Meeting Ph.D. Graduates' Needs in a Changing Global Environment

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While the world is becoming smaller in some senses, the intellectual terrain is becoming ever more difficult to traverse. The physical world is changing at an accelerated pace because of human activities. New technologies and intellectual breakthroughs have profoundly changed our understanding of the environment but also have revealed vast chasms of ignorance at the boundaries between disciplines. Disciplines have fractured, multiplied, and coalesced like volcanic islands in a sea of turmoil. The net result is that interdisciplinary collaborations are increasingly needed to extend research frontiers and address issues at the interface of science and society.

As National Center for Atmospheric Research director and AGU president Timothy L. Killeen cautioned, at a 2005 U.S. National Science Foundation Biocomplexity in the Environment awards meeting in Washington, D. C., "Regardless of the… funding [and other obstacles], this [interdisciplinary, collaborative work on complex environmental systems] is what our life is going to be about continuing into the future....What we do in this generation will determine the destiny of life on our planet." Former U.S. vice president Al Gore, during a Union lecture at the 2006 AGU Fall Meeting, received a standing ovation for his call for Earth scientists to take a more active role in communicating the imperative to reduce human impacts that are leading to global change, especially climate. Gore implored, "We now face a climate crisis without any precedent in all of history and it is imperative that those who have the best evidence of what is occurring spread the knowledge beyond the small discipline in which these studies are usually disseminated."

This is a tall order for any Earth scientist, and particularly for graduates who are launching careers directly into this maelstrom of environmental, academic, and societal transformation. Thankfully, Earth scientists thrive on the unknown and appreciate a good challenge. Earth science is inherently interdisciplinary and integrative, and collaborative work always has been part of the process. The history of our field shows that working together on difficult but socially important questions can be enormously satisfying, and well worth the risks and pitfalls. The new generation of Earth scientists is anxious to meet the challenges ahead.

While a growing number of institutions provide at least some integrative activities and professional development for students and postdocs, many graduates are pretty much set adrift on this tempestuous professional sea. The majority could use more training and mentorship.

The recent guidelines for support of postdoctoral appointees and graduate students, published 2 August 2006 by the U.S. National Science Foundation's (NSF) Directorate for Geosciences (http://www.nsf.gov/pubs/2006/nsf06038/nsf06038.jsp), underscore the responsibilities of advisors as mentors. You can help set these graduates on the smoothest possible course.

This article outlines major needs and offers some easily implemented strategies to help this emerging generation of interdisciplinarians survive and thrive. Challenges were identified and solutions were developed through nine symposia for cohorts of interdisciplinary recent Ph.D. graduates (see http://aslo.org/phd.html) and one workshop consisting of established and early career professionals and devoted to interdisciplinary career development [see *Weiler et al.,* 2004].

The symposia, held 1994–2006, were organized through the Dissertations Initiative for the Advancement of Limnology and Oceanography (DIALOG) and the Dissertations Initiative for the Advancement of Climate Change Research (DISCCRS) (see http://aslo.org/phd.html). Both are sponsored by AGU and other scientific societies, and are modeled after the highly successful Dissertations Symposia in Chemical Oceanography (DISCO; http://discosymposium.org) [*Green and Sackett,* 1988]. Each symposium included roughly 40 invited Ph.D. graduates selected through a rigorous application process. Thirty-eight established and early career interdisciplinarians, invited for their interest in complex environmental systems and professional development, participated in the 2003 workshop.

Symposium and workshop participants recommended solutions that could be implemented quickly and cost-effectively as short, interactive activities or disseminated to a global audience (see http://marcus.whitman.edu/~weilercs/resources/). The suggestions here complement U.S. National Academy of Sciences (NAS) recommendations for facilitating interdisciplinary research [*NAS,* 2005]

Table 1. Symposia and Workshops for Ph.D. Graduates With a Focus on Interdisciplinary Research and Networking

Acronym	Symposium Title	Topic	Dates and Locations
ACCESS	Atmospheric Chemistry Colloquium for Emerging Senior Scientists http://www.asp.bnl.gov/ACCESS/	atmospheric chemistry	date and location TBA
DIALOG	Dissertations Initiative for the Advancement of Limnology and Oceanography http://aslo.org/phd.html	freshwater and oceanic, biological focus	contingent on new funding
DISCO	Dissertations Symposium on Chemical Oceanography http://www.discosymposium.org/	chemical oceanography	date and location TBA
DISCCRS	Dissertations Initiative for the Advancement of Climate Change Research http://disccrs.org/	climate change and impacts, natural and social sciences	8–15 September 2007, Hawaii
ICES/PICES	Conference for Early Career Scientists http://www.pices.int/	marine science	26–29 June 2007, Baltimore, Md.
MYRES	Meeting of Young Researchers in the Earth Sciences http://geodynamics.usc.edu/~becker/myres/	different interdisciplinary topic for each symposium	date and location TBA
NGPR	Next Generation of Polar Researchers http://ccar.colorado.edu/ngpr/	students and recent Ph.D. graduates, natural and social sciences, conducting research during the International Polar Year	4–11 May 2008, Colorado Springs, Colo.
PODS	Dissertations Symposium on Physical Oceanography http://www.pods-symposium.org/	physical oceanography	date and location TBA

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and could be adapted to a broad array of settings (scientific society meetings, academic institutions, government research labs), modified for different audiences (students, teachers, established professionals), and expanded as needed (short courses, long courses, internships, and so forth).

