

2009

National Workshop on the Future of Education in Plant Pathology and Related Disciplines



Presented by APS in cooperation with NSF, USDA-CSREES and USDA-ARS

March 19-20, 2009 / Crystal City Doubletree Hotel / Arlington, VA

Workshop Final Report

Introduction to the Workshop

Within the United States, a network of Land Grant universities with agricultural experiment station and cooperative extension units, together with USDA-ARS research centers and private sector companies have been the backbone upon which knowledge of plant science and crop protection and productivity has been discovered and translated into common usage. This network also is an increasingly vital element in our nation's efforts to ensure agricultural biosecurity. Through much of the 20th century, this network of state, Federal, and private-sector researchers and educators has had profoundly beneficial effects on the nation's agricultural productivity.

An inescapable truth is that the ability of these organizations to successfully carry out their vital agricultural missions has been enabled over the decades by the success of agricultural colleges and universities in educating a steady stream of students who, upon graduation, possess a strong yet broad knowledge within the plant sciences and the ability to apply that knowledge to ever-changing challenges. However, the historic strength of this vital "feeder system" is at risk and, some argue, already faltering. This was evidenced through recent surveys of APS members who stated concerns such as:

- [There is a] *"lack of applied training of graduate students in ALL core areas of plant pathology;"*
- [There is a] *"lack of skilled and broadly trained plant problem diagnosticians;"*
- *"there is an obvious decline in the number of graduate students receiving adequate (if any) exposure to real-world plant disease situations;"*
- [There is a need to] *"train applied plant pathologists so industry and extension have future candidates;"*
- [We see] *"declining student numbers and interest in plant pathology" and*
- *"The loss of faculty with broad expertise and experience in plant pathology is beginning to impact graduate student opportunities."*

While the American Phytopathological Society has become acutely aware of these concerns, our interactions with other plant science-related disciplines have made us aware of the fact that we are not alone. Similar concerns have appeared in print from the Crop Science Society of America, the Soil Science Society of America and the nation's plant breeders. Indeed, in a recent (November 5-7, 2008) meeting of the American Association of Agricultural Scientific Societies, which represents approximately 50,000 scientists from academia, government and industry, "education concerns" was listed among the five priorities for focused attention.

The issues that appear to resonate across these diverse disciplines include (a) declining numbers of qualified applicants for graduate school (which is seen as a problem in the undergraduate “pipeline” of students interested in plant science), (b) declining numbers of faculty with applied- or field-research interests, (c) grant programs that are perceived to favor basic biology over applied research, thereby directing faculty research and narrowing the opportunities for student support and training. These factors have combined to alter the face of graduate education so that it does not possess the “balance” or breadth of training it once had. Concern amongst academic, government and private sector employers has increased accordingly.

The challenges facing education in the agricultural sciences are not limited to graduate education and training. We also face difficulties related to the poor understanding of science amongst the general public, declining performance and interest in the STEM (science, technology, engineering and math) disciplines in the K-12 system, and correspondingly smaller numbers of undergraduate students prepared for or attracted to the agricultural sciences. These issues deserve serious attention by the nation’s Land Grant colleges and universities.

Workshop Description

APS organized this workshop to bring together educators, government leaders, employers, students, and representatives of several professional societies to address critical issues facing education in plant pathology and the larger plant sciences. Specifically, the workshop sought to (1) Bring together information regarding the current and projected status of plant science related disciplines in the US, (2) Identify strategies for strengthening identified vulnerabilities in education and research training opportunities, and (3) Develop action plans for working together to carry out the proposed strategies.

The workshop had approximately 60 invited participants. Among the participants were educators from 1862 and 1890 Land Grant universities, representatives of the American Phytopathological Society, the American Society of Agronomy, the Entomological Society of America, the Botanical Society of America, the American Society of Plant Biologists, the American Society of Horticultural Science, the Soil Science Society of America, the Weed Science Society of America, and the Society of Nematologists. In addition, leaders of Federal agencies (ARS, CSREES, APHIS, the US Forest Service, and NSF) and the private sector (Monsanto, Syngenta, Pioneer Hi-Bred International, Bayer CropScience, AgDia, LABServices, and the National Alliance of Independent Crop Consultants) also participated. Finally, through a competitive process, we identified and invited six APS Education Fellows: three graduate student Fellows and three early career Fellows to provide perspectives on recent graduate education experiences.

The meeting was a 1 ½ day event that consisted of a mix of presentations to frame a topic, followed by breakout sessions to discuss the topic. The agenda and speakers are shown below.

Workshop Program

March 18:

5:00-6:30 PM. Registration and welcome social (Social sponsored by Bayer CropScience, LABServices, NIACC, Monsanto, Pioneer Hi-Bred, Syngenta, and AgDia)

March 19:

Welcome from APS (**Jim Moyer**, President)

Review of workshop goals (**Jacque Fletcher**, Chair, APS Public Policy Board)

Session I: Comparing notes: The future of education in plant science-related disciplines.

Educational challenges facing plant pathology (Jim MacDonald, Professor and Exec. Assoc. Dean, University of California, Davis)

Dr. MacDonald described some of the data obtained in a survey of graduate students, graduate program heads, and employers. The results indicated that employers highly value a broad education and adaptability in employees; that many students desire a broad education with diverse experiences; and that many graduate programs feel increasingly challenged in their ability to offer the kinds of classes or experiences needed for a broad education. Two challenges stood out; one is a heavy reliance on grant funds to support students, which can limit student time and experiences to the objectives of a particular grant, and a second is faculty loss through retirements of individuals with field research interests and a concomitant difficulty in recruiting replacements with similar interests due to budget cuts or limited applicant pools. As a result, only small percentages of private-, government- and university-sector employers expressed high levels of confidence that five years from now they would be able to recruit individuals with the desired breadth of education. On university campuses, undergraduate enrollments are important factors in the allocation of faculty positions and the relatively low enrollments in plant science majors (indeed, in many majors related to the agricultural sciences) leave departments in a tough competitive position as positions are lost through retirement. Smaller numbers of students exposed to the plant sciences also limits the potential pool of graduate students.

