The Making of the Atomic Bomb Study Guide

The Making of the Atomic Bomb by Richard Rhodes

BOOKRAGS

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Introduction

The Making of the Atomic Bomb, by Richard Rhodes, was first published in 1987. For this detailed documentation of the development of the most destructive war weapon ever to be created, Rhodes received widespread recognition, winning the 1987 National Book Award, the 1988 Pulitzer Prize for General Nonfiction, and the 1988 National Book Critics Circle Award for General Nonfiction.

Rhodes provides extensive information on the biographical background and scientific accomplishments of the international collaboration of scientists that culminated in the creation of the first atomic bomb. In 1939, several scientists became aware of the theoretical possibility of creating an atomic bomb, a weapon of mass destruction vastly exceeding the potential of existing military arsenals. But it was not until the United States entered World War II, late in 1941, that priority was given to funding and organizing research into the creation of such a weapon in a secret operation referred to as the Manhattan Project.

The first test atomic bomb, called Trinity, was exploded in the New Mexico desert on July 16, 1945. On August 6, an atomic bomb was dropped on the Japanese city of Hiroshima. Three days later, another atomic bomb was dropped on the Japanese city of Nagasaki. On August 14,1945, Japan agreed to an unconditional surrender to the Allies, thus ending World War II.

Rhodes addresses the difficult moral and ethical dilemmas faced by the scientists of the Manhattan Project, particularly the implications of creating such a weapon of mass destruction. Originally concerned with "pure" scientific research, those who worked on the Manhattan Project were forced to consider the ultimate effect of their research efforts on the future of the human race.

Author Biography

Richard Lee Rhodes was born in Kansas City, Kansas, on July 4,1937, the son of Arthur Rhodes, a railroad mechanic and Georgia (maiden name Collier) Rhodes. When he was only thirteen months old, his mother committed suicide. Richard's eldest brother went to live with relatives while Richard and his brother, Stanley, who was two years older, stayed with their father. When Richard was ten, their father remarried, and their stepmother, Anne Ralena Martin, began a reign of terrifying physical and emotional abuse against the boys while their father passively looked on. After two years of deprivation, torture, and violence, Stanley sneaked out of the house to report this abuse to the police. The boys were removed from their home by state officials and placed in the Drumm Institute, a home for boys near Independence, Missouri. Although the Drumm Institute imposed strict rules upon the boys, who were also required to work at farming, Richard thrived in this environment, becoming an avidreader. In 1955, he graduated from high school with a scholarship to Yale University, in New Haven, Connecticut. He attended Yale from 1955 to 1959, graduating with a bachelor's degree in intellectual history.

Rhodes worked as a writer trainee for *Newsweek* magazine in 1959. In 1960, he married Linda Iredell Hampton and began working as a staff assistant for Radio Free Europe, in New York City. Rhodes joined the Air Force Reserve from 1960 to 1965, during which time he worked as an instructor in English at Westminster College, in Fulton, Missouri, (from 1960 to 1961) and found work as an editor. Rhodes became book editing manager for Hallmark Cards in Kansas City, Missouri, from 1962 to 1970. He was a contributing editor to *Harper's* magazine from 1970 to 1974. He divorced Linda in 1974 and began working as a contributing editor for *Playboy* magazine in Chicago from 1974 to 1980. In 1976, he married Mary Magdalene Evans, whom he later divorced. Rhodes became a contributing editor for *Rolling Stone* magazine, in New York City, from 1988 to 1993. During this time, he was also a visiting fellow in the Defense and Arms Control Study Program at Massachusetts Institute of Technology (1988-1989), and a visiting scholar in the History of Science Department at Harvard University. Although Rhodes had been a severe alcoholic for thirty years, he was inspired to quit drinking by his love for Ginger Untrif, who became his third wife.

Plot Summary

The Scientists

Rhodes describes extensively, up to World War II, the lives and work of an international community of scientists, mostly physicists and chemists, whose work eventually culminated in the making of the first atomic bomb. Theories of the existence of atomic particles date back to Greek philosophy in the fifth century B.C., and, by the seventeenth century A.D. most scientists assumed the existence of the atom. However, no actual proof of the existence of the atom had been formulated until J. J. Thomson discovered the electron in 1897. In 1884, Thomson was chair of the distinguished Cavendish Laboratory at Cambridge where he exerted tremendous influence on a generation of scientists. Einstein's revolutionary theory of relativity was announced in 1915. Leo Szilard, a Hungarian-born Jewish theoretical physicist, entered the University of Berlin in 1921, where he collaborated with Einstein. Ernest Rutherford was a New Zealand born British physicist credited with inventing nuclear physics (also called atomic physics). Rutherford studied under Thomson at the Cavendish Laboratory, replacing Thomson as head of the lab in 1919. Rutherford's most significant accomplishment was the development of a theory of atomic structure called the Rutherford atomic model.

