As a professional society of physiologists involved in research and teaching, the American Physiological Society (APS) is "...devoted to fostering education, scientific research, and the dissemination of information in the physiological sciences." Established long-range goals for education guide the development of current and future programs at all education levels. K–12 outreach programs develop working relationships between physiologists and K–12 teachers within local communities and improve the quality of precollege science education. At the undergraduate level, APS programs foster excellence in physiology education and promote student interest in physiology careers. At the graduate level, activities promote excellence in graduate training and the professional development of students, including a focus on underrepresented groups. At each of these levels, the Society includes activities for the continuing education of its members. Looking to the future, the Society plans to expand the programs and resources offered to researchers and educators at all levels. On-line programs, resources, and communications have been initiated and will play an even more important role in the future.

Key words: precollege science education; undergraduate science education; graduate education; continuing education; on-line resources

A 2nd grader’s eyes widen with surprise as she blows through a straw into an inverted, water-filled plastic jug to measure her lungs’ vital capacity. She is amazed that her lungs hold so much air.

A middle school student notes that his lab partner’s pupils contract when he shines a small light in her eyes during their experiment on reflexes.

A high school science teacher decides to incorporate two inquiry-based activities into her Biology I curriculum to promote the development of her students’ experimental design skills.

A community college faculty member reads an issue of Science. He wishes he better understood the biomedical research methods used so he could explain the results to his students.

An undergraduate student searches the Internet for information on cardiovascular and respiratory responses to exercise and finds graphs, color illustrations, and downloadable models.

A graduate student gives the panels of her poster presentation a final review, packs them into her briefcase, and departs for her first scientific meeting.
A medical school faculty member attends a refresher course on renal physiology before revising his lecture notes and audiovisuals for the coming academic year.

At first glance, these disparate examples seem to have little in common except for their focus on physiology and/or biomedical research. However, they reflect the scope of issues addressed by the American Physiological Society (APS) in its education activities. As activities of a national professional society of physiologists involved in research and teaching, the APS programs seek to address the needs of the overall field of physiology as well as its more than 8,500 members. Education plays a key role in the Society; as detailed in the Society’s mission statement, APS is “...devoted to fostering education, scientific research, and the dissemination of information in the physiological sciences.”

DEVELOPING A STRATEGIC PLAN

In 1992, the APS Council reviewed its prior and current education activities and developed a long-term strategic plan for education activities of the Society. According to the 1992 plan, the primary focus of the APS education activities is “...to foster excellence in physiology education appropriate for each constituency of the APS” (Table 1). The Council also adopted five education objectives in the strategic plan directed toward the overall goal. Each of these objectives is related to the future of physiology education, albeit at different educational levels and focused on different target groups.

Until 1992, the education activities of the Society had been implemented through the Executive Office and various committees. With the adoption of the 1992 strategic plan, however, the Council felt that additional coordination and staff would be needed. They authorized the hiring of a full-time Education Officer and the establishment of the APS Education Office. The Education Office would work with several committees, including the Education Committee, and with the sections, including the Teaching of Physiology Section, to implement the goals and objectives outlined in the strategic plan.

In 1993, the APS Education Committee met to develop specific operational objectives and possible activities for each of the major objectives. As a result, the education activities were targeted at four major areas: graduate/professional education, undergraduate education, K–12 outreach, and the cross-cutting area of continuing education of members. Specific objectives, current activities, and future focus for each of these areas are described below.

