Mechanical Engineering

Momentum

Winter 2019

Bio-Inspiration

The new wave of tough, flexible armor has its beginnings with a tiny mollusk

College of Engineering
Mechanical Engineering
Virginia Tech

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INSIDE

A mechanical engineering senior design team is working with Americare-Plus, George Washington University, and the Buena Vista Police Department to help build a drone to track missing persons. The team is one of dozens of teams who will present their capstone senior design projects later this spring.

Professor Azim Eskandarian - Nicholas and Rebecca Des Champs Professor, ME Department Head
Rosaire Bushey - Communications & Outreach Manager
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ABOUT THE COVER

A 3D printed multi-material provides toughness and flexibility in a single package. Hard scales inspired by chiton mollusks form a rigid, interlocking barrier, on a flexible surface. Photo courtesy of Ling Li.

AZIMESKANDARIAN
NICHOLAS AND REBECCA DES CHAMPS PROFESSOR
DEPARTMENT HEAD, MECHANICAL ENGINEERING

Interdisciplinary engineering

I am delighted to share more innovative interdisciplinary research and discoveries of our faculty and students with you in this issue of our Momentum Magazine.

First, I am pleased to congratulate Drs. Oumar Barry and Ling Li who just received National Science Foundation CAREER Awards to study and develop inspection robots for power lines, and the structural design and formation mechanisms of biomineralized architected metamaterials, respectively. This highly selective honor illustrates our faculty's commitment to cutting-edge research in keeping with our mission as a land-grant university. (Find Dr. Barry's award covered on page 12, and Dr. Li's on page 13.)

Our cover story this quarter is another case for interdisciplinary work. Dr. Ling Li and collaborators at several universities, including MIT and Harvard, conducted an in-depth study of the chiton mollusk to model armor, based on the mollusk's distinctive plating and scale arrangements. (See page 8) Dr. Shima Shahab is working in smart materials and vibrations with collaborators in mining and minerals engineering on a $900,000 project to making mining more efficient and, as a result, safer for miners. (See page 6)

Our nuclear engineering program has recently received two grants worth $850,000 to help both students and faculty. Principals involved are Drs. Ali Haghighat, Juliana Pacheco Duarte, and Azim Eskandarian. The nuclear program will continue to grow with issues as diverse as nuclear security, policy, materials, and energy. (See page 14)

As evident, our trans- and inter-disciplinary collaborative research is helping to solve some of the most pressing and challenging engineering problems with creativity and innovations. Finally, our work also highlights how cross-disciplinary projects are redefining what it means to be a mechanical engineer.

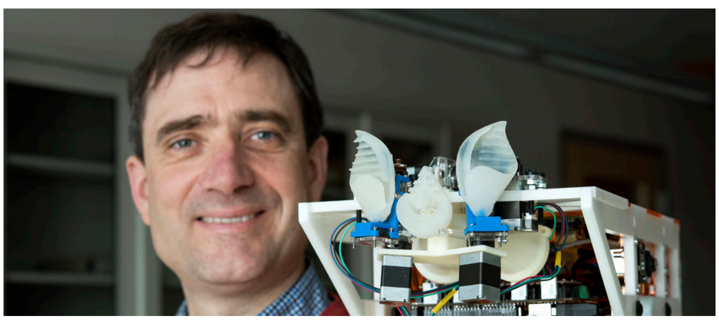
Please enjoy this issue of Momentum, and I hope you all enjoyed your well-deserved break between semesters. Happy new year!

With Best Regards,
Azim Eskandarian

The Lead

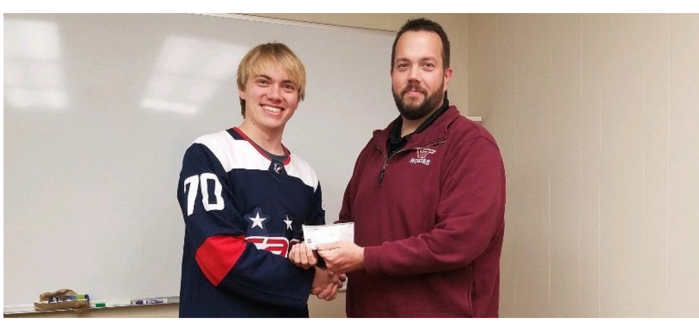
Mehdi Ahmadian, Dan Pletta Professor of Mechanical Engineering, was awarded the 2019 SAE/Magnus Hendrickson Innovation Award. The award honors the renowned inventor and businessman who founded the Hendrickson Motor Truck Company in 1913, and recognizes an individual or team whose research creates significant, positive change and elevates vehicle dynamics to new levels of innovation.

Brian Lattimer, professor of mechanical engineering, received in October, the 2019 Sjolin Award for lifetime contributions to the science of fire engineering. The award came from the International Forum of Fire Research Directors, for Lattimer's work in advanced modeling, simulation, and robotic systems for emergency response and innovative solutions in the area of fire engineering. The award will be presented in April 2020.

