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contents

PRESIDENT'S LETTER

Well, How Did I Get Here? (Once in a Lifetime)

BY GUSTAVO MACINTOSH
ASPB President, Iowa State University

After the ASPB election last year, a former ASPB president told me to start working on this letter as soon as possible (thank you, Nick!). I knew this was sound advice, but of course, I did not take it. There was always something urgent to finish, and the newsletter was so far away. And here I am, a deadline already looming over my head, and no letter. Being President-Elect of the Society has been interesting, and I have found many ups and downs. Reflecting on how I got here made me realize that I am in an unusual position. I have done well in my plant biology career, but I am not a luminary like many of the previous presidents. So, why was I chosen?

I started working with the Society through my involvement with the Midwest Section when I was an assistant professor. Later, I was invited as an ad hoc member of the Minority Affairs Committee (MAC), as it was called then. After a year, I joined the committee as a regular member and served for many years, including the last three as chair. MAC, now the Equity, Diversity, and Inclusion Committee (EDIC), felt like home to me, and I worked with fantastic people. Some became my mentors, others are my role models, and I picked up some incredible friends along the way. (Where can you find a better friend than Michael, who took me to a brewery to rescue me from despair after watching Argentina's loss at the FIFA World Cup final during Plant Biology 2014 in Portland?)

Working with the MAC was always energizing, but for some time we felt that the committee, despite all the good work it did, was frequently tokenized. At some point, though, we noticed a significant change; the Society's leadership started listening to our message. This was also reflective of a bigger change that was happening in parallel among

some of our members, and in society at large. Within ASPB, some transformations started happening, including the Transparency Project, started by Judy Callis; the creation of the Early Career Plant Scientists Section, spearheaded by Rishi Masalia; and the inclusion of early career representatives (ECRs) on governance committees, to name just a few.

My nomination was also a big shift. And I was aware that, given my past work on equity and inclusion at the Society level and elsewhere, there was an intention behind my selection during the nomination process. The possibility to change my professional society, and the sense that there was fertile ground where new growth could happen, convinced me to accept the nomination. And I have taken this as a mandate to guide my activities in service to ASPB members.

How do these factors inform my approach to leading ASPB? Professional societies were built as part of a traditional system that was, by design, exclusive. From member selection (some societies still use the old model of nominations for membership!) to the way societies were governed relied on strict achievements defined by restrictive and exclusionary metrics. The way societies were (and are) funded also relied primarily on the ability of its members to pay for services. A modernized professional society needs a different set of values and structure. Simply put, we need to take the equity and inclusion ideals out of a committee and inject them throughout our professional society. This approach will produce an organization in which everybody feels like they belong.

These changes had already started, even before I was elected, as previous leaders started paying attention to members' concerns. The nomination process for new leadership positions was revised and improved. Now, members have a direct impact on who is nominated. The Nominations Committee that builds the ballot includes ECRs and EDIC representatives and has a more transparent role. A clear sign that the new approach is working is the election of a fantastic and highly qualified individual as our next President-Elect: Leeann Thornton, who is from a primarily undergraduate institution. In an intentional effort to increase the different voices in each committee, we are changing the way we fill committee positions, and we have established different ways in which members can volunteer and self-nominate for those opportunities.

We also want to increase the diversity of people and ideas at our annual Plant Biology meeting. We have opened the meeting program to our members through member-proposed and -organized workshops and concurrent scientific sessions, and this year we have also selected keynote symposia proposed by members. The EDIC has developed a rubric to guide the selection of proposed sessions and to ensure that our

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members are well represented among Plant Biology speakers. Representatives of the EDIC now work directly with the Program Committee to ensure that an equity lens is applied to the whole process. To make the conference more accessible, the budget now includes funds for American Sign Language interpreters, and we offer discounted child care to parents wanting to attend the meeting. And we are still supporting programs that started long ago but still have a big impact, like the Recognition Travel Awards (RTAs). The RTA program has funded hundreds of members from marginalized groups to attend our annual meeting, providing mentorship that in many cases has extended far beyond the conference. I still meet frequently with RTA awardees from many years ago. Indeed, some are my collaborators, and a few are even coauthors on federal grant proposals.

Of course, these changes are sustainable only if they are internalized into the structure of the Society. This year we started the process of writing a new strategic plan, and my main role was to make sure that equity and inclusion principles are central to ASPB operations, starting with its mission. I have truly enjoyed the process because I have seen a mostly very receptive group of leaders, all wanting to support these ideals. We held community listening sessions to gather input from our members, and we asked representatives of all sections and committees to participate in the development of the plan. We hope to share the document with our membership in the near future.

I also realize that strategic plans can be very nice and include lofty goals, but the implementation may never be realized. The main roadblocks are changing priorities and funding. Having a defined mission achieved by consensus, as was done during the first phase of our strategic planning, should help with the former. The financial issue is, on the other hand, thornier. To have an inclusive and equitable Society, we need to change the business model, finding new ways to fund the activities and programs offered by ASPB to ensure that we reduce barriers to participation, including conference registration costs and membership fees. This effort will require creativity and innovation.

Change will elicit pushback. Membership participation and engagement, by loud voices and quiet voices alike, will be needed to strengthen these efforts. We will be listening, and we need feedback. So, participate in Society activities, give us your opinion, ask for what you need, and give what and when you can.

I thought of the title for this letter soon after I started writing, and the Talking Heads song has been playing in my head since (for those of you too young to know it, the video is at https://www.youtube.com/watch?v=5IsSpAOD6K8). Here's hoping that when I am done serving the Society, it is not "same as it ever was, same as it ever was" (hat tip to David Byrne).

We're Listening!

Share your feedback on the Society and ideas to help ASPB better meet members' needs at https://qrco.de/bdXxEM or by scanning the QR code.

Welcome to the *ASPB News* Perspectives column. These articles explore the topical theme of each quarterly issue of the newsletter. They are typically written by members who are actively involved in the work of the Society to support and nurture plant science and plant scientists.

Plant Lipid Love

BY RUTH WELTI and KATHRIN SCHRICK, Kansas State University

Lipids are biological compounds that dissolve in organic solvents but not in water. Unlike many other biological macromolecules, lipids have structures that are not based on repeating monomers. Instead, plant lipids display extensive structural diversity. It's estimated that Arabidopsis is capable of synthesizing ~10,000 lipid structures, and collectively, the plants make over 100,000 such structures (see Figure 1)!

The functions of lipids are also remarkably diverse. Phospholipids, sphingolipids, glycolipids, and sterols have structural roles in cell membranes, regulating their fluidity and permeability. Specialized lipids, such as chlorophyll, with its phytol tail, and other electron carriers, are essential for photosynthesis. Triacylglycerols are constituents of oils involved in energy storage. Some superpower lipids play important signaling roles as hormones or second messengers. Plants additionally rely on lipids for protection from the environment; waxes in the cuticle help them survive drought. The functions of many other lipids, such as arabidopside E, are still largely matters of conjecture. Besides being critical to the lives of plants, lipids are also valuable commodities, with the global market for oilseeds valued at over US$250 billion.

Lipids are among the most fascinating and yet understudied macromolecules in plants. Much is left to learn about the regulation of seed oil production and about the roles of lipids in plant development and resilience to stress. In his 2012 TED Talk "Advice to a Young Scientist," biologist E. O. Wilson stated, "In selecting a subject in which to conduct original research or to develop world-class expertise, take a part of the chosen discipline that is sparsely inhabited.… Find the field and subject not yet popular" (9:05–9:57).

Undergraduate researcher Hieu Nguyen and Kathrin Schrick of Kansas State University examining flowering *Arabidopsis thaliana.*

The world of lipid research might be a "sparsely inhabited" area of plant biology, but it is rich with opportunity. As in other areas of biology, technical advances are key in driving discovery. Innovative tools are continuously being developed and optimized to detect lipids in plant cells and tissues. The increasing use of mass spectrometry for rapid analysis of lipids has played a significant role. Lipidomics approaches are powerful in providing overall lipid composition of a biological sample. Metabolic flux analysis, which uses isotope labeling, is helping characterize lipid biosynthesis and lipid remodeling pathways (Kotapati and Bates, 2021). One goal is to uncover enzymatic

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Figure 1. Structures of several diverse plant lipid molecular species (Sud et al., 2007). Triacylglycerol is a major component of plant oils. Arabidopside E is an oxygenated lipid from Arabidopsis. Stigmasterol is a major sterol in the plant plasma membrane. Phytol is a prenyl side-chain of chlorophyll, the pigment critical for photosynthesis.

FIGURE ASSEMBLY BY PAMELA TAMURA

Plant lipid researchers form a lipid bilayer at Plant Biology 2022. *Left to right:* Zolian Zoong Lwe (Kansas State University), Prasad Parchuri (Washington State University), Ruth Welti (Kansas State University), Vinusha Wickramasinghe (Kansas State University), and Jithesh Vijayan (University of Nebraska–Lincoln).

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bottlenecks in the production of triacylglycerols, the major components of seed oil.

The spatial localization of lipids is another avenue of active research. Although many lipids reside in membranes, others are localized to lipid droplets or are secreted at the tissue surface. Still other types of lipids are transported intracellularly, moving between cells via plasmodesmata or the phloem. It would be ideal to follow lipids at the subcellular level. Fluorescent labeling techniques akin to GFP tagging of proteins are not suitable for most lipids. Matrix-assisted laser desorption/ionization mass spectrometry imaging (MALDI–MSI) holds promise for the spatial characterization of lipids on omics scales (Sturtevant et al., 2021).

Plant lipid research is also taking advantage of advances in tools for the analysis of lipid-metabolic and lipid-signaling proteins, their corresponding genes, and their expression profiles. The recent recognition that lipid binding modulates the function of certain proteins is exciting, and it's likely that this mode of protein regulation is more widespread than is currently known. Recent studies show how lipid binding to florigen, a mobile protein that initiates flowering, controls both the temperature and the diurnal dependence of flowering. In the cold, florigen is sequestered in phloem companion cells by binding to the lipid phosphatidylglycerol in membranes (Jaillais and Parcy, 2021; Susila et al., 2021). When the temperature warms, florigen is released, and it moves to the shoot apex, where florigen action is regulated by binding to molecular species of the lipid phosphatidylcholine that vary in levels diurnally (Nakamura et al., 2014).

Another report implicates very long chain fatty acid–containing ceramides as positional cues in the differentiation of the epidermis (Nagata et al., 2021). A transcription factor controls the synthesis of the lipid that in turn activates the transcription factor in a positive feedback loop. The details of the protein–lipid interaction await further study, but these findings highlight the role of lipids as metabolic signals in plants.

How can you and others get involved in this emerging area of plant biology? Whereas some of the established plant lipid scientists trained as students or postdocs in lipid research labs, others stumbled upon lipids through serendipitous encounters. The plant lipid community welcomes newcomers from interdisciplinary backgrounds—for instance, in the area of synthetic biology—to join forces in making future impacts. Plant lipid enthusiasts will gather at the next Gordon Research Conference on Plant Lipids ("Using Plant Lipid Science to Drive Functional Changes for Human Benefit") from January 29 to February 3, 2023, in Galveston, Texas.

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The Impact of Climate Change on Plant–Pathogen Interactions

BY SHUNYUAN XIAO, University of Maryland

The world faces a grand challenge: climate change, caused by the rapid accumulation of greenhouse gases, especially CO_2, in the atmosphere since the Industrial Revolution. Aside from the increase in the global average temperature, the impact of climate change is readily reflected in extreme weather, such as record-high local summer or winter temperatures and increasingly uneven precipitation causing more frequent and severe droughts and flooding.

Such unusual environmental changes have begun to have a profound impact on many aspects of human society, and especially on agriculture, affecting plants' growth and reproduction, their nutrient content, and their interactions with insects and pathogens. It is estimated that a >60% increase in crop production will be required to feed approximately 10 billion people by 2050 (Tilman et al., 2011). This presents another grand challenge: ensuring food security through sustainable agriculture in the face of climate change. In this article, I share my perspective on the impact of climate change on plant–pathogen interactions and plant diseases in relation to the crop protection essential for sustainable agriculture and food security. I then briefly discuss how the plant science society should respond to the challenges and direct our collective research efforts toward studies of plant–microbe interactions under altered environmental conditions.

A Destabilized Disease Triangle

Every organism has optimal living conditions but can cope with certain variations in environmental conditions. As plant pathologists, we understand that the outcome of plant–pathogen interactions is determined by the genotypes of the engaged plant hosts and the invading pathogens as well as the environment in which the interactions occur. Plant disease develops only when host immunity is subverted by a virulent pathogen under environmental conditions favorable to pathogenesis. This plant–pathogen–environment relationship is known as the "disease triangle" model (Scholthof, 2007; Stevens, 1960).

Global warming and its associated extreme weather patterns will bring about imbalance in or even disruption of the established disease triangle relationship through its impact on growth and defense of the host and growth and pathogenicity of the pathogen. Such alterations may result in changes in disease severity, frequency, and prevalence, as well as the emergence of new diseases, creating heavier disease burden, higher disease risk, and uncertainty in how best to manage crop disease.

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Suppression of Host Immunity at Elevated Temperatures

Because plants are sessile (unless they are transplanted from nursery to field by farmers), and because plant pathogens, including nematodes, live in the same microenvironment as or dwell directly in their host plants, engaged holobionts (i.e., assemblage of hosts and their associated microbes) are particularly sensitive to changes in environmental conditions. Environmental changes, such as increasing temperature, may profoundly change the outcome of plant–pathogen interactions.

Many of us who study plant–microbe interactions have had personal, firsthand experience with how environmental conditions affect our experimental results. I still clearly remember what happened when I took over a resistance (*R*) gene mapping project: the previously mapped *R* gene *RPW8* conferring resistance to powdery mildew in Arabidopsis "jumped" to another chromosome! This was simply because I used a newly furbished growth room (which had more stable growth conditions) to determine the infection phenotypes of the same segregating F2 population. After the cloning of the *R* gene, it was later found that *RPW8*-mediated resistance has intrinsic plasticity because the expression of *RPW8* can be significantly compromised under high temperature (30°C), high relative humidity, or low light (Xiao et al., 2003). Likewise, resistance against other types of pathogens controlled by several classic *R* genes, encoding intracellular nucleotide binding site and leucine repeat immunity receptors, is compromised at high temperature. For more details, read the comprehensive review article on this topic by Velasquez et al. (2018).

