Early radiation therapy was empirical, unprotected, and offered amazing results, as in this 1899 treatment for epithelioma of the nose. (Courtesy of the Center for the American History of Radiology, Reston, Va.)
On Friday, 8 November 1895, a German physicist and university rector worked late in his laboratory. Like many busy academics he was forced to fit his research into time not already allotted to administrative and teaching tasks. His own interest lay in investigating the phenomena of fluorescent emanations from electrically charged sealed glass tubes. In his darkened workroom he shielded a Hittorf–Crookes tube with cardboard in preparation for a series of experiments. While testing the soundness of the shielding he noticed, to his surprise, the glow of a barium platinocyanide-coated screen on a bench about a meter away. He turned his electrical source on and off; the screen glowed on and off as well. This could not, he knew, be the cathode rays familiar to physicists, as they could not have an effect at such a distance. He investigated further.

At some point on that day or the ones that immediately followed, he moved his hand near the glowing screen. He was startled at what appeared to be the shadows of moving bones. After weeks of careful experimentation and the reassuring verification of a photograph of the living bones of his wife’s hand, Wilhelm Conrad Röntgen made his announcement. He had discovered “Eine neue Art von strahlen,” a new kind of ray (Figs. 1.1 and 1.2). From a small physics laboratory in Würzburg came a discovery that would revolutionize medicine. The X ray would change forever the physician’s orientation to the interior of the living body. It would introduce into medicine the first costly, ever-changing, and absolutely necessary machine. And the X ray would touch the lives of millions of sufferers in ways that Röntgen could not have imagined in 1895.

X-Ray Mania

Within weeks news of the magic ray that could see through living human flesh had spread to the United States. “Hidden Solids Revealed!” proclaimed the New York Times science writer on 16 January 1896. The detailed explanation of the simple apparatus needed to generate X rays led hundreds of electricians, photographers, physicists, and physicians in setting up their own experimental “Roentgen outfits.” Anything that could be photographed with a regular
camera was soon the subject of radiography. "Startling Results" announced in the press by Yale physics professors accompanied radiographs of nutmeats inside uncracked walnuts. Radiographs of feet in boots and ringed hands adorned popular and technical journals. Poems, cartoons, patent medicines, and songs employed the X-ray as a metaphor for piercing vision and discernment.

Much has been written about the American public's early fascination with X-rays and later radium. X-ray proof lead underwear was marketed, bone portrait studios opened, and Edison hoped to see an X-ray unit (of his manufacture, of course) in every home (Fig. 1.3). Underlying the many humorous and bizarre examples from a public smitten with the new technology was the notion of infinite possibility inherent in the "new light." The United States in the 1890s seemed a place of limitless opportunity. New inventions crowded the marketplace, industry promised to revolutionize the quality and delivery of goods, and great prosperity seemed just within the reach of anyone with a novel idea. A question formed in the minds of many of the professionals and tradespersons experimenting with X-rays: If this magic ray could see through solid objects, what else might it do?

It was exactly this curiosity and the entrepreneurial spirit of the time that gave some medical writers reservations about Röntgen's discovery. In February 1896 the editors of the Journal of the American Medical Association (J.A.M.A.) cautioned:

There will doubtless be an extensive advertisement of cathode ray baths, X-ray treatments, etc., but it is to be hoped that any active exploitations of these will, until the matter is more elucidated by accurate scientific researches, be confined to the irregulars who have no standing in the regular medical profession.

**Many Practitioners**

Readers of J.A.M.A. understood who were the "regulars" and the "irregulars" in the American medical landscape of the

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**Fig. 1.1 Wilhelm Conrad Röntgen (1845–1923) (Courtesy of the Center for the American History of Radiology, Reston, Va.)**

**Fig. 1.2 The radiograph of Bertha Röntgen's hand was widely reproduced in Europe and the United States. (Courtesy of the Center for the American History of Radiology, Reston, Va.)**

**Fig. 1.3 So great was the fascination with the new discovery that special studios opened where persons with and without physical problems could sit for their "roentgen portraits." (Courtesy of the Center for the American History of Radiology, Reston, Va.)**
1890s, but this was an understanding that sometimes varied with the perspective of the individual physician. Medical practice in the United States was far from a monolithic and unified profession with agreed-upon rules of practice. In the east physicians trained in teaching hospitals with European-influenced programs were considered the cream of medicine. But they constituted only a small percentage of practicing physicians, and an even smaller number of this elite would become directly involved with the new rays. A different class of practitioners, trained at what would later be called “B” medical schools and through extended preceptorships, made up the bulk of American practitioners. Most of these doctors had general practices, many with hospital and clinic affiliations. Membership in medical organizations was open to all doctors with a “legitimate” medical degree, and even this was not scrutinized too closely for quality.

Hovering about the fringe of this corps of physicians who liked to call themselves the “regulars” was a growing number of practitioners who adhered to exotic and sometimes quite colorful theories about the body and healing. Electrotherapists, hydrotherapists, mesmerists, and osteopaths were lumped together with frank charlatans and quacks in the minds of the “regulars.” The public, however, flocked to the new therapies and seemed to welcome with open arms each new “ism” (as the new treatments were mocked in mainstream medical journals). It may be worthwhile here to note the heroic methods still in vogue in much of “regular” medicine when compared to the relatively soothing and non-invasive manipulations of many of these peripheral practitioners.

Electrotherapy in particular was gaining in popularity and legitimacy in the 1890s. Several noted “regulars” had joined the ranks of the electrotherapists, while electrotherapy equipment had begun to turn up in even the most conservative of eastern urban hospitals (Fig. 1.4). Treatment consisted in the application of small amounts of static electricity or current to the afflicted part, though electrical “baths” and other gear were also popular (Fig. 1.5). Electricity was applied to a bewildering range of diseases and dysfunctions:
body and head aches, dermatological problems, impotence, malaise, over-excitability, hair loss, memory loss, tuberculosis, and that catch-all of nineteenth-century women's ailments, neurasthenia.\textsuperscript{10}

Despite an influential national organization, the American Electrotherapeutic Association, and a growing acceptance among both the public and referring physicians, the electrotherapists struggled for professional recognition.\textsuperscript{11} Many had entered medicine "through the back door" as electricians or technicians who acquired first the necessary apparatus and second (often by mail) medical degrees. Electrotherapy, with its vague relief of often even more vague symptoms offered little of the therapeutic decisiveness favored by the "regulars."

