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How did you spend your career, and what contributions did you make to plant science?

I attended South Dakota State University with the intention of teaching high school chemistry; however, a part-time job in a USDA insect biochemistry lab piqued my interest in research (my first publications are on insect biochemistry), and my supervisor, Robert Derr, encouraged me to attend graduate school. I entered the PhD program in biochemistry at Michigan State University in 1965. I chose to focus on plants because I had a background in agriculture, and specifically plants (my parents had a greenhouse nursery business), and I decided to pursue my degree with N. Edward Tolbert in the area of photosynthesis-related metabolism. I recall another professor calling me “foolish” for going in that direction; photosynthesis had been “solved,” and Melvin Calvin had received the Nobel Prize for it, he said. Later that year, of course, C₄-PS broke on the scene, followed close behind by photorespiration (phosphoglycolate metabolism). The field of photosynthesis has never slowed down since. Lesson: follow your interests and passions, no matter what anyone says.

My doctoral research involved phosphoglycolate (and phosphoglycerate) metabolism, a pathway that involves three subcellular organelles—chloroplasts, peroxisomes, and mitochondria. My dissertation research led me to wonder how mitochondrial metabolism (respi-



ratory metabolism) was affected when a significant amount of carbon from photorespiration/glycolate metabolism passed through the mitochondria and produced reducing equivalents that normally would come from the TCA cycle metabolism. Was mitochondrial carbon metabolism curtailed, and if so, how?

This question took me to Lester Reed's lab at the University of Texas at Austin as a postdoctoral fellow. Reed had just established that the mammalian pyruvate dehydrogenase complex (PDC) is partly regulated by protein phosphorylation and dephosphorylation by a specific protein kinase and a P-protein phosphatase. The product of the PDC reaction, acetyl-CoA, provides the primary carbon entry to the TCA cycle. In Reed's lab, I characterized and purified the phosphatase responsible for reactivating the mitochondrial PDC and learned the properties of PDC and its regulation.

In 1971, I started my own research program at the University of Missouri (MU). I set out to estab-

lish whether the plant mitochondrial PDC (mtPDC) was phosphorylated (inactivated) during photosynthesis and photorespiration. Pursuing this goal would take over 40 years, with many branches along the way. In Reed's lab, we could obtain a liter of purified mitochondria from 60 pounds of liver or kidney; I quickly learned this was not so easy to do in plants—obtaining *any* purified mitochondria from *any* tissue of plants proved to be difficult. I was eventually successful by using cauliflower buds and broccoli buds as starting material; cases and cases of one or the other required many hours of shaving the buds and florets, where the mitochondria are rich in abundance. Together with Paul Rubin, we isolated and characterized the plant mtPDC (a first), and later we would establish that the plant mtPDC could undergo phosphorylation and dephosphorylation or inactivation and reactivation. This was the first plant enzyme shown to be regulated by this mechanism (although Anthony Trewavas from the University of Edinburgh had shown earlier that some plant proteins could be phosphorylated).

My lab went on to establish that the mtPDC was phosphorylated or inactivated during photosynthesis in a photorespiration (phosphoglycolate metabolism) manner. Ray Budde and my longtime collaborator Jan Miernyk were central to this work. My lab (and that of David Dennis at Queen's University in Ontario) later established that plants have a second PDC in their plastids that is not regulated by

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the phosphorylation–dephosphorylation mechanism. I had many great graduate students and postdoctoral fellows and research scientists during this time (especially Barb Giles, Nancy David, and Arin Brownlee) who facilitated this research along the way.

I count the formation of the Interdisciplinary Plant Group (IPG) at the University of Missouri as one of my contributions to plant science. The idea and shape of the IPG took hold early during my tenure at MU. It grew out of strong collaborations I had with colleagues in other departments, and we established an informal plant biochemistry and physiology interest group on campus. Don Miles, Dale Blevins, C. J. Nelson, Anton Novacky, Arthur Karr, Russell Larson, David Emerich, Joe Polacco, and Judy Wall were some of the early members. Our goal was simple: collaborating and facilitating the training of graduate students and postdocs. We met regularly to share ideas, expertise, equipment, and resources, as well as to guide graduate students in multidisciplinary approaches. We maintained an open-lab policy.

The IPG flourished when we received financial support from MU's Food for the 21st Century initiative in 1984. These funds allowed us to sponsor seminars and an annual symposium, build fundable training and research programs that funded graduate students, and enhance our core facilities. Most importantly, it allowed us to hire a contingent of fantastic plant scientists, including Thomas Guilfoyle and Gretchen

Hagen, Roy Morris, John C. Walker, Robert Sharp, and Karen Cone. I had the privilege of leading this amazing cadre of scientists for 28 years. By the time I retired as director in 2008, we had 50 plant labs in the IPG. It was a great pleasure to lead the IPG to national and international recognition. The IPG shows what is possible when you remove barriers (real and perceived) and allow science to flourish in a collaborative environment. The idea that interactions, progress, and shared facilities are more important than turf and silos is the culture now on campus at MU. It is a legacy I am exceedingly proud of.

