GROWING MPS

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VirginiaTech
Invent the Future

Welcome!

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Thanks for taking a look at our first issue of the VT Molecular Plant Sciences (MPS) Magazine. It has been an exciting year for MPS faculty, staff, and students, and we have a lot to share with you.

Haven't heard of MPS? It's time to change that. We are a community of scientists that use molecular approaches to unravel the mysteries of plants. Got sick plants? MPS is finding ways to make those plants resistant. Need an alternative source of energy? MPS is developing the next generation of biofuels.

Are you hiring? Our graduates are some of the best and brightest in the world, and they are landing great jobs in academia, government, and industry. In August, 2013, we planted six new 'seeds'—talented first-year graduate students from Florida Gulf Coast University, Walsh University, Tuskegee University, Salisbury University, James Madison University, and Virginia Tech.

Are you new to research in MPS? We want to hear from you! We'd love to talk to you about becoming a part of the MPS community.

Why should you care about MPS? MPS is working on some of the biggest challenges in the world today: disease, hunger, and fuel. MPS is training the next generation of plant scientists, and these scientists are the future. MPS is publishing research that makes a difference, and this research impacts you. MPS is a community, and we welcome you.

ABOUT MPS

The Graduate Program in Molecular Plant Sciences (MPS) at Virginia Tech allows students interested in pursuing a Ph.D. degree in this discipline to work in a wide variety of research areas ranging from plant genomics to disease resistance, metabolic engineering, bioproduction and bioprocessing, and forest biotechnology.

MPS degree candidates who enroll in the program participate in several rotations through laboratories of interest. The program of study includes selections from a range of course offerings, tailored to the background and interests of each student. At the end of the first or second semester of enrollment, a permanent advisor is selected in whose laboratory the dissertation research will be conducted.

The diversity in the MPS program is evident by looking at the federal agencies that fund them: National Science Foundation, United States Department of Agriculture, Department of Energy, and National Institute of Health. Moreover, many laboratories are also supported by various Virginia and US grower organizations and industry.

MPS Abroad

MPS Researcher Brenda Winkel, professor and head of the department of biological sciences, recently traveled to Japan, where she gave the keynote lecture at a workshop on "Metabolons: Dynamics of Plant Secondary Metabolism," at Hokkaido University in Sapporo and seminars at Tohoku University in Sendai and at Kyoto University.

Pictured at left: Winkel in front of the Kinkaku-ji, or golden pavilion, in Kyoto.

IN THIS ISSUE

FRESH PRODUCE

Officers of the Molecular Plant Science Graduate Student Organization, outside Latham Hall. L to R: Phoebe Williams, Jason Lancaster, and Kristen Clermont.

Graduate students plant group to link majors

One of the strengths of the MPS program at Virginia Tech is that it draws in students from many departments who are committed to plant research. However, developing traditions for socialization is more challenging in a non-departmental program, and MPS students **Jason Lancaster**, **Phoebe Williams**, and **Kristen Clermont** decided to change that.

"MPS students have always been social," said Williams, a fourth year Ph.D. student in biochemistry, working in the laboratory of researcher **Glenda Gillaspy.** "We decided that we just needed to take it to the next step. Also, MPS is growing and there was more of a need for an organized unit."

Working with the Virginia Tech Graduate School, the students coined the Molecular Plant Science Graduate Student Organization in May 2013. They are now organizing a student seminar series, occurring the first Tuesday of each month, in which students present their research to fellow students. Also in the works is an annual MPS mini-symposium to be held Feb. 21, 2014. They also wrote a grant to increase bioinformatics resources available to the program, and established a student-to-student mentoring program. They've planned and hosted a number of events, including a chili cook-off and the annual MPS retreat. A student listserv and social media tools were created to further connect the group.

"We created the group to help make new students feel welcome," said Lancaster, a second year Ph.D. student in biological sciences, working in the laboratory of researcher **Dorothea Tholl.** Lancaster, Williams, and Clermont serve as the primary officers of the organization, and students should contact them if they wish to become involved.

John Jelesko named AAAS Fellow

John Jelesko, an associate professor of plant pathology, physiology and weed science, has been named a Fellow of the American Association for the Advancement of Science.