The announcement that a miraculous new ray had been found—and that it could be produced out of the same machines the electrotherapists had been using for decades—brought both hope and the "regulars" to the doorstep of electrotherapists across the United States. Physicians in hospitals wanted to borrow their machines and wanted advice in operating them to secure diagnostic X rays. Several electricians and electrotherapists hung out new shingles as "X-Ray Laboratories."\textsuperscript{12} The door to full acceptance in legitimate medical practice had been opened by their expertise in the new technology. Electrotherapists and their "regular" colleagues forged ahead to test the powers of the X ray.

Post hoc rationales for innovative treatments often save medical workers from looking foolhardy. Many accounts of early X ray treatment begin with notions of redness and erythema after diagnostic work, followed by the reasoned conclusion that "perhaps there might be some beneficial effect on diseased tissues."\textsuperscript{13} In truth, the application of the rays to disease was a natural extension for this body of practitioners who were accustomed to applying electricity for a range of maladies. Even the same apparatus was used (Fig. 1.6). The earliest therapeutic applications of the rays were almost entirely empirical and without rationale or reason. After the fact, when amazing results were noted, electrotherapists and other physicians struggled to make their adventure into the unknown sound scientific. One author, after candidly admitting that his first efforts at radiation therapy had been "purely speculative and empirical" went on to gamely catalog a list of factors he recalled as his rationale—a jumble of thoughts on sunlight, bacteria, ozone, chemicals, and ultraviolet light.\textsuperscript{14} More direct was the author who recalled that "We forged ahead with what glimmer the new light gave us, shining it on whatever diseases came to hand, with the hopes that here and there we might uncover a new and fruitful use."\textsuperscript{15}

**Many Applications**

The therapeutic applications to which the rays were immediately turned were direct reflections of the medical and health concerns of the time. The notion that bacteria were instrumental in the cause and transmission of some diseases had only recently been accepted. Tuberculosis and its related involvements were a primary concern of the age, both as a public health issue and in medical research. In addition, reported incidences of cancer were up dramatically at the turn of the century, causing many physicians to look closely for both the cause and cure for malignancies.\textsuperscript{26} Finally, some practitioners noticed an unexpected and beneficial side-effect of the rays in disease: a striking diminution in pain.

**Benign conditions**

In February 1896 Thomas Edison wrote "What can be easier than to turn
ÉMIL GRUBBÉ
(1875–1960)

On the day the first notices appeared in American papers an electrical engineer and chemical assayer in Chicago was pleased to find that he already possessed the necessary equipment to generate the new rays. An active experimenter with Crookes tubes, Emil Grubbé (1875–1960) had in his assayer’s office the tubes, induction coils, electrical generators, and fluorescent chemicals needed to duplicate Röntgen’s work. Chicago newspapers, like those in other cities, carried detailed directions for setting up the equipment and making radiographs on plain photographic plates. Grubbé set to work immediately, investigating a series of innovations in tubes and generators.

Within two weeks he had developed a troublesome and suppurating erythema on his left hand. He had been using the hand several times daily to test the “penetrating powers” of his new tubes. On 27 January 1896 Grubbé was seen at the Hahnemann Medical College in Chicago. Three professors, J.E. Gilman, A.C. Halphide, and R. Ludlam, offered advice on the burn-like lesion. According to Grubbé, Gilman then stated:

...any physical agent capable of doing so much damage to normal cells and tissues might offer possibilities, if used as a therapeutic agent, in the treatment of pathologic conditions in which pronounced irritative, blistering, or even destructive effects might be desirable.

Drs. Halphide and Ludlam concurred and each agreed to send a patient to Grubbé for trial treatment.

Grubbé later reported that on 28 January 1896 he treated a Mrs. Rose Lee, a fifty-five-year-old patient who suffered with an open inoperable recurrent carcinoma of the left breast. With lead sheets around the breast as shielding, a Crookes tube was suspended about three inches above the site. The treatment lasted one hour—followed by similar treatments over the next seventeen days. The day after Lee’s treatment was initiated, Grubbé saw a Mr. Carr, who was eighty years old with extensive ulcerous lupus vulgaris on his face and neck. He, too, had one-hour exposures daily until mid-February. “And so,” noted Grubbé in his overwrought style nearly fifty years later, “without the blaring of trumpets or the beating of drums, a new therapeutic agent had arrived.”

This strange quiet has been precisely the problem for other physicians and historians who have looked at Grubbé’s achievements. Although the silence was broken in the 1930s by his own hornblowing and drumbeating, there is little evidence to back up Grubbé’s claims and still more reason to doubt that his account was entirely accurate.

First, he did not publish his version of these activities for a number of years. He would defend his uncharacteristic reserve by stating that in 1896 he was not yet a physician, a distinction he achieved with a somewhat dubious medical degree from Hahnemann in 1898. He claimed to have treated many patients between 1896 and the opening of his own X-ray laboratory in 1898, but the referring physicians took credit for his work. This, he asserted, accounted for the unwillingness of any of these physicians to step forward to affirm his earliest therapeutic efforts.

Second, there is the troubling question of the two original patients. Grubbé produced handwritten referral slips on Mrs. Lee and Mr. Carr in the 1930s as proof of events as he described them. Later submitted to FBI analysis, the paper and ink were verified as consistent with those in use at the turn of the century. What was not questioned was the sudden appearance of these crucial documents or the very real oddity of formal referrals written in quite similar styles by physicians sending patients to the factory room of a chemical assayer.
And what became of these patients? Grubbé, in his several accounts of these patients, gave no clue as to the immediate effects of the treatments. He reported that each patient died within a month of the original treatment, Mrs. Lee of systemic carcinoma and Mr. Carr from a skull fracture after falling off one of Chicago’s elevated sidewalks. Exhaustive searches of the warehoused certificates of death for Cook County have located neither a Rose Lee nor an A. Carr for all of 1896 and 1897. On the chance that Grubbé might have changed their names in respect for patient anonymity, a second search was conducted attempting to match similar ages and causes of death. Again, no matches were found.

