
MICRO ISSUE
the Fralin Explorer
Fall 2016
VirginiaTech
Fralin Life Science Institute

WELCOME TO FRALIN

Dennis R. Dean
Director
Fralin Life Science Institute

Thanks for taking the time to look at the latest Fralin Explorer. This issue is of particular interest to me because the topic is microbiology at Virginia Tech. I was first recruited to Virginia Tech back in 1985 and still recall driving from Yellow Springs, Ohio to Blacksburg in mid April for my interview. The change in climate and scenery was so impressive as I departed from a flat landscape and a dreary snowstorm and arrived in mountains that seemed to be alive with dogwoods and redbuds in full bloom. The experience reminded me of the Wizard of Oz –like transition from black and white to stunning Technicolor.

I was truly fortunate to get an offer to join the Department of Anaerobic Microbiology. The environment for developing and sustaining a microbiology research team, which included a combination of undergraduate and graduate students, could not have been better suited to my ambitions. The special aspect of the community at that time included a combination of outstanding scientists who were truly dedicated to the education enterprise. Some of the people that mentored and inspired me included William Claus, Bob Benoit, Noel Krieg, and Al Youston from the Department of Biology. Also, John Johnson, Bob Smibert, Ed Moore, Peg Moore, and Tracy Wilkins were close and remarkably unselfish and supportive colleagues from my home department, the Anaerobe Lab. This special group of people enriched my career in many ways.

In this edition of the Fralin Explorer, there is a special narrative on the Anaerobe Lab and its ultimate transition into the Fralin Life Science Institute. The mission of the institute—with an emphasis on service to the research community and a tradition of promoting and supporting undergraduate research and community service— is clearly grounded in the traditions of the Anaerobe Lab. I also recall the outstanding undergraduate training provided by the core of microbiology professors within the Department of Biology. My own research effort benefitted immensely from having such well-grounded students perform research in my laboratory, so I learned first-hand how effective this group of educator-researchers were. I also learned rather quickly that students graduating from Virginia Tech were, and remain, in very high demand for post-graduate opportunities.

Times change and the individuals that made such a profound effect in launching the careers of a legion of microbiology students have retired. However, what has not changed is their enduring philosophy of high standards in undergraduate training and research excellence. In reading this issue of the Fralin Explorer, I hope you will gain an appreciation that Virginia Tech remains an exciting destination for education and research in the microbial sciences.

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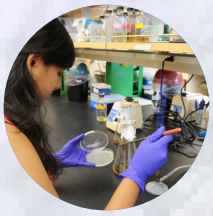
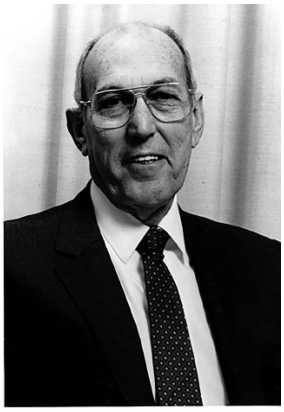


Editor: Lindsay Key. **Writers:** Cassandra Hockman, Lindsay Key, Steven Mackay, Lynn A. Nystrom, Michael Sutphin,
Photographers: Cover by Jelena Djakovic; Cassandra Hockman, Lindsay Key, Kristianne Sooknanan.
Designer: Jelena Djakovic

ABOUT FRALIN



Horace Fralin

The Fralin Life Science Institute is an investment institute committed to supporting research, education, and outreach in Virginia Tech's life sciences community. Residents of the institute's four flagship buildings are automatically considered affiliated faculty members and all other life science researchers on campus are invited to become affiliated faculty members. Affiliated faculty members are given resources necessary to explore new, innovative science that benefits people in the New River Valley, the Commonwealth of Virginia, and the world.

Through seminars, conferences, and research group support, the institute serves as a meeting point for progressive ideas involving multidisciplinary research. It is closely aligned with Virginia Tech's six other research institutes, which include the Virginia Tech Carilion Research Institute, Virginia Tech Transportation Institute, the Institute for Critical Technology and Applied Sciences, the Biocomplexity Institute, the Institute for Society, Culture and Environment, and the Institute for Creativity, Arts and Technology.

Research initiatives within the life sciences receiving the highest priority for support include vector-borne disease, infectious disease, plant sciences, ecology and organismal biology, obesity, and cancer biology. The Fralin Life Science Institute is also actively engaged in cooperative partnerships with colleges, departments, and other institutes that support the life science community.

Virginia Tech's X.J. Meng Elected to the National Academy of Sciences

XJ Meng. Photo by Logan Wallace

X.J. Meng, University Distinguished Professor of Molecular Virology at Virginia Tech, has been elected a member of the National Academy of Sciences. Membership in the academy is one of the highest honors given to a scientist in the United States.

Meng, a virologist in the Department of Biomedical Sciences and Pathobiology at the Virginia-Maryland College of Veterinary Medicine, is one of 84 new members and 21 foreign associates from 14 countries recognized for their distinguished and continuing achievements in original research.

He is the fifth faculty member to be elected to the National Academy of Sciences while at Virginia Tech and the sixth in the university's history. With the selection of Meng, 23 Virginia Tech affiliates have held membership in the national academies, one of the highest honors bestowed in the United States to scientists and engineers.

"Dr. Meng's extraordinary research on emerging and re-emerging animal viruses is bringing national and international acclaim to Virginia Tech," said Virginia Tech President Tim Sands. "His groundbreaking research led to the discovery of new viruses and the invention of a commercially licensed vaccine that is now in use around the world. His work is revolutionizing the way scientists and physicians think about human and animal viruses. We are lucky to have such an accomplished researcher and scholar at Virginia Tech."

Meng's research focuses on emerging and reemerging viral diseases that impact veterinary and human public health. Meng is widely considered one of the world's leading scientists in hepatitis E virus, porcine circovirus type 2, and porcine reproductive and respiratory syndrome virus. Meng's lab developed the first fully-licensed U.S. Department of Agriculture vaccine to protect against porcine circovirus type 2 infection and its associated diseases in pigs, a major threat to the global swine industry. In addition, Meng discovered the swine hepatitis E virus in pigs, which led to the recognition of hepatitis E as a zoonotic disease.

"We have long recognized Dr. Meng's important contributions to the field of molecular virology and are delighted to hear of his recent election to the National Academy of Sciences," said Cyril Clarke, dean of the veterinary college. "This honor not only recognizes the national and international reach of Dr. Meng's scholarship, but also raises the visibility of his outstanding research program at the veterinary college. As a world-class scholar, Dr. Meng is a tremendous asset to our college and community."

Meng has authored or co-authored more than 290 peer-reviewed articles and book chapters. These have been cited more than 18,380 times by other researchers. Meng has been awarded more than 40 research grants as a principal investigator of more than $15 million, and he is also a co-investigator or collaborator on more than 50 other awarded grants of more than $27 million.

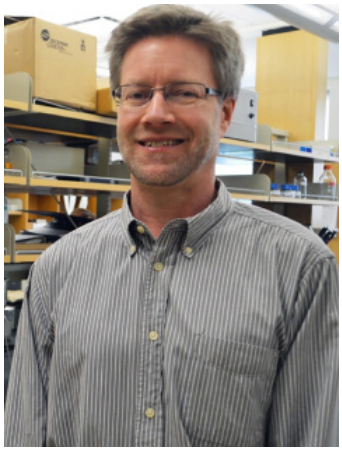
In 2014, Meng was elected a Fellow of the National Academy of Inventors, and in 2013, he became the first faculty member at the veterinary college to be named a University Distinguished Professor. He received the Virginia Tech Alumni Award for Research Excellence in 2008 and the Pfizer Award for Research Excellence in 2001 and then again in 2008. Meng was also elected to the American Academy of Microbiology in 2012.

