COVER STORY

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CELL PIONEER

NJIT RESEARCHER WINS PRESIDENTIAL AWARD, THE HIGHEST NATIONAL HONOR A YOUNG SCIENTIST CAN RECEIVE

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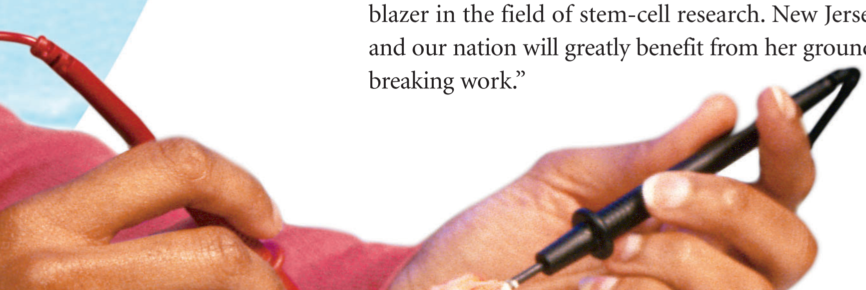
WHEN TREENA LIVINGSTON ARINZEH CULTURES ADULT STEM CELLS, SHE SEES MUCH MORE THAN THE LAB EXPERIMENTS TO WHICH SHE HAS DEVOTED COUNTLESS HOURS. SHE SEES HEALING. SHE SEES A CHILD WITH AN INJURED SPINE RECEIVING AN INJECTION OF STEM CELLS THAT REGENERATE HEALTHY TISSUE AND ALLOW THAT CHILD TO WALK AWAY FROM A WHEELCHAIR.

Arinzeh, assistant professor of biomedical engineering at NJIT, has earned national recognition for her commitment to making such therapy a future reality. Last fall, President Bush awarded her the highest national honor that a young researcher can receive — the Presidential Early Career Award for Scientists and Engineers.

In 2003, the National Science Foundation (NSF) also gave Arinzeh its most prestigious honor — a Faculty Early Career Development award that included a $400,000 research grant. The NSF called her one of the "nation's best young scientific researchers."

After she won the Presidential award, U.S. Congressman Robert Menendez commended Arinzeh's achievements by reading them into the *Congressional Record*. "I rise today to honor Treena Livingston Arinzeh for her outstanding work in the field of stem-cell research," Menendez said on the floor of the House of Representatives. "Today, I ask my colleagues to join me in honoring Arinzeh, a trailblazer in the field of stem-cell research. New Jersey and our nation will greatly benefit from her groundbreaking work."



At the forefront of therapy

What is it about Arinzeh's research that has caught the attention of the NSF, President Bush and Congressman Menendez? In addition to its great future promise, her efforts have already yielded two very significant discoveries. Arinzeh has shown that stem cells can help to regenerate bone tissue, and she has proven that stem cells taken from one person can be implanted in another individual without being rejected.

William Hunter, chair of NJIT's Department of Biomedical Engineering, heads a program that is advancing therapeutic innovation in many areas, including research into the potential of adult stem cells. (See sidebar, "Redesigning Biomedical Engineering at NJIT.") According to Hunter, Arinzeh's research is unique in that she has had success in crafting the right environment for controlling what kind of cells stem cells will develop into — nerve, bone or cartilage, for example. "Treena is working in a world that is at the forefront of medical therapy," he says.

It was only a decade ago that scientists discovered the potential of adult stem cells. Produced by the body in an undifferentiated state, stem cells eventually specialize through natural processes to build and maintain specific tissues and organs. For research purposes, stem cells can be obtained from sources that include embryos, bone marrow, the brain and spinal cord, and intestines. Arinzeh works only with stem cells taken from adult bone marrow. So the controversy over the ethical implications of embryonic stem-cell research, in her case, is moot.

To put it simply, when harvested for research outside the body, stem cells don't know what they want to be when they grow up. Arinzeh aims to provide them with the guidance they need to become different types of cells useful for repairing injuries and curing disease.

