Adapting Postdoctoral Training to Interdisciplinary Science in the 21st Century: The Cancer Prevention Fellowship Program at the National Cancer Institute

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Abstract
Preparing junior scientists for careers in the health sciences has become an immense challenge, given the increasing pace and efficiency of research, changes in funding, and the emerging demand for multidisciplinary approaches to solving problems in the health sciences. Significant technological developments, such as high-speed, multiprocessing computers and robotics, have quickened the pace of research, while new tools for communication, including e-mail and the Internet, have facilitated collaboration and permitted transmission of, at times, overwhelming quantities of information. Greater research funding, particularly in the health sciences, has allowed the expansion of existing programs and the development of new ones. These developments, along with the need for more integrated approaches, have resulted in the creation of both hybrid disciplines, including molecular epidemiology and bioinformatics, as well as interdisciplinary fields that center on specific problems, such as the prevention of cancer, obesity, and diabetes.

The emergence of interdisciplinary science has contributed to the complexity of training scientists. Participation in interdisciplinary science requires knowledge of disciplines outside one’s own and the ability to communicate and collaborate with individuals who may have different approaches to the same problems. Such knowledge and skill may be limited, or even lacking, in recently graduated scientists whose experiences may have been confined to a single research question within one discipline. For them, postdoctoral fellowships are the ideal training ground to acquire the skills needed for careers in interdisciplinary science. However, “traditional” postdoctoral fellowships may not provide trainees with many of the skills and experiences needed for success in 21st century research. New approaches are needed.

In this article, we describe the benefits of and limitations to the traditional postdoctoral model and how this model can be adapted for emerging interdisciplinary health science. We discuss four major problems in training that influence postdoctoral success: multiple demands on mentors that compete for time with fellows, limitations with newer training approaches in an effort to overcome existing problems in postdoctoral training and to address the additional complexities inherent in training those who seek careers in interdisciplinary science. Many aspects of the CPFP, including an efficient infrastructure, a dedicated staff, a capacity to provide educational activities, and the provision of rich research opportunities, may translate well to other postdoctoral programs that face similar issues.

The “Traditional” Postdoctoral Training Model
To become productive scientists, postdoctoral fellows need to perfect the skills acquired in graduate school, and to learn how to craft fundable grant applications. Many fellows will teach, and all need to present their research clearly and coherently. To attain long-term career success and personal satisfaction, fellows need to balance professional and...
personal demands. Finally, after training, they need good jobs—ideally, the independent research positions for which their training has prepared them. To fulfill these needs is the purpose of postdoctoral training.

The traditional model of postdoctoral scientific training consists of a mutually beneficial partnership between a fellow and a mentor. In this idealized model, the fellow is “protected” from expectations to teach or secure support for research during this apprenticeship and uses this time to develop applied research skills, acquire specialized knowledge, and articulate a research agenda. Other benefits include access to the research resources and professional network of the mentor and the launch of the fellow’s career facilitated by the scientific association with the mentor. The more senior partner in this relationship profits from increased productivity, especially when many fellows work in parallel on different aspects of a research program, and the enhanced reputation that comes from the continued success of the fellow after their formal association ends.

This fellow–mentor partnership forms the foundation of the training experience, while other aspects, such as the breadth of training, working conditions, and career guidance, influence its quality. Together, these activities contribute to the value of the traditional model, benefiting both fellow and mentor, strengthening their relationship, and helping fellows fulfill their training needs. Although neither postdoctoral training objectives nor the benefits to fellows and their mentors have changed over time, the pace of research has accelerated, the overall scientific enterprise has grown and new interdisciplinary fields have emerged. It is the contrast between the unchanged aspects of postdoctoral training and the context in which fellows train today that has raised issues regarding the performance of the traditional post doctoral training model for 21st century science.

