Dear Phunday Physics Phans,

Thanks very much in advance for reading my paper. This is the beginning of my dissertation project, so it's at a very preliminary stage and any and all comments will be much appreciated. I'm especially interested in hearing your reactions to the arguments suggested below and where you think I can go with them. Also, I'm still trying to figure out how to narrate the events leading up to the announcement of fission's discovery in a manger that is both historically good and interesting to read, so any advice you have about that would be very helpful as well.

All best,
Jeris

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## Fission and Physics Before the Bomb

In the historiography the discovery of fission is almost always discussed in the context of the atomic bomb. Rather than viewed as an important discovery in its own right, fission is seen simply as one more step on the path to the atomic bomb. It is treated in this way not only in the more popular works such as Richard Rhodes' *The Making of the Atomic Bomb*,[1] but even in more scholarly works, such as the promisingly but misleadingly titled "Nuclear Fission: Reaction to the Discovery in 1939," by Lawrence Badash, Elizabeth Hodes, and Adolph Tiddens,[2] which likewise puts fission in the context of and subordinate to the bomb. However, both scientists and the public had ideas of and about fission in the years following its discovery in 1938 and before the explosion of the first atomic bomb in 1945. In this paper I will explore these ideas and what they imply about the distinction between the disciplines of chemistry and physics in the early twentieth century. First, though, I will introduce fission itself.

In the last decade of the nineteenth century Marie Curie discovered radioactivity, prompting a flurry of scientific research on that topic all over Europe and America. In 1934 this included Irène Curie and Frédéric Joliot's exposing of aluminum to polonium (a radioactive element that emits alpha particles). Curie and Joliot realized that even after they removed the polonium the aluminum remained radioactive.[3] This discovery (of artificial radiation, for which Curie and Joliot would win the 1935 Nobel Prize in Chemistry) in turn led many other European and American scientists' to expose their own non-radioactive elements to radioactivity.

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[1] Similar teleological accounts include Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission* (New York: Van Nostrand Reinhold, 1971), William L. Laurence, *Men and Atoms: The Discovery, the Uses and the Future of Atomic Energy* (New York: Simon and Schuster, 1959), and William E. Stephens, ed., *Nuclear Fission and Atomic Energy* (Lancaster, PA: The Science Press, 1948).
[2] Lawrence Badash, Elizabeth Hodes and Adolph Tiddens, "Nuclear Fission: Reaction to the Discovery in 1939," *Proceedings of the American Philosophical Society* 130 (1986): 196-231,
[3] I. Curie and F. Joliot, "Un nouveau type de radioactivité," *Comptes Rendus* 198 (1934): 254-256.

One such scientist was Enrico Fermi, who in 1934 began exposing every element he could find to a beryllium-radon mixture (a source of neutrons, themselves discovered only a few years earlier). Fermi reasoned that neutrons might be better at altering the nuclear structure of atoms because, being electrically neutral, the neutrons would not be repelled by the positive nucleus. Fermi found that of the elements that became artificially radioactive, lighter elements tended to become lighter (by emitting alpha particles and transmuting into elements two protons lighter), and heavy elements tended become heavier (by emitting beta particles and transmuting into elements one proton heavier). None of the elements changed into elements more than one or two spaces away on the periodic table.[4] Contemporary experiment and theory supported the belief that this was the extent of radioactive transmutation: experimentally no element had been known to decay by jumps of more than one or two spaces on the periodic table, and theoretically it was believed that the force that held the nucleus together would prevent particles weighing more than a few protons or neutrons from entering or leaving the nucleus. Therefore when Fermi irradiated uranium, the heaviest known element, and when the irradiated sample emitted beta radiation, Fermi thought it most likely that some of the uranium atoms in the sample had transmuted into the previously undiscovered element 93, and possibly into elements 94 and 95 as well.[5]

Lise Meitner, a physicist in Berlin, learned of Fermi's research and convinced a colleague at the Kaiser Wilhelm Institute (KWI), the chemist Otto Hahn, to collaborate with her on an attempt to reproduce and extend Fermi's results.[6] After Meitner and Hahn (who were joined in 1935 by the chemist Fritz Strassmann) began irradiating uranium, they quickly confirmed Fermi's results, adding to the growing consensus among

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[4] E. Fermi, "Radioattività provocata da bombardamento di neutroni I, II," *Ricerca Scientifica* 5 (1934): 283, 330-331. English translations in Enrico Fermi, *Collected Papers (Note e Memorie),* E. Segrè, et al., eds. (Chicago: U of Chicago P, 1962): vol. I, 674-676.

