FAIRCHILD Discovery PROGRAM

Biomimicry - Designed by Nature
Pre- and Post-Visit Activities
Grades 6-8

FTBG

Fairchild Tropical Botanic Garden

Welcome!

Dear Teacher:

Thank you for planning a field study at Fairchild Tropical Botanic Garden. The tour you have selected, **Biomimicry**, is designed to teach students about biomimicry, a new branch of science that looks to nature for inspiration in tackling contemporary, environmental problems.

Included in this document is a packet of activities. It can also be found online at: http://www.fairchildgarden.org/education/schoolprograms/discoveryprogram/. **This packet contains pre and post-visit resource materials to support and strengthen the learning experience. We encourage you to implement pre-visit activities as they will enhance and prepare students for the field study.**

Using pre-visit activities allows students to learn the vocabulary and key concepts. It also gives students time to think about what they will be learning during their field study and to start to formulate questions. Post-visit activities allow students to integrate, reflect, process and deepen their learning experience. The lesson plans correlate with the Next Generation Sunshine State Standards. **Please be sure that each teacher attending the field study receives an activity packet.** Feel free to make additional copies of this packet as needed.

The word list provided is especially important for students to study prior to their visit. An understanding of the vocabulary will be a great asset in comprehending the concepts discussed during the field study.

We look forward to your visit to Fairchild Tropical Botanic Garden and hope that you and your students will have an exciting and educational adventure.

Kind Regards,

Laura Tellez
Discovery Program Coordinator
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Introduction to Biomimicry

This unit has been prepared to help you and your students learn about biomimicry and to optimize the learning experience during your field study at Fairchild Tropical Botanic Garden. This multi-disciplinary unit features activities that introduce teachers and students to the concept of biomimicry and provide students a foundation in certain ecological concepts and environmental awareness. An introduction to mapping and Global Positioning System (GPS) is also included, as students will be using maps, compasses, and GPS units to navigate the garden during their visit.

Biomimicry comes from the words: bio, meaning life, and mimesis, meaning mimic. Biomimicry is a relatively new science that studies nature (its models, systems, processes and elements) and then imitates or takes creative inspiration from them to solve human problems sustainably.

Examples and Case Studies of Biomimicry include:

1. Architects have studied the ventilation in **termite mounds**. They are constructed with an effective ventilation system that maintains a constant temperature of 87 degrees Fahrenheit, while the external temperature varies between 37 and 104 degrees Fahrenheit. One building in Zimbabwe was designed based on the termite mound ventilation system and has proven to use 10% of the energy of a typical building its size.
2. The surface of a **lotus leaf**, although seemingly smooth, is rough on a microscale. Water droplets falling into the leaf bead-up. If the surface slopes slightly, water droplets roll off. Rough surfaces on a microscale tend to be more hydrophobic causing water droplets to roll-off instead of sliding-off. As water droplets roll-off, they pick up particles of dirt acting as a self-cleaning mechanism. The superhydrophobic surface of the lotus leaf allows it to stay dry even during a heavy storm. Scientists have developed non-toxic cleaning products and clothing modeled after the lotus leaf.
3. Some seeds, such as **cockleburs,** "hitchhike" on animals. These seeds have developed a hook and lock structure that allows them to attach themselves to passing animals. This mechanism allows the cockleburs to be carried and dispersed to a new location. These seeds inspired the invention of Velcro.
4. Structural color on **butterfly wings** and bird feathers can provide the model for non-toxic dyes for clothing. Certain organisms, including some butterflies and birds, portray a certain color and iridescence caused by the structure of the scales and feathers. which are stacked on top of each other in a way to catch and reflect light rays to portray iridescence.
5. The filtration system of **wetlands** filter out solids and chemicals. Wetlands are used as models for water treatment systems.

Resources:
"Biomimicry: Innovation Inspired by Nature," Janine M Benyus
http://www.odemagazine.com/doc/18/what_would_nature_do/
http://www.biomimicryinstitute.org/
http://www.biomimicryguild.com/
http://nationalzoo.si.edu/Publications/ZooGoer/1999/4/designsfromlife.cfm

Words for a Day at Fairchild

Bauxite: a soft, whitish to reddish-brown rock that forms from the breakdown of clays and is a major source of aluminum. Bauxite consists mainly of hydrous aluminum oxides and aluminum hydroxides along with silica, silt, iron hydroxides, and clay minerals.

