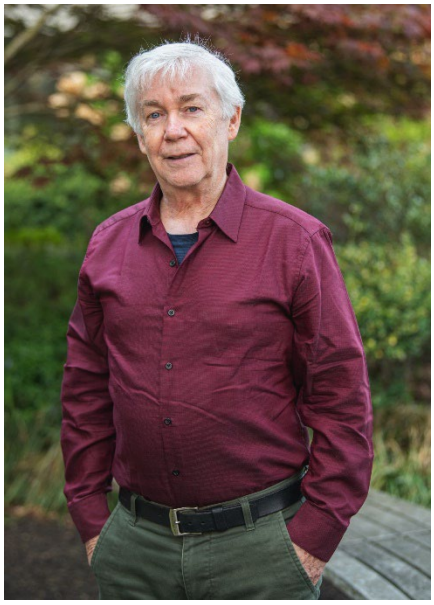
ASPB Pioneer Member

Daniel Cosgrove

How did you spend your career?

Short answer: Mostly by following my curiosity. I trace my start in plant biology to the encouragement from my mom, who loved plants, and from a set of mail-order science kits that I bought when I was ~12 years old. I paid for them with money I earned selling newspapers. A different kit arrived every month, always a surprise; one was a module on root growth and gravitropism of pumpkin seeds; I was hooked. My 'home laboratory' at the time was compact: two shelves in our crowded bathroom that held my mom's ancient light microscope (from when she was a girl), glassware, an alcohol burner, and chemical supplies. A move to another house at the start of high school let me expand my laboratory into a small room in the basement, where I dived into paper chromatography of plant pigments, built a plant growth chamber from scavenged plywood, fluorescent lights, fans and a timer, and assayed plants in different stages of flowering for their hormone contents, using bioassys. My photoperiodism project at the State's science fair contest, held in an MIT convention hall (my first solo trip to a big city) garnered a $500 scholarship that helped pay for my first set of motorized wheels in college, a 250-cc BSA motorcycle. Later that year I attended an NSF-funded summer science training program in plant biology at Purdue University. It was an eye-opener to work in a research setting with others who were also hooked on plant



biology. Fast forward through exploratory research projects as an undergraduate at the University of Oregon and University of Massachusetts to graduate school in the Biology Department at Stanford (with indelible influences from a trio of my graduate advisors Paul Green, Winslow Briggs, and Peter Ray). There, I grappled with the enigma of the rapid modulation of plant growth by light (rapid meaning within seconds). To me, all of this was fascinating and compelling. From two postdoctoral stints, one with Robert Cleland at University of Washington (growth physiology) and the other with the erstwhile team of Ernst Steudle and Ulrich Zimmerman in Germany (of pressure microprobe fame), I gained an appreciation of plant cell wall extensibility and physical approaches to cellular water transport,- both essential aspects of plant cell enlargement. The year in Germany was also a cultural awakening in many respects.

I joined the Biology Department at Penn State as an Assistant Professor in 1983, and progressed through the academic ranks, with sabbaticals in Goettingen, Germany to learn patch clamping (with Rainer Hedrich, 1989) and Berlin to learn methods of plant molecular biology (Max Planck Institute, with Thomas Altmann, 1996). I'm still at Penn State as I write these words. With long-standing support by federal funding agencies (thank you DOE, NSF, NASA), I built a research team – ever changing as is the nature of most university-based research groups – that delved deep into various facets of plant cell growth, gradually becoming more focused on bridging the gaps between molecular, physical, and physiological controls of cell wall growth. Along the way my group discovered wall-loosening proteins, eventually named expansins, which first took shape with the PhD research of Simon McQueen-Mason (you can find a brief summary in *The Plant Cell* 2022: 34: 56–58).

