Prelude to the Manhattan Project

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By the 1930s it was time to discover fission. We knew about isotopes. The Curies and Becquerel had discovered radioactivity. Rutherford had discovered the nucleus. Chadwick had discovered the neutron. Einstein had discovered special relativity and the famous equation $E=mc^2$. Bethe was even publishing about fusion as the source of energy for the Sun. So, it was time.

By the 1930s a human drama was unfolding in Europe and in the Pacific – the rise of fascism. The events of this drama engulfed the world in war and created a need on all sides for weaponry that could defeat the enemy by whatever means.

The intersection of scientific inevitability and war created the environment for the advent of nuclear weapons.

Science was practiced was very differently in the 1920s and 1930s than today. In that era science was highly specialized and compartmentalized. If you were a metallurgist for example it was unlikely that you would have anything to do with a physicist – that all changed in the1940s.

Figure 1 – Leo Szilard (www.biography.com/people/leo-szilard-9500919

In 1933 Leo Szilard (Fig. 1), a Hungarian physicist who took refuge in London from Nazi Germany, read a paper by Rutherford that ridiculed the idea of getting energy from nuclear transmutations. Szilard realized that if you could find an element which is split by neutrons and which would emit two neutrons in the process, then a chain reaction could be started. This is the basic idea of a nuclear weapon -- to generate energy from the chain reaction. Szilard was a chemist by training and knew about the idea of a chemical chain reaction. He adapted this idea to the to the nuclear chain reaction. In 1934 Leo Szilard filed for a patent on the liberation of nuclear energy for power production and other purposes through nuclear transmutation. In the following year he filed an amendment identifying Uranium and Bromine as examples of elements from which neutron interactions can liberate multiple neutrons in the transmutation process.

Szilard worried about keeping the idea of nuclear energy secret. He offered his patents to the British government who initially turned them down. Eventually they accepted the idea that nuclear energy might be an explosive force of some use.

It was in 1934 that Enrico Fermi irradiated Uranium with neutrons. He observed very bright flashes in the detectors that he was using and hypothesized that highly charged particles were emitted along with neutrons in the fission process. Fermi unknowingly may have measured the first observed nuclear fission.

In 1938 Otto Hahn and Fritz Strassman of Germany split the Uranium atom by bombarding it with neutrons and showed that the elements Barium and Krypton are formed. In the same year Lisa Meitner conducted experiments verifying that heavy elements capture neutrons and produce lighter ones, and in the process more neutrons are created. With this discovery, the idea of a nuclear chain reaction became a real possibility. By 1939 the entire scientific community was talking about nuclear fission. Upon hearing about the discovery of fission, Robert Oppenheimer knew that atomic bombs might be possible. Leo Szilard and Enrico Fermi for the first time discussed the possibility of building a Uranium-Carbon lattice that could create a chain reaction. This was the first discussion of a concept for a nuclear reactor.

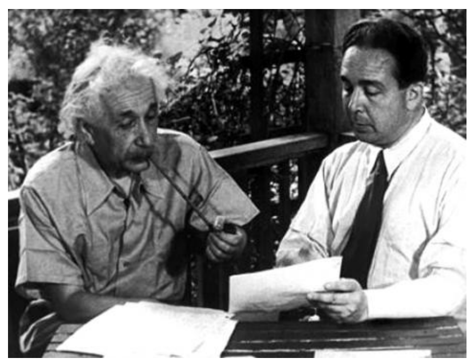

Figure 2 - Einstein and Szilard (www.atomicheritage.org/history/einstein-szilard-letter-1939

Szilard met with Einstein in August of 1939 (Fig. 2) and helped draft a letter to Roosevelt urging rapid work on the Uranium chain reaction. He also convinced Einstein that very large amounts of energy could be released if a chain reaction could be sustained. Einstein believed the German government was pursuing this line of research and that the US should too. Alexander Sachs met with Roosevelt in October of 1939 to discuss the concept of forming a Uranium Committee. This was two months after the receipt of the Einstein letter. The delay in action was a cause of great concern for Szilard and others. Roosevelt was enormously preoccupied with developing events in Europe. The initial meeting with Roosevelt was noncommittal. During a meeting the next day Sachs urged Roosevelt into rapid action. That same day Roosevelt wrote back to Einstein that he had set up a committee to study the issue starting October 1939. Roosevelt was convinced the US could not take the risk that Nazi Germany would develop such a weapon.

Scientists involved in the pursuit of nuclear physics in this era voluntarily set up a restriction of publications concerning fission. As you can imagine this was a radical step for the US scientists who are academically committed to open and free exchange of ideas. The effort was led by Szilard, Bush, Fermi and all the luminaries in the field. It was a voluntary agreement.

Roosevelt appointed Lyman Briggs to be head of the National Bureau of Standards and chair the Uranium Committee. The Committee met for the first time in October of 1939. The Committee was composed of both civilian and military representatives who for the first time were working on a joint project. The first report they issued discussed nuclear power and bombs and requested $6000 to get things going in a serious way. The second report was a bit eclipsed by events because Uranium-235 was discovered as the principal fissioning isotope and there was already a large effort at the Kaiser Wilhelm Institute for Uranium research in Germany. It was clear by this time that there had to be a better organizational model in the US so science in this field could advance. Columbia was working on one idea and Chicago was working on something else. The basic research community of science was simply not used to having such a broad scope of effort spanning the entire country and the world.