K–12 OUTREACH

Three of the 1992 strategic plan objectives (Table 1, objectives 2–4) point toward the need for involvement in precollege science education. Attracting highly qualified students to careers in physiology, enriching the health science curriculum in physiology, developing a scientifically literate public, and promoting public awareness of physiology are all goals that can be—and in some cases, must be—targeted at the precollege level. The Education Committee set six operational objectives for precollege outreach activities; specifically, APS will

- facilitate the ongoing national improvement of science education;
- increase understanding of human physiology among students and teachers;
- create more positive perceptions about scientists among students, parents, and teachers along with a better understanding of what scientists do;

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**TABLE 1**

<table>
<thead>
<tr>
<th>Goal</th>
<th>To foster excellence in physiology education appropriate for each constituency of APS</th>
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<tbody>
<tr>
<td>Objectives</td>
<td>1) To develop a continuing education program designed to enhance the research and teaching capabilities of physiologists</td>
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<td></td>
<td>2) To recruit the best students to physiology by fostering excellence in training</td>
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<td></td>
<td>3) To ensure that physiology is appropriately represented in health science education</td>
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<td></td>
<td>4) To help develop a scientifically literate public and to promote their awareness of physiology</td>
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<td></td>
<td>5) To promote the awareness of physiology in other biomedical sciences to enhance the professional and intellectual environments of APS members</td>
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stimulate interest in science studies and scientific careers, especially careers in physiology;  

improve communication between and interaction among members of the K–12 education community and the physiology education and research communities; and  
cultivate both interest and achievement in science among traditionally underrepresented groups (women, minorities, and persons with disabilities).

Current activities. Activities for grades K–12 focus on creating linkages between the K–12 science education community and the physiology research and teaching community. In particular, programs are designed to encourage the involvement of APS physiologists in outreach to the K–12 science education community. At the elementary level, APS works in conjunction with Baylor College of Medicine in producing, field-testing, and disseminating My Health, My World, a curriculum supplement that emphasizes the influence of environmental factors such as air and water quality on human health. Teachers and APS members can become certified My Health, My World workshop leaders by attending an APS training session.

At the middle and high school levels, the APS Summer Research Programs (Frontiers in Physiology and Explorations in Biomedicine) have proven highly successful in building linkages between teachers and physiologists and in helping teachers adopt the teaching methods recommended by the National Science Education Standards (4). In these programs, teachers spend seven to nine weeks during the summer working in the laboratory of an APS member. Their experience must be a hands-on involvement in the research process. They spend an additional week at a retreat with their fellow awardees, learning how to teach using inquiry-approach methods, discussing their research and the use of animals in research and teaching, and developing a classroom activity that will be subsequently published by APS on-line and/or in an annual monograph, Works in Progress. Frontiers in Physiology is open to teachers nationwide, whereas Explorations in Biomedicine is targeted toward educators serving students on Native American reservations in Montana. Explorations participants spend the summer out of state, working in the lab of an APS member.

As an outgrowth of the Summer Research Program, APS also sponsors Local Outreach Teams (LOTS). LOTs are comprised of APS members, other biomedical researchers, and middle or high school teachers from the local community. Each LOT conducts hands-on, inquiry-based in-service workshops for middle and/or high school teachers in their community on topics including neurophysiology, cardiovascular physiology, exercise physiology, and gastrointestinal physiology.

APS also provides written resources for K–12 educators. These include teacher-developed activities, career materials, teaching resource sheets, and information on the use of animals in research and teaching. With support from NASA, APS recently published a comic book for middle school students, describing what physiology is, what physiologists do, and how students can prepare to become a physiologist. The comic book has been well-received not only by teachers and students but also by APS members, who often use it when they visit science classrooms at middle and high schools. APS offers most of its educational resources to teachers at no cost through mail requests and/or on-line at the APS home page.

Looking to the future. Establishing links between teachers and researchers at the local level will continue to be a key feature of the APS K–12 outreach efforts. However, as more K–12 teachers gain access to the Internet and its resources, the definition of “local community” is changing dramatically. Teachers and their students are looking to the research community as a whole as their resource base. APS has already initiated a number of on-line resources for K–12 educators and will continue to expand these in the future.