Niels Bohr, a Danish physicist, made significant advances with his formulation of the Bohr atomic model. In 1921, Bohr became director of the Institute for Theoretical Physics in Copenhagen, which, under his direction, soon gained an international reputation as a leading center for research on quantum theory and atomic physics. Bohr broke new ground in the application of quantum theory to the study of atomic and molecular particles. Robert J. Oppenheimer, an American theoretical physicist, studied atomic physics under Rutherford at the Cavendish Laboratory. In 1927, Oppenheimer took a post in physics at The University of California at Berkeley and the California Institute of Technology. In 1932, James Chadwick, an English physicist who worked with Rutherford at the Cavendish Laboratory, discovered the neutron. Otto Hahn, a German chemist who was working with Fritz Strassmann, discovered nuclear fission. The Italian physicist Enrico Fermi conducted important research on nuclear fission at the University of Rome.

When Hitler came to power in Germany in 1933, many of Europe's greatest physicists emigrated in order to flee Nazi persecution, several of them settling in the United States. Szilard emigrated to London, where he first conceived of the possibility of creating an atomic bomb, and later settled in the United States, taking a post at Columbia University. Einstein, in particular danger of Nazi persecution due to his international prominence, fled to the United States, where he took a post at the Institute for Advanced Study at Princeton University, in New Jersey. In 1938, Fermi, under the pretext of traveling with his family to Sweden to receive his Nobel Prize, fled fascist Italy, eventually settling in the United States. Meitner fled Nazi Germany in 1938 to settle in Sweden, where she continued her research with her nephew Otto Frisch. After Nazi

Germany invaded Denmark, at the outbreak of World War II, Bohr and his family fled to England and then the United States.

The Manhattan Project

Upon reaching New York in 1939, Bohr alerted Einstein to the possibility of Germany developing an atomic bomb. Along with several colleagues, Bohr persuaded Einstein to write a letter to President Franklin D. Roosevelt, suggesting that the United States initiate research into the development of an atomic bomb before Germany developed one. However, government officials failed to comprehend the enormity of the implications of these new developments, as explained by several brilliant scientists. It was not until the bombing of Pearl Harbor in December of 1941 that the United States entered World War II, at which point the possibility of creating such a military weapon appeared more relevant to government and military officials. The result was the organization in May of 1942 of the secret Manhattan Project, which included several teams of American and British scientists conducting research at such disparate sites as the University of Chicago and Los Alamos, New Mexico. Other locations where scientists were working on the Manhattan Project were the University of California at Berkeley, Columbia University in New York City, and Oak Ridge in Tennessee. It came to be called the Manhattan Project because of the location of the new government office organizing the project, known as the Manhattan Engineer District Office. (The Los Alamos site, however, is most commonly associated with the Manhattan Project.) On July 16, 1945, the first test atomic bomb, named Trinity, was successfully exploded on an air base in Alamogordo, New Mexico. In the meantime, scientists in Great Britain, Germany, Japan, and Russia were coming to the same conclusions about the possibility of creating an atomic bomb. However, several factors discouraged efforts by these nations to develop such a bomb.

Hiroshima and Nagasaki

On April 12, 1945, President Roosevelt died, and Vice President Harry S. Truman was sworn in as president of the United States. Up to that point, Truman had only a vague idea of the goals of the Manhattan Project; he was quickly informed of the significance of its efforts. In May 1945, Germany surrendered to the Allies. Peace negotiations were initiated at the Potsdam Conference, held in a suburb of Berlin, from July 17 to August 2, 1945. President Truman of the United States, Prime Minister Winston Churchill of Great Britain, and Premier Joseph Stalin of Russia, known collectively as the Big Three, were the leading figures in these negotiations. The War with Germany concluded, the Allies sent a message from Potsdam to the Japanese government, calling for unconditional surrender. When Japan refused to surrender, the United States dropped the first offensive atomic bomb on the city of Hiroshima, Japan, on August 6, 1945. The bomb, nicknamed Little Boy, had been carried in a modified B-29 bomber called Enola Gay, flown by Colonel Paul Tibbets. Although the Japanese Emperor Hirohito was willing to surrender, the Japanese military was unyielding, as a result of which the United States dropped a second bomb, nicknamed Fat Man, on the city of Nagasaki, on

August 9. Japan immediately surrendered to the Allies. Both Japanese cities were utterly devastated by the bombs. Hiroshima, with a population of about 350,000, suffered the deaths of 140,000 people as a result of the bombing. Two-thirds of the city was demolished in the explosion. Of Nagasaki's 270,000 residents, some 70,000 died as a result of the bombing, and half of the city was demolished. After the war, the United States began work on developing the more powerful hydrogen bomb.