Agronomy 101: Learning in the second century of ASA (Ken Moore, President, Agronomy Society of America and Professor, Iowa State University)

Dr. Moore noted that Agronomy is similar to ecology in that it is integrative science focused on managed systems. As a professional society, the Agronomy Society of America focuses on the education of practicing professionals and Certified Crop Consultants. However, even though there are good career opportunities, the enrollments in traditional Agronomy B.S. programs are declining. At Iowa State University, they created a web site called "I'm an Agronomist" that is intended to aid undergraduate and graduate student recruitment. Because agronomy is both a science and a profession, Iowa State has initiated a professional M.S. degree program that is both relevant to the needs of industry and available to students from off campus. This is to make the curriculum available to working professionals. As a result, the Agronomy Department has seen an increase in the number of students pursuing a Masters degree, with 2/3 of M.S. candidates in the professional M.S. Agronomy Program. To address the poor exposure of K-12 students to science in general, and plant science in particular, the ASA has become a

participant in the “PlantingScience” initiative of the Botanical Society of America. Dr. Moore has participated as a mentor in this program. He found that it took only a few hours of his time and it was a very enjoyable experience.

Issues, visions, and commitments for education in soil science (Mary Collins, Past President, SSSA and Professor, University of Florida)

Dr. Collins indicated that she had been involved in a study led by the National Academy of Sciences—National Committee for Soil Science that investigated trends in undergraduate education in soil science. They found that soil science is simply not on the radar screen of high school students, or their parents and its association with agriculture is a barrier. In addition, departments often are split between serving agricultural and environmental interests, leading to a confusing variety of department and major names in use around the country. There is a need to update the courses and/or curriculum to better attract students. Because students don’t hear of soil science in high school, they often do not become aware of it until they are in college, and often well along in another major which makes transfer problematic. The parents of students often want them to be in a pre-professional program (e.g., pre-vet, pre-med) and that is a tough barrier to overcome. Strategies to overcome these hurdles include development of programs for middle and high schools, making career opportunities better known, engagement in general education courses to catch students early in their educational career, and make sure that the best, most engaging teachers teach the courses.

Opportunities in education in Entomology Departments (Ernest Delfosse, Vice President-Elect, ESA and Professor, Michigan State University)

Dr. Delfosse described a strategic planning exercise undertaken by the “Council of Entomology Department Administrators” (CEDA), which is an affiliate of the Entomological Society of America. He noted that entomology graduate programs now seem to appeal mostly to international students and that many domestic students have a poorer science education out of high school than students of 30 years ago, so one initiative of CEDA is to work to enhance science literacy in the general population. Because insects are animals that can stir strong emotions in people, they could be useful vehicles in life science education. There is interest in developing appropriate curricula and working toward long-term reform of science education. At the university level, there is a sense that there has been a push to recruit faculty who work below the organismal level, and that this has had negative impacts on entomology’s traditional Land Grant mission and work in biodiversity. As a result, student recruitment is becoming difficult because there are fewer faculty members working in the areas of pest management and biodiversity, where almost 90% of graduate student applicants would like to work. A key challenge to departments is to attract faculty members who can apply and teach modern molecular biology to address pressing practical issues (translational research). Another challenge is to develop a mastery of the various elements of social media so it is possible to engage future students in their electronic worlds.

Tomorrow’s horticulturalists: Who will teach them and how will they learn? (Mary Peet, Immediate Past President of the ASHS and current Chair of the ASHS Board of Directors, and Professor, Dept of Horticultural Science, NC State University)

Dr. Peet noted that fewer students studying horticulture has resulted in fewer and smaller horticulture departments. And the loss of faculty through retirements has led to reduced courses, mentoring and advising for all students. One factor in the reductions is reduced Federal and state funding, so she proposed (not completely tongue-in-cheek) a variation on the

Federal TARP program to aid banks, which she called T(H)ARP for “Troubled Horticultural Assets Recovery Program.” The T(H)ARP program would consist working with community colleges and campus recruiters to increase enrollments and justification for key courses. It also would consist of efforts to increase Federal funding in support of horticultural research. Dr. Peet did see promising trends in the form of the “Specialty Crops Research Initiative,” the increased grant awards due to economic stimulus programs, growing public interest in locally-produced foods and organic foods, and a growing awareness of the importance of broad-based applied research. At the same time, some aspects of horticultural curricula are threatened, such as production courses, applied and hands-on courses, plant breeding courses, and “service” courses in other departments that also are being cut back. Surveys indicated that there is a need for courses in organic and sustainable horticulture, pest management and propagation, as well as courses that provide practical experiences (e.g., internships), and international experiences. Some solutions might include shared courses between institutions or short courses at different universities. Distance Education is viewed as one way to provide course materials. A survey of colleagues prior to the workshop revealed comments such as “We educate too many students in biotechnology and genetics at the graduate level...There are very few individuals with doctoral degrees...in a broad field” and “I do not see another generation coming up behind me that is getting the applied, science-rich, in-depth horticultural training I was privileged to have had.”

Budding plant biologists - Growing from clueless to connected (Jane Ellis, Assoc. Professor, Presbyterian College, and chair of the Amer. Soc. of Plant Biologists Education Committee)

Dr. Ellis reported that the ASPB “Education Committee” and the “Education Foundation” work to provide resources and promote the teaching and learning of science using plants and to encourage plant biology as a career choice. They are active in K-12 programs and regularly have workshops or exhibit booths at meetings of the AAAS, the National Science Teachers Association, and the National Association of Biology Teachers. They also are engaged in the PlantingScience program, which links university-based mentors with K-12 teachers and students attempting simple plant science experiments. The ASPB also developed a pamphlet titled “Principles of Plant Biology” that provides basic plant biology concepts for science education at the K-12 levels. Each of the 12 principles is linked to one or more of the National Research Council’s Life Science education standards and “Inquiry-Based Activity” sheets have been developed to help teachers offer instruction around each of the 12 principles. Other educational materials are designed to get students to notice plants in their everyday life. The ASPB Education Foundation produced a documentary film titled “History’s Harvest” that chronicles 10,000 years of agricultural history. This foundation awards grants to support education and outreach activities that advance plant biology. To promote interest in plant science at the undergraduate level, the ASPB provides travel grants to undergraduate students so they can attend the annual meeting of the society, and they provide small awards for 15 “Summer Undergraduate Research Fellowships” each year. Graduate students in the society serve as “ambassadors” to expand ASPB’s membership base to younger constituents. The society also is very engaged in social media (Face Book, Twitter, Blogs, etc.) to keep members connected. To help students visualize the career opportunities in the plant sciences, ASPB developed a graphic of a tree which shows different educational degrees (along the trunk), and the types of positions one might then be qualified for (as branches off the trunk).