For example, in 1997, teacher activities developed through the Summer Research Programs began to be published on the APS web site. Currently, more than 25 original lab activities are available free to educators. With the availability of user-friendly html editing software, that number is expected to double in the coming year. Recently, an extensive list of hyperlinks to science education sites was added for K–12 educa-
In 1998, the APS Education Office launched an electronic mailing list (listserv) for the nearly 200 current and past Summer Research Teachers and the more than 300 APS members who have volunteered to host teachers. The listserv provides an opportunity for teachers and their students to post questions and comments on physiology and education and to share information on resources and opportunities. Most recently, the APS Teachers Chat Room was established on the Internet Relay Chat system to provide a forum for interactive discussions between and among teachers and physiologists.

In coming years, the APS web site will offer bulletin boards for life sciences teachers and links to teacher-generated web pages. More importantly, it will become an interactive teaching site, offering teachers and students opportunities to collect their own physiology experiment data and submit it to the web page. Each participating classroom’s data will become part of a worldwide physiology experiment in which students can make and test their predictions, graph their results, and present their findings on the web page. In the future, we hope to establish real-time links between classrooms and research laboratories so that students can be both active observers and participants in real research experiments.

**UNDERGRADUATE EDUCATION**

Although physiology is a requisite course for students in many fields of study at the undergraduate level, very few institutions offer a “major” for undergraduate students in physiology. At the same time, the undergraduate years offer most students their first and last chance to study physiology in a classroom and laboratory setting, because relatively few high schools offer elective anatomy and physiology courses. For students in medical fields such as nursing, pharmacy, and medical technology, physiology education forms the foundation for subsequent courses such as pharmacology, endocrinology, and medical microbiology.

The undergraduate years also are the critical point in time to recruit students into graduate study in physiology. Otherwise, physiology as a field remains an unknown to most students and there is slim hope that they will be attracted to it.

Four of the 1992 strategic plan objectives (Table 1, objectives 1–4) indicate the need for APS to support and encourage excellence in undergraduate physiology education. The Education Committee, therefore, directed that APS undergraduate education activities seek to

- work to improve both the quality and quantity of undergraduate physiology education, and
- stimulate and cultivate student interest in graduate and/or professional studies in physiology.

**Current activities.** To improve the quality and quantity of undergraduate physiology education, APS activities provide teaching materials and professional development opportunities for undergraduate faculty. These activities are sponsored and coordinated by the Teaching of Physiology Section, a number of committees, and the APS Education Office.

Society awards, such as the Arthur C. Guyton Physiology Teacher of the Year Award and the Teaching Career Enhancement Award, highlight the importance of teaching. Fellowships are also offered. Through the new Physiology Insights program, faculty at two- and four-year colleges (including community colleges) who teach physiology but do not have extensive training in the field, spend seven to nine weeks actively engaged in research in physiology. With assistance from a member of the Teaching of Physiology Section, the fellows then develop new curricular materials to use in their courses and to share with colleagues via print publications and the Internet. Through the Minority Travel Fellows Program and Explorations in Biomedicine, faculty at colleges and universities serving primarily minority students (including tribal colleges on Native American reservations) can travel to APS meetings to update their content knowledge and laboratory methods. At these meetings, undergraduate faculty will also find special sessions, sponsored by the Teaching of Physiology Section and the Education Committee, offering a forum for the presentation of new methods and materials in physiology education.
Finally, APS works cooperatively with a number of organizations that promote excellence in undergraduate life sciences education. Annually, APS sponsors a speaker for the meeting of the Human Anatomy and Physiology Society (HAPS) and supports the HAPS Course Guidelines for Undergraduate Instruction in Human Anatomy and Physiology. In addition, free resources and materials for undergraduate faculty are provided via exhibits at the annual meetings of both HAPS and the National Association of Biology Teachers (NABT). Finally, APS is a member of the Coalition for Excellence in Life Sciences Education (CELS), an organization representing 19 life sciences societies and focusing on improving undergraduate education.

Undoubtedly, one of the most powerful and positive influences in developing student interest in physiology careers is excellence in physiology education. Therefore, the professional development activities described above not only benefit the students in terms of the quality of their physiology education but also can stimulate their interest in the field. In addition to those described above, APS coordinates a number of recruitment activities at the undergraduate level.