Biomimicry: a new science that studies nature (its models, systems, processes and elements) to imitate or take creative inspiration in order to solve contemporary human problems sustainably.

Climate change: any long-term significant change in the weather patterns of an area.

Compost: a mixture of various decaying organic substances, such as dead leaves or manure, used for fertilizing soil.

Consumer: an organism, usually an animal, that feeds on plants and/or other animals.

Decomposer: an organism, usually bacteria or fungus, that breaks down the cells of dead plants and animals into simpler substances.

Ecological footprint: a measure of how much land and water an individual, a population or an activity requires to produce all the resources it consumes and to absorb all the waste it generates.

Food web: a series of organisms related by predator-prey and consumer-resource interactions.

GIS: Geographic Information System: a computer application used to store, view, and analyze geographical information.

GPS: Global Positioning System: a system of satellites, computers, and receivers that is able to determine at any time the latitude and longitude of a receiver located anywhere on Earth.

Ore: a metal-bearing mineral or rock that can be mined at a profit.

Producer: an organism that is able to produce its own food from inorganic substances, for example a plant.

Reclamation: the conversion of wasteland into suitable land for habitation or cultivation.

Remediation: to contain, treat or remove contaminated water and/or soil.

Satellite: a device launched to orbit the Earth that collects scientific information.

Sustainable: able to be supplied with resources, sustenance or nourishment for an indefinite period of time without damaging the environment or depleting resources.

Pre-Visit Activity 1: Survival Strategies

Objectives

Students develop an understanding of how plant and animal adaptations help species' survival. Students apply these observational skills to ponder how such adaptations could be used as a model for solving contemporary human problems.

Next Generation Sunshine State Standards: SC.6.N.1.1, SC.6.N.1.5, SC.7.N.1.1, SC.7.L.17.3, SC.8.N.3.1

Vocabulary

Adaptation Habitat Climate Change

Materials

- 8.5x11 papers, each with the name of a habitat
- 4-6 index cards, each with the name of an organism with a picture of that organism

Procedure

1. Break students up into small groups (desks can be arranged to create stations). Tape a piece of paper with a habitat name at each station.
2. Hand out a card with an organism name to each group. For the first set of these cards, the organism should match the habitat. (See lists below under "resources").
3. Ask students to work as groups to answer the following questions:
   - What are the conditions in their organism's habitat?
   - What adaptations must the organism have to survive in this habitat?
4. Students rotate among stations. Each group keeps their original organism card, but has a new habitat.
5. Ask students to work in groups to answer the following:
   - What are the conditions in your new habitat?
   - Is your original organism adapted to this environment? Will it live?
   - What new adaptations does your organism need to survive in its new habitat?
6. Repeat steps 1-5 until all groups have worked on each habitat.
7. Each group will then present to the class the reasons why they chose their adaptations and how those adaptations would help the organism survive in the new habitats.
8. Ask students the following questions:
   - In what habitats do humans live?
   - Are our habitats changing? How? [Possible answers include: more reliance on technology and products that may harm the environment, increased pollution, and changing temperature and climate, etc.]
   - How can humans adapt to their changing environment?
   - What things can we do to live more in balance with nature?
   - Can you think of how the different adaptations you studied today could be used to help us live more sustainably?

Adapted from "Adaptation Auction", http://www.biomimicry.info/Curriculum

Pre-Visit Activity 1: Survival Strategies (Continued)

Answer Key

There is no one right answer to many of these questions; however, students should understand that human behavior has caused much destruction to the environment, thus changing our own habitat for the worst. In order to adapt, humans must learn how to live more sustainably by using less natural resources and polluting less. Examples of positive human adaptations include: conserving land, recycling, reusing and reducing harmful waste, reliance on non-renewable resources, greenhouse gas emissions and the use of harmful chemicals.

Tree Frog

Resources

http://www.fi.edu/tfi/units/life/habitat/habitat.html

Habitat Examples	Organism Examples	Adaptation Examples
Tundra	Polar Bear	Slow metabolism; store fat
	Penguin	Fast-drying, insulating feathers
Desert	Desert tortoise	Bladder water storage, can tolerate high levels of urea in their blood to avoid loosing moisture from excessive urination and can go for long periods of time without food or water
Tropical Rainforest	Monkey	Long limbs and tail
	Jaguar	Camouflage
	Poison dart frog	Bright colors
Pine Rockland	Florida panther	Night vision
South Florida Mangrove	Black mangrove tree	Secretes salt from leaves
	Ibis	Long, curved beak
Mountains	Mountain Goat	Suction cup-like hooves
	Cougar	Sharp hearing and sight
Plains	Deer	Long legs
	Wolf	Padded feet

Florida Panther

Polar Bear

Pre-Visit Activity 2: Ecological Footprint

Objectives

Students understand the impact of their decisions and behavior on the environment.
Students apply basic math skills to use collected data to create and solve real-world math problems.

