

WINTER 2022-2023

AURORA SPOREALIS



UNIVERSITY
OF MINNESOTA

CFANS
COLLEGE OF FOOD, AGRICULTURAL
AND NATURAL RESOURCE SCIENCES

PLANT
PATHOLOGY

SECTION OF
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PLANT PATHOLOGY

AURORA SPOREALIS

A Journal

Vol. I, No. 1.

August 1, 1924.

Wherein are recorded the recollections, the ruminations,
and the respirations of those who have drunk from the foaming fount
in the Department of Plant Pathology of the University of Minnesota
and who now spout forth in divers ways.

Let the fount foam and never run dry,
Let the spout squirt and never lose power.

Published by the Seminar Committee, aided and abetted
by many others.

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WHO WE ARE

Since 1907 the Department of Plant Pathology at the University of Minnesota has had a strong impact on plant health, agricultural development, and ecosystem vitality on a local, national, and international scale.

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Dear Friends,



Ruth Dill-Macky
Professor and Department Head

In our discussions immediately ahead of his departure for Colorado in March, Jim Bradeen remarked that in his role as Department Head he rarely found time to spend hours focused on any one activity. Those words have proven to be all rather prophetic. Since stepping into the role of Interim Department Head in April, I have faced a seemingly endless list of tasks, large and small, that have required my attention. The past eight months have not been without challenges for me and the department. Plans to find a new permanent head of the department were derailed when the search was suspended as the college reopened discussions of a realignment on the college administrative structure. This has brought some uncertainty to the department's future structure, but I have been amazed by the passion of our faculty, staff, and students for plant pathology, and I am confident that the future of our discipline is bright. I have also come to appreciate the collegiality and candor that brings such strength to our department. There have also been some highlights to serving as head. In October I travelled to Des Moines, Iowa to attend the World Food Prize Dialogue with five of our graduate students. It was simply wonderful to have some time with some of our students and to participate in the meetings. I think we all gained an appreciation for the important of plant pathology in supporting food production in the face of the challenges presented by Covid, conflict and climate change. In the past few days, the department also concluded a successful search for a new Plant Virologist and I am pleased to be able to share the Robert Alvarez-Quinto will be joining the department as an Assistant Professor at the start of the 2023/24 academic year.

I am writing this note to you on the first day of meteorological winter, the campus is blanketed in snow and the thermometer indicates that it is well below freezing, the semester is almost over, and the year is drawing to a close. With all that has unfolded I am especially grateful to all those that have supported the department through 2022. I wish you all happy holidays and a safe and healthy new year. I am looking forward to all that 2023 will bring.

Best,

A handwritten signature in blue ink that reads "Ruth Dill-Macky". The signature is fluid and cursive, with a long horizontal flourish extending to the right.

Student Life After COVID-19

by Isaac Schmitt

I joined the department as a grad student in September of 2020, when classes were all online and I would go weeks without seeing another person in the lab. Now, two years have gone by and seminars are being held in front of live audiences, undergrads are riding the campus connector sans masks, and people are starting to cough at work again without feeling extreme embarrassment. When I was tasked with writing about the first semester returning to in-person classes I assumed I would collect some fun quotes from fellow grads about their experiences back in person. It turned out that I am not a reporter and getting fellow grad students to give you article-ready statements is a major challenge. Without much input from my fellow graduate students I realized that I was one of only three people in the fall

2020 cohort. I've been in classes from fall 2020 to spring of 2022, and my experience of graduate school has been deeply shaped by the pandemic. So maybe I am a good person to write about what I have learned about education, our department, and myself in the past two years.

Before I was a grad student I worked as an undergraduate lab tech in Dr. Malvick's lab. At that time I was someone who struggled to form connections in my classes. The plant pathology department was one place where I felt comfortable. Plant Pathology is small enough that you recognize people and people recognize you. We have rituals like Wednesday coffee hour that are open to everyone, from the department head to undergrads. The pandemic, of course, put a strain on these types of rituals.

Despite this, I was very impressed with how graduate students still made the effort to foster a sense of community. Even during the depths of Covid in winter 2021 we met on Zoom to have virtual happy hours. At the same time, I was struck throughout the pandemic by how much was lost without in-person time. I have grown to appreciate how much the fun, social side of collegiate life is important for collaboration, for establishing an inclusive environment, and simply because work devoid of any social interaction is joyless and perhaps unsustainable.

Likewise, I was broadly impressed with the quality of education I received during the pandemic. Some of my favorite classes have occurred over Zoom. In some ways I may have been able to learn better at home — I

certainly found that the long days of research and writing I did at home were excellent for my focus. During this isolated time, however, the contributions of everyone in our department towards nurturing some in-person experiences were especially important to supporting our education. Whether it was Dr. Lockhart allowing students to come into his lab on the weekend to perform viral extractions, or Dr. Arenz and Becca Hall making sure that the fungal biology lab was set up so that students could go in one at a time to see the materials, the Covid restrictions made me doubly appreciative of the efforts that were made to give students some semblance of an in-person experience.

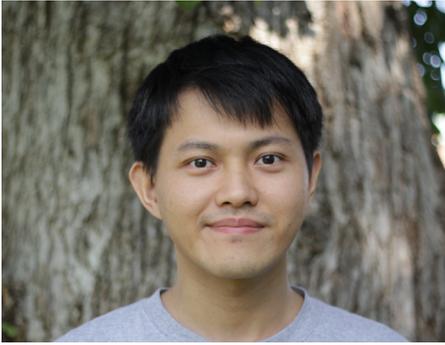
That said, much as I found something to be missing from social events during the pandemic, I also think no amount of effort can fully replace the experience of in-person classes. One of

the only quotes I received from a fellow grad was from Molly Veregge, who said of in-person classes that “I like seeing the shining faces of my friends.” I fully concur. I don’t know if it’s really the quality of education that suffered on Zoom. I’m a very independent learner and I think I could learn most of the content in a given class from behind my computer. What I can’t do is have a spontaneous conversation. In Zoom classes only one person can talk at a time, and you only get to interact in smaller groups during short times set aside for discussion in breakout rooms. The contrast between Zoom and in-person class, where even in masks we constantly form side conversations before class, during breaks, and basically any time the professor is not talking, is night and day. It’s really in the last year that I have gotten to know my fellow grads not just as faces on a screen but as friends.

One of the big lessons I have learned in my life is the value of people and of social health. I think the pandemic has taught us some important lessons about the flexibility afforded by modern communication technology. We really can do a lot of things online which we used to do in person, and there is a definite value to that. However, I strongly believe that there is a risk of assuming nothing is lost when we shift things online. It’s less the explicit goals of education and research that suffer from being fully online than it is the little things that some might even consider inefficiency. On Zoom the professor never had to repeatedly ask for people’s attention before a lecture, and I never missed a key detail because I was finishing up a side conversation with a friend. If the past two years have taught me anything it is that the messiness of real person to person interaction isn’t something to throw away lightly.

New Graduate Students Arrive from Near and Far

Four new graduate students joined our department in Fall 2022.



Hsuan-Fu Wang

Hsuan Fu is pursuing a PhD degree advised by Megan McCaghey. He joins us after getting an MS in Plant Pathology at National Taiwan University in 2016. His research will be focused on characterizing aggressiveness determinants of *Sclerotinia sclerotiorum*, and using gene silencing strategies to target these determinants.



