



BIOMIMICRY: NATURE AS MODEL, MEASURE AND MENTOR



Teacher's Guide

Grade: 6 - 8

Lesson: Biomimicry, Nature as a Model, Measure and Mentor

Number of Class Periods: Three 45-minute periods



The TerraCycle Curriculum Series was co-created by The Cloud Institute for Sustainability Education and Learner-Centered Initiatives.



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Standards

McCrel National Standards

Language Arts - Level III (6-8)

Standard 5: Uses the general skills and strategies of the reading process

1. Establishes and adjusts purposes for reading (e.g., to understand, interpret, solve problems, answer a specific question, form an opinion, skim for facts)

Standard 7: Uses reading skills and strategies to understand and interpret a variety of informational texts

1. Uses reading skills and strategies to understand a variety of informational texts (e.g., directions; print media)
3. Summarizes and paraphrases information in texts (e.g., arranges information in chronological or sequential order; conveys main ideas, critical details, and underlying meaning; uses own words or quoted materials; preserves author's perspective and voice)
4. Uses new information to adjust and extend personal knowledge base
5. Draws conclusions and makes inferences based on explicit and implicit information in texts

Standard 8: Uses listening and speaking strategies for different purposes.

1. Asks questions to seek elaboration and clarification of ideas

EfS Standards and performance Indicators

F 7b: Make a case for why global citizens should understand the basic natural laws and principles including the basic principles of ecology.

F 7e: Make a case for why global citizens should understand the basic natural laws and principles including materials cycle.

G7: Make a contribution that solves more than one problem at a time and minimizes the creation of new problems. (Create value)

G13: Look for challenges that foster learning and growth that increase capabilities.

G21: Do things they haven't done before because that is what it takes to accomplish their goals, solve a problem or be true to their passion. They will reflect on the fact that that is how they learn and grow.

G25: Engage in new experiences in "unknown territory," for the purpose of reaching their goals.

EfS Enduring Understandings

EU10 - It all begins with a change in thinking

EU11 - Live by the Natural Laws

LESSON SUMMARY

This lesson revolves around the ideas and practices of biomimicry – looking to Nature to help us solve our problems. Students will study examples of biomimicry and then apply what they have learned to a problem that they identify in their home, school, or community.

OVERARCHING QUESTION

What can Nature teach us about the principles of sustainable design?

GUIDING QUESTIONS

WHAT IS BIOMIMICRY?

HOW DO HUMANS USE NATURE'S DESIGNS IN ORDER TO SOLVE PROBLEMS? (EU 10)

WHAT ARE SOME EXAMPLES IN MY OWN NEIGHBORHOOD OR SCHOOL COMMUNITY? (EU 10)

HOW CAN I USE BIOMIMICRY TO HELP ME THINK DIFFERENTLY ABOUT A PROBLEM? (EU 10, 11)

Resources/materials for this lesson: Information on biomimicry in handouts and at www.biomimicryinstitute.org and www.askNature.org

- Gyre Animation: <http://www.team847.com/media/animations/2010-animation-operation-gyre>
- Water Animation: <http://www.team847.com/media/animations/2009-animation-purewater-847>

LEARNING OPPORTUNITIES, ACTIVITIES, AND PROCEDURES



DAY 1

PRE-TEST

1. Individually, students respond to the overarching question in writing or graphic representation of any kind. They will re-visit the question at the end of the lesson.
2. Introduce the idea of biomimicry, explain that we are going to look at how Nature can teach us about sustainable design. Explain that “sustainable design” is design that solves more than one problem at a time and minimizes the creation of new problems over time. We’re going to make connections between sustainable design solutions in Nature and human-design solutions, and finally we’ll use a specific sustainable design solution from Nature to help us think of possible solutions to a human-design problem. We’ll also look at some specific solutions from designers in various fields.

The following was excerpted by the Biomimicry Institute (www.biomimicry.org):



THE WISDOM OF NATURE

1. In pairs or triads, students read statements about Nature and find evidence of them in vignettes.
2. Explain to students that they are about to explore a different approach to address problems. We are specifically going to look at how we can learn to successfully address problems by mimicking Nature. You are about to read three statements about Nature. After each one, there is a description of a situation. With one or two partners, find evidence of what the statement is saying in the situation that is presented. Make notes on your findings.



STATEMENT #1: Organisms are exquisitely adapted to their homes and to other organisms while humans are not.

A spider, for instance, produces a waterproof silk that beats Kevlar for toughness and elasticity. Ounce for ounce, it's five times stronger than steel! But the spider manufactures it in water, at room temperature, using no high heats, chemicals, or pressure. Best of all, it doesn't need to drill offshore for petroleum; it takes flies and crickets at one end and produces this miracle material at the other. In a pinch, the spider can even eat part of its old web to make a new one. (adapted from www.biomimicry.org/faq)

WHAT EVIDENCE CAN YOU FIND OF STATEMENT #1 IN THIS EXAMPLE?