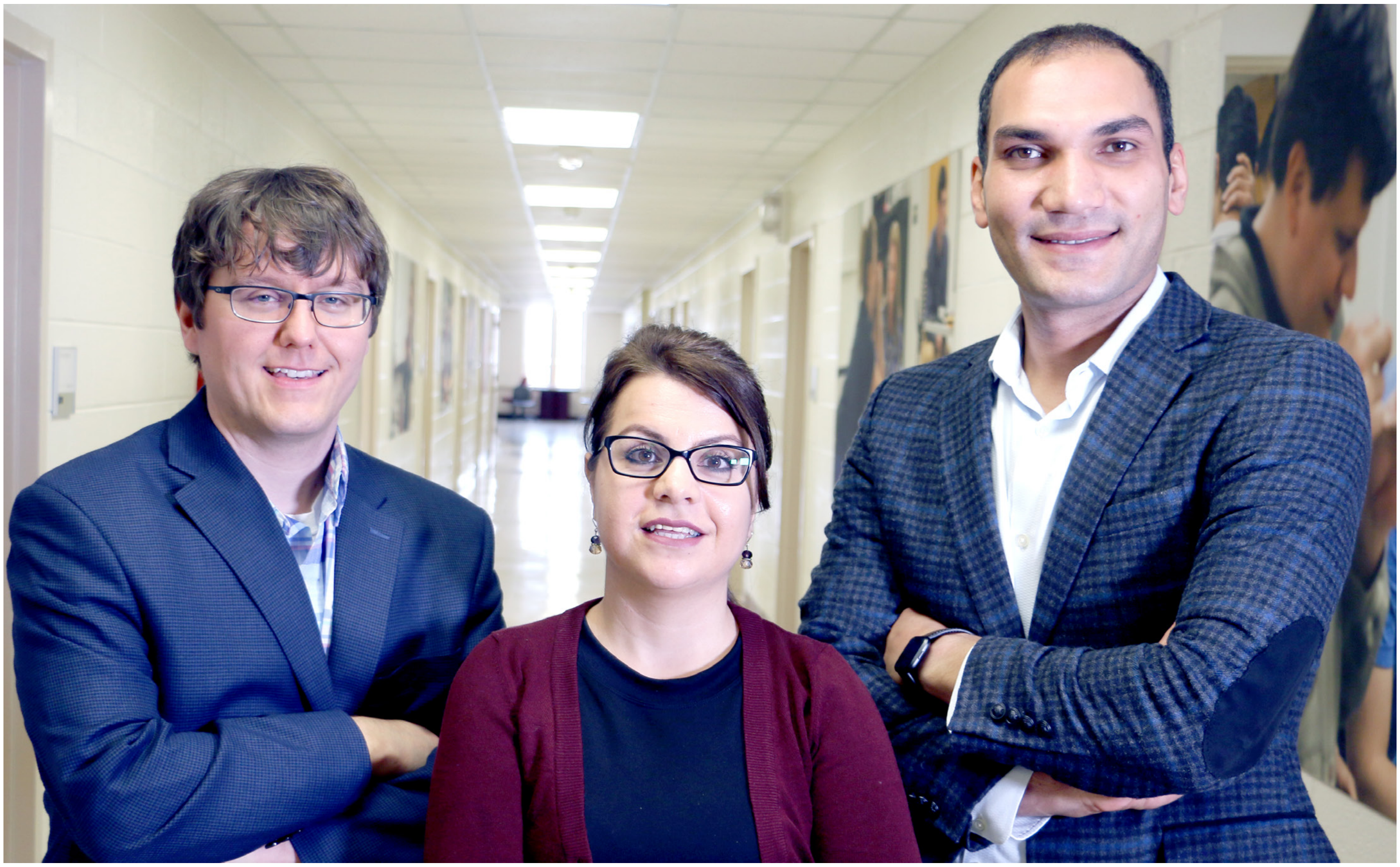


Rolf Mueller, professor of mechanical engineering, was elected a Fellow of the Acoustical Society of America in December. The award will be presented in the spring. Fellows of the society are selected based on rendering conspicuous service or notable contributions to the advancement or diffusion of knowledge of acoustics or the fostering of its practical applications.

Brandon Pieroni, sophomore, and Nolan McGrady, senior, and other Ware Lab students, took their projects to Roanoke in November as part of STEAM Day at the Virginia Museum of Transportation. The museum has a 2005 Formula SAE car on display. Students talked about engineering with more than 1,000 students from two dozen Virginia school systems throughout the course of the event. See the TV coverage of the event here.



Lieutenant Mitch Harrison, Buena Vista Police Dept., presents ME senior Ben Jones with a check for $2,000 courtesy of the Buena Vista Masonic Lodge #186 and BVPD to support the senior design UAV for CareTrak project. The work will help extend the range of a device used to help locate people - specifically children with autism or adults with dementia/Alzheimers so municipalities can quickly find them from a greater distance.



Associate Professor Aaron Noble, mining and minerals engineering; Assistant Professor Shima Shahab, mechanical engineering; and Reserach Scientist Hassan Amini, MME.

$900,000 Multi-disciplinary project aims to make mining more efficient

For people who are involved with mining, there are two things that are paramount to an effective operation – efficiency, and safety, and the industry is always looking for ways to improve both. Researchers at Virginia Tech are leading a multi-disciplinary team in a three-year $900,000 project to improve the efficiency of dust scrubbers in underground mining operations.

Funded by the Alpha Foundation for the Improvement of Mine Health and Safety, Aaron Noble, associate professor, mining and minerals engineering, is working with Shima Shahab, assistant professor of mechanical engineering, and Hassan Amini, a research scientist with mining and minerals engineering, as well as collaborators from Michigan Tech, and Cornell University.

"Underground mines make use of machines called continuous miners that shave off layers of coal or rock with a large cutting wheel at its front," said Noble, the project's primary investigator. "Scrubbers are a kind of dust filter integrated into the design of the cutter. As the machine advances it generates a lot of its own vibrational energy. Part of what we're trying to do is to create a dust suppression system that harvests that vibrational energy to manipulate it in a way that is useful to the suppression effort."

Current dust collection systems require multiple work stoppages during the course of a day to replace and clean filters and hardware. The team will incorporate new materials that better collect dust, and use the continuous miner's vibrations to help keep the filters from clogging as often.

"Currently, most continuous miners use a fixed mesh filter, but we want to replace that with a mesh that can use the specific vibrations of the machine to not only collect more particles, but also, in some capacity, clean itself to allow for a longer time between work stoppages," Noble said.

In the Multiphysics Intelligent and Dynamical Systems (MInDS) laboratory in the mechanical engineering department, Shahab is modeling and testing different meshes through scales. "We are testing different materials and boundary conditions in terms of vibrational responses of the designed mesh, and finding the maximum response of each mesh in a frequency domain to find the optimal product," she said. "And we are using computational fluid dynamics along with particle trajectories simulations to analyze how the particles are attracted by the mesh and how the particles would flow inside the cells of the liquid-coated vibrating mesh."

The computer modeling in Shahab's lab is crucial to finding the right mix of mesh size, material, coating, and vibration frequency to maximize the efficiency of the system.

"There are a lot of minute parameters that need to be dialed in very carefully to produce optimal performance," Noble said. "In addition, testing of prototypes at scale can be expensive both in terms of material costs and testing time. Fortunately, modeling allows us to test many geometries on the computer and choose the best one or two to build and test operationally. The model is key in limiting the number of experiments we have to do with an eye toward the next step and commercialization."

The dust particles on which the team's work is focusing are known as 'respirable' dust which is generally below 10-20 microns in size. Particles of this size don't get caught in a person's mucus membranes but instead, go to a person's lungs.

"Heavier dust settles in the mine but respirable dust travels in all directions with the flow of air," Amini said. "Our focus for the project is to develop technology to meet demonstrable efficiency targets that allow us to catch more particles and go longer between filter changes."

While the team is using operational metrics, safety and efficiency are not mutually exclusive in this regard. If the system is more efficient, then more particles are being taken out of the air which makes the mine safer for workers. Current equipment has an efficiency of around 90 percent, according to Amini, who is the person tasked with building both the model and the full-scale versions of the new equipment.

"We have a goal to develop a novel dust suppression system capable of collecting more than 95 percent of dust particles, and our early testing is very promising," Amini said. "Our goal is to design a technology to overcome the challenges of dust collection in mining operations, minimize operation down times (increase production rate), and ultimately create a safer and healthier environment for underground mine workers."

Noble said a company that builds mining equipment had provided the team with examples of their products so they can focus on designing improvements that can be mated to existing equipment.

"In phase one, which was completed last year, we constructed a small scale model of the new scrubber design – about 6 by 6-inches," Noble said. "As we move into phase two, we'll be collecting additional engineering data and constructing a full-scale prototype for testing purposes. Should this endeavor prove successful, we hope to design our first fully-operational unit in phase three. The ultimate goal is to provide a solution that can augment existing technologies while providing notable performance improvements."

COVER STORY

Mollusk's unique armor system leads to light, flexible, strong bio-inspired, 3D-printed scales