A native of Qingdao, China, Meng earned a medical degree from Binzhau Medical College and a master's degree in microbiology and immunology at Wuhan University College of Medicine. He then completed a Ph.D. in immunobiology from Iowa State University's College of Veterinary Medicine. Prior to joining the Virginia Tech faculty, he worked as the John E. Fogarty Visiting Scientist and a senior staff fellow at the National Institute of Allergy and Infectious Diseases, a part of the National Institutes of Health.

The National Academy of Sciences is a private, nonprofit institution that was established under a congressional charter signed by President Abraham Lincoln in 1863. It recognizes achievement in science by election to membership, and — with the National Academy of Engineering, Institute of Medicine, and National Research Council — provides science, technology, and health policy advice to the federal government and other organizations.

-Michael Sutphin

David Popham Inducted as American Academy of Microbiology Fellow



David Popham. Photo by Steven Mackay

David Popham, professor of biological sciences at Virginia Tech, has been elected as a Fellow of the American Academy of Microbiology (ASM).

An affiliate faculty member of the Fralin Life Science Institute, Popham researches structure, synthesis, and hydrolysis of the mesh-like wall components of bacterial vegetative cells and endospores. His past studies focused on the model gram-positive bacterium *Bacillus subtilis* and the pathogens *Bacillus anthracis* — the anthrax agent — and *Clostridium perfringens* — a dangerous human and animal bacterium.

Popham has used molecular genetic techniques to identify and manipulate the genes that encode enzymes that polymerize and hydrolyze the peptidoglycan cell wall and biochemical methods to characterize structural changes in the cell wall. "Not only is Dr. Popham internationally known for his research contributions in the field of medical microbiology, but he has made his mark while involving both undergraduate and graduate students in creative, leading-edge research in his laboratory," said Brenda Winkel, head of the Department of Biological Sciences, part of the College of Science. "He joins a very elite group of scientists who have been elected fellows of the ASM. The department is delighted at this very significant recognition of Dr. Popham's work by his professional peers."

Popham is one of 78 Fellows inducted in 2016, joining 2,400 total members. Honorees are elected annually through a highly selective, peer-review process based on their records of scientific achievement and original contributions that have advanced microbiology, according to the organization.

He earned his bachelor's degree in biology from Washington University in St. Louis, Missouri, in 1983 and his doctoral degree in microbiology from the University of California Davis in 1989. He worked in two post-doctoral positions, at the Institut de Biologie Physico-Chimique in Paris from 1989 to 1991 and the University of Connecticut Health Center from 1991 to 1996. He joined the Virginia Tech faculty in 1996.

Fellows "represent all subspecialties of microbiology, including basic and applied research, teaching, public health, industry, and government service," according to the academy's website. Fellows from this year's induction come from around the world, including Australia, Canada, China, France, India, Spain, the United Kingdom, and the United States.

The American Academy of Microbiology is the honorific leadership group of the American Society for Microbiology. The academy's mission, according to its website, is "to recognize scientific excellence, as well as foster knowledge and understanding in the microbiological sciences."

-Steven Mackay

Engineers, Scientists to Examine Antibiotic Resistance in Food Chain from Farm to Fork

Growing evidence suggests that agricultural practices, especially widespread antibiotic use, could be contributing to the increasing antibiotic resistance problem in humans.

In order to learn how to effectively control this spread of antibiotic resistance from livestock manure, the U.S. Department of Agriculture (USDA) has awarded a $2.25 million grant to a Virginia Tech team of engineers and scientists to examine the food chain from farm to fork.

One of the team's immediate concerns is to determine if the proposed Food and Drug Administration's (FDA) Food Safety Modernization Act rules for composting manure, intended for the control of pathogens, will effectively limit the spread of antibiotic resistant bacteria.
The team's plan includes tracking the fate of antibiotics, antibiotic resistant bacteria, and antibiotic resistance genes, as they are potentially carried over from manure to fresh produce.

Leading the interdisciplinary group is Amy Pruden, professor of civil and environmental engineering and associate dean in the graduate school at Virginia Tech, a pioneer in examining environmental sources and pathways of antibiotic resistance genes as emerging contaminants.

A 2007 Presidential Early Career Award in Science and Engineering

Members of the Virginia Tech team present for a group meeting.

and a 2006 National Science Foundation CAREER Award recipient, Pruden was also honored with the 2014 Paul L. Busch Award from the Water Environment Research Foundation for innovation in applied water quality research.

Last September President Barack Obama signed an executive order establishing a Task Force for Combatting Antibiotic-Resistant Bacteria. The task force creation came on the heels of a President's Council of Advisors on Science and Technology report on ways to fight antibiotic resistance in the U.S. Part of this report spoke of the "very serious concern" of antibiotic use in animal agriculture.

"Antibiotic resistance is a serious human health threat," Pruden said. "Our goal is to identify all possible means by which we can control the spread of antibiotic resistance so that these drugs continue to work when we need them. In this case, we hope to work with existing practices intended to control the spread of pathogens from livestock manure and to determine how we can ensure that antibiotic resistance also is not spread."
Evidence is showing that antibiotic resistance rates of human pathogens is rising in both hospital acquired and community acquired infections. While looking at ways to minimize the spread of resistance, "the fact that the majority of antibiotic use in the U.S. is for livestock cannot be ignored," Pruden added.

The Food and Drug Administration recently estimated that 80 percent of antibiotics used in the U.S. are administered to livestock. Combine this fact with the knowledge that between "40 and 90 percent of the antibiotic is excreted in the feces and urine where they can remain active and potentially stimulate antibiotic resistance," cautioned Kang Xia, associate professor of crop and soil environmental sciences at Virginia Tech and a co-principal investigator. It reinforces "our call for new strategies."

In the U.S., antimicrobials are widely used for therapy, disease prevention, and growth promotion in animals raised as a source of food. "They generally act by targeting specific aspects of the bacterial cells and inhibiting their growth," Pruden explained. "However the bacteria can become resistant to antibiotics when they carry antibiotic resistance genes."

So, the Virginia Tech team is focusing on these genes "since they can be shared among bacteria, even dead to living bacteria, and could therefore persist during pre-harvest and post-harvest stages," said Pruden. "Antibiotic resistance genes are arguably of greater concern than antibiotic resistant bacteria because they are typically associated with mobile genetic elements that enable them to be passed between microorganisms via horizontal gene transfer, a phenomenon possible even from dead to living cells."

Pruden points out that "horizontal gene transfer is considered to be the most important mechanism driving the spread of antibiotic resistance."

Monica Ponder, an associate professor of food science and technology at Virginia Tech, also a member of the team, noted concerns about produce eaten raw, as vegetable surfaces are naturally colonized by a variety of bacteria, yeasts, and fungi. Most are harmless, but when they do occasionally carry pathogens, the results can be deadly, as was the case in the 2006 outbreak of Escherichia coli O157:H7 linked to spinach.

This contamination can come from lapses in manure management, such as contamination of irrigation water, poor composting, or application too near the harvest time.

"In the U.S., it is not permissible to apply raw manure to fields intended for food production, but there may be simple ways we could improve the composting process, selection of soil type, crop type, or post-harvest washing practices to ensure that antibiotic resistance is not spread," Ponder emphasized.

