COLLEGE OF SCIENCE
BIOLOGICAL SCIENCES
VIRGINIA TECH.

The Department of Biological Sciences is at the center of life sciences research and teaching at Virginia Tech. Our mission is to seamlessly integrate world-class research addressing the grand challenges of the 21st century, from global change to human disease, with preparation of the next generation of scientists.

Happy New Year, alumni, friends and colleagues! Since I last wrote, the Department of Biological Sciences has experienced remarkable growth and change. This fall semester, we welcomed over 500 freshman majors, an increase of nearly 100 over last year. Fortunately, renovations to expand and modernize our teaching labs were completed just in time to accommodate the on rush of new students. These renovations also provided much needed gathering spaces for our students and upgraded several research labs as well as faculty and graduate student offices.

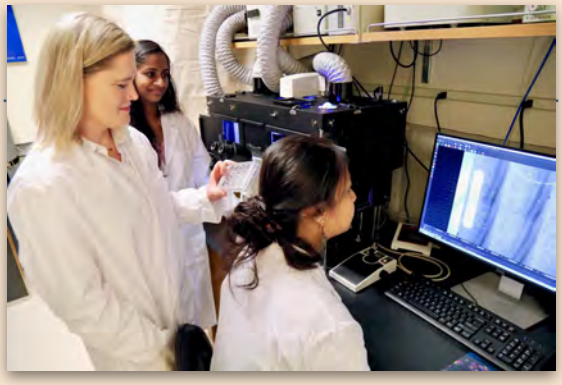
Speaking of renovations!... On the left, an early photo of an on-campus biology lab in 1888, located in the Second Academic Building (which was demolished 1957). On the right, a recent photo of one of the updated teaching labs in Derring Hall

We also have a number of new faces among our faculty. In addition to **Jeremy Draghi** and **Bryan Hsu,** who were mentioned in the Spring newsletter, **Joe Hoyt** has recently been named an assistant professor in the Department. Joe is a disease ecologist focused on understanding the spread of white nose disease in bats and how resistance emerges in some populations, which has far-reaching relevance to other infectious diseases. **Anthony LaMantia** recently joined the faculty as a full professor based at the Fralin Biomedical Research Institute in Roanoke. Anthony's research seeks to understand how complex neural circuits are formed during development and their role in normal brain function and disease. Sadly, we also recently said goodbye to **Martha Muñoz**, and **Chris Lawrence**, who relocated to Yale University and Greenlight Biosciences, respectively– we wish them the best of luck in their new positions.

The achievements of our faculty and students continue to impress. Undergraduate students **Esther Wisdom** and **Amber Abbott** received Goldwater Scholarships. This is the third straight year that Biological Sciences / Microbiology majors have won this scholarship, arguably the most prestigious in STEM disciplines in the United States. We also had had an unprecedented number of graduate fellowship awardees, with 6 of our students winning highly competitive fellowships from the National Science Foundation's Graduate Research Fellowship Program. Our faculty were equally productive, submitting a record number of successful grant applications and winning numerous awards and recognition, some of which are highlighted in this issue.
(continued on page 2)

We welcome comments and items of interest for future newsletters. Please contact Valerie Sutherland (vsutherl@vt.edu) via email, or write to us at the Department of Biological Sciences, 2125 Derring Hall (MC 0406), 926 West Campus Drive, Blacksburg, VA 24061

JONES RECEIVES $1.85 MILLION NIH GRANT TO STUDY SEPSIS. *Written by Kendall Daniels*



(L to R) Caroline Jones , with Ph.D. students Udaya Sree Datla (back), and Brittany Boribong (front), Photo credit: Alex Crookshanks.

One drop of blood contains 5,000 neutrophils, the most abundant type of white blood cell that is deployed by the human immune system. Throughout the entire body, a human has 25 billion of these foot soldiers that are relentlessly patrolling to fight invading pathogens.

But, sometimes, this cellular army misinterprets signals and becomes confused.

Imagine the widespread damage these soldiers could cause if they stepped out of line and attacked the very organs that our lives depend on. Sadly, this is a reality that 1.7 million Americans face every year. This condition is called sepsis.