Jelesko was given the association's highest honor for his distinguished contributions to the field of plant specialized metabolism, particularly in how master regulatory loci and alkaloid-specific transport processes regulate alkaloid accumulation levels, according to the association.

"Dr. Jelesko's designation as a Fellow of AAAS recognizes his significant accomplishments and his commitment to advance plant science and its applications," said Alan Grant, dean of the College of Agriculture and Life Sciences. "His efforts have led to a better understanding of the biology of plant metabolism with significant implications for the pharmaceutical and manufacturing industries."

--Originally published in VT News, Nov. 26, 2013

Stevens' bacterial research highlighted by editors

The work of MPS researcher **Ann Stevens** was recently highlighted in the American Society for Microbiology's Applied and Environmental Microbiology (AEM) journal, touted as an 'article of significant interest' by editors. Stevens studies the mechanism of quorum sensing in order to understand how a gram negative bacterium known as *Pantoea stewartii* is able to cause disease, specifically Stewart's wilt, in corn plants.

Quorum sensing is a mechanism whereby bacterial cells communicate with one another through the use of small molecules called autoinducers—a phenomenon that Stevens likes to jokingly refer to as "bacterial social networking." Overall, her research team seeks to understand how bacteria talk to one another in order to coordinate their behaviors, and ultimately, in many cases, cause disease.

"By understanding the quorum sensing method of bacterial signal transduction and gene regulation, we hope to discover a way to manipulate it in ways that are beneficial to society," Stevens said.

The highlighted AEM article further expanded the research field, as it details

newly identified genes that are regulated by the quorum-sensing regulator EsaR in the *Pantoea stewartti* pathogen. Serving as co-author on the paper was Stevens' graduate student **Revathy Ramachandran**, a Ph.D. student in biological sciences.

"A gene can affect anything in the bacterium, from capsule production to motility," said Ramachandran. "But to be able to test whether these targets affect pathogenesis brings us closer to the ultimate goal of identifying gene targets that can be used for disease intervention strategies."

Revathy Ramachandran works with corn plants in a Latham Hall Laboratory.

MPS researchers conduct extensive soybean study

A multi-disciplinary, multi-university research team is in the middle of a five-year USDA-funded project to gain new knowledge about water mold pathogens—also known as oomycetes—that attack soybean plants. The goal is to create new disease management technologies that integrate with current practices to improve the sustainability of soybean production.

John McDowell, professor of plant pathology, physiology and weed science, leads Virginia Tech's efforts within the group, and collaborates with co-leader Brett Tyler, professor of botany and plant pathology at Oregon State University. The project team is comprised of 29 principal investigators at 18 institutions in 16 states, and two international collaborators.

Researchers will conduct field surveys to determine which pathogens are associated with soybeans, performing DNA-based assays to identify the pathogens. Working specifically with *Phytophthora sojae*, they will also identify essential effectors the pathogen uses and develop a screening system to identify lines that recognize these effectors. **M.A. Saghai Maroof**, professor of crop and soil environmental science, is leading efforts to develop breeding lines to deploy these resistance genes in the field.

Another major effort of this project is to use input from farmers, crop professionals, industry stakeholders and extension personnel to assess the economic, social and regulatory impacts of the technologies developed by this project. Support is provided for a network of extension professionals in all major soybean-growing states to disseminate information about the new tools to the end-users.

Outreach and educational components of the project include expansion of the highly successful Kid's Tech program that introduces elementary and middle school children to STEM disciplines through university-style lectures, and hands-on and online activities. MPS researchers will help to create new modules on sustainable agriculture.

"Soybean is heavily impacted by root and stem rot diseases caused by the oomycetes," McDowell said. "The project leverages new information from genomics to develop technologies that can readily be deployed against these destructive pathogens. Equally important, the research is integrated with economic assessment, extension, and education to ensure that the research is translated into technologies that have real-world impact."

WHERE ARE THEY NOW?

- **Martha Vaughan MPS '10** (Tholl) recently accepted a permanent position as Research Molecular Biologist at the Bacterial Foodborne Pathogens & Mycology Research Unit with the USDA ARS, Peoria, Illinois.

