From the Ground Up

Imagine creating an organism that could rescue an entire country from a deadly disease or save the rainforest from destruction. This is what synthetic biology is about. Synthetic biologists have long been trying to reengineer simple systems to make more complex ones. Searching to expand their horizons, they work for the greater good, to save the planet that we humans live on. Because our planet is changing so rapidly, scientists are trying to create organisms that will save the earth from destroying itself.

The First Signs of Life

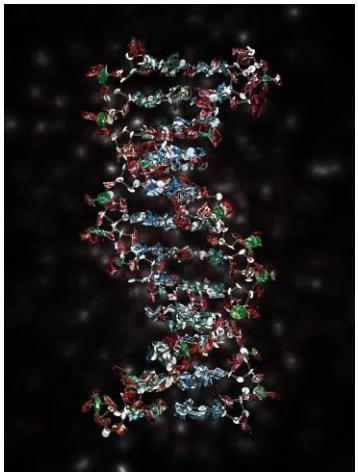

Figure 1
The basic structure of DNA.

We know that organisms evolved from some sort of unicellular creature. Earthquakes, floods, and volcanic eruptions might have brought together the necessary components to create life. These would be carbon, proteins, and the material for making DNA/RNA (See Figure 1). Take, for example, the experiment done by Stanley Miller. He took gases, methane, carbon, and hydrogen, that were thought to make the first life forms and put them into a closed system. Then, he put electric currents through the system to simulate lightning storms like those thought to be on early earth. At the end of a week, he observed that 10-15% of the carbon in the tube had formed into organic compounds. This experiment showed that essential components of life could be synthesized under the conditions thought to be present on early earth (Cromie, Brent).

"Synthetic biology is a field involving synthesis of novel biological systems which are not generally found in nature. It has brought a new paradigm in science as it has enabled scientists to create life from scratch…" (Chopra). The field of synthetic biology already has much of the technology that is required to create life. The practice has been going on for about fifty years, but only in the past four decades or so has the technology finally caught up to the idea. Some goals of synthetic biology are to mass produce drugs for pharmacies and to program bacteria to "seek and destroy" tumors in the body. To do this,

synthetic biologists must know how to create a protein from a gene and then build a system that does what they want it to do.

To build a cell, one needs the necessary components. These are the organelles inside the cell. To name a few, there is the cell membrane, which protects the cell, the ribosomes, which make proteins for the cell, and the Golgi bodies, which are used in the packaging and secreting of energy for the cell(Wayt). When the biologists have all of the internal parts of the cell, then they decide what they want the cell to do. Inserting proteins into a cell can change its function. The biologists decide which protein sequence is right for the cell and put that sequence into a sequence of amino acids for the cell's DNA. Now, the cell knows what to do, when to do it, and why to do it.

Goals and Obstacles

Synthetic biologists have three main goals in mind: to engineer biological systems, redesign current life, and create alternative life (Tucker). The biologists must work together and converse with the whole world to benefit the whole world. To keep the field of study going, new recruits are introduced. Global outreach must occur in order to gain and keep the trust of the population. Many people are opposed to the idea of people being able to alter life to do what they want. They fear that hackers might get to the materials and create pathogens that could wipe out entire countries (See Figure 2). However, the largest obstacle is funding. Synthetic biology is not something that is very reliable. The parts of a cell are not like the wires in a computer. If people give millions of dollars to something, then they expect it to work. Putting expenses into perspective, it takes approximately $1 for every base pair in a strand of DNA. Though $1 seems like a minimal amount to pay for anything, it means that it would take about $5.8 million just to make a minimal life form (Brownlee). Compared to the price of building a human genome, prices like these are nothing. Dangers are associated with synthetic biology, but the people of the world must all agree that in order to save the environment that we live in, we have to make changes to accommodate our way of life.

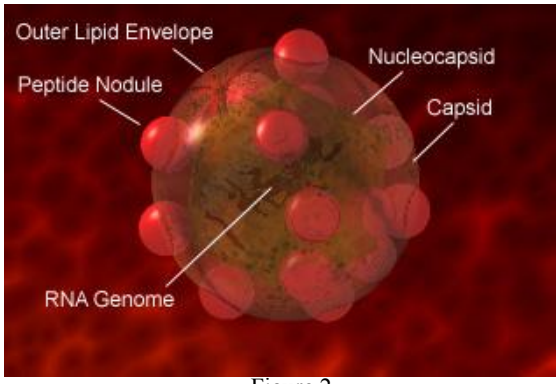

Figure 2
The parts of viruses could be released to hackers.

