News from The National Institute of General Medical Sciences: What IS Training in the Pharmacological Sciences?

Peter C. Preusch[1,2]

The National Institute of General Medical Sciences (NIGMS) has supported research training through the Pharmacological Sciences Predoctoral Training Grant Program since the passage of the National Research Service Act (NRSA) in 1974. The program supports interdisciplinary training in pharmacology, toxicology, medicinal chemistry, pharmaceutical chemistry, and related disciplines. In recent years, there has been a decline in the number of programs (down from 31 in FY1996 to 25 in FY2001). Of particular concern has been the loss of programs in schools of pharmacy and programs with strengths in toxicology or systems and integrative (*in vivo*) pharmacology. These concerns and others were the subject of a meeting held on August 8–9, 2002, in Bethesda, Maryland, titled, "What is Training in the Pharmacological Sciences?" Chairs and deans of relevant academic units, in addition to representatives of relevant scientific societies, industries, and government were invited. Approximately 150 scientists attended, including almost all of the currently funded Pharmacological Sciences (PS) Training Grant Program directors and nine members of the NIGMS Biomedical Research Training initial review group.

Lee Limbird (Vanderbilt University) and Robert Gould (Merck Research Labs) provided academic and industrial overviews of the topic, respectively, and James Hogle (Harvard Medical School) provided a reviewer's perspective. Cynthia Kuhn (Duke University) moderated a panel of recent PS training program graduates that included a spectrum of training outcomes: an assistant professor, an NIH postdoctoral fellow, an industry researcher, and a reviewer for the FDA. Thomas Westfall (St. Louis University) and Brian Cox (Abbott Labs) provided academic and industry perspectives, respectively, on the optimal balance between *in vitro* and *in vivo* research training. David Mangelsdorf (University of Texas Southwestern Medical Center-Dallas) discussed ways to incorporate state-of-the-art methods into training programs. Richard Weinshilboum (Mayo Medical School) spoke about connecting basic and clinical pharmacology. Gordon Amidon (University of Michigan) discussed the contributions of schools of pharmacy. Alan Buckpitt (University of California-Davis) discussed the unique aspects of pharmacology and toxicology training in a veterinary medical school. David Eaton (University of Washington) discussed the history and current relationships between pharmacology and toxicology. Kim Brouwer (University of North Carolina-Chapel Hill) discussed her experiences involving students in clinical research. Breakout discussion groups treated six major topics in two 1-hour long sessions, followed by a plenary read-back and general discussion session.

Remarkably strong consensus appeared around several points:

1. PS training programs exist to provide interdisciplinary training to a broad range of scientists, not just pharmacologists. However, pharmacology is the core discipline in which all trainees should receive instruction.

2. Pharmacokinetics and pharmacodynamics, both broadly defined, are the core of training in pharmacology. Pharmacokinetics was taken to include not only classic concentration vs. time data, but also the molecular, cellular, and genetic mechanisms underlying absorption, distribution, metabolism, elimination, and drug–drug, drug–food, and drug–herbal medicine interactions. Pharmacodynamics was taken to include not only classic dose–response data, but also molecular, cellular, and genetic mechanisms of action, receptor-ligand interaction, signal transduction pathways, and enzyme target inhibition.

3. There is a compelling need for people trained in systems and integrative (*in vivo*) pharmacology. However, an even greater value is placed on people with training in both molecular/cellular approaches AND *in vivo* approaches who are able to integrate results from the molecular level to the human clinical situation. Increased training in systems and integrative pharmacology will depend on faculty interests and the ability to attract funding for the conduct of scientifically compelling research.

4. Incorporation of modern topics and technologies, such as genomics, proteomics, expression arrays, high-throughput screening, and bioinformatics is vital. However, new material needs to be connected to the classic roots of the discipline. What is state-of-the-art training at a given institution is defined by the research activities of the faculty at that institution. Core facilities, team teaching, journal clubs, and seminars are useful ways to introduce new technologies.

5. Scientific diversity in the research opportunities offered should be a natural outcome of the differing strengths of the various institutions around the country. Schools of pharmacy can contribute particularly to both chemically oriented and *in vivo*-oriented training. Schools of veterinary medicine can provide unique opportunities for comparative pharmacology training. Inclusion of programs in toxicology relevant to drug safety and toxicity would be highly appropriate. Wherever relevant strengths exist on a given campus, it would be appropriate to include them in the PS training program.

6. Scientific diversity in the backgrounds and goals of the trainees is also desirable. In addition to PhD and MD/PhD students, PharmD/PhD and DVM/PhD dual-degree students can be appointed to a PS training program during their PhD training years. PharmD and DVM graduates can also be supported during the pursuit of a PhD degree training, although stipend supplementation or debt relief may be needed to be competitive. The creation of additional pharmacology undergraduate courses, programs, and summer research experiences would be a further step to improving the recruitment of students to the PS training program.

