1910–1950

The second decade of the twentieth century was a time of profound and rapid change. The Model T had just been introduced by Ford. The potential of heavier-than-air flight was beginning to be realized. Psychoanalysis was published in 1910, and new disciples emerged from each lecture of Freud or Jung. Americans of enormous wealth, whether from railroads, oil, or financial investments, were establishing foundations that would serve the sciences, the humanities, and society at large. In the United States women’s quest for the vote was on the verge of success.

Europe hovered on the brink of war, but extraordinary developments in science were occurring. Marie Sklodowska Curie had just been awarded the Nobel Prize for chemistry, the first scientist to receive the award twice and in different fields (physics in 1903 and chemistry in 1910). With the establishment of the Pasteur Pavilion of the Institut du Radium, the medical fruits of Curie’s scientific labors had just begun to be realized. Medical applications of ionizing radiations began at the institute under the direction of Claudius Regaud in 1919, on his return from World War I (Fig. 2.1). Regaud characterized the task of the physicians who eventually would be known as radiation oncologists: “Surgeons and radiotherapists who undertake to treat curable cancer assume an exceptionally heavy responsibility because the unique stakes with which they play are the lives of their patients.” Throughout the history of the field the men and women who have pursued radiation oncology have been captivated by this challenge to treat diseases which, if left unchecked, would kill their patients. The intriguing intellectual blend of nuclear physics, human tumor biology and pathology, and nascent radiation biology met with progressively effective tools to deliver ionizing radiations to cure cancers.

In the United States therapeutic uses of ionizing radiations were by no means confined to cancer. Cutaneous inflammations of myriad etiologies, arthritis, epilepsy—all were subjected to exposures by poorly penetrating X rays. Only superficial effects were expected, and only they were observed. Roentgen-ray dermatitis and epilation were considered necessary, even desirable.
The earliest oncologists, taking on the burden anticipated by Regaud, were physicians from three broad groups: radiological generalists, brachytherapists, and radiation oncologists.

The Generalists

The excitement generated by diagnostic images continued to compel a group of physicians to maintain a practice combining both radiodiagnosis and radiotherapy well into the second half of the twentieth century. During the early years the balance between the two was manageable, and much of the available apparatus could serve either purpose.

Francis Williams (1852–1936), a distinguished Boston physician from a family of Harvard Medical School graduates, followed the reports of Röntgen’s discovery with fascination. He quickly became aware not only of the diagnostic power of X rays but also their therapeutic potential. His widely read text, published in 1901 and entitled *The Röntgen Rays in Medicine and Surgery*, was subtitled *As an Aid in Diagnosis and as a Therapeutic Agent*. One of the hallmarks of general radiologists was their preference for fluoroscopy rather than film. Their treatment planning was done in real time, with the tumor first identified fluoroscopically and then treated as so localized. Williams was a proponent of fluoroscopy in his studies of diseases, which he pursued first in a physics laboratory at the Massachusetts Institute of Technology and later in the basement of the Boston City Hospital. He demonstrated cures of basal cell carcinomas of the eyelids and cheek and squamous cell carcinomas of the lower lip. He was among the first radiologists to note the responsiveness of Hodgkin’s disease to X rays. Although he retired as head of the department of radiology at Boston City Hospital in 1915, his influence continued well beyond his death two decades later.

Another influential generalist was Mihran Kassabian (1870–1910), an Armenian who emigrated to the United States and eventually became director of the Roentgen Ray Laboratory of Philadelphia Hospital. Although his death occurred at the very beginning of the period under discussion, he provided important documentation of the actual practice of roentgenotherapy in the United States in his book *Roentgen Rays and Electro-Therapeutics*, published in 1907. The text itself placed great emphasis on the management of radiation dermatitis. The comprehensive survey of practice throughout the United States documented a host of conditions, mostly benign, for which X rays were being administered. He, too, emphasized fluoroscopy in therapeutic practice but paid dearly for it: he died of widespread metastasis from carcinomas that had developed in the skin of his hands.

George Pflahler of Philadelphia, one of the most highly respected pioneers in the field, reflected on his own early practice after being chosen by the founders of the American College of Radiology (ACR) to be their first president (Fig. 2.2). He had advocated a “saturation” method of radiotherapy in which more brief second and third applications were given at short intervals to maintain the effects of the first prolonged application (of course the roentgen as a unit of exposure was yet to be defined). His basis for doing this has recently been rediscovered: he
assumed tumors had a steady loss of radiosensitivity with time, much like the constant rate of loss seen in biochemical processes, so he compressed the delivery of the irradiation to compensate for it, by "topping-up" with repeated applications after the first one.

Preston M. Hickey (1865–1930) was professor of radiology at the University of Michigan in Ann Arbor. He coined the term "cone" for the pyramidal localizing attachments to the tube heads that dominated roentgenotherapy. Light localizers became commercially available in the 1940s.

Although dermatologists were not generalists in the same sense as those who combined roentgenotherapy and roentgendagnosis, they were understandably at the forefront of the practitioners of roentgenotherapy in the earliest years of this era. They were the diagnosticians of the vast array of cutaneous conditions for which irradiation was thought a possible remedy, and they assumed expert status in the management of the dermatitis thought to be a desirable result of X-ray treatments. Among the most influential was William A. Pusey of Chicago; with Eugene W. Caldwell, he published the definitive text of this period, *The Roentgen Rays in Therapeutics and Diagnosis*.

### The Brachytherapists

Several physicians became intrigued by the potential for placing sources of radiances directly in or immediately adjacent to tumors. The sources contained radium or its gaseous daughter, radon. Francis Williams was as prominent in the use of brachytherapy as he was with roentgenotherapy. He purchased his personal supply of radium in Paris and brought it to the United States encapsulated in glass tubes. He and such pioneers as Margaret Abigail Cleaves (1848–1917) of New York placed these tubes in the vagina for cancer of the cervix, applied them to the breast for inoperable mammary cancer, and used them to treat primary carcinomas of the skin such as rodent ulcers.

Many of the early brachytherapists were surgeons. One of them, Robert Abbé (1851–1928) of New York developed a method, now recognized as "afterloading," for cancer of the thyroid. He placed rubber tubes in the neck after thyroidectomy for cancer and then loaded them with glass tubes of radium to enhance the margins of his resection. He also used radium that he had imported from Germany in a specially designed vaginal applicator for the treatment of cancer of the cervix.

