American Society of Plant Biologists
Cultivating a better future through plant biology research

December 6, 2011

Building a 21st Century Bioeconomy

The American Society of Plant Biologists (ASPB) is pleased to submit this statement to the Office of Science and Technology Policy in response to its *Request for Information: Building a 21st Century Bioeconomy*. ASPB is an organization of 5,000 professional plant biology researchers, educators, graduate students, and postdoctoral scientists with members in all 50 states. Our mission is to promote the growth and development of plant biology, encourage and communicate research in plant biology, and promote the interests and growth of plant scientists.

Plant biology research is an integral part of the foundation upon which the bioeconomy builds its success. In fact, plant biology research makes numerous fundamental and applied contributions in the areas of domestic fuel security and environmental stewardship; continued and sustainable development of better foods, fabrics, pharmaceuticals, and building materials; and the understanding of basic biological principles that underpin improvements in the health and nutrition of all Americans.

Understanding the importance of these areas and in order to address future challenges, ASPB recently organized the Plant Science Research Summit. With funding from the National Science Foundation (NSF), U.S. Department of Agriculture (USDA), Department of Energy (DOE), and the Howard Hughes Medical Institute, the Summit brought together representatives from across the full spectrum of plant science research to identify critical gaps in our understanding of plant biology that must be filled over the next ten years or more in order to address the grand challenges facing our nation and the planet. It is our hope that the findings from the Summit and other similar events will be taken into consideration when expanding the vision for building the bioeconomy.

Grand Challenges

Despite the fact that foundational plant biology research—the kind of research funded by agencies like NSF, USDA, DOE, and National Institutes of Health (NIH)—underpins vital advances in practical applications in agriculture, health, energy, and the environment, the amount of money invested in understanding the basic function and mechanisms of plants is relatively small. This is especially true when compared with the significant positive impact crop plants have on the nation's economy and in addressing some of our most urgent challenges like food and energy security. Both individual investigator/small group research programs and interdisciplinary integrated research projects are needed to meet these priorities. The Plant Science Research Summit began to detail those grand challenges, including:

(1) doubling crop yield by 2050 with fewer agricultural inputs through advances in molecular plant breeding and biotechnology that harness the power of integrating genomic and phenomic data to advance predictive modeling;
(2) sequencing 1000 plant genomes to better understand plant diversity in addition to revealing novel pathways leading to useful plant compounds, structures, and enhanced nutrition;

(3) advancing genetic engineering with the goal of producing designer plants that develop specialty storage organs as bioreactors for valuable products to aid in harvest and purification of biofuels, medicinal products, and a variety of other agricultural products;
(4) creating an environmentally and economically sustainable United States agricultural system based on a thorough understanding of ecosystem function.

In early 2012, a report from the Plant Science Research Summit will be published. This report will further detail priorities and needs to address the grand challenges that will directly affect the success of the bioeconomy.

Research and Development

The *21st Century Bioeconomy Blueprint* needs to significantly enhance ongoing research and development activities as key drivers of the bioeconomy, job creation, and U.S. industrial and agronomic competitiveness. A range of research programs and initiatives must be pursued, including the foundational research that underpins future technological advances, high-risk research typically bypassed by industry, the applied work that seeks solutions to the country's most pressing challenges, and the initiatives which bring together teams of top investigators to work on problems at the nexus of disciplines. The full potential of the bioeconomy will only be realized through this type of comprehensive approach.

Specifically, programs like USDA's Agriculture and Food Research Initiative (AFRI) and Agricultural Research Service (ARS), DOE's Biological and Environmental Research (BER) and Basic Energy Sciences (BES) programs, and NSF's Plant Genome Research Program (PGRP) allow plant scientists and their collaborators to pursue new discoveries that will lead to an increased food supply, cleaner and more abundant sources of energy, and healthier people across the globe. These programs also form the foundation for industries that drive the nation's economic growth and ensure that the United States remains a global leader in technological innovation.