- **Will Slade MPS '13** (Winkel, Helm) is now a postdoctoral fellow in the Department of Chemistry at the University of North Carolina Chapel Hill, with Leslie Hicks, leading efforts to develop quantitative phosphoproteomics platforms for *Arabidopsis* and *Chlamydomonas*.

- **Pete Bowerman MPS '10** (Winkel) has moved from a postdoctoral position with June Medford at Colorado State to a position in the Plant Sciences Division of BASF in the Raleigh-Durham area.

- **Piyum Khatibi MPS '11** (Schmale) is currently a postdoctoral research molecular biologist at the USDA.

Researchers observe metabolic reaction in cyanobacteria

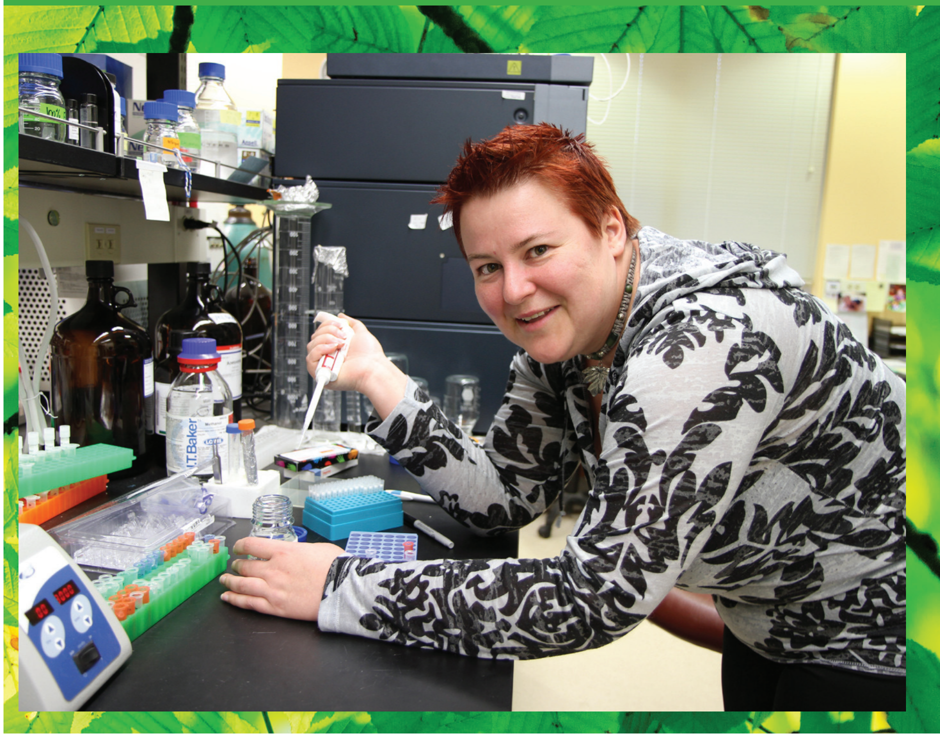


Photo above: Eva Collakhova works in her Latham Hall Laboratory.

Stories and photos byAudra Norris
Communications Assistant
Fralin Life Science Institute

These days, it seems as though gas prices continue to rise and rise. However, thanks to the work of Virginia Tech researchers, relief may be on the horizon in the form of cyanobacteria.

Cyanobacteria are blue-green algae similar in behavior to plants, namely that they both participate in the process of photosynthesis. Because of this, cyanobacteria eat up carbon dioxide and are ideal in combating global warming as well as providing an economically viable and greener fuel source.

Ryan Senger, an assistant professor of biological systems engineering, and Eva Collakova, an assistant professor in plant pathology, physiology, and weed science, recently received $621,182 in funding (NSF-MCB-1243988) for their cyanobacterial research project.

The three-year project,"Enabling Phenotype Predictions of Cyanobacteria", involves experimenting with cyanobacteria's growth under various conditions in an effort to increase lipid content and hydrogen production. Senger's contributions to the project revolve around modeling and analyses, while Collakova focuses on the physical experimentation.

"There are so many experiments required to accomplish our goals, we simply don't have the power to conduct them all. However, with Dr. Senger's phenotype predictor algorithm, we can see what experiments would be most successful and it all becomes much more manageable," said Collakova.

