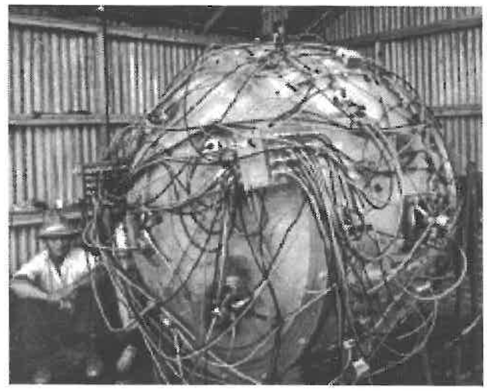
The History and Ethics Behind
The Manhattan Project

Table of Contents



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April 30, 1997

Abstract

On July 16, 1945, the world entered the nuclear age with the detonation of the first atomic bomb. This day will be remembered forever, much like the events that occurred in Hiroshima and Nagasaki. However, the history of the Manhattan Project remained classified for many years. This paper will examine the origins of the project as well as the political and ethical debates that occured before the decision was made to use the bomb.

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The Manhattan Project

Introduction

History allows us to record our successes and failures, but more importantly, it allows us to learn from our mistakes. The Manhattan Project is a prime example. The project allowed the United States to unlock the mysteries of the atom, but it also introduced the most destructive form of warfare known to mankind. More than 50 years later, nuclear weapons are still controversial. In my research, I will explore two of the most important and most unpublicized challenges involved in the project. The first challenge was producing an atom bomb, which involved making new discoveries that would revolutionize war and forever change the history of man. The second challenge involved the ethical debates that occurred in the scientific community on whether or not the bomb should be used. This second challenge is best described by Michael Stoff, history professor at the University of Texas at Austin, when he said, "There are the scientists, who stand at the very center of the Manhattan project, seeking to penetrate the inner structure of the atom. In it, they find a bewitching beauty, but when its energy is unleashed, when its eager inventors confront the bomb's incredible destructiveness, they recoil" [Stoff, 1991].

"The Manhattan Project was a scientific breakthrough, a frantic race for life and death, and a revolution in warfare."

The Manhattan Project was the code name for the US effort during World War II to produce an atomic bomb. Although the project took place mainly in New Mexico, it was named after the Manhattan Engineer District of the US Army Corps of Engineers, based in New York City, where much of the early research was done [Moody, 1995]. The project lasted 4 years, between 1942 - 1946, and cost about $1.8 billion. Today, this amount would be equivalent to over $20 billion [Parshall, 1995]. The project was more than the typical military program to achieve weapons superiority. The Manhattan Project was a scientific breakthrough, a frantic race for life and death, and a revolution in warfare. The project and its controversies took place on a global scale during the worst war in the history of mankind. It had such an impact on our lives, that we should not ignore the history but study it and learn from it.

The project produced three bombs: the first bomb, known as "Gadget", was used as a test model; the second bomb, known as "Little Boy", was detonated over the city of Hiroshima; and the final bomb, known as "Fat Man", was detonated over the city of Nagasaki [Fermi, 1995]. The Manhattan Project was considered the ideal program because of its efficiency, its secrecy, and its cooperation among civilians, military officials, and scientists. It became the forerunner in nuclear development and control. The project marked the beginning to an era of nuclear weapons and scientific discoveries.

In order to properly discuss the history and the ethical debates involved in the Manhattan Project, there is an appendix explaining the key figures in the project and their background. Many scientists were immigrants and had a first hand knowledge of Adolf Hitler's oppression and thirst for atomic power. When a preson's name first appears, it will be linked to their description.

I will first explain why the project was started, what the major challenges were, and what discoveries were made. Once we understand the science behind the bomb, I will discuss the two different designs of the atomic bomb. After the history and the science are explained, the ethical debates will be analyzed. Finally, I will talk about my conclusions and recommendations of the decision to drop the bomb and of future scientific projects.

Title Page | UER Contents | Next

The Manhattan Project

The Manhattan Project

Before this topic is addressed, I will set the stage to the events leading to the Hiroshima and Nagasaki bombings. Historically, the United States has always taken interest in affairs in the Pacific. When the United States spread its influence over the Philippines, Japan probably saw the United States as a threat in their imperialistic dreams in the Orient. Japan took advantage of World War II and began to pursue expansion in the Pacific. Japan responded to the American threat with a sneak attack when they bombed Pearl Harbor on December 7, 1941. The United States then entered World War II aligned with the Allied powers and ended up fighting Japan predominantly on its own in the Pacific.

The first major challenge faced in the Manhattan Project was the ability to find an acceptable and plentiful source of fuel for the bombs. Neils Bohr stated that the isotope Uranium-235 (U-235) was a likely candidate because it was unstable and could sustain a chain reaction. Glen Seaborg found that the isotope Plutonium-239 (P-239) was also a likely candidate. However, obtaining these elements was a major challenge. The second major struggle in the project was being able to sustain a fission chain reaction, which gives the atomic bomb its power. The principles behind fission and chain reactions will be discussed later.