Howard A. Kelly (1858–1943), a professor of gynecology and one of the original faculty of the Johns Hopkins Medical School, teamed with James Douglas, an engineer-industrialist, and Charles Parsons, director of the United States Government Bureau of Mines, to buy Colorado mining claims which yielded carnotite. They financed the processing of this uranium-containing mineral to derive radium which could be sold for more than $100,000 per gram. By 1914 they began to donate grams of radium to major cancer centers, such as the Memorial Hospital of New York and Johns Hopkins University Hospital. Cancer of the cervix was the most widely discussed malignant tumor of women at the time, and Kelly, Leda June Stacey, and Margaret Abigail Cleaves were among the first physicians who treated it with intracavitary "curietherapy."

Charles L. Martin (1895–1979) of Dallas was unusual in several ways. He continued to practice general radiology for the early years of his career (he was
certified in “radiology” by the American Board of Radiology [ABR] in 1934. However, his therapeutic interests were in brachytherapy. He had the rare if not unique distinction of serving as president of both the American Roentgen Ray Society and the American Radium Society. He did not confine his practice to radiation oncology until 1948.  

The Radiation Oncologists

The third group of practitioners included those who quickly confined their practices entirely to the therapeutic uses of radiations for cancer. They were both curiatherapists and roentgentherapists. This group was the smallest of the three in the first half of the twentieth century, but was eventually to develop a “critical mass” in the United States. As sophistication in radiodiagnosis developed, imaging procedures were sought for an increasing number of diseases, and diagnostic radiologists, together with pathologists, became consultants to their colleagues. The radiation oncologists, driven by the desire to help their patients, accepted the expertise of their diagnostic colleagues and devoted themselves full time to the search for the physical and biological bases to effect the cure of cancer. After World War II they steadily took over the practice of therapeutic radiology.

One of the original radiation oncologists was Albert Solland (1873–1946), who was born in Norway and came to the United States at the age of ten. While a medical student at the University of Southern California, he helped build a roentgen-ray generator. In 1904, only four years after his graduation, he was asked to organize the University of California’s first department of radiology. Although he was very influential in the rapidly expanding field of radiology (president of the Radiological Society of North America [RSNA] in 1922, founder of the ACR in 1923), Solland was a pioneer radiation oncologist. He advocated surgical adjuvant radiation therapy for cancer of the breast. He published works on radiation therapy for carcinomas of the oral cavity, cervix, and prostate, as well as leukemia. He even attempted intraoperative radiation therapy (1923).  

In his biography of Albert Solland, Juan del Regato called attention to the birth of supervoltage radiotherapy. In 1930 Solland asked R. A. Millikan (1868–1954) and C. C. Lauritsen (1892–1968) of the California Institute of Technology to permit a trial of clinical radiotherapy in their laboratory of physical research with their new high-voltage roentgen-ray tube and 750,000 volt generator (Fig. 2.3). Solland was allowed to bring patients at night for a trial of high voltage (550 kV) radiotherapy of cancer; thus, he was the earliest radiotherapist in the world to enjoy this privilege. The first patient treated, in October 1930, was Dr. C. Edgerton Carter, who suffered from an inoperable carcinoma of the rectum; two years later he was reported “symptomless and working normally having recovered twenty pounds in weight.”

By the mid-1920s the Mayo Clinic already was organized into separate sections of radiodiagnosis and radiotherapy. Radiotherapy itself was divided, with Arthur Desjardins as director of Therapeutic Roentgenology and Henry Boving as chief of radium therapy (Figs. 2.4a and 2.4b). Desjardins, a gentleman in all senses of the word, was a fine representative of early radiation oncologists in an environment where the
skill of his surgical confrères had become world renowned. He contributed numerous reviews of acute and late effects resulting from irradiation of normal tissues. His scholarship and demeanor undoubtedly were important in the Mayo Clinic’s recognition of the independent specialty of therapeutic radiology.

In the United States and throughout the world, the major limitation of irradiation with the apparatus available was the magnitude of the effects on the skin and subcutaneous tissues. Except for a handful of experiences with high kilovoltage units such as that available to Soiland, the skin was the dose-limiting normal tissue. When considering irradiation of deep-seated tumors, treatments were delivered to the tolerance of the skin with only a hope that the tumor in depth received sufficient scatter electrons to kill some of its cells. Multiple portals of entry, which allowed cross-firing the site of the tumor, were required; it was common to use at least four portals of entry, but six or eight ports were frequently used.

Radium could be placed in natural body cavities, and eventually it became possible to insert radium needles or radon seeds into tumors. Large lesions of the surface, such as advanced carcinomas of the breast and skin, usually could not be treated with radium because of the large quantities needed. Such quantities were available in a few clinics, but preference was given in these circumstances to the use of X rays.

Henri Coutard, forty-three years old and just home from World War I, was among the small group of physicians who formed the staff of the new Radium Institute of the University of Paris in 1919, under the direction of Regaud, whom he had met during the war (Fig. 2.5).* Coutard was intrigued by the work of Regaud on the testes of several animals: a single large application of radium or X rays produced radiodermatitis, the moist desquamation of the skin, which was the dose-limiting phenomenon with roentgenotherapy, but spermatogenesis was not greatly affected. When smaller doses were given several days apart, a lesser degree of radiodermatitis resulted, with a dry desquamation of the skin, but spermatogenesis ceased permanently. Coutard applied this approach to patients who were presented to him with inoperable carcinomas of the larynx and pharynx. He prolonged the treatments over several weeks (whereas Regaud considered ten days of treatment to be the maximum). By the time the roentgen unit was defined and internationally accepted in 1928, Coutard already had presented results of a series of patients with carcinomas of the tonsillar fossa who were cured by roentgenotherapy. Coutard’s protracted-
fractional method of roentgenotherapy was quickly adopted by radiation oncologists around the world.

Maurice Lenz and William Harris, both from New York City, were among many visitors to the Radium Institute of Paris in the 1920s (Figs. 2.6a and 2.6b). Lenz practiced at the Montefiore Hospital and the hospitals affiliated with Columbia University. Harris practiced at Mount Sinai Hospital. In 1931 Coutard made an influential presentation at Mount Sinai Hospital, at the invitation of Harris, on successful roentgenotherapy for inoperable cancer of the larynx and oropharynx.

