LEVELED BOOK • Z²

Biomimicry

MULTI LEVEL Y • Z¹ • Z²

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Focus Question

What important lessons have we learned from biomimicry?

Words to Know

adaptations	exploit	renaissance
contaminating	inhabitants	resources
dispersal	microbes	silica
ecological	microscopic	spew
ecosystems	pigment	sustainable

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Correlation

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Fountas & Pinnell	Y–Z
Reading Recovery	N/A
DRA	70+

Table of Contents

A peacock displays his feathers to attract mates.

Introduction

Did you know that a peacock's feathers aren't really as colorful as they seem? Their bright hues aren't due to **pigment**—they're actually the result of feather structures that bend light like a prism. Ever wonder how swarming locusts keep from colliding? You might be surprised to know their tiny brains have a much faster reaction time than human brains do. The insects can sense and respond to motion at speeds that leave humans in the dust!

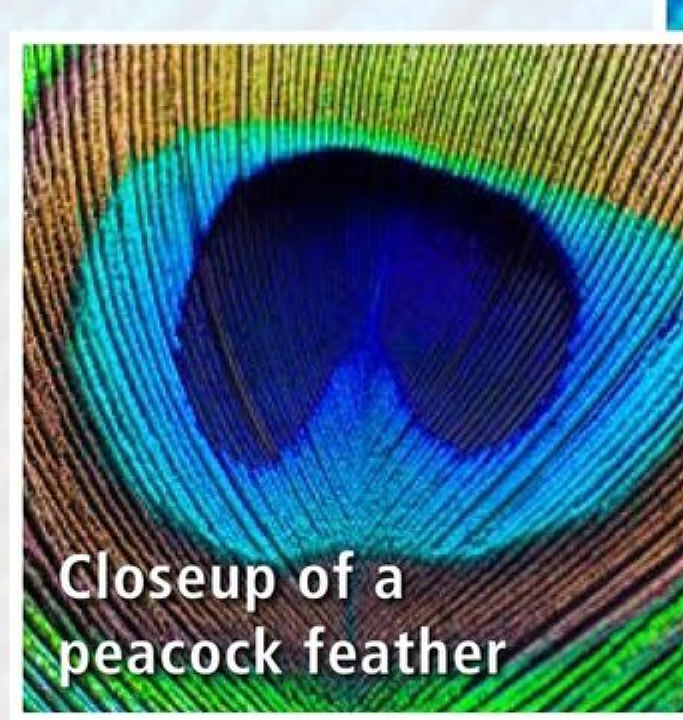
Nature is filled with a vast number of living creatures, each with specialized **adaptations** that help it survive in the wild. For centuries, humans have marveled at the unique qualities of the many plants and animals around us. Now a science called *biomimicry* focuses on how lessons from nature can help solve human problems and improve our lives in **sustainable** ways.

What Is Biomimicry?

The word *biomimicry* is a blend of two words: *bio*, meaning “life,” and *mimic*, meaning “to copy.” Also known as biomimetics, biomimicry involves learning about other organisms’ adaptations and imitating them. Biologists, scientists, designers, engineers, and others observe how organisms live within their **ecosystems** and then look at human situations that might benefit from using similar strategies. The idea is not to **exploit** other creatures, but to understand and apply the principles behind their natural behavior and features.

Reverse Engineering

There are two ways to solve a problem. One is to analyze the problem and craft a solution from scratch. The other way is to look at how a similar problem was solved and study that solution to see if and how it might be applied elsewhere.

