THE UNIVERSITY OF TENNESSEE KNOXVILLE
DEPARTMENT OF MICROBIOLOGY

Microscope

SPRING 2022 **newsletter**

Alumni Spotlight: **Mohammad Moniruzzaman**

BY TAYLOR MATTIOLI

Mohammad Moniruzzaman ('16) is the epitome of a researcher. After obtaining his undergraduate and master's degrees in microbiology in Bangladesh, he was eager to specialize in the field of environmental microbiology and microbial ecology, which led him to The University of Tennessee.

From 2011 to 2016, Moniruzzaman completed his doctoral degree in Professor Steven Wilhelm's lab, focusing on the ecology and molecular interactions of Aureococcus anopagefferens virus (AaV) and its host alga, *Aureococcus anopagefferens*. AaV is a unique "giant virus," which can have thousands of genes. In the case of AaV, its 400 genes make it a dynamic control agent for constraining "brown tide" algal blooms that occur off the East Coast each year.

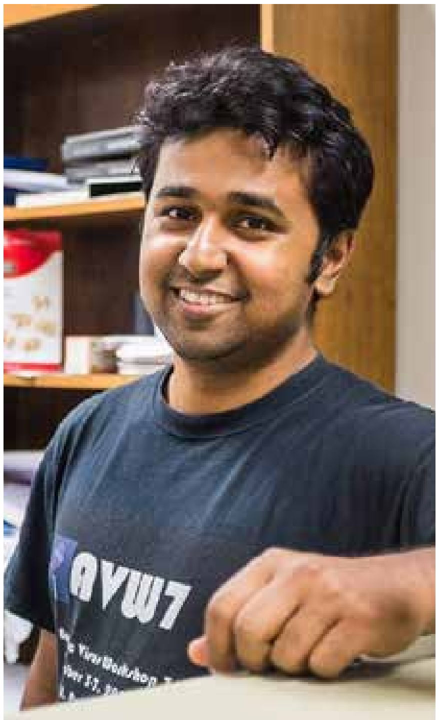
"I became interested in looking at giant viruses and their complex genome, so I have continued to work on them," Moniruzzaman says. "It is very uncharted territory and a fairly new field of research."

Following his time at UT, Moniruzzaman served as a post-doctoral researcher at the Monterey Bay Aquarium Research Institute in Moss Landing, California and subsequently The Virginia Polytechnic Institute and State University, where he worked under Assistant Professor Frank Aylward. In both positions, giant viruses were his focus.

Although he has traveled often and held many positions, Moniruzzaman looks back at his research at UT as a defining point in his career, where one question arose in his study of AaV that has guided his research ever since: why do giant viruses have so many genes?

Moniruzzaman will continue to pursue this question in his next position as an assistant professor in the Department of Marine Biology and Ecology at The University of Miami, beginning in January of 2022. He is excited to continue researching the molecular interactions of viruses and their hosts during infection, specifically investigating how viruses' genes aid in infection and the evolution of host alga in response to a virus.

He is hopeful his work will have wider implications as well, including possible forecasting of algal blooms and their progression.



"Understanding how the viruses are connected to the whole bloom helps us understand the trajectory of the bloom," he explains.

These strategies could be especially helpful as potentially harmful algal blooms increase in occurrence along with global climate change.

Beyond the cover:

Mind the Gap

MESSAGE FROM
THE DEPARTMENT HEAD
HEIDI GOODRICH-BLAIR

In this issue of our newsletter we are proud to share with you some highlights of the exciting and important research being conducted in the Department of Microbiology here at the University of Tennessee, Knoxville. A distinguishing characteristic of academic scientists is their passion for integrating discovery with education. Scientists stand at the edge of knowledge, pushing outward toward information and ideas that can and do change the world for the better.

Throughout my career I have been inspired by the students with whom I have interacted, who are learning where that edge is, where to push, and how to be comfortable with not knowing all the answers. Often, undergraduate researchers are just beginning to realize that there even is an edge, and as educators we are metaphorically holding up signs that say "mind the gap." Graduate student researchers know there is a gap, and have decided to commit themselves to exploring what lies within it. This is a brave decision that causes them to diverge from their peers who are starting or continuing their jobs in the 'real world.' For many, becoming a graduate student means daily struggles: trying to make the experiments work, trying to explain to friends and family why the results were devastating or exciting, trying to explain to a mentor why the experiment was done that way in the first place, and trying to balance the many obligations that come with being a scientist, student, educator, and a human being.