Interestingly, a scientific team led by Sheng-Yang He recently found that elevated temperature negatively affects one of the two mechanisms that regulate the biosynthesis and accumulation of the defense hormone salicylic acid (SA). Specifically, high temperature suppresses the expression of the CBP60g transcription factor that acts as the rate-limiting step for SA production and accumulation and activation of defense responses (Kim et al., 2022). This new finding provides a clear mechanistic explanation for the suppression *R* gene (including *RPW8*) mediated resistance at elevated temperatures because SA production and accumulation, which are temperature sensitive, are a critical early step in plant immunity activation. It is likely that additional molecular mechanisms of suppression of plant immunity under other environmental conditions will be revealed in the near future.

The disease triangle "bent" by climate change. The question mark in the middle highlights the uncertainty about the outcomes of future plant–pathogen interactions.

Furthermore, changes in temperature and humidity also affect the pathogenicity of different types of plant pathogens (Velasquez et al., 2018). Together with the alteration in host immunity, such changes may lead to loss of disease resistance and increased disease severity.

Increased Disease Severity and Emergence of New Diseases

Apart from the impact on the effectiveness of host immunity or pathogenicity, climate change and specifically global warming promote overwintering of various pathogens and their transmitting insect vectors outside tropical areas. This can lead to at least two serious consequences: (1) earlier and more severe plant diseases, because of more available initial pathogen inocula, and (2) expansion of disease into areas where winter temperatures used to be too cold for pathogens or their transmitting vectors to survive. An example of the latter is that in recent years, citrus greening, also called Huanglongbing (HLB), the most destructive disease of citrus, has spread to provinces to the north of Guangdong, China, where HLB was first identified. The primary cause of the northward spread of HLB is believed to be easier overwintering of citrus psyllids, the insects that transmit HLB, because of milder winter temperatures (Wang et al., 2019). Citrus HLB has already largely devastated the citrus industry in Florida and may soon spread to other U.S. citrus-producing states, thanks to the much wider spread of citrus psyllids in recent years.

Another potential risk may come from the release of ancient microbes or their DNA from melted permafrost to the environment. If revivable, ancient microbes either may cause infections directly in today's plants, resulting in the emergence of new diseases, or may interact or compete with contemporary microbes, changing the current microbiota, which may impact the ecosystem and the health of plants and animals within it (Wu et al., 2022).

Escalation of the Plant–Pathogen Arms Race

A more serious problem resulting from climate change may lie in the uncertainty of the outcome of the plant–pathogen long-term coevolutionary struggle. In response to climate change, plants and microbes will eventually adapt to the new environment through epigenetic and genetic changes, but they evolve at very different rates. Obviously, microbes multiply much faster (e.g., bacteria reproduce in hours, fungi in days) than their hosts (e.g., plants reproduce in months or years). This intrinsic difference will most likely give microbes the upper hand in the race for adaptation to a new environment because of their faster fixation of beneficial mutations resulting from point mutations and genetic recombination in the microbial population. Therefore, even if both plants' immunity and pathogens' virulence are negatively impacted by high temperature, bacteria and other microbial pathogens may adapt to higher temperatures much sooner.

This fact creates pressure on researchers, to find key manipulable target genes in plants, and on breeders, to accelerate breeding of crop cultivars whose immunity is more resilient under increased temperature

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Fresh Opportunities for Plant Research in a New Era of Space Exploration

BY ALEXANDER MEYERS, Chair, ASPB Early Career Plant Scientists Section, and
NASA Postdoctoral Program Fellow, Kennedy Space Center

Space provides a platform for some of our most innovative experiments in plant biology. However, space-based plant research is uniquely limited by the infrastructure available to get to, grow in, and return from beyond-Earth environments. Fortunately, continued advances in space exploration technologies may soon bring expanded capabilities to space biology. Reusable launch vehicles continue to bring down costs, new orbital research platforms are in the works, and ambitious exploration initiatives will soon bring humans back to the Moon for the first time in over 50 years.

Plant science has a rich history with the human journey to space, as the environments encountered beyond Earth's atmosphere offer wholly unique research opportunities. The prospect of using plants for eventual long-term human habitation in space makes them an attractive research target. Plants provide calories and breathable oxygen, scrub carbon dioxide from the local atmosphere, and even purify water through transpiration. The low-gravity, high-radiation conditions in space additionally offer a platform to explore fundamental questions in plant science that can't be addressed through conventional terrestrial investigation. Researchers have leveraged the space environment to study plant tropisms, plant architecture, circumnutation, and radiation biology, to name just a few. Space research platforms have facilitated a great many discoveries in plant biology over the decades, but many questions are still unanswered, and future experimentation will rely on the capabilities available to the scientific community.

The International Space Station (ISS) has been an invaluable resource in space-based plant research for over two decades. Dozens of plant experiments have flown aboard ISS, representing over 40 species of plants in experiments that range from phenotypic response analysis to comprehensive multi-omics studies. However, the future of the station remains somewhat opaque. ISS has already outlived its planned lifespan of 15 years. Congress has approved operations on the station through 2030, but its fate beyond that is uncertain. Although the retirement of the ISS will signal the end of an era in microgravity research, a laundry list of commercial entities have begun plans for the next generation of stations in Earth's orbit. The aerospace company Axiom Space plans to launch the first module of its Axiom Station in 2024. Blue Origin, Sierra Space, Boeing, and others recently announced a partnership under which they will construct and launch their modular Orbital Reef space station by 2027. Nanoracks recently announced plans for an orbital greenhouse called StarLab Oasis, a smaller station devoted to plant production and research. The ISS has been the hub of space biology for 20 years, but these new platforms could open the door for a tremendous amount of scientific discovery as current platforms meet the end of their duty to science.

With very few exceptions, plant research in space has been limited to Earth's orbit. NASA's Artemis Program may mark the beginning of exciting opportunities in

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and other environmental conditions. In this context, the He lab's recent demonstration of temperature-resilient disease resistance against pathogens through enhanced expression of highly conserved transcription factor CBP60g may provide a novel strategy for engineering plant immune systems to cope with a warming climate (Kim et al., 2022).

Future Perspectives

As Sheng-Yang He pointed out, "Early career researchers will experience the impact of climate change most, in work and life, unfortunately." I cannot agree more on this. Climate change has begun and will continue to profoundly influence plant–pathogen interactions, which are likely to significantly increase disease frequency and severity in agricultural crops. Wider spread of existing pathogens and the emergence of new diseases during milder winters will further increase disease epidemics in crop plants. These forthcoming changes in turn will impact the mindset and research of our plant pathologists, especially the younger generations. Hence, as He pointed out, there is an urgent call for intensifying global research efforts to understand how climate change influences plant immunity, pathogen virulence, and disease development (Velasquez et al., 2018).

We need future studies in the field of plant pathology to

- assess the disease outcomes of major plant–pathogen interactions using single or multiple changed environmental factors that simulate climate change,
- investigate molecular mechanisms underlying alterations in plants' immunity and pathogens' virulence using different pathosystems under changed environmental conditions,
- evaluate and model future disease outbreaks and infer the structure of sweeping pathogen populations of the future,
- monitor the emergence of new diseases as a consequence of host-range expansion of existing pathogens or revival of ancient pathogens from thawed permafrost, and
- engineer and breed disease-resistant crop cultivars that are more climate resilient.

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beyond-orbit investigations. Begun in 2017, the Artemis Program is a sweeping initiative focused on lunar research. Artemis (named for the huntress twin sister of Apollo, the namesake of humanity's original moonshot program) is a multinational, public–private project, and one of the most ambitious programs in NASA's history. Across a number of missions, Artemis objectives include building a space station in lunar orbit, landing and operating a remote lunar rover, and putting humans on the surface of Earth's Moon for the first time in 50 years. Long-term goals of the program include the establishment of a permanent lunar base and building out the capacity to serve as a steppingstone for Martian exploration.

The Artemis program is set to launch the first of its missions by the end of 2022. Artemis I, an uncrewed mission to test flight components, will launch from Florida, make a couple of laps around the Moon, and return to Earth. In addition to hardware testing, the mission will carry biological samples. A handful of organisms will represent Artemis's aptly named Bio Experiment-1: yeast, Aspergillus fungus, Chlamydomonas algae, and Arabidopsis seeds. These experiments represent some of the very beginnings of biological research beyond Earth's orbit and will help lay the groundwork for the future of lunar and Martian plant biology.

The upcoming changes and opportunities in space research come as ASPB has signaled strengthened support for the field of astrobotany. ASPB advocates with a number of U.S. agencies for support of plant research, and NASA was recently added to that list. Plant Biology 2022 saw a standing-room-only concurrent session entitled Plants for Space, and the ASPB Program Committee has teased the possibility of a plenary space session in 2023 as well. ASPB has always shown support for all branches of plant science; however, a tighter relationship between the Society and the space plant community may prove to strengthen both in the coming years.

The imminent advances in technology and infrastructure will undoubtedly bring changes to the way we conduct research in space. The nature of those changes will not fully come into focus until current exploration initiatives are fully realized, but there is little doubt that the plant science community will play a pivotal role in the future of space biology.

Matanel Hipsch, Nardy Lampl, Einat Zelinger, Orel Barda, Daniel Waiger, and Shilo Rosenwasser (2021). Sensing stress responses in potato with whole-plant redox imaging. *Plant Physiology.* **187(2):** 618–631. https://doi.org/10.1093/plphys/kiab159.

Pioneering New Technologies in the Lab

BY RACHEL BELSKY, ASPB Content Coordinator

Asking new questions allows us to improve upon science culture and research capabilities, as well as expand how current technologies can be modified and adapted to fit various research needs.

Shilo Rosenwasser and his team know the value of this curiosity. In examining the fluorescence of plants to determine stress responses under various conditions, Rosenwasser and coauthors Matanel Hipsch, Nardy Lampl, Einat Zelinger, Orel Barda, and Daniel Waiger pioneered the use of the Advanced Molecular Imager HT in plant science, discussed in their paper "Sensing Stress Responses in Potato with Whole-Plant Redox Imaging" published in the October 2021 issue of *Plant Physiology* (https://doi.org/10.1093/plphys/kiab159). The tool, initially designed for mice studies, gave them valuable insight they would not have been able to obtain using standard equipment.

"We were searching for a different approach that would allow us to capture the fluorescence signals from the living plants. And we knew that people measure fluorescence in mice using in vivo fluorescence images. So, we thought, why can't we do the same in plants?" Rosenwasser said of the novel imager use.

Rosenwasser was aware of the Advanced Molecular Imager HT being used in mice studies but had never used it before for his own research. He sent samples to the lab and was impressed by this system's ability to measure the distinct light signals he hoped to examine. Thus, he decided to pioneer this technology in his study.

> "Being open to discovery allowed this team to embrace alternative technologies that magnified their ability to capture fluorescence signals and improved the breadth of their research.

The team's research required a highly sensitive piece of equipment to detect the low light signals emitted from their biosensors. Moreover, as the team's main research interest was photosynthesis, the equipment had to allow the researchers to examine light responses closely and quickly. Standard imaging technologies were not suitable as many detection systems cannot accurately detect low light signals, affecting the signal-to-noise ratio and the study's overall results.

So, this team needed a highly sensitive imager that would let them detect different light signals and sources. The Advanced Molecular Imager was sensitive enough to detect the low signal emitted from plants and to distinguish autofluorescence from other light emissions, making it perfect for this experiment. The process itself turned into an experiment, led by Matanel Hipsch, a PhD student who applied this equipment to explore stress responses in potato plants for the first time.

In addition to examining stress responses, Rosenwasser and his team were also able to note other intricacies using this strong biosensor. For example, they looked at the signals on the entire plant and measurements that showed younger leaves behaved differently than the older leaves. "This kind of very basic observation you would never have the opportunity to see if you look at pieces of

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leaves under the microscope. Because only when you see this entire picture, you make this very basic observation that young and old leaves react differently to the same signal. It was important to give us more insight," said Rosenwasser.

Being open to discovery allowed this team to embrace alternative technologies that magnified their ability to capture fluorescence signals and improved the breadth of their research. And, as Rosenwasser noted, even basic observations were improved by unconventional imaging technology.

"There is always more to be done and a next step that can occur," said Rosenwasser on the importance of experimenting with different equipment in plant science. "At the end of the day, we are talking about an existing technology that allows us to look differently at how plants work. To drive the next generation, we must continue to take advantage of systems like this that have the sensitivity capabilities we need and create new systems that allow us to work more in the field, which is vital for agriculture and plant sciences."

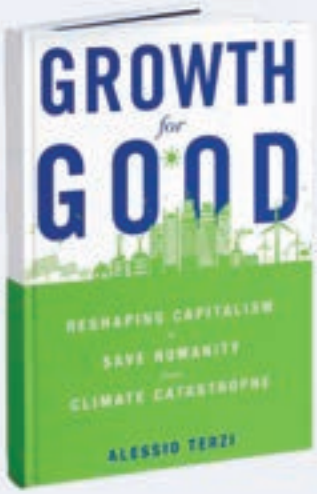
Spectral Instruments Imaging, manufacturer of the imager, featured the Rosenwasser team's study in their materials on the equipment in the hopes of encouraging further innovation. "It's always fascinating to see how our customers have new and exciting ways to implement this technology to further their research," said Melanie Smith, vice president of sales and marketing. "I think there are a lot of plant biologists and researchers in the scientific community that could benefit from using this tool."

SCAN ME

Watch the webinar!

See the webinar discussing this article and others from the October 2021 *Plant Physiology* Focus Issue "Sensors and Controllers: For and From Plants" (https://www.youtube.com/watch?v=3lXfqKU3px4).

