A Quick Review of the Medical Physics Profession

Foreword

The modern practice of medicine relies heavily upon a significant number of physical tools, techniques and principles of physical sciences. The complexity and precision required in the performance of the related diagnostic and therapeutic procedures and the continued endeavours to further enhance these tools has led to the development of the specialty of Medical Physics, which is primarily an applied branch of physics.

It is concerned with the application of the concepts and methods of physics to the diagnosis and treatment of human disease. Medical Physicists interact with several specialities of medicine such as radiotherapy, diagnostic and interventional radiology, nuclear medicine, cardiology, imaging procedures with Ultrasound and Magnetic resonance, medical uses of infrared radiation, the use of lasers in medicine, etc.

Historical Review

Perhaps Leonardo do Vinci, six centuries ago, was the first medical physicist. Certainly it is true that he was profoundly interested in the mechanics of the human locomotion. The subsequent gradual development of physical tools contributed to advances in the biological sciences. One outstanding example is the microscope, developed by the Dutch inventor, van Leeuwenhoek, during the 17th century. The development of the science of electromagnetism in the 19th century enabled physicists to make contributions to medical treatment and diagnosis. D'Arsonval, a French physicist, pioneered the therapeutic use of high-frequency electric currents and pointed the way towards the development of electrical measuring instruments. Since then, sensitive recording voltmeters, starting with the Einthoven string galvanometer, have made possible the development of electrocardiography and electroencephalography.

The discoveries of x-rays and radioactivity by physicists, Roentgen in 1895 and Becquerel in 1896, were rapidly followed by the application of ionising radiations to the diagnosis and treatment of disease. This use has been primarily responsible for bringing physicists directly into the sphere of the hospital. In 1913, Duane began work on radon sources for cancer treatment in a Boston Hospital and was followed in 1915 by Failla in New York. In the 1920's there was only a handful of physicists in medicine, but today, the number exceeds 20,000 worldwide.

The invention of powerful radiation sources to deliver interstitial and intra-cavitary radiation therapy, including Van de Graaff generators, betatrons, cobalt-60 units, linear accelerators, microtrons and cyclotrons for external beam radiation therapy; the application of man-made radionuclides to medical diagnosis and the development of detection devices, such as the gamma cameras and positron emission tomography (PET) scanners; the application of ionising radiation to medical diagnosis and the invention of imaging techniques and devices, such as image intensifiers, computed tomography (CT), and digital radiology; and, more recently, the utilisation of nuclear magnetic resonance (NMR) in medical imaging and spectroscopy have all created a distinct role for medical physicists in the practice of the healing arts. Thus the growth and contribution of medical physics is a natural consequence of the evolution of modern science and technology.

Therefore, issues concerning the use and dangers of ionising and non-ionising radiation, the Medical Physicists, is the most suitable consultant. Is the scientist who can advise and inform correctly the public around the problems of exposure to radiation as well as to disprove myths.

Areas of Activity

Medical physicist are concerned with three areas of activity:

- Clinical service and consultation
- Research and development
- Teaching.

On the average their time is distributed equally among these three areas.

Clinical Service

Medical Physicists are heavily involved in areas of diagnosis and treatment, often with specific patients. These activities take the form of consultations with physician colleagues. The hospitals departments, where the presence of Medical Physicists is essential and continuous are (a) Radiotherapy (b) Nuclear Medicine, and (c) Radiology departments.

In Radiotherapy departments, among the duties and responsibilities of the Medical Physicist, is the planning of radiation treatments for cancer patients, using either external radiation beams or internal radioactive sources. An indispensable service is the accurate measurement of the radiation output from radiation sources employed in cancer therapy. In the specialty of nuclear medicine, medical physicists collaborate with physicians in procedures utilising radionuclides for delineating internal organs and determining important physiological variables, such as metabolic rates and blood flow. Other important services are rendered through investigation of equipment performance, organisation of quality control in imaging systems, design of radiation installations, and control of radiation hazards.

The medical physicist is called upon to contribute clinical and scientific advice and resources to solve the numerous and diverse physical problems that arise continually in many specialised medical areas.