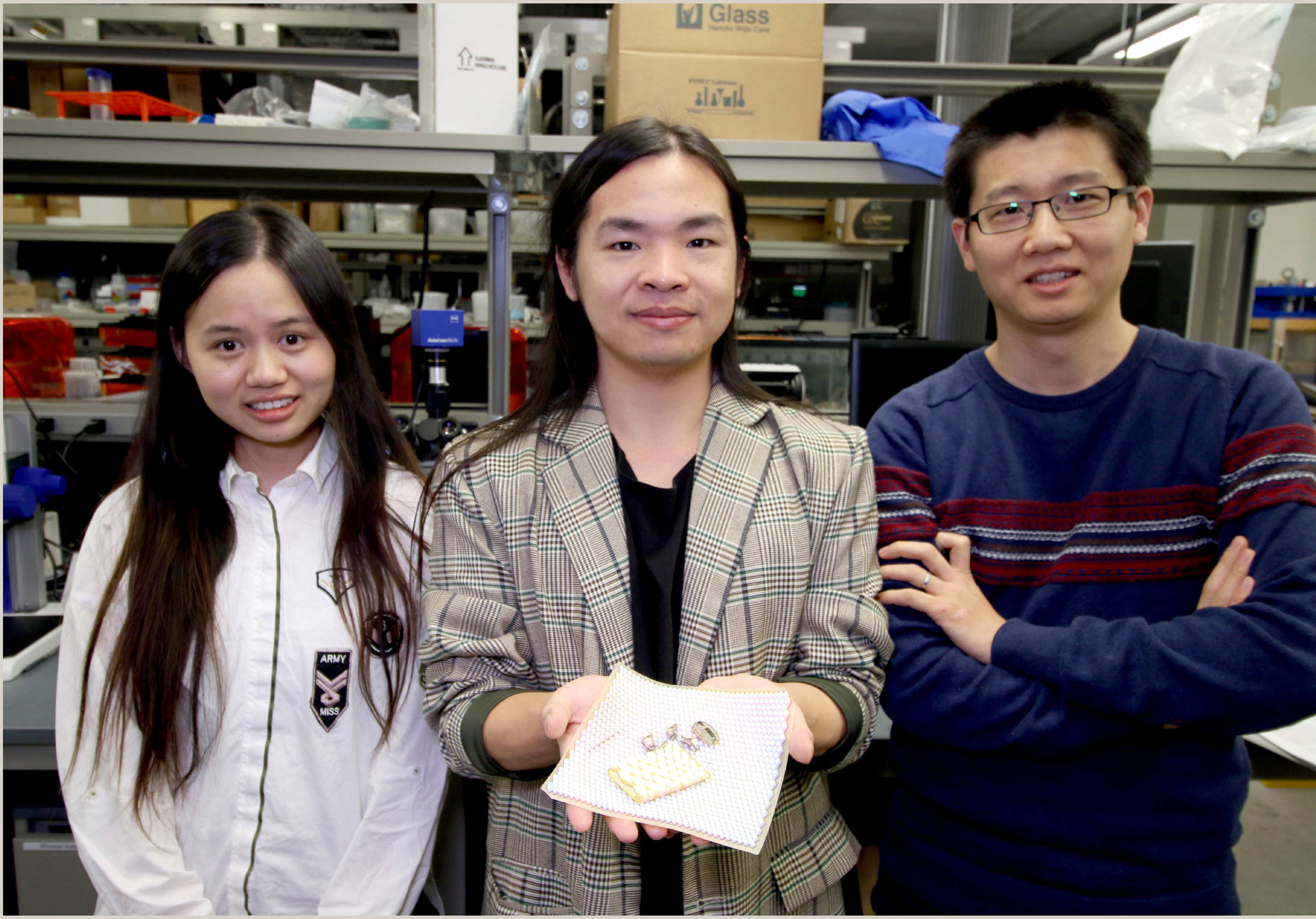
> We studied this biological material in a very detailed way. We quantified its internal micro-structure, chemical composition, nano-mechanical properties, and three-dimensional geometry.
>
> *Assistant Professor Ling Li*

The motivations for using biology as inspiration for engineering vary based on the project, but for Ling Li, assistant professor of mechanical engineering, the combination of flexibility and protection seen in the chiton mollusk was all the motivation necessary.

"The system we've developed is based on the chiton which has a unique biological armor system," Li said. "Most mollusks have a single rigid shell, such as the abalone, or two shells, such as clams. But the chiton has eight mineralized plates covering the top of the creature and around its base it has a girdle of very small scales assembled like fish scales, that provide flexibility as well as protection."

Li's work, which was featured in the journal Nature Communications Dec. 10, is the result of a collaboration with researchers from institutions including the Massachusetts Institute of Technology, the Dana-Farber Cancer Institute at the Harvard Medical School, California State University, Fullerton, the Max Planck Institute of Colloids and Interfaces, Germany, and the Wyss Institute for Biologically Inspired Engineering at Harvard University, and with help from Reza Mirzaeifar, assistant professor of mechanical engineering.

ROSAIRE BUSHEY MECHANICAL ENGINEERING



PhD students Ting Yang and Zhiefei Deng pose with Assistant Professor Ling Li and several 3D printed examples of the armor they created.

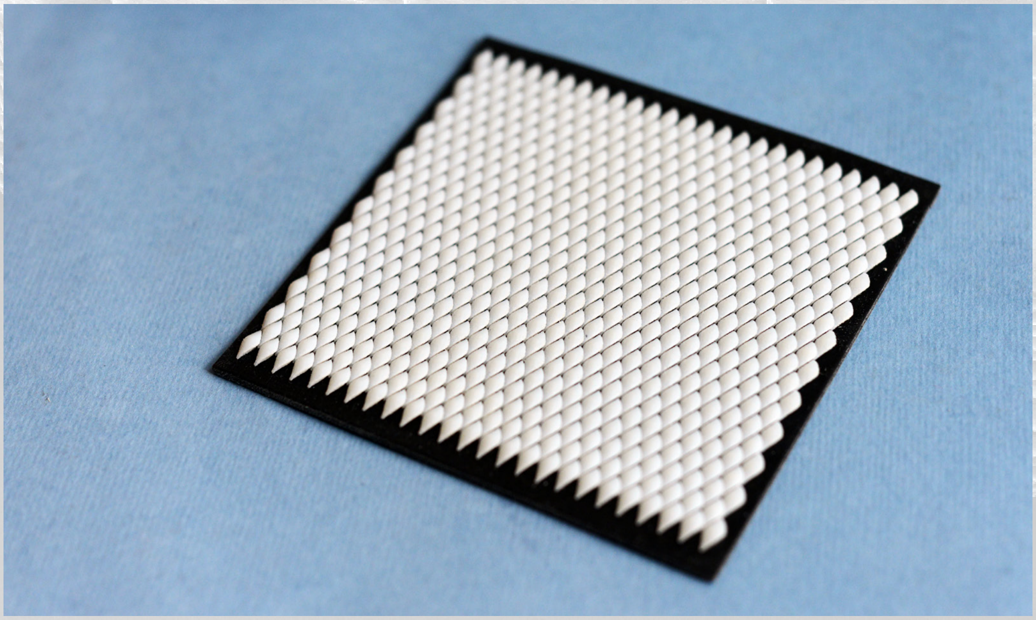
Because the mechanical design of the chiton's girdle scales had not been studied in-depth before, the team of researchers needed to start with basic material and mechanical analysis with the mollusk before using that information as the bio-inspiration for the engineering research.

"We studied this biological material in a very detailed way. We quantified its internal microstructure, chemical composition, nano-mechanical properties, and three-dimensional geometry. We studied the geometrical variations of the scales across multiple chiton species, and we also investigated how the scales assemble together through 3D tomography analysis," Li said.

The team then developed a parametric 3D modeling methodology to mimic the geometry of individual scales. They assembled individual scale units on either flat or curved substrates, where the scales' sizes, orientations, and geometries can also be varied, and used 3D printing to fabricate the bio-inspired scale armor models.

"We produced the chiton scale-inspired scale assembly directly with 3D multi-material printing, which consists of very rigid scales on top of a flexible substrate," Li explained. With these physical prototypes of controlled specimen geometries and sizes, the team conducted direct mechanical testing on them with controlled loading conditions. This allowed the researchers to understand the mechanisms behind the dual protection-flexibility performance of the biological armor system.

Above: The flexible armor tested on a bed of broken glass. Right: The armor is printed with multi material 3D printing allowing for strong scales to be embedded in a flexible base.
Far right top: The flexibility of the armor on display on a roller. Far right middle: a microscopic close-up view of chiton scales from the side. Far right, bottom: A chiton mollusk - the creatures measure about 1 inch in length.



The way the scale armor works is that when in contact with a force, the scales converge inward upon one another to form a solid barrier. When not under force, they can 'move' on top of one another to provide varying amounts of flexibility dependent upon their shape and placement.

"The strength comes from how the scales are organized, from their geometry," Li said. "Reza's team has done an amazing job by using computational modeling to further reveal how the scale armor becomes interlocked and rigid when the external load reaches a critical value."

