

Congressional Update: *Report from the Biomedical Imaging Program
of the National Cancer Institute*

Training the Next Generation of Imaging Scientists and Clinicians¹

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Biomedical imaging is changing rapidly, and research in the field increasingly requires a multidisciplinary, molecular biologic orientation. There is a critical need for imaging scientists with training in molecular biology, engineering, computer sciences, and related fields. The Biomedical Imaging Program in the Division of Cancer Treatment and Diagnosis of the National Cancer Institute (NCI) does not sponsor or administer training grants directly, but it collaborates with the NCI Training Branch. The intent of this collaboration is to facilitate research training for the next generation of academic imaging experts and scientific investigators.

During the past decade, the rapid development of molecular biologic techniques has revolutionized our basic understanding of human disease. In association with the development of basic molecular biologic technologies there has been important development and evolution of computer, engineering, and analytical technologies. These developments have had a tremendous impact on the imaging sciences. Molecular, metabolic, and functional imaging allow clinicians and researchers to study relevant cellular or molecular processes in vivo. These newly developed techniques allow visualization and quantitation of clinically relevant physiologic variables such as blood flow, oxygen consumption, glucose metabolism, proliferative activity, or tissue hypoxia as they take

place in living cells and tissues. As basic scientists gain a better understanding of the fundamental molecular nature of disease, molecular imaging will be an important adjunct in translating this knowledge into clinical practice.

Over the past few years, imaging has been identified as an area of "Extraordinary Opportunity for Investment" in the NCI Bypass Budget Proposal. The NCI Bypass Budget Proposal is a public document produced annually by NCI to identify for the Congress and the Executive Branch those scientific priorities on which the NCI federal budget appropriation will be spent. Molecular imaging has been a particular focus for new programs funded by NCI to meet its Bypass Budget goals. These have included initiatives for In Vivo Cellular and Molecular Imaging Centers, Small Animal Imaging Resource Programs, and programs to improve imaging technologies including probe and ligand development. These and other programs stimulate an increased need for individuals with appropriate research training to meet these goals.

In molecular imaging, as in other emerging fields of research today, scientists must function within interdisciplinary teams rather than as isolated investigators or in simple collaborative settings. Preparing junior and more experienced basic research scientists and clinicians for this type of research environment requires education and career development experiences in highly interdisciplinary and collaborative research settings that are integrated with a specialized curriculum. These education and career development experiences must provide wide access to multiple scientific disciplines and methods, must involve mentors from more than one discipline, and must be tailored to the individual education and training needs of the investigator. Because of the breadth of science involved, these experiences will frequently have to be facilitated and coordinated across departments,

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schools, centers, or institutions. Management of programs with this kind of complexity and diversity requires concerted leadership and dedicated time of interdisciplinary faculty in order to sustain effective interactions within and coordination of the program. Furthermore, for clinicians lacking any prior research training, these experiences may have to include the completion of requirements for an additional degree, such as a master's or PhD degree, and a number of years of research experience beyond the degree to prepare for conducting highly interdisciplinary collaborative research as an independent investigator. National Institutes of Health (NIH) experience suggests that it takes approximately 5 years of didactic and research training for clinicians to become competitive independent investigators, particularly in the highly interdisciplinary disciplines.

In 1998, the NCI in partnership with its external review groups and advisory committees developed a strategic plan for training and career development. In the area of imaging sciences, advisors identified a need for (a) postdoctoral training in molecular imaging; (b) interdisciplinary cross-training of senior investigators in diverse disciplines such as molecular genetics, molecular and cell biology, chemistry, pharmacology, and clinical oncology; and (c) development of multidisciplinary centers, which provide the means for bringing researchers and teams with diverse backgrounds together. A 1997 report from the NCI Imaging Sciences Working Group noted that it is only at those few institutions where imaging programs are conceived with an interdisciplinary goal in mind that the communication gap between researchers in widely diverse areas of science can be successfully bridged.

Current training mechanisms are available to accomplish this important goal, although the plethora of training grant mechanisms available through NIH is often confusing to applicants, and the imaging community needs to be aware of the available resources. We therefore present an overview of the most relevant current NCI mechanisms to support training of individuals in the imaging sciences. These include individual awards to the grantee and larger institutional training grant mechanisms. In particular, young investigators and faculty members should be aware of the K08 award for basic research and the K23 award for patient-oriented research. Training program directors should take advantage of the R25T institutional training grant award. Brief descriptions of the purpose and targeted group to apply for these and a few selected additional award mechanisms follow.

K07: CANCER PREVENTION, CONTROL, BEHAVIORAL, AND POPULATION SCIENCES CAREER DEVELOPMENT AWARD

The NCI K07 Award or the Cancer Prevention, Control, Behavioral, and Population Sciences Career Development Award is for an individual with a doctoral-level degree (eg, PhD, MD, DrPH) or equivalent. This specific award is outlined in the program announcement PAR-99-108. Under the

guidance of a sponsor or mentor, the K07 is designed to help postdoctoral individuals receive the combined didactic and supervised research experiences to become well-trained scientists in cancer prevention, control, behavioral, and population research. For the imaging sciences, such a mechanism could support individuals interested in using imaging in screening and prevention-related research. The K07 is not for individuals pursuing typical basic cancer research careers. Candidates must commit to a 75% full-time professional effort conducting research and research career development. For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/prevention/K07.html>.