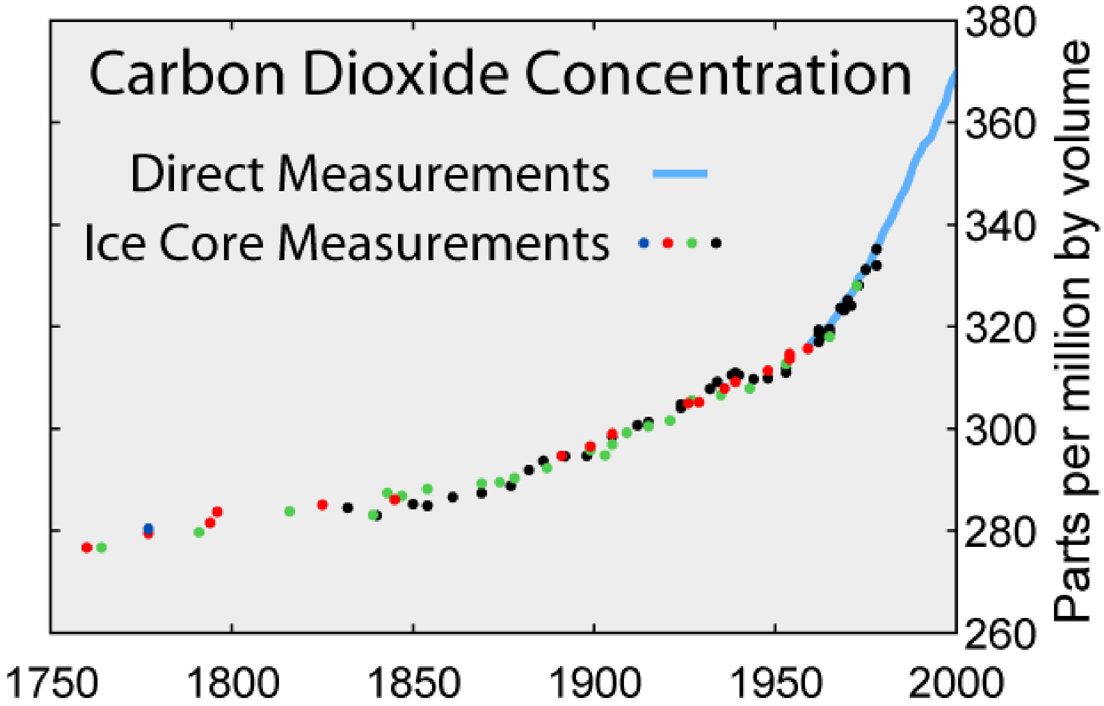
<u>Next Generation Sunshine State Standards:</u> SC.6.N.1.1, SC.6.N.1.5, SC.7.N.1.1, SC.7.L.17.3, SC.8.N.3.1

Materials

- Computers with internet access

Procedure

1. Have students calculate their ecological footprint on a website such as: http://www.myfootprint.org
2. List 3 things they and their families could do to reduce their ecological footprint.



Source: http://www.stuffintheair.com/global-warming-carbon-dioxide.html

3. (Optional) Print the above graph for students and ask them to answer the following questions:
   - What does this graph show us about CO2 levels over time?
   - How could you explain the steep increase in CO2 levels since 1950?

Post-Visit Activity 1: Waste Audit

Objectives

Students can use the correct mathematical formulas to solve real-world problems.
Students can illustrate data using graphs.
Students can explain how accumulating garbage harms the environment and identify steps they can take to reduce waste and environmental pollution.

