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Welcome from Dean Murray Gibson

This issue of the Husky Science Monitor spotlights innovation in the College of Science. Some examples you can read about here:

• Two COS graduate students wanted to try out a hypothesis about why the Caribbean coral are dying, so they launched a crowdsource funding campaign to pay for a research trip to Panama.

• A physics professor started a company after she stumbled on a way to clean water from oil-fracking while studying nanoscale materials for solar applications.

• A spin-off company from our Barnett Institute is working with the leading biopharmaceutical companies on developing and getting approval for frontline biologic drugs.

• Another Barnett researcher is collaborating on a multi-university project to make single doses of biopharmaceuticals in the field for rugged military applications. This method also promises to revolutionize the applications of these powerful, but hard to transport and store, drugs.

• A math professor’s life work to help underprivileged kids get access to calculus in school is credited with raising the level of Calculus in the Boston Schools.

• Pran Nath, one of our most senior physics professors, is seeing his life’s work recognized as particle and astro-physicists realize we must go beyond the “standard model” which has led to several Nobel prizes. Pran’s 1962 paper “Local Supersymmetric Grand Unification” has been cited more than 1,000 times, and is gathering citations at the rate of more than 60 a year even after 50 years.

The seeds of innovation can run very deep, and here in the College of Science, we have made great strides in supporting our faculty and students as they push the envelope and challenge current thinking.
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A major success for the college last year was the acquisition of the Ocean Genome Legacy (northeastern.edu/ogl). Innovator and Northeastern Honorary Degree recipient Don Comb developed this leading collection with the aim to collect DNA samples from every species within the ocean. At a time when the loss of biodiversity is at an all time high, Northeastern will spearhead the collection and study of samples with the aim to achieve sustainability in our precious oceans. The collection is invaluable for our Urban Coastal Sustainability Initiative and is expected to provide unique experiential learning and research possibilities. We are working with a number of countries including, most recently, Malaysia to expand our DNA repository worldwide.

This past summer, researchers from our Marine Science Center provided the science activity in Mission 31—a month-long expedition led by Fabien Cousteau, grandson of the late Jacques Yves Cousteau. The mission took place at Aquarius, the last remaining underwater research station in the world, located nine miles off the coast of Key Largo, Florida. The mission was viewed by more than 330 million people worldwide.

We are proud of our students who win prestigious awards that reflect on themselves and the college, such as biology major Theo Bowe, S’16, who recently received the prestigious Barry M. Goldwater Scholarship, and Brian Conlon, from Northeastern’s Antimicrobial Discovery Center, who was recently awarded the Charles A. King Trust Postdoctoral Fellowship.

We made seven great new tenured/tenure-track faculty hires this year, and you can read here about one of them – Professor of Psychology Peter Bex – who comes to us from Harvard Medical School and uses the science of vision to treat and diagnose visual impairments. Peter’s innovative translational work epitomizes the approach at Northeastern’s College of Science – combining innovative education with cutting edge research on problems that have social impact.

There are so many innovative things happening in the College of Science – thanks to our talented faculty and students. I am proud to represent one of the most dynamic colleges here on campus. Please feel free to stop by and visit us. I hope you enjoy this latest edition of the Husky Science Monitor, and as always, thank you for your support!

Cheers,

J. Murray Gibson
90 percent of Northeastern’s graduates from 2006 through 2013 were employed full time or enrolled in graduate school within nine months of graduation.

85 percent of 2013 graduates who are employed full time are doing work related to their major.

50 percent of 2013 graduates received job offers from a previous co-op employer.

Our interdisciplinary behavioral neuroscience program, which is a joint venture of the Department of Psychology and the Department of Biology, enrolled 101 new freshmen in fall 2014, its largest to date.

The College of Science has an enrolled freshmen SAT average of 1428, which is higher than the university average of 1413.
Biology majors develop a basic understanding of the organization and the processes of life, from molecules and cells through organs and organ systems to populations, species, and evolution. This major allows students to begin to specialize in various exciting sub-disciplines of biology, such as cell biology, molecular biology and genetics, systems biology, animal physiology and zoology, microbiology, and the biological basis of health and disease. This major, coupled with our dedicated Pre-Health/Pre-Med Advisor Team, also prepares its students to be highly competitive for admission into post-graduate degree programs in medicine and other health-related careers.

Northeastern.edu/biology

Biochemistry

The biochemistry major provides thorough training in biochemistry, molecular biology, and chemistry, as well as a strong foundation in mathematics and the physical sciences. Research topics range from bioinformatics; protein biochemistry, including advances in separation sciences, physical characterization, and structure-function relationships; drug development for neglected and other diseases; and nucleic acid biochemistry, including DNA damage and repair, signaling, global regulators, and master switches in networks for early development and tissue regeneration.

Northeastern.edu/biochemistry

Biomedical Physics

Biomedical Physics explores fundamental physical principles relevant for understanding biological phenomena on various scales as well as medical instrumentation and devices. This program offers the option of a pre-med track and partners with Boston-area medical research institutions to offer students a unique interdisciplinary learning experience.

Northeastern.edu/physics

Applied Physics

Considered a bridge between pure physics and engineering, applied physics is used to develop new technologies or solve engineering problems. With this major, students focus on the practical applications of physics.