The Food and Drug Administration has already launched an initiative to promote voluntary phase out of medically important antibiotics such as third generation cephalosporins in food producing animals. "While limiting antibiotic use in livestock makes sense from a practical standpoint, the science of the effect of antibiotic withdrawal on antibiotic resistance is complex"

and other undesirable effects may occur,said team member Katharine Knowlton, the Virginia Tech Colonel Horace E. Alphin Professor of Dairy Science.

The new USDA project will integrate research, education, and extension in order to train future leaders equipped to address complex problems like the spread of antibiotic resistance in the environment and to engage with farmers and livestock producers in translating the research to practice.

"Virginia Tech is the ideal locale for this project given its land-grant mission and highly supportive atmosphere for agricultural extension, for which efforts in this project will be lead by Thomas Archibald and Amber Vallotton," Pruden said. Archibald is an assistant professor of agricultural leadership and community education at Virginia Tech and Vallotton is an assistant professor of horticulture at Virginia Tech.

The team attributes its success in attracting this competitive USDA grant to prior seed funding from the Institute for Critical Technology and Applied Science and a National Science Foundation Research Experience for Undergraduates site, led by Leigh-Anne Krometis, assistant professor of biological systems engineering and W. Cully Hession, professor of biological systems engineering, who round out the team's members. They developed the integrated undergraduate research and education training infrastructure at Virginia Tech.

They will also partner with the Interfaces of Global Change Program, part of Virginia Tech's Interdisciplinary Graduate Education Program, in expanding graduate education opportunities associated with this new project.

-Lynn A. Nystrom

Students Earn University's New Bachelor's Degree in Microbiology

The first students to graduate with Virginia Tech's new bachelor's degree in microbiology, which was approved in 2015, say that their career paths are more in focus now.

The degree provides specialized training for students entering the workforce or post-graduate studies. Microbiology, which involves looking at the structure, function, and uses of microscopic organisms, or microbes, was previously only offered as a concentration option in the department of biological sciences in the College of Science.

"Many employers specifically ask for a degree in microbiology in employment ads, as they do not fully understand the significance of a concentration option," said Ann Stevens, a professor of biological sciences in the College of Science and a Fralin Life Science Institute affiliate. "The new degree promotes and enhances university-industry collaboration."

Microbiologists may find jobs in food production, environment, energy, and human health. Students graduating with Tech's degree can pursue graduate studies, health profession studies (clinical laboratory science, medical, pharmacy, or veterinary schools), or directly enter industrial or government research laboratories..

Brittany Blankenship '15 is now pursuing a Ph.D. in microbiology at the University of California, Davis. She said that the hands-on experiences she received as part of the first degree cohort helped her to realize her love for microbiology.

"Microbes are like complex little people," Blankenship said. "It's fascinating that they can be in any sort of environment and sense the need for nutrients and respond."

Specifically, Blankenship is interested in how a microbe regulates genes in a high versus low nutrient environment.

Tony Lopez '15 planned to serve in the United States Army after graduation, but said that he also plans to pursue a master's degree in microbiology after completing his service.

Holly Packard and Lauren Page participate in an upper level microbiology class in the Fralin Life Science Institute. Birgit Scharf, an assistant professor of biological sciences in the College of Science, teaches the course. Photo by: Lindsay Key

"As a kid, I was always interested in how diseases work," Lopez said. "When I learned about the new degree, I knew I had to sign up."

Lauren Page '15 went on to attend the Virginia-Maryland College of Veterinary Medicine after graduation. She said that the epidemiology and parasitology classes that are part of the 120-credit degree program were most beneficial to her.

"Bacterial, food-borne, and water-borne disease are interesting to me," Page said. "The lab experience I received with the microbiology degree has been great prep for vet school."

Human health issues such as re-emerging diseases (whooping cough and measles) and newly emerging infectious agents (Ebola virus), as well as demand for renewable resources to create global sustainability (microbial fuel cells to food production), have recently put the field of microbiology in the spotlight.

The new microbiology degree helps to advance Virginia Tech's public land-grant mission of serving the Commonwealth of Virginia, the nation, and the world.

"The importance of training in microbiology is reflected directly in the role of microbes in virtually all areas of human experience," said David Popham, a professor of biological sciences in the College of Science and a Fralin Life Science Institute affiliate. "To put it simply, microbes are present and active in every environment we deal with, from forests, lakes, and farms to the relative 'sterility' of a hospital ward and the complex microbiome that is within our own intestinal tract. Our understanding of microbes contributes to almost all fields of scientific and technological endeavor."

-Lindsay Key

Pesticides Used to Help Bees May Actually Harm Them

Pesticides beekeepers are using to improve honeybee health may actually be harming the bees by damaging the bacteria communities in their guts, according to a team led by a Virginia Tech scientist.

The discovery, published in the journal Frontiers in Microbiology, is a concern because alterations can affect the gut's ability to metabolize sugars and peptides, processes that are vital for honeybee health. Beekeepers typically apply pesticides to hives to rid them of harmful parasites such as Varroa mites.

"Although helpful for ridding hives of parasites and pathogens, the chemicals in beekeeper-applied pesticides can be harmful to the bees," said Mark Williams, an associate professor of horticulture in the College of Agriculture and Life Sciences and lead author. "Our research suggests that pesticides could specifically impact the microbes that are crucial to honey bee nutrition and health."

For the project, the team extracted genomic data from honeybees that lived in hives that were treated with pesticides (three different kinds) and compared with those that were not. Samples were pulled from hives in three separate Blacksburg locations.

Honeybees from chlorothalanil-treated hives showed the greatest change in gut microbiome, said Williams, who is also affiliated with the Fralin Life Science Institute.

Looking ahead, the team plans to investigate the specific changes in gut microbiota activities that affect honeybee survival. Honeybees are the foundation of successful high-value food production.

"Our team wants to better describe the core microbiota using bioinformatics to help best characterize the microbes that support healthy honeybees and, thus, stave off disease naturally," said co-author Richard Rodrigues, a postdoctoral researcher at Oregon State University and formerly a graduate student in Williams' lab.

Other authors include Troy Anderson, a former assistant professor of entomology at Virginia Tech; Madhavi Kakumanu, a postdoctoral scientist at North Carolina State University and former Virginia Tech graduate student in Williams' lab; and Alison Reeves, a former graduate student in Anderson's lab.

In Virginia, the approximate rate of hive loss is more than 30 percent per year, and continued losses are expected to drive up the cost for important crops that bees make possible, such as apples, melon and squash.

-Lindsay Key

Photo by: Rob Flynn

THE INTEGRATED MICROBIOLOGY PROGRAM AT VIRGINIA TECH

IMAGINE THIS:

You enter graduate school to start your Ph.D. As the first semester begins, you learn new technologies and techniques, as well as more about the research area of your home lab. Through the process, you find the research different from what you imagined, and your personality doesn't quite gel with the other lab members. You fear the next four to five years might be more grueling than you realized. You wonder: am I a good fit?

A Good Fit for Your Passion

In the Integrated Microbiology Program at Virginia Tech, students spend their first semester working with different faculty members in different labs to ensure they are a good fit for their research area--and their mentors.

"This is the biggest driver of our program," said Clayton Caswell, an assistant professor of biomedical sciences and pathobiology in the Virginia-Maryland College of Veterinary Medicine.