Jay Kim

Jay is pursuing an MS degree

advised by Ashish Ranjan. He received his Bachelor's in Plant Science at the University of Minnesota in 2019. His research focus is in molecular interaction between soybean and its pathogen *Sclerotinia sclerotiorum*. He will be looking into different components of plant and microbial extracellular vesicles and how these vesicles interact with each other.



Alexis Shatrau

Alexis is pursuing an MS degree advised by Dean Malvick. She earned her BS in Biochemistry and Molecular Biology at Michigan Technological University in 2022. Her research will be centered around brown stem

rot (BSR) in soybeans. She will investigate more detailed molecular diagnostic techniques for detecting BSR, as well as finding a current host range for BSR in Minnesota, among other potential projects.



Nisha Paneru Regmi

Nisha is pursuing an MS degree advised by Pablo Olivera Firpo. She earned her BS in Agriculture at Agriculture and Forestry University in Nepal in 2019. Her research focuses on enhancement and diversification of stem rust resistance in wheat. She will also characterize the races of the stem rust pathogen *Puccinia graminis* f. sp. *tritici*, from the international collection.

Get to know the MAES/MDA Plant Growth BSL-3 Containment Facility and its quarantine officers

by Pablo Olivera Firpo

The Plant BSL-3 Facility on the St. Paul Campus is one of seven BSL-3 Plant Containment Facilities in the US. This Facility is co-operated by the Minnesota Department of Agriculture (MDA) and the University of Minnesota (UMN). The MDA funds \$80,000 annually for operating costs and supplies two full-time Quarantine Officers who regulate the plant pathogens and take care of all operations of the facility. The Quarantine Officers alternate on-call duties 24 hours a day, 365 days a year and their duties are to schedule and coordinate preventative maintenance and annual recertification on all safety, security, and containment equipment; serve as liaisons

with federal and state regulatory agencies; train facility users; control access; hold annual drills; review Facility Standard Operating Procedures (SOP) annually; and assist researchers with facilitating their research. UMN owns the building, funds most of the operating costs, maintains the facility and research equipment, and governs all operations that take place inside. The BSL-3 Facility was the first of its kind in the Midwest and consists of 4,500 sq. ft. of secured laboratory and plant growth spaces with complex physical, mechanical, and engineering controls all designed to prevent the release of BSL-3 agents. The facility has two highly sophisticated self-contained greenhouse spaces that do not vent to the outside. It has many biocontainment features and operational practices designed to contain and decontaminate the BSL-3 agents as well as safety and high-security measures.

Biocontainment features used consist of inward airflow, High-Efficiency Particulate Air (HEPA) filters on incoming and outgoing air, a pass-through autoclave, and an effluent decontamination system. Stringent training and proficiency checks are conducted to ensure all facility users and maintenance staff understand and abide by the Standard Operating Procedures to prevent an accidental release of agents into the environment. There are several safety features and protocols in place and the St. Paul Fire Department and UMPD attend annual facility training. The Quarantine Officers are responsible for ongoing maintenance, testing and calibration of equipment, annual recertification of the features listed above, and annual training for over 75 facility users. For over 13 years, this facility has provided a safe space for conducting important research on *Puccinia graminis* f. sp. *tritici* (the





LEFT TO RIGHT: NIK PREVENOST, STEPHANIE DAHL

wheat stem rust pathogen). Over 200 peer-reviewed publications, 100 oral presentations, and 50 conference proceedings and abstracts have come from the research that has taken place in this amazing facility, and many more are expected in the future.

Meet the Quarantine Officers:

Stephanie Dahl was born and raised in Minnesota and currently resides with her two daughters Violet (15) and Elsa (11). She was a city girl but spent many of her summers up on her grandparents' dairy farm in Deer Creek, MN. Who would have thought this city girl's career would revolve around the very crops her grandfather used to plant? Stephanie started her career in 2001 as a summer

intern in Dr. Jim Groth's lab, then took a temporary job with Dr. Les Szabo at the USDA-ARS Cereal Disease Lab until she was offered a Junior Scientist position with Dr. Brian Steffenson in 2002. In 2010, Stephanie accepted a job with MDA where she currently holds the Quarantine Officer position at the Plant BSL-3 facility.

Nik Prenevost got his first student job in Plant Pathology in 2011 working for Dr. Blanchette in the Forest Pathology Lab. After getting his BS degree in Horticulture at UMN, Nik joined Dr. Yue Jin's lab at the USDA ARS Cereal Disease Laboratory. As a lab technician, Nik's work was focused on the wheat stem rust pathogen. This research

led him to his current position as Assistant Quarantine Officer at the BSL-3 Plant Containment Facility. With a strong background in culinary mushroom growing operations and growing systems, Nik applies all his expertise in supporting the operation of this facility. Maintaining containment, security, and safety equipment is now a part of Nik's daily routines while helping to facilitate research inside the facility. Many of the research projects are still headed by previous co-workers from the CDL and the Department of Plant Pathology.

New USDA-ARS adjuncts join the Department of Plant Pathology



Dr. Dan Schlatter, PhD, joined the Department of Plant Pathology as an Adjunct Assistant Professor in 2021. Dan is a USDA-ARS Research Plant Pathologist in the Plant Science Research Unit.

Dan is a lifelong Minnesotan who grew up in New Brighton and spent a lot of time at his family's cabin in Northwest Wisconsin and exploring Northern MN and Ontario by canoe. He was initially introduced to plant pathology as a participant in a UMN life sciences undergraduate research program (LSSURP) during his junior year of college at UMN-Morris. In this program, he worked with the Kinkel lab on a project exploring how different nutrient types and diversities impact the antibiotic-producing potential

of soil *Streptomyces*. After graduating, Dan continued with the Kinkel lab as a lab tech and became fascinated by microbial interactions and the eco-evolutionary drivers of microbial phenotypes that contribute to plant disease suppression.

This led Dan to pursue a PhD advised by Linda Kinkel, where Dan examined (1) the biogeography and local adaptation of antibiotic-producing *Streptomyces* across local, regional, and continental spatial scales and (2) the impacts of long-term nitrogen amendments on *Streptomyces* nutrient-use and quantified tradeoffs between antibiotic inhibition and resistance phenotypes with *Streptomyces* nutrient use. After his PhD, Dan joined the USDA-ARS Wheat Health, Quality, and Genetics Unit in Pullman, WA where he applied his skills in high throughput sequencing and microbial community analysis to better understand the impacts of agricultural management practices on plant-associated microbial communities with a

particular focus on herbicide applications.

As a Research Plant Pathologist, Dan plans to focus on soil- and plant-associated microbiomes in alfalfa cropping systems, their role in plant and soil health, and how they respond to agricultural management practices. Dan's overarching goal as a researcher is to leverage the power of microbiomes to better support plant health and ecosystem sustainability.

As someone who did his PhD at UMN, Dan knows that PLPA is full of great people and UMN is an awesome place to be associated with as an ARS scientist. Dan has enjoyed interacting with familiar faces and getting to know new ones. He stated that "the PLPA community is very friendly and thoughtful and it's great to be a part of it."



Dr. Mitch Elmore, PhD, joined the Department of Plant Pathology as an Adjunct Assistant Professor in January 2022. Mitch is a USDA-ARS Research Plant Pathologist at the Cereal Disease Laboratory.