"The phenotype predictor algorithm will be one of our major contributions that come from this research project," said Senger. "Ultimately, we know that metabolic activity and the chemical composition of a cell comes from a complex function involving the genes of that cell and the environmental conditions it encounters. Our phenotype predictor algorithm will be one of the first attempts to unravel this complex function by considering all potential metabolic reactions in the cell simultaneously."

Collakova and Senger intend to observe cyanobacterial growth under two conditions. One condition places them in the presence of light with some sugars to eat. The second features cyanobacteria in the dark with a substantial food source. Collakova will then examine the biomass of the bacteria

and Senger will use the resulting data in modeling with the phenotype predictor algorithm to determine which metabolic reaction(s) cause(s) cyanobacteria to make more lipid and hydrogen.

"Lipids come in many forms and they are all characterized by having very long strings of hydrocarbons that can be burned like fossil fuels", said Collakova. "However, our society also uses lipids in producing almost everything around us in chemical factories and we would have to produce enormous amounts of these lipids to fulfill both our energy demands and chemical industry just by using cyanobacteria. Our ultimate goal is to be able to provide chemical engineers with a more eco-friendly alternative in chemical production. While the cyanobacterial lipids can be used it in fuel manufacture as well, they alone do not provide sufficient sustainable energy source and should be viewed as a supplement to fossil fuels or different types of renewable biofuels. Ultimately, we will have to come up with a more permanent solution that's best left for the physicists to figure that one out."

The project is also providing an opportunity for lab experiences for graduate students as well as one bright high school student. The educational outreach provides them with hands-on lab experience analyzing biomass by using equipment such as gas chromatography-mass spectrometry and ultra-performance liquid chromatography coupled with multiple detector systems.

The duo has high hopes that their research will have a broad impact on the scientific community. "With a better understanding of metabolic activity and good predictive models, we will use these tools to engineer highly productive cyanobacterial strains," said Senger. "While production of biofuels is a worthwhile goal, ultimately we would like to engineer cyanobacteria to build high-value commodity and specialty chemicals from carbon dioxide and sunlight."

MPS students visit Blacksburg High School

Glenda Gillaspy, professor in the department of biochemistry, recently spearheaded an in-school field trip for MPS students. They traveled to Blacksburg High School to teach high school students the intricacies of microscopes and confocal imaging.

Stationed in the school's STEM lab, each group of high school students was presented with an empirical question and used various microscopes to observe transgenic plants and then present its findings.

Some students observed amyloplasts of under-ripe and yellow bananas, using iodine to be able to see them under the microscope. They learned that sacks in the banana skin fill with glucose and then burst, making yellow bananas sweeter than green ones.

However, the real value of this hands-on learning technique lays not in the information, according to Gillaspy and the science teachers at Blacksburg High School. They feel it's important for the students to have an appreciation of authentic learning. Plus, there is the added bonus of having the highschoolersinteract with the graduate students, who give them a glimpse of what it is like to be an academic researcher.

It's a service that Gillaspy and her team are happy to provide. She says that she prefers to focus on broader impact research where she can see the effects on the public, schools, and the scientific community in general.

"By coming here, we really hope that the scientific process and the inquiry aspects of research become clear," she said. "Also, we hope to pique their interest in science. There's a projected shortage of researchers in the future, so we're trying to engage a new generation."

Photo at right: Glenda Gillaspy points out the parts of a green onion to students in Michael Collver's biology class at Blacksburg High School. The students later placed the onions under a microscope for observation.

POPULAR SCIENCE NAMES DAVID SCHMALE ONE OF 2013'S BRILLIANT TEN

David G. Schmale III, an associate professor of plant pathology, physiology, and weed science in the College of Agriculture and Life Sciences, was named one of *Popular Science*'s 2013 Brilliant Ten in the magazine's October issue.

Schmale's research using drones — also called unmanned aerial vehicles or UAVs — to explore microbial life in the atmosphere earned him a spot on the prestigious list of international scientists, engineers, and thinkers whose innovations change the world.

Schmale and colleagues use research drones to track the movement of dangerous microorganisms that surf atmospheric waves. These atmospheric waves collect, mix, and shuffle microorganisms across cities, states, and even countries. This research has deepened our understanding of the flow of life in the atmosphere, and has contributed unique tools for scientific exploration in the burgeoning field of aeroecology.

