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The Flash of Genius, 12

Radioactive Tracers: George de Hevesy

A failure in a laboratory project—a failure to separate radium-D from lead—started George de Hevesy on a long productive series of researches on radioactive tracers. This was the road to the use of radium D, now known to be the radioactive isotope ^{210}Pb, as a "tracer" in reactions involving lead.

Dr. Hevesy is credited with being the first to apply both natural and artificial isotopes as tracers in studies of plants and animals. He pioneered in the use of radioactive tracer techniques in chemistry, biology, and medicine. For this work he received the Nobel Prize in 1943 and the Atoms for Peace Award in 1959. Dr. Hevesy tells his story as follows:[1]

"Ernest (later Lord) Rutherford, then in Manchester, simultaneously with the discovery of the nucleus of the atom and the study of its properties, was interested in other investigations. Among those investigations was a study of the velocity and absorption of β-particles. Radium D emits very soft β-rays, and the investigation of the properties of the latter required a strong preparation of the radioactive material. Rutherford's institute had appreciable amounts of radium D at their disposal; however, it was mixed with large amounts of lead. A few hundred kilograms of lead chloride containing appreciable amounts of radium D obtained from pitchblend were presented to Rutherford by the Austrian Government which at that time, owned the only uranium mine—Joachimsthal in Bohemia.

"The lead chloride was stored in the cellar of the institute. One day when I met Rutherford in the cellar, he suggested that if I were worth my salt, I should separate radium D from all that nuisance of lead. Being a young man, I was an optimist and fully convinced that I would succeed; but even though I worked very hard for a year, trying a large number of separations, I failed entirely. To make the best of this depressing situation, I decided to make use of the inseparability of radium D from lead. By adding pure radium D of known activity to 1 mg of lead nitrate, the lead present in that compound could be labeled, and its path followed through chemical reactions with the aid of radioactive measurements.

"In 1912, I was spending Christmas at my parent's home in Budapest. I wrote to Dr. Paneth, then an assistant at the Vienna Institute of Radium Research, whom I had met a few weeks earlier when visiting there. I proposed to him that we jointly determine the solubility of sparingly soluble lead sulfides and lead chromates by labeling them with radium D which was available in large amounts and pure condition at the Vienna Institute. The radon formed by decay of radium was pumped off each week, the radium D in turn was available as a decay product of this radon.

"We started our joint investigations with Paneth early in January, 1913, followed by other applications of labeled lead and labeled bismuth in problems of inorganic and electrochemistry. Our first paper was published in 1913 in *Zeitschrift für anorganische Chemie*.[2]

"In the following decade radioactive indicators found application only in the field of inorganic and physical chemistry. Only lead, bismuth, radium, actinium, and thorium could be labeled.

"In 1923, while engaged in the study of the properties on the newly discovered element hafnium at Niels Bohr's Institute in Copenhagen, I got interested in problems of batanica and studied the transportation of lead in bean seedlings using thorium B labeled lead salts. The results of these investigations were published in the *Biochemical Journal* in 1923.[3]

"Dermatologists were interested in those days in replacing arsenic by bismuth in the therapy of syphilis, and my friend the dermatologist Lomholt asked me to advise him in the study of the distribution of bismuth in the animal organism. I suggested using radium E labeled bismuth. The results of investigations of the distribution of labeled bismuth and labeled lead in the rabbit carried out by Christiansen, Lomholt and myself were published in the *Proceedings of the Paris Academy of Sciences* in 1924.

"In April, 1913, after terminating our investigations with Paneth in Vienna, I was indulging in a cup of tea in the Rutherford Institute in the company of Moseley, the founder of X-ray spectroscopy. I happened to mention that I would be much interested in following the path of water molecules contained in the cup of tea through my body. Moseley, a man of great vision, considered my wish to be much too exacting. However, before two decades elapsed, Urey's discovery of heavy water made it possible to label water and to follow the path of labeled water.

"Shortly after his discovery Urey most kindly supplied me with a few liters of labeled water. His water contained $^1/_2$ p.c. of heavy water, which however sufficed to study the interchange of water molecules of the goldfish and those of the surrounding water and to determine the water content of the human body and the mean life time of the water molecules of the latter.

"The availability of concentrated heavy hydrogen made possible the demonstration of the dynamic nature of numerous body constituents by Schonheimer and Rittenberg. These workers applied another stable tracer ^{13}N in their most important studies. Concentrated ^{15}N, ^{13}C, and ^{18}O became available through Urey's work.

"The above mentioned stable isotopes appreciably

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[1] Hevesy, G., Personal Communication.

[2] Hevesy, G., *Zeit. fur Anorg. Chem.*, **82**, 223–8, 1913.

[3] Hevesy, G., *Biochemical Journal*, **17**, 439–45 (1923).

increased the number of tracers. The greatest progress was, however, due to the availability of radioactive isotopes of almost every element following the discovery of artificial radioactivity by Frédéric and Iréne Curie Joliot. Shortly after this discovery we applied radioactive phosphorus prepared by irradiating 10 liters of carbon disulfide with neutrons emitted by mixtures of radium and beryllium. In the first study it was demonstrated that about $^1/_3$ of the mineral constituents of the skeleton is constantly renewed. This investigation was followed by the study of renewal rate of phosphatides and carbohydrates and the formation rate of desoxyribonucleic acid and how this formation is influenced by irradiation with Roentgen rays using radioactive phosphorus as a tracer.

"While many of these studies could be carried out with radioactive phosphorus of very modest activity that could be produced by the action of our neutron sources on carbon disulfide—these sources were sufficient for our clinical blood volume measurements, when trying to trace the origin of the constituents of milk, this was no longer the case. In the experiments, goats were to be injected with radioactive phosphorus (made available through the generosity of Ernest Lawrence). The availability of the cyclotron-produced radioactive bodies was an immense advance in the application of tracers. Our tracers were prepared by Martin Kamen and mailed to us in airmail letters. Today such a procedure would not be permissible, but the mailed samples did hardly any harm to humans, and presumably, not even to simultaneously traveling photographic film."