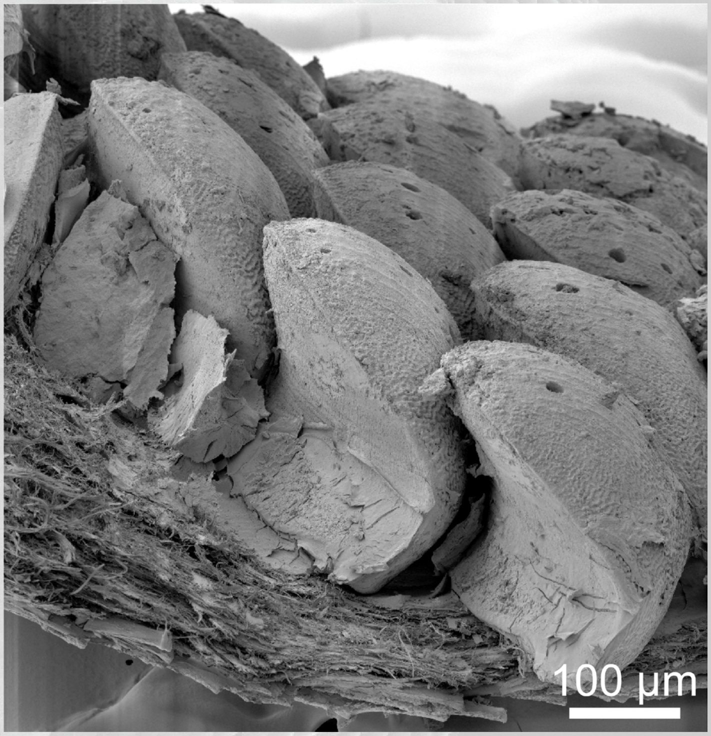
The design of place-specific armor takes into account the size of scales used. Smaller scales, such as those around the girdle of the chiton, are more useful for regions requiring maximum flexibility, while larger scales are used for areas requiring more protection. "Working with Reza, our next step is to expand the space so we can design tailored armor for different body locations. The flexibility vs. protection needs of the chest, for example, will be different than for the elbow or knee, so we would need to design the scale assembly accordingly in terms of scale geometry, size, orientation, etc."

The work being featured began with Department of Defense funding when Li was a graduate research assistant at the Massachusetts Institute of Technology. Since he arrived at Virginia Tech in 2017, the work has continued without sponsorship as part of his start-up funding.

"We started with a pretty pure motivation – looking for multifunctional biological materials," Li said. "We wanted to integrate flexibility and protection and that's very hard to achieve with synthetic systems. We will continue with our research to explore the design space beyond the original biological model system and conduct testing under different load conditions."

Li admits the process, which has taken multiple years, is long, but the work is unique in how they've approached it from the start as a two-step process in conducting the fundamental biological materials research followed by the bio-inspired research.

"Having that level of familiarity with the subject has been very useful to the design and modeling of the armor," Li said. "I think this type of bio-inspired armor will represent a significant improvement to what is currently available."



Barry receives NSF CAREER Award

Oumar Barry, an assistant professor of mechanical engineering is using a National Science Foundation Faculty Early Career Development CAREER award to support fundamental research for a self-powered autonomous robot to prevent electric power line defects.

"The U.S. power grid is more than 50 years old and there's more than 150,000 miles of it – a lot of it in fairly remote areas," said Barry. "The overhead power lines (PLs) are exposed to harsh environments, and wind-induced vibrations (WIV) that limit their lifespan."

Barry's five-year, $500,000 project proposes a multi-functional self-powered autonomous robot (SPAR) for intelligent vibration control and monitoring of power lines. But before a robot can be built, the multiphysics involved need to be fully understood.

Barry's Self-Powered Autonomous Robot (SPAR) concept vehicle

"We need a fundamental understanding of nonlinear dynamic interactions between wind forces, vibrating cables, and a mobile robot, and this hasn't been explored yet," Barry said. "The research goal is to create the tools that will enable construction of SPAR."

Normally, lines are fitted with passive vibration absorbers, but these are often ineffective because of their narrow frequency bandwidth, and they contribute to fatigue damage in cable strands which can eventually result in line failure.

"Inspections of lines are usually done by people on foot patrols or via helicopter-assisted inspection," Barry said. "Both techniques are expensive and dangerous for maintenance personnel. Current inspection robots are starting to be seen but they are bulky, heavy, have a short run time, are energy inefficient, and expensive."

Barry believes that the research necessary to build SPAR will provide fundamental breakthroughs at the interface of energy harvesting, fluid-structure interactions, and vibration control. The project will be broken into four tasks:

1. Construction of a multiphysics model to study wind-cable-robot interactions

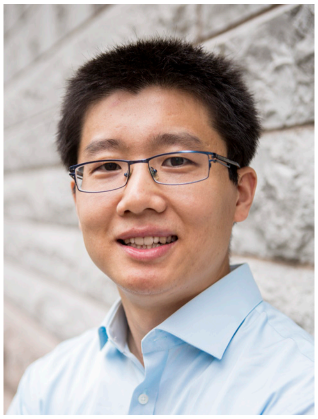
2. Creation of an effective and adaptive electromagnetic energy harvester to power SPAR

3. Development of a WIV control framework to optimize vibration suppression

4. Establishment of a testbed to experimentally investigate the performance of SPAR.

Li receives NSF CAREER Award

Ling Li, an assistant professor of mechanical engineering in the College of Engineering has received a National Science Foundation Faculty Early Career Development CAREER award to support research to study the structural designs and formation mechanisms of biomineralized architected materials.



The $520,000 five-year award will support Li's research of how biomineralized starfish skeletons are designed and formed.

"The internal microscopic structures of many biomineral-based structures found in organisms have extremely intricate 3D organizations," Li said. "They show remarkable mechanical strength, durability and efficiency, despite the fact that they are made of intrinsically brittle minerals and often highly porous."

Li's research group focuses on the understanding the mechanical and multifunctional design of a variety of biological materials, such as low-density biological porous structures and tough biocomposites. His research also aims to develop new materials by utilizing the design strategies learned from biological material systems. For example, his group recently developed a chiton mollusk-inspired armor that provides simultaneous mechanical protection and flexibility.

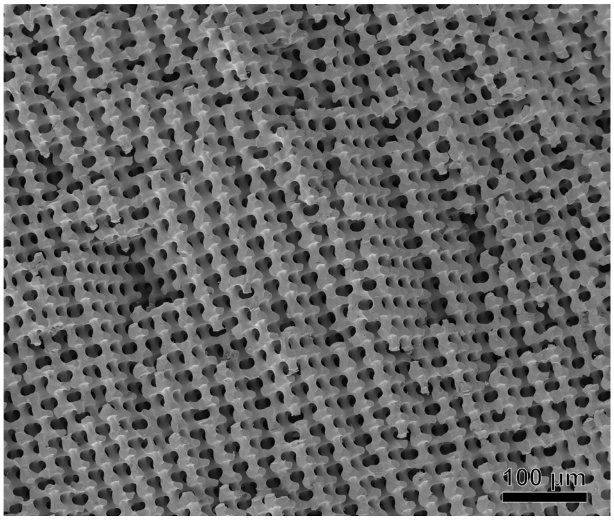
"Currently, we have limited knowledge in explaining how biominerals' complex 3D microstructures are controlled and how they are related to their mechanical properties. By using the biomineralized skeleton in a starfish as a model system, we aim to quantitatively characterize its 3D network-like microstructure, the underlying formation mechanisms as well as its mechanical significance," he said.

Starfish skeletons contain hundreds of millimeter-sized mineralized elements known as ossicles which are embedded within the soft body of the starfish. This skeletal design allows the starfish to be flexible in motion and stiff when required.

"Ossicles are characterized by their lattice-like porous microstructure which is based on a single-crystalline calcite, which makes them lightweight, strong, and damage tolerant," Li said. "The new knowledge gained from this study will provide us better understanding of the 3D structural evolution processes for echinoderms, or possibly, even other invertebrate and vertebrate biomineralized tissues."

Li said the work will provide lessons on the design and fabrication of synthetic low-density materials.

