All 2016 PRL Stories

2016 Anton Lang Memorial Award Winners Announced

4/11/16

Igor Houwat

Ian Major, Ph.D., and **Li Zhang** have added their names to the PRL annals as recipients of the 2016 Anton Lang Memorial Award during a ceremony which took place on Monday, April 4, 2016 at the Biochemistry and Molecular Biology building.

The Anton Lang Memorial Fund was established in honor of the founding director of the Plant Research Laboratory, who passed away in 1996. Proceeds from the fund go towards annually supporting the Anton Lang Memorial Lecture – given this year by **Professor Julia Bailey-Serres**, Ph.D., from the University of California, Riverside – and recognizing a graduate student and a postdoctoral research associate who exemplify the research excellence, ideas, dedication, and vision of Anton Lang.

The awardees received an engraved rosewood piano finish clock, a cash reward, and their names have been added to a permanent award plaque located in the Plant Biology Laboratories.

Helping Plants Defend Themselves

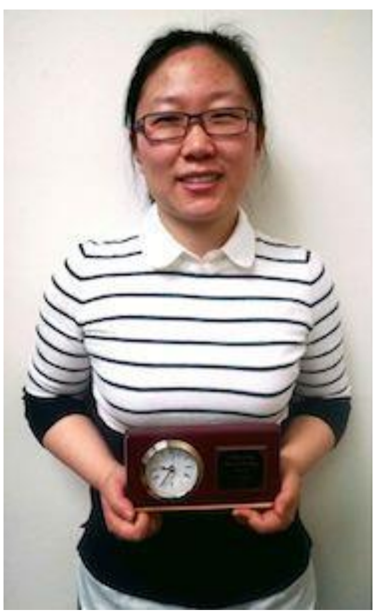


Figure 1 Li Zhang

Li Zhang and Ian Major both focus their research on plant defense. With plants facing increasing stresses such as climate change, pathogens and insects, and an increasing global population, **understanding the intricacies of plant defense mechanisms can help develop crops better suited to overcome these challenges**.

Both scientists have directed their attention toward the Jasmonate hormone, which plays a crucial role in activating plant defenses against insects. Zhang, a plant biology PhD candidate from China working in the lab of Professor and HHMI-GBMF Investigator **Sheng Yang He**, has focused on bacterial interaction with plants, specifically the pathogen *Pseudomonas syringae*. This bacterium secretes a toxin called coronatine, which activates the jasmonate signaling system in the plant. Normally, when a plant senses coronatine, it turns on its insect defense system, which, in turn, leads to downregulation of the plant's bacterial defense system activated by the salicylic acid hormone (*Fun fact: salicylic acid is that anti-inflammatory compound in over-the-counter aspirin and acne meds*). In other words, the bacterium hijacks the plant's defense system, fools it into thinking it is being attacked by an insect (which turns off the pathogen defense), finally allowing the invader to win the battle.

To help counter the attack, Li used a directed mutagenesis approach – a process in which an organism's genetic information can be subtly changed – to reengineer the cell receptor responsible for detecting coronatine. Ultimately, Li was successful in engineering a plant that is not only capable of maintaining a robust defense against bacterial pathogens, but that still maintains appropriate resistance to insect and pest attacks.

Zhang's results were published in the ***Proceedings of the National Academy of Sciences****.*

Figure 2 Ian Major

Ian Major, a postdoc hailing from Canada and residing in the lab of MSU Foundation Professor **Gregg Howe**, focuses on how the jasmonate hormone affects plant growth and energy capture. In one research project, Ian and his collaborators found that, when under attack, the plant's jasmonate signaling triggers rapid and persistent suppression of its own growth, but without a clear sustained effect on photosynthesis. **This challenges the idea that plants attacked by insects repress their photosynthetic activity as part of their defense response**, an idea that has been long taken for granted in plant biology circles.

"Think about it," Ian said, "it never made sense that photosynthesis stopped when the defense mechanism came up. The metabolic reactions for plant chemical defense need a lot of carbon, and it had to come from somewhere." Turning on the plant defense system instead diverts resources to protecting the plant, relegating plant growth mechanisms to the background. These results were published in ***Plant Physiology***.

During the awards ceremony, both recipients repeatedly diverted the attention from themselves, stressing the importance of collaborative work, one of the hallmarks Anton Lang instituted when he founded the PRL in 1965. Ian mused that, "Collaboration is a real strength of MSU PRL."

Figure 3 A full room in anticipation of the awards announcements.

Case in point, Zhang's work was done in collaboration with the Howe (insect defense) and **Yan** labs (computer modeling) within MSU and with the **Boland** lab in Germany (providing and analyzing the JA-Ile ligand). Major worked with the He (pathogen infection), **Kramer** (photosynthesis measurement), Chen (gene expression analysis), and **Sharkey** labs (gas exchange measurement), among others in the MSU and national science communities. "It was a requirement," Ian said. "My background is in defense, but I hadn't worked with photosynthesis. The ability to go across the hall and interact with experts in photosynthesis was a great asset. They helped me with training, testing, and data analysis."

Li confirmed this by adding that, "Collaboration with the Howe lab is very interesting. As we work in the same lab space, I can just drop in and get help almost anytime!"

It is this collaborative spirit which has allowed these significant advances to be made. Ian drove that point home: "If labs were isolated, we could not imagine or intellectualize the next challenges; we would not be able to discover things the way we do when working across plant fields."

PRL Welcomes New Communications Coordinator

4/13/16

Igor Houwat

PRL welcomes its new communications coordinator, Igor Houwat. Igor will be responsible for telling the stories of the PRL and conveying ongoing research in an effort to inform the scientific and general publics on the latest discoveries and events emanating from the 12 resident labs and the MSU community more broadly. He'll also strengthen and maintain relations with alumni in a program that is now 50 years old and boasts a strong relationship with the Department of Energy. He will additionally manage the PRL website content and design.

Igor, who hails from Brazil and Lebanon, is a Michigan State University alumnus with two MAs in Saxophone Performance and Ethnomusicology. He obtained a BA in Marketing from Ferris State University and has worked at local communications firm, MessageMakers. When not at the office, he's either spending time with his lovely girlfriend, Lauren, talking with his mom and sister from Lebanon, practicing his Kung Fu moves, reading, hiking, and when time allows, teaching himself mandarin.

Igor is looking forward to collaborating with the faculty and students, crafting communications and strategies, and he is very excited to learn about the research! To get in touch, call 517.353.2223 or email houwatig@msu.edu. Or, alternatively, he locks himself in his office and practices the oud (Middle Eastern lute); guaranteed he'll be there.

PhotosynQ Video Featured On The Food Fix Website

4/20/16

Igor Houwat

Greg Austic from the **Kramer Lab** is one of the leaders of the **PhotosynQ** platform that is attempting to bring the lab to nature. Most plant research happens in highly controlled lab conditions. Unfortunately, the plants that human beings care most about grow outside where weather, bugs, and animals all impact their growth and health. PhotosynQ aims to create a global community where stakeholders, including educators, researchers, farmers, and citizen scientists collect plant and soil quality data from a single, low cost, handheld device in order to **create and implement locally-based agricultural solutions**.

The **video below** was produced by the **Global Center For Food Systems Innovation**, which aims to find effective and scalable solutions for global food systems and which was an early supporter of PhotosynQ. In the video, **Austic** gives an overview of the platform and touches on:

- The sensor that allows to identify plant disease or yields estimations at a low cost of just hundreds of dollars per device. In comparison, larger companies such as John Deere spend billions of dollars to address similar issues.
- The online platform allowing for global information sharing and discussing.
- How local consultants, breeders, environmental activists, and science each benefit from and influence the platform's evolution.

Currently, PhotosynQ has over 1000 users and over 225,000 measurements collected from all six continents. The developers are planning a massive extension of the project over the coming year. Stay tuned for more.

https://youtu.be/uqmu0rvQhsA

Jin Chen to join University of Kentucky in July

4/25/16

Igor Houwat

Although Jin Chen thinks he has finally gotten used to the cold six years after his first Michigan winter, he is moving on to warmer pastures**.** Currently Assistant Professor of Computer Science and Engineering and also PRL's resident bioinformatician, Chen will join the University of Kentucky College of Medicine – Division of Biomedical Informatics as Associate Professor on July 1st, 2016.

Chen, who was born in Liyang, a small town in the eastern part of China about three hours from Shanghai, has been quite the globetrotter throughout his career. He obtained a Bachelors in Computer Engineering from the Southeast University in Nanjing, China. At that stage, Chen was interested in artificial intelligence, a traditional topic in his field.

"But in 2003, the human genome was sequenced. It was fascinating. Now, people had a book in their hands to tell the human genetic story, but they didn't know the meaning of each word within it." He saw a great opportunity to use his computing skills for the advancement of science. The realization led to a five-year move to Singapore, where he earned his PhD at the National University of Singapore, one of the top three Asian schools of its kind.

He later moved to the US for his Postdoc at the Carnegie Institution for Science at Stanford University - a continuation of his work at the intersection of informatics and biology - before he joined the PRL ranks in 2009.

Figure 1 Jin Chen

The main thrust of Chen's work at PRL has been to build a pheno-informatics program to collect, manage, organize, and analyze big data in plant biology. This tool allows researchers to dig into the vast stores of information to tease out any abnormalities related to natural variations or induced mutations in the plants, and how such abnormalities in plant phenotypes

– observable characteristics of organisms resulting from the interaction of its genotype with the environment - might be associated with changes at the level of DNA. A lot of the effort involves cleaning unwanted noise collected by the sensors or clustering multiple kinds of phenotype data of many plant genotypes.

Chen has had to build the bioinformatics infrastructure from scratch, as the data to be scrutinized is so unique that it could not be analyzed by any other existing computational tool sets. His first framework was built within the Kramer Lab, which has been his primary source of collaboration throughout his tenure at PRL. The program is now used more widely within the MSU community due to its success.

Throughout his career, Chen has published more than 50 papers and has been awarded a National Science Foundation: Advances in Biological Informatics grant in support of his work. **David Kramer**, Hannah Distinguished Professor in Photosynthesis and Bioenergetics, is Co-PI on the grant.

Chen's new position will take him back in time: “My brother is a physician. Moving from here to a medical school is influenced by him because he used to tell me a lot about problems in patient phenotype data within his field.”

We wish Jin Chen much success as he moves on to the next stop in his career!

Undergraduate Research Forum - Part 1/3: Hope Hersh

4/27/16

Igor Houwat

The University Undergraduate Research and Arts Forum (UURAF) provides MSU undergrads with the opportunity to showcase their activities in a public setting. According to the ***website****, "undergraduates gain experience in presenting their research, answer questions about their work from audience members and guests, and receive constructive feedback from judges." Judges interact with presenters& at random to ensure research is solidly understood. The best presenter in each category in each of the three sessions wins a $100 award.*

Not all paths to plant biology are straightforward. Some start from childhood, playing in the dirt or living on farms. Others, like Hope Hersh, travel a path less obvious. Hope, who hails from neighboring Howell, originally wanted to attend medical school at Michigan State University, and lab research, no matter where, was a required stepping stone. She ended up in **Christoph Benning's lab** in the Plant Biology building, "washing dishes and doing lab maintenance" as she bided her time.

Figure 1 Hope attending to her plants

A year later, she was assigned to a postdoc for a semester and had the opportunity to get her feet wet. "I fell in love with it. That's what I really wanted to do. So when the postdoc left, I asked if I could stay on, and they found me a place with another graduate mentor." Fast forward: currently four years into a double bachelor in Biochemistry and Plant Biology, Hope wants to get a PhD in Biochemistry, and at MSU, if she has the option.

Hope's UURAF presentation focused on the *SFR2* gene (*Sensitive to Freezing 2*), discovered in the Benning lab, that could be key in revolutionizing how crops are grown. The implications are significant in the context of a global population growing at the rate of 200,000 people a day and facing food shortage problems. Usually, freezing quickly draws water out from plant cells. This dehydration causes the cells to shrink and eventually collapse into themselves and then burst after thawing, when the water rushes back in. SFR2 is activated in response to freezing in order to create a protective layer around chloroplasts, small bodies in plant cells that are the site of photosynthesis. **If the chloroplasts were not protected from freezing, plant cells would not recover, as they would lose their ability to photosynthesize**.

Studying the plant anti-freeze system

Hope's project is part of a larger effort within the Benning lab to examine whether SFR2 responds to other dehydration stresses than freezing, such as extremes in temperature and salt content (These dehydration extremes, low or high, similarly affect us humans). She has focused her search onto the effects of high salt content to understand if and where the SFR2 gene comes into play.

Generally, gene expression of SFR2 is modified through genetic engineering techniques to optimize the activity of the gene. This is analagous to what plant breeders have done for millennia with crop cross-breeding, except, breeding is more time-intensive than genetic engineering.

"Imagine the implications," Hope exclaims. "In our experiments, we are working with tomatoes because they are important agricultural crops. Even though they have the SFR2 gene, they are still sensitive to freezing. Does that mean that SFR2 is not functioning properly in sensitive plants as tomatoes, or could it be that SFR2 functions to combat other types of dehydration stresses in tomatoes, as I am examining? We're not sure yet. If we understand how the resulting protein functions and can properly implement it, our plants would be theoretically resistant to extreme weather and environmental conditions and could grow anywhere! That's huge!"

Hearing her speak, it is not hard to imagine rows of tomatoes growing robustly in a snow-covered Midwestern field. Weird, but tantalizing.

Bringing the lab to the public

Although the PRL is geared towards **graduates and postdocs**, Hope is among many undergraduates learning the ropes in a nurturing environment. **Beronda Montgomery**, Professor at the PRL, notes that, "The PRL is the sort of place you can do collaborative cutting edge research while incorporating excellent training and mentoring so that students can continue the work in the future. It is the fabric of who we are."

Hope's graduate student advisor, Kenny Wang, usually assigns her projects that double as educational experiences and contributions to the lab's research goals. Their working relationship has flourished as a result of Hope's dedication and Kenny's mentorship. "The work flows so well between us," Hope says. "We can understand each other at a glance. He's become like an older brother to me."

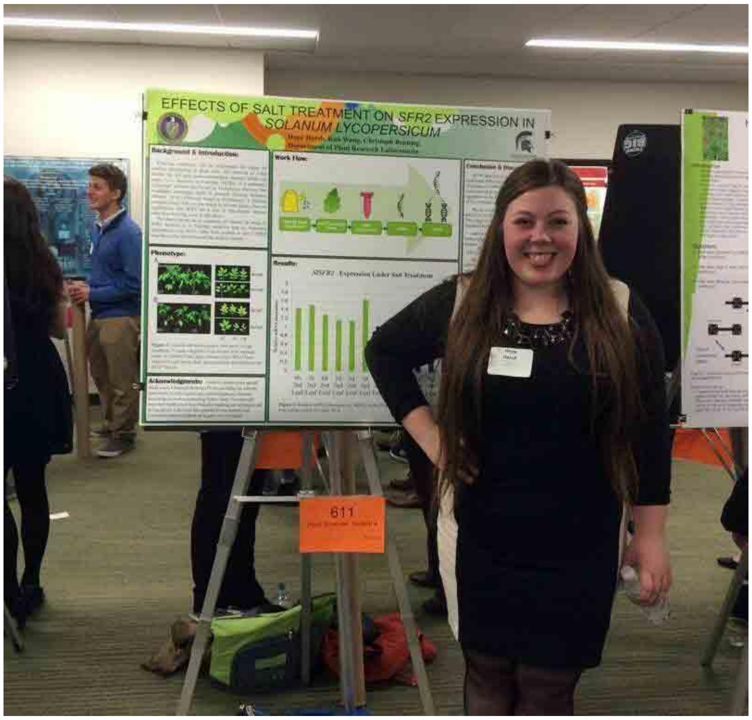


Figure 2 Hope's poster.

The UURAF was Hope’s first time presenting to the general public. “I had done it one-on-one or in a classroom. But at the UURAF, there were so many people, and the atmosphere was chaotic. I was super nervous going into it, but I settled in after the first presentation.” Hope shared her knowledge with postdocs, parents interested in tomatoes, advisors from various departments, and fellow students. She particularly enjoyed interacting with people who knew nothing about biology. “It required a lot more explaining,” she remembers. “I practiced a lot beforehand in front of my boyfriend, and he’s not a scientist. I found that teaching others is really different than writing something down, and I ended picking up a lot of analogies to get the message across.”

Her advice for future presenters? “Know your research inside out, and then you get to show your passion! I was so excited to share something that could potentially change how tomatoes and other crops are grown. And the judges definitely saw that.”

PhotosynQ's first workshop a success

5/4/16

Igor Houwat

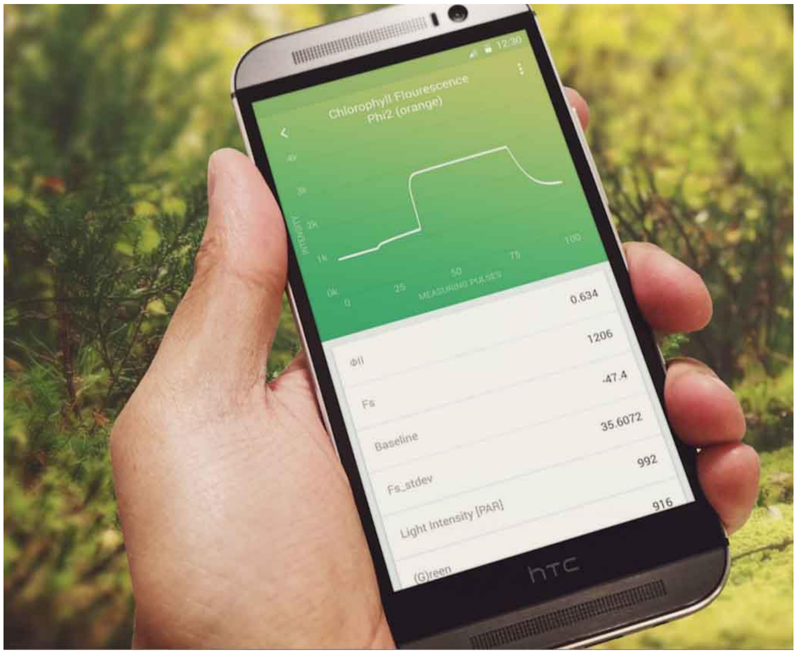
The Kramer lab is itching to take basic science research to the next level, and they know they are on to something big. The lab hosted its first all-day PhotosynQ workshop on April 22 at the MSU Molecular Plant Science Building to share insights into the technology in addition to real world applications**.** It was an intense event, and participants were buoyed by the ripples of passion and joy as Kramer and his group opened their arms to around 100 attendants from the university community and the private sector.

So, what is PhotosynQ?

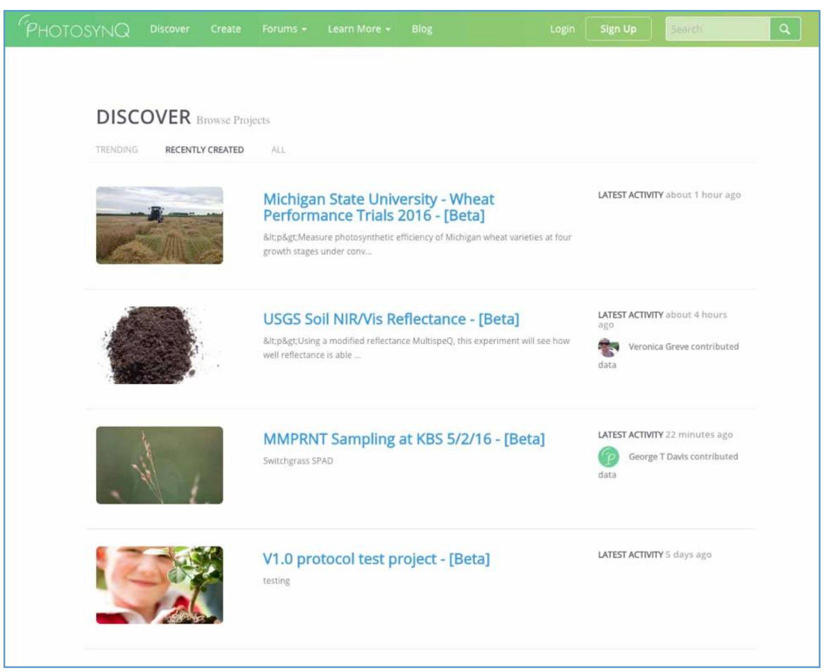
PhotosynQ is a platform that allows educators, researchers, farmers, and citizen scientists to collect plant and soil data from a low cost and easy-to-use handheld device; analyze it as a community in order to better understand how plants function in nature, as opposed to controlled lab experiments; and ultimately create real world solutions based on acquired knowledge. As **David Kramer**, Hannah Distinguished Professor in Photosynthesis and Bioenergetics at the PRL, likes to say, “we are finally bringing the lab to field… and vice versa.”

This is how PhotosynQ works, in a nutshell: Users collect plant data with the MultispeQ device developed by the Kramer lab, measuring anything from light levels, photosynthetic efficiency and chlorophyll levels to soil moisture and seed mold, among other parameters. The MultispeQ cost ranges in the hundreds of dollars, but it can outperform more expensive machinery, largely solving accessibility issues.

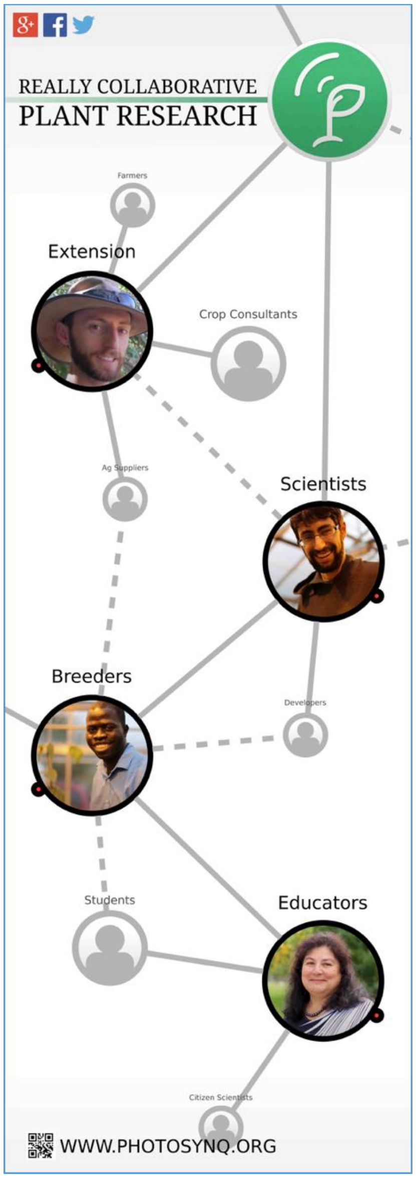
Data from the device is then automatically uploaded to a website, also developed by the lab, via desktop or android devices, where users can create research projects and analyze the data via a rich web interface.



The magic really happens when other subscribers interact with project researchers – sometimes on the opposite side of the globe – to answer questions they might have about their data. For example, **a farmer in Africa could ask a question about soil quality on his land, and dozens of people around the world would be able to answer and also to gain insights into their own work**. Or a high school teacher could use the platform to teach her students basic concepts in the field that complement textbook learning.



The device technology and the website are open source by design and the data publicly available. Plant scientists at the PRL additionally have access to that rich store of data of plants in vivo – previously impossible to do at such a global and extremely affordable scale.



It's an educational win-win for all involved, inspiring another observer to dub PhotosynQ the "**Facebook of plant science**." (Note: PhotosynQ is the platform, MultispeQ is the data-collecting device.) In three short years, PhotosynQ has grown from a small project in Kramer's lab – which includes a unique blend of computer programmers, engineers, and plant biologists – to a global network of researchers with a diverse set of skills and goals. Over 300 devices have been produced, with 227,000 data points uploaded to the website from over 1100 users, which has already yielded wondrous discoveries about plant activity.

For example, measurements with the freshly minted MultispeQ 1.0 during the early stages of plant growth have correlated with later crop yields; ultimately, the team hopes to reach the point they could use such measurements to forecast yields well in advance. This might allow farmers to better predict income, storage space, transportation costs and more far ahead of harvest season and in spite of crop growth challenges such as weather and light fluctuations, disease, and malnutrition.

Sharing the platform with the public

The **PhotosynQ workshop** fell under the wider goal of increasing access to the MSU community and beyond through informational talks, interactive events, device demonstrations, and micro grants for interested applicants. The keynote speech by Kramer was an exciting and widely accessible matter, reflecting that desire to share the technology with scientists, whether professional or amateur.

Figure 1 Kramer speaking to the audience

He specifically invited participants to take control of the platform for their purposes, a mantra often repeated throughout the workshop. Kramer also noted that basic researchers, who made up a majority of the audience, could potentially acquire a tool that could help articulate the connections between basic research and real world applications, an issue they routinely struggle with.