Resource Review



GROWTH FOR GOOD

By Alessio Terzi

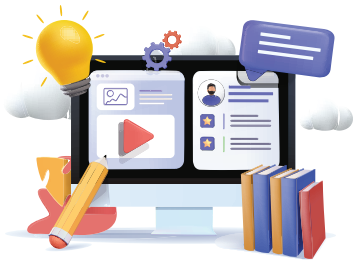
Cambridge: Harvard University Press, 2022

Review by Natasha Raikhel

A lot of books have been written on climate change, and many more will be. However, Growth for Good offers a new fresh optimistic and multidisciplinary perspective, crucially illustrating how scientific research and economic success have always proceeded hand in hand for successful civilizations. This book, suitable for a variety of readers, will be of interest to scientists in plant biology and beyond, showing how only the concerted efforts of all disciplines across societies will allow humanity to overcome the challenges posed by accelerating climate change.

Share your favorite resources with ASPB!

If you find a great book, podcast, video, or other resource, share it with your ASPB community by emailing the title, creator, and a brief review to sblack@aspb.org.



Why I Support the Centennial Challenge Campaign

BY DEBBY DELMER
University of California, Davis, and The Rockefeller Foundation

I first joined ASPB, then the American Society of Plant Physiologists (ASPP), as a PhD student at the University of California San Diego (USCD) about 100 years ago (actually it was 1967). It was a revelation. I truly didn't know xylem from phloem in those days. I majored in bacteriology as an undergraduate at Indiana University, and, at the new UCSD campus, there were no plant biologists yet, my adviser was an immunologist, and like half the small biology faculty led by David Bonner, there was a pervasive interest in tryptophan biosynthesis. When Carlos Miller of cytokinin fame came for a sabbatical, I got assigned to do a rotation with him—and, at his urging, I became a plant biologist and the first one to study tryptophan biosynthesis in plants.


Debby Delmer

Alone, I began to read the plant literature and longed to meet some of the leaders of the field. I still remember—I was so excited to go to my very first plant meeting. The early annual ASPP meetings were relatively small and were held at universities. One of my first memories was of being dragged off to a noisy dorm room packed with faculty, postdocs, and students. Harry Beevers was leading the crowd in his British voice, bellowing "Lloyd George knows my father, father knows Lloyd George!" to the tune of "Onward Christian Soldiers." There were so many "famous" folks of the day, acting like crazy kids—F. C. Steward, Folke Skoog, Joe Varner, Russ Jones, Maarten Chrispeels, Harry's brother Len Beevers, Art Galston, Joe Key, Win Briggs (notice—no women, except the postdocs and grad students). Meeting these notables informally opened the door for talking to them in more serious venues.

As the years passed, equally important to my career were the following: my first short scientific talk at ASPP, the first session I chaired, my first committee membership, my first major symposium talk, serving as president of the Society, and later receiving the ASPB Leadership in Science Public Service Award and the Charles Reid Barnes Life Membership Award. All were key moments for me during my career.

Before becoming an ASPB Legacy Society Founding Member, I donated to a lot of charities, but I had never considered donating to ASPB. But when asked to contribute, I came to realize that ASPB has been a true scientific home for me—many of my best friends have been members, the ASPB journals were my favorite place to publish, and annual meetings have afforded me opportunities to attend valuable symposia both inside and outside my own area of research and were a fabulous way to keep up-to-date for courses I taught—and yes, a place to laugh with old friends. Why wouldn't I want to see ASPB continue to grow and thrive and to nurture the next generation as it had nurtured me?

But, let's face it—times do change, and many other organizations and scientific meetings compete for the younger generation's interests. No longer do young people treasure their collections of plant journals as we did—through library subscriptions, they read online. Small meetings, tailored to their specific interests, are critical to meet leaders in the field and keep up on the latest in one's specific field of research. What should membership in ASPB and attending its annual meeting—much less donating to the Centennial Challenge—offer to attract these younger generations?

Guess what—it offers a lot. First and perhaps foremost—the journals of ASPB—most notably *Plant Physiology* and *The Plant Cell*—are still premier plant science journals. They not only publish great articles, they also attract superb editors and are managed by a skilled staff of professionals—all under the banner of ASPB, an organization that can't survive and do this just through revenues generated from those library subscriptions that give you online free access to research articles. ASPB is not old and stuffy. It developed Plantae.org, which provides a myriad of services particularly aimed at attracting the younger generation. The annual meeting, through its major symposia, is still the very best place to catch up on what is going on outside your own specific area of research—and being a well-informed scientist is one critical key to professional success. ASPB provides young scientists travel grants

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Most Recent ASPB Pioneer Members
(as of November 9, 2022)

Peter Beyer
Nicholas Carpita
Robert Cleland
Hugo Dooner
Gerry Fink
Mary Lou Guerinot
Russell Jones
Carolyn Napoli
William Orgren
James Siedow

https://aspb.org/membership/aspb-pioneer-members/

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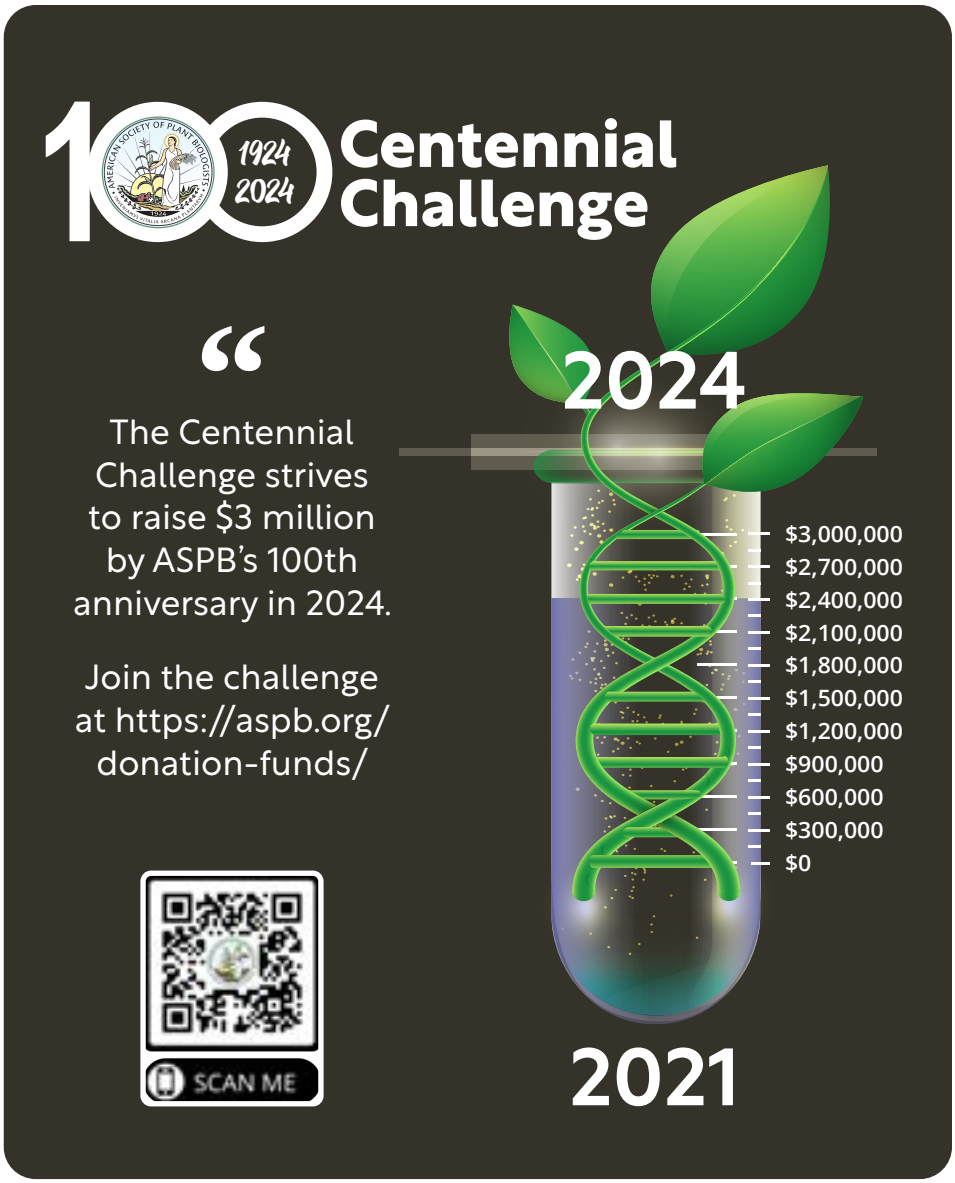
and amazing internships, like the Summer Undergraduate Research Fellowship (SURF), as well as opportunities to join important committees. Though no longer in smoky dorm rooms, ASPB provides opportunities to meet leaders (now including many women!) in all fields of plant science. And the meetings are still fun. None of this comes for free. I urge the young generation of plant scientists to step up and develop a culture of giving regularly to charities and organizations of all kinds, including ASPB. Even a very modest gift to the Centennial Challenge can start you on the track for a lifetime of charitable giving.

And to my old surviving buddies, I will end by tweaking your conscience. Many of you have been incredibly generous so far—but if you haven't yet given to the Centennial Challenge, step up now and give generously. This year, take some of that required minimum distribution from one of your IRAs and give it to the Centennial Challenge. And yes, take a few minutes to talk to your financial adviser or lawyer about your plans for estate giving through your will or beneficiary designations on IRAs or other assets. We all have trouble remembering things these days—but one thing I'm sure we all remember well is our lifelong gratitude and affection for ASPB.

I hope to see you all, young and old, at Plant Biology 2024, where we will celebrate the 100-year journey of ASPB to become the leader in serving global plant science.



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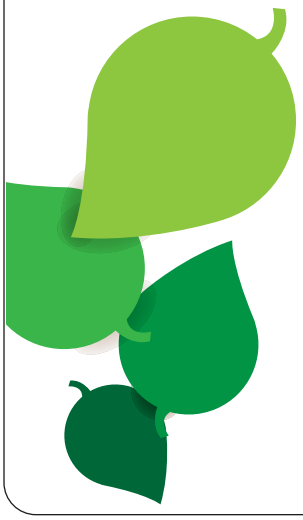

ASPBnews

A PUBLICATION OF THE AMERICAN SOCIETY OF PLANT BIOLOGISTS

See Your Content Published in the *ASPB News!*

As ASPB's member publication, the *ASPB News* is eager to receive submissions from members on topics planned for future issues, including

- Issues surrounding science policy affecting plant science
- Novel approaches to plant science education
- Plant science outreach events and practical ideas members can replicate
- Noteworthy research, techniques, technology, and so forth that are advancing and changing plant science

Send your submission to sblack@aspb.org for consideration.

ASPB/AAAS 2023 Mass Media Science & Engineering Fellows Program

Are you interested in science writing?

Do you want to help people understand complex scientific issues?

Apply for the ASPB/AAAS Mass Media Science & Engineering Fellows Program and learn how to increase public understanding of science and technology. Fellows in the 10-week 2023 summer program will work as reporters in mass media organizations nationwide. **Application window opened October 1, 2022, and closes January 2, 2023.**

Visit **https://www.aaas.org/programs/mass-media-fellowship** for more information.

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WE WANT TO HEAR YOUR STORY!

The *ASPB News* is introducing new content features to highlight ASPB members and their stories, research, and accomplishments. We invite all members to submit content to be featured in upcoming issues.

- **Member Achievements** will share brief member news with the community, such career updates, recent awards, and other milestones. Submit your achievement now!
- **Member Profiles** highlight a member's story and contributions to ASPB and plant science. These profiles may be written by colleagues or solicited by ASPB staff to introduce the people who make up ASPB's global membership.
- **Perspectives** look back on a member's path to plant science and their career or provide insights on issues affecting academia and plant biologists.

Share your updates at https://qrco.de/bdXxXR.

SCAN ME

2022 ASPB/AAAS Mass Media Fellow Reports In

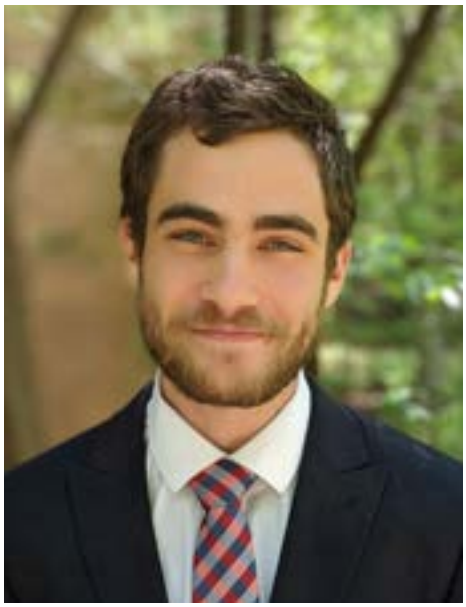
BY MAX HENRY BARNHART
University of Georgia and National Public Radio

For the past three years I have had the pleasure of being a member of ASPB. In that time, I have grown as a plant scientist and a leader through the Ambassador Program and my role as head of science communication for the Early Career Plant Scientists section. But this past summer, ASPB provided support for the most transformational experience of my career to date—my training as a science journalist at National Public Radio (NPR) in Washington, DC, through the ASPB/AAAS Mass Media Science & Engineering Fellowship.

Over the summer I wrote eight articles for *Goats and Soda* (https://www.npr.org/sections/goatsandsoda/), NPR's global health and development blog. My first article was about the origins of the Black Death (https://n.pr/3EA3ioy), and it was a challenge to write. I had to work through learning to interview for the first time, having my science writing edited by a nonscientist, and even some drama between academics on Twitter. The end result was beyond my wildest expectations! That article got well over a million views.

Learning how to do real science journalism was a challenge. It took a month to get the first article out. There were many moments of struggle to go along with the moments of success. But through this process, I came to realize that being a journalist is how I want to continue being a part of science.

Science writing has given me an opportunity to express my creativity and love for science while constantly learning new things. It has also been rewarding in a way that research hasn't, despite the achievements in that realm. Finally, knowing what I want to do after grad school has given me the spark I desperately needed to work through the final stages of my PhD at the University of Georgia.