Finally there is the matter of Grubbé himself. Victim to his many unshielded experiments with the rays, he suffered over one hundred surgical procedures and amputations over his long life. Many acquaintances ascribed his relentless bitterness and contentiousness to his disfigurement and his often-thwarted quest for recognition as “the father of radiotherapy.” A more disagreeable character can hardly be found in radiology’s history. Grubbé’s personal papers and memoirs, on file at the Center for the American History of Radiology, reveal that he was, throughout his life, a difficult and often mean-spirited man. At his death in 1960 he left his extensive library and modest fortune to the University of Chicago with one stipulation: that a biography be written recounting his life and achievements. Paul Hodges, longtime head of the radiology department, reluctantly agreed to take on the task. The more he learned about the departed Grubbé the less he liked him, and the biography is a balanced but perjorative assessment of Grubbé’s life work. Hodges’s advice to an historian in later years was, “If you’re going to be fool enough to leave your money to have your biography written, then try to lead an exemplary life. Failing that, for God’s sake remember to tell your lawyer to stipulate that it be a positive biography.”

There is no definitive answer about Grubbé’s priority in the therapeutic use of the roentgen rays. It is true that he was one of the first to experiment with the rays in the United States and to experience their negative effects, and among the first to set up and successfully run both an X-ray clinic and a radiological school. He later treated successfully many patients with benign and cancerous lesions. But he took credit for, among other things, the introduction of “a new therapeutic era...of radiation therapy,” and, by extension, “treatment with thorium, mesothorium, radium, alpha rays, beta rays, gamma rays, radon, and all the isotopic chemicals which can now be made from the cyclotron [sic], betatron, or other atomic fission devices.” His bombast may have made Grubbé a particularly unappealing pioneer to his medical colleagues and blinded them to the validity of some, if not all, of his claims to early and innovative work in the field.

the rays on the lungs of persons afflicted with consumption? Two weeks later James Burry reported in J.A.M.A. onirradiation of tuberculosis bacilli for two hours in an attempt to assess the "germicidal effects." Numerous researchers wrote of successful in vitro applications of the rays over the next few years. By 1898 reports in the literature covered the beneficial effects of X rays on pulmonary tuberculosis in both guinea pigs and human subjects.

One physician (and ex-electrotherapist), C. H. Brauer of David City, Nebraska, detailed his X-ray treatment of four patients with tuberculosis of the lungs. "For one week I gave daily sittings of eight minutes duration placing a Crooke’s tube ten inches from the body and using such penetration that I could see finger bones with the fluoroscope at four feet." Such descriptions were meant to be helpful to those who wished to duplicate the author’s results, which included diminished coughs, returned appetite, weight gain, and, in one case, “a complete disappearance” of the disease.

Physicians who sought to cure pulmonary tuberculosis with the rays must have been encouraged by the immediate and salutary effects of treatment in lupus vulgaris and associated disfigurements. The first case reported in the United States was by Philip Mill Jones of San Francisco in 1900, but was preceded in 1898 with reports by Freund and Schiff in Germany. In his 1901 textbook Francis Williams summarized more than a dozen cases of lupus vulgaris treated by the X ray with spectacular results. William Fousey and Eugene Caldwell described a number of lupus cases in detail, as did other early textbook authors (Figs. 1.7 and 1.8). These patients were clearly successes, many relieved in a matter of weeks of scars they had borne for years.
Most anthologists of treatments listed lupus vulgaris first in the heading of "tubercular problems," going on to summarize curative attempts in lupus erythematosus, tubercular ulcers, tubercular glands, tuberculosis of the bones and joints, tuberculosis of the conjunctiva, leprosy, actinomycosis, rhinoscleroma, blastomycosis, and a number of other disease entities not seen today as related. In many cases the immediate relief occasioned by the drying effects of the rays may have been confused with a cure. In others, genuine and permanent improvement was noted.

These successes led to immediate applications to any and all dermatological or surface lesions. By 1902 numerous cases had been reported of favorable X-ray treatment of hypertrichosis, acne, psoriasis, alopecia areata, favea, tinea tonsurans, even excessive facial perspiration. Such laundry lists of diseases and symptoms cannot convey the broadness and optimism with which the X ray was applied to disease. And since the rays had proven effective in shrinking swelling in dermatological conditions, some physicians reasoned that internal swellings might be equally susceptible. The X ray was used to treat gout, goiters (Fig. 1.9), and in 1905 was first applied to thymic enlargement in infants.

Leopold Freund, who had pioneered radiation therapy in Europe with the irra-
dition of a disfiguring hairy nevus in 1896, advocated the use of the rays as a medical depilatory. In France and Italy X-ray beauty clinics were opened for the cosmetic removal of unwanted hair. In the United States these treatments were administered discreetly in doctors’ offices (Fig. 1.10).

If some of the early applications of the rays seem farfetched, it is important to remember that there was no more compelling reason to use them on lupus than for hair removal; no system of medical thinking that made X-rays more promising in gout than in cancer. So many beneficial results were observed, and these were so unpredictable and varied, that many X-ray workers felt called to find new and potentially rewarding applications. This explains the eagerness of Mihran Kassabian, who in 1904 obtained permission from the Insane Department of the Philadelphia Hospital to irradiate a number of “epileptic” patients (Fig. 1.11). Looking at the pictures of these patients as they underwent months of irradiation and hair loss, we can see other possible diagnoses. But like many practitioners who experienced mixed results, Kassabian remained upbeat about the experiment, noting that the patients’ seizures had diminished in number and severity and that their hair had grown back with renewed vigor and shine.

What emerged from these numerous uses for the X-ray in benign conditions was not a well-codified system of therapeutics. Instead, the medical literature and textbooks carried exhaustive descriptions of individual cases, outcomes, technique, and idiosyncratic observations. The practitioner was free to choose, with little guidance, from the smorgasbord of treatment sites and methods. There was no consensus on the most favorable approaches.