Uranium and Plutonium Refinement

"The most challenging part of the project was the difficulty in obtaining a large quantity of U-235"

The most challenging part of the project was the difficulty in obtaining a large quantity of U-235 as theorized by Bohr. U-235 is obtained from uranium ore, a natural rock containing the element. The uranium ore is then processed to extract the different uranium isotopes. An isotope of an element such as uranium is basically the same atom structure but with a little more or a little less weight from a neutron added to or subtracted from the nucleus. The nucleus is the center part of an atom, made up of protons and neutrons, which makes up most of the atomic weight. From the uranium ore, two types of isotopes are extracted; one is U-235 which makes up about 1% of the uranium ore, and the other is U-238 which makes up 99% of the uranium ore. U-238 is useless in making an atomic bomb, but U-235 can be used in the bomb because it can sustain a chain reaction, a series of events that lead to or cause an overall effect - like dominoes falling on each other. Several new advances in technology were made in order to separate and to refine the U-235 isotope [Dyson, 1997].

The task to separate the different uranium isotopes proved to be a major obstacle for the scientists. The first method that could be used to separate the isotopes was called magnetic separation. This process was made possible when Ernest O. Lawrence invented the Cyclotron at the University of California, Berkeley laboratories. During magnetic separation, a Uranium Tetrachloride mixture was electrically charged. It was then passed through a magnetic on 180° arc. The lighter U-235 would pass closer to the magnetic and get collected. The heavier U-238 would travel on the outside of the arc and get disposed. However, this process was severely flawed. Many of the arcs, or racetracks, had dirt particles contaminating the oil and the silver bands on the track were rusted. The magnets had to be sent back and cleaned. These delays caused the process to die out. After millions of dollars in construction, only about a gram of U-235 was produce [Rhodes, 1986]. Lawrence's laboratory was later used as the center for radiation studies. A side note, Lawrence was upset that Oppenheimer was appointed the weapons director of the project and that his laboratory, Los Alamos, would be used as location of the weapons development instead of the Berkeley laboratory.

A second method of separation was used. In 1942, Gen. Leslie Groves purchased a section of land in Oak Ridge, Tennessee in order to construct a uranium separation facility. This facility used the principle of gaseous diffusion to separate the uranium isotopes. Since U-235 is slightly lighter than U-238, the process of gaseous diffusion was used to initially separate the two. During the process, the uranium ore is sprayed with fluorine to form Uranium Hexafluoride gas. The gas is then injected into a series of porous filters. These porous filters have an extremely fine matrix that allows the lighter U-235 to pass through faster. After going through several filters, the Uranium Hexafluoride gas has a high concentration of U-235 [Dyson, 1997]. This process was an efficient and effective method for producing the required U-235.

There was a third method used to separate the isotopes called gas centrifuge. In this process, a centrifuge is used to separate the lighter U-235 isotope from its heavier U-238 counterpart. Unfortunately, this process was not efficient and had yet to be tested. The atomic arms race with Germany could not afford the luxury of time, so this process was soon abandoned.

Thanks to a new discovery, U-235 was not the only possible fuel for the atomic bomb. In 1941, Glen Seaborg discovered element 94, Plutonium [Borman, 1995]. Seaborg observed that the isotope P-239 was more unstable than the isotope he discovered, P-238. Seaborg knew that this isotope would make an ideal fuel for the fission reaction needed for the atomic bomb. Seaborg also discovered that U-238 can be transformed into P-239 by leaving it in a nuclear reactor for an extended period of time. In the nuclear reactor, the U-238 picks up extra particles, especially neutrons, because of the high radioactivity. In 1942, Enrico Fermi built a small reactor in Chicago, under the squash courts of the university. He also created the first controllable chain reaction at his lab. Fermi's reactor would become the prototype of five production reactors that were to be built. Gen. Groves immediately began setting up a list of criteria for the new production facility. The reactors had to be moved from Chicago because they were too small and too dangerous because of all the radioactive material produced. Gen. Groves did not want to move the production facilities to Oak Ridge because "[it] was not far from Knoxville" and "[because] no one knew what might happen, if anything, when a chain reaction was attempted in a large reactor"

[Rhodes, 1986]. Gen. Groves felt if an accident occurred, it would destroy the uranium facilities, "[cause] the loss of life and the damage to health in the area", and "wipe out all semblance of security in the project" [Rhodes, 1986]. Therefore, a location was chosen in Hanford, Washington that was isolated and secure.

Now that two possible fuels were available for use in creating the atomic bomb, the actual bombs needed to be designed, tested, and built. However, the lack of uranium and plutonium posed a problem. Another problem was that plutonium was not as fissionable as uranium. These problems would soon be overcome by the brilliant minds on the project, but before we get into the design of the bombs, the issue of fission must be discussed.

Fission

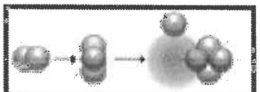


Figure 2. Hydrogen nuclei are fusing to produce a Helium nucleus. [Manhattan, 1997]

At that time, there were two known types of atomic explosions. One was fusion; it was later used to produce the fusion bomb, more commonly known as the Hydrogen Bomb. A fusion explosion starts with a fission reaction, but it gets its power from the combining of the nuclei of several hydrogen isotopes to produce helium nuclei. Figure 2 shows fusion reaction taking place. However, much of the progress of the Hydrogen Bomb was made after the Manhattan Project and World War II. In this paper, I will be focusing on the Manhattan Project and the Atomic Bomb, which started the nuclear arms race.

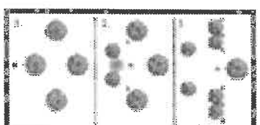


Figure 3. A chain reaction of uranium [Manhattan, 1997].

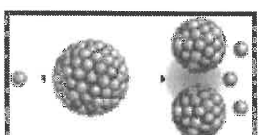


Figure 4. A neutron breaks-up a uranium atom [Manhattan, 1997].

