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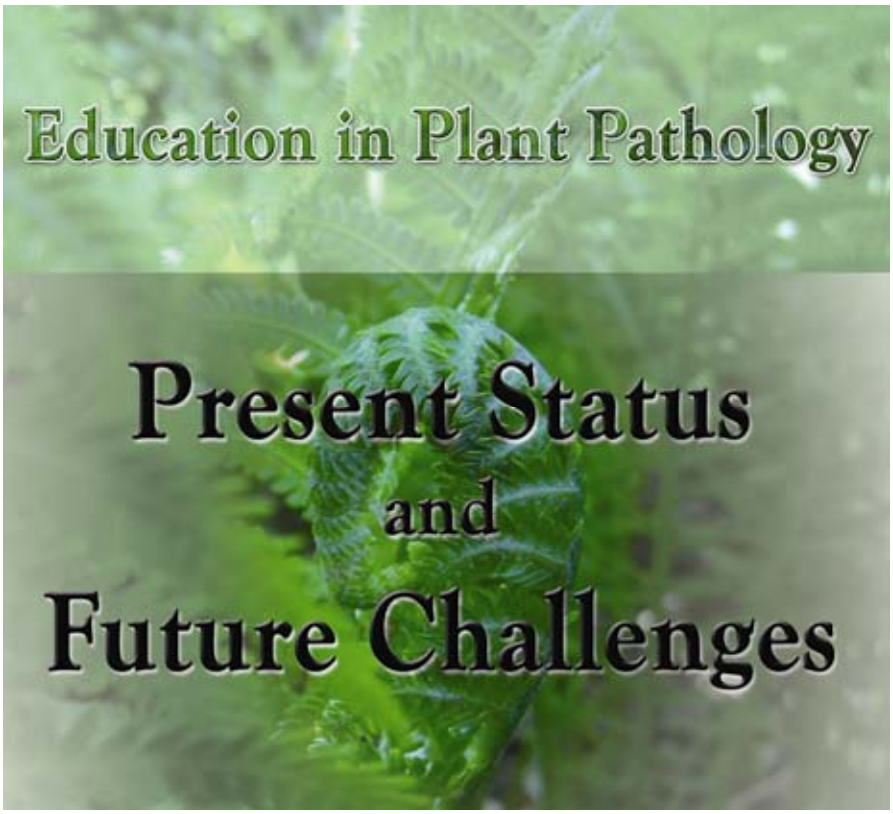

Plant pathology is largely a mission-driven discipline that seeks to increase the fundamental understanding of host–pathogen interactions and the etiology of plant diseases for the purpose of preventing or mitigating crop loss. This is an important mission because all nations face serious challenges in their efforts to prevent disease on plants cultivated for food, fiber, ornamental use, timber, and fuel, as well as those growing in native ecosystems. In 1994, it was estimated that global losses due to plant diseases ranged from 9.7 to 14.2% of potential yield (12). While modern pesticides have reduced crop losses in many situations, the ability of pathogens to readily develop resistance to routinely used pesticides has allowed diseases to remain persistent and serious problems (14). Likewise, pathogens have the capacity to overcome plant resistance genes in major food crops, requiring breeding programs to repeatedly discover and deploy new resistance genes. While much of the economic and social impact data to date (12,14) have focused on agricultural crops and food systems, the same impacts occur on forested lands and within the "green industry", which deals with ornamental and landscape plants used in urban environs.

Apart from the need to minimize losses due to chronic or re-emerging locally endemic diseases, all nations are challenged by the introduction of new pathogens resulting from global movement of plants and plant products. Indeed, Mack et al. (9) predicted that failure to address the issue of biotic invasions could effectively result in severe global consequences, including wholesale loss of agricultural, forestry, and fishery resources in some regions. It has been estimated that losses in the United States due to direct damage by, or control of, invasive species approaches $137 billion per year (13). And in recent years, concerns have emerged over the possibility of deliberate introduction of destructive pathogens into agricultural or natural environments for the purpose of causing economic damage (3). Clearly, there are continuing needs for plant pathologists, knowledge of pathogenic agents, host–pathogen interactions, and effective disease management practices.

Within the United States, a network of public institutions (e.g., Land Grant universities, the USDA, agricultural experiment stations, cooperative extension units, and state departments of agriculture) and private sector companies has served a crucial role in plant pathology. In these entities, plant diseases have been discovered, management strategies developed, and the knowledge transferred to wide-scale practice and/or public policy. Over a period of many decades, the investments of public funds have had profound, beneficial impacts on U.S. food production and distribution. Indeed, through most of the twentieth century, the rate of return on public investment in agricultural research in the United States was shown to range from 20 to 60% (4).

The ability of plant pathologists to contribute to U.S. agricultural productivity over the past century has been enabled by a steady stream of students educated in the system of Land Grant universities. Upon graduation, many of these students were imbued with both a strong knowledge of plant pathology and the ability to apply that knowledge to manage plant diseases. However, in recent years, concerns have been raised with increasing frequency that this vital "feeder system" for plant pathology (and many other agricultural disciplines) is at risk and already faltering. Such concerns have been voiced through a variety of venues, but largely have been expressed anecdotally. However, this perception was sufficiently pervasive to prompt the American Phytopathological Society (APS) to appoint two ad hoc committees to explore the issues so that discussions of this topic could be more fact-based. One ad hoc committee was charged to examine "The Future Education of Plant Pathologists," while the second was charged to study "The Present Status and Future of the Profession of Plant Pathology". This is a report on the findings of the education committee as determined

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through a series of surveys of key groups. Oral reports of the survey results have been presented earlier at APS meetings and in a "webinar" format on APS*net*.

Survey Methods

Three different internet surveys were carried out during the spring of 2007. One targeted graduate student and postdoctoral members of APS to learn what attracted them to plant pathology, to ascertain their career aspirations, and to determine how well prepared they feel for their careers of choice. A second survey targeted the heads of U.S.-based plant pathology graduate programs to learn what the different graduate programs regard as essential educational elements for advanced degrees in plant pathology, and how well prepared their programs are to offer key curricular elements now and into the future. The third survey targeted employers of plant pathologists to learn about the skills they most value in employees, how those might change over the next decade, and their sense of confidence in finding graduates with the desired skills.

Survey questions were developed by the ad hoc committee, with assistance from Readex, Inc. (Stillwater, MN), an information collection and delivery company with whom APS contracts for the purpose of its regular member surveys. The survey itself was carried out by APS as a web-based survey mounted on APS*net*. All potential survey participants were invited to do so by means of an e-mail sent by APS President Jan Leach. The e-mail provided a URL to the APS*net* site housing the survey, provided information about how the results would be used, and assured invitees of the confidentiality of the results. A total of 873 survey notices were sent to all the M.S. and Ph.D. students and postdoctoral trainees in the APS directory. A total of 365 (41.8%) responses were received, which subsequently were divided into four cohorts: (i) students studying in Ph.D. programs outside the United States (n = 55), (ii) students studying in Ph.D. programs within the United States (n = 142), (iii) all M.S. students (n = 62), and (iv) all postdoctoral scholars (n = 106). Invitations also were sent to the heads of 51 U.S.-based graduate programs, and 28 responses (54.9%) were received. A list of employers was developed by APS using the contact information for all unique employers who advertised open positions in *Phytopathology News* between April 2006 and March 2007. A total of 397 employers were invited to participate, and 93 (23.4%) chose to do so. These subsequently were divided into three cohorts: (i) academic institution employers (n = 60), (ii) state or federal government employers (n = 17), and (iii) private sector employers (n = 16).

Many survey questions required participants to respond using a numeric rating scale of 0 to 4, where 0 might mean unimportant or not relevant, and 4 might mean very important or highly relevant. Other questions utilized a Likert scale wherein respondents specified their level of agreement with a given statement on a scale of +2 (strongly agree) to –2 (strongly disagree). In addition to structured survey responses, other questions provided opportunities for a narrative response. Questions of the latter type generated 61 pages of comments from students and postdocs, 13 pages of comments from employers, and 2 pages of comments from the heads of graduate programs. Upon completion of the survey, APS passed the resulting data to the ad hoc committee for analysis. The data were received by the committee in spreadsheet format stripped of all potentially identifying information, such that each respondent was represented only as a row of numeric or textual responses on the spreadsheet.

Survey Results

Attracting students to plant pathology. The three most important factors that initially aroused undergraduate student interest in plant pathology were, in descending order: (i) a work experience in plant pathology, (ii) the encouragement of a friend, family member, teacher, or academic adviser, and (iii) subject exposure through an introductory course in plant pathology (Fig. 1). However, some minor differences among the cohorts were found. For example, in addition to the three factors noted above, students in schools outside the United States were strongly influenced by coursework in microbiology. The results also show that 35% of U.S. Ph.D. students and 45% of the Ph.D. students studying outside the United States perceived employment opportunities as a significant factor influencing their decision to undertake graduate studies in plant pathology.