Dan TerAvest, a post-doc at the Kramer lab, **followed up with a success story from Malawi, a country with a population of 16 million people and one of the poorest on Earth**. Most farmers live on small parcels of land, and yields are low due to to lack of agricultural resources and knowledge. Working alongside farmers and researchers from the government, a local university and the private sector, Dan's efforts have led to the collection of over 40000 data points which have aided Malawian scientists and plant breeders who are working with farmers to increase food production without putting too much pressure on the environment. Dan has also created a collaboration with a Malawian entrepreneur who is on the ground consulting with interested parties, which takes the burden away from the PRL training future Malawian users remotely. The success with which PhotosynQ has been adopted in Malawi is being used as a template for expanding PhotosynQ to other countries, with PhotosynQ expanding, or planning to expand, to Zambia, Uganda, Kenya, and Botswana.

Figure 2 Visitors roaming the exhibit

The afternoon breakout sessions invited observers to contribute insights into how PhotosynQ can further evolve. A major highlight was the **education session, with a heated discussion on how to adapt the platform for high schoolers and undergraduates**. **Greg Austic**, PhotosynQ co-founder, observed that the conversation focused on how to tease out genuine scientific contributions from student projects while adding to their scientific education. He anticipated that such technology could potentially pull students (and teachers) up to the bleeding edge of science early on in their educational development.

"The answers are often murky (at best), the MultispeQ equipment is prototype, and even the measurements can be unproven. Is this too abstract a method to learn anything concrete, or are we showing students, as early as possible, the 'reality' of science? I think this is a question that PhotosynQ and many other projects will run up against as science education changes in the next 20 years." In order to help answer those questions, the Kramer lab has recently formed a PhotosynQ education group which is already preparing for its first test undergraduate workshop in June.

Figure 3 Afternoon session showcasing Photosynq tech breadth

Yet another afternoon highlight was a breakout session focusing on technological applications branching out from the MultispeQ, such as the **CoralspeQ** (underwater data on coral reefs), GrainspeQ (grain), and SoilspeQ (soil). Elsewhere, a cluster of sessions focused on "how-to" subjects ranging from how to use the MultispeQ on the field to a session walking the audience through the intricacies of creating a PhotosynQ project online.

Upcoming horizons

2016 has been a landmark year for the PhotosynQ group. Production on the improved MultispeQ 1.0 will kick into high gear soon, with thousands of devices expected to ship worldwide. The workshop was the first of more to follow. According to Austic, "We've been to many conferences where we present PhotosynQ as a concept, but those always require a refined pitch lacking critical details needed to understand the big picture. In contrast, the first true PhotosynQ workshop allowed us to lay out the full picture - including the science, applications, and how PhotosynQ fits into a broader Open Science Hardware movement."

And the private sector has noticed. TerAvest mentioned a number of successful partnerships over the platform's three years of existence, including **Brandon Bioscience**, a company in Ireland that is using PhotosynQ to evaluate products that boost plant health, and Tree Preservation Australia, which is using PhotosynQ to rehabilitate trees in urban areas.

Figure 4 PhotosynQ's global reach

Newly interested private companies came out to try the technology on April 22, including a Grand Rapids company that uses LED lighting to improve plant yields for high-end agricultural products, and **Syngenta**, the largest agricultural company in the world with $15 billion in annual sales in over 90 countries. In fact, Rick DeRose, Syngenta's Global Expert for Technology Acquisition, met Kramer at a conference only two weeks prior to the workshop and saw an opportunity to enhance his company's data mining strategies.

"Anything that can take breeders' qualitative data and quantify it is interesting to Syngenta, as it improves data quality," DeRose said. "We are also very focused on emerging agriculture, for example, having invested up to $1 billion in Africa alone." (The strategy stems from Syngenta's belief that Africa has the resources to feed its own population and also to become a major world food exporter.) The shared interest in data and emerging economies had DeRose positing Kramer and Syngenta were philosophically aligned on how agriculture needs to move forward.

Although DeRose admitted that there were a few more kinks to work out before the device is industry ready, he has caught the PhotosynQ bug: "Kramer is a rare commodity in that he marries three things in one person – physics, physiology and engineering. PhotosynQ would have been impossible to develop without this mix. In fact, if Syngenta were doing this research, we would take the same steps, and even though the Kramer lab are still identifying the correlations among agronomical traits, they are dead on target to get there, and soon."

Update on May 13, 2016: For a visitor's perspective on the workshop, **visit The Science Writer's blog post.** Jasenka has received many positive comments in response, even some inquiries on how to order the MultispeQ.

Undergraduate Research Forum - Part 2/3: Donna Liebelt

5/6/16

Igor Houwat

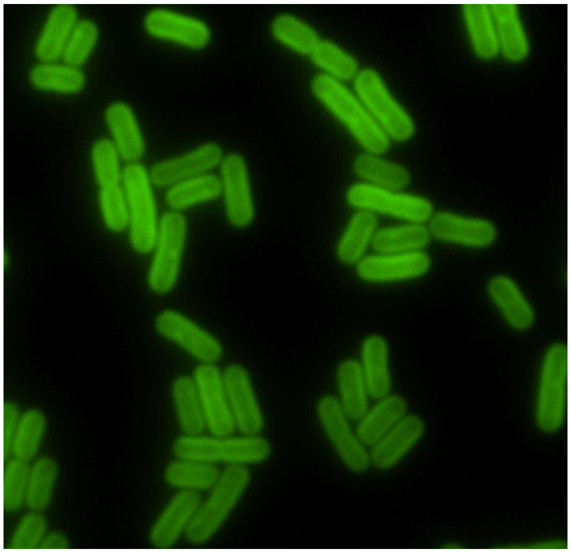
*The University Undergraduate Research and Arts Forum (UURAF) provides MSU undergrads with the opportunity to showcase their activities in a public setting. According to the **website**, "undergraduates gain experience in presenting their research, answer questions about their work from audience members and guests, and receive constructive feedback from judges." Judges interact with presenters at random to ensure research is solidly understood. The best presenter in each category in each of the three sessions wins a $100 award.*

Although Donna Liebelt admits she is scared of sharks, she has no problems tackling *E. coli* with the best of them.

Donna, originally from New Jersey but raised in Allegan, MI, is an undergrad working towards a degree in Biochemistry and Molecular Biology with a Plant, Animal, and Microbial Biotechnology minor. She joined the **Ducat lab** in April of 2015, leading to the work that netted her a first prize at the UURAF. Her research is part of the lab's thrust to build tools that allow scientists to create alternative fuel sources out of photosynthetic organisms, **cyanobacteria in particular**.

Cyanobacteria: miniature energy factories

Anyone who has ever looked outside their car window as they drive through the Michigan countryside will not be surprised to know that there are thousands of years of technology associated with crop plants – anything related to breeding, watering, fertilizing, seeding, growing, etc. – so they can efficiently provide us with food, recreation, and energy.



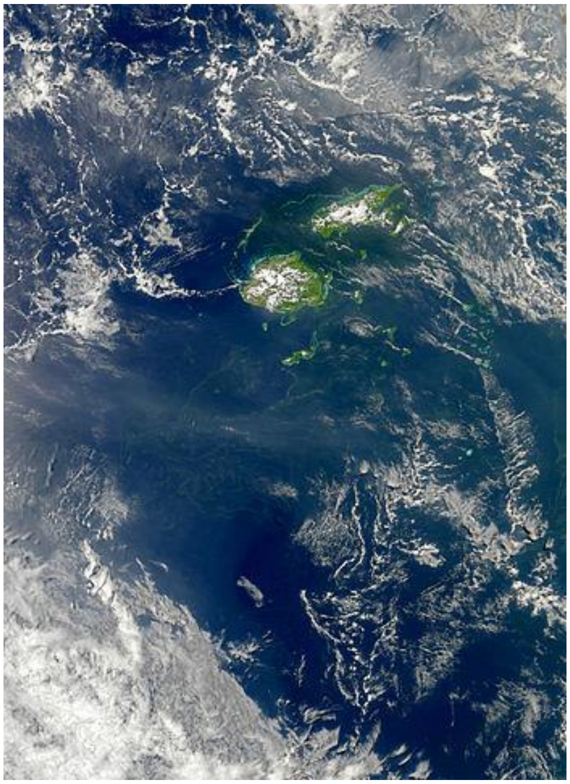
Cyanobacteria as under a fluorescent microscope: each is 3 microns large, 25 times smaller than a human hair.

Recently, however, there is a growing interest in **using cyanobacteria as an alternative photosynthetic organism to provide us with useful compounds**.

Cyanobacteria, otherwise known as blue-green algae, are no neophytes, having successfully survived for billions of years, and even though the research into their cultivation is still fresh, we do know that these microscopic and relatively simple organisms are prodigious energy factories.

Theoretically, cyanobacteria have potential advantages over plants in terms of better photosynthetic efficiency, energy production, and environmental adaptability, as they can thrive in locations hostile to plants and can grow in areas lacking fresh water or arable soil; there have even been observations of healthy specimens clinging to the edges of hot springs or iceberg walls.

When light hits the cyanobacteria, photosynthetic mechanisms are used to transfer the energy contained in these photons to electrons that are stripped from water. These electrons are passed through natural pathways in the cell and used to generate the energy powering cell growth and survival. The Ducat lab is trying to coax these electrons into traveling alternative, engineered pathways so that they could ultimately provide humans with a synthetic "green" energy source.



Another view from space of cyanobacteria, the green filaments, by Fiji By **NASA Earth Observatory**, Public Domain

Undergraduate award winning research

To accomplish this, Donna and other lab members are **looking to alternative pathways to move electrons around in the cell that could be used as a separate path in addition to the photosynthetic pathways found in cyanobacteria**. Enter *E. coli*. This notorious bacterium is known for causing many a bout of severe food poisoning and food recalls, urinary infections, and even meningitis in the less fortunate. Truth be told, most strains are harmless to us (very much like most sharks). *E. coli* is also one of the most well-studied bacteria, has many genetic tools, and therefore is a great testbed to develop new engineering strategies.

The concept Donna is working with is that *E. coli* naturally makes some electron carriers that might be added to those found in cyanobacteria, potentially providing alternative “side routes” to move electrons and power metabolic processes in cyanobacteria for our predetermined uses.

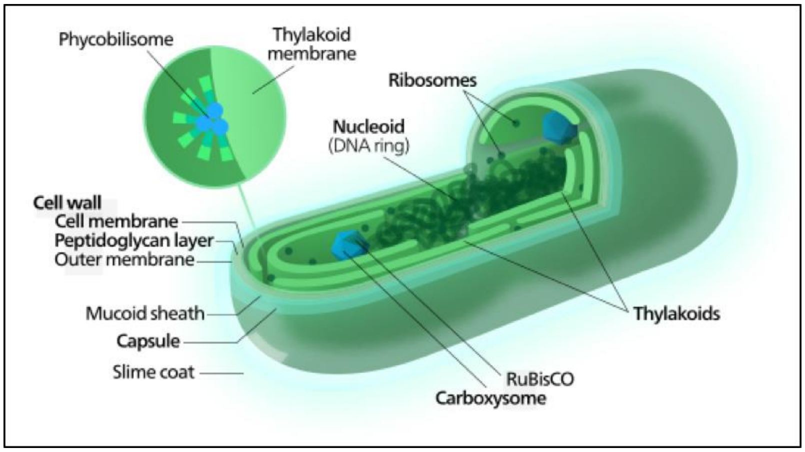


Diagram of a cyanobacterium By **Kelvinsong**, CC BY-SA 3.0

The alternative electron transfer pathway in *E. coli* (and also cyanobacteria) is found in the far edges of the cell, near the cell wall (the dark green outer shell in the diagram), and is made up of a protein with iron, called a cytochrome. Cytochromes carry high-energy electrons from a donor to a receiver – think energy delivery man. They are not naturally formed inside the cell because the enzymes that are responsible for developing them are found outside of the cell membrane. Donna is trying to move these enzymes to the center of *E. coli* to see if cytochromes can be developed inside of the cell instead, as that is where the electrons to be carried are located, making energy transfer a more efficient process.

If and when she succeeds, she will work with her lab on transferring this new pathway back to the cyanobacteria for application. The long-range, “blue-sky” idea is that these cytochromes could then act as a new electron carrier in cyanobacteria: able to accept the electrons generated from photosynthesis and deliver them to alternative metabolic pathways that drive the production of useful compounds, like biofuels.

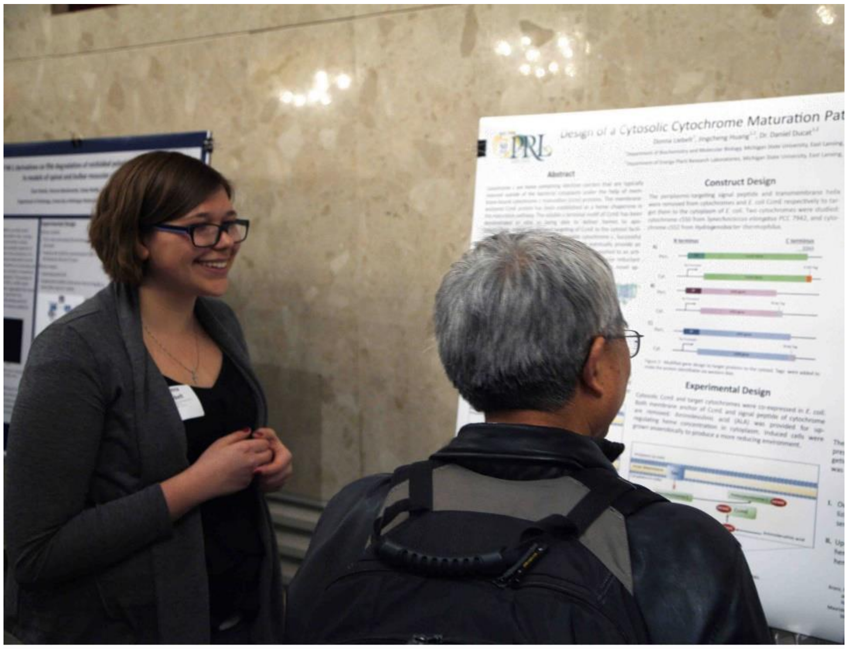
Creating the scientists of the future

Donna’s role as an undergrad at the PRL benefits from a **culture valuing both cutting edge plant research and a nurturing environment for future scientists**. Undergraduates usually work under **graduate student mentors** who guide their educational development and assign educational experiments that contribute to lab research goals. Donna is mentored by Jingcheng Huang, a graduate student from China in the Ducat and **Kramer** labs.

Donna is very appreciative of the opportunity to work with Jingcheng, saying that, “he really encourages independent thought by asking targeted questions, guiding me to an answer without giving it directly. He also challenges me to think independently in order to design my experiments, but when I run into obstacles along the way, he is there to help me solve them!”

Donna is also gushing of Ducat’s influence on her undergraduate career: “There are not enough words to express my appreciation of Dr. Ducat. In addition to being supportive, he makes me feel that each progression in the project, even if a setback, is a celebration in my growth as a scientist.”

Ducat has opened her up to new educational opportunities that were not previously on her radar, such as the UURAF, which she considers very valuable for her development. In addition to the direct benefits to her current project she has gotten from interacting with visitors, one of the main lessons Donna has gleaned from her poster presentation is how to verbally communicate scientific research to diverse audiences, a critical component of scientific engagement with the public.



Donna presenting her poster
Courtesy of Donna Liebelt

She remembers recurring questions during her presentations which indicated parts that needed to be clarified. “At first, I struggled with explaining my project in a way that was specific to the audience,” Donna says. “UURAF visitors had very diverse backgrounds. I would have undergraduates, graduates, and professors around at the same time, so I had to cater to the needs and backgrounds of each of them. Throughout my session, I learned how to read audience expressions, which helped me identify which concepts I needed to elaborate on.”

At first, Donna was shocked to find out that she won the award for her presentation. She insists though that, "There were many behind the scenes that helped me prepare by proofreading, giving suggestions on the poster, and listening to my delivery (repeatedly) until it felt right. It feels amazing that I took something I'm extremely excited about and get other people excited about it too.”

Congratulations to Donna from all of us at the PRL!

Undergraduate Research Forum - Part 3/3: Michael Das

5/12/16

Igor Houwat

*he University Undergraduate Research and Arts Forum (UURAF) provides MSU undergrads with the opportunity to showcase their activities in a public setting. According to the **website**, "undergraduates gain experience in presenting their research, answer questions about their work from audience members and guests, and receive constructive feedback from judges." Judges interact with presenters at random to ensure research is solidly understood. The best presenter in each category in each of the three sessions wins a $100 award.*

Michael Das is a Biochemistry and Molecular Biology undergraduate student in his third year at MSU. He joined the **Howe lab** in February of 2015, where he has primarily worked under Koichi Sugimoto, a postdoc from Japan, in order to understand how plant defense mechanisms have evolved.

Tomato defenses against insects

Plants have developed two strategies to protect themselves against insect herbivores and other pests: inducible defenses which are activated only when a pest is attacking the plant, and constitutive defenses which are produced continuously throughout the plant's life.

Tomato species exhibit both these strategies to protect themselves. A classic example of an induced defense are proteinase inhibitor proteins: when sensing an insect eating them, the plant produces proteins that bind to the insect's digestive enzymes, causing reduced food digestion and loss of nutrients needed for the animal to survive. Constitutive plant defenses include such mechanisms as thorns and trichomes, the latter hair-like structures that cover plants and that secrete toxins and repellents.

Trichomes, dangerous ground for miniature herbivores.
By **incidencematrix**, CC BY 2.0

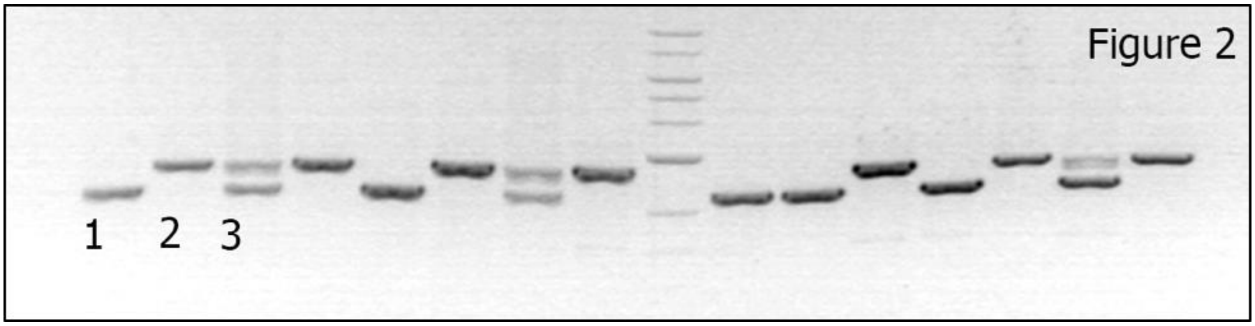
Although cultivated species have similar genetic makeups to their wild counterparts, their defense mechanisms have evolved differently over time. For one, domesticated tomato has lost many of its anti-insect defenses, and little is known about how this has happened. There are also cases, however, where defense mechanisms are stronger in the domesticated species. The Howe lab is examining these differences to understand fundamental principles of how plant defenses evolve.

Michael's project, in specific, is part of a wider effort to determine how inducible defense mechanisms developed in wild tomato species and their domesticated descendants. One common way of going about it is to find the progenitor line of wild tomatoes – to the best of our knowledge – and to identify their defense mechanisms in order to infer what has been weakened or strengthened during the domestication process.

Michael is looking at a particular gene called *ARG2 (arginase 2)* responsible for an induced defense strategy. When the plant senses it is being eaten by a caterpillar, *ARG2* is activated to produce an enzyme that depletes an essential nutrient – the amino acid arginine – in the caterpillar gut.

Michael conducted an experiment in which he cross-bred a wild tomato species that has weak ARG2-based defenses with a cultivated species that has strong induced expression of ARG2. (Interestingly enough, the wild species has strong trichome-based constitutive defenses while the cultivated plant is weak in that regard.) He then examined the progeny from this cross to identify genetic factors involved in the expression of ARG2.

Preliminary results, presented by Michael at the UURAF, indicate that the gene itself is significantly different between the wild and domesticated tomato species. Specifically, the DNA sequence variations have a strong effect on whether or not this inducible defense is activated in response to a threat.



Zooming into tomatoes at the genetic level

It's still unknown why ARG2 is stronger in the cultivated species. "Perhaps it is a necessary anti-insect function for cultivated species," Gregg Howe, MSU Foundation Professor at the PRL, speculates, "but presumably the wild species does not need that function because it has a strong trichome (constitutive) defense. We just don't know yet."

The implications beyond the lab are exciting. In fact, one major breeding technique is to identify desirable traits in wild plant species and then to breed those traits into cultivated crops, while avoiding undesirable characteristics from wild lines (for example, wild tomatoes can come in small sizes or not be very tasty). This process takes time and much trial and error. The identification of novel genetic factors that control inducible plant defenses – including *ARG2*, among many other defense genes – might facilitate the future breeding of crops that use the best from both worlds in order to stand up better to insects.

Practicing presentation skills early on

A major UURAF goal is to allow undergraduates to practice presentation skills in a public setting. Michael acknowledged as much, given this was his first participation in such an event. “I think that the biggest benefit to the UURAF was experiencing the presentation aspect of research. I previously had only been involved in lab work and discussing the project among my peers. The UURAF forced me to think about the project from the perspective of people who did not already know about it.”

Michael in front of his poster at the UURAF

Much like **Hope** and **Donna**, PRL undergrads who also attended the UURAF, Michael took a while to hit his stride. But following multiple iterations, he noticed that he felt a lot more confident and the presentations were a lot smoother. He added, “I feel like the UURAF will help me settle in a lot quicker the next time I go to a similar event.”

Michael, originally from Farmington, MI, plays the trombone in his free time, and when he isn’t in the lab, he is with the MSU marching band supporting Spartan football. “I’ve been doing it for three years now. My last year will be this coming fall - hoping for a good bowl trip to top it off!”

Cheryl Kerfeld featured in MSU President's 2015 Report

5/17/16

Igor Houwat

Banner image by Harley J Seeley

Little did **Cheryl Kerfeld** know that when she got a phone inquiry into her research last fall, she was being interviewed as a prospective profile for Lou Anna Simon's 2016 President's Report.

The recently released document promotes Michigan State University's research abilities in a series of short video pieces. The focus is on those researchers anticipating future challenges and creating solutions towards a sustainable, healthier, better nourished, and safer world in such areas as bioenergy, food security, and public health, among others.

Kerfeld's video, **seen below**, introduces her lab's contributions to the development of sustainable energy sources and other "green" commodities by bioengineering microbes, tiny organisms such as microscopic algae that use solar energy and CO2 as raw materials.

Kerfeld is one of those scientists that puts much effort into communicating with a general audience. The need is pertinent in her field of synthetic biology which is rife with public misinformation; the resulting fears have led to the conjuring of dystopian futures in popular imagination – think miniature robots invading our bodies and streaming through our blood vessels to get a picture of what has been dreamt up.

These nightmares are far from reality. The discipline is much simpler and rests on finding parallels between engineering principles and the inner workings of living systems. And of course, much trial and error in the lab. "It is important to show how synthetic biology works," Kerfeld says," in order for it to be accepted and seen for the good it can do by the public."

A little known fact is that Kerfeld has Masters and Bachelors degrees in English literature, which very likely helps her in communicating her work. Her style relies on an abundance of vivid metaphors that depict the invisible architectures built in the Kerfeld Lab in graspable macroscale terms**.**

In fact, the piece turned out so polished that the President's Office had people phoning in to see if she was really a scientist and not an actor. See for yourselves.

Go here for the 2015 President's Report website.

https://youtu.be/2oMz6g7tpwQ

Brandizzi Lab awarded an NSF grant for corn research

5/23/16

Igor Houwat

The **Brandizzi Lab** has won a 3-year **National Science Foundation** grant towards studying environmental stress effects in corn. The award will fund a collaboration between Iowa State University, The University of North Carolina, and MSU-DOE Plant Research Laboratory (PRL) for an amount of $3.5 million, approximately $700,000 of which will go to the PRL. The PI is Dr. Stephen Howell from Iowa State University, and Dr. Federica Brandizzi will be one of three co-PIs. *(For information on graduate and undergraduate positions,* ***go to the end****.)*

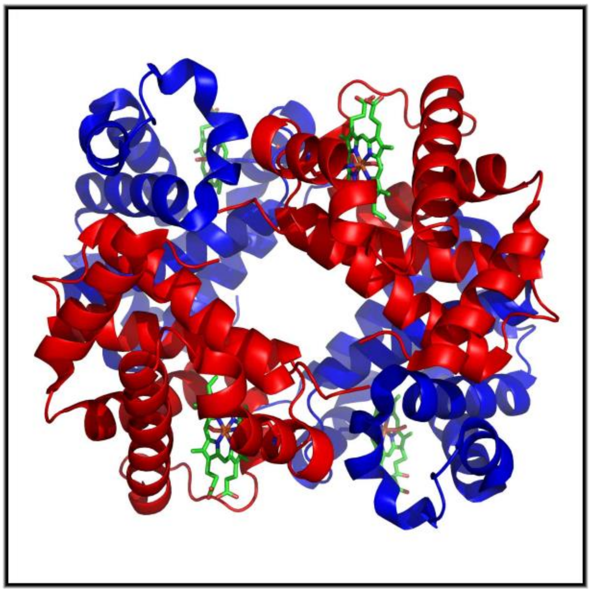
Plant stress is one of the major limitations currently preventing crops from achieving their yield potential. Stresses such as drought, extreme temperatures, and high salt content result in some of the greatest crop losses worldwide, estimated at billions of dollars.