Four Major Problems in Postdoctoral Training Today

A number of factors can compromise the performance of the traditional postdoctoral training model. For example, competing demands on mentors erode time and energy for advising fellows. Today, tasks related to sustaining a career in science, such as staying abreast of new discoveries, writing grants, publishing manuscripts, and teaching, are balanced against training postdoctoral fellows, which is already a substantial responsibility. Moreover, in situations where a mentor has sole responsibility for a fellow, administrative tasks related to training also add to the workload. A problem for those working with a single mentor is the limitation of both scientific and training opportunities to the knowledge, experience, and resources of that mentor.4 This can be especially problematic for fellows working with scientists who are still building their research programs. Such fellows may have limited access to resources and to their mentors because these mentors must spend considerable time, perhaps more than senior investigators, writing grants, which for younger investigators have had lower success rates in recent years.5 These fellows may also have access to fewer professional colleagues through their mentors than fellows working with senior mentors might have, a major limitation to networking and job-hunting opportunities. Overall, factors that affect the abilities and stamina of mentors can have substantially detrimental impacts on training.

The traditional postdoctoral model, while suitable for training within a discipline, may not meet the training needs of scientists interested in interdisciplinary research.4 Cancer prevention is a case in point. Technological advances and major developments in the health sciences, such as sequencing of the human genome, have fostered the growth of this interdisciplinary field that, in the vision of the NCI director, offers new opportunities for discovery, development, and delivery of preventive interventions.6 Research projects and programs in cancer prevention are becoming progressively more complex and increasingly multidisciplinary. Research methodologies are highly diverse, ranging from the latest lab-based techniques—e.g., genomics and proteomics—to randomized prevention trials and on to structural analysis of population-based and individual-based determinants of risk. Investigators must acquire a working knowledge of this complex field—from cancer biology, cancer epidemiology, and societal determinants of cancer risk, to preventive interventions and clinical trials. Although a fellow typically becomes an expert in only one aspect of this broad discipline, the ability to communicate and collaborate in teams with scientists in complementary fields is vital.7 For successful cross-disciplinary communication, knowledge of other fields is needed and requires considerable time and effort to acquire.8 Finding mentors who can provide interdisciplinary training may be difficult in a new field because few interdisciplinary scientists exist and have sufficient perspective to train knowledgeably.7 One strategy for overcoming this potential difficulty is to work with mentors from different fields; however, the challenges for such mentors include learning to collaborate effectively while developing mutual respect and appreciation for each other’s discipline.8

Dissatisfaction with working conditions also threatens the performance of training. Surveys of fellows at U.S. academic institutions reveal that major concerns include low stipends; inadequate health, dental, and retirement benefits; and insufficient career guidance.9,10 Such working conditions may be difficult to tolerate for long periods, particularly by older fellows and those supporting families. University-based surveys have not uncovered widespread discontent regarding either the quality of scientific mentorship or the long hours typically worked.10 However, in anonymous online surveys of postdoctoral fellows, some have expressed emotional invective about their working conditions and treatment by supervisors during training.11 Such dissatisfaction may be due, in part, to unmet expectations emanating from poor communication between fellows and their mentors about their objectives and expectations. While it is not possible to determine whether the online surveys or the university-based surveys more accurately reflect the sentiment of postdoctoral fellows in the U.S., these surveys suggest that fellows experience a broad range of working conditions and accurate characterization of their experiences is a challenge. The transient nature of postdoctoral fellows may have passively allowed working conditions to remain largely as they were in the past and so they become anachronistic. Perhaps working conditions have actually worsened with time. Alternatively, it is possible that recent increased attention
has made these issues more prominent. Regardless of their basis, these concerns require serious consideration.

Finally, postdoctoral training today may not prepare fellows well to compete for jobs, as suggested by the widely shared view that job prospects for postdoctoral fellows are poor. Indeed, in recent years, the availability of research employment opportunities in academia, government, and the private sector has been outpaced by rapid growth in the number of postdoctoral fellows training in the United States. This disparity between the number of postdoctoral fellows and the number of available jobs has created the perception that competition for positions is fierce and that the majority of fellows will have to opt for less desirable positions. This perception is indirectly supported by growth in the number of less-secure, lower-paying, nontenure-track faculty positions in academia and by the increase in the average length of postdoctoral training over time, posited by some to result from fellows extending their training while they look for better jobs.

