

DESIGNER GENES

The Boston Leadership Institute's Summer Program in Biological Research

by Sachi Lagwankar



I've always had a passion for science because it answers a question I consistently have: How? How does the immune system work? How are infections spread among people? How does DNA make us different from one another?

In ninth grade, I finally had the opportunity to take biology. I loved the labs and the lectures, but my favorite part came toward the end of the year when we started learning about genetics. I was amazed at how intricate the DNA replication process is and how, if even a minute part of one of the strands of a DNA molecule is not copied correctly, it can drastically change the organism of which it is a part. I wanted to learn more.

I was searching online for a science camp with a research component when I found the Boston Leadership Institute's Summer Program in Biological Research. The three-week camp, held at The Dana Hall School in Wellesley, Massachusetts, focuses on synthetic biology. It's taught

by Mr. Jim Dixon who, along with colleagues from Harvard and MIT, developed the synthetic biology curriculum BioBuilder. The program sounded like a great way to learn more about biology and experience research. I applied, underwent an interview, and several weeks later received an email saying I had been accepted to the program.

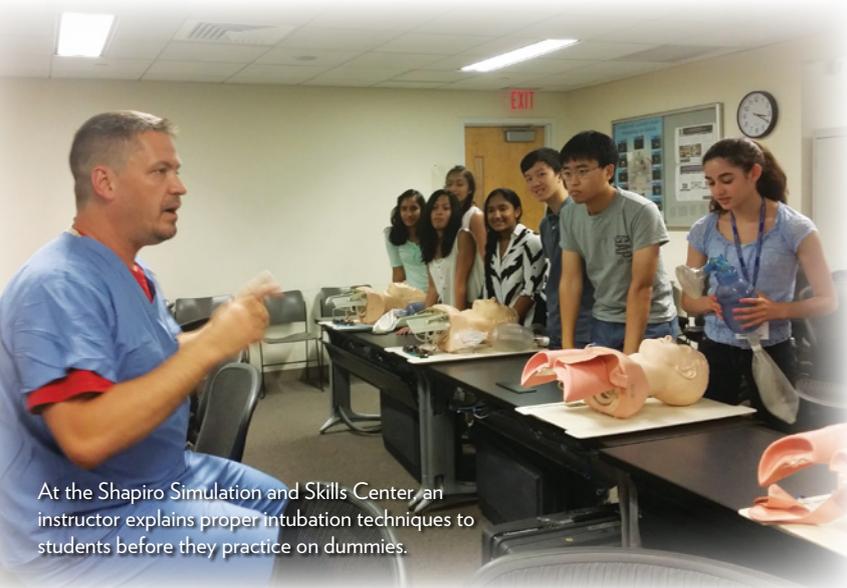
Fast-Growing and Fascinating

Since I live nearby I commuted, but about half of the 27 students in the program—who hailed from such places as California, New Jersey, France, and Saudi Arabia—lived on campus. Together, we learned that synthetic biology is a fairly new, fast-growing area of biology in which engineers design genetic systems such as bacteria that can respond to light in different ways or contain genetic circuits that can be turned on and off. These designer bacteria can be used to detect pollutants in water, for example, as well as poisons such as botulinum. Researchers are also experimenting with ways to use synthetic biology to detect and treat human illness.

Following this general overview of synthetic biology, we attended lectures on bioinformatics (the science of collecting and analyzing complex biological data such as genetic codes), PCR amplification (a technology used to amplify a single copy or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence), and epigenetics (heritable changes in gene expression).

Illuminating Ideas

I was fascinated to learn that scientists had isolated the protein that causes jellyfish to glow under ultraviolet light and used it to track previously invisible disease processes, such as the spread of cancer cells. Researchers are also investigating the possibility of manipulating *E. coli* bacteria, which occur naturally in the digestive tract, to create a gene



At the Shapiro Simulation and Skills Center, an instructor explains proper intubation techniques to students before they practice on dummies.



Sachi, second from left, and students at the BLI Summer Program in Biological Research

that is resistant to other digestive infections caused by bacteria such as *Salmonella enterica*, which is often responsible for food poisoning.

In addition to learning about some applications for synthetic biology, we discussed some of the challenges facing the field. Because gene mapping is a work in progress, scientists seeking to treat many genetic conditions often have to work toward developing treatments without knowing exactly what they're targeting. Understanding which genes to code for can speed the process of developing new treatments and methods in order to help people.

On the Bench and in the Field

In the afternoons, we gathered in state-of-the-art labs to conduct experiments and analyze DNA. In one lab, we inserted genes into bacteria that caused them to glow under ultraviolet light. In another, we explored bioremediation by growing oil-eating bacteria and observing their effectiveness at degrading a variety of oils.

On a field trip to the Karp Laboratory for Advanced Biomaterials and Stem-Cell Based Therapeutics, we saw a real working lab and talked to some of the scientists. Interestingly, biology labs are no longer limited to biologists. There are also mechanical engineers, for example, who apply their knowledge to biological problems such as building devices that can be safely placed into blocked arteries to reopen them.

Manipulating the Enemy Within

As part of the program, we had the opportunity to work on our own design or research project. I'd become interested in quorum sensing after learning about it through a lecture. Quorum sensing is the way bacteria communicate with each other: They send and receive signals,

called autoinducers, to determine their population density in a given area. If they sense there are enough of them, they attack the host cell and take it over. I wanted to understand how we might be able to use this concept to help people.

I watched videos by experts and read research papers that explained some of the work that's been done on quorum sensing, especially as it relates to treating disease. I learned that scientists were exploring the possibility of tricking harmful bacteria into thinking there were more of them than there actually were, prompting an attack that would trigger an immune response and fight them off. I decided to play around with the idea.

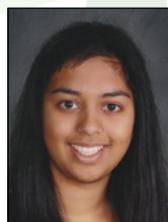
The bacteria *Pseudomonas aeruginosa* causes ear infections, pneumonia, urinary tract infections, diarrhea, meningitis, and certain eye infections. I theorized that if we introduced an autoinducer emitted by *P. aeruginosa* into a human cell—for example, *E. coli*, which is readily available and which proliferates like mad—the *Pseudomonas* bacteria might “think” there were enough soldiers to attack the human cell. In reality, there would be only a few *P. aeruginosa* bacteria, and the person's immune system would attack and kill them before they could cause illness.

My research revealed that in order for someone's immune system to make the needed antibody, they would have to have been previously infected by *P. aeruginosa*. But I also learned that these illnesses are so common that most people have already been infected at some point in their lives. The most challenging issue I encountered was figuring out how to introduce the *P. aeruginosa* bacteria into a human without harming the person. After further research, I reasoned that introducing the protein that makes the *P. aeruginosa* autoinducer into the *E. coli* DNA *ex vivo* (outside the body) might lower the risk to the human.

Promising Science

By program's end, I had written a research paper on quorum sensing and produced a design for a cell that would prevent illness from *P. aeruginosa*. I presented my findings to the group and listened in turn to the presentations of my fellow campers, which included synthetic biology applications that created plastic-eating bacteria and prevented Type 1 Diabetes and malaria.

Through the Boston Leadership Summer Program, I learned how scientists are engineering exciting new methods to use what we know about biology to address big problems, including illness, antibiotic resistance, and pollution. I met people from all over the world, used professional laboratory equipment, and tried my hand at a science that has the potential to revolutionize the way we treat serious illness. I hope to be a part of that revolution. ■



Sachi Lagwankar is a junior at Westwood High School in Massachusetts. When she's not designing cells, Sachi enjoys reading fiction, playing tennis, and volunteering in her community.

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