A USC professor who studies climate and pollution influences policy in California.

“Most roofs, historically, have been dark. They absorb sunlight, then transfer heat into the building and into the atmosphere. A very simple solution to that is to design roofs to reflect sunlight rather than absorb it. Cool roofs. Cool roofs could counter somewhere between a half and two degrees Celsius of warming in urban areas.

“In March 2013, an organization called Climate Resolve organized a one-day workshop on cool roofs, with the idea of bringing together researchers and policy makers, including Los Angeles mayor Antonio Villaraigosa. I [had done] a study to take high-resolution aircraft imagery and used that imagery to quantify how much sunlight is reflected versus absorbed. At the workshop I showed a map of Los Angeles with the corresponding reflectivity of each roof in the city. This visual made it clear that roofs cover a large fraction of Los Angeles, and most roofs absorb nearly all heat from the sun. In December 2013 the city council passed a law requiring any new or refurbished roofs on residential buildings to be cool roofs.

“It was extremely fulfilling to know that results from my research contributed to the evidence justifying the first such policy a city has ever passed.

“I try to follow Einstein’s suggestion that if you can’t explain it to a six-year-old, you don’t understand it yourself. I use my own six-year-old as a test bed.”

―as told to Adam Popescu
Heart on a chip paves the way for personalized cardiac medicines.

What if there were a way to use a patient’s own cells to test his or her response to a cardiac drug before it was administered? Megan McCain, an assistant professor at the University of Southern California, is developing a so-called heart on a chip, roughly the size of a quarter, to do just that.

When she was a postdoc at Harvard, McCain began collaborating with cardiologists at Boston Children’s Hospital. Her colleagues took skin cells from a patient, reprogrammed them to become stem cells, and turned the stem cells into heart cells. “Those heart cells should work pretty much the way your native heart cells should work,” she says. “They’ll have the same genetic information.” McCain then engineered tissues from these heart cells and used the heart-on-a-chip system to examine how the structure and function of healthy tissues differed from that of diseased tissues. The patient-specific cells living on a chip offer a more accurate way to predict how an individual’s heart will respond to a drug than, say, tests using lab animals.

McCain and her team have used the technology to test drug treatment for Barth syndrome, a rare cardiac disease caused by a single-gene mutation. She hopes that this chip will someday be used to test treatments for genetically caused cardiac diseases in general.

Other researchers have also created simulated organs on chips, but the heart presents specific challenges. “It is very mechanical, and it has an electrical side,” says McCain. “I appreciate how delicate, complex, and interesting the heart is.”

—Alexandra Morris

Using control theory to build better interfaces to the brain.

“I was born in Iran. My family immigrated to Canada when I was 16. My parents wanted a better education for me, my brother, and sister. I started out working on information theory, coding theory, and wireless communication. But I wanted to more directly impact people in my research. When I was looking for a PhD topic, I came across neuroscience, and I realized that the same principle could be used to treat brain disorders.

“So I moved from decoding wireless signals to decoding brain signals. I develop brain-machine interfaces that record the activity of neurons while someone plans a movement. This could one day allow disabled patients to move just by thinking about it.

“My work takes a lot of insight from control theory. Say you reach for a glass of water—your brain wants that to happen in a certain time frame, and it’s getting visual feedback, and you can adjust the speed. The brain acts as a ‘feedback controller,’ and I have built models for how that works. I also work on brain-machine interfaces for anesthesia. We decode the level of brain activity and adjust the anesthetic accordingly.

“I started as a professor at Cornell University and moved to the University of Southern California in July. As part of the Obama BRAIN initiative, I’m involved in a project to revolutionize treatments for neuropsychiatric disorders, such as PTSD and depression. We will create a brain-machine interface to decode the neuropsychiatric state of the brain, and decide on a set of electrical stimulation patterns to alleviate the symptoms in real time. This would be an automatic controller—a closed-loop system. And I will build that.

“We know nothing about the signatures of neuropsychiatric disorders in the brain. We need to discover those. I am really excited, because there is so much we don’t know.”

—as told to Antonio Regalado

$109 billion

The annual cost of heart disease in the United States