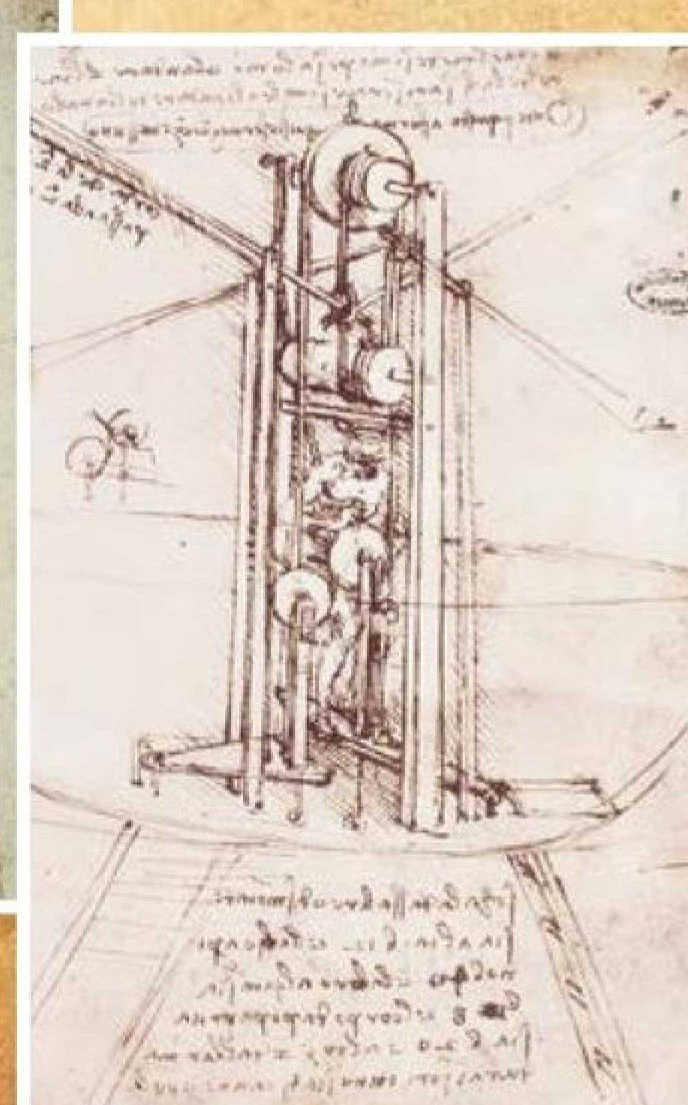


Closeup of a peacock feather

Analyzing existing solutions to solve new problems is what is known as reverse engineering. Biomimicry is a type of reverse engineering that involves looking at a successful design or behavior that already exists and adapting it for a new purpose. For example, some e-reader screens mimic the way peacock feathers bend light as a low-energy way to create multicolor images.

While the science of biomimicry may seem new, its roots actually go back centuries. **Renaissance** scientist and inventor Leonardo da Vinci spent a great deal of time observing nature and sought answers to such questions as "How do birds fly?" His careful study of the natural world inspired his designs of flying machines, webbed gloves for underwater exploration, and even "sink-proof" boats. The devices da Vinci designed were never actually built and used, but modern devices based on the same principles he studied hundreds of years earlier have been successfully developed.

From the simple to the complex, many new tools and devices have been made by inventors who, like da Vinci, use biomimicry to seek solutions that improve life for people around the world.



A self-portrait by Leonardo da Vinci (main) and his drawing of a flying machine (inset)

Velcro under a microscope (left) and a burr (right)

That Comes from *What?*

Velcro

Anyone who's gone on an autumn hike through a meadow knows how difficult it can be to remove prickly seeds called *burrs* from clothing. After one such outing with his dog in 1941, Swiss engineer Georges de Mestral collected burrs from his pet's fur, then examined them under a microscope. He found that each seed was covered with dozens of tiny hooks that latched securely onto hair or thread. The hooks assisted seed **dispersal**, letting passing animals (and people) do the work of sowing a new crop.

De Mestral was inspired by his discovery and created his own version of the burr's hook-and-loop system. Known as Velcro, his invention is made of two pieces of cloth that can be used to temporarily attach objects to each other without the need for tools. Velcro has been used in hundreds of different ways in homes, businesses, and even on space missions!

Reflectors

Those shining bumps commonly seen in road pavement can be lifesavers for drivers on dark nights. Found on streets worldwide, these reflectors were the brainchild of a man named Percy Shaw. While driving one foggy night in 1933, Shaw saw the eyes of a cat reflected in the beam of his car's headlights and realized that if he could mimic that effect, he might be able to help drivers like himself stay safe when visibility was limited.

Shaw first had to learn what made cats' eyes glow in the dark. Cats are nocturnal creatures, and their eyes have a reflective surface behind the retina that creates an effect called *eyeshine* that helps animals see in the dark.

Shaw used this knowledge to design a small sphere with a surface similar to that found in cats' eyes. He named his invention after the animal that

