LESSON PLAN 4:

EVOLUTION, ADAPTATION, & NATURAL SELECTION

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

THIS MATERIAL IS BASED UPON WORK SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION UNDER GRANT NO. 1723559

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

Background Information For Teachers

Overview of this lesson:

The purpose of this lesson is to provide an overview (or review, if students are already familiar with these concepts) of the basic workings of evolution: namely, that evolution happens through adaptation and natural selection. In this lesson, we ran two activities with our students that tried to get these ideas across. First, we did a warm-up drawing exercise in which students' chose an animal and thought of imaginary adaptations that might help it better survive in its current environment, and second, an activity in which students were assigned an organism and adapted it to three different biomes: desert, rainforest, and mountain.

For the second activity, we set up stations around the room that each represented these three biomes. Students were randomly assigned one of five organisms: wolf, chicken, cow, komodo dragon, or raccoon (see worksheet at end of PDF for more details). Students then rotated around from station to station, looking at examples of real-life organisms that are adapted to that biome, and "redesigned" their organism to survive in this new environment by drawing on new features using tracing paper. Morphological adaptations were labeled according to scientific illustration guidelines given in lesson one.

Adapting this lesson to your classroom:

For this lesson, we utilized the RISD Nature Lab's extensive collection of preserved specimens to set up each biome station. This can be approximated by printing out examples of organisms that live in deserts, rainforest, and mountains respectively. Depending on students' familiarity with adaptive strategies, information cards can be provided to explain the structural and behavioral adaptations to the biome the chosen organisms display.

This is an ambitious lesson. We combined two activities that, in hindsight, were each deserving of their own hour-or two-hour session. Nonetheless, we present this lesson as we taught it, which is to say, a lot of content packed into one two-hour session. It is perfectly reasonable to split this lesson into two sessions, or to simplify it by choosing only one of the two drawing activities to do with your students. When working with our tenth grade students, we found that although they had learned about evolution at one point in their studies, for many, the details were fuzzy and required review. We realized after teaching it that this lesson's success relied on prior knowledge about evolution, adaptation, and natural selection that some of our students just did not have. If this is also the case for your students, consider starting with the speculative biology drawing activity and building up, in a later lesson, to the "Adaptation Station" activity.

Standards, Objectives, & Supplies

Grade Level: 10th-11th

Duration: 2 hours

Lesson Concept: Evolution works through adaptation and natural selection to create an organism's design.

Lesson Objectives/Learner Outcomes:

1. Understand that evolution works through adaptation and natural selection to create an organism's design.

2. "Redesign" an organism in response to the pressures of an environment or a biological need.

Instructional Support Materials (if needed):

- Powerpoint with necessary images + journal prompts.
- LCD projector/smartboard
- Printed "Adaptation Assignment" Handouts for each student (see end of PDF)
- Printed "Biome Factsheets" for each station (see end of PDF)
- Stations set up before class that represent three different biomes: Mountain, Desert, and Rainforest. Place "Biome Fact Sheet" at each station (see end of PDF).
- Printed pictures or 3-D (living or preserved) organisms native to Mountain, Desert, and Rainforest environments respectively.

Materials + Supplies:

- Paper or sketchbooks (for students to make their speculative biology drawings)
- Pencils (enough for each student)
- Colored Pencils (assortment of colors, ten to twenty for every small group)
- Tracing paper (three sheets for every student)

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:Cr2.3.iia: Redesign an object, system, place, or design in response to contemporary issues.

