Department of Horticultural Science
Spring/Summer 2017

# Horticulture

**Adventure. Leadership. Excellence. Community.**

## In this Issue

# Exploring the Fundamentals

**Physiology and genetics research in the department has big real-world impacts**

*Emily Ellingson studies the genetics of eastern hemlocks to assist with their conservation. Learn more on page 3.*

UNIVERSITY OF MINNESOTA
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# Leadership.

## Alumni Spotlight: Regulating Crops and Developing Leaders with Angela Hendrickson Culler

It costs as much as $140 million for Monsanto to release a new genetically modified crop, and from start to finish Angela Hendrickson Culler (*Ph.D. Plant Biological Sciences '07*) ensures that crop is safe for people, animals, and the environment. Culler is the lead for Monsanto's U.S. Biotech Regulatory Affairs department and was recently named one of the Saint Louis Business Journal's 40 Under 40, which recognizes individuals who have made significant contributions to their businesses and community. She manages a team of 25 people and is responsible for obtaining and maintaining global regulatory approvals for a $10 billion product portfolio.

"We have oversight from a product's proof of concept through to discontinuation when a product is no longer used," says Culler. That's no small task when getting a product to market can take 10–12 years. Her team will often start work with product developers to understand any unique safety concerns for a crop or trait, manage risk assessment, and look at the long-term picture for where regulatory roadblocks might pop up later. "Regulatory approval is the last step before a crop is released for commercial purposes," says Culler. "We make sure that if there's a safety issue, it's caught as early as possible." Regulatory approval is one of the longest processes in the product development phase, lasting a minimum of six years. Beyond that, Culler's team often conducts post-market evaluations to ensure there are no unforeseen hazards after release. "A lot of people don't realize it, but there are more safety tests and regulations on genetically modified crops than on any other food," says Culler.

Culler has been at Monsanto for the past eight years, but when she first started there she didn't plan to work in the regulatory approval space. Initially she started as a plant biochemist within the regulatory sciences division, but she was quickly drawn to more than just the technical science of safety assessments. "It really stretches different areas of my brain, including the creative side. When people think of regulatory affairs, they usually think of tons and tons of paperwork," she says. "That's only part of what we do. What really makes me passionate about my work is that it's a mixture of hard technical science, social science, and political science. There's a very human aspect to it." While she works closely with the scientists developing Monsanto's new crops, she must also communicate frequently with government officials so they have the right information to perform risk assessments and explain Monsanto's products to the public to dispel myths about GMOs.

Culler is particularly proud of the balance she's managed between having a very successful career and personal life. "I'm still working on it, but I've come to understand what my priorities are," says Culler. That balance has in turn helped her to be a better leader. She strives to be an example to her team, and credits the foundation of her leadership skills to her Ph.D. advisor Jerry Cohen. "Jerry really made a point of showing the people in his lab what it means to be a leader and a manager. He cares for his students and employees as people first, and there's something special about that."

To those considering pursuing plant science at any level, she stresses developing soft skills in addition to the technical ones. "Your CV will get you an interview and a foot in the door, but your ability to communicate, think about matters broadly, and balance being a team player and a leader are what will really stand out," she says. Her other piece of advice is to think critically about how you want to continue to grow. "You don't necessarily need a Master's or Ph.D. to work at a technical organization. The process of learning and pursuing a higher degree provides really great training tools, but it's not the only piece that matters," says Culler. She warns against getting too focused on one path, particularly in graduate school. "Remember that there are scientists in all different parts of a company, and there's more than one way to develop your career." ♦

## Nicholas Howard Uncovers the Honeycrisp Family Tree

Since its release in 1991, Honeycrisp has been harboring a secret: its parents are a mystery. Originally billed as the child of Macoun and Honeygold, researchers quickly discovered that neither of these varieties were the parents of Minnesota's favorite apple. Now, 26 years after its introduction, graduate student Nick Howard (*Applied Plant Sciences, Ph.D.*) has finally uncovered Honeycrisp's true lineage.

The trouble started thanks to a record keeping error back in the 1970's. Though it wasn't discovered until after its release, the parentage information listed in the apple breeding program's records was incorrect. "Understanding the pedigree of Honeycrisp is really important for researchers like myself," says Howard. Knowing an apple's lineage is similar to someone knowing their family's medical history. "Knowledge of Honeycrisp's pedigree allows us to relate the qualities of Honeycrisp to other apples, as its grandparents are likely also in the pedigrees of many modern apple cultivars."