Mitch grew up outside the small town of Centralia in South-Central Illinois. His family had an old farmhouse and about 10 acres of land with a large garden. During the last year of his undergraduate degree, Mitch was fortunate to land a part-time lab technician position at the Donald Danforth Plant Science Center in St. Louis where he worked with Chris Taylor studying molecular nematology. This provided Mitch with experience in diverse projects ranging from using optimization of transformation conditions to produce transgenic roots on plant cuttings using *Agrobacterium rhizogenes*, generating and screening RNAi

constructs to control root-knot and soybean cyst nematodes, and identifying natural products for nematode control. Mitch caught the bug for molecular host-pathogen interactions, effectors, and resistance genes and stated “and I never looked back.” For his PhD, Mitch worked with Gitta Coaker at UC Davis, studying the *Pseudomonas syringae*-*Arabidopsis* pathosystem. His main project used quantitative proteomics to examine how the protein composition of the cell plasma membrane (PM) is remodeled upon activation of NLR-type and PRR-type immune receptors. Then, the newly minted Dr. Mitch Elmore moved to Iowa to work on a crop pathosystem with USDA-ARS scientist Roger Wise. Through a NIFA postdoctoral fellowship, Mitch studied protein-protein interactions that operate between host and pathogen during powdery mildew infection of barley. Mitch developed an impressive and novel system that uses high-throughput sequencing to score the output of yeast two-hybrid screens.

As a Research Plant Pathologist at the Cereal Disease Lab, Mitch plans to develop systems biology resources in barley that can be

used to understand how *Fusarium* infects its hosts and how plants respond at the molecular level. He plans to integrate multi-omics (transcriptome, proteome, metabolome) data to reconstruct dual-organism signaling networks to predict the major regulators of disease resistance and susceptibility. Mitch’s goal is that these projects will identify plant genes that can be pursued in molecular breeding programs or engineered to improve FHB disease resistance.

Mitch looks forward to collaborations with other research groups at UMN and is very excited to work towards translating lab research to the field. Mitch has enjoyed his interactions with people in the Department so far and commented, “it’s been really fun.”

My Plant Path: José E. Solórzano

Can you tell us a little bit about yourself?

I am José E. Solórzano, currently a PhD student researching tar spot of corn, an emerging plant disease. I was born and raised in Danlí, El Paraíso, Honduras, a country in Central America. I grew up immersed in nature, cultivating the soil with multiple crops, and taking care of animals. Early in my life, I wanted to teach and through high school I obtained a degree certifying me to teach elementary school education. In 2014, I moved to Catacamas, Honduras, where I went to the Universidad Nacional de Agricultura y Ganadería (UNAG) to obtain a bachelor's degree in Agronomic Engineering. While deciding what to do for my graduate studies, in 2016 I attended a faculty-led study abroad at Texas Tech University to learn about animal production and food safety. In 2017, in my senior year at UNAG, I was awarded a visiting research scholar position at Louisiana State University (LSU) at the Doyle Mycology Lab to study fungal secondary metabolites. I graduated from UNAG in 2018, and returned to work at LSU at the Doyle Mycology Lab and in 2019 I started my master's

degree. I finished my master's degree in 2021 and the same year started my PhD here at the University of Minnesota.

How did you get involved with plant pathology as a discipline?

During my childhood, I always encountered plant diseases that I wanted to understand in detail. I had access to empirical information but I also wanted to gain scientific knowledge. My first experience with plant pathology as a discipline was in 2015 when I took a plant pathology course which made me gain interest in fungi. At that time, plant pathology was not my final path to take since by then I had learned about animal production, which I was also considering for my future. In 2017, I participated in a study abroad led by UNAG and LSU faculty in Honduras. During that time, I met professors that encouraged me to apply for a visiting research scholar position at LSU. While at LSU, I was introduced to plant pathology through mycology and that is when I decided to continue my path into the discipline of plant pathology.

Tell me about a specific moment

in your life that made you decide to pursue a career in plant pathology.

I decided to pursue a career in plant pathology when I was a visiting scholar at LSU in the Department of Plant Pathology and Crop Physiology. I was working with plant pathogenic fungi, and I felt challenged and intrigued by the research I was doing. Aside from that, being involved in research made me think about its impact on the world. That is one of the moments that made me want to pursue a career in plant pathology.

What has been the most rewarding moment of your career so far, and what led to that moment?

Obtaining my master's degree from LSU. Multiple pieces were fundamental to this achievement but simplified they are multiple methodologies, a constant adaptation to the diverse field of science, and an understanding of multidisciplinary processes.

What do you enjoy most about the department of plant pathology?

It is a welcoming and supportive

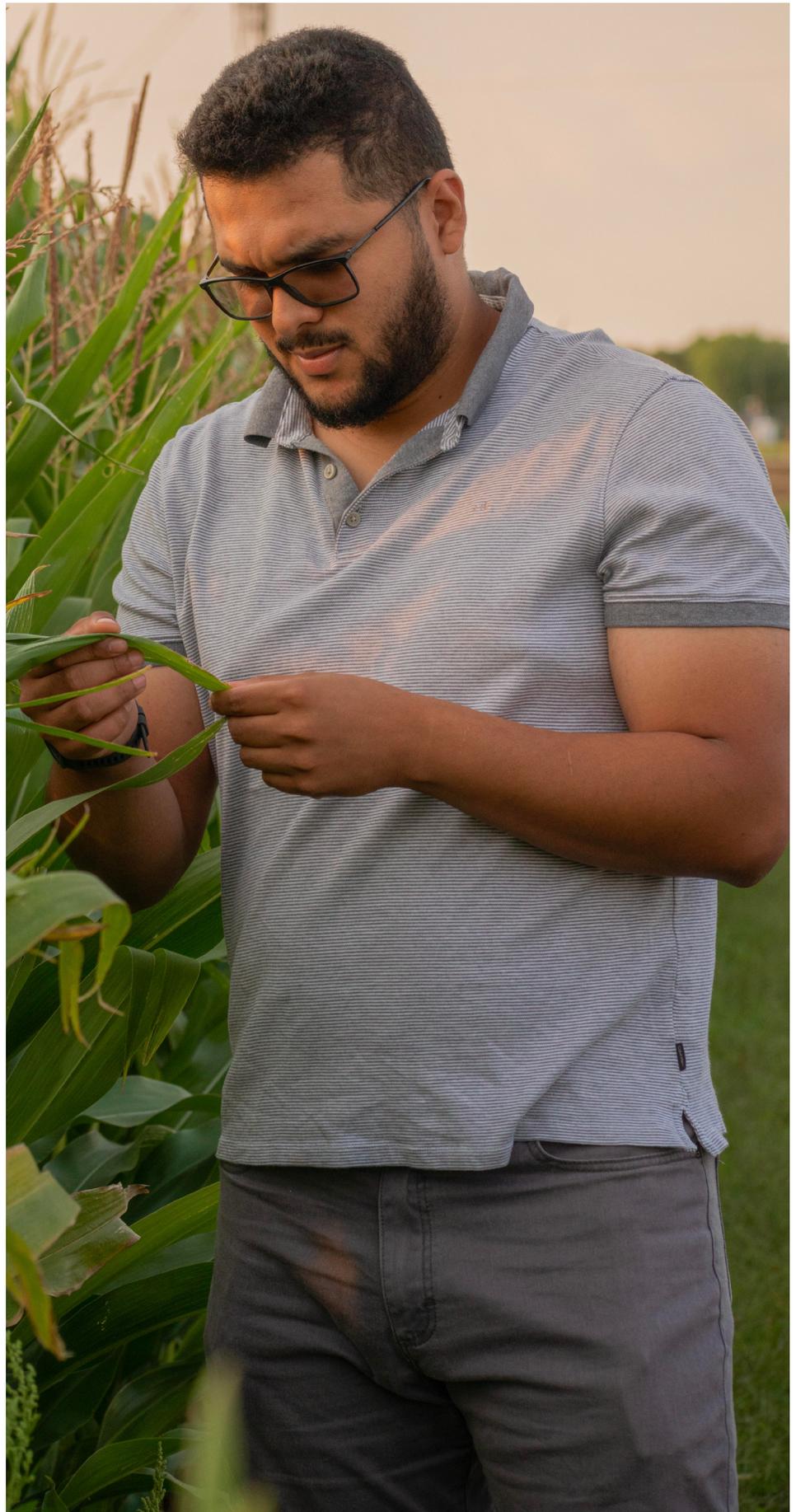
department. I personally enjoy being surrounded by such talented people with different backgrounds and at the same time being able to have interesting conversations.

