LESSON PLAN 5:
BIOMIMICRY, "LOOKS LIKE," & "WORKS LIKE"

Curriculum: Introduction to Biodesign
Unit: 2––Biomimicry
Grade Level: 10th-11th

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TO FIND MORE LESSON PLANS AND TO READ MORE ABOUT THIS CURRICULUM VISIT: BIODESIGNMAKERSPACE.ORG

Background Information For Teachers

Overview of this lesson:

This lesson builds on material covered in Lesson 4, which is focused on how life evolves through adaptation and natural selection. Now, in Lesson 5, we compare how species evolve (slowly and non-directionally) to how designers design (rapidly, and intentionally). We make this connection because we want to highlight the idea that organisms in nature and design objects both evolve over time in response to external forces in a changing environment.

Biomimicry, the focus of this lesson, is when designers look to examples from the natural world to solve design challenges in the built environment. Keep in mind: the drive behind this curriculum is to get students to think about how the natural world, designers, and scientists each approach and solve problems and to ultimately encourage them to utilize and combine these approaches.

Biomimicry is the design of materials, structures, and systems modeled after the natural world. There are particularly famous examples of biomimicry in the history of human innovation that might be useful to highlight in your introduction of this concept. One example we like to share with our students is the kingfisher/bullet train story. In 1994, a Japanese engineer named Eiji Nakatsu **was** looking for a way to get rid of the massive sonic boom that the bullet train made when leaving a tunnel. Nearby residents were complaining about the disruption and the noise exceeded Japan's environmental standards. To solve this problem, Nakatsu took inspiration from the kingfisher, a bird that dives into the water after its prey without making any ripples in the water. Modeling the nose of the train on the beak of this aerodynamic bird, the bullet train now not only no longer created a sonic boom coming out of tunnels, but also was ten percent faster and used fifteen percent less electricity. This is a great story to tell students when introducing biomimicry as it underscores the idea at the core of biomimicry: many human design challenges have already been resolved in designs found in nature.

After reviewing these ideas with students, introduce the hands-on activity for the lesson: "Looks Like/Works Like." This is a design activity familiar to many RISD design students; it is often assigned to get designers to rapidly prototype and to consider form and function separately. In our version of "looks like/works like", it also gets students to closely observe an object or organism found in the natural world, and to begin to think about how its form or function might serve as inspiration in solving a human problem. For directions for this activity, see the full lesson plan.

Adapting this lesson to your classroom:

Before doing this activity, gather a number of organisms that your students can choose from, preferably living or nonliving 3-D representations of that organism (taxidermy or realistic models). At the Nature Lab, we utilized our large

large collection of preserved organisms, which of course, is not available in most classrooms. It is certainly preferable to have 3-D examples of organisms on hand as this activity asks students to, in turn, make 3-D models from the organisms they choose. However, if you need to, printed photos of organisms will suffice. Because this activity is ultimately about how designers might borrow from the natural world, we've found it is most successful if you supply students with organisms that have very visible applications to the human world and to human problems. For example, organisms that pick up things/drop things/retract limbs/camouflage/-climb/fly/stick to things/have shells or scales are sometimes easier for students to conceptualize as being useful in the human world than are mammalian animals that have fewer visible "mechanisms". We've tended toward providing students with jellyfish, starfish, cockroaches, geckos, turtles, armadillos, crabs, bats, butterflies, fish, seashells, because it's a lot easier (than say a bear or a horse) to see how these organisms "work." We also created a board with examples of different ways of creating paper joinery for students' reference, which may help students problem-solve when creating "works-like" models. You can see pictures of these joinery examples within the lesson plan.

Standards, Objectives, & Supplies

Grade Level: 10th-11th

Duration: 2 hours

Lesson Concept: Nature's iteration through evolution is slow and non-directional, but has taken place incrementally over the 3.8 billion years that life has been on this planet. Design, on the other hand, often involves iterative rapid prototyping which leads to new insight and direction for further design ideas. By beginning with an understanding of how natural evolution has met design challenges, we can "jumpstart" our designed solutions.

Lesson Objectives/Learner Outcomes:

1. Understand the differences and similarities between evolution and iterative design.

2. Utilize strategies and techniques designers and scientists use in model making.

3. Engage in making a work of art or design without having a preconceived plan.

Instructional Support Materials (if needed):

- Powerpoint with necessary images + journal prompts.
- LCD projector/smartboard
- "Evolution/Iteration" Handout (see end of PDF)
- Examples of paper joinery
- Examples of "Looks Like/Works" Like Models
- A number of real-life or pre served organisms or printed out pictures of organisms for "Looks Like/Works Like" Activity

Materials + Supplies:

