Inside this issue:

- SPIRA Engineering Camp for Girls Completes Second Summer
- Brown to Lead $4.5 million Multi-University Research Initiative
- Senior Wins Elevator Pitch Competition
Message from the Dean

The School of Engineering provides an exceptional environment for the best and brightest students and faculty alike. Brown engineers are making a difference in the world through their innovative work, and the School of Engineering’s strength is its ability to attract the best and the brightest.

Online Education and the School of Engineering

There has been a lot of media “buzz” recently about online education, and we have to ask ourselves how this will affect Brown and our School of Engineering in the coming years. It’s ironic to contemplate the effect of this new mode of education on engineer- ing, since it is the very developments led by engineers – in computer hardware, displays, communications, networking technologies and software – that have enabled this revo- lution in the first place.

Along those lines, I am happy to report that Brown Engineering is now on Instagram! Please use the hashtag brownengineering when posting any Brown Engineering photos. In addition, we will be launching a revamped School of Engineering website in the spring with improvements in several areas to make it even easier to stay in touch with all the exciting happenings at the School of Engineering.

However, nothing beats a personal visit. When you come back to Providence for a reunion or other business, stop by Rass and Holley, see what has changed (or maybe what hasn’t), say hello to some of your former professors, and reconnect off-campus.

When you come back to Providence for the School of Engineering, we stress an interdisciplinary approach and a broad understanding of underlying global issues. Collaborations across the campus and beyond place like Brown? Many people worry that this will lead to a fundamental change in the business model for the delivery of higher education, and that higher education will go through the same wrenching changes that the music, newspaper and magazine industries have gone through recently.

I’m not worried about these new opportuni- ties. I think online courses have the potential to offer students an even better experience here at Brown, and add even more value to the education that we provide.

The reason I’m optimistic is that the under- graduate experience at Brown is about cre- ating a lifelong community of students and faculty in an intimate and highly personal learning environment. Our engineering courses are “hands-on” in the early years, and this experiential approach, combined with deep faculty engagements and rich interactions between students, resulting from the residential experience, is not going to be duplicated in the foreseeable future by any online experience. In fact, the avail- ability of online resources will enhance what Brown does best, allowing faculty to spend more time with students on individualized problem-solving specifically targeted to the student’s needs.

My feeling is that universities that create value through an experiential community of learning and scholarship will be the ones that thrive in the future. Fortunately, this is the model that Brown has been following for the last 250 years, and I think it is the best model going forward, at least for the next 250 years.

For all School of Engineering gifts and contributions, please call Rick Marshall at 401-683-9877 or email him at Richard_Marshall@brown.edu
IMNI Turns Five!

Brown's Institute for Molecular and Nanoscale Innovation celebrated its fifth anniversary in November.

Over the past decade, there's been an explosion of nanotechnology research worldwide. Harnessing the peculiar properties of matter at the tiniest scales promises to revolutionize manufacturing, healthcare, and information technology. The Institute for Molecular and Nanoscale Innovation (IMNI) is helping to put Brown—and Rhode Island—at the forefront of this emerging science.

"People are asking what can our universities do to help Rhode Island's economy. IMNI is one of those things," said Bob Hurt, IMNI's director and an engineering professor here at Brown. "We can make nanotechnology an area of excellence in Rhode Island and help to put the state at the forefront of the knowledge economy."

In five years, IMNI has grown to include 60 Brown faculty members, a statewide nanotech consortium with URI, and private partnerships with General Motors and Medtronic, a global biotech firm. All told, the group now brings in as much as $8 million in research grants annually.

Hurt expects similar results and further growth over the next five years. IMNI recently received approval from the university to open a new NanoTools facility on campus.

"The lab will have spectroscopic and imaging tools to help us understand the basic properties of the new forms of matter we create," Hurt said. "It will be open to all Brown researchers as well as local industry.

Hurt sees IMNI’s expansion as holding great promise not only for advancing knowledge but as a means for more collaboration with local businesses and industry. "My dream is to be able to establish a fabrication facility in the Knowledge District at some point," he said, "to help nanotechnology become part of the fabric of Providence and Rhode Island."

Spira Engineering Camp Completes Second Year

Four Brown University Engineering undergraduate women run a summer camp for rising tenth grade girls.

Farzahan Ausaluth ’14, Becca Barron ’15, Lizzie Costa ’14 and Jenn Thomas ’14 spent last summer running a four-week engineering camp for rising tenth grade girls. The camp was overseen by faculty advisor Karen Haberstroh, Assistant Professor (Research). Spira has inspired and motivated 38 young women from schools in the Providence area since its start in 2011. A donation from Michael Stern ’58 and a team Undergraduate Teaching and Research Award funded this year’s camp. With a curriculum structured around group learning and hands on projects, these girls are immersed in the world of engineering in an engaging and relevant manner. From bungee jumping Barbie to balsa wood bridges to Arduino, the scope covered in the four weeks is immense.

