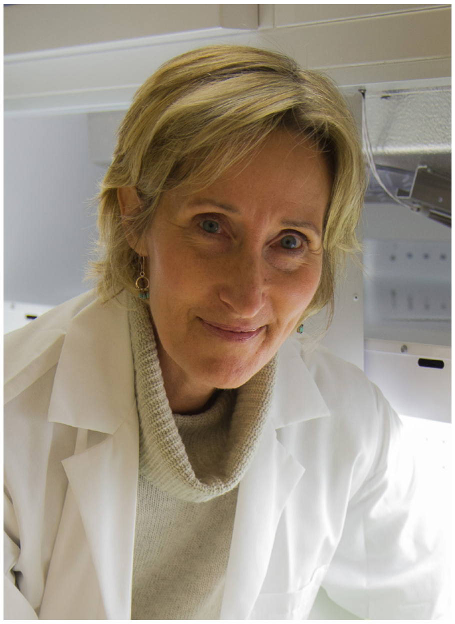
Sally A. Mackenzie

How did you spend your career?

Following graduate and postdoctoral training, I initiated my career at Purdue University as an assistant professor in the Department of Agronomy. I came up through the promotional ranks at Purdue from 1988 to 1997, conducting research and teaching undergraduate-level Introduction to Genetics.

My research at Purdue focused primarily on the question of whether plants can regulate DNA recombination of their mitochondrial genomes in response to environmental cues. The mitochondrion is the cellular site of respiration and carries out numerous metabolic functions for the plant. But mitochondrial perturbation has also been found to be associated with a plant's transition from male fertility to male sterility. Plants are unusual in the recombinogenic nature of their mitochondrial genomes, and we demonstrated that a single nuclear gene can be sufficient to alter mitochondrial genome recombination, triggering changes in the fertility–sterility transition like an on–off switch. We worked with *Phaseolus vulgaris,* the common bean, and we focused on understanding the nature of this mitochondrial recombination activity and its link to environmental cues for self-pollination and out-crossing behaviors. Perhaps most important to my success in transitioning to Purdue was the wonderful mentorship of Niels Nielsen. Having a senior male mentor who was able to push me, test my thinking, and champion my cause was a very significant part of developing confidence in my path.



In 1999, my lab group moved to the University of Nebraska–Lincoln (UNL), where I served as founding director for the Center for Plant Science Innovation, an interdepartmental program designed to enhance UNL's research environment in fundamental plant science. The move provided the impetus to redirect my own research efforts toward identifying and cloning the nuclear gene that controls mitochondrial recombination activity in response to the environment. At that time, positional cloning was the technology of the day, and we moved to *Arabidopsis thaliana* as a model. In 2003, we reported the target gene, designated MSH1, and showed that it interacted with the mitochondrial genome to suppress illegitimate recombination. This discovery allowed us to map all of the recombinationally active repeated sequences within the Arabidopsis mitochondrial genome and also permitted us to investigate mitochondrial genome evolution across Arabidopsis ecotypes and demonstrate that MSH1 likely operates in natural populations.

During these studies, we discovered that MSH1 operates not only in the mitochondrion but also in a specialized plastid in the epidermis, vascular parenchyma, meristem, and reproductive tissues. This finding was important because it showed that multitargeted proteins can possess different properties in different cellular sites. In this case, MSH1 controlled DNA recombination in the mitochondrion but also functioned to control epigenomic stability from the plastid context. Epigenetic reprogramming in plants involves changes in nuclear DNA methylation patterns, small RNA expression, nucleosome spacing, and gene expression. Depletion of MSH1 from the plastid leads to epigenomic reprogramming and phenotypic plasticity in a msh1 mutant and to heritable epigenetic memory in its offspring. The msh1 effect can influence grafting outcomes when msh1 is a rootstock and crossing outcomes when msh1 memory comes from the female or male in a cross. In either case, the outcomes are heritable: enhanced plant fitness, vigor, and yield. These remarkable observations led to the founding of EpiCrop Technologies, a small startup company that investigates the commercial potential of epigenetic breeding for crop improvement and resilience.

In 2017, the Mackenzie lab moved to The Pennsylvania State

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University (PSU). This move allowed us to pursue two exciting research tracks. The first uses computational biology to develop a DNA methylation analysis platform that permits the integration of whole-genome DNA methylation and gene expression data in a range of organisms. The second effort is to investigate the ecological value of epigenetics in plants and its potential for conservation breeding of enhanced environmental resilience. At PSU, I serve as founding director for the Plant Institute, which represents several aspects of the plant sciences, from agricultural to ecological to fundamental and computational.

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

Many of the most exciting discoveries in a career are serendipitous. So it was with our discovery of a sensory plastid in plants. This plastid harbors proteins that, when perturbed, influence epigenomic reprogramming and phenotypic plasticity. This unusual and unexpected finding has important agricultural and ecological potential. The implications of such a system, and its ability to produce heritable memory, are important to understanding adaptation, accelerated evolution, and plant–environment response mechanisms.

When did you become a member of ASPP/ASPB?

I trained as a graduate student under the direction of a plant breeder and a plant pathologist, so I was not really exposed to ASPB until after I took my first faculty position at Purdue. I did not become active in ASPB until my lab's move to Nebraska, when I was asked to join the Publications Committee. This opportunity opened my eyes to the value and satisfaction found in service to the plant science community.

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

ASPB gave me the opportunity to serve my community, and I have found this to be a rewarding and valuable experience. I have met wonderful scientists working in very different fields, and I have had the opportunity to participate in community efforts to support the quality of our journals, raise visibility of plant science research to congressional leaders, participate in national efforts to establish and disseminate priorities for plant research to federal agencies and companies, and serve as ASPB president, a tremendous and unexpected honor. For every small way I have served ASPB, I have received a far greater return in friendships, science, and gratification.

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

I think professional development is a bit tougher now than when I started my career. But perhaps the lessons I have learned still apply. The first advice I would offer is to never become complacent in the skill set you start with; the most important science is often where you are least comfortable and pushing your boundaries. The second is to seek out collaborations early and often; it simply is not possible to know the full breadth of what you need. And the third is advice for women in science: in my experience, having raised two terrific daughters, a career in science can be tough for those who wish to have a full family life. Therefore, be strategic, plan and time transitions in your career carefully, and incorporate computation, communication, business, and applied research skills into your portfolio. These skills enhance your career versatility and allow you to adjust your career goals as your life changes, opening the door to success in administration, entrepreneurship, unanticipated job moves, and self-reinvention.

Academic Family Tree

https://academictree.org/plantbio/peopleinfo.php?pid=649152