Ultimately, as the end of the fellowship approached, I didn't know if I had accomplished enough to make a life for myself doing science journalism. But then, in the end, I was hired part-time! That was a huge vote of confidence, and I am so excited to get to work. There's still so much more to learn, but I will always be grateful for the friends I've made and the way this fellowship turned my life around for the better.

ASPB played a significant role in supporting me through this fellowship, and I am extremely grateful. I'm looking forward to interacting with the Society in new ways as I make this career transition. Next time you see me, don't hesitate to pitch me a cool story about your science! There's nothing I would like more than to share the great work of ASPB and its members with the rest of the world.

Report from the 2022 AAAS Ralph W. F. Hardy Mass Media Science & Engineering Fellow

FIONNA SAMUELS
Colorado State University and Freelance Science Writer

I cannot thank the Ralph W. F. Hardy Endowment, ASPB, and AAAS enough for funding my fellowship this summer. My experience at *Scientific American* was more spectacular than I could have imagined. The summer started off with a bang when I pitched a story about plastic-eating larvae at my first news meeting. I was surprised when I was immediately tasked with turning it into an article in just a couple of days. I was excited when researchers in Australia and Germany were willing to hop on a video call with very little notice, and surprised when the German experts pushed back on some of the hypotheses reported in the paper. In the end, the two groups of researchers connected and were able to make the research even more robust.

After being thrown into the deep end, I decided to pace myself with a mix of embargoed stories and slower news stories. Embargoed stories are like a rollercoaster. When I saw an embargoed piece of research that was interesting, I would write a pitch to my editor for a story. If the pitch was accepted, the race was on to reach out to the authors of the research and find outside experts to comment. As I waited for responses, I outlined the story and came up with questions for my sources. It was a rush to submit the first draft, and a bigger rush to see the story published. In stark contrast sat my own research paper, waiting for me to return to it at the end of the summer.

Slower stories were just as satisfying, but more of a slow burn. One of my favorites

this summer was about the overlap between states that outlaw abortion and those without robust sex education. People were passionate about their work and its impacts. I learned so much about what robust sex education actually entails—everything from consent to pregnancy to healthy relationships. It was difficult to cut interviews down. In the end, I think the piece came out really well, and it remains an important reminder for me that good education is the foundation for all decision making.

I was grateful to try my hand at things beyond writing news stories. I wrote a book review and a couple of question-and-answer articles, one about Paxlovid rebound. I was ecstatic to write and record a podcast about polar bears. I even bought recording equipment to record another at home. Overall, I wrote almost 20 pieces!

I also wanted to try some of the behind-the-scenes aspects of science writing. Luckily, *Scientific American* gives their fellows and interns opportunities to try everything. I got to work with their fact checkers on several writers' stories. For a week, I worked with the opinion editors in an editorial role. I edited multiple articles and commissioned a piece about a South Carolina bill that aimed to make talking about abortions online illegal. Editing is very different from writing, but also incredibly rewarding.

When I wasn't writing, fact checking, or editing, I was running around New York City. I was incredibly lucky to have family in the city. I spent weekends meandering around Central Park, enjoying all the best food I could find, and watching Broadway plays. I really miss the corner bodega I frequented; it haunts my daydreams. Those should be everywhere. After 10 weeks of walking and riding the subway, it was honestly a bit of a shock to get home and drive to the grocery store.

I am so grateful for the opportunity to experience writing as a day job this summer and living in a city. That was a first for me. Now, I plan to focus on my dissertation for the next four months—I desperately need to graduate—and then work full-time as a writer. I can't imagine how the summer could have been better. Thank you for the support!

Milestone Decision for Cathie Martin's Purple Tomatoes

The plant science community recently celebrated news of the USDA decision to allow U.S. consumers to purchase seeds and grow the nutritionally enhanced, anthocyanin-rich purple tomato developed by Cathie Martin, former editor-in-chief of *The Plant Cell*. Anthocyanins are antioxidants associated with a host of health benefits and are important to an anti-inflammatory diet. Although purple-skinned tomato varieties exist, they do not accumulate useful levels of these healthy compounds within the fruit flesh.

Cathie developed the purple tomato in 2008 by engineering a precise genetic "on switch," derived from an edible flower, and has continued working on the project at Norfolk Plant Sciences (NPS), established by Cathie along with Jonathan Jones as a spinout company from the John Innes Centre and The Sainsbury Laboratory. As the United Kingdom's first GM crop company, NPS's aim is to find ways of commercializing plant research with enhanced health-giving compounds.

"This is fantastic! I never thought I would see this day. We are now one step closer to my dream of sharing healthy purple tomatoes with the many people excited to eat them," she said.

This article was adapted with permission from an article that appeared on the John Innes Centre website on September 8, 2022 (https://bit.ly/3MhCcEF).

Govindjee Receives Lifetime Achievement Award for Photosynthesis Research

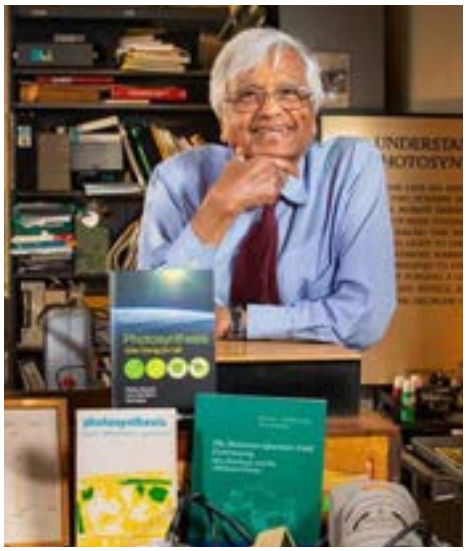


PHOTO BY FRED ZWICKY

University of Illinois Urbana–Champaign plant biology professor emeritus Govindjee is a recipient of a Lifetime Achievement Award from the International Society of Photosynthesis Research, an honor he shares with Eva-Mari Aro, a professor emeritus of molecular plant biology at the University of Turku, in Finland.

Govindjee made pivotal discoveries about the mechanisms that drive photosynthesis in plants and algae and has written or edited dozens of books about the process of photosynthesis and the scientists who studied it.

The anonymously submitted letter of nomination stated that Govindjee "made key contributions to chlorophyll fluorescence induction and photosystem II function. . . . After retirement, he continued to impact the field in many other ways, including by providing a historical perspective of the field."

The award was presented August 5 during the closing ceremony of the 18th International Congress on Photosynthesis Research in New Zealand.

This article first appeared on the University of Illinois website on September 12, 2022 (https://bit.ly/3DYUR63), and is adapted here with permission.

Edgar Cahoon

Center for Plant Science Innovation and University of Nebraska–Lincoln

BY VINUSHA WICKRAMASINGHE
ASPB Ambassador and Kansas State University

Edgar Cahoon's remarkable career in plant biochemistry has focused on lipid metabolism, function, and biotechnology, among other fields. His excitement about scientific questions is not limited to understanding the biosynthesis of various lipid compounds; it also includes lipid-soluble vitamins, antioxidants, and sphingolipids. Collectively, Ed's research has impacts on nutritional biofortification, improvement of crop quality and productivity, and biofuel production. Using camelina and pennycress, Ed is leading scientists from eight institutions toward the production of biofuel and biomaterial that could eventually replace petroleum-based products and reduce the effects of climate change (https://bit.ly/3SwKGJr).

Ed started his career at Virginia Tech, earning a BS in biochemistry, and then received an MS in plant physiology from Cornell University. For his PhD at Michigan State University, he studied plant biochemistry and molecular biology with John Ohlrogge, working on soluble fatty acid desaturases (FAD). As a postdoctoral researcher, he extended his PhD project at Brookhaven National Laboratory, working with John Shanklin to investigate the structure and function of soluble FAD and their relation to other desaturases with different functions.

He joined DuPont Crop Genetics at a time when the company was focused on acquiring knowledge. "I think every company is different, and every time in history is different," Ed reflected. "At that time, we were doing lots of sequencing." He shared his enthusiasm, which led to discoveries. He and his colleagues used Sanger sequencers to generate expressed sequence tags from developing seeds from unusual fatty acid–producing plants. "We were constantly learning something new and publishing." He worked

on his publications after office hours and on weekends, a golden opportunity he felt lucky to have while in industry. Then DuPont acquired Pioneer Hi-Bred International, and the research focus changed to developing products. After five years in industry, he spent six years at the Donald Danforth Plant Science Center and USDA–ARS as a scientist.

In late 2008, Ed joined the Department of Biochemistry at University of Nebraska–Lincoln (UNL) as an associate professor. In 2010 he became a full professor and took an administrative role as director of the Center for Plant Science Innovation while maintaining his research program. At UNL, he continues empowering future generations and doing innovative science.

What got you interested in plant biology in general, and what influences directed you to your specific area of research?

I grew up on a farm in Virginia with a large garden and a forest—lots of trees—around the farm. We grew corn and soybean. I think this early exposure influenced my love for plants. I liked the diversity of plants and found them to be fascinating. I wanted to know how they work and why they are different from one another.

When I went to Virginia Tech for my bachelor's, my major was horticulture to start with. I wanted to study metabolism, though, and during my freshman year I switched to biochemistry. I don't know why, but I thought it was interesting, even though I was not aware of what biochemistry was when I signed up for it. But I came to appreciate the way biochemistry brings together biology and chemistry.

At Virginia Tech, the biochemistry degree was designed in a way in which there were only a few required courses, and I needed to take elective courses. So I took a lot, including horticulture and agronomy, and I mastered the basics, the foundations, of chemistry and biology.

How do you feel about the career path of becoming a professor?

My path to becoming a professor is probably less common. I didn't become a professor after my postdoctoral work because I was hesitant, wandering in the wilderness and trying to find what I wanted to do. I guess I

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lacked the confidence that I could succeed in academia. I was very lucky to have had the opportunity to come to UNL.

Academia was not in my plan. It just happened. It all started at the end of a seminar at the Danforth Center. I had a discussion with the speaker, who was a UNL professor. He told me about the exciting things that were going on at UNL in crop biotechnology and about the field and processing facilities they had for transgenics. It sounded like the kind of place I wanted to be. At that time, I had an established research program and publication record. When my lab moved from the Danforth Center to UNL, one of my postdoctoral scientists was sent early to set up the UNL lab. We packed a moving truck at 5 p.m. on a Friday, drove off to Lincoln, and moved in on Monday and started working. So there wasn't much of a delay, which I imagine is different from starting as an assistant professor.

I enjoy what I do, and I have more freedom. But that freedom comes at the cost of pressure to keep the lab funded. My administrative role as director of our Center for Plant Science Innovation takes up some of my time. Sometimes, I worry that I don't have enough time to focus on my research as much as I should. But I do my best to get everything done.

Importantly, instead of trying to work alone, I am lucky to have collaborators, which has helped my science, and I made many more publications and friends.

What is a Research and Extension Experiences for Undergraduates (REEU) grant?

I wrote an REEU grant to USDA last year. My goal is to build a pipeline for innovations in crop science to be incorporated in food science, including bioprocessing, nutritional evaluation, and creation of novel food products.

My colleagues and I created this program focusing on the recruitment of African American students to enhance their scientific laboratory exposure and encourage them to pursue science as a career. This summer we had six students, four of them from Historically Black Colleges and Universities (HBCUs). Right now, we are planning our recruiting trips to HBCUs next summer to improve awareness of science and our program.

What does your normal day look like, and a normal weekend?

I don't think there is a thing called a "normal" day.

This past month, I have been working on a grant proposal that involves four other states, trying to get stakeholders such as soybean producers and industry together. We had only a month. It was very complicated; I had never done such a big planning grant before. But we submitted it, 45 minutes before the deadline. When it comes to deadlines, I am focused on getting things done. At the same time, people want meetings, interviews, emails, promises to do this and that.

Let me answer your question. I aim to start at 9 a.m., but sometimes I don't until 10 a.m. My days are long, often to after midnight. Saturdays I work from home and try to finish writing tasks.

If you had six months off, what would you do?

I don't think I really want a six-month vacation. I would not know what to do with myself and would probably be bored after one week.

But if I had a week, maybe two, I would spend my time in my yard at home, or get the house in better shape, or go on a multiday bicycle trip.

But six months would be much too long.

As an employer, what are the key qualities you look for in a potential team member?

I like people who are driven by scientific discoveries. What I want to hear is "I want to join your lab to discover this" or "I am curious about this," rather than focusing on publications as your motivation. I expect science to drive you when working in my lab. Because if you do science, publications will follow. If you have writing abilities, that's great. Working hard but smart is always welcomed.

I like people who can laugh a little bit, who are not discouraged by temporary failures—basically people who don't take themselves too seriously and are fun to work with.

What advice would you give a student interested in plant biology?

If you want to do science, you must be very curious. A person curious from the core is one who wants to know why things work the way they do, or is curious in a way that involves solving problems. The world is full of problems.

What do you think is the next big thing in plant biology?

In my understanding, there is a big gap between the fundamental and the translational work we do through metabolic engineering. Metabolic engineering is often guesswork. We insert a gene and see what happens. So I would like to see fields like plant metabolism be predictive. This predictability is crucial for understanding the pieces of molecular components and functions, then putting the pieces together in a system and eventually developing models. When I want to develop a new trait, I want to know precisely what genetic changes to make and what the metabolic outcome will be.

Another area is gene editing. If we could use gene editing to transfer a gene into a very specific region of a genome, we don't have to generate hundreds of independent events to see a desired outcome. Additionally, tools like AlphaFold will change our perception of protein structure and function, giving more opportunities to predictably change amino acids to alter metabolism in a desirable way.

I've noticed your enthusiasm toward research. What is the source of your happiness in doing science? What is your drive?

The next big discovery! I am always driven by the thought of discovery. I still have curiosity and hope. Hope that our contributions in plant science can translate to better lives for people: not only feeding people, but making the bioeconomy stronger so that people are not just healthy, but also prosperous.

If I lose curiosity and hope that science can change the world, then I guess I should not be in science. It's time to give it up.