[5] Enrico Fermi, "Possible Production of Elements of Atomic Number Higher than 92," *Nature* 133 (1934): 898-899.

[6] Meitner's leadership role in the uranium experiments is most well documented in Fritz Krafft, "Internal and External Conditions for the Discovery of Fission by the Berlin Team," in *Otto Hahn and the Rise of Nuclear Physics*, ed. William R. Shea (Dordrecht, Holland: D. Reidel, 1983), and Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of C Press, 1996).

scientists that transuranic elements were being created.[7] Other groups, in particular Irène Curie and Pavel Savitch in Paris, also exposing uranium to neutron sources also believed that they were creating transuranes. So strong was the consensus that new elements were being created, in fact, that Enrico Fermi was awarded the 1938 Nobel Prize in Physics for his discovery of transuranic elements.

One of the few scientists who argued against the scientific community's belief in transuranes was the German chemist Ida Noddack. In September 1934 she published a paper in the *Zeitschrift für Angewandte Chemie* arguing that it was possible that the bombardment of uranium with neutrons split the uranium nuclei into several pieces, and that the existence of new transuranic elements would not be proven until it was demonstrated that the radioactive substances in the irradiated sample were different from every known element, not just elements 82 through 92 (which Fermi had demonstrated).[8] However, because she did not have the best reputation (politically or scientifically) and because she offered no evidence to support her argument that uranium could have split into elements much lighter than itself, Noddack's arguments were quickly dismissed by the Italian, French and German groups.[9]

History progressed outside of the lab as well. Lise Meitner, whose family was Jewish,[10] faced an increasingly difficult situation in Hitler's Germany. As an Austrian she was protected from the Nazi Civil Service Laws until Hitler annexed Austria on March 12th, 1938. On July 13th, 1938 Meitner was finally forced to flee to Sweden.

From Sweden, Meitner continued to participate in the KWI uranium work through almost daily correspondence with Hahn. That fall Hahn and Strassmann identified three new isotopes in their uranium, all of which were chemically similar to barium. Since

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[7] Otto Hahn and Lise Meitner, "Über die künstliche Umwandlung des Urans durch Neutronen," *Naturwissenschaften* 23 (1935): 37-38. English translation in Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission: A Documentary History* (New York: Van Nostrand Reinhold, 1971): 25.
[8] Ida Noddack, "On Element 93," *Zeitschrift fur Angewandte Chemie* 47 (1934): 653. English translation in Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission: A Documentary History* (New York: Van Nostrand Reinhold, 1971): 16-20.
[9] On Noddack see Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of California P, 1996): 168, 271-274.
[10] Meitner is often called Jewish, but this may not be subtle enough. Her family was Jewish, including her parents, although she was raised in a relatively secular household. Meitner herself converted to Protestantism as a young adult, although religion never appears to have played a major role in her life. She was still considered a Jew by the Nazis, who classified anyone with at least one Jewish grandparent as such. See Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of California P, 1996).

radium is also chemically similar to barium, Hahn and Strassmann reasoned that these new substances could be radium isotopes. But uranium would have had to emit two alpha particles together in order to transmute into radium, a process never before observed, meaning that irradiated uranium's behavior was growing curiouser and curiouser.[11]

Hahn, Strassmann, and Meitner continued to question and investigate these confusing new isotopes. With further chemical analysis, Hahn and Strassmann were forced to confront something even stranger: after precipitating the new elements with barium they were completely unable to separate the two. The new "radium isotopes" were apparently not radium, but barium! Hahn immediately wrote Meitner of this new result:

> 19.12.38 [December 19, 1938]…there is something about the "radium isotopes" that is so remarkable that for now we are telling only you.[12] The half-lives of the three isotopes have been determined quite exactly, they can be separated from *all* elements except barium, all reactions are consistent. Only one is not—unless there are very unusual coincidences: the fractionation doesn't work. Our Ra isotopes act like *Ba*.[13]

Hahn and Strassmann also appended a few paragraphs to a paper they were ready to submit on their investigations of the new activities. As they concluded:

> As chemists we really ought to revise the decay scheme given above and insert the symbols Ba, La, Ce, in place of Ra, Ac, Th. However, as "nuclear chemists," working very close to the field of physics, we cannot bring ourselves yet to take such a drastic step which goes against all previous experience in nuclear physics. There could perhaps be a series of unusual coincidences which has given us false indications.[14]

The chemistry convinced Hahn and Strassmann that barium was present in their irradiated uranium, but they had no physical explanation for this result.

