THE UNIVERSITY OF RHODE ISLAND

DIVISION OF RESEARCH AND ECONOMIC DEVELOPMENT

THINK BIG WE DO℠

Momentum:

Research & Innovation

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Fall 2016

Momentum:
Research & Innovation

Welcome to the latest issue of *Momentum: Research and Innovation*. In this issue, the broad spectrum of excellence in scholarly activity and research ongoing at the University of Rhode Island is highlighted. The University is very proud that we can show you the excellence in scholarly works in a wide range of subjects, from music to high technology. The wide breadth of scholarly excellence allows the University of Rhode Island to serve our students and faculty well, and is a major contributor to the University's reputation as a leading research university. We hope that you will enjoy this issue and come back to *Momentum: Research and Innovation* in the future to discover more about the University of Rhode Island.

Sincerely,

Gerald Sonnenfeld, Ph.D.
Vice President for Research
and Economic Development

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Complexity

Merging with Simplicity

written by **EMMA GAUTHIER '18**

Engineers are known for intricate details; their designs tend to involve a multitude of moving parts that are responsible for technological advances in all areas of daily life. But, while elaborate inventions improve our quality of life, Stephen Kennedy, assistant professor of biomedical and chemical engineering at the University of Rhode Island (URI), knows that complexity isn't always the answer, especially at the juncture where engineering and biology merge.

In his lab, Kennedy takes basic electromagnetic principles and applies them to create responsive hydrogels that doctors can surgically or hypodermically implant inside the human body.

Using different kinds of stimulation, including electric, magnetic and ultrasonic fields, these gels can release therapeutic payloads at different rates and times. These gels can contain more than one type of medication at a time. The hydrogels can be targeted, and then release their payloads depending on what, when, where and how the body needs treatment to fight injury and disease.

This method is particularly useful for cancer treatments and tissue regeneration, and is far less complicated than it seems.

"It has important applications, but inherently it's a very simple thing, a sponge that you can squish with a hand-held magnet, for instance," Kennedy says. "As engineers, we want to make things intricate and complicated and cool, but simplicity is sometimes best. When you put something in an animal or person, it has to actually be pretty simple; the more parts it's going to have, the less likely it is to actually work. Biology is complicated enough."

Explaining a potential use, Kennedy says that after a physician removes a tumor from a body, he or she would implant the gel in the tumor's former location — all in the same procedure – to locally deliver therapeutics to prevent tumor resurgence.

The gel is made from biomaterials formed by hydrophilic polymers, one of which is alginate, a product made from algae. Because the gel uses naturally derived molecules in its structure, the body won't reject it when it's implanted.

"It's an awesome material," Kennedy says.

Working with tissue regeneration involves a similar process. For instance, if a person has a large bone defect, the body won't regenerate bone on its own. Kennedy explains that when the defect is too big, doctors can use a strategy that places a material in the defect to act as a scaffold, upon which new bone may grow. Typically, biomaterials can be used as this kind of scaffolding to build upon. The cells that are recruited to rebuild the bone are not always bone cells, but are most likely stem cells that can later become bone cells.

"Once the cells arrive at the site, they need to be told what to do when they get there," Kennedy explains. "Using these gels, doctors can release different drugs at different time points to direct a sequence of regenerative events. This begins by getting stem cells to quickly repopulate that scaffold, which can be achieved by initially delivering drugs that recruit those stem cells."

After the initial delivery, those cells still need to grow. With the addition of subsequent deliveries, those cells can be directed to rapidly multiply and mature into healthy bone cells.

Kennedy notes that he and his lab team of five graduate and 12 undergraduate students are working to answer questions such as, "What do you deliver at what time points, and how much?" A key facet of the gel lies in its capability to release different drugs at different times.

"We need to implement the material, then see what gives the best regenerative outcome," Kennedy says. "Our systems afford that capability."

During cancer treatment, after delivering the first round of chemotherapy, Kennedy explains, many cancer cells can become resistant. A second dose of medication in the gel can be remotely administered at a later time to eradicate any of the remaining cancer cells without requiring a second surgery or injection.

Pictured left to right: URI chemical engineering Ph.D. students Tania Emi, Seyedeh Zahra Moafi, and biomedical and chemical engineering Assistant Professor Stephen Kennedy.

In both procedures, once the gel is inside the body, physicians can stimulate the gel using magnets, ultrasounds, or even light sources. When the gels are stimulated at different frequencies, they vibrate at different rates. The faster the gel vibrates – the more efficient drug releases, providing a means to externally regulate drug delivery doses. Different medical scenarios can call for different drug release regiments, according to Kennedy.

This overall delivery method enhances cancer cell destruction because the gel's targeted release provides tight control over drug concentrations right at the tumor site. In turn, the method minimizes side effects and saves the surrounding non-cancerous tissue. Because the drug deliveries are localized at the tumor site, doctors would be able to flexibly control the dose and period of time in which the drug is administered.

"In many therapies, constant chemotherapeutic concentrations over time are not necessarily optimal," says Kennedy. "When you change the concentration over time, that kills the tumor much faster, and keeps it from growing back."

These are only two of the projects currently under investigation in Kennedy's lab, where he broadly applies his expertise at the intersection of materials science, electromagnetics and biology.

"We are also adapting these stimuli-responsive gels to direct sequences of biological events critical in regenerating vascular tissues, programming the body's immune system to attack tumors, and for managing the inflammatory response in wound-healing applications," Kennedy says. "In other areas we are developing specialized materials for electrically interfacing with neural tissues, as well as electrically endowing orthopedic implant materials with properties that help facilitate their integration with existing bone."

In the future, he sees these stimuli-responsive gels as a cost-effective, outpatient procedure. He anticipates that it will be easier for physicians to adjust drug quantities being administered as needed.

In some circumstances, patients themselves could just use a handheld magnet.

"You need to be able to flexibly control when these events happen and our materials allow that," Kennedy says. "Part of the power of this lies within its simplicity. You don't need a trained person to wield a magnet."

In working in seemingly different scientific fields, Kennedy reminds his students that any one of these fields is inextricably linked to the others. He attributes his varying interests that led him to this point in his career, and being able to merge a background in electromagnetics, materials science with cellular and molecular biology, and stem cell technology. Kennedy uses his experiences to offer advice to his students:

"In medicine, technology and biology can't exist without the other. What good are these technological materials that we are developing if we can't demonstrate their medical and biological utility? The same could be said about medical approaches — medical advances must be driven by technology. Your ability to innovate is limited if you are stuck in a single trajectory. When you jump from one field to another, you're not changing your original background, rather, you are adding to it. These additions diversify your background and inherently put you in a position to innovate."

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"Using these gels, doctors can release different drugs at different time points to direct a sequence of regenerative events."
- Stephen Kennedy

Stephen Kennedy
assistant professor of biomedical & chemical engineering