Maintaining viable plant pathology programs in multidisciplinary departments (Darin Eastburn, Professor, University of Illinois)

Dr. Eastburn described the recent and different histories of departments at three universities: Michigan State University, Montana State University, and the University of Illinois. At Michigan State, plant pathology was carved out of the “Department of Botany and Plant Pathology” in 2001 to create a “Department of Plant Pathology” in a new College of Agriculture and Natural Resources. While this increased esprit de corps among the plant pathologists, and they have sustained student enrollments, it has caused some concerns about future vulnerabilities. At Montana State, Plant Pathology was merged into the plant sciences in the 1990s. Plant Pathology was retained in the department name (the Department of Plant Sciences & Plant Pathology) so it has been possible to maintain M.S. and Ph.D. programs and to replace faculty as needed. At the University of Illinois, however, plant pathology and agronomy were combined into a new department called the Department of Crop Sciences. While this has increased access to undergraduate students, the visibility of plant pathology was lost, as was the graduate program in plant pathology. Compared to 1988, the number of plant pathologists has shrunk by more than 50%, and the plant pathology course offerings have shrunk by just under 50%. A merger that results in such a loss of visibility in the department name can lead to shrinking student enrollments, followed by loss of courses, followed by loss of degree offerings, followed by loss of faculty. When a group like plant pathology becomes a minority in a larger department, they cannot significantly influence votes on department questions related to policy, curriculum, or faculty positions.

Educating plant scientists at 1890 Land Grant universities and colleges: Challenges and successes (Oghenekome Onokpise, Professor and Associate Dean, Florida A&M University, College of Engineering Sciences, Technology and Agriculture (CESTA))

Dr. Onokpise noted that only 13 of the 18 1890 Land Grant institutions offer advanced degrees, with only two offering Ph.D. degrees. Among the Ph.D. programs offered, two relate to the plant sciences: Southern University offers a Ph.D. in Urban Forestry and Alabama A&M offers a Ph.D. in the plant sciences. The Ph.D. programs are all relatively young (5-25 years) and those in the agricultural sciences do not attract large numbers of students...an issue related to the poor public perception of agriculture. There also are relatively few plant scientists at 1890 institutions. Delaware State University only has 6 faculty members qualified to teach graduate level courses in plant or soil science. Undergraduate students struggle financially so that it often takes more than four years to complete a B.S. degree. Funding instability and academic fatigue reduces the numbers interested in advanced studies. A significant portion of those who do go on, never complete their thesis or dissertation. Those who do complete an M.S. degree move on to other universities where the graduate programs are larger and better supported. However, in the face of these challenges, the 1890s have achieved successes; Alabama A&M has graduated 70 M.S. and 40 Ph.D students since 1988 and Florida A&M has graduated 35 M.S. students since 1993—mostly in the plant sciences. Some of the Florida A&M students have gone on to the Doctor of Plant Medicine program at the University of Florida. Dr. Onokpise feels that the “Historically Black Colleges and Universities” could improve the situation through strong recruitment programs, financial aid to attract and retain top students, improved infrastructure and curricula that incorporated newer technologies. Producing minority graduates at the M.S. and Ph.D. levels is critical to our nation’s future. There needs to be more coordinated engagement among the 1890 institutions, and partnerships between 1890 and 1862 institutions.

Strategies for sustaining critical research and educational capacities in Land Grant universities (Randy Woodson, Provost, Purdue University)

Dr. Woodson noted that among the challenges we face is the fact that only 1% of all university provosts have a background in agriculture, so we face an uphill battle in being understood. The campus administration desires faculty who can compete for extramural funding that pays full overhead to offset the institutional costs of facilities and administration. The change in funding base can be illustrated in a “scissor graph” with one line showing steady declines in state funding to the universities, and the other showing steady increases in student tuition and fees to offset the state declines. As the funding shifts toward student-based, out-of-state students become increasingly important to the institution and the campus administration acts to cultivate those parts of the institution that generate the students. Unfortunately, students are not flocking to colleges of agriculture, which has been a driving force in the consolidation of programs like the plant sciences. Also, with the emphasis on faculty who can compete effectively for Federal grants, many institutions have emphasized more fundamental areas of research where it is perceived that there are more funding opportunities. This has all happened at a time when industry is calling for more talent in applied fields of plant sciences. However, in many cases we’ve lost the educational capacity to produce students in these areas. To be successful into the future, the plant sciences need to (1) invest in critical infrastructure such as farms and labs, (2) cultivate strong ties to industry through research, internships, advisory boards, etc., (3) Develop strong teams of academic excellence around crops or problems, and (4) cultivate “bridge-building” stars—those scientists who can work across disciplinary divides. We need to adapt to a university funding model that is student-centered and indirect-cost-centered.

Breakout session I: An assessment of educational challenges in plant science-related disciplines.

Desired outcome: An overview of educational challenges faced by plant science-related disciplines...what are the common issues of concern? Across disciplines, what sorts of curricular elements seem at risk? How do we preserve those that are essential? How can the broad training of students be sustained into the future? What can the different disciplines learn from each other? What are the appropriate roles of government, industry and professional societies in supporting education?

The following points emerged during the breakout sessions:

Common Concerns:

- The demand for field-oriented faculty to replace retiring faculty can't be filled
- How do we populate faculty positions that are field-oriented when grants drive hiring
- Newer (lab-oriented) scientists can't relate to growers
- Funding issues impact the number of students, courses and graduate programs
- Misperception of the diverse career path possibilities when pursuing plant pathology or any of the related disciplines
- Misunderstanding of the connection between what graduate programs offer and food production
- General literacy of the mission of the graduate programs
- The salary for field-oriented grads is lower than for molecular
- Stakeholder needs differ. How can universities meet all those needs?
- Funding decisions are driven by the particular panel input
- How to recruit, retain and reward the best teachers?
- Attention paid to "grant ability" at hiring tilts toward researchers and does not pay adequate attention to excellent teaching or ability to work in "classical areas"

Challenges regarding student recruitment:

- Current students are not interested in agriculture
- Plant sciences not seen as relevant to students...not on their radar screen. Need to reach students early with a positive image of agriculture.
- Inability to attract NUMBERS and QUALITY (best and brightest) of students
- Engage young people themselves to find out how to reach other young people. Use students to attract students.
- Work with students as a "focus group" to develop promotional materials. Find "outputs" that tell good and appealing stories.
- What's important to young people, attracts them to a profession (e.g., Opportunities to have an interesting job, Do something that makes a difference, change the world, Opp to work internationally)
- Include real-life success stories – how plant scientists have achieved public good
- Provide students with real-world examples
- Link to real world examples and/or topical events such as forensics, food safety
- We do everyone a disservice (students and ourselves) by clinging to strict, traditional definitions of our discipline rather than addressing new applications
- General Ed classes, requirement for agricultural science that provides a glimpse of what will interest them
- Hard to attract graduate students with applied interests
- Students choose molecular more than applied. They receive more OFFERS from molecular biology labs, which gives them the impression that molecular biology is where the jobs are
- We have a VERY mature faculty. Students are hesitant to work with very young faculty, or faculty close to retirement.

