Biomimicry:
The Answers May Be Right in Front of Us

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Imagine the blistering African heat. Imagine sweating uncontrollably without the expensive use of an air-cooling system. Now imagine a self-regulating ventilation system that would keep a building at temperatures comfortable for workers and residents in the most extreme temperatures. A building able to maintain constant internal temperature due to its structure and interaction with the local environment, rather than use of expensive external energy sources. How can this be done? you say. The better question is, how was this done? Mark Pearce developed the Eastgate Centre building in Harare, Zimbabwe, which is able to passively cool the structure and does not require a fuel-based air-conditioning system. The energy savings were staggering: 65% less energy used compared to conventional office buildings. Yet the most amazing aspect of this story is that the brilliant design was based on thermal control found in termite mounds throughout Africa. This is design inspired by nature's genius, otherwise known as biomimicry; and as Mr. Pearce has found, it makes financial sense.

Biomimicry is a very new and intriguing discipline that seeks sustainable solutions by emulating nature's time-tested patterns and strategies. In other words, organisms or ecosystems are mimicked in human design. Janine Benyus, the president of the Biomimicry Institute, explains, "Biomimicry is the process of learning from and then emulating life's genius. It's based not on what we can extract from the natural world, but what we can learn from it. Life has been on earth for 3.8 billion years, and in that time life has learned what works and what fits here. Mimicking their designs, strategies, and their recipes could change the way we grow food, power ourselves, conduct business, even the way we make our materials" (Benyus 2009). There are many organisms in the world that have already solved the problems many individuals spend their entire careers trying to solve. Janine Benyus describes a time frame of 3.8 billion years during which species have been evolving and perfecting their methods. This seemingly endless period of R&D has given rise to 10-30 million species with well-adapted solutions. These other organisms are solving the same problems we are facing today in the same context: the Earth. It seems that we have forgotten we are not the first ones to build, heat, and cool a structure; waterproof; make paper; optimize packing space; or even build houses for our young. Many other organisms have been doing these things that have allowed them to be here for billions of years. So the question then becomes: How does life make things? We tend to do the opposite, which has been termed Heat, Beat, Treat. We heat it up, beat it at high pressures, and then use chemicals. This method of carving things from the top down has created 96 percent waste left over and only 4 percent product (Benyus 2009). Life creates conditions conducive to life while maximizing output. Contrary to our belief, these goals are not mutually exclusive. If we can meet our needs and produce at full capacity while making this platform habitable for years to come, this presents the opportunity for enormous economic potential (Borrowing 2007).

While this field may sound unique, this science of "reverse-engineering" has been seen before in history. Joseph Paxton's designs for the Crystal Palace that housed the Great Exhibition of 1851 were based, in part, on his observations of the structure of giant water lilies. George de Mestral, a Swiss engineer, came up with the concept of Velcro after observing the way burdock seeds clung to his clothes and the fur of his dog. Most famously, Leonardo da Vinci's attempt to design the airplane was based on the way birds fly (O'Connell 2009). While these innovators looked to nature to expand human design at the time, many are doing the same today but on a more popularized platform. As we become more and more concerned about the environmental impact of our behavior, biomimicry is becoming fashionable. As Michael Pawlyn, the director of a sustainable architecture firm in Cornwall, explained, "Imitating natural systems is about trying to mimic the amazing effectiveness of ecosystems, where waste from one system or animal is used as nutrients for another. These then become closed loop systems. Often by applying ideas from ecosystems you can turn problems into solutions that are better both environmentally and commercially" (O'Connell 2009). There are some businesses and individuals that have captured this creativity and leveraged it to their advantage. If we take a look at some of the players in this market, we can begin to see how exactly nature's blueprint is leading to economic success.

Dr. Frank Fish, a leading expert on how animals move, was looking at a sculpture of a humpback whale when he noticed that the artists had put bumps on the whale's flippers. This made no sense to him, as everyone knew that the leading edge of a wing had to be smooth and streamlined. But after further investigation, he discovered these bumps were precisely the right shape, located in precisely the right places, to make this enormous animal extremely agile, as the bumps produce vortices that generate more lift and reduce drag. He then set up a firm called Whale Power that uses this concept, which he refers to as "tubercle technology," to design wind turbines, pumps, and fans. He claims these bumpy blades are quieter and more reliable, and, most importantly, produce 20 percent more electricity a year (O'Connell 2009).

The Japanese firm JR West created a train with a rounded front end, hence called the bullet train. But the train was experiencing some difficulties when it entered and exited a tunnel. As the train entered the tunnel it built up a pressure wave, which caused a sonic boom as it exited. The executive team at JR West decided that they needed to find a solution for quieting the train. The kingfisher was the answer. This is an animal that goes from one density of medium (air) to another density of medium (water) without a splash, enabling it to see fish. The engineers thought, what if we do this? They redesigned the train based on the kingfisher's narrow and sleek structure, which resulted in a quieter train, a 10 percent faster train, and one that used 15 percent less electricity (Benyus 2009).