Chapter 1 "Moonshine"

Chapter 1 "Moonshine" Summary

In this Pulitzer Prize winning book, author and historian Richard Rhodes summarizes the lives, decisions, and scientific discoveries involved in making the atomic bomb the United States dropped on Hiroshima and Nagasaki, in Japan, to end the horrible bloodshed of World War II in the Pacific. The book is written after the fact, from the historian's detailed point of view. The author discusses concerns about potential consequences of a multi-national arms race. He intermixes details of scientific discoveries making construction of the bomb possible. He discusses world history and geography, the events of World War II, the process of making the atomic bomb and reasons for using the bomb. Rhodes also highlights the practicalities involved, with detailed biographies of some of the scientists. Some of the biographies have been shortened for this analysis.

In 1933, Leo Szilard, a thirty-five-year-old Jewish Hungarian theoretical physicist, walks through London and imagines the future. Szilard's friend, H.G. Wells, publishes *The Shape of Things to Come*. In 1928, Szilard traveled from Berlin to London to meet Wells and bid for the Central European rights to Wells' tract, *The Open Conspiracy*, describing a public collusion of science-minded industrialists, and financiers, who establish a world republic.

Szilard studies engineering in Budapest until drafted. He receives a leave of absence from the Army to care for his brother and catches the Spanish flu. World War I ends, and he enrolls in the University of Berlin, where the physics faculty includes Nobel laureates Albert Einstein, Max Planck, and Max von Laue. Szilard determines physics is his real interest, and he introduces himself to Albert Einstein and convinces Einstein (who rarely teaches) to conduct a seminar on statistical mechanics. Planck, who studies radiation, has discovered a universal constant. Max von Laue founds the science of X-ray crystallography. Szilard returns to a Berlin full of intellectuals, film stars and journalists. Ludwig Mies van der Rohe designs his first glass-walled skyscraper in postwar Berlin. Yehudi Menuhim, the world famous American child prodigy violinist, debuts, with Einstein in the audience. Fyodor Vinbert, a former Russian officer, is also in Berlin, promoting *The Protocols of the Elders of Zion,* which he personally introduces into Germany. This is a pseudo-Machiavellian, patently fraudulent fantasy of world conquest openly advocating violent destruction of the Jews. The German currency is steeply devalued and banks pay out cash withdrawals by weight.

In three weeks, Szilard solves a baffling inconsistency in thermodynamics, the branch of physics that concerns relations between heat and other forms of energy. He takes it to Einstein, and this becomes Szilard's Ph.D. thesis. Szilard loves inventing. Between 1924 and 1934, he applies to the German patent office individually or jointly with Einstein, for twenty-nine patents, mainly dealing with home refrigeration theory. Szilard also develops the cyclotron, a device for accelerating nuclear particles in a circular magnetic field. Szilard patents it, but Ernest O. Lawrence produces a working model, for which he wins the 1939 Nobel Prize in Physics.

During the 1920's, Szilard studies nuclear physics, the study of atomic nuclei and their energy. British physicist Ernest Rutherford demonstrates that nuclei of some light atoms can be shattered by bombarding them with atomic particles. Most nuclei are strongly positively charged and repel attacking particles. In 1932, James Chadwick of Cambridge confirms the existence of a neutron. Since the neutron has no atomic charge, it will pass through the nucleus' surrounding electrical barrier and open the atomic nucleus for examination.

Szilard reads Wells' book, "The World Set Free," that same year. This prophetic novel, published in 1914, discusses the development of atomic bombs and a world war fought among groups of national powers. Szilard moves to the German Kaiser Wilhelm Institute to work on nuclear physics with Lise Meitner. Adolph Hitler becomes Chancellor of Germany on January 30, 1933. In March, Jewish judges and lawyers in Prussia and Bavaria are dismissed from practice. Jewish businesses are boycotted and Jews are beaten in the streets. Szilard takes a train from Berlin to Vienna the day before the Nazis confiscate the rail system.

In April, thousands of Jewish scholars lose their positions in German universities. Szilard, now in England, helps Jewish scholars and scientists emigrate and to find jobs for them. From the newspaper, he learns that leading scientists in Great Britain are meeting, and that Rutherford denies the possibility of liberation of atomic energy on an industrial scale, calling such speculation "moonshine." Szilard imagines a mechanism whereby more energy might be released in the neutron's bombardment of the nucleus than the neutron itself supplies. This would create a chain reaction. He needs an element which, if split by a neutron, would emit two neutrons. Szilard has conceived the *atomic bomb*.

