helped us get consensus about which ideas worked best. Not everyone had the same first choice, but most of us had the same choices in 1st or 2nd place, so it was pretty easy to narrow down. Then we incorporated the 1st choice idea of the other person, so everyone got something he or she wanted. The BOP activity really helped us start looking at our ideas in a rational way.)*

- Did the activities in this lesson help your team uncover any surprising strengths or weaknesses among your ideas? *(Sample answer: Yes! We were all leaning toward one particular idea, but when we applied the BOP Quiz, we realized it wasn't practical at all!)*

- Are there other criteria that you think should be taken into account when assessing the strength of these ideas? *(Sample answer: One thing we talked about is that we want an idea that both makes a difference in the world and is FUN!)*

DIFFERENTIATION

For the Bio-Brainstorming Activity in Session 2, sometimes individual brainstorming can be as fruitful as group brainstorming. Depending on your class, consider giving students individual time to brainstorm how the design strategies could be applied to their design problem before having them share their ideas with their group.

ADDITIONAL INFORMATION

COMMUNITY CONNECTIONS

Suggest students have some of their after-school meet-ups in an outdoor location. Sometimes being in a natural setting can enhance the creative juices, especially when connecting ideas to nature! You may also want to invite particular community members, such as biologists, naturalists, entrepreneurs, or stakeholders to the classroom to help students brainstorm.

CROSS-DISCIPLINARY CONNECTION: LANGUAGE ARTS

- Suggest students revisit any intentions or goals they set at the beginning of the Biomimicry Design Challenge. This is a good time to check in and see if they are on track. They could look at their initial intention, roles, and responsibilities, and evaluate the work they have completed so far. Suggest they reflect honestly about whether they are making sufficient progress. If students are not meeting their goals, encourage them to brainstorm together about new strategies they could apply or roles they could shift to get back on track. Then have them revise their original plan and recommit to holding one another accountable.

- Students may be interested in using a tool like PenPal Schools to reach out to students in a classroom in another part of the world. They may want to brainstorm with students who have a different point of view, or perhaps they want to run ideas past those students. Students could also challenge students in another part of the world to complete a similar biomimicry design challenge. Because your class will be further along in the process than any newcomers at this point, your students could guide their pen pals, teaching them about the Biomimicry Design Challenge and the design thinking and biomimicry approach they are using to innovate.

CROSS-DISCIPLINARY CONNECTION: ART

Have a lesson on the value of sketching when brainstorming and designing. Demonstrate several different methods of sketching—with pencil, with colored pencils, on small sheets, on large ones, with various computer or smartphone applications, etc. Also discuss that there are different types of sketches—the quick and rough sketches that are simply used to **explore** ideas, those that are intended to be more **persuasive** by showing an idea in a favorable light, others that are designed to **explain** a concept, and still others that **prescribe** exactly how something should work. There are many useful tools on the Internet that are designed to help teach designers the value of visualizing ideas, such as through sketching, such as the Drawing Gym: Teaching Engineers How to Draw, from University College London.

Credit: Getty Images 482140831: Dave and Les Jacobs: Close up of tall wheat stalks in field

ADDITIONAL INFORMATION, continued

ASSESSMENT OPPORTUNITIES

Use a checklist to monitor students' participation in group activities. Suggest students add to their Portfolio examples of any ideas or sketches they identified or created in this lesson that they are particularly proud of. You could also have students self- and group-evaluate their team research material. Collect and review the Design Strategy worksheets. You could use the Cross-Disciplinary Connection: Language Arts to facilitate individual and group reflection and then meet with each team to check and support their ideas for maintaining or improving progress. The Reflection Questions on page 10 also provide an excellent opportunity to check students' understanding of key topics. The Cross-Disciplinary Connections offer further opportunities to reteach, extend, and check each student's progress so far.

TECHNOLOGIES

- There are many brainstorming and creativity tools that students could use in this lesson to help them generate ideas. One useful resource comes from Creativity Tools.

- Have students evaluate the technology tools they have been using so far to communicate outside of class. Has each wiki, Google Doc, e-mail, or other communication tool been serving its intended purpose? Would it be valuable to try new tools or adapt the way the tools are currently being used? Encourage students to work as a group to identify important technology tools and how they plan to use them.

RESOURCES/LINKS

For a variety of related resources, please see the Resource Bank for this grade level and theme. In addition, the following resources were cited in this lesson or relate specifically to this lesson:

Biomimicry Institute. (2016). [home page]. Retrieved from https://biomimicry.org
Biomimicry Institute. (2015). Biomimicry toolbox. Retrieved from http://toolbox.biomimicry.org
Biomimicry Institute. (2016). Large ears used to cool off: Jackrabbit. Retrieved from http://www.asknature.org/strategy/a250478ba7f69e68c71405d931c91d62
Hanks, K. & Belliston, L. (2006). *Rapid Vis. A new method for the rapid visualization of ideas.* (3rd edition).
Mind Tools. (2016). Creativity tools. Retrieved from https://www.mindtools.com/pages/main/newMN_CT.htm
PenPal Schools. (2015). https://www.penpalschools.com
UCL Drawing Gym. (n.d.). Drawing gym: Teaching engineers how to draw. Retrieved from http://www.ucl.ac.uk/drawing-gym/