ideas and opinions presented herein need not necessarily reflect those of the funding agencies.

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MEETINGS

Broader Impact: Guidance for Scientists about Education and Public Outreach

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Most Earth and space scientists devote so much of their energy to research, publication, staying funded, and in some cases teaching and supervising students, that it is hardly surprising many feel they have little time to address funding agencies' requirements to articulate how their proposed research will have an impact beyond academia. Even so, many in the research community acknowledge that it is in their own best interests, and that of the global environment, to communicate not just with their peers, but also with educators, students, the media, resource managers, and policy makers.

So the challenge is: How can researchers reach out to these audiences while staying focused on their primary responsibilities?

The good news is that the obligation to demonstrate the "broader impacts" of publicly funded research, if properly addressed, can actually expand scientists' opportunities. Resourceful investigators can now play an important role in improving science literacy in the United States, to cite just one potential focus, while simultaneously bolstering the competitiveness of their grant proposals. Scientists need not feel they are on their own in pursuing broader impact; there are now resources—organizations and individuals—that can be of assistance.

During the 2004 AGU Fall Meeting, 13–17 December in San Francisco, California, an Ocean Sciences session was convened to provide inspiration and practical guidance to scientists who are interested in or perplexed by the U.S. National Science Foundation's second merit review criterion concerning the broader impacts of proposed activities (http://www.nsf.gov/pubs/gpg/nsf04_23/3.jsp#IIIA2).

Entitled "Broader impact: What busy scientists need to know," the AGU session included presentations by more than 40 scientists, institutional leaders, education and outreach specialists, as well as representatives from professional societies, scientific consortia, informal science education (ISE) organizations (e.g., science centers, aquariums), and funding agencies. Abstracts can be found at http://www.agu.org/meetings/fm04/.

This report highlights kernels of the presenters' collective wisdom.

Broader Impact Matters in Proposal Review

Mounting anecdotal evidence from scientists, particularly those who have served on recent NSF panels, suggests that with all other factors being equal, proposals that include rigorous plans to achieve broader impact have a competitive edge over those that lack such plans. Broader impact encompasses a diverse set of activities, anticipated outcomes, and levels of investment, in terms of both funding and scientists' time. Technology transfer, interactions with the media, and environmental advocacy, to give just a few examples, can be considered broader impact, as each has potential to extend the value of research beyond the conventional academic arena.

Involvement in education and public outreach (EPO) is another increasingly popular and potentially efficient route for many scientists to address broader impact requirements. That EPO is an attractive option is hardly surprising, since all scientists were once students, many teach, and lots are parents or grandparents. Moreover, education figures prominently in the mission statements of the major oceanographic research institutions, and the integration of research and education is a high priority at NSF and other funding agencies. Whatever the focus of one's broader impact efforts, it is wise to consult your funding agency and program officer for guidance, as expectations regarding broader impact differ among and within agencies.

Advice for Scientists

For scientists electing to pursue some type of EPO activity, the following recommendations emerged during the session:

1. *Get real*. In formulating your EPO goals, consider your research interests, time constraints, budget limitations, and desired outcomes. Striving to serve all the needs of all audiences is usually impractical. It is wise to set realistic goals and to seek the advice of an EPO specialist to help you set those goals. However modest or ambitious, your audience choice and your desired outcomes will guide the methods you choose to accomplish your goals.

2. *Link up*. Partnerships are key to EPO success. Just as you might employ analytical specialists, engineers, or computer programmers to assist with technical facets of your research program, you would do well to consult educators, communications specialists, and other professionals in EPO undertakings. And you should do so early on, preferably as your proposal takes shape.

Among the best places to find EPO specialists are the so-called informal science education (ISE) organizations: science centers, natural history museums, aquariums and zoos. Such institutions are poised to inspire, engage, entertain, and educate the public about the marine, terrestrial, and extraterrestrial environments.

They are trusted sources of information for the public, and they reach a lot of people. Last year, one in three Americans visited an aquarium, zoo, or museum, and 85,000 teachers received professional development from aquariums and zoos. Although we might imagine that most learning occurs in formal school settings, children spend less than 20% of their waking hours in school. ISE organizations excel in creating opportunities for lifelong learning for a broad range of audiences including home-schooled students, senior citizens, community groups, service organizations, and families, to name just a few.

Professional societies, including those of scientists (e.g., AGU, American Society of Limnology and Oceanography, American Association for the Advancement of Science) and educators (e.g., National Science Teachers Association, National Marine Educators Association), and scientific consortia (e.g., Joint Oceanographic Institutions, Ocean.US, Ridge 2000, MARGINS) provide community-wide access to an array of EPO opportunities. Most universities have some form of public relations or communications department, a Web presence, and/or an education department that can assist scientists. Another option for finding an appropriate EPO partner is to inquire of colleagues or your program officer. For ocean scientists, enlisting the aid of the NSF-funded Centers for Ocean Sciences Education Excellence (COSEE) Network (http://www.cosee.net/) is an excellent strategy.

Partnerships with ISE professionals can also help well-intended scientists avoid some common pitfalls. One common error is re-creating an existing resource—reinventing the proverbial wheel. Another error is producing a well-intended "resource" for educators that cannot or will not be used because it is difficult to find, isn't aligned with national or state education standards, or isn't grade-level appropriate. Because ISE organizations have the infrastructure to serve large audiences, and employ professionals who are skilled at working with scientists to translate complex concepts for lay audiences, collaboration can maximize the efficiency of EPO undertakings from the scientist's perspective. Efforts to contribute to high-quality existing resources—exhibits, curricula, teacher professional development programs, etc.—often are more successful than attempts to develop such materials from scratch.