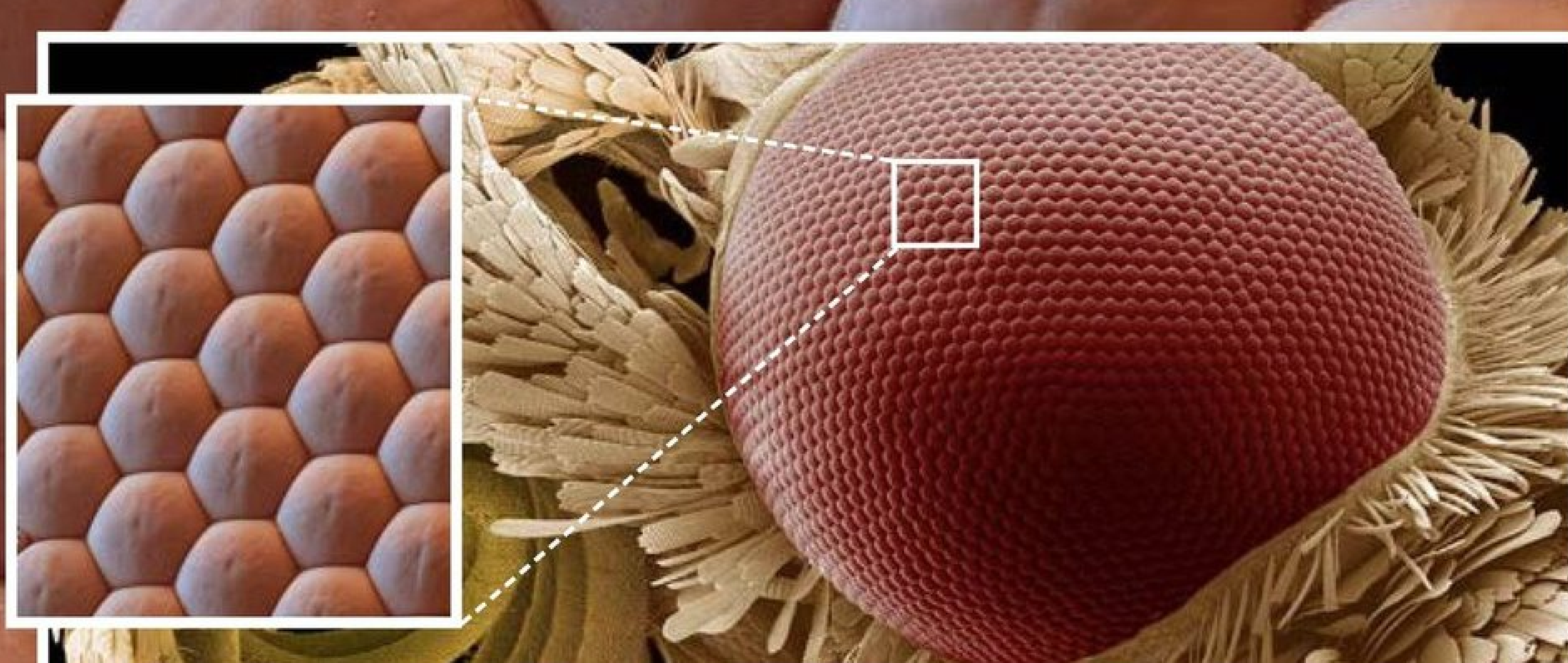
A cat's eyes reflecting light (right), and a Cat's Eye in Yorkshire, United Kingdom (left)

inspired him. The Cat's Eye road marker has changed over the years, but it still glows brightly, marking a safe route through the darkness.

Antireflective Screens

Some creatures have eyes that reduce rather than increase light reflection. Moths' eyes, for example, can absorb any light wavelengths coming at them from any direction. This unique adaptation is key to moth survival; by absorbing instead of reflecting light, their eyes don't draw the attention of predators.

That antireflective ability, however, did catch the attention of researchers trying to design antiglare computer screens. They noticed that moths' eyes have microsized lenses covered with dome-shaped patterns that help the eyes absorb rather than reflect light.



This microscopic view shows the antireflective surface of a moth's eye.

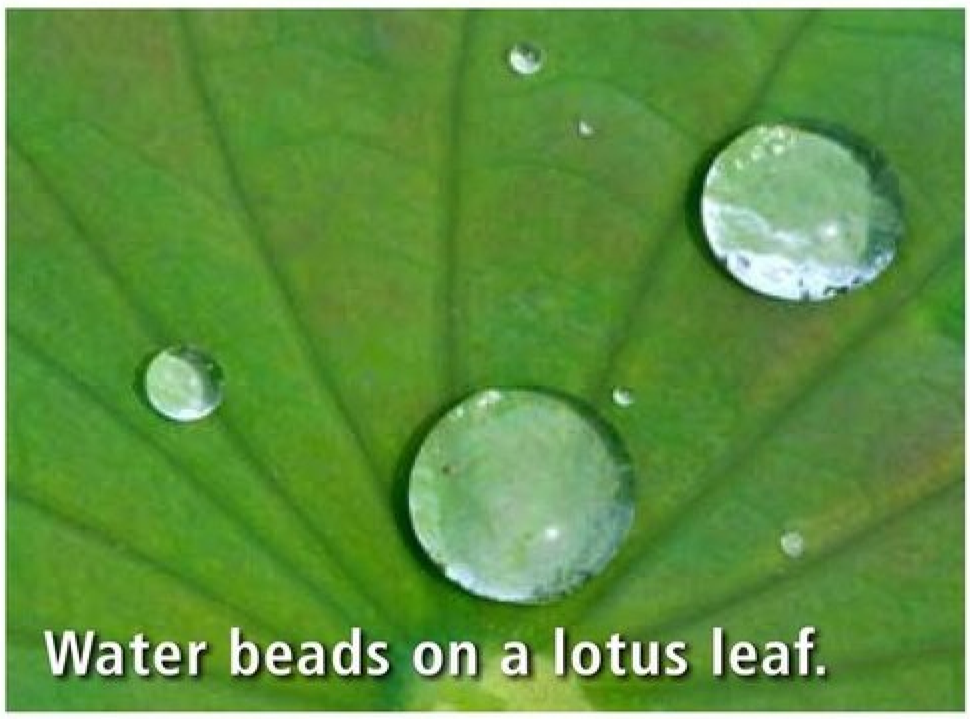
Researchers adapted this idea and stamped similar **microscopic** patterns on screen coatings. The patterns reduced light reflection and glare, making computer work less likely to lead to eyestrain.

