

active bandages, radium compresses and pads, radium insoles (footpads), radium bath tablets, radium eczema cremes (an ointment known as Thorium-X, for example), and radium needle implants. Inhalation therapies were designed to mimic the vapors of radioactive baths, and radioactive tonics were sold along with mesothorium-impregnated milk sugar and even radium-infused chocolate. Radium cures were provided to treat infections, rheumatism, and neuralgia, but also hormonal disorders such as premature aging, arteriosclerosis, hypertension, and diverse nervous disorders, real and imagined ("paralysis agitans," for instance).⁷⁵

Opinions often differed concerning the optimal dose for such treatments, but by modern standards we are talking about extraordinary exposures. A Prof. Friedrich Gudzent of Berlin administered daily doses of up to 100,000 ME of radium (about 3,640 picocuries in the system of reckoning Americans use today) in his "drink cures," while the Viennese radiologist Leopold Freund advised up to 300,000 ME (more than 10,000 picocuries).^{*} Radium compresses involved placing 2–12 micrograms of radium directly onto the area of skin to be treated, and the intramuscular or intravenous injections recommended by Dr. Gudzent were in the neighborhood of 1–5 micrograms of radium every three days for total dosages of up to 100 micrograms.⁷⁶ A fatal dose of ingested or injected radium was commonly believed to be in the range of 100 to 500 micrograms, though there was also evidence from the U.S. dial painters that some of the women showing a bodily contamination of only 1–2 micrograms were experiencing symptoms

* A curie is the quantity of radiation emitted by a gram of pure radium, and a picocurie is a trillionth of a curie. American environmental agencies today measure indoor radon in terms of "picocuries per liter" (pCi/l); one pCi/l means that there are about two radioactive disintegrations of radon 222 for each liter of air every minute. The unit most commonly used in Germany in the 1920s and 1930s was the "Mache-Einheit" (ME), a unit equal in present-day American terminology to 364 picocuries. The unit more commonly used today in international scientific literature is becquerels/m³, where 1 becquerel corresponds to one decay event per second (1 pCi/l = 37 Bq/m³). Picocuries and becquerels are both measures of decay events per unit time; the biological effect of a given dose, however, depends to a great extent on the specific isotopes to which one is exposed and the route of exposure (ingestion, inhalation, etc.).

of radiation poisoning. We now know, it should be pointed out, that fatal cancers can be produced by even tinier doses.

One reason medical professionals may have been slow to appreciate the hazards of radioactivity is that German spas were heavily invested in promoting the curative virtues of radiation. Therapeutic baths were a vital part of the upper-middle-class conception of healing in the 1920s and 1930s (Thomas Mann's *Magic Mountain* captures some of this ethos), and the discovery of "radioactive emanation" in the water of many of these spas led to a belief that radon must be the active ingredient. Millions of Germans traveled to the radioactive spas of Kreuznach, Gastein, and Oberschlema in the first half of the twentieth century, hoping to be revitalized by the experience. (Some of these are still open today, with just as much radon to inhale.)

Enthusiasm for spa cures continued in the Nazi era, urged on as part of the romantic push for natural forms of healing. In 1934, the German Society for Spa- and Climate Healing (Deutsche Gesellschaft für Bäder- und Klimaheilkunde) launched an academic journal, *Der Balneologe*, to boost the baths. Different approaches to water therapy were reviewed—the Finnish practice of throwing water on granite to produce radon in sauna steam, for example—along with ads for healing centers like the Radiumbad St. Joachimsthal, promising help for arteriosclerosis, rheumatism, and gout.⁷⁷ Several of Germany's most famous spas had extremely high levels of radioactivity—like Oberschlema, with a radioactivity of five million picocuries per liter.⁷⁸

Today, when we try to understand why it took so long for radioactive hazards to be taken seriously, it is worth recalling that radium, along with its "emanation," was widely regarded as the health-giving ingredient in mountain springs and spas. Even some of the industry's sharpest critics were seduced by the radiant atom. In 1932, for example, Erich Marx, a Leipzig professor of radio-physics, published an essay on "the radium danger in Germany" in a Viennese daily, cautioning that radium and radon gas could kill. Marx was aware that radon and its daughter products were responsible for the bronchial tumors contracted by Joachimsthal miners, that radium mimicked calcium in the body, and that