I also count among my contributions the establishment of an international working group and symposium focused on plant protein phosphorylation and dephosphorylation. My lab's research on the protein kinase and P-protein phosphatase that regulated mtPDC revealed that the plant world was well behind the animal world in this arena. In response, John C. Walker, Steve Huber, Ray Chollet, Joe Kieber, Alice Harmon, Steve Clouse, and I submitted a triagency Research Coordination Network grant to establish a plant protein working group to share resources such as inhibitors, activators, antibodies, techniques, and information. These funds also allowed us to host a series of symposia aimed at providing a broad survey of the latest advances in the field of protein phosphorylation and to promote interactions among plant scientists around the globe. The plant protein phosphorylation working group, which

spanned 20 years, was exciting and launched many joint efforts. NSF was the primary funding source over the later years as part of their mission to support interdisciplinary and collaborative research.

From 2002 to 2014, I was privileged to serve on the National Science Board (NSB). It was an incredibly rewarding experience to review, shape, and participate in the scientific endeavor of our country at that level. I count among my career highlights the interactions I had with my fellow NSB members, visits to Antarctic's McMurdo and South Pole Stations, and front-row seats to NASA's last shuttle liftoff at Cape Canaveral. I am indebted to Christopher "Kit" Bond, former governor and senator for Missouri, who recommended me for this position to President George W. Bush. Senator Bond was also responsible for my one and only experience with tear gas, when I participated in a panel on biotechnology at the World Trade Organization along with fellow Legacy Society member Brian Larkins.

When did you become a member of ASPP/ASPB?

I became a member of ASPP as a graduate student in 1969.

How did the Society impact your career, and what motivated you to become a Founding Member of the Legacy Society?

The Society gave me the opportunity to meet and interact with fellow members across the country and internationally. These interactions

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were particularly influential in my early career. I recall attending the Society's annual meetings as a graduate student, well before I became a member. It was at these annual meetings that I had the opportunity to talk about research with leaders in the field and, more importantly, to identify myself as a member of a larger plant biology community. I felt like I was a part of something bigger.

I recall that the early annual meetings were on campuses and were small enough that a person could meet almost anyone working in plant biology. (The biochemistry [American Society for Biochemistry and Molecular Biology, Federation of American Societies for Experimental Biology] and chemical [American Chemical Society] society meetings were a lot less intimate.) Indeed, I recall giving the last talk on the last day at an ASPP meeting hosted at Cornell and presuming that no one would be left to hear my talk. Little did I know that in those days, the Society's leaders met at the end of the last day of the annual meeting. So there I was, an assistant professor, with the Society's (really, the field's) heaviest hitters in my audience, such as Martin Gibbs, Andy Benson, Joe

Varner, Bob Burris, Bob Bandurski, Israel Zelitch, Harry Beevers, and Clanton Black, along with my PhD adviser Ed Tolbert. That was one of my career "OMG!" moments that turned into a great opportunity to meet and interact with scientists who, for me, walked on water.

All these early interactions must have had a major impact on me because, as I hope I have conveyed, a major thread of my career has been facilitating collaborations and interactions and promoting science. I went on to serve the Society throughout my career, as secretary from 1991 to 1993 and chair of the Board of Trustees from 1996 to 1999 and as a member of various committees.

Being a Founding Member of the Legacy Society for me is not about paying back ASPB for all it has done for me and my career—which is a lot. It is about paying it forward. The Society is an incredible force in promoting the success of its members. This promotion comes in the form of outreach to policy and decision makers in Washington, DC, in the form of career preparation for young members, and in the form of educating the public at large about plants and their importance to our daily lives.

What important advice would you give to individuals at the start of their career in plant science?

Collaborate. Talk about your work, and learn what your colleagues both in and out of your department and discipline are doing. Find common interests with others, and share your insights and techniques. Go to seminars outside of your immediate interests to learn new techniques and advances that you can use. Volunteer to organize or chair sessions at meetings and conferences—that is, be visible, network, introduce yourself to others, and ask others about their work. Be a good listener and encourage others. The plant science world is a very collegial environment—help keep it that way! Challenge your students and postdocs to be greater than you, and allow them independence. And, of course, be an active member of ASPB and other professional organizations. These organizations are our voice for science and education, and most of all, they are a voice in DC for funding sources.