RADIOACTIVE
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IN
CLINICAL
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QUIMBY
FEITELBERG
SILVER

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EDITH H. QUIMBY, Sc.D.

Professor of Radiology (Physics), College of Physicians and Surgeons Columbia University, New York

SERGEI FEITELBERG, M.D.

Director, Physics Department The Mount Sinai Hospital; Associate Clinical Professor of Radiology, College of Physicians and Surgeons, Columbia University, New York

SOLOMON SILVER, M.D.

Attending Physician; Chief, Thyroid Clinic, The Mount Sinai Hospital; Associate Clinical Professor of Medicine, College of Physicians and Surgeons, Columbia University New York

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Preface

THE artificial production of radioactive isotopes was announced twenty-five years ago, and caused a tremendous sensation among physicists and chemists, but aroused little attention among physicians. However, within a short time physiologists found that the new substances provided powerful tools for metabolic studies, and then some more truly clinical applications became apparent. In 1939 radioactive phosphorus was used as a substitute for whole-body x-irradiation in the treatment of certain blood dyscrasias. About the same time the value of radioactive iodine in the study of thyroid function was demonstrated, and within another three years this material was used in the treatment of toxic goiter. Radioactive iron was simultaneously employed by other groups in various studies relating to red blood cells and iron reserves. By 1940 there was a considerable literature dealing with medical uses of artificially radioactive isotopes, but there was no suggestion that they would eventually provide standard diagnostic and therapeutic procedures. They were obtainable only from cyclotrons, usually at great cost, and frequently in such form as to require considerable chemical manipulation before they could be used.

The discovery of the chain-reacting pile or nuclear reactor changed this picture, but it was not until 1946, after the end of World War II, that even one reactor could be used to provide isotopes for non-military purposes. In July of 1946, the Atomic Energy Commission announced a limited availability of certain isotopes for medical use, at much lower costs than cyclotron products, and in the next six months about 100 shipments were made for medical research in 38 institutions. Ten years later a thousand medical institutions were authorized to obtain the materials, and doctors in some of them were using very large quantities of radioactive isotopes.

At the beginning of this period, each individual or group had to enter an almost uncharted field. Some information was available in the literature, but in general, procedures were developed independently; all studies were essentially on a research basis. However, as their value became known many physicians wanted to avail themselves of the new tools. There were demands for instruction courses and for textbooks; these were intensified by the fact that the Atomic Energy Commission required the physician to have a certain amount of training before issuing him an authorization to obtain radioactive isotopes from their reactor. Few people or groups felt that they had the time or the qualifications to give a comprehensive course, and the books that appeared dealt mainly with limited parts of the field. In any case, progress was being made so rapidly that a book was out of date almost by the time it was published.

In June of 1954, the present authors, with the generous cooperation of physicians and physicists throughout New York City, undertook to offer a four-week full-time comprehensive course in clinical uses of radioactive isotopes. The response was so enthusiastic that they were forced to present the course twice a year, once as originally planned, for non-residents of the city, and once on a basis of one afternoon a week for eight months, for those living within commuting distance. It has now been given eight times, naturally with modifications from year to year. This book is the outgrowth of our experience in lectures, laboratory exercises, and conferences with the approximately 225 students who have completed the course.

It has been written as three quite separate parts, each by the author who has the most to do with that field in teaching the course. But each author owes much to the collaborators who have given so freely of their time and interest. It is hoped that the book will serve as a basis for study both by classes and by individuals, but no claim is made to completeness. In fact, it is certain that considerable supplementary reading will be necessary for everyone who wants a really comprehensive survey of even the generally used procedures. References have been supplied for this purpose, but no effort has been made to assemble a complete bibliography. For any particular type of study, recent papers of the survey type, which are listed, will provide complete sets of references.

We wish to express our grateful appreciation to our colleagues in the presentation of the course, for their generous sharing of their information, and to those other friends who have freely permitted us to use their published material. A special acknowledgement is due to Miss Ellen Ewald, who prepared all the illustrations from sketches supplied by the authors. To our secretaries, Miss Judith M. Weinberg, Mrs. Katherine Johanny, and Miss Blanche Lipkowitz, who have typed and re-typed the manuscript, looked up references, and generally been indispensable, we give our thanks. The publishers' enthusiasm in getting the book under way, and their patient but persistent attention to its progress should receive a large share of the credit in bringing it to completion.

