The 5th Edition of the historical textbook “Johns and Cunningham’s The Physics of Radiology” was published in March 2021. The 4th Edition of this book “The Physics of Radiology” by Professors Johns and Cunningham was published in 1983. The 5th Edition appeared almost after a gap of 34 years which indicates the magnitude of updation required for bringing the revised version. In fact, the authors took about 7 years to realize the dream of bringing the 5th Edition of this classic textbook which itself speak about the volume of work involved in revising and updating the 4th Edition to the recent need of the readers. On the lighter side, 34 years is almost equivalent to the typical working life of a professional, meaning the child who learned the subject from the 4th edition has revised the book while nearing superannuation. The 5th edition of the book is written by internationally renowned academicians, (i) Professor Eva Bezak, UniSA Cancer Research Institute, University of South Australia, Adelaide; Department of Physics, University of Adelaide, Adelaide, South Australia; (ii) Professor Alun H Beddoe, Honorary Professor of Radiological Physics, School of Physics and Astronomy, University of Birmingham, UK; Formerly Head of Department of Medical Physics, Queen Elizabeth Hospital, Birmingham, UK; (iii) Professor Loredana G Marcu, Faculty of Science, University of Oradea, Romania; University of South Australia, Adelaide, Australia; (iv) Professor Martin Ebert, Radiation Oncology, Sir Charles Gairdner Hospital, Perth; Department of Physics, University of Western Australia, Perth, Western Australia; and (v) Professor Roger I Price, Department of Physics, University of Western Australia, Perth, Western Australia; Formerly Head of Department of Medical Technology and Physics, Sir Charles Gairdner Hospital, Perth, Australia.

The Physics of Radiology by Professors Harold Elford Johns and John Robert Cunningham is an iconic textbook (first edition published in 1953 and later updated/revised at an interval of about a decade) and integral reference material for every student/trainee in the radiological and medical physics from the last seven decades. Many of us including three authors of the 5th edition of this book grew up with the 4th edition as a key textbook for radiotherapy physics. In fact, this is not a book rather a legacy of Professors Johns and Cunningham which was required to be carried forward by updating/revising the book periodically. Both authors of the 5th edition of this book and the publisher (Charles C Thomas Publisher Ltd., USA) deserve appreciation and applause to continue upgrading the book in the absence of the original authors.

The present edition of the book contains 22 chapters and 3 appendices (total 1352 pages), whereas the 4th Edition of this book has 17 chapters and 3 appendices (total 796 pages). All the chapters are thoroughly revised and updated by adding newer information which is evident from the difference in the total number of pages (556 pages) between the 5th and 4th edition of the book. Similar chapters of 4th edition have been merged in a single chapter in the 5th edition, for example, contents of Chapters 5 and 6 of the 4th edition with required updation and addition have been presented as chapter 3 in 5th edition. The structure of the 5th edition of the book has slightly been changed in comparison to its 4th edition as far as flow of concept and information are concerned and SI units have been used for all the quantities. Further, nine chapters (Chapter 6 – Radioisotopes for medical imaging and radiotherapy, Chapter 10 – Clinical radiobiology, Chapter 13 – Characteristics of radiotherapy photon beams, Chapter 15 – External photon beam dose calculation, Chapter 17 – Dose prescription and reporting in photon beam treatment, Chapter 18 – External electron beams, Chapter 19 – Radiotherapy with neutrons protons and heavy ions, and Chapter 21 – Molecular radiotherapy) containing most recent information have been included in the 5th Edition of the book which is highly informative and very useful for both students and teachers of the radiological sciences.

