

way, he accumulated information that would provide easy identification of the disease from its symptoms. As a result of this clarification of the picture, it became evident that deaths of workers at least as early as 1922 had been the result of radium poisoning, although attributed by family physicians to other diseases. It is estimated that eventually at least 40 persons died from this disease.

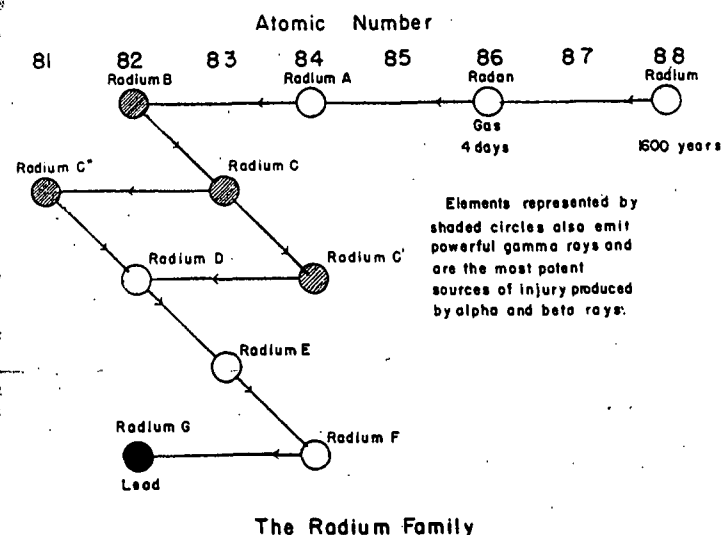
It is of interest to consider the general environment under which these tragic circumstances developed. In the period of World War I and immediately thereafter, about 800 girls, at one time or another, were employed in one plant in New Jersey as radium dial painters. There were other smaller plants in and around New York City. The considerable demand for radium dials for military use caused this rapid expansion of a very small industry, and employees were recruited from other types of work where similar skills were required. Usually they were paid in accordance with the number of articles completed per day and were not warned of any particular hazard, since the dangers from the ingestion of radium were not then understood. Consequently, they adopted procedures that would enable them to produce acceptable work at the most rapid rate. Many of these people had applied other types of paint, in previous employment, which were not sufficiently toxic to produce any ill effects. The fine brushes were pointed by means of the lips. They soon discovered that this was a very effective procedure in radium dial painting. Since the paint consisted chiefly of zinc sulfide suspended in a water solution of gum arabic, occasionally thinned with water to give proper consistency, there was no natural deterrent to the procedure. The amount of radium that a dial painter might ingest under these circumstances has been estimated at from 15 to 200 micrograms per week. This explains in a few words how the situation developed. Early in the investigation, the employers sensed that radium poisoning might be the cause of the deaths and injuries, which were rapidly mounting, and ordered the practice of tipping brushes with the lips discontinued. However, such a regulation was difficult to enforce, and it was not until the advent of plastic adhesives with organic solvents of disagreeable taste and odor that the practice was entirely eliminated.

Although it has been well established that the practice of pointing the brushes with the lips was the predominant cause of the injuries, there are alive today, in apparent good health, workers who used this method for a number of years. This fact is mentioned to show that part of the confusion in arriving at a solution of the problem arose from individual differences among the employees. Those who survived apparently developed a method of pointing the brushes that did not result in ingestion of appreciable amounts of paint; others were more careless in this respect.

2. Radioactive Nature of Radium

Radium is always accompanied by its decay products in amounts dependent on a number of conditions associated with the previous chemical history of the

preparation. The properties of a sample of radium in equilibrium with its decay products will be more readily understood by reference to Figure 3, which shows the genetic relationships in the radium family. We see that the immediate product of radium is a gas, radon, which decays to half-value every 4 days after removal from the source of supply, radium. This transformation is accompanied by the emission of an alpha particle for each atom transformed. By emission of another alpha particle, radon becomes RaA, which in the same way transforms into RaB. RaB changes to RaC by emitting a beta particle. Here, a branching occurs that leads to RaD, which by emitting a beta particle becomes RaE, and this



The Radium Family

Figure 3. The genetic relation of various products originating from the transformation of radium. Heavy black arrows pointed horizontally to the left represent the emission of alpha rays. Diagonal arrows to the right represent the emission of beta rays. Cross-hatched circles represent members that emit strong penetrating gamma rays.

substance in the same way transforms into RaF (polonium). By emitting an alpha particle, RaF becomes RaG, an inactive isotope of lead. The cross-hatched circles represent elements that emit the more powerful gamma rays associated with radium. Thus we can see that radon, even after removal from radium, will have associated with it the products emitting the more powerful radiations capable of producing injury. The quantitative relation between the radon generated in a given time and the amount of the parent radium can be used to measure the amount of radium present by measuring the rate of production of radon.