Research

Medical physicists play a vital and often leading role within the medical research team. Their activities cover wide frontiers, including such key areas as cancer, heart disease and mental illness. In cancer, they work primarily on radiation problems, such as the basic mechanisms of biological change after irradiation, the application of new high-energy machines to patient treatment and the development of new techniques for precise measurement of radiation. Significant computer developments continue in the area of dose calculation for patient treatment and video display of this treatment information. Particle irradiation is an area of active research with promising biological advantages over traditional photon treatments. In heart disease, medical physicists work on the measurement of blood flow and oxygenation. In mental illness, they work on the recording, correlation and interpretation of bioelectric potentials.

Medical physicists are also concerned with research of general medical significance, including the application of computers in medicine and applications of information theory to diagnostic problems; processing, storing and retrieving medical images; measuring the amount of radioactivity in the human body and foodstuffs; and studying the anatomical and temporal distribution of radioactive substances in the body.

Medical physicists are also involved in the development of new instrumentation and technology for use in diagnostic radiology. These include the use of magnetic and electro-optical storage devices for the manipulation of x-ray images, quantitative analysis of both static and dynamic images using computer techniques, radiation methods for the analysis of tissue characteristics and composition, and the exciting new areas of computerised tomography and magnetic resonance imaging for displaying detailed cross-sectional images of the anatomy. Medical physicists are also engaged in research and development on imaging procedures utilising infrared and ultrasound sources. Typical examples of the various research areas presently under active investigation may be found in scientific journals dedicated to the field.

Teaching

Often Medical Physicists are employed in higher educational establishments, where they help train future medical physicists, resident physicians, medical students, radiographic technologists and nurses. They also conduct courses in medical physics and aspects of biophysics and radiobiology for a variety of graduate and postgraduate programmes.

Teaching is a part of the Medical Physicists tasks within hospitals. The continuing education of medical and paramedical personnel in matters of radiation protection is the responsibility of the Medical Physicist.

Professional Position

Medical Physicist are usually employed in hospital and other medical care facilities, university hospitals and other Higher education institutions. In many hospitals, medical physicists hold professional appointments in one of the clinical departments, frequently the radiology department and are members of the professional staff of the hospital. Some of the larger hospitals have considerably more medical physicists organised into medical physics departments.

Medical Physicists cooperate with a wide range of health professionals. Other than the medical and paramedical staff, they often collaborate with engineers and administrative staff to design new equipment and for upgrading techniques and procedures that serve diagnosis and therapy.

As consultants and researchers, medical physicists are held in high regard by the medical profession. In addition to their university and/or hospital appointments, many medical physicists have professional consulting activities outside of their primary employment.

Training of the Medical Physicist

Several universities offer academic programmes in medical physics leading to a master's or doctoral degree. A thorough preparation in general physics is highly desirable before entry into these programmes. The most common programmes emphasise the physical properties and medical applications of radiations of all types.

Academic training alone does not make a medical physicist. Practical experience with medical problems is essential. This experience may be acquired through a residency traineeship or postdoctoral program of one or two years in a hospital. These latter programmes are an important mode of entry into the profession.

Demand for medical physicists

Medical physics is a profession in which there is a steadily growing demand for trained individuals. Most large medical centres now employ medical physicists and many smaller hospitals are seeking well-trained medical physicists. The manpower needs are expected to grow on average of about 5% per year on a global scale.

While radiation therapy continues to be the major field of employment for medical physicists, new developments and greater sophistication in equipment and procedures for diagnostic radiology and nuclear medicine have brought about a substantial increase in positions available in these two fields.

The future

Many forces are working to make medical physics a creative, expanding and rewarding profession for the young scientist about to choose a career. A characteristic of our society is its ever-increasing pre-occupation with health.

Recent technical advances in health care are increasingly available to all persons. Health care now accounts for around 10% of the gross national product of most nations. The research attack on cancer and heart disease is growing yearly. New methods of diagnosis and therapy, are being developed and applied. These methods increasingly demand the special skills of medical physicists not only in research, but also in the application of patient care. Even though the mood today seems to favour emphasis on general practice, it is difficult to see how the human aspiration and endeavours to diagnose and treat human diseases as precisely and as timely as possible, can be curtailed.