Self-Cleaning Paint and Roof Tiles

The lotus plant, better known as the water lily, is revered in some parts of the world for its pure, clean appearance. Lotus plants grow in ponds and rivers where mud and grime are common, yet the leaves stay relatively clean.

Scientists examined lotus leaves and found that the seemingly smooth surface is not smooth at all—it is covered with microscopic bumps that give water drops only a few points on which to rest. Any slight tilt or motion will cause drops to roll off, taking dirt and grime with them as they go.

This knowledge led to the creation of paints and roof tiles with bumpy surfaces that mimic the surface of a lotus leaf. As a result, every time it rains, the outsides of houses with these paints and tiles are cleaned.



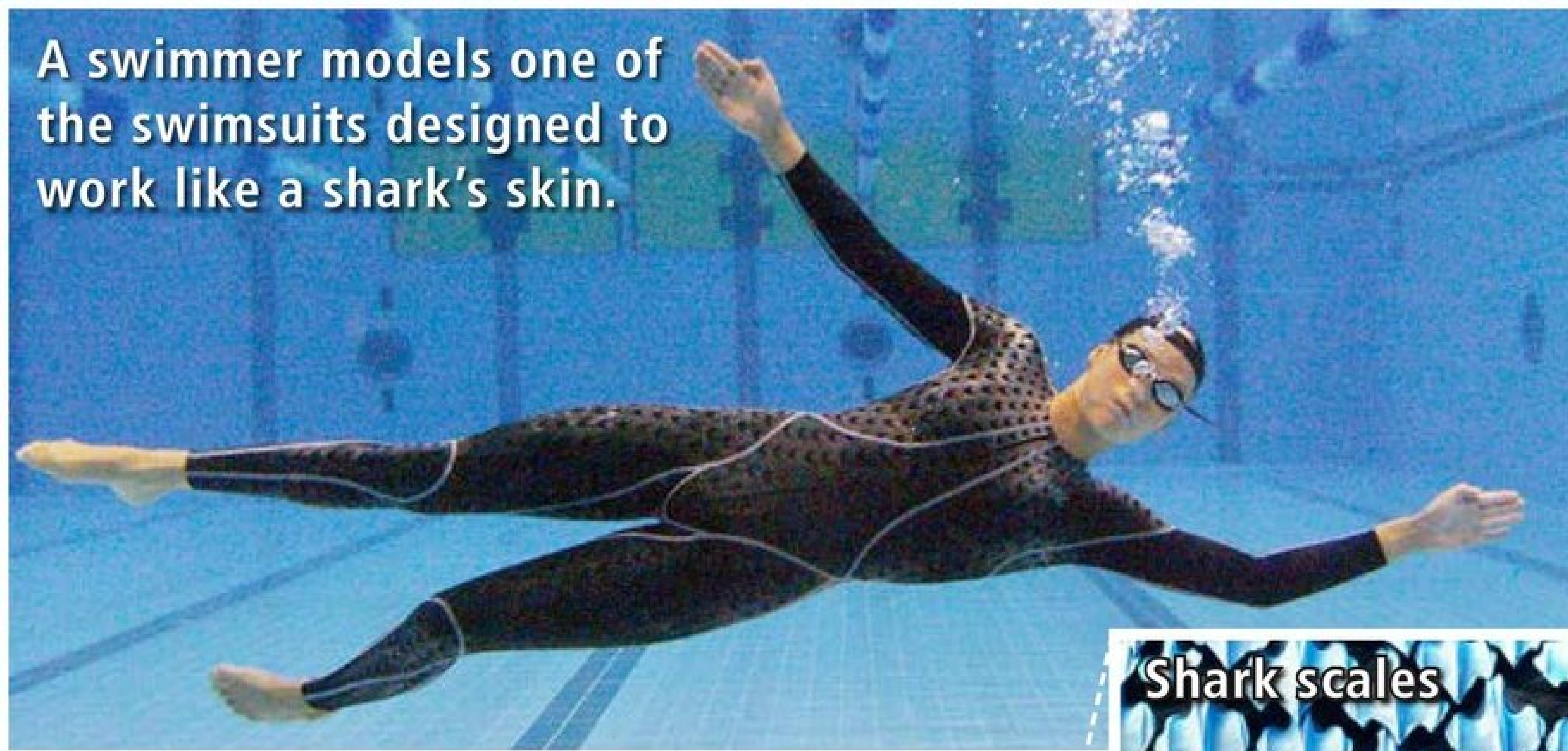
Water beads on a lotus leaf.

The newly designed Shinkansen train pulls into a Tokyo train station.

