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education offerings, will address cardiology; oncology; basic science; neurology; pulmonary; endocrinology; musculoskeletal disorders; genitourinary; gastrointestinal; and other areas, such as hematology, infections, and lymphatics. A CT module will also be included.

These competitively priced modules will offer virtual workstations, providing multimedia graphics and reviews in PET, CT, and/or PET/CT modes. Each module will contain tables, figures, a glossary, and multiple-choice questions (based on clinical decision making), each with a review and test capability. The modules, which will be revised every 3 years, will provide critiques, case studies, surveys, and Web-based checklists and simulations. They will offer complete search capability, indices, and the ability to take notes (and download that information) to develop an individual study guide.

The architects of this innovative program include Alan H. Maurer, MD, chair of the SNM Education Committee; SNM officers; and Lynn Barnes, SNM director of education. Dominique Delbeke, MD, PhD, will serve as chair of the MOC program and will develop a system of module vice chairs, authors, and reviewers.

The program's 3-year business plan and detailed outlines were presented at a summit meeting held at last month's mid-winter meeting. The first 3 demonstration modules (cardiology and oncology) will be available for viewing at the SNM annual meeting, June 18–22, in Toronto. The educational portal from the society's Web site to the MOC programs is expected to be online by September 1.

Although MOC affects physicians, its reach will extend to technologists, radiologists, and scientists. Nuclear medicine technologists are now struggling with changes in continuing education guidelines, which will be required this July. The effects of MOC on our members and the society itself are enormous. SNM stands ready to ease the way for nuclear medicine professionals to continue their lifelong learning with this new MOC program. More information about this initiative will be made available as work progresses in 2005.

Virginia Pappas, CAE
Executive Director, SNM

Physics Applications in Nuclear Medicine: Progress on Many Fronts

The year 2004 was a year of significant progress in the area of physics applications in nuclear medicine. Research marched forward in detector development and reconstruction technology, and new tools became available. Discussion in the dosimetry community about the importance of patient-specific dosimetry continued and was brought to focus at a European congress. Calculational tools, including the OLINDA/EXM code, were developed and released. Electronic resources continued to be a developing field, facilitating international communications and making daily work go faster.

Instrumentation Innovations

New detector materials, imaging tubes, and readout systems are being integrated to create novel detector geometries that are rapidly moving from research to practical clinical imaging devices. Breast imaging devices based on standard NaI crystals and pixelated CsI are being used in different geometries made possible by the use of unrestricted arrays of position-sensitive or multianode photomultiplier tubes. The ability to mount these room temperature devices to crystals arrayed in unusual geometries makes it possible to efficiently surround organs such as the breast in arrays for single-photon or positron imaging. A special session on breast imaging at the 2004 Institute of Electrical and Electronics Engineers Medical Imaging Conference featured a number of the current devices used alone or in conjunction with radiographic imaging ensembles for biopsy correlated nuclear medicine procedures (*1*).

A follow-on to the multiple pinhole dynamic 3D imaging (4D) work for brain flow/function pioneered by the Arizona group has moved from instrumentation to clinical applications (*2–4*). An alternate approach useful in small animals simulated submillimeter resolution in very small regions of a mouse using a commercial 3-head gamma camera with a spherical multipinhole collimator with holes converging on the target region of the body (*5*). Innovations stimulated by the National Institutes of Health (NIH) small animal imaging focus continue to emerge, now joined by major Homeland Security funding for screening devices that attempt to meet the combined need for high sensitivity with energy selectivity.

Many important developments in the field of emission tomography were brought together in an important new

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book produced from manuscripts presented upon Bob Beck's retirement from the University of Chicago to honor his many contributions to theory and practical developments in medical imaging (*6*).

Image Processing

New open systems software packages continue to emerge. The NIH has continued to develop a series of powerful desktop tools for their own work, which they have disseminated for more general use. The initial Macintosh-based NIH Image program made it possible to analyze features in many different classes of medical images. Image J, a nonproprietary PC-based extension of NIH Image broadened the user base. A new and powerful general purpose Medical Image Processing Analysis and Visualization Package (MIPAV) developed by NIH researchers provides JAVA-based tools that run on a variety of platforms. It provides many of the features of the various commercially marketed products that can be adapted in a user-friendly fashion to specific user applications. It reads and writes numerous image formats, including DICOM3.0, GE, Siemens, Analyze, TIFF, and others, and handles PET and SPECT images as well as other imaging modalities. It provides tools for automatic, semiautomatic, and manual segmentation and quantification and rigid and nonrigid registration. It provides many user-selectable tools for image filtering, noise reduction, image compression, and many other useful functions. For additional details see http://mipav.cit.nih.gov/.