STATEMENT #2: Nature has already solved the problems that we are trying to solve (struggle for food, water, space and shelter in a finite habitat).

Dolphin Skin: We study dolphin skin as a prototype for better submarines. Dolphin skin is used as a model to understand how hull material can deform slightly to shrug off water pressure. This can also be used for airplanes and air pressure. (www.biomimicry.org/case_studies_materials)



WHAT ABOUT THIS EXAMPLE ILLUSTRATES STATEMENT #2?

STATEMENT #3: Biomimicry occurs where ecology meets agriculture, medicine, materials science, energy, computing and commerce.

Energy and Leaves: Leaves are able to create energy from the sun, a process called photosynthesis. If humans were able to turn light energy into electricity, it would make energy clean and cheap. The burning of non-renewable and polluting forms of energy production, deforestation for wood burning, and other forms of energy production would no longer be necessary. We can look to leaves to inform us to make better solar collectors. Scientists are currently working on doing this and have uncovered many answers. However, there is still a lot of research to be done for us to fully technically mimic the photosynthetic process of leaves.

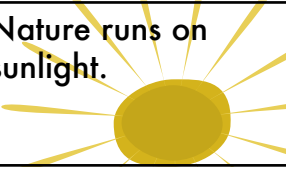


EXPLAIN BIOMIMICRY AS IT IS EVIDENCED IN THIS EXAMPLE.

3. Explain that this exercise was to get us to begin to see examples of design in Nature. You may also want to explain that a lot of what humans think we designed was actually already designed by Nature.
4. Additional examples of biomimicry can be seen at www.askNature.org and further investigation can be done on this site as well as www.biomimicryinstitute.org

DAY 2 - NATURE'S BASIC OPERATING PRINCIPLES

1. Review the example chart with students, especially those that present vocabulary that is new or difficult.

NATURE'S BASIC OPERATING PRINCIPLES (EXAMPLE CHART)

OPERATING PRINCIPLE	EXAMPLE IN NATURE	EXAMPLE OF HOW HUMANS USE THIS TO SOLVE A PROBLEM (SPECIFICALLY MENTION THE PROBLEM)
Nature runs on sunlight. 	Leaves use the sunlight for photosynthesis.	Humans are mimicking how plants process sunlight in order to one day split water into clean-burning fuels. This helps eliminate the problem of pollution-causing energy production.
Nature uses only the energy it needs.	Leaves fall from a tree and are turned into nutrients for the tree.	A business decides to locate its waste recovery facilities close to the facility where waste is produced, to eliminate the need to transport the waste a great distance.
Nature fits form to function.	Vulture wings 	The Wright brothers analyzed vulture wings to come up their designs for airplanes. This solved the problem of figuring out how to design planes.
Nature recycles everything.	Oak-hickory forests	Closed-loop manufacturing - a manufacturing plant that runs on sunlight and reuses all its waste. This eliminates waste material.
Nature rewards cooperation.	Old field succession	Do-nothing farming - method that sows rice, barley, and clover together in one field, so they grow in each other's shade. This eliminates the need for possibly hazardous fertilizer (and eliminates the need to weed.)
Nature thrives on diversity.	Red-wood forest	Industrial eco-parks - Co-located industries work in a food chain, consuming each other's waste. This eliminates waste from several industries at one time.
Nature demands local expertise.	Native grazers (native animals that naturally migrate as they graze)	Holistic ranching mimics the way that native animals graze. This allows grassland to naturally recover, preventing it from becoming unusable. 
Nature curbs excesses from within.	Forest fires clear out space for new healthy growth	Natural selection forestry.
Nature taps the power of limits.	Plants in a given environment thrive within the range of temperatures of that region.	Architects design a building without overdesigning - that is, they don't design a home in a moderate climate for extreme temperature conditions. This results in the use of less building material.

2. In pairs or triads, complete the second chart below by thinking about your community and the world as well. You can look at the first chart above for examples to help you in completing your own chart. Be prepared to share your thinking with the class.

NOTE: If your examples do not fit into the box on the chart, simply put them on a separate page or space and include them as part of your discussion.

- A. Identify specific examples of each principle in Nature. You may use words, pictures, models, and/or symbols to communicate your examples.
- B. Describe problems that humans are trying to solve that relate to each Operating Principle. Once again, you may use words, pictures, models, and/or symbols to clearly communicate your ideas.