EDITH H. QUIMBY
SERGEI FEITELBERG
SOLOMON SILVER

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Radioactive Isotopes in Clinical Practice

Part I
BASIC PHYSICS

Edith H. Quimby

Introduction

A TIME-TABLE OF SIGNIFICANT EVENTS LEADING UP TO THE PRESENT RADIOISOTOPE PICTURE

1808. John Dalton (England) presented first experimental basis for atomic hypothesis.

1811. Amadeo Avogadro (Italy) distinguished between atoms and molecules.

1815. Wm. Prout (England) suggested hydrogen (protyle) as a basic component of all matter.

1869. D. I. Mendeleev (Russia) set up a periodic table of chemical classification of elements.

1895. Wilhelm Roentgen (Germany) discovered x-rays.

1896. Henri Becquerel (France) discovered radioactivity of uranium.

1897. J. J. Thompson (England) discovered that the electron is a constituent of all atoms.

1898. Marie and Pierre Curie (France) discovered polonium and radium.

1900. P. Curie (France) found that the rays from radium consisted of two kinds, of very different penetrating power and deviated in different directions in a magnetic field. These later became known as alpha (α) and beta (β) rays.

1900. P. Villard (France) discovered a third type of radiation from radioactive substances, called it gamma rays (γ), and stated it to be identical with x-rays.

1905. Albert Einstein (Switzerland) proposed the theory of equivalence of mass and energy.

1910. F. Soddy (England) identified isotopes and isobars in naturally radioactive substances.

1911. Ernest Rutherford (England) discovered the atomic nucleus.

1911. C. G. Barkla (England) demonstrated the existence of extranuclear electrons.

1911. Victor Hess (Austria) discovered cosmic rays.

1912. J. J. Thompson (England) demonstrated the existence of isotopes in stable elements.

1912. C. T. R. Wilson (England) invented the cloud chamber for studying ionization tracks.

1913. Neils Bohr (Denmark) proposed an atom model with a central positively charged nucleus and a system of negative orbital electrons.

1913. H. G. J. Moseley (England), from a study of x-ray spectra, developed the system of atomic numbers.

1919. E. Rutherford (England) produced nuclear transmutation by bombarding nitrogen with α particles. He identified one product of the transmutation as a proton.

1932. Harold Urey (USA) discovered heavy hydrogen or deuterium.

1932. James Chadwick (England) discovered the neutron (whose existence Rutherford had suggested in 1919).

1932 J. D. Cockroft and E. T. S. Walton (England) produced nuclear transmutation by artificially accelerated protons

1932. C. D. Anderson (USA) discovered the positron.

1932. E. O. Lawrence (USA) invented the cyclotron.

1934. F. Joliot and I. Curie-Joliot (France) discovered induced radioactivity in light elements by bombardment with natural α particles.

1934. E. O. Lawrence (USA) produced artificially radioactive nuclides by bombardment with artificially accelerated particles.

1934. Enrico Fermi (Italy) produced transformation of nuclei by neutron capture.

1939. O. Hahn and F. Strassman (Germany) discovered nuclear fission.

1939. Lise Meitner and O. Frisch (Sweden) calculated the huge energy release to be expected in nuclear fission.

1939. Enrico Fermi (USA) suggested possibility of a chain reaction in nuclear fission. This was experimentally verified in several laboratories in USA and France.

1939. "Manhattan Project" (USA) was organized for military development of atomic energy.

1940. E. M. MacMillan and P. Abelson (USA) discovered two "transuranic" elements, neptunium and plutonium, following the bombardment of uranium by slow neutrons.

1942. (USA) First self-maintaining nuclear chain reaction in a uranium graphite "pile" or reactor, was initiated in Chicago.

1945. Atomic bombs were exploded July 16th in New Mexico, August 6th and 11th over Hiroshima and Nagasaki, Japan.

1946. (USA) "Manhattan Project," becoming Atomic Energy Commission, announced availability of pile-produced radioactive isotopes for medical, industrial and scientific research. Three hundred shipments made during first year.