First, although APS does not award undergraduate scholarships, it does provide professional development opportunities for undergraduate students involved in physiology research. Specifically, the Minority Travel Fellows Program supports 30–50 minority students annually to travel to APS meetings, present their research, and be mentored by physiologists from across the nation. The Explorations in Biomedicine program provides similar opportunities for students from Native American reservations in Montana.

In addition, a number of APS committees are involved in the development and dissemination of materials to spark student interest. These free materials include career brochures and descriptions, career videos, posters, a list of all U.S. institutions that grant degrees in physiology, the comic book described earlier, and a full section of the APS web page devoted to career resources, including links to other useful sites.

Looking to the future. Cooperative ventures with other life sciences organizations will play an even larger role in future undergraduate activities; collaborative efforts with HAPS and NABT are already being discussed, including conferences and publications. In addition, we hope to expand the Physiology Insights program to involve more fellows from across the nation and to launch a LOT program for Insights fellows and their hosts. The Insights LOTs would provide professional development opportunities for faculty at two- and four-year colleges (including community colleges) in their home communities.

Similar to the K–12 program, on-line resources and services for undergraduate faculty and students will be expanded and upgraded in the future. In 1998, the APS Teaching of Physiology Section listserv was launched and an undergraduate education web page was posted. Most recently, the APS Education Committee established the Archive of Teaching Resources for Physiology Educators, an on-line resource pool of case studies, slides, graphics, videos, audio files, and hyperlinks. Materials for the archive are submitted by members and reviewed before being posted to the web site. The Archive is expected to grow each year, providing free resources for educators at the undergraduate, graduate, and professional levels.

Future projects also may include undergraduate education chat rooms and bulletin boards; on-line data repositories with results from a wide variety of actual physiology experiments from which students and teachers can draw data for analysis; and real-time, on-line experiments with researchers around the nation, offering students opportunities to be part of a much wider variety of research than may be done in the undergraduate laboratory.

GRADUATE AND PROFESSIONAL EDUCATION

At the graduate and professional levels, three strategic goals guide the APS education efforts. Fostering excellence in training to attract the best students to physiology (Table 1) requires that a continuing education program for members be maintained. Ensuring that physiology is appropriately represented in health science education is also critical. In response to these strategic objectives, the Education Committee recommended that APS implement activities to

- facilitate persistence in graduate work to the receipt of a degree;
• enrich the graduate and postdoctoral experience to provide expertise in three critical areas: research skills, professional skills, and assimilation into a network of colleagues;

• increase the diversity of students earning degrees in physiology, particularly in terms of gender and racial/ethnic group; and

• establish specific goals and strategies for future activities on professional/medical education.

Current activities. APS seeks to enrich the graduate and postdoctoral education of students through a number of programs, beginning with strong incentives to become a student member of the Society. Student memberships are free for one year and can be renewed for up to five years for a nominal fee ($15). The Society also offers extensive resources for graduate students and postdoctoral fellows on the APS home page.

A number of travel fellowship programs and student awards allow students to attend critical professional meetings and develop their presentation and networking skills. Particular attention is paid to encouraging the persistence of female and minority graduate students and postdoctoral fellows through travel fellowship programs and graduate and postdoctoral fellowships. Female graduate students and postdoctoral fellows also may participate in the Mentoring Program for Women in Physiology, a nationwide effort that generates a network of mentors and colleagues for students involved in physiology research. Mentoring is done in-person at scientific meetings and via telephone and E-mail.

APS graduate and postdoctoral fellowships are designed to meet specific needs within the discipline, either in recruiting underrepresented students or in cultivating specific skills among future physiologists. For example, the William T. Porter Fellowship Award provides predoctoral support for students from minority groups underrepresented in the field of physiology. The Porter fellowship covers all areas of physiology. APS also sponsors a postdoctoral fellowship in physiological genomics. Because many advances in genomics will ultimately require a functional understanding in the context of the organism, and because special training will be needed to conduct this type of research, the APS Postdoctoral Fellowship in Physiological Genomics was established to allow PhD recipients in molecular biology and genetics to acquire experience in organ system research approaches and, conversely, to allow the physiology doctoral recipient to gain skills in the use of molecular biological tools and genomics. A central criterion is that the postdoctoral project uses the tools of cellular and molecular biology in the setting of the whole animal.