The chapters and contents of the book can be grouped into eight parts. Part I (Chapters 1, 2, and 3) deals with basic concepts and nuclear/radiation physics. Materials in these chapters retain the flavor of the 4th Edition with required updation. Chapter 1 (Basic Concepts) deals with basic
The recent radiotherapy machines which are not available in the 4th edition. Chapter 6 (Radioisotopes for Medical Imaging and Radiotherapy) is a newly added chapter which describes the productions and properties of various radioisotopes and radiopharmaceuticals used in nuclear medicine imaging and therapeutic applications. Design and operational aspects of accelerators including targets used for the production of biomedical radioisotopes and measurement techniques for beam energy and beam currents have also been discussed in detail. This chapter also includes the details on the production of radioisotopes by nuclear reactors, radioisotope generators, synthesis, and quality assurance (QA)/quality control of radiopharmaceuticals. In fact this chapter contains useful information pertaining to nuclear medicine physics.

Part III (Chapters 7 and 8) deals with radiation dosimetry concepts and dosimeters pertaining to radiotherapy dosimetry. Chapter 7 (Radiation Dosimetry: Measurement of Ionizing Radiation) discusses quantities used in radiation dosimetry and their measurement using ionization chamber, reference beam dosimetry (output calibration) protocols (International Atomic Energy Agency, Institute of Physics and Engineering in Medicine/Institute of Physical Sciences in Medicine and American Association of Physicists in Medicine), absorbed dose at interfaces of different materials and theoretical dosimetry methods used in radiotherapy. The details of different dosimetry protocols are new additions. Chapter 8 (Measurement of Radiation: Instrumentation) includes descriptions and uses of different types of dosimeters including ionization chambers, solid-state detectors (diodes and MOSFETs), luminescence dosimeters (thermoluminescent dosimetry and optically stimulated luminescence dosimetry), principles of chemical dosimetry and uses of gel dosimeter in radiotherapy, film dosimetry in radiotherapy and direct measurement of radiation absorbed dose using the calorimeter. This chapter contains details on all the dosimeters used in radiotherapy dosimetry today including new additions (MOSFETs, OSLD, and radiochromic films), and hence, it is highly useful for radiation dosimetry and medical physics professionals.

Part IV (Chapters 9 and 10) is devoted to radiation biology. Chapter 9 (Basic Radiobiology) discusses the basic concepts of radiation biology such as effects of the passage of charged particles through biological materials, linear energy transfer (LET) and dependence of radiation damage on LET, survival curves and mathematical aspects of survival curves, linear quadratic (LQ) model, radiation-induced cellular effects, therapeutic ratio, models for tumor control probability and normal tissue complication probability (NTCP), relative biological effectiveness (RBE) and its dependence on LET and dose fractionation, oxygen enhancement ratio, and its dependence on LET. Chapter 10 (Clinical Radiobiology) is a new chapter that provides details on applied aspects of radiation biology such as tumor growth characteristics, cell cycle and radiosensitivity, five R’s of radiobiology (repair, repopulation, redistribution, reoxygenation, and radiosensitivity), fractionation in radiotherapy and the LQ model, normal
Part V (chapters 11 and 12) deals with medical imaging (X-ray and isotope-based imaging). Chapter 11 (Diagnostic Radiology) deals with all the aspects of X-ray imaging including descriptions on projection digital X-ray radiography, digital flat panel X-ray detectors, determinants of image quality and their assessment (spatial resolution through modulation transfer function, contrast resolution, sources of noise, and signal to noise ratio and contrast to noise ratio, noise power spectrum, and scatter reduction grids), detector quantum efficiency, digital mammography, fluoroscopy and fluorography, computed tomography (CT) by single slice and multiple slice scanners, multidetector computed tomography and 4DCT, measurement of image quality in CT and artifacts of CT images, a complete description of ultrasound (US) in medical imaging including type of transducers/receivers and basics of Doppler imaging, and comprehensive description of MRI including MRI sequences, T2 effects, contrast-enhancing variables, and artifacts of MRI images. Details provided on CT, MRI, Digital systems, US, etc., are new additions to this chapter and almost equivalent to a newly added chapter. Chapter 12 (Diagnostic Nuclear Medicine) contains a complete description of counters/detectors (GM counter, scintillation detector, liquid scintillation counter, and semiconductor detector) and scanners (Gamma Camera, single-photon emission tomography [SPECT], and positron emission tomography [PET] scanners) used in isotope-based imaging (nuclear medicine imaging). This chapter provides crisp but clear descriptions about the architecture and functional aspects of Gamma camera, SPECT and PET image reconstruction techniques, image quality and corrections needed in the data, QA of these scanners, image artifacts, emerging technologies, and suitable radiopharmaceuticals. Kinetic modeling techniques for nuclear medicine, optimization of diagnostic doses to patients, and absorbed dose arising from radionuclide therapy have also been discussed in this chapter. Descriptions about SPECT and PET are the new additions to this chapter.