In 2009, I led a successful effort to form a multidisciplinary center funded by DOE's Energy Frontier Research Center Program to research the structure and assembly of plant cell walls. The center fosters collaborative research that combines physical and biological approaches to uncover how plants make cellulose microfibrils and how those microfibrils physically interact with other microfibrils and with matrix polymers to form cell walls with versatile properties. It's been gratifying to help steer efforts toward fundamental discoveries with an eye towards future innovations in the materials and energy fields.

What do you consider to be your most important contributions to plant science?

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With the commitment, hard work and inspiration of numerous students, postdocs, technicians and collaborators, my lab was key to:

- Developing new ways to understand and measure wall stress relaxation in living cells and define its central role in plant cell growth. The inspiration for this work can be traced to a brief letter to Nature in 1972 authored by my mentors Peter Ray, Paul Green, and Robert Cleland, who pointed out that appreciation of the role of stress relaxation was missing in the literature on plant growth. The letter did not address the biochemical nature of stress relaxation, which I pondered for years, eventually addressing it head-on by searching for the causative agents.

- Identifying expansin proteins as the protein catalysts of 'acid growth' and wall stress relaxation, followed by cloning of expansin genes, solving several expansin structures by X-ray crystallography (with the collaboration of Neela Yennawar), discovering additional groups of expansins in plants and in microbes, and working out some of the evolutionary history and biological roles of the expansin groups. This prolific saga continues in many labs around the globe. Yet, the detailed molecular basis of wall loosening by expansins remains an unsolved problem.

- Reopening the question of primary cell wall structure and the molecular basis for wall expansive growth. This issue is still in flux today, but a satisfying answer requires a quantitative physical model to connect cell wall organization at the nanoscale with cell wall mechanical properties. In 2021, we published such a model in Science; it explains the structural bases of wall elasticity and plasticity, but wall creep induced by expansins is not yet part of this model.

When did you become a member of ASPP/ASPB?

I attended my first ASPP meeting in 1978 (Blacksburg, Virginia) as a graduate student and likely joined that year. The format of the meeting in those days was a demanding series of short talks (15 min), mostly given by students. It was a mind-numbing format, but the exposure for students could be really helpful, potentially leading to follow-up discussions and seminar invitations, as happened to me. Two decades later, the meeting format was very different, the Society of plant physiologists voted to call themselves plant biologists; I served as President when ASPP transitioned to ASPB; perhaps the many 'Vote ASPB' buttons I handed out at the summer meeting made a difference in the membership vote?

How did the Society impact your career and what was your motivation for becoming a Founding Member of the Legacy Society?

In the first half of my career, ASPP was my scientific 'home' in the wide world of science. It fostered the friendly community and scientific meetings of scientists interested in the physiology and development of plants, and of course was the publisher of one of the premier journals in the field. ASPP meetings were important for networking, as there were far fewer meetings in those years, which predated web-based networking and the proliferation of the more specialized meetings we see today. ASPP was also a leading advocate for research funding and for public issues related to plant physiology. I joined the ASPB Legacy Society as a means of supporting the organization that has fostered the science of plant biology – which is more important than ever for the ecology of our planet and for the wellbeing of human societies today.

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

The ancient Greek adage 'know thyself' comes to mind. Know where your talents lie and build your career on those talents, but realize that talents and interests evolve like friendships; some stay for life, others wax and wane as circumstances change. Take such changes in stride as the normal course of life. Seek ways to extend your research, for instance by incorporating new approaches, by building collaborations with scientists with different backgrounds and outlooks, by identifying new questions related to your research, or new ways to see your research by connecting your research to broader contexts, by finding ways to foster your creativity (and that of those around you) and by feeding your enthusiasm for learning. Remember too that science is a social enterprise, and it needs your support. When the time comes, serve by agreeing to review manuscripts and grant proposals, by working on

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science panels that need your perspective, by encouraging other scientists and students with words of appreciation, by seeking opportunities to explain to the public how science (even your work!) contributes to making the world a better place. And remember to enjoy your journey.