Chapter 1 "Moonshine" Analysis

Leo Szilard, his history, scientific discoveries, and concerns about the future of the world, continue throughout this book. He is a main character and a brilliant scientist with quite legitimate worries about the possibility of a future nuclear arms race once an atomic bomb is constructed. The intermixing of scientists and world history helps the reader keep matters in perspective as the scientists continue their work under increasingly adverse conditions in Europe. Note that Szilard envisions the atomic bomb that Ernest Rutherford calls "moonshine," his term for "nonsense." The activities of the scientists and Adolph Hitler's rise to power enforcing anti-Jewish policies provide continuing conflict throughout the text, as most of the nuclear scientists flee Europe for Britain and the United States. The reader must imagine the creative brilliance of science fiction writer H. G. Wells, who so vividly envisioned the future.

Chapter 2 "Atoms and Void"

Chapter 2 "Atoms and Void" Summary

Isaac Newton envisions atoms as small billiard balls. In 1873, the Scottish physicist James Maxwell decides atoms do not exist. By 1894, atoms are useful in chemistry to explain why certain substances (elements) combine to make other substances but cannot be broken down. Ernest Rutherford, of New Zealand, discovers radio waves in 1893 and moves to Cambridge in England to develop his findings. One month after Rutherford arrives at Cambridge, German physicist Wilhelm Roentgen discovers X-rays. Englishman J. J. Thompson discovers the electron. When electrons are stripped away from a nucleus, it leaves a massive, positively charged remainder - the proton. In 1900, Rutherford reports his discovery of a radioactive gas emanating from thorium. Marie and Pierre Curie discover that radium (purified from uranium ores) gives off a radioactive gas. In 1911, Rutherford dissects the atom. Rutherford wins the 1908 Nobel Prize in chemistry and moves to Manchester, England.

Rutherford meets Chaim Weizmann, the Russian-Jewish biochemist later elected first president of Israel, who is working in Manchester on fermentation products. Rutherford's experiments required a means of counting and seeing individual alpha particles. He works with Hans Geiger to develop a counter. Neils Bohn, the Danish theoretical physicist, then twenty-seven years old, moves to Manchester for experience working with radioactivity.

Chapter 2 "Atoms and Void" Analysis

This short chapter reviews early discoveries and theories about the nature of the atom and identifies scientists, whose work continues in later chapters. While this book was obviously intended for general readership, much of the text assumes the reader has background in physics. This makes some of the chapters very tedious reading, especially, when scientific theories are proposed that go nowhere. If the reader skips a chapter, the reader may well miss the name of an important person not elsewhere identified for the first time or an important scientific discovery.

Chapter 3 "Tvi"

Chapter 3 "Tvi" Summary

Ernest Rutherford meets Niels Bohr, a muscular, athletic Dane, whose contributions to Twentieth Century physics rank second only to Albert Einstein's. The brilliant Bohr is always anxious and full of sell-doubts. He tries mathematics, experimental physics, and physiology. His first scientific paper is published before he receives his Master's Degree and determines the surface tension of water. Bohr receives his Ph.D. in 1911, becomes engaged to Margrethe Norland, the sister of a friend, and starts work at Cavendish Laboratory at Cambridge. Rutherford, working at Manchester, speaks at Cavendish and recruits Bohr for research in radioactivity in Manchester. Bohr becomes friends with the young Hungarian radio-chemist, George de Hevesy.

Bohr learns radiochemistry from de Hevesy and realizes that the chemical properties of elements depend on the number and distribution of electrons in their atoms. He sets out the order of elements on the *periodic table* for the first time. He continues to work on his model of the atom, marries Margrethe, and teaches at the University of Copenhagen. They retreat to the country, where Bohr writes paper "On the constitution of atoms and molecules," which he mails to Rutherford. This paper changes the course of physics wins Bohr the 1920 Nobel Prize.

Bohr uses the works of Max Planck and Albert Einstein to confront problems with Rutherford's model of the atom. Classical mathematics predicts Rutherford's model of an atom with a small, massive central nucleus surrounded by orbiting electrons is unstable. It is not. Bohr suggests that classical mechanics is inadequate to describe atoms and will have to yield to Planck's quantum approach. Nothing about Rutherford's design of the atom justifies its stability, so he redesigns and redefines the atom and publishes a controversial paper in 1913 entitled, "On the constitution of atoms and molecules."

Chapter 3 "Tvi" Analysis

This chapter contains a long biography of Neils Bohr, which, while interesting, provides too much information for a book about the making of the atomic bomb. The brilliant Dr. Bohr created the periodic chart of elements. The chapter title comes from writings of the Danish philosopher Soren Kierkegaard, who died in 1855.

Bohr's reading of Kierkegaard caused him to see the world as black and white, either/or, making him always full of doubts. This moral conflict foreshadows that of many scientists, whose discoveries make the atomic bomb possible and will haunt Neils Bohr for life.

