There was, however, one person who didn't believe that these discoveries were transuranium elements. In 1934, Ida Noddack wrote a paper asking if these observations could not be due to isotopes in the middle of the periodic table (4). Fermi had not proved that the decay products were transuranium elements. Even then, however, we didn't see the light. This paper was in the literature from the beginning, and was ignored.

Early in 1939, Hahn and Strassmann described experiments that confirmed that they had observed radioactive barium and lanthanum isotopes as a result of the bombardment of uranium with neutrons (5). Hahn and Strassmann were absolutely nonplussed by their results, and the tone of that 1939 paper was more or less along the lines of : "You're not going to believe this, but this is what we found--actually, when you bombard uranium with neutrons, you get barium." Subsequent work showed that the other radioactivities previously ascribed to transuranium elements are actually also due to uranium fission products.

I remember when this news came to Berkeley. It was reported at what was called the Journal Club in the Physics Department, a meeting I attended every Monday night. Somebody got up and said, "You know, all of these transuranium elements that Hahn and Strassmann have been finding are due to the splitting of uranium in half. . ." Before he had finished the sentence, I said to myself, "My God, how stupid we have been! Obviously, that should be the explanation."

First Transuranium Elements, Neptunium (93) and Plutonium (94)

With those radioactivities identified as fission products, there were no longer any transuranium elements left. However, in later investigations by Edwin M. McMillan (6) at Berkeley and others elsewhere, one of the radioactivities behaved differently from the others. The beta radioactivity with a half-life of about 2 days did not separate by recoil from thin layers of uranium, as did the energetic fission products, when uranium was bombarded with slow neutrons. Along toward the spring of 1940, McMillan began to come to the conclusion that the 2.3-day activity might actually be due to the daughter of the 23-minute uranium-239 and thus might indeed be an isotope of element 93 with the mass number 239 (93-239). Phil Abelson joined him in this work in the spring of 1940, and together they were able to chemically separate and identify and thus discover (1) element 93 (Figure 2) formed in the following reaction sequences:

$$^{238}_{92}U + ^{1}_{0}n \rightarrow + ^{239}_{92}U + \gamma$$

$$^{239}_{92}U \xrightarrow[t_{1/2} = 23.5\ min]{\beta^-} {}^{239}93 \xrightarrow[t_{1/2} = 2.36\ d]{\beta^-}$$