

## COMMENTARY

# The Plant Science Decadal Vision

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The enormous challenges to 21st century societies that include rapidly rising global population, ensuring food security, the need for increased food production in the face of changing climates with lower agricultural inputs, guaranteeing adequate nutrition to reduce the global burden of chronic disease, and the escalating need for energy produced from renewable feedstocks, have been viewed as providing an unprecedented opportunity for raising the profile of plant science research. To be sure, plant science can contribute to addressing these grand challenges in innovative and sustainable ways. However, there is a danger that accompanies such an opportunity: that the plant science research community, long starved of adequate investment, acts without the appropriate prioritization of research for solutions that are not only scientifically feasible but also technologically implementable, beneficial for society, and truly sustainable. For this reason, the report that has come out of the American Plant Science Research Summit (Plant Science Research Summit, 2013) is particularly welcome. Focus and direction of the research to be undertaken to solve the world's biggest and most urgent long-term problems must be paramount. The likely consequences for plant science, if it fails to deliver, are that it will lose the support of society and funding agencies. To put it another way, with increased investment comes greatly increased responsibilities, which require community oversight and prioritization.

The Plant Science Decadal Vision has fleshed out the ideas raised in 2009 by the National Academies (National Research Council, 2009) on food, energy, environment, and health to propose five specific goals for shaping research on plants in the decade 2015 to 2025:

- 1) Increase the ability to predict plant traits from plant genomes in diverse environments
- 2) Assemble plant traits in different ways to solve problems
- 3) Discover, catalog, and utilize plant-derived chemicals
- 4) Enhance the ability to find answers in a torrent of data
- 5) Create a T-training environment for plant science doctoral students

What is proposed in the Decadal Vision will undoubtedly reinforce the already strong research themes in the United States, but the strategic efforts needed to address the grand challenges for society demand a broadening of these research themes. It is time for plant science to shed the view that molecular genetics, genomics, and cell biology are paramount approaches to understanding and improving agriculture and instead to emphasize the importance of translating the enormous advances we have made in plant biology into solutions for society. As an individual, Norman Borlaug contributed more than any other to ensuring food security, although without the benefits of molecular genetics, genomics, and cell biology. Imagine what we could achieve collectively using all the tools these disciplines now provide but with our focus, like Borlaug's, on crop improvement. Although the Decadal Vision makes a call to empower multidisciplinary teams to identify and introduce desired traits into crops, the real need is to encourage breeders, agronomists, and whole-plant physiologists to work much more closely with those researching plant genetics, genomics, and cell biology to define the most important traits, to develop feasible strategies for crop improvement, and to implement these despite the many limitations that applications impose. The Decadal Vision calls for greater recruitment of bioinformaticians and modelers to plant research. This will allow more

rapid progress in the design of improved traits for crops, but the input of physiologists must be retained, particularly whole-plant physiologists and ecophysiologists, to ensure that the traits are as robust in the field as they are in the laboratory or greenhouse. Training a generation to analyze databases will not compensate for the generation of plant breeders we are losing to retirement.

The promotion of plant chemistry by the Decadal Vision is very welcome, given that plant biochemistry has, in the recent past, been of rather low priority. The enormous, under-developed resource of plants for bio-prospecting for medicinal compounds is highlighted, although the vision is restricted to potential pharmaceutical applications with little consideration of the accompanying problems of biopiracy and the need to engage medical and pharmaceutical research fields in the assessment of phytochemicals. It is unclear from where the authors of the Decadal Vision believe the expertise for high-throughput assays of the mechanisms of action of therapeutic phytochemicals will be recruited. The Decadal Vision could, and in my opinion should, have given greater emphasis to the importance of plants and phytochemicals in foods. Chronic disease is the unacknowledged grand challenge of the 21st century and is being fueled by declining nutritional quality of diets and the obesity epidemic. In my view, a serious shortcoming of the Decadal Vision is the lack of emphasis on nutritional improvement of food crops or any mention of promoting consumption of diets rich in fruit and vegetables.

The proposals in the Decadal Vision for a reimagining of graduate training are important in a national context. It is astonishing to a non-U.S. reader that the median time for completing a PhD in Life Sciences in the United States is nearly 7 years. The measures proposed in the Decadal Vision include adding horizontal skills, international training,

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more frequent industrial placements, and enhanced communication with scientists in other disciplines, policy makers, and the general public. These measures will undoubtedly improve the attractiveness of graduate programs, although I doubt whether seamless 7-year bachelor–doctoral programs will improve diversity because these would require far earlier commitment and specialization than at present. The most urgent need must be to reduce the time for a PhD to a maximum of 4 years, as is standard across Europe, so that graduates feel that alternative careers are possible even after completion of a PhD. Emphasis within doctoral programs on general life skills such as how to design an informative test/experiment, how to interpret data critically, where to find the answers to specific questions, and, particularly important, how to self-motivate, would mean that a PhD in plant science could be viewed as valuable training for a diversity of careers, not just scientific teaching or research positions.

Although we face global challenges, much of our research is funded by individual countries or groups of countries. Although the United States has been a leader in agricultural research, the rapid increases in funding and progress in other countries give the opportunity for greater international coordination. Of the research published in *The Plant Cell*, 70% comes from researchers outside the United States, and 30% of the ASPB membership resides outside of the United States. Clearly, a Decadal Vision from the perspective of the United States needs to address both national and international objectives. The Decadal Vision statement lays out a framework for the United States that could be strengthened by greater emphasis on international collaborations. Those that drafted the Decadal Vision might consider, in collaboration with international leaders in plant science, stakeholders, and representatives of the public, especially from those countries that will be impacted most by the challenges of food security and climate change,

building a broader vision to propose global priorities, perhaps through the stewardship of the Global Plant Council. The milestones proposed in the Decadal Vision will support and accelerate progress in the most promising areas of plant biology currently in the United States. However, what is needed is further consideration of how these coordinated efforts will be integrated with research on plants, agricultural improvement, and innovation globally. This expanded vision, built on consensus from all the key stakeholders, will be essential for successful implementation of measures arising from research on plants to address the grand challenges facing all societies.

## REFERENCES

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