Northeastern.edu/physics

Behavioral Neuroscience

Behavioral Neuroscience focuses on the biological basis of behavior. The program combines the disciplines of biology and psychology to appreciate the scope of behavior and then understand how the behavior of humans and animals is controlled by physiological systems. Course work is designed to provide an understanding of nerve cells, chemical neurotransmission, and neural circuits, as well as fundamental biological processes such as inheritance, development, and physiology and then to see how these biological mechanisms give rise to normal and pathological behavior. The curriculum includes a strong background in biology, psychology, chemistry, and mathematics and is uniquely designed to prepare students for higher degree granting programs in graduate or medical school. In addition, students with a bachelor’s degree are qualified for employment in a variety of fields from clinical and basic research to positions in health care or biotechnology.

Northeastern.edu/bns

Chemistry

The Chemistry & Chemical Biology program provides the fundamental scientific background and practical training for students as they prepare for chemically related careers or advanced study in fields such as the traditional chemical specialties, biochemistry, materials science, forensic science, medicine, education, and law.

Northeastern.edu/chemistry
Mathematics
Mathematics is one of mankind’s oldest intellectual pursuits, and has long provided guidance and inspiration for the development of science and technology. In addition to its inherent interest and beauty, mathematics is a rich source of methods for analyzing and solving problems encountered in the physical world. Today, mathematics is a thriving field of research with impact in virtually all fields of human endeavor, including science, business, the arts, and the social sciences.
www.math.neu.edu

Psychology
The Psychology Department offers a full range of courses in the fundamental science of mind, brain, and behavior, and on topics related to clinical, counseling, and educational psychology. The curriculum explores such questions as how brain function regulates behavior, what constitutes abnormal personality, how individuals work in groups, and how people develop emotionally and cognitively. Through hands-on laboratory research, small-group seminar discussions, and core coursework, the program helps prepare students for graduate training and careers in all areas of psychology, and in related fields such as education, business, forensic science, and health services.
Northeastern.edu/psychology

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As a Physics major a student explores the fundamental physical principles that govern natural phenomena ranging in scale from collisions of subatomic particles, to atoms and molecules, to various condensed phases such as solids and liquids, to exploding stars and colliding galaxies.
Northeastern.edu/physics

Linguistics
Linguistics is the scientific study of human language. A growing and exciting field, it has links to diverse fields including cognitive psychology, philosophy, neuroscience, computer science, artificial intelligence, sociology, language teaching, anthropology, education, and the law. Linguistics is a key component of the field of cognitive science, the study of the structure and function of human cognitive processes.
Northeastern.edu/linguistics

Environmental Science
Our Bachelor of Science in Environmental Science degree is organized for students who want to acquire the scientific background to help solve environmental problems from a multi-disciplinary perspective. Our program equips you to investigate and develop technical, economic, institutional, behavioral, and conservation-oriented solutions to environmental problems. Every student develops core knowledge in environmental science, geology, biology, chemistry, and mathematics early in the program. Students then select one of the following areas as a program focus for their upper-level coursework:
- Geoscience
- Conservation science
- Marine Science
We provide an Independent Track for students whose interests do not fall into one of these four concentration areas. Students who elect this option work with a faculty advisor to identify a group of mid- to upper-level science courses that are aligned with the student’s career interests.
Northeastern.edu/mes

Environmental Studies
Environmental Studies is an interdisciplinary program drawing from 12 departments, designed to provide a flexible platform for students whose primary interests lie at the intersection of science and environmental policy. Students with a degree in Environmental Studies may choose to specialize in anything from environmental media communications to areas of conservation and environmental protection.
Northeastern.edu/mes

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Northeastern.edu/physics
New Faculty

Welcome to Northeastern!

Peter Bex
Professor, Psychology
Conducts theoretical and applied research in normally-sighted observers, in aging observers and in observers with visual impairments, including low vision and amblyopia

Ana-Maria Castravet
Associate Professor, Mathematics
Algebraic geometry, related invariant theory and computational aspects

Konstantin Khrapko
Professor, Biology
Mitochondrial physiology and pathology in human aging and disease

Gabor Lippner
Assistant Professor, Mathematics
Discrete mathematics with an emphasis on using methods from analysis, geometry, and topology

Emanuele Macri
Associate Professor, Mathematics
Algebraic geometry – derived category theory

Roman Manetsch
Associate Professor, Chemistry & Chemical Biology joint w/Pharmaceutical Sciences Bouvé & Faculty Fellow in the Center for Drug Discovery
Fragment-based lead discovery and hit-to-lead optimization focusing on malaria and other infectious diseases

Olga Vitek
Associate Professor, Chemistry & Chemical Biology, Computer & Information Science
Applies bioinformatics and biostatistics to clinical proteomics

Dori Woods
Assistant Professor, Biology
Reproductive biology, stem cell biology, regenerative medicine, aging

Ting Zhou
Associate Professor, Mathematics
PDE theory and analysis of inverse problems in various imaging and tomography methods, theoretical designs of invisible cloaks
Science can be high-tech. But the project Dr. William Hancock and other members of the Barnett Institute are working on is the stuff of science fiction...or at least science future. And it’s happening right now!

With grant funding from DARPA, Hancock is working with MIT on the “small-scale production, purification and testing of protein drugs one dose at a time.”

The program is called an integrated and scalable cyto-technology (InSCyT) platform for biopharmaceutical manufacturing on demand. Instead of the traditional process where a pharmaceutical company wields a broad and massively expensive brush to craft and test new drugs, Hancock and the MIT team have taken an approach that’s focused on drug manufacture on a much smaller scale. Then we use the latest Northeastern analytical technology to examine medicines at the molecular level.