Cells

"Living machines reproduce, but as they do, they mutate" (Heart and Survivors). We all know that life starts with cells. DNA (deoxyribonucleic acid) controls the nature of these cells. DNA contains the codes for the functions of the cell. DNA allows the cell to make an exact copy of itself. When a cell prepares to make a copy of itself, the DNA is transcribed into RNA (ribonucleic acid). Changing the DNA into RNA allows the cell's code to be secure. RNA uses a slightly different sequence in order to prevent the genetic code from being stolen. The RNA helps to make another cell as the first cell divides by making the proteins and enzymes that make the proteins for the new cell. In the end, there are two cells with the exact same DNA and, as such, the same function (Brent). However, in order to create an artificial organism, scientists must first understand how the natural and fundamental processes of life work. They have already taken huge steps in the direction of making a living, breathing organism. Scientists have categorized the various functions of the parts of the cell, and have figured out how to turn on the signals that make cells do what they do. Knowing this will enable the people of the present and future to define the functions of the living organisms on the planet and model our own creations after them.

Environmental Issues

The main focus of synthetic biology is to improve and/or save the environment from human contamination. The products of nuclear plants create so much toxic waste, and pollute so much of the air that Mother Nature can not handle it all (See Figure 4). Minefields are one such problem. When mines are left in the earth, people could start building homes or shops and they could explode. Researchers are experimenting with a bacterium that will help to solve this problem. They have injected a protein sequence into a bacterium that they will release into areas with supposed levels of dynamite (TNT). The bacteria will spread out across that area and check for TNT. If they find any, they will change color to alert the scientists that the area is contaminated. Scientists also want to make the bacteria ingest the TNT, so the area will be clean. But that will take even more time (Brent).

Scientists at Lawrence Berkley National Laboratory are trying to engineer a bacterium that will help to dispose of toxic waste from nuclear power plants. They are experimenting with *E. coli*. They modify the bacteria's "sense of smell", or its ability to determine the identity of unknown substances, so

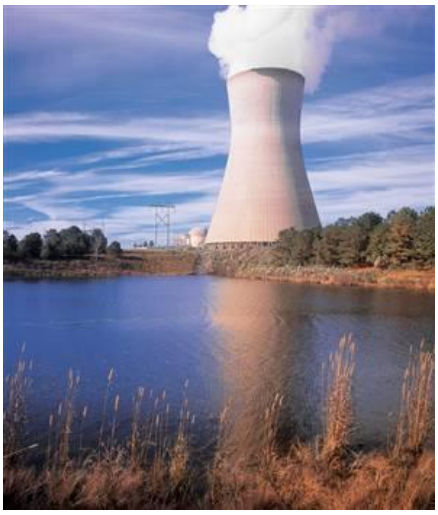

Figure 3
The waste from nuclear plants destroys acres of clean earth each year.

that it recognizes the nuclear products like uranium and plutonium. The bacteria would swim towards the waste, find the toxic parts, and digest it, leaving clean wastewater (Brent, Heart and Survivors). These actions will help to decontaminate the environment. A less harmful environment will help with the extinction of animals and make our earth cleaner. With a cleaner earth, the soil will be better quality. Better soil will lead to greater crop yields and higher food quality. Because food will be better, prices could possibly go down. Lower prices could help many people to get the proper nutrition that they need in their diet.

An interesting experiment went on at Harvard University. Scientists made DNA play tic-tac-toe. While this is not the best representation of the accomplishments of synthetic biology, it demonstrates that logic can be encoded into DNA and that the DNA can be made to do logical things (Chopra).

With the high prices of gas rising even higher, alternate energy sources need to be found and distributed around the world. Synthetic biologists have discovered a bacterium that can extract plant cellulose. Experiments like these might lead to the production of hydrogen as a fuel source (Brownlee).

One daily material that uses up the earth's natural resources is the production of medicine (See Figure 5). An example of a medicine that depletes natural resources is the anti-malarial drug called *artemisinin.* This drug is produced from a wormwood plant that grows in Southeast Asian mangrove swamps (Chopra). In many developing countries, the strains of malaria are becoming resistant to the current medicines. The developing countries can not afford the expensive malaria drug. Synthetic biologists have used *E. coli* to make the precursor to *artemisinin* (Cromie). Making the substances used to make the drug drastically lowers the cost of the medicine

Figure 4
Many modern medicines deplete rainforests.

and allows the countries to save their rainforests, where many modern medicines come from. This approach is also being applied to a drug that could fight HIV.

What Happens Next?

Synthetic biology is a field of study that requires much of the world to participate. A strong foundation is needed in order to gain the materials for synthesizing biological parts. Funding is needed from the government. To get funding, biologists need to prove that synthetic biology can be depended upon and used to help the world and its environment. The more participation that biologists have, the more likely that they will succeed. The progress that has been made by these people will make the human population able to save our home. With the right tools, we can rebuild that which we have destroyed and make new things that will save the future.

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