<u>Next Generation Sunshine State Standards:</u> SC.6.N.1.1, SC.6.N.1.5, SC.7.N.1.1, SC.7.L.17.3, SC.8.N.3.1, MA.6.A.1.3, MA.6.A.3.1, MA.6.A.5.3, MA.7.A.1.2, MA.8.A.1.4, MA.8.A.1.6,

Procedure

1. Have students weigh the collective trash and recycling from their lunches.
2. Have students calculate the following:
   - How many pounds of garbage did we produce at lunch?
   - How many pounds of garbage would this become in one week of school? one month? one year?
   - Do the same calculations for the recycling.
   - What percent of the total waste was recycled from your school lunch?
3. Ask students to create a graph illustrating the weight of garbage and recycling that would be thrown out over the course of a year.
4. Ask students to list the different materials from their lunch that were thrown away (i.e. paper, cardboard, plastic, etc)?
5. Print out the table on the next page and hand out to students.
6. Ask students to fill in the grid.
7. Ask students to create a bar chart illustrating the time period for each of the materials to decompose.

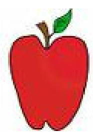
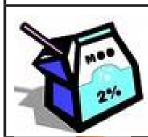
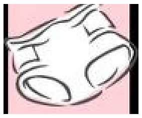
Resources

www.thatdanny.com/2008/06/06/how-long-does-it-take-a-plastic-bag-or-a-glass-bottle-to-decompose/
http://www.deq.state.or.us/lq/pubs/docs/sw/OregonGreenSchoolTools.pdf
http://www.epa.gov/epaoswer/non-hw/composting/index.htm

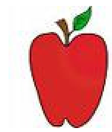
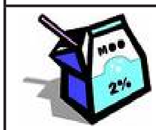
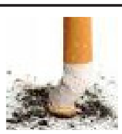
Name ____Date __________________________

Table Illustrating Time Period for Each Material to Decompose

Fill in the table using the information provided by your teacher or from your own research:

Material		Decomposition Timeframe					
		<1 year	5-10 years	10-20 years	20-100 years	100+ years	Never
	**Leaves**						
	**Apple Core**						
	**Paper**						
	**Milk Carton**						
	**Cigarette Butt**						
	**Plastic Bag**						
	**Disposable diaper**						
	**Soda can**						
	**Glass Bottle**						
	**Styrofoam**						

Teacher's Answer Key

Material		Decomposition Timeframe					
		<1 year	5-10 years	10-20 years	20-100 years	100+ years	Never
	**Leaves**	1-3 months					
	**Apple Core**	2 months					
	**Paper**	2.5 months					
	**Milk Carton**		5 years				
	**Cigarette Butt**			10-12 years			
	**Plastic Bag**			10-20 years	20-100 years	100+ years	
	**Disposable diaper**				75 years		
	**Soda can**					200-500 years	
	**Glass Bottle**					500 years	
	**Styrofoam**						Never

Post-Visit Activity 2: How Can Recycling Aluminum Help Rainforests?

Objective

Students will understand how aluminum is processed, the environmental impacts of bauxite mining, and the importance of recycling.

Next Generation Sunshine State Standards: LA.6.1.5.1, LA.6.1.6.1, LA.6.1.6.2, LA.6.1.7.4, LA.7.1.5.1, LA.7.1.6.1, LA.7.1.6.2, LA.7.1.7.4, LA.8.1.5.1, LA.8.1.6.1, LA.8.1.6.2, LA.8.1.7.4, SC.6.N.1.1, SC.6.N.1.5, SC.7.N.1.1, SC.7.L.17.3, SC.8.N.3.1

Vocabulary

Bauxite Reclamation Remediation Ore

Materials

- Atlas with world map
- Examples of products containing aluminum (aluminum foil, soda can, food sieve)
- Copies of "Bauxite and Aluminum Mining Worksheet"
- Examples of products containing iron (nail, magnet, tool, car part or pictures)

Hyacinth Macaws, Native to the Rainforests in Central and South America

Background

Aluminum is the second most used metal (after iron). The ore from which aluminum is produced is called bauxite. Bauxite undergoes refining steps to become alumina first and then aluminum. Aluminum may be stored in sheet-rolls or in ingots until it is re-melted in a processing plant to take its final shape.

The United States produces one fourth of all aluminum produced in the world. Although there are bauxite deposits in Arkansas, the alumina being processed in the U.S. comes from major producing countries such as Australia, Guinea (West Africa) and Jamaica.

Bauxite is an ore comprised of several aluminum oxides, which form in nature by extensive chemical weathering of certain type of rocks (e.g. volcanic). Chemical weathering is more intense in warm, humid regions. For this reason, bauxite deposits are found within tropical rainforests in broad, shallow layers under the soil. Bauxite can also be found in formerly tropical regions, which is the reason why bauxite deposits are found in Arkansas.

