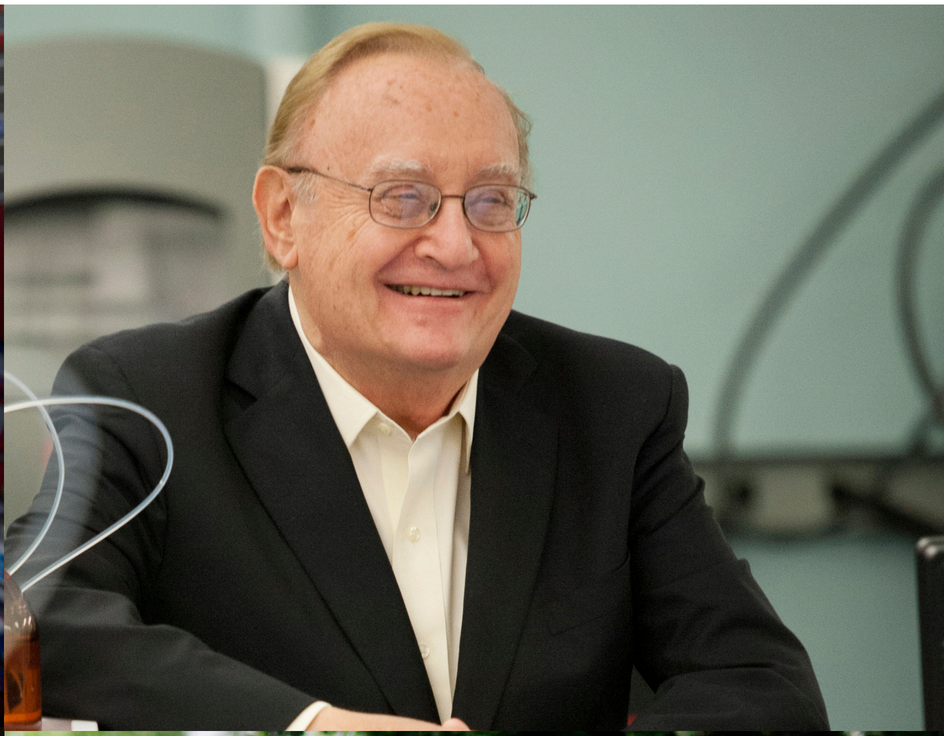
Northeastern University
College of Science

AROUND THE COLLEGE

Summer 2015



The rules of the water

June 8, 2015 - This summer, an interdisciplinary research team led by Marine and Environmental Sciences professor Geoff Trussell will study community organization and connectivity of rocky intertidal habitats throughout the Gulf of Maine. The project is intended to help inform the development of predictive ecological models that can be used to improve how these ecosystems are managed and preserved.

The study's goal is to identify common rules governing community organization that can be scaled up to explain broad biogeographic variation across the Gulf of Maine. The gulf spans 36,000 square miles, including the shores of Northeastern's Marine Science Center and extending as far north as the Canadian provinces of Nova Scotia and New Brunswick.

"Until you get a general understanding of rules that may apply across all communities, it's going to be very difficult to understand how to manage them," said Trussell, who is director of Northeastern's Marine Science Center in Nahant, Massachusetts, and chair of the Department of Marine and Environmental Sciences.

The research study — which is supported by a $1.7 million award from the National Science Foundation's Biological Oceanography program — has broad implications. According to Trussell, waters in the Gulf of Maine are warming at a faster rate than nearly all of the world's other saltwater ocean basins. Plus, he said, they're being increasingly invaded by non-native species.

The researchers will survey 22 sites throughout the Gulf of Maine to evaluate the variation in factors such as species composition, food availability, wave energy, and other environmental stressors and analyze what is driving the differences between these coastal marine communities. Trussell noted that past studies have historically focused on the southern Gulf of Maine. Theirs, he said, will be the first to focus on the entire Gulf in order to better understand the various factors driving individual community dynamics.

Trussell is the lead principal investigator on the project, which brings together experts in ecology, predictive modeling, and marine community connectivity. The team includes co-principal investigator Tarik Gouhier, an assistant professor whose lab in Nahant focuses on developing dynamical models to understand ecological and environmental processes; student researchers from the MSC; and researchers from the University of Massachusetts Boston, the Downeast Institute, and the University of Maine.

Trussell noted that his former doctoral student, Elizabeth Bryson, played a key role in research published last year in the journal *Ecological Monographs* showing distinct differences in how marine communities are structured in the northern Gulf compared to the south. These findings, he added, provided compelling evidence that more work needed to be done to inform adequate scaling of local rules that pertain to the entire Gulf of Maine.

"Here you have communities that superficially look similar," Trussell said. "They contain the same species and so on, but they have different processes operating to determine how they recover from disturbance and how they are ultimately organized."

These differing community dynamics are vast and complex. For many communities, coastal oceanography is a major factor, as it influences the delivery of species from one community to another. The abundance of certain species is also dictated by water temperature. Another factor is seaweed—in the northern Gulf it is a critical marine resource for harvesters and in the south it plays a key role in buffering many species from the heat stress.

Trussell added that invasive species—and how warming waters enhance their establishment—play a huge role in how these communities are organized.

"If we're going to be able to predict those impacts, we really need to understand how these communities work across this broad scale," he said.

Student designs sensor for ocean microplastic research

June 9, 2015 - More than 250 metric tons of microplastic are estimated to be floating in the world's oceans. And the cost to take a research vessel out to study those particles and their dispersion patterns can be astronomical.

To solve the high-cost issue, without sacrificing on data collection, a Northeastern student created a sensor to gather and categorize microplastics.

Ethan Edson, S'15, presented his "Mantaray" prototype sensor at RISE:2015 this past April and earned the undergraduate award in the Engineering and Technology category. He graduated in May with his bachelor's degree in environmental science.

As a first deployment this summer, Edson said he hopes to use the sensor to collect microplastics in Boston Harbor.

His inspiration for the project came while participating in the SEA Semester program in Woods Hole, Massachusetts, two years ago, when Edson was studying bacteria growth on microplastics that he collected by dragging a net behind a boat. He saw an opportunity to streamline the process and eliminate the need for manpower or a research vessel.

"It just seemed like there could be a better way to have a sensor that could collect microplastics," Edson said.

Microplastics are defined as particles that are smaller than five millimeters. Edson explained on his RISE poster that microplastics are becoming invasive in marine ecosystems and are harmful to marine species. Identifying global dispersal patterns is difficult because of diverse concentrations across the world's oceans.

The "Mantaray" features a flow-through system to pump sea surface water through itself. An optical sensor identifies microplastics within the water and stores them in one of 28 filters. The device would also include a GPS system to track where in the ocean the microplastics are collected, as well as a water temperature sensor and a salinity sensor.

Following RISE, Edson continued working on the apparatus that would hold the sensor when it's in water. One of the key components of the apparatus will be a solar panel on top so the sensor's batteries can stay charged.

"The biggest issue with oceanographic instruments is battery power," Edson explained. "Having a solar panel is pretty crucial and can make the deployment last longer."

In order to eliminate the need for a research vessel, Edson said he would like to explore the possibility of attaching the "Mantaray" to other ships that already travel through the ocean every day. "If people are going through the ocean anyway and don't mind strapping something to their boat, it might be an easy way to collect data," he said.

Funding for this project came from a Provost's Undergraduate Research and Creative Endeavors Award, and Edson did most of the work at Northeastern's Marine Science Center in Nahant, Massachusetts, under the direction of professor Mark Patterson, who holds joint appointments in the College of Science and the College of Engineering.

Edson has a patent pending on the sensor through Northeastern's Center for Research Innovation.

Former chair, professor retires after 36 years

June 17, 2015 - After 36 years of outstanding contribution to Northeastern University, its students, and the field of coastal geology, Dr. Peter S. Rosen retired as Associate Professor Emeritus on January 1, 2015.

Beyond serving as the chairperson for the Department of Earth and Environmental Sciences from 1997-2007, Dr. Rosen helped lead the "transformation of a classical geology department into an environmental science department."

It was this dedication to students and the department that made Dr. Rosen so influential within both the Northeastern and Boston communities. He was involved with the Boston Marine Studies Consortium, Northeastern's Muckenhoupt Scholarship Program, and Northeastern's Law and Public Policy Program. He was also known for his engagement with students, including his popular field trips for geology courses and the research he conducted with undergraduates.

Dr. Rosen's service to the field extended beyond his work at Northeastern. Primarily a coastal geologist, his areas of interest include sand dune and salt marsh process, the evolution of beaches and barrier islands, and the impacts of glaciation and sea level rise on shorelines. His fieldwork has taken him as far as Eastern Canada, the Caribbean, Brazil, and Israel, although he has spent most of his career in Massachusetts. "The diversity of shoreline processes is remarkable," he notes about the area inside Boston Harbor, which he is still studying with colleagues from Boston University.

His publications include over 100 papers, book chapters, abstracts, field guides, and technical reports, and he developed a new method for measuring wind-driven coastal sand transport. His research has also led to practical projects in the field, including study of the distribution of Native American archaeological sites in the Harbor and work on the evolution of seawall and wharf construction on the Massachusetts coastline.

Dr. Rosen plans to continue his contributions to the field of coastal geology, dedicating his time to research on shorelines and regulatory issues, and visiting the world's diverse shorelines.

All students and faculty involved in the marine and environmental sciences at Northeastern will benefit from Dr. Rosen's decades of passion and innovation, and the department as a whole extends its congratulations and thanks to a uniquely dedicated researcher and educator.

Science is the thing – helping humanity is the goal

June 23, 2015 - Ting Zhou is an associate professor in the College of Science's Department of Mathematics. Following a path that took her from her native China and Nanjing University, Zhou pursued and achieved her PhD at the University of Washington and subsequently arrived in Boston at Northeastern University.

If all math problems were as clear-cut as her journey, Zhou would be out of a job. But the main tenet of mathematics and science is discovery and that path isn't always clear. Luckily, Zhou derives satisfaction from both the math solutions and the collaborative process.

"Besides the satisfaction after solving a problem and discovering a new thing, which is 90 percent of the joy and excitement," she said. "I like the interaction and communication among mathematicians, who are so genuine and passionate about what they do. This is mutual between me and my collaborators, and I'm striving to make my students feel the same."

Zhou's passion has fueled her various fields of study: using partial differential equations (PDE) for real-life modeling while getting her masters at the University of Victoria; and leveraging the math behind inverse problems to focus on solutions for medical imaging and geophysical prospection.

In the case of inverse problems, she says the connection between math and physics is obvious. In fact, even the type of mathematical analysis used in solving such problems is a lot of times motivated by plain physics.

"I am fascinated by such math that you can visualize," said Zhou.

It's this type of math that often offers solutions that are immediately applicable in the real world. Focused on imaging technology, she and her colleagues used math to determine new ways to use current imaging techniques and to improve on them.

For instance, she used inverse problem solving to measure electromagnetic fields near the surface of the object of interest to reconstruct the electromagnetic property inside the object. Since property values vary dramatically depending on tissue types (cancerous vs. healthy tissue), she and her collaborator Pedro Caro were able to answer "the uniqueness question of such inverse problems for Maxwell's equations."

Blurring the lines between traditional science and science fiction, Zhou is also working on transformation optics based cloaking. That's right, cloaking. She explains that waves of light can be bent if you know how to modify electromagnetic fields.

"The idea is that the mathematics predicts certain design of an electromagnetic shell would bend electromagnetic waves (including lights)," said Zhou. "Away from the center region the shell encloses and return it back later to its original path. So whatever is inside the center is not visible. A motivation of such research is the advancement in material science, namely the availability of metamaterials, which allows customization of electromagnetic materials."

Lastly, going back to advances that can help medical professionals, she's working on coupled physics medical imaging modality. By combining two types of wave propagations, for example sound waves and optical waves, there is a hope that they can produce images with better contrast and higher resolution. Existing modalities include photo-acoustic tomography, which has produced very sharp images of blood vessels under skin.

If changing lives and delving into cool technology weren't enough, Zhou actually walks the walk. She professes that you need to love what you do – no matter what you're doing. She says that people need to know what they want to do so they can focus on discovery and not be distracted.

To that end, Northeastern and the College of Science have provided Zhou with an ideal environment. She says the collaborative atmosphere and the administration help make her job as a professor and researcher more productive and successful.

"The college oversees the faculty members in all the departments and they have a very good idea of their research strength and impact," said Zhou. "This makes them the best party to realize interdisciplinary collaborations. This happens not only inside the college, but among colleges too. As an applied mathematician, this is an important passage to see our research having impact on areas that is closer to real life."

The future for Zhou – as for all of us – is unwritten. She says that her dreams are in-line with her past successes, but also driven by her desire to discover.

"I have big dreams as everyone else, solving the most important problems and make great discoveries that change the world fundamentally," she said. "But most of the time, I am realistic and focus on any thing that has the potential to improve the life of the world using my skills."

As a professor, her goal is to teach and ignite a fire for discovery in her students. As a researcher, she wants to see her findings applied in imaging technologies broadly and successfully.

"Jackpot if I can see a real invisible cloak is built one day," said Zhou. "We are in a golden age of science. People believe in, almost blindly, that scientific discoveries always help the development of human kind. I believe that too. As the only subject in this realm, scientists/scientific community (including those in the universities, research departments of major technology companies and so on) have never been so powerful in the history and hence they don't help drive discovery, rather their work is to discover."

Undergraduate research leads to NSF graduate research fellow award

June 23, 2015 - Sara Williams remembers her first fieldwork experience well. It was after the BP oil spill and she, and a team of students under the direction of Dr. Mark Patterson, were using an autonomous underwater vehicle (AUV) to look for traces of oil in a Louisiana saltmarsh. "We had to walk the robot into this small lake where all of the fishermen dumped their fish heads and turkey necks," said Williams, "I remember long, hot days with hordes of mosquitoes and dangerous thunderstorms." While that sort of research may intimidate the average undergraduate, it hardly fazed Williams and has done nothing to deter her from her unrelenting focus on the pressing environmental questions at hand.

Of the more than 16,000 National Science Foundation graduate research fellowship applicants this year, only 2,000 were awarded. Among the promising graduate students that applied, the few picked were chosen for excellence in their area of research and their potential to continue pushing the boundaries of science's knowledge. It's a rare honor and represents a bright future in their field of interest. One of this year's recipients, Sara Williams, is currently a Research Technician at Northeastern's Marine Science Center and also an incoming graduate student in Northeastern's Ecology, Evolution, and Marine Biology PhD program.

