What You Already Know

Scientific discoveries can improve our lives. The discovery of bacteria led to the invention of modern medicine. The discovery of electricity led to the invention of the light bulb. Discoveries can lead to new technologies. Technology is the knowledge, products, and processes that solve problems and make work easier. Just as scientific methods are used to answer scientific questions, people often use the design process to develop technology. This process involves identifying a problem, researching, designing, and then testing possible solutions.

The design process is a set of steps for developing products and processes that solve problems. The design process can help you make a plan. It can help you organize ideas. People may use different steps when designing a new product. They may use the steps in a different order. However this process is used, the goal remains the same—to solve problems.

When designing a new product, it is useful to make a prototype. A prototype is the first fully working product that uses your design solution.
Designs in Nature

You may have seen a spider walking upside down on its web. Perhaps you have seen a gecko climb up a wall and hang from its toes. If you have visited a zoo, you have probably seen penguins swimming gracefully through the water. Imagine what it would be like if a robot could move like a spider, or a car could move like a gecko, or even a boat could glide like a penguin.

Engineers are scientists who use the design process to solve problems. Many engineers look to the adaptations found in nature to help them solve problems. They have been inspired to design robots that move like bugs and kayaks that are controlled by flippers like those on penguins. In fact, burs on a dog’s fur led to the invention of something you may even use every day. That invention is VELCRO®.
Seed-Inspired Fasteners

One of the first and most successful products that used a design found in nature was VELCRO®. VELCRO® was invented by George de Mestral. He was an engineer who designed practical devices.

One day de Mestral noticed burs stuck to his dog’s fur. He removed a few of the burs. He looked at them under a microscope to see how they worked. The spines on each bur had tiny hooks on their tips. These hooks were the right size for grabbing onto the loops in an animal’s fur. He was fascinated by this hook-and-loop system.

George de Mestral wanted to develop an artificial hook-and-loop system. His system would have two parts. One part would be the hook side, similar to the burs. The other part would be soft, similar to an animal’s fur. It took him three years of experimenting before he was able to get the two parts to stick together. Even then, the two parts did not stick together as well as the burs and animal fur. He experimented some more. He used different materials. He discovered that nylon made the best hook-and-loop system. Today this fastener inspired by nature is extraordinarily useful.
Bug-Inspired Robots

Arthropods are animals with hard bodies and jointed legs. Instead of sticking straight down, their legs sprawl out. Each leg is made up of several parts. Each part is able to bend in different directions. Having bendable legs that spread out allows cockroaches to run fast and spiders to crawl upside down.

Scientists are fascinated by arthropods because of the unusual ways in which they can move. Perhaps they could invent robots that move in as many ways as arthropods. These robots could go many places that people cannot.

Engineers set up a laboratory to study these insects. The lab is a gym where bugs do exercises so that engineers can study them. What they learned has helped engineers build robots inspired by cockroaches and spiders. These robots cannot move exactly like arthropods, but their legs do copy the arthropods’ motions. One robot, called iSPRAWL, is designed to move like a cockroach. NASA has developed robots that move like spiders. These robots can even help explore space.
Penguin-Inspired Boats

Penguins are birds that do not fly through the air. Instead, they seem to fly through the water! Penguins have stiff wings called flippers. Their flippers can push hard through the water. This helps the penguin move fast. Their flippers can also bend and twist in different directions. This feature lets them turn and stop quickly.

Penguins swim with grace. No boats can move through the water quite like a penguin. But what if they could?

Boats do not have flippers. They have propellers. A propeller has spinning blades that push against the water and make the boat move. Boats with flippers could take advantage of some of a penguin’s abilities. Designing a boat with flippers was not easy. Engineers had to figure out what shape and what materials would make the best flippers. They designed a kayak that uses flippers. To move this boat, a person pushes pedals. The pedals cause the flippers to move back and forth. Then the boat moves like a penguin.
Artificial Spider Silk

Spiders can do something special. They make silk. Their silk is one of the strongest materials made by any animal. One ounce of spider silk is five times as strong as an ounce of steel! It is lighter and stronger than anything made by people. However, it is difficult to collect spider silk. Spiders cannot be raised on farms. If they were crowded together on a farm, spiders would eat each other. Scientists decided to learn how spiders make silk and try to copy the process. They focused on the golden orb weaver spider because it makes the strongest silk.

The female spider makes silk in glands inside her body. The glands make a thick liquid called dope. The spider ejects the dope into the air, where it hardens into silk. Scientists have removed cell parts that tell the glands how to make dope. These parts are called genes. They put these genes into goats. Then the milk that the goats produce contains spider dope. Dope from goat’s milk can be turned into spider silk. Now engineers are in the process of designing new products that can use goat’s milk silk.
The Future

Using designs from nature is a new area of science. It has given us many ideas for solving problems. There is a lot of research that is being done. However, successful products are few. VELCRO® is the most famous. Several different labs are trying to copy the stickiness of gecko feet. So far none has been able to do it. Many companies have gone out of business trying to make artificial spider silk. Why is it so difficult to copy nature?

Nature includes living things. Living things are not designed like products. The adaptations that we find useful, such as strong spider silk or hooks on burs, have developed over time as a way to increase living things’ chances for survival. The usefulness of spider silk comes from more than just the thick liquid of which it is made. It also comes from the way it is spun into thin threads as it leaves the spider’s body. Copying these natural adaptations is very complex.

Researchers are learning more about how nature works. There are still many things we do not understand. However, nature does provide a powerful tool for inspiring new products.
Glossary

**arthropod**  a hard-shelled animal without a backbone, such as an insect, a spider, or a crab

**dope**  a thick liquid that is made in a spider’s glands and that becomes spider silk when exposed to air

**engineer**  a person who uses scientific knowledge to design new products and processes

**gene**  a cell part that carries information that determines physical traits of living things