When deciding which university graduate program to enter, 85% of U.S. Ph.D. students identified "Faculty research interest match" as a highly influential factor (i.e., 85% gave a rating of 3 or 4 on a scale of 0 to 4) (data not shown). Other decision factors, and the percentage of students who rated them a 3 or 4, were: "Availability of assistantships" (83%), "Reputation/stature of faculty" (81%), "Specializations of the faculty" (77%), "Department/program ranking" (71%), and "Personal considerations" (65%). Students entering M.S. programs had somewhat different priorities, with the leading decision factors and the percentage of students who rated them a 3 or 4 being: "Availability of assistantships" (69%), "Personal considerations" (68%), "Geographic region of the country" (66%), "Recommendation of undergraduate advisor" (64%), "Faculty research interest match" (60%), and "Reputation/stature of the faculty" (58%) (data not shown). In contrast to students, 100% of the graduate program heads who responded to the survey rated "Department/program ranking" a 3 or 4 (i.e., considered it highly influential) in student decisions about which university program to enter. Other factors and the percentage of program heads who rated them a 3 or 4 were: "Availability of assistantships" (97%), "Reputation/stature of faculty" (92%), "Breadth of opportunities" (89%), "Department web site" (78%), "Amount paid for assistantships" (78%), and "Opportunity to visit the department" (78%) (data not shown).

With regard to their success in recruiting graduate students, the most commonly identified constraint, recognized by 82% of the heads of graduate programs, was student support. This may reflect the fact that the vast majority of graduate students in U.S. schools are supported on grant funds (Fig. 2) and the feeling expressed by a number of respondents that grant funds have become increasingly competitive and limiting. In comments associated with this question, one graduate program head stated "Not enough offers are being made [to students because] faculty have limited

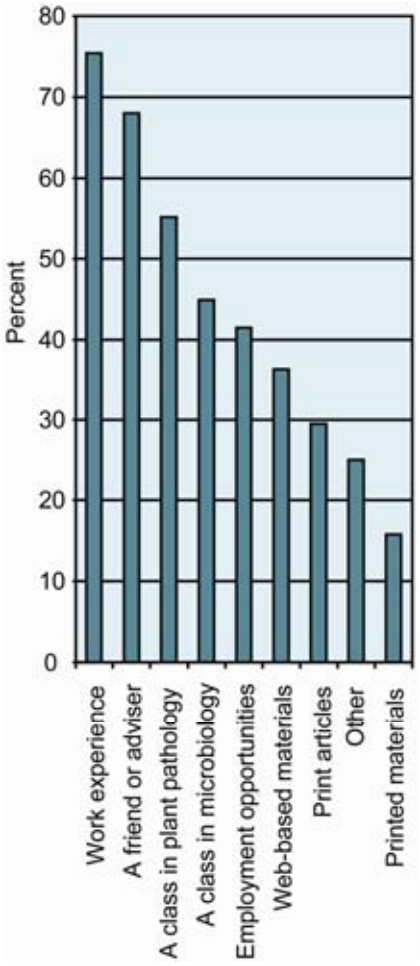

Fig. 1. Percentage of all students and postdocs who considered various factors (shown on the x-axis) to be highly influential (i.e., assigned a rating of 3 or 4 on a 0 to 4 scale) in their decision to pursue graduate studies in plant pathology.

funds." Many heads of graduate programs indicated the need for increased federal funding to support fundamental and translational research and also noted that grants drive research agendas and thus define the educational focus of students dependent on assistantship funds for support.

In addition to funding limitations, 60% of the heads of graduate programs identified the need for "More faculty in the area(s) of student interest" as an important constraint in student recruitment. Although this could indirectly relate to student funding opportunities, one program head stated "The number of faculty is below critical mass to provide a comprehensive graduate program," and another stated, "We are part of a merged department, and visibility of plant pathology is low."

Courses of instruction and student educational aspirations. The heads of graduate programs were asked to identify, from a supplied list, the courses that were required, highly recommended, optional, or not available for students in their graduate programs. The course selections were identified separately for M.S. and Ph.D. programs. The results showed that the lists of required plus highly recommended courses are virtually identical for M.S. and Ph.D. students (Fig. 3). The only substantive differences were in molecular biology, biochemistry/physiology, experimental design, and genetics, which were more frequently required or highly recommended for Ph.D. students. Within these data, approximately 40% of the responding graduate programs identified mycology, bacteriology, and virology as required courses for Ph.D. students, while 30 to 35% of the programs applied those requirements to M.S. students (data on required courses not shown separately). Courses in nematology, statistics, and professionalism were required for Ph.D. students at 30, 28, and 27% of the graduate programs, respectively (data not shown).

The five courses most commonly considered to be highly recommended for Ph.D. students included molecular biology, statistics, experimental design, virology, and biochemistry/physiology (61, 57, 57, 50, and 50% of responding institutions, respectively) (data not shown separately). The five most common courses highly recommended for M.S. students were statistics, virology, molecular biology, mycology, and bacteriology (57, 57, 54, 54, and 43% of responding institutions, respectively) (data not shown separately). Approximately 20% of the responding graduate programs indicated that they did not offer courses in epidemiology, nematology, or a course in crop diseases that included an in-the-field component (data not shown).

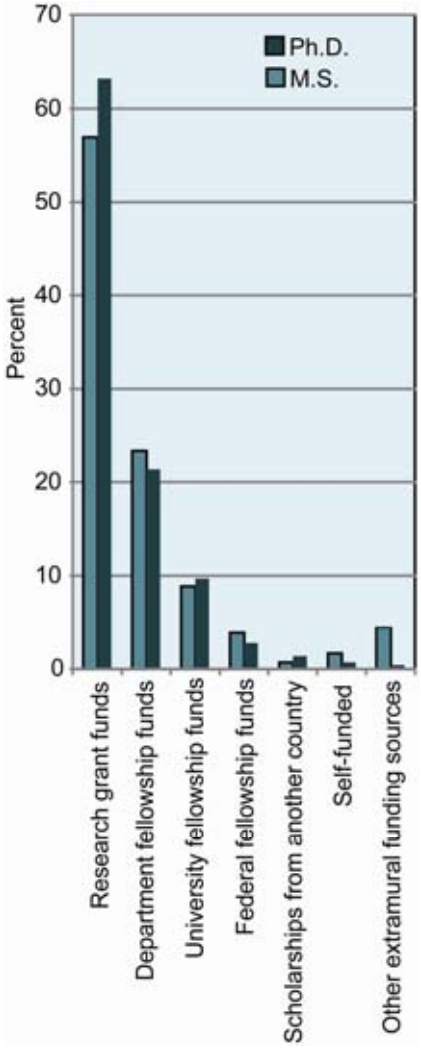

Fig. 2. Percentage of M.S. and Ph.D. students supported from various fund sources, as reported by the heads of responding graduate programs.

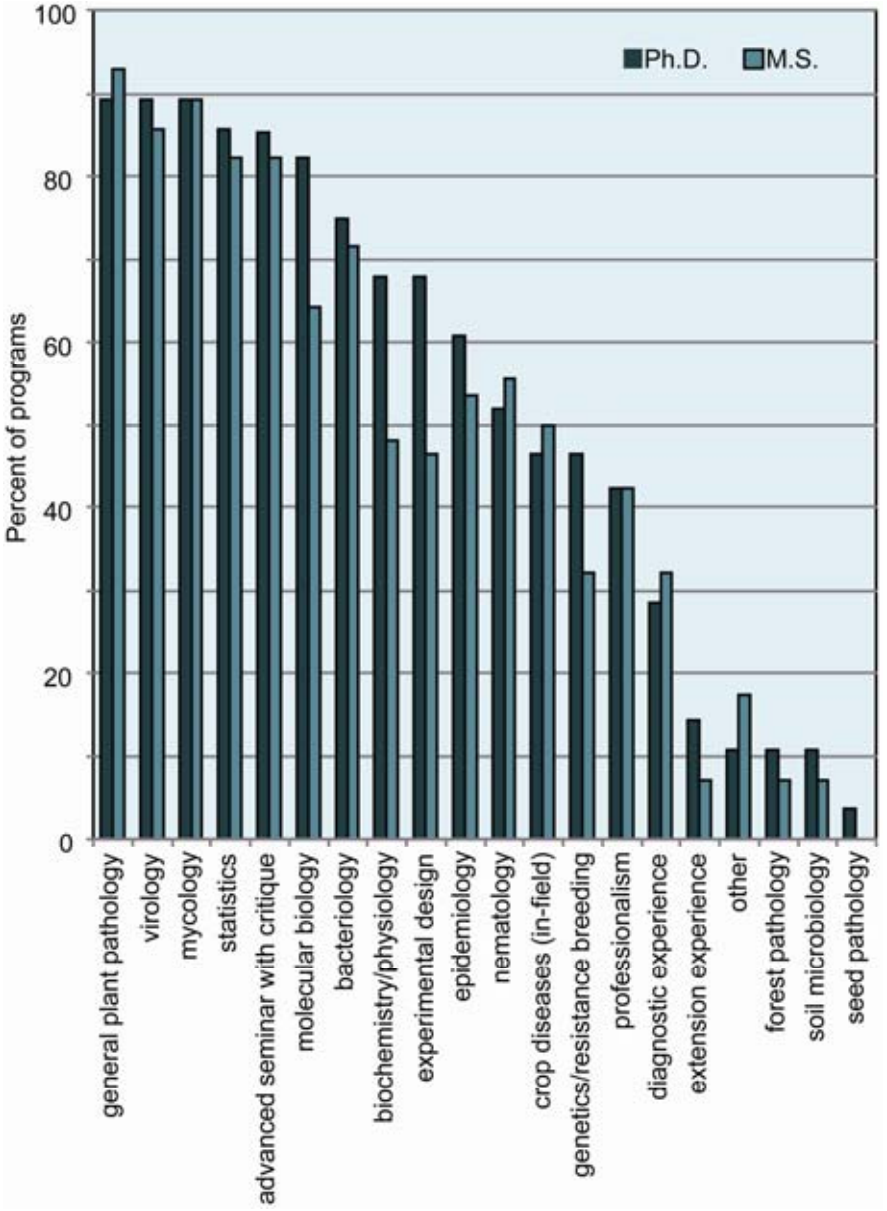

Fig. 3. Courses that graduate program heads indicated were either required or highly recommended for M.S. and Ph.D. students. Each bar represents the sum of the percentage of programs indicating courses were required plus the percentage of programs indicating courses were highly recommended.