What makes the atomic bomb so powerful and destructive is the chain reaction that occurs, called fission. Neils Bohr paved the way towards the discovery of fission with his studies of atoms. Fission occurs when the central part of an atom, the nucleus, breaks up into two equal fragments. Once a neutron breaks-up the uranium atom, the fragments release other neutrons that break-up more atoms and so on. Figure 3 illustrates a fission chain reaction, and Figure 4 shows a close-up of what occurs during fission.

This chain reaction takes place in only millionths of a second. The amount of power released during this chain reaction is about several hundred million volts of energy which is released at detonation. When P-235 undergoes fission, it gives up off large amounts of heat and radiation. The radiation given off is called Gamma Radiation, the deadliest form known to man. P-239 can also undergo this violent chain reaction. Due to the differences in the structures of plutonium and uranium, alternative bomb designs had to be created. The inner workings of the bombs will be discussed in the next section.

Previous | Title Page | UER Contents | Next

The Manhattan Project

Atomic Bomb Design

Figure 5. "Little Boy" is seen on the left, and "Fat Man" is seen on the right.

The Manhattan Project yielded three atomic bombs. The first bomb was known as "Gadget" and was a test model of the plutonium bomb because its design was more complicated. The next bomb was know as "Little Boy" which was a uranium bomb and was used in warfare over the city of Hiroshima. The uranium bomb did not have a test model because it was a very simple design and because there was not enough uranium to produce two bombs. The last bomb was know as "Fat Man" which was the same design as the "Gadget" but was actually used in warfare over the city of Nagasaki. The following will explain the inner workings of "Little Boy" and "Fat Man". Figure 5 is a photograph of the two bombs used in warfare.

"Little Boy" - The Uranium Bomb

Uranium is a much more fissionable isotope. The actual bomb was a simpler design than its counterpart. Richard Feyman was responsible for calculating the amount of uranium needed to achieve critical mass. Critical mass is the amount of uranium needed to start the chain reaction. However, if you have more than the required mass to start the reaction, or supercritical mass, the reaction would take place faster and grow exponentially. Feyman calculated about 50 kilograms (110 lb.) of pure uranium. However, the uranium obtained was seldom pure, so a large amount would be needed. Robert Oppenheimer said that the required supercritical mass would be about 100 kilograms (220 lb.). Uranium resources were very rare so the bomb would have to be simple and guaranteed to work. The luxury of a test model would not be available.

Because uranium is more fissionable, the bomb would be based on a gun-type detonator. Basically, a section of uranium would be shaped with a center section missing. The center section, a perfect fit, would be place away from the large uranium mass. A conventional explosive would be used to propel the center section into the large section. Both sections would then weld together and start the reaction. This bomb was what is known as an altimeter bomb. An altimeter is a device that can determine the height from the surface of the Earth by measuring air pressure. Basically, the bomb would explode above the ground. The section of land immediately below the center of detonation was know as the hypocenter. The areas of destruction caused by the bomb will be discussed later.

"Fat Man" - The Plutonium Bomb

Plutonium was more challenging to use because it was not as fissionable as uranium. The first major obstacle in designing this bomb was to determine what the supercritical mass for plutonium would be. Richard Feyman and Hans Bethe had calculate the supercritical mass to about 16 kilograms (35.2 lb.). However, it was calculated that this mass could be reduced to 10 kilograms (22 lb.) if the plutonium was surrounded by the U-238 isotope [Dyson, 1997]. This was a major discovery since plutonium was limited and U-238 was not.

In order to start the chain reaction, the mass of plutonium must be fused together while a radioactive source emitted a neutron. The way the bomb was design was that a Beryllium/Polonium mixture, radioactive elements that release neutrons, would be placed in the center of a sphere. The sphere would be made up of equally spaced and shaped plutonium sections. The sphere looked a lot like a soccer ball. When the bomb was detonated, the sphere would implode, or collapse inward, causing all the plutonium to fuse together, reach supercritical mass, and start the chain reaction. The initial explosion, which caused the implosion, would be made by conventional explosive. All this would occur in a fraction of a second (about one ten-millionth). This bomb was also an altimeter bomb. Both bombs had many safety options to guarantee the success of the detonation as well as the safety of the delivery crew.

Common Safety Features In Both Bombs

Both bombs had additional safety features like lead shields, fuses, and neutron deflectors. A lead shield basically protects the people and the bomb's mechanisms from the radioactivity of the uranium and plutonium. The radioactivity could easily short circuit the bombs electronic devices and could easily poison the people around the bomb. Fuses were used as a guard against premature explosion of the nuclear elements and the conventional explosives. The fuses would be installed just minutes before the bombs were launched. Neutron deflectors were made up of uranium-238. These deflectors had two purposes. In the uranium bomb, the deflectors would keep stray neutrons from the center section away from the larger mass. If the deflectors were not used, critical mass could be reached. In the plutonium bomb, the deflectors help the plutonium pieces (comprising the soccer ball) from losing their neutrons by reflecting the stray neutrons back. Uranium-238 was used because it was not fissionable, it was great at reflecting neutrons, and it was available in large quantities.

After all the theory and designing, many questions still remained about the plutonium bomb. The implosion part of the bomb was never used before; even the brightest minds could not guarantee its success. The only way to know if the plutonium bomb would work would be to test it.