Recognition of the importance of fractionation profoundly affected the practice of radiation oncology, as well as the expectations of both patients and practitioners. Standard textbooks, for example Clinical Roentgen Therapy, edited by Ernst A. Pohle, chair of the department of radiology and physical therapy of the University of Wisconsin, reflected this new understanding (Fig. 2.7). Gordon E. Richards of the University of Toronto observed, in the 1938 edition of Pohle’s text, “The improvement which has followed upon the adoption of the method introduced by Coutard, of Paris, and known by his name has been little short of spectacular.”

Whether fractionated or not, radiation therapy was fully appreciated for its effects on markedly radiosensitive tumors such as malignant tumors of lymphoid structures (lymphosarcomas and Hodgkin’s disease), seminoma, myeloma, and Ewing’s sarcoma of bone. These malignant diseases were recognized not only as strikingly responsive to irradiation but even potentially curable. In addition, the tumor, which had been recognized...
concurrently in France by Regaud and in Germany by Schmincke and called lymphoepithelioma, was also recognized as exquisitely sensitive and often curable. The far more common variants of squamous cell carcinoma of the upper respiratory and upper digestive tracts were not consistently curable until the fractionated method of Coutard was adopted (Table 2.1).

Mammary carcinomas were recognized as moderately responsive from the earliest, crude administrations of ionizing radiations. Preference was given to mastectomy for all patients who were operable. However, Lenz reported in 1946 that ten of thirty-one patients deemed inoperable by the criteria of Haagensen and Stout were alive and free of local recurrence or distant metastasis more than five years after roentgen therapy.\textsuperscript{18}

Carcinomas of the cervix were the most important conquest of radiation therapy in the era of roentgen therapy, so much so that many radiation oncologists became recognized as leading experts in this disease, contributing to knowledge of clinical evolution, staging, classification, treatment, and prognosis. Successful treatment of cervical cancer, however, was not a consequence of external irradiation, but rather a triumph of brachytherapy. The Stockholm (Radiumhemmet) technique of brief, intensive applications of simultaneous intrauterine and vaginal radium repeated twice; the Paris (Radium Institute) technique of applying a colpostat for four or five days, followed by an intrauterine “tandem” for a similar period; and the Manchester (Holt Radium Institute) variation of the Paris technique all proved strikingly effective for women whose tumors were manifestly inoperable. It was evident that curability by brachytherapy alone was confined to tumors that were not bulky, i.e., which were of lower stage. The success with brachytherapy, however, led to many more innovative and persistent means of external roentgen therapy. Multiple portals of entry were required to achieve maximum doses in depth, since each field was limited by the tolerance of the skin and subcutaneous tissues. There was no clearer example of treating to the tolerance of the skin and hoping the tumor deep within the pelvis received enough total dose.

Major forms of cancer, notably carcinomas of the lung, esophagus, prostate, and bladder, were not considered curable with conventional X rays. They required the development of equipment that produced far more penetrating radiations, equipment that would become widely available in the supervoltage era. But the fact that conditions were not considered curable did not prevent physicians from using palliative radiations to treat swelling and to relieve pain.

The X-ray era ended as it began, with optimism and foreboding. The
quite satisfactorily on a part-time basis by any well-trained radiologist. This viewpoint served as a major impediment to progress in some of the most prestigious institutions in the United States.

There continued to be little interest among medical students in the United States in the fledgling discipline of radiation oncology. The handful of practitioners, no more than a few dozen, most of whom immigrated from Europe or had trained there, were aware that supravoltage radiation therapy was soon to be a powerful instrument in their hands for the care of patients with cancer. As a forerunner of progress to come, Juan A. del Regato, yet another student of Coutard, brought his clinical experience together with the tumor pathology expertise of Lauren Ackerman to publish in 1947, Cancer: Diagnosis, Treatment, Prognosis, the first comprehensive textbook in which radiation therapy was presented side by side with surgery (Fig. 2.8). This pre-

hopes and fears were far more directly related to ionizing radiations than they were at the beginning of the era. The end of World War II was, itself, a cause for vast relief in the United States, but the troubled peace of the Cold War was increasingly evident. The cloud first evident over Hiroshima and Nagasaki, no longer visible but just as threatening, made physicians wonder why a colleague would seek to spend his or her career in such a hostile environment.

In spite of the dramatic therapeutic progress made with X rays and radium, some generalists held that radiation oncology was not a fundamentally different discipline than radiodiagnosis. Throughout the post-World War II era and even into the 1980s, prominent figures in radiology contended that radiation therapy was a relatively trivial enterprise—a sideline to the larger field of radiological diagnosis. They contended that radiation oncology was not a newly emerging specialty and that it should not be recognized with separate administrative or departmental status. They felt it could be practiced
saged the enormous contributions radiation oncologists were to make to the care of patients with cancer in the next two decades.

**SUPERVERTAGE ERA: 1950–1970**

The supervoltage era actually dawned well before 1950. The clinical exploitation of high-energy x-rays by Albert Solland has already been noted. The first x-ray tube capable of operating at one million volts was developed by another Scandinavian, Charles Lauritsen, a Danish-born engineer. With the assistance of the 1923 Nobel Laureate in physics, Robert A. Millikan, and the General Electric X-ray Corporation, Lauritsen succeeded in establishing a 700,000-volt unit for clinical use at the California Institute of Technology.

One of the earliest systematic explorations of supervoltage roentgenotherapy was by Franz Buschke and Simeon T. Cantril at the Tumor Institute of the Swedish Hospital in Seattle (Figs. 2.9a and 2.9b). Buschke was a product of the demanding German educational system. He graduated from the University of Berlin and became one of the rising stars of Hans Schinz at the Röntgeninstitut of the University of Zürich. He was profoundly affected by a brief period as an observer at the Radium Institute in Paris, where he first met Cantril. These two pioneer radiation oncologists thus had come under the influence of Henri Coutard. When they became responsible for the equipment at the Swedish Hospital in 1938, they were among only thirty-nine radiation oncologists in the United States.

From the same careful daily observation methods learned from Coutard, they concluded that supervoltage irradiation had definite advantages over orthovoltage roentgenotherapy. The record of their observations, presented in a monograph, *Supervoltage Roentgenotherapy*, published in 1950, marked a turning point in radiation oncology.

There was considerable disagreement as to the value of supervoltage roentgenotherapy. Sherwood Moore, professor of radiology at Washington University in St. Louis, wrote to Juan del Regato, "I have observed these generators in operation at the California Institute of Technology, Memorial Hospital in New York, Huntington Hospital in Boston and the Massachusetts General Hospital in Boston and elsewhere. My opinion after years of observation is unmistakable against the use of million volt x-radiations in the treatment of disease." However, the weight of opinion among most radiation oncologists by the end of World War II was so great that they sought two-million-volt generators rather than accept lower energies.