- Printer paper or newsprint for models (enough for each student to have a small stack of paper)
- Scissors (for each student)
- Tape (a roll for every small group, or, ideally, per student)
- Glue (a glue stick for each student or hot glue guns to share)
- String or yarn (several yard-lengths per small group)

Science / Art Standards

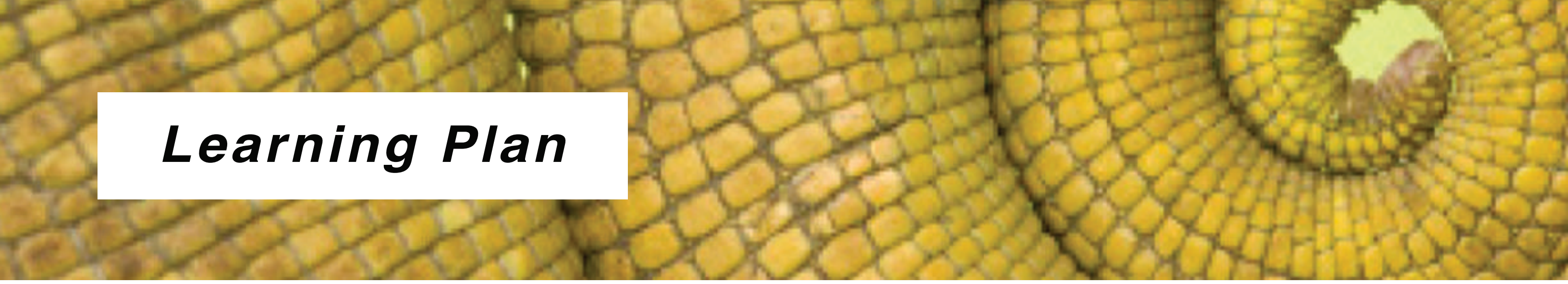
SCIENCE (Next Generation Science Standards):

LS4B Natural Selection - Natural Selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.

LS4C Adaptation - Evolution results primarily from genetic variation of individuals in a species, competition for resources and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence or extinction, can change when conditions change.

ART (National Core Art Standards):

VA:Cr2.1.ia Engage in making a work of art or design without having a preconceived plan.



Learning Plan

Stage 1: Motivation

1. Introduction Lecture Part I: Review of Evolution + How is evolution similar and dissimilar to design? Review with students the ways in which evolution works: over millions of years, through natural selection and adaptations resulting from random genetic mutation. Ask students: What does this have in common with design? How is it different? In this lesson, we are making the connection between how designers design and the way nature evolves. Specifically, we are thinking about how the form and function of an organism represents adaptations that have evolved to meet design challenges and how we can design innovations in the built environment using those strategies. Introduce key design terms "iteration" and "prototype" (see end of PDF for vocabulary definitions). Make a blank Venn diagram of "Evolution" and "Design Iteration" on the board and populate it by asking your students what they know about both (see end of PDF for "Evolution/Iteration" handout to see what this might look like). Reiterate the ways in which evolution is slow and non-directional, while design is rapid and intentional. *(10 minutes)*

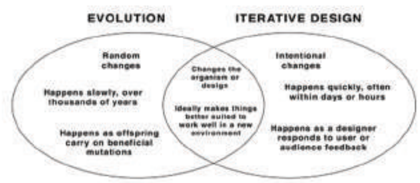


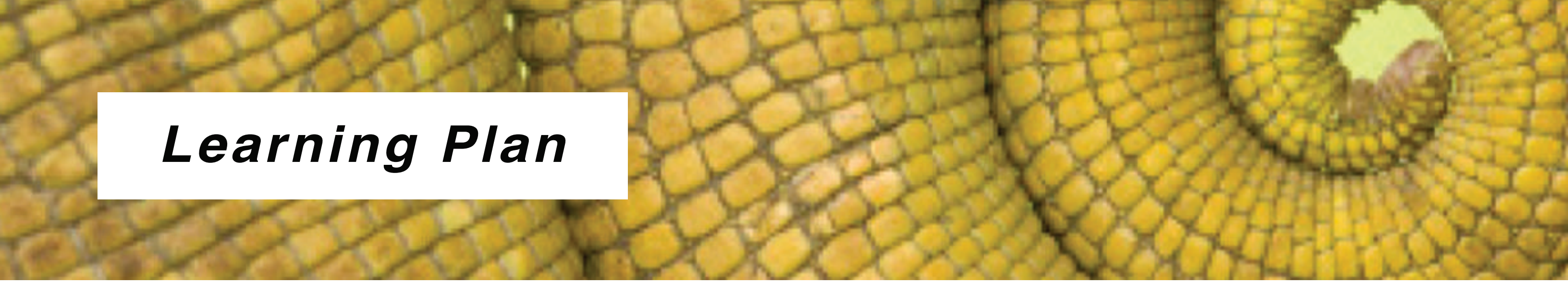
Image: Venn Diagram of Evolution and Iterative Design that you can lead your students in making. (see end of PDF)

Image: For a great example of biomimicry, look to Japan's shinkansen or "bullet trains" and how a kingfisher came to be instrumental in solving one of its huge design problems.