Radiation Dosimetry and Radiobiology

One of the notable but sad events of 2004 was the passing of Lauriston S. Taylor at age 102, one of the important pioneers of radiation protection philosophy, a founding member of the International Commission on Radiological Protection (ICRP), and author of numerous important and influential works, including *Organization for Radiation Protection* (*7*).

2004 was the year that α-emitter dosimetry jumped into our collective consciousness. Miederer et al. (*8*) described the pharmacokinetics, dosimetry, and toxicity of ^{225}Ac-HuM195 in nonhuman primates. We also began more serious inquiry into ways to calculate dose to the tissues of animals used in preclinical work. A paper by Hindorf et al. (*9*) presented some preliminary dose factors and discussed parameters of importance to the calculations. Stabin et al. (*10*) presented voxel-based, realistic models of a rat and mouse, with dose factors for electrons and photons developed for generalized use.

Nettleton et al. (*11*), reporting on a group of patients with prostate cancer who opted for orchidectomy and were administered ^{111}In or ^{201}Tl before surgery, showed that the predicted values of testicular uptake by the ICRP "for ^{111}In might be too low by a factor of 4, whereas those for ^{201}Tl might be too high by a factor of 4" (*12*). Indeed the overestimate of testicular uptake of ^{201}Tl has been a subject of study for several years by Thomas et al. (*13*), who have produced a paper thoroughly evaluating existing models for ^{201}Tl and presenting a complete and up-to-date dosimetry summary, including a significantly lower estimate of testicular dose than that in the ICRP tables. As noted by Nettleton et al. and by Thomas et al., further work is needed to evaluate small scale dose issues within the testes.

The use of ^{99m}Tc-annexin V for detection of apoptotic responses continued to be demonstrated and investigated (*14–17*). Two groups demonstrated interesting methods for minimizing red marrow dose during radioiodine therapy (*18,19*).

In years past, we have focused on criteria for release of radioactive patients, and the issue has not completely gone away (*20*). In 2004, concerns related to homeland security brought up a new problem involving the public: nuclear medicine patients have triggered radiation detection alarms in public transportation centers and other locations, causing unnecessary concerns and possibly travel delays for the patients and others (*21*). Several authors have looked at this issue. A fairly thorough and innovative investigation was undertaken by Zuckier et al. (*22*), in which responses at a few meters in the presence of radiopharmaceuticals were assessed and times after administration were calculated during which patients should carry letters from their physicians documenting the identities and quantities of the radiopharmaceuticals administered.

The debate continues, and is perhaps reaching a peak, over whether dosimetry for nuclear medicine patients should follow more of a "radiation oncology" or a "chemotherapy" model—that is, whether patient-specific dosimetry and optimization of individual patients' tumor and normal tissue doses is optimal or whether patients should be given what is basically a "one size fits all" approach, perhaps with minor modifications allowing for differences in body weight. Keith Britton (*23*), in *The Journal of Nuclear Medicine* (*JNM*), asked in a letter to the editor, "Should we insist on the nuclear medicine approach to cancer therapy, in which potential nonresponders are excluded by imaging, or should we follow an apparently oncologic approach whereby as long as the marrow is safe, it does not matter whether the tumor receives an adequate or inadequate amount of therapy or whether the patient receives unnecessary radionuclide therapy? Should not we uphold the basic principles of nuclear medicine and radiation protection for radionuclide therapy?" As a follow-up to the 30-year Oak Ridge (and, in 2002, Nashville), TN, radiopharmaceutical dosimetry symposium series, the "1st International Symposium on Radionuclide Therapy and Radiopharmaceutical Dosimetry" was held in conjunction with the 2004 European Association of Nuclear Medicine (EANM) Congress in Helsinki, Finland, September 4–8. In addition to the presentation of a number of significant papers on radiation dose models and methods, spirited debate among physicians, physicists, and other professionals ensued on this topic of the need for patient-specific dosimetry therapy. The organizers did an excellent job of integrating the symposium into the EANM congress and of bringing together professionals from the different disciplines to debate this and other issues. The result was a rather surprising consensus that dosimetry should be more integrated into routine nuclear medicine therapy practice. Dr. Glenn Flux of the UK noted the regulations of the European Union that basically mandated such practice, and encouraged attendees to adopt the practice, noting that progress was already moving in this direction as a result of regulatory pressure and the presence of better calculational tools (see, for example, the article by Sgouros et al. in *JNM [24]*) and will not likely move backward later. After the meeting, a number of centers have begun to share data and methods in the hopes of establishing reasonable, standardized protocols for gathering data for dosimetry. This effort is being coordinated by members of the RADAR group (*25*).