Survival Training for Interdisciplinarians

Whether student or Ph.D. graduate, the following strategies should help emerging interdisciplinarians plot their professional course and successfully navigate their careers.

Effective communication is the cornerstone of interdisciplinary work, and exchange across disciplines is an increasing imperative. Success begins with the establishment of a common language, not the focused, discipline-specific dialect that students often learn [see *Moser and Dilling,* 2004]. Sadly, this fundamental skill is often overlooked in graduate education due to the emphasis on specialist meetings and publications. Communications training should be provided along with opportunities to practice skills. More venues could be provided for students and graduates to share research and interact informally with colleagues from different departments. This could be accomplished through seminars organized across disciplinary boundaries, or even through informal brown-bag lunch or other social gatherings.

The communications skills used for interdisciplinary research collaborations will also work when communicating beyond the ivory tower. Researchers are increasingly required to interact with educators, the media, stakeholders, policy makers, and so forth. Given the increased emphasis on outreach by U.S. federal agencies, creative hands-on training should be provided to facilitate communication and interaction with nonspecialist audiences. The NSF-sponsored Centers for Ocean Sciences Education Excellence (COSEE; http://www.cosee.net/) promote partnerships between research scientists and educators, disseminate best practices in ocean sciences education, and promote ocean education as a charismatic, interdisciplinary vehicle for creating a more scientifically literate workforce and citizenry. Most of their ideas could be translated or reconfigured to fit other Earth science disciplines.

Further, given the scope of work involved in the study of complex environmental systems, scientists increasingly collaborate on large projects with multiple players. These research teams often encompass numerous institutions, disciplines, cultures, and personality types. Interpersonal, team-building, leadership, and administrative skills are therefore imperative. Training in these skills is routinely provided in the for-profit sector where innovation and efficiency are highly valued. Effective models from industry should be adapted to academic settings and become standard practice for researchers engaged in interdisciplinary work. Such education can and probably should be delegated to experts. Many institutions offer some form of training, though it may be in a psychology, business, or other department. DIALOG, DISCCRS, and the On the Cutting Edge project mentioned below offer sessions in most of these areas. Alternatively, trained facilitators could be brought to campus for intensive training sessions.

In addition, professional development for beginning scientists is critical. Today's graduates are often more interdisciplinary than the institutions that train or might hire them, and academic positions are generally scarce. Not surprisingly, many graduates look for positions outside academia. Students and postdocs need to be aware of the full spectrum of professional opportunities and 'learn the trade' as well as develop their research expertise. Mentors should share insights on how to survive in the current institutional environment, and how to build a career in this time of change. Advice and resources should be offered on careers beyond academia, how to secure an interdisciplinary research position, how to obtain external funds for research, how to secure tenure or other promotions, where to publish, how to build a professional legacy, and so forth.

Many great resources are available, some from other disciplines. For example, the Howard Hughes Medical Institute has published a manual for biomedical researchers [*Howard Hughes Medical Institute*, 2004]. The National Association of Geoscience Teachers' Digital Library for Earth System Education's (NAGT/DLESE) On the Cutting Edge project (http://serc.carleton.edu/nagtworkshops/index.html) helps geoscience faculty by providing professional-development workshops, resources, and opportunities for faculty to interact online and in person. In addition, the resource page developed through the DIALOG and DISCCRS initiatives (http://marcus.whitman.edu/~weilercs/resources/) includes many links for students and early career researchers.

Forging interdisciplinary connections early on will be critical to young scientists' futures. Disciplinary specialization is still necessary but not necessarily sufficient. Understanding of other disciplines and a diverse collegial network are essential for interdisciplinarians. Networks should eventually transcend institutional boundaries, but the process could and should begin with students interacting with members of numerous departments within their Ph.D. institution. Lasting collegial bonds take time to form, and informal interactions facilitate the process. Receptions after seminars, brown-bag lunches, and other informal cross-departmental gatherings can serve as catalysts for collegial networks as well as breadth of knowledge.

Upcoming Symposia for Interdisciplinary Scientists

Forming interdisciplinary college peer networks will be critical to survival in the competitive academic and research environment. Society and other large meetings play a key role in bringing specialists together, transmitting new knowledge, and providing a forum to renew collegial relationships. However, such gatherings are often so large that it is difficult to initiate new collegial connections. Dedicated meetings for early career researchers, such as those listed in Table 1, provide a mechanism to initiate and cement collegial relationships that can develop throughout a professional lifetime.

Please encourage your students and recent graduates to take advantage of the growing number of short courses and symposia for early career researchers dedicated to interdisciplinary science (see Table 1). Many currently run on regular cycles, and more are planned over the next several years in conjunction with the upcoming International Polar Year. The list in Table 1 includes a sampling, but also watch for other opportunities. Participation is usually by application, and space generally is limited. See the Web sites in Table 1 for details.

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