Chapter 4 "The Long Grave Already Dug"

Chapter 4 "The Long Grave Already Dug" Summary

Kaiser Wilhelm II, Queen Victoria of England's oldest grandson, dedicates the Kaiser Wilhelm Institutes in Berlin in 1912. Otto Hahn, a first rate radio-chemist, starts work there. In 1907 he meets Lise Meitner from Austria, the second woman in history to earn a Ph.D. at the University of Vienna, who has published two papers on alpha and beta radiation. They become friends and collaborators. Max Planck appoints her to an assistantship for financial support. Hahn and Meitner move together to the Kaiser Wilhelm Institute in 1912 to research radioactivity.

In 1913, Niels Bohr and his young wife return to England, when Harry Moseley and C. G. Darwin determine how to use X-ray spectroscopy to study the nature of the atom. In September, the Rutherfords and the Bohrs attend the annual meeting of the British Association in Birmingham, England. Marie Curie comes from France. Bohr learns that Einstein is deeply impressed with his paper and his theories that, if right, would be one of the greatest discoveries ever. Harry Moseley's work confirms Bohr's theory of the atom.

When World War I begins, Niels Bohr and his wife travel from Denmark to Manchester, England. Chaim Weizmann, the Russian born Jewish biochemist and Rutherford's friend, then at Manchester, is a passionate Zionist. He admires British democracy, so he severs ties with the international Zionist organization which hates Czarist Russia, then England's ally. He believes that the Western democracies will win the war and that Jewish destiny is with them. Weizman, his wife and young son are in Switzerland, when World War I begins. In Paris they visit Baron Edmond de Rothchild, the financial mainstay of pioneering Jewish settlements in Palestine. Weizmann's childhood was in an impoverished western area of Russia set aside for Jews, the "Pale of Settlement." As a scientist, Weizmann discovers an anerobic organism that decomposes starch. He plans to make synthetic rubber. Instead he finds a mash that creates ethyl alcohol, acetone, and butanol. The British Admiralty, Winston Churchill as First Lord, needs acetone for cordite, a propellant for in heavy artillery. English, Scottish, and Irish distilleries make acetone. When the Germans shut down the shipping of American corn, the British use horse chestnuts. Prime Minister David Lloyd George wants to honor Dr. Weizman, who wants nothing for himself. He wants a national home for Jews in Palestine. This "Balfour Declaration" commitment is a letter from Arthur Balfour to Baron Edmond de Rothschild stating that the British will favorably view a national home for the Jewish people in Palestine and work to accomplish it.

World War I turns into a stagnant war of opposing trenches near Ypres. The Germans use caustic and asphyxiating chlorine gas, contrary to the terms of the Hague Declaration of 1899. Otto Hahn, a lieutenant in the infantry reserve, helps install 5,730 chlorine cylinders. Hahn goes to German-occupied Brussels to work with Fritz Haber on gas warfare to end the war sooner. The Germans' massive chemical industry is far ahead of the Allies in production of chemicals for gas warfare. The Germans use phosgene, which is quite toxic and evaporates slowly, and causes more than 80 per cent of the war's gas fatalities, chlorpicrin, a cheap compound of picric acid and bleaching powder, and mustard gas against their enemies The French retaliate with cyanide. Fritz Haber's wife, a chemist and his childhood sweetheart, demands that he abandon gas work as barbaric and perverted. He refuses, and Clara Haber commits suicide.

The Allied campaign at the Turkish Gallipoli Peninsula begins in 1915. The Turks resist, backed by the Germans. After much bloodshed, this war also deteriorates into trench warfare on both sides. Churchill is expelled from the War Cabinet. The Germans use oversized biplanes called "Gothas" to bomb England. The Kaiser makes London a bombing target. The Germans develop bigger planes and a magnesium incendiary that cannot be put out with water. The British develop air operations. The United States makes a vast war-gas arsenal in less than a year. The British turn to artillery and machine guns, the basic slaughtering tools of the war, invented by Americans. Machine guns mechanize war. The sides retreat again into trench warfare - "the long grave already dug" (John Masefield's ironic phrase, page 103) until a new machine, the tank, ends the stalemate. The Americans reinforce the British and World War I ends.

Chapter 4 "The Long Grave Already Dug" Analysis

The horrors of World War I illustrate why Britain and other countries were reluctant to engage Hitler immediately. They had just fought the Germans once and won, with terrible casualties and weapons of war. This chapter also illustrates how hostilities escalate once war begins. The reader will note that this increase of violence happens again in World War II and should consider the effect of World War I's atrocities on British Prime Minister Neville Chamberlain's efforts to appease Hitler rather than rush into war.

