

Q&A: Makarand Paranjape explores the microscale for medicine

Blending physics, materials science, chemistry, and biology, the researcher designs devices to improve human health.

“The simplicity of any kind of device—that’s what makes it successful.” Makarand Paranjape has studied the design and fabrication of microscale devices since his days as a doctoral student. Even before that, as a child, he relished taking apart broken radios, marveling at the “three-legged crea-

tures” inside. He later learned they were transistors.

Paranjape is now an associate professor of physics at Georgetown University and the director of the Georgetown Nanoscience and Microtechnology Laboratory. Elected as a fellow of the National Academy of Inventors in 2024,

he holds 21 issued and pending patents. He is also considering launching a startup company. Focusing on commercialization is unusual in most physics departments, he says, noting that they often prioritize journal publications over patents.

One of Paranjape’s microscale devices is a Band-Aid-like transdermal patch that measures molecules like glucose without using needles. The lessons learned while experiencing the twists and turns of trying to commercialize the technology have led him to explore new applications for the patch that expand its reach to drug delivery and diagnostic testing. Paranjape says his favorite parts of research are applying his designs toward making health management more efficient and patient friendly.

PT: Tell me about your path into research.

PARANJAPE: My father was a theoretical physicist at Lakehead University in Ontario, Canada. My uncle and cousin are also theoretical physicists. When I was growing up, I liked the lifestyle that my dad had. He could do the research of his choosing. I wanted to follow in my dad’s footsteps, to which most dads would say, “Yeah, absolutely.” But my dad knew that I had more of a hands-on experimental side to me, so he suggested that engineering might be better for me.

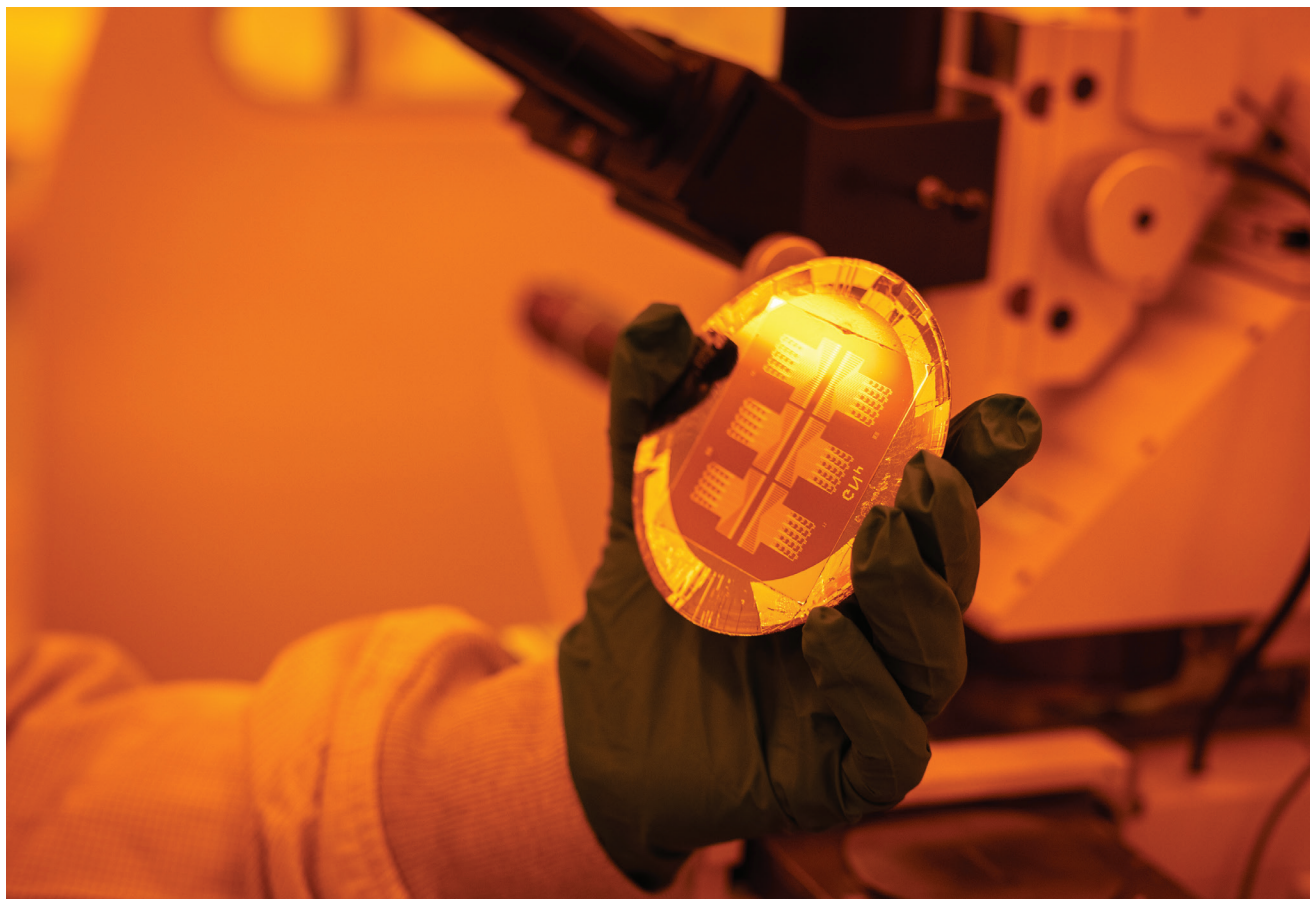
I went into electrical engineering, and I obtained my bachelor’s, master’s, and PhD at the University of Alberta in Edmonton, Canada. Even though my dad had told me there are more jobs for engineering than for physics, ironically, where do I end up? In a physics department.

