Macromolecules Innovation Institute
At the intersection of science, engineering, and society

VIRGINIA TECH™

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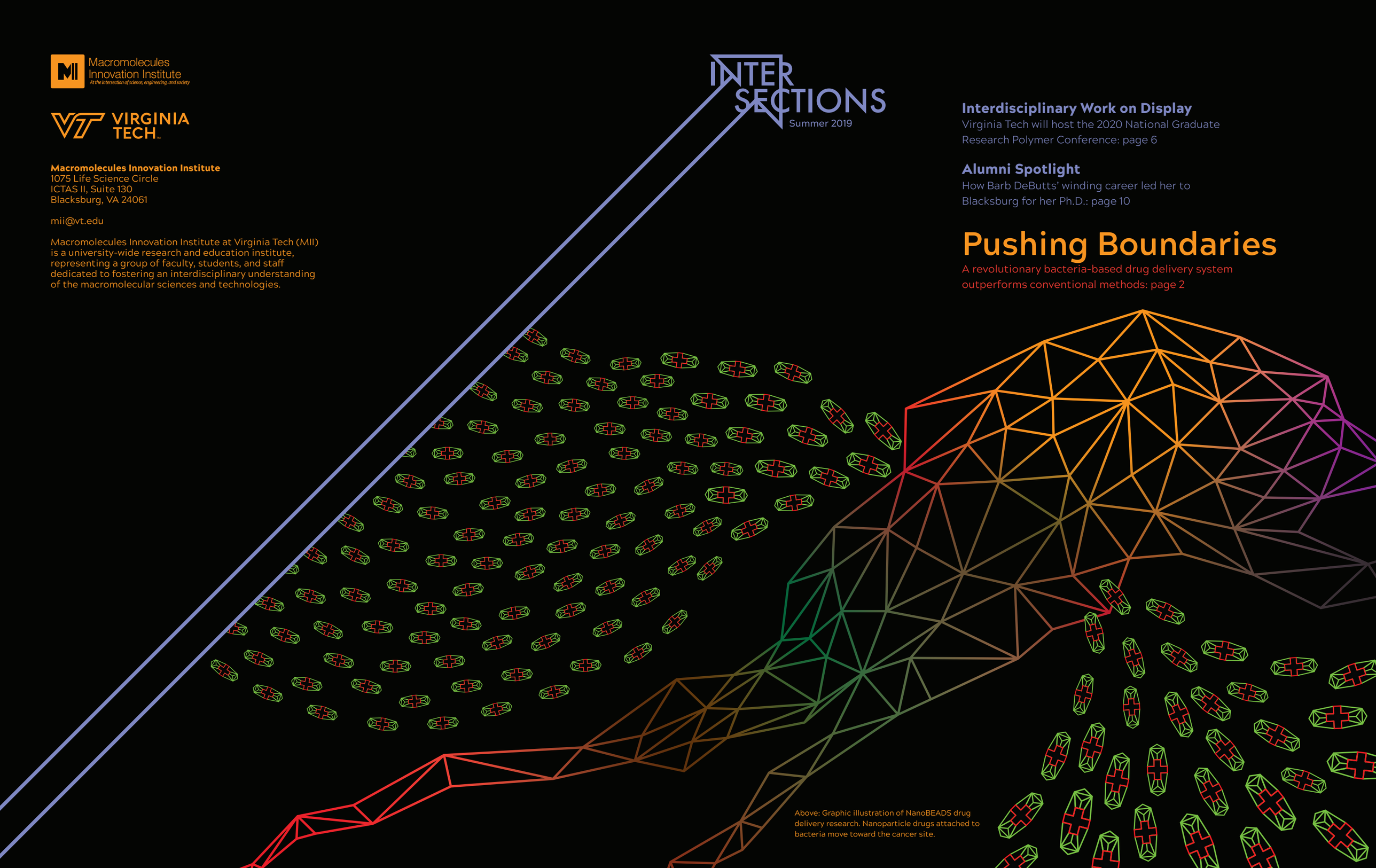
Macromolecules Innovation Institute at Virginia Tech (MII) is a university-wide research and education institute, representing a group of faculty, students, and staff dedicated to fostering an interdisciplinary understanding of the macromolecular sciences and technologies.

INTERSECTIONS

Summer 2019

Pushing Boundaries

A revolutionary bacteria-based drug delivery system outperforms conventional methods: page 2



Above: Graphic illustration of NanoBEADS drug delivery research. Nanoparticle drugs attached to bacteria move toward the cancer site.

INTERSECTIONS

Summer 2019

TABLE OF CONTENTS

A LETTER FROM THE DIRECTOR

Timothy Long

Dear Colleagues:

We are quickly approaching the 100th anniversary of Hermann Staudinger's landmark paper defining macromolecules, and in his 1953 Nobel Lecture, he proceeds to challenge the scientific community to allow this prestigious prize to serve as a catalyst for "further fruitful development" in macromolecular chemistry. Staudinger's "catalyst" was amazingly efficient. Fast forward to 2020, and over 660 billion pounds of polymers are manufactured each year across the globe! From high-performance polyolefins for food packaging and artificial hip joints to high-temperature polyimides that enable space exploration and mobile phones, polymers continue to improve the quality and quantity of our lives.

The Macromolecules Innovation Institute (MII) is uniquely positioned as a virtual research institute at Virginia Tech, and we embody the strength of the entire University. MII is not a Department; the University is our Department! We continue to attract top graduate students with an expectation of interdisciplinary research and education at novel intersections of science and engineering. Our research expenditures continue to growth with partnerships with industry, federal agencies, and national laboratories. Polymeric materials are reaching into architecture (thanks to Prof. Joe Wheeler) and mechanical engineering (thanks to Profs. Rayne Zheng and Chris Williams).