Sepsis occurs when the body's immune system over responds to an infection. If the condition is not diagnosed early enough, it can lead to organ failure and death. According to the Center for Disease Control and Prevention, sepsis is responsible for the deaths of 270,000 Americans every year - and it is the number one killer in U.S. hospitals.

"It's like you are having this war inside your body. We want to understand how we can tune the immune cells so that they can fight infections without this huge overreaction that leads to sepsis," said **Caroline Jones**, Assistant Professor of Biological Sciences.

Jones received a $1.85 million MIRA R35 grant from the National Institute of General Medical Sciences (NIGMS), one of the National Institutes of Health (NIH), to study the factors that underlie the decision-making processes that determine immune cell migration, differentiation, and activation in response to sepsis.

The MIRA grant, which stands for Maximizing Investigators' Research Award, provides scientists with greater stability and flexibility in their research, which inherently increases the chances for scientists to make huge breakthroughs in the field.

This past March, Jones published a paper in Frontiers in Immunology with **Liwu Li**, Professor of Biological Sciences, and **Brittany Boribong**, a graduate student in Genetics, Bioinformatics, and Computational Biology, who was the first author.

This work was in part funded by the Dean's Discovery Fund that was awarded to Jones and Li by the dean of the College of Science, **Sally Morton**, last year. **(continued on page 9)**

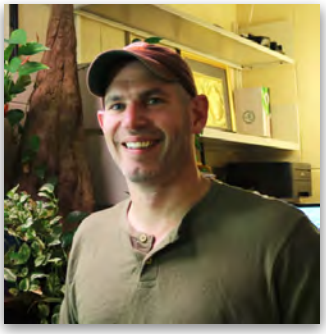
(Continued from page 1) As in the previous newsletter, I would also like to draw attention to our devoted and talented staff, who make possible everything that we do. This time around, I want to specifically thank **Karen Fraley** in our undergraduate advising office. As if finding classroom space for our largest ever freshman class wasn't enough, she also had to keep our advising program afloat in the midst of a nearly complete changeover of our professional advising staff. Karen did all of this flawlessly, and always with a welcoming smile on her face. She is the consummate team player and the department and I are most grateful for her efforts.

Unfortunately, all of these exciting developments come at a cost, and support for graduate students and core facilities has not kept pace with increasing costs. In order to maintain our strength as a department during these times of transition, we are increasingly reliant on private gifts and are grateful to have such a solid bedrock of dedicated alumni and friends. If you are in a position to make a gift or bequest to the Department of Biological Sciences, please visit https://apps.es.vt.edu/onlinegiving/gift?fund=881317, or contact me directly (rscohen1@vt.edu). I continue to enjoy my role in aiding the success of our department, and I look forward to another great semester!

––**Bob Cohen**, Professor and Department Head, Department of Biological Sciences

BROWN LAB RESEARCHERS DISCOVER CONNECTION BETWEEN SYMBIOTIC WORMS AND THE MAGNETIC ORIENTATION OF CRAYFISH.

Written by Rasha Aridi



From migratory birds to newly hatched turtles making their way to the sea, studies have shown that animals use the Earth's magnetic field to orient themselves.

Crayfish are no different. However, their use of magnetic cues is influenced by the number of symbiotic worms that live on the crustaceans' bodies.

"This is the first study to demonstrate that crayfish can detect and respond to the earth's magnetic field. What I think makes this study really unique is that it is the first to study the effect of symbionts on magnetoreception," said **Bryan Brown**, Associate Professor of Biological Sciences.

Brown studies large-scale aquatic community ecology. His work focuses on how multiple species interact in aquatic habitats and how those interactions are altered by changing environmental conditions. Brown has studied crayfish symbiosis for more than 20 years; last year, he completed a 17-day kayaking trip to assess invasive crayfish species.

In a study published in Scientific Reports, Brown and a team of researchers from Virginia Tech looked at the connection between symbionts and crayfish's ability to magnetically orient themselves.