For Ausaluth, a mechanical engineering concentrator, and Costa, a biomedical engineering concentrator, this was their second year’s camp. With a curriculum structured around group learning and hands on projects, these girls are immersed in the world of engineering in an engaging and relevant manner. From bungee jumping Barbie to balsa wood bridges to Arduino, the scope covered in the four weeks is immense.

For Ausaluth, a mechanical engineering concentrator, and Costa, a biomedical engineering concentrator, this was their second year around with Spira. As co-founders of the program, they have seen the progress Spira has made over the past two years. Barron and Thomas, both concentrating in civil engineering, joined the Spira team in the spring of 2012. With their own fresh perspectives, they have since shared equal responsibility for planning and running the camp.

“Our recent focus has been on making Spira sustainable. We addressed this from many angles," says Ausaluth.

The team has diligently worked on this common focus concentrating on their lessons, network and alumni involvement. The coordinators sought mentors who could assist them with effective lesson planning strategies and delivery to make the lessons more varied. By reaching out to a greater number of engineering companies, professionals and Brown University professors, Spira was able to expand its network, increase field trips and have more guest speakers. Both Spira’s website and its Facebook page allow Spira alumni to remain connected to both the camp and the engineering world.

Additionally, the implementation of a mentoring program enabled past campers to contribute to the classroom dynamic while continuing their interest in STEM. These changes allow for the coordinators to evaluate the progress of Spira and work toward an educational model that best serves the campers.

Since last year, Spira has doubled the number of field trips and increased the intake of girls from public schools. Spira is now working on increasing the number of female guest speakers, allowing mentors to be more involved in lessons, and getting better connected to the pedagogical resources available at Brown University.

Over 100 posters were presented by IMNI professors, postdoctoral researchers and graduate students.
A SMART(er) Way to Track Influenza

Brown University researchers have created a reliable and fast flu detection test that can be carried in a first aid kit. The novel prototype device isolates influenza RNA using a combination of magnetics and microfluidics, then amplifies and detects probes bound to the RNA. The technology could lead to real-time tracking of influenza.

Results are published in the Journal of Molecular Diagnostics.

In April 2009, the world took notice as reports surfaced of a virus in Mexico that had mutated from pigs and was being passed from human to human. The H1N1 “swine flu” as the virus was named, circulated worldwide, killing more than 18,000 people, according to the World Health Organization. The Centers for Disease Control and Prevention in the United States said it was the first global pandemic in more than four decades. Swine flu will not be the last viral mutation to cause a worldwide stir. One way to contain the next outbreak is by administering tests at the infection’s source, pinpointing and tracking the pathogen’s spread in real time. But such efforts have been stymied by devices that are costly, unwieldy and unreliable. Now, biomedical engineers at Brown University and Memorial Hospital in Rhode Island have developed a biochip that can detect the presence of influenza by zeroing in on the specific RNA sequence and then using tiny magnets in a tube to separate the flu-ridden sequence from the rest of the RNA strand.

“The device allows us to design probes that are both sensitive and specific,” Tripathi said. “If there is no RNA partners, the Brown-led team at Brown and the corresponding author on the paper, published in the Journal of Molecular Diagnostics. “It’s a low-cost device for active, on-site detection, whether it’s influenza, HIV, or TB.”

“We wanted to make something simple,” said Anubhav Tripathi, associate professor of engineering at Brown and the corresponding author on the paper, published in the Journal of Molecular Diagnostics. “It’s a low-cost device for active, on-site detection, whether it’s influenza, HIV, or TB.”

The Brown assay is called SMART, which stands for “A Simple Method for Amplifying RNA Targets.” Physically, it is essentially a series of tubes with bulbs on each end, etched like channels into the biochip.

There are other pathogen-diagnostic detectors, notably the Polymerase Chain Reaction device (which targets DNA) and the Nucleic Acid Sequence-Based Amplification (which also targets RNA). The SMART detector is unique in that the engineers use a DNA probe with base letters that match the code in the targeted sequence. This ensures the probe will latch on only to the specific RNA strand being assayed. The team inundates the sample with probes, to ensure that all RNA molecules bind to a probe.

“This approach creates excess: probes with no RNA partners. The Brown-led team attached the probes to 2.8 micron magnetic beads that carry the genetic sequence for the influenza RNA sequence. The engineers then used a magnet to slowly drag the RNA-probe pairs collected in a bulb through a tube that narrows to 50 microns and then deposit the probes at a bulb at the other end. This convergence of magnetism (the magnets’ movement through the narrowing channel and the bulbs) separated the RNA-probe pairs from the surrounding biological debris, allowing clinicians to isolate the influenza strains readily and rapidly for analysis. The team tracked the RNA-probe beads flawlessly at speeds up to 0.75 millimeters per second.