Can you describe how being part of this department has helped your mission as a scientist?

Coming to this department has propelled my mission as a scientist. My advisor, the staff, and all the students have been supportive. They all encourage me and have helped me in many ways that either directly or indirectly have and continue to influence my mission as a scientist.

Can you tell us about your plans for the future?

I would like to become an educator and scientist with a desire for continuous learning, and the ability to explain and develop ideas to understand events that impact the health of organisms. I want to translate science into knowledge for people regardless of their background and status.



My Plant Path: Becca Hall



Can you tell us a little bit about yourself?

My name is Becca and I'm the Instructional Support Specialist and Outreach Coordinator for the department, which means I organize and teach many of our lab courses and develop outreach opportunities. I have been working in this position since the spring of 2020 and am a recent graduate of the department.

How did you get involved with plant pathology as a discipline?

I grew up hunting for morel mushrooms with my father and grandfather every spring, so I've had an interest in fungi since a young age. My senior year of high school, I took an environmental studies course where we spent a lot of class time in the woods near our school making observations. I decided to pick up a mushroom identification book and see what all I could find, matching the fungi I found to photos in the books. It was the first time I really started noticing mushrooms for their beauty, besides those to eat.

After high school, I attended Clarion University of Pennsylvania to become a high school biology

teacher. At Clarion, mycology was offered as an elective and it was where I truly fell in love with the world of fungi. My mycology professor and mentor approached me with the opportunity to complete an undergraduate research project comparing the biodiversity and heavy metal composition of basidiomycete mushrooms found in sites of acid mine drainage. After this experience, I knew that I wanted to pursue a career working with fungi instead of teaching in a high school setting. My mentor had a degree in plant pathology and encouraged me to explore the discipline as it tends to be a more applied and better funded field of science. She then helped me apply to a plant pathology summer undergraduate research assistantship at Cornell University.

Tell me about a specific moment in your life that made you decide to pursue a career in plant pathology.

My internship at Cornell. My project during this internship was studying the mechanisms of fungicide resistance of grape powdery mildew. The summer

scholars program is a nine-week program in which undergraduate students conduct research and present their findings at a poster session at the end of the summer. It is essentially a crash course of what a graduate student research assistantship is like and definitely prepared me for my time pursuing my master's degree.

What has been the most rewarding moment of your career so far, and what led to that moment?

Seeing students from my classes become interested in a future in plant pathology and pursuing a graduate degree in the discipline. Depending on the semester and enrollment, I can have up to eighty students in my courses each semester. I have a shared goal with the faculty I teach with to hopefully convince a few students to think about a future in plant pathology.

What do you enjoy most about the department of plant pathology?

The culture. I feel so lucky to be a part of a department that is

filled with such passionate and caring individuals. While we are a small department, we are mighty in the impact that we have on our community and ecosystem as a whole.

Can you describe how being part of this department has helped your mission as a scientist?

I have had nothing but support from the department for all of my crazy ideas. Even when I was a graduate student with plans for outreach or social events through the plant pathology graduate student organization. I am incredibly fortunate to have found a position that allows me to teach and share my love of fungi.

Can you tell us about your plans for the future?

To continue to inspire students in our lab courses to be interested in the field of plant pathology. I also have many plans for outreach programs in the future and ideas for videos in the works. Stay tuned. :)

Lab Update: Spotlight on Samac Lab

by Dan Schlatter

What projects have you been working on lately?

My students and I have been working on several projects related to disease resistance in alfalfa. Also, I have been aiding in the development of a reference genome sequence for alfalfa and development of universal sets of SNP markers that can be used in alfalfa breeding. We have a USDA-NIFA grant that is focused on development of alfalfa protein concentrate as a component of feed for rainbow trout, to replace soybean meal or fish meal, and make aquaculture more sustainable. As part of my administrative responsibilities with ARS, I have been recruiting 6 new scientists for the unit over the past 3 years, helping to get their research programs launched, and overseeing the renovation of our greenhouse range.

What drew you to this research?

Several years ago, I was asked to test soil samples for the presence of *Aphanomyces euteiches*, the cause of Aphanomyces root rot of alfalfa. The farmer was having trouble with getting alfalfa established and disease on adult plants. This led to surveying soils in MN and NY for races of *A. euteiches*. We found that Aphanomyces root rot was the major problem on

alfalfa. We identified soils that had very aggressive isolates of *A. euteiches* as well as soils with high levels of *Pythium* species. To try to resolve the number of races of *A. euteiches*, we started working on mapping resistance to Aphanomyces root rot of alfalfa and understanding the nature of resistance. We found that many of the *Pythium* isolates were not controlled by the usual seed treatments, metalaxyl or mefenoxam, suggesting that other seed treatments might be useful in alfalfa establishment. Another project is to understand bacterial stem blight (BSB) of alfalfa caused by *Pseudomonas syringae* pv. *syringae* and *P. viridiflava*. This disease is associated with frost damage because *P. syringae* is an ice nucleating bacterium. The disease was previously thought to be sporadic but appears to be an emerging problem in many parts of the country. I think it has been overlooked as a cause of leaf loss during early spring. Here in St. Paul, alfalfa plants show only mild disease symptoms after near freezing temperatures in April, but by May there is a very high level of leaf loss throughout the field. Damage previously might have been attributed to frost damage without looking deeper for symptoms of disease.

What are you hoping to learn?