"Important pathogens of plants, domestic animals, and humans can be transported over long distances in the atmosphere. Drones are important tools to study how these pathogens travel from one location to another," said Schmale. "They can be used to help predict potential outbreaks of human and animal diseases, and even help farmers time their application of pesticides to thwart crop destruction."

Other young researchers on the Brilliant Ten list this year include a Massachusetts Institute of Technology engineer who is innovating new tools for structural design, a University of Pennsylvania researcher examining gene expression, and a California Institute of Technology scientist exploring weather patterns of far-away planets.

"This collection of 10 brilliant young researchers is our chance to honor the most promising work — and the most hardworking people — in science and technology today," said Jake Ward, editor-in-chief of *Popular Science*. "This year's winners are particularly distinguished and I'm proud to welcome them all as members of the 2013 Brilliant Ten."

Written by Zeke Barlow
Academic Programs and Research Communications Manager, College of Agriculture and Life Sciences

David Schmale works with drones at the Kentland Experimental Systems Laboratory near Kentland Farms in Blacksburg, Va.

Schmale, his team, and collaborators have had a number of high-impact findings since he began exploring high-flying microorganisms with drones.

"David is a tremendous innovator who is advancing our knowledge of food safety and biosecurity by using new research tools that examine previously uncharted regions," said **Elizabeth Grabau,** head of the Department of Plant Pathology, Physiology, and Weed Science.

He was the first to develop an autonomous drone to sample microorganisms in the lower atmosphere. This new technology was published in the *Journal of Field Robotics* in 2008.

Schmale and his collaborator S**hane Ross**, an associate professor of engineering science and mechanics at Virginia Tech, have discovered that important pathogens of plants, animals, and humans are transported tens to hundreds of kilometers via invisible atmospheric waves known as atmospheric transport barriers. This work was published in the journal *Chaos* in 2011.

His drones collected strains of a fungus that caused a devastating disease of wheat and produced dangerous toxins that far exceeded U.S. food safety threshold levels. This work was published in the journal *Aerobiologia* in 2012.

These discoveries have unleashed new and exciting civilian applications for drones, such as scouting for pests above crops and validating models for the spread of pathogens.

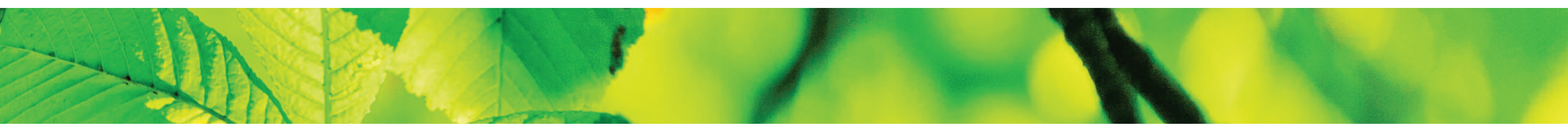
Full article published in VT News Sept. 17, 2013

KENTLAND EXPERIMENTAL SYSTEMS LABORATORY

Established in 2012, the Kentland Experimental Aerial Systems Laboratory is a shared laboratory of the College of Agriculture and Life Sciences and College of Engineering at Virginia Tech. It provides 2,000-square-feet of space for students and faculty members in both colleges to conduct research that will examine everything from the spread of airborne plant pathogens to the creation of more high-tech submarines. The lab is used to educate and train the next generation of agricultural scientists and engineers.

DID YOU KNOW?

Dr. Schmale recently gave a TEDx talk at Virginia Tech's TEDx event, held November 9, 2013 at the Center for the Arts at Virginia Tech. The title of his talk was "Drone-ing for Life in the Atmosphere." The video can be viewed at www.tedxvirginiatech.com.



STUDENT SPOTLIGHT

Kim helps tomato plants fend off sneaky, ninja-like invaders

In the same way that a coach tirelessly reviews an offensive play made against his or her team, scientists who study parasitic plants also analyze attacks, hoping to understand what mechanisms these sneaky 'ninja-like' invaders use to conquer defenseless host plants.

