Biomimicry: sewage treatment and natural resources

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The environment is suffering. Population is rising. Our natural resources are being depleted. Global warming is no longer fiction; it is fact. With these environmental catastrophes in mind, it is obvious that something must be done in order to preserve life, as we know it. Biomimicry is a field that concentrates on working with the environment to make human practices more sustainable. Biomimicry examines nature’s models, systems, processes, and elements; then, it uses them to solve human problems and issues sustainably.

A more basic definition of biomimicry would be that it simply uses nature as a guide to make human practices less harmful to the environment. A couple of examples of implementing biomimicry are the uses of non-toxic adhesives, inspired by geckos (energy efficient buildings inspired by termite mounds), and resistance-free antibiotics, inspired by red seaweed. Biomimicry is a term that derives from “ bionics”. Bionics has the same basic principle of biomimicry; it uses nature as a guide. However, bionics does not include the sustainability focus of biomimicry.

The principle of nature as a guide for action or development was around long before there was any need for sustainability. In the late 1400’s, Leonardo da Vinci used his own observations from nature to develop ideas for a flying machine. He studied and focused on birds, fascinated with how they were able to fly. During the 1900’s, Willem Kolff used studies from nature as a guide to developing the first kidney dialysis machine. By using nature as a starting point, Kolff was able to invent a machine that would save thousands of lives during his lifetime alone.

Bausch & Lomb developed the world’s first soft contact lens with ideas generated from various observations of water magnification in nature. One of bionics’ most famous inventors was George de Mestral. He developed Velcro in response to interactions with nature. Mestral was out walking with his dog when he noticed burrs sticking to himself and his dog. He became very interested in how the burrs were able to stick to his pants and his dog’s hair. He studied the burrs’ ability to attach to other materials and from the results of his observations, he created Velcro (Llyod).

Discoveries like these do not necessarily work with the intention to improve sustainability, but they paved the way for modern Biomimicry. All organisms on the Earth face the same problems that humans do; but, unlike humans, they are able to manage in a sustainable way. Some organisms are able to endure extreme forces of nature. Tusks are physical adaptations that allow some animals to brave nature. For example, the rhinoceros tusks are able to handle more force than many man made substances can. Some animals can even safely distribute energy, such as the electric eel.

All trees can manage water movement easily. Also, nature produces many bright and extravagant colors that could be used in sustainable ways. Humans also have access to all of these things, but current methods of achieving them are harmful to the environment. Mass amount of natural resources and energy are needed and depleted in the creation of substances that can handle extreme forces. Moving water through and around cities uses a lot of energy to run pumps. Pipes must be made to help transport the water, which destroys land and requires many different natural resources.

We can replicate and produce different colors, but doing so requires the uses of dyes, which are very harmful to the environment. We can accomplish all that nature does, but our goal should be to be able to accomplish these things without wasting natural resources, emitting harmful gases into the air, or poisoning the ground and natural water systems. The architectural design of buildings is one focus of biomimicry. Big buildings consume large amounts of natural resources and energy. Most of the big buildings today have energy-powered central heating and cooling systems.

The cost, as you can imagine, for heating or cooling a big office building is very expensive. Costs are not limited to the monetary expense of operating these systems; there are costs to the environment, as well. So, what if these heating and cooling systems were not needed? What if a building could maintain a constant temperature without the need for expending much energy? Not only would companies save money by minimizing the costs associated with heating and cooling, but they would also save natural resources and emit fewer greenhouse gases.

By engaging in a pro-environment approach to housing their companies, credibility of the company would increase with much of the public. By applying biomimicry, all of this is possible. In Zimbabwe, a green building has been constructed which is modeled after the self-cooling mounds of African termites. The building has no conventional air-conditioning or heating, and the temperature stays regulated year round with dramatically less energy consumption. The termites, from which the building was designed, feed on a fungus that must be kept at exactly 87 degrees.

The temperature in this region of Africa ranges from 35 degrees at night to 104 degrees during the day. The termites keep the mound temperature constant by continuously opening and closing a series of heating and cooling vents. Using a system of carefully adjusted currents, air is sucked in at the lower part of the mound and then moves up through a tunnel to the peak. The termites constantly dig new vents and plug up old ones in order to regulate the temperature (Doan). The building in Zimbabwe, largely made of concrete, has a ventilation system that operates in a similar way as the termite mound.