The researchers found that ectosymbionts – species that live on the outside of the host's body and have mutually beneficial relationships with their hosts – affect a crayfish's use of the Earth's magnetic field as a directional reference.

Lukas Landler and **James Skelton** (pictured left), both Ph.D. students who graduated in 2015 from the Department of Biological Sciences, combined their areas of expertise to develop this study. Landler, who earned his Ph.D. under **John Phillips**, studied the neuronal basis of magnetoreception, while Skelton, one of Brown's Ph.D. students, studied the interspecific relationships in aquatic macroinvertebrate species. Phillips, Professor of Biological Sciences, specializes in magnetic field detection and sensory ecology.

"Magnetoreception is one of the more mysterious things about animals, because nobody fully knows how that mechanism works," said Brown, who is also an affiliated faculty member of the Global Change Center, housed within the Fralin Life Sciences Institute.

It is well established that animals use a variety of directional cues, including sun position, star patterns, polarized skylight, and the Earth's magnetic field to guide their movements. What is less understood is why a wide variety of animals, when not actively moving, spontaneously align themselves along roughly the north-south axis relative to the magnetic field.

Worms and crayfish live in symbiosis with one another – the worms feed on parasites and keep the crayfish's exoskeleton clean, especially its gills. In exchange, the worms get food, protection, and access to favorable habitat. The natural density of worms found on crayfish tends to be in the moderate range, which is most beneficial for the crayfish.

"Our previous work has shown that along the gradient from no worms to high density, the relationship between host and ectosymbionts goes from mutualism to parasitism," Brown said. "In parallel with this change in the relationship between crayfish hosts and worms, the response of crayfish to the magnetic field goes from quadramodal alignment to bimodal alignment to a random distribution as the density of worms increases." **(continued on page 10)**

ALUMNI SPOTLIGHT

Adapted from articles by Jenny Kincaid Boone and Morgan Gstalter

Camille Schrier didn't grow up singing, playing piano, or dancing.

She participated in sports, primarily swimming, equestrian, field hockey, and track and field, and dreamed of becoming a meteorologist or a marine biologist – anything in the science field.

Since then, the Virginia Tech alumna, who was one of the first Hokies to graduate in 2018 with a systems biology major, hasn't strayed too far from science.

In June 2019, she took her science skills to a larger stage. Wearing a lab coat, goggles, and high heels, she performed an exploding chemistry experiment as her talent in the Miss Virginia competition in Lynchburg – and she won. And last month, Schrier was crowned Miss America 2020.

Her victory is no surprise to her professors at Virginia Tech, who remember Schrier, also a biochemistry major, as one of the brightest students in their courses. "She definitely made the best presentations in my class," said **Jing Chen**, an assistant professor of biological sciences who taught Schrier in several courses. "She was very good at explaining the background information and her results."

During her year-long reign as Miss Virginia, Schrier has worked to raise awareness of drug safety and abuse prevention and to promote science, technology, engineering, and math education and careers in schools throughout the state, with a focus on attracting girls to the path.

"I want to be that role model for them," said Schrier, who chose a chemistry demonstration for the competition to showcase what she could bring to schools during her reign.

The demonstration, called elephant toothpaste, is a reaction of hydrogen peroxide and potassium iodide that produces a huge, billowing stream of steaming foam. Pageant staff had to wear thermal gloves while cleaning up the stage afterwards, Schrier said.

"I wanted to do something that was entertaining and was able to show the talents that I do have," said Schrier, who is enrolled in the doctorate program at Virginia Commonwealth University's School of Pharmacy. Schrier said she hopes to "break stereotypes about what it means to be a Miss America in 2020" by being a "woman of science" that is also true to herself.

"I'm not the beauty queen," she said. "I'm the brand ambassador for this organization and I'm more than just someone with a crown on my head."

The 99th Miss America competition featured several changes to the traditional pageant, including the second year without a swimsuit competition or judging on physical appearance.