Sharklet Technologies realized that we are not the first ones who have had to protect ourselves from bacteria. The Galapagos shark demonstrates this, as this is an animal which has no bacteria or any sort of fouling on its surface. This is not a fast moving shark, but rather a slower moving shark, so the question is, How does this animal keep its body free of bacteria buildup? It uses no chemicals but instead uses a particular pattern of its skin denticles. This unique pattern on its skin restricts bacteria particles from landing and forming (Benyus 2009). Sharklet Technologies realized the ingeniousness of this specific design. The company is now putting this pattern on surfaces in hospitals to keep bacteria from landing, which has proven to be more effective than using antibacterial chemicals, as many organisms are now becoming drug-resistant to these. This technology was tested against the traditional antibacterial chemicals most commonly seen in hospitals, and the results were overwhelming. After 14 days, 54 percent of the surface area sprayed with the antibacterial chemicals was covered with bacteria. Only 7 percent of the surface area was covered with bacteria when Sharklet Technologies' surface pattern design was used (Chung 2010). The issue of bacteria buildup becomes a serious issue when we realize hospital-acquired infections are now killing more people per year in the United States than those who die from AIDS and car accidents combined. The number is around 100,000 (Benyus 2009).

Color creation is a very interesting concept that butterflies have mastered. Many butterfly species use light-interacting structures on their wing scales to produce color. The scales on the wings are composed of nano-size layered structures that, rather than statically absorbing and reflecting certain light wavelengths as pigments and dyes do, selectively cancel out certain colors through wavelength interference while reflecting others. This all depends on the exact structure and interspatial distance between diffracting layers. This system of producing color allows for the dynamic control of light flow and wavelength interaction, which butterflies rely upon for camouflage, thermoregulation, and signaling (Vukusic 2010). Designers at Qualcomm picked up on this design and are now using these systems of structurally produced color, as this does not require the toxic heavy metals or manufacturing methods common with many pigments and dyes. They are calling it mirasol display technology, which is based on the reflective technology called IMOD (Interferometric MODulation). This innovative system creates rapid color change, is highly reflective, remains vibrant under low-light conditions, and requires less energy than other electronic display methods. It is so reflective that the display itself can be seen even in direct sunlight. All these characteristics make it perfect for display light on cell phones (Qualcomm 2009).

In the automotive industry, collision threat detection still presents a great challenge for research and development. Individuals are looking for censoring and detecting mechanisms that can help reduce our 3.6 million car collisions per year in the U.S. Locusts can travel in swarms up to 80 million while occupying a single square kilometer and never collide with one another (Benyus 2009). Like many insects, they can see many more images per second than we do. With this ability, they can react to things that are approaching very rapidly and make their escape before collision. Locusts display this talent due to a large neuron called the locust giant movement detector (LGMD) located behind their eyes. This neuron releases a large burst of energy whenever a locust is on a collision course with another locust or a predatory bird. It was found that the LGMD releases more energy when something is coming directly at the locust. These spikes in energy allow the locust to take action, which from motion detection to reaction takes about 45 milliseconds (Roach 2010). The Locust Project, based at the University of Newcastle in England, is beginning to create a single-chip bio-inspired visual perception system for automotive applications based on this insect. It focuses on an integrated visual neurosystem for collision avoidance, which integrates sensing, perception, and action-control features (Rind 2005).

The R&D team over at Nissan has taken this a step further. The Japanese firm set itself the goal of halving the number of deaths or serious injuries involving its vehicles between 1995 and 2015. Instead of the locust, its weapon was the bumblebee. Nissan engineers also realized that a bee's eyes allow it to fly uninterrupted inside its personal space. They wanted to recreate the function of a bee's compound eye with a field of vision more than 300 degrees wide. So they came up with the idea of a laser range finder. This technology detects obstacles up to two meters away within a 180-degree radius in front of the car. This then calculates the distance and sends a signal to an onboard microprocessor that helps the driver to avoid a collision. Nissan's principal engineer, Toshiyuki Andou, explains, “"The split-second it detects an obstacle, the robot will mimic the movements of a bee and instantly change direction by turning its wheels at right angles or greater to avoid a collision." This impressive technology is seen in Nissan's recent new microrobotic car, the BR23C (O'Connell 2009).

Yet discussing biomimetic ideas and getting people to buy into the concept are two very different things, and in all reality, it may take some time before a majority of businesses and individuals start adapting these methods. This field is very radical compared to the current design and building practices. It has no objective standards of measurement, which makes its goals of sustainability seem unattainable (Mint 2010). Michael Plotnick, a spokesperson for a biomimetic consultant group, explained, “It's emerging and with emerging disciplines and sciences, there's not a formula, model, checklist or book.” Also some still feel that, just as many companies have done with the commotion for the Green Revolution, businesses are jumping on the bandwagon solely for publicity purposes. Jon Gardzelewski, an architect who teaches architectural design at the University of Wyoming, says, “In reality few biomimetic projects are under way or even in design—from my experience, attempts to incorporate biomimicry are superficial marketing efforts at best.” He and many others attribute the recent infatuation with biomimicry to the eagerness of firms racing to have the greatest number of LEED accredited professionals for marketing purposes, instead of actually achieving a more sustainable design. He adds, “Just because one considers natural solutions, modern technology should not be discredited .You may look at a bird's wing to design a plane, but you will not find a combustion engine in nature. We must merge both" (Bergeron 2010).

This is where bringing business and biomimicry together will depend on the variety of participants in the field. It needs to be a discipline composed of biologists, engineers, designers, and business people together looking for sustainable and economic solutions (Walker 2010). It is this kind of diversity that will ensure that biomimicry is embraced by various walks of life and the real world problems can be solved without the watered-down efforts for promotional schemes. Just as Mark Pearce with the Eastgate Centre building, or Frank Fish with Whale Power, and so many others have seen, these strategies work for the bottom line. Now again imagine a beautiful botanic garden. Imagine it to be a self-sufficient system in regard to water and energy without relying on fossil fuel. Yet this time imagine this luscious greenery converting into the greenery that we all care about, dollars. This is biomimicry.

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