ASPB encourages due consideration for interdisciplinary research in the *Bioeconomy Blueprint*, as work at the intersection of plant biology and other scientific disciplines lies at the heart of our ability to make game-changing advances in areas of national importance. For example, plant biology is at the center of numerous scientific breakthroughs in the increasingly interdisciplinary world of alternative energy research. Interfaces among plant biology, engineering, chemistry, and physics represent critical frontiers in both basic biofuels research and bioenergy production.

Similarly, with the increase in plant genome sequencing and functional genomics, the integration of plant biology and computer science is essential to our understanding of complex biological systems ranging from single cells to entire ecosystems. Dealing with the "data deluge" is now a universal theme in all of biology. Innovative methods to dramatically compress large data sets and create better interfaces for the retrieval of standardized data through plain-language queries are necessary to maximize usage of the existing data. In addition to improvements in extracting valuable data from the large volumes available, progress needs to be made in connecting the vast amount of gene sequence and expression information to gene function. While it is unlikely in the near future to create a high-throughput system for characterizing individual gene function, further support for the foundational research that has provided a majority of the functional data currently available would continue to build on the existing groundwork. Additionally, the establishment of medium-throughput facilities staffed with a tiered workforce with a range of educational backgrounds to tackle the increasingly challenging functional characterization of gene products would also begin to address this need.

Moving Life Sciences Breakthroughs from Lab to Market

Although fundamental research is the first stage of the nation's bioeconomy, it is essential that policies are established that encourage the transition of laboratory research to the commercial marketplace. Because plant biology plays a key role underpinning the agriculture, energy, and life science industries, ASPB supports mechanisms to ensure the transition of cutting-edge research to the marketplace to fuel economic growth. However, there are significant barriers to bridging the gap between the many promising potential products that emerge from foundational research and their translation into products with tangible societal benefits. For example, if publishing high-profile papers continues to be the measuring stick for success in academic research, translational research will always be of lower priority. Furthermore, moving research to the market place is a time-consuming and nuanced process. While all research may not be directly translated from bench to marketplace, it is important to remember that the incremental advances that arise from foundational research may lead to large conceptual advances that one day will make the leap to the marketplace.

As such, the *Bioeconomy Blueprint* should encourage the development of highly visible mechanisms for the funding of translational research, additional incentives for translational research in academia, and public-private partnerships to bridge the gap between fundamental research and product development. Additional federal support for translational research would provide a pathway to market for promising ideas which otherwise may never leave the lab.

The federal government is and should continue to be an economic catalyst by supporting the high-risk, high-reward research that offers potentially groundbreaking solutions, but is too novel to attract private support. As DOE's Advanced Research Projects Agency-Energy (ARPA-E) has proven, federal support for high-risk proposals can move potentially transformative ideas to a place where they can attract significant private support. Providing additional funding for high-risk proposals to transition research to a point at which it can generate interest from industry, venture capital, or angel investors would be a significant boon to growing the U.S. bioeconomy.

Workforce Development

Current estimates predict a shortfall in the needed scientific and engineering workforce as the demographics of the U.S. workforce continue to change. For example, there is a clear need for additional scientists in the areas of interdisciplinary energy research and plant breeding. ASPB applauds the creation of programs like the USDA National Institute of Food and Agriculture's Fellows program to address this problem. However, given the expected need for additional scientists and engineers who are well-grounded in agricultural research and development activities, ASPB calls for targeted funding of specific programs such as training grants and fellowships. One example is the Integrative Graduate Education and Research Traineeship (IGERT) program at NSF. IGERT successfully fosters the development of novel programs that provide multidisciplinary graduate training. ASPB encourages expansion of the IGERT program and the development of analogous programs at other agencies to train a greater number of innovative science leaders for the future.

ASPB further urges the expansion of NSF's fellowship and career development programs, such as the Postdoctoral Research Fellowships in Biology, the Graduate Research Fellowship (GRF) and the Faculty Early Career Development (CAREER) programs. Such an expansion would provide greater continuity in funding opportunities for the country's most promising early-career scientists. Additionally, such continuity and broader availability of prestigious and well-supported fellowships

may help retain underrepresented groups in the science, technology, engineering, and mathematics (STEM) fields.