“When we amplify the probes, we have disease detection,” Tripathi said. “If there is no influenza, there will be no probes (at the end bulb). This separation part is crucial.”

Once separated, or amplified, the RNA can be analyzed using conventional techniques, such as nucleic acid sequence-based amplification (NASBA).

The chips created in Tripathi’s lab are less than two inches across and can fit four tube-and-bulb channels. Tripathi said the chips could be commercially manufactured and made so more channels could be etched on each.

The team is working on separate technologies for biohazard detection.

By David Orenstein

Anubhav Tripathi

“We wanted to make something simple. It’s a low-cost device for active, on-site detection, whether it’s influenza, HIV, or TB.”

Schematic of SMART Technology and Detection of 2011 Flu Patient Samples from the Memorial Hospital of Rhode Island. (below). (Collaborators Drs. Steven Opal and Andrew Artenstein)
Understanding Traumatic Brain Injury

Assistant Professor of Engineering Christian Franck is studying TBI at the cellular level and designed significant upgrades to a helmet that measures impacts.

Helmets haven’t changed much since the late 1970s. Most are even tested in the same fashion, a simple drop test which is designed to gauge their ability to prevent skull fractures. The track record is impressive—with skull fractures resulting in very few of all helmet-protected head injuries.

However, as Brown University Assistant Professor of Engineering Christian Franck points out, helmet technology’s ability to prevent skull fractures has introduced a new set of issues: “Today’s helmets are keeping people alive—but now brains are damaged.” Such damage is often missed, as the worst of it may have occurred at the cellular level. Cellular damage often takes months, or years, to manifest related symptoms. The delay or absence of a proper diagnosis can have tragic results for traumatic brain injury (TBI) victims.

Franck is part of a Rhode Island Science and Technology Council (STAC) award-funded collaborative research team that is producing substantive results in addressing head trauma injury issues. He first became interested in TBI while at Harvard. There, as part of a biophysics group led by Kevin “Kit” Parker, he looked at blast injury as part of a biophysics group led by Kevin Parker, he looked at blast injury as part of a biophysics group led by Kevin Parker, and saw that some of the issues of great concern to the U.S. military.

Current combat operations have become a matter of great concern to the U.S. military. Military leaders acknowledge TBI’s tremendous impact, both on service members’ health and safety, as well as troop readiness and retention.

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As he worked with brain cells that had been subjected to TBI, Franck became interested in the forces these cells ‘see.’ Franck explains:

“The thing about TBI is that everything starts with the cells.

When they die, or change networks—all that affects how we perceive memory, what we think, and potentially impacts different functions.”

When Franck arrived at Brown University, a comprehensive medical school project related to TBI was already underway. The project, led by Henry F. Lippitt Professor of Orthopaedics Dr. Trey Crisco, in collaboration with Dartmouth and Virginia Tech, involved instrumenting NCAA players’ helmets with accelerometers in order to measure the acceleration of their heads during impact, then comparing results with subsequent diagnoses of concussions by medics on the field.

Hearing of the research, Franck recognized an opportunity to continue his inquiry into TBI, and soon was in contact with Dr. Crisco. TBI, regardless of whether incurred in combat or on the football field, is diagnosed and treated in subjective fashion. Franck, working with Dr. Crisco and supported by STAC, has been helping to move science towards an objective assessment of TBI cases. Other collaborators include experts from Brown Med, Rhode Island Hospital, Simula, and the Veterans Administration Hospital.

The project team was granted the STAC award in 2009. One part of their work, the science investigation, involved looking at cells and how they ‘see’ and respond to forces. This work uses equipment that enables the construction of elegant 3-D computer models of damaged brain cells.

The other part of the STAC-funded work involved a translational engineering application, using Dr. Crisco’s original design for an apparatus that gets fitted into helmets in order to measure impacts. With support from STAC, Franck and other Brown engineers devised significant upgrades to the original design. The resulting prototype was successful enough to inspire an Ohio-based helmet technology company, Team Wendy, to invest in a collaboration. The current system is well on its way to being able to measure a hit and instantaneously signal the level of injury to medical personnel up to a mile away. This technology has incredible potential for military applications. “In a blink, the medic would see on the screen, ‘This person’s going to have a concussion,’” explains Franck.

All of the system’s electronics are manufactured in Rhode Island. Team Wendy now has a proposal before Congress for additional funding. Were it to be funded, the state would reap immediate benefits.

Of his team’s efforts, Franck says, “We’ve done really well.” He attributes a lot of the work’s success to STAC’s support. “People say, ‘What can you do with such a small amount of money?’ In academia... it allows you to... get people together, develop fertile ground, establish an infrastructure—then, if the community is supportive, you can really make something. Every big building starts small.”