A native of Richmond, Virginia, Williams showed an early affinity for water, getting her SCUBA diving certification at the young age of 15. Her love of the marine world continued through college at The College of William and Mary where she completed her undergraduate degree in physics with a minor in biology. For her honor's thesis she measured the mixing time of fluids inside the digestive system of corals. Dr. Mark Patterson, Williams' undergraduate thesis advisor and now doctoral advisor, explained, "Sara is a great example of how research begun while an undergraduate can have lasting influence on a person's career in science. She was willing to tackle challenging measurement problems in understanding how corals work as living machines."

Explaining the importance of coral reefs, Williams cites their use as a habitat for fisheries, rich biodiversity providing for new medical compounds, and natural barrier to storms. Unfortunately, our ability to protect these valuable resources is hindered by a lack of knowledge. "Just like how doctors need to understand how the human body works, we need to understand how corals work to see how they will respond to stress," said Williams. Corals are colonial organisms and their individual units, polyps, are connected by an "internal plumbing system," called the gastrovascular system. Williams appreciated the importance of understanding this system and drew upon her background in physics to design a novel method for analyzing the flow rate of fluid through these gastrovascular systems.

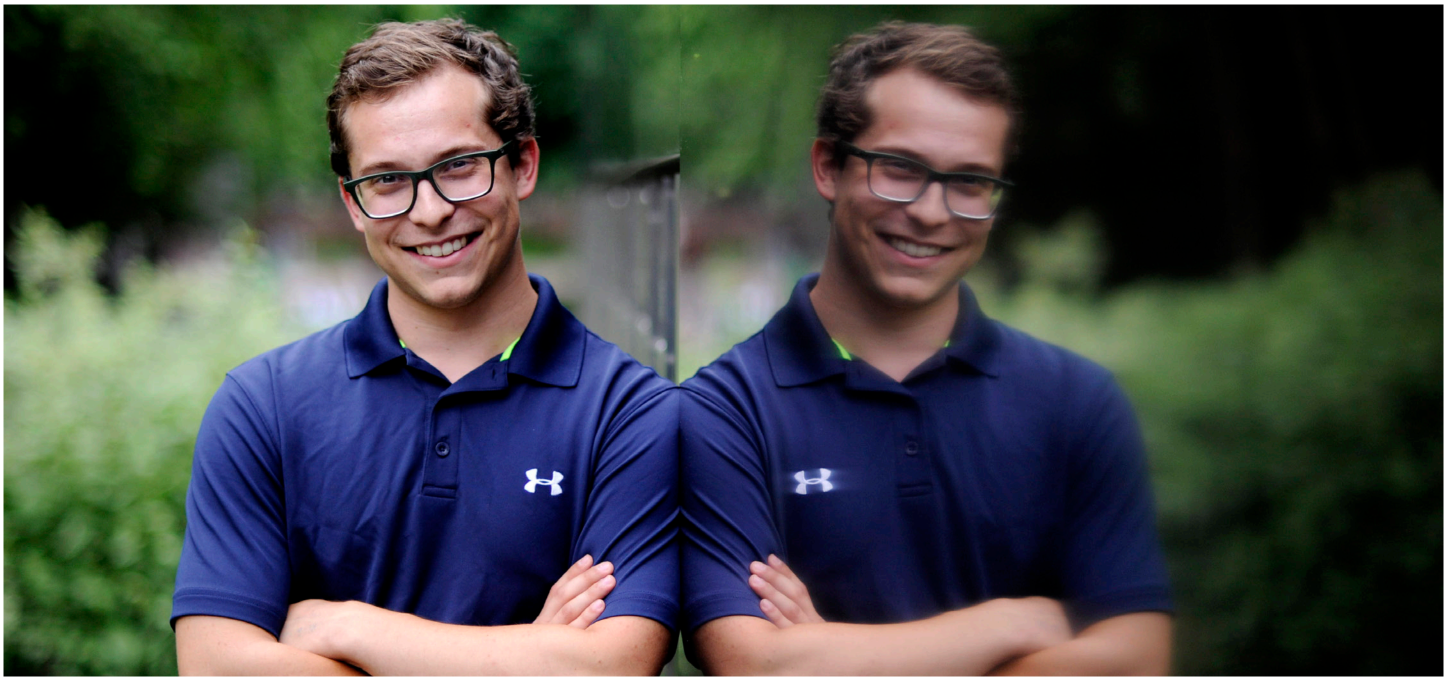
Williams realized that she could take advantage of the natural symbiotic algae that live inside coral tissue and produce oxygen in the presence of light. By turning off the light and then measuring the oxygen drop inside coral polyps with specialized glass microsensors inserted into the polyp's mouth, Williams could determine the "mixing time" of fluid within the coral gastrovascular system. From that breakthrough, and continued work, Williams has created predictive models that enable researchers to measure the "connectedness" of networks of polyps. Williams has proposed to study how different types of polyp connection affect how corals share resources and respond to environmental stress; and then, by using network theory, create a "6-degrees-of-coral-polyp-separation" model. This sort of predictive analysis ties in well with another of Williams' former projects that she undertook while working at Mote Marine Lab in Sarasota, FL as part of a NSF Research Experience for Undergraduates internship: mapping patches of coral reef to determine whether symptomatic corals were afflicted by contagious disease or eliciting an environmental response. Another long-term goal of Williams' research is to understand and predict which coral species are most affected by environmental stress based on their level of connectivity so that irreversible damage might be mitigated.

For other students and nascent researchers, Williams had the following advice: "you have to keep asking questions and make your own opportunities; you can't wait for people to just hand you a research project." She cited her own experience approaching her current mentor and adviser, Dr. Patterson, during her Introduction to Marine Science class. "When I started the course, I sat in the front row every day, and after the very last class of the semester I went up and just asked if I could work in his lab," said Williams. Explaining the appeal of Dr. Patterson's research, Williams said that it matched closely with what she had dreamed of doing, "I knew that his lab would be the key to my combining physics, biology, and diving while at the College of William and Mary."

Never one to miss out on an adventure, Williams took part in Fabien Cousteau's historic Mission 31 where, on top of doing fieldwork, she Skyped with Boston's Museum of Science from the world's only underwater research facility, Aquarius. Sixty feet beneath the ocean surface and nine miles off the coast of Key Largo, FL, Williams was explaining the physiology of coral to viewers 1,500 miles away. "Sara has a gift for communicating science to the lay public," said Dr. Patterson, "it has proven valuable in the efforts of the Marine Science Center to raise awareness of what we do in the area of Urban Coastal Sustainability globally." Other examples of Williams' ability to communicate have been through her help giving laboratory tours to Northeastern Board of Trustees, visiting congresspeople, as well as staff and donors. "She has also excelled at creating online lesson plans and other content for STEM education," said Dr. Patterson.

"I am especially pleased Sara has been recognized by the NSF for her intellectual drive to combine disparate fields to understand the problem of how corals cope with global warming and disease," said Patterson. "The NSF GFRP selection committee was impressed by Sara's ability to bridge the world of physics, mathematical modeling, and biology in her research."

Long-term, Williams sees herself in either academia or at a research institute like Mote Marine Lab. "I'd like to continue studying coral physiology and biomechanics, however, my proposed research can also be expanded to better understand other modular organisms and networks." When it comes to the future of her research, Williams isn't worried about reaching a roadblock. "My favorite aspect of science is that the answer to one question often creates so many more questions," she said. Williams is hopeful that her research on networks and resource sharing in coral will lead to applications for security, transportation, and other technical networks: "Corals are just another system of links and nodes, we can learn a lot from nature's networks and apply millions of years of evolutionary adaptations to improve upon society's infrastructure."



Swiss Mountains beckon physics student for dream co-op

June 24, 2015 - When it came time to choose a college, Nick DePorzio found a piece of information that solidified his choice to attend Northeastern.

One of the university's more than 2,900 co-op sites is CERN, the European Organization for Nuclear Research, which hosts the world's largest and most powerful particle accelerator. As DePorzio explained, CERN is the "holy grail" of destinations for anyone studying particle physics.

"Having that opportunity at your grasp as an undergraduate was really exciting," said DePorzio, S'17.

The physics major will finally grab hold of that opportunity next month, when he begins his work at CERN in Geneva, Switzerland, for his second co-op as a Northeastern student. He'll be working with College of Science professor Darien Wood and associate professor Emanuela Barberis.

CERN is the world's most complex experimental facility, built over a 10-year period by more than 10,000 collaborating scientists around the world. It gives researchers the chance to test physics theories, particularly through its proton-proton collision detectors.

This is an exciting time for the collider, which earlier this month went back online following a two-year hiatus for upgrades after it found the elusive Higgs Boson. Those upgrades included doubling the operating energy at which the protons are hurled at each other.

DePorzio will be tasked with monitoring a new trigger system that will determine which collision events look strong enough for further analysis. The new system was developed to compensate for the increased operating energy.

"The system looks to define the window of where to look for a certain event and the energy it produces," DePorzio said.

Because the particles are thrown around in the collider with such great energy and magnitude, DePorzio said he's excited to see first-hand the shift from introductory physics, where classical laws dictate how things move and operate, to a state where those laws really don't apply anymore.

This co-op will also be faster paced than DePorzio's first co-op, at least in terms of the speed the particles are moving. For his first co-op, DePorzio worked at the Laboratori Nazionali del Gran Sasso in Italy, where researchers test particles at the lowest energy possible.

On his first co-op, DePorzio maintained a video blog and interviewed researchers working in the lab to better explain the experiments taking place. He hopes to do something similar at the collider.

Researchers find the organization of the human brain to be nearly ideal

July 6, 2015 - Have you ever wondered why the human brain evolved the way it did?

A new study by Northeastern physicist Dmitri Krioukov and his colleagues suggests an answer: to expedite the transfer of information from one brain region to another, enabling us to operate at peak capacity.

The paper, published in the July 3 issue of *Nature Communications*, reveals that the structure of the human brain has an almost ideal network of connections—the links that permit information to travel from, say, the auditory cortex (responsible for hearing) to the motor cortex (responsible for movement) so we can do everything from raise our hand in class in response to a question to rock out to the beat of The 1975.

The findings represent more than a confirmation of our evolutionary progress. They could have important implications for pinpointing the cause of neurological disorders and eventually developing therapies to treat them.

"An optimal network in the brain would have the smallest number of connections possible, to minimize cost, and at the same time it would have maximum navigability—that is, the most direct pathways for routing signals from any possible source to any possible destination," says Krioukov. It's a balance, he explains, raising and lowering his hands to indicate a scale. The study presents a new strategy to find the connections that achieve that balance or, as he puts it, "the sweet spot."

Krioukov, an associate professor in the Department of Physics, studies networks, from those related to massive Internet datasets to those defining our brains. In the new research, he and his co-authors used sophisticated statistical analyses based on Nobel laureate John Nash's contributions to game theory to construct a map of an idealized brain network—one that optimized the transfer of information. They then compared the idealized map of the brain to a map of the brain's real network and asked the question "How close are the two?"

Remarkably so. They were surprised to learn that 89 percent of the connections in the idealized brain network showed up in the real brain network as well. "That means the brain was evolutionarily designed to be very, very close to what our algorithm shows," says Krioukov.

The scientists' strategy bucks tradition: It lets function—in this case, navigability—drive the structure of the idealized network, thereby showing which links are essential for optimal navigation. Most researchers in the field, says Krioukov, build models of the real network first, and only then address function, an approach that does not highlight the most crucial links.

The new strategy is also transferable to a variety of disciplines. The study, whose co-authors are at the Budapest University of Technology and Economics, mapped six diverse navigable networks in total, including that of the Internet, U.S. airports, and Hungarian roads. The Hungarian road network, for example, gave travelers the "luxury to go on a road trip without a map," the authors wrote.

Future applications of the research cross disciplines, too. Knowing what links in a network are the most critical for navigation tells you where to focus protective measures, whether the site is the Internet, roadways, train routes, or flight patterns. "Conversely, if you're a good guy facing a terrorist network, you know what links to attack first," says Krioukov. A systems designer could locate the missing connections necessary to maximize the navigability of a computer network and add them.

In the brain, the links existing in the idealized network are likely those required for normal brain function, says Krioukov. He points to a maze of magenta and turquoise tangles coursing through a brain illustration in his paper and traces the magenta trail, which is present in both the ideal and real brains. "So we suspect that they are the primary candidates to look at if some disease develops—to see if they are damaged or broken." Looking to the future, he speculates that once such links are identified, new drugs or surgical techniques could perhaps be developed to target them and repair, or circumvent, the damage.

"At the end of the day, what we are trying to do is to fix the diseased network so that it can resume its normal function," says Krioukov.

Why biology students have misconceptions about science

July 7, 2015 - Zebras developed stripes to avoid predators.

No, that statement wasn't ripped from the annals of *Who Wants to Be a Millionaire?* It's an example of a "misconception"—a term biology-education researchers use to describe a scientifically inaccurate idea held by biology students, even majors in the field.

In fact, new research by Northeastern associate professor John Coley and his team has found that both biology and non-biology majors are equally prone to agreeing with common scientific misconceptions. The difference is that biology majors give more systematic reasons for why they agree or disagree with the inaccurate ideas presented to them—a finding that points to the way they are taught science.

The findings, published earlier this year in *CBE-Life Sciences Education*, could change the way instructors teach science—and improve how students learn it.

Misconceptions come from intuitive thinking

In the study, Coley and his team surveyed Northeastern University students, both biology majors and non-biology majors, about whether or not they agreed with several scientific ideas—which unbeknownst to the students were inaccurate. Their study yielded some startling results, namely that biology majors agreed with common scientific misconceptions nearly as frequently as non-biology majors. But interestingly, biology majors were much more systematic in their reasoning for agreeing or disagreeing with these ideas—which the researchers say indicates that biology education itself is reinforcing these intuitive ways of thinking.

"A misconception is not just a factual error," says Coley, a psychologist in the College of Science who studies cognition. "It's a belief that, while contrary to how scientists understand a phenomenon, arises from our intuitive ways of organizing knowledge."

From evolution to cell biology, biology and non-biology majors agreed nearly to the same degree, differed on reasons

To dive deeply into the minds of biology students, Coley teamed up with Kimberly Tanner, a neurobiologist at San Francisco State University trained in science-education research. The study, which represents a breakthrough in interdisciplinary research, examines the thought processes driving students' misconceptions across biological disciplines, from evolution to ecology to cell biology.

The authors hypothesized that seemingly unrelated biological misconceptions—about cellular respiration, say, or plant nutrition—sprang not from the complexity of the material but from our intuitive ways of understanding the world. They posited three types of intuitive thinking: cause-effect driven ("zebras developed stripes for protection"), conflating internal properties with external features ("different cells have different DNA"), and imbuing nonhuman species with human characteristics ("plants get food from the soil").

To test their hypothesis, they asked 137 Northeastern undergraduates—69 biology majors with AP biology credit and 68 non-majors with non-science AP credit, to show comparable accomplishment—to indicate their level of agreement with six biological misconceptions, each linked to a type of intuitive thinking. They also asked the students to write down their reasoning.