“We get to apply our state of the art mass spectrometry to characterize every molecule in protein drugs produced by a new technology,” said Hancock. “And perhaps discover novel and unexpected changes in the protein drugs.”

Over the first two years, the program has produced two drugs for patient use. He says they are currently working on the production of two more drugs to be completed by 2015. It’s a new approach that adds some flexibility to where and how patients can be treated.

“The large team hopes to develop a new approach to the manufacture of protein drugs which will allow the access of patients in remote places,” said Hancock. “As well giving members of the U.S. Armed Forces access to these life saving drugs.”

With a collaborative approach at its core, the InSCyT platform leverages skills from a variety of scientists. Hancock says top innovators in manufacturing technology are involved and that has helped the program. Information is shared in both directions and the results have been impressive.

According to Hancock, the global business of protein medications is worth $100 billion and helps an extraordinary number of patients. The downside is that a single impure drug can cause harm...so that’s what the technology and testing is all about. The goal is to ensure safe protein drugs that combat myriad diseases for the patients who need them and that’s where Hancock and technology developed at the Barnett Institute comes in.

“It is the task of the university scientist to develop better technology for testing and the industry scientist to implement this technology into a rigorous testing program,” said Hancock.

Hancock explained the complexity of this research. “The power of analytical biotechnology is so advanced that we can detect a difference in one atom in a protein molecule of 500,000 atoms,” said Hancock. “This has profound implications for the future of the Life Sciences because a small change in structure can alter the biology of an organism.”

The next time you’re wondering about some of the ads for new medications you see on TV, think about DARPA, MIT, Northeastern scientists. Their work and vision is contributing to the massive global effort to make it possible for patients all over the world to get well and live healthy lives. And realize it all starts one protein dose at a time.
“There is a crisis in the United States,” said Professor Robert Case, College of Science Mathematics Department. “Rigorous mathematics is unavailable to a large segment of the population, in particular African-American and Latino-American young people, and new immigrants.”

As a predictor of college success, Case explains that mathematics achievement in high school is it. Meaning that without a strong understanding and proficiency in math, students are likely to have difficulty when they reach college. So Case has attacked the problem head-on. He’s using a unique outreach program and Northeastern University’s prominence to help local schools institute strong calculus courses through their systems.

Using 1989 as the tipping point year, he indicates that few local high schools even had a Calculus program in place. Through collaboration and support from the College of Science especially Professors Gilmore and Donald King; and other
members of the Department of Mathematics, he's been able to assist schools in developing a richer mathematics curriculum for all students. And he can point to success.

“One high school went from a single-digit pass-rate in the AP exam to a pass-rate of 94 percent,” said Case.

But developing a better curriculum is only part of his involvement. Case sees math as a life skill and therefore delivers instruction and support wherever possible.

“A cornerstone of the outreach work is a special summer program, Bridge to Calculus,” said Case. The program brings over 100 rising Seniors onto the campus of Northeastern University each summer for an intensive calculus preparation in their high schools beginning the following September. One school sent a cohort of students of Haitian and Hispanic extraction and students from the group studied calculus the following year and then went on to graduate from a range of colleges, including Hamilton, Bryn Mawr, and MIT. These students are generally the first in their family to attend college.” The summer program is implemented by Prof. Donald King and Rajini Jesudason, as well as highly experienced Boston teachers, and Northeastern undergrads as mentors to the high school students.

Citing the beauty and utility of mathematics as the facets that drew him to the field, Case says the discipline is misunderstood. While many think it's all about memorizing formulas, just the opposite is true.

“The logical nature of the subject makes it ideal for the process of discovery,” said Case. “I had the opportunity to become immersed in the Socratic approach to teaching, where the pedagogy consists of simply asking carefully prepared sequences of questions. Mathematics teaching and learning becomes a dialogue, a living script, rather than an exposition. In the 1980’s, with the assistance of Prof. Carla Oblas who is an expert in the Socratic teaching of mathematics, I had the support to offer an entire course, integral calculus without a single declarative sentence, and the level of involvement of the students was remarkable. There is a story, a narrative, in each branch of mathematics, something longing to be communicated. There is a special kind of satisfaction in discovery, or in solving a problem.”

Beyond that discovery phase, Case sees a certain responsibility falling to those educational institutions with the bandwidth and the capability to assist in learning of all types. He says the power Northeastern wields in the landscape of education is significant and thinks the school “has a conspicuous presence in the city of Boston and a historic mission to educate Boston youth.”

Ultimately, Case says we have to do better in our school systems from start to finish. While his role is to bring better mathematics education into play, he's clearly talking about the entire learning process as well.

“We need to move to produce powerful schools in our cities, and mathematics teaching-and-learning are pivotal in this process,” he said. “Northeastern University, by history and by location, has a special role and opportunity and responsibility in Boston to collaborate in achieving this goal.”

Using his own teachers, colleagues, and historical scientists as examples, Case extolls the virtues of mathematics. It's a love for the field that is clear in all dedicated professors no matter what subject they teach. He talks about the absolute beauty, power, and order of mathematics as he see it.

“Galileo is eloquent about this: ‘The great book of the philosophy of the universe stands open for all to read; but the language in which this book is written is the language of mathematics...without this, we are like people stumbling about in a dark labyrinth,’” said Case. “Powerful and unexpected ideas have emerged. Newton found a way to deal with continuous change in space and time – calculus. More recently, a mathematician named Georg Cantor discovered infinitely large numbers of genuinely different sizes! It was an open question whether there were any other numbers between the two purported “smallest” of these infinite numbers. Amazingly, in 1965 Paul Cohen proved that we could never settle this question with our current mathematics.”