When graduate students were asked about their career aspirations, the careers of highest interest (i.e., those receiving a rating of 3 or 4) to the greatest percentage of U.S. Ph.D. students were: "Scientist in a government agency" (82%), "International researcher" (e.g., CGIAR) (71%), "Faculty member at a major research university" (71%), "Research scientist in private industry" (62%), and "Cooperative extension specialist or advisor" (57%) (data not shown). Students studying for Ph.D. degrees outside the United States expressed strong interest (a rating of 3 or 4) in the same career areas, but by approximately 10% greater margins (data not shown). The aspirations of M.S. students were somewhat different, with the greatest percentages strongly favoring positions such as: "Scientist in a government agency" (80%), "Cooperative extension specialist or advisor" (75%), "Diagnostician" (67%), "Research scientist in private industry" (66%), and "International researcher" (e.g., CGIAR) (59%) (data not shown).

Almost 90% of the heads of graduate programs indicated that their programs provide students with strong preparation for careers as a "Faculty member at a major research university," a "Faculty member at a non-research university," and a "Scientist in a government agency" (data not shown). In addition, 85% felt that they provide strong preparation for a career as a "Cooperative extension specialist or advisor," and 82% felt they provide strong preparation for students interested in becoming a "Research scientist in private industry" or a "Research technician" (data not shown). The student views regarding career preparation were more conservative. For example, among U.S. Ph.D. students, 77% indicated they felt well-prepared (i.e., entered a rating of 3 or 4) for a career as a "Researcher at a major research university," which was 12% fewer than the responding program heads. Likewise, the percentages of U.S. Ph.D. students who feel well-prepared for careers as a "Faculty member at a non-research university," "Cooperative extension specialist or advisor," and "Research scientist in private industry" were 53, 70, and 66%, respectively (and 37, 15, and 16% fewer than the program head responses, respectively) (data not shown).

Using an unstructured response format, students were asked to identify the greatest "positive" they experienced while pursuing a graduate degree. Upon reading the many narrative responses to this question, a number of common themes emerged, which allowed the responses to be categorized and grouped according to similarity, and to determine the percentages of respondents holding similar opinions. Among the U.S. Ph.D. respondents, 23% identified "Independence/freedom" as the greatest positive, whereas half that percentage (or less) of the other responding cohorts identified that same feature (Table 1). Among U.S. Ph.D. and all M.S. students, 20 and 22%, respectively, identified "Broad training/experience" as positives, while only 13% of international Ph.D. and 12% of all postdocs did so. Almost 43% of the Ph.D. students studying in countries other than the United States identified "Personal growth" as the most positive aspect of their graduate training, which was double the level of other responding groups (Table 1).

To gain further insights, students were asked to identify what improvement could be made to enhance the graduate education experience. The responses were again characterized and grouped according to similarity. The aspect that most respondents identified for improvement was "Broader training/experience" (Table 2). Other frequently identified aspects included "Career preparation," "Coursework," and "Networking/collaboration" (Table 2). The latter factor was more frequently mentioned by Ph.D. students studying outside the United States, as was "Financial support" and "Faculty or faculty mentor" (Table 2).

In another question that allowed for an unstructured response, students and postdocs were asked to identify what they anticipated as "the biggest challenge in obtaining [their] desired position after graduate school." The greatest percentage (31%) of U.S. Ph.D. students gave responses that were grouped under the category of "Lack of available positions" (Table 3). However, this was not the dominant challenge identified by non-U.S. Ph.D. students or postdocs, who identified "Personal considerations" as their greatest challenge (40 and 42%, respectively) (Table 3). Among the M.S. students, approximately equal numbers identified "Position availability" (29%) and "Personal considerations" (33%) as the greatest challenges facing them in the job market (Table 3).

Concern over position availability was expressed in comments such as: "Lack of

Table 1. Percentage of students and postdocs who identified particular experiences as the greatest "positive" of their graduate experience[a]

Experience	U.S. Ph.D.	Intl. Ph.D.	M.S.	Postdoc
Teamwork	1	0	0	0
Teaching/communication	2	2	2	1
Resources/equipment/facilities	1	0	3	3
Personal growth	15	43	27	25
Networking/collaboration	13	11	22	18
International experiences	3	15	0	14
Independence/freedom	23	11	7	12
Importance of project	1	0	0	0
Financial support	0	0	0	0
Faculty or faculty mentor	10	2	15	10
Depth of training/experience	8	4	2	3
Coursework	3	0	2	3
Career preparation	0	0	0	0
Broad training/experience	20	13	22	12

[a] U.S. Ph.D. cohort consisted of all domestic and international students studying in a U.S.-based program. International Ph.D. cohort consisted of all students studying for their degree in a country other than the United States.

Table 2. Percentage of students and postdocs who identified particular experiences that could be improved for an even better graduate school experience[a]

Experience	U.S. Ph.D.	Intl. Ph.D.	M.S.	Postdoc
Teamwork	0	0	2	0
Teaching/communication	11	2	0	8
Resources/equipment/facilities	3	10	2	0
Personal growth	5	5	13	15
Networking/collaboration	9	19	4	11
International experiences	4	10	2	9
Independence/freedom	0	0	2	2
Importance of project	0	0	0	0
Financial support	5	14	6	6
Faculty or faculty mentor	5	12	4	2
Depth of training/experience	1	2	4	5
Coursework	12	10	19	2
Career preparation	20	2	9	20
Broader training/experience	27	14	34	22

[a] U.S. Ph.D. cohort consisted of all domestic and international students studying in a U.S.-based program. International Ph.D. cohort consisted of all students studying for their degree in a country other than the United States.

applied and/or extension positions at universities," "Too many graduates and few jobs," "Funding...lack of positions in plant pathology with a focus on plant pathology," "Job availability in my specific geographic location," "Competition, and finding a position that I will enjoy," and "My goal is to obtain a faculty position, but there are few of these positions…. There are probably other careers I would be satisfied with, but as a student, I had little guidance regarding careers outside academia, therefore, the biggest challenge is finding out what kinds positions are available."

The challenges grouped under "Personal considerations" were articulated as: "Finding a job in my area of interest that is in a geographic location acceptable to my family," "The availability of positions in locations that can also accommodate a career for my spouse," "Acquiring the additional skills I need to succeed in science and to stand above the tough competition," and "I came from China, therefore language, writing and speaking." These personal concerns, while real enough to the individuals, do not stand out as challenges that uniquely affect graduates in the field of plant pathology.

Other challenges mentioned by respondents included "Experience" (e.g., [to get a job as a faculty member] "I lack teaching experience" or [I need] "a post-doctoral fellowship in a bigger lab"), the challenge of acquiring "Help in locating positions" (e.g., "Finding out what positions exist outside of university research"), and the challenge of "Career preparation" (e.g., "I have sufficient knowledge of molecular techniques, but not enough for most positions that are available," or "Overspecialization in [my graduate] training").

Employer expectations. In the surveys of employers, we sought to identify the attributes most valued in applicants for positions, and whether the values placed on attributes might change over the next 10 years. To provide a context, employers were asked to identify the types of positions filled in recent years. For academic employers, the most commonly recruited positions were for "Post-doctoral researcher" (43%), "Research technician" (39%), and "Faculty member" (14%). For government employers, the most commonly filled positions were "Research technician" (28%), "Scientist" (23%), "Diagnostician" (18%), and "Post-doctoral researcher" (17%). For private sector employers, the most commonly filled positions were "Scientist" (42%) and "Research technician" (39%).

With respect to recent recruitments, employers were asked to rate the overall quality of applicant pools on a scale from "Very weak" to "Outstanding." Although most respondents (42%) rated applicant pools good (Fig. 4A), another 38% of respondents rated the applicant pools very good to outstanding. Only 20% of respondents rated applicant pools weak to very weak (Fig. 4A). On the other hand, when employers were asked to rate the overall quality of applicant pools on a scale from "Much better today" to "Much better 10 years ago," 43% responded that the applicant pools were somewhat to much better 10 years ago, and 35% felt they were about the same (Fig. 4B). Only 22% of respondents felt the plant pathology applicant pools were somewhat to much better today as compared to 10 years ago (Fig. 4B). The data shown in Figure 4 were calculated by summing the responses from all three employer groups. While they were generally reflective of the responses of each individual group, it was noted that the academic employer group was the only one that contained any ratings of "Much better today" (3% of respondents).