By 1910 most physicians who used radiation therapy in their practices agreed that the rays had not lived up to their early promise in the treatment of pulmonary tuberculosis. The gradual realization that there were dangers in unlimited applications of radiation led to conservatism among some practitioners. But great successes had been noted in a range of diseases and symptoms, and radiation
would remain the treatment of choice for many of these benign conditions well into the middle of the twentieth century.

**The X Rays in Cancer**

The effects of the rays in benign skin disease led to similar applications in surface cancers. But cancer had been uppermost in the minds of many observers since the announcement of Röntgen's discovery. In 1896 Nikola Tesla, the electrical inventor, wondered if it might be possible to "load" X rays with cancer-fighting drugs or chemicals and project them into the body. Articles questioned whether cancer, the "modern disease," might be treated with the new rays.

The works of Tage Sjögren and Thor Stenbeck in 1898 and 1899 are often cited as the first treatments of skin cancer, with a successfully treated case of basal cell carcinoma and one of squamous cell carcinoma. At the same time this work was in progress, a pathologist and medical student in Washington, D. C., had begun the treatment of a patient diagnosed with epithelioma of the skin. Wallace Merrill and Walter Johnson published their results with this and other patients in 1900, noting:

> We are firmly convinced that, by means of the proper application of X rays under conditions of no practical discomfort to the patient, we can bring about the painless removal of the slow-growing epithelioma.

It is noteworthy that both the Swedes and Merrill and Johnson combined these initial treatments with surgery.

The X rays offered hope previously unavailable, and soon applications had been made to a range of surface lesions. By 1901 and 1902 numerous reports of promising treatment of "cutaneous carcinoma" appeared in medical journals. Sequeira, at the London Hospital, reported on more than one hundred cases he had treated by 1903. He noted a number of recurrences after treatment, but stated optimistically that "as a matter of practical import the recurrences are usual-

ly easily removed by fresh applications of the rays." Many practitioners seem to have had difficulty in distinguishing the relief of symptoms from a total extirpation of the disease. For some this was perhaps the result of lack of experience with cancer. Surgeons knew the tenacity of the disease, even when it appeared to have been excised.

William Pusey described the number of cases of skin cancers treated by the rays by 1904 as "a veritable torrent of literature." Kassabian listed numerous authors and their results in 1907, including his own minority opinion that surgery as an adjunct to radiation was unnecessary and could potentially diminish the healing effects of the rays. He conceded that there was little agreement on methods or results:

> Some prefer the soft and others the hard tube. Views also vary as to the duration of the seances and their frequency. It is asserted by some that a slight dermatitis is always to be aimed at, in order to obtain the proper action. The great variety of cases encountered will allow of no special technique; the peculiarities of the epithelioma themselves will frequently dictate the method to be pursued.

Using these many approaches, X rays had by 1907 been used to treat carcinoma of the orbit and eyelid, as well as "subdural nodular masses." Pusey presented a chart of sixty-nine patients treated for various forms of epithelioma, including history, record of treatment, outcome, and follow up. Most were listed as "well" after periods of eighteen to twenty-four months (Fig. 1.12).

Émile Grubbe stated that he had treated a woman for cancer of the breast in 1896. In 1897 Gocht in Germany reported two cases of inoperable breast cancer treat-

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*Fig. 1.12 Skin cancer treatment, around 1902. Note that the shielding is held in the patient's exposed hand. (Courtesy of the Center for the American History of Radiology, Reston, Va.)*
ed without beneficial results. George Hopkins in Philadelphia in 1901 treated two cases, one of which was deemed a cure. As with cutaneous involvements, treatments were usually given every two to four days until positive results were noted or "to the limit of the patient's tolerance." Kasabian detailed six cases, reporting that he had irradiated more cancers of the breast with varying outcomes, but "would report only on those cases which gave good results."

Pusey praised the cosmetic healing in patients who had appeared first with open cancers following mastectomies. Of one patient he said, "It seems hardly credible that this scar represents the site of the previous tumor mass" (Fig. 1.13). He also recorded the first treatment of a male patient with breast cancer. In summarizing his patients up to 1904, Pusey noted that eighteen of thirty-one breast cancer patients had died. Most had been referred as inoperable and with open, suppurating involvements. He accurately observed that the treatment prolonged life, added comfort, and provided relief from painful dressings. In a few cases it seemed to have effected a complete cure.

With improved and specialized treatment tubes, the rays were aimed at cancers of the larynx and esophagus and at cervical cancer. In 1902 Clarence E. Skinner began treating a patient for a large ovarian tumor. Over fifteen months she received 136 treatments and was pronounced cured by Skinner. Seven years later she was reported to have had no recurrence of the large mass, although she was bothered by a persistent and worsening X-ray burn over the exposed area.

Treatments of similar deep-seated cancers were reported with increasing frequency but inconsistent results. The equipment of the period was simply inadequate to heal effectively deep within the body without damaging healthy tissues. Many practitioners reported excellent results in the short term, but others were skeptical. Kasabian was direct:

I believe that in many instances, where brilliant results were achieved in irradiation of sarcomas, in all probability there was a mistake in diagnosis and a less malignant affection was present or else the operators were a little too enthusiastic when making their reports.

Most deserving of enthusiasm in the treatment of deep-seated disease were the initial attempts to improve the condition of patients with leukemia and pseudoleukemia (at the time synonymous with Hodgkin's disease). The latter had been considered uniformly fatal to children and adults who presented with the characteristic symptoms. In 1901 Pusey was the first to treat patients with Hodgkin's and reported two cases "symptomatically cured" at the meeting of the Chicago Medical Society in February 1902. His first patient, a four-year-old with extensive lymphatic involvement, had been discharged from the hospital as incurable (Fig. 1.14). Initial radiation therapy reduced the symptoms, which returned in six months. Again, the X rays diminished the swelling and improved the general clinical picture, but a few months later the child died "of inspiration pneumonia." Pusey considered this case a cure.

Nicholas Senn reported the treatment of two patients with positive results in 1904. It is noteworthy that all these early applications of the rays to deep-seated and
systemic cancers were extended over many days, sometimes into years, with acknowledgement of the possibility of future irradiations on recurrence. The term "therapy" was not lightly applied. This was a commitment for both practitioner and patient, sometimes for as many as one hundred return appointments and gradual improvement.

