MEDICAL PHYSICS

Medical Physics is an applied branch of physics involving the application of physics concepts and methods to the diagnosis and treatment of human disease. It is an interdisciplinary field that integrates core knowledge in traditional physics disciplines with specific domain knowledge in:

- the science of healthcare delivery, particularly in ensuring the accuracy and safety of medical diagnostic and therapeutic procedures;
- bioeffects related to exposures to ionizing and non-ionizing electromagnetic radiation, ultrasonic energy, and strong magnetic fields;
- optimization of imaging and therapeutic procedures to maximize benefit and minimize risk to the patient and healthcare provider;
- evaluation and communication of benefits and risks to patients and healthcare providers;
- image science and image analysis;
- data analysis and statistics;
- clinical trial design, implementation and oversight;
- quality assurance and quality improvement processes;
- electrical, mechanical, and biomedical engineering;
- control systems, including computer controlled, mechanical, and electronic systems;
- mathematics;
- computer science;
- computational modeling;
- detector design and fabrication.

WHAT DO MEDICAL PHYSICISTS DO?

Medical physicists are involved in a wide range of activities, including clinical service and consultation, research and development, education, radiation and magnetic resonance safety, and administration. Medical physicists are also involved in non-clinical careers, working in industry, governmental and regulatory agencies, and accreditation organizations.

CLINICAL SERVICE & CONSULTATION

Many medical physicists are involved in providing the accurate, safe, and efficacious patient care, particularly in the fields of medical imaging and radiation therapy. These activities include consultations with physician colleagues to enable optimal imaging or treatment protocols or consultations with patients with regard to radiation doses. In radiation oncology departments, medical physicists play an essential role in the planning and quality assurance of radiation treatments for cancer patients, using external beams of high energy X-rays, electrons, protons, or other charged particles, or internal radioactive sources.

The accurate measurement and characterization of the amount of radiation produced by a radiation source is an indispensable service performed by medical physicists. These services are essential in medical specialties that utilize ionizing radiation for medical imaging, especially radiology and cardiology, and in radiation oncology, where high doses of ionizing radiation must be accurately delivered to effectively treat cancer while minimizing harm to healthy tissues. In radiation therapy, the dose to be delivered must be accurately modeled in specialized treatment planning software in order to optimize the individualized technique used to treat each patient.

In the specialty of nuclear medicine, physicists collaborate with physicians to perform imaging procedures that use radionuclides to identify metabolically active tissues or to measure physiologically important variables, such blood flow. Other important services provided by medical physicists include the quantitative evaluation of equipment perfor-mance, design of radiation and electromagnetic shielding, control of radiation and electromagnetic hazards, and oversight of quality assurance and patient safety programs. The medical physicist contributes clinical and scientific expertise and resources to solve the numerous and diverse problems that can arise in many areas of medicine.

RESEARCH & DEVELOPMENT

Medical physicists play a vital and often leading role in biomedical research. Their activities cover a wide range of clinical and technical specialties. They investigate questions involving the biological effects of ionizing, electromagnetic and ultrasonic irradiation, develop and apply new diagnostic and treatment modalities, design new techniques for the delivery, modeling, and precise measurement of radiation, and perform a wide variety of studies of clinical outcomes and effectiveness.

Patient dose calculations and modeling of clinical dose response remain an active area of investigation, as does particle irradiation, which offers promising biological advantages over traditional photon treatments. In heart disease, physicists work on the measurement of blood flow and oxygenation, and the development of non-invasive stop-motion imaging of cardiovascular structures and diseases. In neurosciences, functional imaging modalities, particularly PET and MR imaging, are being used to unlock the mysteries of how the healthy brain processes information and how various diseases disrupt these processes. Medical physicists are heavily involved in the development of new instrumentation and technology for use in medical imaging, as well as in various therapeutic applications.

Typical examples of the various research areas presently under active investigation may be found in scientific journals dedicated to this field. Two journals, *Medical Physics* and the *Journal of Applied Clinical Medical Physics*, are published by AAPM. In addition, AAPM holds two national scientific meetings a year, their annual meeting in the summer and, in joint sponsorship with the Radiological Society of North America, a winter meeting. Special summer courses, workshops, and regional chapters meetings are also held by AAPM.