Part VI (Chapters 13–21) deals with the various aspects of radiotherapy. Chapter 13 (Characteristics of Radiotherapy Photon Beams) is a new chapter that describes the basic characteristics of the incident photon beams such as beam profile and radiation beam penumbra at a given plane in a medium, requirements for Monte Carlo-based modeling, characteristics of MV X-rays produced by medical electron accelerators, the impact of filter and collimation, photon beams with and without flattening filters, modulated photon beams, beam contamination, intervening components, neutron production, and leakage radiation. Characteristics of Co-60 gamma rays from telecobalt machine have also been described. Chapter 14 (The Interaction of Photon Beams with Scattering Medium) discusses quantification of dose in the scattering medium and comparison of dose distributions, patterns of dose in a scattering medium (dose build-up, surface dose, decrease of dose with depth, lateral electronic equilibrium, off-axis dose distribution including flatness and symmetry, isodose distribution, dose to exit surface of the medium, impact of inhomogeneity, modulation, and impact of magnetic fields), empirical descriptions of depth dose through central axis dosimetry parameters (TAR, backscatter factor/peak scatter factor, PDD, tissue-phantom ratio/tissue-maximum ratio, scatter-air ratio, and scatter-maximum ratio), off-axis ratio, equivalent squares and circles for rectangular and irregular fields, and estimation of dosimetry parameters for irregular fields. The dose output and its variation with field size, field geometry, treatment accessories, flattening filter, and beam modulation have also been included. The details on asymmetric fields and modulated and composite fields are the new additions to this chapter.

Chapter 15 (External Photon Beam Dose Calculation) is a new chapter that deals with modeling and calculation of absolute and relative doses, dose calculation requirements (uncertainties, deviations, errors, tolerances, accuracy, spatial resolution, and calculation speed and verification of calculated dose), definition of geometry and media (coordinate systems, medium for calculation and specification of dose, calculation grids, depth and path length scaling, and medium artifacts), algorithms for dose calculation such as algorithm based on empirical descriptions of dose distributions (point dose and MU calculation, combining primary and scatter components, corrections for inhomogeneities), algorithm based on deposition kernels (dose deposition kernels, pencil beam kernels, and point kernels) and algorithms based on particle transport (stochastic and deterministic methods). The comparison of photon dose calculations through relative dose distribution and clinical impact of differences in dose calculation has also been included in this chapter. Chapter 16 (Photon Beam Treatment-Dose Prescription and Reporting) is a new chapter that provides details on flow of radiotherapy treatment, dosimetric and geometric uncertainties in treatment planning and delivery, definition of anatomical volumes (clinical target volume, planning target volume, internal target volume, organ at risk, margins, treated and irradiated volumes), functional volumes, recommendations of dose prescription and reporting (reference points, dose-volume histogram [DVH]), physical and radiobiological metrics, and spatial dose assessment. Chapter 17 (Photon Beam Treatment-Planning and Delivery) is a new chapter that discusses various treatment techniques such as pair of beams, wedge beams, multiple coplanar beams, arc therapy, modulated beams, noncoplanar beams, stereotactic treatments, matching fields, and whole-body treatment techniques. The approaches for treatment plan optimization and treatment plan verification have also been discussed in details.