Postdoctoral fellows interested in interdisciplinary fields may face additional challenges, as they are likely to compete more successfully for positions at the boundaries between disciplines but less successfully for positions focused on issues central to a discipline. Moreover, finding positions that take full advantage of their diverse skills may not be easy when interdisciplinary fields are relatively new. Conversely, in interdisciplinary fields that experience tremendous growth, new scientists may have numerous employment prospects. In cancer prevention, junior scientists have many job opportunities, as suggested by our observation in one of the leading cancer prevention journals, Cancer Epidemiology, Biomarkers, and Prevention, of a four-fold increase over the past five years in listings for assistant professor positions. Thus, while the general perception suggests intense competition for few positions, in some fields, particularly interdisciplinary ones, the experience is different. Altogether, this indicates that the state of postdoctoral employment is complex and that the effectiveness of traditional postdoctoral training should be considered in this context.

Training in the Interdisciplinary Health Sciences: The National Cancer Institute’s Cancer Prevention Fellowship Program

Based at the NCI, the CPFP is a three-year postdoctoral program of which the goal is to provide its fellows with a strong foundation in the field of cancer prevention through education, mentored research, and structured professional development training activities that emphasize multidisciplinary approaches and leadership skills (http://www.cancer.gov/prevention/pob/). As of Fall 2004, there were 48 fellows in the CPFP and more than 100 alumni.

The CPFP offers the opportunity to pursue a one-year Master of Public Health degree during the first year of the fellowship. Formal academic training in public health is followed by two years of mentored research with senior scientists at the NCI, typically in one or more of the following five areas: laboratory-based cancer prevention research, epidemiologic research (including molecular epidemiologic studies and prevention trials), behavioral science research, prevention-related policy research, and research on quantitative or qualitative methodologies. During the mentored experience, fellows conduct innovative cancer prevention research, present results at major scientific meetings, and publish findings in peer-reviewed journals. To complement these research activities, the program provides opportunities to learn about current cancer prevention research and practice, along with many professional development activities to enhance fellows’ scientific productivity and efficiency.

Addressing Postdoctoral Training Issues

The structural features and program staff of the CPFP help minimize the burden of competing demands upon mentors. The presence of a dedicated program staff releases mentors from a number of administrative responsibilities, like recruiting applicants and processing the administrative appointments of fellows. Fellows’ stipends and annual increases are not dependent on their mentors’ resources, thus relieving mentors of a substantial burden borne by investigators who rely on research grant support. Although mentors are primarily responsible for fellows’ scientific training, fellows are also supervised and evaluated by the CPFP staff, several of whom are scientists in cancer prevention. In addition, the CPFP provides schooling in fundamental professional skills, such as grantsmanship and public speaking, which in a traditional training model would otherwise be shouldered by each mentor. Thus, through its structure and staff, the CPFP helps reduce nonscientific training demands on mentors, thereby enhancing the postdoctoral experience by allowing the time devoted to training to focus more on the scientific development of fellows.

In addition to reducing administrative burdens on mentors, the CPFP infrastructure provides an efficient mechanism for the interdisciplinary education of fellows. Each summer, incoming fellows participate in a two-part continuing medical education (CME)-accredited course organized by the CPFP, The Summer Curriculum in Cancer Prevention. The first part, The Principles and Practice of Cancer Prevention and Control Course, provides an overview of the fundamental concepts, methods, issues, and applications related to current research and practice of cancer prevention and control. The second part, The Molecular Prevention Course, introduces the molecular biology and genetics of cancer, as well as the basic laboratory approaches applied to cutting-edge research in molecular epidemiology, nutrition, chemoprevention, biomarkers, and translational research. A hands-on laboratory experience gives fellows direct experience with these methods. Fellows possessing different expertise learn from each other through The Fellows Research Meeting, a weekly forum for fellows to share their research, as well as at the weekly CME-accredited Cancer Prevention Colloquia seminar series that features research from leaders in the field. These coordinated activities provide fellows with perspective on many of the disciplines that address the problems of cancer prevention.