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[11] O. Hahn and F. Strassmann, "Concerning the Creation of Radium Isotopes from Uranium By Irradiation with Fast and Slow Neutrons," *Naturwissenschaften* 26 (1938): 755. English translation in Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission: A Documentary History* (New York: Van Nostrand Reinhold, 1971): 41-42.

[12] In a 1996 letter to the editor, M. Goldhaber writes that "Hahn telephoned Weizsäcker to tell him of the discovery of barium," that Hahn did not in fact tell only Meitner. This is something I have to investigate further. M. Goldhaber, "Fact and fission," *Nature* 384 (1996): 510.

[13] Quoted in Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of California P, 1996): 233.

[14] O. Hahn and F. Strassmann, "Concerning the Existence of Alkaline Earth Metals Resulting from Neutron Irradiation of Uranium," *Naturwissenschaften* 27 (1939): 11. English translation in Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission: A Documentary History* (New York: Van Nostrand Reinhold, 1971): 44-47, quote on 47.

Meitner read Hahn's letter while spending the holidays with her nephew Otto Frisch, who was also a physicist. Meitner was convinced of Hahn and Strassmann's chemical abilities and certain that they had not made a mistake, so she and Frisch began to ponder what physical process could have yielded such results. The story, as told in Frisch's autobiography,[15] and repeated in nearly everything written on the discovery of fission, has it that after Meitner showed Frisch Hahn's letter, aunt and nephew set out into the Swedish countryside, Frisch on skis and Meitner proving she could keep up on foot, discussing the strange experimental results. They first realized that if the uranium nucleus were something like a drop of water, as the liquid-drop model of the nucleus proposed, its "surface tension" might barely be enough to balance the mutual repulsion of the large number of positively-charged protons that comprised it, barely enough to keep it from breaking apart. The capture of a free neutron, then, might disrupt this tenuous equilibrium, causing the nuclear "drop" to elongate, shifting the balance in favor of the now mutually-repulsive, positively-charged ends, and allowing the drop to break apart into two approximately equal halves.

How, then, would these two new nuclei, each roughly half the mass of the uranium nucleus, acquire the energy to fly away from one another, as their mutual electric repulsion dictated they must? At this point, the story goes, Meitner and Frisch sat down on a log, and Meitner, using paper and pencil she found in her pocket, calculated that the mass difference between a uranium nucleus and a barium and krypton nucleus was roughly one-fifth the mass of a proton.[16] Using Einstein's famous equation, E = m*c^2, Meitner calculated that this mass transformed into energy would allow the two new nuclei to travel away from one another at great speed, much faster than that seen in any previously observed nuclear reaction. This speed would be so great that it would be easy to detect any particles traveling at it, which Frisch did when he returned to his lab at Niels Bohr's Institute after the holidays and irradiated his own uranium. Once in Copenhagen, Frisch also told Niels Bohr of Hahn and Strassmann's results and his and

[15] Otto Frisch, *What Little I Remember* (Cambridge: Cambridge U P, 1991 [1979]): 115-6.
[16] Any atom made up of more than one nucleon weighs a bit less than the protons and neutrons that comprise it would weigh in sum independently. This is because that bit of mass is transformed into the binding energy holding the nucleus together.

Meitner's explanation. According to Frisch, Bohr immediately understood and is famously supposed to have responded, "Oh, what idiots we all have been!"[17]

Shortly after learning of fission, Bohr left Copenhagen for scientific meetings in the United States, promising not to publicize the idea of fission until Meitner and Frisch had published on it. En route, however, Bohr did discuss Meitner and Frisch's ideas with the physicist Léon Rosenfeld. Upon arriving in New York Bohr spent a few days at Columbia with Enrico Fermi, while Rosenfeld traveled to Princeton and, because Bohr had neglected to tell him to wait for Meitner and Frisch's paper to come out, promptly told the physics journal club there of the discovery. After Frisch and Meitner's papers were published,[18] Bohr publicly announced the discovery of fission on January 26, 1939 at the fifth Washington Conference on Theoretical Physics, in Washington, D.C.