In addition to the CAREER Award, Li received the 2018 Air Force Office of Research Young Faculty Award, and the 2019 MIT Technology Review TR35 China Award, and the 2019 College of Engineering Dean's Award for Outstanding New Assistant Professor.



At left, the 3D microstructure of a biomineralized skeleton of a starfish.

Juliana Duarte, center, with members of her laboratory.

Grants provide $850K for nuclear faculty, graduate student fellowships

The nuclear engineering program in the department of mechanical engineering has been awarded two grants totaling $850,000 by the Nuclear Regulatory Commission's Integrated University Program for faculty development and graduate student fellowships. The IUP was authorized by Congress in 2009 to enhance the nuclear workforce.

Since nuclear engineering was re-established at Virginia Tech in 2007, the program has been successful in receiving several grants totaling about $2.8 million. "The NRC's Integrated University Program has been instrumental in attracting highly-qualified faculty and graduate students to the nuclear engineering program," said Alireza Haghighat, professor and director of mechanical engineering's nuclear engineering program.

"We are delighted to have received these grants to enhance our nuclear engineering program which has had a strong tradition of scholarship since its inception at Virginia Tech," said Azim Eskandarian, mechanical engineering department head and Nicholas and Rebecca Des Champs Chaired Professor. "We are building unique capabilities in nuclear engineering which are taking advantage of collaborations within VT with ME faculty and experts across the university, including material science and engineering, physics, and chemistry, among others, as well as partnering with regional universities and engaging with productive international exchanges," Eskandarian said.

Faculty Development

The Nuclear Regulatory Commission has

awarded the department $450,000 to support faculty development for its nuclear engineering program. The three-year grant and its Principal Investigator, Eskandarian, will support Juliana P. Duarte, assistant professor of mechanical engineering, to help improve the modeling used in nuclear power plants, one of Duarte's areas of expertise. The NRC provided the grants to 11 universities. Eskandarian said the program supported the hire of Duarte under the Intelligent Infrastructure for Human-Centered Communities Destination Area, a transdisciplinary initiative to balance technological advancement to a fair, equitable, and suitable society.

"In a carbon-constrained world, it's important that nuclear energy is more advanced, economical, proliferation resistant, and safer," Duarte said. Along with existing faculty, Duarte will expand the nuclear engineering program's computational and experimental capabilities in thermal-hydraulics, and safety of advanced nuclear reactors.

"In thermal-hydraulics, the research will focus on an experimental program to study post-critical heat flux, including transition and film boiling heat transfer regimes," said Duarte, who received her Ph.D. in nuclear engineering and engineering physics from the University of Wisconsin-Madison in 2018. "The experiments will be used to improve the fundamental understanding of multi-phase problems and to develop semi-empirical correlations to improve modeling currently used in computational fluid dynamics and thermal-hydraulic system codes."

The NRC funding specifically targets tenure-track faculty in the first six years of their careers and includes support for developing proposals for research, initiating or continuing research projects, and other areas.

Duarte's research interests include, nuclear safety analysis, thermal-hydraulic systems, experimental and computational two-phase flow, advanced light-water reactors, and small modular reactors. She is also interested in the heat transfer performance of accident-tolerant fuels, particularly in the surface effect on the critical heat flux and minimum film boiling temperature at operating conditions.

Student Fellowships

A fellowship grant of $400,000 over four years was awarded in support of Virginia Tech's Multi-Campus Nuclear Engineering Fellowship Program. The program will offer graduate fellowships to students enrolled in the nuclear engineering program at both Blacksburg and the greater Washington D.C. metropolitan area campuses. According to principal investigator Haghighat, the program will include midshipmen enrolled in the Accelerated Masters of Engineering in Nuclear Engineering program at the U.S. Naval Academy.

"Fellows pursue graduate education in nuclear engineering with a focus on advanced simulation techniques and codes, nuclear materials chemistry and radiation effects, nuclear reactor design and simulation, nuclear security and nonproliferation, and reactor safety," Haghighat said.

The fellowships will allow the nuclear program to recruit and educate highly-qualified nuclear engineers and scientists who will contribute to the U.S. nuclear educational institutions, private organizations, and government agencies and laboratories.

Since 2009, 18 graduate students have benefited from the fellowship program with 14 students having completed MS and PhD degrees in nuclear engineering. These students are now successfully employed in different sectors, including U.S. national labs, universities, nuclear vendors, and the USNA.

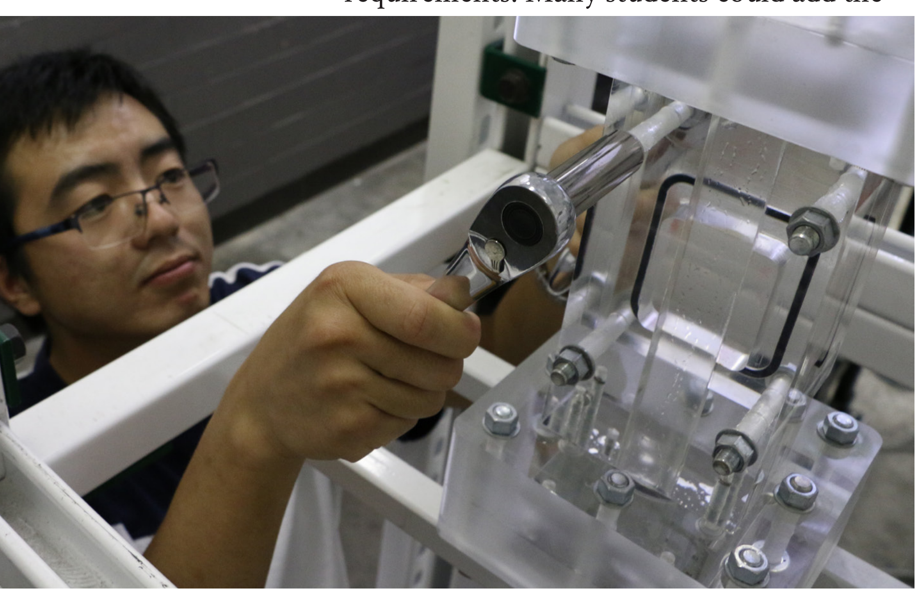
Mechanical engineering offers new minor in nuclear engineering

Beginning January 2020, a minor in nuclear engineering will be available to College of Engineering and College of Science undergraduate students in addition to other majors that meet the course requirements. Naval ROTC students are encouraged to obtain the minor if they will be going into the nuclear Navy.

"The goal of the minor is to prepare engineering and science students for careers at nuclear engineering-related companies, nuclear power plants, state and national government positions, the Nuclear Regulatory Commission, the U.S. Navy, naval shipyards that build nuclear-powered ships and submarines, and for graduate students in nuclear engineering," said Mark Pierson, associate professor of practice in mechanical engineering.

The minor requires 18 credit hours with four required courses and two electives. Most engineering and science students take an introduction to differential equations course, which is a prerequisite for some of the nuclear engineering courses. An additional five courses are then needed to complete the minor.

As most engineering degrees require five technical electives, the nuclear course electives would in most cases satisfy technical elective requirements. Many students could add the nuclear engineering minor without adding to their academic course load.



The minor, according to Pierson, will also help encourage students to pursue graduate degrees in nuclear engineering offered through the mechanical engineering department.

Interested students should check with their academic advisors to see the full list of prerequisites for nuclear engineering courses.

Minor Requirements: 18 credit hours

Required courses (4):

- MATH 2214 - Introduction to differential equations

- NSEG 3145 - Fundamentals of nuclear engineering I (Fall)

- NSEG 3146 - Fundamentals of nuclear engineering II (Spring)

- NSEG 3604 - Radiation detection, protection and shielding

NSEG 5114 – Nuclear engineering fundamentals may be substituted for NSEG 3145/3146 sequence, but then a third elective course will be required for the total 18 credit hours.