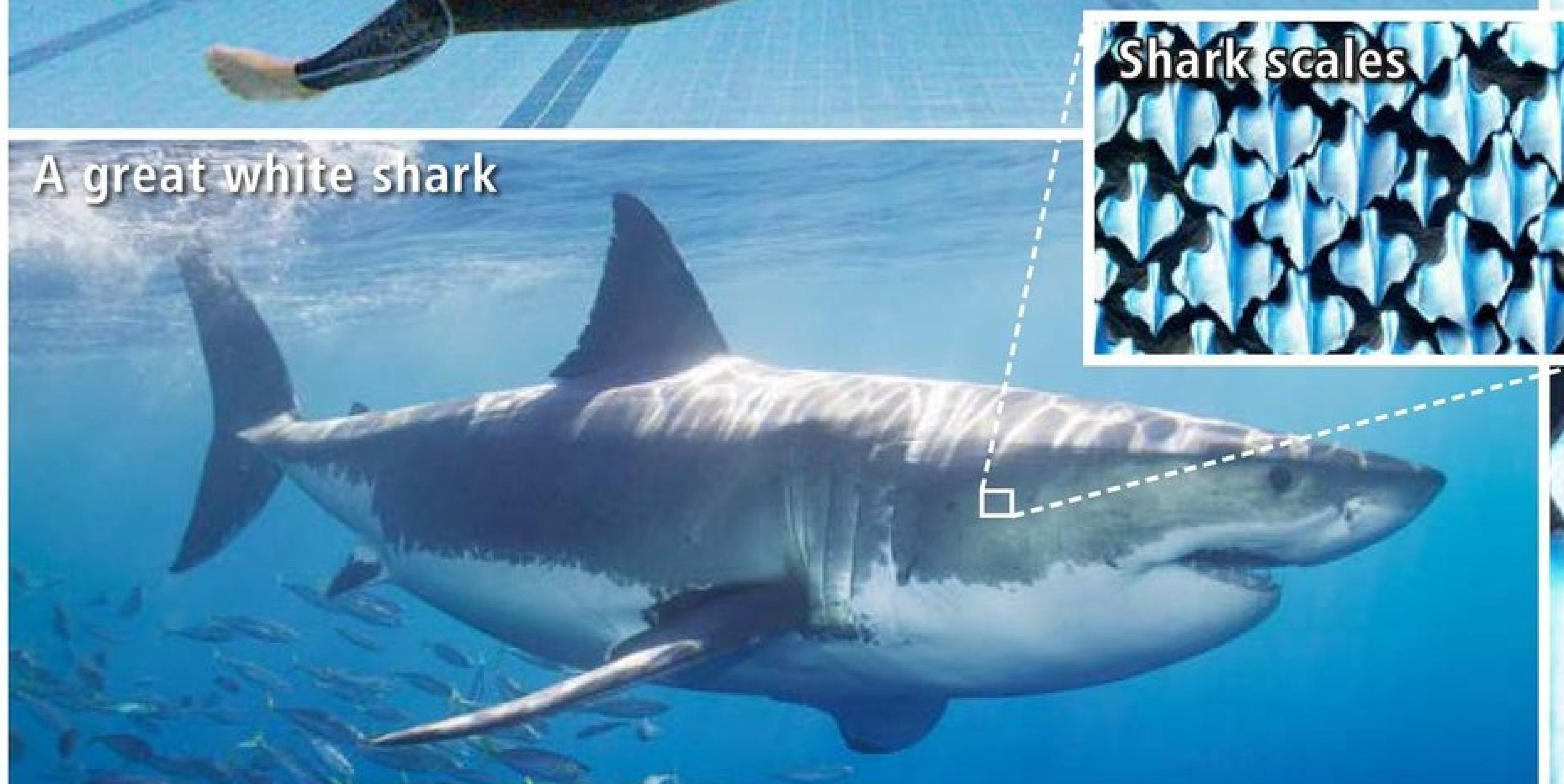
Shinkansen Train

Japan's Shinkansen train is among the world's fastest, traveling at speeds up to 210 kilometers per hour (130 mph). For a time, it was also among the world's loudest. As the train sped through a tunnel, it created air pressure waves that left the tunnel at the speed of sound, resulting in a thunderous noise, or sonic boom, that startled and frightened local residents.

To fix this problem, the designers of the train looked to the kingfisher, a small diving bird with a uniquely shaped beak and head that help it pass easily from one fluid environment to another with little resistance or loss of speed. A new train nose design based on a kingfisher's beak not only solved the noise problem but also increased the train's speed while in tunnels.



A swimmer models one of the swimsuits designed to work like a shark's skin.