Challenges regarding student education:

- Disconnect between what Land Grants teach and what the industry needs (e.g., business sense, hands-on, communication)
- Focus on training students who can think critically and have problem solving skills.
- Emphasize the 'scientific method'
- People skills (ethics, team work, etc)
- Industry could help universities enhance student skills through internship programs
- Balance between content and skills; balance between versatility and the need for certain courses
- Need experiential learning to help students "get it": benefits of real world learning (field & labs) [Link education with skills needed to work in the real world]
- Practical experience very lacking at the expense of molecular training.
- Need flexible training programs to accommodate the experiential side
- Strong emphasis on experiential training & critical thinking (lab rotations, etc)
- We do a good job of teaching the applied sciences in the classroom, but do not teach well how to be an applied scientist
- Need to be able to educate broadly without losing depth (who will teach them? new scientists can't relate to growers)
- There is a conundrum...students need to have broad experiences in their curriculum, but they are expected to focus on their MS and PhD work
- Ensure rigor of program, no matter what the focus (courses are watered down sometimes to accommodate interdisciplinary students that don't have strong core

courses in background.... faculty can't 'string courses together', i.e., build on courses from one semester to next, leading to continuous reviewing of information.)

- Today's plant science students don't grow up with practical experience (on the farm)
- Outreach to students in summer programs, partner with industry, grants from government.
- Need to partner across universities and with industry for practical training.
- Need to provide training opportunities from lab to field (internships, fellowships)
- Post docs in applied areas
- Summer field crops for molecular biologists
- Could preserve some essential courses by developing on-line materials with hands-on elements
- Need to partner across universities with distance education

Educational elements at risk:

- Specialty courses...especially lab courses, which is where students gain experience in hands-on exercises
- Upper-level specialty courses (e.g., plant virology)
- applied agriculture, organismal biology, core pathology areas
- Most at-risk subjects are nematology, forest pathology, and field-based plant pathology

Challenges regarding student support:

- Need sources of funds for grad assistantships
- Need funding models that support experiential training
- Hard to identify grant programs in applied plant sciences
- Funding drives graduate education; formula funding is drying up, federal grants especially.
- It seems that Federal grants are limited in applied areas (relative to basic) so fewer students can be supported
- Competitive grants are not the easiest means of supporting students---short term relative to degree program
- Money for research seeks people who may not have the skill needed to teach students in "classical areas".
- Industry needs to engage more in internships

Challenges regarding public relations:

- Public thinks that food comes from the grocery store
- Lack of literacy of the public and policymakers
- Need to overcome PR problems with agriculture
- Ag needs a new brand image (the city mouse versus the country mouse) Pecking order in academia
- Agriculture gets a lot of bad press because so many Federal dollars are committed "earmarks" and crop supports that are commonly referred to as wasteful "pork".
- Problem of farmers seen as enemies of the earth
- This is partly a marketing problem. Need to change the "brand" of agriculture and/or plant sciences
- Molecular or applied—it's all about the PLANTS. Life on earth is dependent on plants.
- Need to develop strong communication skills and materials/resources to communicate relevance to the public

- Industry (commercial production) can influence colleges of agriculture to maintain basic agricultural disciplines – strong influence by commodity groups (can be + & -) Helps serve this niche.

Challenges regarding data:

- Need more data...work with professional societies and Federal agencies
- Need to collect and share data. Percent of graduates employed, salaries, placement, etc.
- Need more information about what industry needs...undergrad/grad students
- Industry needs to help get data together in a coordinated way from the employer side
- There probably is enough data already. Need to consolidate information from different societies.
- Maybe the Feds (NSF? NRC?) could work in collaboration with societies to do more comprehensive surveys across the agricultural sciences
- Leaders of societies need to communicate with each other regularly concerning common needs and approaches to Federal officials
- There is a 40% attrition rate for American graduate students across the science and engineering fields (according to NSF figures). Why? How to address? What are the figures for the agricultural sciences?
- Can we gather data about recent M.S. and Ph.D. students and what they are doing now in their careers?
- Need to get data to people who have influence

Session II: Educational needs for the future

The future educational needs of industry employers (Bill Dolezal, Pioneer Hi-Bred International)

Dr. Dolezal indicated that this is actually an exciting time to be in the plant sciences because new technologies are allowing great strides. National data on degrees earned show that the numbers of B.S. degrees in agricultural and environmental sciences grew in the past two decades, but have been declining over the past five years. To remain relevant to industry, teaching programs need to place greater emphasis on management skills, interpersonal skills and technical skills. These are transferable skills that are needed not just in industry, but also in running a research lab: Budgets, ethics, team-building, goal-setting, human resources, etc. Dealing with people is the key issue. In terms of technical skills, students need to know both the molecular and applied worlds. Molecular plant biology can lead to new discoveries, but there also needs to be people to evaluate those discoveries under field conditions...to translate basic discoveries into practical solutions. Students learn more when they are actively involved in real-life situations/scenarios. Industry can and will help in this through a variety of possible mechanisms: industry professionals spending a semester teaching at academic institutions; faculty spending sabbatical leave time working in industry; and student internships. Dr. Dolezal indicated that the skills and abilities needed by college graduates are, in order of importance: Interpersonal Communication Skills; Critical Thinking Skills; Writing Skills; Computer Skills; Cultural/Gender Awareness Sensitivity; Quantitative Analysis Skills; Knowledge of Business Management; Oral Presentation Skills; Knowledge of Accounting/Finance; Intern/Co-op Work Experience; Knowledge of Macroeconomics, International Trade; Broad-based Knowledge in Liberal Arts; International Experience; Foreign Language Skills; and Production Agriculture Experience.

Critical role of ARS plant scientists in feeding and fueling the nation (Antoinette Betschart, Associate Director, USDA ARS)

Dr. Betschart quoted from the 2009 NAS report on "Transforming Agricultural Education for a Changing World" and said that the time to act is now. ARS is the largest single public employer of plant pathologists and biologists in the U.S. The numbers of plant scientists employed by ARS has increased from 2000 to 2008, although funding for ARS has been flat in inflation-adjusted dollars. The challenges ARS seeks to address are related to food/national security, exotic and emerging crop diseases, bioenergy, climate change, food safety, globalization and population increases. Plant pathology is critical to meeting of future challenges, but there are fewer people going into agricultural science degree programs, and the emphasis is mainly on fundamental science. Education cannot be approached as an "either/or" proposition (field or bench). A balance is needed. ARS seeks people interested in doing research directed to the solution of problems. This requires "interpersonal competencies" (to work in interdisciplinary teams, and to reach out to producers and growers) and "scientific competencies" (the ability to form hypotheses, design experiments, analyze experiments, and with a broad multidisciplinary knowledge including crop production and agronomics). The international team working on the new Ug99 strain of wheat rust was given as an example of how important it is to be able to work in large, multidisciplinary teams on both a national and international scale. Professional flexibility and lifelong learning were noted as critical attributes for success in the modern world of agricultural research.