To keep searching for answers to important math questions, we need to keep young minds engaged in the discipline. Case's initiative is doing just that.

There is a crisis in the United States. Rigorous mathematics is unavailable to a large segment of the population, in particular African-American and Latino-American young people, and new immigrants.
What’s Wiping Out the Caribbean Corals?

by Angela Herring

Right now is a really cool time to be addressing these issues because we have a lot of emerging genetic techniques that people are just starting to use to ask questions about the microbiology of corals.

Here’s what we know about white-band disease: It has already killed up to 95 percent of the Caribbean’s reef-building elkhorn and staghorn corals, and it’s caused by an infectious bacteria that seems to be transmitted through the water and by coral-eating snails.

But two student-researchers working in Northeastern associate professor of marine and environmental science Steve Vollmer’s lab are trying to change that: Sarah Gignoux-Wolfschon, a fourth-year doctoral candidate, and undergraduate Felicia Aronson, S’16, an environmental science major with a concentration in marine science. Together, they are using the resources they raised from a crowdfunding science campaign to figure out what’s killing the Caribbean corals.

“Before this, we knew that white-band disease was caused by a bacteria, and we had a list of potential pathogens,” said Gignoux-Wolfschon, noting that these findings emerged from previous research at Vollmer’s lab. The pathogen list was the product of a large-scale genetic sequencing analysis led by Gignoux-Wolfschon. Now she and Aronson have launched a systematic research program to sift through that list in the hopes of identifying the culprit.

Working at the Smithsonian Tropical Research Institute in Bocas del Toro, Panama, Gignoux-Wolfschon and Aronson spent the month of June performing a series of experiments in which they administered various antibiotics to diseased coral slurries contained in bench-top aquariums. Antibiotics kill different bacterial types, so when healthy corals contract the disease despite treatment, the team is able to home in on the characteristics of the culprit bacteria.

They also performed an opposing experiment in which they exposed healthy corals to disease slurries grown in different environmental conditions that select for different bacteria to see if they contract disease. “If we grow a specific group of bacteria and it still transmits the disease, we know the pathogen is likely in this group,” Gignoux-Wolfschon explained.

The student-researchers raised their funding goal of $3,180 in just three days through experiment.com, marking the third fastest success story in the crowdfunding website’s history. Upon reaching that goal, they extended their campaign to more than double the original amount, which they also raised in record time.

Backed by this financial support, Gignoux-Wolfschon and Aronson brought bacterial samples back to Boston, where they will now begin performing exhaustive genetic analyses. “Right now is a really cool time to be addressing these issues because we have a lot of emerging genetic techniques that people are just starting to use to ask questions about the microbiology of corals,” Aronson said.

They’re using those tools to understand how the diseased coral community is different from the healthy community in ways that haven’t been possible before. The approach is somewhat novel in the field of marine ecology, Gignoux-Wolfschon said, and it’s part of why she’s doing it. As an undergraduate at Wesleyan University, she studied blood-vessel formation using genetic-based techniques. “I wanted to take those skills and apply them to a more conservation and ecology based research program,” she explained.
Latika Menon – The Science of Water Purification by Jeff Cutler

Latika Menon uses physics and nanomaterials to purify water. But it’s not as easy as it sounds. Menon and her team spent years in search of new types of materials that could be applied to this worldwide problem.

They discovered that materials – such as titanium dioxide (or titania) – are ideal for the robust filtration necessary to make water safe to reuse after efforts like fracking and other intensive procedures. According to Menon, she wasn’t focused on the fracking industry specifically, but her technology fits well with the oil and gas industry.

Titanium dioxide nanotubes have a unique tubular architecture in which the tubes are arranged parallel to each other. Forming titania nanotubes, the material remains robust in the face of temperature and chemical agents. It’s also anti-microbial and biocompatible, which Menon says makes it very effective for the use of water purification.

“As soon as we made the discovery in our lab,” said Menon. “We patented the technology and subsequently, we continued to look for niche applications where this technology could provide disruptive solutions.”

During that discovery phase, the team learned of the need for new types of robust filtration materials for the oil and gas industry – specifically to treat fluids used in hydraulic fracking. As she describes it, the inherent porosity of the nanotubular architecture and the inherent robustness and the stability of the material make it a good choice for filtration media for rugged applications in the oil and gas industry.

Moving forward, they now have some funding from the Massachusetts Clean Energy Center and from a major oil and gas company, to develop prototypes of filtration products. In fact, Menon Laboratories, Inc. was launched for continued product development and subsequent commercialization.

An ultimate concern with fracking has been the possible contamination of drinking water. While that might still occur if oil and contaminants are released into the water table, the Menon materials may be able to offer effective water treatment and recycling solutions, which would limit the amount of fresh water used in fracking. By limiting this there are huge savings in money and resources. But none of this would have been possible without a mindset of collaborative study.

Menon appreciates that her collaboration with the oil and gas industry has helped her team stay at the forefront of technology.

“We get to learn about the current pain points and how our research can provide solutions to some unsolved problems,” she said. “The global need for water treatment solutions cannot be emphasized enough. By addressing this niche application first, our hope is to be able to address water treatment solutions globally, for example, removal of As, F, and other toxic elements (common problem in countries such as India), desalination (of particular concern in the middle-east), etc.”

Menon’s other work has applications in solar power using these same titanium dioxide nanostructures. And it’s that research that keeps her excited.