Policy Update

BY JOANNA RATIGAN
Lewis-Burke Associates, LLC

Congressional Updates

Senate Appropriations Committee Releases FY2023 Spending Bills

On July 28, the Senate Appropriations Committee released all 12 of its fiscal year 2023 (FY2023) appropriations bills. These bills will be starting points for negotiations with the House following the midterm elections. As with the House bills, the Senate showed significant support for environmental and climate programs, though the proposed increases were not as steep. Since Republicans won enough seats in the midterm elections to gain a majority in the House, Democrats will have a vested interest in getting these climate provisions across the finish line before the new Congress is sworn in early in January.

- **Department of Energy (DOE):** The DOE Office of Science would receive $8.1 billion, an 8% increase above fiscal year 2022 (FY2022) enacted levels, including $913.6 million for Biological and Environmental Research, $103.7 million or 12.8% over FY2022 and slightly above both the House bill and the budget request.
- **National Science Foundation (NSF):** NSF would receive a total of $10.4 billion, $1.5 billion above the FY2022 enacted level and greater than the House proposal of $9.6 billion. The Committee supports the Biden administration's requested funding of $913 million for the U.S. Global Change Research Program and $500 million for clean energy technology.
- **U.S. Department of Agriculture (USDA):** The National Institute of Food and Agriculture would receive $1.691 billion, about 5% over FY2022, including $455 million for the Agriculture and Food Research Initiative (AFRI), a $10 million increase over the FY2022 enacted level. The Committee would fund Sustainable Agriculture Research and Education (SARE) at $50 million, a $5 million increase over FY2022. The Committee does not include any funding for the Agriculture Advanced Research and Development Authority (AGARDA), which was authorized in the 2018 Farm Bill and received $1 million in FY2022. The bill would provide an additional $5 million for USDA Climate Hubs, which was not included in the House bill.
- **Department of Health and Human Services (HHS):** The bill would provide $100 million to climate and health programs at the Centers for Disease Control and Prevention (CDC), a substantial increase of $90 million over FY2022, $3 million for the HHS Office of Climate Change and Health Equity (OCCHE), and $918 million to the National Institute of Environmental Health Sciences (NIEHS) at the National Institutes of Health (NIH). Similar to the House, the Senate bill does not include any funding explicitly for the Climate Change and Health Initiative at NIH.

Sources and Additional Information

- The FY2023 Senate Commerce, Justice, Science Appropriations Subcommittee report containing recommendations for NSF funding is available at https://tinyurl.com/293xwntf.
- The FY2023 Senate Energy and Water Appropriations Subcommittee report containing recommendations for DOE funding is available at https://tinyurl.com/mryzecmk.
- The FY2023 Senate Agriculture Appropriations Subcommittee report containing recommendations for USDA funding is available at https://tinyurl.com/3a5z8nz2.
- The FY2023 Senate Labor, Health and Human Services, and Education Appropriations Subcommittee report containing recommendations for HHS funding is available at https://tinyurl.com/yc4n7u7b.

Inflation Reduction Act Signed into Law with Significant Energy and Climate Provisions

On August 16, President Biden signed the *Inflation Reduction Act* into law, a substantial legislative package with provisions concerning climate change, clean energy, health care, and taxes. Overall, the bill is estimated to raise approximately $739 billion in revenue and spend $433 billion on energy, climate, health care, and tax policies. The bill provides $370 billion to support the deployment of clean energy technologies and reduce greenhouse gas emissions to combat climate change and meet the Biden administration's target of cutting emissions by 52% from 2005 levels by 2030. In addition, through inclusion of a revised methane fee and attention to air pollution, the bill hopes to enable the U.S. to meet its goal of reducing anthropogenic methane emissions by at least 30% by 2030 from 2020 levels.

Most of the funding included in the bill is for new and expanded tax credits to incentivize U.S. manufacturing and deployment of clean energy technologies, as well as energy rebates and other consumer tax credits for home energy-efficiency improvements to lower consumer energy costs. The bill also imposes the first-ever fee on methane emissions. The legislation provides $2 billion for the DOE National Lab research facilities and infrastructure modernization to support innovation in clean energy technologies and other DOE science and technology missions, and $20 billion to the USDA for climate-smart agricultural conservation

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programs. These investments will be distributed through a variety of programs that aim to reduce emissions, improve soil health, and increase carbon sequestration. Additionally, USDA's Natural Resources Conservation Service will receive $1 billion to provide technical assistance and $300 million for quantifying carbon sequestration and greenhouse gas emissions through field-based data collection.

Sources and Additional Information

- The Lewis-Burke analysis of the reconciliation bill is available at https://tinyurl.com/yw7fx4jx.
- The full text of the *Inflation Reduction Act of 2022* is available at https://tinyurl.com/c2ufuabd.

Congress Passes CHIPS+Science Act Authorizing Support for Environmental Research

On July 28, Congress passed the *CHIPS+-Science Act* (*CHIPS+*), a long-awaited innovation package to boost U.S. competitiveness in science and technology. This package appropriates $54 billion for semiconductor research and development and authorizes $102 billion to advance major research initiatives at the NSF, the DOE, the National Institute of Standards and Technology (NIST), and the National Aeronautics and Space Administration (NASA), and creates a new bioeconomy research and development national initiative.

The legislation authorizes $81 billion for NSF over five years, growing annual authorized funding to $19 billion in fiscal year 2027 (FY2027). The provisions authorizing the new Technology, Innovation, and Partnerships Directorate emphasize the focus on ten key technology areas, which include disaster prevention and mitigation, biotechnology and synthetic biology, advanced energy and efficiency technologies, and advanced materials science. There are also several provisions concerning specific research areas including climate change, food-energy-water, sustainable chemistry research and education, precision agriculture, risk and resilience, and support for biological collections.

The package authorizes $68 billion over five years at the DOE and advances policy for major research and infrastructure initiatives. The centerpiece of authorized DOE investments would be $50.3 billion for the DOE Office of Science over the next five years, a significant boost from a $7.5 billion FY2022 enacted level to nearly $11 billion by FY2027. It also provides authorization to support the National Labs and research programs supported by DOE's applied energy offices, including $11.2 billion for emerging technologies research and development. *CHIPS+* also includes the *Bioeconomy Research and Development Act*, which would establish a National Engineering Biology Research and Development Initiative through the White House Office of Science and Technology Policy (OSTP). Additionally, the bill directs OSTP to establish an interagency committee to help facilitate federal coordination of biotechnology research and development, and an advisory committee on engineering biology research and development comprised of representatives from research and academic institutions.

Sources and Additional Information

- The complete Lewis-Burke analysis of *CHIPS+* is available at https://tinyurl.com/yz4t98me.
- The full *CHIPS+* bill text can be found at https://tinyurl.com/mw95wd9m.
- The section-by-section summary can be found at https://tinyurl.com/3v4ey2ba.

Agency and Administration Updates

White House Launches New Efforts to Boost the U.S. Bioeconomy

On September 12, the Biden administration announced a new Executive Order (EO) and holding an accompanying White House summit to launch a new National Biotechnology and Biomanufacturing Initiative (NBBI), acknowledging the significant potential benefits of biotechnology and biomanufacturing to climate change, energy, and agriculture. The NBBI aims to unite federal agencies in strengthening investments in research and development in biotechnology, and increase domestic biomanufacturing production capacity. The Initiative emphasizes the need for improved biological data sharing, regulatory frameworks, and evaluation metrics, as well as the importance of training and supporting a diverse, skilled workforce to advance the bioeconomy. Among other actions, the EO directs federal agencies and departments to evaluate and report on their current investments in biotechnology and biomanufacturing. The administration will then use these reports to shape future budget requests, which in turn could lead to new funding from Congress in FY2024 and beyond.

Sources and Additional Information

- The full EO is available at https://tinyurl.com/bdhbbw5m.
- A recording of the White House Summit on Biotechnology and Biomanufacturing is available at https://tinyurl.com/58djp4b7.

NSF BIO Directorate Holds Fall Advisory Committee Meeting

On September 13 and 14, the NSF held its Fall Advisory Committee meeting for the Biological Sciences Directorate (BIO), the last one led by the current head of BIO, Joanne Tornow. Beginning October 1, the current Deputy Assistant Director of BIO, Simon Malcomber, began serving as Acting Assistant Director. The meeting began with an overview of the existing challenges and opportunities that BIO faces; at the forefront of this list is building a sustainable future through climate resilience and clean energy research. To achieve this goal, BIO discussed the need for cross-cutting, interdisciplinary collaboration to promote curiosity-driven, use-inspired research and to build up the STEM workforce. Another primary goal for the Directorate is to build the research capacity of new faculty in biology to broaden participation within the field and strengthen the research experiences of undergraduates

Sources and Additional Information

- A recording of the September 13 meeting sessions is available at https://tinyurl.com/3phetety, and the September 14 sessions are available at https://tinyurl.com/24n2wkfj.

NIEHS Discusses Emerging Environmental Health Opportunities During Advisory Council Meeting

NIH NIEHS held its advisory council meeting in mid-September to discuss updates

from the Institute. In his director's report, Rick Woychik described what he views as five major emerging opportunities for environmental health researchers: (1) precision environmental health, an approach that analyzes genome and epigenome profiles and exposures across the lifespan to understand individual risk and prevent disease; (2) climate change and health, highlighting the importance of the NIEHS-led NIH Climate Change and Health Initiative; (3) predictive translational toxicology; (4) environmental justice and health disparities; and (5) computational biology and data science, to allow environmental health sciences to utilize innovative data-driven approaches to advance scientific discovery. These themes are likely to shape the upcoming NIEHS strategic plan for 2024–2028, for which the Institute will soon solicit public input.

Sources and Additional Information

- More information on the NIEHS Advisory Council meeting is available at https://tinyurl.com/bdd8nwrf.

Department of Energy Releases Implementation Plan for Justice40 Initiative

During his first week in office, President Biden issued an Executive Order establishing the Justice40 Initiative, which requires 40% of benefits from Federal investments in climate change and clean energy go to disadvantaged communities (DACs). After an internal review, the DOE named 146 ongoing programs which will seek to incorporate the direction from the Justice40 initiative. While the agency is not creating a new program, it did release a list of programs which will be covered under Justice40 and highlights its top priorities to advance environmental justice and an equitable clean energy future, and details how program offices are implementing strategies for disadvantaged communities. For all 146 programs, there are likely to be updates to their solicitations to include Justice40 requirements and awardees are likely to have a closer tie to the initiative.

Sources and Additional Information

- More information on DOE's implementation of the Justice40 initiative can be found at https://tinyurl.com/bdfuynpd.

Biden Administration Issues Guidance on Public Access to Federally Funded Research

On August 25, the White House OSTP issued a Memorandum on Ensuring Free, Immediate, and Equitable Access to Federally Funded Research. The guidance included in this memorandum builds upon a 2013 memorandum issued by the Obama administration, which directed all federal departments and agencies with more than $100 million in annual research and development (R&D) expenditures to develop a plan to support increased public access of federally funded research, with a focus on access to scholarly publication and digital data resulting from such research. In the updated guidance, OSTP asserts that public feedback has indicated that a major limitation of the 2013 policy is the optional 12-month embargo on making data and publications stemming from federally funded research publicly available. The guidance updates and extends the 2013 policy by directing federal agencies to update their public access policies to make publications and research stemming from federally funded research publicly accessible, without an embargo or cost. Agencies must fully implement these updated policies by December 31, 2025.

OSTP directs agencies with more than $100 million in annual R&D expenditures to update their public access plan within 180 days, removing all embargos on scholarly publications resulting from federally funded research, ensuring machine readability of articles posted in publication repositories, and updating data policies to ensure data associated with scholarly publications resulting from federally funded research is made immediately publicly available upon publication. In addition, agencies must consult with impacted stakeholders as they develop their plans, and they must make publishing and data-sharing costs allowable in research grants. Agencies must publish their updated plans by the end of 2024.

Sources and Additional Information

- The updated guidance is available at https://tinyurl.com/yc67rkyc.
- The 2013 memorandum is available at https://tinyurl.com/2p9tmyun.

Biden Administration Announces FY2024 Research and Development Priorities

The White House Office of Management and Budget and OSTP have released the memorandum for multi-agency research and development (R&D) priorities for FY2024. This annual memo provides guidance to federal agencies on science and technology priorities for the next budget request and highlights the importance of federally supported R&D to address societal grand challenges affecting the U.S., including climate change, health, prosperity, security, environmental quality, equity, and justice for all Americans. The memo includes the Biden administration's focus on innovation and the translation of basic research into the commercial sector. It also emphasizes the importance of engagement with every region of the U.S. along with investments at Historically Black Colleges and Universities and other Minority Serving Institutions, as well as "rural communities, and other disadvantaged communities that have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality." The multi-agency R&D priorities outlined in the memo are Preparing for and Preventing Pandemics; Tackling Climate Change; Advancing National Security and Technological Competitiveness; and Innovating for Equity. Additionally, the new areas of emphasis in this year's memo are Reducing the Death Rate from Cancer by Half; Cultivating an Equitable STEM Education, Engagement, and Workforce Ecosystem; and Promoting Open Science and Community-Engaged R&D.

Sources and Additional Information

- The FY2024 R&D memo can be found at https://tinyurl.com/4xnkvenb.

Arati Prabhakar Confirmed as OSTP Director

In late September, the Senate confirmed Arati Prabhakar as the new Director of the White House OSTP by a vote of 56–40. With her confirmation, she becomes the first woman and the first person of color to lead OSTP. She has a background in engineering and applied physics and previously served as

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the Director of the NIST and as the Director of the Defense Advanced Research Projects Agency. Prabhakar also has experience across the industry and non-profit sectors, working in executive roles, as a venture capitalist, and founding an organization focused on developing solutions to issues of climate, health, information technology, and equal opportunity.

Sources and Additional Information

- An OSTP statement on Prabhakar's confirmation is available at https://tinyurl.com/3e4xse9j.
- A record of the confirmation vote is available at https://tinyurl.com/2xcs7d6t.