Essential skills for success in the Cooperative Extension Service (Paul Coreil, Vice Provost for Extension, LSU)

Dr. Coreil pointed out that the role of Cooperative Extension is changing. Its historic role was to disseminate research-based information to stakeholders, but that has evolved to a current role of not only disseminating research-based information to stakeholders, but also developing the information through research. In the future, it is expected that Cooperative Extension Specialists will need to develop and disseminate research-based information to stakeholders in addition to teaching and training the next generation of applied researchers. There are a number of significant changes that have happened. For example, split appointments have become the trend, and the way people seek information through electronic media has changed the face of Extension programming. In addition to technological changes in communication, Specialists must account for the social etiquette and various learning behaviors of an increasingly diverse clientele. There also is an increasing need to document the effectiveness of Extension programs through quantified changes in behavior. Recent trends in graduate education are having an impact on the training of students who might go into Extension: the encouragement of students to skip the M.S. and directly enter the Ph.D. program; an over-emphasis on molecular research; and the linkage of student support to grants that forces early specialization, decreased breadth of training, and a narrow range of disciplinary choices. The Specialists of the future must have broad training in plant pathology and the plant sciences, broad training in communication skills (oral, written and electronic), training in grantsmanship and program evaluation, and the social skills to interact with a very diverse clientele. They also must be trained to teach, do applied research and mentor graduate students. Industry could help by providing support for graduate education in areas that meet their needs, or by providing more internship/on-the-job experiences. Government also could help by providing support for graduate education in areas not funded through traditional granting agencies (e.g., internships in disease clinics, extension, etc.).

**The following presentations were made by
the six APS Education Fellows**

Opening doors to opportunity and encouraging students to step through (Kimberly Webb, APS Early Career Education Fellow, USDA-ARS, Ft. Collins, CO)

Dr Webb reported that he had obtained a broad education in graduate school, but felt that it was largely due to “luck” and that “luck” should not be the mechanism determining the breadth of graduate education. One can never predict the positions that will be available, so breadth of knowledge and experience is critical. The experience of many students, however, is that their graduate programs tend to give them experience only on their thesis project. To broaden experiences, it was suggested that mechanisms be developed to give students international experiences; field trips and hands-on experiences for “molecular” students; workshops or lab projects for “field” students; internship experiences; and coursework that exposes students to statistics, agronomy, economics and/or business courses. It also was noted that B.S. and M.S. level pathologists are becoming a rarity, and there are many employment opportunities that do not require a Ph.D. Finally, students need to learn interviewing skills.

Re-conceptualizing The "Modern" Plant Pathologist: The Need for an Alternative Paradigm in Plant Pathology Education (Tim Durham, APS Early Career Education Fellow, Assistant Professor, Nicholls State University, Thibodaux, LA.)

Professor Durham earned his DPM from the University of Florida. He feels that the breadth of educational experiences and experiential learning in the DPM program were very positive attributes. A number of critiques of science graduates were offered: (1) Graduates often have a narrow set of experiences...they are not worldly enough. This could be corrected by a compulsory semester abroad, an extension rotation, or field pathology courses, (2) Graduates can be “dittoheads” (i.e., lacking ability for independent thought) and need to improve their improvisational skills (e.g., through a semester abroad), (3) Graduates have an overreliance on genomics. Programs need to be sure students do not lose microscopy/diagnostic skills, and (4) Graduates are not knowledgeable about the machinations of government. They need to be introduced to science policy as part of their education.

Peace Corps and Plant Pathology: Pathways to Success! (Kristina Owens, APS Early Career Education Fellow, USDA-APHIS, Annapolis, MD)

Ms. Owens earned her M.S. degree through the “Master’s International Programs in Agriculture, Forestry & Natural Resources,” a cooperative program between universities and the Peace Corps that allows students to enroll in a M.S. program, complete their coursework, spend two years overseas working on a project, and then returning to school to finish their degrees. Ms. Owens worked in southern Bolivia helping local growers with the horticultural and pathology problems associated with cultivation of the Cherimoya fruit tree. In her present position, she aids in the development and validation of pathogen detection methods and provides hands-on training in new technologies to diagnosticians. She feels strongly that the international experience she gained through the cooperative Peace Corps program was a unique and outstanding educational experience that helped her see the impact of problems on “stakeholders” and required her to be flexible and to take broad approaches to problem-solving. There currently are no plant pathology programs engaged in the Masters International program, and she encourages programs to explore this opportunity.

Plant Pathology at the crossroads: attracting the Millennial Generation (Olufemi Alabi, APS Graduate Student Education Fellow Ph.D. candidate, Washington State University)

Mr. Alabi focused his presentation on the critical issue of student recruitment. He noted that the Millennial Generation is closely tied to their parents and we need to be aware of this in recruitment efforts...parents hold a lot of sway in the decision. Millennials also are driven to be successful, want to “give back” to society, and are team-oriented. They make heavy use of social media for communicating. Their view of science is that it is vague, abstract, difficult or boring. American society is largely detached from agriculture, which contrasts with Nigeria where people are very close to their food supply and have many hands-on experiences in food production. It is crucial that agriculture and plant science be made a component of the K-12 curriculum by working with teachers. Also need to connect to the parents...perhaps through science fairs. Hands-on experiences are crucial with today’s youth, and Mr. Alabi described some of the efforts undertaken at Washington State University.

Increasing APS visibility to the nation’s undergraduates: why it matters, from a student’s perspective (Lindsay Triplett, APS Graduate Student Education Fellow, Ph.D. candidate, Michigan State University)

Ms. Triplett also focused her presentation on the issue of increasing the visibility of plant science. High school guidance counselors, who help students examine career possibilities, know virtually nothing about the plant sciences. What attracts students to a particular field of study? One factor is an inspiring teacher, but most undergraduates never interact with a plant

pathologist. Another is a positive research experience, but many areas of the agricultural sciences are not well-represented in summer research positions. After reporting some data that showed the small proportion of summer internships in the plant sciences, Ms. Triplett posed three questions to the group: (1) how can we let more undergraduates know about opportunities in agricultural sciences now and down the road?, (2) how can the agricultural sciences community welcome and support undergraduate summer researchers?, and (3) should undergraduate research opportunities in field and extension work be expanded?