2. Introduction Lecture Part II: What is biomimicry? Tell students: There is name for the type of design that looks closely at evolutionary adaptations that resolve design challenges and utilizes those solutions in design innovations for human life. This is called biomimicry. Show powerpoint with examples of biomimicry/stories of biomimetic innovation. *(10 minutes)*

Stage 2: Exploration

"Looks Like/Works Like" Activity: Explain that in this class we are doing a design activity called "Looks Like/Works Like." Preview the activity and show examples. Tell students: "First, you're going to pick an organism that you like (from print-outs or 3-D examples). Then you'll have thirty minutes to make a model out of paper (and tape, glue, and string if you need it) that looks like your organism. This prototype won't really have any function except to resemble your organism. Second, **you'll** have thirty minutes to make different a model that shows how your organism works. This prototype might look nothing like your organism but will replicate one of its important functions. For example, if your or-



ism opens and closes, your prototype should open and close, even if it looks nothing like what you started with. Maybe your organism has a layered shell, so you figure out how to replicate this layered 'armor' effect. Neither protoype needs to look perfect, and it's okay, and even encouraged to try a couple versions to get your protoype right."

1. "Looks Like" Activity *(30 minutes)*
2. "Works Like" Activity *(30 minutes)*

Extension Activity: "Unusual Uses" Game (if time). Students clean up and return to tables/small groups to play "Unusual Uses" game. Have each small group pick one of the "works like" models made by someone in the group (it doesn't matter whose). Each small group then has five minutes to collectively come up with as many "unusual uses" for that object as possible. For example, if someone has created a model that opens and closes, possible unusual uses could be: a door, a bank vault, a sculpture, food storage, etc. The group with the highest number of "unusual uses" wins. (10 minutes)

Stage 3: Reflection

1. Five-Minute Journaling. Students clean up and return to tables to journal for five minutes. Teacher can pick one prompt for all students to respond to, or students can choose from three prompts. (Writing: 5 minutes, if desired: 5 minute pair share or group share)

- 3-D to 2-D Challenge: Pick an object in the room and draw a "looks like" model in two minutes and a "works like" model in two minutes.
- What was one problem you encountered while making your models? How did you solve it, if at all? Write a paragraph.
- How are evolution and iterative design similar? How are they different? Explain in a venn diagram, paragraph, or drawing.

2. "So what?" Lesson Recap. Ask students: What did we do today? Why is it important? Emphasize key ideas covered and larger context for today's learning—for example "We started today by talking about how nature's way of "iterating" is through evolution which is slow and non-directional, while design often involves rapid prototyping which leads to new insight and direction for further design ideas. Today we made our own rapidly iterated prototypes based on nature's mil-

Image: Specimens we pulled from the Nature Lab's collection for students to base their "Looks Like/ Works Like" models on.

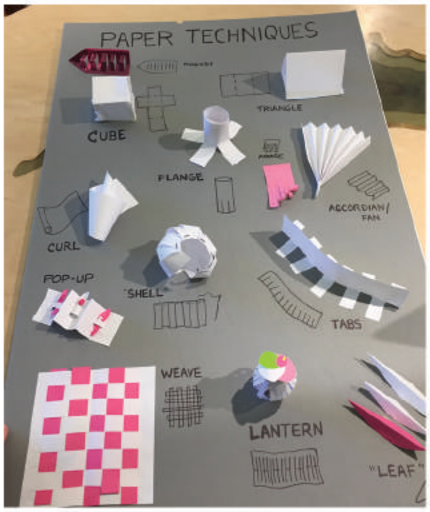


Image: While the purpose of this activity is to rapidly prototype and we were more interest in concept over appearance, we did provide some examples of how to work with paper, should students feel stuck.

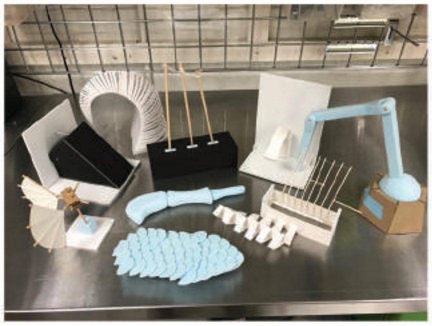


Image: "Works Like" models made by RISD students lions-of-years-old designs. Biomimicry is important because by beginning with an understanding of how evolution has resolved design challenges, we can ‘jumpstart’ our designed solutions.” *(5 minutes)*