Corn in particular is of interest due to its ubiquity in US food, feed, and fuel supply systems. **We know that corn undergoes a lot of heat stress during growing season, with severe negative effects on these crops**. Corn yields usually increase up to temperatures reaching 29 C/84.2 F. Any temperatures beyond that threshold are very harmful, and the losses in yield are much steeper beyond that threshold than the increases below it.

The USDA estimates there are more than **90 million acres of corn plantations in the US alone**. With the looming prospect of global warming and the uncertainty it will impose on US and global food security, it is easy to see the urgency of improving corn and, in general, plant resistance to adverse **environmental stressors such as heat**. Beyond obvious and highly visible green solutions that should lead to a cleaner environment and more sustainable food systems, there are ways in which these plants can be genetically encouraged to better cope with the challenges they are bound to face.

How corn protects itself

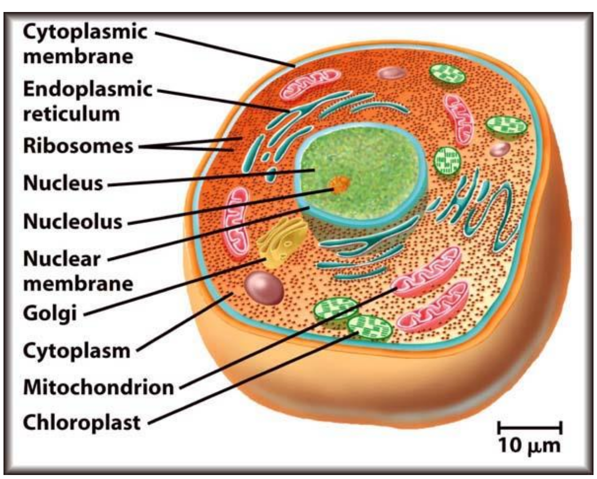
Plants contain complex networks of communication and trafficking in order to properly function.



A protein, in this case, "blood."
By **Zephyris**, CC BY-SA 3.0

Within each plant cell, there is a massive manufacturing facility called the endoplasmic reticulum (ER) which produces and provides quality control over many of the plant's proteins, the so-called building blocks necessary for life. In specific, proteins have to be folded into precise 3D structures during production. Only then can they perform their biological functions, be it for energy generation, growth, defense, etc.

After undergoing production and inspection, these proteins are sent over to the Golgi apparatus – which works like a post office – where they are "finished," packaged and shipped off to the appropriate destinations within the plant cell.



The ER and Golgi apparatus connect the nucleus, the mastermind, to the extremities.
By **AJ Cann**, CC BY-SA 2.0

Extreme stressors, such as heat, can negatively affect this system and lead to the production of misfolded or unfolded proteins that are useless to plants. There is a mechanism within the ER, called the unfolded protein response (UPR), by which plants perceive and respond to these conditions. When there is an accumulation of defective proteins in the ER, the system becomes overloaded. This situation activates the UPR, which then triggers genetic functions that restore normal performance, by temporarily halting protein production to stop the train wreck, clearing out the badly formed proteins, and signaling the increase of production of new and well-formed protein structures.

Out of the lab, into the ground

The NSF project goal is to better understand how the UPR functions in corn and to examine genetic ways of increasing resistance to environmental stressors.

Not much is known about how the relevant genes interact to successfully activate the UPR. (In contrast, these have been well studied in animals.) Consequently, the grant team will conduct research on the corn UPR response both in the lab and in two fields at the University of North Carolina and Iowa State.

By **Jereme Rauckman**, CC BY 2.0, 2014

Increasing this body of knowledge has both scientific intellectual and real world implications. For one, understanding how corn's visible (physiological) and invisible (molecular and genetic) traits correlate could explain how ER stress can affect important plant characteristics such as seed weight or yield. For example, it has been already discovered that the UPR is deeply entwined in plant cell makeup and development.

On a more immediate scale, however, understanding those UPR genes could lead to the bioengineering of plants that do better Jiu jitsu in stressful situations. In specific, the grantees are interested in increasing the UPR's reactivation of new protein production after undergoing "stress treatment" or optimizing how the UPR degrades damaged proteins.

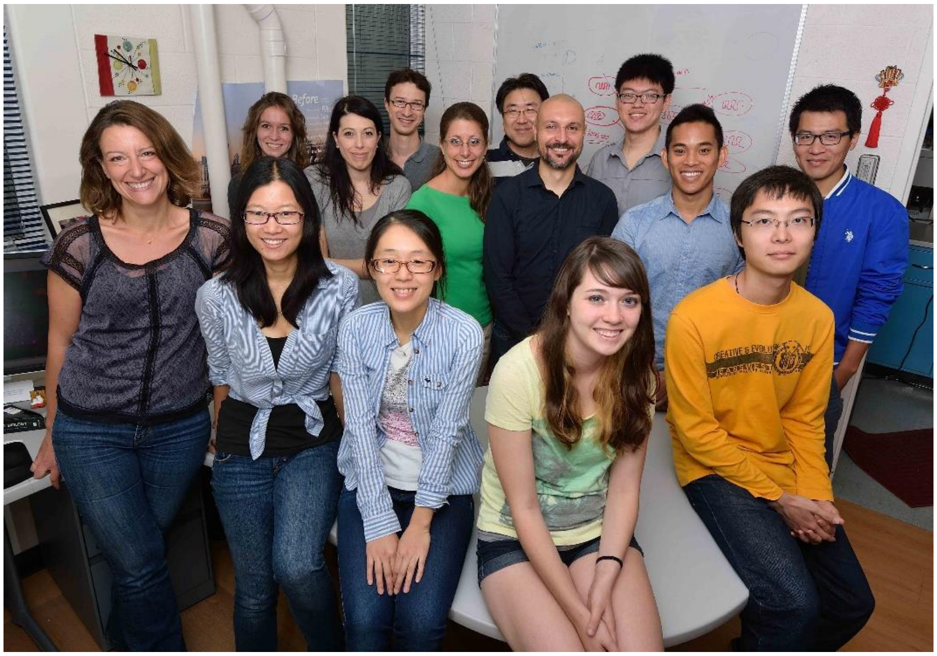
All this aims towards increasing corn production efficiency. Even tiny increments towards this goal, as small as 1% to 5%, have massive effects on productivity (keep in mind those 90 million acres of corn plantation in the US alone), with potential improvements in such areas as food supply or biomass generation for those well-advertised green solutions inundating our collective consciousness, from POTUS speeches and government policy, to social media and everyday conversations.

There will be new graduate and undergraduate positions throughout the duration of the grant. For more information, visit PRL's ***graduate page*** *in addition to Dr. Brandizzi's* ***faculty*** *and* ***lab*** *pages. For inquiries, contact Dr. Brandizzi at* ***fb@msu.edu****.*

Brandizzi Lab celebrates 10 years at MSU

5/31/16

Igor Houwat

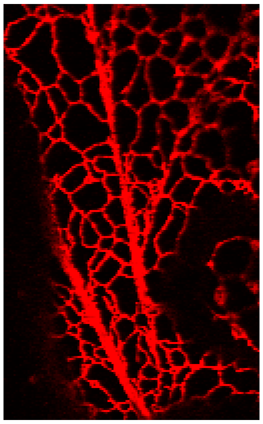


Banner image by Harley J Seeley Photography

The **Brandizzi Lab** is celebrating its ten-year anniversary at MSU this May under the leadership of Dr. Federica Brandizzi, MSU Foundation Professor at the PRL.

Brandizzi's research seeks to understand how plants produce materials of many kinds and **resist stress on Earth and in space environments**. She has focused on critical plant cellular organs, called organelles, that build the cell, allow it to grow, and enable it to respond to external signals**.**

In specific, and with the aid of numerous and enthusiastic mentees in her lab, she has looked at the endoplasmic reticulum, a massive manufacturing facility that produces most of plant proteins, and the Golgi apparatus, the post office that receives, finishes, and ships those proteins to the right destinations within the cell. In support of studying such plant organelles in live cells, Brandizzi has pioneered the implementation of an advanced imaging technique, confocal microscopy, which enhances the quality and quantity of information that can be gathered in cells through a microscope.



Gorgeous endoplasmic reticulum as seen with a confocal microscope

It is important to understand how the endoplasmic reticulum and the Golgi work, since they allow us to produce the foods that we eat, in addition to other useful things including, clothes, oils, construction materials, and precursors for biofuels. "Plants are major players in the biotechnology boom and hold great promise for production of a wide range of compounds," says Brandizzi. "If we are to make best use of plants as living factories, we must understand the mechanics of the production process."

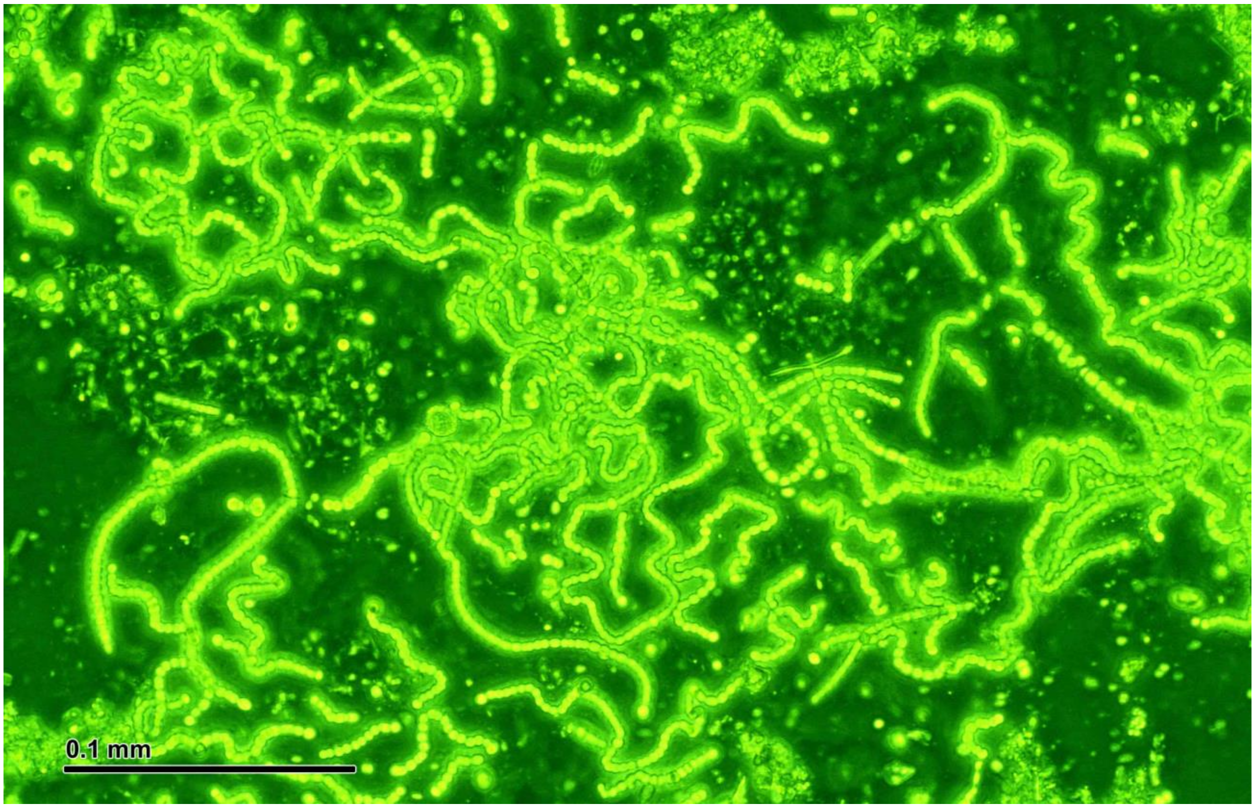
In addition to her role at the PRL, Brandizzi is lead for the Plants Area at the DOE Energy Great Lakes Bioenergy Research Center (**GLBRC**) at MSU. Throughout her career, Brandizzi has published around 120 peer-reviewed manuscripts. She has mentored dozens upon dozens of undergraduates, graduate students, post-docs, high schoolers, and teachers from all around the world. Her work has been funded by the Department of Energy, National Science Foundation, NASA, and Michigan State University, among others. Her numerous awards and honors include prestigious fellowships such as a BBSRC David Phillips Fellowship, and lectureships, such the Bob B. Buchanan Endowed Lectureship and the Clayton Person Lectureship.

And she is showing no signs of slowing down, **with the lab just announcing a new multi-institutional NSF grant earlier this month**: "The PRL is THE place to be to do great research on photosynthetic organisms."

Montgomery publishes on light harvesting efficiency

6/7/16

Igor Houwat, Beronda Montgomery



***Banner image** by Doc. RNDr. Josef Reischig, CSc., CC BY-SA 3.*

We all learned about photosynthesis in school: Plants convert light energy into chemical energy, and that fuels most of the planet's living beings.

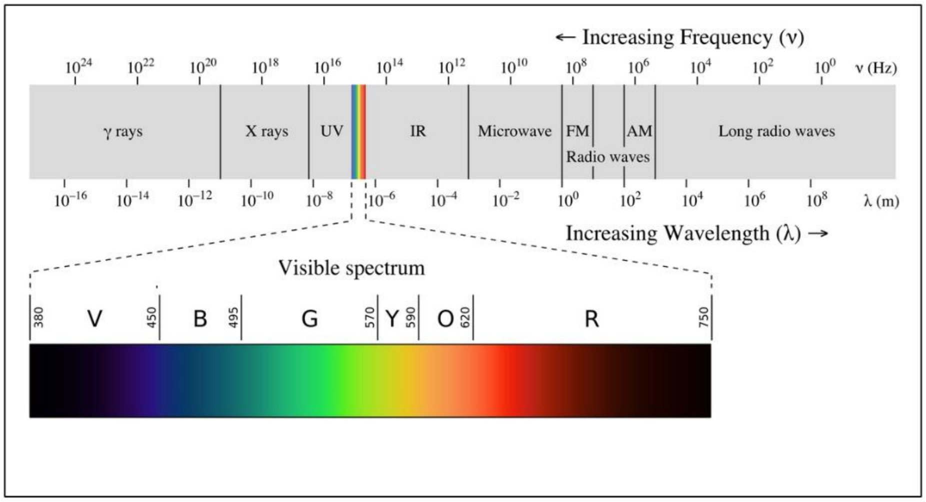
Yes... but not quite.

Beronda Montgomery, Professor at the PRL, has **published an article in the journal *Algal Research*** – in collaboration with the **Kramer Lab** – that delves into how photosynthesis has evolved differently in nature, particularly in cyanobacteria.

Humans use plants for leisure, fuel, and food, and all these functions depend on plants' ability to photosynthesize in order to grow. We already know that plants do not capture most of the light they are exposed to, but they grow well with what they get. The PRL is looking for ways to increase plant light-harvesting capacity, which would theoretically increase harnessable energy for our own uses without overloading the plants. But Montgomery's research shows how photosynthesis is complicated to manipulate.

How cyanobacteria captures light

Light travels in waves of different lengths, each wavelength perceived as a unique color when reflected on surfaces. For example, a red shirt reflects red waves and absorbs all the others in the light spectrum; that is why we see "red" when the reflected light reaches our eyes. White light, such as sunlight, reflects all colors in the spectrum; black absorbs them all.



The light we see is in the visible spectrum, a small fraction of the waves surrounding us.
*By **Philip Ronan, Gringer** - CC BY-SA 3.0*

Plant growth is affected by such light quality, and Montgomery has focused on how cyanobacteria properly capture available light in changing environments.

Many cyanobacteria live in water, alternatively sinking or floating. While surface water is rich in red light, deeper levels have abundant green light and scarcer red light. To adapt to these different environments, the cyanobacteria cell produces **Phycobilisomes (PBS)**, made of stacks of donut-like proteins that act as light-harvesting antennae. These proteins specialize in different wavelengths: some capture red light, others green light, and so on.

Each environment requires a unique protein mix for maximum light capture, and any changes in light quality affects that mix. To over simplify, the cyanobacteria might need a majority of red capturing proteins when close to the surface, but as the organism goes deeper – a process which can take up to two or three days – it will eventually need 75% green capturing proteins and 25% red as it adapts to the new surroundings.

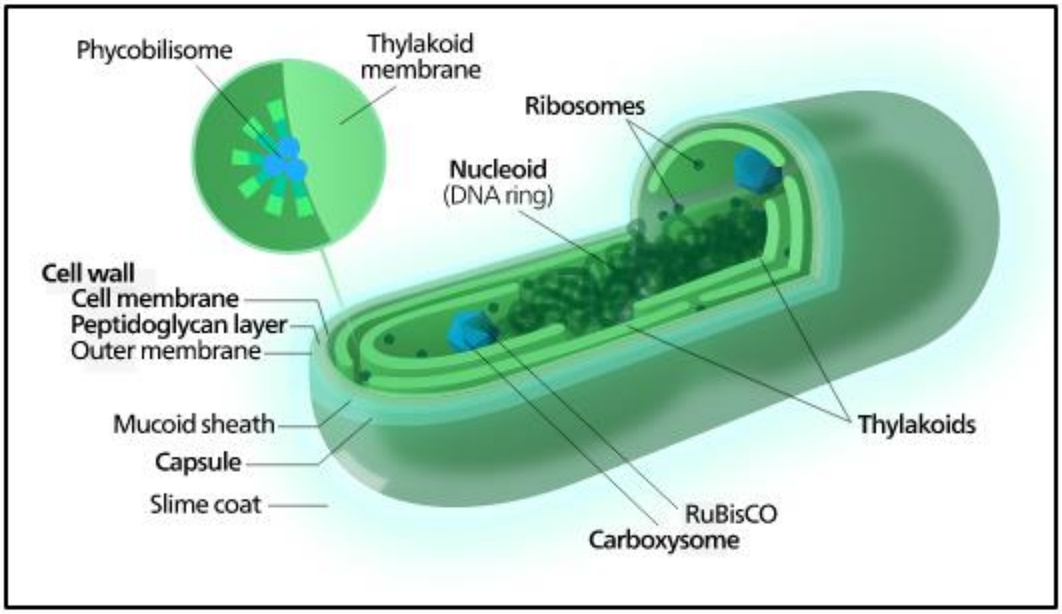
Producing these proteins uses up energy. If they are unused, they are discarded. In that case, the energy that went into their production is considered wasted, as it could have been used elsewhere.

That is exactly what happens as cyanobacteria adapt protein mixes to new light conditions: formerly useful proteins are replaced with new and better suited ones. Transitions are costly propositions.

The pros and cons of light capture

Montgomery's study examined the pros and cons of building and changing PBS and how costly transitions really are. Montgomery used a cyanobacteria mutant, deficient in PBS such that it did not adapt to light changes. That allowed for comparisons with the normal **wild type (WT)** under two sets of light conditions: constant, that mimic the gradual passing hours of the day, and fluctuating, that mimic sinking, floating, or environmental situations such as cloudy skies or water mixing.

Under the constant light conditions, WT grew faster than the mutants, due to the gradual adaptations to the “latest” light surroundings.



Notice the phycobilisome antennae-like formations on the top left.
By ***Kelvinsong*** *- CC BY-SA 3.0*

Highly fluctuating light conditions were quite costly to the WT due to the constant building of new proteins and the damage resulting from protein mismatch with external light availability (That mismatch produced reactive oxygen species, the same molecules that contribute to cell damage and aging in humans). WT had longer stacks of PBS, indicating the need for abundant proteins to adapt to these uncertain transitional situations – much like a satellite dish needing to be bigger when the signal is weak.

The mutant fared well against the WT in highly fluctuating light conditions, as it comparatively spent much less energy due to its inability to adapt to surrounding changes.

These findings confirm observations in nature. The WT strain dominates, since long-term and stable light situations are maintained for a longer portion of the organisms’s life cycle. Fluctuations are comparatively short-term events.

Looking towards a green economy

This fundamental research sheds a light on the evolution of variations in light capturing abilities. (Another twist from the study: species similar to the mutant do naturally exist in the world, although in much smaller numbers.) Although similar studies have been conducted on various cyanobacteria species, this is the first to compare one that adapts to different wavelengths.

Why cyanobacteria? These organisms, **which have higher photosynthetic efficiency than land plants**, have been recently examined as potential sources of renewable energy and other useful compounds. **Increasing their energy output would take us a step closer to bringing biofuels to the market**. Various PRL labs are working precisely on this issue, from the **Ducat lab's** cyanobacteria harvesting research, to the **Kerfeld lab's** creation of miniature energy factories in a lab environment, to the **Kramer's lab use of big data** towards understanding photosynthetic mechanisms, only to name a few projects.

Coaxing cyanobacteria into accepting more light might enhance the coming of green economies, but Montgomery's insights indicate that perhaps what we consider a currently missed opportunity is precisely what keeps these organisms balanced and alive.

Hu co-authors paper on the regulation of plant stress response

6/10/16

Igor Houwat

Banner image by Harley J Seeley

Peroxisomes are little cellular membrane-delimited compartments that break down fatty acids – important sources of cell fuels – and get rid of reactive oxygen species, also known as ROS and very damaging to plant cells (also a cause of aging in humans).

The research examined how the so-called peroxules, membraneous extensions of peroxisomes are associated with ROS in plant cells. It was found that a peroxisome protein, PEX11a, regulates peroxule formations as a response to environmental stress signals that lead to the accumulation of ROS, and brings ROS levels back under control.

The findings have been published in the journal *Plant Physiology*. The authors, in addition to **Hu**, are Maria Rodrigues-Serrano, Maria C Romero-Puertas, Maria Sanz-Fernandez, and Luisa M. Sandalio, all from the Department of Biochemistry and Molecular and Cellular Biology of Plants, Estación 6 Experimental del Zaidín-CSIC in Granada, Spain.

Go here for a full online copy of the article.

Sushi and science: creating a student community of minds

6/21/16

Igor Houwat, Bethany Hout

Early on in graduate school, Bethany Huot witnessed an experience that changed her outlook on science. She knew a post doc in her lab who had been struggling with his path for some time. He was slated to present at a science conference but had not been very motivated during his preparations. Bethany made the trip with him – her first time at a conference – and observed as he shared knowledge and learned from peers and experts in the field. In a matter of days, his depression morphed itself into a zeal to return to the bench, a dramatic transformation that Bethany would not soon forget.

Bethany strikes you as the person with a strong drive to help people. She lights up when one mentions community building. And with a bubbling personality and seemingly endless energy, she seems to always find a way to bring people together around inspiring ideas.

It all started during a trip following high school to a Vietnamese agriculture training center run by one person. “He was using his knowledge base to teach sustainable practices to farmers. I thought he was making an immediate and real impact on the world, and I wanted to do that too.” The plan was to start out in biology at Western Michigan University before transferring to MSU for agriculture, but an inspirational mentor got her hooked on molecular biology. Today, she is a PhD candidate in Cell and Molecular Biology studying plant stress in the **Sheng Yang He** and **Beronda Montgomery** labs.

Graduate school sucked Bethany into research, a time consuming and lonely endeavor similar to what that post doc had experienced. Bethany kept wondering why he had had to travel states away to have his aha moment when there were buildings full of experts around him. Why didn’t people talk more together, where they were?

Building a community of minds

Her realization was that science, especially the joyful variety, is done in supportive and active communities. So she resolved to create what she calls a “Community of Minds” at MSU where students could learn from and help each other out.

Bethany’s first attempts to recreate the conference experience at MSU were pie nights and coffee hours, but neither worked. However, over the next couple of years, two conferences, a 2013 Keystone and a 2014 MPMI, helped shape her ideas for fostering local science communication and excitement. In preparing for the second conference, “I figured I would be relatively close to the **Weigel** and **Sainsbury** labs, so I could use the opportunity to visit them. I think they all assumed I was shopping for a post doc position, but I just wanted to talk to cool people doing cool science. Isn’t that part of what science is about, the community?” Bethany found this experience extremely invigorating. “The best part was talking with so many people about the science they were doing and discovering I had ideas I could contribute. I found myself asking again, ‘Why don’t we do this all the time with our local peers and professors?’”