By Hallie Steele/RI STAC
Through a new Multidisciplinary University Research Initiative (MURI) awarded by the Air Force Office of Scientific Research (AFOSR), Brown will lead an effort to study new optical materials and their interactions with light at the quantum scale.

The field of metamaterials has already expanded the range of optical materials and phenomena available at larger, classical scales. People are doing things with metamaterials that we couldn’t have imagined before. For example, researchers are making metamaterials with negative refractive indices, which can literally bend light backward around objects. Others have used metamaterials to make lenses that can image things smaller than the diffraction limit of traditional lenses. What we’re doing now is asking what happens when we bring these metamaterials down to the scale of quantum emitters — the level of things that can emit a single photon at a time.

Can you talk a bit about the challenges involved in doing this?

When you talk about the way light interacts with matter at the quantum level, the types of interactions and the strength of those interactions are limited by a size mismatch. The optical wavelength is something like 100 times larger than a quantum emitter. For example, a quantum dot — a small bit of semiconductor we can use as a light emitter — is 5 to 10 nanometers. The wavelength of light is on the order of 500 to 1,000 nanometers. The problem is that the quantum dot doesn’t know there’s a wave. It can’t see the spatial variation of the light wave, just its average intensity. So we need to shrink the wavelength of light to increase our interactions. Or we might increase the wavelength to collectively interact with many quantum emitters. And hopefully we can learn something fundamental about the nature of light that opens up new ways of manipulating these interactions. Those are the types of things we’ll be addressing.

In quantum optics we’re limited in part by the kinds of materials we can use. One of the common materials for quantum optics today is the nitrogen vacancy defect in diamonds, so-called diamond NV centers. As you can imagine, diamond is not the cheapest or most scalable technology. The challenge posed for us is how to use the semiconductor materials we use for electronics and extend their optical properties with metamaterial designs, so we can perform quantum optics at wavelengths and with materials commonly used in telecommunications today.

How does the research you’re doing in your lab at Brown fit in?

It’s usually assumed that all light-matter interactions at visible frequencies result from the push-pull forces exerted by electric fields. These are called electric dipole transitions. One of the things we do in my lab is study things that aren’t electric dipoles — for example, magnetic dipoles. Because of the size mismatch we just discussed, it’s often assumed that magnetic dipole transitions are around 100,000 times less likely to happen than electric dipole transitions. In other words, it’s assumed that light emission from magnetic dipoles simply doesn’t happen. But the fact is we see magnetic dipole emission every day from the lanthanide ions that are commonly found in fluorescent lights. What we’ve been able to do is quantify the magnetic nature of light.
Like sumo wrestlers, two LEGO® robots made their way around an oval ring, grabbing, swatting at each other, and trying with great gusto to push the other robot out of the ring to win the match. Ten young boys—third, fourth, and fifth graders—at the Paul Cuffee Middle School in Providence cheered on their creations, watching in delight as their aggressors responded to pre-programmed commands and light sensors to make their way around the ring in pursuit of the opponent. At each turn, parents and volunteer instructors joined in the cheering at the school’s cafeteria on Friday, July 20th. It was the culmination of a three-week pilot program designed to pique children’s interest in engineering and computer science.

The LEGO® robotic program was a partnership between Brown’s Science Center and the Paul Cuffee Middle School. Ten student participants were divided into two teams—the Panthers and the Demons of Nothingness—and instructed in the finer points of computer programming and engineering using LEGO® robots as the teaching tool.

Students used a kit that not only contained LEGO® pieces but robots’ “brains,” which were connected to laptops so students could program the brains to respond to light, touch, ultrasonic, sound, color, temperature, accelerometer, compass, and radio-frequency identification sensors.

Brown engineering students Mike Lazos ’14 and Raymon Baek ’15 helped the students design, build and program robots for four hours every day during the three-week summer program. According to instructor Baek, the program was a tremendous success.

“The kids were very bright and went beyond our expectations,” Baek said. “We always finished the planned curriculum a lot quicker than expected, which kept Mike and me improvising to stay ahead of the students.”

Instructors Raymon Baek ’14 and Michael Lazos ’15 were impressed that students mastered the material so quickly.

In the final battle, the instructors’ own robot was thrown for a loss.

The students used visual programming software with easily readable icons and distinct colors for each type of tile. For example, movement tiles would tell the robot to move and sensor tiles would tell the program to rely on a specific sensor. The program used wait statements, (e.g., wait for a certain sound level or touch sensor to be activated), switch statements, (e.g., if the light sensor detects a dark area, move right; move left for a bright area), and loops. These commands made it possible for the robots to compete in the sumo wrestling challenge and an obstacle course.