The results were astonishing. The difference between how frequently both biology and non-biology majors agreed with misconceptions was "surprisingly small," says Coley, with 93 percent of biology majors and 98 percent of non-majors agreeing with at least one misconception. And both groups employed varied types of intuitive thinking. Remarkable—"amazing to me!" exclaims Tanner—was the tight correlation only among the biology majors between the type of reasoning they employed (say, cause-effect driven) and the type of misconception they agreed with ("zebras developed stripes to avoid predators").

The non-biology majors were "kind of promiscuous," notes Tanner, while the biology majors were far more systematic. "That suggests that biology education itself—the way students learn the subject—is reinforcing these intuitive ways of thinking and, potentially, reinforcing the misconceptions as well."

These are not isolated misunderstandings

Next, Coley and Tanner will look at students as they advance through their biological studies and at how biology teachers present information in the classroom. "Our work shows that these are not isolated misunderstandings, which is how they've been viewed," says Coley, "but rather that there are systems of misconceptions—all generated from underlying intuitive ways of thinking."

One way to counteract those systems, says Coley, would be to make students "explicitly aware," in the first week of an introductory class, of basic principles of cognitive science. "Intuitive ways of thinking are deeply embedded in our cognitive systems, and they're useful in everyday contexts," says Coley. "But they are not appropriate for explaining scientific phenomena.

"We need to help students think hard about how cognition works, not just in terms of how we memorize material, but in terms of how we organize knowledge in different domains."

So about those zebras

Thinking that zebras got stripes to dodge predators, Coley says, is an example of a misconception arising from a particular type of intuitive thinking: Our minds automatically attribute cause and effect to phenomena or events, even when there might be none.

But evolution doesn't involve "forward thinking," or intention—ancestral zebras didn't sprout stripes to blend in with their surroundings. Rather, given a population of zebra-like animals varying in stripedness, those with abundant verticals had a selective advantage over their plainer relatives: Hence, they were more successful at reproducing, and over time, the stripes prevailed.

Northeastern faculty conducting research with CERN

July 8, 2015 - What does it take to push the boundaries on the known facts of what the universe is made up of?

Sharp minds, for sure. But a lot of technology, no small amount of planning, and a surprising number of breaks are also needed.

The European Organization for Nuclear Research, or CERN (the acronym coming from the French "Conseil Européen pour la Recherche Nucléaire"), has been making groundbreaking discoveries in nuclear and particle physics since its establishment in 1952. The instruments at CERN are particle accelerators and detectors, including the world's largest and most powerful particle accelerator, the Large Hadron Collider (LHC). These machines smash beams of particles together at extremely high energies and record what occurs.

Ever since the beginning, when European scientists came together at the end of WWII and broke ground on the Franco-Swiss border, CERN has been an example of what can happen if people put their differences aside and work for a common goal. In the case of CERN, the differences are scientists of all different ages from every continent, and the goal is ultimate scientific advancement.

But cooperation is not the only skill necessary to keep breaking ground – it also takes meticulous organization.

The 26 experiments currently running at CERN have timelines that span from years to decades, including a project that Northeastern University is involved in, Compact Muon Solenoid (CMS), referring to key design aspects of the particle detector.

The challenge that the LHC must face is how such large, complex experiments can span such a long periods of time when the technology required to meet their goals might not even be invented yet. To combat this, the LHC has a schedule stretching out 20 years in advance, to 2035, outlining when it will be running and when it will be on a shutdown — periods of time, lasting about 18 months, when the systems can be updated and parts of the detector that are normally inaccessible can be repaired and upgraded.

These shutdowns are an integral part of keeping the projects running smoothly. While some aspects of CERN projects, such as advanced computer software, can be updated while the system is working, Toyoko Orimoto, assistant professor of physics at Northeastern, sees the shutdown time as valuable because it also allows the scientists time to catch up on all of the knowledge they might have garnered from experiments up until that time.

"[Being at CERN when the LHC is running] is great, but it can also be very demanding – everyone is trying to ensure that the detector is running smoothly, in addition to analyzing the data as it arrives," Orimoto explained. During the shutdown period, scientists get to update as much as the machinery does. "The scientists can make new tools, continue analyzing and publishing data, focus on projects that we didn't have the time for during running periods," Orimoto continued. Such a point is evidenced by the fact that publication rates out of CERN remained constant, even during the last shutdown.

Midyear of 2015 brought the startup of Run 2 of the LHC, which is now producing 13 TeV proton collisions, the highest particle collisions ever created in a laboratory. Scientists at CERN are coming down off of the wave that was the discovery of the Higgs Boson, the last puzzle piece in the Standard Model, which explains the universe's building blocks. The mission for this Run after last run's victory? "New Physics!" exclaims Orimoto. "The last run was about completing the Standard Model. But there is a lot that the Standard Model doesn't explain. There really is the need for new physics. We are looking for the next big discovery — dark matter, maybe other dimensions, leptoquarks."

The Northeastern CMS group receives support from the National Science Foundation and the Department of Energy, and includes four professors: Orimoto, Darien Wood, George Alverson, and Emanuela Barberis, as well as post-docs, graduate students, and co-op students. The CMS group at Northeastern is looking forward to analyzing Run 2 data, in order to show these science fiction topics as science fact. Many of the Northeastern CMS graduate students and post-docs are based at CERN, having helped upgrade the detector during the shutdown. Two new co-op students are also joining the team for the fall cycle: rising senior physics undergrad Nick Deporzio and rising fourth-year combined physics and mathematics undergrad Alex Coda. The two co-ops will be working on coding and detector development under Professors Barberis, Orimoto, and Wood.

With scientists (and particles) gathering momentum once again, it is an exciting time to be at CERN. Only time will tell what kind of new physics might be discovered.

A shark-infested co-op experience

July 9, 2015 - When given the chance to study and swim with sharks for a few months, most people would probably politely—or more likely impolitely—decline.

Not Northeastern student Eva Hayes, S'16. When she found a position available at the Bimini Sharklab in the Bahamas, she immediately applied for what she called her "dream co-op."

"Growing up in California I've always been fascinated with sharks," said Hayes, a combined major in international affairs and environmental sciences. "We'd swim in the ocean and were aware there could be sharks in there."

Her work at the lab

The Sharklab, a nonprofit established in 1990, works to advance knowledge of marine animal biology, especially sharks and rays, through cutting-edge field and laboratory research. Hayes has been working there since March, and her many responsibilities range from non-invasively tagging sharks for tracking purposes, to helping advanced degree students with their research projects.

A primary focus of the lab is studying the habits of juvenile lemon sharks. To help the lab collect data, Hayes worked some 12-hour night shifts at a lemon shark nursery tagging all of the lemon sharks they catch and release.

One of her most rewarding experiences happened when she first arrived there in the spring, during hammerhead shark season. It was then that she got to dive with great hammerheads—the largest of the species—and help tag them.

"This co-op has definitely helped me delve into the shark world," Hayes said. "I'm very interested in shark habitat loss, which I have seen a direct impact of here."

Beyond what she has learned about sharks, Hayes said she has also gained experience in community outreach and education, and in designing experiments.

Sharks are in the news

Sharks have been making a lot of headlines in recent weeks due to a string of attacks off the coast of North Carolina. Hayes noted that her Sharklab colleagues have been keeping a close eye on the news, and the belief is that the attacks could be related to a number of factors. Among them are that warmer ocean temperatures are resulting in increased shark metabolism, and that the water closer to shore is saltier than normal.

Experts say that bull sharks are among those thought to be involved in these incidents. In fact, Hayes has had two encounters with bull sharks, which she described as "unpredictable," during her co-op at Bimini. She said both times were a bit surprising: one was while she was diving with hammerheads and the other was when she was swimming after work. She was not attacked in either case.

"In the case of shark attacks, they are doing test bites," Hayes explained, cautioning swimmers to be aware of their surroundings when they're in the ocean. "It's a case of mistaken identity. They are trying to feed but they aren't interested in humans."

This week also happens to be "Shark Week," Discovery Channel's weeklong dedication to all things sharks. "It's super fun for us because we just really love sharks," Hayes said, "and we love it because it gives sharks positive media attention."

Professor turns into coral polyp for Comic-Con

July 10, 2015 - Northeastern professor Mark Patterson never imagined he'd one day attend Comic-Con, much less in costume. But there he was Thursday afternoon dressed as a coral polyp, walking around Exhibit Hall amid the thousands of visitors worldwide who flock to the annual pop-culture convention in San Diego.

Patterson, an expert in marine robotics who holds joint appointments in the College of Science and the College of Engineering, will participate in a panel discussion Friday focused on Aquaman; he and other experts will discuss their experiences living underwater and how science is leading to new breakthroughs that are bringing humans closer than ever to becoming aquatic beings. For his part, Patterson has visited and lived in the underwater research lab Aquarius numerous times and last summer participated in Mission 31, a 31-day expedition off Florida's coast.

But a day earlier, Patterson used his Comic-Con 2015 experience to raise awareness about the dangers of marine creatures ingesting microplastics in the ocean. Ethan Edson, S'15, an undergraduate in his lab at the Marine Science Center, has developed a low-cost prototype, called the MantaRay, that is equipped with a sensor to measure microplastic concentrations in bodies of water. Edson presented the research and received an award at RISE:2015 in April.

"I've never been to Comic-Con, and this will be an interesting way to raise awareness about urban coastal sustainability," Patterson said by phone on Thursday afternoon, moments before heading over to Comic-Con by trolley, decked out in full costume.

He added, "I never imagined going, even though I love movies with action heroes and ones that have underwater themes, like The Abyss, which I've seen over and over and over."

The costume

At Comic-Con, Patterson walked the room alongside others dressed as Storm Troopers, superheroes, and other pop-culture icons. His coral polyp costume includes a 3XL-size salmon-colored men's jersey and a ring around his neck sprouting homemade tentacles; polyps use tentacles to catch microscopic animal life. The costume's gut area also features a cut-away of a coral polyp's digestive system to show where the marine creature has ingested microplastics.

He also carried a scale model of the MantaRay to explain to interested onlookers how it works.

"I'm hoping a lot of people stop me and say, 'What the heck is this all about?'" he said.

The dangers of microplastics

Not only was Patterson thrilled to be attending Comic-Con, but he also saw is as a great outreach opportunity. Microplastics, he explained, are particles that are five millimeters in size and are becoming pervasive in the world's oceans due to pollution. Ingesting these small particles, he said, can cause marine organisms to develop a host of ingestion problems and can also cause harmful pollutants and bacteria to be transported around the world.

Patterson said there is a critical need for improving how microplastics are tracked and monitored. Now, this process takes place by dragging a small net behind a research vessel and counting the particles present in that given volume of water. MantaRay, he said, addresses the need for a cheaper, more reliable autonomous sensor to perform this task and collect data on plastic dispersion.

Chemistry professor, Bradstreet Chair consults FDA committees

July 20, 2015 - Professor William Hancock, the Bradstreet Chair in Chemistry and Chemical Biology and a professor in the Barnett Institute, has been invited to serve as a consultant to the Advisory Committee for Pharmaceutical Science and Clinical Pharmacology in the Center for Drug Evaluation and Research (CDER) at the Food and Drug Administration (FDA).

CDER advisory committees provide the FDA with independent expert advice on scientific, technical, and policy matters in more than 50 different areas, ranging from antimicrobial drugs to gene therapies to dental products, and each committee typically meets two to four times a year. Advisory committee consultants may be asked to serve on a number of different committees depending on their expertise.

Dr. Hancock, an expert in protein drugs, says he anticipates advising on analytical, manufacturing, formation, and quality control issues. His career in analytical biotechnology has involved working with and for the FDA in the past: in 1982, he presented research at an FDA meeting supporting the approval of synthetic insulin as a therapy for diabetes, which led to the agency accepting novel bioanalytical assays as evidence in submissions for new protein drugs. Shortly afterwards, he joined the FDA as a visiting scientist, establishing a HPLC assay for the activity of insulin products.

As an advisory committee consultant, Dr. Hancock, along with other advisors, may be asked to provide advice on scientific and technical issues concerning the safety and effectiveness of drug products for use in the treatment of a broad spectrum of human diseases, and as required, the quality characteristics which such drugs purport or are represented to have, and as required, any other product for which the Food and Drug Administration has regulatory responsibility, and make appropriate recommendations to the Commissioner of Food and Drugs. Advisory committees' recommendations are not binding but are influential.

Continuing his work at the intersection of academia, industry, and regulatory policy, Dr. Hancock's research group has developed new analytical approaches to characterize a number of protein drugs, including human growth hormone, gamma-interferon, tissue plasminogen activator and antibodies. In these studies his group has also pioneered the application of "hyphenated" chromatography-mass spectrometry for product characterization and to facilitate regulatory approval.

Dr. Hancock has participated in other FDA sponsored meetings such as the "Well Characterized Biotechnology Product" and also testified before the Senate Judiciary Committee on "The Law of Biologic Medicine," while continuing to translate biotechnology from the laboratory to industrial practice, eventually resulting in his invitation to join the FDA's group of advisory committee consultants.

Through his service with the advisory committees, Dr. Hancock will be able to use his expertise to advise the FDA on the safety and effectiveness of new protein drugs and shape the future development of novel therapeutics.

Two humanitarians bring hope to promising students in Kenya

July 23, 2015 - On the final afternoon of their 10-day humanitarian mission to Kenya, Chelsey Goldberg and Alexa Armstrong reconnected with a boy named Sammuel and then took him to the optometrist. Sammuel, 10, struggled to see, and exposure to the sun burned his eyes something fierce.

"We were well-versed on his condition," said Goldberg, a fifth-year human services major at Northeastern University, "and we knew that we could potentially save him from becoming blind by taking him to the eye doctor."

In short order, the optometrist gave Sammuel a routine exam and concluded that he was suffering from allergies, which were damaging his lenses. To alleviate his pain, he prescribed an antibiotic and provided him a pair of anti-glare prescription glasses.

Goldberg and Armstrong doled out $75 for the service, which comprised the exam, the medication, and the specs, and Sammuel beamed with joy. Finally, he could see.

"I'm feeling great!" Sammuel told Goldberg, after posing for a photo in his new glasses. Goldberg, for her part, could not contain her glee. "To change this kid's life," she noted in a recent phone interview, "was one of the best feelings in the world."

Sammuel's story is but one of several uplifting anecdotes that Goldberg shared, a single tale amid a handful of hopeful narratives derived from the young humanitarian's life-changing experiences in Kenya.

Care for Kenya

Goldberg, SSH'16, and Armstrong, S'16, departed for the East African country on July 3, intent on delivering school supplies and other essential goods to some five-dozen impoverished yet promising students in two cities: Eldoret and Nakuru.

