READING 2

Biomimetics

1 For centuries, engineers and scientists have been borrowing design ideas from **nature**. The structure of the lily pad is said to have been the inspiration for the design of London's Crystal Palace, a towering monument of iron and glass, built in 1851. The design for the Eiffel Tower, too, was based on a structure found in nature – the human thighbone[1]. More recently, the inspiration from biology has progressed to a smaller scale, with investigations into the molecular structure of living materials that are responsible for their unique properties. Scientists are attempting to unlock nature's secrets in order to imitate them and perhaps, even enhance them.

WHILE YOU READ 1

Underline the sentences that support this claim.

I. Nature's Template

2 As part of the field of *biomimetics*, which refers to any man-made products based on designs, structures, or processes that are adapted or derived from nature, these investigations seek to improve the materials we use in manufacturing and in consumer products. Joanna McKittrick, a professor of Mechanical and Aerospace Engineering at the University of California, San Diego, offers her own view of biomimetics: "Mother Nature gives us templates. We are trying to understand them better so we can implement them in new materials" (Jacobs School, 2013). Biomimetics has heavily influenced the field of materials science. Here the search is on for materials with desirable combinations of properties that cannot be found in traditional materials, like metals and ceramics.

3 Long aware of the brilliance of natural design and the valuable properties of natural substances, materials scientists are now probing the plant and animal world in pursuit of substances that are stronger, lighter, and tougher than those available today. Some of these natural materials, such as metal and wood, have been available in abundance, while others are difficult to secure in large quantity. The first task of biomimetics, therefore, is the discovery of new materials with these desirable properties. The second, and equally important, task is working with nature to make new products available on a large scale. Based on what they have discovered in nature's designs, scientists and engineers are developing more efficient and **cost-effective** ways to reproduce these new materials and products in their laboratories.

WHILE YOU READ 2

Use context and your knowledge of word parts to guess the meaning of *cost-effective*. Does it mean (a) inexpensive, (b) high profit compared to cost, or (c) inexpensive to produce in large quantities?

II. Lightweight and High Tensile Strength

4 Due to its strength and versatility, steel has been the mainstay of modern industrial manufacturing for more than a hundred years, yet some of nature's humblest creatures make material that is considerably stronger. In tensile strength, spider silk rivals both steel and Kevlar. However, it has

[1] *thighbone:* one of the bones of the upper leg

additional properties that these other materials do not possess. Able to stretch five times its original length without breaking, it remains flexible in cold temperatures, it is biodegradable, and above all, due to its low density, it is remarkably light. A pound of spider silk could extend the entire length of the **equator**.

WHILE YOU READ 3

What can you infer about the properties of spider silk? (a) They are man-made. (b) They are similar to the properties of steel. (c) They are desirable.

5 Unfortunately, there is a major obstacle to commercial production of natural spider silk: its production requires an extraordinary investment of labor. As part of an artistic project, 70 people spent 4 years collecting silk from a million spiders to create an 11-by-4-foot (3.5 × 1.2 meter) textile[2], which now hangs in the Museum of Natural History in New York. Clearly, spider silk production is not a very practical enterprise. Any hope for doing so on an industrial scale cannot rely on spiders. Nevertheless, materials engineers are determined to figure out a cost-effective way to mass-produce it by cutting the spiders out of the process. Currently underway are two projects to tackle this problem, both using genetic engineering to produce spider silk without spiders. Scientists at the Japanese startup company Spiber have deciphered the genetic code responsible for the production of a key protein in spider silk, fibroin. They have used this information to genetically engineer bacteria to produce silk fibers in the laboratory. Just one gram of the protein can yield more than five miles (eight kilometers) of genetically engineered thread. In another spider-silk project, Randy Lewis, a molecular biologist at the University of Wyoming, in the United States, is also using genetic engineering, but taking a somewhat different approach. He has inserted the gene for spider silk protein production into female goats. As a result of this genetic alteration, the goats produce milk that contains the silk protein, fibroin. After a complex extraction process, a single liter of goat's milk yields just a few drops of the purified protein, which can be used in the manufacture of silk threads. Neither project has produced any silk for commercial purposes yet, but the scientists hope they will achieve that goal in the very near **future**.

Item made of spider silk

WHILE YOU READ 4

What is the text structure of paragraph 5? Highlight some of the words that signal this structure.

III. High-compression Strength and Toughness

6 Materials with high-compression strength, such as ceramics and glass, are often quite brittle. Chalk, a common example of calcium carbonate, is among the world's most abundant substances. It exhibits surprisingly high

[2] *textile:* cloth

compression strength, maintaining its form even under heavy pressure. Yet, it is so brittle that even a small child can snap a piece of chalk in half. When a blow introduces a crack into its structure, the chalk cannot absorb the energy. The crack is propagated throughout the structure, and it eventually breaks the chalk apart.

7 The abalone, a sea snail that has existed for millions of years, has solved this problem at the microscopic level, with a shell that exhibits both compression strength and considerable toughness. The calcium carbonate in the shell consists of multiple layers of hexagonal plates which fit together like bricks in a wall. (See Figure 4.5.) On their own, these plates are brittle, much like chalk, and would offer little protection for the abalone. However, between these plates, the abalone inserts a protein that it is constantly producing. This layer of protein toughens the shell and allows it to absorb energy without cracking or breaking as chalk does. In fact, the shell is so strong that sea mammals trying to smash the shells against rocks in order to pry out the tasty snail are often unsuccessful. Using the insights they have gained from the abalone shell, materials scientists are working to create stronger ceramics and other new materials.

8 Always eager to develop and test innovative ideas, the scientists in charge of these biomimetic projects believe they have much to learn from Mother Nature, who is undoubtedly the greatest innovator of all. In nature's laboratory, there is both fierce competition and great danger, and as a result, all successful designs have gone through rigorous and thorough testing – thousands or even millions of years of life on Earth.

Figure 4.5 An abalone shell