Learning Plan

Stage 1: Motivation

1. Introduction Lecture Part I: What is evolution? Introduce (or likely review) with your students the meaning of evolution, adaptation, and natural selection. *(10 minutes)*

2. Introduction Lecture Part II: What is Speculative Biology? Introduce speculative biology. Speculative biology, or speculative evolution, is a term that refers to a very conceptual re-interpretation of biology that creatively imagines the evolution of life in a wide variety of scenarios. What would a cow look like if it had to adapt to survive in a jungle? How might humans evolve over the next hundred-thousand years? What adaptations will organisms need to survive climate change? Show students examples of speculative biology drawings ("The Flooer" and "Reedstilt" by Dougal Dixon are good examples). Introduce warm-up game in which students will create their own speculative biology drawings. *(10 minutes)*

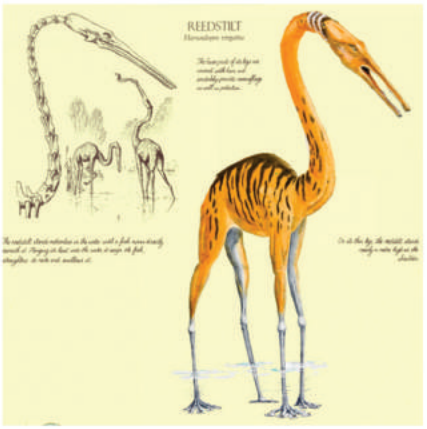

Image: Dougal Dixon's speculative biology drawing, "The Reedstilt"

Stage 2: Exploration

1. Speculative Biology Warm-Up Activity. Each student will choose an organism for which she can imagine an adaptation that would make its life better in the current world. Examples: a cat that evolves wings to fly down to the backyard for prowling, or a horse that grows spines that make it impossible to ride. Students draw their organism with its new, imagined adaptations. These can be fantastical; this is a warm-up activity meant to be a fun (not necessarily realistic) way of getting students practicing "redesigning" an organism based on external pressures. We had ipads on hand for students to look up pictures of the organism they had chosen in order to better draw it, but making the perfect drawing isn't the point of this exercise. Encourage students to make use of outlines and labeling if they're less comfortable with representational drawing, and to reference scientific drawing techniques learned in Lesson 1. *(15-20 minutes)*

Image: "Cheetah adapted to survive in the jungle"—a speculative biology drawing by one of our co-teachers at the Nature Lab.

2. Adaptation Station Activity. Assign students at random the following five organisms: wolf, chicken, cow, komodo dragon, or raccoon. Give students a handout with their assigned organism on it (see end of PDF) and three sheets of tracing paper. Students then choose a biome station to go to, and observe how real-life organisms in that biome have

adapted to survive there, and finally, add adaptations to their organism to help it survive in this new environment. Lay tracing paper over the worksheet and add these adaptations to the existing drawing. As an example of what this might look like, if a student who has been assigned a wolf goes to the desert biome station, he may need to think about adapting it to camouflage with the sand, or to lose some of its thick fur so it does not overheat in the desert temperatures. Students can choose to stay at one station for the full hour, or spend twenty minutes at each station. *(60 minutes)*

Extension activity: Have students pick one of the drawings they made at one of the Adaptation Stations to turn into a speculative biology poster. Show examples of Dougal Dixon's speculative biology drawings and have students create a drawing in this style, featuring labels and new scientific name for the organism.

Image: One of the biome stations we set up in our makerspace. We brought out a number of specimens that are native to rainforest environments for students to look at and reference.

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)*

- In what ways did your organism adapt when it entered a new environment? What problems did your organism encounter? How did you resolve them, if at all? Write a paragraph or make a drawing.
- Can you imagine another organism that might benefit from a symbiotic relationship with one of the organisms you drew? Draw a picture or write a description.
- What adaptations might humans might make in the next hundred thousand years? Write a paragraph or make a drawing.

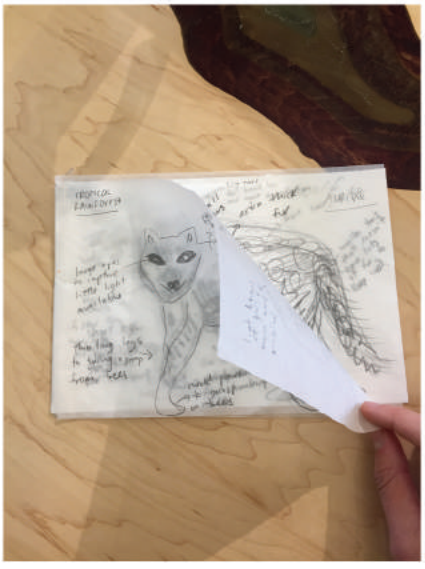

Image: One student's drawings from the "Adaptation Station" Activity. This drawing shows the adaptations a raccoon might need for three different biomes.