The Trinity Test Site

After years of hard work and theoretical calculations, the scientists were ready to see if their bomb would work. The scientists were confident that the uranium bomb would work; however, there were too many unknowns in the plutonium bomb. The biggest question came from the implosion, would the bomb work or would it be a dud? Kenneth T. Bainbridge was appointed the test director. Planning for the event began almost eight months prior. The first step was to find a suitable test site. Many sites were considered, but Bainbridge selected an isolated section of land near Alamogordo, New Mexico. The valley, between the Rio Grande river and the Sierra Oscura mountains, was called the Jornada del Muerto. It was Oppenheimer who chose to code-name the test Trinity [Fermi, 1995].

Several events took place that would cause great controversy before the test. One major event was the death of President Roosevelt in April; President Truman would be taking office and would have to be update. The project was so secret that President Truman was not notified about its existence until he took the oath of office. Another event that affected the test was the surrender of Germany in May. Even though the war with Japan was still continuing, the scientists were beginning to have doubts on whether the bomb should be used [Fermi, 1995].

The scientists were too wrapped up in the technical questions, that they ignored the philosophical ones. The test would proceed as scheduled. Gen. Groves had approved the test the bomb so that President Truman would attend the Postsdam meeting with Stalin and Churchill knowing the results. The terrain to the test site was a major obstacle. However, bumpy roads, scorpions, and rattlesnakes were the least of their problems. Nobody really new what the radioactive fallout would be. A test would be conducted using 100 tons of TNT and a certain amount of radioactive material in order to calibrate measuring equipment as well as test radioactive fallout. The military would now be prepared to evacuate farms if the explosion went wrong. Gen. Groves was also very worried that if the project did not succeed, precious and valuable plutonium would be wasted. Even though there was more plutonium than uranium, plutonium was still very hard to obtain. The test would have to be perfect.

Figure 7. Trinity test taken 10,000 yards away, 0.025 seconds after detonation. [Fermi, 1995]

Against the advice of the army meteorologist, Jack Hubbard, Gen. Groves scheduled the test for July 16, 1945. Thunderstorms during the night before postponed the test for several hours. Anxiety ran high. It was recorded that Fermi upset Gen. Groves by wondering out loud if the explosion would ignite the atmosphere. At 4 A.M., the scientist began to turn on their measuring devices. The observers, located 10,000 yards north of the blast, were ordered to lie flat, face down on the floor. Everybody ignored the order. Welder glasses and suntan lotion were used for protection in order to see the explosion. Over a hundred thousand photographs were taken of the explosion to guarantee its documentation [Fermi, 1995]. Figure 7 is one of the many pictures taken during the test.

"The explosion was equivalent to about 20,000 tons of TNT."

During the explosion, Fermi tore up several pieces of paper and threw them into the air. He was so busy trying to measure the shock wave that he did not even hear the loud noise the bomb made [Fermi, 1995]. Soon after the explosion, Fermi went out on a lead line tank to inspect the damage. The explosion was much more powerful than they had originally expected. The explosion was equivalent to about 20,000 tons of TNT.

The land under the explosion was divided into section of destructiveness. Up to half a mile radius from the hypocenter was called the vaporization point (98% fatalities, bodies were either missing or burned beyond recognition). Everything is destroyed in this area. Temperatures almost immediately rise to 3000° to 4000° C. Up to a 1 mile radius was called the total destruction zone (90% fatalities). All the buildings above ground were destroyed. Up to a 1.75 mile radius was called the severe blast damage area (65% fatalities, 30% injuries). Large structures collapsed and damage was done to bridges and roads. Rivers were even known to flow counter-current. Up to a 2.5 mile radius was known as the severe heat damage area (50% fatalities, 45% injuries). Everything in this area had some kind of burn damage. Most of the people killed in this area were suffocated because the oxygen was used up by the fires. Up to a 3 mile radius was known as severe fire and wind damage areas (15% fatalities, 50% injuries). Homes and other buildings are damaged. People were blown around and suffered 2nd and 3rd degree burns, if they survived. The power of the bombs was inhumane and questionable. The results of the two bombs used in warfare will be examined in the next section.

Previous Title Page UER Contents Next

The Manhattan Project

Ethical Debates Concerning the Use of the Atomic Bomb

As the Manhattan Projected made advances more expenditures became necessary including the construction of plants and secret bases across the United States. Early stages of development met with relative success and good fortune and led to politicians' decisions to expand the project. Eventually, questions began to be raised in Congress over the legitimacy of expenditures. The US Secretary of War, Henry Stimson, suggested to President Roosevelt that prosecution for anti-trust violations of two key companies in the Manhattan Project be set aside for the time being [Stoff, 1991]. All these incidences suggest that the massive expenditures on the development of the bomb, certain executive decisions, and the fact that it was all kept secret from Congress and the American public would lead to political troubles for the President and high ranking officials. This is supported by the director of the Office of War Mobilization James Byrnes's memo to the President on March 3, 1945 where he states that "if the project proves a failure, it will lead to relentless investigations and criticism" and "(a)n unfavorable finding would at least indicate the need for further justification by those who are responsible for the project" [Stoff, 1991]. To avoid embarrassing investigations, the Manhattan Project had to be a success and would lead to the assumption that the bombs would be used. However, keep in mind that Germany had surrendered in May of 1945, three months before the bombs were used. Arguments for and against the use of the bombs in warfare will be examined, followed by the decisions and consequences made during the war.