Caswell and Birgit Scharf, an associate professor of biological sciences in the College of Science, head the doctoral program, and together lead first-year students through a series of three laboratory rotations during their first semester.

"We want students to spend time meeting with faculty and other graduate students, and get a sense of the different labs and the research areas we have to offer," said Caswell.

Before the fall term begins, incoming students learn about the research areas before choosing three labs to join for a four-week period. During each rotation, students work on a month-long project led by the lab's head faculty member. The goal of these projects is to expose students to the lab's people, including students and faculty, how it's run, its research projects, and the technical aspects of conducting the research itself.

"The benefit for the students is the ability to learn more about each research project and each faculty member before committing to multiple years on a project," said David Popham, a professor of biological sciences in the College of Science. Popham led the effort to establish the initial program in 2004, and served as its chair for ten years until he was succeeded by Stephen Melville, an associate professor of biological sciences in the College of Science.

In 2014, Caswell and Scharf took over the program. Since then, they have furthered the program's emphasis on effective student-faculty appointments, as well as on the importance of effective communication and collaboration across faculty, students, and disciplines. As its name implies, the program integrates different departments and disciplines that have microbiology as a common thread, including ecology, biology, crop and soil sciences, biochemistry, and veterinary medicine.

These collaborations are further enhanced during the program's weekly seminars, which are composed of the program's faculty, graduate, and senior undergraduate students. During the seminars, first-year students present on what they have learned and experienced during their rotations, and advanced students present a literature review related to their research. In addition, faculty members both within and outside the program present their work, which helps first-year students see where they might best fit.

Top: Students get quality time together during the weekly microbiology research symposia. Bottom: Clayton Caswell introduces Steve Melville at the 2016 microbiology symposium for graduate students. Lead, pg. 9: Clayton Caswell and Birgit Scharf. All photos by Cassandra Hockman

From the students

Blake Sanders, 2nd year PhD student in Daniel Slade's lab

Blake came to Virginia Tech after receiving his bachelor's degree in biology from Mars Hill College and a master's degree in cell and molecular biology from Appalachian State University. He loves to learn new things, he said, so when he started the lab rotations, he was energized by the opportunity to learn new techniques from microscopy to cell culturing. During his first rotation, he was also introduced to the Type V secretion systems of *Fusobacterium nucleatum*, an anaerobic bacteria, which continued to intrigue him throughout the first semester.

What was the rotation process like?

"The rotation process teaches you a lot about graduate school. It helps you develop a work ethic, time management, how to know your way around a lab, and how to adapt when things don't go as planned," said Sanders. "For me, graduate school is like adding tools to your tool belt, and the rotation process did exactly this. I learned new techniques and ways of doing things, even if they weren't what I would end up doing. They are still useful skills that I now have."

How did you know which lab to choose?

"When Thanksgiving Break came, I took journal articles home from each of the labs' research areas. I read them and considered which areas I wanted to learn more about," said Sanders. "I also like to ask: what can you imagine yourself doing if you had to come to the lab in the middle of the night in the snow, and your car won't start? For me, the choice was clear, and I'm that much more passionate about what I do because I'm genuinely fascinated by it."

Bidisha Barat, 3rd year PhD student in David Popham's lab

Bidisha already had a fair amount of research experience when she came to Virginia Tech. Since she earned two degrees in microbiology -- a bachelor's from the University of Mumbai and a Master's from Bangalore University in India -- she used the rotation process to get to know the people and the research.

What was the rotation process like?

"Primarily the rotation program helped me experience a variety of interdisciplinary research opportunities such as emerging infectious diseases, environmental microbiology, plant-microbe interactions, and food microbiology, so the rotations gave me perspective on new research procedures and concepts," said Barat. "The lab rotations also allowed me to meet different people in the program, both faculty and students, develop communication skills, and help me identify my research strengths."

How did you know which lab to choose?

"This was extremely difficult because I would have been happy in multiple labs. Ultimately, my decision came down to what I really wanted to study, which was pathogenic bacteriology. The lab environment and interactions with the PI also played a big role in my decision."

- Cassandra Hockman

Picking the Lab, Finding a Good Fit

After three rounds of lab rotations, first-year students have a difficult yet exciting task: They must use the third week in November – the university's Thanksgiving break – to think carefully about which lab to join. When they return, they give their top choice to Caswell, who works to best place them.

Alumni: Where are they now?

"I currently work as a Defense Threat Reduction Agency-sponsored NRC Postdoctoral Research Associate at the U.S. Army Edgewood Chemical Biological Center (ECBC) in Aberdeen Proving Ground, MD. My research involves the use of synthetic biology for microbial forensic and biodefense applications. The Interdepartmental Microbiology Graduate Program at Virginia Tech provided me a strong foundation in microbiological theory and techniques and solidified my ability to problem-solve and think critically."

- Casey B. Bernhards, Ph.D., 2014
Graduate of David Popham's lab

"I'm currently an NRC Postdoctoral Research Associate at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) in Frederick, MD, where I work on vaccine development for Burkholderia biothreat agents. The program gave me the necessary training to develop into a well-rounded scientist and provided me the opportunity to become a microbiologist at a world-renowned biodefense institute."

- Robert Cory Bernhards, Ph.D., 2013
Graduate of Schubot's Lab

"I am now a postdoc working on microbial functional genomics at Lawrence Berkeley National Lab. There is just so much I've learned from the fantastic faculties and colleagues. If I have to pick one, I would say always keep the communication going and yourself motivated, or get them to help you to stay motivated, you will have a wonderful graduate school experience in this program."

- Hualan Liu, Ph.D., 2014
Graduate of Melville Lab

"It was a wonderful six years during my Ph.D. training in the Microbiology program. Most graduates would agree that some of the best aspects of the program are the exciting science projects, active communication and collaboration, beautiful campus, and low living cost. I would also emphasize the great mentorship that I believe was invaluable to me. While I was doing my first postdoc at John Hopkins University and continued the journey at Lawrence Berkeley National Laboratory, I found how great it is when my mentors are always there to support me."

- Yan Chen, Ph.D., 2014
Graduate of David Popham's Lab

The Program's Steering Committee

Coy Allen:
Assistant professor of inflammatory disease, Virginia-Maryland College of Veterinary Medicine

Daniel Slade:
Assistant professor of biochemistry, College of Agriculture and Life Sciences

Brian Badgley:
Assistant professor of crop & soil environmental sciences, College of Agriculture and Life Sciences

Birgit Scharf:
Associate professor of biological sciences, College of Science

Clayton Caswell:
Assistant professor of bacteriology, Virginia-Maryland College of Veterinary Medicine