The 2004 study that proved Honeycrisp was not the child of Macoun and Honeygold also hypothesized that Keepsake was a parent, but at the time there wasn't enough genetic information to confirm that or figure out the other parent. In entered the USDA-SCRI initiative RosBREED, which focuses on developing and applying modern DNA tests and related breeding methods to different plant breeding programs across the U.S. The wealth of genetic data generated through this project opened up the opportunity for Howard to dig further into Honeycrisp's pedigree, and his results were recently published in Nature's *Horticulture Research*.

Howard's research confirmed that Honeycrisp is the child of Keepsake and discovered that the other parent is an unreleased University of Minnesota selection, MN1627. Though MN1627 is no longer available, finding this connection allowed Howard to further identify Duchess of Oldenburg and Golden Delicious as grandparents through the MN1627 side, ultimately connecting Honeycrisp to many cultivars of worldwide significance.

Howard's findings are not only scientifically significant, but culturally significant as well. "It's a lot like how a museum gives us a glimpse into the lives of people long ago," says Howard. As it turns out, the pedigree of Honeycrisp stretches back to Europe. Duchess of Oldenburg was brought to the U.S. from England in 1835, but potentially originated far earlier in Germany or Russia. "Duchess of Oldenburg is still grown in specialty orchards, so you could go to this orchard in the early summer and experience firsthand the apple that is part of the genetic bedrock of the UMN apple breeding program."

The ability to connect Honeycrisp to its pedigree will help us better understand the genetic underpinning of its crisp texture, leading to the development of even better apples than before. For years Honeycrisp's pedigree has remained hidden in shadow, but now it can sit proudly among its family tree. ♦

**Above:** *Honeycrisp being collected.*
**Below:** *Nick Howard in the apple orchard.*

## Saving the Eastern Hemlock: Student Spotlight on Emily Ellingson

*By Tara Henderson*

For the last three years, Emily Ellingson (*Applied Plant Sciences, M.S.*) has spent her days studying and growing a single type of tree: the eastern hemlock. Ellingson, who is advised by Stan Hokanson and Jim Bradeen, is utilizing microsatellite markers to determine genetic diversity within Minnesota's native eastern hemlock population in the hopes of improving conservation efforts for the tree.

The eastern hemlock is a slow-growing and long-lived conifer that acts as a foundation species across its range, helping to regulate the ecosystems in which it occurs. While these trees numbered somewhere around 5,000 in Minnesota in the early 1900s, they have since dwindled to less than 50 mature trees in the entire state, earning them a spot on the state's endangered species list in 2013. Because of its endangered status the Minnesota Department of Natural Resources (DNR) protects current stands of eastern hemlock, but Ellingson hopes that combining basic genetics and conservation science will further efforts.

Just like the trees she studies, Ellingson is a Minnesota native who became fascinated by plants while studying biology and environmental studies at Saint Olaf College. After college she started working at botanical gardens and arboreta, developing a passion for plants and the unique ways in which they enrich our lives. "Public gardens offer a valuable blend of art and science," she says, "and offer unique teaching opportunities for our daily lives." Her work with eastern hemlock combines her passion for the work done by public gardens and her interests in conservation.

**Above:** *Cuttings produced by Ellingson for studying the success rate of cuttings vs. growing from seed.*

"We take a basic to applied approach," says Ellingson. "Using basic genetics and propagation approaches, we can understand how we can most effectively conserve the species in Minneso-

ta." Her goal is to understand the genetic diversity of eastern hemlock native to Minnesota, which will help to determine if cultivated trees and their seedlings can be considered native—and thus used in conservation efforts.

Her research started with a list of 21 published genomic markers, which help identify individuals or species. Of those 21, eight were highly variable, showing large amounts of selectively neutral mutation across Minnesota eastern hemlock. "These markers have a high mutation rate," she says. "We're able to measure the variation in different areas of the genome and put together a robust genetic analysis of the populations. We could even find differences that we'd want to preserve in our conservation efforts."