Within days of the January 26, 1939 announcement of the discovery of fission, the history of fission began to be written. Over the next few weeks numerous articles were published in American newspapers on the announcement of the process and American scientists' verification that it occurs. All of these articles present a similar narrative of the discovery, beginning with Otto Hahn's observation that his sample of irradiated uranium contained barium, and ending with Niels Bohr's public announcement of the new nuclear reaction.

Most noticeable in this first round of reporting on fission is the attention paid to the disciplinary identity of fission and its discoverers. Although the articles, in both popular American newspapers and the popular scientific press (multidisciplinary journals such as *Science*, *Scientific Monthly*, etc.), diverge on other points, and contain different and varied inaccuracies, they all agree that fission is a "physics phenomenon, " and that its discovery was announced by Niels Bohr, famous physicist, at a conference on theoretical physics. Further, none of the articles have Bohr learning of fission from a chemist—some other physicist, or at least unspecified "scientist" is always included in the discovery narrative between chemistry and Bohr. This is accomplished either by

[17] Otto Frisch, *What Little I Remember* (Cambridge: Cambridge U P, 1991 [1979]): 116. The Bohr quote appears in essentially everything written on the discovery of fission.
[18] Lise Meitner and O. R. Frisch, "Disintegration of Uranium by Neutrons: A New Type of Nuclear Reaction," *Nature* 143 (1939): 239-240. O. R. Frisch, "Physical Evidence for the Division of Heavy Nuclei Under Neutron Bombardment," *Nature* 143 (1939): 276.

ignoring Hahn's (and, if he is mentioned, Strassmann's) disciplinary identity and calling him simply a scientist, doctor or professor, or by including Lise Meitner, physicist, in the narrative to transmute Hahn's chemistry into Bohr's physics.

For example, in the first *New York Times* article on fission "physics" or "physicists" are mentioned four times and fission is twice called a "physics phenomenon," while chemistry is mentioned not once. Although Hahn is given sole credit for the discovery he is called simply "Dr." and is not identified as a chemist.[19] The first *Washington Post* and *Los Angeles Times* articles on the discovery are similar – physics is mentioned more than once while the disciplinary identity of Hahn, still the sole discoverer, remains unspecified.[20] The repeated mentions of physics in these articles suggests that is was not simply incomplete information that led Hahn's professional identity as a chemist to be ignored; rather, fission was actively considered and constructed as the property of physics and physicists. Even months and years later, Hahn and Strassmann continue appear as unspecified scientists or even physicists. For example, in a December 1938 *New York Times* article, Hahn and Strassmann are referred to simply as "Drs.," while "other physicists" are mentioned two paragraphs later.[21]

In articles published a few days after January 28th, on the reproduction of fission in American laboratories, Hahn is correctly identified as a chemist yet physicists are still given the prominent role in the discovery. These articles depict Hahn simply as an observer of barium, unable to formulate the explanation that physicists, the true discoverers of the new phenomenon, offered. In the *Washington Post* Hahn, "a German *chemist*…found residues of barium, and unable to determine the *physical* explanation for his results, asked the advise of a former colleague, Dr. Lise Mitner [*sic*, emphasis added]."[22] In a longer article in the *New York Times* Enrico Fermi and Niels Bohr, "two European Nobel Prize winners in physics," are given "a prominent part in the work," along with Lise Meitner and Otto Frisch. Hahn and Strassmann play a minor role, having

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[19] "Atom Explosion Frees 200,000,000 Volts; New Physics Phenomenon Credited to Hahn," *New York Times*, Jan. 29, 1939: 2.

[20] "Atom Breaking Revealed to Scientists Here," *Washington Post*, Jan. 28, 1939: 19; "American Scientists Stirred by Explosion of Atoms," *Los Angeles Times*, Jan. 29, 1939: 5.

[21] "Year in Science," *New York Times*, Dec. 1939.

[22] "Scientists Produce 200,000,000 Volts Here, In N.Y. and Baltimore by Exploding Atoms," *Washington Post*, Jan. 31, 1939: 15.