Back in the US, she decided to rebrand her efforts into **The Pub Club,** an informal, weekly gathering of PRL, **Plant Biology** and **PSM** labs that do similar research. "The 'Pub' refers to the publications we are all striving for and also the day when scientists regularly talked about their work at the local pub over a couple of beers."

PI Q&A Day.
By Bethany Huot

Bethany says that the formula that finally worked has four essential ingredients:

1. **Consistency:** They meet each Friday at 4 PM in MPS, fulfilling the **group's mission**, "to be available to each member when their schedule allows and their needs require."
2. **Student-led and PI approved:** A group like this needs to be student driven. However, Bethany adds, without enthusiastic support and participation from PIs, students and post docs will not feel encouraged to participate.
3. **Snacks:** "Not the scruffy store bought cookies. Yummy snacks. People come when there is food, no question." There is no alcohol involved at The Pub Club, but Bethany has found that has not been necessary. Members have gotten very creative, such as Koichi, a post doc in the **Howe lab** who set up a make-your-own sushi bar, complete with a demo and protocol!
4. **Networking:** "This is where we bring the conference home. Every month, we invite a guest speaker to join what we call our **Mug Club**. We've had 18 so far. I am happy to say I have never had a single person turn down a request to share their insights with us. In fact, some like **HHMI's** Carl Rhodes have returned on their own to visit our Friday gathering."

Since beginning in the fall of 2014, The Pub Club has averaged 10-20 members and 3-5 participating PIs. Weekly gatherings start with 5-minute science updates, a suggestion by her PI, Sheng Yang He. "Now, new undergrads, grad students and post docs joining a Pub Club lab have a way of making connections, learning about resources for science news, hearing about stories they missed and sharing the stories they found interesting."

Following science updates, each week takes a different path. This last semester included topics like creating an elevator pitch, "chalk talks" and research presentations on their new AQUOS BOARD. "The key here is to keep it small and informal. This helps make everyone feel comfortable to ask questions or share comments." Additionally, each semester tackles a RCR topic (ethics related to research) and the recurring PI Q&A day. The last, a group favorite, has members submitting questions in a box, and at the end of the semester, these are randomly drawn so the PIs take turns discussing them with the group.

Koichi about to unleash his sushi skills.
By Bethany Huot

Meeting on the edge of science

Soon after the group started to take off, Bethany realized the need for an online platform to store and share resources. "We had so many great resources and advice being shared at the meetings we really needed a way to compile them in an organized fashion for current and future use. We now have a website, called **The Pub Club Hub**, containing weekly meeting summaries, pictures, posts, RSS feeds for jobs and science journals, **pages of resources on teaching, job hunting**, bioinformatics and more. We also have a weekly newsletter called, 'Keeping Up With The Hub.'"

One major change in the group's growth came unexpectedly. Beronda Montgomery made a guest appearance tackling goal-setting, expectations, and the creating of individual definitions of success, which inspired an increased focus on career development topics. "Beronda's advice resonated and resulted in a series of meetings related to helping us identify our passions and goals, identifying the needed skills to accomplish them, and recognizing opportunities to acquire and hone these skills." Those have included leadership, organization, planning, budgeting, mentoring, and teaching skills, among others.

Another milestone of sorts was triggered by **Shin-Han Shiu's** visit to The Pub Club in the fall of 2014. His advice on acquiring basic computational skills without becoming full-fledged bioinformaticians led to the creation of Python Group, a spin-off group with a bioinformatics focus. In spirit with The Pub Club's philosophy, activities are not bound by topic. "Last semester, an undergraduate student in the Friesen lab, Katie Wozniak, took on the opportunity and the responsibility to coordinate Python Group. As a result, she was able to gain both computational and leadership/organizational skills." Katie has told Bethany **this was noticed and mentioned by many who interviewed her for graduate school**.

The Pub Club also now listens to future employers and helps each other with what they affectionately call "The Void" employment opportunities present. "It's about post doc and graduate training, acquiring these communication and networking skills that would produce better science and better scientists. Just picture that group of students attending their annual meetings, getting there already excited with a list of people to meet and questions to ask! They would be the most sought after job applicants."

Bethany with Sheng Yang He at the Christmas party.
Photo courtesy of Bethany Huot

Successes and challenges

The Pub Club has been a huge success, thanks in large part to the support and participation of PIs. It continues to develop, including another significant milestone this past May, when the “Community of Minds” went global with a Skype mini-conference with the famous **Weigel World** in Germany.

However, the greatest challenge has been convincing people that such a venture is not extracurricular, but a vital component of scientific training and development. “There is so much pressure to be ‘at your bench’ it is really difficult to convince students to invest in anything else. Now, more than ever, we as scientists must be able to communicate our science effectively to diverse audiences. The Pub Club gives us a weekly opportunity to practice this and other very important skills.”

Bethany is graduating later this year. She hopes someone will take charge in her stead, and she has received some inquiries from interested students. Whatever happens, Bethany is taking the “Community of Minds” with her. “The Pub Club has helped me clarify my personal passion: helping people discover who they are, what they want and then helping them to achieve those goals by providing encouragement and resources to do so. It’s about gaining independence, and it’s much different than working towards a job title that may not even be there after graduation.”

A far cry from that struggling, isolated post doc.

'Road testing' plants reveals photosynthesis secrets

6/23/16

Igor Houwat, David Kramer

Imagine that you want to test drive a new car, but you're not allowed to take it out of the parking lot. You may start the engine, but you wouldn't know, for instance, how it handles on the freeway or winding roads, or if the tires grip on wet pavement. To really know how that car performs, it needs to be road tested and its components carefully monitored.

A similar problem has faced scientists studying plants, and in particular photosynthesis, the process by which plants capture solar energy to generate all of our food and some of our fuels.

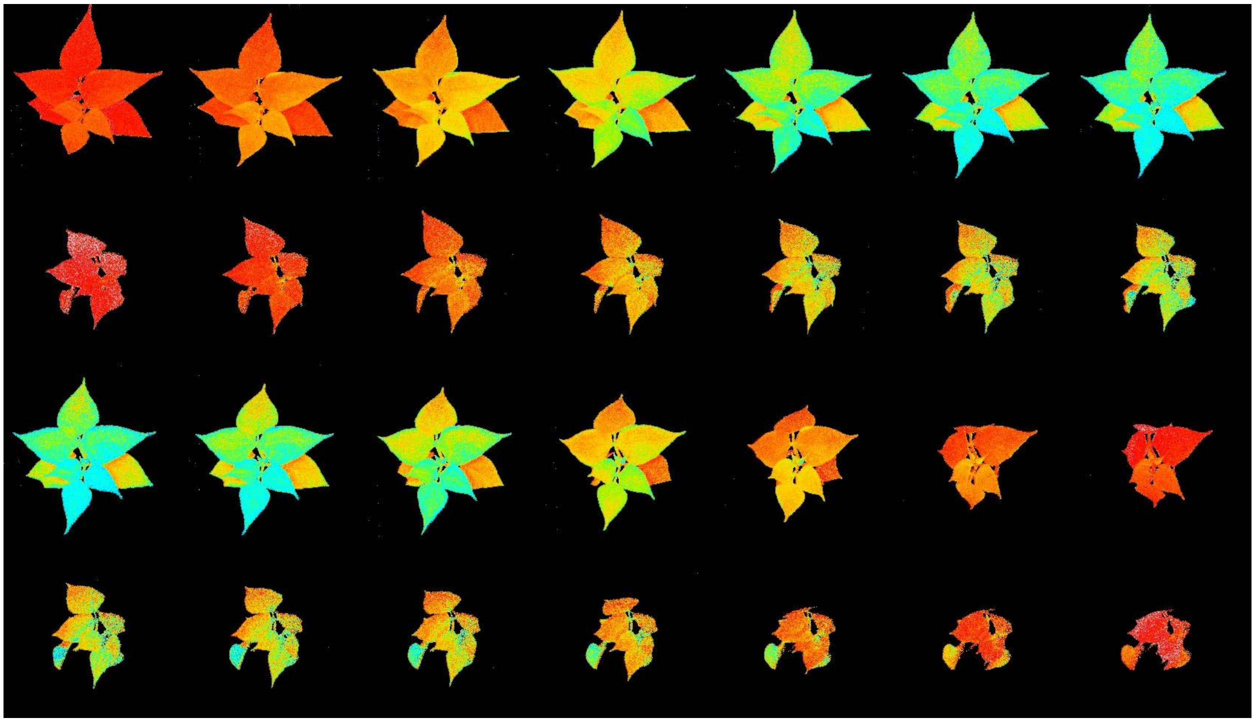
For decades, these scientists have been studying photosynthesis in the lab with sophisticated instruments and under carefully controlled conditions. In fact, this "reductionist" approach has allowed researchers to systematically dissect complex processes like photosynthesis into component parts that are much simpler to study.

The result has been that we have a pretty detailed picture of this wonderful biological machine that has powered life for over a billion years.

But scientists still don't understand how this beautiful machine works "on the road," that is, its natural environment. The problem is both highly complex and extremely important. Photosynthesis is highly sensitive to rapid changes in environmental conditions like light, temperature, humidity, and the availability of water and nutrients.

Even more critically, **when the plant cannot properly control photosynthesis under these conditions, it can produce toxic side reactions that can damage or kill it, leading to loss of yield**.

"We now suspect that many, if not most, of the genes in a plant are there to help it cope with these environmental changes and perils," says **Dr. David Kramer**, Hannah Distinguished Professor in Photosynthesis and Bioenergetics at the MSU-DOE Plant Research Laboratory (PRL).



A heat map from the DEPI chamber.
By Kramer Lab

"And although we know a lot about the core machinery of photosynthesis, we have very little idea what these other genes do. Yet these are the very components that not only keep photosynthesis working efficiently but also keep it from killing the plant!"

Bringing nature to the lab

Part of the problem is that photosynthesis has not been 'road tested,' and laboratory conditions don't properly engage plant genes. The Kramer lab (funded by the **Department of Energy, Office of Science, Basic Energy Sciences**) and the **MSU Center for Advanced Algal and Plant Phenotyping** (CAAPP) have both set out to solve this problem by bridging the gaps between the lab and the natural environment.

To do this, the PRL assembled a broad team of scientists (Linda Savage, Dr. Jeffrey Cruz, Dr. Mio Cruz, Geoffry Davis), engineers (Robert Zegarac), and software developers (Dr. Jin Chen) to build new technologies.

In a new breakthrough, the team has developed a simulation chamber called **Dynamic Environmental Photosynthetic Imaging, or DEPI** for short, that captures the types of environmental conditions seen in the field and replays them in the lab.

Among its many features, it can play with light intensities and durations or replay past weather patterns that have been recorded or new ones projected for the future.

“The chambers are equipped with special cameras that can detect and quantify visible signals produced in real time by plants during photosynthesis, and we can see them as pictures and movies,” says Linda Savage, facilities manager at CAAPP. (The image at the very top is an example of a photosynthetic activity heat map of various plants.)

The DEPI chamber ready to test a new batch of plants. By Kramer lab

While traditional methods might rely on sensors applied to a single leaf at a single point in time, DEPI reveals what is happening in the whole plant, over an unlimited time period. As a result, plants are **demonstrating a whole range of new processes, most notably varying behaviors under dynamic environmental conditions, such as when light changes rapidly** as it might do on a windy day with partially cloudy skies.

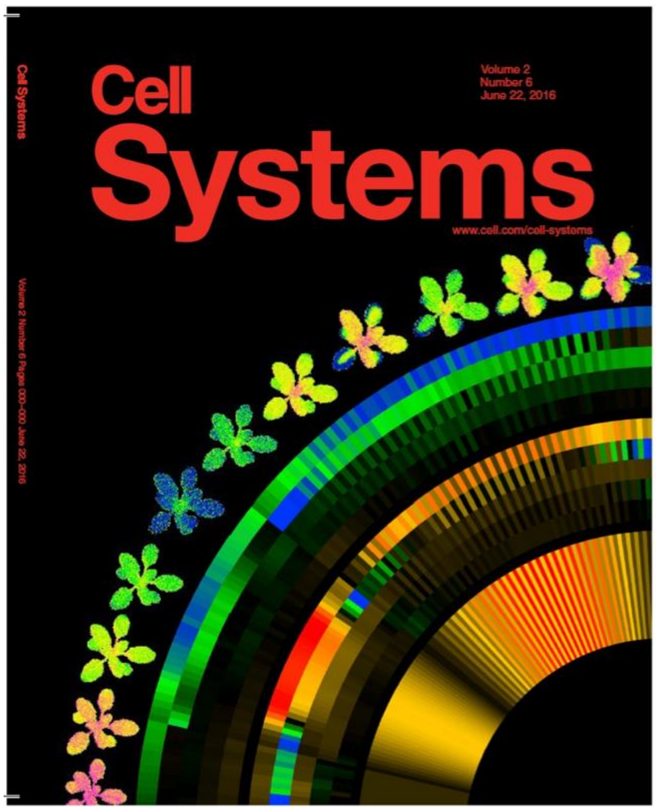
But, CAAPP director Jeff Cruz says, “Because these simulated conditions are reproducible in DEPI and because of our sophisticated monitors, we can study these processes with high precision and in great detail.”

DEPI can also monitor hundreds of plants at the same time, which can be used to identify and compare specific genes that are involved in these processes. “Once we know the process and the genes, we can identify superior variants and potentially combine genes or traits into elite varieties that can lead to improved field (or road) performance,” Kramer says.

In fact, photosynthesis is thought to be a major limitation for crop productivity, but because it is highly complex and has been difficult to study, it has not received the same attention from scientists as other traits.

That is precisely one of the problems PRL is addressing, according to **Dr. Christoph Benning**, PRL Director and MSU Foundation Professor. “Our scientists are dedicating considerable efforts to understanding basic mechanisms of photosynthesis and how the ‘solar panel,’ the photosynthetic membrane and ultimately the leaf, is built."

"David Kramer and his team have taken photosynthesis research to the next level by studying plant photosynthesis in DEPI’s sophisticated environmental chambers. This has led to new insights into what limits photosynthesis under conditions that ultimately matter to the practitioner, the farmer, or gardener.”



The journal cover, including plant heat maps, indicating photosynthetic activity. ***Source: Elsevier (CC BY 4.0)***

Towards a global system

The CAAPP has built an array of DEPI systems that are already being used on a wide range of projects at MSU to fuel discoveries into plant responses to environmental stresses like drought, extreme weather conditions, or pathogen infections.

Dr. Gregg Howe, MSU Foundation Professor, specializes in plant defense against herbivores and insects. His lab used the DEPI system towards publishing a recent Plant Physiology article. “DEPI helped us understand how the stress responses in plants are connected with photosynthetic efficiency, and there are some data reported in that paper that clearly would have not been possible without the high frequency measurements we got from it.”

The CAAPP aims to expand DEPI’s potential. There are massive amounts of data on plant species, too much for any one institution to tackle. And with global warming challenging plants – and by extension the global food supply – to react to increasingly unexpected environmental conditions, humans need to find smart solutions to maintain and improve yields, and fast.

That is why Kramer envisions the creation of a multi-institutional international network of DEPI chambers, allowing researchers around the world to collectively tackle these bigger questions and imagine real and impactful solutions to some of our most pressing problems. The DEPI at MSU is a first step into that larger vision.

The Kramer lab has published the article on DEPI in the Cell Systems journal (it is featured in the cover). **The paper can be accessed here**.

PhotosynQ helping Malawian farmers increase yields

7/11/16

Igor Houwat, Dan TerAvest

Banner image of farm landscape in central Malawi by ILRI/Stevie Mann, CC BY 2.0, via Wikimedia Commons.

SUMMARY

- A fascinating collaboration has developed between the Kramer lab and Malawian partners to improve land management practices in one of the poorest nations on the planet.
- The group is using an innovative, homegrown technology called PhotosynQ that allows for plant and soil data collection.
- The technology comes at a fraction of the cost of current market solutions.
- After resolving logisitical issues specific to Malawi, PhotosynQ usage rates have soared.
- The Kramer lab aims to replicate this experience in other countries.

In January 2015, Dan TerAvest flew to Malawi to teach local groups how to use a new technology called PhotosynQ that would help farmers improve yields and better manage their lands. Over a period of two weeks, he trained eight staff and students from Lilongwe University of Agriculture and Natural Resources, four staff from Malawian government extension agencies, and a slew of other researchers. The training went well, and the technology's potential garnered a lot of excitement.

Then Dan returned to the US. And his Malawian network went silent.

This challenge sparked a rethinking process on deploying PhotosynQ that has led to a fantastic partnership between the **David Kramer lab** at the MSU-DOE Plant Research Lab (PRL), the John Reganold lab at Washington State University, and local researchers in Malawi.

Applying technology in developing countries

PhotosynQ was devised in the Kramer lab to bring sophisticated technology to the field. **Users clip a low-cost device, constructed at the PRL, to a leaf and get loads of data about plant health and photosynthetic activity**. The results are uploaded to a website, and participants from around the globe can interact with each other and learn from the data, in other words, something of a social media network for plant science.

Dan, a postdoc with a joint appointment at **Washington State University** and the PRL, had long had an interest in applying science towards supporting developing countries. When he joined the Kramer lab, he saw PhotosynQ was ripe for Malawi, an Eastern African country where he had previously done fieldwork and built a network of researchers, government officials, and farmers.

"Malawi has a population of 16 million people, and it is one of the poorest countries on Earth. Most farmers live on small parcels of land, and their yields are low because of a lack of agricultural resources and knowledge. Keep in mind that farmland is not homogenous, so farmers cannot follow blanket recommendations on what crops to plant or what seed to get. They need specific solutions, and current agricultural technologies on the market can be cost prohibitive. That was a gap PhotosynQ could fill."

Malawi, capital city: Lilongwe By Rei-artur, CC BY-SA 3.0, via Wikimedia Commons

The Kramer lab received grant awards from USAID and the McKnight Foundation (the latter a joint PRL-Washington State University project) to deploy PhotosynQ in Malawi and to teach local researchers and farmers how to generate data from agricultural land. In turn, collaborating Malawian researchers and government officials would use the data aggregate to suggest best practices accounting for factors such as economic approach or field and climate conditions.

From disappointment to "Finding Frank"

The idea was solid and the initial reception in Malawi encouraging, but the project ground to a halt after that training session in early 2015. Back in the US, Dan racked his brains with PhotosynQ co-founders, **Dr. David Kramer**, head of the Kramer lab, and Greg Austic. How could they get people in the field collecting data? What went wrong?

The issue was infrastructure. Despite being in its infancy, **PhotosynQ has been used widely across the globe, with over 1,300 users on six continents and 275,000 experimental data sets collected**, but this was the first attempt to create a centralized research hub outside of the US. Internet connections were poor in Malawi, which made data uploading hard, and the research infrastructure for PhotosynQ was weak despite the training.

That is when the “data entrepreneur” concept came up. “Having ‘customer service’ dictate solutions from a lab in Michigan, 10,000 miles away, was not going to cut it,” Dan says.

“We had to pay someone to collect data on the ground and connect it with complementary research that was already going on in Malawi. We had to dictate less and just enhance what already was in place. And that’s how we found Frank.”

Frank Mnthambala had worked years ago for Dan as a research assistant during Dan’s field work in Malawi as a PhD student at Washington State University. Frank had gone on to earn a Masters degree in agriculture from Lilongwe University and was working at a local research center when he got the call to join the PhotosynQ team. He was immediately hooked.

Frank representing PhotosynQ on the ground

“Once we had him onboard and ready, we went back to the people I trained and told them that they could call this guy in Lilongwe, because he was doing this job. Suddenly, everybody was calling him.

What changed? Well, when you get a new gadget you are bound to run into a problem, and if you can't fix it, you put it in a drawer. For example, you need to follow certain steps to use PhotosynQ, otherwise it won't work. Or people forget to sync information with the website. These are all simple problems, but unless someone can resolve them quickly, they turn into mountains. Frank took care of that."

Data streams in

The amount of collected data exploded. In the first third of 2015, only one project was successfully completed, with 800 data points collected. After Frank joined, 14 projects were deemed fruitful and 30,000 data points were collected throughout the rest of that year.

Dan notes that PhotosynQ is now being used by Malawian researchers to find solutions in crop breeding ("Which seed should I plant?") and crop management ("Once I have the seed, how do I plant it? How do I till the soil? How many seeds do I use? Basically, the what, where, and how.") for small land holders.

Training in Chitedze

For example, Donald, from the Department of Agricultural Research Services, Ministry of Agriculture and Food Security, has been identifying varieties of sunflower, imported from South Africa, that grow well in Malawi and that will increase market availability. Ivy, another researcher from the same institution, is looking at improving fertilizer and water management practices for maize and cowpea.

Other projects are examining drought tolerance in sweet potato and soybean varieties, crucial crops in parts of Malawi that suffer from frequent dry spells. One university is even trying to introduce quinoa – a high nutrition food – to the country by testing varieties from around the world.

A chain reaction of successes

In 2015, most of the work was done on research stations in highly controlled lab environments. But since PhotosynQ's mission is to take lab technology to the field, 2016 has seen new projects conducted on 118 smallholder farms around the country.

Researchers are focusing on specific crop management issues facing farmers, such as soil depletion, financial constraints, erratic weather, and so on.

These efforts are also impacting plant science on a broader level back at the PRL, according to Dr. Kramer: "We get access to all this data from so many different crops under so many different places and conditions. As we are analyzing it, we are learning how plants work and getting important clues about how to improve them."

And Frank is now a bit of a legend in the lab, says Dan. "When we think of the best person to use PhotosynQ, anywhere, we joke that we're looking for a 'Frank,' or we've found a 'Frank.'"

Frank has started his own consulting company and spends most of his time training Malawian groups how to use the technology. He is currently exploring a collaboration with a private seed company interested in measuring its products' effectiveness.

Malawi has become a testing ground for future projects, Dan says.

"I hope this will open up avenues into other countries, once the logistical and technical problems are figured out in Malawi. We currently have a budding hub in Zambia, and there has been some interest in Uganda. I was also just in Ethiopia, where I met with local McKnight Foundation grantees to examine ways we could collaborate together. I don't really care where we apply the technology, as long as it is out there helping others do better!"

Acidification tells plants it's deadly freezing

7/18/16

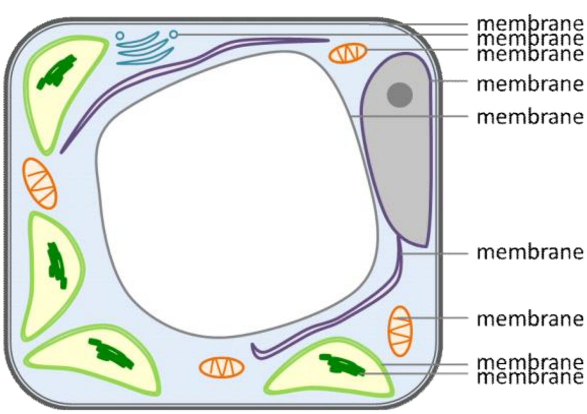
Igor Houwat, Rebecca Roston

Source: Jerology.tumblr.com

A new study from the **Benning lab** shows how plants sense freezing temperatures through increased cellular acidification. The results, **published in the July issue of *Plant Physiology***, have ramifications into biofuel and food security solutions.

"We know a lot about how plants sense some things," says Rebecca Roston, former Benning lab postdoc and currently an assistant professor at University of Lincoln Nebraska. "But how they sense and react to the environment is a relatively new field in plant biology."

Cellular 'gated communities'



“Most of what we see when we look at pictures of cells is membranes,” Rebecca says. “They are important because they separate parts of the cell, called organelles, from each other by selectively controlling the flow of products. This is crucial, because just a small amount of leakage from some organelle membranes is enough to kill the cell.”

Cell membranes are constantly remodeled to adapt to growth and stress, much like how bones grow to support kids’ changing structures. And during cold temperatures, membranes are remodeled to reduce damage in response to low temperatures.

Freezing damage

But not all plants that survive the cold make it through freezing temperatures.

“Freezing is an additional stress that causes ice crystals to form outside the cell. Water then rushes out due to osmosis, leaving behind the cell organelles, now tightly packed together.”

“Freezing also destabilizes cell membranes and reduces their ability to separate cell components.”

“Both tightly packed organelles and unstable membranes result in organelles vulnerable to fusing and susceptible to leakage and damage.”

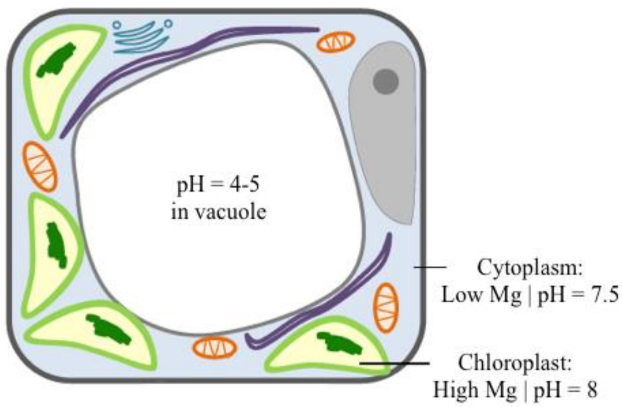
“When freezing ends, water rushes back into the helpless cell, overfilling and killing it.”