To determine what employers value, we asked them to identify, from a prepared list, the six most important attributes they look for in candidates. Among academic employers, the six attributes identified by the greatest percentage of employers were "Critical thinking" (78%), "Communication skills" (73%), "Ability to work in a team" (64%), "Ability to work independently" (58%), "Experience with molecular biology" (57%), and "In-depth knowledge of a particular subject" (51%) (Fig. 5A). Note that the most commonly recruited positions among academic employers are postdoctoral researchers and research technicians. Only 14% of the recruitments reported in this survey were for faculty positions at academic institutions, and for those, the six attributes identified by the greatest percentage of respondents were

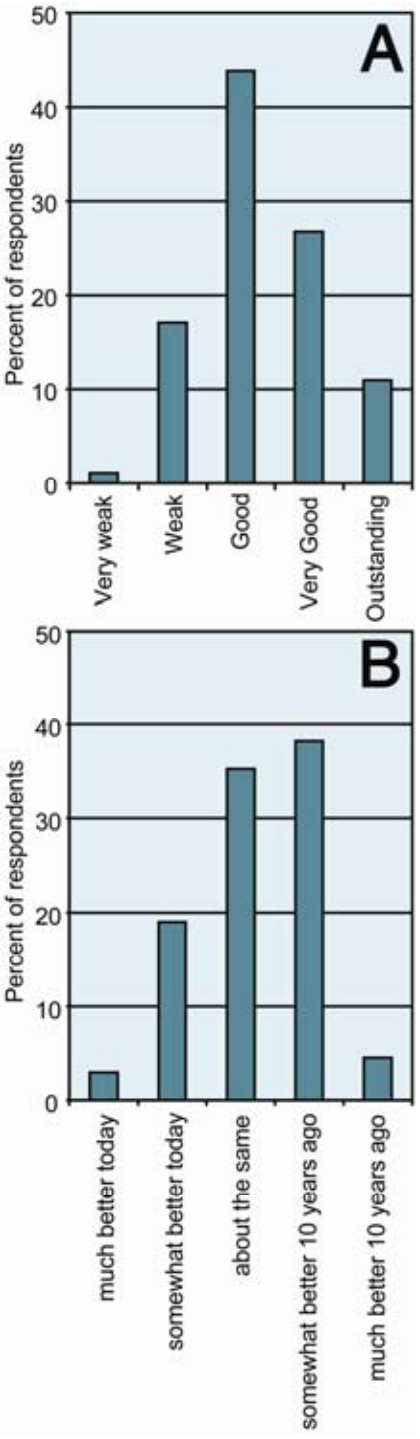

Fig. 4. Responses of employers to questions asking them to A, rate the overall quality of applicant pools today and B, compare the applicant pools of today with those of 10 years ago.

Table 3. Challenges perceived by students and postdocs with regard to obtaining their desired career position[a]

Anticipated challenge	U.S. Ph.D.	Non-U.S. Ph.D.	M.S.	Postdoc
Visa status	5	0	5	3
Preparation for desired positions	11	5	9	8
Personal considerations	15	41	33	43
Lack of available positions	31	16	30	23
Institutional issues	0	8	2	1
Getting help locating positions	15	16	9	8
Availability of grant funds	1	0	2	6
Financial concerns	2	3	2	1
Experience	16	5	9	6
No concerns	5	5	0	3

[a] U.S. Ph.D. cohort consisted of all domestic and international students studying in a U.S.-based program. International Ph.D. cohort consisted of all students studying for their degree in a country other than the U.S.

"Critical thinking" (92%), "Communication skills" (83%), "In-depth knowledge of a particular subject" (83%), "Ability to compete for grants" (67%), "Degree in plant pathology" (63%), and "Experience with molecular biology" (54%).

Among government employers, the six attributes identified by the greatest percentage of employers were "Experience with molecular biology" (79%), "Ability to work in a team" (72%), "Communication skills" (67%), "Critical thinking" (63%), "In-depth knowledge of a particular subject" (51%), and "The ability to work independently" (48%) (Fig. 5B). Note that government employers most commonly recruited for research technicians and scientists.

Among private-sector employers, the six attributes identified by the greatest percentage of employers were "The ability to work in a team" (100%), "Field experience with plant diseases" (56%), "The ability to work independently" (56%), "Broad knowledge of plant pathology" (50%), "Knowledge of crops and horticulture" (50%), and "Communication skills" (50%) (Fig. 5C). This ranking differed markedly from the academic and governmental employers, reflecting the different needs and mission of private-sector employers.

This same list of attributes was presented to employers in a follow-up question in which they were asked to project 10 years into the future and identify the skill sets that they are likely to seek in candidates. In this question, respondents were not limited to just six attributes, but could select from among the entire list. The results (Fig. 6) represent the percentage of respondents who identified each of the various attributes.

Among academic employers, the attributes identified by the greatest percentage (>80%) of respondents were "Communication skills," "Critical thinking," "Ability to work independently," "Ability to work in a team," and "Experience with molecular biology and biotechnology" (Fig. 6A). Among government employers, the attributes identified by the greatest percentage (>80%) of respondents were "Experience with molecular biology and biotechnology," "Ability to work in a team," "Communication skills," "Critical thinking," and "Field experience with plant diseases" (Fig. 6B). Among private sector employers, the attributes identified by the greatest percentage (>80%) of respondents were "Ability to work in a team," "Field experience with plant diseases," "Communication skills," "Broad knowledge of plant pathology," "Knowledge of crops/horticulture," "Critical thinking," "The ability to work independently," and "The ability to employ statistical analyses" (Fig. 6C).

With the exception of "Ability to employ statistical analyses" and "Grant writing" skills, there was a fair amount of commonality between academic and gov-

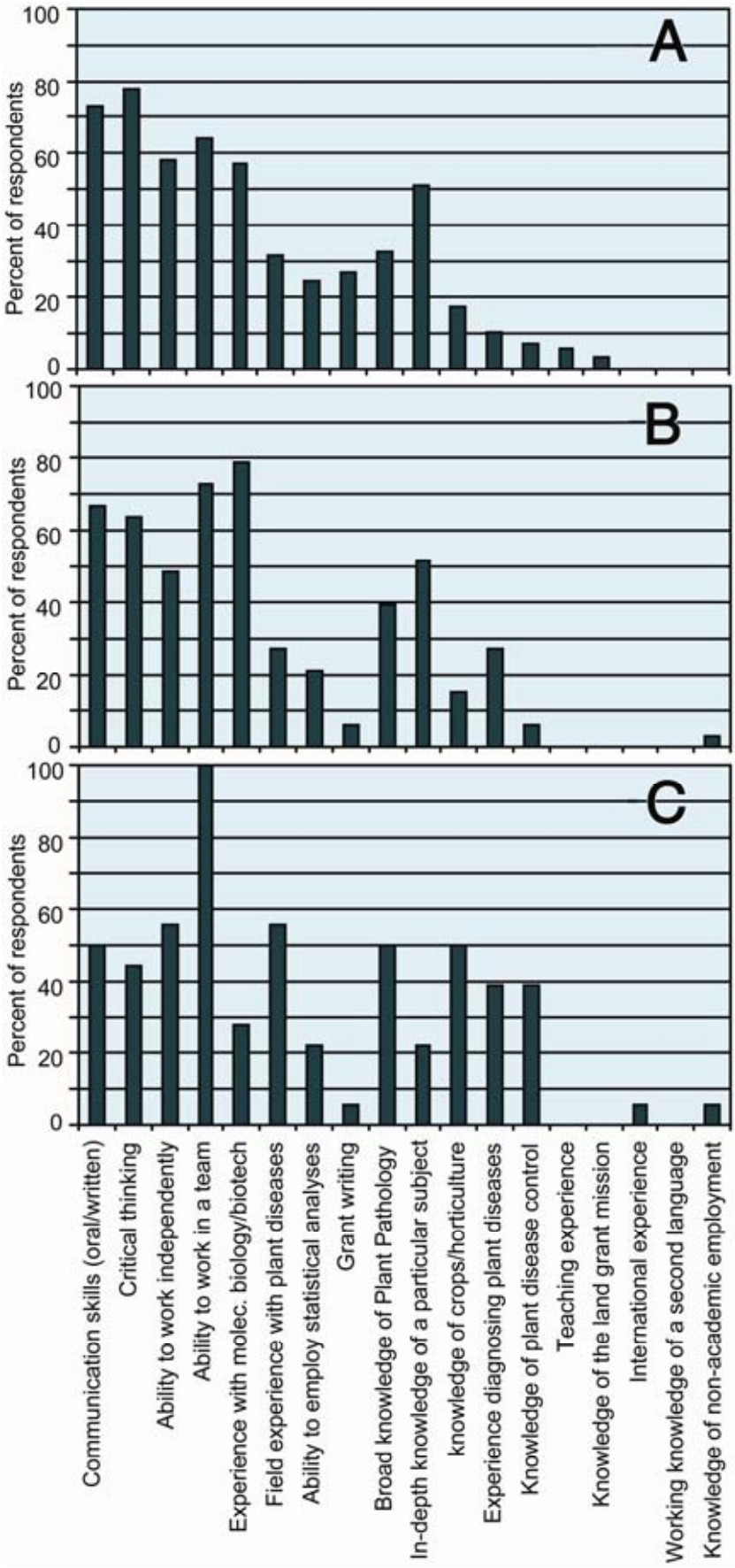

Fig. 5. Attributes of position applicants most highly valued by A, academic, B, government, and C, private sector employers. Respondents were asked to identify the top six attributes they look for in candidates for positions. Bar height indicates percentage of employers who identified each of the attributes among their top six.