Gilbert Fletcher collaborated with Leonard Grimmett, a physicist from England who joined the M. D. Anderson Cancer Center in 1949, in the design of the first cobalt-60 (\(^{60}\text{Co}\)) teletherapy unit. Grimmet had already designed a teletherapy unit containing 5 grams of radium that became the primary unit for treatment of cancer of the head and neck at the Royal Marsden Hospital in London.\(^{24,25,26}\)

The \(^{60}\text{Co}\) containing device he developed with Fletcher was approved by the United States Atomic Energy Commission in 1950 and became the principal treatment unit at M. D. Anderson.
Juan del Regato (b. 1909)

Juan Angel del Regato was born in Camaguey, Cuba, the son of Damiana Manzano Nunez, of Mayan ancestry, and of Juan del Regato Castaneda, of Castillian ancestry. He received his high school education in Santa Clara, Cuba, from 1922 to 1926, then undertook the study of medicine at the University of Havana from 1926 to 1930. When the university was closed due to political unrest in 1930, the Cuban Liga Contra el Cancer sponsored del Regato’s continued studies at the University of Paris through 1934. He received his medical degree in 1937 with a medal-winning thesis on successful radiotherapy of inoperable cancers of the maxillary antrum. He also followed a two-year course and received the Diploma of Radiophysics and Radiotherapy of the University of Paris. He served as an assistant at the Radium Institute of Paris, where he came to know Coutard, Regaud, Marie Curie, Lacassagne, and other founders of the field of radiation therapy.

Early in 1937 del Regato came to the United States, bringing with him the Paris tradition of specialization at a time when only a handful of American physicians practiced radiation therapy exclusively. He was a research fellow of the National Cancer Institute (1941–1943); director of radiotherapy at the Ellis Fischel Cancer Center in Columbia, Missouri; and director of the Penrose Cancer Hospital in Colorado Springs (1949–1974). He became professor of radiology at the University of South Florida, Tampa (1974–1981), and emeritus professor of radiology (1981) and distinguished physician of the Veterans Administration. Among numerous awards and honors he has received gold medals from the Radiological Society of North America (1966), the American College of Radiology (1968), and the American Society for Therapeutic Radiology and Oncology (ASTRO) (1977) as well as the American Medical Association Scientific Achievement Award (1993).

Unique in the field, del Regato is noted for his clinical, technical, scholarly, and organizational achievements. In the clinic, his active involvement in ongoing studies and interest in developing new delivery systems led to the development of the del Regato localizer—the first light localizer in the field. His writings include the groundbreaking Cancer, with Lauren Ackerman, and a growing body of historical works tracing the personalities and events which have shaped radiation oncology. He has served as an officer in numerous organizations, and it was through his personal efforts that the American Club of Radiotherapists was formed in 1958. Today the organization is ASTRO, the world’s largest association devoted to radiation oncology.

del Regato’s greatest and most lasting contribution to the field is his ongoing dedication to training young radiation oncologists. The legion of radiation oncologists who trained with del Regato now numbers in the hundreds, and their respect and fondness for the “Chief” is reflected in their support for the activities of the del Regato Foundation, organized to further educational and academic achievement in the field. Dr. del Regato, whose rich and productive life has spanned almost the entire history of the field, remains an active and vital contributor to radiation oncology.
in 1954. A 22-megavolt (MV) Allis Chalmers betatron was installed a year later. With these resources and expanding therapeutic activities, Fletcher was able to divest himself of most of his diagnostic responsibilities.

The clinical observations that were published by Fletcher and his colleagues over the next twenty years changed the practice of radiation oncology not only in the United States but throughout the world. Their results were especially striking for patients with cancer of the upper respiratory and digestive tracts, for whom $^{60}$Co teletherapy became a salvation, and for advanced cancer of the cervix, which was shown to be curable in high proportion with skillful use of the betatron.

Although much slower in finding widespread use, the earliest medical linear accelerators were also under development at this time. Henry Kaplan joined the staff of the Stanford University Medical School (then located in San Francisco) in 1948. He was aware that the existing megavoltage accelerators, 1- and 2-mega-electron-volt (MeV) resonance transformers and Van de Graaff electrostatic generators, available to him produced less penetrating photon beams ($HVL = 7$ mm lead [$Pb$]) than $^{60}$Co gamma rays ($11$ mm Pb $HVL$). So, he sought out members of the physics department who had been working for more than a decade on linear accelerators. Edward Ginzen (b. 1915) of W. W. Hansen's group, which had developed a variety of microwave devices between 1938 and 1947, was a major collaborator from the start. Kaplan was the driving force from the medical perspective. Many other scientists, including Russell and Sigurd Varian, C. J. Karzmark, and J. Haimson, contributed to the design, development, and clinical implementation of the first linear accelerator used to treat patients in the United States. It was introduced at Stanford in 1955 and produced 5 MV X rays.

It should be noted that D. W. Fry’s group at the Telecommunications Research Establishment (TRE) at Great Malvern, England, was actively investi-
HENRY KAPLAN (1918-1984)

Henry Seymour Kaplan was born in Chicago in 1918, the son of Sarah Brilliant and Nathan M. Kaplan. He received a B.S. degree from the University of Chicago and his M.D. degree from Rush Medical College in 1940, then served an internship at the Michael Reese Hospital. He went to Minneapolis for training in general radiology under the prestigious radiologist Leo Rigler at the University of Minnesota. There he received his first exposure to radiation therapy under Karl Stenstrom, Ph.D. (1891-1973). With Rigler, Kaplan made an interesting study of early detection of cancer of the stomach.

He was certified in general radiology by the American Board of Radiology in 1944 and took a position as an instructor and assistant professor of radiology at Yale University Medical School, where he pursued radiodiagnostic interests. A laboratory worker at heart, Kaplan took a fellowship to do experimental research at the National Cancer Institute, where he did original work on leukemia.