[1] Program Director, Pharmacological Sciences Training Grant Program; Pharmacology, Physiology, and Biologic Chemistry Division; National Institute of General Medical Sciences, 45 Center Drive, MSC 6200, Bethesda, Maryland 20892-6200.

[2] To whom correspondence should be addressed. (e-mail: preuschp@nigms.nih.gov)

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7. Inclusion of a clinical orientation course or a clinical rotation as an option in the PhD program may produce students with a greater appreciation for the conduct of clinical research and better understanding of the relationship between basic and clinical research. However, systems and integrative (*in vivo*) pharmacology training involving human subjects would require a much more extensive clinical research experience and may only be practical for students who already have considerable clinical background (e.g., MD and PharmD students). Inclusion of additional clinical faculty in some programs may be desirable.

8. Industrial experience would be a useful training option for some students and might be offered, e.g., as a substitute for one of the academic summer rotations. However, such experiences should not be mandated for all students or all programs.

9. Changes in medical education have resulted in the elimination of traditional medical physiology and pharmacology courses at many institutions. Graduate programs must adapt and most have established separate graduate courses to meet their needs. Elimination of animal labs in both medical and graduate education has reduced opportunities to gain *in vivo* experience and also teaching experience. Innovative approaches are needed to provide these opportunities.

10. The most valued aspects of PS training are common to all NIGMS training programs, i.e., problem-solving skills, communication skills, self-learning skills. General knowledge of physiologic and pharmacological principles were valued by the participants. Specific details of any course or specific drug class were not important.

An informal survey of PS training grant program directors showed that the majority of PhD graduates have gone on to postdocs distributed among academia (70%), industry (18%), and government (12%). Of the graduates reported to be in permanent positions, most were in industry (37%) with fewer in academia (20%), medicine (22%), or nontraditional careers (11%). Only a few have left science altogether (10%).

Based on discussions at the meeting, industry and academia are actually looking for very similar attributes in a new employee: i) evidence of accomplishment as documented by peer reviewed publications; ii) the ability to envision multiple approaches to a problem; iii) the ability to understand the big picture; iv) the flexibility to work on new projects; and v) the ability to communicate across a broad range of scientific areas. Industry can teach its new employees how to discover and develop new drugs, but it cannot teach them basic learning skills and integrative thinking.

In seeking to define what is good training in PS, it is not reasonable to expect all students to be masters of everything. However, it is reasonable to expect students to have a broad exposure in PS as well as depth in some areas. It is not reasonable for most institutions to cover the entire breadth of activity from structure-based drug design to human clinical trials. However, the NIGMS portfolio of training programs should cover that full spectrum and more. Individual programs may be expected to have strengths in selected areas. However, where it is feasible to do so, programs are encouraged to reach out to colleagues around their campuses to be as inclusive as possible within the limits of what is manageable.

Since 1974, a total of 41 different PS training programs have been funded by NIGMS. Almost half of the currently funded training programs were initiated in the initial 3-year ramp-up of programs after the passage of the NRSA in 1974. An almost equal number of programs initiated in the period 1974 to 1977 have now ended. The recent decline in the number of funded programs suggests a need for reexamination and rejuvenation of the portfolio of NIGMS supported programs.

A total of 79 institutions are currently supported by one or more of the 10 types of NIGMS predoctoral (PhD or MD/PhD) training grants. Eighty percent are located on campuses with a medical school, a school of pharmacy, or a school of veterinary medicine, i.e., academic units that could logically provide the base for development of a PS training program. Of those schools, only about one third received PS training grant awards in FY2001. This suggests a substantial cadre of research-intensive institutions from which new PS programs might arise. Furthermore, considering the nation at large, there are another 88 institutions with either schools of medicine (56), schools of pharmacy (49), or schools of veterinary medicine (14)—some with multiple relevant schools on the same campus—that currently receive no NIGMS training grants. Some of these 88 institutions might also be competitive for a PS training grant award.

Although all of the PS training programs differ in detail, most have many features in common. Potential applicants are highly encouraged to contact NIGMS staff.

General information about the training program is available at the following URL: http://www.nigms.nih.gov/funding/trngmech.html. Information about the review of applications is available at: http://www.nigms.nih.gov/funding/nrsatablesintro.html.

Details of the meeting, including the meeting booklet of background information and references, and a more extensive meeting report are available on the NIGMS PS Training web page: http://www.nigms.nih.gov/pharmscitraining. The speakers' presentations are available as PowerPoint slide files or hardcopy handouts upon request. Please contact the author to request any or all of the presentations.