Arguments For The Use Of The Bomb

An important argument for the use of the atomic bomb was the distrust of the Soviet Union by the British and eventually the Americans. The British distrust is demonstrated in a memo of a meeting between the US and the UK on July 22,1943 where Winston Churchill states that "it would never do to have Germany or Russia win the race for something that might be used for international blackmail" [Stoff, 1991]. Both of these countries feared that the USSR might try to expand its influence after the war, and neither of them wanted to see the USSR with atomic power or wanted to lose their advantage in postwar negotiations. The US and UK were right about the USSR's aims at expansion. Concern over Russian expansion was mentioned in Stimson's diary entry on July 23, 1945 where he writes about Russian concerns for influence in the Pacific and present expanding influence in Eastern European countries [Stoff, 1991]. This fact really made the US want to keep the USSR from entering the Pacific Theater and be able to influence the postwar outcome there. Again, this was another factor that meant the atomic bomb would have to be dropped if it would result in shortening the war and keeping the USSR out of the Pacific.

By 1945, the US had the Japanese forces on the run. The planned invasion of Japan is discussed in the President's meeting on June 18, 1945 with the Joint Chiefs of Staff [Stoff, 1991]. In this meeting, the fanatical resistance of the Japanese is discussed along with the decision to continue with the "operation" before the planned assault on November 1 and to wait for the Japanese response. US leaders were uncertain when the Japanese would surrender, but they all agreed that eventually they would have no choice. The US knew of the "Japanese maneuverings for peace" on July 16, 1945 but wanted an unconditional surrender from the Japanese and presented them with the terms of surrender in the Proclamation of the Postsdam Conference [Stoff, 1991]. The Japanese did not want to lose their emperor and wanted it instilled as a condition of their surrender. In fact, many Japanese leaders had made the decision to end the war by May 1945 but were trying to convince the Japanese military leaders and to hold out for their condition for surrender. Unfortunately, Radio Tokyo broadcasted that Japan would not surrender and continue to fight on July 28, 1945 and had not responded to the Allies terms for surrender [Stoff, 1991].

This did not help curb the decision to drop the bomb since the US seemed to want to end the war as fast as possible for political reasons. On August 6, 1945, "Little Boy" exploded about 1,750 to 1,900 feet above the city of Hiroshima. The target was the Aioi Bridge, but it missed by 550 feet. On August 9, 1945, "Fat Man" exploded about 1,650 feet above the city of Nagasaki. This bombed missed by over a mile, but it still destroyed half the city. A section title Aftermath will be dedicated to these two bombings. On August 11, 1945, Japan surrendered but only because they were allowed to keep their emperor [Stoff, 1991]. Japan had entered their surrender through the Swiss Government which relayed the message to the US Government. Because of the third party involvement and negotiations, Japan officially surrendered on August 15, 1945.

Arguments Against The Use Of The Bomb

The second major challenge that occurred was due to the scientists that produced the bombs were now against its use. Many scientists argued to the end that the bomb should not be used for ethical reasons. They also warned of an arms race that would develop after the end of WWII. The different opinions were given in The Franck Report on June 11, 1945 which includes Glen Seaborg (who is a Nobel Laureate and the only living man named after an element) and Leonard Szilard. Politicians did not listen. Byrnes makes the decision to have scientists pursue the invention of the more powerful hydrogen bomb. In Stimson's letter and memo to the President on September 11, 1945, Stimson admits that "feverish activity on the part of the Soviet toward the development of this bomb in what will in effect be a secret armament race of a rather desperate character. There is evidence to indicate that such activity may have already commenced" [Stoff, 1991]. The Cold War started in this fashion because the scientists were right about the consequences of not trusting the Russians.

The major struggle took place in the form of the Franck Report that urged President Truman not to use the bomb without a demonstration where Japanese observers could see first hand the power of the bomb. This would allow the Japanese the opportunity to surrender without the using the bomb on their island. The Franck Report was chaired by J. Franck, G. T. Seaborg, L. Szilard, and others. Unfortunately, the project was now out of scientific hands and now it was a military issue. During an interview, Seaborg said that a possible reason why the US did not demonstrate the bomb was because there would not be enough uranium or plutonium to produce another bomb. Szilard, along with Albert Einstein, was responsible for starting the project. Einstein even said, "I made one great mistake in my life - when I signed that letter to President Roosevelt recommending that atom bombs be made, but there was some justification - the danger that the Germans would make them" [Kraus, 1996]. Szilard, along with 69 other scientist from the project's Metallurgic Laboratory (MetLab), wrote a letter protesting the use of the bomb to President Truman. Unfortunately, the letter was no use; President Truman would continue to support the bombings. Szilard and others continued to protest its use but never succeeded. In 1962, Szilard established the Council for a Livable World, a Washington lobby group involved in nuclear arms control and foreign policies. He was also involved in establishing the civilian control of the Atomic Energy Commission in 1946.

Not all scientists were against the use of the bomb. In a report by A. H. Compton, E. O. Lawrence, J. R. Oppenheimer, and E. Fermi titled "Recommendations on the immediate use of nuclear weapons", Oppenheimer wrote for the panel, "we can purpose no technical demonstration likely to bring an end to the war; we see no acceptable alternative to direct military use" [Stoff, 1991]. Many scientists felt that the US was not attacking Japan, but it was defending itself from a country who attacked the US first, remember Pearl Harbor. However, many of these scientists did oppose the use of the second bomb so quickly. They felt the US should have waited longer for Japan to surrender.

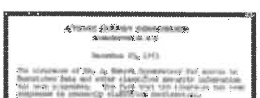


Figure 8. Consequences of Oppenheimer's advocacy for nuclear weapons control [Manhattan, 1997].