In the Aphanomyces root rot project, we hope to identify candidate resistance genes and markers associated with resistance. So far, resistance to race 1 localizes to chromosome 1 while resistance to race 2 localizes to chromosome 2 suggesting that there are just two races. However, we can identify plants with resistance to a single *A. euteiches* isolate, suggesting that resistance genes are segregating, and that there may be multiple races. Sequencing of the resistance loci should help to resolve this question and provide markers for breeding resistant cultivars. In the area of seed treatments, we identified several fungicides that have broad activity against soilborne alfalfa pathogens in vitro. However, in tests with field soil taken from locations with poor alfalfa establishment, the newer treatments are no better than mefenoxam. Working with Dan Schlatter and graduate student Leta Larsen to do metagenomics analyses of soil and plants, we have found that there may be additional pathogens causing seedling diseases that have not been recognized in the past. In the BSB project, current graduate student Yeidymar Moya is working on mapping resistance to the disease and characterizing resistance. Hopefully, we will learn if resistance is due to a

hypersensitive response or is due to resistance to toxins or other effectors produced by *P. syringae*.

Have you learned anything exciting or surprising?

We found that resistance to Aphanomyces root rot is mediated by a strong and rapid hypersensitive response followed by production of physical and chemical barriers to invasion by the pathogen. By profiling the oomycetes, fungi, and bacterial communities in the alfalfa rhizosphere and endosphere, we have evidence for presence of several pathogens causing disease on alfalfa that were not previously recognized or not previously found in North America. If this turns out to be true, plant breeders can work on developing resistance to these pathogens to increase seedling establishment. When we were isolating bacteria from plants with BSB symptoms, former graduate student Savana Lipps found a second bacterium, *P. viridiflava*, causes disease symptoms. Previously, that bacterium had been found to cause root rot of alfalfa, but we found it to cause blight and wilt symptoms.

What are possible future directions for this research?

I am excited to continue the BSB research by tracking *P. syringae* and *P. viridiflava* on the plant surface and within plants using fluorescent labels and confocal

microscopy to get a better understanding of how they each contribute to disease and how they interact. We also will use a new growth chamber to replicate field conditions at and below freezing temperatures (0 to -10°C) to advance knowledge in epidemiology of the disease. By developing alfalfa with resistance to BSB, we might increase resistance to frost damage, which is a significant problem in many parts of the US. The genome sequences of *P. syringae* and *P. viridiflava* assembled by Savana open the door to identifying effectors important in causing disease on alfalfa. No disease resistance genes have been cloned from alfalfa, so we may be able to clone and verify resistance genes to Aphanomyces root rot

and BSB. I am also excited to isolate new pathogens of alfalfa and determine their influence on seedling establishment and root rot of adult plants.

Is there anything else you'd like to share about your program?

Currently we can tell a farmer that a specific pathogen such as *A. euteiches* is present in the field but cannot predict if there will be significant damage from disease. By measuring specific pathogen DNA concentrations in field soil by quantitative PCR assay and correlating that to damage on alfalfa seedlings, we hope to develop an index for expected damage under disease conducive conditions that can help a farmer with crop management decisions.



SAMAC SHOWS ALFALFA PLOTS

Ben Lockhart's World of Bold Discovery

by Annie Harvieux



Professor Benham Lockhart has a hard-earned reputation for his discovery and research of the “Badnavirus” group as well as for the virology he has done internationally, both setting up modern laboratories for plant virus research and consulting on several continents.

Anyone in the halls of the Department of Plant Pathology could tell you, though, that Lockhart’s impact on an interpersonal level has been every bit as powerful as his scientific discoveries. A devoted mentor to his students and a naturally curious person, Lockhart’s presence on campus and in the classroom have inspired many of today’s brightest virologists, and have helped his colleagues remember the love of knowledge and the fascination with the natural world that got them into the field in the first place.

In light of Lockhart’s retirement

from the department, we wanted to provide an overview of some of his greatest impacts and accomplishments, both scientifically and in the lives of others. Not all quotations submitted are included in this article; however, they all can be found at z.umn.edu/LockhartMemories.

Ben’s Career: A VERY Brief Overview

Lockhart was born in Kingstown, St. Vincent, the West Indies in 1945. After getting his BS degree in tropical agriculture from the University of the West Indies in 1965, he came to the United States to get his PhD in plant pathology at the University of California at Riverside, graduating in 1969. Following that, he was a postdoctoral fellow at both the University of Nebraska and the University of California at Berkeley.

He became a faculty member at the University of Minnesota Department of Plant Pathology in 1971, the same year he began working at the Institut Agronomique et Veterinaire at Hassan II University in Rabat, Morocco. In Morocco, Lockhart developed two modern laboratories for plant virology research, along with

characterizing many plant viruses causing the most serious impacts on Moroccan agriculture. As colleague Deb Samac put it, “Ben probably knows more about plant viruses than anyone on the planet. He made amazing contributions to understanding of plant viruses, most notably pioneering work on badnaviruses that integrate into plant genomes. He also spent innumerable hours on applied virology in Morocco and Kenya, helping local scientists diagnose and manage viral diseases. He was incredibly humble about all of his accomplishments. Most importantly, he loved his work and instilled that love into everyone around him.”

Back in Minnesota, Lockhart researched a little-known group of nonenveloped bacilliform plant viruses, eventually obtaining full-length genomic sequences of several viruses of this type and naming them the “Badnavirus” group, type member CoYMV, with the collaboration of Neil Olszewski and University students. Olszewski recalls, “We had a long productive collaboration that was fun and energizing. This would not have been possible if not for Ben’s generosity, enthusiasm and his excitement for understanding the world.”

Olszewski elaborates on the impact of Ben's research in his work on banana streak virus also: "The PCR detection method, together with Professor Lockhart's recognition that tissue culture could trigger banana streak virus infections in healthy bananas, led to his discovery that the genomes of several different badnaviruses were integrated in the nuclear genome of banana. More importantly, he demonstrated that the integrated sequences were capable of causing virus infections. Prior to these discoveries, plant genomes were not known to harbor infectious virus sequences. Professor Lockhart and other groups around the world have shown that infectious virus sequences occur in a number of plant species. His work with banana, where infectious sequences are present in breeding material, has highlighted the importance of selecting breeding material that is free of potentially infectious sequences."

Ben's Legacy as Teacher and Colleague

Lockhart became a full professor at the University of Minnesota in 1986, where both his drive to understand the world and his encouragement of those around him have profoundly shaped the department's progress.

"I don't know anyone else whose career and life passion so completely overlapped," says Brett Arenz. "His devotion to the discipline of plant virology was singular. He never seemed

stressed or tired from his work, he was simply excited to see what he could find in plants. His energy was boundless and he always had a friendly congenial nature."

As a role model, Lockhart led the department by example in what it means to be fully engaged in their work. "Ben believed the best approach to learning and discovery was through hands-on experience," recalls Carol Ishimaru. "He didn't sit in an office and talk about science. He worked at the bench every day, modeling a strong work ethic as well as the determination, patience and mastery it takes to become an accomplished scientist."

Lockhart's passion for his work was infectious, and drew his students and staff into the fun. "My favorite memory is looking at him so happily preparing his samples for virus purification while listening to music on his stereo. It was truly inspiring for me to see his face of happiness doing what he loved to do the most. Depending on the day of the week

the music could be bluegrass, orchestra, rock, traditional music from Africa, or Mexico," says Robert Alvarez-Quinto. "One of my favorite activities to do with Ben was going virus hunting with him. We used to go to nurseries, conservatories, arboretums, and fields. During the commute, we used to chat about the different viruses he discovered and projects we should start working on next."

