

Fly Eyes and Whale Hearts: Solving Problems Nature's Way

"Biomimicry is a field whose time has come" proclaimed Achim Steiner, head of the United Nations Environment Programme, at a 2008 conference in Germany on the loss of biodiversity. The conference was attended by 160 nations. "Anyone doubting the economic and development value of the natural world need only sift through the extraordinary number of commercially promising inventions now emerging."

From pacemakers inspired by a whale's powerful 2,000-pound heart to improvements in computer screens courtesy of the fly, we are in a breakthrough period of innovation inspired by nature. Use this Teachable Moment to introduce your students to this new and fascinating field, where life science meets engineering and entrepreneurship.

National Standards Addressed

Science Standards

- Develop understandings about scientific inquiry
- Develop understanding of structure and functions in living systems
- Develop understanding of the diversity and adaptations of organisms
- Develop understanding of science and technology in society



Options for Using Student Activities and Worksheets

Worksheet 1—Bio Brainstorm: Briefly introduce the term *biomimicry*, and then carry out this quick brainstorm activity to ground the concept. You can do the activity as a full group or divide students into teams and ask each team to report back. Students may know a lot or very little about each item. Use what they know and/or be prepared to give hints that prompt their thinking (see answer key). You could also bring in examples of real items (a shell, burr, etc.,) or show slides and have students brainstorm what each might be able to teach us. You might also assign the *Washington Post* article as introductory reading before moving on to the next activities.

Worksheet 2—Ask Wise Old Mother Nature: Students can work individually, as pairs, or in small teams. Provide additional instructions for presentations as appropriate (e.g., using PowerPoint, planning the amount of time for each presentation).

Worksheet 3—Bioinspiration Exhibition: Students can work individually, as pairs, or in small teams. Younger students may need more support. For example, you might have students share from their observation notebooks and brainstorm applications as a group. If students seem most excited about a short list of 4–5 ideas (regardless of the original source), have teams select the idea they want to work on from that list.

Worksheet 3—Peer Feedback: Focus students on substance—the ideas represented by the design and the overall effectiveness of the presentation.

Worksheet 3—Awards (optional): Consider awards or special citations for designs. (Examples: most useful, most commercially viable, most imaginative, best presentation, best illustration, most bizarre)

Web Sites and Online References



Washington Post.com: Inventors Find Inspiration in Natural Phenomenon

www.washingtonpost.com/wp-dyn/content/article/2008/12/28/AR2008122801436.html

National Geographic: Biomimetics—Imitating Designs from Nature

<http://ngm.nationalgeographic.com/geopedia/Biomimetics>

National Geographic: Designs by Nature (Image Gallery)

<http://ngm.nationalgeographic.com/2008/04/biomimetics/clark-photography>

Entrepreneurs of the Natural World Showcase their Ground Breaking Solutions to the Environmental Challenges of the 21st Century—Nature's 100 Best Initiative Publishes Findings

www.unep.org/Documents.Multilingual/Default.Print.asp?DocumentID=535&ArticleID=5816&l=en

Environmental News Network: Whales, Lizards Inspire Hi-Tech Bio-Mimicry

www.enn.com/wildlife/article/36922

TED Talks: Biomimicry

http://blog.ted.com/2008/04/biomimicry_in_n.php

Nature's 100 Best: The Innovation Candidate List

www.n100best.org/list.html

Nature's 100 Best Initiative Publishes Preliminary Findings on How to Green

www.solutions-site.org/artman/publish/article_398.shtml

Ask Nature: Featured Pages

www.asknature.org/article/view/featured_pages

Biomimicry: Learning from Nature

www.cbc.ca/natureofthings/features.html#

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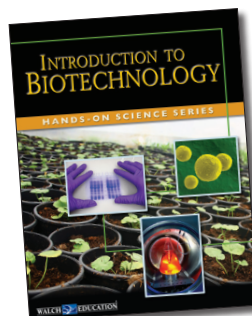
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Teacher Background Information

Taking inspiration from nature is nothing new. The plane, submarine, telephone, and thousands of other human products and systems are based on lessons we have learned from observing animals, plants, and other natural phenomena. Today, however, thanks to technology, we have the ability to study and model natural phenomena in ways previously impractical or impossible. This has led to a new field of science called *biomimetics* or *biomimicry*—the process of applying biological principles to human designs and challenges.

As renowned biomimeticist or “bioneer” Janine Benyus puts it: “Nature has done 3.8 billion years of R&D, with 10 to 30 million species with well-adapted solutions.” If we can emulate nature’s methods or “genius,” we can make huge advances in medicine, energy, manufacturing, food production, communication, transportation and just about any human endeavor.

Other interesting background points:

- Biomimicry or biometrics is an offshoot of bioengineering—except that it works in reverse. Bioengineers apply the tools and methods of engineering to living things. Biomimeticists use biology to inspire creative engineering solutions.
- Biomimicry is also known as *bionics*—a term coined back in the late 1950s by Jack Steele, an American medical doctor interested in neuroanatomy who worked with the Air Force on cyborg research.
- Many scientists view the increasing interest in biomimetics as the dawning of new age: we’ve transitioned through the Stone, Bronze, Iron, and Steel Ages and through the most recent era, which focused on non-metallic and composite materials, into a biomaterials or “smart materials” age inspired by nature.
- The field of biomimetics draws a very interdisciplinary crowd, including biologists, engineers, medical researchers, corporate interests, and entrepreneurs.
- Work is currently under way in England to create a “biological patents” database that would enable someone working on a particular technological or engineering design challenge to find ideas or possible solutions inspired by nature. So, for example, an engineer interested in “defying gravity” could enter those keywords and get a list of methods and properties used by various animals to do this. This would make it easier to connect discoveries made by biologists and researchers with engineers who might use them.