The outside air that is pulled in is either warmed or cooled by the building mass, depending on which is hotter between the building concrete and the air. The outside air is then vented into the building’s floors and offices before exiting through chimneys at the top. The complex also consists of two buildings side by side that are separated by an open space that is covered by glass and open to the local breezes. This open-air atrium also helps to circulate air within the buildings (Doan). Another biomimicry building design idea is one modeled after the skin of one of nature’s hardiest plants. This desert plant is the cactus.

Cacti are able to regulate their temperature in the some of the hottest and driest climates on the planet. The design has hundreds of smart shades that open and close depending on the strength of the sun. By limiting the amount of sun entering a building, the idea would be that you could also limit the amount of heat trapped within. While a building of this design has yet to be constructed, it has drawn the interest of many different architects and investors. Another aspect of biomimicry is observing those processes in

nature that could help us design more efficient man-made systems. Nature does not waste anything.

The waste of one organism becomes the food of another. Nature is cyclical and everything is reused. On the other hand, humans waste close to everything. Human waste has become a problem in contributing to pollution. So, the idea of industrial ecology has been developed to address that problem. Industrial ecology is the shifting of industrial process from linear systems, in which resource and capital move through the system to become waste, to a closed loop system where wastes become inputs for new processes. The main goal of Industrial Ecology is to exchange wastes, by-products, and energy among closely situated firms (Indigo Development).

Industrial ecology has many benefits. It benefits industry, with the opportunity to decrease production costs through increased materials and energy efficiency waste recycling. It benefits the environment through the restoration of damaged ecosystems, the reduction of sources of pollution and waste, and decreased demand for natural resources. It benefits society by enhancing economic performance and development, and by reducing solid and liquid waste streams that lead to reductions in demands on municipal infrastructure and budgets. Kalundborg, Denmark is an example of one of the world’s best working industrial eco-systems.

In Kalundborg, there are four major industries: Denmark’s largest coal-fired power station, Denmark’s largest oil refinery, a large plasterboard factory, and an international biotechnology company. All four industries are involved in a series of material and waste exchanges. In other words, they form a

closed system that recycles within their companies, as opposed to discarding waste materials. The coal plant produces ash which is used in a cement plant, gypsum whish is used by the plasterboard plant, steam which is used by the oil refinery and the biotech plant, and heat which goes to greenhouses, fish farms, and to help heat houses.

The oil refinery produces gas for the coal plant and also relays its wastewater to the coal plant. The toxins produced by the oil refinery are given to a sulfuric acid manufacturer. The biotech plant produces sludge and yeast, which are both useful in agriculture practices (Indigo Development). One of the greatest natural services nature provides is clean water. Sewage treatment facilities today consume a lot of energy, are very sophisticated, and require the addition of chemicals to purify drinking water.

Nature accomplishes the purification of water without added energy and without harmful outcomes for the environment. Modern sewage treatment plants have many downsides. They are very large and complex, and they require a high-energy input. Their size and needs makes these plants very expensive to build and to run. Sewage plants can pollute nearby bodies of water due to the uses of chemicals, like chlorine. These plants require a nearby body of water, which increases the chance of pollution. They also produce toxic sludge that must be disposed of properly.

Toxic sludge is very difficult to dispose of, which makes this an expensive process. Modern sewage treatment plants have high maintenance costs, and require intensive monitoring. Because of these drawbacks, living machines have been developed to combat the negative effects of sewage treatment

plants. A living machine is a self-contained sewage treatment system designed to treat a specific waste stream using principles of ecological engineering. This treatment is done using diverse communities of bacteria, algae, plants, trees, snails, fish, and other living organisms.

Living machine technology was developed to purify sewage or other polluted water by replicating and accelerating the natural purification processes of streams, ponds and marshes, without harming the environment. Living systems do not require the chemical inputs traditional sewage treatment systems require. They cost much less to operate than traditional systems and they are capable of purifying water just as well, if not better than, previous methods. They do not harm the environment by polluting nearby water systems and they require dramatically less energy input.