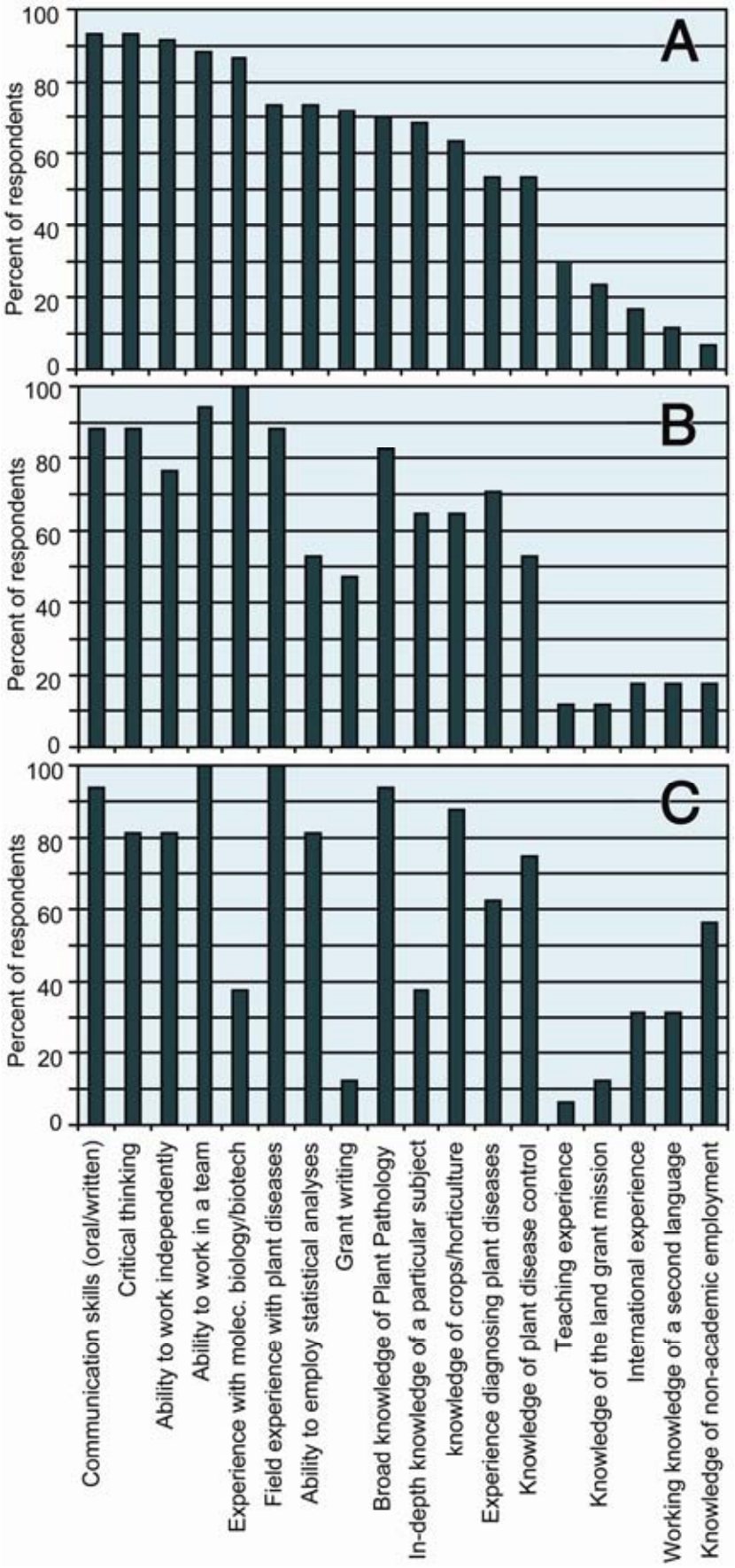

Fig. 6. Attributes that A, academic, B, government, and C, private sector employers anticipate seeking in employees over the next 10 years. Respondents were asked to identify all the attributes that they anticipate seeking. Bar height indicates percentage of respondents who identified each of the various attributes.

ernment employer respondents (Fig. 6A and B). A majority of all employers indicated that in the future, they are likely to seek "Field experience with plant diseases," "Broad knowledge of plant pathology," "Experience diagnosing plant diseases," and "Knowledge of plant disease control," although these attributes were identified by a greater percentage of private sector (Fig. 6C) and government (Fig. 6B) employers than by academic employers (Fig. 6A). These differences likely are due to the different types of positions most typically recruited by these employers (see above).

When asked to rate their confidence (on a scale of 0 to 4, where 0 = no confidence and 4 = high confidence) of finding future candidates with desired attributes, 65 to 90% of all respondents in the three employer groups expressed strong confidence (i.e., a rating of 3 to 4) that they could find candidates well-trained in "Molecular biology," "In-depth knowledge of a particular subject," "The ability to work independently," and "The ability to work in a team" (Table 4). Conversely, among academic employers, only 44, 35, 41, and 33% had strong confidence that they would be able to find candidates with "Knowledge of plant disease control," "Field experience with plant diseases," "Experience diagnosing plant diseases," and "Broad knowledge of plant pathology," respectively. Government employers were even more pessimistic, with only 22, 20, 15, and 33%, respectively, expressing confidence that they could find candidates with these same attributes. On the other hand, private-sector employers were marginally more optimistic, with 50, 44, 50, and 47% expressing confidence that they will be able to find candidates with "Knowledge of plant disease control," "Field experience with plant diseases," "Experience diagnosing plant diseases," and "Broad knowledge of plant pathology," respectively (Table 4).

In one open-ended question, employers were asked to identify "What improvements to plant pathology graduate degree programs would most help graduates meet the needs of your unit?" The resulting responses were categorized and sorted according to the topic(s) raised. Most respondents identified a single issue, although some identified two or even three. In such cases, each mentioned issue was categorized independently.

Upon categorizing and sorting the responses, it became clear that the improvement most commonly identified (representing 60% of all responses, data not shown) was "broad training" of students. This need was expressed in statements such as: "Broad knowledge of agriculture and an understanding of field-based realities, such that basic research can be conducted appropriately, would be a great help," "Strong background in general plant

pathology in addition to specialization," "Trained better in mycology (broader knowledge of many fungi, not only the subject of their research), virology, bacteriology, and epidemiology of diseases," "Broad training in plant pathology integrating both practical and basic aspects," "Broader exposure to more traditional aspects of plant pathology, such as knowledge of the organisms—most are too narrowly trained," and "Broader training in concepts of plant pathology and more in-depth exposure to practical aspects of plant pathology (e.g., disease diagnosis and control)."

The next most commonly mentioned area of improvement in plant pathology graduate degree programs (comprising 15% of all topics identified, data not shown) was actually related to the aforementioned topic and was categorized as "Practicality/field experience." This need was expressed in comments such as: "Field experience and knowledge of disease control methods," "Have field experience in addition to the laboratory bench science," "Keep one foot in the furrow, please!" and "Provide diagnosis training and ability to do field work."

The third most commonly mentioned area of improvement (comprising 12% of all topics identified, data not shown) was categorized as "Communication skills," and was expressed in comments such as: "I would like to see more emphasis placed on technical communication and data analysis," "Greater emphasis on communication skills and working within interdisciplinary teams," and "Good communication skills cannot be emphasized enough. These are critical to both advancing research programs and team performance." Other potential improvements to graduate programs mentioned to lesser extents by academic, government, and private sector employers were "Teamwork," "More professional/leadership development," "Grant preparation experience," "Critical thinking skills," "Coursework enhancements," "Skills in basic science/technology," "International training," and "Recruitment programs to attract students."

Potential educational vulnerabilities. To assess the current and projected capability of U.S.-based plant pathology programs to deliver their curricula, the heads of graduate programs were asked to identify areas of expertise currently existing among their respective faculties. The areas of expertise were presented as both crop-based (e.g., cereals, small fruits) and discipline based (e.g., mycology, nematology), and were the same crop and discipline specialties currently used in the APS membership database to classify member expertise. After identifying the current areas of expertise, the program heads then were asked to identify those areas where there was concern about sustaining expertise over the next 10 years.

The responses to these two questions are summarized in Figure 7 and show, for example, that 16 of the 28 responding programs (57%) reported a specialization in "Diseases of forest trees" (Fig. 7A). Of those 16 programs, 62% (i.e., 10 of the programs) indicated a high degree of concern regarding their ability to sustain that specialization over the next 10 years (Fig. 7A). Likewise, 55% of the programs that have specialties in "Ornamental/shade tree diseases," 46% with specialties in "Fruit tree diseases," 44% with specialties in "Vegetable crops," and 42% of those with specialties in "Nursery/ornamental crops" expressed high degrees of concern with regard to sustaining those specializations in the future. Only "Forage crops" and "Root crops" evoked levels of concern that were <30%, with only 20 and 25% of current programs expressing concern, respectively (Fig. 7A).