Proteins to the rescue

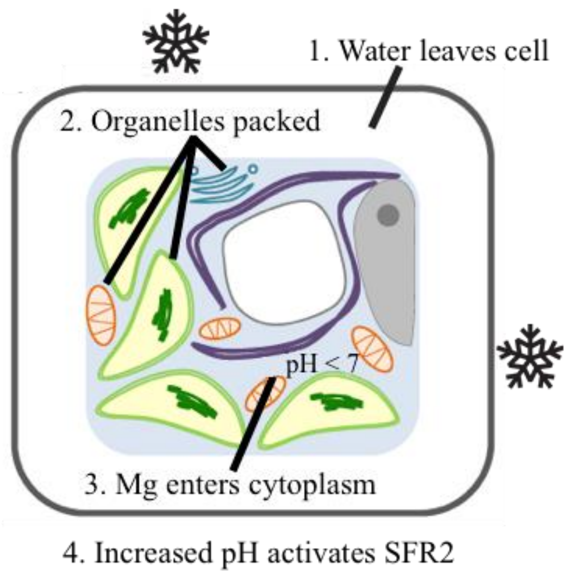
Dr. Christoph Benning’s lab had previously identified a protein – **SFR2 (*sensitive to freezing*) – which only activates during freezing conditions**. “We found that SFR2 protects the chloroplast, the plant’s energy factory. We also found that SFR2 requires Magnesium (Mg) for activation,” says Christoph.

That experiment was limited to isolated proteins**.** “This time around,” says Rebecca, “we wanted to test SFR2 in its native context, at the chloroplast, leaf tissue, and whole-plant levels, to see if our earlier study held. And what we found was unexpected and fantastically interesting: freezing causes a rise in acidity in the cytoplasm, basically most of the rest of the cell, and SFR2 actually responds to this acidification.”

This is what Rebecca and Christoph believe happens during freezing. Normally, chloroplasts contain high levels of acidic Mg, which is kept separate from the relatively less acidic cytoplasm (pH in the diagrams).



But when freezing damages cell membranes, Mg passes freely through the chloroplast into the cell, raising the cell's acid levels. That activates SFR2.



The acidification trend was confirmed at the leaf tissue and whole-plant level.

Acidification as signal

"We also found out that artificially raising acid levels while maintaining normal temperatures caused the plant to perform changes that occurred during freezing, indicating that acidification is a general signal for freezing protective measures."

"It's like a lighthouse, which is a general sign of land and message to keep boats away. But if you take a flashlight one night and make it look like there is a lighthouse on a clifftop, boats will avoid your area."

Towards biofuels and food security

SFR2 activity increases oil production in plant cells, although the reason is unknown. "Perhaps the plant is storing high energy compounds in anticipation of resuming normal function once freezing is over."

Interestingly, **these oils are precursors for commercially usable biofuels, another area of interest to the Benning lab**.

Understanding freezing responses could also help improve plant yields. “Even though our climate is getting warmer, we will continue getting cold extremes, and seasonal cold remains a critical factor for agricultural stability. For example, a study found that grasses tolerant to low temperatures were up to 59% more productive than maize in temperate areas. That gap is huge.”

Innovative PRL research impresses at international workshop

4/26/16

Igor Houwat

PRL members captivated attendees at the 12th Workshop on Cyanobacteria at Arizona State University, winning two out of six possible prizes for best poster presentation.

The workshop is targeted towards graduate student and post doc research on cyanobacteria, also known as blue-green algae, which has great potential in **creating renewable energy** and other **useful biotechnological compounds**.

This year's event attracted 200 faculty, postdocs, graduate students, and industry members from around the world. Six poster sessions were held, and judges selected one winning poster per session.

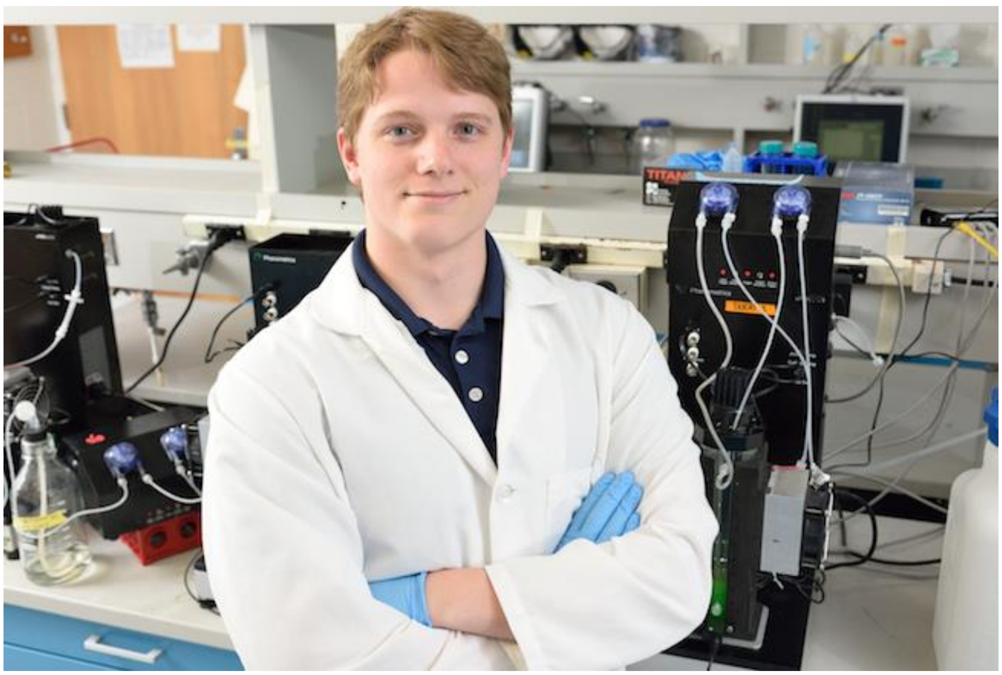
Our two winners, Derek Fedeson, a 4th year PhD candidate in the Genetics Program in the **Ducat lab** and Aiko Turmo, a lab assistant in the **Kerfeld lab** with a BS in Genetics, shared their reflections in the following interview.

2016 Cyanobacteria workshop attendees. By Samantha Lloyd, VisLab

What got you into this field?

DEREK: One of my earliest memories of a movie theater was going to see Godzilla with my father, when I was seven. In the film, the military recruits a scientist who studied the effects of radiation on earthworms near Chernobyl, documenting their increasing size. The theory was that radiation from the nuclear tests in the Pacific Ocean had led to the creation of Godzilla. And I thought that was AWESOME. Later on I watched Jurassic Park on VHS with my family and learned that genetics were something that could be manipulated. These works of science fiction really got me interested in genetics and DNA and how we could use genetics to benefit society, or at least build something really cool.

AIKO: I got an undergrad degree in genetics, but I came first from premed. I actually went into genetics because my sister had a genetic disorder and my brother has type 1 diabetes, so I wanted to know more about these disorders. When I graduated, I found a job as a lab technician at the Kerfeld lab, and the more I worked here, the more I enjoyed the synthetic biology.



Derek Fedeson. By Harley J Seeley Photography

What's your research on?

AIKO: **We're trying to reengineer a protein structure, found in many bacteria, to turn it into a nanoreactor (*a miniature factory*) that could sustainably create useful chemicals**. For example, I've worked with isoprene, a smaller chemical that is easy to work with and is popular because it is used to create synthetic rubber. And the only way to create rubber right now is through trees and petroleum. So, our research is pretty innovative.

DEREK: For my project, **I am working to engineer cyanobacterial cells to produce proteins on their outermost surfaces, where these proteins can then interact with the cell's environment**. Cyanobacteria are relatively easy to grow and simple to work with, which is what allows us to do this work. We're the first group to successfully modify a strain of cyanobacteria to express an engineered surface protein that is definitively available to interact with the environment. Down the road, we can imagine applications where this technology would allow for such proteins to break down heavy metals in the environment or enhance the harvesting of biomass as a source of renewable energy.

What motivated you to attend the workshop?

DEREK: It was a great opportunity for networking and sharing my research with people who have a vested interest in what I'm doing. I was excited to present my work to fellow scientists who understood the importance and implications of my research.

AIKO: I agree with Derek. We are trying to get our work out there, and I was also looking for positive criticism.

Why do you think you won?

AIKO: What we are doing is cutting edge. The application of my research, if it works out, is very exciting. There are other chemicals that could be produced with this nanoreactor system for bio technology purposes.

DEREK: I'll agree with Aiko that the projects coming out of the PRL are novel and I believe this had a great deal to do with why we received these awards. Honestly, I didn't actually know that there were going to be awards. It was the end of the last presentation of the workshop when they announced, "…and now it's time for awards!". I was not expecting to receive an award and I was entirely unprepared, having changed into casual khaki shorts and a t-shirt. And, of course, I was the last person called…

Aiko Turmo

What advice would you give other students presenting for the first time?

AIKO: I wish I were more confident. This was my first conference, and I felt intimidated. I didn't realize that most people were graduate students who were attending for the first time too. It is ok to make a couple of mistakes, because it is a friendly environment.

DEREK: Practice your talk with someone who might know a little bit about what you are doing but doesn't have the inside scoop on your research. That'll bring to surface any topics that need clarification. During the conference presentation, I realized it would have been great to have an additional figure at the bottom of the poster to explain why I changed an experimental protocol. I had practiced my presentation with my fellow lab members who already knew the reasons behind that change. However, a first timer-would not, and would have raised questions about this change. Although I was able to explain my logic during the presentation, it would have been much better to have that figure to back up my statements.

How did your lab mentors support you?

AIKO: Dr. Kerfeld always motivates her lab to give 100% and pushes for a high standard. She also is very patient and very good at explaining things. I actually worked directly with Raul, a post doc in the lab, and he reflected that attitude, especially helping me out whenever I made a mistake. It's a quick way to learn.

DEREK: I think that Danny Ducat is a spectacular mentor. He has a critical eye and will work through things with you. In general, if you have a question that you have to ask right now, his door is always open. He really wants students to be excited about their work, and he is passionate about the research in the lab.

A slew of student awards in July

8/1/16

Igor Houwat

Li Zhang, a PhD student in the **He lab**, was awarded the **2016 Bessey Best Publication Award** from the Plant Biology Graduate Committee **for her work on plant defense against pathogens**. The award is for grad students who have published a first-authored paper in the calendar year, based on research carried out primarily during graduate studies at MSU.

Adam Seroka, Alshae Logan, and *Evan Angelos* were each awarded **The Plant Biotechnology Health and Sustainability Fellowship**. This NIH funded program supports researchers interested in advancing plant science for the betterment of mankind, either by directly improving health and nutrition or by aiding in sustainable agricultural practices. Among the benefits of winning the award is an internship at an industry, non-governmental, or governmental institution. Current industry partners include Neogen, Syngenta, and Lucigen, **among other big names.** **Go here for more program information**.

Adam, from the **He lab**, is examining the regulatory mechanism underlying plant movement in response to biotic (living) and abiotic (nonliving) stimuli.

Alshae, from the **Montgomery lab**, is studying a recently discovered second messenger molecule, cyclic-di-AMP, which might play a central role in combating stress from osmosis**,** a stress that is becoming a common problem for cyanobacteria in their habitats.

Evan, from the **Brandizzi lab**, is collaborating with NASA scientists to see how plants respond to gravity changes and spaceflight. He will be launching mutant plants to the International Space Station on Space-X Flight 12 in June 2017 to understand why plants do not grow well in space. In other words… space plants!

Spreading the science bug to the classroom

8/5/16

Igor Houwat, Stefanie Tietz

Years ago, Dr. David Kramer envisioned the construction of a cheap and user-friendly device to collect data on plant health and photosynthetic activity. It would allow researchers, farmers, and other agricultural practitioners to bypass the need for similar yet prohibitively expensive technologies on the market.

Fast forward to today, Kramer and his lab have built **PhotosynQ**, a platform boasting a suite of tools and a thriving website housing the 300,000 data points collected from users around the world. Subscribers can interact with each other and learn from the data, which is accessible to everyone.

Think social media network for plant science.

Data is immediately available on an app. By Harley J Seeley Photography.

The PhotosynQ Education Group

"I also thought PhotosynQ could enhance science education. It is hard to create complex, 'real' science lessons that also get students immediate feedback on their work, and our tools can help solve these problems," says **Kramer, Hannah Distinguished Professor at the PRL**.

Kramer’s interest has encouraged two of his lab members, Ruby Carrillo and Stefanie Tietz, and an industry partner, Brian Collins, to create the PhotosynQ Education Group.

“Despite our different academic backgrounds, we three have an immense interest in application-based learning, which we believe better engages students with STEM topics,” says Ruby, a PhD candidate.

Stefanie, a post doc, agrees: “The old lecture system alone can be boring, and we want to promote active and meaningful learning experiences.”

“And our main goal is to use PhotosynQ to peak student interest into scientific inquiry and to fight misconceptions about biology,” says Brian, who has a PhD in Learning, Technology, and Culture from MSU.

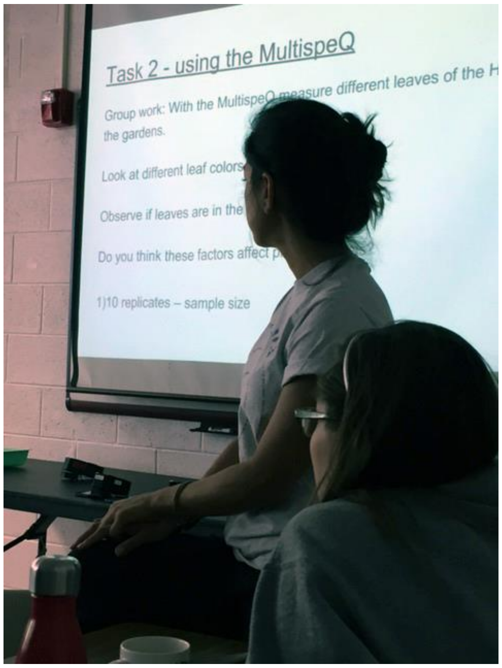
Two students experimenting in the field

Inaugural workshop

PhotosynQ can be adapted to many educational contexts, from amateur scientists poking around their backyards, to high schoolers learning basic concepts, up to graduate students working towards their degrees.

The first trial workshop, however, focused on undergraduate learning, bringing together 15 interns from the **Plant Genomics @ MSU Research Experience for Undergraduates Program**.

For 3 hours, the students were instructed on **basic science skills**, namely how to carefully collect and process data, which is crucial for building research questions.



Learning how to use the device

"We had the students use our tools to help them think scientifically. On our end, we wanted to see if undergraduate researchers benefit when instructed on how to devise a research question and whether a 'realistic' tool aided the process." Ruby says.

"We did run into some bugs with our units, since they were still in beta," says Stefanie,
"but it was an encouraging start."

"We were actually surprised to inspire some great informal discussions about what it's like to do a graduate degree. And that gets to the heart of it, getting people excited about science," adds Brian.

Dr. Cornelius Barry, Associate Professor in the Department of Horticulture and Director of the Plant Genomics @ MSU REU Site, agrees. "The opportunity to work with the PhotosynQ Education Group was a great experience for our REU interns. For many of them, this summer was their first exposure to research, and learning to formulate a research question, collect data, and interpret and report that data represents a fundamental skill that all scientists need to acquire. PhotosynQ is an excellent educational device to teach students the basics of scientific inquiry."

REU interns

The team now plans to develop modules for classroom use, and there is already interest from some undergraduate biology teachers. “We’ll encourage more hands-on activities or perhaps ask students to create proposals on how they would use PhotosynQ in their education,” Brian adds.

“We are currently seeking funding opportunities and partners at MSU,” Stefanie concludes. “Then we can build an educational community that will plug into the wider PhotosynQ platform.”

Fighting back the Yellow Dragon

8/9/16

Igor Houwat, Jonathan Walton

Citrus greening is currently one of the most economically devastating citrus diseases worldwide, affecting over 40 countries in Asia, Africa, and the Americas. Also known as Citrus Huanglongbing, (literally, "Yellow Dragon Disease"), or HLB for short, the disease is caused by a bacterium, and symptoms include yellow shoots, splotchy leaves, stunted tree growth, and irregularly-shaped and bitter fruit.

HLB has made US headlines, particularly in Florida, a state whose citrus industry, **valued at $10 billion, is so important to the economy that oranges are featured on its license plates**. But since the disease hit in 2005, crops have been decimated, and **some question whether Florida's industry will survive.**

"Currently, there is no cure. Usually, the only thing to do is destroy the tree to stop the disease from spreading," says **Dr. Jonathan Walton, Professor at the PRL**.

Metaphorical fighting of the dragon. By Baltasar Vischi, CC BY 2.0

Infected citrus plants are difficult to maintain and regenerate, which makes studying the disease a challenge. Many treatments have been tried to control HLB, including penicillin and antibiotic treatments.

Now, a team of international scientists from Cuba, Japan, and the US, **including Walton**, are suggesting a plant steroid might help with managing the disease.

Brown seeds in infected mandarin. [By J.M. Bové, CC BY-NC 3.0]

More devastating than real dragons. [By H.D. Catling, CC BY-NC 3.0]

Countering with plant steroids

"Plant steroids are relatively a new subject of study," Walton says. "We used to think steroids were only important for regulating the growth of animals."

Animal steroids are a class of hormones that help with metabolism, inflammation, immunity, and normal development. Recently, however, scientists have discovered that plants also use steroids, called brassinosteroids, to control their growth and development.

“Brassinosteroids have been found to activate genes involved in defense against plant diseases, so the researchers in this study were curious as to whether they could be used to control HLB.”

The experiment involved spraying brassinosteroids on citrus plants, both under greenhouse conditions and in planted fields. The treated plants showed a dramatic improvement in health, with up to 160-fold reductions in their bacterial levels.

Improvements were more pronounced in the greenhouse, however. “It’s because there are a lot of field factors beyond our power: weather, soil, humidity, and so on. These are easier to control in a greenhouse.”

“But the important point is that brassinosteroids did contribute towards activating plant defenses that play some role in resistance against HLB. That was the pleasant surprise.”

Dr. Walton. By Harley J Seeley Photography

“The flipside is that these experiments didn’t eradicate the disease. When spraying stopped, bacterial numbers went back up. Maybe this brassinosteroid is limited in its ability to spread in the plant or is too unstable. We will have to experiment with different spraying schedules or longer treatment periods.”

That is why the researchers suggest that brassinosteroids might one day be a tool to be used within an integrated disease management approach that includes other control methods.

“Will this approach to controlling HLB be implemented some day? We don’t know yet. These things ultimately boil down to cost, and sometimes, the price of curing a disease is too expensive to justify. Looking ahead, researchers will have to demonstrate the economic benefits of spraying brassinosteroids.”

The findings have been published in the ***PLoS One*** journal.

David Kramer wins innovation prize from ISPR

8/19/16

Igor Houwat

The PRL's **David M. Kramer**, Hannah Distinguished Professor in photosynthesis and bioenergetics, is the 2016 recipient of the **International Society of Photosynthesis Research** (ISPR) Innovation Award.

The ISPR, founded in 1995, aims to promote the development of photosynthesis research as a basic and applied science. The ISPR Innovation Award, sponsored by **LI-COR Biosciences**, recognizes, "outstanding achievement in the transfer of photosynthesis research to the benefit of society at large, enhancing the visibility of the discipline in the process."

This is second major award for Kramer in 2016, the other being the prestigious Charles F. Kettering award for excellence in Photosynthesis Research.

"It is great to get the recognition for our work, but I really think the credit goes to all the great people I've been privileged to work with and the terrific support from MSU and our funders," said Kramer, also a professor in the **Department of Biochemistry and Molecular Biology**.

Kramer's research seeks to understand how plants convert light energy into forms usable for life, how these processes function at both molecular and physiological levels, and how they are regulated and controlled.

Some of the most innovative work to come from the Kramer lab is the development of **tools to directly observe the processes of photosynthesis as they occur in living plants**. These techniques are currently being used in many labs around the world to understand how plants respond to rapidly changing environmental conditions, and ultimately to improve the productivity of crops.

The work led to formation of the **Center for Advanced Algal and Plant Phenotyping**, which aims to both develop such new scientific tools and to bring them to the broader community of scientists, researchers extension agents, and farmers.

"Kramer and his team have developed a collection of ingenious devices and accompanying data analysis software that enable the study of plants and algae under conditions more closely simulating the natural environment", said **Christoph Benning, MSU Foundation Professor and Director of the MSU-DOE Plant Research Laboratory**. "Making these tools broadly available is enabling the larger scientific community to answer basic and applied questions about photosynthesis in novel ways."

Kramer received his B.S. in Biology and M.S. in Cell Biology from the University of Dayton and his Ph.D in Biophysics from the University of Illinois. After a post-doc in Paris, France, and professorship at Washington State University, he accepted the John A. Hannah professorship at MSU in 2010. Kramer's research is supported by a number of agencies, including the U.S. Department of Energy, U.S. Aid for

International Development, National Science Foundation, the McKnight Foundation and the John A. Hannah Foundation.

Kramer recently accepted the award at the ISPR's 17th International Congress on Photosynthesis Research in Maastricht, The Netherlands.

Kerfeld lab reveals a new light-responsive protein family

8/24/16

Igor Houwat, Matthew Melnicki

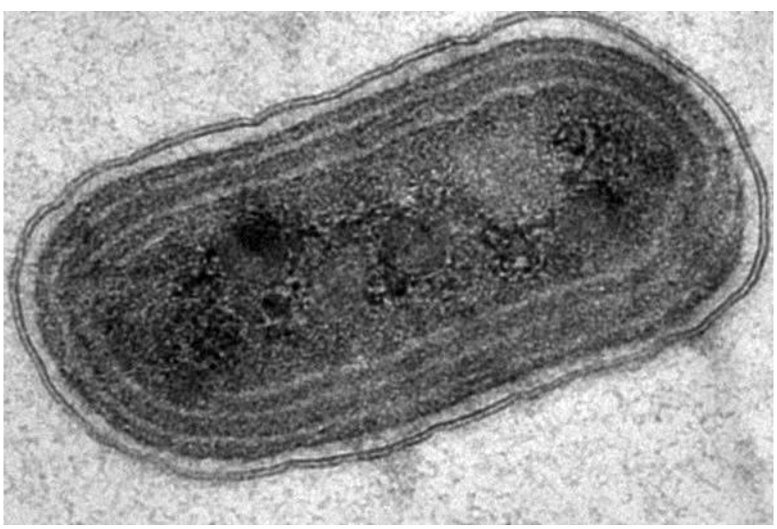
SUMMARY

- The **Kerfeld lab** has discovered an ancestral protein family in cyanobacteria.
- This discovery adds to our knowledge of cyanobacterial evolution and opens doors to exciting applications in medicine, biotechnology, and beyond.
- The finding has been **published in this issue of Molecular Plant** (**abstract here**).

Cyanobacteria, formerly known as blue-green algae, evolved on Earth billions of years ago. And these simple organisms – one cyanobacterial cell is 25 times smaller than a human hair – are extremely captivating to those who study them, including Dr. Matt Melnicki.

“Cyanobacteria were probably the first organisms to do photosynthesis with water,” says Matt, a postdoc in the Kerfeld Lab and one of the study’s primary researchers. “Almost every organism on the planet gets its energy ultimately from this kind of photosynthesis, and thus much of what is taught in biology classes depends on cyanobacteria evolving that capability.”

These underappreciated organisms, which dominate the oceans, are also the very reason we have a breathable atmosphere nowadays – after all, one of the byproducts of photosynthesis is oxygen, released into the air.



Each cell 25 times smaller than a human hair. By Eric Young, MSU-DOE Plant Research Laboratory

Two light protection functions: the OCP

Scientists have known for a while that most cyanobacteria contain a unique protein, the Orange Carotenoid Protein (OCP).