K08: MENTORED CLINICAL SCIENTIST DEVELOPMENT AWARD

The Mentored Clinical Scientist Development Award, or K08, is designed to help medically trained individuals become well-trained, laboratory-based cancer researchers. It supports up to 5 years of combined didactic and supervised (ie, mentored) research experiences to acquire the methodological and theoretical research skills needed to become an independent scientist. These may or may not be individuals who have chosen to complete their clinical training (or the equivalent) and devote some of their time to clinical practice. For individuals who chose to pursue a career dedicated to patient-oriented research and clinical practice, the NCI employs a different career development award, the Mentored Patient-oriented Research Career Development Award, or K23 (see below). For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/basicmd/K08.html>.

K22: TRANSITION CAREER DEVELOPMENT AWARD

The Transition Career Development Award, or K22, is designed for an individual candidate who has been educated as a clinician scientist (eg, MD) and is ready to pursue an independent research career. Candidates must have a minimum of 2 years of mentored postdoctoral cancer research experience or less than 1 year in a suitable independent position with previous, continuous postdoctoral cancer research experience at the time of the application. The K22 is not for individuals without clinical degrees who are pursuing basic science cancer research careers. The purpose of the award is to provide protected time for newly independent investigators to develop and receive support for their initial cancer research programs. Candidates must commit 75% of a full-time professional effort to conducting research and research career development. The unique feature of this award is that an individual can apply while in a postdoctoral position without institutional representation and can receive funding based on his or her potential for independent research. Individuals in postdoctoral

positions can apply without an institutional affiliation; faculty in an independent position for less than 1 year also can apply without an institutional affiliation. Successful K22 applicants can be supported for up to 3 years, and these awards are not renewable. For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/basicmd/K22.html>.

K23: MENTORED PATIENT-ORIENTED RESEARCH CAREER DEVELOPMENT AWARD

The purpose of the Mentored Patient-Oriented Research Career Development Award, or K23, is to support the career development of clinically trained professionals who have made a commitment to focus on patient-oriented research. Patient-oriented research is defined as research conducted with human subjects (or on material of human origin such as tissues, specimens, and cognitive phenomena) for which an investigator directly interacts with human subjects. This area of research includes mechanisms of human disease, therapeutic interventions, clinical trials, and the development of new technologies. This mechanism provides support for up to 5 years of combined didactic and supervised (ie, mentored) research experiences to acquire the methodological and theoretical research skills needed to become an independent clinical investigator. For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/clinical/K23.html>.

K25: MENTORED QUANTITATIVE RESEARCH CAREER DEVELOPMENT AWARD

The purpose of the Mentored Quantitative Research Career Development Award, or K25, is to engender and foster interdisciplinary activities by supporting the career development of investigators with quantitative scientific or engineering backgrounds outside of biology or medicine who have made a commitment to focus their research endeavors on behavioral or biomedical research (basic or clinical). This mechanism is aimed at research-oriented scientists with experience at the level of junior faculty (eg, early to mid-levels of assistant professor or research assistant professor ranks). This award provides support for a period of supervised study and research for professionals with such backgrounds who have the potential to integrate their expertise with biomedicine and develop into productive investigators. Examples of quantita-

tive scientific and technical backgrounds outside of biology or medicine considered appropriate for this award include but are not limited to mathematics, statistics, computer science, informatics, physics, chemistry, and engineering. For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/translational/translational.html>.

R25T: CANCER EDUCATION AND CAREER DEVELOPMENT PROGRAM

The Cancer Education and Career Development Program, or R25T, is applicable to highly interdisciplinary areas of research such as imaging that require sustained leadership, dedicated faculty time, specialized curriculum development and implementation, interdisciplinary research environments, and more than one mentor per program participant to achieve their education and research career development objectives. The purpose of this specialized R25 grant mechanism is to support the development and implementation of curriculum-dependent programs to train predoctoral and postdoctoral candidates in cancer research settings that are highly interdisciplinary and collaborative. This R25 mechanism is ideal for those institutions that are interested in training imaging scientists. It provides increased salary support for the trainees, research support, and faculty/mentor salary support compared to other institutional training mechanisms. For more specific information, please refer to the following Web site: <http://cancertraining.nci.nih.gov/research/prevention/R25tfull.html>.

CONCLUSION

The information above provides an overview of the most relevant mechanisms currently available to train the next generation of research imaging investigators, scientists, and clinicians. NCI staff members are ready to assist the leadership of academic radiology in research training for the next generation of imaging scientists and clinicians. More specific information on these and other training programs at the National Cancer Institute is available at the following Web site: <http://cancertraining.nci.nih.gov/index.html>. In addition to these government-funded programs, the professional societies related to radiology imaging will also have to take a fundamental role in ensuring that appropriately trained and educated individuals are available to meet the imaging research needs of the future.