Schrier opened up on stage about battling an eating disorder and said she decided to compete after the swimsuit portion was removed, AP reported. **(continued on page 11)**

SELECTED NEW GRANTS

Associate Professor **Zhaomin Yang** is principal investigator on a $1m, 4-year grant from the National Science Foundation entitled, "Cyclic di-GMP Regulation of PilB in Motility and Biofilm." **Deb Kelly**, a former VT/VTCRI faculty member, currently at Penn State, is a co-PI. "To go, or to stay, that is the decision a bacterium must make in any environment it encounters. To go, it must assemble a motility apparatus and disable structures for attachment to surfaces. To stay, it needs to establish a protected settlement by producing building materials of its own to form a bacterial biofilm on a solid surface. This decision and its execution by bacteria profoundly impact our lives and society because biofilms can form on so many critical environmental surfaces. This research project probes at the molecular level how a bacterium makes and executes this decision to either form biofilms or move by enabling its motility. Besides advancing basic microbiology, this project will allow integrated teaching and learning opportunities as well as interdisciplinary training of both graduate and undergraduate students. In addition, a variety of outreach activities will be performed to help diversify our STEM workforce."

Assistant Professor **Kate Langwig** is PI on a $2.5m (with $400K to Virginia Tech), 5-year grant from the United States NSF-EEID and the China NSF entitled, "US-China Collaboration: Lessons from the past: synthesizing drivers of host persistence across a pathogen invasion gradient." Assistant Professor **Joseph Hoyt** is among the co-PI's on the project. The invasion of pathogens into new regions has caused widespread population declines and driven some species to extinction. However, after host species initially decline from disease, it is unclear how some hosts can coexist with pathogens, particularly when the pathogens are lethal. Understanding the mechanisms of host-pathogen coexistence can provide insight into pathways that promote healthy host populations, including disease management strategies and treatments. This global project is a collaboration between U.S. and Chinese scientists and will examine how bats survive with a deadly fungal pathogen that causes white-nose syndrome. This work will explore whether similar coexistence strategies have arisen in bats repeatedly as the disease spread from Asia, to Europe, and then to North America over the last several thousand years. This project also includes communications training for wildlife disease researchers and stakeholders, work with state and local resource managers to develop disease management strategies, and the establishment of international networks to promote cross-border wildlife conservation.

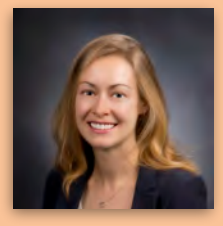
Professor **Dorothea Tholl** is PI on a $766K, 3-year grant from the National Science Foundation entitled, "Collaborative Research: Emergence of terpene cyclization in animals." Associate Professor **Florian Schubot** is among the co-PI's on the project. Chemical interactions between organisms represent a key form of communication in nature and is mediated by diverse arrays of small molecules. These molecules or chemical cues serve critical roles in maintaining and driving species diversity and ecosystem functions. Using interdisciplinary methods, the team of investigators explore the question of how chemical compounds emerge and adopt biological functions with a specific focus on understanding the emergence of terpenes - a major family of molecules used by insects to ward off enemies and pathogens, search for food, and attract or seek out mates. Integrating computational modeling and molecular modifications, the project reconstructs the evolution of enzymes that are central to the generation of terpene chemical diversity in insects. Through their study, the investigators will develop an integrated empirical and theoretical platform that will serve as a blueprint for tracing the evolution of various protein families. The project has broader societal and educational impacts, including potential generation of target enzyme products and gene variants for industrial applications and translation of research results into a visual installation, which will be accessible to the general public through theaters at Virginia Tech and the Science Museum of Western Virginia.