The central activity for CPFP fellows, as for those in traditional postdoctoral fellowships, is mentored research. Here, the CPFP provides a direct opportunity for experience in interdisciplinary research. Fellows start their mentored research under the guidance of a single mentor, with fellow–mentor matching based on shared scientific interests, compatible working styles, and proposed
projects. Fellows typically work closely with their mentor throughout the training period. However, to facilitate the development of their own research agendas, fellows also frequently work with other investigators, both at the NCI and at other institutions, through short-term field experiences. In this way, the CPFP differs from a traditional postdoctoral training experience: Instead of fellows being restricted to the research interests and resources of a single mentor, the CPFP encourages fellows to pursue additional research experiences with investigators who may have training and expertise in other disciplines.

The CPFP also supports interdisciplinary training by offering the opportunity to earn a Master of Public Health degree. This didactic training allows fellows to acquire fundamental skills in the methods of public health research and provides a common language for communication with prevention scientists and practitioners from other disciplines. This feature is particularly relevant for scientists and health care professionals seeking careers in translational cancer prevention research. Bench scientists with such training are able to integrate population-based approaches and laboratory techniques, while clinicians can apply such tools to cancer prevention clinical trials.

The CPFP addresses the problem of dissatisfaction with working conditions by making the creation of an excellent training environment an ongoing priority. For example, since fellows distracted by insecurity brought on by poor institutional support cannot fully embrace the opportunities of their fellowship, the CPFP has always offered competitive stipends, full health and dental benefits, vacation, sick leave, and family leave as per policies prescribed for U.S. Government employees. Stipend levels are set according to National Institutes of Health (NIH)/NCI policies, with higher starting stipends given for additional years of previous postdoctoral experience and training in underrepresented scientific disciplines in cancer prevention, such as epidemiology and biostatistics. By providing stipends and benefits that sustain a reasonable quality of life, the program attracts many highly qualified doctoral-level candidates. Another factor that influences overall satisfaction is the amount of control that fellows have over their training. Compared with fellows in a traditional fellowship, CPFP fellows have considerable opportunities to develop their own research programs; because they enter the CPFP before matching with a mentor, they choose mentors from among numerous NCI investigators who offer a variety of research projects without having to consider other factors like stipends or benefits.

To prevent the misunderstandings that can lay the groundwork for discontent, the CPFP ensures that the objectives, expectations, and responsibilities of fellows, their mentors, and the CPFP staff are clearly delineated. Fellows and their mentors have many opportunities to express their objectives and expectations with CPFP staff through regularly scheduled meetings, fellows’ progress reports, and orientation sessions for both fellows and mentors. Such an arrangement helps prevent problems from developing and provides fellows with multiple perspectives, as well as an avenue to resolve potential disputes, a feature lacking at many institutions that train postdoctoral fellows. The CPFP actively communicates its policies, procedures, and expectations through a variety of mechanisms. First, stipend level, benefits, and major policies are explained in the offer letter sent to each individual entering the CPFP. A full description is provided in a Handbook of Policies and Procedures (available online to fellows) that is reviewed in detail during the orientation week for new fellows. At orientation, other resources and program activities are discussed, such as annual sponsorship by the CPFP to a scientific meeting of the fellow’s choice, funds for additional workshops and courses, and opportunities for service to the CPFP. Clear communication promotes the fellows’ understanding of the program’s expectations and resources, thereby helping them take full advantage of all the opportunities available to them and increasing the potential for a high-quality experience.