The duo volunteered under the auspices of True Start Athletics' Care for Kenya project, which seeks to provide particularly needy students with the tools to succeed in the classroom. They divided their time in each city equally, first donating backpacks, storybooks, and encyclopedias to students in Eldoret, and then doling out supplies to similarly studious kids in Nakuru.

The altruistic expedition, Goldberg explained, dovetailed with her longstanding interest in global service. "The human services field is all about helping people," she said, "and giving back to the community is one of my biggest passions."

Goldberg and Armstrong raised more than $2,000 for their humanitarian mission through the Northeastern Fund's Catalyst program, which makes it easy to follow, connect with, and support the university's most inspiring student projects. And they harnessed the power of their positions on Northeastern's Student-Athlete Advisory Committee—Goldberg is the president, Armstrong the vice-president—to launch a school supplies drive, wherein student-athletes donated pencils, tennis balls, and flying discs to the youngsters.

"We wanted to do our part to bring as many supplies to Kenya as we could," said Goldberg, a former forward on the women's hockey team, "and the drive sounded like the perfect idea to get a lot of athletes involved."

Family ties

Goldberg and Armstrong interviewed scores of students at each of the six schools they visited, taking notes on their material needs, their home lives, and their hobbies. After collecting the data and donating some items, they traveled into town via safari van to purchase more clothing, sports equipment, and educational books for the kids, whose ages ranged from 5 to 15. One studious teen named Bryan, an eighth-grader at the Kelewet primary school in Nakuru, where the Northeastern humanitarians first met Sammuel, asked for a test practice book with which to prepare for his upcoming secondary school exam.

"He is a very smart young man, who has dreams to become an engineer," Goldberg blogged, explaining Bryan's story. "He cannot afford secondary school, but he is such a brilliant student that truly enjoys school. Hopefully we will be able to get him to where he would like to go."

Goldberg and Armstrong also donated money to particularly needy families in behalf of True Start Athletics. Two cousins from the Bwayi School in Eldoret—a 14 year-old named Matthew and a 15 year-old named Peter—received $220. Peter, whose parents died in tribal clashes, and Matthew, whose father makes 50 cents per day chopping and selling firewood, live in a small mud hut, whose cramped space is filled with 10 other family members. It's not uncommon for them to eat leaves for dinner, and when Goldberg and Armstrong showed up and handed them the money, Matthew's mom and dad started crying.

"It was probably the most emotional and rewarding experience of my life," Goldberg recalled. "They were speechless and I didn't know what to say because I had never been exposed to something like this."

A relatively small amount of money goes a long way in Kenya—a can of coke is 58 cents, a dozen eggs $1.57—and the donation, Goldberg noted, will help keep the family afloat for more than a year.

Two humanitarians bring hope to promising students in Kenya (continued)

A new life for Edda

One of the most heartrending stories Goldberg told me focused on Edda, an undernourished 14 year-old girl who loves school and dreams of becoming a nurse.

Goldberg and Edda struck up a friendship some two weeks ago, when the former met the latter during her visit to the Park View primary school in Nakuru. Edda, Goldberg learned, was on the verge of being sold off into marriage by her alcoholic father, who last year sold her 15 year-old sister for $240. The only way to protect Edda from suffering the same fate, Goldberg explained, was to remove her from her home, and then enroll her in the local boarding school. After getting permission from Edda's mother, Goldberg and Armstrong did just that, paying for the tuition for her first term, which she began earlier this week.

"I can't believe you're here," Edda told Goldberg in Swahili, after her new friend had taken her shopping for her boarding school uniform. Noted Goldberg: "It means so much knowing that we could change her life."

There's no doubt that Goldberg and Armstrong's work in Kenya made a distinctly positive impact on scores of studious kids and their families. What's also without debate is the mission's life-changing effect on the young humanitarians themselves.

Future dreams

Goldberg has long dreamed of becoming a motivational speaker. She once pictured herself atop a stage, looking out before a sea of hapless athletes, down on their luck men and women who'd struggled to overcome injuries and disappointing performances. She could relate to them, she thought, she could tell them how she broke both her legs playing hockey, underwent multiple surgeries, and then considered quitting the sport she loved. And she could inspire them too, sharing how she harnessed her optimism, how she rehabbed like crazy, how she overcame adversity—and the fear of re-injury— to go on to play 90 games for the Huskies.

But then she visited Kenya, and the scope of her career dreams expanded. Witnessing the living conditions of the vast majority of Kenyans, she said, many of whom live in mud huts or in tarps on the roadside, put her life in perspective and compelled her to reconsider the scale of her professional aspirations.

"We have been born into opportunity," Goldberg explained. "When people here start having trouble with their jobs or questioning their future path, they should realize that they don't have it so badly." No longer, she told me, does she want to limit herself to an audience of athletes. Now, she said, she wants to target "all people who are feeling down for whatever reason and work with them to overcome their negativity."

Goldberg will put her motivational speaking skills to work this fall, when she begins a co-op with Dale Carnegie Training, the nation's leader in professional and corporate development. Her focus, her manager told her, will be the millennial generation, members of Generation Y for whom she will give inspirational presentations. "He thinks I have the power to motivate and inspire people in my generation to keep succeeding and developing," Goldberg said.

International co-op boosts student's interest in sustainability

July 27, 2015 - Marley Kimelman, S/SSH'18, spent his first co-op experience at Northeastern immersed in one international city's green initiatives and environmental projects. He learned them, walked them, pitched them, and blogged them.

Kimelman, a rising third-year student and combined major in environmental studies and international affairs, was on co-op from January to July in Cape Town, South Africa, in the city's Environmental Resource Management Department. He said his proudest achievement was helping to reinvigorate a stagnant water heritage project. The city wanted to showcase water appreciation and its importance to the city's history, and Kimelman's boss tapped him and a colleague to design an initiative that would accomplish this objective.

Ultimately, they developed a walking tour across the city featuring stops at water tunnels, dams, treatment plants, reservoirs, and a yet-to-be-built museum. Kimelman conducted extensive research and wrote a feasibility report outlining the project, including the route, the budget, and the economic impact, as well as his own recommendations.

The goals of the project, he said, are two-fold: to explore the city's rich water history and to raise awareness for protecting and conserving water resources.

"That was the coolest part of the co-op, working on this project every day from start to finish," said Kimelman, who passed the project along to another city employee upon completing his co-op. "It's been given the go-ahead, and it was very rewarding to be a part of it."

Public outreach

Beyond this project, Kimelman was involved in the city's green initiatives in many other ways. He attended city meetings on sustainability issues and did outreach to promote these efforts to business and community stakeholders as well as to the public at large.

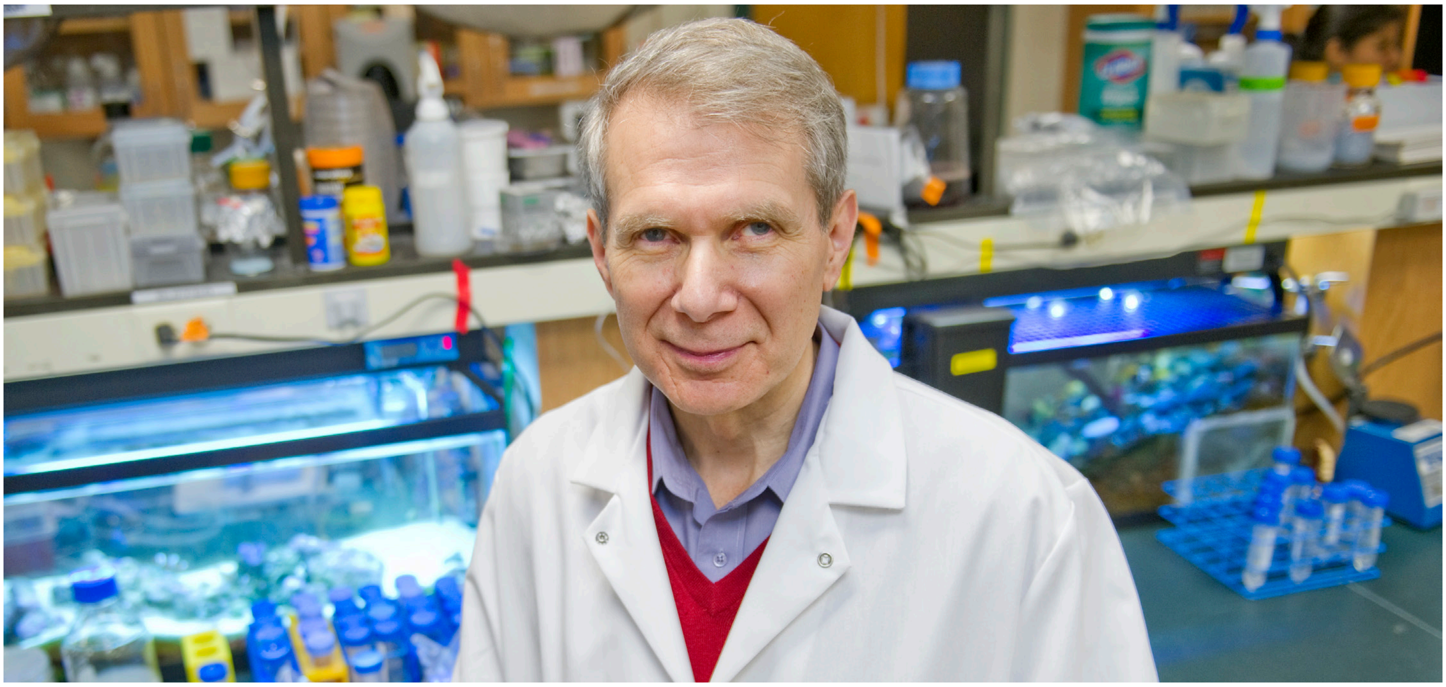
Kimelman noted that his co-op in Cape Town came as the city pushed to reinvest in and attract more people to its green spaces, one of which is Trafalgar Park. He said this park, located in the Cape Town suburb of Woodstock, has been underutilized and was fenced off from local businesses. Part of his job was going door-to-door pitching business owners on the benefits of investing in the park, some tips for which he sought from other thriving city park managers. He also worked on a program to bring a day-long outdoor classroom in the park for teachers and students from nearby schools.

Green blog

During Kimelman's co-op, another unexpected opportunity arose: bringing increased attention to the Cape Town Green Map, which highlights the city's many green spaces and sustainability projects. To help promote the map, he started a blog that featured his first-person accounts of visiting locations such as a recycling facility, an organic composting farm, and a wine farm that uses biodynamic agricultural practices. The blog, he said, helped "bring a voice" to these interesting places, and his posts were promoted via social media.

Kimelman explained that he gained invaluable experience on this co-op, particularly with regard to learning how a city's sustainability programs go from inception to implementation. He's looking forward to applying his new knowledge in the classroom this fall and in his role as director of marketing and public relations for the Husky Environmental Action Team, the student organization also known as HEAT.

"I learned more than I ever thought I could," Kimelman said of his co-op, adding that the experience opened his eyes to other work opportunities in the environmental sector beyond city government. He pointed in particular to a potential career with an environmental law firm, a social enterprise, or a non-governmental organization.



New research opens the door for treatment of relapsing bacterial infections

July 29, 2015 - It's one thing to grow bacteria in a test tube, perform a screen in the lab, and find a mutation in the pathogen's genes. It's a whole other thing, and much rarer, to find the exact same mutation in nature—in this case, in E. coli in urine samples from some 500 patients suffering from relapsing urinary tract infections.

The confluent discovery, by University Distinguished Professor Kim Lewis and his colleagues, was published on Wednesday in the journal *Nature*. It could put people with relapsing UTIs on the fast track for a new therapeutic regimen that Lewis described in an earlier paper.

"We took a large collection of E. coli isolates from patients with relapsing UTIs," explains Lewis, who is director of the Antimicrobial Discovery Center. "And we found that quite a number of those isolates had exactly the same mutation—in a gene called hipA—that we and other scientists have seen in test-tube experiments."

She was delighted by what she saw: hipA leapt to the fore in both populations. Pooja Balani, a doctoral student in Lewis' lab at the time of the study and a first author of the paper, spent countless hours performing a genetic screen with then Northeastern research assistant professor Marin Vulić and poring over both test-tube cultures of E. coli and patients' UTI isolates, in search of hipA mutations.

The "persister" breakthrough

An estimated 150 million UTIs occur each year worldwide, accounting for $6 billion in healthcare costs, according to the American Urological Association. The bacterium E. coli is responsible for the majority of them. Antibiotics are the standard treatment, but often the infection returns when treatment is stopped.

Lewis' lab had spent years trying to learn why, and in 2001 published a paper that brought the answer into the light of day: A subpopulation of bacterial cells called "persisters" was conferring antibiotic "tolerance."

Antibiotic tolerance is distinct from antibiotic "resistance," which occurs when a pathogen acquires a genetic mutation that allows it to code for a protein that destroys the antibiotic. Think of it this way: With resistance, the bacteria brandish a new killer weapon. With tolerance, the bacteria hide in a foxhole, waiting till the enemy has fled. Then they come out and multiply.

Bacteria are one-cell organisms. To reproduce, they simply divide: One cell becomes two cells, and so on, until an army of progeny infect the host—here, a person's urinary tract. But sometimes the division results in one active bacteria cell, which continues to grow and divide, and one that is alive but stops growing—it is dormant, existing in what Lewis calls "a sporelike state." That is a persister cell.

"There's a small subpopulation of persisters that are formed by all pathogens we've studied so far," says Lewis. Because antibiotics attack only actively functioning bacterial cells, he says, persisters escape the onslaught.

"Persisters are like a bet-hedging defense strategy for bacteria," says Balani. "Ultimately they save the population."