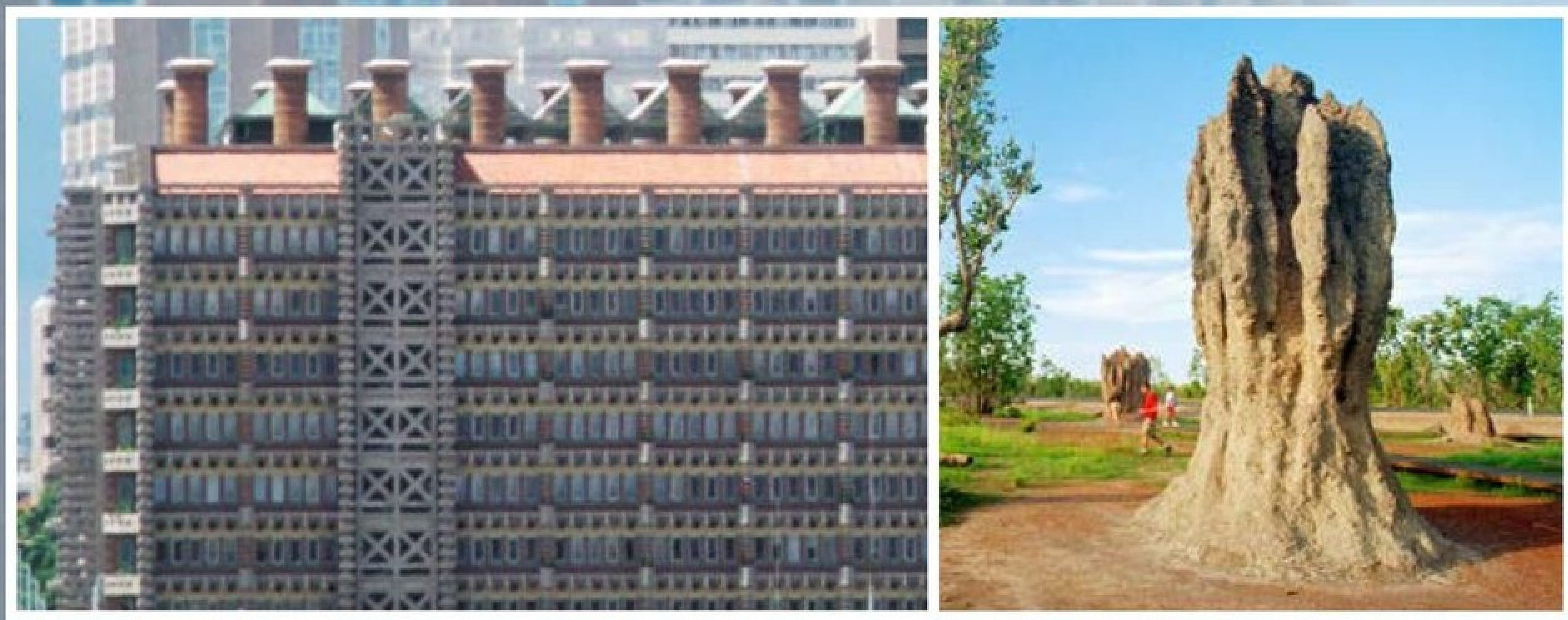
A great white shark

Shark scales

Swimsuits

Sharks have been swimming in the ocean since before the time of the dinosaurs. Their bodies are well adapted to moving through the water. Sharkskin has tiny grooved scales that help these animals glide smoothly and quickly.

In order to swim faster, competitive swimmers tried swimsuits that mimicked the design of sharkskin. The new suits did seem to help, as 80 percent of the swimmers who wore those suits at the 2000 Sydney Olympics won medals.



The Eastgate Centre (left) releases hot air through vents along the sides and top of the building like a termite mound (right).

Cooling Systems

Termite mounds can sometimes be taller than an adult human. These high-rise insect homes have a natural cooling system based on hot air's tendency to rise. Termites keep their mounds cool with a complex system of tunnels and vents that run from deep in the ground to the top of the mound. The heat inside the mound escapes through the top, while cooler air comes up from below, keeping the mound at a constant, comfortable temperature.

The Eastgate Centre in Harare, Zimbabwe, was built with these same ideas in mind. It uses heat-resistant materials and special vents at the top to keep the large building cool—without air conditioning. Consequently, it uses only 10 percent of the energy that a normal building of the same size would use.

The Moss Landing power plant in California (right) was one of the first to turn carbon dioxide into cement using a process similar to one that corals use (left).

Building Materials

Other living things, such as coral, have inspired builders to recycle waste into usable building materials. When carbon dioxide in the atmosphere mixes with seawater, it changes into calcium carbonate. Corals use this mineral to create spectacular, massive coral reefs.

Like corals, people can recycle carbon dioxide into building material. Carbon dioxide is an industrial waste product. Some coastal power plants that would ordinarily **spew** massive amounts of carbon dioxide into the air are instead bubbling it through seawater to create one of the ingredients of cement. Instead of going up in smoke, the gas is permanently captured as carbonate. This keeps the air clean and provides a commonly used raw material.

Why Is Biomimicry So Important?

Biomimicry is more than just an interesting way to create "nature knockoffs." The benefits of applying natural solutions to human problems are many. One of the most obvious is that nature's solutions are tried-and-true strategies that developed over time. We know they really work. The organisms that rely on them simply wouldn't survive if they didn't!