"In my view, one of the greatest privileges of being a faculty member at an institution like ours is watching graduate students grow in their confidence as they realize that they are the world's expert in the length of the gap they have chosen to study, and as they hone and expand on their ability to communicate old and new scientific ideas to anyone and everyone."

Graduate students are the linchpins of academic research. They are at the frontline of the gap, spending hours at the bench, computer, and field to wrangle large amounts of data and small amounts of liquid into something interpretable for the world. They are at the frontline of our 'mind the gap' campaign, helping convey in the classroom and instructional labs the results and importance of scientific discovery to hundreds of undergraduates, most of whom will not share their enthusiasm. They are at the frontline of our self-awareness and image as a department, reminding us of our obligations, both scientific and nonscientific to all members of society; reminding us often of why we are pursuing new knowledge.

Here in the department, as we start the spring semester of 2022, we have just finished interviewing students for the incoming graduate class of fall 2022. The first-year students are entering their second semester and have made the important decision of joining a lab, which will define the general area of the gap they will be exploring. The second-year students are developing and defending their project goals and approaches as they take their preliminary exam or defend their thesis. And the continuing dissertators are running ahead of their mentors, calling back as they transform the unknown into the known.

As you read through the newsletter and gain a glimpse into the stories of some of our graduate students and faculty, I hope you will share my gratitude and awe for their choice to dedicate themselves to scientific inquiry. This choice, though difficult, makes all the difference to making sure the rest of us have solid ground beneath us.

HEIDI GOODRICH-BLAIR
David and Sandra White Professor and
Head of Microbiology

Faculty Spotlight:
Ben Parker and the Parker Lab

BY TAYLOR MATTIOLI

Walking into Ben Parker's lab, you are greeted by rows upon rows of small plants, each in their own enclosed container with a complex handwritten label. What initially looks like a greenhouse operation changes quickly when you look closely at the plants: each is covered by hundreds of tiny bugs, or pea aphids.

Parker's lab utilizes the pea aphid as a model organism to study its life history traits and genetics and uses the findings to further understand larger questions in biology, evolutionary biology, and microbiology. The pea aphid system offers two main advantages: the insects give live birth to genetically identical offspring in just 10 days, and their bodies contain a simple microbial community, allowing Parker and his researchers to easily add or remove microbes in the systems and complete various mechanistic studies.

Bacteria are one microbe that inhabit aphids. They are vertically transmitted, which means they are passed from parents to offspring, and can form important symbiotic relationships with their hosts.

"The bacteria *Regiella insecticola* makes aphids resistant to the fungal pathogen *Pandora neoaphidis*," Parker elaborates. "Not all aphids harbor *Regiella*, but those that do are more resistant to fungal infections."

However, the bacteria are not entirely beneficial.

"One big question we are interested in is how the aphid's immune system evolves to accommodate these beneficial bacteria in ways that still allow it to fight off bacterial pathogens," Parker says.

For example, the lab has been focusing on the phenoloxidase mechanism, which is an enzyme aphids use in melanization (a method insects use to fight pathogenic microbes). Aphids harboring *Regiella* have reduced gene expression of the phenoloxidase enzyme producing genes.

The lab theorizes that this occurs because the bacteria are attempting to maximize their abundance, despite compromising the aphid's ability to fight off other bacteria, but this finding is just a first glimpse into the mechanism.

"We want to understand that in a broader context," Parker states. "We want to know what effects that has on interactions with pathogenic bacteria and how those mechanisms are evolving in natural populations."

Viral genes are also vertically transmitted between aphid parents and their offspring. One such gene has interesting morphological effects on the host wherein in two genetically identical offspring, one can be winged while the other is wingless.

This occurrence is an example of a phenotypically plastic trait, or a morphological trait influenced by the environment. In this case, the environmental trait influencing gene expression is plant crowdedness, which aphids have evolved to sense. The viral gene triggers the production of winged offspring by making aphids more sensitive to crowding.

"When it is too crowded, they produce winged offspring, so they can fly to another plant and start over," Parker explains.

Currently, the Parker lab is focusing their studies on the genome and microbiome of the *Pandora neoaphidis* fungal pathogen. Additionally, they are working to understand aphid immune systems and how different aphid genotypes interact with bacteria. This talented group undoubtedly has a promising future.