While in Bethesda he was offered the position of professor of radiology at the Stanford University Medical School. The position called primarily for competence in radiodiagnosis, but Kaplan chose to emphasize the needs of therapeutic radiology with which he was less conversant but in which he achieved undisputed leadership. At that time, most patients with Hodgkin's disease were being inadequately treated by general radiologists under the assumption that small doses of radiation were sufficient to give lasting palliation. Kaplan had learned that it was possible to sterilize the tumor locally with moderately high doses and also that it was advantageous to irradiate the neighboring areas of potential subclinical involvement. He made this his own subject and wrote extensively on it. He recommended vast fields irradiating the cervical, thoracic, and abdominal areas of potential involvement with moderately high doses in relatively short time. This approach was widely adopted, not without untoward effects resulting from the emphasis on total dose and a lesser concern about fractionation. Kaplan went on to recommend staging laparotomies and splenectomies, which led to a vast accumulation of knowledge about the natural history of Hodgkin's disease.

The need for a training program for radiation oncologists was evident, and Kaplan, in his position as a member of the National Advisory Cancer Council, contributed to the extension of federal grants for the establishment of training centers.

When Edward Ginzton undertook to build a linear accelerator at Stanford, Kaplan encouraged him and endeavored to put its originally fixed horizontal beam to the treatment of various forms of cancer with unquestionable success. Kaplan emphasized the role of radiobiological research, putting his hopes successfully in electrontherapy, hibaroxyn therapy, radiosensitizers, and other promising approaches.

He was a founder and president of the Radiation Research Society, elected to the National Academy of Sciences, received the Atoms for Peace Award, the Charles L. Kettering Award, and the gold medal of the American Society for Therapeutic and Radiation Oncology—all richly deserved. An ambitious man, he was kind and generous with his associates and residents. As had his father, Kaplan died of cancer of the lung, on 4 February 1984.

—Juan A. del Regato, M.D.
tions of roentgens at depth and more comprehensive dose distributions expressed in rads.

Supervoltage therapy permitted adequate doses to be delivered in depth for diseases thought intractable to radiation therapy: cancer of the lung, esophagus, bladder, and especially carcinoma of the prostate. In a short period of time advanced inoperable adenocarcinomas of the prostate came to be the province of the radiation oncologist. Urologists were astounded to find the palpable evidence of these tumors steadily disappearing, usually over a period of many months. Juan del Regato, Malcolm Bagshaw, and Frederick George each made independent observations of the effectiveness of $^{60}$Co gamma rays and 6 MV X rays.

The demonstration that early Hodgkin's disease could be cured with extensive supervoltage irradiation also astounded the medical community. Since the disease afflicted a largely youthful group of patients, the impact of the results was greater than the numbers of patients affected would suggest. The conceptual framework for irradiating lymphatic regions which were not clinically involved had been laid by Rene Gilbert (1892-1962) forty years earlier. Vera Peters (1911-1993) and her colleagues at the Princess Margaret Hospital of Toronto had demonstrated the value of a clinical staging classification and wide-field irradiation; they achieved extraordinary results, especially in patients diagnosed in "early" stages (bipedal lymphography was not available at that time). The results were so extraordinary that they were dismissed by many radiologists and hematologists; patients continued to be treated with brief courses of X rays or individual cytotoxic drugs such as nitrogen mustard. Henry Kaplan and his Stanford University hematologist colleague, Saul Rosenberg (b. 1928), were responsible for the confirmation of the effectiveness of relatively high dose extensive irradiation and especially for the education of the medical community of this efficacy.

Radiation therapy as a postoperative adjuvant to radical mastectomy became widely used in the care of women with carcinoma of the breast. Whereas conventional X rays were suitable for irradiation of the chest wall, the use of $^{60}$Co teletherapy permitted more careful modulation of the reactions and, in addition, the peripheral lymphatic regions could be treated with little reaction. The value of postoperative irradiation continued to be the subject of debate between strong proponents and detractors: the former emphasized the reduction in local-regional recurrence, and the latter noted the lack of increase in survival rates.

It quickly became evident that cancer of the lung benefited from megavoltage irradiation far more than it had from conventional X rays. Palliation of most symptoms could be achieved consistently. The questions were whether survival of patients with inoperable tumors was altered and whether it depended on the total dose delivered. The most definitive study during this period was launched in the early 1960s by investigators of the Department of Veterans Affairs. Radiation therapy was compared with supportive care. In spite of the fact that 90 percent of participating institutions did not yet have supervoltage equipment and the total dose prescribed was rather low, and in spite of the fact that small cell carcinomas constituted one-fifth of the patients treated, a small but statistically significant improvement in survival with radiation therapy was reported to the scientific assembly of the RSNA in 1966.

The price that had to be paid for this revolution in cancer treatment was a demand for radiation therapy nationwide far exceeding the available physicians, equipment, and support staff. A compelling solution for this dilemma was to treat patients less often with larger individual doses. Several formulas, based on laboratory data or acute effects on the skin of man and animals, were thought to facilitate fewer treatments with the same results. The most popular of these mathematical expressions in the United States was that developed by
Gilbert Fletcher (1911-1992)

Gilbert Hungerford Fletcher was born in Paris in 1911, the son of Marie Auspel of Auvergne and of Walter Scott Fletcher, an American residing in France who would die when Gilbert was only three years old. In 1929 he graduated from the private Stanislas High School and registered at the Sorbonne to study Latin, Greek, and philosophy. His older brother moved the family business to Belgium, and Gilbert finished a baccalaureate in engineering at Louvain in 1932. He also received a masters degree in mathematics from the University of Brussels in 1935.

His interests turned to medicine, and he received his medical degree in 1941, during the German occupation. As the son of an American citizen, he was entitled to a United States passport, permitting him to leave Belgium. After a residence of only a few months in gynecology at the French Hospital in New York, he entered training in general radiology at the New York Hospital, where he met and married Mary Walker Critz, a resident in pediatrics. He was certified by the American Board of Radiology in 1945.

As a captain in the United States Army, Fletcher was assigned as a radiologist to the Veteran's Office in Pittsburgh. He met Randolph Lee Clark, who was recruiting staff for a new cancer institution in Houston. But Fletcher's weakest point in his training and experience had been radiotherapy. He was offered a fellowship and spent several months in Paris, Stockholm, London, and Manchester as an observer. He was particularly impressed by Baclesse and Paterson. On his return in 1948 he was appointed head of the department of radiology at M. D. Anderson Hospital, with responsibilities in radiodiagnosis and radiotherapy.