Among disciplinary areas, 75% (i.e., 21 of 28) of the responding programs reported having specialized expertise in "Bacteriology," and of those, 48% (i.e., 10 of the 21) expressed a high degree of concern regarding their ability to sustain the specialization into the future (Fig. 7B). Similarly, among the programs currently offering specializations in "Forest pathology," "Biochemistry/physiology," and "Virology," a total of 43, 42, and 41% expressed a high degree of concern about sustaining them into the future. The only specialization with a level of concern <30% was "Molecular biology" at 19% (i.e., with only 5 out of the 27 current programs expressing a high degree of concern) (Fig. 7B).

When the heads of graduate programs were asked in an unstructured format to describe the nature of their concerns with regard to sustaining areas of expertise, 18 of the 28 responded, and their responses fell into two general themes. Approximately half indicated that for vacated positions, permission to recruit for new faculty was either slow to come, or did not come at all. The other program chairs indicated that their main difficulty was finding well-qualified individuals. As one respondent stated, there was a "lack of enough trained people to fill the need." Some of this sentiment appeared to reflect reluctance on the part of faculty to hire in certain areas (e.g., "Commodity based pathology is increasingly difficult to support"), which seemed to blend with a desire to recruit individuals having a particular and apparently hard-to-find mix of attributes (e.g., [It is difficult to] "find well-qualified individuals with sufficient interest to cover the area in question while also having the inclination and ability to sustain a fundamental, federally-funded research program").

In addition to the plant pathology specializations described above, the heads of graduate programs were asked to rank the overall importance of various attributes of graduate student training (the same attributes employers ranked, see Figures 5 and 6), and then to estimate their current and future (10-year horizon) ability to equip students with those attributes. Relative to present capability, an additional 19% of the graduate programs estimated that they will be well equipped (i.e., responded with a rating of 3 to 4) to prepare students with "Grant writing skills" in the future (Table 5). Likewise, an additional 15, 12, and 12% of programs estimated that in the future they will be well equipped to offer "International experience," "Advanced instrumentation experience," and "The ability to employ statistical analyses to experiments," respectively (Table 5).

On the other hand, relative to current capability, 31% fewer graduate programs

Table 4. Percentage of academic, government, and private-sector employers with a high degree of confidence (i.e., a rating of 3 or 4 on a scale of 0 to 4) that they will be successful in finding top-quality candidates with the listed attributes

	Employment sector		
Attribute	**Academic**	**Government**	**Private**
Experience with molec. biology/biotech	94	76	80
Ability to work independently	73	80	87
Ability to work in a team	73	76	75
In-depth knowledge of a particular subject	67	64	89
Ability to employ statistical analyses	60	50	62
Communication skills (oral/written)	58	47	60
Critical thinking	51	53	57
Working knowledge of a second language	45	40	14
Knowledge of crops/horticulture	45	25	67
Knowledge of plant disease control	44	22	50
International experience	42	60	14
Experience diagnosing plant diseases	41	15	50
Knowledge of non-academic employment	40	0	44
Grant writing	37	33	38
Field experience with plant diseases	35	20	44
Teaching experience	33	33	29
Broad knowledge of plant pathology	33	33	47
Knowledge of the land grant mission	29	33	29

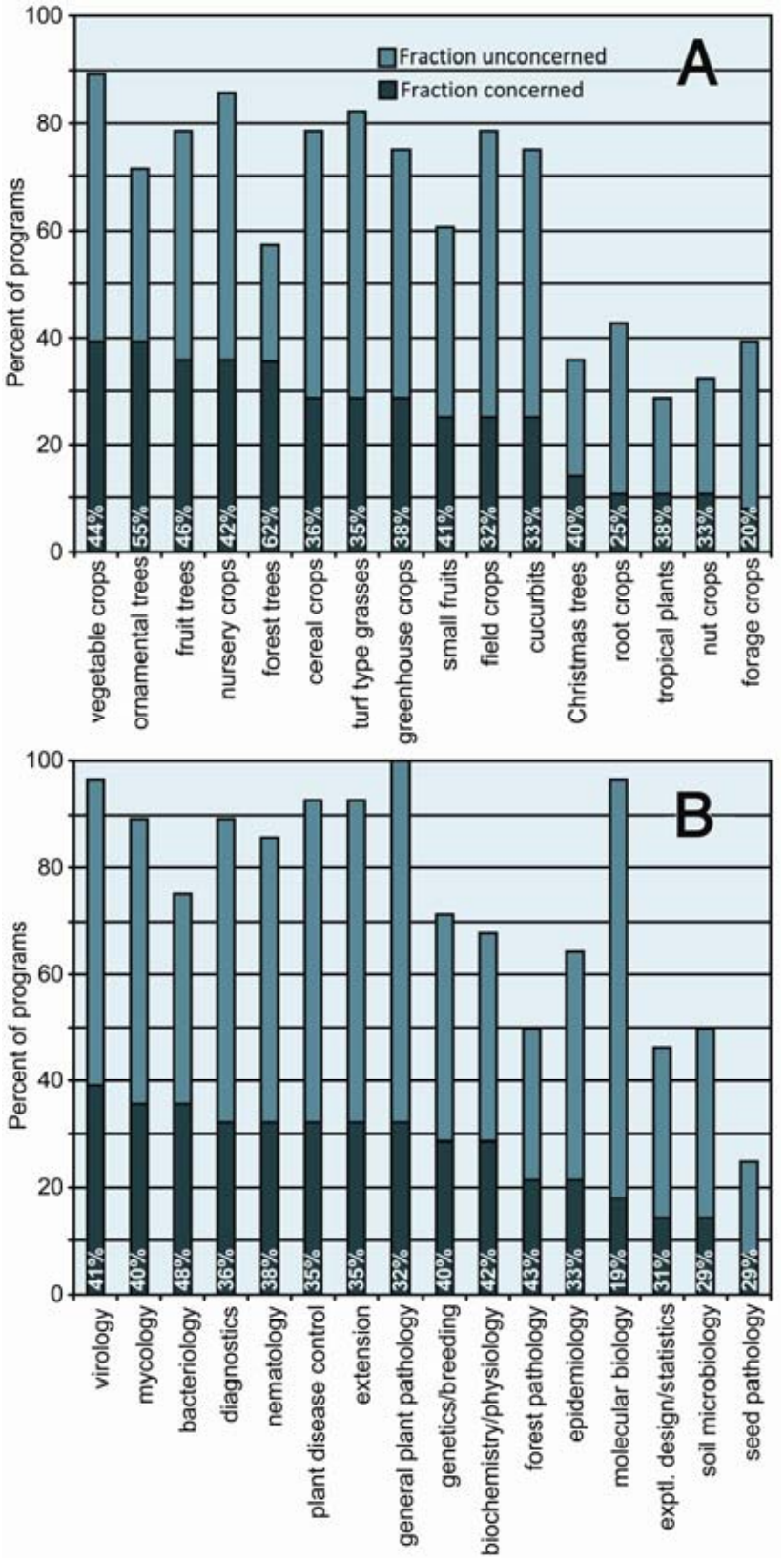

Fig. 7. Current crop (A) and subject matter (B) specializations within graduate programs. Total bar height (dark + light) indicates percentage of graduate programs (out of 28 respondents) that currently have expertise in the indicated specializations. Height of dark bars indicates percentage of graduate programs that expressed significant concern (a rating of 3 or 4 on a scale of 0 to 4) with regard to sustaining those specializations over the next decade. Height of light bars indicates percentage of graduate programs that expressed little to no concern (a rating of 0 to 2). White numbers in dark bars indicate percentage of total bar height taken up by the lower element (i.e., percentage of those programs possessing a particular specialization that are concerned about their continuing ability to do so).

estimate that they will be well equipped in the future to provide students with "Knowledge of plant disease control" (Table 5). Similarly, 16, 31, and 12% fewer graduate programs estimate that they will be well equipped to provide students "Field experience with plant diseases," "Knowledge of plant disease control," and "Broad knowledge of plant pathology," respectively (Table 5).

This sense of reduced educational capability may underlie the responses of graduate program heads to a series of statements to which they were asked to indicate their level of agreement on a Likert scale from "strongly agree" to "strongly disagree" (Table 6). Just over 80% of the program heads agreed strongly or moderately (and none disagreed) with the statement that "There will be fewer free-standing plant pathology departments in the future" (Table 6). This may be reflective of the concerns expressed by some graduate program heads (quoted above) regarding their inability to refill vacated positions, possibly leading over time to pressures for merger with other programs. Indeed, the extent to which department mergers occurred from 1975 to 2008 recently was documented in a survey by Ray Martyn during his year as APS president (2007–2008). He surveyed departments that housed plant pathology at 1862 Land Grant universities and found that the number of "free-standing" plant pathology departments decreased from 29 to 16 between 1975 and 2008 (*personal communication*). Most of those lost as free-standing departments were combined with other units so that they became "Department of Entomology and Plant Pathology" or some similar name combination. However, some departments merged with other units such that plant pathology no longer appears in the department name (e.g., "Department of Plant and Microbial Biology"). Indeed, Martyn found that from 1975 to 2008, there was a fourfold increase in the number of departments (from 4 to 16) that underwent name changes in which plant pathology was dropped from the department name (*personal communication*).