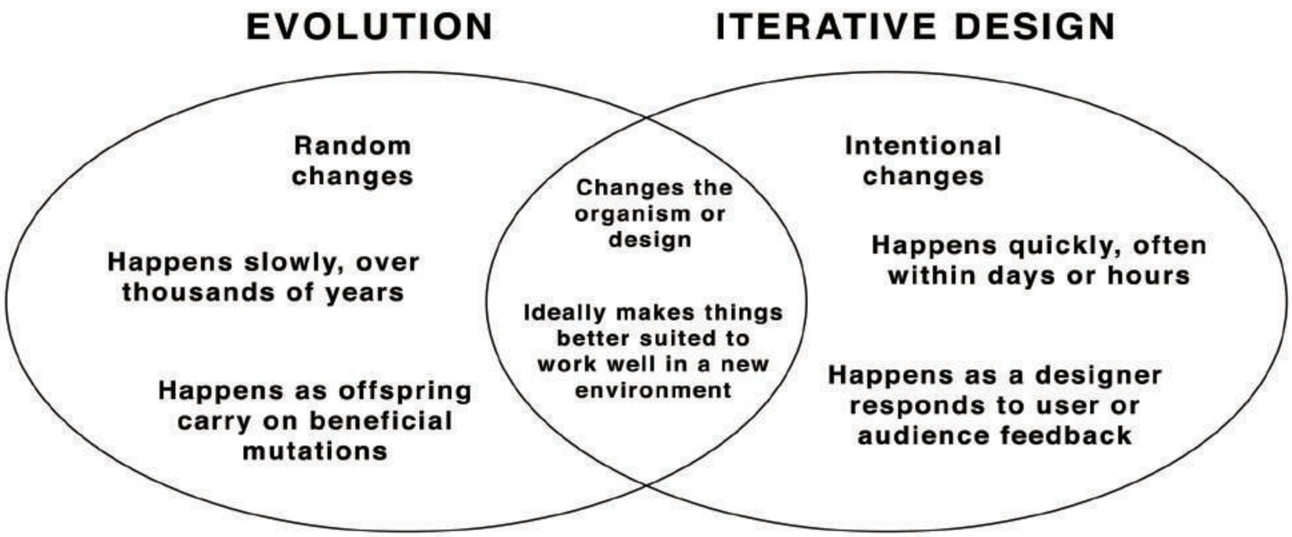
Image: One student’s “looks like” and “works like” models at the end of the class period

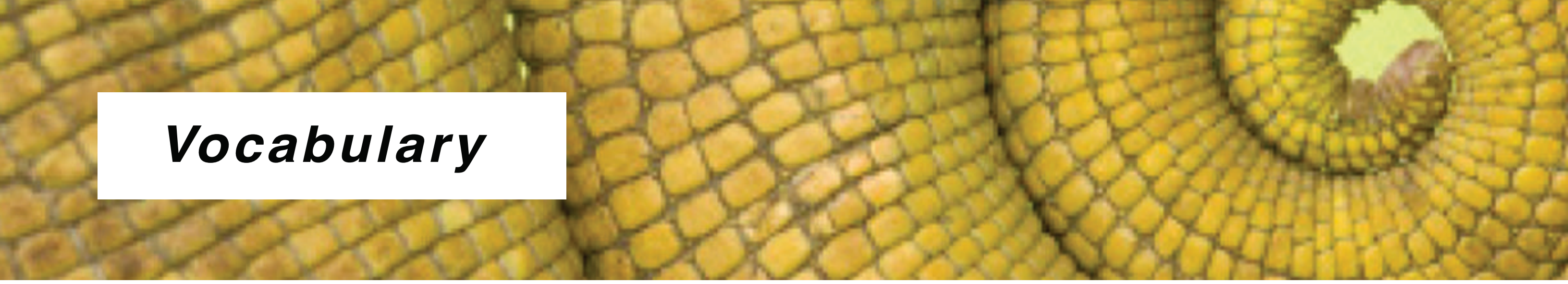
Image: Students play “Unusual Uses” game

Evolution & Iteration

How are evolution and design similar? How are they dissimilar?

Nature's iteration through evolution is slow and non-directional, while design often involves iterative rapid prototyping which leads to new insight and direction for further design ideas. By beginning with an understanding of how nature has solved design challenges, we can "jumpstart" our designed solutions.





Vocabulary

Terms:

Biomimicry: The design and production of materials, structures, and systems that are modeled on biological entities and processes.

Prototype: A first model of something on which you base later designs. It's a first try or a first draft.

Iteration: Versions of a design or artwork.

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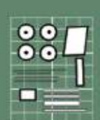
A version of a design or artwork.



Prototype

Prototype:

A first model of something on which you base later designs. It's a first try or a first draft.

Biomimicry

Biomimicry:

the design and production of materials, structures, and systems that are modeled on biological entities and processes.