Graduate Student Spotlights

BY TAYLOR MATTIOLI

BIKASH BOGATI

Hailing from Nepal, **Bikash Bogati** has traveled far to pursue his doctoral degree at the University of Tennessee. In Nepal, he obtained his undergraduate degree in medical microbiology and worked in a diagnostic microbiology lab. He now works with Associate Professor Elizabeth Fozo studying how bacteria survive different stress conditions.

Specifically, he focuses on enterohemorrhagic *E. coli*, or EHEC, which is a food-borne pathogen. EHEC produces the Shiga toxin, which causes damage to the intestinal wall and severe illness in humans.

"I'm looking into a gene segment that codes for a type I toxin protein, called ZorO, to see how it helps the bacteria to survive in different stress conditions," Bogati said.

Not much is known about this small protein or its specific function; however, when ZorO is artificially overproduced, cell growth stasis and death ensue.

"My dissertation work mostly focuses on what we overproduce as toxic [in the lab] might be helpful for the bacteria," Bogati explains. "This protein can help the bacteria survive antibiotics that we have been testing in the lab."

Understanding this system is important, as antibiotic resistance is a growing concern.

"It is really challenging to have antibiotics synthesized compared to how fast the bacteria are gaining resistance," Bogati elaborates.

During his time at UT, Bogati has contributed to more than just the understanding of *E. coli*. In 2018, he was inspired to seek community service opportunities when he was asked, "what would you do if you had an extra hour in your day?"

"I said that I would do something for others, because whatever time I have, I'm using on myself," he smiles. He now volunteers with Volunteer Assisted Transportation, which connects volunteer drivers to individuals in need of transportation.

The organization has had a large impact on Bogati's view of America, and he has learned much from those he drives.

"As an international student, we are used to the school life, and we don't have much interaction with people outside of school," he laughs. "I started getting to know their lives. I now realize our lives are all pretty similar."

His eyes shine as he talks about the veterans, teachers, and other passengers he has connected with. "We can learn so much from their lives and experiences."

After he obtains his PhD, Bogati will continue to study infectious diseases and antibiotic resistance as a postdoctoral researcher at Emory University. He is eager to continue volunteering as well.

THERESA JONES

Generally, it is rather easy to ignore the complex microbiome surrounding our everyday endeavors; however, as you listen to **Theresa Jones** passionately describe *T. gondii* toxoplasma, which she studies as doctoral researcher in Associate Professor Chunlei Su's lab, you start to look at your environment through the eyes of a microbiologist.

Jones explains that toxoplasma is found everywhere in the world, and although it generally goes unnoticed with a healthy immune system, many illnesses are linked to this parasite.

It is also extremely dangerous for pregnant women, making it an undeniable concern. Hoping to mitigate its negative effects, Jones studies the little understood *T. gondii* sexual reproduction processes using an uncommon study environment: cat intestines.

Why cats? House cats are, surprisingly, a common avenue for the spread of *T. gondii*, as they often become infected by prey that harbor the parasite in their muscle tissues. Thousands of *T. gondii* oocysts, or encapsulated zygotes, spread into the environment when an infected cat defecates, infecting humans who consume contaminated water or vegetables.

Specifically, Jones aims to create a lab-friendly environment for toxoplasma research.

"I'm working on an in-vitro system to support sexual reproduction," Jones elaborates. "I'm trying to replicate what happens in cat intestines in a culture tube."

Building this system could help shed light on the complex process without the need for live animals.

Aside from her research, Jones is also dedicated to improving diversity, equity, and inclusion efforts within the UT microbiology department. Her efforts stem from her own feelings of underrepresentation in academia.

"Being a black woman and coming from a different background, I noticed I was treated differently in the classroom," she says. As her education advanced, she noted there were increasingly fewer students who looked like her. "People have this idea of what a scientist looks like, but why can't a scientist look like me?" Jones found herself asking.

During the summer of 2020, she approached the department about creating a diversity committee, and soon, Jones and faculty members Todd Reynolds, Jill Mikucki, and David Talmy had created a space for open discussions and effective planning. The group created a detailed diversity plan, which aimed to address Jones's concerns.

"We set intentional goals to create a welcoming environment and attract and retain more people that are underrepresented," Jones explains. The committee also created newsletters, invited lecturers from underrepresented backgrounds, and notified the department of diversity-focused events.

Jones is incredibly happy with the results of the committee's efforts. "I'm starting to see different people and viewpoints coming in and pouring out," she smiles. "It is such a beautiful thing!"