In recent years, some concerns have arisen about the status of recent doctoral recipients in certain fields of science and engineering. Scattered reports of long job-search times and underemployment called for a more systematic look at new doctoral graduates in science and engineering. In conjunction with the Commission on Professionals in Science and Technology and more than a dozen other professional societies, APS initiated an ongoing annual study of the status of new doctorate recipients in physiology (3). Results have been very positive, showing a good job market for physiology graduates. Information from the annual study is provided for educators, researchers, and students in the APS journal The Physiologist and on-line at the APS web page.

APS Education activities also focus on professional development among physiology educators at the graduate and professional school levels. Some activities have already been noted above, for example, the Arthur C. Guyton Award, sessions sponsored by the Teaching of Physiology Section at the Experimental Biology meeting, and the Archive of Teaching Resources for Physiology Educators. Of course, this journal, Advances in Physiology Education, is APS’s leading repository of proven materials and methods for physiology educators.

The Education Committee and Teaching of Physiology Section sponsor an annual refresher course for physiology educators that is presented at the Experimental Biology meeting. Refresher courses are designed to provide both an intensive overview of content in one of the areas of physiology and opportunities to review new teaching methods and materials for physiology instruction. They are targeted especially for nonspecialists who have teaching responsibilities in the content...
The courses have proven a popular session at the meeting and are rated highly by participants. In previous years, topics have included gastrointestinal physiology (1996), respiratory physiology (1997), and renal physiology (1998); papers from each course have been published in the subsequent December issues of Advances in Physiology Education. A refresher course on cardiovascular physiology will be presented at Experimental Biology ’99 in Washington, DC.

Finally, in conjunction with the Association of Chairs of Departments of Physiology (ACDP), members of the Education Committee are working on promoting the role of physiology in medical education. Members of both groups have been actively involved in American Association of Medical Colleges meetings on the future of medical education.

**Looking to the future**

One of the long-range goals of the APS Education efforts has been to develop standards for guiding the development of physiology curricula in graduate and medical schools. Currently, the APS Teaching of Physiology Section and Education Committee, along with members of ACDP, are developing plans for this project.

Similar to its efforts at the undergraduate level, APS will expand its continuing education activities and development of resources for physiology researchers and educators at the graduate and professional levels. New efforts may include on-line refresher courses and courses on new research methods. The APS Section listservs will continue to serve as a forum for discussion and a conduit for information for both researchers and educators. Also, the APS annual meeting and fall conferences, as in the past, will provide outstanding opportunities for professional development of research and education skills.

**SUMMARY**

The role of a professional scientific society in education is far reaching. In the case of APS, it encompasses a wide variety of educational settings, from the preschool level to continuing education for its members. It embodies a number of objectives, including fostering high-quality education but also sparking student interest in the field of physiology... and making sure that the opportunities are available to allow that interest to develop into a physiology career. It entails guiding policy at the national level to promote standards for physiology education, but it also means helping an individual educator with problems that arise in his or her classroom.

Prioritizing these many objectives can be difficult. Because APS is a membership organization, the input of individual members is important in allocating resources for objectives and activities. Periodically, APS conducts a Membership Needs Survey to determine what the members feel are key issues for the Society to address. Responses from the 1997 survey clearly indicated that the membership places a high priority on education issues, not just at the graduate or professional level, but at all levels, including outreach to grades K–12 (1).

From the perspective of a professional society, the future of physiology education is exciting, with new technologies and more effective teaching methods making excellence in education in our field a realistic goal. Furthermore, it is a goal that APS supports and one in which, with continued support and involvement of the Society’s membership, APS can play a significant role.

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**References**