Lockhart's hands-on, curiosity-driven style of teaching and learning resonated deeply with many budding plant pathologists. Matt Rouse recalls, "I had the pleasure of taking Ben's plant virology class section. I had previously taken a more traditional plant virology course at another university. Ben did not have PowerPoint slides, lectures, or a classroom. We met in his lab and he talked about what he was currently doing research on. He had us participate in his research. I remember more about plant virology from Ben's lab



LOCKHART, ALVAREZ-QUINTO, AND COLLABORATORS FROM KENYA AGRICULTURAL AND LIVESTOCK RESEARCH ORGANIZATION (KARLO).

than from the traditional course. Often students would follow up their work in Ben's lab/class with publications."

"He was a very special teacher, James Percich reminisces. "He could present difficult concepts in a clear and exciting way so that both undergraduate and graduate students could clearly understand."

He was also always happy to lend a helping hand. Jennifer Flynn characterizes his impact on her career, stating, "He was accessible. He taught me a lot even though I never took his class. Ben was a wonderful collaborator with the Plant Disease Clinic which let us provide the hard-to-find service of transmission electron microscopy (TEM) to clients of the PDC."

Brett Arenz adds, "Ben was an incredible resource for us in the Plant Disease Clinic as

plant viruses can be difficult to diagnose and require specialized techniques. He diagnosed dozens of samples for us per year and would do so with no prior notice. Just bring them up and drop them off in his lab and he would often have a diagnosis in a day or two. His reputation as a world authority in viral diagnostics meant we would even get samples from other plant disease clinics in different states that didn't have the ability to test for many of these viruses."

Ben's Presence on Campus

Many collaborators and department members appreciated Lockhart as a coworker as much as they appreciated him as a scientist, recalling the fun and engrossing conversations Lockhart could create so easily.

"His curiosity about viruses was infectious," recalls Carol Ishimaru.

"Ben reminded me of why I became a plant microbiologist—it's fun and fascinating!"

When asked about his favorite memory of working with Lockhart, Neil Olszewski says, "Talking with Ben about any subject. Ben in his quiet, kind and unassuming way observed the world and came to deep insights. Every conversation was a joy and you always came away enriched."

Lockhart was always happy to share his work with colleagues. Nevin Young recalls enjoying "Running into Ben at almost any time of the day out in the greenhouse — where he'd be happy to show off a new virus — that is — plant showing symptoms out in his collection."

Deb Samac remembers how he would turn mundane moments into lively conversations about the natural world. "When waiting for a gel or a centrifuge to finish a run, Ben would observe the birds outside of Christensen Labs from the hallway window. We had many lively discussions about the birds he saw migrating through campus."

Taking an interest in others is natural to him. "While I was working in the bacteriology lab in Christensen, Ben always stopped in as he walked by just to say hello and ask what I was working on," says Kristi Ledman. "He also always asked how my two dogs were doing. I really appreciated his kindness during our interactions on campus."

Ben's Legacy as Mentor





LOCKHART AND BAUMANN

“Ben’s greatest legacy will be the many graduate students that he advised in his laboratory who became prominent scientists in their own right,” says Brian Steffenson. A common theme when speaking to those who studied or worked with Lockhart is his belief in, and empowerment of, his students and their abilities as scientists.

“I came to Ben’s lab as an art major my freshman year, always having an interest in science but not knowing where to begin,” Mattie Baumann remembers. “Ben hired me without a second thought, I remember him telling me that science is like cooking, given the tools and recipes, anyone can learn. For four years I worked as Ben’s lab assistant, learning not only bench techniques but also how to better approach, communicate, and solve problems. Ben helped me to think about things in ways I hadn’t before; his faith in me

and attention in the lab made a world of difference. I am now a research technologist at a virology company in industry, and can wholeheartedly say I would not be where I am today without Ben Lockhart.”

Grace Anderson had a similarly empowering experience, sharing, “As a woman who returned to school later in life, I did not often feel included, considered or even seen. Ben was a friend, mentor, collaborator, inspiration, and teacher whose breadth of knowledge and desire to share had no bounds. I would not be here if he had not offered me a project on a grant he had been given to study viruses in Hosta. I will forever be grateful that he saw me and let me into the world of plant pathology.”

He also impacted students by teaching them how to deal with the unexpected as a learning opportunity rather than a setback, and to take chances and be daring when entering new territory. As Robert Alvarez-Quinto put it, “Before knowing Ben, every time I found some unusual results in my experiments or results that did not fit what was already known about a system or model, I immediately thought that was a mistake or error I made. But Ben taught me to think outside the box. ‘If you repeat your experiments multiple times, then it is not a mistake, it is a novel discovery you have made.’ With a big smile on his face and genuine excitement he said, ‘Let’s repeat this experiment.’ He also taught

me to be courageous when presenting my results and trust in my research and data. Some research results in virology are so novel that other scientists usually do not accept them immediately.”

Lockhart allowed and facilitated students stepping up to challenges. Sita Paudel recalls, “Actually, I started my research experiences with him, but due to an unexpected situation I struggled with many things. However, this situation helped me to be more motivated, confident and more mature in my graduate study.”

Ben’s Impact Continues

Lockhart is no longer seen on-campus as he retired in 2021, but his legacy lives on. “Not only did Ben make great discoveries himself, he trained a great number of students who have gone on to become noted virologists in their own right around the world,” says Brett Arenz.

In a time of increasing social isolation, material challenges, and life stressors that can impede creativity and curiosity, everything that Benham Lockhart provided to his students is more vital than ever before.

As Dimitre Molov stated, “I will always be indebted to Professor Lockhart’s time, energy, and generosity, and for his selfless contribution to my education, career, and professional growth.”

Jim Bradeen: Innovating by Inclusion

by Annie Harvieux



When many people think of a strong leader in higher ed or elsewhere, they often picture someone who calls executive shots with authority, or holds a high-ranking position for a long period of time. While both of those things are true about Professor Jim (James) Bradeen's role in the UMN Department of Plant Pathology, he was a much more nuanced and impactful type of leader. Bradeen took his leadership position as a means of directly connecting and benefiting numerous people in the department, and nourishing the group in a time of much change and opportunity.

Bradeen received his BS in Horticulture at Michigan State University before moving on to University of Wisconsin-Madison for his MS and PhD degrees in Plant Breeding & Genetics. He started at the University of Minnesota in 2002, where he remained for twenty years (until

2022), rising both to the ranks of full professor and department head for the Department of Plant Pathology. His research focused on resistance genes of plant families including Solanaceae (potato, tomato, tobacco) and Rosaceae (apple, strawberry, peach), with work including mapping scab resistance genes in apples, and developing molecular markers for marker-assisted breeding of black spot resistant roses.

As a Teacher

Many current and former students reference the positive impact Bradeen made on their careers. His broad intellectual curiosity, kind and inclusive mentorship, and emphasis on the joy and excitement of scientific discovery are just a few key ways his style of educating has helped shape and motivate a new generation of great plant pathologists.

Former Bradeen Lab postdoc Leon Van Eck shares, "What I particularly admire about how Jim sees the world is that the beauty of nature and science is integral to it all. Whether he is teaching students about evolutionary arms races between potatoes and their pathogens, thinking about the genetic potential of crop wild relatives, or researching

the diversification of NB-LRR genes in apples, he is very clear in communicating to the world that these subjects are not only important, but gorgeous. . . In this way, he greatly encouraged me to frame my own pursuit of science as an inherently creative endeavor. His excitement over a new graph or data figure was not something he could ever hide, and his lab was the safe space that allowed me to explore and take risks."

