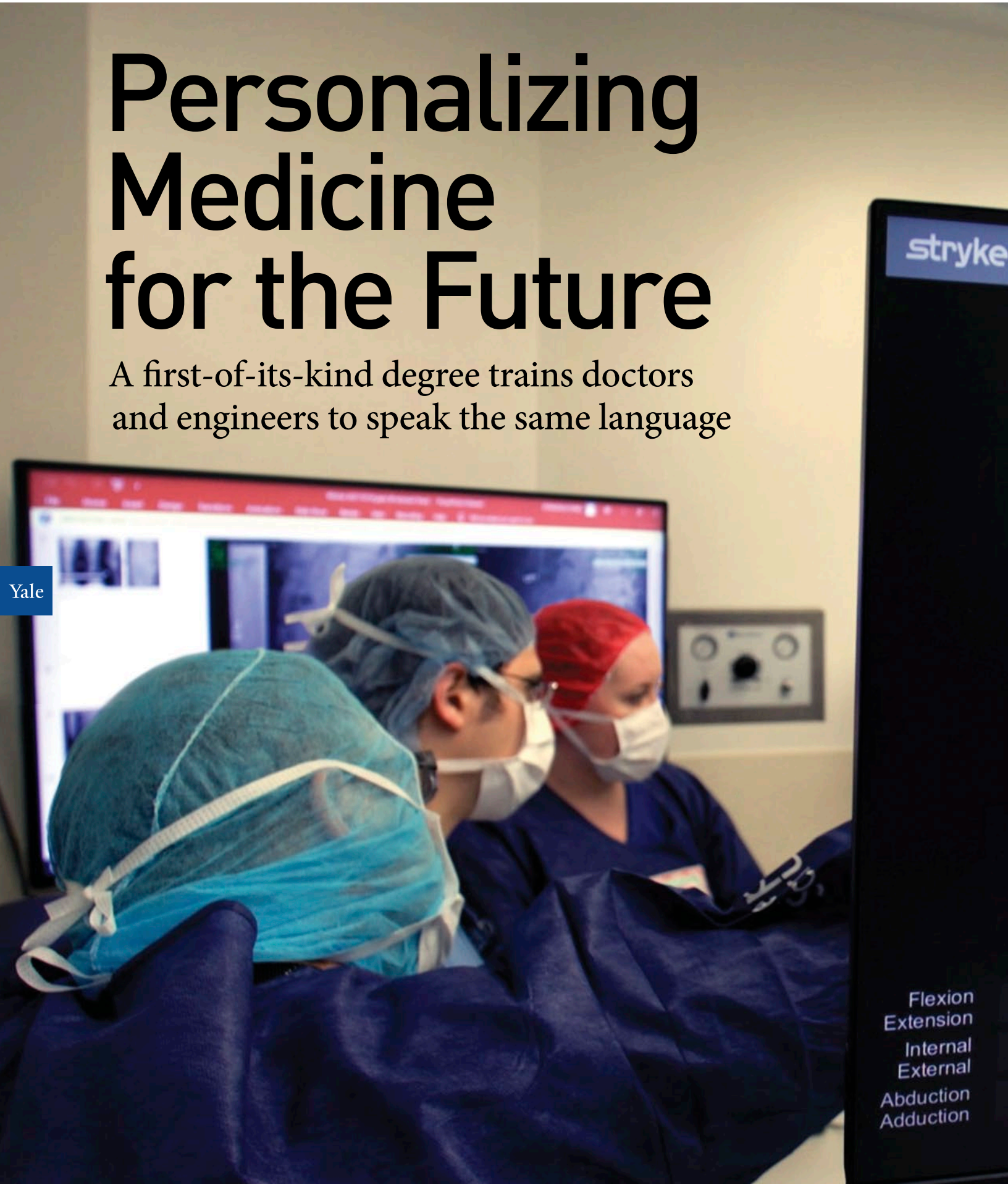
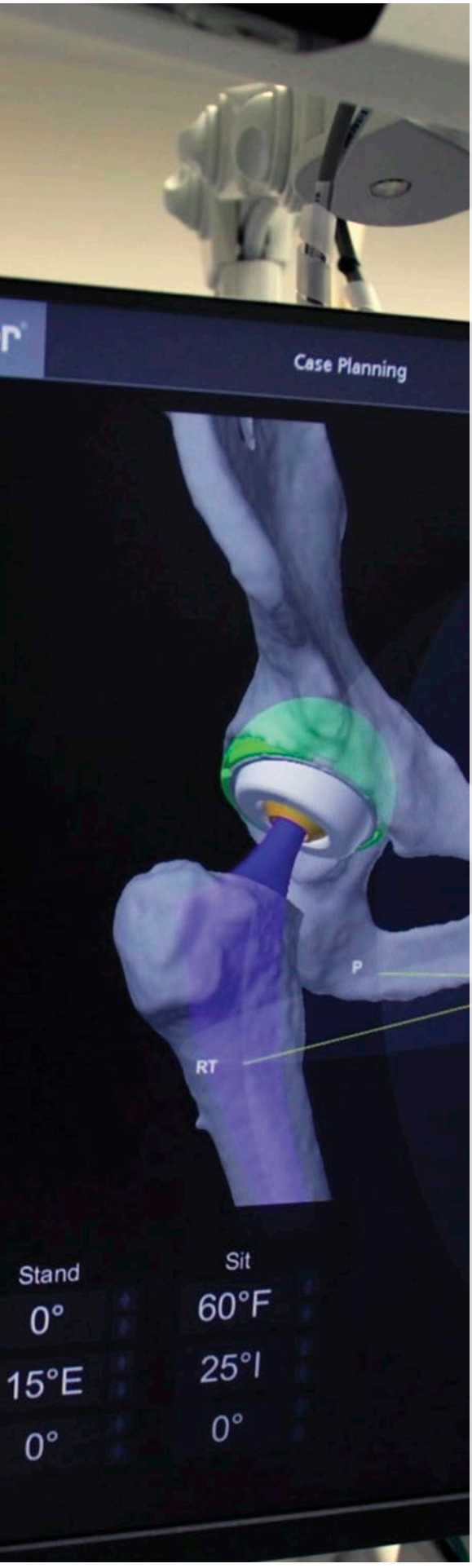
Personalizing Medicine for the Future