One potential impact of such mergers is on the vitality of graduate programs. There was a mix of views among the graduate program heads regarding the statement "Plant pathology graduate programs can thrive in combined departments," with 33% registering strong to moderate disagreement and 44% registering moderate to strong agreement (Table 6). However, the survey data of Martyn showed that during the period of 1975 to 2008, as department mergers occurred, there was a concomitant 17% decrease (from 42 to 35) in the number of plant pathology degree programs in the United States (*personal communication*). Gadoury et al. (5) associated the mergers of departments and the disappearance of "plant pathology" from

department names with the nearly complete loss of undergraduate and graduate training in plant pathology in the New England states between 1980 and 2008.

With regard to other statements presented to the graduate program heads, approximately 78 and 70% agreed moderately to strongly with the statements "Career opportunities for specialists in plant pathology appear bright" and "The future of fundamental plant pathology research looks bright," respectively (Table 6). Although the program heads generally agreed, they expressed their agreement much less strongly in response to the statements "Career opportunities for generalists in plant pathology appear bright," "The future of applied plant pathology research looks bright," and "The future of extension plant pathology looks bright" (Table 6). These less positive responses may relate to concerns about anticipated loss of certain expertise in graduate programs (Table 5) or the concerns (quoted above) about the availability of funding to support field- or commodity-based research programs.

What respondents would like to see from APS. Each of the surveyed groups (students/postdocs, program heads, and employers) was asked to identify what roles, if any, they felt APS should play in the education arena. Each group identified different roles for APS that tended to connect back to their core concerns. For example, the roles identified by graduate program heads tended to be more along the lines of practical experience and resources. This was evident when they were asked to indicate their level of agreement with a series of statements. For example, to the statement "APS should work with industry to create internship experiences [for students]," 96% of the program heads indicated moderate to strong agreement and none indicated disagreement (data not shown). Likewise, 81 and 78% of the program heads indicated moderate to strong agreement with the statements "APS should seek endowments to support graduate education in plant pathology" and "APS should seek Federal support for graduate education in plant pathology," respectively (data not shown).

The responses of students and postdocs were to a more unstructured question, but generally could be described as looking to APS for help in networking and career guidance. In the words of some of the respondents: "I think APS could offer more guidance to students who wish to pursue non-research aspects of plant pathology in the industry and the government," "I think APS could be an outlet for students to get a broader perspective of what is available. Unfortunately, my university pushes for high-profile faculty research positions, and frowns at all else," "I think attending meetings and getting to know others in the field will help me better understand the various types of careers available to someone with my degree," "Career development workshops at the annual meetings could help," and "I look to APS to help me identify and connect with potential employers, as well as to keep me up to date on current issues in plant pathology that are outside of my area of specialization." Other comments from students and postdocs that fell outside these two general themes included: "APS should request the US government to increase the H1-B visa quotas for the people who obtained their degree in the US," "APS is too narrowed down to American schools and opportunities. It needs to expand rapidly internationally," "[I appreciate that APS] allowed Doctor of Plant Medicine students to receive travel grants to come to meetings to discuss the program and its benefits," and "I think APS should take a stronger stand for applied research. Most research today is focused on molecular aspects. Applied research is still needed and I think many universities don't realize that yet. APS could provide information to the universities on the importance of applied research."

Several themes also emerged from the responses of employers, and these were grouped based on their similarity. One theme, identified by 23% of the respondents, was that APS should seek to influ-

Table 5. Percentage of responding graduate program heads who regarded various educational attributes as very important (i.e., a rating of 3 or 4 on a scale of 0 to 4) for Ph.D. students, compared to the percentage of programs that reported they were well-equipped to provide those attributes now, and the percent feeling they will be well-equipped provide those attributes 10 years into the future

		Ability to provide	
Educational attribute	**Importance**	**Now**	**Future**
Critical thinking	100	77	85
Communication skills (oral and written)	100	85	88
The tools of molecular biology/biotechnology	100	96	96
Grant writing	96	54	73
In-depth knowledge of a particular aspect of plant pathology	96	100	92
Ability to work independently	93	92	96
Ability to employ statistical analysis in experiments	89	69	81
Ability to work in a team	82	81	81
Advanced instrumentation	82	69	81
Teaching experience	79	65	73
Broad knowledge of plant pathology	79	72	60
Field experience with plant diseases	79	81	65
Knowledge of plant disease control	71	73	42
Experience diagnosing plant diseases	68	77	73
Knowledge of crops/horticulture	54	65	52
Knowledge of non-academic employment (e.g., industry)	46	42	46
Knowledge of the mission of Land Grant universities	29	64	64
International experience	25	27	42
Working knowledge of a second language	7	15	19

Table 6. Percentage of graduate program heads who indicated varying levels of agreement with each statement, with +2 indicating strong agreement, –2 indicating strong disagreement, and 0 indicating neutrality

	Percent respondents				
Statement	**+2**	**+1**	**0**	**–1**	**–2**
There will be fewer free-standing plant pathology departments in the future	41	41	19	0	0
Plant pathology graduate programs can thrive in combined departments	22	22	22	19	15
The future of fundamental plant pathology research looks bright	37	33	22	7	0
The future of applied plant pathology research looks bright	30	26	33	7	4
The future of extension plant pathology looks bright	19	26	44	7	4
The career opportunities for specialists in plant pathology looks bright	22	56	15	4	4
The career opportunities for generalists in plant pathology looks bright	11	48	30	7	4
Industry should play a greater role in graduate education	44	30	19	7	0

ence education. The methods proposed included: "Stimulate or even host debates on graduate curriculum that will meet future needs," "Informal accreditation to assess quality of training received at each institution," "APS should help to formulate and direct plant pathology programs in an advisory capacity," and "APS needs to provide reasons and incentives to emphasize the teaching of classical plant pathology skills such as taxonomy and microbiology. While molecular technology is an important research and diagnostic tool, it should augment, not replace the classical tools. Our collective knowledge of classical plant pathology is leaking, draining away, without being replaced in new students."

Another 22% of employers felt that APS's role should be to influence national policy. These comments included: "Increase advocacy within federal and state agencies regulating grant funding and other programs that finance degree programs," "Lobby funding sources to direct more funds towards traditional plant path problems," "It is critical that the public and the lawmakers understand the impact of plant diseases on our food supply and economy," and "Some of the elite ruling class of APS have pushed for funding narrow fundamental research and are thus a part of the problem."

The third major area of response, called out by 20% of responding employers, fit under the category of professional development. Comments under this category included: "Provide forums for basic areas of plant pathology, e.g., disease control, variety development, cultural control, crop-specific and disease-specific meetings and workshops," "Continue offering workshops directed to young professionals to increase their skill range," and "Holding workshops on professional development (communication skills, grant writing, working in teams)."

One role for APS mentioned by 10% of the respondents was that of trend-monitoring. This was expressed in comments such as "APS is in a key position to be able to monitor national needs, trends, and the plant pathology 'climate' to anticipate and prepare for these changes," and "Track and report decline trends in plant pathology education, training of domestic students, providing support for public policy and lobbying."

In addition to specific roles that APS might assume, many respondents offered general comments about the future of plant pathology. For example, one graduate program head stated "If you want to see what will happen in much of the country in the next 10 years, take a look at what has happened in New England over the last 10 to 15. There is a general lack of interest in botany and the applied plant sciences in most academic institutions." Another commented "Critical to the future health of plant pathology are: 1) increased federal funding for fundamental and translational research (something on the NIH model) and 2) a greater awareness of the opportunities in plant pathology among undergraduate students interested in science."

One employer from the academic sector commented that "In the past 20-25 years, the focus in plant pathology education shifted from basic and applied science to molecular biology. While molecular biology and the associated techniques present a valuable tool for working in our field, too much emphasis has been placed in this area. We are no longer a profession of applied scientists. Too few plant pathologists are really capable of diagnosing and managing plant diseases. We need to balance the applied science with modern techniques so that we can effectively help to reduce the impact and severity of diseases - worldwide." Another employer, from the government sector, commented that "Graduates have become so focused and dependent on molecular technology that they no longer have the ability to see the big picture and efficiently analyze or diagnose plant problems. They must start from scratch in new positions, even as new PhDs because they no longer have the skills or knowledge of advanced mycology, bacteriology, virology, and nematology," and another stated "I am very worried about the ability of departments to provide broad-based training in plant pathology in all pathogen groups - over the last 15 years, many departments have lost the critical mass to do this. I would say there are only 10 departments in the country that can do this."