Acceptance of radiation dosimetry in the clinic depends on 2 critical factors: the ability to produce accurate, reproducible results, and the ability to link the results to observed effects. This, too, was a topic of major emphasis at the EANM meeting. There, the *JNM* papers by Siegel et al. (*26*) and Shen et al. (*27*), demonstrating methods for performing patient-specific corrections for marrow mass and improving dose/effect correlations, continued to be discussed. In July, de Jong and colleagues (*28*), in the words of Stan Goldsmith (*29*), "convincingly demonstrated that, in radionuclide dosimetry, it is not valid to assume a uniform distribution of radiation sources in a target organ and, hence, that it is not appropriate to compare radiation effects from absorbed doses delivered by external-beam sources with doses from injected radionuclides." Several excellent presentations at the EANM congress touched on this issue, and should be appearing in early 2005 as meeting proceedings in special issues of *Cancer Biotherapy and Radiopharmaceuticals*. Papers by Konijnenberg et al., extending previous work (*30*), and Pauwels et al. gave further evidence that reliable associations of radiation dose (particularly when expressed as biologically effective dose [BED, see also a previous paper by Bodey et al. (*31*)]) with effects in the kidneys can be made and provide a strong link to our knowledge of dose–effect relationships from external beam therapy, when properly assessed. Thus, the prospects for the use of radiation dosimetry in practical settings were dramatically strengthened. Other relevant information was published in a special section of *Cancer Biotherapy & Radiopharmaceuticals* (*32*). The proceedings of a Medical Internal Radiation Dose (MIRD) Committee-sponsored continuing medical education session entitled "Kidney Dose–Response for Radionuclide Therapy," held at the 50th annual meeting of the SNM, in New Orleans in 2003, were presented in this special section.

Electronic Resources

As reported in this article last year, the RAdiation Dose Assessment Resource (RADAR) Web site (www.doseinfo-radar.com) was developed to freely disseminate widely used data and information (standardized dose estimates, decay data, absorbed fractions, dose conversion factors, information on radiobiology, and dosimetry literature). Published articles support the scientific basis for the data on this site (*33–35*). In 2004, the OLINDA/EXM software, the purported successor to the MIRDOSE 3 code, was released (*36–38*). Vanderbilt University began distribution of the code in October 2004, after receiving U.S. Food and Drug Administration approval of the code through a 510(K) mechanism.

A number of interesting e-mail lists (NucMed, RadPharm, PETmail, Medical Imaging (Archive-Comm-L), Radsafe, Dose-Net, and others) are available for exchanging information actively with other interested parties. Subscriptions are free, and digest versions (once-per-day summaries of all posts) are usually available. A large number of Yahoo groups also exist with relevance to this area of science (but which are too numerous to mention). Many of these use a bulletin-board approach to exchange information. See http://hps.org/resources.html for more details.

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Imaging Informatics and Nuclear Medicine

For nuclear medicine, among the most "computerized" of imaging specialties, the year 2004 brought physicians, physicists, and technologists face-to-face with what has become the biggest challenge to all of imaging practice: the rapid increase in size and complexity of datasets. Although nuclear medicine was largely isolated from this rapid growth in the past, the advent of PET/CT and the promise of routine SPECT/CT have made the "image overload" associated with multichannel CT a new and, in many cases, daunting factor in planning for aspects as diverse as patient throughput, image interpretation, departmental workflow, and image archive, storage, and retrieval. Many clinical users are actively working with manufacturers to answer important questions, including, "How can we maintain throughput when it takes longer to reconstruct and send the images to an archive or to workstations than it does to scan the patient, thus creating a bottleneck?" The question of image overload was addressed at major imaging meetings in 2004, and the Society for Computer Applications in Radiology held a special symposium on the topic in Bethesda, MD, earlier this month.

Another trend that began elsewhere in imaging but that is beginning to resonate in nuclear medicine is the routine use of 3D/multiplanar images. Picture archiving and communications (PACS) vendors are increasingly including 3D/multiplanar solutions in their products, but at the same time are struggling to find ways to integrate these with existing technologies. A new trend for 2004 was more general acceptance of the idea of doing 3D processing on a server rather than at the level of the

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