Assistant Professor **Frank Aylward** is principal investigator on a $555k, 3-year grant from the National Science Foundation entitled, "IIBR Informatics: Innovative Software and Databases to Leverage RNA Polymerase as a Phylogenetic Marker in Metagenomic Data." **Liqing Zhang**, of VT Computer Science, is co-PI. Advancing our knowledge of the extent and nature of biodiversity on Earth is a fundamental challenge in Biology. The largest uncharacterized reservoir of phylogenetic diversity on the planet resides in cryptic lineages of Bacteria and Archaea, often referred to as "microbial dark matter", that cannot be cultivated in the laboratory and are only known to exist from cultivation-independent molecular methods. Understanding the physiology, evolutionary history, and environmental impact of these groups is a major frontier for future research, and studies in this area have already led to important discoveries in biogeochemistry, evolutionary biology, and cellular physiology. Advances in high-throughput DNA sequencing together with developments in the field of metagenomics have provided an unprecedented amount of metagenomic data that can now be mined to discover novel microbial lineages, but new computational methods are required for leveraging this "big data" to achieve these biological insights. This project focuses on developing computational tools to assess microbial diversity in metagenomic data through analysis of sequences of RNA polymerase (RNAP). RNAP is a high-resolution phylogenetic marker gene that provides accurate taxonomic assignments for Bacteria and Archaea and can be leveraged to identify and classify cryptic microbial lineages in the biosphere. This work will also involve the training of graduate and undergraduate students in computational biology and bioinformatics as well as the integration of these bioinformatic approaches into university curricula.

Assistant Professor **Erin Hotchkiss** is principal investigator on a $489k,34-year grant from the National Science Foundation entitled, "Collaborative Proposal: MRA: Linking land-to-water transport and stream carbon cycling to inform microsystem carbon balance." Carbon is the energy currency of ecosystems. Carbon emissions from streams and rivers are important sources of carbon to the atmosphere. Scientists rarely measure the movement of carbon from air to plants, into soils and groundwater, through streams and rivers, and back to the atmosphere. This research will develop new methods and data to measure terrestrial carbon cycling through freshwaters. This project will also train diverse students and professionals to conduct research linking terrestrial and freshwater carbon flows. Educators will complete summer research projects using environmental sensors and public datasets to enhance K-12 student understanding of research. Collaborations with industry partners will create common standards for freshwater sensor measurements. The project will also develop open-source software to improve water quality and carbon cycling research with data collected by sensors.

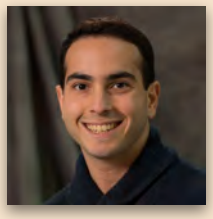
Professor **Brenda Winkel** is principal investigator on a $300k, 2-year grant from the National Science Foundation entitled, "Collaborative Research: Innovating technologies to inform synthetic plant metabolism through a new understanding of the cellular protein machinery." **Rich Helm** of VT Biochemistry and **Deb Kelly**, former faculty member at VT/VTCRI, currently at Penn State, are co-PI's on the project. Plant metabolism is a high priority target for synthetic biology, with significant potential to address global challenges ranging from food production to energy and the environment. However, the successful application of synthetic biology strategies in complex eukaryotes faces unique challenges. In particular, large gaps remain in the knowledge of how cellular processes are controlled at the nanoscale, which is an essential component of engineering design. The project will develop new electron microscopy-based strategies to visualize and create structural models of labile protein complexes captured from plant cells. Ultra-sensitive methods will be established to rigorously identify the protein components of these complexes using advanced proteomics and in planta validation techniques. This will establish a critical new framework for synthetic metabolism. The project will also create a unique interdisciplinary/inter-institution training environment at Virginia Tech and Pennsylvania State University that will engage students at all levels of education.

AWARDS AND RECOGNITIONS



Associate Professor **Cayelan Carey** has been awarded the International Society of Limnology's Kilham Award, which is their premier mid-career achievement award for outstanding contributions to limnology research. The Kilham Award is given every 2 to 3 years to a Society member. Dr. Carey will receive the award at the 2020 International Society of Limnology Conference in Gwangju, South Korea, where she will present the Kilham Lecture on her research on freshwater biochemistry. Congratulations, Dr. Carey!

Rich Walker, Associate Professor and Associate Department Head, was named the Advisor of the Month for September 2019 by the VT Office of Undergraduate Advising. Asked, "What do you enjoy about your role in advising?", Dr. Walker replied, "I enjoy helping students see the potential within themselves. My hope is that my efforts will not only enhance my advisees' success while they are on campus, but will also make a meaningful impact long after they leave Virginia Tech, especially when they have the opportunity to serve as advisors or mentors themselves." Congratulations on this well-deserved recognition!