> "For outstanding research in emerging tissue engineering technologies in which cells, instead of drugs, are used to treat diseases or disorders. Her educational activities include developing curricula and community outreach to underrepresented groups."
>
> *—Presidential Early Career Award Citation*

The list of conditions for which stem-cell treatment holds promise grows almost daily. It now includes Parkinson's, diabetes, Alzheimer's, cancer and traumatic brain injury. But given the publicity and controversy swirling around stem cells, people often don't realize that the research is still at an early stage. It will take years before stem-cell research translates into medical applications that can help the sick or injured. Stem-cell research is in a stage comparable to that of the semiconductor industry during the 1940s, Arinzeh says — filled with potential but at least five or ten years from becoming a viable medical therapy.

Arinzeh, at age 34, has pushed the basic science of stem cells forward and she has a chance of taking it another step. "Treena has all the earmarks of a technical superstar," says Michael Jaffe, professor of biomedical engineering and chemistry at NJIT, who was a research fellow at Hoechst Celanese Corporation before entering academia. "If anyone can take stem-cell research forward, she can," he adds. "The odds of her, or of anyone, doing that is like playing the lottery. The odds are against you, but they are a lot worse if you don't buy a ticket. Treena has a ticket."

Two winning discoveries

As mentioned earlier, Arinzeh has already made two stem-cell breakthroughs. Several years ago, her paper in the *Journal of Biomedical Materials Research* documented the first of these discoveries. The paper focused on her work with biomaterials known as scaffolds — specifically, calcium phosphates — that act as a framework for growing stem cells and which can prompt them to become the cellular building material of bone or other tissues. Arinzeh conducted cell-culture experiments and studies of rats with bone defects that showed how the biomaterials stimulated stem cells to produce new bone tissue and repair the animals' bones.

Her findings could help cancer patients who've had tumors removed from their bones, and who may even face the amputation of an affected limb because the diseased area is so extensive. Conceivably, therapy resulting from Arinzeh's work could repair such damage by regenerating bone tissue. This approach could also help osteoporosis patients who have fractured bones. Other biomaterials she is testing might lead to therapies to repair cartilage, tendons and neuronal tissue.

This research may sound like science fiction, but Arinzeh's lab techniques are fairly standard. She mixes human blood extracted from bone marrow with a special liquid and uses a centrifuge to separate the stem cells. Arinzeh then puts those cells in a culture dish, where they grow on top of a thin film of scaffold material. "I wait a few weeks and look for the properties I want," she says.

Arinzeh's second discovery, which she described in a paper for the *Journal of Bone and Joint Surgery*, was that adult stem cells taken from one person could be implanted in another without being rejected. Scientists had thought that the recipient's immune system would reject such donor cells. It was among the most significant findings in stem-cell research in the past few years.

Partners in research

Arinzeh has formed key research partnerships across New Jersey. In addition to NJIT's Jaffe, she is collaborating with orthopedic surgeon Louis Rizio on a project that uses stem cells to repair cartilage. Rizio is affiliated with the University of Medicine and Dentistry of New Jersey (UMDNJ), which is funding the research. They have also applied to the National Institutes of Health for additional funding.

Arinzeh has teamed with another orthopedic surgeon, Sheldon Lin, to investigate the use of stem cells for bone repair in diabetic patients. She also does research with Joachim Kohn, who directs the New Jersey Center for Biomaterials. The two are studying how polymers interact with stem cells, possibly to repair bone, cartilage, and even neurons in patients suffering from brain injuries.

The makings of an engineer

Arinzeh didn't set out to be a stem-cell pioneer. Born and raised in Cherry Hill, New Jersey, Arinzeh attended the public schools there. Her mother was a high-school teacher and her father worked as a biochemist. In high school, her favorite subjects were math and science. Her high-school physics teacher, a mentor, told her she had the makings of an engineer.

A mechanical engineering major at Rutgers University, she became involved with rehabilitative engineering during a summer internship at the University of California at Berkeley. During that internship, she saw how engineers used technology to help the handicapped through prosthetic devices and other means. She loved the experience, and it started her on the path to a master's degree in biomedical engineering at Johns Hopkins and a PhD at the University of Pennsylvania.

Instead of teaching, Arinzeh's first job after completing her doctorate was as a product-development engineer at Osiris Therapeutics, a biotech company in Baltimore that specializes in stem-cell based therapies. She wanted to see how stem-cell products were developed, from research to clinical trial, to the marketplace. There, she saw firsthand the promise and limitations of stem-cell research.

