A Sustainable Environment: Our Obligation to Protect God's Gift

by
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Environmental Innovation Through Biomimicry

A number of years ago in southwestern United States, there was a small mountain that was home to a large herd of deer. Unfortunately, there was also a large number of wolves that would attack and kill the deer. A decision was made by the local government to rid the area of the wolves in order to protect the deer. This action satisfied all the residents of the area, but another problem occurred a few years later. Shortly after an extended rainy season, the mountainside was inundated with mudslides, something that had never occurred before under similar weather conditions. Scientists studied the situation extensively and concluded that the mudslides were the result of killing the wolves. How could that be possible? By killing the wolves, the deer population increased significantly, requiring more food for the animals. The amount of vegetation on the mountainside could not sustain the growing deer population, and soon this vegetation decreased to a point that it no longer could hold the soil in place. Simply stated, the disruption of nature's system caused the mudslides.

Instead of making changes to the biological system created by God that could produce negative results, we should learn from it and develop new innovative systems. This is simply called "biomimicry", mimicking nature's biological system. One such example is the process of photosynthesis, which means, "using light to put something together". Here plants, algae and bacteria take carbon dioxide, water and sunlight to produce energy-rich sugars while releasing oxygen. Animals, including humans, take that oxygen and the sugars and transform them back to carbon dioxide, water and energy. Without the sunlight, this photosynthesis reaction could not take place. Almost 100 years ago, an Italian chemistry professor, Giacomo Ciamician, wrote in *Science* magazine that some day our landscape would change from power plants to a large array of glass that would mimic photosynthesis and produce another form of energy. Through his inspiration, we now have acres and acres of solar cells made of silicon, a material that allows for the production of energy, even though it is nowhere found in the plant structure.

Another example is how spiders produce several different kinds of silk for various functions, such as forming a web or rappelling from drop-offs. Each one is mixed in its own gland, extruded through its own spinneret, and endowed with its own chemical and physical properties. The properties of these silks are really astounding when compared to man-made materials. Compared on an equal weight basis, some silks are five times stronger than steel and five times tougher than Kevlar, the material used for bulletproof vests. At the same time, the silk can be very elastic and stretch up to 40% of its original length, something not possible by steel wire. Just imagine if someone could learn to do what the spider does, taking a renewable, soluble material and making an extremely strong water-insoluble fiber using very little energy and generating no toxic waste. By analyzing the spider's process and reproducing it, the entire fiber industry would change dramatically.

Still another example is the abalone, a shellfish that is know for its delicious meat as well as its smooth inner coating that makes the shell as "hard as nails". A car could drive over an abalone shell and have no impact. It is stronger than any known ceramic, but why? It consists of an intricate crystal architecture that allows it to shrug off stress. If you can see the structure from the side, it consists of hexagonal disks of calcium carbonate stacked in a brick-wall formation. Between the "bricks" is a polymer that gives the formation some flexibility to ward off the head-on stress. The ceramics that are produced commercially, such as glass, porcelain, and bricks, are manufactured by taking earthy inorganic particles and subject them to heat and pressure. The result is a very strong material, but brittle and subject to cracking. Scientists are now looking at natural designs like the abalone inner coating to determine how to reproduce that structure synthetically.

Another amazing natural phenomenon is how bivalves, or mussels in particular, can attach themselves to almost anything in water. If you look closely to a mussel, you can see hundreds of small translucent threads (about two centimeters long) extending like plastic tethers from the bivalve to the attached object. These tethers are called byssus, and they are truly amazing. When the bivalve wants to attach itself to an object, it will stick out a fleshy foot and creates a chemical complex at the end of the byssus where there is a small disk. Through the small disk, called a plaque, a natural adhesive is squirted between the plaque and the attaching surface. Within three to four minutes, the entire process is complete including the curing of the adhesive. The adhesives industry has been trying for many years to find an adhesive that will function in moist conditions and stick to anything. The mussels can do just that.

The rhinoceros population in the world is dwindling very rapidly – like the black rhino population in Africa, which has gone from 65,000 in 1970 to about 2,300 today. The unfortunate reason for this decline is the illegal killing of these animals for the horns protruding from the rhino's head. Because of their composition, these horns sell for tens of thousand of dollars. One way to stop the slaughter of rhinos is to find a synthetic substitute for the horns. When analyzed, it was determined that these horns are made of keratin, the same tough, fibrous protein that is in our fingernails. However, grinding up our cut fingernails won't do any good because it is not the keratin itself that gives the horns its coveted strength and luster, but rather the structure. Upon careful examination of a horn cross-section, the pattern was recognized to be similar to the graphite-fiber-reinforced composite that have been recently engineered for race cars, tennis rackets, and the new lightweight Boeing 777 airplane. We just learned how to produce a very strong and lightweight material, whereas nature has been doing it for millions of years. However, there is still more to learn as most engineered composites do not have both compression and torsion strength like the rhino's horn – and they can't heal themselves.

We can learn much more about how to protect the environment and at the same time progress as the demand for our natural resources increases. To meet these demands, we may be able to innovate by taking lessons from nature. A revelation of how much lies around us can be found in the outstanding book by Janine Benyus titled *Biomimicry*.