Worksheet 1: Bio Brainstorm (Warm-Up)

Scientists, engineers, and inventors have always been inspired by nature. Birds taught us to fly; fish taught us to swim. These days, however, bio-inspired design—also called **biomimicry** or **biomimetics**—has entered an entirely new, exciting era thanks to technology and the push for greener, sustainable living. More and more people want to understand how nature works and imitate it to solve human problems. Everything from the modest earthworm to the magnificent humpback whale has secrets to reveal.

Look at the list below and/or other items shared by your teacher and brainstorm how each might inspire innovations that could benefit humans.

Start by discussing what you know about each animal, plant, or phenomenon. What features and capabilities does it have? How does it behave? How might a particular feature or capability have applications for humans? Can you imagine an improved or new product inspired by the feature?

	Features/Capabilities/Behaviors	Possible Applications for Humans
Gecko		
Burr (plant)		
Bees/bee hive		
Plant leaf		
Spider		

Worksheet 2: Ask Wise Old Mother Nature

Select an animal or plant from the list below or pick one of your own, with approval from your teacher. Research it to learn more about it and the human applications and designs it is inspiring.

abalone

pine cone

bombardier beetle

resurrection plant (Africa)

boxfish

sea cucumber

dolphin

sea worm

earthworm

shark

electric eel

termite mound

fly

toucan

humpback whale

other: _____

lotus plant

Research Questions/Presentation Outline

1. Description

Briefly describe the animal or plant. What are its key features, characteristics, and abilities?

Locate and include a good picture of your item. Label key features relevant to your presentation topic.

2. Biomimicry Research Interest

Which abilities or features have scientists and others tried to mimic—or, what are they currently investigating?

Why does the plant or animal have this feature or ability to begin with?

3. Human Applications

What human and commercial applications, actual or theorized, are scientists and others focused on?

Do you see any other applications?

Do you see other ways this animal or plant might inspire us? Are there other features you think are worth investigating?

Worksheet 3: Bioinspiration Exhibition

You are now ready for hands-on biomimicry field work. For this activity, you will find your own example of a natural phenomenon by walking around and observing nature around you. You will then imagine and present a design that illustrates how what you observed might have potential for humans.

Instructions

1. Keep an observation notebook or field journal for one full day. In it, record “natural” things you encounter—animals, plants, or natural phenomena. Observe each closely and list any characteristics, abilities, or behaviors you notice. Jot down any thoughts or questions you have about how something works or why.

In many cases, you may have seen the item or feature many times before (a dog’s paw or tree). This time, however, give everything much more thorough inspection and reflection.

2. Review your observations and select one that inspires you: something about it suggests possible usefulness or relevance for humans. Realistic and practical or imaginative, even fantastical, uses are acceptable.
3. Research the natural phenomenon. Prepare a brief 1–2 paragraph explanation of what it is and how it works. Find a picture or create an illustration and label relevant features.
4. Next, “invent” your bio-inspired design. Draw and label a prototype that illustrates the design. Include a 1–2 paragraph design summary that includes:
 - a name for your design
 - a description of what the design is and its purpose
 - the key value and benefits of the technology—the advance it represents or human problem it solves
 - the feature or ability in nature that the design mimics
 - a list of any information sources you used
5. Showcase your designs in class. Browse the gallery of designs and provide a feedback form for each design.

Answer Key

Worksheet 1

Student answers will vary but may include examples such as the following. You may need to give a few hints or examples to spark their thinking.

	Features/Capabilities/Behaviors	Possible Applications for Humans
Gecko	Special toe pads so they can walk on smooth and vertical surfaces (wall, ceilings)	<ul style="list-style-type: none"> • New types of adhesive materials; materials that are strong and can stick and come off again easily • Shoes that allow humans to walk vertically • Robots that can walk vertically and upside down • Space exploration—vehicles with legs rather than wheels
Burr (plant seed)	Attaches itself to clothing or fur Hard to remove	Velcro was inspired by the burr
Bees/bee hive	Make hives—waterproof on the outside, honeycomb structure Communicate and organize themselves to maximize collection of nectar (“swarm intelligence”)	<ul style="list-style-type: none"> • Building materials, architectural techniques, storage efficiency • Bee behavior is being studied in order to improve computer server hosting technology (optimizing communication among a network of servers) or to help reduce energy use in buildings (because different appliances and systems need to communicate about when to be on or not, peak use times, etc.)
Plant leaf	Repels water Lightweight but strong and flexible	Clothing, construction materials
Spider	Walks on any surface Makes own silk for webs—light, flexible, incredibly strong, some threads are glue-covered	<ul style="list-style-type: none"> • Robots or vehicles • New “silk”-based building materials • Silk-based medical materials—could be used to help heal wounds, repair tissues, replace or strengthen tendons and ligaments • Silk-based substitute for Kevlar bulletproof clothing

Worksheet 2

[Answers TK??]

Worksheet 3

[Answers TK??]