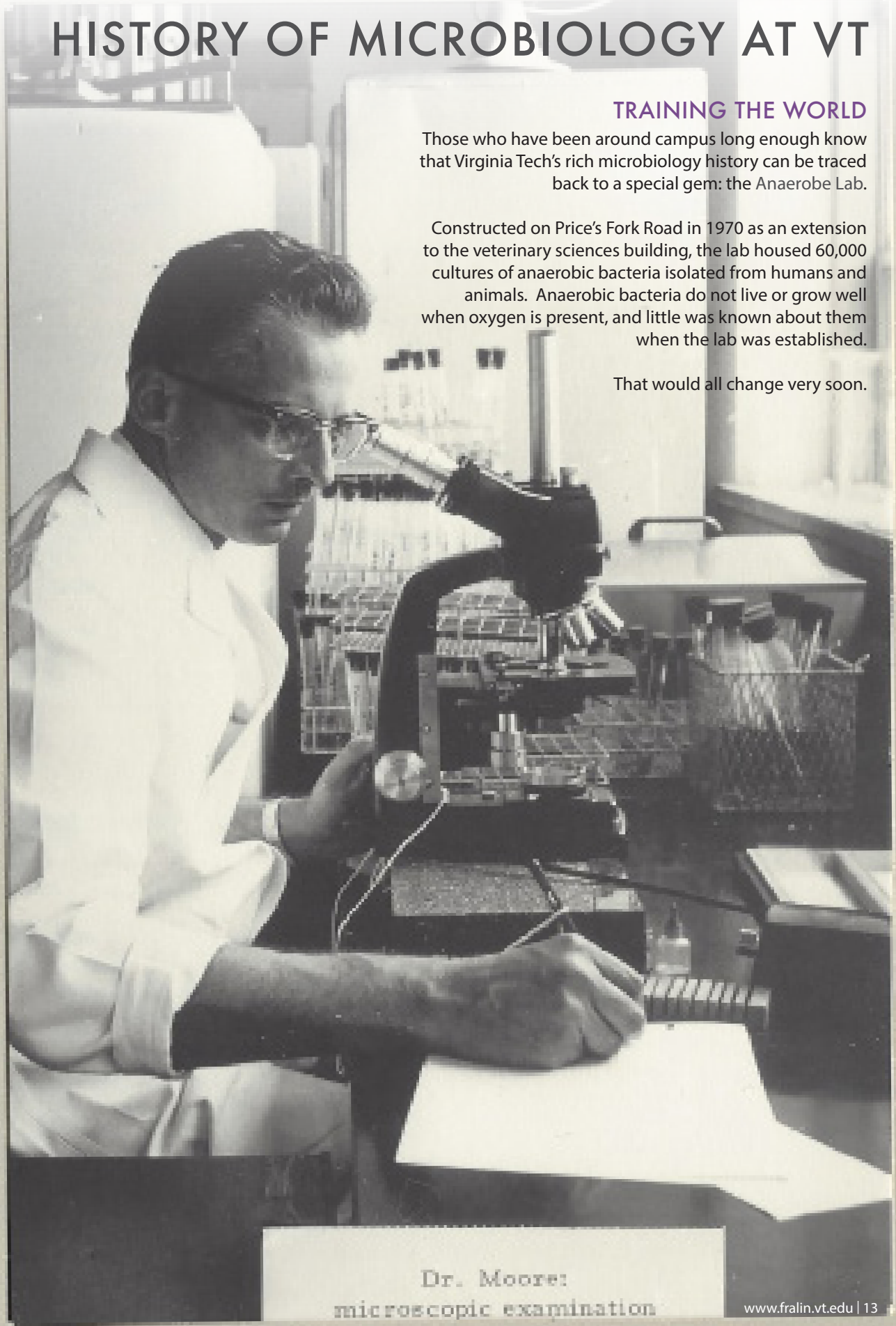
HISTORY OF MICROBIOLOGY AT VT

TRAINING THE WORLD

Those who have been around campus long enough know that Virginia Tech's rich microbiology history can be traced back to a special gem: the Anaerobe Lab.

Constructed on Price's Fork Road in 1970 as an extension to the veterinary sciences building, the lab housed 60,000 cultures of anaerobic bacteria isolated from humans and animals. Anaerobic bacteria do not live or grow well when oxygen is present, and little was known about them when the lab was established.

That would all change very soon.



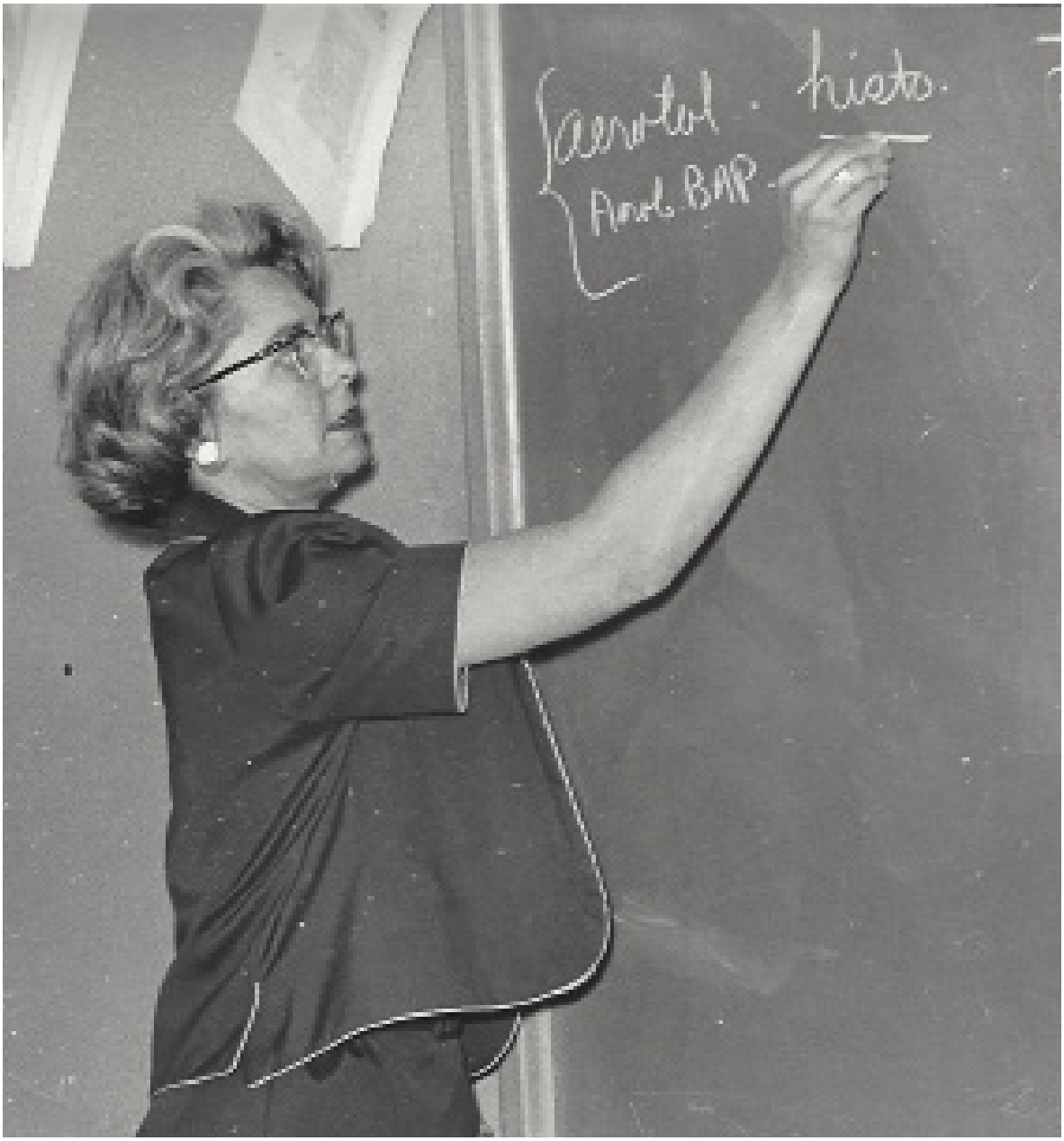
Virginia Tech faculty members W.E.C. "Ed" Moore and Lillian V. "Peg" Holdeman Moore led the charge to create the facility. They met at an American Society of Microbiology meeting in the late 1960s, when Peg Moore (then "Holdeman") was employed at the Centers for Disease Control in Atlanta, Ga.