PT: What inspired you to focus on biomedical research?

PARANJAPE: I got into biomedical technologies when I went to Vancouver for my second postdoc. One of our projects was with a biology professor who wanted to see how cells grow when they are fed. Typically, biologists monitor the growth of hundreds of thousands of cells, weigh them, feed them, and then weigh them afterward. The biologists would then divide the total weight by the number of cells to figure



MAKARAND PARANJAPE (Image from Georgetown University.)



A TRANSDERMAL PATCH, here on a silicon handle wafer, has been a major focus of Makarand Paranjape's research at Georgetown since the early 2000s. (Image from Georgetown University.)

out the weight per cell. Everything was based on averages, but we wanted to try to see if we could do a weight measurement on just one cell.

So, we created a MEMS [microelectromechanical systems] device. It's like a simple cantilever beam, which is like a diving board over a swimming pool. And this diving board has a natural resonant frequency at which it oscillates. If you put a mass like a cell on the MEMS cantilever, it oscillates at a slightly different frequency. And as you feed the cell, its mass increases, and the resonant frequency changes.

This was 1994, so it was pretty exciting. It made me think, Why aren't there other MEMS devices interacting with more biological entities, or even with human physiology? Antibodies, white and red blood cells, viruses—their length scales are similar to what micro- and nanodevices use. Putting MEMS devices and biology together was what really excited me about going into this biomedical area.

PT: What inspired the transdermal patch?

PARANJAPE: We started on the project fairly soon after I arrived at Georgetown as an assistant professor in 1998. It was funded through DARPA [Defense Advanced Research Projects Agency]. They wanted to evaluate a war fighter's severity of injury. The severity of injury can be determined by monitoring two biomolecules in the blood: glucose and lactate. These two biomolecules start to spike and do weird things as your blood volume decreases, so DARPA wanted a completely nonintrusive, noninvasive device that's always monitoring the soldier's glucose and lactate. Our patch technology was born from that idea.

PT: How did you go about it?

PARANJAPE: Our idea was to go after the interstitial fluid. The interstitial fluid bathes every living cell in your body. Small biomolecules like glucose

leave the blood through tiny pores in our capillaries and travel into the interstitial fluid to feed cells. If you can sample interstitial fluid rather than blood, you're going to get most of the markers of interest, including glucose and lactate.

The interstitial fluid is just under the topmost layer of your skin, called the stratum corneum. People often refer to it as a dead skin layer. If you can get past the stratum corneum, then you've got a whole pool of interstitial fluid underneath. Blood vessels and nerve endings are far below this layer.

The patch uses a miniaturized stove-top coil that turns on and off on the millisecond scale. The thermal pulse that's generated by this little coil vaporizes—or ablates—only the topmost layer of skin locally. The interstitial fluid comes out through the resulting micropore because the heart is providing hydrostatic pressure to push out the fluid. We sample that fluid and look for biomolecules using standard

electrochemical or mass spectroscopy processes.

PT: Did DARPA choose your technology?

PARANJAPE: After three years, they said they weren't going to implement it for their soldiers. The patch technology was ours to run with however we wanted. So, we thought, why don't we go after the diabetes market?

In 2013, we did a clinical trial. Our trial comprised 10 people with type 1 diabetes, and we applied the patch to their arms or forearms and did the test. Out of the 10, not one felt anything. It turned out that the detections of glucose by the patch tracked nicely with actual blood draws. The company sponsoring the clinical trial immediately licensed the technology.

The clinical trial was one of the most rewarding things I've ever done. I never thought in my wildest dreams I'd be involved in a clinical trial of my own device.

PT: What happened when you tried to bring the technology to market?

PARANJAPE: The company found that cracking the glucose market is very difficult. I'd be lying if I didn't say I wasn't disappointed. But I think the more disappointing part was that the major pharmaceutical players that we talked with bristled at the fact that the patch technology measures glucose in interstitial fluid and not blood. They contended that physicians only think about blood-glucose concentrations. Now almost every major continuous glucose monitor on the market takes measurements of glucose in interstitial fluid.