William Benham Snow described a typical series of treatments for Hodgkin's disease in 1903. Exposures were made with the tube at a distance of 12 to 20 inches, with a medium or high-vacuum tube "for its tonic effects on the structures." The patients were seen daily, with exposures made directly over the involved glands on alternate days from general irradiation of the trunk.

The beneficial results noted do not seem to have given way to immediate widespread use of the technique, perhaps because of the commitment of time and the relative paucity of cases of leukemias compared with cutaneous and site-specific lesions. In 1905 Joseph Glapp and Joseph Smith chaired a session on the treatment of Hodgkin's disease at the meeting of the Chicago Medical Society. Although Senn, Pusey, and others presented promising results, the ensuing discussion centered exclusively on the attending members' own experiences with the rays in dermatological disorders.

Not everyone was ready to see protracted X-ray treatments as beneficial in systemic illness, in part because of a fundamental misunderstanding of the disease process. The work of G. Arneth in Germany, as summarized by Kassabian, illustrated this difficulty. Arneth believed the rays did "not cure the lesion, but they destroyed the parasites which are the cause of the lesions." The action of the X-rays was like that of quinine in malaria, "curing the patient by killing off the microorganisms causing the trouble." This explanation and its implications for therapy were not likely to yield promising results, since the assumption was that the "parasites" could be killed off in short order.

The list of cancers treated by irradiation with beneficial results was long in 1910. But there remained little agreement on specific methods, few comparative or long-term follow-ups, and no satisfactory explanation for successes in some cases and failures in others.

**ANALGESIC AND PALLIATIVE APPLICATIONS**

Early in 1897 American medical journals carried tantalizing reports of Russian experiments concluding that X-rays had quieting effects on the central nervous system in frogs. Subsequent reports from Germany chronicled surprising success rates in treating "severe neuralgia" with just a few exposures to the rays. In the United States reports of successful treatment of skin lesions in lupus and other diseases were often accompanied with notations on diminution of pain. In one report submitted to the New York Academy of Medicine in 1902 the physician stated that he "had almost invariably noted cessation
of pain after the first treatment” of lupus with the X ray. In a survey of potential uses for radiation another physician wrote: “The most astonishing feature is that the X-ray possesses powerful analgesic properties, immediately relieving pain.”

The exact mechanism by which the rays appeared to relieve pain in surface lesions was the subject of some dispute. To the electrotherapists, who long had believed in the curative powers of applied current, the results seemed predictable. One electrotherapist even opined that “the relief of pain is due to the action of a high-tension current and connected in no way with the X- or cathode-rays.” Others ascribed pain relief to the effects of ozone produced by the generator or to the desiccating properties of the rays.

The positive results could not be denied. In Boston Seabury W. Allen chronicled the relief from pain experienced by patients treated with X rays for maladies ranging from chronic rheumatoid arthritis to suppurrating tubercular lesions. Among his notable results was a thirty-six year old woman with arthritis and severely limited flexion of the fingers. After two diagnostic X rays she reported that she had resumed playing the piano, with no pain. Another patient, aged twelve, suffering from what was described as “a painful bilateral tubercular sinus of the neck of one year’s duration” felt well enough after two irradiations to go home and throw snowballs. Allen theorized that “the nerve supply of the parts in question” held the answer to these “cures.” He noted particularly that the pain-relieving effects often occurred at a distance from the body parts exposed to the light but supplied by nerves which had been exposed. He concluded: “It seems reasonable to suspect that X rays may influence distant parts, either reflexly or through some electric phenomena along the course of the nerves.” This was precisely the kind of theory the electrotherapists found most appealing.

The same pain relief noted in benign skin conditions was observed very early in the treatment of cancer with the X ray. Several physicians cited the marked relief of pain as “usually the prompt result of the use of X rays in malignant neoplasms.”

After a survey of six case histories in 1902, one doctor noted that the X ray had “a very marked influence upon the pain of nearly all types of malignant tumors, causing entire relief in many cases.” The first application of the rays to malignancies were in surface lesions, where it was found that pain and discharge were substantially reduced. Soon the rays were applied to more deep-seated cancers. First on William Morton’s 1902 list of the ten beneficial properties of the X-ray in cancer was “relief from excruciating pain and constant suffering, often immediately.” In the same year the editor of the J.A.M.A. summarized the reports and views of many physicians:

In cancers en cuirasse where the chest was imprisoned as in a vise to the constant intense discomfort of the patient, relief was afforded almost immediately after exposure. In the extremely tender cancers of the breast in which often the weight of clothing becomes insupportable, the exaggerated sensitiveness can be made to disappear...It would seem, then, that the X-rays may be resorted to in all inoperable and painful cancers.

The key word in this assessment was “inoperable,” for physicians soon came to view the X ray as an analgesic of potentially limitless benefit to terminal cancer patients. One editor wrote: “Even if not curative the X rays have a very decided palliative effect in many cases, reducing discharge, destroying offensive odor, relieving pain, and generally rendering what remains of life more comfortable both to the patients and to those who have the care of them.” The X ray, another physician predicted, would enable the afflicted patient to “spend the last few days or months in comfort, compared to the untold suffering heretofore experienced with such growths.”

Moreover, the use of the X ray as a palliative in cancer promised to diminish the dual problem of patient addiction to and physician complicity in the overuse of morphine and other opiates. Several authors gratefully acknowledged that their patients could now spend “what remnant of life is left them in comfort and free from the effects of the continuous use of opium.” Another physician, in a series of case histories, noted that many patients he treated
for cancer of the breast came to him already using large doses of morphine, but "after a few irradiations," the opiates were no longer required.81 Perhaps the greatest attraction of the pain-killing effects of the X-ray for many practitioners was the seeming congruence with the first tenet of the Hippocratic oath: to do no harm. In detailing his own experience with treating several types of cancer, Pusey concluded that "as X-ray exposures may be given these patients without disturbing them or interfering with their comfort, there seems no reason why they should not have the benefit of the remotest chance of relief."82 Physicians with X-ray apparatus in their offices found themselves seeing more and more patients who had been rejected as inoperable by surgeons.83 Prolonged irradiation of the terminally ill was believed to be harmless to all involved—practitioners and patients—and besides relieving pain carried the possibility of improvement in the disease itself. Grubbe noted the beneficial tendency to "prolong life even in hopeless cases."84 At the turn of the century the X-ray was viewed as both a palliative and a last glimmer of hope for sufferers. A series of alarming discoveries and events would soon dim the general optimism and confidence in the "miraculous soothing rays."