In addition to expanded fellowship opportunities, ASPB encourages a revolution in academic training of graduates and undergraduates. Many academic programs currently train graduate students to ultimately become tenure-track faculty members. However, only about a quarter of these graduates will eventually achieve this goal. It is important to focus a portion of the training efforts on translating research into application and inviting students to discover how the private sector operates. A reduced emphasis on coursework may allow more time for student opportunities to explore industry as well as other "alternative" careers in science. For undergraduate education, a shift in focus from simply learning the facts to conceptualizing and exploring the process of science in a student centered environment, along the lines of the NSF's and the American Association for the Advancement of Science's *Vision and Change* project, is needed. These types of alterations in the current training system will produce a better-rounded workforce able to adjust to the ever-advancing atmosphere of the life-sciences.

The foundation for encouraging successful entrepreneurship also lies in education. Curricula should be restructured to be more multidisciplinary in nature and include a blend of science with business. Furthermore, risk taking needs to be embraced in academia. Many feel that a substantial portion of the work in a grant proposal must have already been completed to be assured an award. This creates a cycle where more and more of the available funding is awarded to established faculty continuing to work on informative, yet relatively low-risk research. To encourage entrepreneurship and high-risk research in early career scientists, greater incentives must be instated. Programs like NSF's CREATIV and several of NIH's Common Fund programs represent a much needed step in this direction, yet additional funding opportunities of this nature must be established in the agencies that typically fund research for agriculture and other fundamental research in plant biology.

ASPB also urges the further development of programs aimed at increasing the diversity of the scientific workforce by leveraging professional scientific societies' commitment to providing a professional home for scientists throughout their education and careers and to help promote and sustain broad participation in the sciences.

Reducing Regulatory Barriers to the Bioeconomy

ASPB recognizes the need for common-sense regulatory policies that protect both the producer and the consumer. Regulations should ensure that technology is developed responsibly; they should not smother innovation. Current regulatory cost estimates for releasing a genetically engineered (GE) crop onto the market are on the order of $30 million, even as many investigations into the safety of GE crops have shown no adverse effects. In fact, some GE crops have diminished the environmental burden of agriculture by reducing the need for agricultural inputs. Recent advances in agricultural technology hold the potential to provide nutritious food for millions more people worldwide and provide significant environmental benefits. However, current incentives in industry are focused on "input" traits that are of economic benefit to the producers, rather than "output" traits, such as improved nutritional qualities, that are of interest and value to consumers. Thus, the economic regulatory burden cannot be shouldered alone by academic labs with an interest in improving traits that benefit society. Regulatory reform that encourages innovation while addressing realistic safety issues and economic incentives should be a top priority of the *Bioeconomy Blueprint*, as regulations informed by sound science have an important role in protecting and incentivizing all involved.

Regulations also must remain flexible and keep pace with rapidly occurring technological advances. For example, researchers now can manipulate a plant's individual genes to enhance agriculturally important traits, akin to trait improvement through traditional plant breeding. Yet the regulatory measures for simply altering an endogenous plant gene are equivalent to those governing the introduction of completely foreign genetic material. A tiered system of regulations could be introduced dependent on the level of risk to the environment and consumers.

Although regulations are a necessary component of the innovation ecosystem, the *Bioeconomy Blueprint* should outline regulatory goals that do not inhibit future innovation. A key element of this is not layering new regulations upon old ones to the point at which rules become confused or overly restrictive. Simply put, regulations are important in creating an atmosphere which benefits both consumers and producers, but they should not be so cumbersome they stunt future economic growth.

Conclusion

Basic research is vital to underpinning, maintaining, and growing the nation's bioeconomy. Moreover, plant biology research forms the foundation for numerous technology developments that Americans utilize and benefit from every day. Given the current economic environment, it is more important than ever to support scientific research that will facilitate revolutionary breakthroughs in producing nutritious foods, providing sustainable energy, developing new medicines, and protecting our environment, as research in these areas will spur economic growth and job creation. We thank you for your attention and we stand ready to offer continued support for this urgent and compelling vision for the future.