NATURE’S BASIC OPERATING PRINCEPLES

OPERATING PRINCIPLE	EXAMPLE IN NATURE	EXAMPLE OF HOW HUMANS USE THIS TO SOLVE A PROBLEM (SPECIFICALLY MENTION THE PROBLEM)
Nature runs on sunlight.		
Nature uses only the energy it needs.		
Nature fits form to function.		
Nature recycles everything.		
Nature rewards cooperation.		
Nature thrives on diversity.		
Nature demands local expertise.		
Nature curbs excesses from within.		
Nature taps the power of limits.		

DAY 3 - LOOKING TO NATURE FOR HELP

1. Describe the context of a problem or a challenge faced by you, your friends, your family or your community.

EXAMPLE: My family lives in a region with very variable rainfall - near drought for half the year, and torrential rains for the other half.

2. Next pose the challenges that this situation presents in the form of a series of questions that focus on doing or accomplishing something.

EXAMPLE: How can we capture and store rainwater from the rainy season to use during the drought? How can we minimize or prevent the saturation and erosion that happens during the rainy season? How can we capture and manage our use of water? How can we distribute water during rainy or dry seasons?

3. To help shift out of your own mindset and into a biomimicry frame, change the focus of the question from yourself or society to Nature. Shift the structure of your questions so that they now question how Nature accomplishes what you want to achieve.

EXAMPLE: How does Nature capture and store rainwater? How does Nature minimize or prevent saturation and erosion from too much rain? How does Nature capture and manage its use of water? How does Nature distribute water during rainy or dry seasons?

Add to your questions if more come to mind.

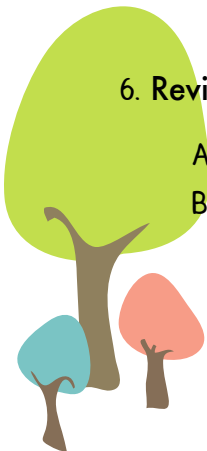
4. Share these questions in groups of three or four and help one another revise or identify additional questions.
5. Finally, push your thinking even further by trying to identify an analogy in Nature, which could contribute to a solution to that problem.

Example: Squirrels have to contend with an analogous problem. They get all their nuts in the fall, so they too are in a "feast or famine" situation with regard to the availability of a crucial natural resource. Squirrels store their nuts; perhaps your region could do something similar with your water? The squirrel's problem and solution provides an analogy or a metaphor that can help solve this problem.



6. Review your "How does Nature..." questions and your analogy.

- A. What ideas are you getting for possible solutions?
- B. What can you do to continue thinking or learn more about this?



POST TEST

Revisit your response to the overarching question and revise it to reflect your current thinking. When you look at the revised response, what do you think you have learned?

Instructional/Environmental Modifications/Differentiated Strategies

- Size and composition of groups can be adjusted to meet specific needs of students
- Students who need more guidance can be grouped with the teacher or an assistant to complete the chart on Day 2.

EfS Assessment/Scoring Criteria

What do I need to collect or administer to prove that students have grown towards and/or achieved desired outcomes/standards?

EfS/ National Standard	EfS/National Performance Indicator (letter and number)	Assessment Instrument	Scoring Criteria
F Natural Laws and Ecological Principles	F7	Pre and post with statement about learning	Response includes the importance of understanding basic natural laws and principles
G Inventing and Affecting the Future	G7	Look to Nature for help 6a and b	Ideas for possible solutions are designed to solve more than one problem at a time and minimize the creation of new problems
G Inventing and Affecting the Future	G13	Look to Nature for help	Students look for challenges foster learning and growth and increase students' capabilities
G Inventing and Affecting the Future	G21	Completed chart Final reflection	Response indicates that they considered things they hadn't done before in order to solve a problem; Response includes reflection on the learning that results
G Inventing and Affecting the Future	G25	Look to Nature for help	Biomimicry design is aligned with one or more operating principles. New thinking causes students to engage in new experiences in "unknown territory"

Note to Teachers: Student attainment of enduring understandings can be monitored through the questions identified with (EU).

Language Arts Level III Standard 5	1	Completed Chart	Students establish and adjust purposes for reading to understand, solve problems, answer a specific question, form an opinion, skim for facts
Language Arts Level III Standard 7	1	Completed Chart Look to Nature for help	Students use reading skill sand strategies to help them understand directions and print media
	3	Completed Chart	Students summarize and paraphrase information from texts
	4	Completed Chart Look to Nature for help Pre and post with statement about learning	Students use new information about biomimicry to adjust and extend personal knowledge base
	5	Completed Chart Look to Nature for help	Students draw conclusions and make inferences based on explicit and implicit information in texts
Language Arts Level III Standard 8	1	Completed Chart Look to Nature for help	Students ask questions to seek elaboration and clarification of ideas