A first-of-its-kind degree trains doctors and engineers to speak the same language





High-resolution imaging, 3D printing and modeling, and other technologies have radically changed healthcare and how some doctors are treating their patients. Certain cases that, in the recent past, would have automatically been paired up with a standard treatment are now being addressed with one-of-a-kind solutions.

For instance, Dr. Daniel Wiznia said, a patient might come to him with a defect in his or her bone structure.

"We can create a 3D model of that," said Wiznia, assistant professor of orthopaedics and rehabilitation and mechanical engineering & materials science. "We can figure out in a 3-dimensional space how we're going to reposition the bones, and how a plate is going to bring the two ends together. We can also print out custom instruments — I can create a 3D-printed guide that will lock onto the bone and guide me to where I put the drill or tell me where I cut the bone and create a specific little notch."

Wiznia's specialty is orthopedics, but this is a seismic shift in healthcare that cuts across disciplines — neurosurgery, for instance, or vascular surgery.

"In cardiology, we can create 3D models of a patient's heart and see what the pathology is," he said. "We can determine beforehand how we want to treat that pathology. We can look at different vascular patterns and see how best to access those sites."

That means, on a per-patient basis, a physician can tailor not only their techniques but the tools and implants themselves to the specific case and the specific patient's anatomy. This makes sense. After all, we aren't made up of parts mass-manufactured in a factory. Every person's physical make-up departs from the norm in some way.

So the technology for this type of personalized medicine is there. What's needed now is a generation of physicians and engineers who know what it can do, how to use it, and can speak the same language to each other.

To that end, the Yale School of Engineering & Applied Science and the Yale School of Medicine have launched the first-of-its-kind Master of Science in Personalized Medicine & Applied Engineering program. The one-year advanced degree program began this summer and it's designed to bring engineers, computer scientists, and medical professionals together to learn

Continued →

Above: *The first-of-its-kind degree program brings engineers, computer scientists, and medical professionals together to improve patient outcomes.*

the new technologies in 3D medicine and imaging with the goal of improving patient outcomes. Students who go through the program will know how to — among other skills — generate high-resolution imagery, design and create 3D models of anatomy, use 3D printing to create customized medical instruments, and program surgical plans into robots and other computer-guided systems.

"They're going to come out of this with a good background in how to use and develop tools to improve treatment, diagnosis, and healthcare in general," said Steven Tommasini, research scientist at the School of Medicine.

All the principals involved in getting the program off the ground agree that Yale is the perfect setting for an entirely new kind of interdisciplinary degree. SEAS Deputy Dean Vincent Wilczynski noted that the university's culture of collaboration was a critical component.

"The new degree builds on the strong partnerships in research and education between the two schools and creates new opportunities to create innovative solutions for health care," Wilczynski said. "The combination of educators, practitioners, and researchers will certainly lead to the development of innovative medical devices and processes."