From the lab to the bedside

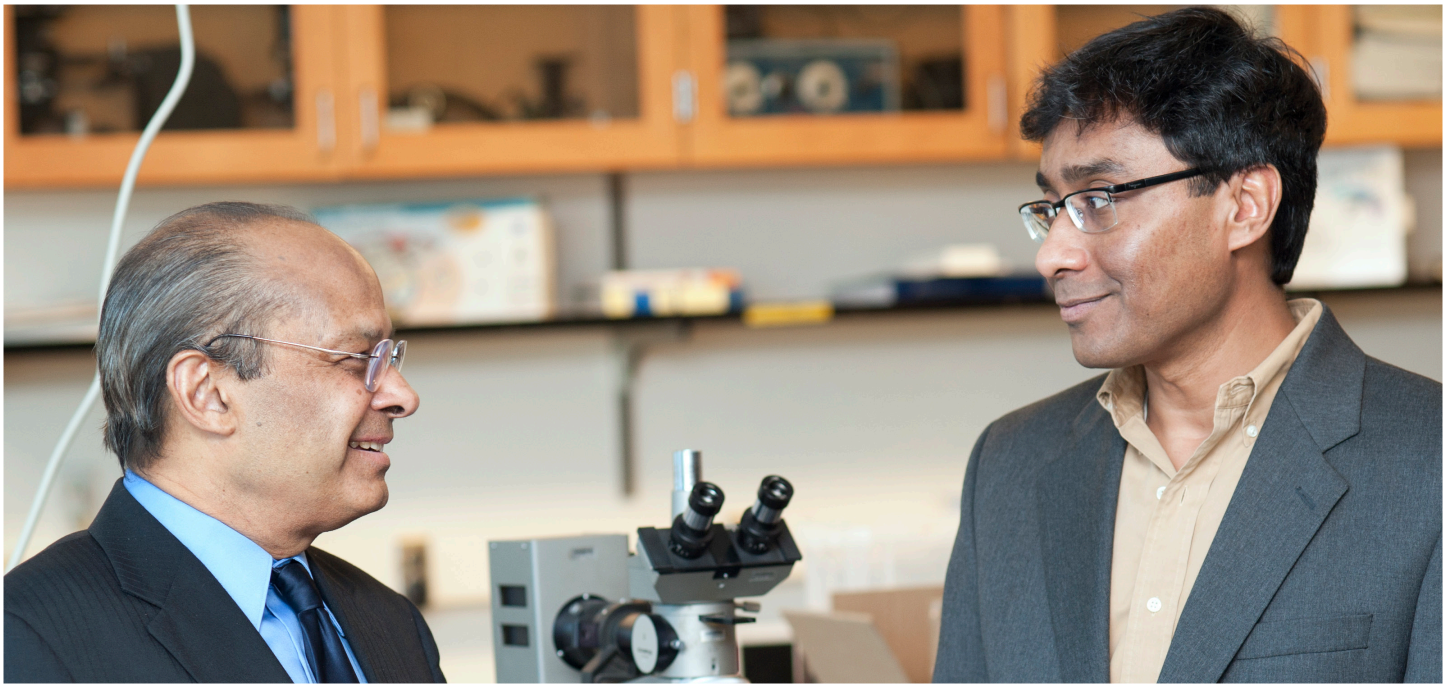
Collaborators in the new study included Maria A. Schumacher, Richard G. Brennan, and their students at Duke University School of Medicine, who analyzed the structure of hipA to determine how the mutation increased production of persister cells. What they found was a molecular balancing act gone awry.

The hipA gene codes for a protein—a toxin. The toxin is usually held in check by another protein, an antitoxin, that is coded for by another gene, hipB. Toxin-antitoxin gene pairs are "scattered around the chromosomes of all bacteria we know of," says Lewis. A mutation in either gene, however, can throw the balance off kilter. Hence, the more toxin produced by hipA, the more likely the cell will shut down—that is, become a persister. "The hipA mutation gives rise to about 1,000 times more persisters than a gene without it," says Lewis.

Knowing this genetic mechanism could enable clinicians to customize treatment for relapsing UTIs. "You can track whether your patient has E. coli with a hipA mutation, and if so, introduce a pulse-dosing regimen," says Lewis, citing his earlier paper about pulse dosing and the pathogen that causes Lyme disease.

Pulse dosing, he says, is straightforward: You give the patient an antibiotic and it kills all the growing cells. Then the persister cells start "waking up." But before they can divide to form a new population, you hit them with the antibiotic again.

"In a test tube, if you repeat this a couple of times, you can completely eradicate the population," Lewis says. "I believe that the same thing can be done in people."



From cameras to computers, new material could change how we work and play

July 31, 2015 - Serendipity has as much a place in science as in love.

That's what Northeastern physicists Swastik Kar and Srinivas Sridhar found during their four-year project to modify graphene, a stronger-than-steel infinitesimally thin lattice of tightly packed carbon atoms. Primarily funded by the Army Research Laboratory and Defense Advanced Research Projects Agency, or DARPA, the researchers were charged with imbuing the decade-old material with thermal sensitivity for use in infrared imaging devices such as night-vision goggles for the military.

What they unearthed, published Friday in the journal *Science Advances*, was so much more: an entirely new material spun out of boron, nitrogen, carbon, and oxygen that shows evidence of magnetic, optical, and electrical properties as well as DARPA's sought-after thermal ones. Its potential applications run the gamut: from 20-megapixel arrays for cellphone cameras to photo detectors to atomically thin transistors that when multiplied by the billions could fuel computers.

"We had to start from scratch and build everything," says Kar, an assistant professor of physics in the College of Science. "We were on a journey, creating a new path, a new direction of research."

The pair was familiar with "alloys," controlled combinations of elements that resulted in materials with properties that surpassed graphene's—for example, the addition of boron and nitrogen to graphene's carbon to connote the conductivity necessary to produce an electrical insulator. But no one had ever thought of choosing oxygen to add to the mix.

What led the Northeastern researchers to do so?

"Well, we didn't choose oxygen," says Kar, smiling broadly. "Oxygen chose us."

Oxygen, of course, is everywhere. Indeed, Kar and Sridhar spent a lot of time trying to get rid of the oxygen seeping into their brew, worried that it would contaminate the "pure" material they were seeking to develop.

"That's where the Aha! moment happened for us," says Kar. "We realized we could not ignore the role that oxygen plays in the way these elements mix together."

"So instead of trying to remove oxygen, we thought: Let's control its introduction," adds Sridhar, the Arts and Sciences Distinguished Professor of Physics and director of Northeastern's Electronic Materials Research Institute.

Oxygen, it turned out, was behaving in the reaction chamber in a way the scientists had never anticipated: It was determining how the other elements—the boron, carbon, and nitrogen—combined in a solid, crystal form, while also inserting itself into the lattice. The trace amounts of oxygen were, metaphorically, "etching away" some of the patches of carbon, explains Kar, making room for the boron and nitrogen to fill the gaps.

"It was as if the oxygen was controlling the geometric structure," says Sridhar.

They named the new material, sensibly, 2D-BNCO, representing the four elements in the mix and the two-dimensionality of the super-thin lightweight material, and set about characterizing and manufacturing it, to ensure it was both reproducible and scalable. That meant investigating the myriad permutations of the four ingredients, holding three constant while varying the measurement of the remaining one, and vice versa, multiple times over.

After each trial, they analyzed the structure and the functional properties of the product—electrical, optical—using electron microscopes and spectroscopic tools, and collaborated with computational physicists, who created models of the structures to see if the configurations would be feasible in the real world.

Next they will examine the new material's mechanical properties and begin to experimentally validate the magnetic ones conferred, surprisingly, by the intermingling of these four nonmagnetic elements. "You begin to see very quickly how complicated that process is," says Kar.

Helping with that complexity were collaborators from around the globe. In addition to Northeastern associate research scientists, postdoctoral fellows, and graduate students, contributors included researchers in government, industry, and academia from the United States, Mexico, and India.

"There is still a long way to go but there are clear indications that we can tune the electrical properties of these materials," says Sridhar. "And if we find the right combination, we will very likely get to that point where we reach the thermal sensitivity that DARPA was initially looking for as well as many as-yet unforeseen applications."

Researchers in Shansky Lab make cover of Biological Psychiatry

August 6, 2015 - Rebecca Shansky, assistant professor of psychology at Northeastern University, and her research team have spent two years working on their most recent publication. The article, Sex-Specific Neuroanatomical Correlates of Fear Expression in Prefrontal-Amygdala Circuits, was picked up by *Biological Psychiatry,* one of the most highly cited and well-recognized journals in the field of neuroscience. A few months later, Shansky and her collaborators were notified of the icing on the cake: the paper would be the cover story of the August 2015 print issue of the journal.

The publication centers on how the brain responds to stress on the neuroanatomical level, and differences in fear behavior between males and females. Graduate student Tina Gruene spearheaded the research.

“I gave Tina the project, and she mostly did the whole thing herself,” Shansky said. “She’s amazing.”

The journal cover features a stunning visual of a pyramidal neuron, captured in Shansky’s lab by unique neural imaging technologies. Besides being visually arresting, the high-resolution images allow for more precision in interpretation.

“The better images you have, the more accurate your data are going to be,” Shansky said.

The study itself focuses mainly on a common type of learned fear behavior known as “freezing.” Shansky and Gruene, along with a team of undergraduate assistants, sought out to discover potential differences between male and female responses.

Although they did not report an overall difference in freezing levels for males and females, the researchers did uncover some small but significant differences within subpopulations of both sexes. For example, females with high levels of estrogen showed less freezing than those with low estrogen after extinction conditioning.

The study also suggested an exciting new area for exploration of patterns of fear behavior. Freezing is the outward manifestation of fear most commonly studied by neuroscientists, but Shansky and Gruene also observed a previously unstudied fear response–darting around enclosures.

Shansky is encouraged by this new development. “We’re trying to understand the natural differences in behavior and the neural mechanisms that underlie each of these,” she said. “The darting behavior is a new kind of fear expression that no one has really talked about.”

These recent discoveries as well as ongoing research in Shansky’s lab may have implications regarding current treatment of fear-related disorders in humans, such as Post-Traumatic Stress Disorder (PTSD). According to Shansky, women are twice as likely to develop these conditions, so further research may lead to more gender-specific treatment for anxiety disorders.

How we feel what we feel

August 10, 2015 - A recent *New York Times* Sunday Review piece by Lisa Feldman Barrett, University Distinguished Professor of Psychology, dismantles the age-old misconception that individual emotions—anger, disgust, fear, sadness, joy—arise from specific "blobs of brain circuitry" anchored in discrete regions of the human brain. Barrett's own groundbreaking research, conducted in the Interdisciplinary Affective Science Laboratory, gives the lie to this "blob-ology" model. In a comprehensive analysis of neuroimaging studies over a 15-year span, she and her colleagues showed that, in reality, a set of interacting brain regions are active during a whole slew of emotional states. None of these brain regions is specific to emotion, or to any other mental state. Instead, the brain is filled with general-purpose ingredients—or networks—that interact to produce our feelings, thoughts, and actions.

The Sunday Review piece followed her op-ed in WBUR's CommonHealth about Pixar's movie *Inside Out*, which explores how emotions operate in a young girl's mind. "It's a great movie," she told us, "but it's completely inaccurate as far as the neuroscience goes." We asked Barrett to provide some insight on the real science.

What is wrong with the "blob-ology" model and why do you think it persists?

Since the time of Plato, Western philosophy has conceived of the human mind as being made up of "faculties," or separate abilities—to think, to feel, to perceive, and so on. This view has persisted through millennia. Psychology became a science in the mid-19th century, as researchers started using the methods of physiology and neurology to find the physical bases of these mental faculties. They looked for specific areas, or "blobs," in the brain: Where does fear live? Where does language live? Where does intelligence live? Through the ages, some people have argued against this "faculty" view, but it's never had center stage.

Blob-ology persists because of psychological "essentialism." People tend to believe that instances of a biological or psychological category—say, all instances of the category "cocker spaniel" or all instances of an emotion category such as "anger"—share an "essence" that makes them what they are, even if that essence isn't known or hasn't yet been identified. Darwin vanquished essentialism when he realized that any species is a conceptual category filled with instances that vary from one another. Yet essentialism still exists and is well known to interfere with people's understanding of science, particularly natural selection, evolution, and emotion.

Different parts of our brains mature at different rates as we move from childhood through adolescence to adulthood. How does the brain construct emotional experiences—and do those mechanisms change as we grow?

There are networks—circuits of connected neurons—that are intrinsic to everyone's brain unless you have certain illnesses. Some of these networks are there at birth, some of them develop, at different rates, as we age. The networks overlap because the brain regions have to talk to one another. These networks interact to perform functions that are important for a whole host of psychological phenomena.

Very young infants don't have emotions, really. They can feel pleasant or unpleasant, they can smile with pleasure or cry in discomfort, they can be fussy or calm. This is what scientists call "affect." We might see young infants as emotional, but that's our interpretation of their actions. Eventually they learn "concepts" to interpret their own sensations. This allows them to go from using the word "sad" to refer to any "bad" feeling to specifically using this word to mean sadness but not anger, fear, or disgust. As children grow older, they can distinguish more concepts, such as awe, gratitude, and compassion. They learn to control their behavior by using these emotion concepts.

College students have even more complex emotion concepts, for example, distinguishing irritation from frustration. Research shows that the more emotion concepts you know, the better off you'll be—socially and academically—because the more distinctions you can make, the better you can regulate yourself and communicate with others.

What role does "context"—our prior experiences, our own biological makeup—play in how our bodies respond when we experience different emotions?

Every thought, feeling, or perception that you have is context-based even if you don't realize it. For example, all instances of anger are not the same. Sometimes you're seething, sometimes you're calm but boiling inside. Sometimes you scowl, sometimes you chuckle, sometimes you show nothing on your face at all. Your heart, lungs, and other body systems react differently based on your response. The point is that you have a wide variety of ways of being angry or sad or happy.

A whole set of networks across the brain—for memory, concepts, language, vision, etc.—are cooperating and constructing each experience for you, and out of them emerges a mental state that you experience as a feeling or a thought or a perception.

Northeastern program preps Boston teens for calculus

August 11, 2015 - For six weeks this summer, some 120 students from Boston Public Schools made an early morning trek from across the city to Northeastern's campus, where they engaged in a math enrichment program designed to prepare them for calculus courses in high school.

The high school students—most of whom will be seniors starting this fall—wrapped up their final exams and presentations in the Bridge to Calculus program late last week, and many marveled over what they had learned and accomplished.

The curriculum consisted of instruction, group work, and projects covering pre-calculus topics including applications and interpretations of functions, trigonometry, and intro to calculus. This year, thanks to support from the Massachusetts-based MathWorks, the free program added a component for select students featuring MATLAB—a dynamic computing language the company developed.

"This program really allows you to propel yourself forward, especially if you have the will," said Daniel, who attends the Jeremiah E. Burke High School. Rising seniors Jason Daniel and Ronald Francois raved about the program on Thursday, a short time after completing their finals. The program, they said, provided an intellectually stimulating environment in which they were eager to learn, challenged to push themselves academically, and given the opportunity to get hands-on experience with MATLAB.

Holly Liao, a rising senior at the John D. O'Bryant School of Math and Science, said math is her favorite subject but she struggled with pre-calculus as a junior. She applied to the Bridge to Calculus program to advance her knowledge in preparation for taking an Advanced Placement calculus course this fall. But like Daniel and Francois, she also became intrigued with MATLAB and learning the basics of coding.

"I think it's really opened doors for me," Liao said of the program.

The program ran Mondays through Thursdays from 7:30 to 9:15 a.m., with the MATLAB component taught in sessions immediately thereafter and on Fridays. Boston Public School teachers led the in-classroom instruction. Joining the teachers were mentors, most of them Northeastern undergraduate and graduate students, who assisted with tutoring and provided perspective on college life and the application process.