Graduate Education and Training: What does it mean to be a Graduate Student? (Michelle Moyer, APS Graduate Student Education Fellow, Ph.D. candidate, Cornell University)

Ms. Moyer indicated that students do notice the educational gaps that are occurring in graduate programs. Students also are cognizant of the push to “specialize,” and that today’s graduate programs can represent a form of “clonal propagation” (of major professors). She pointed out the need to stay focused on the core principles of graduate education: Critical learning skills; Communication skills; Networking skills; and Research skills. She indicated that graduate programs need to recognize and respect the line that distinguishes between “graduate student” and “graduate technician.” In an environment of “clonal propagation” students often feel that they have limited career options. A better effort needs to be made to educate and prepare students for a diversity of professions, such as consultant, teacher, science writer, political advisor, etc. These should not be treated as if they are less worthy career paths. It is important to build a strong foundation and to keep in mind the definition of the Ph.D. as a doctor of philosophy (doctor=a learned or authoritative teacher and philosophy=the pursuit of wisdom). In her talk, Ms. Moyer also described some of the programs that faculty and students participate in to bring science into K-12 classrooms. This broadens the student experience.

Breakout session II: An assessment of market needs and how they should be reflected in educational programs.

Desired outcome: Develop an understanding of what is needed to prepare graduate students for the positions of the future. What do employers in the private sector, the government and academic institutions (Land Grant and non-Land Grant) anticipate as proficiencies needed for the future? What is needed to prepare students for a highly globalized working environment? How well positioned are graduate programs to deliver M.S. and Ph.D. graduates with the skills needed for the future? Will workforce preparation require fundamental changes in educational content or methods? What changes are needed to prepare students for the diversity of positions available?

The following points emerged during the breakout sessions:

Future Proficiencies:

- Students need opportunities to work/gain experience outside the university
- What would we give up in the curriculum to increase diversifying experiences (professionalism/internships/international travel)?
- If leadership and business cannot be incorporated into curricula, where will these attributes come from? Workshops at annual meetings?
- Students need to have a PRACTICAL understanding of both molecular and non-molecular research

- M.S. and Ph.D. curricula not connected to business needs. Don't understand how business works. Business training is missing.
- Internships are important. Can industry help to support students?
- Could societies serve as portals to summer internships? Could they link with sister societies around the world to identify international experiences?
- Societies should set up booths at annual meetings to provide information on opportunities for fellowships, travel funds, etc. Serve as a clearing house for opportunities.
- Students need a broad-based education with professional aspects such as how to manage people. Should be a connection between scientific training and professional life.
- Get "senior" graduate students into the USDA grant-writing workshops held around the country?
- It is hard to shake out time for an immersive experience (international or in private sector) due to reliance on grant funding to support students.
- Breadth of training also includes breadth of exposure...INTERNATIONALIZATION
- International experience is becoming more and more important...but opportunities/funding easier to find for undergraduates than graduate students.
- Working/learning abroad contributes to breadth and adaptability
- Opportunities for students vary from department to department, and from faculty member to faculty member
- Can professional societies raise to support such experiences
- Work with international members of our societies to establish experience opportunities
- International experiences can be expensive. Are there opportunities for shorter (e.g., 2 wk), less expensive experiences? Just to see problems up close. If inexpensive, students could self-fund.
- Can international experiences be "modular" (brief)? Exchanges with universities in developing countries.
- Shorter experiences would be better for students at 1890 institutions, because they often are under financial pressures to finish as quickly as possible.
- Societies need to create a welcoming environment for new attendees...foster networking. Faculty bear a responsibility to introduce their students to colleagues.
- Need to internationalize curricula
- Study Abroad works for undergrads. NSF has graduate foreign scholarships, but harder to obtain for agriculture.
- What do we mean by "global skills" or "global outlook"?
- Create international/intern experiences in partnership with industry. University gives credit for experience.

Student Preparation:

- Students need breadth so they are adaptable to future changes...lifelong learning
- Breadth implies ability to read and interpret literature across disciplines
- Students need to learn critical thinking BEYOND their thesis. (need to define critical thinking).
- Oral exams should encourage/force critical thinking
- Need to teach students to the "Scientific Method." Vital for critical thinking and breadth.
- Students need to develop strong communication (oral/written) skills...but this is a challenge in a Google/Facebook/Twitter/Texting society
- Students need to learn that posted information is not always accurate and peer-reviewed

- Ethics needs to be built into curricula
- Students may not need to know specific crops, but they need to know the basics of crop plant production
- Students need molecular skills, critical thinking, communication and flexibility. Also international experience
- Need a "summer camp" for molecular biologists to assure they have an opportunity to connect to real-world plant production
- Require students to give seminars to broader audiences (outside their discipline) as a communication experience
- Offer more teaching opportunities to students. If not classroom, then extension teaching.
- Allow students to have the opportunity to fail....don't treat like technicians for research projects
- Develop interactive, experiential training; integrate problem-solving skills with academic rigor
- Need "case-based" studies in graduate programs to teach critical thinking and analysis skills.
- Need to develop teamwork skills. Projects with sociological and ethical topics
- Student support from grants does not allow the flexibility needed for things like rotations to broaden experience.
- Need to bolster M.S. programs. They may be the appropriate level of training for many jobs, but M.S. programs are withering
- Reduce redundancy in classes (faculty need to work together to string courses....flow of classes....which is very difficult given diversity of needs and backgrounds)
- Grad programs are still better off than we sometimes fear. Need a system for exchanging "best practices"
- Faculty need to re-evaluate how we are evaluated
- Should scientific societies certify (accredit) degree programs?
- Need more "Professionalism" opportunities for students and early-career professionals (e.g., people management skills, presentation skills)
- Link the UG with a graduate student or post doc or tech so they get continuous training
- Let UG's see the passion
- Need to remember that undergrad experiences in labs are portals to graduate programs.
- Are teaching and research success so different that we need different groups of faculty...one dedicated to teaching and the other to research?

Session III: Thinking strategically about the future

Adaptive Evolution: Society Collaborations Enhancing Science Education (Bill Dahl, Exec. Dir., Botanical Society of America)

Mr. Dahl described the educational programs that the Botanical Society of America is engaged in, and how it has partnered with other professional societies to develop and offer “PlantingScience,” a web site (www.plantingscience.org) dedicated to helping middle and high school students understand science and the scientific process—using plant biology as the learning context. Students work through relatively simple experiments with their teachers, and with the aid of a scientist mentor who communicates with the students via the web. Students work in teams for a hands-on experience that provides peer-to-peer interaction that aligns with national and state science standards. The interactions with the science mentors requires relatively little time on the part of the mentors (approximately 2-3 hours total time over a 3-week period). The BSA has found that emeritus members, graduate students and early career professionals are particularly attracted to this activity. Mr. Dahl is seeking to expand the ranks of mentors—with a goal of 2% from each of the affiliated societies—so as to greatly expand the reach of PlantingScience and then numbers of students exposed to science through plants. Mr. Dahl also introduced the group to “ChloroFilms” (www.chlorofilms.org), a series of YouTube videos that seek to expand public appreciation and understanding of plant life.