After the war and the end of the project, Oppenheimer began to regret the discovery of nuclear weapons because his main rival, Edward Teller, began working on the Hydrogen Bomb. The Hydrogen Bomb used the principle of fusion, which made it even more powerful than the fission bombs. Oppenheimer's regrets are seen throughout the Manhattan Project. After the Trinity Test, Oppenheimer turned to a technician and said in a sober voice, "I have become Death; the destroyer of worlds." Another colleague turned towards Oppenheimer and said, "Now we're all sons of bitches." By 1946, the Atomic Energy Commission was established under civilian control and Oppenheimer was chairman of the General Advisory Committee. This committee gave more than technical advice, it had a lot of influence over decisions [Kraus, 1996]. Oppenheimer was very out spoken about the United Nations gaining more control over nuclear development. This controversy caused many people interested in military policy to fear Oppenheimer. In 1952, Oppenheimer faced the Gray Board hearings were he was accused of being sympathetic to the communists. Oppenheimer's hearing occurred during the Joseph McCarthy era when everyone feared communists, so Oppenheimer lost his security clearance [Kraus, 1996]. Figure 8 shows a section of a letter to the Atomic Energy Commission about Oppenheimer's security clearance revocation.

Neils Bohr became an advocate for the peaceful use of this new found power. In 1950, Bohr published a letter to the United Nations in which he pleaded for a world without nuclear weapons. He dedicated the remainder of his life to speaking against the negative uses of nuclear research [Kraus, 1996].

Decisions And Consequences

President Truman ordered two atomic bombs to be used during World War II. This small section cannot do justice to the effect and the impact the bombings had on the people of Japan. I do hope that this section can put into perspective the destructive force of the bombs.

On August 6, 1945, a B-29 "Flying Fortress" named the Enola Gay dropped the uranium bomb known as "Little Boy" over the city of Hiroshima. It missed the Aioi Bridge, its target, by 550 feet. The explosion was equivalent to 18,000 tons of TNT. Even though the bomb missed, the power of the explosion destroyed the bridge as well as the city. Instantly, 66,000 people were killed and over 69,000 people were injured [Dyson, 1997]. The story does not end there. Due to the radioactive fallout, many more people died. By the end of 1945, it was estimated that 140,000 people died in Hiroshima as a result of the explosion [Fermi, 1995]. Radiation was a major factor after 1945. Between 1946 and 1951, over 60,000 people died from radiation related illnesses. Unfortunately, the US decided to drop a second bomb three days later.

On August 9, 1945, a second B-29 "Flying Fortress" named the Bock's Car dropped the plutonium bomb known as "Fat Man" over the city of Nagasaki. This mission was plagued with problems. This plane took off with a small fuel tank. There were several clouds over Nagasaki, making targeting difficult. With no fuel left and a break in the clouds, the decision was made to drop the bomb. It missed by over a mile. The bomb still managed to destroy half the city as well as the near by mountains. Even though the plutonium bomb was more powerful than the uranium bomb, casualties were less because the bomb missed. Instantly, 39,000 people were killed and over 25,000 people were injured [Dyson, 1997]. However, radiation poisoning had only begun. By the end of 1945, it was estimated that 70,000 people died in Nagasaki because of the explosion [Fermi, 1995].

Previous | Title Page | UER Contents | Next

The Manhattan Project

Conclusions and Recommendations

In the end, I believe that the use of the atomic bomb and the decisions made during its development were like a double-edged sword. I agree with the comment that the Japanese would have surrendered before November 1, 1945 that was made in Stoff's book. This means that the Soviet Union would most likely not have had much influence in the Pacific after the war. Japan is an island with limited resources, and the naval blockades were strangling the nation. The atomic bomb might have prevented the immediate and extensive Soviet influence in the postwar Pacific, but we still witnessed several nations turn to communism and come under the umbrella of the Soviet Union. The research into the atomic bomb was necessary because Germany was doing the same. Germany, the major atomic threat, surrendered in May 1945. Because Japan did not have any atomic weapons, I do not believe it was necessary to use the bomb.

"When the US dropped the bomb, we lost the moral superiority over Japan"

The loss of innocent lives at Hiroshima and Nagasaki is inexcusable. I can comprehend the loss of soldiers and adults aiding the war effort during a battle, but the murder of children is never justified. President Truman agrees with this idea as seen in his comment made on August 10, 1945 where it is written about his order to halt all other plans for use of atomic weapons on Japan because "(h)e didn't like the idea of killing," as he said, "[especially] all those kids" [Stoff, 1991]. These murders stained America's image. Peace efforts were already underway with Japan and should have received full attention and given a chance before the bombs were dropped. In Stimson's memo and letter to the President on July 2, 1945, he states the current situation of Japan and that "Japan is susceptible to reason in such a crisis to a much greater extent than is indicated by our current press and other current comment" [Stoff, 1991]. When the US dropped the bomb, we lost the moral superiority over Japan that Stimson talked about in this letter.

The Cold War that resulted after WWII led to massive expenditures of resources by both nations. These expenditures had benefits because our economy experienced many booms from the defense industry and saw the invention of revolutionary new products. Recently, we have seen the Soviet Union crumble and realized that containment policies worked and the US triumphed, but was it worth the murder of the civilians and children in Nagasaki and Hiroshima? I would say no.

The following two quotes best summarizes the problems with science and irresponsibility. First, I will start with Robert Oppenheimer, scientific director of the Manhattan Project, who said, "It is a profound and necessary truth that the deep things in science are not found because they are useful; they are found because it was possible to find them" [Rhodes, 1986]. I believe too many times, scientists are too busy asking themselves if they can do something, and forget to ask themselves if they should do it. As long as science exists, these ethical debates will take place like the present day controversy of cloning sheep, cows, and possibly humans. Science must start taking responsibility for their actions.