Chapter 5 "Men from Mars"

Chapter 5 "Men from Mars" Summary

Budapest, Hungary, thrives during the early 1900's. It has the first European subway, connecting Budapest with its suburbs. The city of Pest is a center of banking, brokering, and lucrative trading in grain, fruit, wine, beef, leather, timber, and industrial production. Jews make up five per cent of the Hungarian population in 1910. They create Hungary's capitalization and industrialization boom. Jewish families own 37.5 of Hungary's arable land. By 1920, Jews make up 50.6 per cent of Hungary's lawyers, 53 percent of its commercial businessman, 59.9 of its doctors, and 80 percent of its financiers. The only other significant middle class is the bureaucracy of poor Hungarian gentry that vies with the Jews for political power. The Jewish commercial elite allies with the old nobility and the monarchy, creating a large class of ennobled Jews.

George de Hevesy's prosperous maternal grandfather, S. V. Schossberger, in 1863, becomes the first unconverted Jew ennobled since the Middle Ages. In 1895 de Hevesy's entire family is ennobled. Mor Karman, who founds the celebrated Minta school, reorganizes the haphazard Hungarian school system along German lines and takes control of education from the religious institutions that have long dominated it. The prospering Hungarian Jewish middle class produces seven of the 20th Century's most exceptional scientists: Theodor von Karman, George de Hevesy, Michael Polanyi, Leo Szilard, Eugene Wigner, John von Neumann, and Edward Teller. All leave Hungary as young men. De Hevesy and Wigner win Nobel prizes.

The mystery of such a concentration of ability from remote and provincial Hungary fascinates the scientific community, which spreads rumors that these men were really visitors from Mars. They cannot speak without an accent that will give them away, so they claim to be Hungarians, whom nobody can understand, anyway. These are brilliant scientists, who leave Hungary because of the lack of scientific opportunity and increasingly violent anti-Semitism. These young men displayed their brilliance as children. At age six, Von Karman multiplies six figure numbers in his head. Von Neumann jokes with his dad in classical Greek and demonstrates his photographic memory. Edward Teller is late to talk but begins with complete sentences. Teller reads science fiction (Jules Verne) where he learns of the possibilities of man's unlimited improvement. In the 1890's, Szilard, Teller, and von Karman, attend the same school and study physics. Wigner and von Neumann attend a Lutheran school. Von Neumann's mathematical brilliance is such that he becomes the youngest member of the Princeton Institute for Advanced Study in 1933.

Chapter 5 "Men from Mars" Analysis

This fascinating chapter provides a detailed historical background of several brilliant Jewish Hungarian nuclear scientists later involved in making the atomic bomb. This historical analysis helps the reader understand why these scientists were so reluctant to leave their homeland, when they were forced out by Hitler's policies and illustrates the excellence of their early schooling.

Chapter 6 "Machines"

Chapter 6 "Machines" Summary

With Sir Ernest Rutherford's as Director, the Cavendish Laboratory at Cambridge, England, becomes the center for experimental physics after World War I. There, in 1919, he announces that *he* has split the atom. Rutherford and his co-workers disintegrate other light atoms until they hit a barrier -- the naturally radioactive sources. Americans develop particle acceleration at Berkeley, California. Ernest Orlando Lawrence, the man, who later founds big-machine physics in America, comes to Berkeley in 1928, one year before Robert Oppenheimer. They know that protons can be accelerated by generating them in a discharge tube and then repelling or attracting them electrically, but they cannot confine the million volts of electricity necessary to penetrate the electrical barrier of the heavier nuclei. Norwegian Rolf Wideroe invents an accelerator tube that will avoid the high-voltage problems. Lawrence calculates the size of the tube he needs to be two miles long and designs an efficient spiral accelerator. Oppenheimer and Lawrence become friends. Oppenheimer designs the chamber that produces Lawrence's needed 80,000 volt protons, the first working *cyclotron*.

In 1920, Ernest Rutherford suggests existence of the neutron. James Chadwick and Hans Geiger, among others, work with Rutherford to prove it. Scientists at Marie Curie's Radium Institute in France make it the world's largest source of radioactive polonium. Chadwick continues to work until he proves the neutron is the third basic constituent of matter. Since the neutron carries no electrical charge, the electrical barrier of the nucleus does not block its entrance. The neutron will be a new nuclear probe of surpassing power of penetration. The discovery of the neutron in 1932 is hailed as the beginning of true nuclear physics.

Chapter 6 "Machines" Analysis

The author covers more detailed scientific discoveries in this 34 page chapter. He tends to throw out names of scientists without significant further identification, i.e. James Chadwick and Rolf Wideroe in this chapter. The scientific details included, along with detailed drawings, are of interest to those with a background in physics. All chapters must be read to follow the chain of character identifications and interactions later in the book. The author does not provide a separate chart or brief biography summarizing what each significant person contributed to nuclear research. Scientific discoveries are roughly in chronological order.