Gunjune Kim of Chicago, Ill., a fourth year doctoral student in the department of plant pathology, physiology and weed science in the College of Agriculture and Life Sciences, is working with **Jim Westwood**, a professor in that department, to analyze the attack methods of *Cuscuta pentagona*, a thin, weedy vine-like plant native to North America.


Gunjune Kim works with tomato plants in Dr. Jim Westwood's Latham Hall laboratory.

The parasitic plant has earned many folk names, including devil's guts, strangleweed, and witch's hair, and is commonly called dodder. It attacks common crop plants like tomatoes, potatoes and alfalfa by coiling itself around the stem and then penetrating between host cells. Once the parasitic plant has penetrated the host plant, the plants begin swapping ribonucleic acid (RNA), according to data from Westwood and Kim's study.

"We're fascinated by what our data shows," Kim said. "Our hypothesis is that both plants are sending gene transcripts to each other. This is truly a strange phenomenon."

Kim's research approach uses a new twist on next-generation sequencing. He generates millions of RNA sequences from the parasite tissue and then uses powerful computers to sort out the host and parasite RNAs. For his dissertation, he will continue to test the RNA exchange hypothesis, and examine what becomes of the RNAs once they are transferred to the other plant.

Overall, Kim and Westwood want to understand this mechanism better so that they can determine what role it plays in the parasite's interaction with the host plant. It is possible that tampering with this mechanism could stop the parasitism that is affecting food and forage crops throughout the world.

"Dodder is one of the most difficult weeds to control. Once it is established on a crop, about all you can do is plow under the plants in hopes of keeping it from spreading and reproducing," Westwood said.

Kim said that the MPS program further convinced him that Virginia Tech was the right place to complete his Ph.D.

He holds a master's degree in plant sciences from Southern Illinois University and a bachelor's degree in chemistry from the University of Illinois-Chicago. After completing his doctoral degree, Kim plans to stay on with Westwood as a postdoctoral researcher.

Written by Lindsay Key
Communications Officer
Fralin Life Science Institute

FUN FACTS: Q&A WITH KIM

Why do you want to be a scientist? When did you know?

The basic principle underlying the scientific method motivates me to understand the world around me. From past to present, scientists have worked to resolve significant world problems. I would like to apply myself to help solve future global food issues and elucidate the mechanisms behind naturally occurring cross-species interactions. If you knew me a long time ago, you would never imagine I would get a Ph.D degree in a Plant Science field because my friends and family were telling me that I was much better in arts and music. However, one day I realized that I do have scientist blood in my body and that I enjoyed working in this field.

What attracted you to your particular field of science?

When I was doing my second rotation with Dr. Westwood from the MPS program, host-parasitic plant interactions caught my attention. It is still fascinating for me to understand the mechanisms behind cross-species interactions. Additionally, the fact that the parasitic plant field has the full potential to discover many unexplored areas, is appealing to me and I see infinite possibilities to do translational science in this field.

Be a geek: what's your favorite piece of equipment to use in the lab? Why?

My favorite piece of equipment is the Robocycler Gradient 96 PCR Machine. It is an old machine but I like the unique design. Since it has 4 temperature blocks with a robotic arm, it is not necessary for the machine to take time ramping like other machines with only 1 temperature block. This saves a lot of time to do PCR. I hear other scientists spending at least 4-5 hours to do one PCR reaction with their one block machines but it took me only an hour and half to do a PCR with the Robocycler. Also, our Robocycler has Dr. Kary Mullis' (Received nobel prize for invention of PCR) signature on it.

What are your ultimate career goals?

I would like to make meaningful contributions in the area of plant-parasitic interactions and become a professor at an academic institution.

Jim Westwood

Students Develop High Performance Computational Resources

contributed by Dr. Jim Westwood

Big Data is presenting life scientists with same challenges and opportunities that are impacting manufacturing, business, intelligence, and other sectors. For example, the emergence of Next Generation Sequencing (NGS) has increased the efficiency of DNA sequencing to the point that the quantity of data from a biological experiment can easily outstrip the capacity of researchers to make sense of it. A single experiment on plant response to pathogen attack can easily sequence a plant's entire transcriptome many times over, resulting in datasets containing billions of sequences that overwhelm typical research computers.