The students had to be creative about using sensors to follow a zigzag path through the obstacle course, navigating through various boxes, capturing colored balls from a central area, and bringing them back to their starting points. The Panthers easily won the obstacle course because they built a robot that had a robotic arm that pulled nearly all the balls back to its starting point in one trial.

As for the battle arena, the Demons of Nothingness won because their robot was very bulky and stable. “Mike and I decided to surprise them by introducing our own robot that we assumed was invincible,” said Baek. “We had the three robots fight it out in the ring. To our surprise, our robot was pushed out of the ring and the Demons of Nothingness reigned victorious.”

During the three-week program, the instructors gained some insight about the challenges of teaching. “The boys loved to build, but the programming, which required them to sit still and concentrate, was a challenge. They need to get up and run around every so often to burn off some energy,” said Baek.

In this pilot effort, all participants, including the students, teachers, learning concept, and execution proved to be a perfect match.
Engineering Senior Wins Elevator Pitch Competition


Three of the top ten finalists were from Steve Petteruti’s Entrepreneurship I class, Engineering 1930G. Cory Abbe ‘13, a BEO concentrator, pitched Sonacatch 3D, an all-inclusive travel trowel system that keeps underwater fishing nets safe from harm. Other members of the team included David Killian, a computer science concentrator, Vanessa Munoz, a BEO concentrator, and Moss Amer, a BEO director.

Joshua Gold ‘13, pitched PowerHouse, a power output meter that delivers key readings of the power output of oarsmen. Other members of his team include mechanical engineering concentrators Elizabeth Gambuzi ‘13 and Francisco Oliveira ‘13, as well as Alice Leung ‘13, who is concentrating in electrical engineering.

Tim Kwak ‘13, a BEO concentrator, pitched SEVA, software that will allow mariners to indicate their preferred content to be broadcast on a satellite network. Other members of his team included Ilana Foni ‘13, a materials engineering concentrator, Ian Hovander ‘13, a computer engineering concentrator, and William Gasner, a BEO concentrator.

The other two finalists are also active participants in the Entrepreneurship Program’s Idea Labs. Cliff Weitzman ‘16, pitched Boardbrake, an attachable brake for longboards to make skateboarding safer. Sidney Kushner ‘13 presented CCCchampions, a nonprofit corporation he established to build a national network that links children with cancer to professional athletes.

Established in 2000, the Rhode Island Business Plan Competition was recently named one of the top 40 business plan competitions in the country, and has awarded more than $1.2 million in prizes to competitors developing companies across many industries. The contest required the competitors to pitch their business idea to a panel of eight expert judges from the Rhode Island business community in 90 seconds. The elevator pitch contest is a prelude to the annual Business Plan Competition, which features more than $200,000 in cash and prizes. Applications for the business plan competition close on April 1. Winners will be announced on May 2.


Brown Engineers Without Borders Returns to the DR

The community of Los Sanchez lies in the center of the Dominican Republic. It is on the outskirts of Tires, an agriculturally-based municipality, isolated from the rest of the country by a ring of high mountains. Home to about 300 people, the community is very self-contained. Most children do not travel far from their homes as they become adults. The pride of the community is El Centro Educativo de los Sanchez, a government-constructed one-room schoolhouse with one teacher and 35 students. The school is one of ten primary schools in Tires, but the municipality is home to only one high school, which is located in a different community.

The Brown University Chapter of Engineers Without Borders (EWB) established the groundwork for a long-term partnership with Los Sanchez in late August. Members travelled to the community and met with administrative, health, and school officials as well as the teacher from El Centro Educativo de los Sanchez, Angela Jimenez. A key area of research within the chapter has been sanitation hygiene and the design of a sanitation facility that is sustainable from both environmental and economic perspectives. Sanitation is a major point of concern at the school, where a set of pit latrines provide the only bathroom facilities available to students. There is no running water and no access to toilet paper. Health Administrator Dr. Saif Haider explains that latrines such as the ones in Los Sanchez create pockets of illness that inhibit students’ abilities to learn in a healthy environment. The people of Los Sanchez desire to install flush toilets, but the funds for such a project have yet to be found. In other parts of Tires where flush toilets are in use, waste is typically flushed into a pit and then pumped out periodically into a gutter that runs behind a row of houses.

Brown EWB hopes to work closely with school officials and the people of Los Sanchez to make the sanitation facilities at El Centro Educativo de los Sanchez healthy and environmentally sustainable. The modifications, which may include a new toilet system and handwashing system, will be presented alongside an education plan and pictorial instructional materials about basic hygiene to be presented to the children in the school system. The final aim of this program is to turn the school into a healthy learning space and build a bond between a group of Brown students and a foreign community.

by Dana Dourdeville ’15

Brown alumni and students had another strong showing at the seventh annual Rhode Island Elevator Pitch contest, as David Emanuel ’13, a senior mechanical engineering concentrator, took home the top prize. It was the fifth consecutive year a Brown student or alumnus has won.