Impressed by her expertise in botulism, Ed Moore recruited her to come work with him at Virginia Tech, where he and colleague Elizabeth Cabo studied anaerobic bacteria living in the intestinal tracts of humans and animals.

Together, they envisioned an Anaerobe Lab devoted to the study of anaerobes of all types from all angles. They relentlessly applied for funding for three years until they secured a grant from the National Institutes of Health and their dream came true. Paul Bowman of the General Medical Sciences division of NIH was the first to have faith in what the group was doing, according to Peg Moore.

"The grant proposal process felt like fifty years," said Peg Moore. "It was hard to find a funding agency that would take a chance on anaerobic bacteria, because so little was known about them at the time."

The first thing that the Moores did after moving into their new space—which included a teaching



lab, and eight research laboratories—was hire other scientists who were experts in the field. They recruited Louis D.S. Smith, an expert in pathogenic microbes from Montana State University. They also brought in John Johnson, experienced in studies of DNA/DNA relationships among bacteria; C.S. Cummins, an established scientist in the study of bacteria cell walls; and Robert M. Smibert, already at Virginia Tech and recognized for expertise in studies of spirochetes and campylobacteria.

Tracy Wilkins, a scientist and entrepreneur who would go on to become director of the Anaerobe Lab in 1985 when the Moores married, came in 1972. In 1985, Wilkins hired Dennis Dean, who would later become the director of the Fralin Life Science Institute at Virginia Tech.

In the 1970s and 1980s, the Anaerobe Lab team quickly became internationally known as the "go to" group for anaerobic microbiology.

With a grant from the National Cancer Institute, they studied populations of intestinal bacteria related to colon cancer, investigating the link between cultural diets and disease.

With a grant from NASA, they determined that people isolated in space capsules do not exchange bacterial communities.

The team isolated tens of thousands of their own strains of bacteria for the collection, and also acquired three historical collections from Prevot at the Pasteur Institute, Ivan Hall, and Leland McClung.

"The freeze-dried cultures and analytical records of each represented all of the anaerobes that we isolated during 30 years of work on clinical infections, periodontal disease, colon cancer, and special floral studies," wrote Ed Moore in a document presented to the National Academy of Science in May 1995. "The collection represented over 300 person-years of work and was continually studied to produce better diagnostic procedures and species identification."

Scientists worldwide consulted a manual that the Moores developed with instructions for how to isolate, grow, and identify anaerobic bacteria. They also taught an annual two-week training course for more than 15 years.

"The Moores trained the world in how to work with anaerobic bacteria, and why it's important," said Don Ball, who came to Virginia Tech in 1966 to study biochemistry. Ball completed his master's degree at Virginia Tech under the guidance of Wilkins and worked in various hospitals before coming back to work at the Anaerobe Lab as a senior lab specialist in 1984.

"From the time I met Dr. Wilkins and the Anaerobe Lab faculty as a graduate student, I dreamed of working for this world-class institution with world class scientists," said Ball. "They had ignited a passion for the study of the relatively unknown world of anaerobic bacteria. I had witnessed first hand their importance in human health and disease while working in clinical microbiology at several different major medical centers."

Citing budget concerns, the university closed the Anaerobe Lab in 1995. The collection was split among several entities, including the CDC, ATCC, dental laboratories and individual scientists. Ed Moore died in 1996, and Peg Moore retired shortly thereafter. Faculty members remaining at the lab were transitioned full-time to Virginia Tech's biochemistry department.

Although the closing of the Anaerobe Lab was disheartening, the entrepreneurial spirit of the Moores inspired remaining faculty to continue to expand the life sci-

Student Spotlight: Ben Webb

Ben Webb.

One bacterium's devotion to finding its host plant is nothing to sniff at.

Thanks to years of evolution, *Sinorhizobium meliloti* bacteria have developed super-noses that allow them to sniff out alfalfa plants underground and swim to them through the soil.

Ben Webb, a Ph.D. student in the department of biological sciences in the College of Science, has devoted his graduate career to pinpointing exactly which molecules are involved in the underground union.

Without the bacteria, alfalfa plants—one of the most popular foraging crops for livestock in the United States—cannot fix nitrogen or grow very well. In turn, the bacteria rely on alfalfa for food and nourishment.

To attract the bacteria, the plant sends out attractants such as sugars, amino acids, betaines, and other undiscovered molecules underground, through its germinating seeds.

To determine which molecules play a crucial role, Webb—with guidance from his advisor Birgit Scharf—used liquid chromatography and mass spectrometry to analyze the alfalfa seed exudate. By observing molecule masses, they were able to identify the molecules and measure their relative abundance. Webb tested the most promising molecules with a chemotaxis assay to determine which are attractants for *S. meliloti*.

Webb also investigated the bacterial side of the connection. To identify which of the bacterium's chemoreceptors are used to sense attractants, he knocked out single chemoreceptor genes creating 'mutant' bacterial strains. Each strain was tested for its ability to sense an attractant molecule.

Lastly, Webb purified the individual receptors, and then mixed the receptor and the attractant molecule together, watching for a change of heat that indicates a chemical reaction, and direct binding.

Based on this series of experiments, Webb concluded that certain betaines are the strongest attractants for the bacteria, and that the bacterial McpX chemoreceptor is most effective at sensing the attractant. This sort of scientific matchmaking and its resultant strong bond could greatly inform and benefit agricultural practices in the future.

"Matching the strong attractants with their cognate chemoreceptors will help us in designing *S. meliloti* strains with a more preferential chemotaxis towards the host alfalfa, which would propagate the symbiosis more efficiently," said Webb, who defended his dissertation in August. "In essence, these chemoreceptors are to bacteria as noses are to humans, except *S. melioti* has eight of these noses," said Webb.

Webb was a sophomore in college when he looked down a microscope and found his calling in the form of a plate full of bright, squirming bacteria.
"My mind was blown," Webb said. "I couldn't believe that there was this whole other universe under my nose this whole time, complete with a vast variety of species portraying similar ecological principles yet on a scale invisible to the naked eye."

As an undergraduate at Virginia Tech, Webb was mentored by then-graduate student Sean Mury in the lab of David Popham, a professor of biological sciences in the College of Science. When Webb graduated with a bachelor's degree in Biological Sciences in 2010, he entered the Interdepartmental Microbiology Graduate Program, where he rotated between three different labs, ultimately matching with Scharf, an assistant professor of biological sciences in the College of Science and a Fralin Life Science Institute affiliate.

"Ben contributed greatly to the success of my lab, not only because of his scholarly accomplishments, but also due to his engaging personality," said Scharf. "I am extremely thankful that Ben shares my passion for mentoring. It was wonderful to watch the seed that I planted germinate and fully develop, and I am looking forward to seeing Ben continue our devotion for nurturing future seeds."

Webb has five first author publications, and won the award for 'Outstanding Talk by a Graduate Student' at the Bacterial Locomotion and Signal Transduction meeting in 2015, according to Scharf.

"His excellent presentation skills are just one reflection of his dedication to teaching. Ben has advised

seven undergraduate researchers in my lab by enabling them to grow and succeed," said Scharf.

In 2015, Webb received the Noel Krieg Graduate Fellowship for excellence in teaching and research from the Department of Biological Sciences at Virginia Tech. He is one of the first recipients of the fellowship, which honors Noel Krieg, an Alumni Distinguished Professor Emeritus of Biological Sciences.