Students of the Molecular Plant Science (MPS) program recognized this problem and have worked together to purchase a shared use computer capable of processing these datasets. To facilitate widespread use of this machine, they also set up systems for training and sharing expertise among themselves that will enable the entire VT plant science research community to capitalize on the NGS revolution.

MPS students **Gunjune Kim, Kevin Fedkenheuer, Michael Fedkenheuer, Alex Weisberg, and Yihui Fang** collaborated to obtain $23,340 to purchase a high performance "whole genome sequencing server" computer. The server was installed and setup by fellow students Delasa Aghamirzaie, Neelam Redekar and Curtis Klumas.

Yet another group, led by **Michelle Price, Megan LeBlanc and Phoebe Williams,** organized a workshop for the MPS community to introduce the computer and discuss challenges in sequence assembly. Nearly 50 students and faculty attended the workshop, which was held on April 11 and featured Dr. Roger Barthelson, a genome assembly expert from the iPlant Collaborative at the University of Arizona to provide training.

He discussed how the field of plant transcriptome and genome assembly is still in its infancy and how obtaining optimal results hinges on many nuances of data collection and processing. Nearly all labs associated with MPS are dealing with some aspect of NGS data and the new computer will accelerate discoveries in plant biology at Virginia Tech.

Few students have the opportunity or commitment to make such a substantial contribution to their institution. The amount of work involved was formidable, but they handled every detail from conceptual planning through installation and implementation of usage policies. Most of the funds for the computer and workshop were obtained from a competitive grants program run by MPS, which generally awards small sums to individual students to support research activities, training, and conference participation.

This large team of students is unprecedented and reflects both the widespread need for more computing capacity and the collaborative spirit of MPS. The students were also innovative in leveraging additional funds from the Translational Plant Science (TIPS) IGEP and from the Fralin Life Science Institute, securing and modifying a suitable space for the computer in Latham Hall, and arranging for sustained IT support, thanks to the PPWS department.

TALKING PLANTS

Zach Nimchuk is Virginia Tech's most recent addition to the Molecular Plant Sciences program. He is an assistant professor of biological sciences in the College of Science and an expert in the area of plant development. Nimchuk worked as a postdoctoral associate at the California Institute of Technology before beginning his position with Virginia Tech in August 2013. He holds a Ph.D. in biology from the University of North Carolina at Chapel Hill, and a B.S. in botany from the University of Toronto.

Can you tell us more about your research?

We're primarily interested in plant development. All plant development ultimately originates from populations of stem cells. These populations are located throughout the plant, and they contribute to shoot, root, and vascular plant growth. Essentially every aspect of a plant that is important to us economically or agronomically is derived from the activity of these cells.

My lab studies how these stem cell populations arise, and how they're regulated. We look at how stem cells decide when to divide, when to differentiate, and how many stem cells to make. We also look at the pathways and players that control these processes at a molecular level. The ultimate long-term goal is to understand how these pathways work and use them to modify and improve crop plants.

We know that targeting stem cell functions has been successful in the past because when we can look at the domestication of some crops we see traits that we've selected for during domestication that are associated with alterations in some of the genes that we actually study in the lab here. So, we know that modifying stem cell pathways is one of the things that we can use to improve crops.

What have you learned about stem cells so far?

Stem cells don't operate by themselves. They depend upon signals derived from their neighboring cells that tell them how many stem cells there should be, and when they should divide, when they should not divide, and what they should differentiate into. That signal exchange between the neighboring cells and the stem cells themselves is something that we focus on quite a bit. Particularly, we look at a series of receptor kinases that control the rate of stem cell production.

We have a secondary interest in understanding how these pathways have been modified during plant growth. There's a considerable variation in plant growth forms in both nature and also in agriculture. One of the things we want to know is how stem cell pathways have been altered through evolution or domestication to form the variety of plants that we see on our planet.

We focus on the model plant A*rabidopsis*, but we're also branching out to other plants that are more important economically and agriculturally. We work on both monocot and dicot plants. We're interested in the comparisons between the two plant classes, but we're also interested in some of the similarities. At this point, it will be interesting to see if we can take information from one and translate it into the other. I think by doing this we're going to have a much broader understanding about how evolution shapes stem cell development and development in general.