Our Future at Risk: The Need for Diversity in Plant Science Departments (Marla McIntosh, Professor, University of Maryland)

Dr. McIntosh referred to agriculture as the “mother science” and pointed out that we have a crisis with regard to [lack of] diversity. She made a simple analogy to point out the importance of diversity...that the Southern Corn Leaf Blight epidemic of the 1970s was enabled by genetic homogeneity in the corn crop. Population diversity is critical to healthy crops and the same applies to the workforce. To achieve gender diversity, the proportion of women hired needs to increase, and they need to feel that they can succeed in their careers. It was noted that the NSF Survey of Earned Doctorates shows that the percent of women earning Ph.D. degrees in plant science related disciplines increased in the 10 years between 1996 and 2005, and that by 2005, 35-50% of all earned Ph.D.s were awarded to women (with the exceptions of agronomy and plant breeding, which were 17% and 20%, respectively). However, data enumerating the numbers of faculty by rank (i.e., assistant, associate and full professor) shows that unlike their male counterparts, the numbers of females in higher faculty ranks is not increasing as one might expect over a career. The “pipeline” is leaky with regard to female faculty. NSF data across the agricultural, biological and environmental sciences shows that among males, most are full professors and the smallest portion are in instructor/lecturer titles. The exact opposite is true for females. Dr. McIntosh noted that there is a need for more successful female role models and women in leadership positions. The tenure process is seen as problematic...there need to be “family-friendly” policies, mentoring systems and transparent tenure requirements. Agriculture and academia are integral and necessary for a better society, and women comprise half of our society. We need to be proactive in meeting the needs of a sustainable and productive workforce. The demand for quality scientists and educators exceeds the supply, so it is crucial that we address the leaks in the pipeline and capture talent that is now being lost.

A generalist degree in Plant Health: Present and Future... The start-up of the DPH program at the University of Nebraska-Lincoln (Anne Vidaver, professor, University of Nebraska, Lincoln).

Dr. Vidaver described the 4-year effort undertaken by her and colleagues at the University of Nebraska to establish a new degree called “Doctor of Plant Health.” It is the second such program established in the United States. It is intended to be analogous to the Dr. of Veterinary Medicine, the Dr. of Medicine, and the Dr. of Public Health. The program was initiated in response to industry, state and Federal government concerns about the loss of “generalists” in plant pathology. The program is intended to train plant doctors who can assist growers with the best possible integrated pest, pathogen and agronomic management practices. To enter the program, students must hold a B.S. or B.A. degree in a biological or related field. They complete 100 hours of coursework, 20 hours of internship experience, and participate in a research project. The coursework includes plant pathology, entomology, weed science, soil science, quantitative tools, and law/policy. The university administration has provided some start-up funds, student aid and tuition relief. The challenges faced by the program include continuing student support, faculty recognition, and degree acceptance in the marketplace. There also are concerns about the loss of teaching faculty with applied experience due to retirements. It was noted that APS could play a useful role in publicizing current programs, by working to encourage equity in student financial support in institutional, state and Federal funding, and establishing a support vehicle through the APS Foundation.

Funding for Research Programs and Students with Interests in Field-oriented Research (Ann Lichens-Park, National Program Leader, USDA-CSREES)

Dr. Lichens-Park described a number of grants programs that support research and students with field research interests. These include the Specialty Crop Research Initiative (~\$47M in FY 09); the Sustainable Ag. Res. and Education Program (\$13.4M in FY 08); Crops at Risk (~\$1.3M in FY 08); Critical and Emerging Pests and Diseases (~\$0.4M in FY09); Risk Avoidance and Mitigation Program (~\$4.2M in FY 08); Pest Management Alternative Program (~\$1.4M in FY 08); and Methyl Bromide Transitions (~\$3M in FY 08). Programs under the new Agriculture and Food Research Initiative (AFRI) include Plant Biosecurity Program (~\$4.3M in FY09); Plant Breeding and Education (~\$6.5M in FY09); Microbial Biology: Microbial Associations with Plants (~\$7.4M in FY09); and Microbial Genomics: Functional Genomics of Microorganisms (~\$5M in FY09). Dr. Lichens-Park pointed out that it is difficult to talk about “basic” and “applied” research as if they are different things. It really needs to be viewed as a continuum. To illustrate this she described the future of microbial genomics. Genomes have been sequenced and are presently being annotated. Annotating involves hypothesizing what a gene might do. The next step is functional testing of the hypothesis. To accomplish this, microbial genomics is headed toward the field...illustrating the continuum between fundamental and field-oriented research. She emphasized that if there are areas in the plant sciences that need greater research support, we need to be alert to agency requests for stakeholder input into program planning. She indicated that workshops to which agency representatives are invited are also effective means of informing the program planning process.

Graduate Education in the Plant Sciences supported by NSF (Bill Hahn, NSF Program Dir., Div. of Graduate Education)

Dr. Hahn noted that it is difficult to know precisely how many graduate students are supported on NSF funds. The Fellow and Trainee programs [e.g., Graduate Research Fellowships Program (GRFP), Integrative Graduate Education and Research Traineeship (IGERT),

Graduate STEM Fellows in K-12 Education (GK12), and the Bridge-to-the-Doctorate Program] support approximately 5,000 students. These programs can be very precisely tracked in terms of numbers of students and other demographic data because they provide direct support to students. However, the bulk of students supported on NSF funds (estimated to be 25,000 per year) are research assistants on individual investigator grants. The large number of people involved and the indirect nature of this student support makes it impossible to collect accurate numeric and demographic data each year, but in total it is estimated that NSF provides approximately \$1Bil/year to support the graduate student enterprise. There are different implications with the different types of funding. Fellowships provide students with complete flexibility and independence in their graduate pursuits, while Traineeships have a distinct curricular focus. RAs, which are the most common form of graduate student support, really support the research enterprise and resemble apprenticeships, even though students are there for an education. Dr. Hahn noted that the awards given out under the GRFP are, on a disciplinary basis, proportional to the total number of applicants (i.e., if half the applications came from discipline X, half the awards would go to discipline X). He noted that for the 2009 competition, only 1.5% of all the applications come from the agricultural plant sciences, so their share of the awards will be proportionately small. He also noted that fewer than half of all Ph.D. graduates go on to academia...so why do we continue to train them so narrowly for such careers? He noted that graduate students should receive broader scientific training in the fundamentals of science and discipline, interdisciplinary work, fieldwork, theory and application, as well as training in "practical things" such as communication, teamwork, management, entrepreneurship, cross-cultural training, ethics, internships, and other skill sets. He urged meeting participants to focus on student recruitment via undergraduate research activities, the encouragement of student applications to the GRFP, and a focus on graduate education rather than an apprenticeship so that students can explore a variety of career pathways.