“The potential to discover new types of nanomaterials with novel functionalities is what is most intriguing,” she said. “Some of the materials that we are studying in the lab, such as titanium dioxide and gallium nitride are already well-known. Yet, in our research we have been able to demonstrate new features hitherto unknown.”

With Northeastern College of Science as her foundation, Menon has formed a few opinions about science as a practice. She says science and physics in particular instills in us ‘problem-solving’ skills. She explains her approach as one that lets the research guide the science rather than vice versa. And she can’t emphasize enough the team nature of scientific research and discovery.

“Much of what has been achieved in my laboratory has been largely due to the efforts of the numerous highly motivated and enthusiastic students (including graduate, undergraduate, and high school students) and post-docs that have graduated from my laboratory in the last nine years,” said Menon. “Most of them have moved on to exciting positions in academia and industry. It feels good to know that my lab has been able to make meaningful contribution in their lives and careers.”
Kate Allstadt –
The Science of Big Data, Seismology, and Saving Lives

by Jeff Cutler

Kate Allstadt is a 2008 B.Sc. graduate of Northeastern and a postdoctoral researcher at the University of Washington. Her current project is called M9 (m9.ess.washington.edu) – a multidisciplinary effort to investigate all aspects of the hazards posed by large subduction zone earthquakes on the fault that stretches from northern California to southern British Columbia. The project spans geoscience to engineering to social aspects and community planning.
In her role as a scientist focused on natural hazards and seismology, Allstadt constantly sees the forces of nature as “awe-inspiring” and contends our understanding of them requires focused scientific attention. Never was this more evident than in the spring of 2014 when a mudslide in Oso, Washington claimed more than 40 lives.

While the slope involved in the disaster was known to be unstable, regular seismic activity had taken place there for thousands of years. According to Allstadt, one of the biggest challenges scientists face is determining when landslides will occur or how likely they are to occur within a certain time frame.

A major issue with the Oso event was some of the people living below the slope didn’t know slope stability was an issue or that a slide could be so rapid and catastrophic – something even some scientists didn’t realize.

Ironically, the study of this type of disaster and the forecasting of potential events is an inexact science. There is lots of seismic data collected on a regular basis at trouble spots all over the world. This data is collected and analyzed by scientists who then provide their analysis to decision makers. The process then becomes one of balancing acceptable risk with the cost of resources for monitoring and mitigating a hazard.

Some of this mitigation might involve restricting development in dangerous areas or reclaiming/buying back property in an area deemed unsafe.

“I hope that my field of study, and the contributions I make to it, will help to identify cheaper and more effective ways to monitor potentially active slopes through seismic and other methods,” said Allstadt.

She added that she hopes the communication process improves to the point that geologists and scientists who know about potential hazards are able to relay this information to policymakers and emergency management officials who can better communicate this information to citizens.

Some areas of study have shown a lot of promise when it comes to early warning systems. For example, Allstadt says scientists are getting better at identifying over long timescales where, what, and how often various earthquakes can occur and what the likely impacts will be.

“Additionally, on short timescales, once an earthquake starts, we can give warning within seconds to populated areas of the onset of strong shaking,” she said. “This is called earthquake early warning, it is in an exploratory stage for the west coast of the US – a full system has not yet been funded for the US, but early warning systems have been operational and successful for years in many other countries like Japan and Mexico.”

When it comes to landslides – a topic Allstadt focused on from a seismic perspective for part of her PhD work – there are ways of monitoring slow movements that can accelerate into rapid large-scale movements, like that at Oso, using a range of instruments including but not limited to seismic methods.

“Tools are installed locally, are costly, and require identifying specific slopes ahead of time,” she said. “Which can be a problem when you have countless numbers of potentially unstable slopes like in Washington.”

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“However, like early warning for earthquakes, for very large landslides, like the collapse of the flanks of Mount Rainier for example,” she added. “These slides can turn into mudflows that can travel for tens to hundreds of kilometers reaching areas where many thousands of people now live.”

The science can lead to a better understanding of the physics of landslides and how they generate seismic waves, and what those seismic waves can tell us. DOWN THE LINE, this science might even save lives and make predicting disasters more accurate.

Like most of scientific exploration, data plays a huge role in results. In some seismic data stations, there are 100 samples per second taken. Multiply this by several hundred seismic stations across the Pacific Northwest and you realize that there is a huge amount of data to be analyzed on a regular basis.

Allstadt says at University of Washington they have started to team up with the computer scientists who specialize in big data because managing, applying, and scaling up data analysis techniques can help locate signals hidden in the noise…and that could lead to breakthroughs in reporting on potential disasters.

Allstadt took an interest at an early age, some of which was fostered by her high school teachers and access to local observatories and science and math camps. Science might have stopped there, but she was driven by curiosity into the field of seismology.

“I find seismology intriguing because it is geology of the present – it’s a way of studying the dynamic geologic processes that shape our planet over long timescales, like earthquakes, landslides, and volcanoes, as they happen in the present,” said Allstadt.

With a solid foundation in physics, chemistry, and math, she believes the experiences and staff at Northeastern – specifically field trips and the faculty served to add an element of dynamic learning that strengthened her commitment to her field.

In the fall of 2014, Allstadt will continue her scientific journey with a post-doctoral fellowship funded by the National Science Foundation. She’ll go to Vancouver, WA and the USGS Cascades Volcano Observatory to undertake her research project.

As any scientist well-versed in seismic and geological studies will tell you, the impact we have on the planet pales in comparison to what the Earth has already been through.