Other educators valued Bradeen's classroom ethos as well. Professor Jim Kurle shared how Bradeen helped enhance his classroom work, noting, "Jim was always positive about my research and particularly my teaching, frequently offering constructive suggestions about new media, software, and the internet for outreach and for teaching."

Current PhD student Jacob Botkin recalls, "Jim was my instructor for Current Topics, where we discussed current literature in plant pathology. In this course Jim facilitated many stimulating discussions that were highly beneficial for my understanding."

Professor Emeritus Richard Zeyen added, "Jim's energy and enthusiasm were contagious. It was just what I personally needed

toward the end of my long career at Minnesota. He gave the Department hope in rather dire economic times.”

As a Departmental Leader

While many faculty and staff in university settings resist change out of fear, Bradeen actively implemented changes and innovations in the department to improve the working environment for faculty, students, and staff alike.

Much of Bradeen’s positive impact has been rooted in his making the choice to be an active, empathetic, and supportive presence in the working lives of department members, even when it may be easier not to. Kurlle recalls, “In a couple very difficult human relations situations where Jim could have simply walked away from the confrontation Jim stepped in, analyzed the situation, and came up with a solution respecting the individuals involved without blame or confrontation. His actions took real courage and sensitivity.”

Bradeen brought genuine respect and appreciation to his interactions with all staff, including non-faculty positions. “I appreciate that Jim took time to listen to and connect with the staff researchers in the department - so often we can feel overlooked or sidelined in the academic environment! Jim uplifted us and gave us opportunities to lead in new ways,” shared Rebecca Curland. “I felt valued and supported



BRADEEN WELCOMES THE RANJAN-KHOKHANI FAMILY TO MINNESOTA

while Jim was the head of PLPA. His leadership shifted the culture in our department in a positive direction.” This sentiment has been anecdotally shared by a number of research, administrative, and other non-faculty staff.

Making time for department members was a cornerstone of Bradeen’s leadership style. Assistant Professor Devanshi Khokhani shares, “I have been fortunate to interact with Jim, especially for a new faculty who needs guidance at every step to establish their research program.”

Jennifer Flynn of the Plant Disease Clinic also values Bradeen’s support: “Jim was always a source of encouragement and moral support even during some of my darkest academic and professional days.”

Professor Deb Samac appreciates Bradeen’s value of collaboration and communication inside and outside the department and university. “He is always forward

thinking about ways to improve communication and community. He made huge advances in our visibility through developing a communications position in the department and stewarding the Stakman-Borlaug Center [for Sustainable Plant Health].”

Mary Buschette shares what a joy Bradeen was to work with from an Alumni and Constituent Relations perspective as well: “Jim was a great advocate, partner, champion and supporter. I appreciated any opportunity to collaborate with him.” Her favorite collaborations? “Planning the 9 Billion and Counting Symposium in 2016 that celebrated the work of Norman Borlaug, planning the 50 years and Beyond event celebrating the 50th anniversary of Borlaug receiving the Nobel Peace Prize and collaborating on the Plant Pathology Living Legacy project.”

Championing diversity in academia and sciences, particularly with LGBTQ+ scientists, was another area in



BRADEEN WAS A CO-LEADER OF UMN SCIPRIDE

which Bradeen excelled, both in his own department and as a co-organizer of the annual University of Minnesota SciPride event. Van Eck says, “he continues to advocate for young LGBTQ scientists eager for a career in STEM, and his visibility continues to matter to many queer scientists, myself included.”

Now

In Spring 2022, Bradeen departed the University of Minnesota to become the new Associate Vice President for Colorado State University spur strategy, based in Fort Collins. His legacy in the Department of Plant Pathology, however, carries on, with the department forever better due to his contributions.

Professor Ruth Dill-Macky, who stepped into the role of Interim Department Head upon Jim’s departure, said she is grateful for the many things Jim did for the department in his leadership role. “As our department head he increased the visibility of the research and teaching done by

the department, developed an amazing administrative team that supports the department’s mission and worked to shape the departmental culture to be more inclusive than it has ever been.”

“He fundamentally changed the culture of the department making it more inclusive, diverse and welcoming to all,” says Samac of Bradeen’s legacy.

Zeyen shares, “Jim’s Headship was the first social media savvy headship in the history of the Department. I realized the importance of that media for both internal and external recognition. It also attracted a different type of student, one that was more aware of the world around us.”

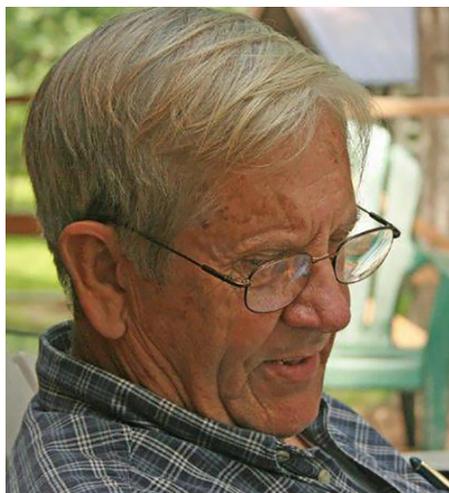
Van Eck, now an Assistant Professor at Augsburg University, cites Bradeen as a huge impact on his day-to-day work. “He is the kind of mentor I’m trying to be to my own students now. In tricky situations I often think, ‘What would Jim do?’ Jim would be brave, dynamic, and compassionate, because he embodies those values.”

All memories and quotations shared by department community are available to view at z.umn.edu/BradeenMemories.



HAVING FUN WITH STUDENTS AT THE APS ANNUAL MEETING

In Memoriam



Alan P. Roelfs (1936- 2022)

Dr. Alan P. Roelfs retired from the USDA-ARS Cereal Rust Laboratory on January 2, 1994, after 32 years with the US Department of Agriculture and 23 years in the Department of Plant Pathology at the University of Minnesota.

Dr. Roelfs was born in Stockton, Kansas on November 18, 1936. He received his BS and MS degrees from Kansas State University in 1959 and 1964. As a graduate student at Kansas State, he also worked as a research technician for the USDA Agricultural Research Service. In 1966, Alan accepted a position as Plant Pathologist with the USDA Animal and Plant Health Inspection Service in the Cereal Rust Laboratory on the

St. Paul campus of the University of Minnesota. At the same time, he enrolled as a PhD student in the Plant Pathology Department. When Dr. Roelfs received his PhD in 1970, he was promoted to the position of USDA-ARS Research Plant Pathologist at the Cereal Rust Laboratory, and he became an adjunct member of the faculty of Department of Plant Pathology. Dr. Roelfs continued his career at the Cereal Rust Laboratory from 1970 through 1993, serving as Acting Director in 1981. In addition to his USDA research assignment, Dr. Roelfs participated enthusiastically in teaching, committee work, and other activities in the Department of Plant Pathology. During his career, he guided 11 MS and 8 PhD students through their degree programs in Plant Pathology at Minnesota.