Ubadah Sabbagh, a TBMH graduate student in **Michael Fox's** lab, has won a six-year $390,000 NIH Blueprint Diversity Specialized Predoctoral to Postdoctoral Advancement in Neuroscience (D-SPAN) Award. Designed to support outstanding doctoral candidates of underrepresented backgrounds in neuroscience research, D-SPAN was awarded to just 18 students from across the nation in last year. Ubadah's remaining graduate school tuition, travel to conferences, postdoctoral salary, and research expenses will be covered for the next six years. Congratulations, Ubadah!

Kristen Bretz, a Ph.D. student in **Erin Hotchkiss's** lab, has been named the 2019 William R. Walker Graduate Research Fellow by the Virginia Water Resources Research Center. Established to honor the late William Walker, the founding director of the VWRRC, the award has been given since 1999 to recognize and support graduate students in water resources who are pursuing work in a field different from their undergraduate study, or who have returned to school following a period of professional work. Prior to starting her research at Virginia Tech, Kristen received her M.S. from UNC Chapel Hill where she studied arctic lake methane dynamics. She also worked for USDA for several years. She returned to freshwater research for the opportunity to study streams of her native Blue Ridge mountains, and she is currently investigating how changes in headwater network connectivity affect stream carbon processing. Congratulations, Kristen!

Andrew Pregnall, a member of the VT Honors College who recently received B.S. degrees in both Microbiology and History, has been named a British Marshall Scholar, making him the first Hokie to receive the prestigious Marshall Scholarship in 15 years. The Marshall Scholarship is a nationally competitive scholarship founded in 1953 to grant distinguished American students graduate study at any British university. Each year, colleges and universities from across eight regions endorse their best and brightest to the scholarship's candidate pool. Andrew is driven by his passion to remodel the health care system to improve the health outcomes of the LGBTQ community. As a Marshall Scholar, he will continue to pursue his ambition by studying health data analytics at the University of Leeds in the United Kingdom. Congratulations, Andrew!

THE FIRST ANNUAL DEPARTMENT OF BIOLOGICAL SCIENCES TAILGATE EVENT!

The first **Biological Sciences Tailgate** is successfully in the books! This event was supported by the Department and the College of Science, and over 100 alumni, faculty, staff, graduate students, undergrads, and family members attended the event on Saturday, September 14, 2019. Attendees of all ages - from toddlers to seasoned alumni - enjoyed brunch, lawn games, and community. The location in Hahn Horticulture Pavilion served as a tranquil venue with gorgeous plantings and Orange Effect koi providing a suitably biological backdrop.

Even better, the Hokies went on to defeat Furman 24-17 afterwards! Thanks go out to the tailgate organizing committee, which included **Katie Lafon** (Director of Alumni Relations, College of Science), **Jordan Metzgar** (Curator of the Massey Herbarium), **Meryl Mims** (Assistant Professor), **Valerie Sutherland** (Program Support Tech), and **Alaina Weinheimer** (Ph.D. student in the Aylward Lab). Keep an eye out on our department website for future events, and please let us know if you're interested in participating in next season's tailgate!

GO HOKIES!

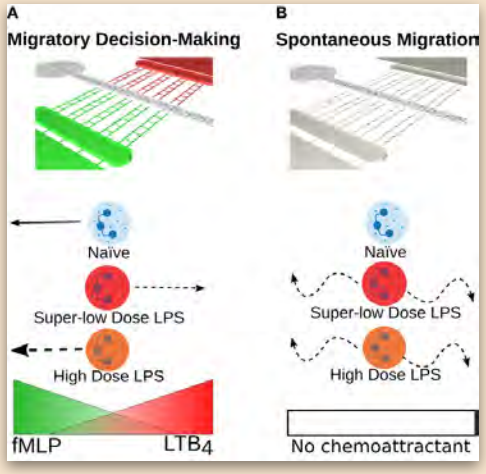
(Continued from page 2) Acting as a stepping stone to their current research, the paper showed that the decision-making process of neutrophils becomes faulty when immune cells are exposed to very low levels of inflammation.