In the feverish post-war development of radiotherapy he was an unknown, but, blessed with native ingenuity and an abundance of patients, no one rose as rapidly to acquire experience and be recognized as an authority. He developed techniques and pragmatic gadgets that were widely adopted. An indefatigable worker, he made systematic analyses of his own experiences, pointing out causes of failure and complications. His lectures, embellished by his Gallic accent, were remarkably educational presentations of his abundant material. He was also an incisive debater. With his associates he contributed various devices for brachytherapy of cancer of the cervix. He contributed to the development of one of the first cobalt-60 units.

It was not until 1965 that he relinquished his diagnostic obligations to devote himself to the utilization of supervoltage and the investigation of hibaroxy- and electron-therapies.

Fletcher was a founding member of the International Club of Radiotherapists (1953), president of the American Radium Society (ARS) (1963), and of the American Society of Therapeutic Radiologists (ASTRO) (1967). As chairman of the Committee on Radiological Studies he endeavored to initiate meaningful clinical cooperative studies and trials of combined radiotherapy and chemotherapy. In his brilliant career he earned the Béclère and Janeway medals, as well as the gold medals of the Radiological Society of North America, ASTRO, and the ARS. His associates and former residents founded a Fletcher Society. A man of innate genius and pragmatic resourcefulness, he enjoyed their adulation. On 11 January 1992 Fletcher died of heart failure.

—Juan A. del Regato, M.D.
Frank Ellis in the 1960s. Ellis's move to this country after his retirement from Oxford University in 1970 gave further impetus to this practice.

Victor Marcial (b. 1924, Fig. 2.10) conducted a survey of fractionation practices in 1965 as an activity of the Committee for Radiation Therapy Studies (CRTS). 30 A questionnaire was sent to the members of the American Society of Therapeutic Radiologists and to selected centers in Canada, the United Kingdom, and France. Of the ninety-five institutions represented by the replies, thirty expressed their units in roentgens (R), twenty-six used rads, and thirty-nine did not specify the units used. He found that most institutions in the United States and Canada treated with single fractions daily, five days per week; the usual fraction size was 200 R or rads, and the total doses ranged from 5,000 to 7,000 R or rads. The British centers usually completed treatment in three or four weeks. There was considerable variability, however. Many institutions treated patients for two weeks and then gave them a rest just at the time mucosal reactions would be expected. This was especially popular when it was unclear whether the patient was being treated with palliative or curative intent; the patient was sent away for two or three weeks, and if he or she returned in improved condition, additional irradiation was given.

In the late 1950s another new trend was seen in the field, less obvious than but of equal importance with supervoltage therapy. This was the expansion of training programs emphasizing radiation oncology. Initially an increase in radiation oncology training was supported by the National Cancer Institute (NCI). The new training programs were designed to emphasize oncology at least as much as radiation in the emerging specialty. Only a few of the earliest full-time practitioners of radiation oncology had been certified by the ABR in therapeutic radiology, in contrast to the much more common certification in radiology, both diagnostic and therapeutic. This new generation of radiation oncologists, trained in the United States, began to augment the influence of their mentors. The full expression of the training expansion was not seen until the 1970s and 1980s. By the mid-1980s all available residency positions in radiation oncology were filled, mostly with candidates who had graduated with superior records from medical schools throughout the United States.

The third phenomenon, formalized clinical research in oncology, sputtered for more than a decade before gradually establishing a firm foundation. 31 Several prospective comparative clinical trials were begun by the Office of Veterans Affairs, the Eastern Cooperative Group in Solid Tumor Chemotherapy, the Surgery Adjuvant Breast Group, and two groups that were endorsed by the CRTS, one for Hodgkin’s disease and another for carcinoma of the prostate. Each suffered. Either the leadership was primarily interested in a modality other than radiation therapy, or there was insufficient infrastructure—data managers, research nurses, biostatisticians, and physicians—to sustain studies which, by their very nature, required many years for completion.

The CRTS, initially chaired by Gilbert Fletcher, had been formed with the encouragement of Kenneth Endicott, director of the NCI in 1963. Endicott wished to have a single set of recommendations from the radiation oncology community rather than the many bits of advice he was receiving. In addi-
tion to development of training grants in radiation oncology, CRTS endorsed the concept of a cooperative group devoted to radiation oncology research. The seventeen cooperative groups which had been formed in the mid-1950s had little interest in questions involving radiation therapy. The Hodgkin's and prostate trials that had started in 1967 had required entirely different groups of investigators and statistical centers, and CRTS wanted to develop a cooperative group which would not have to be reinvented with each new study.\(^2\)

Simon Kramer (b. 1918, Fig. 2.11), a member of CRTS, wished to pursue a study of intravenous methotrexate prior to radiation therapy for advanced carcinomas of the upper respiratory and digestive tracts. This was endorsed by CRTS, and he received a grant from the NCI to organize a group, the Radiation Therapy Oncology Group (RTOG). The original award was to the Jefferson Medical College in 1968, but the grantee became the ACR in 1975, the first award that provided direct support to participating institutions.

The period between 1950 and 1970 in the history of the practice of radiation oncology in the United States can best be characterized as having generated much momentum. Supervoltage radiation therapy was immediately superior to conventional X rays with regard to reactions in the skin and subcutaneous tissues. It could be used to relieve symptoms from advanced cancers like skeletal and cerebral metastasis, cancer of the lung, esophagus, pelvic tumors, and it seemed able to eliminate some tumors in the short run: Hodgkin's disease, inoperable carcinomas of the prostate, and advanced cancer of the cervix. The full expression of the supervoltage revolution was seen only after 1970, when improved treatments became available and sufficient numbers of new radiation oncologists were trained to use the equipment. Then it would become evident that fully half of all cancer patients would need radiation therapy and that radiation oncologists would be required increasingly "to assume an exceptionally heavy responsibility" for their lives, as Regaud had challenged decades before.


The final quarter of the first hundred years of radiation oncology began with a Cold War between the United States and the Union of Soviet Socialist Republics, an Iron Curtain in Europe, and a gradual awakening of economic superpowers in the Far East. The United States was mired in a civil war in southeast Asia. The major commitment of armed forces to combat in Vietnam influenced the careers of many physicians who were obligated to military service through enlistment or draft.

The care of patients with cancer was dominated by surgeons. Not only was complete resection the most consistent curative approach—albeit frequently with major morbidity—but the widespread availability of general surgeons and surgical subspecialists led to their assuming responsibilities for administration of cytotoxic drugs and hormones as well as for the care of many patients who had inoperable or recurrent tumors and needed thoughtful and compassionate care while dying.