ALLISON MASON

It is well known that microbial communities play a large role in decomposition, but when it comes to truly understanding the details of soil microbial ecology during human and animal decomposition, researchers are just beginning to scratch the surface. **Allison Mason**, a doctoral student in Associate Professor Jennifer Debruyn's lab, seeks to bridge this gap in knowledge.

Mason is applying targeted studies and various DNA and RNA sequencing analyses to identify soil microbes present throughout human and animal decomposition. Additionally, she seeks to find patterns in how these communities shift over the course of decomposition.

"When all the nutrients are flushed into the soil, we see that a lot of the heterotrophic microbes will use those nutrients and deplete available oxygen." Mason explains. "Then, we see a shift toward more anaerobic taxa and taxa that we expect to be present in the animal microbiome, like gut microbes." Overtime, the oxygen levels rise, and the microbiome shifts yet again.

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However, identifying the different microbiological communities is just one factor of her research. Mason also aims to explain why these changes occur and what specific decomposition roles are being performed. Currently, she is investigating how intrinsic factors, such as sex, age, or BMI of the deceased impact the soil's microbiome during decomposition, which can be applied to forensic science practices. The university's Anthropology Research Facility has served as an invaluable resource for her, as this is where she completes much of her fieldwork.

Much of her research is composed of searching for trends or patterns in microbial presence, but the complexity of humans and animals can make it difficult to distinguish these patterns.

"If we do happen to see a strong trend, it might signify that there is something present since you are seeing a signal through all the noise," Mason elaborates, "But if there is no trend, you wonder if there really isn't a trend or if you just don't have the right sample set."

Despite her hard work so far, the opportunity for discovery is vast, and Mason is just getting started.

"We've started evolving the idea of which microbes are there, but we haven't really linked what they're doing with molecular specifics," she explains. Regardless of the vast unknowns, Mason is excited for what lies ahead.

Chances are, many have heard of the fungal pathogen *Candida albicans* without realizing it. The pathogen causes many diseases, including yeast infections, which cause significant issues for women worldwide, and thrush, which is a mouth yeast infection that is common in babies and AIDS sufferers.

Andy Wagner, a doctoral researcher in Professor Todd Reynolds's lab, focuses his work on this pesky pathogen. Wagner explains that while yeast infections may be uncomfortable, they are generally mild and easily treated; however, *Candida albicans* can occasionally cause bloodstream infections. Although rare, these infections have a mortality rate of about 30-50 percent, and they can be especially problematic for people with compromised immune systems.

Wagner's work specifically focuses on the idea that microbiologists can alter how the disease is recognized by the patient's immune system to create a more favorable outcome for the patient. To make these alterations, Wagner focuses on *Candida albicans*' cell wall, which is composed of three main layers: a basal layer composed of chitin, a middle layer composed of beta glucans, and an outer protein coat.

"The host's immune system recognizes the beta glucans layer of this cell wall," Wagner explains. "The outer protein coat serves as a barrier that prevents it from being recognized by the host immune system."

Inducing the cell to expose its beta glucans layer is no easy task.

"There are signal transduction pathways that sense an outside change and will transmit the signal into the fungus to make it change its structural organization," Wagner explains. "We found that if we can disrupt these signal transduction pathways, we can get the fungus to inappropriately expose the beta glucans layer."

Essentially, by altering the signaling pathways, Wagner alters how the cell wall is made. Currently, he is seeing overproduction of the basal layer and underproduction of the outer protein layer.

"The basal layer is definitely being affected, which prevents the cell wall from being put together correctly," Wager states. That, in turn, makes the recognizable beta glucan layer more visible to the host's immune receptors. This process is aptly termed "unmasking."

Wagner's results are promising. "If we infect mice with these mutant fungus cells, we find they are able to recognize and clear the infection and survive longer," he smiles.

In the future, Wagner wants to continue working on disease-causing fungi, and he is hopeful that unmasking can be applied to other fungi as well.

GRADUATE STUDENT SPOTLIGHTS

Marie Curie once wrote "One never notices what has been done; one can only see what remains to be done." While speaking with doctoral researcher **Jill Walton**, it's clear she is the embodiment of Curie's words. As she excitedly tells me about her studies, volunteer work, and outreach dreams, I see her vision for a more intentional use of research, academia, and scholarship to benefit not only scientific knowledge, but also humanity.

Walton studies the roseobacter clade of marine bacteria in Professor Alison Buchan's lab. Roseobacter has a unique ability to degrade stable benzene rings, making it a promising candidate for the natural removal of polycyclic aromatic hydrocarbons (PAHs), which are anthropogenic pollutants composed of 2 to 6 fused benzene rings.