Our Macromolecular Science and Engineering degree now accounts for nearly 50% of the total 120 affiliated graduate students. Our students have now formed a MACR student council (thank you to our students!), leading to a successful proposal to host the summer 2020 National Graduate Research Polymer Conference in partnership with the ACS Division of Polymer Chemistry.

A special thank you to Prof. Chris Williams for his vision toward advancing manufacturing and challenging more from synthetic chemists. Thank you to Kim Felix and Prof. Bob Moore for their attention to student recruitment, integrated education, and continued refinement of a university model for graduate education. MII remains fiscally sound thanks to the efforts of Janika Simmons, and this fiscal position allows us to further invest in our students, faculty, and instrumentation. We are only as successful as our visible portals to society, and thanks to Andrew Tie for his efforts to promote the many accomplishments of our students and faculty. Our University Stakeholders with leadership from Prof. Stefan Duma together with our vibrant external advisory board led by Dr. Tim Schaffer (ExxonMobil) cultivate an atmosphere of excellence and global leadership. MII does not represent only a select few; MII represents the collective commitment and passion of nearly 30 core faculty and over 120 graduate students.

Please help us celebrate Hermann Staudinger's declaration in 1920 during the 2019 MII Technical Conference and Review (November 2019) with an ensemble of lectures and posters that describe our latest advances in macromolecular science and engineering.

Thank you for your continued support of Staudinger's vision and the Macromolecules Innovation Institute!

Timothy E. Long

NanoBEADS

Virginia Tech researchers create a bacteria-based drug delivery system that outperforms conventional methods.

An interdisciplinary team of three Virginia Tech faculty members affiliated with the Macromolecules Innovation Institute has created a drug delivery system that could radically expand cancer treatment options.

The conventional cancer treatment method of injecting nanoparticle drugs into the bloodstream results in low efficacy. Due to the complexities of the human body, very few of those nanoparticles actually reach the cancer site, and once there, there's limited delivery across the cancer tissue.

The new system created at Virginia Tech is known as Nanoscale Bacteria-Enabled Autonomous Drug Delivery System (NanoBEADS). Researchers have developed a process to chemically attach nanoparticles of anti-cancer drugs onto attenuated bacteria cells, which they have shown to be more effective than the passive delivery of injections at reaching cancer sites.

NanoBEADS has produced results in both *in vitro* (in tumor spheroids) and *in vivo* (in living mice) models showing up to 100-fold improvements in the distribution and retention of nanoparticles in cancerous tissues.

This is a product of the five-year National Science Foundation CAREER Award of Bahareh Behkam, associate professor of mechanical engineering. Collaborators on this interdisciplinary team are Rick Davis, professor of chemical engineering, and Coy Allen, assistant professor of biomedical sciences and pathobiology in the Virginia-Maryland College of Veterinary Medicine.

"You can make the most amazing drugs, but if you cannot deliver it where it needs to go, it cannot be very effective," Behkam said. "By improving the delivery, you can enhance efficacy."

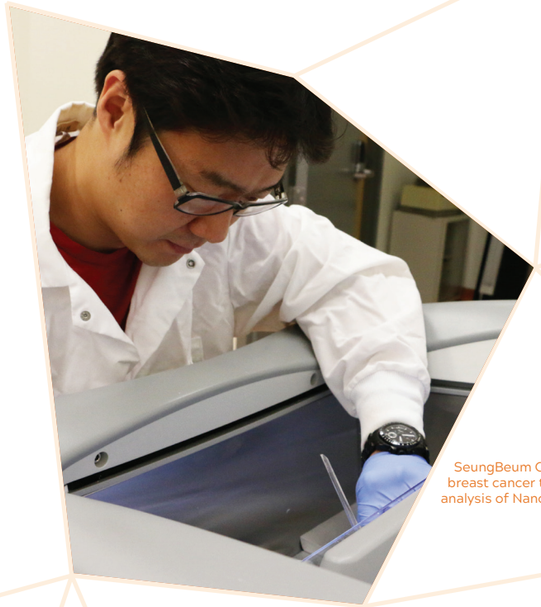
This work, which combines expertise in mechanical engineering, biomedical engineering, chemical engineering, and veterinary medicine, was detailed in Advanced Science.

USING SALMONELLA FOR GOOD

Humans have noticed, even as far back as Ancient Egypt, that cancer went into remission if the patient also contracted an infection like salmonella. Neither are ideal, but humans can treat salmonella infections more effectively than cancer.

In modern times, Allen said the idea of treating cancer with infections traces back to the late 1800s and has evolved into immunotherapy, in which doctors try to activate the immune system to attack cancerous cells.

Of course, salmonella is harmful to humans, but a weakened version could in theory provide the benefits of immunotherapy without the harmful effects of salmonella infection. The concept is similar to humans receiving a weakened flu virus in a vaccine to build immunity.



SeungBeum Chris Suh slicing an excised breast cancer tumor sample for quantitative analysis of NanoBEADS penetration in the tumor.

The NanoBEADS PIs – Behkam, Allen, and Davis – and Ying Zhan, a third-year mechanical engineering Ph.D. student in Behkam's lab, discuss their research.

Coy Allen
Virginia-Maryland College
of Veterinary Medicine

Bahareh Behkam
Department of
Mechanical Engineering

Rick Davis
Department of
Chemical Engineering

Over six years ago, Behkam came up with the idea of augmenting bacterial immunotherapy to also attack cancer with conventional anti-cancer drugs. The problem was the passive delivery of anti-cancer drugs doesn't work very well.

Given her background in bio-hybrid microrobotics, she wanted to use salmonella bacteria as autonomous vehicles to transport the medicine, in nanoparticle form, directly to the cancer site.