EDUCATION

Many academically-involved medical physicists have faculty appointments at universities and colleges, where they help train future medical physicists, resident physicians, medical students, and technologists who operate the various types of equipment used to perform medical imaging and treatment. They also teach courses in medical physics and aspects of biophysics and radiobiology for a variety of graduate and undergraduate students. Both in the classroom and in the lab, medical physicists provide the education and training necessary to support the continued demand for medical physicists, both in the clinical and research and development environments. The Commission on Accreditation of Medical Physics Education Programs, jointly sponsored by the American College of Radiology and AAPM, ensures high educational standards in the field.

WHAT DO MEDICAL PHYSICISTS DO? [cont.]

RADIATION & MAGNETIC RESONANCE SAFETY

Medical physicists play an important role in ensuring patient and provider safety. They may serve as an institution's radiation safety officer (RSO) or magnetic resonance safety officer (MRSO), where they are responsible for developing safety policies and procedures, ensuring adequate education for employees who deal with environments where radiation or strong magnetic fields are present, conducting compliance audits, and answering questions from patients and providers. Where state or federal regulations apply, they are responsible for ensuring compliance with regulatory requirements, obtaining needed licenses, participating in regulatory inspections, and responding to any violations of regulatory requirements or patient or provider incidents. In academic medical centers, the RSO or MRSO may also serve on or chair institutional safety committees, who must approve research use of radiation emitting devices or materials.

ADMINISTRATION

Medical physicists are responsible for a number of administrative activities, both within clinical practice and academia. Many medical centers and universities have a department or division of medical physics that is led by a senior physicist who is responsible for recruitment, oversight and assessment of medical physics personnel, procuring adequate space and funding, directing educational programs, and providing strategic leadership. In academic radiology and radiation oncology departments, a medical physicist is often selected to serve as the departmental vice-chair of research. Some medical physicists have served as senior administrators at a large university, often as the dean of research, and in a few cases, a medical physicist has served as the chair of a radiology or radiation oncology department. Medical physicists play key roles in institutional committees, including, but not limited to, the radiation safety committee, magnetic resonance safety committee, research committee, education committee, cancer committee, quality committee, equipment specification and selection committees, and the institutional review board.

INDUSTRY

Many imaging and radiation oncology-related companies employ medical physicists in their research and development organizations, often as leaders of the development teams for new products in imaging and radiation treatment. Medical physicists are also extensively involved in the product management and marketing sides of these organizations. In these roles, medical physicists direct clinical trials to determine the effectiveness of new healthcare technologies, contribute their first-hand clinical and technical expertise to their research and development teams, interact with healthcare providers when questions arise regarding optimal product use, and provide feedback from the user community to their organization.

GOVERNMENTAL AND REGULATORY

The responsibility for ensuring the safe use of radioactive materials and radiation-producing machines is shared by a number of federal agencies and states. Medical physicists promote close and cooperative working relationships with numerous government bodies and organizations, including Congress, federal and state agencies, related professional societies and a range of medical providers, corporations and suppliers to advocate for uniform radiation protection regulations and practices and to provide expert leadership in radiation-related issues.

Additionally, medical physicists are employed by governmental organizations to provide domain expertise in medical imaging, radiation oncology, and other radiation emitting devices. Some assist in the writing or review of legislative or guidance documents and in the evaluation of medical devices for safe and efficacious use. You can find medical physicists working at the Food and Drug Administration, typically in the Center for Devices and Radiological Health; the National Institutes of Health; the U.S. Departments of Veteran Affairs, Health and Human Services, Defense, and Homeland Security; and in every branch of the military, typically through the U.S. Public Health Service as commissioned officers.

ACCREDITATION ORGANIZATIONS

Medical Physicists work closely with national accreditation organizations to ensure that consistent, high quality clinical outcomes are achieved. Medical Physicists perform quality control testing on imaging and radiation therapy equipment that assesses radiation dose, image quality, and the functionality of safety features to ensure optimal equipment performance.

Additionally, medical physicists are employed by accreditation organizations to contribute their clinical and technical expertise to the development and oversight of accreditation programs. They interface with clinical medical physicists to answer questions from the user community, and to communicate to their organization the problems and limitations that are experienced in the field.