Emanuel pitched Lock’d, which enables travelers to attach their backpacks to stationary objects such as hostel beds and train seats.

“With even just a little bit of funding we will fully develop a working prototype, enabling Lock’d to give travelers what they deserve: a worry-free and relaxing adventure,” he said. Emanuel is currently in Darryn Washsky’s ENGIN1010 class, “The Entrepreneurial Process: Innovation in Practice,” and he and his team developed Lock’d as their semester business plan project. Emanuel has also been active in the Entrepreneurship Program’s Idea Labs. The other members of Emanuel’s team are Amanda Lee ’13, Matthew Klimerman ’13, Joseph Stall ’13, and Mehves Tangun ’13. Stall is a business, entrepreneurship and organizations (BEO) concentrator, and Tangun is an engineering and economics double concentrator.

The event, sponsored by the Rhode Island Business Plan Competition, was held at the Johnson & Wales University HarborSide Campus and included 46 presenters. A total of $1,000 in cash prizes was awarded to the top 10 presenters. Out of the 46 to pitch, 14 had Brown connections, including 12 current students. Of the 10 finalists, an impressive six were from Brown.

Three of the top ten finalists were from Steve Petteruti’s Entrepreneurship I class, Engineering 1930G. Cory Abbe ‘13, a BEO concentrator, pitched Sonacatch 3D, an all-inclusive travel trowel system that keeps underwater fishing nets safe from harm. Other members of the team included David Killian, a computer science concentrator, Vanessa Munoz, a BEO concentrator, and Moss Amer, a BEO director.

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by Dana Dourdeville ’15
A team of Brown University researchers has received a $750,000 grant to design an oscillating underwater wing that can capture energy from flowing water in rivers and tidal basins. The funding comes from the Department of Energy’s Advanced Research Projects Agency—Energy (ARPA-E), which funds breakthrough technologies that show fundamental technical promise but are too early for private-sector investment.

“Marine and hydrokinetic energy is a vast and renewable energy source,” said Shreyas Mandre, assistant professor of engineering who will lead Brown’s effort with colleagues Kenneth Breuer in engineering and Heather Leslie in ecology and evolutionary biology. “The main advantage of hydrokinetic energy, unlike solar or wind power, is that the availability is predictable.”

The wing would capture forces exerted on it by flowing water in much the same way airplane wings capture lift force from wind. “This lift force causes the hydrofoil to heave up and down periodically, and this motion can be used to generate electricity,” Mandre said.

The award supports developing proof-of-concept for this potential technology, and complements current efforts to investigate the fundamental hydrodynamic mechanisms of energy conversion funded by the Air Force Office of Scientific Research.
Jennifer Franck

Passenger jet or flapping bat, Jennifer Franck writes code that simulates the flow of air around things with wings. The computational approach has advantages and efficiencies, especially for someone to whom coding comes naturally.

One of the questions Franck looked at is why bats flap their wings, as opposed to using them for soaring flight. “There’s a theory that bats evolved from passive gliders to actively flapping their wings,” she said. “The question was, what’s the benefit of flapping.”

Franck’s models helped to show that flapping creates vortices — tiny pockets of low air pressure — above a bat’s wings. Those vortices create extra lift and may be part of the reason flapping is worth the effort.

Franck has also used her models to explore applications that might improve aircraft flight. “Say you want an airplane to have more lift,” she said. “Could you apply some sort of device on the wing that would pump some extra energy into the flow and give you better performance? I’m interested in applying code to those types of flow control questions.”

There are significant advantages to the computational approach, Franck says. It’s much easier, for example, to modify the parameters of an experiment on a computer than it is to design new physical models for wind tunnel tests. Another advantage is that computer models help to isolate the specific aspects of a problem that researchers are trying to address.

“We generally model a very simple airfoil that’s often just two dimensional because it simplifies the problem,” Franck said. “If we’re looking at the basic physics behind a problem, we don’t want to make things too complicated.”

Though the models may be simple, the code that generates them is not. Most of Franck’s programs require computer clusters that string together multiple processors. For some of her research, Franck has used a cluster at Brown’s Center for Computation and Visualization. For other projects she’s used the Department of Defense’s Army Research Lab cluster in Maryland.

It’s a long way from the Commodore 64, but Franck is right at home. “Coding has always been my fascination,” she said. “It’s nice to see the thoroughness, and rewards originality and creativity,” he says. “It’s nice to see the traditional quality of science — the main reason why many of us chose to do science in the first place — is retained here.”

Not to mention, he adds, that Brown is known for employing many of the “rock stars” in the field of solid mechanics over the years.