While the genetic information is useful, Ellingson has noticed that different trees have different propagation needs, which could hinder the eastern hemlock's success in the future. For the second part of her project, Ellingson has propagated vegetative cuttings—small clippings from trees that are genetic clones—and over 1300 seedlings from 20 different mother trees. Understanding the propagation needs of these seedlings while also being able to examine their genetics helps to inform the best growing strategies.

"Our end goal is to provide an action plan for land managers to help restore native Minnesota eastern hemlock," says Ellingson. "The DNR, public gardens, and state and municipal parks with eastern hemlock will then be able to use this information for conservation." Ellingson hopes that resources provided at the Minnesota Landscape Arboretum can help bring awareness to the tree, and with public support her research will build the foundation for the future of the eastern hemlock in Minnesota. ♦

**Left:** *Emily Ellingson looking at young eastern hemlock trees.*

## Developing the Next Generation

It's not a secret that the horticultural industry has been struggling to find the next generation of plant professionals. In 2015 the USDA estimated that only 61% of high-skilled job openings in the food, agriculture, renewable natural resources, and environment fields in the United States would be filled. Part of the problem faculty members at the U of M identified to explain this trend was an issue of perception about what studying horticulture entailed and the job prospects after graduation. To address this problem, the decision was made in 2013 to restructure curriculum from two majors— applied plant sciences and horticulture—into a single major called plant science, which also led to the development of a food systems major. All students in the plant science major have a broad core curriculum that gives them solid training in all aspects of plant science—they learn about general plant biology, plant production, basic soil science, plant-insect interactions, and more. "That interdisciplinarity and foundation of plant science will help students think more broadly about what they do and carry those principles from one area of horticulture to another," says major coordinator Eric Watkins. This makes students better rounded and offers them flexibility in their career choice.

**Above:** *Plant science students assisting with floriculture research.*

As students progress in their college career, they begin to take more focused courses according to their interests. "Advanced coursework hasn't changed," says Watkins. "Students work with a faculty member to identify the upper level courses that make sense for them and their career goals. This gives them greater flexibility and promotes on-time graduation." For example, a student who is interested in plant breeding can choose to take courses like AGRO 3660: Plant Genetic Resources and HORT 4071W: Applications of Biotechnology to Plant Improvement.

Students have noticed the benefits of this change as well. One student commented in an anonymous survey completed shortly before graduation, "I am extremely satisfied with the strength of the coursework in the plant breeding track. When I visit plant breeders I can have intelligent conversations with them about their work, and I know a lot about the profession." Other students have praised the ability of the major to tailor the curriculum to their interests, while others have appreciated the interdisciplinary nature of their education. And most importantly, the development of the plant science major has led to an increase in enrollment and higher degree satisfaction—which means more students educated for the jobs employers desperately need highly skilled employees to fill. ♦

# Excellence.

## Call for Nominations: Horticultural Science Distinguished Alumnus Award

Nominations are now open for the Department of Horticultural Science Distinguished Alumnus Award. This award will honor an alumnus/alumna who has attained professional distinction in horticultural science as evidenced by outstanding professional achievement on a state, national, or international level.

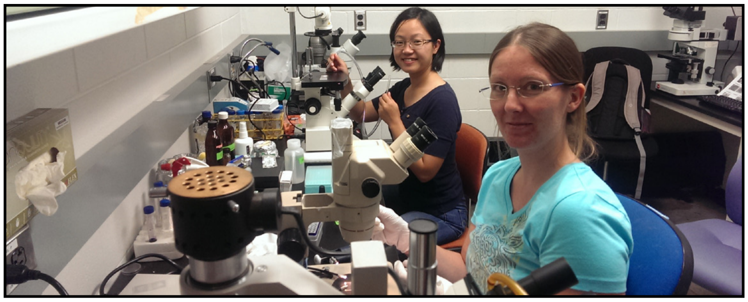
Nominees will be chosen based on demonstrated distinction in their professional lives, recognition as an authority within the field of horticultural science, and exceptional service to or volunteer activities in her/his field. The recipient will receive the award in the spring of 2018 at HortSci Grows.