Breakout session III: An assessment of strategic options.

Desired outcome: What are the "best practices" for attracting undergraduate students into the plant sciences and ultimately into graduate studies? How might we work to have the plant sciences thought of in the same context as the STEM disciplines (Science, Technology, Engineering and Mathematics) so that they become natural parts of K-12 and undergraduate science education? How do we bridge the support gap for students interested in a broad education, as opposed to one defined by a research grant? Is it possible to build employment-sector experiences into graduate education? What are the proper roles of professional societies and employers in issues of education?

The following points emerged during the breakout sessions:

Attracting students:

Get every plant-related society involved in the PlantingScience initiative

- Engage emeritus members and early career members as PlantingScience mentors
- Engage in PlantingScience
- We need more inter-societal communication and cooperation
- Utilize social networking media. See Chlorofilms.org (sponsored by the ASPB and BSA) for examples of how plants can be presented. Also "The Plant Detective" at <http://www.floradelaterre.com/home.html>
- No YouTube video will replace hands-on experience and a charismatic teacher.
- Need our best teachers engaged in undergraduate classes so students can catch the excitement

- We need to mentor a larger cadre of mentors. Develop specific learning objectives.
- Need to value the scholarly contributions of excellent teaching and extension
- What are the job opportunities? We do not do a good job of advertizing the many career paths. Societies should work together to accomplish this.
- Entomologists use "insect fairs" to attract students. Plant scientists need something similar. Work through 4-H? FFA?
- Need to do a better job of career communication
- We are too invisible. We need to work to make undergrads aware of the opportunities available in plant sciences. Work with teachers/counselors.
- Professional societies could connect better with teachers through FFA, 4-H, AIBS, 1890 schools (through 1890 organization)
- Create internships with industry and government (including city, county, state and Federal)
- Develop employment for high school kids (15-18) in summer work experiences. Crop consultants could do this. Offer CEUs for mentoring students? (explore with NIACC, CCCA, CAPCA etc).
- Need undergraduate research experiences to "hook" students
- Need resources for undergraduate internships
- Partner with industry/ARS/EPA for internships
- Give undergraduate students class credit for research on an "undergraduate thesis."
- Opportunities to build greater experiential value into education through internships with industry, APHIS?
- Tuskegee University has a requirement for students to spend on semester away from the university doing service work.
- Give undergraduate students free membership in professional societies
- Bring undergrads to society meetings. Pair up with a mentor to make it a positive experience.
- Students get awards from APS (and perhaps other societies) in the National Science and Engineering Fair. We do not do a good job of follow-up recognition.
- Society involvement provides a community to students...can help in disciplinary retention.

Broad background:

- Interdisciplinary training may require that students spend an extra year to get the breadth of experience they need. b. Conundrum: need to get a degree with research in an area at the forefront of discipline AND pick up broad training.
- Specialty crops and plant breeding research funding provides opportunity for applied research/education support
- Invite growers to attend annual meetings to present real world situations.
- DPH/DPM can provide a broader education because not focused on a research project...but student funding is a limiting factor.
- Doctor of Plant Health/Medicine do not qualify for typical (research-based) assistantships. Many work part-time or take out loans.
- Need to link resources and opportunities for those students interested in broad training
- Some societies provide student travel awards to attend annual meetings...can funds be generated to support travel to international meetings as well to broaden experiences?
- NSF has funding for professional masters. Need to make such opportunities known to students.
- Need get "agriculture" included in the core curriculum of undergraduates

Elevating the plant sciences:

- Get plant sciences into the high school curriculum
- Biotechnology is a common denominator in STEM (STEAM) and provides a portal to the plant sciences. Ecology is another portal opportunity.
- Need to study the education standards and find ways to fit plant science examples into required curricula
- Engage in science fairs. Create awards for the best agriculturally-related projects. Make presentations in DC through CAST or CoFarm
- High school gardens (Tuskegee University hosts "victory gardens" for kids in the city)
- AAAS Section O (Agriculture) may be a good venue, as it is a society representing all agricultural related societies; would give the national attention
- Co-host career fairs & use intersociety links to share career advertising opportunities
- Societies should develop standardized, positive talking points about opportunities in the plant sciences (tractor to table)
- Need to be more quick and organized about capitalizing on what appears in the news
- Develop outreach partnerships around "Food" ... plant science, econ, food sciences, etc.
- "It's all about plants" without them, there would be no life on earth.

Session IV: Workshop Wrap-up

Through group discussion, try to achieve consensus on the next steps. For example, what are the key issues that need to be addressed, and how should we address them? What should be the role of professional societies? What should be the role of government? What should be the role of the private sector? How can the results of this workshop best be used to stimulate a national coalition or strategy for sustaining strong educational programs in the plant sciences at Land Grant Colleges of Agriculture and other institutions? Where do we go from here? How do we collaborate across societies, employment sectors and universities to accomplish common goals?

The following points emerged out of the final group discussion:

- We need to work on a common site for posting of employment opportunities in the plant sciences. This will also help potential students see the career opportunities
- Everyone should engage in the PlantingScience web site. Societies can encourage emeriti, graduate students and early career professionals to serve as on-line mentors. It only requires about 3 hours of time spread over 6 weeks.
- We need to get the society leaders together to discuss outreach and other common priorities. Develop common messages that resonate across all the plant sciences. Identify target audiences and messages
- We need to get more data about the status of the plant sciences writ large. Can we get graduation, recruitment and placement data through NSF?
- We need to engage with the Biology Directorate...they are working to redefine biology education for the future and we need to work to keep plants in the curriculum.
- We need to get the societies together to discuss the future of plant science.
- We need to work together to increase funding that supports translational (field-oriented) research
- We need to elevate public perception of plant sciences (and all of agriculture) through outreach and common messages
- We need to work on increasing "generalized" support for students to better enable broad education and experiences
- We should get the education committees of the different societies working in a coordinated way to get plant science into the K-12 curriculum and into undergraduate education.

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