Aside from his work on Euplectella, Kesari has worked extensively on understanding adhesive properties and surface roughness, including a theoretical basis for why things like sticky notes and packing tape stick better when you push them down harder. He also studies failure patterns in polymer-based materials.

Kesari earned his Ph.D. from Stanford in 2011. He grew up in southern India, where his fascination with engineering started.

“My father worked in irrigation,” he said. “One of the early experiences I had was going to these small irrigation canals to play. The entire community revolved around water for crops and everything else, and I could see just having a simple stone structure changed people’s lives so dramatically.”

He came to view engineering as humanity’s way of putting our collective foot down, no longer helpless against the blind whims of droughts and floods.

“Engineering, it seems to me, is a very special enterprise,” he said. Through it “we control our own destiny.”

Haneesh Kesari

As an engineer, Haneesh Kesari takes his inspiration from nature.

The new assistant professor of engineering marvels at how nature takes a few proteins and a bit of calcium or silica and creates structures with amazing material properties — emergent properties that might seem impossible given limited raw ingredients.

“Nature is doing it,” he says, “hence it is possible. How to do it is what my research will be focused on.”

Kesari is currently studying Euplectella, a genus of sea sponges. Sea creatures might seem strange territory for a materials scientist, but Euplectella have peculiarities that make them something of an engineering marvel. Whereas most animal species form skeletons with calcium, Euplectella are made mostly of silica — glass. But don’t think of these creatures as the fragile Ming vases of the sea. On the contrary, their skeletons are strikingly robust.

Kesari is interested specifically in the root-like appendages that fix the animals to the ocean floor. The glassy structures, called basalia spicules, have properties similar to man-made fiber optic cable, only the sponge-made versions are substantially stronger and more flexible. Imaging these appendages at the nanoscale reveals an intricate construction. Each spicule is made of concentric layers, some made of glass, others made of a polymer. It’s the pattern in which these layers are arranged that caught Kesari’s attention.

“You see it and think, ‘Is this really an animal skeleton or is it a figure from a math book?’” he said. “It had an algorithmic beauty to it. We didn’t know what the algorithm was, but felt that there had to be one, because it had such regularity to it.”

Kesari thought this pattern might contribute to the spicules’ renouned strength, so he set to work calculating what pattern of layers would be the strongest given the materials in the spicule. “We calculated it and it so happens the resulting algorithm matches very well with what we see in the spicule,” he said.

Amazing what nature can accomplish given enough time. Understanding these sorts of mathematical regularities in nature could lead to the man-made materials of the future. It’s a slow and difficult process, Kesari says, but Brown is the perfect place for that sort of research. There’s a culture in the School of Engineering that “encourages the pursuit of rigor and thoroughness, and rewards originality and creativity,” he says. “It’s nice to see the traditional quality of science — the main reason why many of us chose to do science in the first place — is retained here.”

Meet the New Faculty
Indrek Külaots

Graphene — sheets of carbon that are one atom thick — could help take mercury and other nasty pollutants out of circulation if only there were a way to keep the sheets from sticking together. Indrek Külaots is working on a system of nanoscale pillars.

But for all its miraculousness, graphene has a problem. The sheets have a tendency to get stuck together in stacks when processed, which decreases this vast surface area on each sheet. Think of two sheets of paper stapled at all four corners. It’s not possible to write on the back of the first page or the front of the second because those surfaces are stuck together.

“My research is how to interrupt this stacking,” Külaots said. “How can we get something in the middle so we can actually use the inner layer space as well?”

He’s developing tiny carbon columns to do the job.

“It’s just a pillar, like in ancient Rome,” he said. “But when you’re working at the nanoscale it’s not that easy.” Despite the difficulty, Külaots has had success using his pillars to recover some of this lost space, and recently presented his work at one of the world’s top conferences on carbon materials.

“These pillared graphene and graphene oxide systems have a great potential in the fields of gas storage, separation, and catalysis, if properly converted into bulk materials,” he said.

Such is the fast-paced world of engineering:

Indrek Külaots is using garbage to make the world a cleaner place.

Indrek Külaots was born in Estonia. After earning his master’s degree in mechanical engineering at the Tallinn Technical University, he worked on a project to recycle fly ash, a byproduct produced by the burning of oil shale.

His work on that subject caught the eye of Eric Suuberg, an engineering professor at Brown. Suuberg thought Külaots’ work could be applied to fly ash created by the burning of coal, which is a major concern in the United States.

“He saw my work and said, ‘Why don’t you apply?’” Külaots said. “So I came to Brown as a Ph.D. student and I never left.”

After earning a master’s degree in applied mathematics in 2000 and a Ph.D. in chemical engineering in 2001, Külaots stayed at Brown as a senior research engineer. In 2009, he was awarded a joint position as lecturer and research engineer. This year he joins the faculty as a lecturer.