Anyone may nominate an individual for this award, and individuals are welcome to self-nominate. Eligibility requirements and award criteria are at z.umn.edu/hortscialumnusaward2018. ♦

**Nominations due June 15, 2017**

View criteria and apply at z.umn.edu/hortscialumnusaward2018

Please contact Echo Martin (mart1794@umn.edu) or 612-624-4242 with any questions.



## Staff Spotlight on Stefanie Dukowic-Schulze

Stefanie Dukowic-Schulze (*above, right*) has been a researcher in Changbin Chen's lab since 2011. Originally from southern Germany near Heidelberg, Dukowic-Schulze has published 14 papers in her time with the U of M and given presentations on her research around the world.

**How did you become interested in plant biology?**

I've always loved teaching and learning, and I just didn't want to stop—so I went to the University of Karlsruhe, now Karlsruhe Institute of Technology, to study general biology. Someone in the botanical department spoke to me about a research position, which eventually led to my thesis. I hadn't been exposed to research before then, but now it's become a real, true passion of mine. I couldn't give it up now.

**What are you researching?**

Most of my research comes back to meiosis. Right now we're trying to understand where recombination events take place. You have two chromosomes and they pair together. Before they separate again, they exchange some parts, called crossovers, and this is a recombination event. Understanding where those crossovers happen and why they happen in those locations is particularly important for introducing genetic variety into plant breeding. We're looking at maize right now. When you move from a model plant to a crop plant, you really start to see the potential of your research. The next phase is looking at maize in different temperatures and the effects on crossovers.

**How have you and your work grown?**

Dr. Chen is so great at supporting the people in his lab and helping them grow while also letting them be independent. This independence has helped me to develop my own research niches that no one else has looked at, like the role of mitochondria during meiosis and the role of specific RNA's in 3-dimensional chromosome dynamics. I've had the opportunity to attend professional conferences each year as well. This has been great for networking and getting input from the greater community on my work, as well as expanding my own thinking.

**What advice do you have for others who are pursuing a post-doctoral position?**

First, look for a lab that both gives you technical skills and helps you develop professionally. There are labs out there that might give you a lot of high impact publications, but they might not develop you as your own researcher. Second, look for fellowships early on after completing your Ph.D. There are a lot within the first four years, but after that it's a lot harder to find fellowships. Oh, and make sure to give yourself hard deadlines for publications! ♦

# Precision Control: Engineering a Multi-Partition Growth Chamber

Traditional growth chambers control several environmental factors, such as humidity, light, and temperature. Some experiments, however, require more precise control of multiple factors—such as salinity and air composition—which traditional growth chambers either don't manage efficiently or can't manage at all. Traditional growth chambers just didn't cut it for the Hegeman lab, where scientists are trying to gather data on plant metabolomics over time, but researcher Calvin Peters had the solution. Peters engineered specialized multi-partition growth chambers that can control almost any aspect of a plant's environment—allowing for more precise measurements and better-controlled experiments.

The key to the metabolomics research currently underway in the Hegeman lab is carbon. The basic experiment starts with seedlings being germinated in the dark, as light is needed for carbon fixation. Once the plants have germinated they're placed into the chamber, sealed, and purged with $CO_2$-free air. Researchers pump in 13$CO_2$, which contains a stable isotope of carbon called carbon-13. Over time, the chambers are switched individually back to 12$CO_2$. At different points in a plant's life cycle researchers freeze the plant in liquid nitrogen and measure the change of the isotope through the plant.

"You can actually trace the carbon isotope," says Peters. "It has no physiological effect on the plant, but just changing the carbon isotope changes the weight of the molecules incorporating it, which can then be measured."