We try to study things on an integrative level. We combine a lot of genetics because we want to study genes that are critical for these pathways. We also do a lot of live imaging, using microscopy, to try and see where these genes are expressed and function, and we do genomics, to try and identify pathway targets.

Why are you interested in plant devel-

opment? Why do you think it's important for us to understand?

I have a general interest in biology. I was one of those kids who would go down to the stream and lift up rocks and collect leaves and stuff. So, in some sense I've always been a biologist. I've just gotten fortunate enough to take some of that passion into an actual career.

One of the main reasons why we should be studying plant biology is that we're facing a really important crisis in the next century. We're predicted to double the planet's population by the middle of the next century, and in order to feed all of these people, we're going to need to double our yield of all the major crops. The current estimates that are being published suggest that we are well below this target as of now.

What we really need is a concerted effort to attack this problem. I think that improving plant development is one of the parts of the solution. It's not going to be the only thing. There's no magic bullet here. It's going to require a lot of different fields that are very diverse to tackle this, ranging from economics and sociology to the sciences, but plant biology can play a very important role in helping to boost crop yields and feed people.

So, you think if you can understand how plants develop, that you could either speed that up or assist plants in producing more food?

Yes, but it will be long process. We focus on model plants first, because they are easy to work with, yet do all the things other plants do. I think the ultimate goal is to try to identify key regulators and come up with really smart ways of deploying them in crops of interest. Understanding pathways enough to deploy them in crops is a challenging goal, but a worthy one. We would like to improve how crops grow, or how much fruit they make, or improve their growth range.

Habitat, stress and the environment impact development. Understanding that interaction might help mitigate crop losses, and create new varieties. So some of the other things we study here is how some stem cells pools contribute to the developmental structures necessary for C4 photosynthesis, a form of photosynthesis that is beneficial under arid conditions. The idea is that if we can understand how these pathways are integrated, then we can put them into plants that don't have C4 photosynthesis and change where they could grow and under what environmental conditions they could grow.

We're also interested in understanding how stresses and environmental impacts ultimately target the growth of the plant. A lot of these environmental stresses, either abiotic or biotic in nature, have negative impacts on the way plants grow and substantially reduce yield. At some frequency, those pathways have to be feeding into the regulatory pathways that control development and growth.

Are you collaborating with anyone at Virginia Tech?

There are several collaborations I have imitated here. One example is that we've identified several target genes for some of the receptor-kinases that control stem cell function, and what we would like to do next is integrate this into a larger image of how the pathways are functioning, by identifying the transcriptional regulators of these target genes, and also what other genes that they control. To do this, we're taking a genomics approach with the group of Chris Lawrence at VBI, and we're also taking a biological mathematical modeling approach with Dr. Tyson's group. We've submitted a proposal to the NSF that covers this work and we're very excited about it.

As you begin aquiring students for your new lab, what are you looking for in a student?

The key thing that you're looking for is interest and passion—those are the most important aspects I think you can have in a student. Nobody's born into this world knowing how to use a confocal microscope; it's an acquired skill. But interest, curiosity and intellect are the things that you really want in a student. We teach students how to do science and work with them but ultimately you want to make yourself redundant in the process. When students know how to use the lab and ask questions on their own without you, then I feel like we've really done our job as educators and as mentors.

Photo: Zach Nimchuk studies *Arabidopsis* in his Latham Hall laboratory.

AROUND MPS

MPS student Mike Fedkenheur describes his research at a poster symposium held in Latham Hall during student recruitment weekend in October 2013.

Prospective students networked with current MPS students at the student recruitment weekend held in October 2013.

Kristen Clermont, a second year Ph.D. student in MPS, explains her research to a prospective student during the October 2013 recruitment weekend.

MPS researcher David Schmale swings a bat in an attempt to hit the ball into the river at the Faculty vs. Students baseball game held at Bisset Park in Radford, Va. in May 2013, as part of the annual MPS Retreat.

MPS students and faculty members, after competing in the 2013 MPS Retreat's Faculty vs. Students baseball game. John McDowell reports, "the students won."

Students and faculty members listen to presentations at the River Company Restaurant in Radford, Va., as part of the 2013 MPS Retreat.

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