Electives (2):

- MSE 4384 - Nuclear materials

- NSEG 4204 - Nuclear fuel cycle

- NSEG 4214 - Nuclear power plant operations

- NSEG 4424 - Reactor thermal hydraulics

- NSEG 4994 - Nuclear engineering undergraduate research (3 hours max)

- NSEG 4974 - Nuclear engineering independent study (3 hours max)

Sandu named Robert E. Hord Jr. Professor of Mechanical Engineering

The Virginia Tech Board of Visitors Nov. 18 approved the appointment of Corina Sandu as the Robert E. Hord Jr. Professor in Mechanical Engineering.

Sandu is also the associate department head for graduate studies in the department. Her appointment brings the number of faculty who hold named or endowed professorships to twelve. Four additional faculty are recognized as John R. Jones III Faculty Fellows.

Sandu's original contributions to the field of multibody system dynamics and vehicle dynamics are widely recognized. She is a Fellow of the American Society of Mechanical Engineers, and a Fellow of the Society of Automobile Engineers. In 2019, she received the SAE's Forest R. McFarland Award for the second time, and she has been recognized for her service to SAE's international publication board. She earned the International Society for Terrain-Vehicle Systems best paper award in 2017, and an ISTVS collaborative small research award in 2015. She also was the recipient of the 2013 SAE Rodica Baranescu Award for Technical and Leadership Excellence in Commercial Vehicles Engineering.

Sandu earned her Engineering Diploma from Bucharest (Romania) Polytechnic Institute in the field of Mechanics in 1991. Her MS and PhD in mechanical engineering were earned from the University of Iowa in 1995

and 2000, respectively.

Over the course of Sandu's career she has published 77 journal papers in addition to more than 95 peer-reviewed proceedings papers, seven book chapters, three provisional patents/disclosures, 46 invited presentations, and her work has been cited more than 1,900 times.

Working on projects with sponsors including the National Science Foundation, NASA, Goodyear, Caterpillar, and others, Sandu has been involved in more than $12 million of research funding, including more than $3.7 million directly supporting her work.

She currently advises two doctoral and four masters students, and is a committee member for current students including 14 doctoral, nine MS, and one non-thesis MS. She has advised 16 doctoral students to graduation, 19 MS students, and has served on committees for 27 PhD, 37 MS, two non-thesis MS, and four M. Eng. students who have graduated.

Sandu's service to her field, the university, College of Engineering, and the department show a long-standing and consistent commitment.

"Since Corina came to Virginia Tech she has exemplified the highest ideals of scholarship, service, and commitment to her students," said Azim Eskandarian, department head and Nicholas and Rebecca Des Champ Chair. "Her engagement with her students is matched only by her leadership within the university and the mechanical engineering field. Her body of work and the accolades she has received reflect a consistency of excellence. In my time as department head, her work has been relentlessly guided by principles of excellence whether she's teaching a class, designing a new class, working on research, or working for the betterment of the university or her field through professional service. She is a consummate professional whose research, teaching, and involvement exemplify the goals to which we all aspire."

The Robert E. Hord Jr. Professorship in Mechanical Engineering was established with a generous gift from the estate of Robert E. Hord Jr. ('41). The professorship supports an outstanding professor within the Department of Mechanical Engineering for a renewable term of five years. The department currently has two faculty members who are designated as Hord Professors.


Mechanical Engineering's Wing Ng, and the Department of Chemistry's Timothy Long

Virginia Tech faculty honored by the State Council of Higher Education for Virginia

Two researchers from Virginia Tech received 2020 Outstanding Faculty Awards from the State Council of Higher Education for Virginia.

This year's recipients are Wing Ng, an Alumni Distinguished Professor and the Christoper C. Kraft Endowed Professor in the Department of Mechanical Engineering, and Timothy Long, a professor of chemistry in the College of Science and director of the Macromolecules Innovation Institute in the Institute for Critical Technology and Applied Science.

Established in 1987, the Outstanding Faculty Awards were created by the State Council of Higher Education for Virginia, the commonwealth's coordinating agency for higher education, to recognize faculty from institutions across the state that exemplify the highest standards of teaching, scholarship, and service, as described by the agency. Virginia Tech faculty are consistently honored by the state council: 37 faculty have received the award since 1987.

Ng and Long are part of a group of 12 recipients narrowed from among 85 nominees in a process that involves review by peers and selection by a committee of leaders from the public and private sectors. The honorees will attend an awards ceremony in Richmond in March.

Wing Ng

For more than 37 years, Ng has worked to advance knowledge and innovation in fluid mechanics, heat transfer, and aero-acoustics of gas turbine engines and aero propulsion. Since he joined the Virginia Tech community in 1984, Ng and his research team have pioneered multiple applications of active flow and noise control in turbine engines.

"I feel very fortunate to receive this prestigious and competitive award," said Ng. "I am very thankful to my department and Virginia Tech for providing the resources to help me advance my career. I am truly blessed."

Ng has published more than 300 articles for propulsion-related research areas, including transonic turbine blade aerodynamics, the development of advanced diagnostic techniques for flow measurement in turbine engines, the acoustics of jet noise, and the acoustics of drones and unmanned air vehicles.

As the co-director of Virginia Tech's Advanced Propulsion and Power Lab, Ng helps lead a team of mechanical engineering and aerospace and ocean engineering researchers as they examine critical areas like supersonic jet noise reduction, turbulence modeling, and intake distortion flow quantification.

In 1998, Ng founded Techsburg Inc., a Blacksburg-based company that provides engineering services and precision manufacturing to defense, aerospace, and energy industries. Ng's contributions included classified and proprietary engineering work for major U.S. engine manufacturers and engineering system integrators, such as Northrop Grumman, Pratt & Whitney, Honeywell, and Solar Turbines. In recognition of his work with Techsburg, Ng was named to the Virginia Tech Entrepreneur Hall of Fame in 2017. Ng continues to provide leadership and strategic planning to guide the company to its current success.

Ng has been recognized on multiple occasions for his achievements as a teacher and researcher throughout his time at Virginia Tech, having received the Ralph R. Teetor Educational Award from the Society of Automotive Engineers in 1986, the Virginia Tech Sporn Award for Excellence in Teaching Engineering Subjects in 1987, the Dean's Award for Excellence in Research in 2013, and the university's William E. Wine Award for teaching excellence in 2014. He has received the College of Engineering Certificate of Teaching Excellence four times.

In 2019, Ng was elected as a Fellow in the American Institute of Aeronautics and Astronautics, and in 1996 as a Fellow of the American Society of Mechanical Engineers. He has held the Christopher C. Kraft Endowed Professorship since 1996.

Ng received his master's and doctoral degrees in mechanical engineering from the Massachusetts Institute of Technology in 1980 and 1984, respectively.

Tim Long

Long graduated with a Ph.D. in chemistry from Virginia Tech in 1987 and then spent a decade as a research scientist at Eastman Kodak Company and Eastman Chemical Company. Since his return to Blacksburg as a faculty member, Long has chalked up more than 50 patents in the field of macromolecular science and engineering and more than 250 peer-reviewed publications.

He and his research team have received more than $50 million in research funding during the past 18 years.

Among the materials he has developed or co-developed are a biomedical gel designed for use in cervical cancer treatment and a new way to print a high-temperature polymeric material known as Kapton into solid 3-D shapes rather than flat sheets — a win for its main usage to insulate space craft and satellites from extreme heat and cold.

"Receiving this prestigious distinction requires a team of exceptional graduate students, a university with unwavering support for our international leadership in polymeric materials, and a supportive wife and family, and without this collective support that surrounds me, this award would truly not be possible," Long said.

Among his awards are the 2010 Virginia Tech Alumni Research Award, the 2012 American Chemical Society POLY Mark Scholar Award, the Adhesion Society's Robert L. Patrick Fellowship Award in 2014, a 2015 Virginia Scientist of the Year honor, and the 2019 Chemistry of Thermoplastic Elastomers Award by the Rubber Division of the American Chemical Society, as well as the IBM Faculty Award, and the 3M Faculty Award.