IPBES Approves New Thematic Assessment of Sustainable Use of Wild Species

The 139 member states of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), an independent intergovernmental body established by states to strengthen the science-policy interface for biodiversity and ecosystem services, approved its Thematic Assessment of the Sustainable Use of Wild Species. The report is the culmination of years of work by 85 leading natural and social scientists, holders of traditional knowledge, and 200 contributing authors. The publication, which elevates science as a part of the political agenda setting for biodiversity conservation globally, supports the notion that billions of people rely on and benefit from the use of wild species; that the sustainable use of wild species is central to the identity and existence of many indigenous peoples and local communities; and that ensuring sustainability of the use of wild species is critical to reversing the global trend in biodiversity decline. Negotiators are anticipated to refer to the report as they finalize the Post 2020 Global Biodiversity Framework at the UN Convention on Biological Diversity COP 15, which will be held in December of 2022 in Montreal, Canada.

Sources and Additional Information

- The IPBES press release about the report and report are available at https://tinyurl.com/3pcrprm9.

Funding and Engagement Opportunities

NSF Releases Solicitation for Synthesis Center for Molecular and Cellular Sciences (SCMCS)

The NSF has released a new solicitation to establish a Synthesis Center for Molecular and Cellular Sciences (SCMCS). This new Center, supported by the BIO, aims to advance research on "complex molecular and cellular phenomena through innovative synthesis and integration of available biological data and related scientific knowledge." The Center will provide the vision, infrastructure, and expertise to support community coordination of information in molecular and cellular biosciences. The Center will support open science principles and a team science approach to ensure effective data sharing and collaboration between the biological, chemical, computational, mathematical, and physical sciences and engineering fields, as well as training programs for the next generation of researchers to engage in "data-intensive, cross-disciplinary, and collaborative science." The Center is also expected to facilitate participation of a diverse group of researchers from different types of institutions across the U.S. NSF plans to make one award of $20 million as a cooperative agreement for an initial period of five years, with the option of an additional (single) five-year renewal. Preliminary proposals are required and are due January 13, 2023. Full proposals are due July 7, 2023.

Sources and Additional Information

- The SCMS program page is available at https://tinyurl.com/bdfs7wjn.
- The SCMS solicitation is available at https://tinyurl.com/2wwcfaxk.

NSF Issues Dear Colleague Letter –Critical Aspects of Sustainability (CAS): Innovative Solutions to Sustainable Chemistry (CAS-SC)

NSF has issued a Dear Colleague Letter (DCL) announcing the creation of the Critical Aspects of Sustainability: Innovative Solutions to Sustainable Chemistry Program (CAS-SC) under the Critical Aspects of Sustainability (CAS) umbrella initiative which was initiated in early 2021 to support acceleration of NSF's work related to climate change, sustainability, and conservation. CAS-SC was created to expand national sustainability research through proposal submissions focused on quantitative sustainable chemistry as well as industrial partnerships. Similar to the original CAS program, teams that are interested in submitting a full proposal are required to submit a concept outline to the appropriate participating NSF division at https://suitability.nsf.gov/s/ with a project title, list of team members, a summary of the project concept, and a description of how the proposed research contributes to the field of sustainable chemistry. NSF has not indicated a level of funding that will be made available for this program. It is likely to follow the format of the original CAS program, in which individual divisions dedicate funds to meritorious projects as they are received without a quota or minimum number of projects to select.

Sources and Additional Information

- The full DCL can be found at https://tinyurl.com/sj7sh9hk.
- The CAS site can be found at https://tinyurl.com/yxmf9mfv.

Jane Silverthorne

1953–2022

BY BLAKE MEYERS, Donald Danforth Plant Science Center and University of Missouri-Columbia, ANNE SYLVESTER, University of Chicago Marine Biological Laboratory, and SCOTT JACKSON, Bayer Crop Science

Jane Silverthorne passed away peacefully at her home in Arlington, Virginia, on August 18, 2022. Jane was a colleague, mentor, and friend, as well as a scientific leader who changed the landscape of plant biology and transformed the lives of many.

Jane was born July 26, 1953, in Somerset, England. The family moved regularly while she was a child, and she spent time in England, Scotland, and Malta. Jane gained a love of history and art through her travels as a child and her time spent in Malta, where she had returned in recent years to visit. Jane is survived by her sister Alison Silverthorne, her beloved nephew William Silverthorne, and her brother Clive Silverthorne.

Jane attended the University of Sussex in Brighton, where she received her BSc in Biology. She received her PhD from the School of Biological Sciences at the University of Warwick, working with R. John Ellis on protein synthesis in chloroplasts. Jane then joined Elaine Tobin's lab for postdoctoral research at the University of California, Los Angeles. During her postdoc, Jane was the first to identify that phytochrome affected transcription, thereby contributing to seminal proof for the role of light-regulated gene expression in plants.

In 1987, Jane started her academic career as an assistant professor in the Department of Molecular, Cellular, and Developmental Biology at the University of California, Santa Cruz, where she advanced through the ranks to earn tenure and then full professorship. Her research group continued to study how phytochrome regulates plant growth and development using the in vivo system of transcriptional regulation in *Lemna gibba,* which she had advanced in the Tobin lab. Jane soon expanded her research to include *Ginkgo biloba* and *Pinus palustris,* spearheading a comparative approach to understanding light-regulated expression and its impact on chlorophyll biosynthesis.

Jane was an innovator, an exceptional team player and collaborator, and a creative game changer. These skills became evident in 1999, when Jane joined NSF as a temporary program director with the newly established Plant Genome Research Program (PGRP). In this role, she brought her scientific knowledge and leadership skills to a funding program that transformed plant biology and genomics. And it was in this role that many members of the ASPB community came to know and appreciate Jane—through proposal submissions, reviews, panels, and awards from the PGRP.

Jane continued to oversee the successes of the early days of the PGRP as an NSF rotator through 2003. Recognizing her strengths and leadership potential, Machi Dilworth successfully recruited Jane to apply for the position of a permanent program director. At that time, Jane became a U.S. citizen, but she never lost her roots in and love of the United Kingdom or her passion for art and travel. She relinquished her U.K. citizenship to serve in the federal government and was naturalized in Virginia, surrounded by friends and colleagues.

Jane at a site visit to USDA's Dale Bumpers Rice Research Center in 2003.

Jane's tenure at NSF was contemporaneous with the inception and development of the PGRP. Under the formative guidance of Mary Clutter and Machi Dilworth, Jane helped oversee the funding and direction of a program that transformed plant genomics

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Jane and Mary Clutter at a San Diego beach waiting for a green flash in 2007.

Jane, standing next to the U.S. flag, with friends and colleagues, after her citizenship ceremony in 2003.

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and ultimately agriculture. The current 24-year success of the PGRP was due in large part to Jane's steadfast leadership and vision, even as she progressed to new roles and contributions at NSF. She relied on cross-fertilization of ideas from genomics experts beyond plant biology through the National Plant Genome Initiative's Interagency Working Group on Plant Genomics. Either behind the scenes or as chair, Jane led the interagency group and authored many of their five-year strategic plans.

Jane adroitly managed the PGRP by leading, collaborating, and establishing new and creative programs to engage and support the research community. One of Jane's great skills was to identify scientific needs and bring together plant biologists and stakeholders to achieve new frontiers in science. Examples of this approach include initiating Ideas Labs at NSF, promoting the concept of Research Sprints (https://vimeo.com/222724913), and guiding and supporting programs such as Metabolomics for a Low Carbon Society, the PGRP's Developing Country Collaboration, and the Basic Research to Enable Agricultural Development (BREAD) program, a collaboration with the Bill & Melinda Gates Foundation and the first of its kind. Jane also led a partnership with the U.K. Biotechnology and Biological Science Research Council to hold Ideas Labs focused on photosynthesis and nitrogen fixation. Her initiation and oversight of the Young Investigator Award Program in 2002 to 2005 supported a generation of scientists who are leaders today.

Jane at a small farm in Nairobi during a BREAD site visit in 2011.

From 2006 to 2008, while still at NSF, Jane served as an adviser to the White House Office of Science and Technology Policy. Upon her return, Jane influenced the broader biological sciences at NSF by serving in various senior management roles starting in the Division of Integrative Organismal Systems, first as deputy division director and then as division director. In 2014, she became the deputy assistant director for the Directorate for Biological Sciences, the role she served in until her retirement from NSF in 2017.

In her work at NSF and beyond, Jane remained committed to foundational research in biology as essential for societal progress. She brought to this commitment a deep understanding that basic research can and must lead to societal outcomes. Her emphasis on supporting basic plant biology research that can ultimately improve agriculture guided her actions and influenced those around her. For those of us who were privileged to serve as program directors alongside Jane at NSF, we watched and learned from her leadership skills throughout her career and past her retirement in 2017. After retirement, Jane continued to be active in science, serving as senior scientific adviser for the Supporters of Agricultural Research Foundation and as chair of the scientific advisory board and board member for the Boyce Thompson Institute. Jane's commitment to science and its impact on agriculture never waned, and she was an inspiration to all.

Over the course of her career, Jane received awards and honors that include election as a Fellow of AAAS in 2012 and selection for ASPB's Leadership in Science Public Service Award in 2020. But she did so much more than what appears on paper. Jane's impact as a scientific and leadership mentor is one of her great legacies. Jane brought integrity, clarity, and kindness to those she directly and indirectly mentored. Her commitment to advancing science, to early career scientists, and to all those whose voices are not routinely heard was constant. Jane's impact on the national and international scientific community continues.

The Boyce Thompson Institute Scientific Advisory Board meeting in May, 2022. From left, visible faces only: Scott Jackson, Eric Lyons, Dan Klessig, Andrew Nelson, Jane Silverthorne, Greg Martin.

See additional personal notes, stories, and tributes from friends and colleagues of Jane on the ASPB blog (https://blog.aspb.org/remembering-jane-silverthorne/).

A memorial service will be held in Arlington, Virginia, on March 27, 2023; for more details, please contact one of the authors of the tribute.

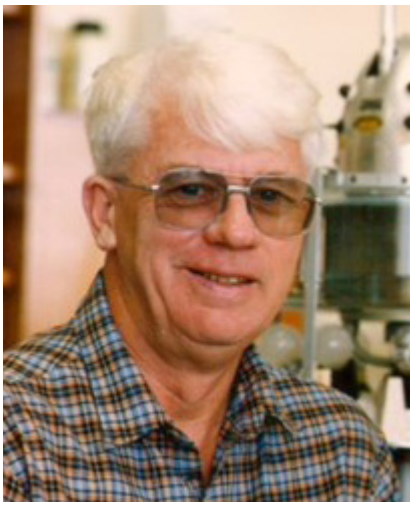
A version of this article first appeared on the Royal Society of New Zealand website (https://bit.ly/3FhQILe).

Philip Grattan Roughan

1937–2022

Fellow of the Royal Society of New Zealand

BY JOHN BROWSE, JOHN CRONAN, and JOHN OHLROGGE, with contributions from SALLY ROUGHAN and NICK ROUGHAN



P. Grattan Roughan made fundamental contributions to plant lipid science that now form the core of our understanding of fatty acid metabolism in photosynthetic organisms. As a leading plant lipid researcher, Grattan reminded the world that great science can originate from all parts of the world and that the best insights sometimes come with a little distance from the crowds. His work and life gained the sincere admiration of his many colleagues and friends throughout the world.

Grattan was born July 4, 1937, in Dunedin, New Zealand. At school he excelled at rugby and especially tennis, representing Southland around the country. He left school in 1954 with no clear goal in mind. He entertained a career in teaching but was encouraged by his school principal to set his sights toward higher education. In 1955 he had a few laboring jobs, but it was while working at a hospital laboratory that the idea of a career in science seemed to take root. He graduated from the University of Otago with BSc (1960) and MSc (1962) degrees, and between 1962 and 1965 he worked at the Wallaceville Research Centre of the Department of Agriculture and Fisheries, where he met his future wife, Sally. Grattan and Sally were married in 1963 in Upper Hutt and moved to Palmerston North in 1965, when Grattan accepted a scientist position with the Plant Physiology Division (PPD) of the Department of Scientific and Industrial Research. After completing his PhD at Massey University in 1968, Grattan became focused on lipid metabolism in plants.

Grattan was a gifted hands-on experimental scientist who loved to work at the bench and did so throughout his entire career. His discoveries rewrote the textbook description of lipid synthesis in plants and led to his election as a fellow of the Royal Society of New Zealand in 1988 and to the award of DSc from the University of Otago in 1989. Grattan also received the DSIR Ministerial Award for Excellence in Science and a Fulbright Scholarship in 1990.

During his long career, Grattan worked with a series of collaborators, including Roger Slack, Ross Holland, Sue Gardiner, and John Browse, and visiting scientists, including Jurgen Soll, Ernst Heinz, Guy Thompson, John Cronan, Ikuo Nishida, and John Ohlrogge. He enjoyed visiting and doing research in laboratories in the United States and Australia during periods of sabbatical leave. Everyone who worked with him came to appreciate the creativity he brought to his research and his scientific productivity. Grattan and Sally were wonderful hosts who helped visiting scientists feel more than welcome, found accommodations for their stay, made arrangements for their children to attend New Zealand schools, and led tours of their favorite places. They could make simple get-togethers feel festive and joyful. Many fell in love with New Zealand and made return trips whenever possible.

Research group at Palmerston North, ca. 1982. Left to right: seated—Ernst Heinz, Roger Slack, John Browse; standing—William Laing, Sue Gardiner, Grattan Roughan.

In 1970, Grattan published results of $^{14}CO_2$ and ^{14}C-acetate radiotracer experiments with pumpkin leaves that demonstrated that fatty acids synthesized in the chloroplast of leaf cells were very rapidly incorporated into phosphatidylcholine, the main structural lipid of the endoplasmic reticulum. The labeling kinetics of fatty acids on phosphatidylcholine indicated that this lipid was a major substrate for the synthesis of polyunsaturated lipids in plant leaves. In the same year, Grattan persuaded Roger Slack to join PPD, and together they set out to understand and expand upon the in vivo results from Grattan's pumpkin experiments.