Researchers observed that these low levels of inflammation primed the immune system for an excessively violent response to an invader. They also noticed that the cells migrated spontaneously through the microenvironment, instead of heading to the site of infection.

"Sometimes neutrophils get lost when they are exposed to super low levels of inflammation. And you can imagine that a person that is unhealthy, like if they have leaky gut syndrome or an unhealthy diet, would have this low level of inflammation. And then when they get an infection, their immune cells make the wrong decisions, and they respond in the wrong way," said Jones.

"It's that secondary hit where they get sepsis. They were predisposed to that earlier on because of the programming of the cells." By monitoring inflammation, Jones hopes that this research can help doctors and patients nip sepsis in the bud.

Popular literature has shown that there are certain diets and lifestyle changes that can help patients regulate their inflammation levels. If researchers can find a way to closely monitor cellular functions in a medical setting, patients will be able to see if they are predisposed to not only sepsis, but other inflammatory diseases as well.



"Inflammation can play a role in basically every disease, and controlling your inflammatory levels is highly important," said Jones. Using in vitro and in vivo models, Jones and her team will be able to ensure that their research is effective from bench to bedside.

"We will take a reductionist approach with the in vitro microfluidic chip, where we can precisely control certain variables. And then in the in vivo situation, we can then confirm what we are observing and that what we are looking at are the most important factors or variables."

Jones and her team will begin by taking cells from septic patients. Using a microfluidic chip, they will manipulate the microenvironment to see under what conditions cells can migrate properly and fight pathogens effectively. Although using this method provides researchers with a large amount of data, this doesn't exactly mirror the processes that are going on inside of a living organism.

To take things to the next level, researchers will implant hydrogels into mouse models to visualize how cells will migrate and fight in a whole organism. These hydrogels will also allow researchers to tune what signals a cell receives.

Most scientists would agree that having too much data is never a bad thing. For Jones, she needs an extra set of hands to make sense of these large data sets and modelling. So**, Stanca Ciupe, Lauren Childs**, and **Matthias Chung**, all in Virginia Tech's Department of Mathematics in the College of Science, will be pitching in to help Jones and her efforts.

"We have to have mathematicians on board to be able to make sense of it. It's not just yes and no. It gets much more complicated than that. When you are taking patient samples, there are tons of variables and there are a lot of phenotypes that we are looking at."

Jones is a strong proponent of interdisciplinary research because she is often faced with solving intractable problems, which she calls "big questions," with sepsis being one of them. **(continued on page 10)**

(Continued from page 9) "There are so many complexities, and I really think that you need to take the strengths of all of these different fields and put them together to be able to answer these types of questions." If researchers are able to understand the basic mechanisms behind inflammation and sepsis, Jones would next want to explore how sepsis affects brain function.

"It is known with 60 percent of people that survive sepsis develop post-traumatic stress disorder (PTSD). It could be because they went through such a traumatic event, but it is likely also chemical - that they have these huge levels of inflammation that affect their brain."

In addition to Li's immunology group and Boribong, Jones is collaborating with **Susanti Ie**, a specialist in critical care medicine and associate professor in the Department of Internal Medicine at the Virginia Tech Carilion School of Medicine, who will assist with the identification and collection of patient samples for this research.

(Continued from page 3) Quadramodal alignment is consistent with systematic search of the area surrounding a fixed reference point to which the searching individual returns after each foray. Consistent with the quadramodal response being part of an "active" response, crayfish without ectosymbionts showed significantly higher levels of activity than those in the other two groups. In contrast, bimodal alignment is indicative of a resting state in which standardizing the "projection" of the outside world onto the visual system may make it easier for the crayfish to detect and identify novel features of its surroundings. For example, this would help the crayfish lying in wait under the edge of a rock to distinguish between the approach of a potential predator versus that of potential prey, a distinction critical to the crayfish's survival that must be made before deciding whether or not to leave the safety of its refuge.

