Introducing Green Chemistry: Biomimicry Matching Game

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

Teacher Background Information:

Biomimicry is the science and art of emulating Nature’s best biological ideas to solve human problems. The natural world is made up of very good green chemists. Consider animals and how they make their own shelter and get all the food they need from other things in nature. This is all done without having to use any gas or electricity or taking more than they need, and they produce little waste or waste that can be used by other living things.

Many scientists looking for green solutions are turning to nature for answers to some of our problems with chemical processes. For example, the spider’s web is coated with one of nature’s strongest adhesives, so scientists have recently done studies of what we call “Spider Web Glue.” They found that it is made from proteins with sugars attached to the molecules (glycoproteins). The DNA and enzymes in the spider synthesize this glue, and scientists are working now to find ways to mimic this process.

Biomimicry and green chemistry complement each other incredibly well. For more information and to see the inspiration for this segment of the lesson, please check out: <http://www.biomimicryinstitute.org/> and [www.asknature.org](http://www.asknature.org).

Reminder: Biomimicry Matching Cards can be found on the Beyond Benign website: [www.beyondbenign.org](http://www.beyondbenign.org)

**Learning Objectives:** Students will…

* Apply their knowledge of natural images and match them with the corresponding technology

**Key Terms:** Biomimicry, green chemistry, innovation, technology

Materials (per student group):

One set of Biomimicry Matching Game cards

**Time Required:** 20–40 minutes

NGSS Standards Met:

Biomimicry Matching Game Extension:

ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints that account for societal needs and wants.

Teacher Preparation:

Print Biomimicry Matching Game cards and review answers.

Keys for Success:

Encourage the students to be creative with their rationale for matching the images from nature with the technology.

Teacher Procedure:

1. Hand out sets of the Biomimicry Matching Game cards to student groups of four.
2. Ask the class to define Biomimicry. Explain that biomimicry is deriving inspiration and ideas from nature.
3. Instruct the groups to match the technology/product card to the animal card they believe was the inspiration.
4. Give groups approximately 5 minutes to brainstorm and match the cards.
5. Ask groups to report their matches and explain their choices.
6. Briefly review and clarify any questions using the answer guide.
7. Connect how green chemistry is the intentional design of safer products and processes. Use this as a platform to talk about the 12 principles of green chemistry.

Wrap-up Questions for Students (group reflection or individual handouts):

* 1. Define biomimicry.
  2. Define green chemistry.
  3. What are the key differences between the two fields?
  4. Identify a plant or animal that could inspire the redevelopment of a product and explain how that would help build a more sustainable future.
  5. With your group, select one biomimetic technology and provide a brief presentation to the class on the technology related to the 3 key criteria of green chemistry: cost, safety, and performance.

Answer Key:

|  |  |
| --- | --- |
| Lotus flower | Self-cleaning paint |
| Bee | Smart grid technology |
| School of fish | Vertical wind turbines |
| Pomphorhynchus Laevis | Skin graft |
| Firefly | More efficient LED light |
| Kingfisher | Bullet train |
| Namibian beetle | Water-capture device |
| Blue mussel | Toxin-free plywood adhesive |

**Biomimicry Matching Game Answer Guide**

A+3. Lotus flower leaves have a myriad of crevices to trap a maze of air that water droplets lay on top of, so the slightest breeze causes the water to roll off and take attached dirt particles with it. Microscopic rough surface additives have been added to paint, glass, and fabric finishes in order to create the “lotus effect.” This allows cleaners to use less harmful chemicals.

B+1. EnviroGridTM created a wireless energy management solution inspired by the way that bees communicate and coordinate with each other (swarm logic). They created a mesh network so that the devices communicate autonomously between each other. Previously, each device functioned in isolation, which caused overlaps in energy demand. This new technology spreads out energy demand between devices and saves a lot of energy, is less costly, and lowers pollution.

C+5. Schools of fish align themselves at optimal positions to increase their forward propulsions. Each fish uses the kinetic energy kicked off by the fish in front of it to move forward. If a fish was swimming on its own, that kinetic energy would be lost to the water. Vertical axis wind turbines take the same concept: each is placed so it turns in the opposite direction of its neighbors. This increases efficiency since opposing spins lower the drag on each of the turbines and allow the turbines to be placed closer together.

D+6. The parasitic worm, Pomphorhynchus Laevis, uses its razorlike spiny head to pierce its host’s intestines, then inflates its head inside the tissue to latch on. The skin graft adhesive is designed similarly, with a patch of tiny needles whose tips swell when exposed to water; this keeps the graft in place. This graft is three times as strong as surgical staples.

E+4. The fast-moving bullet train initially produced extremely loud claps when it emerged from a tunnel because of the change in air pressure. The structure of the front of the train was redesigned to mimic the shape of the Kingfisher’s beak because of its ability to dive into water seamlessly with minimal splashes. This design resulted in a quieter train that uses 15% less energy.

F+2. The exoskeleton of the firefly’s abdomen has jagged scales with sharp edges that let out more light. When a similar layer was placed on top of an LED light, it increased the amount of light emitted by 55%. Since most of the light produced by LEDs was previously reflected back into itself, this “lantern” placed on top acts as an anti-reflective to increase efficiency and reduce energy.

G+8. The Namibian beetle lives in one of the driest deserts in the world and obtains all of the water it needs from ocean fog, due to the unique surface of its back. Microscopic bumps with hydrophilic (water attracting) tips and hydrophobic (water repelling) sides cover its hardened forewings. Water droplets materialize on its back—out of thin air—then slide down channels into its awaiting mouth. Synthetic surfaces mimicking the beetle’s back have been created and are being used to generate clean freshwater supplies in arid regions and refugee camps. Dew Bank is one such product.

H+7. Blue mussels live in the water and stick to the sides of rocks with the assistance of byssus thread protein. Scientists have studied this protein to develop a formaldehyde-free adhesive that’s now used in the making of plywood. Columbia Forest Products and Professor Li at the University of Oregon were recognized with a Presidential Green Chemistry Challenge Award in 2007 for developing this technology, called Pure Bond.