He also has served as editor-in-chief of Polymer International, a Wiley publication.

From left: Doctoral student Xiaofan Li, undergraduate students Erin Jones and Yixing Zhu, doctoral student and team captain, Jia Mi, and academic advisor Professor Lei Zuo and postdoc, Qiaofeng Li

Graduate student receives $25,000 from EPA

Twenty-one teams are taking part in the 16th Annual Environmental Protection Agency's People, Prosperity and the Planet (P3) design competition. Recently the agency awarded $25,000 to mechanical engineering graduate student Jia Mi to work on Virginia Tech's entry.

The two-phase competition offers opportunities for student teams to design solutions for a sustainable future. The first phase awards up to $25,000 to test, research, and develop designs that promote development and serve as proof-of-concept. Phase II award grants can provide up to $100,000 to continue development and demonstration of the design. The phase-1 project will be shown in the 2020 National Student Design Expo (NDSE) in June at National Harbor, Maryland.

"We do a lot of research on ocean wave energy harvesting in the Center for Energy Harvesting Materials and Systems (CEHMS), mostly targeting large-scale wave energy harvesting," Mi said. "The P3 competition wants small-scale systems to provide safe and sustainable water resources. I thought we could use some of the technology we're looking at in our larger-scale work for this project. Our goal is to demonstrate a functional prototype with a 65L/day desalination capacity."

Mi's team includes a postdoctoral associate, a doctoral student and two undergraduates who will leverage the mechanical motion rectifier (MMR) designed by faculty advisor Lei Zuo, professor of mechanical engineering and John R. Jones III Faculty Fellow, to operate a portable desalination system powered by hybrid renewable energy that will use both solar and wave energy along with a membrane to produce drinking water from saline water.

"The system includes three floating buoys about one-square meter in size," Mi explained. "The solar panels attached on the buoy surface will heat water, while the buoy system with MMR-based pump will capture wave energy to pump water through the membrane where salts are removed and the drinkable water is stored in a holding tank."

The entire desalination process takes place inside the buoys with the intent that someone in a boat can acquire fresh water from a storage tank easily each day.

Funding from the P3 competition was announced in September and Mi's team is currently engaged in the dynamic modeling and design stage of the competition.

"We'll have a model by March that we can test in a wave tank," Mi said.

If the team makes it through to stage two of the competition, Mi said they would then look at the possibility of open ocean testing.

The joys of living-learning

The Tarazagas - from left: Penelope, Pablo, Valentina, Vanessa, Isa, and Lucas.

You can also find this article in Virginia Tech Magazine

MARYA BARLOW
FOR VIRGINIA TECH

A faculty family of six has grown to embrace 325 students in Virginia Tech's Honors Residential Commons. Their close-knit bond is one of the many reasons you'll be seeing more living-learning programs (LLP) at Virginia Tech, as the university prepares to have 65 percent of on-campus students in LLPs by 2025.

Two years ago, Pablo Tarazaga and his family of six left their house in Blacksburg's Woodbine neighborhood to join 325 honors students in a residential hall on Virginia Tech's main campus.

Tarazaga, wife Vanessa '05, a son, three daughters, and a collie moved into a sunny, furnished faculty condo on the fourth floor of East Ambler Johnston Hall. The prolific researcher, associate professor of mechanical engineering, and Virginia Tech alumnus M.S. '04, Ph.D. '09, hoped to use his new role as faculty principal in the Honors Residential Commons (HRC) to forge connections with students beyond the classroom.

"I never thought of the university as just a place for vocation and study," said Tarazaga, a John R. Jones III faculty fellow. "It's about the formation of the student as a whole, as a thinking person. My wife and I were really drawn to being part of these students' lives and helping them walk through this challenging, formative time."

Practically overnight, the Tarazaga clan morphed from a band of six into a tight-knit family of hundreds.

Students came by the dozens to join the Tarazagas for Tuesday dinners in the D2 dining hall, Friday Principal's Teas, and Saturday ice cream socials. HRC residents and the Tarazaga children worked on homework assignments side-by-side. Spontaneous games of tag, hide-and-seek, kickball, and soccer with the kids became stress-relieving diversions for the college students. Tarazaga family movie nights swelled to 40-person affairs.

And the interactions continued to grow—in quantity, in attendance, and in creativity.

Over Tuesday night Spanish Coffees, students and faculty practiced Spanish conversation skills. Tarazaga family holidays expanded to include students who remained on campus during breaks. Using a secure messaging platform, the family created a group called "Tarazaga Family Happenings" to invite residents to participate in daily activities like walks with the dog, outdoor games, visits to the farmers' market, or crafts in the apartment. In an elementary school parking lot before one of the children's soccer games, the students even staged a surprise tailgate party—complete with a grill, music, and a large Hokie cheering section.

And on the night before final exams last May, 50 students lined up inside the Tarazaga's apartment where the family served Breakfast for Dinner—pancakes, waffles, and mini-quiches—assembly-line style.

"They're like parents away from home," said Devon Barbour, a junior physics major who is spending her third year in the HRC because of the Tarazagas. "They welcome us into their home. They've made us such an intimate part of their lives. They give so much to this community and don't ask for anything in return."

Taking a break from manning the pancake grill, the Tarazagas observed the students congregating at their long dining table.

"It's been a blessing," said Vanessa. "The students really embraced our family. Our kids love it. They say they never want to leave."

"We didn't realize the extent to which those great relationships would develop," added Pablo. "We do life together. It's walking with the students in the formation of who they are. For me, this is very fulfilling way of being a professor."

From "crazy" to coveted

When Frank Shushok introduced the residential college model at Virginia Tech in 2009, the reception was cautiously optimistic.

"People said the idea that faculty might want to live with our students was crazy," said Shushok, senior associate vice president for student affairs and associate professor of higher education. "What we're finding is it's having as profound of an impact on faculty as it does on students. Many of our faculty are saying it's the single most powerful and influential experience in strengthening the way they teach and their empathy and understanding of students. They love being invested in students' lives in a longitudinal way."

Frank Shushok, interim vice president for student affairs.

Today, 37 percent of the university's on-campus students reside in living-learning programs. Nearly 1,500 students live in the university's three residential colleges: the HRC, led by Tarazaga; the Residential College at West Ambler Johnston, led by associate professor of history Danna Agmon; and the Leadership and Social Change Residential College, led by assistant professor of landscape architecture C.L. Bohannon MLA '04, Ph.D. '14.

Another 2,950 students live in living-learning communities (LLCs), student communities that unite residents in common interests and disciplines, like engineering, the arts, or the Corps of Cadets. Each offers ongoing opportunities for students and faculty to spend meaningful time together. For example, faculty and staff may join LLC students in the residential environment to teach a class, provide mentoring and advising, or participate in social and academic activities.

By 2025, Virginia Tech aims to provide living-learning programs for 65 percent of on-campus students. The university's Master Plan includes the addition of eight new LLPs that will house 3,400 students over the next decade. In Virginia Tech's Creativity and Innovation District, construction is underway for an LLP slated to accommodate 600 students with interests in the arts, technology, and entrepreneurship in 2021.

Shushok says living-learning programs not only blend academic and student life, but also enrich the university's close-knit culture. "Residential environments on college campuses are often very underutilized resources," he said. "When we move from sleep-eat environments to live-learn environments, this creates the groundwork for the kind of education that we espouse and deeply admire."

Regarded as a pioneer in the field, Shushok successfully instituted residential colleges at Baylor University a decade before introducing them at Virginia Tech. He's published numerous studies that affirm the benefits of living-learning environments—benefits that include improved student academic performance, co-curricular engagement, persistence toward graduation, and overall well-being—and he co-authored one of the first studies to examine the faculty benefits.