The work began with Behkam's first doctoral student, Mahama Aziz Traore, constructing the first generation of NanoBEADS by assembling tens of polystyrene nanoparticles onto *E. coli* bacteria. After thoroughly studying the dynamics and control aspects of the NanoBEADS systems for a few years, Behkam brought Davis into the project because he had experience creating polymer nanoparticles for drug delivery.

"She mentioned this radically different approach for delivering drugs and nanoparticles," Davis said. "I walked away from the conversation thinking, 'Man, if this thing could work, it would be fantastic.'"

Behkam chose this particular bacterial strain, *Salmonella enterica serovar Typhimurium VNP20009*, because it has been thoroughly studied and successfully tested in a phase one clinical trial.

"Its (salmonella's) job as a pathogen is to penetrate through the tissue," Behkam said. "What we thought is if bacteria are so good at moving through the tissue, how about coupling nanomedicine with the bacterium to carry that medicine much farther than it'd passively diffuse on its own?"

TRIAL AND ERROR

Although Behkam had a vision for the new drug delivery system, it took several years for it to become reality.

"The process of creating nanoparticles and then attaching them to bacteria in a robust and repeatable manner was challenging, but add on top of that ensuring the bacteria stay alive, discovering the mechanism of bacteria transport in cancerous tissue, and devising ways to quantitatively describe the effectiveness of NanoBEADS, and this was a difficult project," Davis said.

SeungBeum Suh, Behkam's former Ph.D. student, and Amy Jo, Davis' former Ph.D. student, worked together on attaching nanoparticles while keeping the bacteria alive. It wasn't until their fourth attempt that they started finding success.

"We collaborated to make these particles, and we attached them to the bacteria," Behkam said. "Then the question was what is the mechanism of their translocation in the tumor? How far do they go into the tumor? How do we present a quantitative measure of their performance?"

Behkam along with Suh and current doctoral student Ying Zhan tested their nanoparticle-attached salmonella in lab-grown tumors. They found up to 80-fold improvements in nanoparticle penetration and distribution using the NanoBEADS platform, compared to passively diffusing nanoparticles.

Furthermore, Suh and Behkam found out that NanoBEADS largely penetrate the tumor by translocating through the space in between cancer cells.

Behkam wanted to strengthen the NanoBEADS results past the *in vitro* stage. With a top-flight veterinary school down the road, she enlisted Allen, her fellow MII faculty member, to test the NanoBEADS system *in vivo*. Tests in breast cancer tumors in mice produced results showing significant improvements compared to passive delivery.

The tests showed that there was about 1,000 times more salmonella cells in the tumor compared to the liver and 10,000 times more than the spleen.

"Most notably, the salmonella itself helped keep the particles in the tumor up to 100-fold better, which would suggest it would be an effective delivery vehicle," Allen said.

The next step in the research is to load cancer therapeutics into the NanoBEADS system to test the potential enhancement in efficacy.

FROM BENCH TO KENNEL TO BEDSIDE

The collaboration highlights the diversity of interdisciplinary research possible through MII and Virginia Tech.

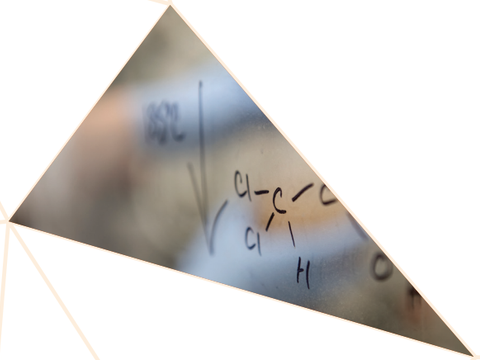
"The synergistic integration of diverse expertise has been essential to the high-impact discoveries that resulted from this work," Behkam said.

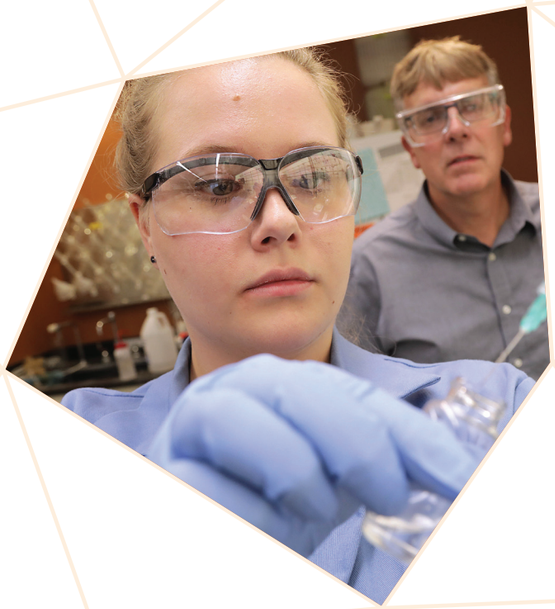
With the addition of the Virginia Tech Carilion School of Medicine and Fralin Biomedical Research Institute at VTC, Allen said Virginia Tech has the possibility to test scientific research "from bench to kennel to bedside."

"The project could not move forward without each of the three parts," Allen said. "The study would not have gotten into such a high impact journal without having the chemistry, the background of the pathogen, the idea, and having the physiological and clinical relevance of testing it in an actual tumor in an actual animal model."

Davis said all drug delivery mechanisms have to go through animal trials, so having an "absolutely fantastic" college of veterinary medicine on campus took the research to a higher level.

"One thing that attracted me to this project was the ability to work with people like Bahareh and Coy who work with cells and animal studies to really translate the work," Davis said. "It's hard to find that combination of people in a lot of schools."





NATIONAL GRADUATE RESEARCH POLYMER CONFERENCE RETURNS

The largest polymer graduate student conference will return to Blacksburg in 2020.