The technology of personalized medicine brings engineering and medicine together. The program is designed to get both sides speaking the same language.

"The engineers need a background in anatomy that they don't have, and maybe a background in radiology and imaging that they don't have," said Lisa Lattanza, chair and professor of orthopaedics and rehabilitation. "The people coming from the School of Medicine side need to know how to segment images and how to work with computer-aided design drawings and things like that. The idea is that we want surgeons to come out who can do this, and we want engineers who can come out and do this."

Lattanza has been using 3D technology since 2012 and has conducted more than 250 surgical cases. She started out working with a 3D company in Belgium. That worked out great as long as she was assigned to a company engineer who was skilled in what she needed for her orthopedic work. That wasn't always the case. This is where the idea came from for the new degree.

"I mean, you can't just phone it in and send the images to the engineer and expect them to plan the operation," she said. "You have to be there, engaged, and know how you would get there without the technology and then know what the technology can and can't do for you."

Along the way, she also saw the technology surge in popularity among her fellow surgeons, not all fully understanding its capabilities and limitations.

"So if you paired up a new engineer with a new surgeon trying to do this, it's a disaster waiting to happen."

After she worked on an outline of the program with Wiznia, Tommasini, and Wilczynski, they then pitched it to SEAS and the School of Medicine. Everyone was 100% behind it right from the start.

"There's nobody that doesn't like it, and everybody sees the need for it," Lattanza said. "It's the proverbial basket of kittens."

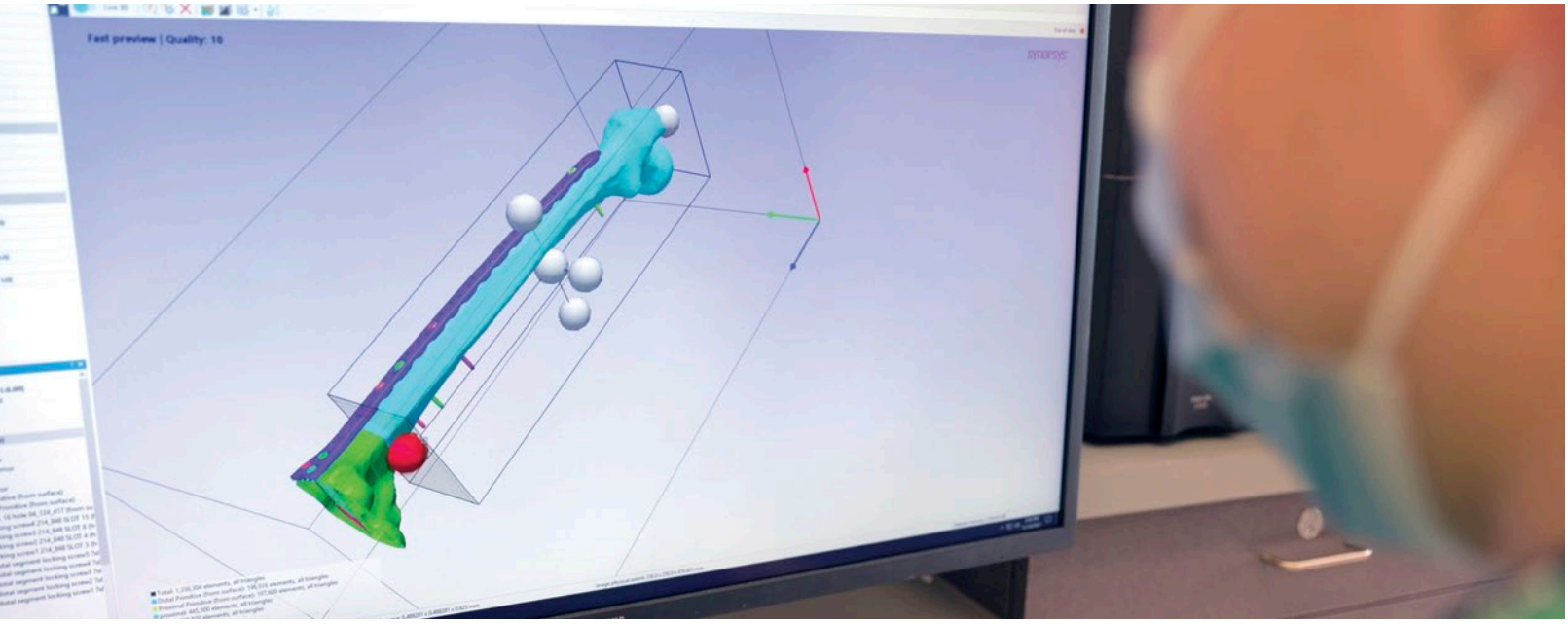
To graduate, students will need to take two electives and six required courses, which include a Personalized Medicine Seminar, a course on biomedical 3D Printing, and one on Medical Device Design. Courses are taught by both clinical and ladder faculty from the School of Medicine and SEAS.