"SOME UNTOWARD RESULTS"; X-RAY BURNS

Unusual effects on the skin and hair of practitioners and patients were noted almost immediately after X-rays came into wide use in the United States. Grubbe later reported that the first of his many overexposures came in the third week of January 1896, with painful lesions on one hand. In April John Daniel, a physicist at Vanderbilt, reported hair loss in a volunteer patient (the dean of the medical school) sitting for a radiograph.85 In July W. Marcus in Berlin published an account of a radiographer's public demonstration model, who had experienced "severe skin reactions," including epilation.86

By the fall reports of "X-ray burns" or roentgen dermatitis were common in medical journals and newspapers. Described as resembling "a severe sunburn, with the accompanying pain, swelling, blistering, and discoloration," most such burns were discounted as short-lived and the result of something other than the X-ray.87 At this distance the widespread reluctance to suspect the irradiation as the motive factor in these burns seems puzzling. But the notion that any substance, especially an invisible light, might cause this sort of destruction of skin and tissue was entirely foreign to medical thinking in the 1890s.88

Many observers were convinced that the burns were caused by ozone from the electrical apparatus or by sparks unnoticed in the excitement of the therapy setting. Others speculated that some persons were more susceptible to the effects of the rays, having "X-ray idiosyncrasies" rather like allergies. Still others believed the lesions were caused by uncustomed handling of photographic chemicals.89 Others witnessed that burns in some patients were the unavoidable results of the sufferers' "existing nervous and mental conditions."90

Careful workers with the new rays soon realized that the problem was more complex. Elihu Thomson at the Edison Laboratories reported distressing symptoms among X-ray workers there and even experimented on his own hands.91 William Rollins, with his brother-in-law and roentgen pioneer Francis Williams, observed a number of deleterious effects. Rollins provoked a torrent of disagreement in his blunt 1901 article "X-Light Kills."92

Many practitioners watched as what they had assumed to be temporary burns turn into chronic lesions. In late 1896 G. G. Skinner reported a painful roentgen dermatitis on his hand followed by complete desquamation. Five weeks later the stubborn lesion remained about two inches wide and three inches long (Fig. 1.15).93 At Johns Hopkins in 1897 T. Gilchrist reported at length on a case of roentgen dermatitis with unfamiliar characteristics and slow healing.94 Evidence was mounting, but for many practitioners word came too slowly and too late.

The case of Mihran Kasabian (1879–1910) provides an excellent look at the ways in which a full-time radiologist and radiotherapist perceived the dangers of X-rays in these earliest years. A medical doctor with an interest in electrotherapy,
Kassabian began work with the X ray around 1900, and was appointed director of the Roentgen Ray Laboratory of the Philadelphia General Hospital. Early photographs of Kassabian at work in radiography and radiotherapy reveal that, like most of his colleagues, he used little or no shielding. He experienced a series of mild sunburn-like erythemas on his hands and face, with some loss of hair. By 1904 he had noted "chronic dermatitis" with the "nails disfigured and deformed, and they never regained their normal appearance and condition. The skin of the hands remains tough and indurated, with the subsequent occurrence of atrophy." Kassabian documented the deteriorating condition of his hands from dermatitis to serial amputations in a number of photographs taken between 1906 and 1909 (Fig. 1.16).

He took a special interest in the explanations for these injuries offered by his colleagues, as well as their suggested treatments. In 1907 he published Röntgen Rays and Electrotherapeutics, which was widely read and respected. Here he listed the eight most popular explanations for the cause of X-ray burns, ranging from ultraviolet light to "the flight of minute platinum atoms." In his comprehensive survey of radiotherapists around the world Kassabian asked how his colleagues treated the roentgen dermatitis. Answers ranged from the smug ("Never had any case of dermatitis to treat") to the dismissive ("Treat as any other burn"). Kassabian applied salves of zinc and lanolin, took meticulous notes on his deteriorating condition, and died in 1910.

It had been clear for some time to many practitioners that the X-ray dermatitis was not just "any other burn." In 1902 G. S. Johnston followed up an earlier assertion that it was the rays themselves that caused damage with the observation that the "keratotic peaks" noticed on the hands of radiologists were actually "precancerous conditions prone to epithelialomatous change." Excision and inspection of one of the hard patches of skin revealed "an intense lymphocytosis with a proliferation of fibroblasts." The death of Edison's assistant Clarence Dally in 1904, after a gruesome series of amputations and other surgeries, made the public and the broader medical profession aware of the dangers of X rays. By this time many practitioners like Kassabian.
had already noticed alarming symptoms in themselves and their assistants.

Around the world physicians and pathologists looked more carefully at the action of the rays and were forced to conclude that the ray that could cure could also harm. Previous efforts at shielding patients and practitioners from X-ray "sunburn" now took on added significance. Shielded tubes, special filters, and massive screens were added. Determined, if largely ineffective, efforts were made to measure and regulate the amount of radiation given in each treatment. Kassabian recommended that radiation suites be constructed, where the physician worked in a room separated by lead walls from the patient and X-ray tube, monitoring the procedure by a series of wall-mounted mirrors (Fig. 1.17). 100

By 1910 the enthusiasm of the early years of empirical applications and unlooked-for successes had dimmed. Many of the pioneers were gone, still others ill, from a process they did not entirely understand. Still to come were mysterious and fatal leukemias and anemias associated with X-ray work. Those who took up the field of radiation therapy approached it with great caution, and a growing curiosity about the nature of the action of radiations in the body.