The second quote is by General Omar N. Bradley, Chief of Staff, United States Army, who said in 1948, "We have too many men of science, too few men of God. We have grasped the mystery of the atom and rejected the Sermon of the Mount . . . The world has achieved brilliance without wisdom, power without conscience. Ours is a world of nuclear giants and ethical infants. We know more about war than we know about peace, more about killing than we know about living." The Manhattan Project changed all of our lives. It changed the history of mankind and civilization. The ultimate lesson learned is that scientists, and ultimately citizens, must taken responsibility for their action. Science should be use for the improvement of our lives and not for our destruction.

Previous Title Page UER Contents Next

The Manhattan Project

Appendix: Key Figures in the Manhattan Project

Figure 1. From left: Neils Bohr, Robert Oppenheimer, Richard Feyman, Enrico Fermi [Manhattan, 1997]

"We were aware of what it might mean if they beat us to the draw in the development of the atomic bombs"

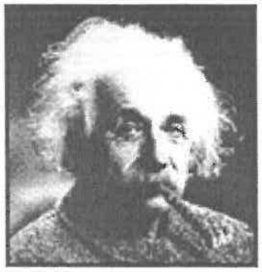
Even before its entrance into the war, the United States had become very concerned with the threat of the Axis powers. Franklin D. Roosevelt received a letter from Albert Einstein on August 2, 1939, which he paid special attention to it. In his letter, Einstein said that a new field of physics had opened up the possibility of, "the construction of bombs... extremely powerful bombs of a new type" [Stoff, 1991]. Atomic bombs would be capable of inflicting massive damage on an enemy installation. Einstein also said that, "Germany had actually stopped the sale of uranium from Czechoslovakian mines" and "in Berlin...some of the American work on uranium is being repeated" [Stoff, 1991]. Einstein's last statements were of the most concern to Roosevelt and led him to create a committee to investigate the feasibility of designing and building atomic weapons. On March 9, 1942, Vannevar Bush reported to the President in a letter that the bomb would be more powerful and more easily delivered to a target [Stoff, 1991]. He also emphasized that the US would become involved in a race with its enemies in development of this new weapon. Concern over Germany developing the atomic bomb before the US was also reflected in the scientific community. These concerns are best illustrated in Oppenheimer's autobiographical sketch where he states, "(w)e [scientists] were aware of what it might mean if they [Germans] beat us to the draw in the development of the atomic bombs" [Stoff, 1991]. Roosevelt responded to Bush's letter and decided to pursue this project with full speed and with the utmost secrecy. The fact that Germany had been pursuing atomic weapons was enough to get the project started, keep it going, and have it placed under the utmost secrecy.

Many of the scientists, like Einstein and Szilard, involved in the project were responsible for getting it started. However, the Manhattan project involved a large array of physicists, chemists, and military and civilian personnel. It would be impossible to include everyone involved. In my discussion, I will only focus on some key figures of the project. Figure 1 is a photograph of four of the scientists responsible for developing the atomic bomb.

Albert Einstein, left, and Leo Szilard

Leo Szilard

During April of 1933, Adolf Hitler passed the first anti-Jewish law that stripped "non-Aryan" scientists of their post, causing over 100 physicist to flee Germany [Rhodes, 1986]. Szilard was one of these scientist who relocated to England. It was in England where Szilard conceived the idea that a nuclear chain reaction was possible. In 1935, he was part of the discovery of gamma ray induced emission of neutrons from a radioactive source such as beryllium. In 1938, Szilard came to the United States and learned about the discovery of fission. From the above paragraph, you could see that Szilard was convinced that the United States had to become involved in a very expensive and dangerous race to study fission. Since he was not well known in the United States, he seeked the help and the fame of Albert Einstein. Together, they wrote a letter to President Roosevelt and asked for research money in order to study fission. On December 2, 1942, Szilard and Enrico Fermi achieved the first controlled chain reactor at the University of Chicago [Kraus, 1996]. The Manhattan Project was started soon after that. Szilard would be a key force in the protests against the use of the bombs.



Albert Einstein

With the help of Leo Szilard, Einstein convinced President Roosevelt that Germany may be using uranium and fission research to create a new type of super bomb. His arguments are best seen in the introduction of this section. Einstein helped the United States to begin the same type of research of uranium and fission that was occurring in Germany. It was not until the day after the Pearl Harbor attack, December 6, 1941, that substantial funds were allocated to the research. These funds allowed Enrico Fermi to achieve the first controllable chain reaction [Kraus, 1996]. Einstein was never officially part of the Manhattan Project, but he was one of the scientists responsible for getting it started (and later for protesting the use of the bombs).

Glen Seaborg

Seaborg was a chemistry professor at the University of California, Berkeley. He, along with graduate student Arthur C. Whal and fellow chemistry instructor Joseph W. Kennedy, discovered the element plutonium. They discovered the isotope Plutonium-238 (P-238), but they later produced the isotope Plutonium-239 (P-239), which was fissionable and a likely atomic bomb. Seaborg also developed a process for separating weapons-grade plutonium from uranium in nuclear reactors [Borman, 1995]. Seaborg was never officially involved in the program, but his discoveries led to the plutonium importance in the project.