Osiris researchers had made significant strides with stem cells, and even conducted a Phase One clinical trial using them to repair bone in the human jaw. But they couldn't overcome one obstacle. Stem cells can indeed turn into cartilage and bone tissue, but to do so they need something to which they can adhere, and which will consistently prompt them to become the type of cells desired for therapy.

"Finding the right scaffold, that's the trick," Arinzeh says. "Companies doing stem-cell research didn't know how to identify the right scaffold. At Osiris, this was a major limitation."

To overcome this limitation, Arinzeh returned to academia. In 2001, she joined the faculty at NJIT, where much of her effort is focused on using calcium-phosphate scaffolds to promote stem-cell growth and differentiation. While Arinzeh has achieved considerable success, much work remains to be done with respect to understanding and directing the processes involved. It might take five years; it might take ten. But Arinzeh is confident that one day she'll find the "trick" that will lead to therapeutic trials in a clinical setting.

Balancing work and home

With research, teaching, advising students and applying for grants, Arinzeh estimates she spends about 70 hours a week at work. How does she balance work and home life? "I don't," she quips. "I'd need three of me to do that." When pressed, she says the key is managing her time well. Her academic schedule is flexible, and she gets a lot of work done between 9 p.m. and midnight, after her one-year-old daughter goes to bed.

She lives in Jersey City with her husband, an investment banker, and her daughter Nneka, whose name means "woman is great" in Nigerian. Her husband, Uzo, is Nigerian. They are expecting another child.

In the free time she does manage to find, Arinzeh likes to travel, see plays, jog, and play with her daughter. She enjoys taking Nneka to live performances, especially *Sesame Street*. She also plays the flute, piano, violin and percussion. In high school, she was in the wind ensemble, the orchestra and the marching band. She was also, she concedes, a cheerleader.

What does Arinzeh think about being a black woman working in fields dominated by white men? "I don't think about it much," she says. "I just work hard. Or I tell myself, 'you're unique.' But I know it's a national problem. There are not enough of us in engineering and science."

Taking a look at the HapticMaster in the new Motor Control and Rehabilitation Laboratory are (left to right) junior Juan F. Londono, graduate student Qinyin Qiu and freshman Hamid Bayce. Student participation in research is a primary goal at NJIT across all academic programs, including work with the HapticMaster to improve therapies for stroke patients.

REDESIGNING BIOMEDICAL ENGINEERING AT NJIT

When he first saw the floor plan for the Department of Biomedical Engineering in NJIT's new East Building — a swath of conventional cubicles for classrooms and offices — Associate Professor Richard Foulds reached for a pen. Foulds, who confesses to be a repressed architect, knew what he and his colleagues wanted — a layout in which spaces for teaching, research and mentoring students would form a single interactive unit. So, pen in hand, he redrew the plan.

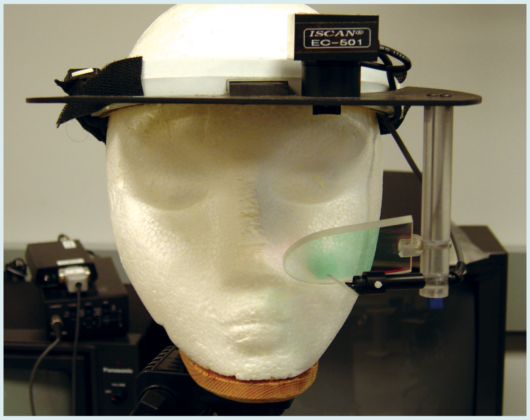
"The architect did a terrific job of implementing our ideas," says Foulds, an associate professor of biomedical engineering, offering a tour of the department that occupies the sixth floor of the East Building. In the department's two teaching studios, Foulds and other faculty members are pioneering a new way to educate engineers. With the studio method, students are educated in the fundamentals of engineering not by lecture and recitation, but by hands-on, experiment-based learning. The studio method was first used in architecture schools, Foulds notes, and he and his colleagues have adapted it for engineering.

In an introductory design class, students work in teams to build small robots. One of the robots is programmed to perform angioplasty on pasta; another to perform amniocentesis on a jelly donut; and a third is programmed to reattach the perforated tip of a frankfurter. These imaginative exercises teach the students how to use technology to assist surgeons.

"Our students love studio learning, which has caused enrollment in the biomedical department to mushroom," says Foulds.

Close to the studios are all faculty offices. And it's not just their professors' offices that are near the students. There are ten new labs close by, too, where students work with their instructors on research that is advancing biomedical engineering.