PT: What did you do next?

PARANJAPE: The company that licensed the technology is looking at other molecules to detect using the patch, like alcohol. And I am starting a

project right now looking at biomarkers for traumatic brain injury.

We're also looking at using the patch as a drug-delivery technology platform for treating diseases like Parkinson's. The patches that exist right now on the market, like the nicotine patch, must chemically modify a drug to be delivered through the topmost intact layer of skin. The drug must go through FDA [Food and Drug Administration] approval again. With our process, we're taking FDA-approved drugs and not modifying them.

I've also applied for a patent that uses my patch technology to simplify the diagnosis of cystic fibrosis. Collaborating with my wife, a cystic fibrosis physician at Johns Hopkins University, we are targeting the patch for use in countries like India and China and regions in Africa where cystic fibrosis is often misdiagnosed.

PT: What would you say to others considering commercializing their research?

Quantum sector jobs span specialties, degree requirements

Jobs in engineering, information technology, and research together make up nearly half of the roles in the global quantum workforce. Yet many quantum-related jobs in business development, arts and design, sales, community services, and other fields listed in the figure do not rely on STEM skills. (See also *PHYSICS TODAY*, April

2025, page 17.) The chart is adapted from one in a 2025 report by the Quantum Economic Development Consortium (QED-C), which provides research and market forecasts on the quantum economy.

Data reveal other qualities that employers in the quantum space are looking for in candidates. Last year, using

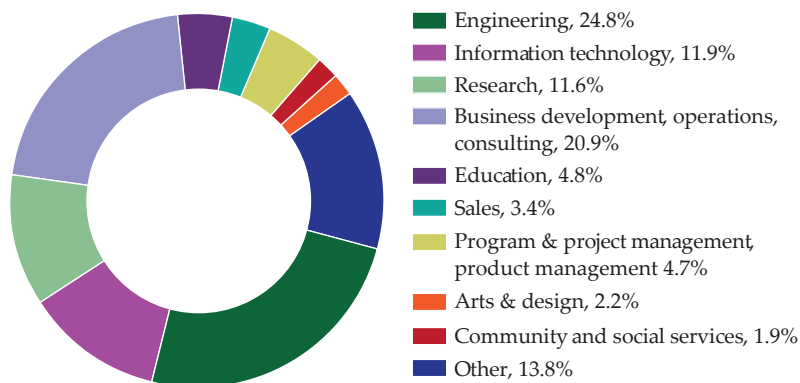
QED-C and Quantum Computing Report job postings from 2021 to 2023, the Chicago Quantum Exchange (CQE)—whose members include five universities and two national labs—did an analysis of more than 5000 roles in the quantum technology workforce. Among the ads posted in 2022 and 2023, about 31% requested that candidates have a PhD, and some 14% specified a master's degree. The remainder of the positions required a degree no more advanced than a bachelor's or no degree.

The authors of the CQE report found that the percentage of jobs requiring PhDs slipped from about 35% for 2021 to 29% for 2023, whereas the percentage asking for a bachelor's degree rose from about 35% to 38%. Ads for positions in the industry sector were less likely to require a PhD than were ads for roles in academia or government.