So, by mimicking a process of nature, sewage water can be treated in a very progressive, efficient, and sustainable way (Living Machines). John Todd developed the first living machine waste treatment plant that yields clean water from sewage in Cape Cod. His system begins with the raw sewage entering an area containing tanks occupied by complex communities of organisms. Each tank has it’s own ecosystem specializing in a specific phase of decomposition. Bacteria consume the organic sewage and turn ammonia into nitrates. The nitrates are used as food for algae and fertilizer for duckweed.

Zooplankton and snails consume the algae. Floating plants soak up the leftovers. Bulrushes and cattails make the toxins harmless. Trees absorb heavy metals. After spending ten days in the filtering series of ecosystems,

the water flows clear into an artificial outdoor wetland to be reintroduced into the local hydrologic cycle (Living Machines). Evolution works to make species more efficient, therefore making them more capable of surviving in their environment. Some common examples of evolution are camouflaged features that make the species more capable of getting to food or fish fins that allow for more speed and control.

These evolutionary and adaptive changes can be studied and manipulated to help make human processes more efficient. In Toronto, WhalePower Corporation is using the fins of humpback whales to help design a better and more efficient wind turbine. Humpback whales have survived for a long period of time. Over this long period of time, they have developed more proficient fins that allow for more agility. The little bumps on humpback fins result in 32 percent less drag and an 8 percent rise in lift when compared to a smooth fin.

Stephen Dewar, director of research and development at WhalePower, says that ongoing tests at the Wind Energy Institute of Canada, in the province of Prince Edward Island, have shown the blades modeled after humpback fins to be more stable, quiet, and durable than conventional blades. “ The turbine has survived being hit by the edge of a hurricane, and it survived wind-driven snow and ice,” he says. WhalePower has also shown in demonstrations that tubercle-lined blades on industrial ceiling fans can operate 20 percent more efficiently than conventional blades can, and they do a better job at circulating air flow in a building (Hamilton).

A new concept car from Mercedes-Benz based on the shape of an odd tropical fish has been developed. Wind tunnel testing of a clay model revealed a drag coefficient of just 0. 06, startlingly close to the ideal 0. 04 drag coefficient of a water droplet. (Phenix) Using the shape of the tropical boxfish, designers achieved an aerodynamic design with 20% less fuel consumption and as much as an 80% reduction in nitrogen oxide emissions. The engine is a 19-litre 4-cylinder direct-injection turbodiesel. The car has 138 horsepower, and it has 221 pounds of torque. At 56 miles an hour, the car gets an astounding 84 miles per gallon. (Phenix)

The next example of biomimicry comes from a plant rather than an animal. The plant is known as the lotus plant. The lotus plant has a unique hydrophobic microstructure that forces water droplets to bead and roll off. These water beads clean the leaf as they roll off and take contaminants with them. Researchers have developed a way of using this idea to create paint pigments with the same characteristics. The goal is improve the lifespan of numerous hard-to-clean materials such as stucco, concrete, and other exterior wall finishes. The paint is highly resistant to water, dirt, mold, mildew, chalk, and even UV rays (Lotus Effect).

It can help surfaces stay dry and clean, and it could help decrease maintenance cleaning and water costs for building owners. The first and most successful product with superhydrophobic self-cleaning properties was the facade paint Lotusan launched in 1999, and it has been applied on more than 500, 000 buildings worldwide (Lotus Effect). This number is increasing on a daily basis. Since the implementation of hydrophobic paint, uses of it have spread drastically. It is now being applied to fabrics, which could

potentially decrease the need for washing clothes and reduce water wasted in laundry cycles.

The uses for this design are unlimited. The Industrial Revolution is over. It is time to change from the thought process that there are plenty of natural resources, because there are not. Our world is growing, and along with that growth comes the need for change. There are many ways to go about this. People are working on alternate fuel sources that are not as harmful to the environment. Examples are wind energy, solar energy, and electric cars. While these ideas are essential, there are many other parts needed in order to make a change. Nature has survived long before human life ever came to be.

Throughout this time nature has prospered without causing harm to its self. How is this done? Well that is the question. Nature is often taken for granted, even though we cannot survive without it. Instead of working against nature it would be much easier to work with it. This is where biomimicry comes into play. Biomimicry is the idea of using nature as a guide in order to make human life more sustainable. Many ideas have already been put into play like green buildings, living machines, and the lotus effect. Biomimicry will continue to play a crucial role in the transition from life as we know it to a more sustainable life.