Nature's solutions also tend to be surprisingly elegant in their simplicity. There's nothing terribly complex about burrs or lotus leaves once you see how they're constructed, yet those parts are highly effective at helping plants survive and thrive.

Perhaps the biggest benefit is that biomimicry helps us apply solutions that have little negative impact on our environment. Compared to other species, humans leave a sizeable **ecological** footprint on our planet, creating a lot of waste

Plastic bottles and trash litter a beach.

when manufacturing and later discarding all sorts of products. The resulting chemicals and trash are harmful not only to ourselves, but also to the other **inhabitants** of our planet. Rather than stripping Earth of its **resources** and **contaminating** its ecosystems to meet our needs, we can view the environment as a whole system and consider our role in that system.

In nature, any waste becomes a resource for another organism, such as a dead tree becoming food, shelter, and energy for hundreds of living things. All the different parts of an ecosystem work together in a sustainable way without using up or damaging resources. It has taken many thousands of years to create these sustainable environments, and each living thing—and its adaptations—plays a certain role.

Through the science of biomimicry, we have a chance to see how these sustainable environments survive and how the organisms within them work together. By studying these relationships, we can


Mushrooms and moss grow on a fallen tree.

learn and adapt how we live and make the things we use to help solve our challenges and live in more sustainable ways. People can take their cue from nature and do their part by being careful about what resources they use and by considering what happens when they're finished with them.

The Future of Biomimicry

Artificial Leaves

Many people see solar panels as an ecological choice for generating energy, but the usual process for creating solar panels is actually not very ecological. Mining and processing the **silica** used to make solar cells is costly, requires lots of energy, and creates waste products that are difficult to dispose of safely.

Traditional solar cells made from silica

Solar Ivy (right) acts like artificial leaves, turning sunlight into energy as a tree does (left).

A solution may lie in the way green plants change light into food energy through photosynthesis. Scientists are experimenting with a new type of solar cell that uses organic dyes to mimic how green chlorophyll in plants absorbs sunlight. These new cells may provide a less costly and more ecologically sound method for capturing and using the power of the Sun.


An Antarctic ice fish

Fish Antifreeze

Vehicles and machines that operate in icy weather often use chemical antifreeze to keep parts from freezing up. Chemical antifreeze is effective, but highly toxic to living tissue, so it must be used carefully.

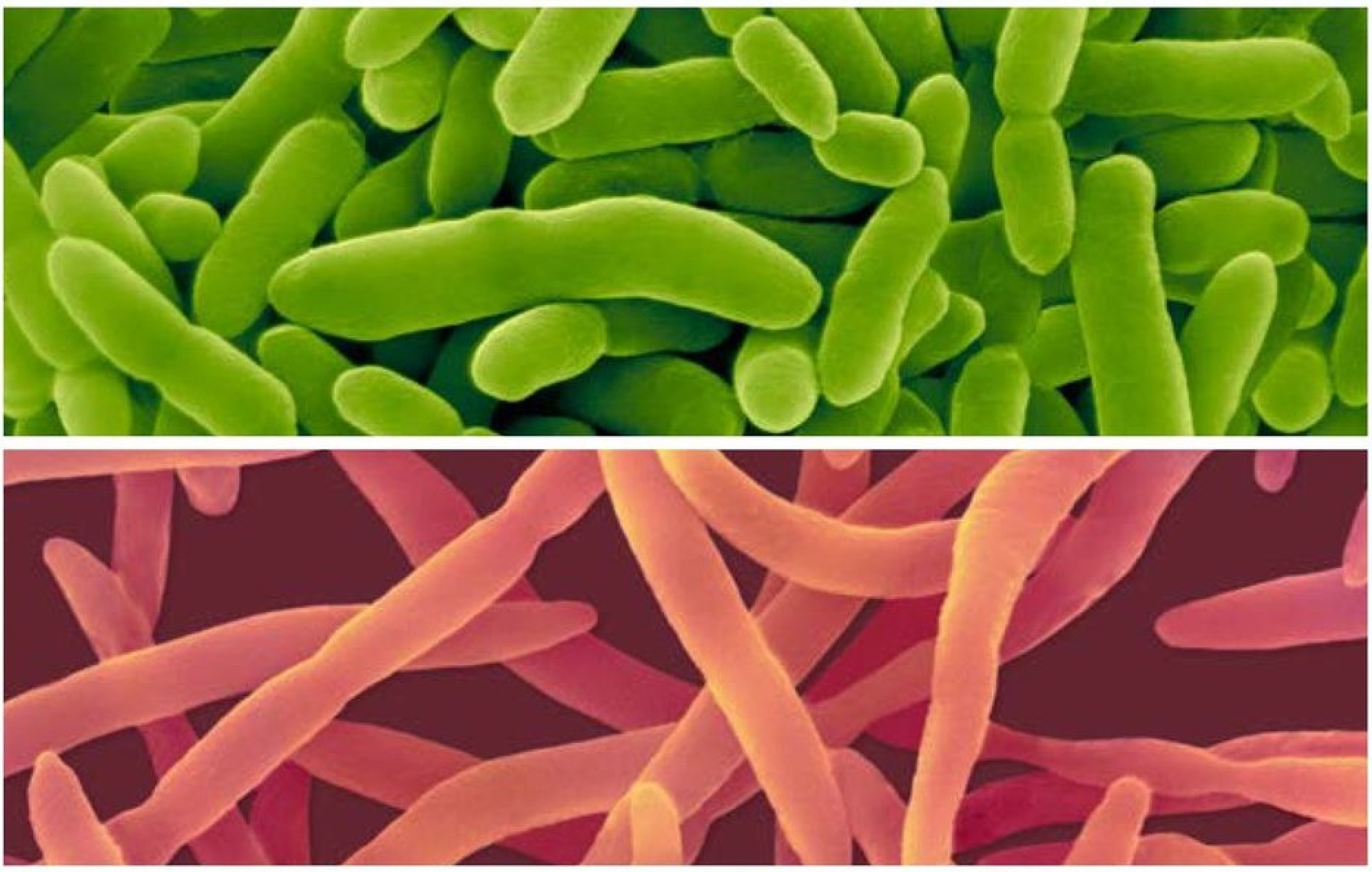
There is another type of antifreeze, however, that is not toxic and in fact helps living things survive in the Antarctic and on the chilly ocean floor. Some species of fish can survive extreme cold thanks to a natural protein in their bloodstream that prevents ice crystals from forming. Researchers are hoping to learn how to create similar proteins and adapt them to help preserve human organs for transplant.