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 "Evolution works through adaptation and natural selection to create an organism's design. Adaptation and natural selection are nature's way of responding to and solving problems. This is important in the larger context of our learning because we are trying to understand the ways that nature solves problems, and to think about what we might borrow from nature to apply to human life."

Adaptation Assignment

You have been assigned...a WOLF

Directions: In this exercise, you will use "speculative biology" to imagine adaptations your organism might make to better adapt to a change in its environment. You will adapt your organism to three different biomes: Rainforest, Mountain, and Desert. Place tracing paper over the image below, and draw on your new adaptations (this way you don't have to start from scratch with each drawing, and instead can build onto an existing drawing). Label adaptations. Adaptations can include:

Structural Adaptation – some part(s) of your body change(s) to give you an advantage
Camouflage – blending in to the new environment so you're not so noticeable
Mimicry – pretending to be something you're not, for the benefits it gives you
Behavior adaptations – often associated with structural adaptations
Hibernation – sleep out the rough period. Usually associated with energy conservation measures such as increased fat storage

Remember that there are tradeoffs in adaptations, for example, large size increases your ability to stay warm, but in general decreases mobility, increases need for food and oxygen, and puts strain on the body's systems – consider a happy medium! Keep in mind: Where is my organism adapted to, what does it already do well?

Adaptation Assignment

You have been assigned...a RACCOON

Directions: In this exercise, you will use "speculative biology" to imagine adaptations your organism might make to better adapt to a change in its environment. You will adapt your organism to three different biomes: Rainforest, Mountain, and Desert. Place tracing paper over the image below, and draw on your new adaptations (this way you don't have to start from scratch with each drawing, and instead can build onto an existing drawing). Label adaptations. Adaptations can include:

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Adaptation Assignment

You have been assigned...a COW

Directions: In this exercise, you will use "speculative biology" to imagine adaptations your organism might make to better adapt to a change in its environment. You will adapt your organism to three different biomes: Rainforest, Mountain, and Desert. Place tracing paper over the image below, and draw on your new adaptations (this way you don't have to start from scratch with each drawing, and instead can build onto an existing drawing). Label adaptations. Adaptations can include:

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NSF RISD Nature Lab

Adaptation Assignment

You have been assigned...a CHICKEN

Directions: In this exercise, you will use "speculative biology" to imagine adaptations your organism might make to better adapt to a change in its environment. You will adapt your organism to three different biomes: Rainforest, Mountain, and Desert. Place tracing paper over the image below, and draw on your new adaptations (this way you don't have to start from scratch with each drawing, and instead can build onto an existing drawing). Label adaptations. Adaptations can include:

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Nature Lab

Adaptation Assignment

You have been assigned...a KOMODO DRAGON

Directions: In this exercise, you will use "speculative biology" to imagine adaptations your organism might make to better adapt to a change in its environment. You will adapt your organism to three different biomes: Rainforest, Mountain, and Desert. Place tracing paper over the image below, and draw on your new adaptations (this way you don't have to start from scratch with each drawing, and instead can build onto an existing drawing). Label adaptations. Adaptations can include:

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NSF RISD Nature Lab

Biome Factsheet: Desert

Desert Environment: Covering 1/5 of the earth's surface, deserts are really dry – they receive less than 50 cm of rainfall a year – Contrast that with Providence, at 191cm of precipitation a year. Deserts also receive more than twice the sunshine of humid regions, and lose almost twice as much heat at night. When the rains do come, they are intense, and often cause flooding. There's also very little shelter, as vegetation is sparse or non-existent, and windstorms may be frequent.

World's deserts shown in yellow

What you need to consider when adapting to this environment:

Lack of water
- How can you adapt to conserve water?
- How can you adapt to gather water?

