Putting Together Synthetic Biology

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While it may sound like something out of science fiction, the field of synthetic biology is emerging as one of the most promising and exciting fields in biology today.

In studying synthetic biology, scientists are looking to understand biological systems, such as the chemical chain reactions that occur when you digest food, or the different molecules involved in reading a strand of RNA. Scientists break these systems down into parts and find ways to use those parts to create entirely new systems, with different effects.

Synthetic biology borrows a lot from engineering. For example, a computer can be seen as a system of parts: different types of circuits working together to process data. But the different electronic components in a laptop computer can also be found in a smart phone and even other kinds of machines, such as medical equipment.

In the same way, synthetic biology seeks to create a way to identify different biological "parts" which can be combined in different ways to build a multitude of biological machines with effects ranging from synthesizing drugs to creating bioethanols and bioplastics. And these parts can refer to anything from molecules that affect the encoding of genes, to the molecules involved in the synthesis of different substances.

The phrase "synthetic biology" may conjure up images of creatures engineered in a laboratory, but that possibility remains in the realm of fiction for now. While the field is still a long way from what we see in *Star Trek*, it has already produced valuable results.

One of the most significant breakthroughs in the field, for example, is the engineering of a pathway in yeast cells to produce artemisinin, the drug used to treat malaria. While artemisinin had already been discovered before this, the synthetic biology breakthrough makes the large-scale manufacture of the drug much faster and more efficient.

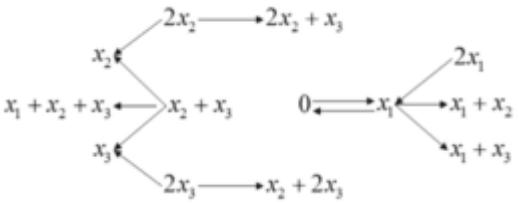
This is an incredibly challenging field, and for advancements to be made, scientists from many different fields, such as engineering, chemistry, and biology, must work together, and many different types of research have to be done so that researchers will be able to pull all these tools together to achieve the lofty goal of designing new biological systems.

An important field in this effort is chemistry, especially since an incredible number of chemical reactions are what power the different functions of biological systems.

Mark Jayson Cortez, Allen Nazareno, and Dr. Eduardo Mendoza, from the University of the Philippines Los Baños, have used mathematics and computer modeling to look into different networks of chemical reactions. In a paper published in the *Journal of Mathematical Chemistry* (available from Springer under Open Access), they represented different chemical reactions as mathematical models. Using these mathematical representations of chemical reactions, the researchers were able to

develop an algorithm to assist in searching for chemical reactions with similar dynamic properties.

This work takes after an area of mathematics called representation theory. This field looks to represent abstract structures as more concrete mathematical ideas. In this case chemical reactions, since they cannot be observed at the molecular level, are represented through mathematics.



The researchers used mathematical models like this to represent chemical reactions.

The researchers represented different chemical reactions by treating the different molecular complexes in that reaction as vertices in a graph, and the chemical reaction as an arc between the different vertices. For this study, the researchers also built on previous research finding that chemical reactions under certain conditions can be represented by a set of equations. These equations can be used to identify reactions with similar dynamic properties, despite involving different molecules.

Using these concepts, the researchers were able to create an algorithm that, given a certain network of reactions, would be able to find different networks of reactions with similar dynamic properties. The different reactions would be able to impart different effects on an organism, without being disruptive in terms of the greater scheme of the organism's chemistry.

To use a metaphor, we can think of an organism like a computer, equipped with many different ports. Plugging a power cable into a USB slot will not work because only devices with USB slots can interact with the USB ports. However, there are many devices such as keyboards, flash drives, and smart phones that make use of USB slots. And each connected device will have a different effect on the function of the computer.

The chemical reactions being studied here can be seen as the different devices that can be plugged into the different ports in a computer, and the algorithm developed by Cortez, Nazareno, and Mendoza is a way to find different chemical reaction networks to "fit" in the slots of the computer.

By identifying these different reaction networks, researchers can now consider the different effects and products that these reactions can bring to the organisms of which they will be a part.

One of the particular reaction networks that the researchers examined was the fermentation of glucose in yeast cells—the same pathway that gives us alcoholic drinks, as well artemisinin, the malaria drug.

With this research, Cortez, Nazareno, and Mendoza have started the development of what could become an extremely effective way of analyzing chemical reaction networks for use in synthetic biology. Establishing synthetic biology's links with engineering, this algorithm could be very useful in helping scientists come up with a list of biological "parts" with different uses and effects that can be incorporated into different organisms.

This work also presents many directions for future research. For example, because the algorithm was developed with a certain type of chemical reaction in mind, adjustments will need to be made before it will be able to take into account many other types of reaction. And while the algorithm presented different chemical reaction networks, the real-life viability of these networks still needs to be tested before they can be applied anywhere.

Luis Wilfrido Atienza graduated from the Ateneo de Manila University, with a BS in Biology, and a minor in poetry. He currently works as a copywriter for a sustainability agency, and spends some of his free time writing about science.