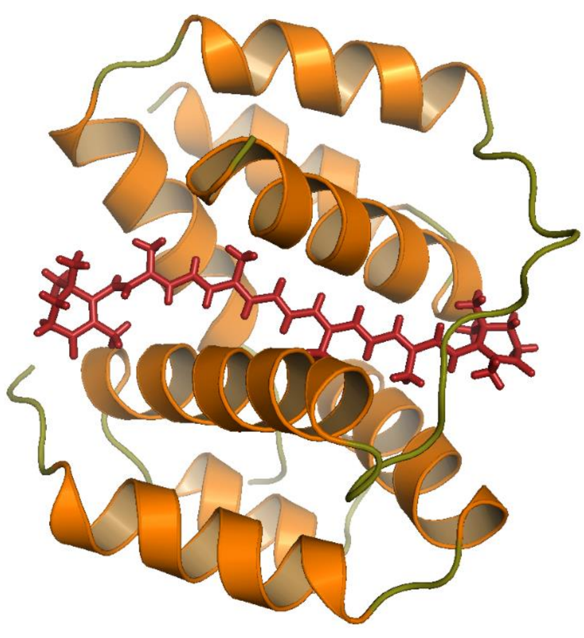
Each OCP carries a carotenoid pigment in order to perform **two crucial protective functions**.

First, the OCP protects cyanobacteria overexposed to bright light by dissipating the excess absorbed light as heat. This “sunscreen” function prevents the photosynthetic machinery from burning out.

Second, the OCP scavenges harmful byproducts of photosynthesis that would otherwise damage the same photosynthetic system that produced them. (We eat leafy greens and drink orange juice to protect our bodies from such molecules).

Introducing the ancestor: HCP

The **Kerfeld Lab** - headed by Dr. Cheryl Kerfeld, Hannah Distinguished Professor of Structural Bioengineering - has now identified a new protein family they say were the OCP’s progenitors. These ancestors, named Helical Carotenoid Proteins (HCP) because of their coiled helix structures, consist of nine different protein sub-groups.



Coiled helix shapes (orange). By Matt Melnicki, MSU-DOE Plant Research Laboratory

Modern cyanobacteria still contain genetic codes for the HCP family, which was how the Kerfeld Lab was able to discover it. “It turns out that the majority of cyanobacteria have at least one HCP or the OCP, or both, so there must be something important about them. We’ve uncovered a large diversity among the HCPs and we believe that the nine HCP sub-types each do something different.”

In fact, the HCPs look very similar to the OCP, and the research hints at which particular type of HCP evolved into the modern OCP. "At some point – potentially a couple billion years ago – one of the HCPs acquired the ability to dissipate excess light, which provided an important fitness advantage."

Cyanobacteria can't run away or hide when light gets too bright, Matt adds. So acquring that sunscreen function allowed these organisms to venture out into riskier habitats where they had better access to light - such as those without shade, high UV exposure, or other stressful areas where photosynthesis doesn't work at full capacity.

The Kerfeld lab thinks the HCP family may have additional functions distinct from the OCP's, explaining why these ancestors have remained needed throughout the eons.

The green swirls represent a cyanobacteria bloom in Lake Atitlán, Guatemala. By NASA Earth Observatory

Towards "light" applications

With increased understanding of these simple proteins, **the Kerfeld lab are turning their attention to applied fields like medicine or biotechnology**.

"The majority of known pigment-binding proteins are either stuck in lipid membranes in the cell – which makes them hard to work with – or are otherwise large and complex. The discovery of these HCPs, especially their diversity and solubility in water, opens new doors."

One area of interest is optogenetics, a recently developed technology that uses light to control specific cells in living tissues (**watch this great introduction below**). Optogenetics is teaching us about how we wake up or how we learn. It has transformed the stumbling of rats afflicted with Parkinson's into a steady walk and has led to insights into autism and depression.

In this context, the OCP and HCP, both responsive to light, could be used as switches that, when targeted by a light source, turn on predetermined functions – such as activating a neural pathway so scientists can observe it or curing a disease.

Medical applications could involve HCPs or OCPs transporting carotenoids – which are antioxidants – to pinpoint areas of oxidative damage in the human body or to combat diseases such as cancer. “We could brainstorm all day about what we could do with these things! Essentially, the limit will be our own creativity!”

https://youtu.be/Nb07TLkJ3Ww

Undergrads make strong showing at Mid-SURE Symposium

8/29/16

Igor Houwat

The Mid-Michigan Symposium for Undergraduate Research Experiences – or **Mid-SURE** for short – provides undergraduate researchers, visiting students participating in MSU summer research programs (such as the **REU**), and other students from select institutions with, "an opportunity for students involved in research and creative activities at Michigan State and select institutions to share their work with their peers, faculty, and external audiences."

Mid-SURE 2016 took place on July 27 on the 4th floor of Spartan Stadium.

Following is a highlight of some of the participants and their research:

- **Samuel Vaitkevicius**, from the **Brandizzi lab** looked at a protein that is vital for an essential defensive mechanism used by plants and animals alike in the face of environmental stressors.
- **Thien Crisanto (visiting from Humboldt State University) and Daniel O'Hagan** from the **Ducat lab** examined how to build and improve synthetic microbial communities that are driven by sunlight by using an organism that has lived for billions of years: cyanobacteria.
- **Nicole Haddad (visiting from Purdue University)** worked with the **Howe lab** on research demonstrating the importance of certain chemical compounds towards defending plants against herbivores.
- **Ciara Fromwiller and Sean McGuire**, from the **Kerfeld lab**, explored strategies to reengineer a protein structure, found in many bacteria, so it becomes a miniature factory that could create green energy or sustainably produce materials for use in biotechnology fields.
- **Olivia Stephens (visiting from Spelman College)**, from the **Montgomery lab**, examined plant light receptors and how different parts of the light spectrum affect plant growth and development.

Plants have their cake and eat it too

8/30/16

Igor Houwat, Ian Major

Banner photo by [Marie-Lan Nguyen, CC BY 3.0.]

Scientists have thought for a long time now that plants have a remarkable ability to grow or defend themselves, but they don't do a good job doing both functions at the same time.

The **Howe lab** has created a plant that challenges that assumption, and the future implications for agriculture and food security could be very significant.

"The long-held idea makes intuitive sense," says Dr. Gregg Howe, co-author of the study. "If you think about it, plants work with a limited amount of resources, and it would seem like they would prioritize these resources for particular processes – in this case, growth or defense – depending on the need."

Casual observations would confirm this concept, known as the defense-growth trade-off. Plants that defend more are smaller, yet plants that grow more have severely weakened defenses.

Creating a genetic test

Marcelo Campos, a former graduate student in the Howe lab and lead co-author of the study, wondered if they could devise a genetic approach to somehow make a plant that can have it both ways.

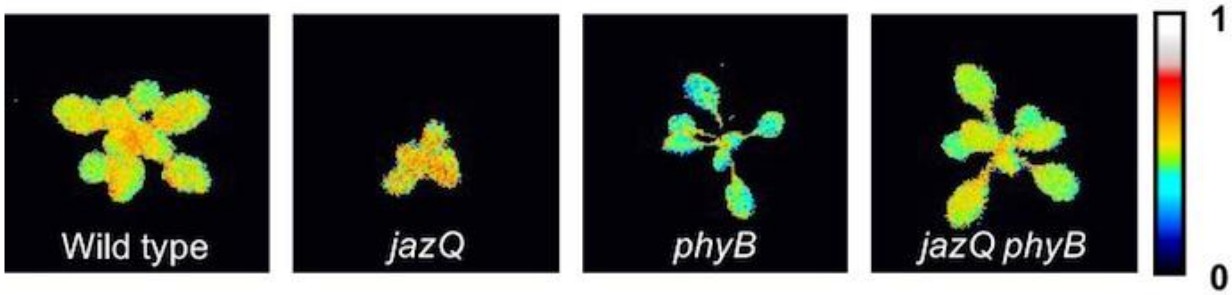
"To be honest," says Dr. Gregg Howe, "I was a bit skeptical at first, because it's impossible to predict how a random combination of genes will affect an organism's interaction with the environment. But I encouraged him to go ahead and try it."

First, it was necessary to create a plant – which they named jazQ – that produced high levels of defense compounds at all times, even when the plant was under no threat from insects.

The jazQ plant was indeed remarkably resistant to insect attackers but, as predicted by the defense-growth trade-off idea, also grew much slower than its wild counterparts.

Taking the next step, the lab randomly mutated thousands of jazQ plants to see if they could find a fast growing plant that retained the high defense feature. The team found that some plants grew fast, but they had lost their ability to defend in the process.

But, and to the researchers' surprise, one stood out.



The new plant, far right, defended better and grew as well as its wild counterpart. By the Howe lab

"Have Your Cake and Eat It Too"

All plants have molecular pathways dedicated to the production of proteins, hormones, or other molecules that are used to develop and protect the plant. An analogy would be the logistical network of drivers, warehouses, and communications systems that work together to deliver a package from its starting point right to your doorstep.

It turns out that molecular pathways for plant growth and defense are generally antagonistic to each other. So when one is more active, the other tends to be reduced.

Looking closer at the new plant, the researchers found a very interesting mechanism to explain how it worked. The specific mutation, which removed a photoreceptor (called phytochrome B) that is part of the growth pathway and is responsible for detecting red light, suddenly dissolved the antagonism, and both pathways appeared to work at full capacity.

"Our lab has been joking around that this plant has its cake and eats it too!'"

Dismantling the Defense-Growth Trade-off

The Howe lab's unexpected findings challenge the idea that defense-growth trade-offs are caused by diversion of limited resources to one process at the expense of another.

In the future, we could grow more crops while using less pesticides.

“There must be some other reason why stressed plants grow more slowly than non-stressed plants. This is a phenomenon that is also seen in animals and bacteria, so why do stressed plants grow slower?” That is next on the lab's agenda.

“Down the road, we are also interested in applying this genetic combination to crop plants”, says Ian Major, study co-author and post doc in the Howe lab.

For example, packing crops, such as corn, closer together increases yield. But increased planting density results in crops growing taller as they compete intensely for sunlight, which makes them vulnerable to insects and pathogens.

“But if we **make appropriate genetic modifications through breeding or molecular approaches**, we can hopefully help design the next generation of crops to meet the food and fuel demands of the growing world population.”

The study has been published in **Nature Communications**. Other collaborators include **Dr. David Kramer** and **Dr. Thomas Sharkey** from MSU and **Dr. Georg Jander** from Cornell University.

Banner photo by **Marie-Lan Nguyen, CC BY 3.0**.

For a short history on the phrase “Have your cake and eat it too”, check out this article.

The building of impactful science careers

9/14/16

Igor Houwat, Christoph Benning

Two decades of effort

Science articles present us with fascinating glimpses into our world or visions of future possibilities. Yet when we get a science story from NPR or social media, the backstory behind discovery takes the backseat. It is like watching a movie montage where an ordinary person turns into a martial arts master in no time, with barely a glimpse into the effort it took to get good.

Science is actually a long-haul project and often starts with basic, sometimes unexpected discoveries. The latest publication involving the **Benning lab** and its collaborators describes one such endeavor that took over two decades to complete.

The study, published in the **Proceedings of the National Academy of Sciences USA**, examines a protein – called DGD1 – involved in making one of the most abundant lipids in the world. These same lipids are used to build the membranes inside chloroplasts which are responsible for photosynthesis, the process that converts sun light into much of the planet's usable energy.

"These lipids provide the glue that holds the photosynthetic machinery together in membranes. Losing a set of these lipids, the machinery will be damaged," says Dr. Christoph Benning, plant lipid expert.

The DGD1 protein is made of two parts. One was demonstrated decades ago to make the lipid. The other part, the subject of this latest study, has been found to shuttle the produced lipids from the outer parts of the chloroplast to its inner parts so that they build the photosynthetic membranes.

For a single protein, DGD1 holds much sway over the plant's well-being. In lab experiments, plants that missed either half of the two-piece production and delivery system didn't grow well or got sick.

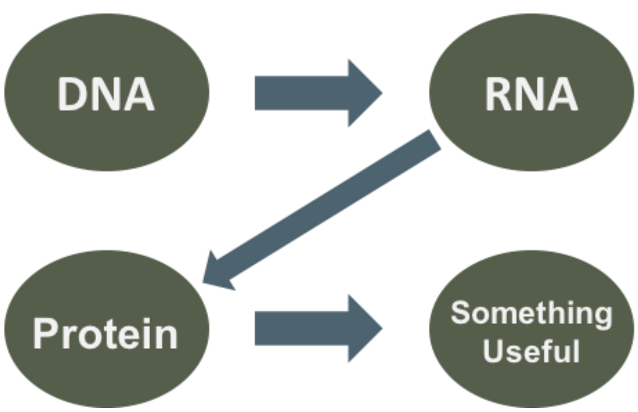
Benning with his German lab on a trip. Peter Dörmann in the back, center.

Germany, 1995: discovering DGD1

"This is a story of a collaborative effort that has taken a long time, from the discovery to figuring out how an important plant protein works. I feel proud about having been part of this effort since a number of people have built their careers around this research," says Benning.

This all started in 1995, when Benning was running his first lab at the Institut für Genbiologische Forschung Berlin GmbH in his native Germany.

"We did somewhat of a brute-force genetic mutant screen and stumbled on an Arabidopsis plant (*Arabidopsis is the 'lab rat' of plants*) that was missing 90% of this very important lipid. We didn't know the responsible gene or protein or how either worked to produce the lipid, but we knew the lipid was relevant to photosynthesis, because the mutant plants were smaller and bushier than usual."



DNA/genes lead to proteins. Proteins make useful things, like lipids.

Right from the outset, the group figured out that the mutant plant missed a protein for making the lipid. They christened it DGD1, after the scientific name of the missing lipid.

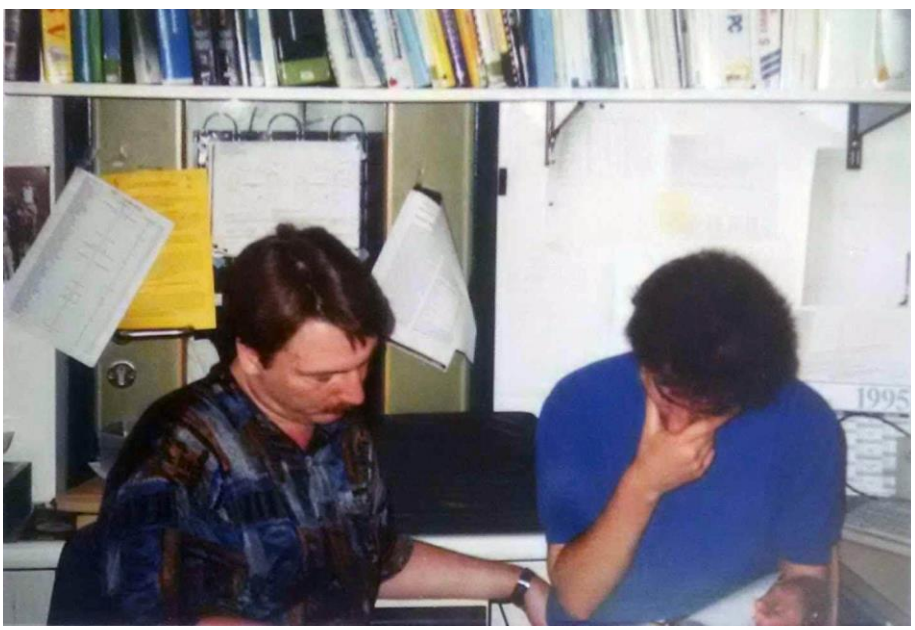
“We published the mutant in *Plant Cell*. People in the scientific community just thought it was amazing that missing one type of lipid could have such an effect, and I truly believe that this paper was key in getting me my job at MSU.” The first author was Peter Dörmann, a post doc working with Benning.

MSU, 1999: identifying the DGD1 protein

Three years later, the Benning group, now at MSU, identified the gene behind the defective protein and missing lipid in the mutant. This was a three-year genetic mapping feat, since the Arabidopsis genome was not yet fully deciphered.

“It was a big deal at the time, because without the genome as reference, we didn’t have the resources to easily identify the gene defective in the mutant. When the genome became available in 2000, we had a basis to confirm our findings against a larger reference library, where we immediately found a second protein similar to ours.”

With the gene identified, the group was now able to isolate the protein and see how it worked. “We knew right away that one part of the protein was important for building the membrane of the photosynthetic machinery. But the other part, we had to speculate. We came up with a hypothesis that it was important for transporting these lipids, but we couldn’t prove it.”



Benning and Dörmann at work

Benning, Ilse Balbo, the marvelous technician who found the mutant and was involved in mapping the gene, and Dörmann, who had followed his mentor to MSU, published the new findings in a *Science* paper in 1999.

“This second paper on finding the DGD1 gene and protein contributed much to my promotion to Associate professor with tenure at MSU. We speculated on how the two protein parts might work together, but we got it wrong, because we didn't know enough about it at the time", Benning reminisces.

A new career flourishes

With a *Science* paper under his belt, Dörmann left the Benning lab to pursue his own career in Germany.

"Before students or post docs leave my lab, I often let them be a corresponding author on a research paper so they get mentored on the publishing process, a cornerstone of scientific careers."

"I also have handed down projects to my postdoctoral researchers so that they can continue the research on their own. At some point, mentors have to stop being involved in their mentees' work so that they can develop their own careers, much like weening your kids."

That is exactly what Dörmann did, starting his own lab and continuing the work on DGD1, while Benning moved on to new research topics.

"Dörmann and his students have published a number of papers on this protein. He corrected the error we made in the 1999 *Science* paper and showed how the protein correctly works. His lab also demonstrated how a plant deficient in DGD1 ended up sick because of defects in photosynthesis," Benning adds.

This latest publication is the culmination of 15 years of research to prove the original hypothesis that DGD1 is also responsible for the transport of the lipid it produces.

Dörmann (center)

"Dörmann and I have built a career with the research we started back in 1995 (***Dörmann is now at the University of Bonn in Germany*** *and Benning is now director of the PRL*). Many others, including PRL's own **John Froehlich**, collaborated on this subject. It's an example of how big – and in this case accidental – discoveries lead to big publications, which are crucial to growing scientific careers."

2016 and beyond: movie montage moment

In the large scheme of things, this is the story of the discovery of one protein among thousands that exist in every plant cell. The twenty years it took to tease out DGD1's function is not an unusual timeframe for scientists.

But it is incremental basic discoveries that set the foundations for future applications that change society - in this case, perhaps how to **increase photosynthetic efficiency** or even how to replicate nature and build an artificial photosynthetic membrane in the test tube.

Given that plants are not perfect at harnessing the sunlight and converting it into useful things, increasing their production capacity, even in small increments, has huge consequences on food security and **renewable energy solutions** for the 21st century.

Additional contributors to the study include Amely Kelly and Barbara Kalisch, both first authors. Photographs courtesy of Christoph Benning.

The dangers of overcharging your plants

10/4/16

Igor Houwat, Geoffry Davis, David Kramer

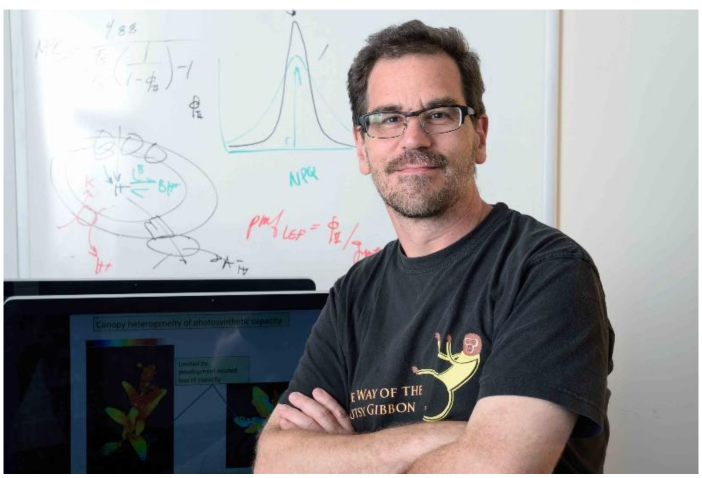
Engineers are constantly trying to make phone batteries more efficient and lighter, and they do so by packing together very thin layers of the metal lithium. The problem is that overcharging these batteries can lead to serious damage, even fires that have been in the news recently.

It turns out that nature has been dealing with a similar problem for a long time in the process of photosynthesis, the source of energy for most life on our planet. Our food supply depends on photosynthesis being efficient, and so do some of our renewable materials. And in the effort to help feed billions more people, or to power our jets and cars with biofuels, scientists have been trying to figure out how to improve this process.

But capturing light is a dangerous business for plants. And in its latest study, published in the prestigious open-access journal, eLife (**go to article**), the **Kramer lab** has discovered that photosynthesis can often overcharge plants, potentially killing them.

Storing energy in different forms

To be able to perform photosynthesis, chloroplasts, **the tiny "solar panels"** in plants – have to absorb light that has very high energy and convert it into usable forms that power the plant.



Dr. Kramer

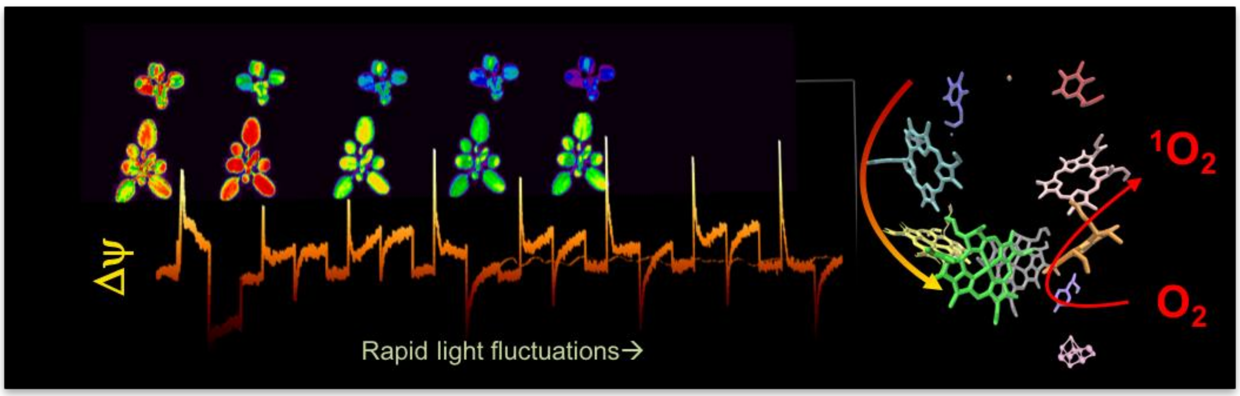
Chloroplasts do this by using the light energy to strip electrons from water and store them in various compounds, similar to what happens when we charge batteries. But unlike batteries, plants have to store energy in different forms in order to perform different jobs. A much more fascinating picture!

The Kramer lab has been studying one of these forms of storing light energy, an electric field generated by the chloroplast. Stored across an ultra-thin membrane in the chloroplast, the field powers a process that makes ATP, an essential 'energy currency' needed by the plant to survive and grow.

Dangerous electric spikes

In this latest study, **Geoffry Davis** from Kramer's group has discovered that too much of this electric field can cause huge problems, because it destabilizes the other parts of photosynthesis, which then end up self-destructing.

"When the field gets too large, it makes some of the electrons move backwards from the way they should," says Dr. David Kramer Hannah Distinguished Professor in Photosynthesis and Bioenergetics at the PRL. "This wastes energy, but even worse, if these electrons end up on special chlorophyll molecules, they can transform oxygen from the air into a chemical that can damage or kill the plant."



A depiction of the energy spikes. By the Kramer lab

Scientists have known for a while that this damaging chemical is a byproduct of photosynthesis, but they haven't known the extent to which this is a major limitation on plant productivity. The reason is that plants have been studied in bits and pieces in the lab, isolated from the organism and its environment.

With that in mind, the Kramer group, through support from the **U.S. Department of Energy (Basic Energy Sciences)**, has developed the **technologies that allow them to study photosynthesis in living plants under the conditions they experience in the real world**.

And these technologies have been yielding surprising insights. According to Geoffry, "When the leaves move in the wind or clouds go by, the light hitting the leaves can flicker very rapidly. These rapid changes cause very large spikes in the electric field, enough to cause a lot of damage."

"Think about it: these changes in light conditions happen all the time in nature."

Inefficient natural defenses

Plants can partially protect themselves from this electric overcharge, but they do this by shedding energy that would otherwise be used productively.

The result is that, out in the field, plants typically store only about 1% of the energy that they absorb as biomass that is suitable for human use. But it's theoretically possible to store much more.

Geoffry Davis

Even worse, Geoffry says, the protective mechanisms are often too slow to protect against large spikes in electric field that happen when the light flickers.

"We need plants that can respond more rapidly so they can protect themselves without losing production efficiency. We have been looking at a wide range of different plants that do a better job and also making mutations in plants to figure out what makes them more or less sensitive. This is giving us some important clues about how to proceed."

Aiming to grow better plants

One of the collaborators on the team, **Professor William Rutherford**, sums up the study's importance nicely: "There are many ways to kill a photosynthesizer with light, but this discovery is probably the most credible in terms of mechanism and physiological relevance. These big spikes in the electric field simply replace our hand-waving explanations…that is a big step forward."