Among private sector employers, we received comments such as: "While basic research is important to advance agriculture in the U.S., students need to be aware that the purpose of the education is to advance society, not just advance knowledge for its own sake," "Plant pathologists, even those who plan a career in the lab, need to see the diseases in the 'real world' in order to understand their biology. We are in danger of becoming technologists rather than biologists," and "APS should not only focus on graduate education but on undergraduate plant pathology education. Many of our positions are entry level positions and there are no candidates that have more than a single plant pathology course (if that) applying for positions. Most candidates for our positions have BS degrees in horticulture but we want some working knowledge of plant pathogen/host interactions."

Conclusions

In recent years, APS members have expressed concerns regarding the loss of field-oriented expertise in departments, reduced funding to support students, reduced support for applied or field-oriented research, and a narrow skill set in applicants for positions. These concerns have surfaced through a variety of venues, such as comments in the biennial membership survey. Although APS leaders have been aware of the concerns, the scattered and anecdotal nature of their expression has made it difficult to adequately characterize or act upon them. It was for this reason that the ad hoc Committee on the Future Education of Plant Pathologists was formed, and the surveys reported here represent the first comprehensive examination of this topic within APS. The 27 to 57% response rates are considered reflective of a highly engaged and motivated population, and will provide a much-needed baseline for future reference. The data also illustrate some very clear challenges that need to be addressed.

In the surveys, some respondents urged APS to do more to increase student interest in plant pathology (e.g., "APS should play a more active role in recruiting new graduate students"). However, the student/postdoctoral survey indicated that two of the three most important factors that attract undergraduate students toward graduate studies in plant pathology are largely under the control of plant pathology faculty: giving students a work experience in plant pathology and exposing students to a class in plant pathology (Fig. 1). These findings closely resemble those of an earlier survey of graduate students carried out in 2005–2006 (D. Gadoury, *unpublished*), and argue that the ability to interest students in plant pathology largely resides in academic departments. Thus, departments need to pay a great deal of attention to the quality of these experiences so that they are effective recruitment vehicles. If this could be coordinated on a national level, departments could significantly increase undergraduate exposure to plant pathology and likely increase the overall pool of students interested in plant pathology graduate studies.

A challenge overarching that of capturing student interest in plant pathology is the growing challenge of finding students to attract in the first place. In reality, plant pathology can only hope to attract a subset of those college students who generally are interested in the plant, molecular, and microbial sciences, and therefore are seeking relevant work experiences and classes. However, in the past two decades, there has been a decline in the numbers of students enrolled in plant science–related majors in the United States (1,10), which has had the concomitant effect of reducing the total number of undergraduate students who might be exposed to plant pathology through work or classroom experiences.

Decreased student interest in the plant sciences may grow as an area of concern for graduate programs; however, the greatest concern currently, as expressed by the program heads, is financial. In response to a question regarding the constraints that

need to be overcome for their programs to have greater success in student recruitment, over 80% of the program heads indicated "Greater capability of student support." Our survey data showed a heavy reliance on grant funds to support students (Fig. 2), and when this fact is coupled with the statements of graduate program heads that extramural funds are increasingly difficult to obtain, it explains why the heads feel constrained with regard to student support.

The reliance on grant funds to support students (Fig. 2) and the competitive nature of those funds may be a factor in the perception of employers that many graduates lack sufficient breadth of training (see quotes above). One obvious hypothesis to explain this is that faculty mentors and supported students feel pressured to accomplish their specific research project objectives in order to improve their chances of continuation funding, since it often takes more than a single grant cycle for students to complete advanced degrees. This focused effort may be a factor contributing to the high level of confidence among employers that they will be able to find future employees with an in-depth knowledge of a particular subject, and their lesser confidence about finding future employees with a broad knowledge across many subjects (Table 4).

It is not possible to carefully compare the coursework expectations of today (Fig. 3) with those of 30 years ago (11)—even discounting the significant differences in specific course content as a result of advances in knowledge and technology over the past 30 years. It was puzzling, however, that nearly 80% of graduate program heads considered "Field experience with plant diseases" an important feature of graduate education (Table 5), while ≤50% of the programs included an "in-field" experience with crop diseases among the courses required or recommended for students (Fig. 3). Because 20% of the responding programs indicated they did not offer such a course (data not shown), the implication is that approximately 30% of the programs that do offer such a course do not include it among coursework expectations for their students.

It also was interesting to note that among the skill sets that many employers feel will be in demand (Fig. 6) are skills (e.g., "Field experience with plant diseases," "Knowledge of disease control," and "Broad knowledge of plant pathology") that fewer graduate programs feel they will be prepared to offer in the future (Table 5). This may explain the pessimism expressed by employers with regard to finding applicants with these attributes (Table 4). And while it could be argued that the pessimism among academic employers represents a feedback loop caused by concern for these aspects of their own curricula, there is no self-reinforcement loop to explain the pessimism of government and private sector employers (Table 4). Clearly, there has been some erosion of confidence in the ability of graduate programs to expose students to certain educational elements valued by employers.

This erosion of confidence also appears to be reflected in the responses of graduate program heads, many of whom felt that there will be fewer free-standing departments in the future, and some of whom expressed a view that plant pathology programs do not thrive in mixed departments (Table 6). It also may explain the numbers of graduate programs that lacked confidence with regard to maintaining certain elements of their curriculum into the future (Fig. 7).

While there may be an element of bias in some responses from the graduate program heads due to their roles as defenders and promoters of their programs, the gap between the projected needs of employers (Fig. 6) and what graduate programs feel confident they can provide in the future (Table 5) probably is real because it already is a growing concern in the minds of employers. This developing gap should be a concern to U.S. agricultural and natural resource interests because the ability of university, government, and private sector entities to successfully research and manage endemic or invasive plant diseases depends upon the continuing ability of agricultural colleges and universities across the United States to prepare students with a strong knowledge of plant pathology and application of that knowledge to the challenge of disease management. However, the historic strength of this vital feeder system is at risk—such that plant pathology seemingly is standing at a very important tipping point in its history. And the challenge is very different from the growing "tower of Babel" noted 45 years ago by J. C. Walker (16), which was a reference to emerging subdisciplines within plant pathology, each having unique terminologies and technologies, and which raised fears of disciplinary fragmentation. Today's challenge also differs from the professional dichotomy noted 50 years ago by J. G. Horsfall (7), who subsequently argued for two types of terminal degrees in plant pathology: one as a scientist (the Ph.D.) and one as a practitioner (analogous to a medical doctor). The challenge now approaching seems to be one of shrinking educational capacity in the field-related aspects of plant pathology. Thus, the concern is not about differing jargons (16) or whether there should be two types of degrees (7), but rather it is about the continuing ability of plant pathology programs to prepare students for the mission of disease management, the raison d'être for the discipline of plant pathology. This concern becomes particularly acute when considered in light of the fact that plant pathology is rapidly approaching a period that will see many talented and experienced faculty members retire from universities over a relatively brief span of time (5). In many cases, the people lost from universities will be the very people best able to educate and mentor the broadly trained plant pathologists who employers perceive to be in shrinking supply. This is an issue deserving serious attention.

It seems important to keep in mind that the demographic and educational capacity challenges reported here are not unique to plant pathology—they are shared by a number of other fields of research and education in the nation's system of Land Grant Colleges of Agriculture. Similar concerns have been expressed in, for example, plant breeding (6) and crop science (2), and recently stimulated the American Society of Horticultural Science and the International Society of Horticultural Science to establish a joint task force on the "Future of Horticultural Science." Compounding the problems of eroding capacity in graduate education is the growing challenge of even attracting talented undergraduate students into the plant sciences (1,10).

Although there clearly are challenges facing plant pathology and many other agriculturally related disciplines, it seems important to keep these issues in some perspective. One has only to read the many historical articles and perspectives related to plant pathology to realize that almost as soon as the American Phytopathological Society was founded in 1908, people speculated about the demise of plant pathology as a distinct discipline. Indeed, plant pathology has weathered earlier episodes of disciplinary erosion and inadequate research support (8), and while the challenges we face (in terms of loss of faculty expertise, lack of undergraduate students interested in the plant sciences, etc.) seem daunting, we should remember the words of W. C. Snyder (15) when he said in 1971, "Today the sciences, including plant pathology, and even the universities are in trouble. Troubled times are continuous and current troubles always seem the most severe."

There are a number of potential actions that emerge from this survey effort. One occurred in March 2009, when APS hosted a workshop that brought together representatives of nine professional societies related to the plant sciences, as well as a sampling of government and private sector employers and department heads, for the purpose of discussing these issues and developing strategies for working together to address them. A complete summary of this workshop is available on APS*net* at http://www.apsnet.org/online/proceedings/Education_Workshop/. This workshop has stimulated discussions within APS and related professional societies about collaborative efforts that would seek to increase student awareness of the plant sci-

ences, increase funding opportunities for translational research, increase student financial aid to support those with broad interests, and a variety of other strategies appropriate for professional organizations and employers to engage in. Actions that can be taken now at the level of individual departments include maximizing the opportunities for undergraduate students to have positive exposures to plant pathology through work experience and/or introductory classes. The survey also indicates the importance of recruiting faculty members who can carry out competitive research programs while also enriching a depart-


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ment's ability to provide field experiences for students. Finally, APS and its related societies need to continuously work to keep the importance of agricultural research in front of federal and state decision makers, and to monitor trends and provide departments and government agencies with the best possible data regarding nationwide educational trends and the skills being sought by employers.

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