EXPLAINING THE RAYS: EARLY RESEARCH

The rays could heal and they could kill—but how? Many explanations were offered to explain the effects of radiation. Researchers looked for explanations inside and outside the body's cells. They looked in plants and single-celled animals. But as late as 1915 one specialist in the field admitted that "the mechanism by which the disturbances have been brought about remains unexplained." 101

Early experiments had been simple, training the rays on bacteria to determine "killing" effects and testing the susceptibilities of laboratory animals to varying amounts and exposures to X rays (Fig. 1.18). One of the first of these experimenters was the unfortunate professor who, in February 1896, believed he had raised a drowned lab rat from the dead by the force of X rays—certainly the ultimate therapeutic effect. 102 Most results were not so spectacular, and with wide variations in tubes, currents, and technique, such studies yielded few useful or replicable conclusions.

A number of early investigators in the United States and Europe looked at the effects of radiation on plants and on protozoa. In 1897 Lopriore noted the stimulating effects of short exposures on plant growth, while Schaudinn observed the destructive (coagulating) effects of larger amounts of radiation. 103, 104 Schaudinn also reported on a direct correlation between the amount of fluid in certain protozoa and their susceptibility to the rays. 105

In 1908 Albers-Schönberg in Germany and Bergonie and Tribondeau in France published reports indicating the spermici-
AN ORGANIZATION FOR RADIATION THERAPISTS?

Communication was important in a field where new discoveries seemed to be made every day, and one important venue for such exchanges of information was the medical specialty organization. The American Electrotherapeutic Association (AETA) had been founded in 1891 and included both marginal practitioners and medical luminaries. The AETA prided itself on an ecumenical outlook, including in its ranks a number of different medical specialties, including surgery, dermatology, psychiatry, dentistry, and others. The AETA embraced the therapeutic possibilities of the new ray, featuring lectures on the subject at its October 1896 meeting. Many Fellows of the association became prominent radiologists, while many who wished to work with the new rays sought to join the organization.

Some early specialists in radiation, however, found association with the electrotherapists to be less than desirable and felt that the new field of X rays warranted its own separate organization. The first meeting of the Roentgen Society of America (later the American Roentgen Ray Society [ARRS]) was held in December 1900. Over two thousand invitations to membership were sent out, and full status was accorded to anyone who was already a member of any other medical or scientific society. The official organ, the American X-Ray Journal, published numerous articles on X-ray therapy in its short existence, and the ARRS served early radiation therapists with information, collegiality, and a forum for discussion of new methods. In 1905, however, the ARRS dropped seventy-five members whose credentials were considered "dubious." Many of these were members of the AETA without legitimate training, but who had incorporated the use of X rays into their therapeutic practices.

To modern eyes, there seems to have been a substantial portion of journal space (in the American Journal of Roentgenology), meeting time, and committee activity devoted to radiation therapy topics within the ARRS after 1905. But the few physicians who practiced radiation therapy exclusively and those in whose work it played a major role sometimes felt as though they had been "tarred by the brush of the ejected members." With the rise in radium therapy and the creation of a domestic American radium product after 1914, a few practitioners and sponsors felt the time was right for an organization devoted to healing with radiation.

On 22 June 1916 during the annual meeting of the American Medical Association, a group of physicians met in Detroit and agreed to found a society in which workers from different disciplines would exchange experiences and contribute to the advancement of the therapeutic uses of radium. The American Radium Society was formally organized in October 1916, dedicated to the promotion of the scientific study of radium, its physical properties, and its therapeutic applications. Members included surgeons, radiologists, gynecologists, physicists, and a few manufacturers of radium. The ARS was a model of interdisciplinary collaboration, and the scientific sessions included groundbreaking clinical reports each year, often including studies in X-ray therapy as well. The ARS would take an active stance on behalf of radiation therapists on legislative and regulatory issues, and its committees would serve as reference points on practice and ethical issues. Radiation therapists would enter the post-World War I medical world with a strong and purposeful organization acting on their behalf, although they were joined in this organization by many other specialists. The small numbers of radiation therapists could not have supported a separate organization in these years and would not for many years to come.
dal properties of the X ray and radium, as well as the ability to induce sterility with the
rays. This focused additional interest on the action of the rays on dividing cells
and on embryos. Perthes's work with ascaris eggs and the revelation by Regaud and
Blanc that the mitotic phase of the cell was the point of lesser resistance to radiation
were widely reviewed in the United States literature. Some authors speculated
on the meaning this held for the offspring of radiologists, as well as the welfare of their
patients. With the publication of their widely accepted law in 1906, Tribondeau
and Bergonie sought to draw conclusions from the disparate findings of many
researchers in the field: "The effects of irradiation on the cells are more intense
the greater their [the cells'] reproductive activity; the longer their mitotic phases, and the
less their morphology and functions are established." Some observers immediately
pointed out inconsistencies in observed research results and the law, but in a field
where there were few dependable rules and nothing was ever quite predictable,
Tribondeau and Bergonie had provided substantial comfort, however flawed, to
many theorists.

In Baltimore Gilman and Baetjer studied the effects of X rays on development in
fertilized hens' eggs. Still other researchers looked at the systemic effects of
the rays. Heineke observed extensive effects on the lymphoid tissues of rabbits and
guinea pigs and was first to note the rapid depletion of irradiated bone marrow.

It was clear by 1910 that radiation had a retarding effect on growth in some organisms
and a deadly action in others, that cell division and maturity were crucial factors in
determining these effects, and that sensitivity to radiation varied widely. This was of
little help in explaining the mysterious healing powers of the rays. In fact, little of
the research fit at all into the largely empirical picture of radiation therapy in the period.
The competing theories of Schwartz, Hertwig, and Packard, involving foci as
diverse as lecinthin, chromatín, and enzymes, did little to affect daily work with patients in
the years that followed before the first World War. In fact, Hugo de Vries, noted
botanist and biologist, in 1913 summarized results thus far and recommended only one
possible concrete application: "...we may hope some day to apply the physiological
activity of the rays of Roentgen and Curie to experimental morphology." His ideas
about "experimental evolution" would have given even the most adventuresome radiation
therapist pause.