And increasing photosynthetic efficiency, even by a small percentage (say 1 or 2 percent), could dramatically increase crop yield. More importantly, such photosynthesis-related increases would not require additional fertilizer or other inputs, an improvement over the **first Green Revolution** due to it being intrinsically more sustainable.

Kramer emphasizes that we are going to have to find newer ways to sustain an expanding population. “There is not much more new arable land to use. So we are going to have to breed or create more efficient plants that use the resources better. And we’ve already tapped out a lot of the ‘easy’ ways to make plants more efficient.”

Kramer concludes, “Now we have to get into the engine of photosynthesis and figure out how to squeeze a few more horsepower out of it. This is a much harder problem, but that’s where the energy losses are.”

Additional collaborators include Atsuko Kanazawa, Mark Aurel Schöttler, Kaori Kohzuma, John E. Froehlich, A. William Rutherford, Mio Satoh-Cruz, Deepika Minhas, Stefanie Tietz, and Amit Dhingra.

Banner of phone battery, expanded due to short-circuit, ***by Mpt-matthew CC BY-SA 3.0***.

Updated 5/17/17: The article has been recommended in F1000Prime as being of special significance in its field.

In Remembrance: Dr. Kentaro Inoue (1968-2016)

10/6/16

Kenneth Keegstra, Aaron Liepman and John Froehlich

On August 31, 2016, the PRL lost a dear colleague and friend, when Kentaro Inoue was killed in a tragic accident as he rode his bicycle to work en route to the UC-Davis campus.

Kentaro Inoue was born in Japan in 1968 and spent his early years there. He received his PhD in 1996 from the School of Pharmaceutical Sciences at the University of Tokyo working with Yutaka Ebizuka on a novel plant enzyme involved in the synthesis of plant steroids. His studies included detection of the enzyme, purification of the protein, and molecular cloning of the gene.

Dr. Kentaro Inoue By The Noble Foundation

He then performed postdoctoral research with Rick Dixon at the Noble Foundation where he studied enzymes involved in lignin biosynthesis. During a second postdoctoral period with Ken Keegstra in the Plant Research Laboratory at Michigan State University, Kentaro began studying chloroplast biogenesis, a topic that he would pursue for the remainder of his very productive scientific career. His early studies focused on **biophysical aspects of the interaction between precursor proteins and the surface of chloroplasts**. He later moved into **other aspects of precursor structure and function**, especially as he began his independent career at the University of California at Davis in 2002.

Kentaro is remembered as much for his brilliant scientific mind as for the collegiality and positive spirit he brought into the laboratory. Kentaro was a valuable team member, always willing to help his labmates, to brainstorm and troubleshoot experiments, and to provide constructive criticism. Kentaro possessed great wit and a dry sense of humor that was appreciated by his colleagues and brought levity to the lab. His "poker-face" made it difficult to tell that the joke was on you, until it was too late! Kentaro was a friend, teacher, and source of inspiration to many at the PRL.

Kentaro also had a special way of bridging languages. For example, when Teruko Konishi arrived to work in Ken's lab, Kentaro tried to "teach" her the proper pronunciation of her unfortunate e-mail address (konish*t@msu.edu). Poor Teruko! Others in the lab nearly died of laughter. On the other side of that coin, Kentaro was a very helpful teacher of the Japanese language. He taught his labmates some very useful words that could be used to get the attention of Japanese colleagues (definitely not rude words!).

Kentaro was an avid cycling enthusiast. So much so, that Kentaro even had a **bike trail named after him called, "Kentaro's Monster,"** located at Burchfield Park-Mountain Bike Trails in Mason, MI. Sometimes the "Monster" conquered Kentaro and sometimes Kentaro conquered his "Monster"! So if you're ever in Michigan and you're into thrill rides just try the "Monster"!   Kentaro also enjoyed the adventures and challenges that came with participating in numerous cycling races.   Even his commitment to commuting to work by bicycle spoke to his love of cycling and his concern for the environment.

Our "Monster" biker, friend, and PRL colleague will be greatly missed!

Kentaro is survived by his wife, Amy, his parents, Drs. Yasuhiko and Yuko Inoue, and by his sister, Meiko Inoue, in Japan.

The link below is provided for anyone who wishes to **make a contribution** towards Kentaro's memorial bench in the UC-Davis Arboretum.

Undergrad researchers get a taste of graduate student life

10/11/16

Igor Houwat

The **Plant Genomics @ MSU REU** program graduated its most recent intern cohort this summer.

MSU is part of the National Science Foundation **Research Experience for Undergraduates (REU)** program, which funds over 100 universities across the country. The program gives undergraduates a taste of graduate student life as they start developing their budding careers, through active research in educational environments. Research sites around the country are tackling a diverse range of topics, like raptors, honey bees in Turkey, neurobiology, and many, many others.

It probably does not come as a surprise that, given MSU's seasoned history in studying plants, we have an REU site focused on plant sciences that attracts students from **across the US**.

Teaching plant research

"Plants are essential to human health and nutrition and we utilize them as sources of food, fuel, fiber and pharmaceuticals," says **Dr. Cornelius Barry,** Associate Professor in the Department of Horticulture and Director of the Plant Genomics @ MSU REU Program. "And MSU is a leader in plant science research with over 100 faculty engaged in research and teaching that spans the applied to basic science continuum.

"The REU program provides opportunities for students to come to MSU each summer and enrich their undergraduate experience through participating in a mentored research project under the guidance of a faculty mentor."

Thien

In 2016, 19 students participated in the program from across the US, including 5 who were mentored by PRL faculty.

Thien Crisanto, an undergrad at Humboldt State University, came to MSU for precisely that reason: "I had a list of about twenty REUs, and MSU's Plant Genomics REU was my number one choice. The research conducted by the professors were right up my alley; I wanted to do molecular and genetic work on plants. The fact that the REU offered a competitive research package (stipend, food, housing, travel) also made me want to come to MSU. "

Thien was with the **Ducat lab**, studying ways to create **microbial co-existing cultures around cyanobacteria**, one of the most productive photosynthetic organisms on the planet. The ultimate goal of that project is to create an alternative fuel source someday.

Olivia Stephens, an undergrad from Spelman College who worked with the **Montgomery lab**, **studied one of the ways plants use light in order to develop and grow**. She felt that this exposure to research and mentors helped sharpen her critical and analytical thinking skills.

Olivia

Developing well-rounded scientists

In addition to doing research, students participated in group meetings and activities, **attended professional development workshops**, and got the opportunity to discuss graduate school opportunities with current graduate students.

Thien, who is in the process of applying for graduate school, found these interactions helped her explore what she did and did not want for the future. “Connecting with students and faculty gave me much insight on the application process and what it’s like to be in graduate school.”

Olivia adds that, “The program improved my relationships and networks in the scientific community, especially interactions with graduate students. I believe that peer experiences make the most impact and that the social aspect of research is quite often less emphasized.”

And the program is working. Many **REU alumni** have gone on to successful graduate careers, winning NSF Graduate Research Fellowships or being published in prestigious journals.

With worldwide population growth, increasingly limited natural resources, and the continued problem of climate change, there is a need to explore new food and biofuel solutions. The Plant Genomics @ MSU REU Program is among those projects equipping our upcoming generation of scientists with the knowledge and tools to carry on the torch.

Joe Aung awarded a Pathway to Independence Award

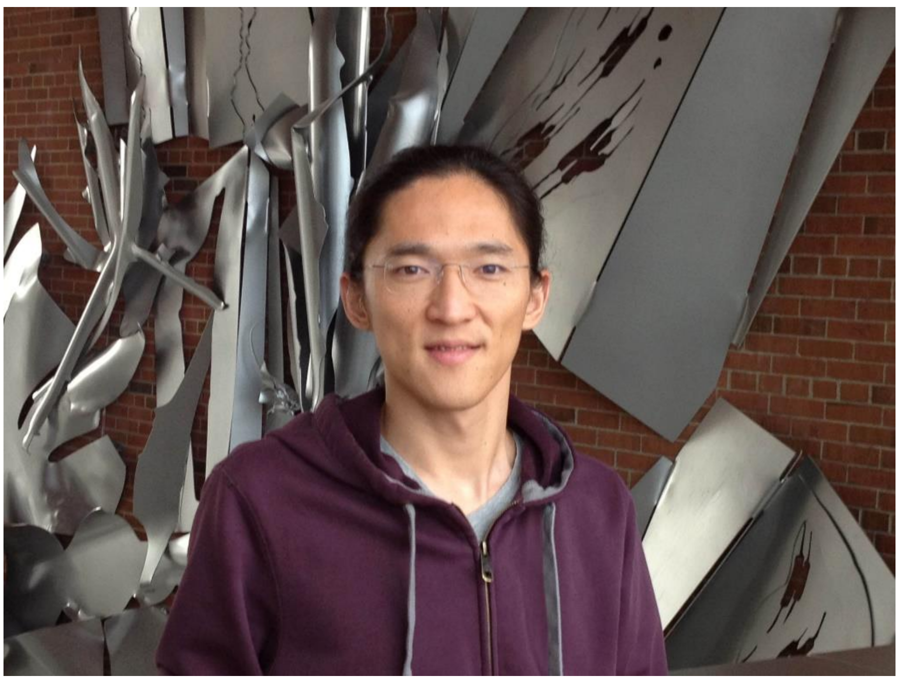
10/27/16

Igor Houwat

Kyaw (Joe) Aung, a post-doc in the **He lab**, has won a 2016 National Institutes of Health Pathway to Independence Award that will provide up to $837,000 of financial support over 4 years.

Joe's research will focus on how harmful bacteria infect plants.

The program, "provides an opportunity for promising postdoctoral scientists to receive both mentored and independent research support from the same award." The goal is to help awardees transition towards independent careers in two phases. The first provides 1-2 years of mentored support while the second is activated once the person is at an appropriate independent research position and provides 3 years of support.

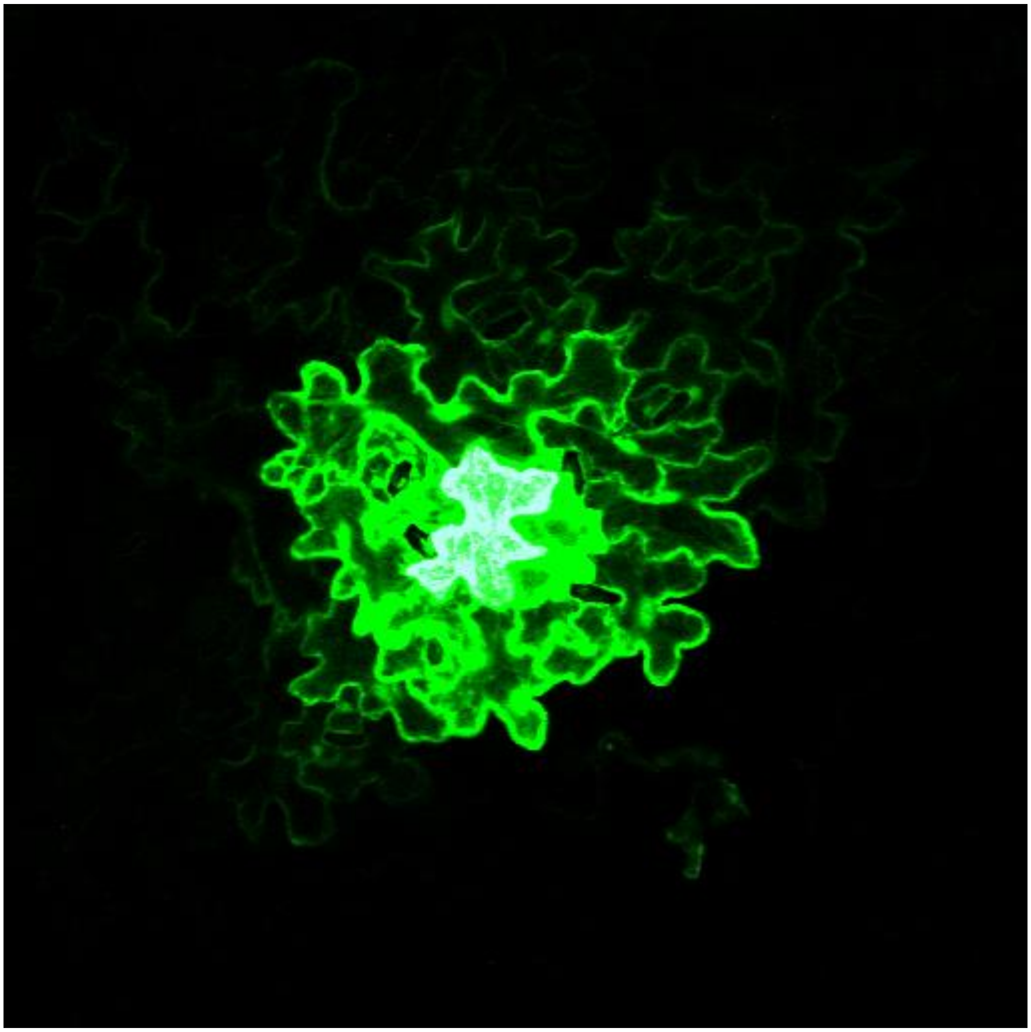


Joe Aung

Studying bacterial invasions

Scientists have known for a while about the fascinating **battle that goes on when bacteria try to invade plants**. The plants can recognize the invasion with special receptors that activate their defenses. But the bacteria counter with an injection of over thirty molecules into plant cells in order to overcome these defenses.

Joe wants to look at what happens once the bacteria have infiltrated the host tissues, and the motivation behind this research is to tackle a food security matter by understanding how bad bacteria make plants sick.



Gorgeous confocal microscopy plant image By Joe Aung

"I want to reveal how the bacteria manipulate the communication network between the plant cells. Perhaps hijacking the plant cell-to-cell communication network is the way it spreads the damage."

"I also want to look at how the different compartments inside each plant cell respond to and coordinate with each other upon bacterial infection. This is unexplored ground in scientific circles."

Reflection

Joe was born and raised in Burma/Myanmar. At 18 years of age, he moved to Taiwan where he obtained a B.S. and a M.S. in Horticulture from the National Chung Hsing University, followed by over four years in a research position at the Institute of BioAgriculture Sciences, Academia Sinica, Taiwan. He obtained his PhD at MSU in the **Hu lab** and has been a post-doc for almost five years in the He lab, studying the cell biology of plant and bacteria interactions.

Smaller plants indicate successful bacteria invasion By Joe Aung

“I have been extremely fortunate to have had trained at the PRL over the past ten years. Sheng Yang He is one the most inspirational people I know and is able to push me out of my comfort zone in order to attain goals beyond my wildest dreams. He has given me tremendous freedom, guidance, and support over the years to prepare my future career in science.”

Sheng Yang He adds of his mentee, “Joe is clearly one of the most capable, yet extremely modest and nicest postdocs I have mentored in my scientific career. Receiving a NIH K99 award is both a well-deserved recognition of Joe’s achievements and a great opportunity for launching his independent scientific career."

Joe remembers feeling simultaneously excited and overwhelmed when he got the news about the award. "It is a humbling experience to know that I was chosen among a group of talented post-docs. I feel especially proud to be awarded as a plant person since this award historically funds research in advancing human disease diagnosis, treatment, and prevention.”

But Joe thinks that his unique angle in studying how bad bacteria manipulate communications between plant cells won over the funding reviewers. “In certain ways, we react to our surroundings in similar ways to plants. This research might give us a new angle into studying why and how we humans get sick.”

Geoffry Davis wins ISPR presentation award

11/7/16

Igor Houwat

Geoffry Davis has won an award from the International Society of Photosynthesis Research (ISPR) for his presentation talk at the **17th International Congress on Photosynthesis Research**.

The **ISPR**, founded in 1995, aims to promote the development of photosynthesis research as a basic and applied science. The International Congress, held once every three years, took place in Maastricht, the Netherlands, and Davis's **winning presentation was in the top three from among 600 posters**.

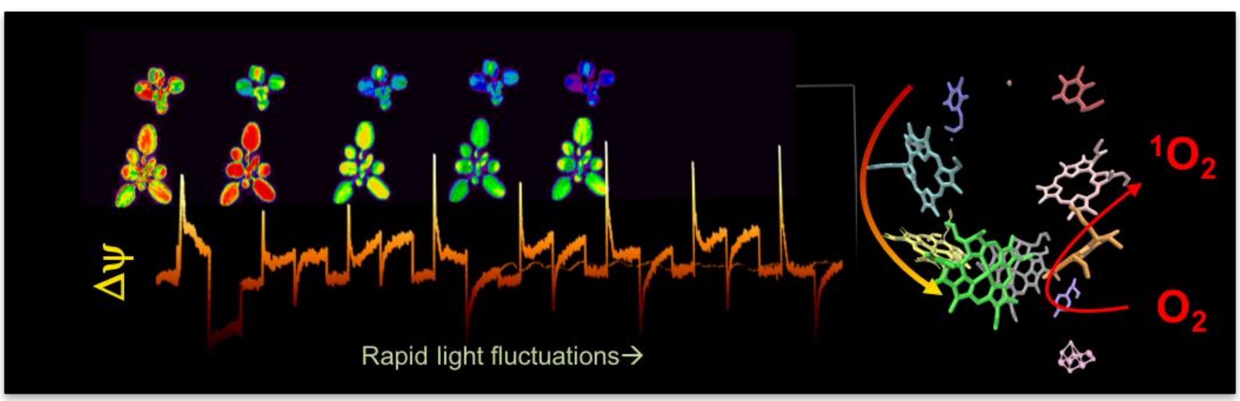
Damage from fluctuating light

Geoffry, a PhD candidate in Cell and Molecular Biology who works in the **Kramer lab** at the MSU-DOE Plant Research Lab, has been examining photosynthesis, the source of energy for most of life on our planet. The specific study in question **examines one of the forms plants store captured sunlight**, an electric field generated by the chloroplast, the plant's energy producing machine.

The discovery is that the electric field can spike in the presence of highly fluctuating light, 'overcharging' the plant and potentially damaging, even killing, it. "Think about it," Geoffry says "light flickers all the time in nature (think of a leaf blowing in the wind or of a cloudy day)."

In addition to presenting his poster at the Congress, Geoffry was invited by conference organizers to give a seminar about his research.

"The talk went well, a lot of people really liked the story, and many agree with it! This is new work that contributes to our understanding of photosynthetic productivity and how plants live in their natural environment. Much of the previous body of photosynthesis research has been studied in isolated complexes or proteins."



A depiction of energy spikes damaging to plants. By the Kramer lab

Researching plants in dynamic environments

A remarkable aspect of Geoffry's work is that researchers over the past decades figured out various aspects of the mechanism described in his research, by studying these isolated bits and pieces.

But no one was able to connect the dots until the Kramer lab at MSU **developed the tools to study photosynthesis processes in living plants under real-world conditions**.

It also became clear that **the living plant works very differently compared to its isolated bits**. Specifically, in the 1980s, it was generally thought that there was little, if any, electric field across one of the chloroplast components, called the thylakoid.

“But it turns out the electric field is both very important to store energy and also potentially very damaging to the plant under fluctuating light conditions. Back then, scientists didn’t have the tools and information we have today, so no one put it in the context of a living, breathing organism.”

Moving forward

Geoffry believes this will change the way people look at photosynthesis. “I think within a couple of years, this research will be influential. Even though one can get a snapshot of how things work in the lab or even draw a cartoon of how things work, photosynthesis is turning out to be a more dynamic process than many have expected.”

Geoffry Davis

From a basic research aspect, Geoffry thinks researchers will want to understand how this electric field is controlled inside living plants, at the molecular level.

And there are application potentials. “Photosynthesis only uses a small amount of the light hitting the Earth. The idea is that if a system could use more of that light, one could generate more energy through photosynthesis.”

With that in mind, scientists have been trying to **breed better plants that would increase crop yields** for food and renewable resources.

“On the plus side, maybe we can discover plants that protect themselves from these changes in light, now we know the danger this situation poses. But, a less rosy implication is that, if flickering light can damage or kill plants, having plants that absorb more light might not be a viable strategy for increasing energy production. We don’t know the answer yet.”

Geoffry, originally from Las Vegas, obtained his BS in Biochemistry at the University of Maine in 2012. He joined MSU that same year and joined the Kramer lab in 2013. His study was recently published in the journal, eLIFE (**link to** publication and **link to news release**).

Managing photosynthesis' traffic jams

11/10/16

Igor Houwat, Bradley Abramson, Danny Ducat

In the drive to create sustainable energy sources, there is a push to get cyanobacteria and algae to produce biofuels. But a major barrier to market adoption has been simple math: productio n costs are too prohibitive, as the efficiency of converting solar energy into useful compounds is not high enough.

The **Ducat lab**, however, has coaxed a lab-grown cyanobacteria to increase photosynthetic efficiency while simultaneously producing bioproducts, a remarkable technique that might remove that long-standing economic barrier.

The results have been **published in the *Plant and Cell Physiology*** journal.

Figure 1 By Joey Kyber, Pexels License

A potential new source of energy

Sugar is at the heart of modern biotechnology. Take bioethanol: it is a biofuel made by taking sugar molecules in a plant, such as corn or sugarcane, and fermenting them into alcohol.

But there is a limit to how much we can squeeze out from plants.

Dr. Danny Ducat, an Assistant Professor at the Department of Biochemistry and Molecular Biology, says, "Think about it, we use plants, such as corn, to feed people and animals and also to produce biofuels like ethanol. These are competing markets that can make certain resources scarce, like fertile land and fresh water."

"Cyanobacteria are highly productive and could potentially become an alternative source of sugars. This would be ideal for biotechnology, with cyanobacteria taking some of the load away from crops and plants while not competing with them for soil or water."

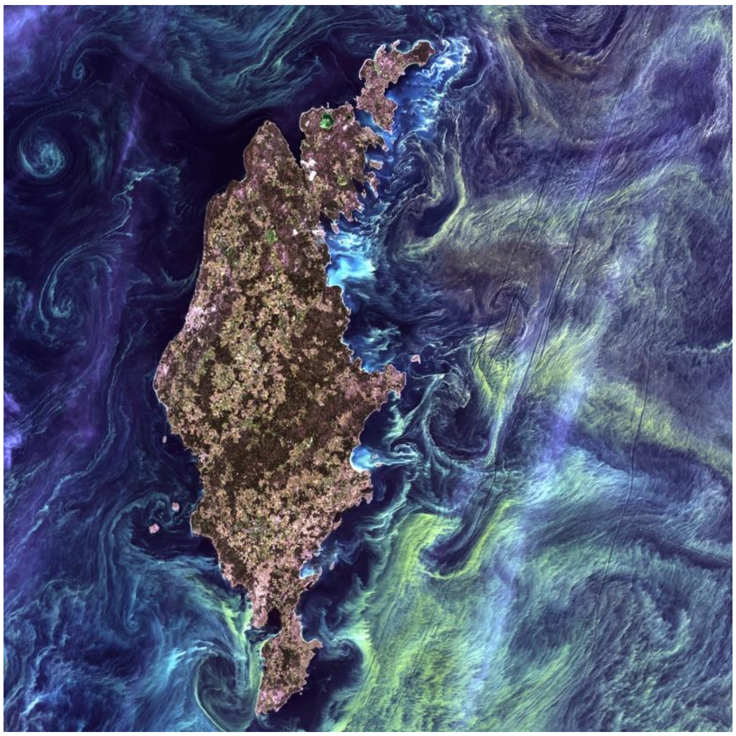


Figure 2 Cyanobacteria can grow in environments that would be hostile to land plants: salt water, hot springs, even icebergs.

A mysteriously productive synthetic organism

With that in mind, the Ducat lab created a sucrose-exporting cyanobacteria years ago, with the idea it would eventually produce useful bioproducts.

"The lab strains were very productive but did things we did not understand. For example, we noticed an unexpected increase in productivity, which seemed non-intuitive," Danny says.

Danny expected the lab cells would get sickly, because forcing the cyanobacteria to produce and export sucrose was not part of their usual function nor useful for their survival. Instead they increased in productive efficiency.

Bradley Abramson, a PhD student in Danny's lab, was interested in exploring why, and the answer was in the process of photosynthesis.

Photosynthesis traffic

Photosynthesis is the source of energy for most life on our planet. And photosynthetic organisms have to manage the process very much like highway traffic, where the cars are energy and carbon. And much like on our roads, backups do happen.

For example, an apple tree captures energy with photosynthesis in the leaves, and stores some of that energy - in the form of sugars – in apples. A longstanding observation is that, if you chop off all of the apples, the sugars have fewer places to go, and the ensuing sugar "traffic jam" can lead to a reduction of production in the leaves.

Conversely, if any leaves are removed - say, blown away in a storm - the remaining leaves may pick up the pace in the short-term to make up for their lower numbers.