Retired Northeastern math professor Bob Case founded the program with National Science Foundation funding 20 years ago, and the program now runs out of Northeastern's Department of Mathematics in the College of Science. Rajini Jesudason, a part-time lecturer in the department, is coordinating the program this year, having been involved with the program for six years. Northeastern associate professor of mathematics Donald King is the faculty chair of the program.

At the completion of the program, students are recommended for pre-calculus, calculus, or AP calculus based on the progress they've made. Overall, program administrators said, Bridge to Calculus aims to cultivate greater access to a strong math curriculum in students' schools and provide high school students with math and critical thinking skills that will help them achieve success in their final years of high school, in college, and beyond.

"The goal is to strengthen the public school system," Jesudason said.

Cutting costs: sustainability matters even in complex networks

August 11, 2015 - You're driving down the highway in your Honda Civic. You press the pedal to the metal and the speedometer flips to 90 as you torque into the fast lane. How much effort have you, and the car, expended?

No, this is not a pop quiz in a physics class.

It's an example of how, every day, we expend energy when we control the networks in our lives—in this case, a network whose components include the car's accelerator, steering wheel, and brake. Knowing how much that effort "costs" can help determine which components to manipulate—and to what degree—to ensure the smoothest, safest ride as you accelerate from 55 to 90 miles per hour.

On Monday, Northeastern researchers revealed just such a measuring strategy in a new paper published in *Nature Physics.*

"We provide a metric—called 'control energy'—to characterize the amount of effort needed to control real-world complex systems," says first author Gang Yan, a postdoctoral research associate in Northeastern's Center for Complex Network Research, which is directed by Albert-László Barabási, Robert Gray Dodge Professor of Network Science and the paper's corresponding author.

These self-organized networks, unlike an engineered one under your car's hood, include cellular networks, social networks, and mobile-sensor networks. That makes potential applications of Yan's metric wide-ranging: from helping to identify key points in the metabolic pathways of bacterial cells that new drugs might target to determining the most critical areas to monitor and protect in an online security system.

"Estimating the control energy, or effort, is key in executing most control applications, from controlling digital devices to understanding the control principles of the cell," says Barabási. "These results have multiple applications in many different domains where control of the network becomes a key objective."

The evolution of a network

A network comprises points of connection, or "nodes"—individual units, such as a metabolite, a gene, a person, or even a gas pedal—and the links or interactions tying those nodes to one another. "Driver nodes" are the select nodes that network administrators zap with external signals in order to control the system. The condition of a driver node—for example, a gene coding a protein or a person expressing his opinion about a political candidate—evolves over time as a result of both the node's internal dynamics and how it connects with its neighbors.

Previous studies of the control mechanisms of complex systems focused on identifying these driver nodes, says Yan. His finding goes further, enabling a kind of network cost-benefit analysis. With it, network scientists could identify not only the minimum number of driver nodes to target for input signals but also the "cheapest," most energy-efficient ones.

"It would be extremely difficult to control a large network by inputting signals to only one driver node," says Yan. "But it's not practical to input signals to all the nodes—that would take a huge toll on the system. Our finding provides a way to make a tradeoff between the number of driver nodes and the cost of controlling the system."

Barabási, who co-authored a breakthrough *Nature* paper describing an algorithm to ascertain the number of driver nodes required to control complex networks, points to the important insights of Yan and his colleagues in the application of control.

"Most networks are not functional if they cannot control themselves," he says. "Indeed, that need for control determines the system's architecture, whether the network is a brain, a cell, or a technological system. A key question in this process is the amount of effort needed to control the system. The paper by Yan and his colleagues offers fundamental results on this subject, by showing that moving a system in some directions can be easy, but in others can be excruciatingly difficult or costly."

Georgios Tsekenis, now a postdoctoral research fellow at Harvard University, is the paper's co-first author. Researchers Baruch Barzel, Jean-Jacques Slotine, and Yang-Yu Liu from Bar-Ilan University, the Massachusetts Institute of Technology, Harvard Medical School, and the Dana Farber Cancer Institute, respectively, also contributed to the paper.

Should we be worried about the plague?

August 12, 2015 - California's Department of Public Health and Yosemite National Park announced last week that a child contracted the plague after visiting the park in July. The case was the third in the U.S. to be reported in recent months and, while the child in California is recovering, two people in Colorado died from the disease earlier this summer.

Though the plague is not new to the U.S.—reportedly arriving in 1900—it is rare. According to the Centers for Disease Control and Prevention, on average, seven human plague cases are reported in the U.S. each year.

With the plague's recent return to the news, we took a look at some myths and truths about the centuries-old disease and spoke with statistical physicist Alessandro Vespignani, the Sternberg Distinguished Professor of Physics, Computer Science, and Health Sciences at Northeastern.

The plague is generally transmitted through human-to-human contact.
[MYTH] According to the World Health Organization, the plague is an infectious disease caused by bacteria—Yersinia Pestis—that is usually found in small animals and their fleas. The disease is transmitted by the bite of infected fleas or, less frequently, through direct contact with infected animals, such as rats or squirrels. Human-to-human transmission typically requires direct contact with a person with pneumonic plague. Such a case has not been documented in the U.S. since 1924.

[EXPERT] *Vespignani:* "Direct contact with infected animals or humans and, more rarely, aerosol inhalation or the consuming of contaminated food are other routes of transmission. In areas where plague is endemic in the animal population, it is good to avoid small rodents, avoid direct contact with potentially infected animals, and use flea control products."

In the U.S., the plague is most prevalent in the western part of the country.
[TRUTH] According to the CDC, human cases in the U.S. generally occur in rural regions of northern Arizona, California, southern Colorado, western Nevada, northern New Mexico, and southern Oregon. Since 1970, only one case of human plague has been reported east of Texas.

[EXPERT] *Vespignani:* "Sanitation and pest control have made urban outbreaks very rare. In the U.S., the last was in 1924. Plague needs an animal reservoir, and now it is limited to rural areas, especially in semi-arid regions."

The plague is untreatable and often results in death.
[MYTH] For centuries, this was the case. But with modern medicine, the plague, though a very serious illness, is treatable with commonly available antibiotics. According to the CDC, in the pre-antibiotic era, mortality resulting from the plague in the U.S. was 66 percent. By 2010, that rate decreased to 11 percent. For centuries, the plague caused widespread panic and remarkable mortality rates. There have been three recorded plague pandemics, from the Justinian Plague in the early Middle Ages, to the "Black Death" or Great Plague that swept across Asia, Europe, and Africa beginning in the 1300s, to the Modern Plague that spread to port cities around the world in the late 1800s and early 1900s.

[EXPERT] *Vespignani:* "If diagnosed early enough, the plague is treatable with antibiotics. This is obviously a game-changer with respect to what happened during the Great Plague, where no cure nor understanding of the transmission mechanism were available."

Vespignani on the potential for another pandemic: "In 2013 there were little less than 800 cases of plague worldwide. Plague epidemics are still possible where the plague is endemic in an animal reservoir. However, the modern knowledge of the disease, prevention strategy, and the availability of antibiotics make large outbreaks extremely unlikely."

Climate change forces scientists to speak up

August 13, 2015 - A decade ago, whenever the topic of climate change would come up, Northeastern's Brian Helmuth would focus solely on the scientific facts while deliberately ignoring the potential long-term societal implications.

It's the way that Helmuth, whose research centers on climate change's impact on coastal ecosystems, was trained. But, he recalled, "It was so dry. No one would ever listen and it didn't enact any change."

Now—as those previously hush-hush impacts of climate change become more and more obvious—Helmuth has adopted a different tone.

"Since my kids are going to inherit this planet, I decided that I have to talk about the implications and not just the scientific facts," said Helmuth, a professor of environmental science and public policy with joint appointments in the College of Science and the School of Public Policy and Urban Affairs. "I am careful that if I say something is true, I make sure it can be backed up by science. But I'm not afraid now to also say 'Here is what is going to happen if we don't act on that information.'"

Walking the line

Finding the balance between engaging in a thoughtful debate and being perceived as Chicken Little exclaiming the sky is falling is something climate change scientists wrestle with more and more. They want to make sure people are properly informed on what is happening and what can be done, but don't want to be perceived as over-exaggerating alarmists, as featured in this story published in *Esquire* last month.

"There is this view that if you don't take an extreme view, then it is not being communicated well," said Auroop Ganguly, an associate professor of civil and environmental engineering.

An expert in climate extremes and water sustainability, Ganguly considers himself an optimistic person. But, much to his surprise, he finds self-doubt creeping into his mind when debating certain aspects of climate change, such as adaptation, how society is adjusting to climate change's impact, and mitigation, efforts to reduce greenhouse gas emissions.

"Adaptation is where I do see a lot of hope," Ganguly said. "I wouldn't say it is happening at the pace it needs to, but it is happening. When I think about mitigation, that is where, unknown to myself until recently, I have this level of pessimism."

Matthew Nisbet, an associate professor in the College of Arts, Media and Design who studies the overlap between communications and science and technology, said that getting the general public interested in climate change won't come by speaking more urgently on the issue.

"In some ways, if scientists do choose to be more urgent, more vocal, and potentially more political, there is a possibility of the message backfiring and undercutting public faith in the actual science," said Nisbet.

Instead, the focus needs to be on a broad array of solutions that do not fit easily with any particular political agenda. Examples include emphasizing the many benefits of investing in clean energy innovations, high tech farming practices, more resilient cities and communities, and more equitable, sustainable economies.

Helmuth noted that climate change scientists have to consider their audience. "Sharing stories is the only way to get people to listen, and you have to make it as local as possible," he said.

It's all about location

The local and regional level is where all three experts agreed scientists can see the benefit of their climate change messaging. Nisbet said getting out and meeting with people who are seeing direct impacts of climate change—like fishermen and farmers—not only informs the scientists but gets stakeholders involved in solution planning.

"The idea is that instead of one-way communication by engaging the public through the press, scientists invest in local forums and initiatives where relevant groups come together to discuss a problem and consider solutions, "said Nisbet who serves on a U.S. National Academies committee studying these strategies and advises the American Association for the Advance of Science on the topic. "The public needs to have an active role in the decision-making and solution process."

Helmuth has already begun a project to learn more about what climate change is doing at the local level, and has tasked Northeastern undergraduate student Megan Reilly with traveling to coastal New England towns to hear residents' stories.

"We want to record these stories on a very local level and help the story teller understand how what they are seeing makes sense because it fits into the larger context of global climate change," Helmuth said.

Carnivorous conchs to blame for oyster decline

August 14, 2015 - What happens when a drought in Florida estuaries causes a rise in the salt levels in water? Fewer wild oysters appear on restaurant menus, for starters.

New research from Northeastern University marine and environmental sciences professor David Kimbro and graduate student Hanna Garland, published in *PLOS ONE,* links the deterioration of oyster reefs in Florida's Matanzas River Estuary (MRE) to a population outbreak of carnivorous conchs and high water salinity—or saltiness—caused by a prolonged regional drought.

This isn't just bad news for oyster lovers.

"Coastal ecosystems around the world depend greatly on the services provided by oysters," Kimbro said. "They are important for the stabilization of shorelines, filtration of coastal water, protection of important economically valuable fishes and invertebrates, and the removal of excess nitrogen."

As a result of degradation, overharvesting, and human activity, the global abundance of this habitat has declined by 85 percent, according to the Nature Conservancy. Today, most of the world's remaining reefs are concentrated in only six eco-regions—four in the United States.

"Luckily, there are government and non-government-led efforts that will begin to restore this habitat in 15 different states," Kimbro said. "But if an area to be restored contains or is likely to develop an outbreak of conchs like the one in Matanzas, then the restoration effort will fail, regardless of the expenditure of effort or expense, unless the salinity and conch problem is first solved."

When one of these eco-regions experiences an environmental stress, like that seen in the Floridian estuary, the impact can be felt across industry and ecosystems.

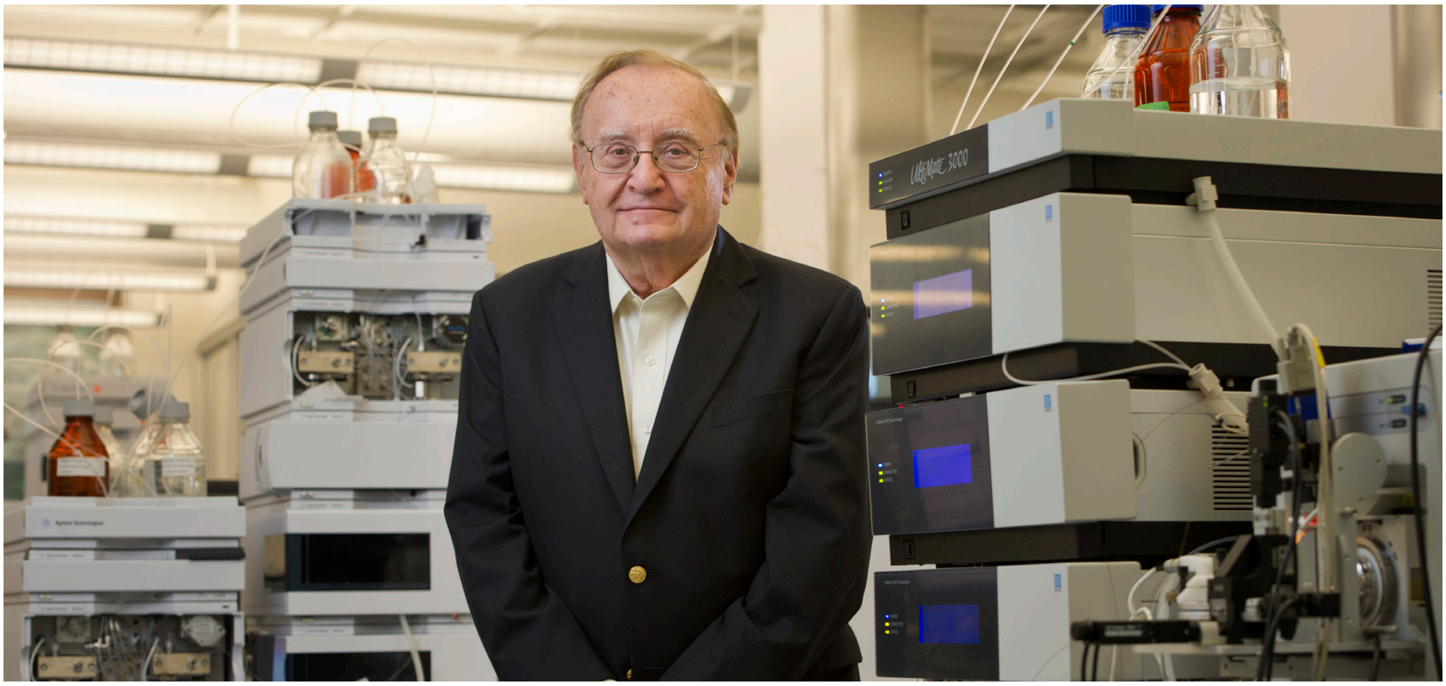
"Environmental change and consumer pressure—the conchs being the consumer—can impact foundation species like oysters on their own," Kimbro said. "But we have a case here where it is the interaction between the two stressors that is causing the greatest impact on the decline of the oysters."