**CONCLUSION**

By 1910 many of the growing number of American roentgenologists included some
form of radiation therapy in their practices. All looked with a mixture of fear and awe at
the range of results occasioned by their work with the "healing rays." Some limitations
had been admitted, while new applications and techniques were explored. With fewer
untrained practitioners in the field, public confidence in radiation therapy was on the
rise. Better apparatus, greater protection, and the introduction of filtration had
improved the clinical picture. Radium would soon be more readily available from
domestic sources.

Obstacles to immediate progress remained formidable. The handful of
physicians practicing radiotherapy exclusively did not promise soon to constitute a
bona fide medical profession. Biological concepts on the action of the rays could
provide no consistent explanation of their action which could readily be translated
into technique. Dosage remained difficult to control and virtually impossible to com-
pare from clinic to clinic or treatment to treatment. But the hope that radiation
therapy held out to sufferers was too great to ignore. Addressing the American
Roentgen Ray Society in 1915, President Alfred Gray said, "Today, not withstanding the
limitations, the roentgen rays have an established field in the treatment of dis-
case that few, if any, other known agent may enter." The X ray had proven a
"light in dark places," offering hope and the promise of cures where there previously had been none.
REFERENCES


9. In New York and Chicago a number of respected physicians, among them William Morton, George Beard, and Margaret Cleaves, had adopted electrotherapy as a standard treatment for any number of illnesses and had static machines installed in hospitals and clinics.

10. The range of illnesses and conditions (presumed and real) at which electrostatic energy was aimed are included in numerous textbooks from the period and in the records of the American Electrotherapeutic Association. One title will suffice to indicate the range of diseases treated. In 1899 William J. Morton published "Electrostatic Currents and the Cure of Locomotor Ataxia, Rheumatoid Arthritis, Neuritis, Migraine, Incontinence of Urine, Sexual Impotence and Uterine Fibroids," Medical Record 55 (1889):849-859.


12. Among those opening X-ray laboratories were W.C. Fuchs in Chicago, M.E. Parberry in St. Louis, Heber Roberts also in St. Louis, and Samuel Morell in New York. Typically these laboratories were located near (but not in) hospitals, and the patient, whatever his or her condition, was brought out of the hospital for the X-ray examination or treatment.

13. Grubbé would give this explanation as would countless others. The defect in the argument was that they had previously used electricity for the same ailments without similar rationalizes.


17. See, for example, the detailed instructions which appeared throughout January and February 1896 in the New York Times. So easy to follow were these directions that, among other groups of hobbyists, a Brooklyn X-Ray Boys' Club was founded for amateur experimentation.


19. Ibid., p. 52.

20. Around 1900 Grubbé began to argue at local and national medical meetings that he, and not fellow-Chicagoan Harry Pratt, had pioneered radiation therapy, but it was not until the 1930s that Grubbé began to push his case in the literature.


22. Ironically, FBI analysis would lead to the destruction of these notes. The corrosive chemical used for dating darkened and crumpled both slips so that they are today almost illegible. They can be found in the Medical Sciences Collection, National Museum of American History, at the Smithsonian Institution. It should also be noted that proving that the paper and ink were of the right age is not entirely convincing to anyone who has noted that in Grubbé's own collections at the Center for the American History of Radiology he saved every piece of scrap paper, bill, napkin, matchbook, wrapper, and other paper product that came his way during his long life. Had he chosen to postdate the referrals he would have had no problem coming up with paper from 1896.

In 1986 the authors arranged through the good offices of Mr. Michael Fish to visit the suburban warehouses where older Cook County death certificates are stored and catalogued in large volumes. Every death certificate for 1896 and 1897 was read.

Hodges, Paul; Emil Grubbé (Chicago: Univ. of Chicago Press, 1956).

Taped Interview, Paul Hodges to Nancy Knight, through Lloyd Havas, 15 July 1983.

Grubbé, X-Ray Treatment, p. 52.


Jones, Philip Mill, J.A.M.A. (1900); and Freund and Schiff, Archiv fur Derm. und Syph. 42 (1898).


This is only a sampling of the types of cases listed by Pusey and Caldwell as "tubercular" and amenable to radiation therapy.


These cases are summarized in the textbooks of the period, many with serial photographs of treatment over time. Surgical intervention for breast cancer was not the norm. In fact, most patients at the turn of the century reported only after the cancers had become inoperable.


Pusey and Caldwell, p. 440.

Kassabian, p. 460.

Ibid., p. 463.

Pusey and Caldwell, p. 459.

Ibid., pp. 500-509.


Kassabian, p. 465.

Pusey and Caldwell, p. 531.

Ibid., p. 540.

Ibid., p. 552.

Ibid., p. 552.


Kassabian, p. 476.

Pusey, p. 628.

Pusey, pp. 629-631.


Kassabian, p. 486.


81 Varney, "Results.
83 Pusey, "Cases of Sarcoma."
84 Grubhè, É., "X-Rays in Cancer," Medical Record 62 (1902).
88 Although there had been several reports linking testicular cancer to the profession of chimney cleaners and thereby to carbon in soot, most nineteenth-century physicians would have balked at the idea that cancer could be caused by contact with substances outside the body.
95 Photographs of Kassabian at work in his Philadelphia laboratory have been widely published and are on file at the Center for the American History of Radiology in Reston, Virginia.
97 ibid., p. 398.
98 The unnumbered appendices of Kassabian's books provide a wealth of information on the manner, extent, and technique of practice by one of the world's foremost radiotherapists in 1907. The questionnaire was detailed and the responses show a remarkable range of practice and disagreement on the manner in which the X-ray should be applied.
100 Kassabian, Röntgen Rays, p. 408.
104 There was a brief period of excitement in Europe when it was believed that the X-ray might cause a form of "perpetual youth" in plants, and by extension, humans. Radium revived this interest; see "Radium and Longevity," J.A.M.A. 43 (1904):617.
110 Kassabian noted in his textbook that despite growing research that might indicate otherwise, he personally knew six men active in radiology who had fathered healthy children in 1906 and 1907, see Kassabian, p. 414. Such small sample optimism would not last long; later studies would reveal that many early radiologists were receiving sterilizing doses of the rays.
115 These competing theories were summarized in Richards, "Biological Explanations," pp. 908-909.