Virginia Tech has been named the host of the 2020 National Graduate Research Polymer Conference (NGRPC), sponsored by the American Chemical Society's Division of Polymer Chemistry.

The NGRPC is one of the largest polymer student conferences in the country. Blacksburg last hosted the biennial conference in 1996.

An organizing committee of 10 graduate students within the Macromolecules Innovation Institute (MII) initiated and led the effort to create the proposal for hosting the conference. The committee chairs are Philip Scott, Emily Wilts, Priya Venkatraman, and Bradley Sutliff, all of whom are Macromolecular Science and Engineering (MACR) Ph.D. students.

"Our proposal is about building intersections in polymer science," Scott said. "To that end, we're taking a conference that has historically been heavily polymer chemistry and trying to use what's available at Virginia Tech to broaden that out to include all of polymer science and engineering."

With 70 affiliated faculty in seven colleges across Virginia Tech, MII, and the MACR program are strongly committed to interdisciplinary work in the polymer field.

"Virginia Tech stands as a fantastic example for how to lead in interdisciplinary research," Scott said. "We have a lot to offer other schools in the effort to connect the different corners of polymer research."

The Virginia Tech NGRPC organizing committee is planning to hold the three-day conference in July 13-15, 2020. It's expecting several hundred graduate students from across the country to attend. In addition to budgeting, outreach, and other practical considerations in the proposal, the committee also included their vision of the themes for this conference.

"We're really excited to be able to put on a conference by graduate students for graduate students," Wilts said. "We're really trying to get across that theme of interdisciplinary across all sciences and engineering and how we relate in the middle with polymers."

Venkatraman said in addition to MII and MACR, she wants attendees to see everything Blacksburg has to offer, from the campus to the Hokie Spirit.

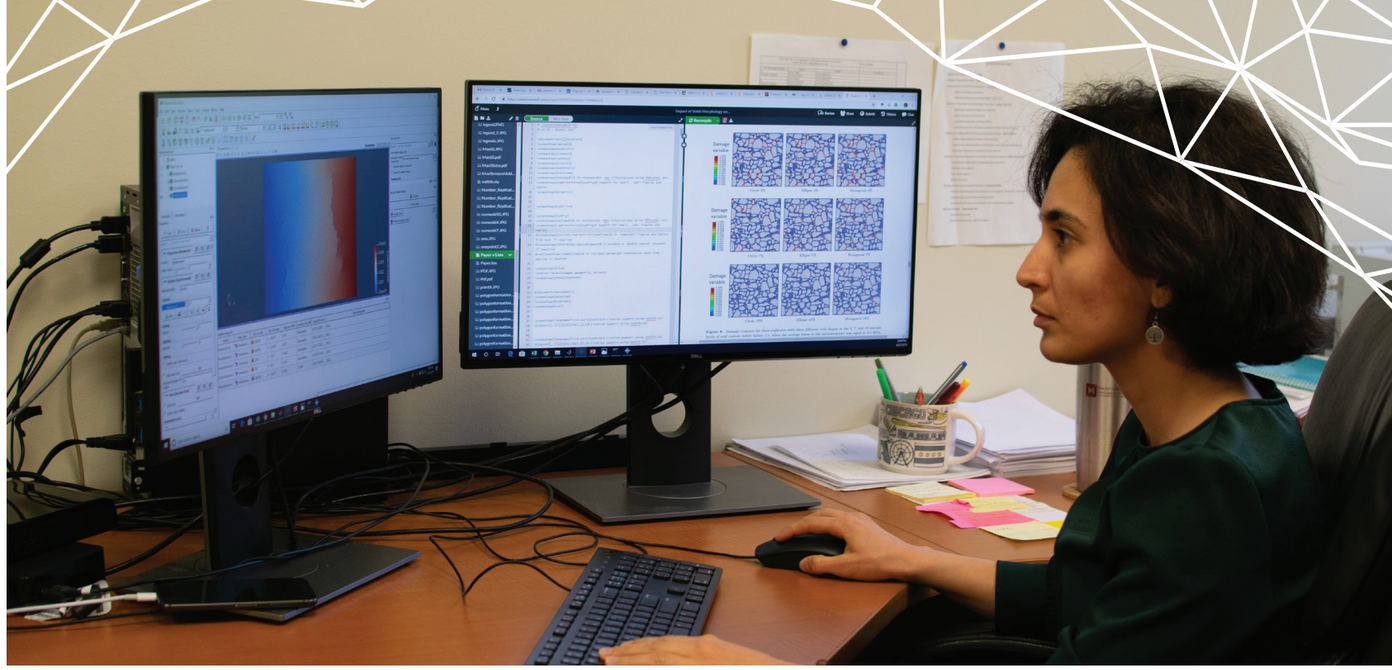
"It's awesome that we get to invite people to come here and see what we do," Venkatraman said. "What we put out is all of the work the students, faculty, and staff do to put together this institute and program."

Robert Moore, professor of chemistry and the director of the MACR program, has previously sat on the committee that approves these proposals. Moore said in his experience he saw many faculty-led submissions, but the student-led effort in the Virginia Tech proposal was probably a key factor for winning the 2020 proposal.

"Our students at Virginia Tech are working tremendously hard to build recognition as leaders in the polymer community, and we, the faculty, are so proud of their accomplishment," Moore said. "It is with great confidence in our students that we are now looking forward to a tremendous conference that will continue to bring profound distinction to our program."

SHAKIBA LEADS MII EFFORTS IN COMPUTATIONAL MODELING

Workshop brings together Virginia Tech computational modeling experts.



Maryam Shakiba, an assistant professor in the Charles Edward Via, Jr. Department of Civil and Environmental Engineering, is leading MII's collaborations in computational modeling.