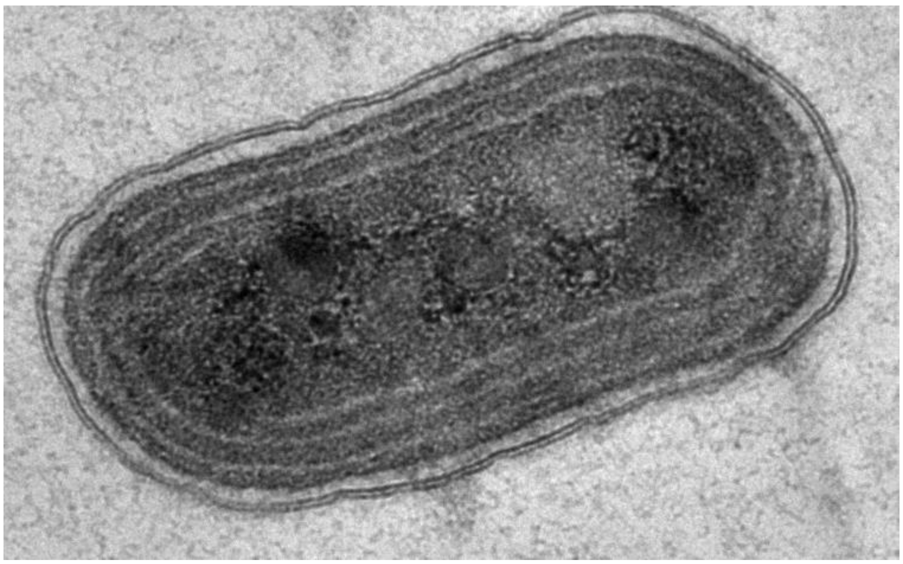


Figure 3 A cyanobacterial cell, 25 times smaller than a human hair. By the Ducat lab

Molecular Off-ramps

What Bradley found was that sucrose export led to an increase in photosynthetic efficiency to compensate for the amount of sucrose exported. In other words, more of the energy from sunlight was used towards producing the sugars.

"By introducing sugar export to a cell's activity, we have essentially built a new off-ramp, using the traffic analogy," according to Bradley. "The off-ramp relieves traffic jams by letting more cars (energy) exit the road. This lets traffic (photosynthesis) flow more regularly and efficiently because the road is less crowded."

Call it a win-win: the cyanobacteria produce lots of a useful product for society while being more effective at photosynthesis.

Where to build off-ramps

Although other scientists have observed similar results in their efforts to produce biofuels, Bradley's study is the first to understand the mechanism behind the productivity bump.

Next, the Ducat lab wants to examine the links between energy production and export, how these links are sensed by the cyanobacteria, and how this all affects cyanobacteria's productivity and health.

And the potential industrial applications, which is Bradley's passion, are exciting.

"Now we need to understand where and how to build new off-ramps," Bradley adds. "This is not just about sucrose. It is becoming evident this happens in many cyanobacteria strains engineered to produce something. By understanding what is happening in these strains, we can begin to engineer greater efficiency, which means we can expect greater production at a lower cost."

Adam Jordan joins VWR as Sales Associate

11/21/16

Igor Houwat

Adam Jordan, a former Research Tech with the **Ducat lab**, has started a new career chapter as Sales Associate for VWR.

VWR, based in Pennsylvania, is a global provider of products and services to labs and production facilities in the pharmaceutical, biotechnology, and healthcare industries, among others. The company boasted over $4 billion in sales in 2015 and has over 9,300 associates.

Adam's sales territory will cover the University of Notre Dame, Van Andel Institute, Western Michigan University, and Grand Valley State University.

Soon after Adam graduated from Central Michigan University in 2012 with a dual degree in Neuroscience and Psychology, Danny Ducat hired him to jumpstart the Ducat lab.

"When I first arrived, it was just Danny and I, with minimal equipment. I had the invaluable experience of filling the lab with supplies and equipment, as well as informally acting as the lab manager. As a fitting end, we both recently submitted an article to the journal of *Applied and Environmental Microbiology*."

"I've had the privilege of working with incredible researchers during my time at MSU. To be a part of such a historic and world-renowned department is something that I am, and will continue to be, incredibly proud of. I have made fruitful relationships and life-long friends. I have to thank Danny for allowing me to be a part of this. I also have to thank Linda Danhoff for always being an incredible resource and friend."

Of his former lab member, Danny says, "Adam has been with us pretty much since Day 1 of the lab here at the PRL. He was often the first face for new students just getting their bearings, and has always been a go-to guy for all sorts of random questions and troubleshooting. He has been relentlessly friendly and good-natured throughout it all and has helped to shape the lab into what it is today. We're all very happy to see him take the next steps for his career, while being a little sad to see him go."

Congratulations and good luck, Adam!

The highs and lows of scientific research

12/5/16

Igor Houwat, Xiufang Xin, Kinya Nomura

Toddlers constantly bumble about their surroundings, accidentally learning how things work. Flipping a switch makes a room go dark; squeezing a fuzzy toy makes a funny squeak.

Doing science can be just as unpredictable, as the researchers behind the **He lab's** latest study, Xiufang Xin and Kinya Nomura, tell it.

The study, **published in the journal, *Nature***, establishes a connection between high environmental humidity levels and bacterial plant disease.

The harmful bacteria live in the space between plant cells in the leaves – known as the apoplast - one normally filled with air so plants can breathe and do photosynthesis.

It was found that the bacteria trick the plant into producing water in the apoplast, causing water flooding in plant leaves, a favorable environment for bacteria to multiply aggressively. (**Full story here**).

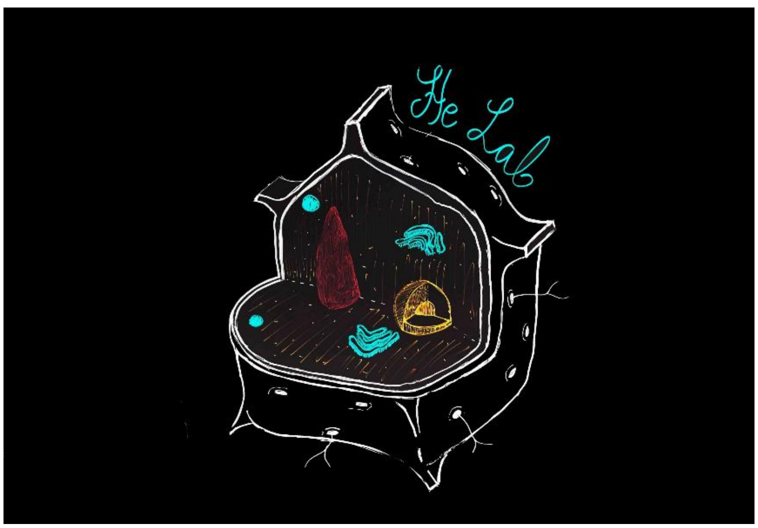


Figure 1 By Harley J Seeley Photography

Plant defenders

Xiufang, a post-doc from China, joined the He lab for her doctoral work in 2009. "It was the first time I learned about plant interactions with microbes, and I liked the research projects, the environment, and the good science they were doing."

Kinya Nomura, a post-doc from Japan, has been a cornerstone in the lab since he joined in 2000. "I like the USA, the experiments are interesting, and there are many fascinating and diverse people here, especially compared to Japan. Also, when I applied to American institutes, my wife preferred we stay close to a big lake, like Lake Michigan."

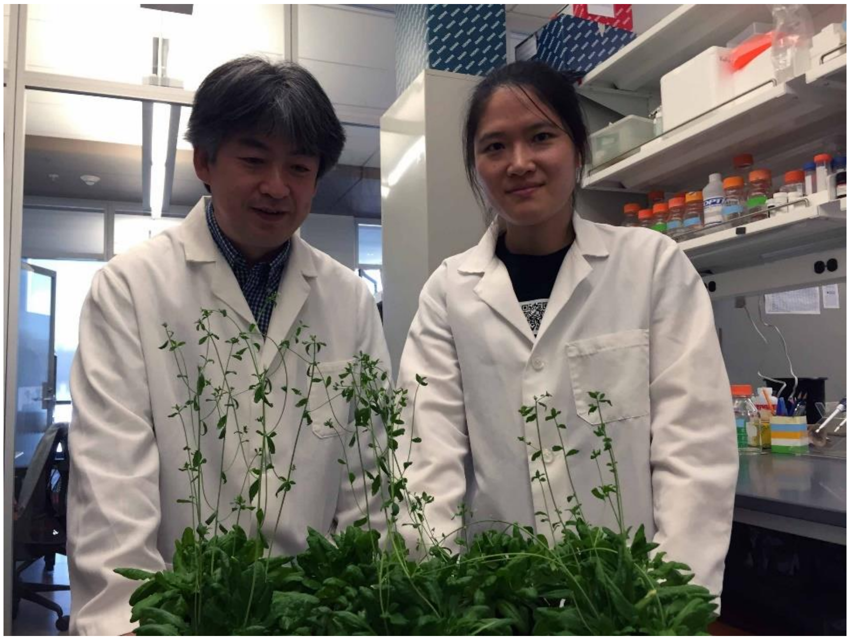


Figure 2 Kinya Nomura (left) and Xiufang Xin (right)

In 2014, Xiufang was close to graduation and planning to leave MSU, but she and Kinya stumbled on an intriguing observation that led to them teaming up on a new project.

A lucky research break

Studying the world around us is a complex business according to Kinya. “Living things are complicated, and most of the times, our hypotheses – our educated guesses – about how things work are wrong. Yet, once in a while, we come across ‘strange’ data and stumble on the right guess. It’s luck within a framework.”

That is what happened as Xiufang and Kinya tested plants under varying environmental conditions. They kept observing that humidity levels had a huge effect on disease development.

“We didn’t design that initial experiment to seek this particular knowledge,” Xiufang says. “But this repeated observation pointed us towards some underlying mechanism.”

How to play in the lab

Making sense of the unexpected data required creative thinking. “Data is not straightforward,” Kinya says. “Two people might look at the same data set and draw very different conclusions.” Case in point, water flooding of the apoplast, while known in the field for quite a while, had not been connected to a major bacterial virulence strategy until now.

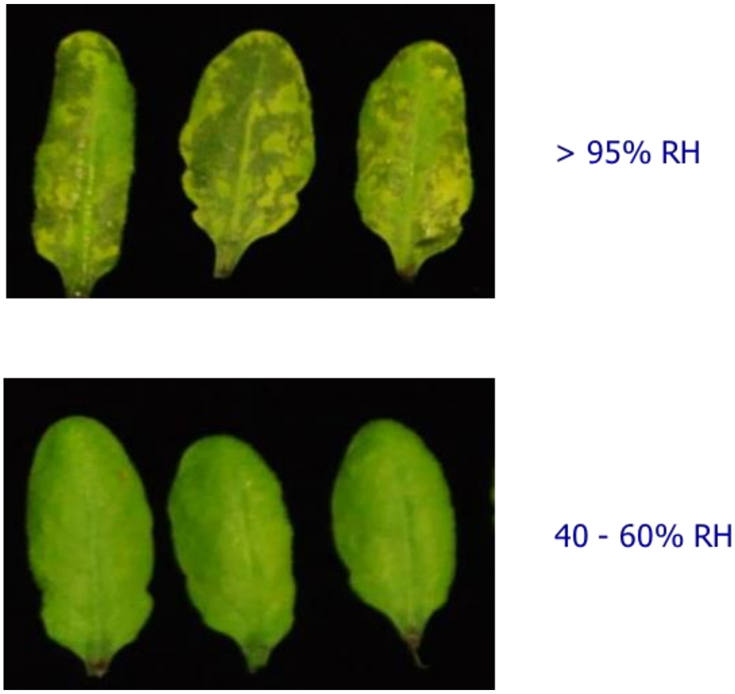


Figure 3 Splotchy leaves, top, due to higher humidity and water soaking. Courtesy of He lab

And what fuels a creative mindset is an innate curiosity to understand the world.

“Often there is something that intrigues you that you don’t completely understand, but you really want to figure out how it works,” Xiufang says. “Then you read and think a lot about the question. In fact, most good scientists love their work and are probably always thinking about it, much like our mentor, Sheng Yang.”

Kinya agrees, “I’m curious about a lot of things around me! Just recently, I wanted to check acidity levels in an insect-eating plant I have at home, because insects just melt on contact with it. So, I got a sample into the lab to test it out. Sometimes, though, this tendency of mine backfires, because I need to give attention to my wife and daughter!”

The flip-side to curiosity is that most experimentations trying to prove a point fail. No matter how carefully they prepare, Xiufang and Kinya estimate a 10 to 20 percent chance of getting successful, positive data.

Advice for aspiring scientists

But both are quick to point out that failure is part of the journey and that success ultimately comes from intrinsic motivation. “One might survive going through the motions of graduate school, but odds are it will be very challenging to have a productive science career without curiosity and inner drive,” Xiufang says.

Their advice for budding scientists: Find out if you have an intellectual bent for science and build a basic knowledge base to start out. Cultivate critical thinking skills; keep thirsty, and always read and learn in your discipline.

And balance the fun of curiosity with persistence in the face of inevitable unexpected or failed results.

With that attitude (**and with some luck!**), you could thrive, Xiufang says. “When it works out, as it did for us in this study, you have this awesome sense of accomplishment because you are the first to discover a piece of the puzzle. To me, that is one of the best rewards for doing science. It is intellectually satisfying and inspires me to continue learning new things.”

Kinya sums it up: “Discovery feels good, even if no one else on this planet cares about the result.”

Sean McGuire awarded Undergraduate Research Fellowship

12/12/16

Igor Houwat

Sean McGuire, an undergraduate in the **Kerfeld lab**, has been awarded the Undergraduate Research Fellowship from the Department of Biochemistry and Molecular Biology (BMB).

The fellowship is given to BMB undergrads who, "[have] attained at least junior standing, [carry] a 3.0 GPA or higher, and are committed to pursuing a career in research. These are students who want to do research, but cannot because of the need to work."

A junior-level undergraduate student in the BMB department, Sean joined the Kerfeld lab around a year ago when his interest was piqued by their work on cyanobacteria.

"I now conduct research, under my mentor, Dr. Clement Aussignargues (a post-doc in the Kerfeld lab) on miniature compartments that are found in many types of bacteria in nature. We are trying to engineer these isolated compartments, in the lab, so they become nanofactories that produce useful things for society, such as renewable energy or rubber – the latter which currently comes from trees or petroleum."

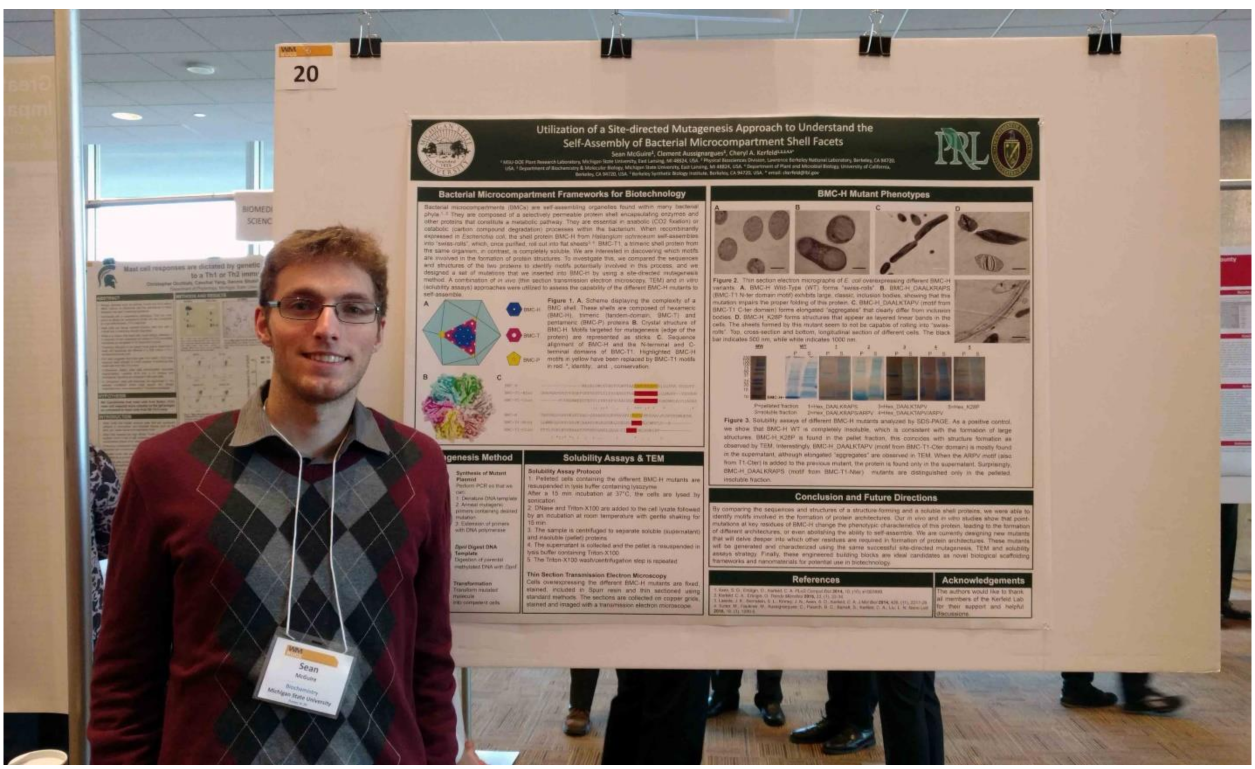


Figure 1 Photo courtesy of Sean McGuire

"Sean demonstrates a remarkable passion and enthusiasm, not only for the project he conducts, but also for science in general," Clement, Sean's mentor, says. "Because of his tremendous dedication and curiosity, this engineering project moves forward at a terrific pace. Having the opportunity to work with a highly motivated and talented young researcher like him is a real pleasure!"

Sean notes his gratitude for the recognition. "I think this award reflects my ability to multitask a highly rigorous course load while conducting research," he says. "I also plan on attending graduate school, perhaps even here at MSU!"

"Wherever I end up, I want to be able to have an outstanding graduate experience in order to expand my horizons and to acquire the necessary knowledge to carefully design an entire research project. In 10 years, I can picture myself finishing up a post-doctoral position and beginning to start the next chapter of my life in either academia or industry."

Congrats, Sean!

2016 Kende Award goes to Dr. Marcelo Campos

12/14/16

Igor Houwat

Figure 1 Dr. Howe introducing Marcelo to a packed room

Dr. Marcelo Campos, a former doctoral candidate in the **Howe lab**, has added his name to the PRL annals as a recipient of the **2016 Kende Award**, which recognizes the best doctoral dissertation in the plant sciences at MSU from the previous two years.

In addition to receiving a monetary award, Marcelo presented a seminar at the Plant Biology Building on December 12. His talk challenged a long held notion in biology circles that plants cannot simultaneously defend and grow well. **In fact, as he demonstrated in a mutant plant, they can.**

“I never imagined myself winning the Hans Kende award!” Marcelo says. “Dr. Gregg Howe has a nice track record of people winning it, and he has been a great boss and PI to me. At the same time, this means a lot personally, since I work with plant hormones. Hans Kende was a giant in this field, and I read his papers even before I came to the PRL.”

Figure 2 Dr. Marcelo Campos

Marcelo hails from Sao Paulo, the largest city in Brazil. He obtained his Bachelors at the Catholic University of Brasilia and his Masters at the University of Sao Paulo, where he worked with plant hormones and defense functions in tomato.

In 2009, he joined the PRL. “I really wanted to join the Howe lab, so much so that I didn’t apply to any other grad schools. I was really lucky it worked out!” His initial project was a continuation of his research with tomatoes, but two years into his degree, he had no results, and funding was running out.

“Gregg threw me a lifeline. Another post doc was experimenting on a plant, Arabidopsis, by removing its defense genes, one by one. I was to study these mutants to describe their distinct features. It was a new plant for me and unfamiliar research territory. I was basically starting from scratch, very scary.”

In retrospect, Marcelo thinks this was the best decision he ever took. His project took off, culminating in an **article in *Nature Communications***.

Dr. Howe, a MSU Foundation Professor says, “Marcelo has all of the qualities that professors like to see in their students: smart, hard working, intellectually independent and, in the case of Marcelo, eternally optimistic. I’m privileged to have worked with Marcelo and grateful for his many contributions to our lab”.

Marcelo is now a post doc at the University of Brasilia, where he has resumed tomato research while assuming some teaching and administrative duties. “I decided to move back home because I had family and a girlfriend there. Also, I lost a dog in Brazil and a dear friend in a car accident during my time at the PRL.”

“It was a trade-off. Unfortunately, doing quality science in Brazil is difficult, with no funding, poor infrastructure, and an unfavorable political and economic climate. For example, it took months to get a testing kit in the mail, which delayed my research. Here, I would cross the street to the BMB store and buy it right away. You have no idea the amazing resources there are at the PRL until you leave!”

Understanding a cell part construction manager

12/21/16

Igor Houwat, Jianping Hu

Figure 1 Banner of construction site by By [Jakob Montrasio](), CC BY 2.0

The **Hu lab** has deepened our understanding of a protein, called SP1, that controls how cells build an internal part, the peroxisome, crucial for maintaining healthy plants and animals.

Dr. Jianping Hu, Professor at the PRL, says, "Peroxisomes are like food processors that break down fatty acids (fats) into smaller pieces so they can be used to produce energy, and they also help protect their hosts from environmental stresses."

The Hu lab observed that SP1, like a gatekeeper, controls the level of proteins (called PEX, for peroxins) that import the building tools into peroxisomes. SP1 breaks some of these PEX proteins down once they have performed their necessary functions.

Hu says, “SP1 does that so that protein import into the peroxisome is controlled and not overly active when not needed. It is important to maintain this balance, and SP1 facilitates it.”

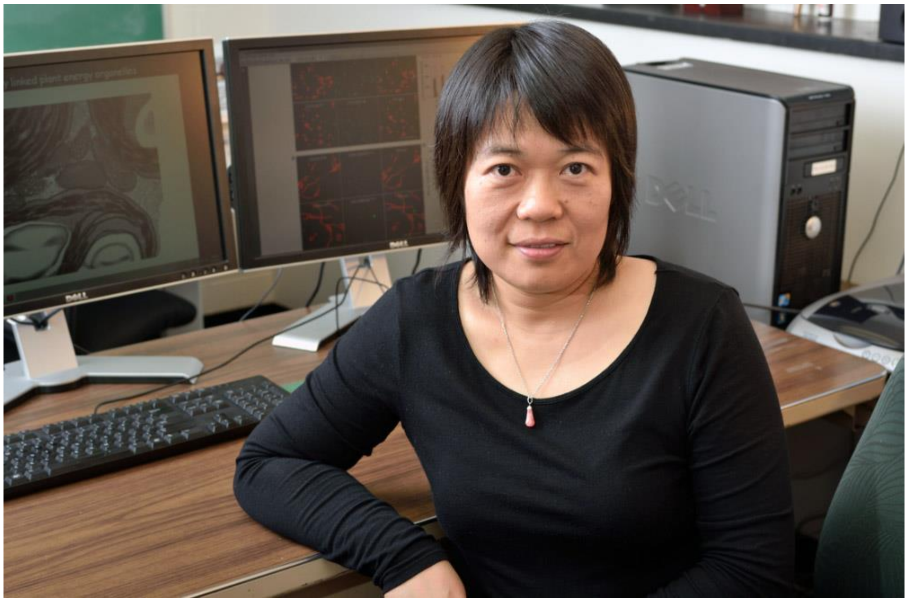


Figure 2 Dr. Jianping Hu. By Harley J Seeley Photography

In one experiment, the Hu lab identified mutants with deficient PEX proteins – in other words, the building tools weren't being appropriately shuttled into the peroxisome.

Then, SP1 was removed. "Without SP1, these PEX proteins could not be degraded, so they accumulated in the plant. This stabilization of the PEX proteins led to an enhanced import of the 'building tools', therefore rescuing some of the deficiencies of the original mutants and reinforcing the idea of SP1's role as a 'building regulator'."

From ag to human medicine applications

"This is new and exciting work," Hu says. "We already knew that SP1 helped control protein import into the chloroplast, another part of plant cells responsible for providing food and energy to most of the planet. **It seems SP1 wears many hats after all**."

"And understanding how these cellular building processes are controlled could someday lead us to real-world agricultural solutions, such as molecular strategies to engineer crops with better metabolism or improved defenses against diseases."

Hu also found that SP1 shares characteristics with a protein found in humans, opening the possibility that this family of proteins controls the construction of multiple cell parts over many different species.

"Perhaps the biomedical field will someday use this information **to cure human peroxisomal disorders, which can be devastating** (*symptoms include poor growth, neurological dysfunctions, hearing/visual problems, liver disease, etc*), as peroxisomes carry out essential functions in the human body."

This research was funded by the National Science Foundation. The findings have been **published in the journal, *Proceedings of the National Academy of Sciences***. Additional MSU researchers contributing to the study include: Rongui Pan and John Satkovich from the MSU-DOE Plant Research Laboratory.