Chapter 7 "Exodus"

Chapter 7 "Exodus" Summary

Albert Einstein is in Berlin in 1919, when he becomes an international celebrity. At age forty-three, he is in the first rank of theoretical physicists and has been nominated for the Nobel Prize in all but two years since 1910. He is still young, with a massive, heavily muscled body, dark mustache, and thick black hair beginning to gray. His loud laugh is thought rude by his enemies. In the past year, he suffered through a stomach ulcer, jaundice, and a divorce, lost and gained 56 pounds, and watched his mother die of cancer. His dark brown eyes provide comfort and honesty for his visitors. In 1919, his theory of relativity is proven through studies during an eclipse of the sun. German physicists are upset that a Jewish physicist should receive such attention and plan to boycott Einstein's lectures at Berlin University. He speaks anyway, and the Germans rudely interrupt him.

The Committee of German Scientists for the Preservation of Pure Scholarship attacks Einstein's relativity theory as a Jewish corruption and Einstein as a tasteless self-promoter. Einstein considers renouncing German citizenship and leaving, as he has before.

Einstein and his second wife Elsa leave on a trip to the Far East, and he receives notice of his Nobel Prize en route. By the time he returns to Berlin, the Germans are more preoccupied with economics than politics. The Einsteins continue to travel abroad. When they return to Germany, anti-Semitism is strong in Berlin and rampant in Munich, where Adolph Hitler drafts his party's platform in the cramped office of the German Workers Party. Hitler's "Beer Hall Putsch" results in his jailing. He writes *Mein Kampf* and details his hatred of Jewish people.

A strange forgery called *The Protocols of the Elders of Zion* appears and becomes Hitler's text for world domination. It provides the secular myth and structure Hitler needs for his anti-Semitic plans. This book was concocted by the head of the Czarist secret police in Paris, who borrows and paraphrases Machiavelli's speeches in a French work of political satire, *Dialogues from Hell Between Montesquieu and Machiavelli* (published in 1864), without changing their order, and attributes it to a secret Jewish council. It is in the form of lectures that begin in mid-sentence. While much of the book is incoherent, the *Protocols* elaborate three main themes: an attack on liberalism, the political methods of the Jewish world conspiracy, and an outline of the world government the Elders expect soon to install. As Hitler uses the text, the Elders want to establish a world autocracy ruled by a male leader. He finds a basis for his pathological fear and hatred of the Jews and determines that it will be easy to take the world from the Jews, who rule the world with a small, unarmed group

In 1933, Adolf Hitler, age forty-three, becomes Chancellor of Germany. The Nazis assume total power and move to legalize anti-Semitism and abolish the rights of

German Jews. At first the scientists dismiss his proposed dictatorship as rubbish and do not take Hitler seriously. The Third Reich promulgates its first anti-Jewish ordinance on April 7. This law strips a quarter of the physicists of Germany, including eleven who had or would earn Nobel Prizes, of their positions and income. The scientists leave Germany to survive. Einstein and the older Hungarians have already left. Theodor von Karman, who pioneered aeronautical physics, goes to the California Institute of Technology. Einstein is hired by the Princeton Institute for Advanced Study, where he will not have to teach. By mid-March 1933, Einstein removes his furniture and papers from Berlin and renounces his German citizenship again.

Princeton University takes in John von Neumann and Eugene Wigner in 1930. Leo Szilard in Berlin wants to stay and fight the Nazis. He goes to work with Lise Meitner at the Kaiser Wilhelm Institute and leaves Berlin. Pauli is in Zurich. By now the University of Berlin and the University of Frankfurt have lost at least a third of their faculties. The promising young theoretical physicist Hans Bethe learns of his dismissal from Tubingen University from a student and then reads it in the paper. Bethe becomes an assistant professor at Cornell in 1935. Edward Teller, both Jewish and not a German citizen, goes to Copenhagen to work with Neils Bohr. Bohr is traveling throughout Germany to determine who needs help to leave. The young scientists and scholars as yet unpublished and without international reputation need organized support. Leo Szilard goes to Vienna to talk with Sir William Beveridge, director of the London School of Economics. Beveridge agrees to find places for the academic victims of Nazism and takes Szilard with him to London. The Academic Assistance Council is headed by Ernest Rutherford and includes such men as A.E. Houseman and John Maynard Keynes.

