Summary of Panel 4, Nuclear Medicine Applications Workshop on Training Requirements for Chemists in Nuclear Medicine, Nuclear Industry, and Related Areas

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Introduction

The application of nuclear and radiochemistry to the practice of medicine and in biomedical research has been described as one of the intellectual frontiers of chemistry related to the national well-being as described in the 1985 Pimentel Report (Opportunities in Chemistry, National Academy Press, Washington, DC 1985, page 265). The "chemistry of life processes" was given as one of the five frontiers deserving high priority. The practice of nuclear medicine, biomedical research and all support related activities depends on the use of radioactive materials. It is therefore axiomatic that nuclear and radiochemistry play a vital role in the continued growth of these fields. It follows that the need for training in radiochemistry is an imperative. It is a matter of great concern to this panel that while the demand for knowledgeable people is increasing, the supply from the core educational facilities of this country is decreasing.

Discussion

We recognize that research in nuclear medicine is not a common interest of faculty members in universities with graduate programs in chemistry; thus there is a problem in attracting chemists to this field. We further recognize that public awareness, indeed fears of nuclear matters, is regrettably real, yet we are also aware that few patients seeking medical care will deny themselves that care because radioactive materials are involved. Therefore we consider that a central issue is the dissemination of information on opportunities in this area and on the benefits to the public in order to stimulate greater interest and awareness in university chemistry departments.

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Stimulating interest in careers in chemistry related to the nuclear medicine area can be effected in several ways: by promoting lectures to undergraduates and graduates perhaps as part of a course or as career seminars with solid scientific content; by increasing efforts to provide articles for the popular scientific literature, e.g., Science, Accounts of Chemical Research, Chemical Reviews and Quarterly Reviews; by holding symposia at national and local meetings of the American Chemical Society on topics related to nuclear medicine; and by attempting to dispel the myths surrounding radioactivity and the biological effects of radiation. Such an effort could be particularly effective in nuclear medicine since the positive societal benefits are easily documented and readily supported.

As examples of some specific areas where training and knowledge of nuclear and radiochemistry are necessary, one can consider the needs of medical centers, industry, universities, and national laboratories.

The needs of medical centers can be put in perspective with two examples. One of the modalities at the frontier of new medical technologies is exemplified by cyclotron - PET (positron emission tomography) centers. In the past twelve years PET centers have grown from four to twenty four in the U.S. At present most are engaged in basic and clinical research. Routine clinical application is just beginning. Future growth will require chemists trained principally in organic and inorganic chemistry but with training in radiochemistry to develop and provide the radionuclides and labeled compounds required. A knowledge and appreciation of radiation and radiochemistry is essential.

Another aspect concerns the needs of nuclear pharmacists, trained professionals who work in many major health care delivery centers and commercial nuclear pharmacies. The increasing sophistication of the labeled

drugs with which they deal makes training in radiochemistry essential to their mission. Additional educational requirements will be placed on the nuclear pharmacist especially as the number of clinical PET centers increases.

Turning to the radiopharmaceutical industry we foresee a large and continuing need for chemists primarily for research and development, but also to staff key positions in other departments such as manufacturing, waste disposal and radiation protection. The primary field of chemical specialization may be in organic or inorganic synthesis, analytical chemistry or biochemistry, yet a background in radiochemical methods and instrumentation is essential. In the ethical drug area, while no necessary connection exists with nuclear medicine, radiolabeled drugs are used extensively in the study of drug metabolism, pharmacokinetics, drug biodistribution, drug delivery systems, bioavailability and molecular pharmacology. These studies, intrinsic to drug discovery, development and approval, requires synthetic chemists and pharmaceutical scientists who must be knowledgeable in radiolabeling, radioanalytical techniques and the basic properties of radioactive materials. The future demands on these researchers will be even greater due to both increased sophistication of pharmacologic studies requiring isotopic methods and new approaches in the study of dynamic factors in drug activity by PET. Thus, training of these researchers will require knowledge of positron-emitting isotopes as well as the traditional isotopes of pharmaceutical research, tritium, carbon-14, and iodine-125.

Radioimmunoassay (RIA) is another area in industry which requires radiochemistry. While the breadth of RIA is limited primarily to radioligands labeled with tritium and iodine-125, the development of these materials and their purification has been the province of biochemists and immunochemists with backgrounds in radiotracer synthesis and development. RIA will remain a

vital part of the in vitro diagnostic field with a modest, but very real, need for chemists with training in radiochemical techniques.