In addition to teaching classes in chemical, mechanical, and environmental engineering, he’s expanding his research program to include a hot topic in the material sciences world: graphene.

Graphene is a one-atom-thick sheet of carbon, with vast surface area. It began getting notoriety a few years ago and quickly gained a reputation as a miracle material. Its electrical properties make it a likely successor of silicon in microprocessors. It also holds promise as a way to store gases like hydrogen for use in fuel cells, and it can catalyze chemical reactions.

But not that easy.” Despite the difficulty, Külaots has had success using his pillars to recover some of this lost space, and recently presented his work at one of the world’s top conferences on carbon materials.

“These pillared graphene and graphene oxide systems have a great potential in the fields of gas storage, separation, and catalysis, if properly converted into bulk materials,” he said.

Such is the fast-paced world of engineering:

Before graphene makes it out of the lab and into production, Külaots is thinking of ways to make it better.

Jacob Rosenstein

Biological sensors that detect currents at the nanoscale would have important clinical applications, but how to separate signal from noise when the current lasts for 10 microseconds? Jacob Rosenstein has theories and devices that enable measurement at small timescales.

Jacob Rosenstein enjoyed his undergraduate years at Brown and certainly made the most of them. He graduated magna cum laude and co-founded a company with Anubhav Tripathi, associate professor of engineering. Still, when Rosenstein graduated in 2005, continuing in academia was far from his mind.

But seven years later, following a stint in the semiconductor industry and now all but finished with a Ph.D. from Columbia University, he’s set to return to Brown for a job as an assistant professor of engineering. Much as he did while a Brown student, he plans to continue innovating at the nexus of electronics and biology.

“I am excited to see what we can do to leverage all of that advanced technology for biological and chemical sensors.”

Rosenstein was a busy senior at Brown. At the same time he was developing a new microphone array platform with Harvey Silverman, professor of engineering, he was also working with Tripathi to develop instruments for microfluidic chips, which are integrated circuits that control the flow of fluids rather than electrical current. They founded Gauge Microfluidics in Providence to commercialize the work.

“Gauge Microfluidics is to make new electronics and experimental setups to reduce the noise level and therefore enable measurements at timescales that people have not been able to measure.”

Now back at Brown, Rosenstein is looking forward to exploring other opportunities in biotechnology. He’s applied the university’s success in harnessing signals directly from neurons in the brain with the BrainGate sensor is a particularly inspiring example.

“Today, there are a lot of other interesting diagnoses, sensors, and hybrid systems that are mostly unexplored,” he said. “I’m very excited to test the waters and get to know the pure sciences and life sciences groups at Brown, and hopefully I can be a hub of instrumentation, sensing, and high-performance electronics.”

Rosenstein returns with an established track record of exactly that.
Studying Renewable Energy in Costa Rica Through the Green Program

I cannot speak highly enough of the Green Program. I first learned about it from an email sent to the School of Engineering’s mailing list. It came at a moment when the clutter of my email inbox was representative of my plans for life after graduation. I needed a direction and purpose for the skills that I have acquired and developed as a Brown Engineering student. I wanted to continue working with renewable energies; I wanted to travel; and I wanted to help the world.

It described a two week engineering course in Costa Rica that studied renewable energies and included several visits to the state’s various renewable energy plants. Though appealing and exactly what I was searching for, I held my reservations about the program’s educational curriculum – which also advertised visits to Costa Rican microbreweries. It seemed like a fun tropical vacation hidden under the guise of hands-on experience and learning.

Having completed the two weeks abroad, I can truthfully admit that I was completely blown away by the program. My concerns over the educational quality of the program were put to rest on the first day when we met our instructor. His lectures were among the most engaging I have ever experienced – rivaling those at Brown. We learned about his professional experience in energy, which provided me insight on what my career might look like five years from now. The program exposed me to incredible opportunities I otherwise would not have experienced.

On one trip, we visited a wind farm to learn about its operation, entered into the turbine base and climbed down its rotors for maintenance. We also visited two hydropower plants and witnessed the extreme disparity in scale between different renewable energy technologies. Thanks to this course I was also able to finally visualize, in its entirety, the trapezoid representation of a turbine from ENGM72 class (Thermodynamics).

It was a perfect balance of education, fun, and adventure. Some days, I would find myself going straight from a biomass plant tour to a zip-line of the jungle canopy or a conservation zoo where injured animals are nursed. It seemed like a fun tropical vacation hidden under the guise of hands-on experience and learning.

As expected, Costa Rica is a tropical paradise. Its natural and cultural beauty is like no other place. I will surely return one day to stunning beaches, delectable foods, and of course, excellent microbrews.

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