Above: *Physicians can tailor their tools and implants to a specific patient's anatomy.* Below: *3D printers are frequently utilized to create customized medical instruments, anatomy models for surgical planning, and more.*

As part of the program, the students spend the summer in a "clinical immersion" phase where they shadow physicians in various fields, observing surgeries and doctor-patient interactions. More than 40 healthcare workers from 11 fields, including orthopaedics, radiology, cardiology, and neurology volunteered to take part as mentors for the program.

"I think the summer program will help them get familiar with the medical environment, be able to speak the clinicians' language, and see what the clinical process is like, from the O.R. to just meeting with patients," Tommasini said.

Continued →



Left: *New technologies in 3D medicine have surged in recent years allowing doctors to better customize patient care.*
Right: *Derek DeMel '22 and Dr. Daniel Wiznia study a 3D model to discuss the best approach for treatment.*

Derek DeMel '22, who graduated in May with a bachelor's degree in biomedical engineering, says this phase of the program was invaluable.

"I think it's so important for the pre-med people in the program to learn about how these devices are engineered," he said. "And in the engineers' case, if we're going to go ahead and make these technologies, ultimately they're useless if we don't actually know what the doctors want and what the patients need."

Specifically, DeMel is interested in preventive medicine and the idea of being able to print organs and tissues rather than having to rely on just transplants. He's also open to working with medical devices more broadly. In either case, he sees the program giving him the boost in skills that he needs.

"With this program and the extra year as a grad student, you get so much more access and more closeness to the faculty. I really think this program is going to help teach me more of what I need to know."

After taking the School of Engineering's Medical Device Design course as an undergrad, Ashley Anthony '22 decided she wanted to do more hands-on engineering, particularly in a clinical setting.

"What appeals to me about the program is that I want to be able to help people, and I personally enjoy just solving problems," said Anthony, who also majored in biomedical engineering. "I think most engineers also have this kind of personality trait where they just like to be able to work through a problem and create something that fixes it."

As a student from Guyana, Anthony said the program has also gotten her thinking about how to make devices and personalized medicine more accessible to people living in a low-resource region.

"What are some of the ways that we can make things more cost effective?" she said. "What are some of the ways that we can make things not just available to larger swaths of people but also design devices that can be manufactured and made more accessible in places with fewer resources?"

And with a grant from the National Institutes of Health, the clinical immersion phase of the program is offered to up to five undergraduate students each summer. In the following spring semester, these students also take the Medical Device Design course taught by Wiznia and Tommasini.

"We use the summer program as a tie-in so they learn about different problems that exist, and then they can come up with ideas that could be used as projects for the device class," Tommasini said.

Among the three undergraduate students who took for the first summer immersion phase was Caroline Reiner, who is majoring in computer science and psychology.

"I've always been interested in health and medicine, but I also have this itch to innovate and create," she said. "When I found out about the program, it seemed like the perfect intersection between my interests. I get to be with the patients and also express my creative side. And in classes, we learned that there are a lot of AI applications in medicine and healthcare."

As part of the immersive program, she observed surgeries and doctor-patient interactions in the fields of urology, orthopaedics, and infectious diseases.

"The doctors that were in the room, they would always be pointing out things on the screen, teaching me things, and answering my questions," she said. "It was really helpful."

Like her fellow undergrads in the program, Reiner will be taking the Medical Device Design course in the spring. The summer program has her already thinking about potential projects, like redesigning a soft tissue biopsy gun commonly used to take tissue samples. She thinks it can be made more efficient and quieter (patients often complain about the noise it makes).

As much as the program is focused on bringing students up to date on the technology of personalize medicine, it's also about preparing them for the future of the field. Lattanza noted that the skills and knowledge that the students learn in the program are the kind that will increase because technology will continue to advance. As a result, the field of personalized medicine is going to quickly morph over time.

"Right now, we're talking mostly about 3D modeling and virtual planning of surgery, but eventually we might be talking about developing a 3D molecule that can be used in some way in the body, or the printing of bone and cartilage," she said. "We want to create the people who are going to solve those problems ten years from now. I don't want to hear that people are still putting in plastic and metal joints — I want to hear that people have figured out how to resurface cartilage and grow bone in a way that's necessary to solve some of these bigger problems."