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Review of Radiation Oncology Physics: A Handbook for Teachers and Students

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PREAMBLE

Radiation therapy, also referred to as radiotherapy, radiation oncology or therapeutic radiology, is one of the three principal modalities used in treatment of malignant disease (cancer), the other two being surgery and chemotherapy. In contrast to other medical specialties that rely mainly on the clinical knowledge and experience of medical specialists, radiotherapy, with its use of ionising radiation in treatment of cancer, relies heavily on modern technology and collaborative efforts of several professionals whose coordinated team approach greatly influences the outcome of the treatment.

The radiotherapy team consists of radiation oncologists, medical physicists, dosimetrists, and radiation therapy technologists: all professionals characterized by widely differing educational backgrounds and one common link – the need to understand the basic elements of radiation physics and the interaction of ionising radiation with human tissue in particular. This specialized area of physics is referred to as *radiation oncology physics* and proficiency in this branch of physics is an absolute necessity for anybody who aspires to achieve excellence in any of the four professions constituting the radiotherapy team.

This book is dedicated to students and teachers involved in programmes that train professionals for work in radiation oncology. It provides a compilation of facts on the physics as applied to radiation oncology and as such will be useful to graduate students and residents in medical physics programmes, to residents in radiation oncology, as well as to students in dosimetry and radiotherapy technology programmes. The level of understanding of the material covered will, of course, be different for the various student groups; however, the basic language and knowledge for all student groups will be the same. The text will also be of use to candidates preparing for professional certification examinations be it in radiation oncology, medical physics, dosimetry, or radiotherapy technology.

The intent of the text is to serve as a factual supplement to the various textbooks on medical physics and to provide basic radiation oncology physics knowledge in the form of a syllabus covering all modern aspects of radiation oncology physics. While the text is mainly aimed at radiation oncology professionals, certain parts of it may also be of interest in other branches of medicine that use ionising radiation not for treatment of disease but for diagnosis of disease (diagnostic radiology and nuclear medicine). The content may also be useful for physicists who are involved in studies of radiation hazards and radiation protection (health physics).

I would like to thank all the authors for their contributions as well as colleagues and my wife Mariana for advice and encouragement throughout this project.

Ervin B. Podgorsak

FOREWORD

In the late nineties, following a re-focusing of the work within the Dosimetry and Medical Radiation Physics Section (DMRP), the IAEA initiated a systematic and comprehensive plan to support the development of teaching programmes in medical radiation physics for many of its Member States. Multiple projects were initiated at various levels which, together with the well known short-term training courses and specialization fellowships funded by IAEA Technical Cooperation Projects, aimed at supporting countries to develop their own university-based M.Sc. programmes in medical radiation physics.

One of the early programmatic activities by DMRP in this period was the development of a "Syllabus in Radiotherapy Physics", with the goal of harmonizing the various levels of training that the IAEA provided, mainly through short-term courses. This was done during 1997-1998 by a group of physicists from Europe and North America with long experience in the teaching of medical physics (B. Nilsson, Sweden; B. Planskoy, UK; J.C. Rosenwald, France; and N. Suntharalingam, USA) under the supervision of the then DMRP Section Head, P. Andreo. The result of this work was released as an internal report (IAEA DMRP-9802), and its success encouraged the next step aimed at supporting more directly the material used in the various M.Sc. programmes.

In 1999 a consultants' meeting (R. Alfonso, Cuba; E. Podgorsak, Canada; G. Rajan, India; W. Strydom, South Africa; and N. Suntharalingam, USA) was conducted under P. Andreo's supervision to analyze the task to be implemented. The possibility of writing a "Primer in Radiotherapy Physics", based on the Syllabus above, which would provide physicists in developing countries with a modern and affordable text book was considered first. Arguments against this option were the wide availability of several excellent basic books in Radiotherapy Physics (even if it was difficult to recommend one in particular as being comprehensive), and the risk that the Primer would simply become another book, not necessarily better than the existing ones. Ultimately, a second option seemed more reasonable, which was to develop a "Teachers Guide", where the various topics in the Syllabus would be expanded to form a detailed "bullet list" containing the basic guidelines of the material to be included in each topic so that lectures to students could be prepared accordingly. This should include a comprehensive bibliography in order to harmonize the content of the lectures in different sites. During 1999-2000 the consultants named above prepared an initial draft of some chapters. After the departure of P. Andreo from the IAEA, J. Izewska took on responsibility for the project and searched for an editor to build the Guide and fulfill its initial goal.

During the period 2001-2002, E. Podgorsak (Canada) was appointed editor of the project and under the supervision of K. Shortt, the new DMRP Section Head, and in conjunction with J. Izewska, he implemented a change in strategy that led to the successful completion of the entire project. With enormous enthusiasm and professionalism, he redesigned the contents so that the book became a comprehensive "Handbook for Teachers and Students", with coverage deeper than a simple Guide. As well, he expanded considerably the initial list of topics by engaging an enhanced list of international contributors.

The “Handbook for Teachers and Students in Radiation Oncology Physics” aims at providing the basis for the education of medical physicists initiating their university studies in the field. It is not designed to replace the large number of textbooks available, which will still be necessary to deepen the level of knowledge in specific topics reviewed by the Handbook since it now includes the most recent advances in radiation therapy techniques available today. It is expected that the Handbook will successfully fill a gap in the teaching material for the specialty of Medical Radiation Physics, providing in a single manageable volume the largest possible coverage available today. Its wide dissemination by the IAEA will contribute undoubtedly to the harmonization of education in the field and be of value to new comers as well as those preparing for their certification as medical physicists.

At this stage, the IAEA is publishing the Handbook as “working material” seeking comments, corrections and feedback.

IAEA scientific officers of the project were: P. Andreo, J. Izewska and K. Shortt.

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Review of Radiation Oncology Physics: A Handbook for Teachers and Students. CHAPTER 11. COMPUTERIZED TREATMENT PLANNING SYSTEMS FOR EXTERNAL PHOTON BEAM RADIOTHERAPY MICHAEL D.C. EVANS Department of Medical Physics McGill University Health Centre MontrÃ©al, QuÃ©bec, Canada.Â Patient anatomy and tumour targets can be represented as 3 dimensional models. The entire process of treatment planning involves many steps and the medical physicist is responsible for the overall integrity of the computerized treatment planning system to accurately and reliably produce dose-distributions and associated calculations for external beam radiotherapy.