Chapter 18 (External Electron Beams) is a new chapter that provides comprehensive details about the external electron beams
including beam characteristics, absorbed dose in a scattering medium, dose calculation methods, treatment planning, and delivery including electron field matching, electron-photon field matching, and total skin electron therapy. Chapter 19 (Radiotherapy with Neutrons, Protons, and Heavy Ions) is a new chapter that discusses various aspects of particle and heavy ion therapy such as rationale for using high LET particles, neutron radiotherapy (equipment, dosimetry, and treatment planning) including boron neutron capture therapy, proton radiotherapy (clinical indications, radiobiology and fractionation, equipment, dosimetry, and treatment planning), and salient features of heavy particle/ion therapy.

Chapter 20 (Brachytherapy) discusses in detail the physical and clinical aspects of brachytherapy including sealed and unsealed sources. Specifically, this chapter provides information on physical characteristics of sealed beta, gamma, and neutron emitting brachytherapy sources; dose prescription and calculation including historical dosimetry systems (Stockholm, Paris and Manchester systems), and current dosimetry systems (TG-43 and model-based calculations plus dosimetry systems for intracavitary, interstitial, superficial including eye plaque and intraluminal brachytherapy), low dose rate/high dose rate and miniature X-ray therapy sources and equipment, QA of sealed sources and equipment; details of unsealed sources used for radiotherapy (I-131, P-32, Lu-177, Y-90, In-111, Sr-90, and Sm-153), QA of unsealed sources, and advantages of brachytherapy over beam therapy has also been included.

Chapter 21 (Molecular Radiotherapy) is a new chapter provides the details of molecular and hybrid radiotherapy. Although molecular radiotherapy is in its infancy in comparison to beam therapy and chemotherapy, it has obtained notable success and expanding rapidly. Thus, this chapter deals with the various aspects of a relatively newer technique including details of hybrid beam therapy and molecular radiotherapy. Radiobiological aspects of molecular therapy and hybrid therapy using LQ model have also been discussed in detail with suitable examples. Methods of dose assessments from internally deposited radiopharmaceuticals including MIRD technique have been included in this chapter. This chapter contains details on RADAR formulation, calculation of effective dose for common diagnostic nuclear medicine procedures, RBE for stochastic and deterministic effects, and other dose-related quantities (biologically effective dose, DVH and BED volume histogram, equivalent uniform dose, and isoeffective dose) for predicting deterministic effects and NTCP curves and applications for molecular radiotherapy.

Part VII (Chapter 22) deals with radiation protection and safety. Chapter 22 (Radiation Protection) provides the details on radiation quantities and units (absorbed dose, organ dose, equivalent dose, radiation weighting factors, tissue weighting factors, and effective dose) sources of radiation (natural and man-made), types and effects of exposures to ionizing radiation (stochastic and deterministic effects, dose limits, personnel exposures in diagnostic and interventional radiology, risk of secondary cancer after radiotherapy, and radiation hormesis), radiation shielding (radiation sources, shielding materials, factors affecting shielding calculations, shielding calculations for beam therapy, brachytherapy, and diagnostic radiology facilities), radiation shielding evaluation (inspection before and during construction, radiation warning lights, interlocks, and restrictions), and personnel monitoring (personnel radiation monitors and operational quantities for personnel dosimetry).

Part VIII is three appendices which contain very useful data required for the calculations of various parameters. Appendix A contains basic data (constants, units and conversion factors, Compton coefficients, Energy and photon fluence for Roentgen and specific gamma ray constants, interaction coefficients, and stopping powers, etc.), Appendix B contains data related to photon radiation therapy, and Appendix C contains data related to electron radiation therapy.

All the topics/sub-topics in all the chapters are explained in a very simple manner, and numerical examples have also been provided so that the readers could understand the concepts easily. A large number of references have been listed in each of the chapters which can be referred by readers for further readings. In deed, this edition of the book is a complete textbook of radiological/medical physics and radiation safety, and hopefully, it is useful for a variety of medical radiation professionals including medical physicists, radiation dosimetrists, radiation oncologists, radiologists, and nuclear medicine physicians. My sincere gratitude to the authors and the publisher for their effort and dedication in presenting such a versatile textbook.