The team found in this case that conchs reproduce better in water with a high salinity. Because of the deficit of freshwater and increase in salinity from the drought, conch larvae proliferated, resulting in an abundance of the conch, which then led to a greater consumption of oysters on the reef.

While the team determined the conch population outbreak to be the proximal cause of oyster loss, it is the salinity of the water spurred by the multi-year drought that is the ultimate cause, because that is what led to a spike in the carnivorous conch population.

Kimbro says there is optimism the reef could recover if the high salinization subsides. And a normalized conch population can actually be beneficial to oyster reproduction—after conchs pry open the oyster valves to consume the tissue inside, they leave behind a clean internal cavity, which oyster larvae can then use for its own development.

This research, along with additional studies on the conch-oyster dynamic in this eco-region could prove vital to oyster reef conservation efforts.



A new era in academic-industrial interaction

August 19, 2015 - The prevailing view of research science is that professors and laboratory staff work on obscure challenges for which a lifetime might not be enough time to solve. Further, there are some who also feel academic scientists focus too much on projects that might only have limited application in the 'real' world. If you're in either camp, you haven't met Dr. Barry Karger, a Distinguished Professor and James L. Waters Chair in Analytical Chemistry at Northeastern's College of Science, and the Director of the Barnett Institute.

For Karger, science and research needs to be directed toward solutions that solve problems." As scientists at the Barnett Institute, we have a strong focus on trying to solve important problems," said Karger.

Since his arrival at Northeastern in 1963, Karger has honed this focus to attack real, significant problems. In fact, his career as a bioanalytical chemist has allowed him the ability to have impact in biotechnology, human genome science and other areas. In recognition of his success, he has received many national and international awards.

"When I began in the 1960s, the purer you were in research, the more prestigious you were," said Karger. "If you worked on applications – even to solve problems – that was looked at as less prestigious."

That changed in the decades following his start as a professor. While the interaction between academia and industry was quite limited at first, companies found that collaboration with skilled scientists could help them develop new technologies, products, medicines, and save lives.

It was a distinction between basic research versus application of a solution. Prestige these days is still available in the pure research realm, but there is a lot more recognition and reward for those who solve problems and create startups and companies to commercialize scientific research.

"There needs to be a balance," said Karger. "But one sees how things have changed. The relationship between scientists in universities and industry is only growing. I believe it's far different now from when I began at Northeastern, and the ties will only continue to strengthen between academia and industry."

Examples of this new era include the relationships many pharmaceutical and biotechnology companies have with university researchers. Industry is changing, and the field of chemistry is more important than ever. Karger says the fields within each specialty are diffuse and that means that scientific knowledge has to span across different fields of study.

What he's indicating is that collaborating with specialists in different scientific and business fields is a requirement instead of a luxury. It's something he's tried to foster his entire career because he saw the value of different approaches, training and perspectives.

"I have collaborations with engineers, medical professionals (Dana Farber, MGH), the biotech industry, instrument companies and more," said Karger. "One can't be pigeonholed. You need to be broad. It's a given that you need to be an expert in your field, but you also need to understand the big picture."

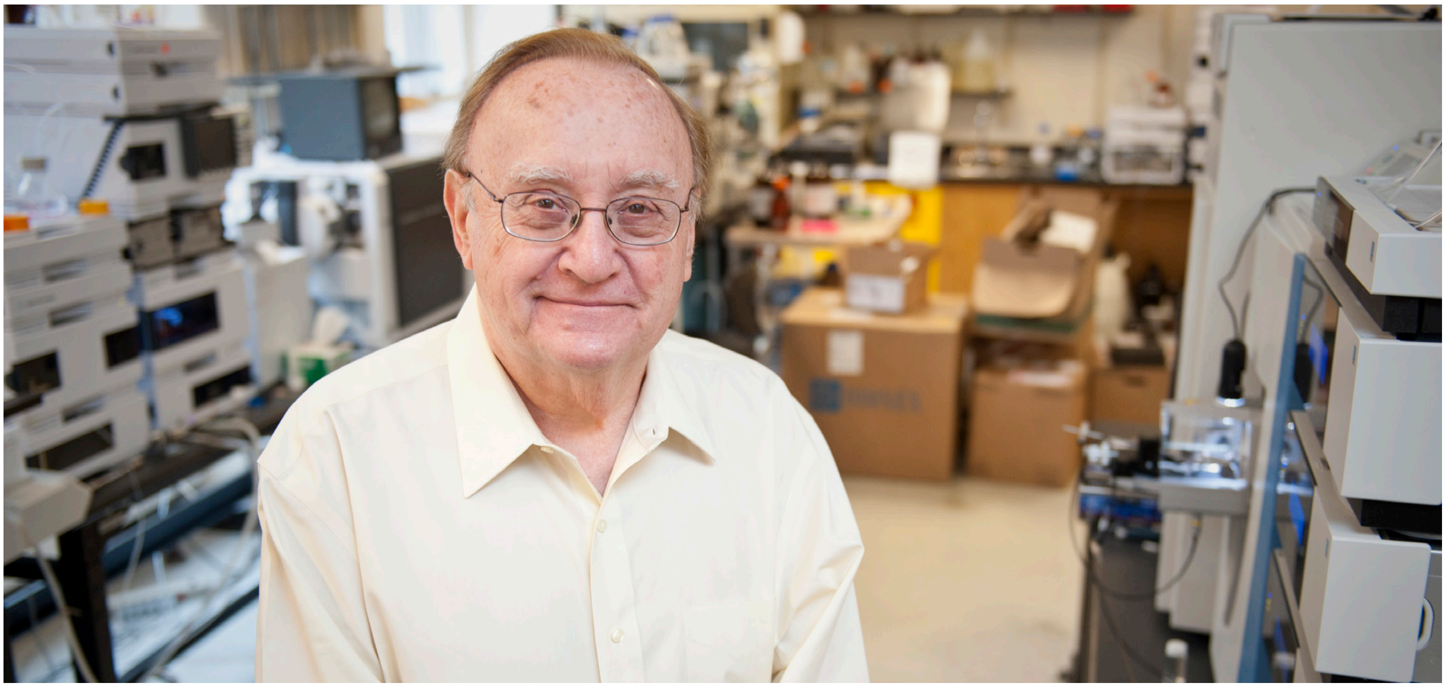
The key ingredient he points to is understanding problems from everyone's point of view. Also, maintaining a focus on outcome and impact rather than simply "impact factor" is critically important.

As a parallel, Karger has had great impact on the students and partners he's worked with over the years. He says the Institute has seen more than 400 PhD, post- doctoral, and staff scientists emerge through its doors, and one of his happiest moments is seeing these alumni succeed.

"One of the things that is unique about being a professor is mentoring young people," said Karger. "At the Institute, we have a roster of alumni who have gone on to major success both academically and in industry, many with biotechnology companies."

But it's not without its challenges. Karger likens the process to any learning – mentoring and watching people grow is key.

"When we get new students, they are like wild horses. To see them change over their career at Northeastern, and then after graduating, see them in the field," said Karger. "This is one of the great joys of being a professor."



A new era in academic-industrial interaction (continued)

He credits the development of Northeastern as a world-class institution for making this possible. With aggressive hiring in the 2000s, Northeastern positioned itself in a superior state for research and teaching. And today, he says, it's a wonderful collection of excellent faculty and facilities. Joint appointments between colleges at Northeastern only strengthens the collaborative spirit and helps provide professors with insight into other specialties.

"It's an interdisciplinary and collaborative mentality that succeeds," said Karger.

Speaking of research with impact, Karger is currently working closely with biotechnology companies to develop tools to help analyze the complex protein drug products that are made from living organisms. His work right now also includes the ability to study very limited amounts of clinical samples and still find results in the understanding of diseases such as cancer. Diagnostic markers and drug targets will be the outcome of his work.

This work underscores his belief that scientific research is having an impact. The community at Northeastern – and at the companies with which he's working – are exciting to be involved with, and his team is hardly ever bored. Essentially, more than half a century after he started, Karger believes his field continues to be valuable, and students can find a rich future in it.

"In many jobs, people are in a cubby hole, and they look forward to retire because they are bored," said Karger. "I'm not going to say there aren't aggravations being a professor. But at the same time there's a lot of satisfaction, and it's really interesting. With the research that's going on now at Northeastern, it's just getting more exciting."

The interaction and the results speak for themselves. Dr. Barry Karger is still paving the way for scientific exploration and collaboration on campus and within the industrial community.

Chemistry department garners national recognition

August 24, 2015 - Northeastern's chemistry department was recently named top 10 in a review of career support services among American chemistry departments. The high ranking, a cumulative result of career support services, and quality of network, came as no surprise to department chair Dr. Graham Jones.

"We are well positioned to market our graduates to industry," said Jones, "we know how to develop and place people because we have been aligned with market needs for some time." Noting that there has been a recent rise in PhD numbers, Dr. Jones says Northeastern's chemistry department stands out for its ability to help candidates both up to graduation and beyond it. "If only one third of the PhDs get jobs, it is not good for the profession. In our position, it is perfect because we are positioned for industry and mindful of the market," said Jones.

As an example, Jones referenced the department's Industrial PhD program. For a portion of the chemistry department's students, the Industrial PhD program has emerged as an innovative solution to an all-too-familiar problem for scientists without a PhD: the glass ceiling. Scientists with master's degrees will often reach a point in their career where they are no longer able to progress without having a doctorate degree. The result? They must put their career on hold to return to school.

Realizing the potential of a less drastic system, the chemistry department created a program whereby PhD candidates keep their industry position, devoting 20 to 30 percent of their time at work towards a doctoral project (either at work or at Northeastern). For the program's participants it is the best of both worlds: novel basic research, like that of their postdoctoral adviser, combined with the applied science mindset of industry.

For some scientists, leaving their company and sacrificing both their job and salary is an unviable option. With a daughter and mortgage, recent Industrial graduate Dr. Emily Stoler believes the hybrid approach was the best match for her needs. "I had my eye on the program since I began at [Warner Babcock Institute for Green Chemistry.]," said Stoler, "I may have ended up in the same position, but this was a route where I was able to keep my job."

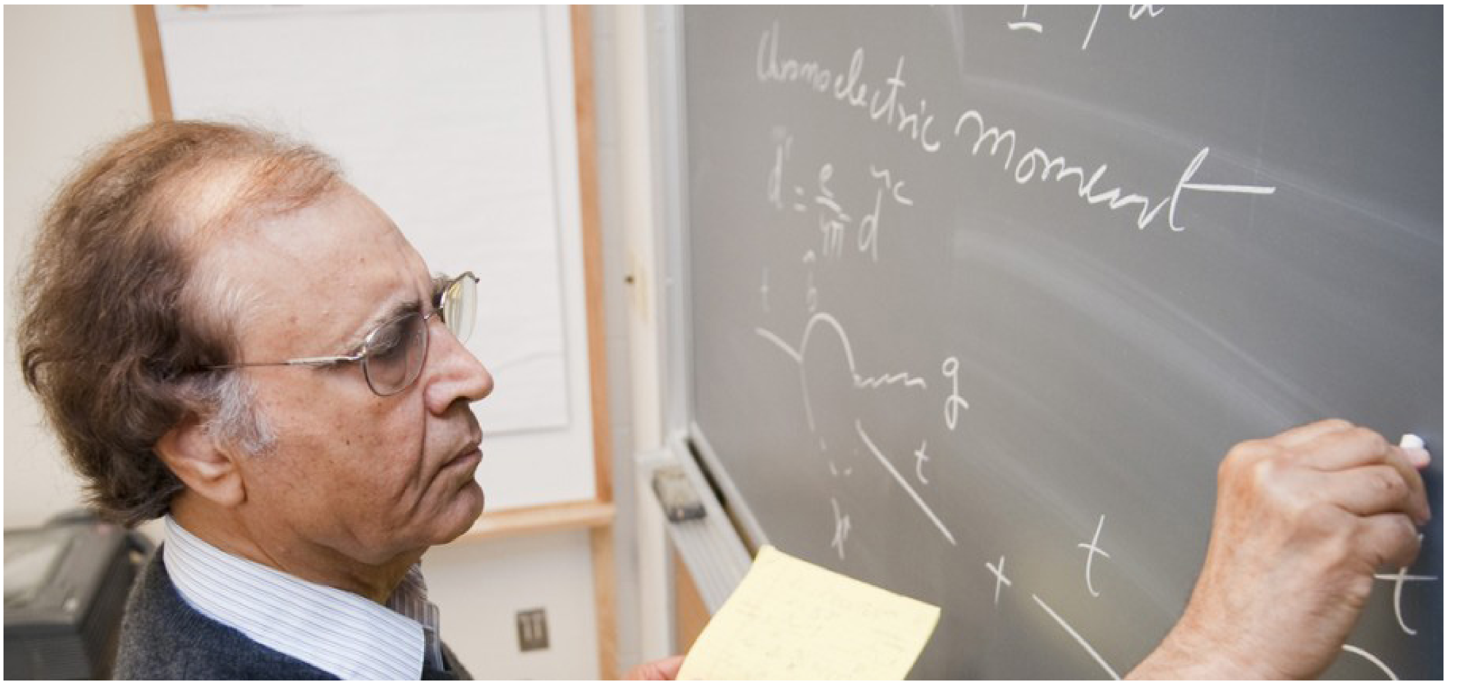
Stoler was able to do novel research of non-covalent derivatization, an alterative to traditional chemical synthesis and a core technology at her company.

While acknowledging that night classes, research, and work were a schedule-filling combination, she believes that tackling the program was the right decision. "If you do not have a PhD, you are not going anywhere. You cannot look at upper-management positions," said Stoler. Today she is director of material science R&D at Warner Babcock, having been promoted as soon as she finished her degree.

Stoler said the program gave her a better perspective for what to expect from industry: "the way you design a program is structurally different in industry."

Given that only 23 percent of PhDs continue towards tenure track positions, and 53 percent of Chemistry doctoral students rank industry work as a top choice career path, the Northeastern's Industrial program has managed to address a previously unmet need. Not only do candidates conduct novel basic research but they also do so in an environment that closely matches their career objectives. "Industry requires particular skills. It is better to get exposed and understand the problems sooner than later," said Jones.