The needs described to this point concern chemists and pharmacists with advanced degrees whose primary training is not in nuclear and radiochemistry, but rather in organic, inorganic, analytical or biochemistry. This is an important distinction. Regardless of major discipline, however, effective use of these skills also depends on a knowledge of radiochemistry. A need also exists for involvement by specialists in nuclear and radiochemistry. The measurement of accurate nuclear reaction cross sections, optimization of target design, production of radionuclides for diagnosis and therapy, design of new radionuclide generators, and cyclotron or other accelerator technology for radionuclide production, are areas which are not in the normal purview of synthetic or analytical chemists. For example, the development of therapeutic applications, particularly the radioimmunotherapy of cancer using labeled monoclonal antibodies, is a current area of intense research interest and effort. The selection of appropriate nuclides for therapy and the development of an adequate supply for clinical use, is a major need. This work will require a significant number of highly trained nuclear and radiochemists at national laboratories, universities, and industry to develop methods for adequate production of these nuclides.

The need for chemists trained as nuclear and radiochemists or with some training in this field as a part of their education is large and increasing, ironically at a time when available training is decreasing. To place this in perspective, a table of current needs will underscore this statement. This table gives the number of positions currently available for chemists and pharmacists in nuclear medicine and related disciplines in which a knowledge of radiochemistry is necessary. An estimate is given for each area for 1993.

Table 1. The Need for Personnel With An Advanced Degree

	1988[a]	1993[b]
Medical Centers		
a. Imaging and Related Fields	15	40
b. Nuclear Pharmacy	10	30
Industry		
a. Radiopharmaceutical Manufacture	40	60
b. Ethical Drugs	40	80
c. RIA	5	5
Universities/National Labs	10	10
TOTAL	120	225

a. The numbers in this column are primarily based on open positions gleaned from classified advertisements. Personal knowledge of needs and openings by members of the panel were also included.

b. The numbers in this column are based on the projections given by members of the panel as to open positions to become available in 1993.

The position papers accompanying this section provide details as to the needs for radiochemical traning for professionals working in nuclear medicine and related areas.

Conclusion

In summarizing our position on radiochemistry training for chemists who provide the basic research and clinical effort that is necessary to support the field of nuclear medicine, we present the following conclusions.

1. Increasing public awareness of the importance and significance of radioactive materials in public health and indeed in other aspects of the welfare of our society is of prime importance.

2. Chemistry departments should be encouraged to provide, where possible, an upper level course in nuclear and radiochemistry to students in their department and allow course entry to other faculties at the university in question (cross listing).

3. The panel feels that specialized application of aspects of nuclear and radiochemistry can best be served by postgraduate education at a select number of centers, perhaps five to seven, where the faculty, infrastructure and equipment exist to facilitate such a course. Extended in depth training could be accomplished with fellowships for some individuals following completion of the course. These courses may not be uniform in content, but they will be specialized and tailored to the needs of those who work in nuclear medicine and health related fields.

4. The panel wishes to underscore the desperate need for professionals trained in radiochemistry as a national priority for the continued vitality of an important segment of the health care delivery system. Quality of care and the ability to deliver this care will not only suffer but will decline in the next decade without some redress of this need.

Summary

Nuclear medicine is currently facing a desperate shortage of organic and inorganic chemists and nuclear pharmacists who also have advanced training in nuclear and radiochemistry. Ironically, this shortfall is occurring in the face of rapid growth and technological advances which have made the practice of nuclear medicine an integral part of the modern health care system. Approximately 120 professionals are needed to fill positions which exist now (in 1988) in medical centers, in industry and in universities and national laboratories, and it is estimated that this shortfall will rise to 225 by 1993. This shortage threatens to limit the availability of radiopharmaceuticals required in routine hospital procedures and to impede the development of new diagnostic and therapeutic agents. To redress this need and prevent a similar shortfall in the future, this panel recommends immediate action and a long-term commitment to the following: educating the public on the benefits of nuclear medicine; informing undergraduate and graduate chemistry students about career opportunities in nuclear medicine; offering upper level courses in nuclear and radiochemistry (including laboratory) in universities; establishing training centers and fellowships at the postgraduate level for specialized education in the aspects of nuclear and radiochemistry required by the nuclear medicine profession.