"reported their startling observations on Jan. 6 without offering any theory to explain the new phenomenon."[23]

Articles on the discovery of fission in scientific periodicals likewise present fission as a physical phenomenon. In *The Scientific Monthly*, Merle Tuve (himself a physicist) writes, "The experiments under consideration pertain to the nuclei, though the *chemical* properties of atoms depend almost entirely on their outer negative electrons. It is the atomic nuclei that contain the keys to the *most important* properties of matter [emphasis added]."[24] That is, while chemists interest themselves in atoms as a whole, physicists are concerned with the more important nucleus, putting fission in their domain. Other articles are less strident with regard to the relative importance of physics and chemistry, but always follow Hahn and Strassmann's chemical observation with Meitner and Frisch's physical interpretation. For example, also in *The Scientific Monthly*, "…regarding the *chemical* discovery of Professor Hahn and his coworkers of disintegration of uranium into the comparatively light element barium…the *physical* interpretation of this was first made by Frisch and Meitner [emphasis added]."[25]

Clearly, fission was identified as a physical phenomenon by those reporting its discovery in the United States in 1939. But what did this mean to the participants in the fission story at that time? To begin, as the articles cited above suggest, physics and chemistry were distinct disciplines in the early twentieth century. Historians of science generally agree that at some point in the late eighteenth or early nineteenth century physics and chemistry evolved (or revolved) into defined, separate disciplines. Traditionally Lavoisier, who applied precise analytical methods to chemical experiments and declared "that in every operation there is an equal quantity of material before and after the operation,"[26] has been seen as the father of modern chemistry just as Newton and Galileo were the fathers of modern physics. This interpretation dates the "Chemical Revolution" to 1770-1790. Alan Rocke is one historian who argues for this periodization,

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[23] "Vast Energy Freed by Uranium Atom," *New York Times*, Jan. 31, 1939: 18.
[24] M. A. Tuve, "Splitting of Uranium Atoms," *The Scientific Monthly* 48:3 (March 1939): 282.
[25] John A. Fleming, "The Fifth Washington Conference on Theoretical Physics," *The Scientific Monthly* 48:3 (March 1939): 281.
[26] Antoine Lavoisier, *Traité élémentaire de chemie* (Paris: Cuchet, 1789) 1: 140-41, quoted in Frederic Lawrence Holmes, *Antoine Lavoisier—The Next Crucial Year, or The Sources of His Quantitative Method in Chemistry* (Princeton: Princeton U P, 1998): 7.

arguing that in the late eighteenth century chemists, interested in identifying the components of gases and liquids, split from physicists, more interested in explaining the physical world through the use of mechanical models, and established their own discipline.[27] In contrast, the historian of chemistry Mary Jo Nye argues that this Chemical Revolution marked the beginning of the evolution of physics, as a more analytical discipline, away from chemistry, the more pragmatic and historic discipline.[28] In either case, by the mid-1800s, chemistry and physics were distinct from one another.

How long such distinctness lasted, however, is up for debate. Nye argues that by 1950 the development of theoretical chemistry (such as valence electron theory) brought the disciplines close together again. Radioactivity, another prominent area of research in twentieth century science, also brought chemists and physicists into close contact, even in the same lab. One such pair, of course, was the chemist Otto Hahn and physicist Lise Meitner, who worked together and separately in the same institute on various experiments involving radioactivity for four decades. Throughout Meitner and Hahn's many years of collaboration, however, this pair appears to have held on to their individual professional identities. In the 1930s, for example, when working on the irradiation of uranium, Hahn (and their new colleague Fritz Strassmann, also a chemist) performed the chemical analysis (such as fractional crystallization) and Meitner the physical (such as analysis of the radioactive decay), with the aim of together identifying the elements produced when uranium was exposed to neutrons. Bureaucratically the pair also remained committed to their respective disciplines: Hahn was director of the Kaiser Wilhelm Institute (KWI) for Chemistry, and Meitner head of the KWI physics section. Even geographically, Meitner and Hahn kept physics and chemistry separate. Meitner's labs were on the ground floor of the KWI building and she was known to say, "Hahn dear, go upstairs, you understand nothing of physics!"[29] In sum, although Meitner and Hahn worked together for many years, Hahn clearly considered himself a chemist and Meitner clearly considered herself a physicist.

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[27] Alan J. Rocke, *Chemical Atomism in the Nineteenth Century: From Dalton to Cannizzaro* (Columbus: Ohio State U P, 1984).

[28] Mary Jo Nye, *From Chemical Philosophy to Theoretical Chemistry: Dynamics of Matter and Dynamics of Disciplines, 1800-1950* (Berkeley: U of California P, 1993): 32-53.

[29] "Hähnchen, Geh' nach oben, von Physik verstehst Du nichts!" Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of California P, 1996): 178.