To help its fellows compete for jobs, the CPFP employs a number of strategies throughout the fellows’ training. Although job competition within each field depends both on the growth of that field and the number of qualified applicants available, applicants with the best training and most relevant experience will have the greatest competitive advantage regardless of the field. Toward that end, the CPFP places major emphasis on providing a rich environment to promote research output in the form of peer-reviewed publications and scientific presentations, which are among the leading criteria by which employers evaluate prospective candidates. To complement fellows’ scientific development, the CPFP provides a professional development “curriculum” aimed at developing each fellow’s mastery of the skills that scientists require for success, including proficiency in communication (both verbal and written), knowledge of grants and grantsmanship, personal productivity and efficient time management, and a capacity for team-building. Activities include a three-day workshop on public speaking tailored for the CPFP that emphasizes scientific presentations, as well as a four-day Grants and Grantsmanship Workshop that includes lectures by program administrators from the American Cancer Society and the NCI’s Cancer Training Branch, major funding organizations from which fellows are likely to seek funds. In addition to providing broad overviews of funding priorities, the speakers highlight career development award mechanisms geared for new investigators in cancer prevention. On the last day, fellows critique their own research proposals in a mock study section that is led by a former Scientific Research Administrator from the NIH Center for Scientific Review who oversaw the study section that reviews cancer epidemiology and prevention grant applications. Following the workshop, fellows preparing to submit grant applications meet biweekly for staff-facilitated sessions that provide feedback on study design, scientific approach, and grantsmanship. This working group is particularly useful for those developing career development awards, such as the NCI K07 Cancer Prevention Career Development Award, for submission immediately after starting new positions. Altogether, these activities aim to increase individual effectiveness and performance, and ultimately, to promote the likelihood of long-term success. Since the workshop was first offered in 2000, 22 grants have been submitted by fellows, and of the 20 grants that have been reviewed, 16 have been funded—nearly an 80% funding rate.
Starting early in their fellowships, fellows receive career guidance from the CPFP staff. During individual annual progress review meetings, CPFP staff discuss the fellow’s plans for research and coach the fellow to articulate his or her individual research agenda, both verbally and by encouraging the design of a series of related research projects that build upon a theme. For those who are midway through the fellowship, CPFP staff work with fellows and their mentors to ensure continuing research productivity. Staff pass along job announcements, facilitate contacts with potential employers, and discuss with fellows all aspects of job hunting, including how to create strategic networking opportunities at conferences. Staff also provide coaching and feedback on job application packages, preparation for interviews, and negotiation for salaries and start-up funds. Current fellows have access to a rich network of professional contacts for research expertise and employment strategies through the CPFP staff, their research mentors, other fellows, and the more than 100 CPFP alumni. Since 1987, the average length of stay in the CPFP has increased from two years to 3.5 years in 1999, in part because of the option to pursue an MPH degree. All of those who have pursued an MPH degree have successfully completed the degree requirements and received their degrees. For them, a payback period of twice the length of MPH training is required and only two fellows have departed from the program for paid positions before completing this requirement. Most fellows leave the CPFP for jobs as tenure-track assistant professors at universities (18%) or equivalent positions at cancer centers (11%), in the government (55%), private sector (11%), and in medical practice (6%).

The mission and program activities of the CPFP are consistent with the recommendations for training scientists in cancer prevention and control outlined in 1996 by Love and Engstrom.17 These authors emphasized the need for junior scientists to focus their research efforts and to have mentors who provide research training and opportunities for visibility in the field, who are knowledgeable of informal professional networks and systems, and who can advise about job hunting. Other U.S. postdoctoral training programs in cancer prevention and control also follow these recommendations18 and some emphasize special research themes, such as nutrition.19 Most receive funding from the NCI through the R25T Cancer Education and Career Development mechanism established in 1992.20 To achieve interdisciplinary training, funding guidelines describe specific attributes for training programs, which parallel the structure and activities of the CPFP, the largest cancer prevention postdoctoral training program in the United States. While no single program can resolve within itself all of the challenges facing postdoctoral training, aspects of the CPFP may be useful to integrate into other interdisciplinary training programs and to strengthen postdoctoral training in other fields.

Summary
Training postdoctoral fellows well has never been easy, and in the 21st century, new models for training are needed to overcome both old problems and new challenges to training. The need is particularly relevant to interdisciplinary fields, like cancer prevention, that have yet to be established as disciplines at universities and graduate schools. Until academe incorporates these fields, postdoctoral training can help these fields develop by preparing junior scientists for interdisciplinary research. Indeed, the CPFP was designed to attract professionals to cancer prevention to fill employment gaps in the growing field and to develop a cadre of scientists who would eventually take on leadership positions within the field by providing them with research training and career development activities and by facilitating their placement in positions in the field. Many aspects of the CPFP, including an efficient infrastructure, a dedicated staff, a capacity to provide educational activities, and the provision of rich research opportunities, may translate well to other postdoctoral programs that face similar issues.

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