Both roseobacter and PAHs -- which come from oil spills, industrial discharge, wastewater, and runoff -- are largely abundant in coastal environments. This mutual presence, along with roseobacter's degradation ability, present a promising situation.

"Roseobacter and the pollutants are there. They show the ability to degrade smaller compounds, so can they degrade more complex, structurally similar compounds?" Walton summarizes.

Her overarching goal is to create an effective solution for PAH removal in degraded coastal environments.

"I'm looking at roseobacter's ability in a lab environment to degrade these pollutants to see if we can harness its ability to bioremediate these areas," she explains. "If we know how to stimulate them, we can use what is already there instead of adding nonnative solutions."

Little is known about the intricacies of roseobacter's degradation ability; however, these hurdles do not phase Walton.

"We just need to put all the pieces together and build the story," she enthusiastically states.

Walton's passion for research and solution-oriented mindset extends outside of the lab as well, resulting in an extensive list of extracurricular involvement. She regularly volunteers at the Sustainable Future Center, serves as the Microbiology Department's Graduate Students Association Outreach and Engagement chair, and lends her voice to the Student Disability Services (SDS) Student Advisory Board.

But her engagement does not stop here. Walton is a participant in the Community Engagement Academy offered through UT's Diversity and Engagement Department where she applies her love for research to outreach initiatives.

"We have been learning about engaged scholarship," she explains. "We are focusing on engagement that not only benefits the community, but also our professional interests."

Her goal is to utilize her connection with the Sustainable Future Center to implement a community soil and water testing initiative. Walton hopes to provide free testing kits and educational workshops for community members.

"I don't want there to be any barriers to participation," she elaborates. "I am really excited about it! I think it has a lot of potential to be great and an initiative other people will continue when I am no longer here."

Walton undoubtedly has a bright future ahead of her. Her passion for scientific discovery and her boundless kindness make her invaluable to both academia and her community.

Read more online at **micro.utk.edu**.

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A distinguishing characteristic of academic scientists is their passion for integrating discovery with education. Scientists stand at the edge of knowledge, pushing outward toward information and ideas that change the world for the better. Our graduate students dedicate themselves to scientific inquiry and explore what lies within "the gap."

Support from our alumni and friends helps us recruit graduate students who will learn from our faculty and advance in their academic careers to push the boundaries of knowledge for the next generation.

Thank you to our supporters for their endowed support of our graduate students.

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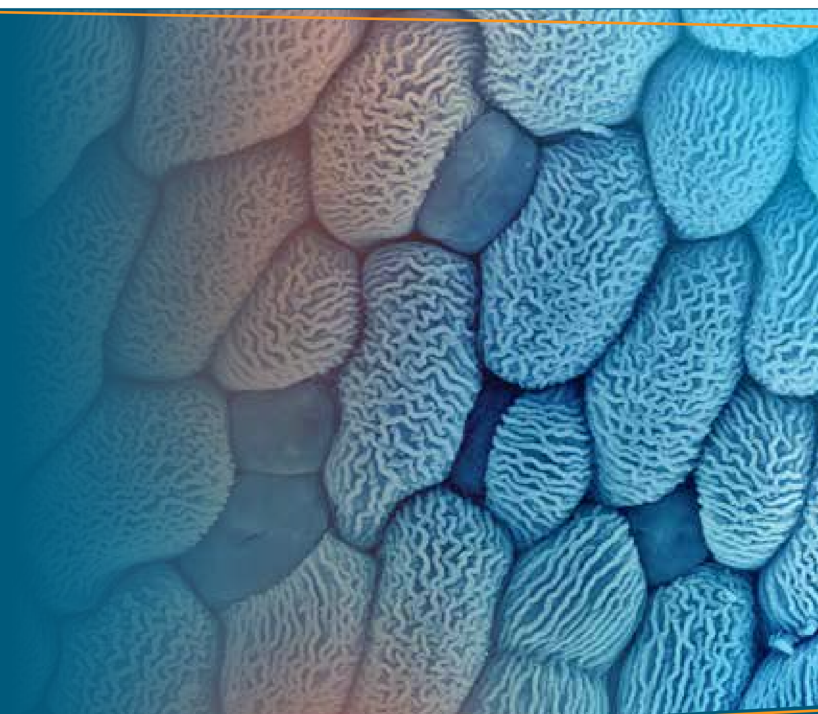

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