The active phosphorus content of the urine and faeces shows great fluctuations during the first few days after the intake of the preparation. Later, it becomes fairly constant; and we have obviously to deal with the excretion of phosphorus which has already been deposited for a while in the skeleton, the muscles, or other organs, and which has been displaced again. From our experiments, it follows that the average time which a phosphorus atom thus spends in the organism of a normally fed rat is about two months. This is also supported by the fact that rats killed about a month after the intake of phosphorus contain only about half the active phosphorus found in those killed after a week's time. This result strongly supports the view that the formation of the bones is a dynamic process, the bone continuously taking up phosphorus atoms which are partly or wholly lost again, and are replaced by other phosphorus atoms. In the case of an adult rat, about 30 per cent of the phosphorus atoms deposited in the skeleton were removed in the course of twenty days.

In another set of experiments we investigated the different parts of the skeleton. No conspicuous differences in the active phosphorus content could be found, with the exception of the teeth. The front teeth, which grow rapidly in rats, contained a larger part of the 2 mgm. phosphorus taken than the average of the whole skeleton, the ratio being about 10:1 in the case of adult and 6:1 in that of half-adult rats, whereas the molar teeth took up less than the average per gram of the skeleton, the ratio being 1:2 in the most extreme case. A detailed account of these and further results will be published elsewhere.

We wish to express our thanks to Prof. Niels Bohr for the kind interest he has taken in this work. For the preparation of the radioactive sources, and helpful assistance in making the measurements, we would also like to thank Mr. J. Ambrosen and Mr. S. Høffer-Jensen.

O. CHIEVITZ
G. HEVESY
Finsen Hospital and
Institute of Theoretical Physics
Copenhagen
Sept. 13, 1935

## COMMENTARY BY WILLIAM G. MYERS

*Historian, The Society of Nuclear Medicine*
*Ohio State University Hospital, Columbus, Ohio*

Professor Hevesy kindly paused sufficiently long for me to make the photograph on the right when Doctor Paul C. Aebersold and I visited his laboratory in Stockholm in August 1950. He had been awarded the Nobel Prize for Chemistry 7 years before, in 1943 (*2*). This was just 30 years after Fritz Paneth and he published an account of their first use of a naturally occurring radionuclide, 21-year $^{210}$Pb (Ra D), as a radioindicator in chemistry (*3*). Ten years later, in 1923, Hevesy was first to use 10.6-hr $^{212}$Pb (Th B) as a radioindicator in studies in plants (*4*). And the following year he collaborated in the initial uses of radioindicators in animals with 5-day $^{210}$Bi (Ra E), as well as $^{210}$Pb again. Thus, Hevesy was well prepared promptly to embrace the opportunities provided by the discoveries of radioindicators of many physiologic elements that soon followed the announcement of artificial radioactivity in Paris in 1934 (*5*).

GEORG CHARLES DE HEVESY

He related to Aebersold and me how the $^{32}$P was generated for these studies, carried out with Chievitz in Copenhagen the following year. Apparently, the $\alpha$-particles emitted by 3.8-day $^{222}$Rn (harvested from about 100 mg of $^{226}Ra$ loaned by Professor Niels Bohr) impinged on powdered beryllium to produce neutrons (*6*). This source of neutrons, many of which had high energies, was immersed in several liters of carbon disulfide for a few weeks (*6–8*). Transmutation occurred in the $^{32}_{16}S(n,p)^{32}_{15}P$ nuclear reaction (*6*) to yield at most only a few microcuries of $^{32}P$ having high specific activity. Evaporation subsequently of the carbon disulfide (*7,8*), followed by chemical conversion of the residue to phosphate, yielded the desired $^{32}P$-phosphate.

A solution of this tracer phosphate was evaporated on bits of bread (*7,8*) which then were fed to rats. The radioactivities of samples of various tissues, urine, and feces were determined with a G–M tube as a function of time after feeding.

Particularly notable among the findings reported in this first study with a man-made radioindicator in biomedicine is the discovery of the dynamic state of the body constituents: *"This result strongly supports the view that the formation of the bones is a dynamic process, the bone continuously taking up phosphorus atoms which are partly or wholly lost again, and are replaced by other phosphorus atoms. . . ."* [my italics].

Professor Hevesy indicated to Doctor Aebersold and me his gratitude to Professor Ernest Lawrence for supplying him soon thereafter with thousandfold greater amounts of $^{32}P$ which had been generated in the 37-in. cyclotron in Berkeley by Aebersold, and which Hevesy received in the mail! This permitted extension of the radioindicator studies not only in animals, but to man as well (*7,8*).

Few men have influenced my thinking and ways of teaching as did Hevesy. His laboratory in Stockholm was about 4 × 6 m at most. He used the clock on the wall for timing the discharge rates of his gold-leaf electroscopes, which he constructed himself. He seemed to regard with some concern because of its complexity a scale-of-eight circuit which had been a gift from a friend, but which he had not yet taken time to master.

Among the many treasures Hevesy sent me were several letters which either were handwritten or were typewritten by him. And these were sent many years after he became a Nobel Laureate! Humility characterized the man and simplicity was his watchword. His intellectual and innovative prowess, reflected in one hundred of his publications collected in two volumes totaling 1,047 pages (*8*), is his enduring monument.

## REFERENCES


*1.* CHIEVITZ O, HEVESY G: Radioactive indicators in the study of phosphorus metabolism in rats. *Nature* 136: 754–755, 1935

*2.* HEVESY G: Some applications of isotopic indicators. In *Les Prix Nobel en 1940–1944*, Stockholm, Norstedt & Söner, 1946, pp 95–127

*3.* PANETH F, HEVESY G: Über Radioelemente als Indikatoren in der analytischen Chemie. *Monatsh Chem* 34: 1401–1407, 1913

*4.* HEVESY G: The absorption and translocation of lead by plants. A contribution to the application of the method of radioactive indicators in the investigation of the change of substance in plants. *Biochem J* 17: 439–445, 1923

*5.* JOLIOT F, CURIE I: Artificial production of a new kind of radio-element. *Nature* 133: 201, 1934

*6.* HEVESY G: *Radioactive Indicators*, 556 pp, New York, Interscience Publishers, 1949, p 2

*7.* CHIEVITZ O, HEVESY G: Studies on the metabolism of phosphorus in animals. *Kgl Danske Videnskabernes Selskab. Biologiske Meddelelser* 13: 9–33, 1937

*8.* HEVESY G: In *Adventures in Radioisotope Research*, New York, Pergamon Press, 1962, pp 152–167


For reprints contact: William G. Myers, Ohio State University Hospital, 410 West Tenth Ave., Columbus, Ohio 43210.