Experts across Virginia Tech gathered in 2018 for the second annual computational materials modeling workshop in an effort to strengthen and propel the transdisciplinary work.

The workshop falls under the scope of the Economical and Sustainable Materials Strategic Growth Area (ESM SGA), one of the university's identified areas of potential strength.

Computational modeling is a branch of science that uses mathematics, physics, engineering, and computer science principles to simulate and predict the response of complex systems. Computational modeling can be used at all scales and across disciplines–from the microscale that predicts the interactions of atoms to the infrastructure level that predicts the performance of bridges. This workshop focused on computational modeling for the research and application of materials.

The event is the brainchild of Maryam Shakiba, assistant professor of civil and environmental engineering, and the Macromolecules Innovation Institute (MII), where Shakiba is an affiliated faculty member.

"Historically, Virginia Tech has been very strong in computational work," Shakiba said. "We had lots of pioneers spread all over in the engineering mechanics department and now in mechanical, civil engineering, aerospace, biomedical and engineering mechanics, chemical engineering, and also science departments."

The Department of Civil and Environmental Engineering and the Department of Mechanical Engineering co-sponsored the event along with MII and the ESM SGA.

"Computational methods in the future are going to accelerate what we do as scientists and researchers," said Timothy Long, professor of chemistry and the director of MII. "Understanding how those tools can be used and increasing the awareness of those skills across campus will have a very profound impact on discovery and the materials."

COLLABORATING WITH MODELERS ACROSS CAMPUS

Shakiba said she had two goals for the workshop. The first was to establish connections and dialogue between computational modeling experts who work across different scales (microscale, mesoscale, macroscale).

The second was to discuss funding challenges and opportunities for interdisciplinary collaborations.

"We want people who are doing experimental work to know what are the capabilities and strength of computational work on campus," said Shakiba, whose own research models the response of composite materials at the mesoscale due to effects of mechanical loading and degradational environmental conditions such as moisture or temperature.

The workshop featured 14 presenters from six departments in the College of Engineering, College of Science, and the Molecular Science Software Institute. Shakiba estimates there are more than 25 materials researchers at Virginia Tech using computational modeling methods.

Headlining the talks was one external plenary speaker: Bobby Sumpter, the interim director of the Center for Nanophase Materials Sciences at Oak Ridge National Laboratory (ORNL). He spoke about the capabilities at ORNL and the potential for collaborations with Virginia Tech.

VIRGINIA TECH'S FOCUS ON MATERIALS

Roberto Leon–the David H. Burrows Professor of Construction Engineering in the Department of Civil and Environmental Engineering and a member of the ESM SGA–lauded the workshop with the SGA's other efforts, including an upcoming minor in materials and a new course called "The Science of Materials in Everyday Life."

"We're making a concerted effort to make materials a forefront research area," Leon said.

Shakiba said she wants to continue nurturing the computation modeling community which plays a big role in ESM SGA's future efforts. She said Virginia Tech has the potential to lead in this field with both modelers and experimentalists on campus who can design, manufacture, and then test the materials they're creating.

"The ultimate goal is to design or manufacture smart, responsive, sustainable, and resilient materials for different engineering applications," Shakiba said. "To achieve that goal, we need interdisciplinary research."

ALUMNI SPOTLIGHT

After a winding route in industry, Barb DeButts found a home in the MACR program.

When Barb DeButts arrived at Virginia Tech in 2015, she already knew she was different than her peers in the Macromolecular Science and Engineering (MACR) Ph.D. program.

She possessed an undergraduate degree in fine arts and a decade of work experience in non-science or engineering fields, but she was ready for a new challenge.

"I didn't expect for me to make sense to everyone in the program," DeButts said. "That's something I had to earn and prove."

BARRIERS IN THE WORKPLACE

Prior to Virginia Tech, DeButts worked in the construction industry. She started as an administrative assistant at a construction company specializing in residential and commercial glazing, and quickly earned greater responsibilities. Although she moved into operations management, her true goal was to learn the trade and become a glazer.

At first, the owner didn't think she, as a woman, could do the job. He only relented to watch her fail - which she did at first - but through her dogged persistence, DeButts picked up the skills.

"I was the only woman he ever trained in his 42 years in the business as a glazer," DeButts said. "From there, I started running the company as his proxy because he was looking to retire."

Although DeButts had broken through the gender barrier in her company, she realized there were limitations to her career.

"As a woman in construction, I was limited," DeButts said. "It was always a fight to learn. Learning should be something that's open to everyone and doesn't have those boundaries or barriers. I realized that the only way to open every door is to get an education."

BACK TO SCHOOL

Although she hadn't taken a math or science course in 13 years, DeButts decided to carve out a path in a STEM field. After taking classes at Ocean County Community College, she completed a Research Experience for Undergraduates in Mechanical and Aerospace Engineering at Case Western Reserve University. For the REU summer program, she worked in the lab of Professor Ica Manas in the Department of Macromolecular Science and Engineering.

The next logical step was to enroll in a formal engineering degree program, but she was uncertain of what type of engineering to pursue or if she would be accepted into a Ph.D. program.

"I applied to master's and second bachelor's programs in addition to Ph.D. programs because everybody said there's no way you'll get into a Ph.D. program with your background," DeButts said. "I applied predominantly to chemical engineering programs, but because I had worked in a polymer lab in the Macromolecular Science and Engineering department at Case, I knew I enjoyed the field. When I stumbled across the (MACR) website at Virginia Tech, I knew I had to apply."

DeButts presented a unique application and resume, but the MACR admissions committee recognized her potential and accepted her.

ADJUSTING TO GRADUATE SCHOOL

The fact that DeButts had experienced multiple career paths prior to graduate school helped her maintain focus and dedication while completing her Ph.D.