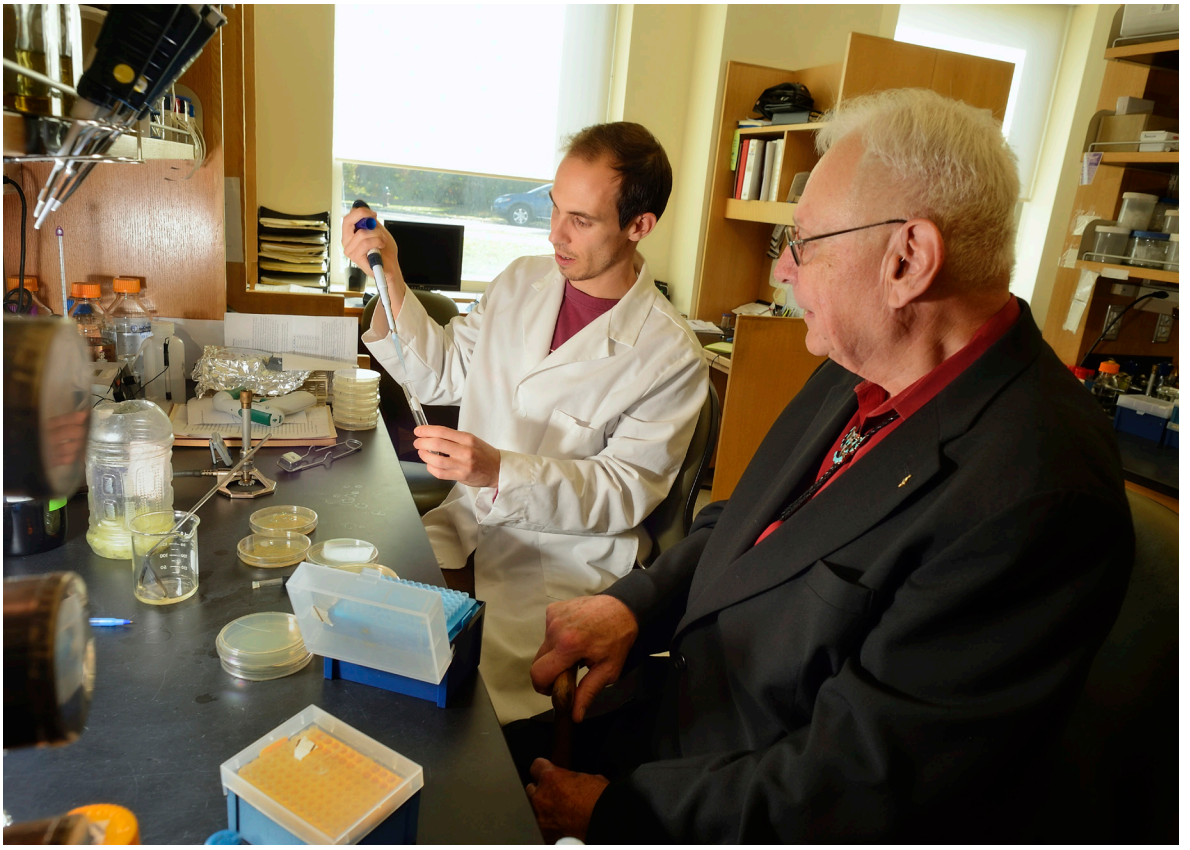
"Ben has the kind of teaching style that helps you grow as you learn. He helps you use the tools and abilities you already have to solve problems, which ends up yielding an understanding of both your work and yourself," said Karl Compton, Webb's former student. "He is exceptionally friendly and personable to everyone who comes into lab. If I had to use one word to describe him, it would be nurturing. In the future, it is my hope (though it may not necessarily be his own) that he does something that at least in part involves helping and teaching others - it is something of a gift he has."

In 2016, Webb received the John Johnson Award for Excellence in Microbiology from the Fralin Life Science Institute at Virginia Tech.

H is actively involved with the newly revised Integrated Microbiology Program (IMP) and the Translational Plant Sciences (TPS) program at Virginia Tech.

-Lindsay Key

Top: Ben Webb with advisor Birgit Scharf (left) and Mary Ann Johnson, wife of the late John Johnson. Photo by Lindsay Key. Bottom: Ben Webb with Noel Krieg. Photo by Jim Stroup.



Coffee Break with a Scientist: Brian Badgley

Brian Badgley
Assistant Professor, Crop & Soil Environmental Sciences Faculty, Global Change Center

What is the focus of your current research?

We conduct research in environmental microbiology with a focus on two broad areas. The first is related to the role that microorganisms play in maintaining the function of natural and engineered ecosystems. Specifically, we are interested in how environmental factors shape patterns of microbial diversity and how such changes in diversity affect important processes such as nutrient cycling. Two examples of research projects in this area include how the soil microbiome recovers during ecosystem restoration and reforestation of reclaimed mine lands and how microbial communities in bioretention cells contribute to stormwater treatment.

Our second area of research is related to microbial transport and water quality, with a specific focus on the fate of pathogens and fecal indicator bacteria at the watershed scale. We are currently investigating how ecological interactions between microbial contaminants from different sources and watershed processes affect water quality modeling and management. By combining new methods in environmental genomics with traditional culture-based techniques, we seek to gain new insights into these important dynamics in a variety of habitats. We also strive to develop highly collaborative and interdisciplinary projects, working with a variety of colleagues from ecology, engineering, agriculture, chemistry, and public health.

How did you become interested in your line of research?

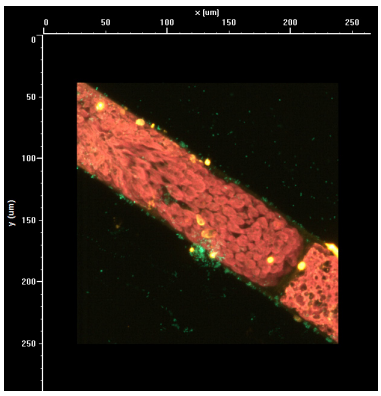
By accident, actually. My background, including most of my educational training, is in biology and marine science and my early research career was focused on biological oceanography, specifically on nutrient cycling in coral reefs and seagrass beds. However, during my PhD program, my advisor accepted a job in Hawaii. Having kids at the time, we were not able to make the same move so I began working with a microbiologist on my committee as a co-advisor.

At first, I thought I would continue my research. However, I quickly learned that I was fascinated with the field of environmental microbiology, especially during the current molecular age, which was producing so much exciting new discovery of the important roles that microorganisms play in ecosystems. So, I actually rewrote my dissertation proposal, changed my research, and have focused on microbiology ever since.

What do you feel are some of the biggest challenges scientists face today?

There are many, unfortunately. It's not original, but the decreases in available research funding and very low success rates for proposals is a significant challenge. And that is not just to complain that it makes the job difficult (many people have difficult jobs) but it is unfortunate how much time is spent by scientists writing proposals, which is time that could be spent teaching or conducting active research.

Another challenge that I perceive is the growing complexity of the challenges faced by society that scientists are trying to address. First, this means that scientists need to constantly broaden their perspectives and innovate new ways of collaborating across different disciplines in meaningful ways. This is actually a very exciting and stimulating part of the job for me, but it is certainly not a simple challenge to overcome. The flip side of scientific complexity, however, is that we live in an age where popular media and public attention spans are as short as ever and it seems there is a constant push to reduce information to short, pithy sound bites. This trend makes it increasingly difficult to both educate the public about how science works, how best to move forward to tackle important issues, and communicate results of research into complex problems.