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As part of this exploration, Grattan decided to investigate fatty acid metabolism in isolated chloroplasts. He recognized that many studies of isolated chloroplasts were based on preparations with fatty acid synthesis rates far below those occurring in intact plants, and therefore likely not representative of whole plant metabolism. Systematic evaluation of all materials and procedures led to his use of young, rapidly expanding spinach or pea plants grown hydroponically. Leaves from these plants were harvested within two hours of the start of the light cycle, followed by rapid homogenization and centrifugations performed within five to seven minutes. Chloroplasts produced by this procedure synthesized fatty acids at rates equal to or above those observed in intact plants and five- to tenfold higher than rates reported from almost all other groups.

I (JB) joined Grattan and Roger's group at PPD in 1978. Grattan's daily routine was to cycle to the lab, arriving by 8 a.m. to prepare media and harvest spinach leaves. By 9 a.m. he was assaying the freshly prepared chloroplasts in his trusty Warburg apparatus with a selection of carefully chosen substrates and cofactors. The exquisitely simple and elegant experiments he performed provided the in vitro evidence to complement results from in vivo labeling experiments with intact plant tissues.

By 1980, Grattan and the lipid group at PPD were able to define for the first time the two major pathways of glycerolipid synthesis. One, the prokaryotic pathway, is confined to the chloroplast, and in most plants it makes a minor quantitative contribution to total cellular lipid synthesis. The second, the eukaryotic pathway, is an elaborate collaboration between the chloroplast, the cytoplasm, the endoplasmic reticulum, and other organelles of the cell involving export, import, and metabolism of lipid intermediates to facilitate and control the composition of each membrane system in the cell. This two-pathway model is now the textbook paradigm that guides and facilitates our investigation and understanding of membrane lipid synthesis and the many roles that these lipids play in membrane function, cell biology, and life processes of plants. As a tribute to this seminal contribution, a chloroplast fatty acid that is central to the prokaryotic pathway is now named Roughanic acid.

Roughanic acid.

In 1984 Grattan and Sally moved to Auckland, where Grattan continued his research at the Mount Albert Research Centre. There he focused on fatty acid synthesis in chloroplasts and detailed the implications of the distribution of acyl carrier protein (ACP) intermediates in this process. His high-activity chloroplast preparations allowed the first reliable analysis of concentrations, composition, and turnover of acyl-ACP and acyl-CoA pools in plant chloroplasts. Analyses of fatty acid synthesis revealed the very fast turnover of acyl-ACP pools (5–10 seconds), and the rapid changes in pools between light and dark provided direct evidence for regulation of fatty acid synthesis by acetyl-CoA carboxylase, the first committed step in the pathway. Other key discoveries based on chloroplasts included evidence for a membrane-associated assembly of fatty acid synthesis enzymes and of acyl-CoA synthetase localization on the chloroplast envelope.

> "I could not imagine what I would rather be doing. When Nick and Joanne asked in the early 70s what I did at the lab all day, I could only compare my work with playing in the sandpit. How lucky is that?
>
> —Grattan Roughan

Grattan also probed hypotheses on how membrane lipid composition might determine the chilling sensitivity of species such as amaranthus, soya bean, and maize that are damaged and killed by nonfreezing temperatures in the range of 0°C to 10°C. His extensive analysis of chilling-sensitive and chilling-resistant plants indicated that there is no simple relationship between membrane lipid composition and chilling damage. Instead, it is likely that plants that evolved in the world's tropical regions acquired traits that are beneficial in consistently warm environments but that result in damage at colder temperatures typical of temperate regions.

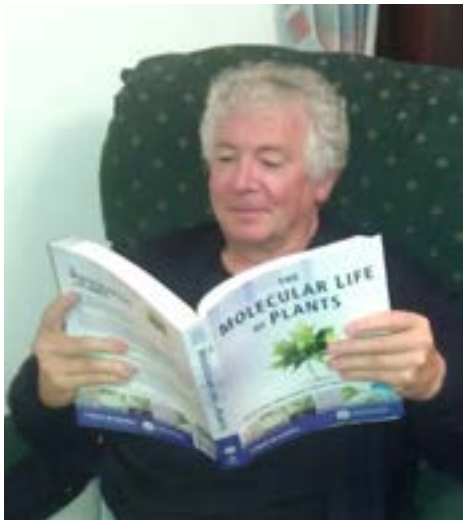
In 1985–86 I (JC) spent a sabbatical leave with Grattan in the Mount Albert Research Centre. I was enamored with the prokaryotic fatty acid synthesis in chloroplasts; I worked with fatty acid synthesis in bacteria, while Grattan was the chloroplast expert. I must confess, however, that escaping an Illinois winter was also a factor. Grattan and I first met when my wife and I landed in Auckland with our two little boys. Grattan and I became good friends almost immediately, and that friendship prospered and endured. My idea was to use the ACP techniques we had developed for *E. coli* in chloroplast lysates. This had some success and contributed to the chilling sensitivity analysis. However, my enduring contribution was to prepare the silver nitrate required for chromatographic separations of saturated and unsaturated fatty acids. Grattan's supply was almost nil; the price of silver was sky high, and funds were scarce. However, while poking around in the small storeroom, I found small dusty bottles containing several hundred grams of silver nitrite, which I oxidized to silver nitrate and crystallized. Grattan was still using this supply when he closed his lab.

Judging by my later trips to New Zealand, Grattan's retirement mainly involved family and old friends. Grattan and Sally decided to take no more overseas trips (Australia did not count), and they traveled extensively in New Zealand and Australia, often with relatives and friends—Grattan was a marvelous and enthusiastic driver. They first lived in a charming vacation "batch" (house) on Algies Bay north of Auckland. However, this was on a challenging bluff overlooking the sea, which engendered a lot of stairs that came to be too much (Grattan had bad knees from his rugby days). Their two children, Nick and Joanne, and grandchildren had moved to the South Island and lived in Wanaka, a resort town. Sally and Grattan visited Wanaka several times and decided to move there. They found an ideal house in a retirement community that had gardens and communal greenhouses where Grattan could grow his chili peppers. They were very happy there. Grattan occasionally wanted to talk science and was pleased when I told him that he could see on Google Scholar whether his papers were being cited.

Remembering Howard "Sid" Thomas

1948–2022

BY WENDY SILK, ELEANOR CRUMP, HELEN OUGHAM, and RUSSELL JONES



Howard Thomas—known to almost everyone as Sid—was born and educated in Neath, South Wales. He earned a BSc and a PhD at the University of Wales, Aberystwyth, and had a career in scientific research based at the Welsh Plant Breeding Station, subsequently the Institute of Grassland and Environmental Research (IGER), near Aberystwyth.

His scientific interests focused particularly on leaf senescence and chlorophyll catabolism, and his group played a leading role in identifying the gene underlying the green/yellow seed trait studied by Mendel. He spent a sabbatical year at the University of California, Davis, in the 1970s and collaborated widely, with visiting positions at Tohoku University in Sendai, Japan, and the University of Zurich in Switzerland. By the end of his career, Sid was IGER's strategic development director. He was a fellow of the Linnean Society and of the Learned Society of Wales.

Sid was a long-term member of ASPB, and because of his expertise in chlorophyll catabolism and senescence, he was invited to contribute to *Biochemistry and Molecular Biology of Plants,* published jointly by ASPB and Wiley. Sid, together with his wife Helen Ougham, Russell Jones, and Susan Waaland, collaborated to write the undergraduate textbook *The Molecular Life of Plants,* also published jointly by ASPB and Wiley-Blackwell.

After retirement, Sid held an emeritus professor position at Aberystwyth University. He served as an editor of *New Phytologist* for many years and was treasurer and on the board of trustees of the New Phytologist Foundation. He was an ISI Highly Cited Researcher and published more than 200 research papers, books, and reviews. He was still publishing at the time of his death in July 2022.

Sid was not only a scientist; he was also a talented jazz musician, composer, and collaborator working with artists and English literature academics. He wrote about music, literature, and much more. The book *Food and the Literary Imagination* (by Jayne Elisabeth Archer, Richard Marggraf Turley, and Howard Thomas, Palgrave Macmillan, 2014) explores the authors' joint interest in how food security, the food chain, and concerns about its corruption and disruption are represented in literature, including in plays, poetry, and novels.

After retirement, Sid wrote four books on subjects reflecting his own philosophy of science and the natural world: *Senescence, The Tale of the Three Little Pigments* (chlorophylls, carotenoids, and anthocyanins), *The War Between Trees and Grasses,* and *Plant Blindness*. The latter is a topic on which Sid, Helen, and Dawn Sanders also wrote jointly. He was committed to the belief that collaboration between scientists and those engaged in the creative arts was of value to all those concerned and to society as a whole. This belief was further reflected in a collaboration with artists Heather Ackroyd and Dan Harvey, who used growing grass as one of the media in their works. This experience led to new artworks, talks, and workshops run jointly by scientists and artists, as well as novel research based on the information content of plant images.

From childhood, Sid was fascinated by jazz. His musical interests and accomplishments were broad. He played clarinet from an early age and taught himself jazz piano. After retirement from IGER, he described his musical development in the memoir "Confessions of an Accidental Jazz Pianist," and he published a guide to jazz harmony for

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Pale Creatures

The yew endures four thousand years.
The mayfly dances for a few summer hours.
And so it goes: every thing lives a lifetime.

Something lives under every stone—
Pale creatures hatching by the light of the moon.
And so it goes: every thing lives a lifetime.

Time, a hare and tortoise race.
Lichen on a sundial's face.
Life's now. Time's never.
And so it goes: the glass falls hour by hour, forever.

Daughters of Adam, sons of Eve,
Cast fleeting shadows on the walls of the cave.
And so it goes: every thing lives a lifetime.

Melting clockface, leafless tree.
Apple where the head should be.
Still life. Still standing.
And so it goes: to fly is easy, the hard part is landing.

Meanwhile, in awful solitude,
Out there two galaxies approach and collide.

And so it goes: every thing lives a lifetime.

Words and music by Sid Thomas (on YouTube at https://bit.ly/3SwEXDY or on Spotify at https://spoti.fi/3rfzGVH).

New Staff

AZIZ ALAM JOINS ASPB AS THE NEW SENIOR ACCOUNTANT

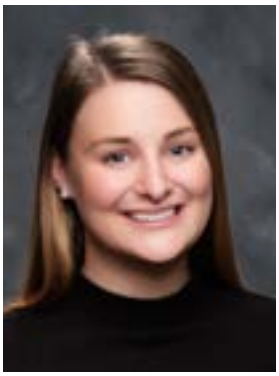
Aziz graduated with a finance degree but was more interested in the accounting field, and over the past eight years he has worked in various accounting functions. Key industries he has worked in are telecommunications, automotive marketing, broadcast media, and aquaculture.

Aziz started his career as an automotive service biller for an auto repair business and moved on to work for a DC-based automotive/RV marketing firm on all aspects of the accounting function. Beginning in 2018 Aziz worked for a Singapore-based telecom company on financial reconciliations and sales tax compliance. He also worked for an aquaculture startup, setting up accounting systems and processes. Before moving to ASPB, Aziz performed all the revenue and cash inflow activity for a DC-based nonprofit.

At ASPB Aziz will be handling revenue and invoicing, among many other duties. He will report to Teressa Leath, ASPB's accounting manager.

Outside of work, Aziz likes hiking, playing soccer with his three-year-old, and cooking and trying out different cuisines.

RACHEL BELSKY JOINS ASPB IN NEW DUAL-FOCUS ROLE



Rachel Belsky joined ASPB on September 29 as peer review manager and content coordinator. This new, dual-focus role includes supporting *The Plant Cell* as a member of the peer review management team to ensure a high-quality peer review process for authors, reviewers, and editors. Rachel also will focus on developing new content and storytelling initiatives for ASPB.

Rachel worked in content and account management for the past four years at a digital marketing agency. Previously, she was an assistant project manager at the PSEG Institute for Sustainability Studies. Her passion for writing and editing has allowed her to work in a wide range of fields including journalism, business, and technology.

Rachel earned a bachelor's degree in English literature with a minor in film. She is certified in Google Analytics, SEO Fundamentals, and AP style proofreading and editing.

Rachel also has a certificate in sports counseling. She coaches youth soccer and was director of player development for the Virginia Commonwealth University women's soccer team.

In her spare time, Rachel enjoys traveling, hiking, doing yoga, and reading with a hot cup of coffee. She currently resides in Richmond, Virginia, with her partner and their two adorable dogs.

SID THOMAS

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pianists. He delved into recording and synthesizer technology and created multi-instrumental recordings both in his son Ben's studio in Wales and in his own Cwtch Studio in Kent. For the symposium "A Song of Botany" at the 2011 International Botanical Congress in Melbourne, Sid wrote music for Helen Ougham's lyrics "Peas in Our Time" to celebrate their success in cloning a Mendelian gene. Sid and Helen contributed actively to Wendy Silk's NSF networking project to enhance science learning via the arts.

Sid wrote lyrics and produced original compositions (e.g., https://www.youtube.com/watch?v=ooVAO_8qF5I); he made jazz arrangements of standards ranging from 17th-century madrigals to Neil Young country tunes. He wrote about love, of course, but other topics included the plague of 1665, evolution, photosystem II, spinach, and the different lifespans among biota. He collaborated with vocalists Maggie Nicols, Nance Wilson, and Veronique Bouchet, among others, in arranging and performing a diverse collection of songs and instrumental pieces. From 2016 to 2020 he published six jazz albums on Spotify, YouTube, and Apple Music. In 2020, Sid's "Alkanet Everywhere" (https://bit.ly/3BKJJqE), inspired by the profusion of *Pentaglottis sempervirens* that sprang up that year in the village of Wye where he and Helen lived, was shortlisted for the Chairman's Prize section of the United Kingdom's King Lear Prizes competition. In the last months of his life, Sid revelled at a positive review on Creative Sauce, a YouTube channel, and he enjoyed being a jazz impresario, scheduling performances at the New Flying Horse, a local pub.

Sid is survived by Helen, who is also a fellow of the Linnean Society and of the Learned Society of Wales; his son Ben; and grandsons Rowan, Brodie, and Sammy. He will be greatly missed as a much-loved and inspirational husband, father, grandfather, uncle, colleague, and mentor to the next generation of scientists.

More about his life and work can be found at https://sidthomas.net/wp/.