"It is a new model," said Jones. Encouragingly, it is one that appears to be working. Moving forward, Jones sees the program as a possible template for other fields like biology and biochemistry, where glass ceilings are just as prevalent.



Professor's Paper of the Week shows evolution of particle physics

August 25, 2015 - A recent paper by Pran Nath, Distinguished Professor of Physics, was chosen as Paper of the Week in *Physica Scripta*, Journal of the Royal Swedish Academy of Sciences. It documents the great physics breakthroughs he and the physicists he worked with have made over the past 50 years while at Northeastern University. Nath has been a prolific researcher with over 400 papers in this period. However, his paper in Physica Scripta in particular captures the mind and the imagination of the reader in a way that shows how the field of particle physics has evolved over the past decades and how his own work was transformational in the evolution of the field.

In fact, looking back at his long and prolific career, Nath can easily reference the top moments that were transformational. "I would say there are three pivotal points in my career," Nath explained. "I arrived [at Northeastern] in 1966 as an assistant professor, and very shortly after that, I started working on a project with colleagues that lead to a breakthrough. We developed a new Lagrangian approach to the study of physics of mesons and this approach continues to be valid several decades later."

A lot of Nath's stories could be told that way. The second breakthrough of his work came when he and his colleague, the late Richard Arnowitt, extended the theory of supersymmetry by bringing in gravity, which other scientists eventually developed into string theory.

The third breakthrough, arguably his magnum opus, was in helping create the Minimal Supergravity model known as mSUGRA, which joins the fields of supersymmetry, gravity and particle physics. The mSUGRA model predicts a host of new particles popularly known as superparticles. It is one of the most widely investigated models of particle physics and is currently continuing to be explored at the Large Hadron Collider—the world's largest and most powerful particle accelerator, located in Geneva, Switzerland.

Supersparticles have not been seen so far, but this is due to the high scale of energy required to see them, according to Nath. "It's quite simple—we just haven't reached the level of energy to see them." According to the work Nath and his group have done, the discovery of the Higgs boson in 2012 at a mass higher than expected requires the superparticle mass to be high, which in turn requires the energy of the particle physics accelerators to be rather large to see them.

Nath explains that the biggest barrier to the exploration of new particle physics is ultimately the highest energy scale physicists can achieve in the laboratory. There could be a whole slew of new physics out there that we currently cannot reach because the energy scale is not high enough. But our ability to increase reachable energy scales has increased exponentially since the 1950s, and Nath, along with other scientists working in this field, have been there to shepherd much of the new science through this period.

Nath's work has contributed significantly to a revolution in the way that particle physics was seen by the world. By the mid-60s, scientists were beginning to realize that particle physics known up to that point just was not enough to explain all the various and new phenomena around them. The development of new particle accelerators and advanced mechanisms for particle detection allowed for new physics to be explored at higher and higher energies, and the push to advance to ever higher energies isn't slowing down anytime soon. This gives hope to Nath that his work will continue to be utilized in the exploration of new physics at larger particle accelerators in the future.

Nath started his research at Northeastern in the mid-'60s. In the 50 years since, both Nath and the scientific community have seen the limits of what is possible tested by leaps and bounds. While, as Nath explains, our current knowledge of the Universe is incomplete, there is no denying the impact of the work he has done to try and rectify this problem.

Which spoken language rules operate in ASL?

August 26, 2015 - Research on spoken languages has shown that they rely on the human brain's ability to unconsciously encode patterns in speech in the form of abstract rules—for instance, upon hearing the words "bagogo" and "fatiti," people can comprehend the ABB pattern and recognize it in other meaningless sounds like "malulu." Now, Northeastern University professor Iris Berent has received a grant from the National Science Foundation to investigate whether similar rules operate in American Sign Language (ASL).

Rules play a critical role in languages: comprehension of abstract rules lets people generate new words and sentences, allowing language to evolve. The study of sign languages allows researchers to examine whether the capacity to learn rules is unique to spoken languages, or whether it is inherent to the language system in general. Prior work by Berent and Northeastern student Amanda Dupuis has shown that signed languages display the same generative patterns as spoken languages—in other words, "rules rule" in both signed and spoken language. This runs counter to the common assumption that since signs often resemble the words they convey—for instance, the shape of objects—signed languages are merely a form of mimicry, and do not rely on abstract rules the way spoken languages do. "Our research turns this misconception on its head," says Berent.

This idea has significant implications for the understanding of the neurological basis of language: the same brain mechanisms may be responsible for dealing with the structure of both spoken and signed languages. In addition, this suggests that sign languages are not merely manual mimicry of spoken language; rather, they operate by similar abstract rules. "Language structure seems to be a product of an abstract language system, not the auditory system," Professor Berent explains. "Languages are more similar to each other than what might initially appear." Berent will explore this concept using Near Infrared Spectroscopy to study the brains of infants, and through behavioral research with both signing and nonsigning adults. In the future, she hopes to study the genetic and neurological mechanisms that build structures across modalities (speech and signed gestures).

Berent's lab encourages signers to participate in their experiments, and offers interested students the chance to study the structure of sign languages.

Graduate researcher wins fellowship to design drugs to combat deadly disease

August 31, 2015 - When Northeastern graduate student Dana Klug learned, in mid-July, that she had won a prestigious predoctoral fellowship from the American Chemical Society Division of Medicinal Chemistry, she did what researchers in labs around the world do on such occasions.

She hit "high elbows" with her advisor, associate professor of chemistry and chemical biology Michael Pollastri, who heads Northeastern's Laboratory for Neglected Disease Drug Discovery.

"You have gloves on," Klug explains, laughing, "so you bump elbows instead of doing a high five."

In Klug's case, those gloved hands had spent countless hours manipulating chemical compounds—small molecules that Pollastri's lab had identified as possible drug candidates to treat Human African trypanosomiasis, or sleeping sickness, a deadly disease transmitted by tsetse flies that affects tens of thousands of people in rural Africa annually.

The $26,000 fellowship, given to graduate students in their third or fourth year of study, will enable Klug to continue designing and synthesizing variations of 16 of those compounds in the coming year in an effort to find the ones most effective at killing the parasite that causes the disease.

"This is a national award and is really competitive," says Pollastri, who with his colleagues in 2014 reported identifying 797 compounds as "starting points" for discovering new drugs for sleeping sickness after screening more than 42,000 compounds supplied by collaborator GlaxoSmithKline, the global healthcare company.

Klug's 16 compounds, broken into two groups with similar chemical structures, come from those 797. "Students in the top medicinal chemistry research groups in the country apply to this program, and only three received the award this year," says Pollastri. "It's a strong statement about Dana's promise as a future leader in the field."

Klug's interest in neglected tropical diseases such as sleeping sickness was sparked as an undergraduate at DePaul University, in Chicago, where she majored in chemistry and minored in biology and sociology, taking courses in global health. Her undergraduate research advisor, associate professor Caitlin Karver, had been a postdoctoral fellow in Pollastri's lab and recommended that she apply to Northeastern for her doctoral studies. "How's that for a small world?" says Pollastri.

Upon acceptance into Northeastern's chemistry Ph.D. program, Klug received a College of Science Distinguished Graduate Fellowship, which allowed her to jump directly into research with Pollastri's team in October 2013. She did so with alacrity: "She's one of those students to whom you explain something once or just vaguely and she takes that and runs with it independently," says Pollastri.

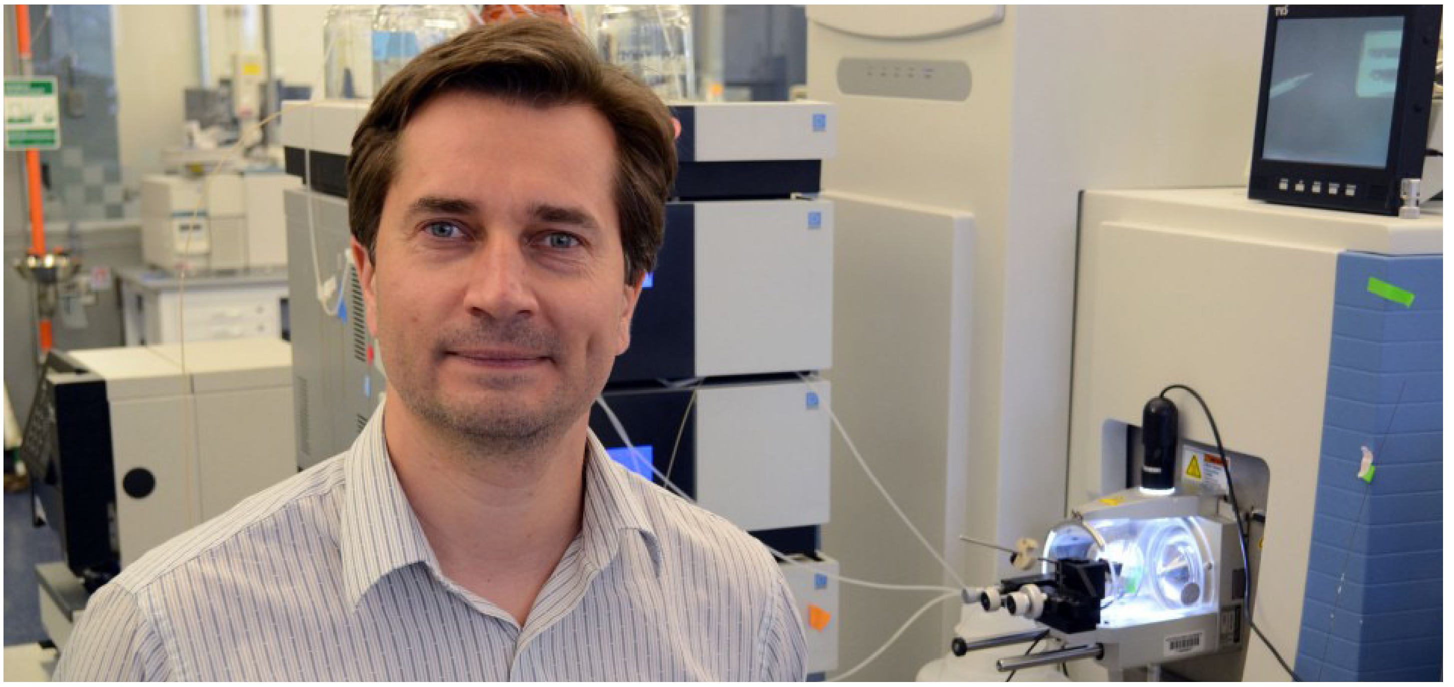
In designing her compounds, Klug is like a chef crafting a gourmet dish, adding an atom of, say, hydrogen here, removing an atom of nitrogen there, or shifting an element left to right to transform the chemical structure of the individual molecule. "Synthesis is all about making and breaking bonds between elements," she says. "Each reaction brings about a specific structural transformation that results in a new compound, which is then purified and used as the starting material for the next reaction in the synthesis."

Klug sends each iteration off to the Spanish National Research Council, in Granada, Spain, where collaborator Miguel Navarro and the GlaxoSmithKline team mix it with both the sleeping-sickness parasite, Trypanosoma brucei, and human cells to test for potency in the first case and toxicity in the second.

What happens in those Petri dishes helps determine Klug's next step. The 797 compounds Pollastri's lab initially selected as "hits" against T. brucei work by inhibiting proteins called kinases, which are found in both humans and parasites. The job of kinases is to add phosphate groups—structures of oxygen and phosporous—to other proteins inside cells, spurring those proteins to facilitate cell growth and division. "If you inhibit human kinases, you can stop cell growth," says Klug. "We believe that same inhibitory action occurs in parasites, killing them or blocking their ability to reproduce."

The results in Spain provide clues for new variations.

Knocking out T. brucei is a tall order, but one to which Klug is committed. "The original hits have a pretty good profile so I'm working on scaling up one of them to possibly test in an animal model," she says. "But I also have many plans for a lot of different compound variations that I want to make."



Rare cell studies earn researcher prestigious Mass Spectrometry Award

September 9, 2015 - Alexander R. Ivanov, research associate professor in the Barnett Institute of Chemical and Biological Analysis, has received a research award from the American Society for Mass Spectrometry. The award, one of only two given each year, provides a financial grant to young scientists to promote academic research in mass spectrometry. Professor Ivanov was presented with the award, sponsored by the Waters Corporation, in a plenary session of the 2015 ASMS annual conference in St. Louis, which more than 7,000 people attended.

Professor Ivanov's research focuses on the advancement of mass spectrometry-based proteomic techniques for challenging biomedical applications. The main topics that Professor Ivanov is currently interested in include the development of ultra-low flow liquid phase separation techniques and interfacing them with advanced mass spectrometry for high-sensitivity proteomic profiling of biological samples and analysis of proteins and protein complexes in their native non-denatured states. Dr. Ivanov uses similar techniques for detailed characterization of isoforms and post-translational modifications of biologically active proteins, including biopharmaceuticals. Another rapidly emerging area that he studies using mass spectrometry-based proteomics is characterization of extracellular vesicles, including circulating exosomes and microparticles, as potential sources of biomarkers for disease diagnostics. Professor Ivanov has been also actively involved in national and international initiatives to develop standards for proteomic research.

The particular bioanalytical problem that Professor Ivanov proposed as part of the application process for the ASMS Research Award was the deep proteomic characterization of "rare cells," which he describes as cells of limited availability that are difficult to obtain, including circulating tumor cells, stem cells and other progenitor cells. In the awarded proposal, Professor Ivanov designs new techniques to process and analyze limited populations of circulating rare cells and potentially individual single cells. The proposed research is largely based on his earlier results, published as the cover article in the June 2015 issue of the journal *Molecular & Cellular Proteomics.*

In this article, he takes a collaborative, multi-disciplinary approach to rare-cell proteomics, which starts by capturing and isolating individually selected cells using a microfluidic device developed by Shashi Murthy, a professor in the Department of Chemical Engineering, and his colleagues. A novel cell lysis process that Professor Ivanov developed then breaks apart the cells without using any chemicals, which enables accessing the cellular proteins with minimal losses. Finally, those proteins are characterized by advanced separation and mass spectrometry techniques in collaboration with the research group of Professor Barry Karger, director of the Barnett Institute. The paper describes the applications of the developed approach to the analysis of limited populations of cancer cells, hematopoietic stem cells, and endothelial progenitor cells in small volumes of whole blood.

Professor Ivanov hopes that the cover article, along with the ASMS research award, will further spur interest in the biomedical community and among funding agencies regarding the exciting new analytical approaches he has been developing and the interdisciplinary research that he and his colleagues at the Barnett Institute are conducting. The medical implications of this research include tracking disease progression by profiling small populations of tumor cells or individual brain neurons, which could enable personalized treatments for patients; characterizing the biology of cells in their microenvironments; and better understanding the differentiation of stem cells for developing new regenerative therapies.

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