Hematologists and those committed to the nascent specialty of medical oncology were becoming aware of striking successes with the use of cytotoxic
drugs for some rare malignant tumors, notably gestational choriocarcinomas and a B-cell lymphoma of African children. Furthermore, there were reports of very preliminary experiences suggesting success with the use of combinations of antineoplastic drugs in patients with less rare malignant disease, such as disseminated testicular carcinomas and Hodgkin’s disease.

Radiation oncology was undergoing profound and rapid change. Supervoltage radiation therapy, in the form of $^{60}$Co teletherapy units, betatrons, and linear electronic accelerators, was becoming much more widely available. This technology was being used with readily demonstrable effectiveness by general radiologists who elected to confine their activities to the care of patients with cancer and, increasingly, by physicians trained exclusively in radiation oncology. By 1975 training in general radiology, i.e., both diagnostic radiology and therapeutic radiology, was no longer offered. The ABR had ceased certification of physicians in the combined field. By 1980 a majority of universities that offered training in radiology had established separate departments of radiation oncology.

Most groups of physicians who practiced radiology either recruited new associates who were trained exclusively in radiation oncology or agreed that one or more of their colleagues would confine his or her practice to the care of patients with cancer. As a result, by 1983 there were more than 1,600 full-time radiation oncologists, compared with only 111 twenty years earlier.

**Schools and Practice Policies**

Several individuals and the schools that developed around their approaches to training dominated practice, especially in the 1980s and even today. Each of the schools was characterized by a creative individual with a forceful personality both within the institution and nationally, by the active collaboration of colleagues from other specialties, and by important training programs.

One of the most influential schools developed around Gilbert H. Fletcher and his colleagues at the University of Texas M. D. Anderson Cancer Center. Fletcher’s influence on the practice of radiation oncology in the United States was and is to this day a formidable one. It was confined, however, in large part to the treatment of patients with cancer of the upper aerodigestive tract and more broadly the head and neck (excluding brain tumors) and gynecologic cancer—especially cancer of the cervix. The influence of cancer of the head and neck was dependent upon collaborations with surgical colleagues William S. Macomb and Richard H. Jesse. The importance of dental oncology and diagnostic imaging was considerable. Until the mid-1960s there were no full-time residents at M. D. Anderson, but many physicians who had begun training elsewhere took two-year fellowships at the institution. As the residency program expanded in the 1970s, Fletcher’s influence in the field became even greater.

Fletcher’s influence was extended by his student Rodney Million, who established a department of radiation oncology at the University of Florida in Gainesville in 1964. Million established an effective collaboration with Nicholas Cassisi, a surgeon trained by Joseph Ogura in St. Louis. Million and Cassisi learned from each other, adding to what they had learned from their mentors. In many cases the independent collaboration of the work of Fletcher and his colleagues at M. D. Anderson by the Million–Cassisi practice at the University of Florida emphasized the reproducibility of Fletcher’s results and concepts. This was especially true in the management of carcinomas of the glottic and supraglottic larynx and the piriform sinus.

In the field of gynecologic cancer Fletcher is identified especially with the treatment of carcinoma of the cervix. He was an early advocate of high-energy photons using the betatron for whole pelvic irradiation and over time evolved several modifications of the RS (Radium Institute) Manchester approach to intracavitary applications.
of radium. As the field of after-loading with brachytherapy evolved in the 1960s, the Fletcher-Suit applicator, modified in later years by Luis Delelos, became one of the most popular means of applying brachytherapy with tandem and ovoids.

Two other influences in North America vied with Fletcher's approach to cancer of the cervix. One was promulgated by Victor Marcial at the University of Puerto Rico. He and his colleagues emphasized a slower rate of delivery of external beam radiation therapy, used a single intracavitary application of radium, and attempted to select from the wide range of applicators available that system which most appropriately suited the clinical circumstances of the patients they encountered. The Princess Margaret Hospital in Toronto, promoting the more rapid fractionation of external radiation common in the United Kingdom, also had a considerable impact on the practice of radiation oncology. All of these influences waned in the 1980s as successful screening with cervical cytology and colposcopy led to consistent treatment of cervical intraepithelial neoplasia and a striking reduction in the incidence of invasive cervical cancer.

Hodgkin's Disease

The treatment of Hodgkin's disease underwent profound changes in the 1970s. As data were analyzed in the 1980s it became clear that treatment changes dating from the early 1970s had resulted in a decrease in the annual mortality of this uncommon malady. Yet standard textbooks that were available a decade before these treatment changes (ca. 1960) depicted Hodgkin's disease as uniformly fatal but acknowledged that some patients could live for prolonged periods of time following surgical or radiotherapeutic intervention.

The fundamental observations that radiation therapy could produce prolonged periods of freedom from all evidence of the disease were made by Rene Gilbert in the 1920s. Very careful observations by this physician from Geneva, Switzerland, revealed that Hodgkin's disease failed in a predictable pattern after local irradiation, namely in immediately contiguous sites. Moreover, he observed that lymphatic regions required treatment beyond the period required for the adenopathy to disappear or it would recur at the same site. This led him to practice the use of more prolonged periods of irradiation, i.e., to higher total doses and to irradiate extensively sites without clinical evidence of involvement in order to prevent contiguous recurrence.

These observations had been corroborated by others, notably Vera Peters of the Princess Margaret Hospital of Toronto, who documented long-term, disease-free survival related to extensiveness of irradiation and clinical stage.

Henry Kaplan, chairman of the department of radiology at Stanford University Medical Center, and Saul Rosenberg, a renowned hematologist, championed the use of extensive prophylactic irradiation of clinically uninvolved areas. They advocated the "mantle" field, which permitted the simultaneous irradiation of all major supradiaphragmatic lymph node-bearing areas so as to avoid multiple adjacent fields. The extent of irradiation was dependent upon the stage. Staging classifications were developed in the mid-1960s and represented an evolution of the classification used by Vera Peters but relied upon bipedal lymphography to investigate infradiaphragmatic nodes. International workshops in Paris; Rye, New York; and eventually Ann Arbor, Michigan, were based on an evolving understanding of sites previously involved at the time of diagnosis and those most likely to have new manifestations of disease following local, regional, or mantle irradiation.