Highlighting Contributions and Experiences of Undergraduate Researchers at Plant Biology 2022

BY AMANDA STORM, CARINA COLLINS, and KAREN HICKS, PUI Section Steering Committee

Undergraduate research experiences (UREs) are a cornerstone of advancement in science. All plant scientists have a story about how they started their career in science, and for many that story involves a URE. These experiences not only engage and retain students in STEM fields, but also provide them with an understanding and appreciation for science that informs their decisions as educated citizens, even if they don't remain in research. UREs have also been shown to encourage members of underrepresented groups to remain in STEM fields, promoting diversity of thought in the scientific community. Because of UREs, research conducted by undergraduates contributes significantly to science and to society, especially at primarily undergraduate institutions (PUIs), where nearly all research is conducted with undergraduates.

At Plant Biology 2022, research at a PUI contributed in part or fully to at least two community concurrent talks, seven selected concurrent talks, two plenary talks, and 66 posters. The contribution is even greater at regional section conferences, which are well suited for undergraduates to present their research because of their smaller size and lower cost of attendance. The opportunity for undergraduates to present their work and compete for awards at national and regional conferences allows them to gain professional skills, network with peers and future mentors, and build their identity as scientists. We checked in with some of the PUI undergraduates who presented research at PB2022 to highlight their contribution to research and their experiences at the conference.

AUSTIN CHILES

Whitman College

Biochemistry, Biophysics, and Molecular Biology major

Research mentor: Britney Moss

PB2022 poster: Design and Development of a Novel Auxin Biosensor: ShadowAuxin

Research summary: My research focused on building a biosensor that positively reported the concentration of the plant hormone auxin using proteins encoded within DNA. The construct utilized the biophysical concept of fluorescence resonance energy transfer along with the nuclear auxin signaling pathway to indirectly measure the concentration of auxin in vivo.

Favorite conference experience: I loved the nightly poster sessions. It was so cool to mingle with presenters and see everyone's posters!

Future goals: I hope to pursue a PhD or an MD/PhD focusing on molecular biology, specifically transcriptional regulation.

KATHERINE STEGEMANN

Marian University

Biology and Chemistry double major

Research mentor: Carina Collins

PB2022 poster: Building a Molecular Model for OPS Function in *Arabidopsis thaliana:* The Relationship Between Immunity and Growth

Research summary: I worked to elucidate the function of the plant protein OCTOPUS (OPS) as it plays a role in immunity and growth in *Arabidopsis thaliana.* I focused on expression of the *ops* gene over time when treated with the immune stimulant flg22 and the growth-inducing plant hormone brassinosteroid.

Favorite conference experience: My favorite part of PB2022 was interacting with my fellow undergraduate researchers. I was able to form relationships with new people by bonding over our research and undergraduate studies.

Future goals: My future goals have been all over the place, but I have finally decided on a career in physical therapy. I am applying to doctor of physical therapy programs this fall.

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HISHAM TADFIE

Williams College

Biology major

Research mentor: Cynthia Holland

PB2022 poster: Evolution of Substrate Specificity in Plant Anthranilate Methyltransferases

Research summary: What mechanisms do plants use to regulate the flux of anthranilate between primary and specialized metabolite biosynthesis? Additionally, how might the enzymes necessary for the biosynthesis of anthranilate derivatives have evolved?

Favorite conference experience: Listening to a talk about the applications of cannabinoid metabolic engineering in microalgae.

Future goals: I plan to attend graduate school and earn a PhD in biochemistry.

JO BÙI

Kenyon College (Boyce Thompson Institute)

Biology major

Research mentor: Karen Hicks

PB2022 poster: *COP1*-Like Genes Regulate Sexual Reproduction in *Physcomitrium patens*

Research summary: I worked with a team to determine whether seasonal regulation of sexual reproduction uses the same pathways in angiosperms and bryophytes, suggesting an ancient mechanism predating land plant divergence. Using reverse genetics, we found interesting evidence for conservation and divergence of *COP1*-like genes between the model moss *Physcomitrium patens* and angiosperms.

Favorite conference experience: The party! It was fun to let loose with my research mentor and to see how great at dancing the plant science community is.

Future goals: I plan to work for 2 years at Boyce Thompson and to start graduate school in plant science.

MIRIAM LI

Williams College

Biology and Chinese double major

Research mentor: Cynthia Holland

PB2022 poster: Biochemical Investigation of Anthranilate Phosphoribosyltransferase in Plants

Research summary: Whereas humans require the essential amino acid tryptophan (Trp) from their diet, plants, fungi, and bacteria have retained the enzymes necessary to synthesize Trp de novo. Our studies characterizing one of these enzymes in the Trp biosynthesis pathway, anthranilate phosphoribosyltransferase, can allow for a greater understanding of its evolution, regulation, and specificity.

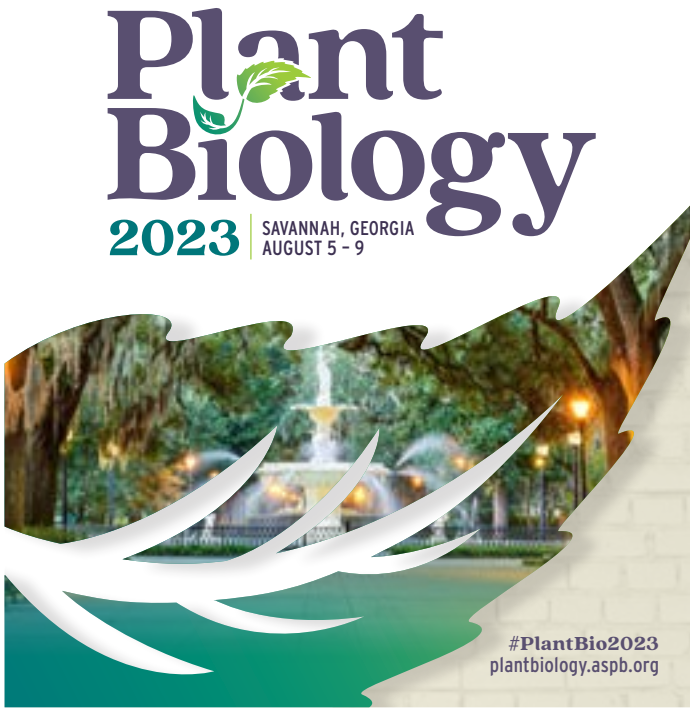
Favorite conference experience: Getting to attend different talks and hear about all the exciting research and applications!

Future goals: I plan to continue to work in and around research.

Plant Biology 2022 Workshop on Interviewing

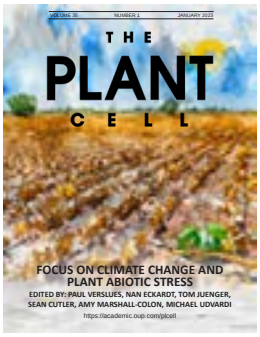
At Plant Biology 2022, ASPB's Membership Committee hosted a workshop on interviewing for undergraduate and graduate students looking for a graduate school or job. The workshop kicked off with a short talk by Kathrin Schrick of Kansas State University on the basics of interviewing. The undergraduates then arranged themselves around the room, and rotating interviewers asked them a series of questions and provided thoughtful feedback on their responses. Comments from students after the workshop indicated the workshop was a success, so the Membership Committee plans a repeat performance at Plant Biology 2023.

The interviewers preparing to descend on the interviewees.
PHOTO BY VINUSHA WICKRAMASINGHE



From ASPB Journals

January 2023 Issue of *The Plant Cell* will Feature AI-Generated Cover



The Plant Cell's January 2023 Focus Issue on Climate Change and Plant Abiotic Stress made use of a novel tool to generate a cover image. DALL-E 2 is an artificial intelligence (AI) system by OpenAI LP that creates images and art from natural-language descriptions. Users provide concepts, attributes, and styles that DALL-E 2 then uses to create unique images. Learn more about the tool at https://openai.com/dall-e-2/.

The Plant Cell Appoints New Guest Editors

Jijie Chai
Max Planck Institute for Plant Breeding Research, Cologne, Germany

Jijie is a professor in the Department of Chemistry and Institute of Biochemistry at the University of Cologne, Germany. He earned his PhD from Peking Union Medical College, Beijing, China, and was a postdoctoral fellow at Princeton University in New Jersey. He leads a structural laboratory that is mainly interested in plant RLKs/RLPs and NLR receptors, both of which have critical roles in plant innate immunity.

Mathilde Grelon
Institut Jean-Pierre Bourgin, INRAE

Mathilde is a senior scientist at the Institut Jean-Pierre Bourgin in Versailles, France.

Plant Physiology Appoints New Monitoring Editors

Clay Carter
University of Minnesota

Clay is a professor in the Department of Plant & Microbial Biology at the University of Minnesota. His major research interest is in the molecular basis of plant–biotic interactions, with a focus on the evolution, development, and biochemistry of nectaries and nectars.

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Lily Cheung
Georgia Tech School of Chemical & Biomolecular Engineering

Lily is a chemical engineer who developed a passion for plant biology during her postdoctoral work at the Carnegie Institution for Science. Her lab at Georgia Tech designs biomolecular and computational tools to quantify and model sugar transport, from the cellular to the whole-plant scale.

Qiaohong Duan
Shandong Agricultural University

Qiaohong studies the molecular mechanisms underlying fertilization events in flowering plants, particularly the Cruciferae family of vegetable plants, under normal and complex situations as encountered in nature. Her research combines physiological, molecular, genetics, and biochemical approaches. She is also interested in transforming her mechanistic findings into breeding techniques.

Alisa Huffaker
University of California, San Diego

Alisa received her PhD and completed her postdoctoral training in plant defense signaling at the Institute of Biological Chemistry at Washington State University. Her research interests center on plant peptide signals, Peps, which regulate broad spectrum plant defense responses against pathogens and herbivores, and their application to manipulate plant resistance to biotic attack.

Ana María Laxalt
Instituto de Investigaciones Biológicas (IIB) CONICET–UNMdP

Ana studies the role of lipid signaling in plant stress, with a special focus on plant defense responses, as well as the role of the different phospholipases C and D in the perception of pathogens and the induction of defense responses, including stomata movement.

Sibongile Mafu
University of Massachusetts Amherst

Sibongile completed her PhD at Iowa State University and postdoctoral training at the University of California, Davis. Her research interests focus on exploring the biochemical diversity underlying plant natural product chemistry through elucidation of the biosynthetic components involved in the formation of specialized metabolites.

Newest Teaching Tools in Plant Biology Now Available

The Floral Transition and Adaptation to a Changing Environment: From Model Species to Cereal Crops

Designed by Michela Osnato

Published with the November 2022 issue of *The Plant Cell* and freely available at https://doi.org/10.1093/plcell/koac304, this lesson "examines the gene regulatory networks underpinning the floral transition, looking first at the model plant *Arabidopsis thaliana* and then at important cereal crops. Next, it explores how plants have adapted to different regions and how the changing climate might affect flowering and thus food security."

Happening on Plantae

Plantae Webinar Series

In a new series of webinars, members of the Plantae Fellows program and select contributors will gather to discuss various important plant science–related topics that are relevant today. Take advantage of the opportunity to engage with Plantae's global plant science community. Stay updated at https://plantae.org/education/plantae-webinars.

Check Out Plantae's Job Board

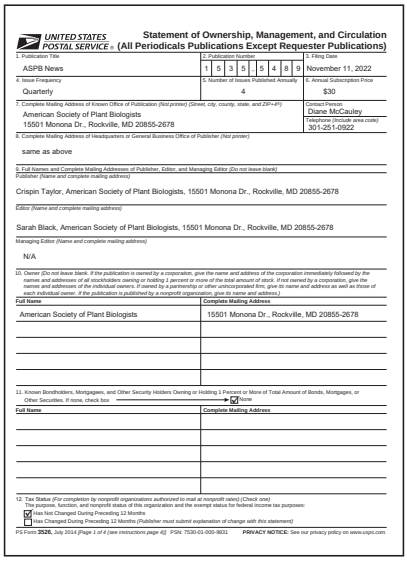
https://jobs.plantae.org/

Plantae Fellows Program

Plantae Fellows help nurture and grow the Plantae community by being highly engaged contributors who curate content and facilitate discussions. In September, the 2022 Plantae Fellows cohort held their annual planning meeting to collectively curate and map the 2023 Plantae content. Plantae Fellows will produce content with three focused themes: education, career, and community. Stay updated at https://plantae.org.

Plant Science Research Weekly

Plantae editors highlight new plant science research articles with short summaries that describe key findings and links to the full articles. Get this exciting roundup of plant science research delivered right to your inbox. Subscribe at https://plantae.org/research/wwrtw/.



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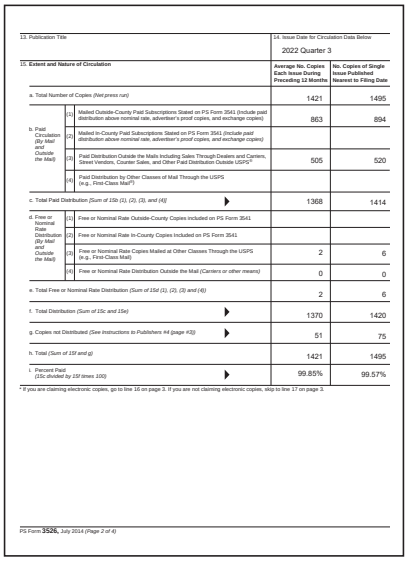

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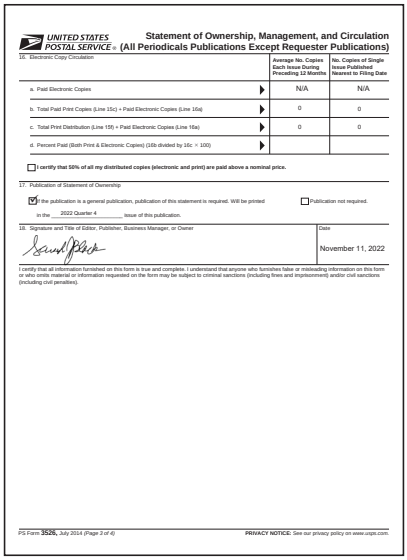

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