Because the ore is spread as a layer beneath the soil, it is mined in open pits. Open mining is a highly destructive extraction technique that damages and disturbs the delicate nature of rainforest habitats and promotes the loss of rainforest soils. The need for land reclamation in mining areas and the benefits of recycling of aluminum are greatly illustrated in this activity.

Adapted from : Rainforests, Recycling, and Bauxite, Mélida Gutiérrez

Post-Visit Activity 3: How Can Recycling Aluminum Help Rainforests? (Continued)

Procedure

1. Show students products containing aluminum and those containing iron.
2. Discuss the different properties of each (aluminum is light-weight, less strong than iron, rust resistant, able to take different shapes, will not react with water, and non-magnetic). Ask them to brainstorm more products containing aluminum (aluminum siding, screen doors, pots and pans, etc).
3. Explain why bauxite is formed as a "residual" ore in warm, humid regions.
4. Let students locate the major bauxite producing countries on a world map and see how their occurrence coincides with tropical rainforests.
5. Read the description of "typical bauxite mining and aluminum processing" (next page) and have students answer the questions listed on the worksheet.

Teacher Answer Key

1. **What problems are caused by the mining of bauxite?**
   Destruction of rainforest habitat and top soil.
2. **Name some things that could be saved by recycling aluminum.**
   Rainforest habitat, soil and wood, money to buy and transport bauxite, electricity, reduced greenhouse gas emissions.
3. **Describe how an open pit mine can be reclaimed.**
   Collection of soil and water samples help assess any pollution created by bauxite mining. If pollution is detected, remediate until chemical(s) concentration(s) are at non-threatening levels. Some of the remediation technologies are: excavation, pumping and treating and soil vapor extraction. Choose the most appropriate remediation technology taking into account that remediation can be a long-term process that may take several years depending on the level of damage, pollution and the chemicals detected at the chosen site for remediation. After remediation is completed, the ground can be covered with material and top soil, followed by planting of new grass and trees. It is important to remember that there are other indicators of pollution that are not found in water and soil samples, such as the health conditions of humans, animals and plants. Recurrence of certain disease(s) can be related to environmental pollution.
4. **Soil devoid of vegetation in the rainforest is washed away by rains in a matter of days. How would this affect your reclamation efforts above?**
   Top soil will have to be purchased and transported from somewhere else increasing the cost of reclamation.
5. **How would the environmental and health effects of bauxite open mining change if it was recycled instead of mined?**
   Open pit mines would not have to be dug in tropical regions; bauxite and alumina will not have to be transported; electricity will not have to be used as much; and landfill space will be saved.
6. **What are some reasons that more people do not recycle?**
   People may not know about the benefits to recycling; recycling centers may not be centrally located; the community may not have recycling programs in place.
7. **Brainstorm about some ways to encourage recycling (a) at home, and (b) in your school.**

Bauxite and Aluminum Processing Worksheet

Directions: Read the text below and answer the questions that follow.

Most bauxite is mined in open pits. First, bulldozers clear away trees, rocks and topsoil. The ground is then loosened with explosives and the soil and bauxite lumps are loaded into trucks and transported to be processed.

The bauxite and soil mixture is crushed and washed to remove some of the clay and sand waste. Then, it's dried out through a heating process (wood from the rainforest is likely the heating source).

Crushed, washed bauxite is transported to a refinery where it is transformed into alumina by a series of chemical reactions. Alumina is a fine white powder. Alumina is loaded into a ship and transported to a smelter in an industrialized country.

In the smelter, alumina is placed into a large pot and heated at high temperatures to remove the oxygen. Molten aluminum is transported into a cast house, where other materials are added to make the product stronger, and then poured into molds to form blocks of aluminum called "ingots". These processes are extremely electricity intensive.

Ingots are transported into the final plant where the aluminum will be re-melted, hammered or molded into its final shape.

Questions

1. Can you write a description of the processing path for aluminum cans that get recycled?

2. What problems do you see with the mining of bauxite?

3. Name the positive impacts of recycling aluminum and how it would affect the environment.

4. Reclamation is the process of restoring disturbed land to its original condition.
Describe how an open pit mine can be reclaimed.

5. Soil devoid of vegetation in the rainforest is washed away by rains in a matter of days. How would this affect your reclamation efforts above?

6. How would the steps described in your answers to questions 1 to 3 change, if aluminum was recycled instead of mined?

7. Why do you think people do not recycle? How could that be changed?

8. Brainstorm about some ways to encourage recycling (a) at home, and (b) in your school.