Allstadt says the impact she’d like to have is on society and our place on the planet.

“I hope to help us spend a longer time here, notably by helping us better understand and prepare for natural disasters that threaten us,” she said.

A moving sentiment from a scientist who understands seismic activity well enough to have made it her life’s work.
Dr. Peter Bex, a faculty member in the Psychology Department at the College of Science, has spent decades treating eye ailments. But he has done so in a multidisciplinary approach that actually uses the science of the mind – psychology – to enhance diagnosis and treatment. While there’s a proximity relationship between human optics and brain function, Bex’ studies go beyond that. He’s focusing on how a patient’s perceptions can either hinder or help treatment and recovery from visual diseases.

To fully understand the connection, psychology should be explained. As Bex says, psychology studies behavior at many levels – “from the molecular and cellular level of neural coding and communication all the way up to the behavior of global populations.”

Using a psychological approach, he is able to help patients recognize when they’re starting to have visual issues. In most cases, the changes are so gradual that people don’t become aware of them until treatment is less effective. Since treatment for eye disorders is best done in early stages, melding psychology and ophthalmology is the best approach.

“It is critical to help people become aware that they may have a problem as soon as possible,” said Bex. “So they can seek treatment. Additionally, it is important to monitor progression or remediation in people who are receiving treatment and this requires sensitive measurements of visual function.”

Working with patients who have amblyopia (a developmental problem that primarily affects vision in one eye of children); Age-related macular degeneration (an aging disease that primarily causes blindness in central vision); and glaucoma (an aging disease that primarily causes blindness in peripheral vision), Bex concentrates on different types of intervention and rehab for each.

In his studies, Bex has found that psychologists can use empirical and computational methods to understand and model these problems to provide the greatest benefit to patients. And new methods are being introduced every day. “This includes range of sensory assessments and patient reported outcomes,” said Bex. “As we develop more sophisticated models of human behavior and sensory function, we have been able to develop more detailed and precise assessments of visual structure and function. This leads to more informative and reliable methods to quantify the burden of vision loss, and thus more accurate predictions of the prognosis and outcomes to help patients and their families prepare for the future and to seek appropriate rehabilitation. These data feed directly into the process of clinical management.”

Over the last decade and a half, Bex has been in clinical research centers at a variety of health facilities and hospitals here and abroad. His field of translational research – using basic sciences to provide insight and direction in clinical situations – has grown rapidly and now plays a critical role for innumerable patients.

“The translational component of my specialty is especially intriguing because it allows me to see direct benefits (or not) of my research,” said Bex. “The connection between basic and clinical science is closer and faster than is possible in many research areas. Furthermore, conversations with patients who have visual impairment provide fascinating insights into normal development, aging and plasticity.”

As many of the best doctors comment, knowing the patient as a person is often the best way to understand the issues they face. Bex emphasizes the power science has in helping anyone understand the world…especially when it comes to medicine.

“I think we are all scientists at heart – we are all trying to understand things that interest and surprise us,” he said. “A course in science can help us to think rationally about problems, to formulate and test hypothesis about them and to critically evaluate our observations. An important part of scientific inquiry is finding out and accepting that our ideas may be wrong or may be challenged or rejected by others. This happens all the time and can be frustrating and discouraging, but the continuous revision and refinement of understanding is a critical part of the scientific process.”

Ultimately, Peter Bex is using his understanding of people, his training in psychology and science, and his medical background to provide vision to patients and the College of Science.

I think we are all scientists at heart – we are all trying to understand things that interest and surprise us.
Biologic drugs are highly complex, but they may be the answer to many medical illnesses and conditions that currently have no treatment available. The problem is, these drugs are not easy to characterize and test. Unlike most drugs that are chemically synthesized, biological products are protein-based and biologically produced. This means the drug development and testing stages are often much more complex.

To answer this need, Northeastern University’s College of Science and the Barnett Institute launched BioAnalytix two years ago. Led by CEO Kirtland Poss, BioAnalytix is now filling a critical gap in the area of biologic drug development and launch. “What we do is unique and in demand,” said Poss. “There is a lot of complexity to biologic drugs, and they need precise characterization throughout the development process – and it’s hard to do.”

For the past 10 years, the Barnett Institute has been applying its characterization techniques to biologic drugs in early stage development. In 2012, BioAnalytix was formed to help with the later-stage development decisions and regulatory filings for these cutting-edge drugs.

Currently, BioAnalytix is working with leading pharmaceutical companies in the U.S., Europe, and Asia, typically on later stage drug development. This is the stage where a biologic drug looks promising, and the drug company is looking to move on to Phase 3 clinical trials or regulatory approvals – the final stages before going on the market.

Over the past year, BioAnalytix has made some very significant progress. The company is hiring an industry-seasoned CFO, and has also moved to Cambridge, where it is surrounded by many leading pharmaceutical companies, but is still close to its original home, the Barnett Institute.

“BioAnalytix will continue to maintain and grow its affiliation with Northeastern University and the Barnett, because it is a very natural and real win for both of us,” said Poss. “They benefit from more exposure to pharmaceutical companies, and we benefit from exposure to cutting-edge innovation and early stage research that is truly world-leading in these areas. As we grow, this will continue to benefit both.”
Sir Richard Roberts: Nobel Laureate, Knight, and Northeastern Professor

Emily Ashbolt, Biomedical Physics, 2017

“One of the problems with teaching students now,” said Sir Richard Roberts, “is that you fill them up with facts and knowledge and then have them just regurgitate this information, and that is not an effective way to have them learn processes.” Leaning back in his chair in his Ipswich, Massachusetts office, overlooking the lush grounds of New England Biolabs (NEB) the enzyme reagent lab where he has spent the past seven years and is Chief Scientific Officer, Roberts looks far from how someone might picture a knighted Nobel Laureate. "I am a big believer in discovery-based learning.”