Recognize the potential long-term value of the partnerships you create. In many cases the individuals, organizations, and programs that you work with to address broader impact will be accessible to you for years to come.

3. *Listen up*. It is not enough to find and connect with talented ISE partners; you must actually listen to them. Just as you are the expert when it comes to the science, educators are experts in their field. Respect for educators' professionalism will go a long way toward developing clear expectations for all those involved in the partnership and ultimately achieving your goals. Inform yourself about educators' needs and priorities (e.g., requirement to address national science standards). Your ISE partner has the pulse of audience needs and should be able to help you shape attainable and relevant outcomes for your EPO.

4. *Simplify*. Accept that you may need to simplify your work. In many cases, effective EPO projects can be designed around the fundamental concepts underpinning specialized research. Recognize that communicating complex stories may require several concurrent approaches.

5. *Team up*. If you supervise graduate students and post-docs, encourage their involvement in your EPO planning and implementation. You will be setting the stage for the next generation of mutually beneficial scientist-educator collaborations while at the same time alleviating at least part of the burden on your time.

6. *Fork over*. Every component of your research program—equipment, personnel, publication, travel—has associated costs, and your EPO program is also likely to require funding. Allocate sufficient resources—time, expertise, and money—to the planning and implementation of your EPO effort. Your proposal budget should be adequate to achieve the desired outcomes. Your educator-partner can provide guidance on the costs of various project elements, e.g., salaries, equipment, and evaluation.

7. *Take stock*. Include plans to have your EPO activities formally evaluated. Evaluation is a profession unto itself, and you should work with an evaluator who has expertise with the type of project you've chosen. Once again, your educator-partner or the education department of a university may be able to assist you in finding an appropriate evaluator.

NSF offers useful advice on evaluation in The 2002 User-Friendly Handbook for Project Evaluation (http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf02057) and at http://www.nsf.gov/ehr/rec/eval_of_projects.jsp, a site which includes information on finding an evaluator. A directory of evaluators can be found at http://ec.wmich.edu/evaldir/index. html.

Before you begin an EPO project, it can be useful to have an evaluator conduct a needs assessment with your intended audience to ensure that the message you choose and the way you convey it will resonate with that particular group. Later in the course of the project, audience feedback will help with decisions you make regarding your involvement in future projects. As in the research enterprise, there are lessons to be learned even from EPO projects that do not go as expected.

8. *Have fun!* Take some risks and enjoy the resultant interactions. EPO activities and scientist-educator partnerships can be highly gratifying for all involved. Done well, involvement in EPO can transform a burdensome quest for broader impact into a rewarding experience.

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GEOPHYSICISTS

John D. Hewlett (1922–2004)

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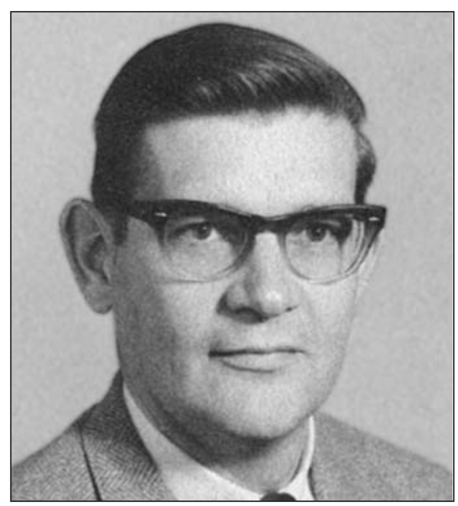

John D. Hewlett, a pioneer in forest and hillslope hydrology, passed away on 19 July 2004 in Athens, Georgia, where he had retired after a distinguished career with the University of Georgia and the United States Forest Service. Hewlett helped transform our views of catchment hydrology through his development of the variable source area model of streamflow generation from forested catchments and the interflow model of base flow sustenance in mountainous environments.

Hewlett was born on 29 March 1922 in Philadelphia, Pennsylvania, and was reared in the Shenandoah Valley of Virginia. He entered military service in 1942 and served in the European Theater of World War II until the end of the war. He earned his bachelor's degree in forestry from New York State College of Forestry in Syracuse in 1949 and a master of science degree in forest ecology from Syracuse University in 1956. In 1960, he obtained a doctorate degree from Duke University, Durham, North Carolina, with an emphasis on plant water physiology.

In 1956, Hewlett joined the staff of the Coweeta Hydrologic Laboratory, at the U.S. Department of Agriculture's Southeastern Forest Experiment Station in western North Carolina. He became project leader, and served until 1964 when he joined the faculty of the School of Forest Resources at the University of Georgia in Athens.

Hewlett was one of the first to recognize the error in attributing all storm flow to Horton overland flow in forested, rural catchments. His thinking was strongly influenced by early research at Coweeta by M. D. Hoover and C. R. Hursh, who described a dynamic form of subsurface flow that contributed to storm flow. Hewlett took these concepts and his theory of saturated/unsaturated drainage from the soil profile and verified them experimentally, with colleague A. R. Hibbert, using artificially