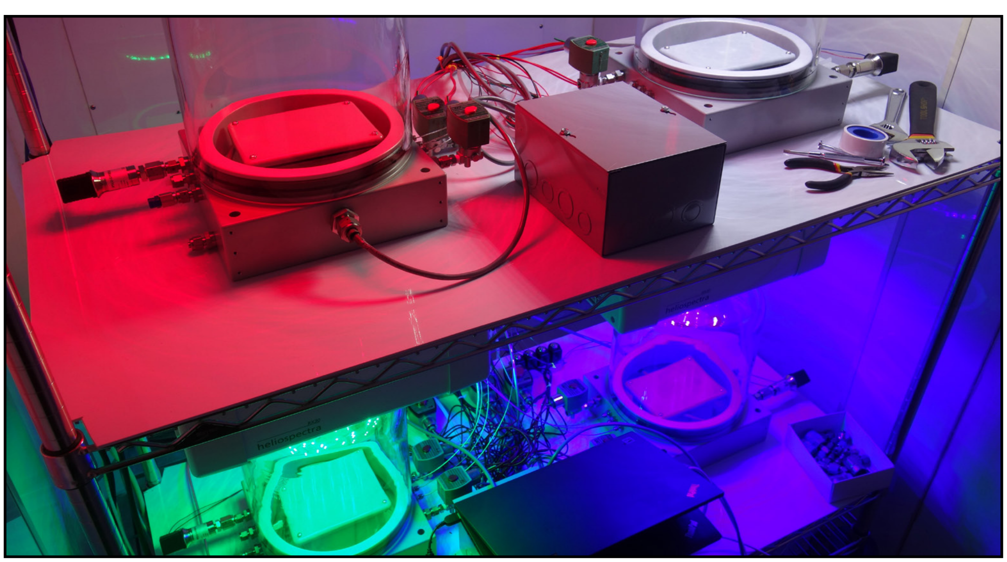
With previous labeling growth chambers, researchers would need to switch the carbon isotope on all the plants in the chamber at the same time. This meant that an experiment would need to be restarted from the beginning to get data points further along in the plant's growth. Because Peters' chambers are partitioned, they can alter the isotope on a single group of plants at different points in a plant's growth cycle to gather more detail on how different processes change over time.

The system appears intimidating, but the parts aren't special. "Other than the aluminum base, which we had custom built," says Peters, "everything is made from easily accessible parts. You can get things like the electronics and the pods from anywhere that sells computer or growth chamber parts." Peters has a dual degree in chemistry and biochemistry and was hired to research metabolic flux, but electronics has always been a hobby of his. "I drew it all up using CAD software, and programmed it using C, C++, and Python."

Light, media pH, water content, humidity, and more are all controlled in each chamber to ensure consistency throughout the experiment. Adding nutrient solution or removing waste can be done without opening the chambers. "Its automated design minimizes human intervention and avoids hazards," says Peters. "The computer is basically just a display; the chambers run on their own independent of the computer. Even if the laptop crashes, microcontrollers still run the chambers."

These chambers are useful for studying metabolic flux, but they have potential far beyond this application. They can be used to easily study a combination of stresses, such as salinity, light, nutrient solution, heat/cold, or $CO_2$. They are extremely customizable, and will ensure that the variables not being studied remain consistent.

"When it runs right, it's incredibly satisfying," says Peters. Other labs have shown interest in the chambers Peters has created, but as of yet he hasn't heard of anyone building something similar. His experience with this project has led him to pursue a software engineering degree while he continues his work in the Hegeman lab. "The chambers aren't complete," he says. "There's always something else to do and a way to make it better." Though the chamber may be made up of easily accessible parts, the precision it provides to the Hegeman lab and other researchers who utilize it has value beyond measure. ♦



**Left:** *The multi-partition growth chambers, with the lights on each pod set to a different wavelength.*

Department of Horticultural Science
College of Food, Agricultural & Natural Resource Sciences
University of Minnesota
1970 Folwell Avenue
St. Paul, MN 55108



## Connect with Us!

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## The 3rd Floor Alderman Lobby Complete!

Thank you to everyone who donated to our crowd funding campaign to renovate the lobby last December. Thanks to all our alumni, staff, faculty, and even current students we raised nearly $30,000 towards the lobby. A special thank you goes to Emily Hoover, Jim Luby, and Neil Anderson, who matched the donations from the crowd funding campaign.

Because of everyone's generous donations, whether it was $15 or $1,000, we were able to complete the redesign with all the features included in our original plan. In addition to increasing the seating area and adding a projection screen students can use, photographic artwork detailing department strengths line the walls.

Students actively use the space daily, often occupying every table—particularly before an exam. Thank you again to everyone who gave a gift and spread the word. The third floor lobby has transformed into a welcoming space for the entire department, and we couldn't have done it without you. ♦

This newsletter was written by Echo Martin unless noted otherwise, and edited by Samantha Grover and Lauren Matushin.
Please direct any questions or comments to Echo Martin at mart1794@umn.edu.