Dr. Roelfs devoted his career to understanding cereal rust diseases, particularly wheat stem rust and wheat leaf rust. His vast experience in rust surveys served as a foundation for his important contributions to epidemiology of rust diseases and to understanding complex interactions between resistant varieties of small grains and pathogenic races of rust fungi. His research with James Groth

and other colleagues led to major advances in the study of population genetics of plant pathogens, culminating in their classic work on population structure of the wheat stem rust fungus in the Great Plains. Dr. Roelfs published over 100 papers in refereed journals as well as numerous book chapters and other publications. With Bill Bushnell, he co-edited the two-volume treatise on *The Cereal Rusts*, a comprehensive treatment of all aspects of host-parasite interactions and biology of cereal rust fungi. In recognition of his outstanding research contributions, Dr. Roelfs was named a Fellow of the American Phytopathological Society in 1986.

Dr. Roelfs was recognized as one of the world's major leaders in cereal rust research. His name has been ranked with such past and present leaders in rust research such as I.A. Watson and R.A. McIntosh of Australia, J.W. Martens and D.J. Samborski of Canada, R. Johnson of England, and J.C. Zadoks of the Netherlands. Dr. Roelfs was the foliar disease expert on the National Academy of Science delegation to China for wheat studies in 1976. He was twice invited to serve as consultant

for epidemiology of cereal rusts with the Intra-American Institute for Agricultural Research based in Brazil, and he was an FAO consultant on wheat diseases in Pakistan. He also served as an advisor for cereal disease research in India, Mexico, and Morocco. Dr. Roelfs' presence at the Cereal Rust Lab served as a magnet for visiting scientist from all over the world.

Dr. Roelfs' great vitality and vast store of knowledge on cereal diseases was not lost to his colleagues upon his retirement. He retained a part-time association with the Cereal Disease Laboratory (formerly named Cereal Rust Laboratory) and the Department of Plant Pathology, and maintained several active research interests including studies of the biology and evolutionary relationships of rusts in the *Puccinia recondita* (leaf rust) species complex. From his home near Grantsburg, Wisconsin, Dr. Roelfs was also pursuing studies of the rusts of native North American prairie grasses and their acial hosts.

Additionally after retirement, Dr. Roelfs served as a national coordinator of research on Karnal bunt, a consultant on the emerging virulent wheat stem rust race (Ug99) in Africa, and provided assistance in cereal rust race identification in Syria.



William Rodgers "Bill" Bushnell (1931 - 2022)

By Professor Emeritus Richard J. Zeyen & Mrs. Maria Foley

Bill Bushnell was born August 19, 1931, in Wooster, Ohio, to John and Dyllone Bushnell. He was the youngest of their four sons. His father, John Bushnell, a faculty member in Horticulture at Ohio State University, worked at the Ohio Agricultural Experiment Station (OAES) in Wooster.

Bill and his brothers (Jack, Clif and Bob) grew up in a household steeped in reading and learning. The boys often worked with their father in various capacities on the OAES, especially during World War II when there was a shortage of manpower. Thus Bill grew up around applied scientists and the results of their scientific endeavors. He loved working with people who had traveled the world over, and he

enjoyed learning by doing. Clif and Jack taught him the basics of guitar playing. Bill became an accomplished, and largely self-taught, guitar and banjo player. Later in life it was determined that Bill's method of guitar playing was distinctive.

In 1948 he enrolled at the University of Chicago where he received a Bachelor of Arts in 1951. He then enrolled at Ohio State University and received a Bachelor of Science in Botany in 1953 and a Master of Science in Botany in 1955. It was at Ohio State that he met Ann, who was interested in learning to play guitar. Already united by music, in 1952 they were united in marriage. Their son Tom was born in Wooster, Ohio, in 1956.

In 1956 the small Bushnell family moved to Madison, Wisconsin, where second son John was born. Bill worked on his PhD in Botany under the distinguished Professor Paul J. Allen. He researched the physiology of the "green island effect" in barley, which is caused by infection of the powdery mildew fungus *Blumeria graminis*. He received his PhD in 1960 and was immediately hired by the United States Department of Agriculture's Agricultural Research Service's Cereal Rust Laboratory (CRL) which is located on the St. Paul campus of the University of Minnesota. Ann and Bill's daughter Maria (Molly) was born in Minnesota in 1962. Minnesota would become home for the Bushnells and Bill spent his

entire career with the CRL until his 2003 retirement.

To fellow scientists who didn't know him, Bill could seem quiet and not easily given to casual conversation. It took some effort to establish a dialog with him, but once established he revealed himself to have great scientific depth. Even in his early 30s, he was a well-known researcher in the physiology of powdery mildew and rust diseases of cereal plants. By his late 40s he had become a giant in this field of research. He traveled widely and was a guest speaker at many national and international conferences. In addition, researchers from all over the world came to Minnesota to confer with Bill. He was regarded by many of his peers as "a scientist's scientist." Very few scientists are ever regarded this highly by their peers.

In 1997 the CRL became the USDA-ARS 'Cereal Disease Laboratory' (CDL) and expanded beyond rust research. Fusarium head blight of wheat and barley became a major research emphasis. Accordingly, Bill's research gradually shifted from powdery mildew and rust diseases to the attacking mechanism(s) of the fungus *Fusarium graminearum* on barley.

Throughout his 40+ years Bill was an Adjunct Faculty and Graduate Faculty member of the Department of Plant Pathology at Minnesota. He participated in seminars, gave guest lectures in

graduate classes and was a superb graduate student adviser. Bill was a research collaborator with several University of Minnesota faculty and also worked with research collaborators in Germany, Japan, England, Wales and Israel. Several of his research collaborators became personal friends, enjoying his and Ann's warmth and insights.

Bill was a member of the American Phytopathological Society, the American Society of Plant Physiologists, and the American Association for the Advancement of Science, among others. He served as an associate editor for the journal *Phytopathology* and as a senior editor of the journal *Physiological and Molecular Plant Pathology*. In addition, he was an author and a co-editor on a 1984 two-book series entitled *The Cereal Rusts*, and served in the same capacity for a 2002 book entitled *The Powdery Mildews: A Comprehensive Treatise*.

William R. Bushnell garnered many honors as a scientist. He was a Fellow of the American Society of Phytopathology and was elected to Sigma Xi (the International Honor Society for Scientific Research). He received the E.C. Stakman Award (the Department of Plant Pathology's highest award). He also received numerous USDA commendations and awards.

Besides being a "scientist's scientist," a husband and a father,

Bill was an avid gardener and musician. Gardening and music were forms of relaxation and joy for Bill. He and Ann often hosted visiting scientists and collaborators at their home, and it was not unusual for Bill and Ann to play and sing for their friends. They also played and sang at holiday gatherings in the CDL and in the Department of Plant Pathology, where their talents were much appreciated.

Throughout their lives together, Bill and Ann enjoyed the fellowship of their Unitarian Church friends. They were also deeply interested in bluegrass music and its preservation. One Christmas holiday season they surprised their friends with gifts of a DVD featuring many of their duets. There was a very strong bond between Bill and Ann, and that was always in evidence. In fact, for their friends it was hard to even imagine one without the other.

Bill and Ann were married for 68 years. While it was very difficult for Bill when Ann passed away in 2021, he continued to live independently until his passing in 2022; still studying, thinking and remaining interested in daily events and the natural world.

AURORA SPOREALIS

DEPARTMENT OF PLANT PATHOLOGY

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