In June of 1940 Roosevelt approved the formation of the National Defense Research Council (NDRC) at the urging of Vannevar Bush (Fig. 3) who would play a principal role in the reorganization of science. Roosevelt transferred the Uranium Committee to the NDRC under Bush. In the fall of 1940 Bush recognized that reorganization without direct involvement of the military would not be productive. He suggested that enrichment of U-235 be the main focus. All these initial reports that came out of the Committee were very discouraging concerning the time scale for the development of a weapon before 1946. A major breakthrough came when they realized that a bomb needed fissioning from fast neutrons not thermal ones. It was a race between the speed of sound which characterizes speed of the assembly of the Uranium metal with the speed of light which characterizes the speed of the chain reaction. None of these initial reports suggested that a Plutonium bomb may be a pathway to weapon.

Figure 3 – Vannevar Bush (http://www.ibiblio.org/pioneers/bush.html

In July of 1941 Bush received the MAUD report from the British. MAUD was the codename for Uranium project in Britain. The British reported that a sufficiently purified mass of U-235 could support a chain reaction by fast neutrons. This idea built on theoretical work by Peierls and Frisch. The critical mass was estimated in this work to be about 10 kg and said a bomb was possible with this amount. The report also contained plans for a bomb that were drawn up by the University group in Cambridge which was highly respected in the US. The report also totally dismissed the idea of a Plutonium weapon as an option. The report said that enrichment by gaseous diffusion, electromagnetic separation, and centrifuge would probably be the most successful approaches. However, they supported enrichment by gaseous diffusion by an overwhelming majority.

This report detailed progress by Nazi Germany which they claimed were significant. These actions by the Committee were the vehicle alerting Soviet intelligence about Anglo-American discussions on the topic. In the United States, Enrico Fermi was added as head of the theoretical efforts and Harold Urey was added as head of the isotope separation and heavy water research.

By the winter to spring of 1942 it was clear to the research community that there were two pathways to building a bomb – the Uranium pathway and the Plutonium pathway. The major obstacle for the Uranium pathway was the enrichment of U-235. Harold Urey was working on the gaseous diffusion and centrifuges for this problem. Lawrence however, concentrated on electromagnetic separation.

Significant quantities of Uranium ore were needed for this research. There was already 1200 tons in storage on Staten Island. The Uranium ore had to be turned into metal and then Uranium hexafluoride for the centrifuge and diffusion process experiments. Murphy arranged for DuPont and Harshaw to provide the industrial production of these materials. It turned out that Lawrence had already been very successful with electromagnetic separation of U- 235. The report to Roosevelt in March of 1942 stated that Lawrence's work may make the bomb possible on a short timescale. In 1945 this claim was also bolstered by the fact that the critical mass estimates had been substantially lowered from the earlier reports. Roosevelt told Bush that the whole effort should be pushed very significantly.

For the Plutonium pathway the major obstacle was reactor production. Plutonium is produced in a reactor and is not naturally occurring. No one knew about the spontaneous fission neutron problem yet. Fermi was still working at Columbia with plans to relocate to Chicago. Theoretical work continued at Princeton and Berkeley. Under the west grandstand at Stagg Field, Allison began building the first reactor - a graphite moderated Uranium design. Recent US calculations had cast significant doubt on the MAUD report for its negative findings on Plutonium. By May of 1942 the committee on Uranium decided to go forward with all enrichment approaches for U-235 and for the production of Pu-239. At this time, it was not clear which path would be successful. The whole project was too critical to the war effort to down-select prematurely

The scale of the effort to go forward with the production of Plutonium and enriched Uranium led to the involvement of the Army Corps of Engineers. The government realized that very large industrial scale facilities would be needed to make these ideas a reality. There were very delicate negotiations with the Army for the University control of the research and Army control of the production.

However, it was agreed that an Army officer would be an overall charge of the project.

In the summer of 1942 the initial Army organization was based in New York City from which the new organization got its name -- the Manhattan Engineering District project. After several organizational efforts Leslie Grove (Fig. 4) was promoted to Brig. Gen. and became the head of the Manhattan project in September of 1942.

Figure 4 – General Leslie Groves (www.atomicarchive.com/Bios/GrovesPhoto.shtml)

Groves acted quickly to resolve ambiguities involving the approaches and by November of 1942 Plutonium was seen as the most promising approach but Uranium was not abandoned. The centrifuge project was canceled in favor of the electromagnetic and gaseous diffusion enrichment because of the difficulty of the approach.

In October Grove discussed with Oppenheimer the suggested isolated sites for the location of the laboratory. Oppenheimer was selected to be the head of the bomb research and development laboratory which was to be built in Los Alamos New Mexico. The production site for materials would be built in Clinton Tennessee.

Figure 5 – J. Robert Oppenheimer (https://www.atomicheritage.org/profile/j-robert-oppenheimer