"I didn't come to this decision to go to graduate school lightly. I left a full-time job and life in the real world to go back to school and pursue a new career," DeButts said.

Graduate school didn't start out easy for her, however. She originally started in the lab of Robert Moore, Professor of Chemistry and Director of the MACR program, but DeButts quickly realized this wasn't the right fit for her.

"The projects were really interesting, but I realized I liked chemistry in theory," DeButts said. "When it came to working on actual chemistry experiments, I didn't feel that joy I thought I would."

Thanks to the options available in the MACR program, Dr. Moore helped her find a new home in a more engineering-focused laboratory. She landed in the Department of Biological Systems Engineering with Professor Justin Barone.

For her dissertation work, DeButts has investigated agricultural proteins as reinforcing fillers in polymer composites. She has focused on optimizing the processing-property relationships of the reinforced systems. As sustainable materials, the proteins could present a renewable, less expensive, and better-performing filler for applications such as green tires or biodegradable flexible packaging.

LOOKING BACK AND LOOKING FORWARD

After completing the interview season in Fall 2018, DeButts received multiple job offers. She accepted a position as a Principal Investigator in Research and Development for DuPont's Tyvek group in Richmond, Virginia. Fittingly, she will once again be working in the Safety and Construction business.

Working in MII's interdisciplinary environment proved to be a great asset for potential employers.

"As I went through the interview process, the phrase that kept coming up again and again was you need to work in cross-functional teams," DeButts said. "The fact that I'm not relegated to a single department here or faculty from a single discipline has been really helpful."

As DeButts looks back at her time in Blacksburg, she admits it was extremely challenging but also says she wouldn't change any of it. Now with her doctorate, she has reached the goals she set when she decided to continue her education.

"It really has been an honor and a privilege to be part of this program," DeButts said. "I am eternally grateful to Bob Moore and Tim Long and Chris Williams for having the foresight, or whatever it was, to bring me into this program given my unusual application.

"I've got a terminal degree in an engineering field in a great program. I just completed the interview season, and, as I went in, giving these research presentations, I realized I had achieved what I wanted. I opened all those doors."

MACR STUDENT COUNCIL

Emily Wilts

Most departments on campus, and every interdisciplinary graduate education program (IGEP), have a student organization to address student-related issues and offer support through graduate careers. Because the Macromolecular Science and Engineering (MACR) graduate degree program houses students in many departments, we thought a student-run organization to bring everyone together would benefit students in terms of well-being and ease of their time here at Virginia Polytechnic Institute and State University.

We formed a MACR student council, beginning in Spring 2018, composing of one representative from each lab with MACR students to organize social events, help with recruiting and orientation, and make every MACR student feel at home.

Between Spring 2018 and Spring 2019 the MACR Student Council facilitated student volunteers for orientation week and recruitment weekend and helped develop the plan of events based on previous experiences.

In Fall 2018, we sent students to regional conferences and local universities to help spread the word about the MACR program. We also worked with the MII staff and directors to facilitate program changes that benefit the students. In February 2019 we hosted the first annual First Year Welcome Party to foster a community between all cohorts of the MACR programs and to welcome our first-year students to Virginia Tech.

In the future, we hope to continue these traditions, and we will work with MII staff and directors to host more social events and become a part of the MII Technical Conference in Fall 2019.

Executive Board: Emily M. Wilts, Camden Chatham, Priya Venkatraman, Bradley Sutliff

Members: Brady Hall, Barbara DeButts, Chris Kasprzak, Garrett Godshall, Glenn Spiering, Jack Bryant, James Brown, Keyton Feller, Tyler White, Sarah Blosch, and Ryan Carrazzone

MII EVENTS

MII TECHNICAL CONFERENCE & REVIEW
Register at mii.vt.edu

Held every 18 months, the technical conference and review provides MII students and faculty an opportunity to showcase their research to industry and government partners. MII hopes the gathering will also continue to reinvigorate interdisciplinary collaborations across campus. The theme of the 2019 conference will be "Innovations at the Intersections of Science and Engineering."

When: November 4-6, 2019

Where: Inn at Virginia Tech and Skelton Conference Center

Who: MII Faculty, Students, Staff, and Industrial Partners

What: 3 days of lectures, posters, and networking. Come see the latest in polymer research at MII.