Discovery-based learning is certainly a field that Roberts is familiar with. Growing up in southwest England, Roberts learned much about science from making fireworks behind his parents’ house. “My parents were fairly uneducated,” he shared. “I don’t think they knew what I was doing. By the time I got to study chemistry in school, I’d seen all of it.”

Sir Richard Roberts was named as a Northeastern Distinguished University Professor at the beginning of 2014, and is hoping to inspire the next generation of molecular biologists.

Robert’s dream is to bring new genome sequencing, and, even more importantly, the determination of gene functions, into regular biological studies. “There are already some universities for which this is an integrated part of their curriculum,” said Roberts. “If we don’t
make serious effort, we are not going to learn about it.” Many genes have yet to be decoded, and among those that have been, the larger significance of many is unknown. “This is a huge problem,” Roberts recognized.

However, there is an alternative, he added: “It is also an area where undergraduates can really have an impact.” Northeastern strives for innovation, and tucking regular discoveries into standard scheduling definitely appeals. For Roberts knowing how to do research and associated field work is far more important than the “regurgitation” of standard studies.

Roberts’ day starts at 6 a.m. and he is often conducting research through the day and into the evening hours. “I still do research; most of my time is still spent doing research.” He recognizes the immense importance in innovative education for not just undergraduates, but anyone studying science. As he dives into his work at Northeastern, Roberts feels that his personal area of expertise, genes, will serve as an important tool for students: “One, it’s really good for undergrads to be involved in learning about how to work with genes. Two, this is an area in which [students] have the potential to make quite significant contributions to science, if the type of research is tailored properly.”

For Sir Richard Roberts, research is less of a method and more of a way of life. “Seeing things for the first time—things that never have been seen before—it doesn’t matter whether they are little things or big things, it’s exciting.”

This story was taken from an issue of NUScience – Northeastern’s student-run science magazine. If you would like to read more articles and check out past issues, visit nuscimag.com. If you would like to support this wonderful student initiative, please contact Helaine Silverman (h.silverman@neu.edu).
When asked to select top achievements in a scientific career spanning decades, Professor Pran Nath came up with five – each more impressive than the last. Professor Nath has been with Northeastern University for nearly 50 years and the research he’s worked on has implications for the universe.

To understand the topics Nath shared, you’d have to understand supergravity theory (an extension of the work Einstein began); the unification of particle physics and gravity and proton lifetimes and decay rates. Nath is currently using dark matter to search for answers to questions that might explain our very existence. These questions pertain to matter and radiation and how they comprise the galaxies, our planet, and life on Earth.

“Without matter, the universe would be simply radiation and there would be no life,” said Nath. “So the existence of matter is critical to our existence. However, the visible matter in the universe does not account for all the matter in the galaxies. From the rotation curves of galaxies you can infer that there is dark matter which is not visible to us through telescopes. We know of its existence through its gravitational pull on the visible part of the galaxies. It turns out that the total energy budget of the universe contains only about 4 percent of visible matter, about 23 percent is dark matter and the rest is dark energy.”

The work Nath’s been doing recently provides strong clues to the nature of dark matter. Unfortunately, the origin of dark energy is still a mystery to be solved. For calculational purposes dark energy can be described by a so called lambda term in Einstein equations. Einstein first put this term in his equations but later took it out describing inclusion of the lambda term as his biggest mistake. In that he was wrong, Einstein just didn’t know what he had found.

“So even Einstein’s mistakes find favor with nature,” said Nath.

What is most exciting about physics is that the equations we write on paper can describe the phenomena of nature.

Stephen Hawking meets with Northeastern physics students in 1990. Prof. Nath is pictured next to Hawking.

Pran Nath – 50 Years of Proving that Matter Matters

It’s fun to hear Nath discuss Einstein and others because the collaborative process in science transcends time. Where one person makes progress on a theory, others can add to that progress and ultimately the teamwork often proves more valuable than the solo exploration. Nath says this has been a constant during his career regardless of his physical location.

“I collaborate with many theorists whether I am at the university or visiting CERN or some other laboratory in the US or abroad,” he said. “The main difference between working at a big laboratory like CERN and at a university is that in a big laboratory everyone is on the same page. They know the relevance of what you are doing. At a university there are a variety of competing groups and one needs to continuously justify why
trying to understand the universe is an important endeavor as opposed to other research projects. Of course, this is more than compensated in a university because here you have the opportunity to interact with students who have an intuitive understanding of the importance of fundamental science’s innate importance and are drawn to it.”

In this regard, Nath says the environment at the College of Science makes collaboration and teaching easier. With myriad requests from students to assist with Nath’s work, there’s no need to persuade students on the importance of fundamental physics. Students are here to learn and he says that’s why they chose to study physics in the first place.

Physics plays a huge role in understanding the universe, but it takes time and insight to realize this.

“Physics has benefits which can be profound but are not always apparent in the short haul,” said Nath. “The work on colliders at CERN lead to the invention of the Internet which was initially used by the large experimental groups at CERN to communicate with each other. As another example, particle physics enters in cancer cure through high energy gamma rays and through neutron beam therapy.