In the Human Performance Laboratory, for instance, Professor Michael Lacker is working with students and colleagues to collect data on human motion. They have developed a new method for finding motion solutions, based in math and physics, which can help athletes improve their performance by showing them how best to move their bodies. The method can also help the elderly or individuals of any age whose movement has been affected by various impairments to find comfortable and safe motion, such as a more energy-efficient and stable walk.



Research under way in the Neuromuscular Engineering Lab could lead to a compact wearable system that will improve communication for people whose hearing is severely impaired.

PHOTOS: CHRISTINA CROVETTO

In the Motor Control and Rehabilitation Laboratory, there's a robot known as the HapticMaster. Sergei Adamovich, assistant professor of biomedical engineering, has a research grant from the National Institutes of Health to see if robots and computers can be used to create therapies that help patients relearn movements lost as a result of strokes. Only one other university in the nation — Northwestern — has a HapticMaster, Adamovich says. A stroke patient with limited movement in his or her arms holds onto the robot's metal arm, which is programmed to perform repetitive arm exercises. Patients do the exercises with the robot while playing virtual reality games on the computer. The games guide their motions and make the exercises more fun and engaging. Patients can also wear a programmed glove that helps them open their paralyzed fingers.

The Neuromuscular Engineering Laboratory is where Foulds and his students are developing a computer program to help hearing-impaired people communicate. The program is designed to recognize sign language and convert it into spoken English and, conversely, to convert spoken words into animated images that can be displayed on a small computer screen. The ultimate goal is to develop a wearable system, perhaps one small enough to be incorporated into a pair of eyeglasses.

Tara Alvarez, assistant professor of biomedical engineering, is conducting research in the Vision and Neural Engineering Laboratory that could help people with vision problems such as those associated with learning difficulties. She is studying the brain to understand the control of eye movements and other related motor functions. Alvarez is using functional magnetic resonance imaging (fMRI) to investigate how motor learning facilitates visual tracking as well as advanced digital signal processing to research neuro-control.

It is research like this that has made biomedical engineering such a success at NJIT — research being conducted in new spaces that enhance the intellectual excitement shared by students and faculty alike.

To learn more about biomedical engineering at NJIT, visit www.njit.edu/bme. Also, see "Catching the Fourth Wave" by William Hunter in the spring 2003 issue of *NJIT Magazine* at www.njit.edu/publicinfo/pdf/wave.pdf.

And she does what she can to counter that problem. She received her NSF Faculty Early Career award in part because of her proposal to encourage minority and female high-school students in New Jersey and New York to study science and engineering. She mentors Newark high-school students who are in Project SEED, the American Chemical Society's social action program. She also gives lectures on stem-cell research and education to teachers at all-girl high schools in northern New Jersey.

"Gender-wise, it's getting better," Arinzeh says. "I see a lot of women at academic conferences. But the numbers for minorities working in engineering are stagnant. I'd say only one or two percent of the engineers I see are minorities."

In the end: hope

Suwah Amara, an African-American woman with a rare bone disease, is just the kind of person Arinzeh seeks to encourage academically, and to help through her research. A student in Arinzeh's biomaterials class, Amara is a 22-year-old biomedical-engineering major. She has fibrous dysplasia, which makes her bones so brittle that they can fracture with the slightest exertion.

"My bones break so easily," says Amara in a straightforward way, without self-pity. "I broke the bone in my upper arm five times. I've broken both my thighbones. The bone in my lower leg has broken so many times I've lost count." One time, the simple task of uncapping a pen broke her forearm.

Once, after class, Amara asked Arinzeh if stem-cell research might help cure her brittle bones. Arinzeh spoke with Amara about stem cells and gave her names of researchers who might be working on fibrous dysplasia.

That gave Amara hope. "It's admirable that Dr. Arinzeh is trying to help people like me," Amara says. "One day, I'd love to be able to walk without crutches." In Amara's eyes, Arinzeh is a role model as well. That Arinzeh, a young black woman, received the Presidential award "strengthens the hope of all minority women that we, too, can excel in research," Amara adds.

But Arinzeh's relationship with Amara is mutually beneficial. For in the end, it's knowing people like Amara, with her determination to succeed and yearning to walk unimpaired, that motivates Arinzeh to continue spending all those hours in the lab. ■