E. coli growing on Cladophora algae in the Great Lakes. Courtesy of Brian Badgley.

Brian Badgley conducts soil research in a bioretention pond on campus. Photo by Jim Stroup.

Why did you choose to continue your career at Virginia Tech?

Two reasons. First, it represents a relatively unique combination of several desirable factors for a scientist, especially one interested in environmental systems. It is a major research university that attracts world-class colleagues and resources, yet it is situated in a small town in a beautiful part of the country with easy access to outdoor recreation. Furthermore, its strengths in agriculture and engineering are very attractive to me as an environmental microbiologist, given that many microbiology programs around the country are almost entirely dominated by health sciences.

Second is that the atmosphere of collaboration and collegiality at VT is one of the best I have ever experienced. From the first day of my interview through my arrival at VT all the way to now, it has been an incredibly open and welcoming community with endless opportunities for collaborative research. In fact, one of the biggest challenges of my job has been to learn to say no to opportunities to avoid taking on too many different projects.

Which aspect of your research are you most excited about right now?

We are interested in the microbiome, and there has been a considerable amount of research in the last ten years describing patterns of microbial diversity and how microbial communities change in environmental systems. What I am most excited about right now are the opportunities available at VT to collaborate on the next step: understanding the functional relationships that cause observed changes in the microbiome to occur and also the result of those changes on the function or health of the

Hometown:
Hilliard, OH

Educational Background:
- B.S. Zoology, University of Georgia
- M.S. Marine Estuarine and Environmental Science, University of Maryland
- Ph.D. Biology, University of South Florida

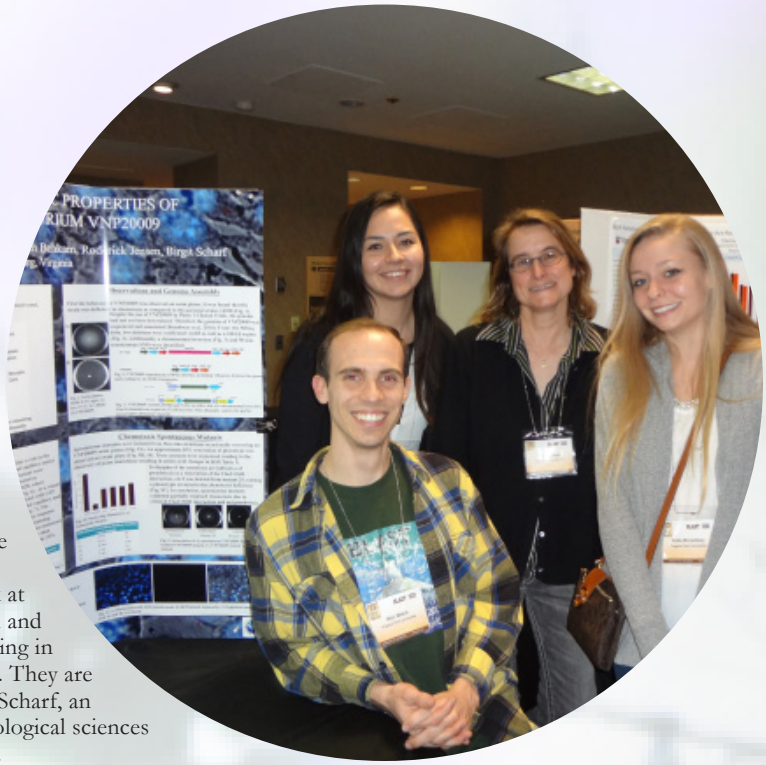
Hobbies:
Sailing, Hiking, Reading, Cooking

A favorite book or two:
- The Saratine Mosaic, Guy Gavriel Kay
- The Aubrey-Maturin series by Patrick O'Brian

Favorite type of music or artist: Lots… Off the top of my head: Beethoven, R.E.M., Thelonius Monk, and The Roots

AROUND FRALIN: MICRO LENS

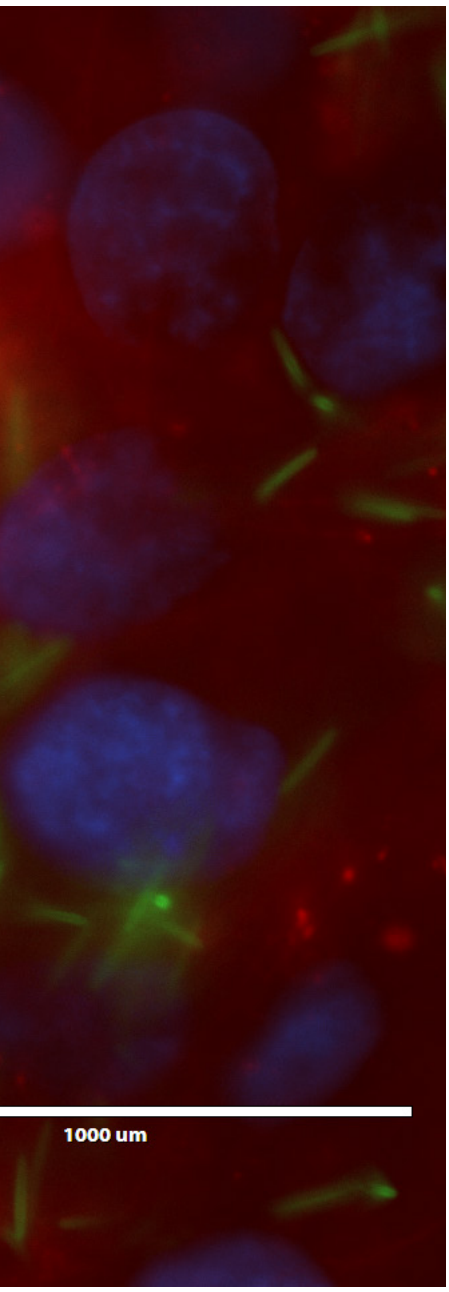
Students in Professor Ann Stevens' microbial physiology class perform the Volta experiment in the Duck Pond. For the experiment, students harvest methane gas in an inverted funnel that's produced by microbes in the pond's anaerobic sediments. They then light the gas on fire to demonstrate the microbial activities on a visible scale.
Photo by: Kristianne Sooknanan.



Students Ben Webb, Katie Broadway, and Floricel Gonzalez presented work at the Bacterial Locomotion and Signal Transduction meeting in Tuscon, Arizona, in 2015. They are pictured here with Birgit Scharf, an associate professor of biological sciences in the College of Science.

Kristi DeCourcy manages the Fralin Imaging Center, which includes a state-of-the-art Zeiss LSM 880 confocal laser scanning microscope. The instrument is operated on a fee-for-use basis, and more information is available on the Fralin website. *Photo by Lindsay Key.*

Coy Allen, assistant professor in the department of biomedical sciences and pathobiology, presents on his research at the 2016 Virginia Tech Microbiology Symposium. Allen studies *Photo by: Lindsay Key.*



Can you guess what's in the image? If you guess correctly, you win a prize!

Tweet to @FralinLifeSci and use the hashtag #micromystery before Dec. 1.

Fralin Life Science Institute
Fralin Hall
West Campus Drive
Room 101
Virginia Tech 0346
Blacksburg, VA 24061

540-231-6933 (v)
540-231-7126 (f)

www.fralin.vt.edu