The technology that is currently being developed at CERN to accelerate the beams will eventually find numerous industrial applications as well as the methods that CERN has developed to store big data and analyze it online are remarkable and are likely to have industrial applications.”

Ultimately, says Nath, fundamental science of this type fulfills the basic human need to explore and explain our world. To look at it another way, Nath’s work aims to provide answers to the biggest questions of our lives. And he says the next few years will be even more exciting as The Large Hadron Collider (LHC) at CERN, in Geneva, ramps up the energy of the accelerator from 8 TeV to 13 TeV in an effort to create conditions close to the Big Bang time.

Through this work, Nath and scientists around the world will move closer to the ultimate goal of finding a fully unified theory of all interactions including gravity which is consistent with quantum theory.

“What is most exciting about physics is that the equations we write on paper can describe the phenomena of nature,” said Nath. “This is true also, of course, of all science. But in physics and especially in particle physics you are exploring nature at its most elementary level. And physics at the most elementary level is amazingly beautiful”.

“The theories I have worked on have implications not only at colliders but also in satellite experiments looking for anti-matter and underground experiments for the direct detection of dark matter,” he said. “So the possibility that some of the ideas I have worked on over the past decades could be tested in experiments at the large hadron collider and in satellite and underground experiments is a very exciting prospect.”

Nath looks at science as an essential facet to any education. It affects our lives and our understanding of the universe. Through his teaching and research at Northeastern and the College of Science, Nath has helped generations of students and scientists see that physics really matters.
MSC and Mission 31 Dubbed a Success
Mark Patterson, Brian Helmuth, Liz Magee, Gracy Young, Allison Matzelle, Amanda Swayer, Sara Williams, Francis Choi, Jessica Torossian, and Nicholas Colvard, and all of the Marine Science Center at Northeastern University took part in Mission 31 – a research mission lead by Fabien Cousteau, grandson of Jaques-Yves Cousteau, the famed ocean explorer and creator of the first ocean floor habitat for humans. To read more, visit northeastern.edu/mission31

Three COS Faculty Honored as Highly Cited Researchers
Three faculty members in the College of Science have been named to Thomson Reuters’ “Highly Cited Researchers 2014” list. Albert-Laszlo Barabasi of Physics, the late Andrei Zelevinsky of Mathematics, and Alexandros Makriyannis of Chemistry and Chemical Biology are all on this year’s list.

The list highlights researchers from the sciences and social sciences and contains articles and reviews in journals indexed in the Web of Science Core Collection during the 11-year period of 2002 to 2012.

Two COS PhD Students Receive Outstanding Graduate Student Research Awards
Allison Matzelle and Tanya Rogers were awarded the highly-competitive and prestigious National Science Foundation Graduate Research Fellowship Award which aims to help ensure the vitality of the human resource base of science and engineering in the United States.

Two Mathematics Professors Receive Sloan Fellowship
Professors Ivan Loseu and Benjamin Webster were both awarded two-year fellowships presented by the Alfred P. Sloan Foundation.

ADC postdoc receives prestigious award
Brian Conlon, a Senior Scientist in Northeastern University’s Antimicrobial Discovery Center, received a Charles A. King Trust Postdoctoral Fellowship. The fellowship is two years with an award of $95,000. Conlon’s project is titled, “Determining the Mechanism of Persister Formation and Resuscitation in Staphylococcus Aureus.” He will work on this with mentorship from Dr. Kim Lewis.

Prof. Albert-Laszlo Barabasi

Prof. Joanne Miller

Prof. Ivan Loseu

Prof. Miller Recognized for Pioneering Research
Joanne Miller, Matthews Distinguished University Professor and chair of the Department of Psychology, was recently recognized by the Acoustical Society of America for her pioneering research on human language processing in the field of speech perception. A symposium was held in her honor.

Prof. Karger Receives Beckman Medal
Northeastern professor Barry Karger, whose contributions to analytical chemistry helped enable the sequencing of the human genome, received the Arnold O. Beckman Medal and Award for Outstanding Scientific Achievements in the field of electrodriven separation techniques.

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Prof. Joanne Miller

Prof. Ivan Loseu

Prof. Barry Karger
Undergraduate chemistry student awarded university grant

Congratulations to Kristian Teichert, an undergraduate biochemistry student who works in Professor John Engen’s lab. Kristian has been awarded an Honors Early Research Grant. In addition, Kristian has been a driving force behind NEPTUN, a program that works to bring high school students to campus to take classes designed and taught by college students.

An Exciting First Year Culminates with Prestigious NSF Grant

What would make the first year on a new job even more exciting? Being awarded a prestigious, five-year, nearly million-dollar grant from the National Science Foundation. Assistant professor of physics Paul Whitford was recently awarded a CAREER Award by the NSF to help fund his project, “Disorder, tRNA composition and energy transduction in the ribosome.”

Physics Grad Wins Dept. of Energy Award

The Department of Energy’s National Energy Research Scientific Computing Center (NERSC) recently announced the winners of their inaugural High Performance Computing (HPC) Achievement Awards. Included in the award winners is former Northeastern physics student Tanmoy Das. Das, a former student of Professor Arun Bansil, is now a postdoctoral researcher at Los Alamos National Laboratory.
We want to hear from you!

The College of Science wants to know what you have been up to since graduation – it’s always exciting to hear how well our alumni are doing. Whether it’s a new job, baby, or a wedding announcement, send your updates to j.swartz@neu.edu, and we’ll feature them on our COS alumni page (northeastern.edu/cos/alumni). We look forward to hearing from you!