Pablo serves up breakfast - for dinner - just one of the ways in which the Tarazaga's open their home to more than 300 student members of the Honors Residential Commons in East Ambler Johnston.

Virginia Tech remains relatively unique among peer land-grant research universities for embracing residential colleges. The Residential College Society, founded in 2014 at the university, has blossomed into a national organization of universities exchanging best practices.

In a 2011 report, "Students as teachers: What faculty learn by living on campus," published in the Journal of College and University Student Housing, faculty principals overwhelmingly said their roles as LLP mentors made their work more rewarding and additionally enriched their family lives.

"The transfer of knowledge goes both ways. I learn a lot from the students," said Bohannon. Bohannon leads approximately 300 students as faculty principal in the Leadership and Social Change Residential College, which focuses on integrating sustainability, social responsibility, food equality, and environmental justice into daily life.

"My interactions with the students make me a better teacher in the classroom and help me be the instructor and advisor I wish I'd had as an undergraduate," he said.

A family away from home

Students living in the Honors Residential College are universally effusive when it comes to their living-learning experience with the Tarazagas.

Nathan Schlundt, a junior from Los Angeles, said moving into the Honors Residential College improved his entire outlook. "My first year was kind of lonely because I was far from home and hadn't found my niche yet," said Schlundt, a computer science major, as he waited in line at the Tarazaga's Breakfast for Dinner feast. "When I came to the HRC, it was a total 180. Dr. T and his family produce a great sense of community. They're always bringing us together and inviting us into their home with events like this. Look at them—they'll cook three hours just for us."

Tyler Pugh, a junior double-majoring in industrial systems engineering and Spanish, said Tarazaga has become a mentor. "I really wish I had him as a professor," said Pugh, who is also a resident advisor in the HRC. "Dr. Tarazaga is so invested in his students' character. We get coffee every Saturday and talk about anything and everything. Sometimes I forget he's an award-winning researcher. I wasn't able to go back home for New Year's with my family, which is a tradition we usually celebrate together. The Tarazagas invited me here. Another day over winter break, I had dinner with them. They bring the home into the dorm for us."

Pugh said having kids and a dog around has also been a highlight.

"When I'm with them, I'm not a student anymore. I'm part of the family. I forget my tests and papers. This is my time to de-stress," he said. "When you're able to sit down and just color with them, it takes your mind off of being a student. You can enjoy just being a friend with these kids."

Enriching faculty families

After moving into Ambler Johnston, the Tarazagas noticed the positive impact on their children right away.

"It's an immersive living-learning environment for them, too," said Vanessa, who home-schools all four children. "The campus is a wonderful, lively place to grow up. There's always something interesting going on that we can integrate into their schoolwork. And the students are great role models. They study with them, play with them, and welcome them into their lives."

The faculty principal arrangement isn't without its drawbacks—like when the fire alarm went off 22 times during the semester after the Tarazagas moved in with a new baby. Sometimes upstairs neighbors need gentle reminders to tread more softly in the common area above the couple's master bedroom, and more often than not, a quick trip out to walk the dog can evolve into a half-hour conversation with passing students, staff, or faculty.

But the positives far outweigh the negatives, the family resoundingly agrees. Asked if he misses his neighborhood and backyard, the Tarazaga's 11-year-old son is emphatic. "I have the biggest, best backyard right here," he said, gesturing toward the Drillfield.

'Pretty darn transformational'

Vanessa Tarazaga smiles while cooking and holding her baby, Valentina.

The faculty principal position is a three-year commitment, which can be renewed just once. At the end of their first three-year term, the Tarazagas signed on again. The faculty principals in the other two residential colleges also chose to stay.

According to Shushok, more than 900 students chose to return to their living-learning programs this fall—and about 2,700 entering first-year students applied to join one. A dozen faculty members have scheduled appointments to discuss becoming a faculty principal.

Tim Baird, associate professor of geography and senior fellow of the Institute for Creativity, Arts, and Technology, is interested in applying to become a faculty principal in the Creativity and Innovation District. His wife and three children are excited about the prospect.

"We think it would be good for our kids and strengthen our family," he said. "For me, this is what it means to be a professor in its entirety. When you're ensconced in academics, student life, facilities, and all the facets of the university, you can see it more clearly and be more effective in contributing."

For Shushok, the growing interest is validation that Virginia Tech is on the right path.

"We should take heart that we have the most student-centered faculty that are also amazing, productive researchers and scholars," he said. "That says a lot about the education you can get at Virginia Tech. In many ways, our residence halls are exemplars of transdisciplinary learning. Bringing together students, faculty, and staff of different acculturations and expertise to work together, think together, and dream together.

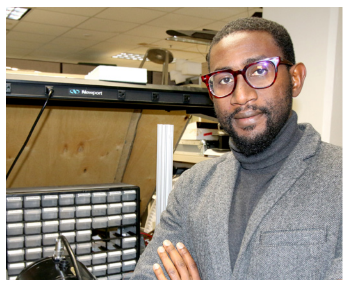
"At the end of the day, that's pretty darn transformational."

Department news

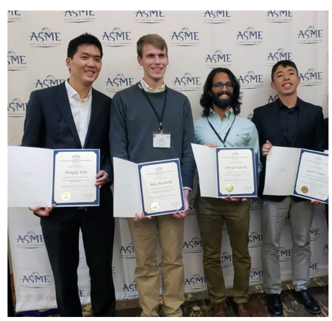
Rolf Mueller

Professor Rolf Mueller was published in the Journal of Experimental Biology in September. The paper was titled, **Dynamic Relationship Between Noseleaf and Pinnae in Echolocating Hipposiderid Bats.**

Oumar Barry



Assistant professor Oumar Barry and his students earned two best paper awards at the ASME Dynamic Systems and Control Conference. The papers were: **On the Dynamics and Control of a Full Wrist Exoskeleton for Tremor Alleviation**, and: **Self-Resonant Energy Harvester with a Passively Tuned Sliding Mass**



PhD students Hongjip Kim, left, and Jiamin Wang, right, received Best Student Paper Finalist awards at the 2019 ASME DSCC.

Barry was also published in journals, including:

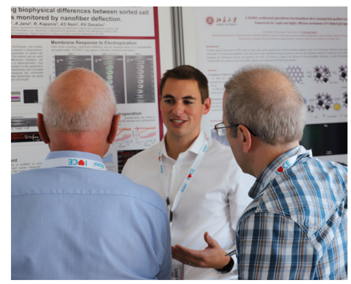
Spectro-Spatial Analyses of a Nonlinear Metamaterial With Multiple Nonlinear Local Resonators. Nonlinear Dynamics.

Exact Nonlinear Dynamic Analysis of a Beam with Nonlinear Vibration Absorber and with Various Boundary Conditions. ASME Journal of Computational and Nonlinear Dynamics.

On the Improvement of Vibration Mitigation and Energy Harvesting Using Electromagnetic Vibration Absorber-Inerter: Exact H2 Optimization. Journal of Vibration and Acoustics.

Vibration of Sandwich Beams with Tip Mass: Numerical and Experimental Investigations. Composite Structures.

Philip Graybill



At the 3rd World Congress on Electroporation, and ITP 2019, graduate student Philip Graybill (Amrinder Nain lab) earned first place for best poster, second place in the Engineering Division, and first place for coolest image. Graybill also was recognized for his work in biomedical engineering being of exceptional quality. Graybill also won a poster award from the Royal Society of Chemistry.

Shima Shahab

Assistant Professor Shima Shahab has been appointed as Associate Editor of the Journal of Intelligent Material Systems and Structures.

Shahab also earned the 2019 ASME Energy Harvesting Best Paper Award for: **Acoustic Holograms in Contactless Ultrasonic Power Transfer Systems: Modeling and Experiment**, presented at the ASME Conference on Smart Materials, Adaptive Structures and Intelligent Systems conference in September.