Hahn, Strassmann, Meitner and Frisch also appear to have understood their discovery of fission in the context of scientific disciplines. In the paper in which they first proposed that the "transuranic" elements were actually transition metals, Hahn and Strassmann differentiated as chemists between what they could offer: the chemical identification of barium, and what they could not offer: an explanation for this finding.[30] Likewise, Meitner congratulated Hahn and Strassmann on their chemical experiments, differentiating them from Frisch's physical recoil experiment: "The recoil experiments confirm only the fact of splitting, but *not* into *what* it splits. That, after all, can only be determined by chemistry, and therefore every one of your experiments is extremely important."[31] Although Hahn, Meitner, Strassmann and Frisch all believed they had participated (to varying extents) in the discovery of fission, they did recognize that chemistry and physics contributed different things to the discovery.

Therefore, according to both historians of science and participants in the discovery of fission, in 1939 physics and chemistry were considered separate disciplines. Yet the fact that there was consensus that physics and chemistry were different does not mean that there was consensus about what each of the two disciplines was. Hahn, for example, would later argue that it was not his being a chemist that had prevented him from interpreting the barium data, but the popular mindset of contemporary physicists. As he reportedly said more than once, "The physicists wouldn't allow it."[32] The differences between individuals' definitions of chemistry versus physics in this period are also evident in a speech made by Senator Sheridan Downey in August 1940. In the speech Downey discussed a newspaper article on the potential for atomic energy written by William Laurence, and Laurence in turn discusses the speech in his 1959 book *Men and Atoms*. In the article, portions of which Downey read aloud, Laurence discusses "experiments at the physics department of Columbia University," "Prof. John R. Dunning, Columbia physicist," and "other leading physicists." Yet, when Downey discusses the scientific issues in his own words, he always refers to "chemists." In the portion of

[30] O. Hahn and F. Strassmann, "Concerning the Existence of Alkaline Earth Metals Resulting from Neutron Irradiation of Uranium," *Naturwissenschaften* 27 (1939): 11; English translation in Hans G. Graetzer and David L. Anderson, *The Discovery of Nuclear Fission: A Documentary History* (New York: Van Nostrand Reinhold, 1971): 44-47.
[31] Ruth Lewin Sime, *Lise Meitner: A Life in Physics* (Berkeley: U of California P, 1996): 252.
[32] William L. Laurence, *Men and Atoms: The Discovery, Uses and the Future of Atomic Energy* (New York: Simon and Schuster, 1959): 27.

Downey's speech printed in *Men and Atoms*, Downey mentions "chemists" five times and physicists none (except for three "physicists" in the portion of Laurence's article that he read aloud).[33] Clearly, Laurence's and Downey's definitions of physics and chemistry are different, yet they both refer consistently to one or the other, suggesting that they both consider physics and chemistry different things.

Although physics and chemistry were widely considered different subjects during the first half of the twentieth century, then, the dividing line between the two was not clearly drawn. This gave individuals the ability to choose whether new developments in physical science, such as the discovery of fission, were physics or chemistry. The active identification of fission as a physical phenomenon, then, suggests that physics was regarded as the more eminent science, even before the post-WWII era of big physics. Having been discovered, at least in part, by chemists, fission could have been presented as a chemical discovery, but was instead immediately classified as physics. Sometimes (as in Tuve's article) this was explicitly because fission concerned the "important" parts of the atom.[34] In other articles the authors' extreme propensity to classify fission—a widely noted and therefore probably important discovery—as physics simply suggests this. As historians of science have documented, after the explosion of the atomic bomb, the prestige of physics, measured in terms of dollars, students, and so on, significantly rose.[35] This growth is thought to be the result of the identification of the bomb as the product of physics, as it was depicted in Henry Smyth's official history of the Manhattan Project.[36] Already in 1939, however, fission was identified as something important and therefore physical, which suggests that the twentieth century rise of physics began even before the Manhattan Project did.

[33] William L. Laurence, *Men and Atoms: The Discovery, Uses and the Future of Atomic Energy* (New York: Simon and Schuster, 1959): 43-46.
[34] M. A. Tuve, "Splitting of Uranium Atoms," *The Scientific Monthly* 48:3 (March 1939): 282.
[35] See for example Paul Forman, "Behind Quantum Electronics: National Security as a Basis for Physical Research in the United States, 1940-1960," *HSPS* 18 (1987): 149-229.
[36] See for example Rebecca Press Schwartz's forthcoming dissertation.