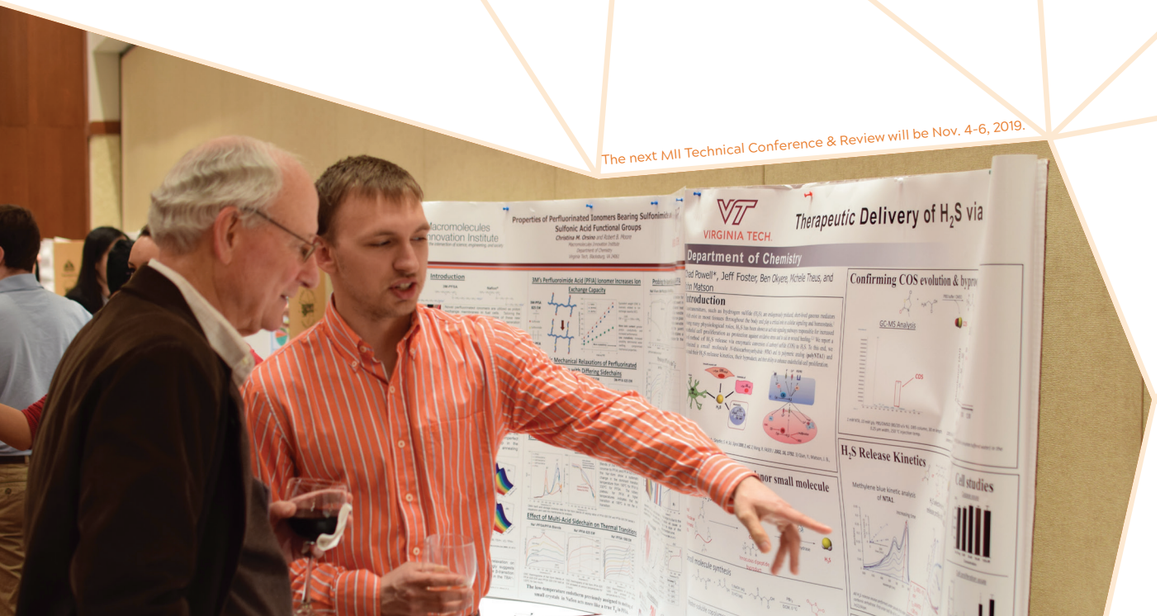
ADHESION SCIENCE SHORT COURSE TURNS 30

For three decades, Virginia Tech professors have taught this unique lecture-laboratory short course for industry and government partners who produce or utilize adhesives and sealants.

The 2019 program welcomed John Matson to the short course faculty, which now consists of:

- Michael Bortner, Assistant Professor, Chemical Engineering
- Rick Davis, Professor, Chemical Engineering
- David Dillard, Adhesive and Sealant Professor, Biomedical Engineering & Mechanics
- Alan Esker, Professor, Chemistry
- Charles Frazier, Thomas M. Brooks Professor, Sustainable Biomaterials
- Timothy Long, Professor, Chemistry
- John Matson, Associate Professor, Chemistry

Registration for the 2020 short course will open in December 2019.



The next MII Technical Conference & Review will be Nov. 4-6, 2019.

MMDC UPDATES

NEW INSTRUMENTATION IN THE MMDC

The Macromolecular Materials Discovery Center continues to be a model for shared facilities at Virginia Tech. The MMDC welcomed several new instruments to its collection, including an OMNISEC REVEAL UPLC detector (Ultra-high Performance Liquid Chromatography) and an XploRA PLUS Raman Microscope.

UPLC is an advanced technique to separate, identify, and quantify compounds. This advanced OMNISEC REVEAL UPLC has a multi-detector capability to efficiently analyze these compounds.

The Raman Microscope stemmed from a Request for Proposals for MII faculty to add to the MMDC. This winning submission was chosen for its high potential impact on MII research. Interest in *in-situ* Raman capabilities spans multiple MII researchers working in polymer nanocomposites, nanomaterials, biologically relevant materials, composites, packaging, polymer characterization, and surface adhesion. Gary Seidel, an associate professor in the Department of Aerospace and Ocean Engineering, led a collaborative effort with professors in multiple colleges and departments.

NEW FACILITIES MANAGER

The MMDC also welcomes Dr. Gayan Appuhamillage as the new facilities manager, taking over from Dr. Charles Carfagna. Dr. Appuhamillage came to Virginia Tech in 2018 as a postdoctoral research associate in Professor Tim Long's group after earning his Ph.D. at the University of Texas at Dallas. Dr. Appuhamillage will continue his postdoctoral research in 3D printing in addition to leading the MMDC.

The MMDC is a shared facility open to both internal and external users. MII faculty have access to the lab at a discounted rate. Please contact Dr. Appuhamillage for any inquiries about the MMDC at gayan7@vt.edu.

Gayan Appuhamillage

STUDENT ACCOMPLISHMENTS

Philip Scott

2018 Excellence in Graduate Polymer Research Award, ACS Division of Polymer Chemistry (POLY)

Fourth-year Macromolecular Science and Engineering Ph.D. student

Advisor: Timothy Long (Department of Chemistry)

Dissertation work: "My work uses synthetic design of polymer systems to address modern challenges for elastomers. This ranges from investigating exciting new ways to implement elastomers as 3D printable materials to introducing new ionic functionality and electrical response in elastic materials."

About the award: "I am deeply honored to have received this award and excited for the opportunity it brings to share my research with experts in the field at ACS!"

Favorite thing about MII and Virginia Tech: "The leading emphasis to which Virginia Tech and MII give interdisciplinary research. This approach is absolutely the future of research and none of my own would be possible without collaboration across multiple fields of polymer science and engineering."

Alex Haring

2019 Outstanding Doctoral Student in Interdisciplinary Programs Award, Virginia Tech Graduate School

Fourth-year Macromolecular Science and Engineering Ph.D. student

Advisor: Blake Johnson (Department of Industrial Science and Engineering)

Dissertation work: "The title of my dissertation is 'Sensing in 3D Printed Neural Microphysiological Systems.' Microphysiological systems are miniaturized tissues or organs designed to mimic *in vivo* conditions as accurately as possible *in vitro*, with the primary goal of disease modeling. This is done by introducing higher order functionality beyond traditional cell cultures. These functionalities can include flow, heterogeneous or gradient chemical environments, three dimensionality, electrical or mechanical stimulation, or heterogeneous co-cultures.
I am interested primarily in neural microphysiological systems, which we use to model diseases or disorders of the neurvous system such as peripheral nerve injury or brain tumors. My work has two primary goals: First, using 3D printing to manufacture new designs of these systems not previously possible, with an emphasis on extracellular matrix mimicking hydrogel based 3D cell cultures. Second, to design and integrate sensors into these systems for real-time monitoring of mechanical properties such as modulus and density, or biological properties such as gene expression and cell migration."

About the award: Every year, Virginia Tech awards one outstanding doctoral student award to each college, and one for students in interdisciplinary programs. Haring was nominated by Dr. Blake Johnson, his advisor, and Dr. Robert Moore, the MACR director.