Temperature Extremes
- How can you keep cool during the day/during the summer?
- How can you keep warm at night/during the winter?

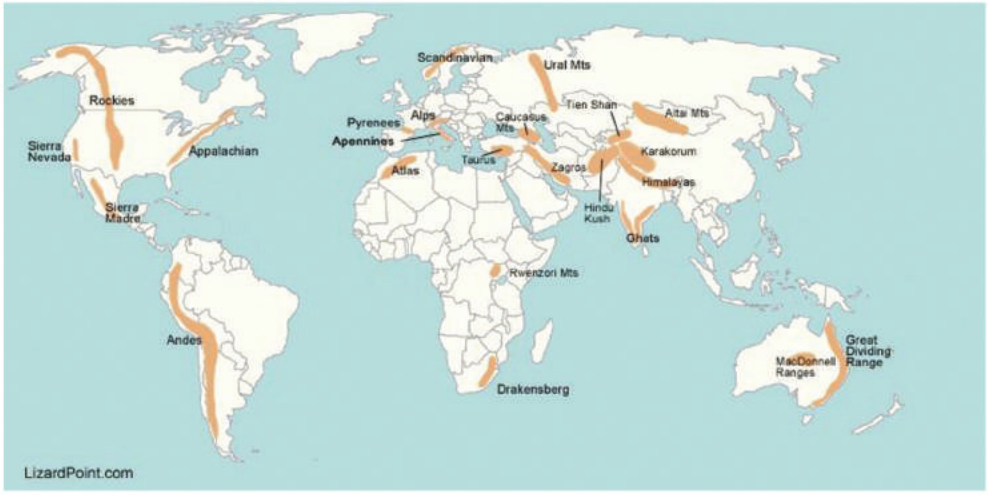
Sand
- How can you protect yourself from sand storms?
- How can you move on the sand?

Unprotected expanses
- How will you camouflage or hide?

Nature Lab

Biome Factsheet: Mountain

Mountain (Alpine) Environment: Mountain environments can have different climates and types of vegetation, depending on altitude and relief. At higher altitudes, organisms have to combat steep slopes, high winds, shallow and rocky soil or bare rock, cold temperatures, and snow accumulation. These factors make it nearly impossible for trees to grow, and so vegetation, if it exists at all, consists of low shrubs or herbaceous plants.



World's major mountain ranges shown in orange

What you need to consider when adapting to this environment:

Steep slopes
- How can you move across steep incline?
- How can you "grip" the land?

Low Oxygen
- What adaptations allow you to conserve oxygen?
- What adaptations allow you to remove more oxygen from the air you breathe?

Cold temperatures
- How can you generate or conserve body heat?
- How can you manage in the ice and snow?

Biome Factsheet: Rainforest

Rainforest Environment: Rainforests are typically found near and around the equator and are characterized by high annual rainfall. Rainforest environments are wet, humid, and have abundant vegetation, most notably thick forests of tall trees with broad leaves. They can be temperate (as in the United States' Pacific Northwest) or tropical (as in those found in the Amazon). Rainforests are host to an abundance of biodiversity; almost every type of organism is represented in this ecosystem. Still, organisms must find ways to survive in an environment that is constantly wet, dark below the tree canopy, and full of other organisms that might compete with or prey on them.

World's rainforests shown in green.

What you need to consider when adapting to this environment:

Constant Moisture
- How can you adapt to stay dry in a constantly wet environment?

Darkness below tree canopy
- How can you see well in a dark environment?
- How will you adapt to having very little sunlight?

Prey & Predators
- How can you keep yourself safe from predators?
- How can you catch prey?

Vocabulary

Terms:

Organism: A living thing.

Species: A group of similar organisms capable of exchanging genes or interbreeding.

Evolution: The gradual development and increasing diversity of species over time.

Adaptation: A process of change in which something becomes better suited to its environment.

Natural Selection: A theory developed by Charles Darwin that explains how organisms that are better adapted to live in their environments survive and produce offspring, creating a slow change in a species over time.

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