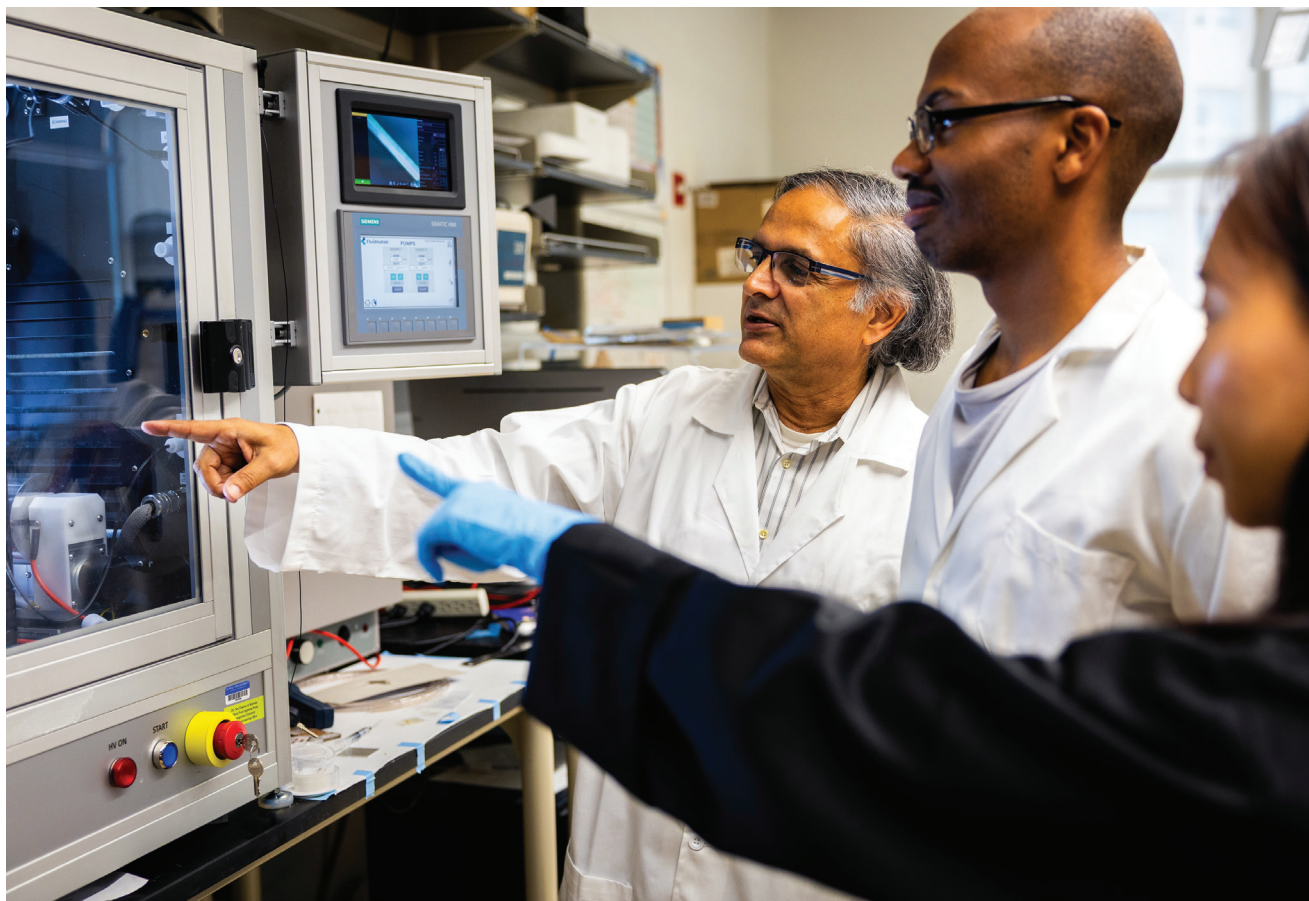
For more information on the quantum workforce, see the reports at <https://quantumconsortium.org/publications/stateofthequantumindustry2025/#2025report> and <https://chicagoquantum.org/degereports>.

Tonya Gary

Quantum workforce by role



(Figure adapted from Quantum Economic Development Consortium (QED-C), *State of the Global Quantum Industry*, 2025.)



THE CLEAN ROOM at the Georgetown Nanoscience and Microtechnology Laboratory is the workspace for Makarand Paranjape (left) and graduate students Darrian Mills (center) and Karma Dema (right). (Image from Georgetown University.)

PARANJAPE: People wrongly think that once you patent a technology, you can't publish about it. No. You can publish, but make sure you have the patent application submitted before you publish. If you do it the other way around, you cannot get a patent because you've made a public disclosure.

If you're ever wondering whether to get a patent, get it. You just submit an application to your university's technology office. They will assess whether it's a patentable idea, and if it is, then they'll pay for it. In the end, the university owns that patent.

PT: Where do you see the influence of physics in biomedical fields?

PARANJAPE: A lot of biomedical advancements are a result of physics. You look at imaging technologies that are widespread, like MRI and CT and PET scans. The invention of MRI contrast agents allowed for new ways to brighten what you're looking at. Now physics in

the nanorealm is starting to look at quantum effects and the use of nanoparticles for delivery of drugs. There's always going to be some overlap.

PT: What advice would you give people interested in interdisciplinary research?

PARANJAPE: I do all this work in physiology and biomedicine, but the last time I took a biology course was in grade 12. You pick up everything that you need to know along the way. A person should not feel restricted or anxious about not having the appropriate background.

Try to get into a research environment early—you learn so much from that. I've got a tremendous group of grad students past and present, but I also have a huge number of undergrads who work in my lab. I also had six high school students this summer.

PT: Has your work been affected by recent US funding cuts?

PARANJAPE: At the moment, I'm not funded by NSF or the National Institutes of Health, so the US federal grants situation is a little less problematic for me. It has affected our enrollment, in the number of grad students we could take. If there are no students doing such cutting-edge research, the whole innovation process may grind to a halt.

PT: What's next?

PARANJAPE: We're looking at initiating a startup company for the drug-delivery technology. Being an electrical engineer in the physics department who is working on devices that have potential applications for health care and who is starting a business—it's a little daunting, but I think it's also exciting. I have business advisers already in place, and I'm taking some business courses and getting my feet wet in that area.

Jenessa Duncombe