"This award is recognition of the hard work that my research group and I, as well as our team of interdisciplinary collaborators, have been putting into these projects," Haring said.

Favorite thing about MII and Virginia Tech: "My favorite thing about MII is the diversity of knowledge bases across the institute which creates a rich research environment."

Emily M. Wilts

2019 Runner-up, the College of Science Roundtable Scholarship

Third-year Macromolecular Science and Engineering Ph.D. student

Advisor: Timothy Long (Department of Chemistry)

Dissertation work: Synthesis and characterization of water-soluble and biodegradable materials for additive manufacturing

About the award: "The College of Science Roundtable Scholarship is awarded by the COS Roundtable, which is made up of dedicated alumni from various fields. I am honored to be a runner-up for this award as it was an amazing opportunity to meet the members of the Roundtable and learn about their experiences."

Favorite thing about MII and Virginia Tech: "The collaborative nature of the institute across all subsets of science and engineering impressed me when I was applying to graduate school, and it still impresses me today. To solve some of the world's greatest challenges, all disciplines of science and engineering must team up, which is exactly how MII and VT conducts research."

REU WRAP UP

Kim Felix
REU Program Director

As the Macromolecules Innovation Institute (MII) continues to produce exciting new research proposals for the future, we would like to take a moment to reflect on the past cycle of the National Science Foundation's Research Experience for Undergraduates (REU) program that took place in the summer of 2018. This past summer was particularly notable as it marked the concluding chapter of the Materials Innovation at the Intersection of Food-Energy-Water Systems themed research programming.

MII boasts a historic tradition of hosting REUs, having participated in 29 consecutive years of summer research programming at Virginia Tech. As a result, we've seen many students utilize the numerous opportunities an esteemed REU program can afford and have ushered a growing number of students into graduate school with world renowned faculty at our campus here in Blacksburg. Undoubtedly, the experience has left an indelible impression on the lives of countless students for well over two decades.

As in years past, the students from our summer 2018 class were among the best and brightest researchers. We assembled an eclectic group of undergraduates from top-ranked institutions such as Bethel University and Vassar College to focus on socially conscientious and environmentally engaging research. The breadth and depth of diversity in our student body continues to strengthen the program and adds an invaluable element that makes each summer a memorable and poignant experience.

Sixteen undergraduates were tasked to find solutions to the agricultural/food shortage, develop sustainable energy sources, and address shrinking water reserves. Their daily activities included lab work as well as attending seminars, technical trainings, and taking courses. Students invented meaningful solutions to the growing problem of scarcity by communicating their research with a 30-second commercial conceptualizing their work in an audio/visual format consisting of an educational element informing the consumer of the food-energy-water crisis and a call to action challenging the viewer to actively contribute to the solution through social change and activism.

The outcomes of their projects made evident that the students invested much thought into practical sustainable solutions as the fruits of their labor produced publications, patent submissions, presentations, and posters showcased at various national conferences. The culmination of the REU produced a record number of undergraduate students engaged in research and the submission of a paper to Polymer International entitled: *Envisioning Our Homes in 2118: Demands for Intelligent Materials to Address Food, Energy, and Water for a Growing Population*.

As a graduate institution we remain committed to supporting over 100 undergraduate researchers within MII. The conclusion of the food-energy-water themed REU leaves MII in an excellent position to continue to propose new ideas for funding and research exploration. We look forward to forging ahead with new themes and can't wait to work with the next group of ambitious undergraduates in the summer of 2020!

FACULTY AWARDS

Michael Bortner

Assistant Professor
Chemical Engineering

College of Engineering Undergraduate Research Advisor of the Year, elected by the Student Engineers' Council, 2018-19

Michael von Spakovsky

Robert E. Hort Jr. Professor
Mechanical Engineering

Named the Robert E. Hord, Jr. Professor in Mechanical Engineering

Jonathan Boreyko

Assistant Professor
Mechanical Engineering

Junior Faculty Award, ICTAS

Ferdinand P. Beer and E. Russell Johnston, Jr., Outstanding New Mechanics Educator Award, ASEE Mechanics Division, 2018

John Matson

Associate Professor
Chemistry

Camille Dreyfus Teacher-Scholar Award, 2018

ACS POLY Division Research of the Month, April 2018

ACS PMSE Division Young Investigator Award, 2018

Christopher Williams

Professor
Mechanical Engineering

Graduate Alumni Advising Award, Virginia Tech Office of the Provost, 2018

Blake Johnson

Assistant Professor
Industrial and Systems Engineering

College of Engineering Undergraduate Research Advisor Award from the Student Engineers' Council, 2018

Outstanding New Assistant Professor, COE Dean's Awards for Excellence, 2018

SOLVAY SEMINAR SERIES

FALL 2018

AUGUST 29

Prof. Julie Kornfield

California Institute of Technology

SEPTEMBER 5

Prof. Sanat Kumar

Columbia University

SEPTEMBER 26

Prof. Jaime Grunlan

Texas A&M University

OCTOBER 10

Prof. Jeff Youngblood

Purdue University

OCTOBER 24

Dr. Ahmet Kusoglu

Lawrence Berkeley National Laboratory

NOVEMBER 7

Dr. Erik Hagberg

Archer Daniels Midland

SPRING 2019

JANUARY 30

Prof. Rana Ashkar

Virginia Tech

FEBRUARY 27

Prof Athanassios Z. Panagiotopoulos

Princeton University

MARCH 20

Prof. Gareth McKinley

Massachusetts Institute of Technology

APRIL 3

Prof. Gary Hamed

University of Akron

APRIL 17

Prof. Nenad Miljkovic

University of Illinois at Urbana-Champaign

APRIL 24

Dr. Todd Alam

Sandia National Laboratories

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