Another important development that led to decreased mortality in Hodgkin's disease was the introduction of combination chemotherapy using MOPP—mechlorethamine (nitrogen mustard), vincristine, procarbazine, and prednisone. MOPP became the most widely recognized effective combination chemotherapy regimen.
Clinical trials were soon underway to investigate comparisons between involved field radiation therapy and more extensive irradiation (mantle or extended field). Kaplan and his colleagues advocated the extensive irradiation but did not actually participate in the clinical trials. Similarly, MOPP, which was developed at the NCI facility in Bethesda, Maryland, was investigated by many cooperative groups nationally and internationally, but the NCI investigators did not lead those trials. Kaplan and Rosenberg, with great credibility among both radiation oncologists and hematologists, convinced a large number of physicians caring for patients with Hodgkin's disease that extended-field radiation therapy was the accepted standard. Carbone, DeVita, and their colleagues from the NCI similarly convinced hematologists throughout the nation that MOPP was the standard for patients with advanced disease.

There was considerable potential morbidity with irradiation of very large irregular fields to high total doses. Kaplan recommended a total dose of 44 grays (Gy) in four weeks. Based on a retrospective review of published data, however, questions began to be raised in the mid-1970s as to the morbidity of doses this high. Moreover, an expanding body of data between the mid-1970s and 1992 indicated that the maximal control of Hodgkin's disease was achieved with total dose between 34 and 38 Gy. Concerns about late cardiac effects were increased with the publication of long-term results from Stanford University and other centers. It is now clear that the total dose of radiation administered must be kept to a minimum, 30 Gy for subclinical disease and 38 Gy for tumors greater than 5 centimeters in greatest dimension. Chemotherapy prior to radiation therapy has been used successfully to reduce large masses, especially in the mediastinum, and to permit the protection of more pulmonary tissues. Brief courses of chemotherapy followed by radiation reduced the risk of pulmonary morbidity.

Adenocarcinoma of the Prostate

This most common malignant disease of men is another example of striking benefits from supervoltage radiation therapy. It was not possible to deliver sufficient doses of conventional X rays to the center of the male pelvis to eradicate cancer of the prostate. Unlike cancer of the cervix, which permitted intercavitory brachytherapy as a component of treatment, adenocarcinoma of the prostate required external irradiation alone. The first observation of potential benefit from 60Co teletherapy was published by del Regato in 1962. Malcolm Bagshaw, Fred George, and del Regato each reported small series of patients who remained free of all evidence of cancer of the prostate at least five years after external irradiation in the mid-1960s.

Buoyed by these concurrent observations, urologists and radiation oncologists throughout the nation quickly mounted a prospective comparative trial of radiation therapy compared with radiation and low-dose diethylstilbestrol (DES) treatment. This trial quickly facilitated transfer of concepts and the techniques of the radiation of the prostate to the community at large. Although the clinical trial enrolled nearly four-hundred men, all of whom were followed until death or at least twenty years, the question of adjuvant hormone therapy remained unanswered.

Shifts occurred in the treatment of unresectable carcinoma of the prostate in the early 1970s; the shift was from orchietomy and/or administration of DES for inoperable patients without distant metastasis to high-dose pelvic dose irradiation. The radiotherapeutic management of cancer of the prostate is very well documented by the PCSs issued initially by Kramer in the early 1970s and continued to the present time. They have shown a high degree of local tumor control for small lesions with total dosage of 65 Gy. They have documented a relatively high control rate for a more advanced (T3/T4) tumors. However, the recent available prostate-specific antigen (PSA) deter-
mination has demonstrated that the consistency of control of these more advanced tumors is much less than was thought on clinical grounds alone.

The possible benefit of adjunctive androgen suppression with radiation therapy has resulted in apparent improvement in local control and progression-free survival, although no overall survival benefit has been shown to date.

Nonetheless, a striking improvement in five-year survival rates has been documented by the American Cancer Society. Between the early to mid-1960s and late 1980s, the five-year survival rate increased from 47 percent to 72 percent. Since there is no evidence in the literature to show an influence of hormonal treatment on survival, and since the diagnosis is a result of PSA-based screening which was not a factor until 1989, the only tenable explanation for the striking improvement in survival is the widespread adoption of radiation in the management of men with inoperable but nonmetastatic adenocarcinoma of the prostate.

Cancer of the Breast

More American women are afflicted by cancer of the breast than any other malignant disease. Arguably more intense research efforts and more dollars have been spent on cancer of the breast than any other malignant disease. Unfortunately there is no difference in the annual mortality rate at present than there was fifty years ago. This is despite the increasing availability of well-trained general surgeons, the widespread use of adjuvant radiation therapy since the 1950s, and the even more widespread use of postoperative cytotoxic chemotherapy and hormones since the 1970s.

What is clearly demonstrable is the increasingly widespread adoption of treatments that permit conservation of the breast. First practiced in many institutions in North America, notably the Princess Margaret Hospital in Toronto, Ontario, and the M. D. Anderson Cancer Center in Houston, breast conservation developed the most vocal and effective advocates in France and Italy. Bernard Pierquin, first at the Gustave Roussy Institute in Villejuif and then at the Centre Hospitalier Henri Mondor in Creteil, France, encouraged excisional biopsy, external irradiation of the entire breast and lymphatics, and then interstitial irradiation with iridium-192. Umberto Veronesi, a highly respected Italian surgeon, launched a prospective trial comparing quadrantectomy plus breast irradiation versus mastectomy at the Italian national cancer institute in Milan. The Milan study was the first comparative trial to show that patients who were afforded breast conservation had the same survival rates as those who had mastectomies.

The most influential group in the United States was that at the Joint Center for Radiation Therapy in Boston. Samuel Hellman enlisted the interest of surgeons at the Harvard teaching hospitals, most prominently William Silen, surgeon-in-chief at the Beth-Israil Hospital, to practice breast conservation. Their collaboration, joined by Jay R. Harris, influenced a large number of surgeons and radiation oncologists around the country through their publications, lectures, and workshops in Boston. Nonetheless, by the early 1990s, only one-quarter of women in the northeastern United States were treated with breast conservation and in some states only one woman in twenty was treated in this manner.

CONCLUSION

It is not possible to enumerate, let alone elaborate, the contributions of
radiation therapy to the care of patients with cancer. As the second century of the therapeutic use of radiation dawns, health care payment reform demands that physicians and patients examine even more seriously the value of treatments offered them. The value of radiation therapy, carefully planned and administered by radiation oncologists and the collaborating healthcare team (physicists, dosimetrist, therapists, nurses), will be recognized as great. Clinical research to increase effectiveness and to expand the indications for radiation therapy will become more formalized and more sophisticated to build upon the enormous scientific and clinical base of the first hundred years.

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