Neils Bohr

Bohr was one of the most important figures in nuclear theory. He was the first person to say that the nucleus of an atom is 1/10,000 the size that it was suspected to be. It was his "droplet model" theory that paved the way for fission. Basically, this theory stated that if a neutron hit the heavy nucleus of an atom, a fission reaction might be initiated. Bohr also fled from Jewish persecution in Germany. Once in the United States, Bohr completely outline the require process of neutron emission. One of his most famous discoveries was that the rare isotope Uranium-235 (U-235) was fissionable and that the common isotope Uranium-238 (U-238) was not [Kraus, 1996]. This discovery led to the Manhattan Project's breakthrough that the tiny fragments from the result of fission could release neutrons. During a *fission* chain *reaction* , it was formulated that a large amount of energy could be released.

Richard Feyman

Feyman, born in New York, was a brilliant physicist and mathematician. He accelerated in differential and integral calculus. He attended MIT to pursue physics, and later, went to Princeton for Graduate School. It was

during his graduate studies, at the age of 24, that he was asked to join the Manhattan Project. He teamed up with Hans Bethe, his mentor, to figure out key mathematical equations such as the amount of fissionable material needed to achieve an explosion ["Manhattan," 1997]. One of his talents was the ability to solve equations quickly in his head. Together, Feyman and Bethe discovered a shortcut to solving third order equations [Kraus, 1996]. Interesting side note, Feyman was asked by NASA in 1985 to determine the cause of the Space Shuttle Challenger's explosion. He shocked NASA and the world when he said it was because of a faulty O-Ring ["Manhattan," 1997].

Enrico Fermi

Fermi began his career with the study of physics in Italy. He decided to switch his area of research to nuclear physics because he believed the next important advances would be made by studying the nucleus. He decided to leave Italy in 1938, after winning the Nobel Prize, because of increasing tension with Germany. Fermi moved to New York where Bohr began to update him on the progress of fission. Fermi immediately began to research fission because he saw the possibility of the emission of neutrons as the start of a chain reaction [Kraus, 1996]. On December 2, 1942, he produced a controllable chain reaction which was the foundation of the atomic bomb. He then moved to New Mexico where he worked on the Manhattan Project.

J. Robert Oppenheimer

Oppenheimer graduate summa cum laude from Harvard with a degree in chemistry. He completed this four year degree program in only three years. He pursued a graduate studies program at Cambridge University, Cavendish Laboratory, but quit soon after because he experienced a nervous break down. Oppenheimer received his Ph.D. in 1927 from German Gottigen University in theoretical physics. He moved back to the United States to convey his new discoveries of physics ["Manhattan," 1997]. After hearing about Bohr's discoveries and fission, he began to think of use for the energy released during this reaction. In the summer of 1942, Oppenhemier organized a conference in Berkeley, California where top physicist discussed the possibility of an atomic bomb. In 1943, he became the scientific director for the Manhattan Project. Oppenheimer was involved with every step of the project. He became an advocate for nuclear arms control.

General Leslie Groves

In early 1942, Groves was the deputy to the chief of construction for the Army Corps of Engineers and was in charge of the construction of the Pentagon, the world's largest office building [Seidel, 1997]. Groves wanted his next project to be overseas, but instead, he was assigned to head a top secret weapons project. He tried to get reassigned, but his attempts were unsuccessful. However, Groves took on the weapons project and was determined to make it work. He renamed the project "The Manhattan District" (later shorten to The Manhattan Project) because it was customary to name new districts after the leader of the project's, Colonel James Marshall, headquarters. Marshall was in charge of building all the facilities required for the project. The project was also renamed because its original title "Development of Substitute Materials" gave away to much information. Groves' aggressive management style and determination were key factors to the success of the Manhattan Project.

After the US was committed to develop an atomic bomb, the Manhattan Project was created to organized all the scientific minds and resources. All the scientists above had different backgrounds as well as different areas of expertise. The project could now use its scientists to conquer any obstacle or challenge that was encountered while developing the atomic bomb.

Previous Title Page UER Contents

The Manhattan Project

Glossary

Critical Mass: The exact amount of material needed to sustain a fission chain reaction.

Fission: A reaction in which a neutron causes the nucleus of an atom to split in two fragments. This reaction also causes the release of energy as well as more neutrons.

Fission chain reaction: A chain reaction occurs when the neutrons released during fission cause other nuclei to split and release more neutrons. The process is repeated; large amounts of energy are released during this reaction. A chain reaction is like a domino system where the first domino knocks down two dominos and each of those dominos knocks down two more dominos, etc.

Fissionable: Material, like the isotopes Uranium-235 and Plutonium-239, that are unstable and can undergo the fission reaction.

Fusion: A second type of nuclear reaction where nuclei combine to form a large nucleus. During this reaction, energy is also released.

Implode: Collapse inward (opposite of explode). Implosion is caused when explosives are detonated on the outside of an object, which causes a shockwave to travel inward and crush the object.

Isotope: The name given to atom that has acquired or lost one or more neutrons from its nucleus. The atom's structure is relatively the same, but the added or subtracted weight may cause the atom to have new properties (such as being fissionable).

Plutonium-239: P-239 is a man-made and unstable isotope of plutonium, discovered by Glen Seaborg. It also has the capability of undergoing a fission chain reaction.

Supercritical: When the amount of fissionable material is greater than the amount needed to sustain a fission chain reaction., the result is a large amount of energy, because of the excess material, which causes an explosion.

Uranium-235: U-235 is a rare and unstable isotope of uranium ore. It has the capability of undergoing a fission chain reaction.

Title Page UER Contents

The Manhattan Project

Glossary

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Title Page | UER Contents