"Symbioses are really complicated. To make sense of them, ecologists tend to pigeonhole them into familiar little boxes like 'cleaning symbiosis.' But if we stop there, some fascinating and important nuances are lost. I love this study because it shows that these worms don't just clean crayfish. At higher densities the worms become a little annoying, and being annoying has real effects on how crayfish behave, which stimuli they respond to, and perhaps how well they can find their way home. It shows just how intimate and complex these interactions really are," Skelton said.

At high densities, ectosymbionts can injure the crayfish, feeding on gill tissue when all the organic matter that worms normally consume has been removed by other worms. As a consequence, the researchers speculate that at high densities of ectosymbionts, crayfish may seek out a safe refuge or burrow where they can safely groom to reduce the worm population. If so, visual features may be more useful than the magnetic field in finding the entrance. However, further research is clearly needed to pin down how the ectosymbionts directly influence the crayfish's behaviors.

"As of now, there are very few conservation efforts directed at symbiotic organisms," Brown said. "Every organism has symbionts; the more we know about them, the more important they appear to be."

This study furthers the scientific understanding of the evolutionary forces shaping sensory systems, how symbionts influence a host's response to magnetic cues, and how symbiotic interactions affects the host's and ectosymbiont's fitness.

This study was funded by the National Science Foundation, the Society for Integrative and Comparative Biology, the Global Change Center (formerly Organismal Biology and Ecology) Seed Grant, and the Virginia Tech Graduate Research and Development Program.

"I kind of figured that I would never get on that stage because I was a woman who did not want to get into a swimsuit on stage. And I didn't have a performing talent, which is really ironic now," she said.

The 51 women who participate are now called "candidates" instead of "contestants." They compete for a $50,000 scholarship and the role of Miss America, a one-year paid position.

"To make it relevant for these young women, it was important for us as a scholarship and service organization to make sure that we were reflective of this generation, meaning that you no longer had to be defined by some sort of ideal," Regina Hopper, president and CEO of the Miss America Organization, told the AP.

Schrier succeeds 2019 Miss America Nia Franklin, a classically trained opera singer from New York.

Science demonstrations have become popular in the past few years for talent portions of some pageants nationwide, said Hilary Levey Friedman, a sociologist and expert on beauty pageants. Based on Schrier's recent success, there could be more of these talent demonstrations in the future.

While at Virginia Tech, Schrier was involved in the Kappa Delta Sorority, attended Blacksburg Baptist Church, and interned at a pharmaceutical company. Science was her focus.

A Pennsylvania native, Schrier first visited Virginia Tech as a high schooler when she attended C-Tech, an engineering camp for girls. She transferred to the university her junior year, and initially, entered the engineering program. But she was drawn to systems biology, a new major for which students use math to solve biological problems.

Schrier's work ethic impressed **Shihoko Kojima**, an assistant professor of biological sciences at Virginia Tech, who is affiliated with the Fralin Life Science Institute. As a senior, Schrier worked in Kojima's Steger Hall research lab for her thesis evaluating a gene critical for regulating circadian rhythm.

"Camille is a person who puts in the work, no matter how hard it is," said Kojima.

Schrier is not new to the pageant world. As a teenager, she competed in pageants in the summer because they helped build her presentation skills, she said.

When the Miss America organization announced last year that it would eliminate the swimsuit competition and focus less on contestants' appearances, "it resonated with me," she said. But to gain entrance into the Miss America pageant, Schrier had to first win the Miss Virginia competition and she only had three weeks to prepare! She won using the elephant toothpaste demonstration as her talent, which she modeled after a performance by Kate the Chemist, a professor at the University of Texas who travels around the country doing chemistry demonstrations for children.

Schrier isn't the only Virginia Tech alumna who has been crowned Miss Virginia. Several others have won the crown, but only one, Kylene Barker, was named Miss America in 1978.

Schrier is currently taking a year off pharmacy school for her Miss Virginia responsibilities. This fall, she visited Virginia Tech for the annual Virginia Tech Science Festival, where she hosted a booth and carried out a science demonstration. (At left, she's pictured at the festival with Dr. Kojima.)

"I am totally impressed having her as Miss Virginia," Chen said. "It definitely puts a very positive image on how people view what's valuable in a woman in today's society."

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