This microscopic view (inset) shows how spiders, such as the funnel spider (main) create the silk for their webs.

Spider Silk

If you've ever accidentally walked into a spider's web, you know how sticky and strong it is. Strands of spider silk are three times as strong as threads of steel. Silk strength and spiderwebs' unique designs make them flexible but sturdy.

Scientists hope that by analyzing spider silk and spiderweb design they can create material that mimics the strength and flexibility of arachnid architecture. Such material could be used in fences along highways that could absorb the impact of a speeding vehicle and minimize crash injuries.



These microscopic views show two types of microorganisms that produce natural plastics.

Natural Plastics

Plastic is everywhere, it seems—humans make millions of tons of this durable material, and it's used in everything from medical devices to toys. Once those items are discarded, however, their durability becomes a problem, resulting in huge piles of waste that don't go away.

Scientists think they may have found an alternative to artificial plastics in natural plastics produced by microorganisms. Bacteria play a role not only in the production of natural plastics, but also in their disposal—different **microbes** in soil feed on natural plastic refuse, turning it into carbon dioxide and water.


A chimpanzee eats medicinal plants.

Medicine

Animals in the wild can become ill, just as humans can, but some species, such as chimpanzees and monkeys, seem to know just how to treat their ailments by using native plants or minerals. Observing animal behavior to learn how these species treat themselves may provide insights into potential uses for human illness.

Conclusion

Nature provides important lessons for humans, but there is still much to be learned. By studying the living things around us, scientists can find inspiration for solutions to important problems and learn how we can live more sustainably. The best answers may be right under our noses, waiting to be discovered through the science of biomimicry.

Glossary

adaptations *(n.)* changes in an organism or species that allow it to survive better in its environment (p. 4)

contaminating *(v.)* making something unusable or unsafe by adding a harmful or unwanted substance (p. 16)

dispersal *(n.)* the process by which organisms or things move or are moved and spread out over a wide area (p. 7)

ecological *(adj.)* of or relating to the relationships among organisms or between organisms and their environment (p. 15)

ecosystems *(n.)* communities of living things together with their habitats (p. 5)

exploit *(v.)* to use someone or something for profit or advantage; to make use of someone or something (p. 5)

inhabitants *(n.)* people or other animals that live in certain locations (p. 16)

microbes *(n.)* microscopic organisms (p. 21)

microscopic *(adj.)* so small that it can only be seen using a microscope (p. 10)

pigment *(n.)* a substance that gives color to something (p. 4)

Renaissance *(n.)* the sudden explosion of science, culture, and art that swept through Europe from the fourteenth to sixteenth centuries (p. 6)

resources *(n.)* supplies of valuable or very useful things (p. 16)

silica *(n.)* a hard compound found in quartz and sand, often used to make glass (p. 17)

spew *(v.)* to spit out or expel a large amount of something in a fast or forceful way (p. 14)

sustainable *(adj.)* able to be used in a way that does not completely use up or cause permanent damage to a resource (p. 4)

Biomimicry

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Word Count: 2,272

Connections

Writing

Which plant or animal adaptation do you think has provided the most important lesson for humans? Write a persuasive essay using information from the book, as well as outside resources, to support your answer.

Science

Research other examples of biomimicry not found in the book. Choose one and write an informational paragraph about it. Create a poster that includes your paragraph to share with your class.