In the United States, John Dewey assembles a Faculty Fellowship Fund at Columbia University. The major U.S. effort is the Emergency Committee in Aid of Displaced German Scholars. Szilard beats the bushes that summer as a volunteer traveling and working to coordinate existing groups and start new ones. Einstein wants to create a university for exiles. The Bohrs coordinate their own efforts with Szilard's. Bohr convenes his summer conference in Copenhagen, but it is an employment meeting. Bohr places Teller at University College in London. As the Depression eases, immigration increases to the United States. About one hundred refugee physicists go to the United States between 1933 and 1941. His first night in the United States, Hans Bethe walks all over New York City. A chemist, Kurt Mendelssohn, remembers waking up the morning after his escape. He has slept long and soundly, having gone to bed in London without fear that the SS men would come for him at 3:00 a.m.

Chapter 7 "Exodus" Analysis

The author provides fascinating historical details about the Jewish people and their migrations, Albert Einstein's life, Hitler's rise to power in Germany, and the considerable difficulties involved in getting Jewish scientists from Europe to safety in other countries. It is hard to believe that a known forgery, *The Protocols of the Elders of Zion,* becomes the basis for Hitler's *Mein Kampf,* and the reader should be cautious about so stating without further research.

Chapter 8 "Stirring and Digging"

Chapter 8 "Stirring and Digging" Summary

George Gamov sees the Solvey Converence in Brussels in 1933 as his means of escape from Russia, rapidly becoming inhospitable to theoretical physicists, and both he and his wife Rho attend en route to America. The Conference is devoted to nuclear physics. Those attending include Marie Curie, Rutherford, Bohr, Lisa Meitner, Heisenberg, Pauli, Enrico Fermi, Chadwick, Gamow, Irene and Frederick Joliot-Curie, Patrick Blacket, and Rudolf Peierls. Ernest Lawrence is the token American. They debate the structure of the proton. The Joliots have discovered how to make matter radioactive by artificial means, which is confirmed by the new Geiger counter. Marie Curie, Irene's mother, is overjoyed that they have demonstrated artificially forcing the nucleus to release some of its energy in radioactive decay.

Leo Szilard, now in London, becomes obsessed with chain reactions. He files patent applications on inducing a chain reaction and creating artificial radioactivity. This idea encourages Enrico Fermi and his team in Rome. Fermi completes his a fundamental paper on beta decay and begins actual neutron bombardment experiments. He marries Laura Capon, daughter of a Jewish naval officer. His experiments take place in the basement of the physics institute in Rome. He enlists other physicists, and they begin to experiment with uranium. Leo Szilard applies for a patent for the "liberation of nuclear energy for power production and other purposes through nuclear transmutation" including a chain reaction and describes critical mass as the "volume of a chain reacting substance necessary to make the chain reaction self-sustaining" (page 214) on July 4, 1934, the day Marie Curie dies. He asks to use the radium at St. Bartholomew's Hospital for experiments. He teams with T. A. Chalmers to separate iodine isotopes by bombarding a compound with neutrons. Oxford now considers Szilard an expert in nuclear physics.

Chapter 8 "Stirring and Digging" Analysis

The author expands on widening European hostility towards the Jewish intellectuals and their families. Leo Szilard patents the nuclear chain reaction in England. Such patents will be re-negotiated later in the book during the actual making of the atomic bomb. The reader again learns of the scientific discoveries and work performed by these nuclear experts, some of whom are not further identified. Development of the chain reaction is proceeding simultaneously in several European countries as the scientists freely write papers and exchange information.

Chapter 9 "An Extensive Burst"

Chapter 9 "An Extensive Burst" Summary

In the 1930's, Lise Meitner, Otto Hahn, and Fritz Strassman, working in Germany at the Kaiser Wilheim Institute, try to sort out the elements created, when neutrons bombard the heaviest natural elements. In the midst of Meitner's work, Hitler occupies Austria, making Meitner a German Jew, and her grant is abruptly withdrawn. Meitner flees to Holland on an old passport and continues to Copenhagen and the Bohrs. Neils Bohr finds her a position and the Nobel Foundation provides a grant. Leo Szilard is also looking for a patron in the United States in 1938. He meets Jewish financier Lewis Lichtenstein Strauss, a partner at a New York investment-banking house and a self-made millionaire, who became aware of the acute shortage of radium for cancer treatment after both parents die from cancer. Szilard, working at St. Bartholomew's Hospital to break up beryllium with X-rays, agrees to give Strauss his interest in a patent to produce radioactive cobalt in quantity for hospitals as a memorial to Strauss' parents.

Mussolini joins Hitler and starts his anti-Semitic campaign in Italy. He declares that Jews are not humans. Italian Jews have been largely assimilated into the general population. Fermi is Catholic, and the Fermi's two children might be exempted, but his wife Laura is Jewish. Fermi accepts a professorship at Columbia and goes to Copenhagen to Bohr's annual meeting. There Bohr's tells him he will have the Nobel Prize in 1938 if he wants it. Bohr will use the money to take his family to the United States.

Neville Chamberlain meets with Hitler and agrees that Czechoslovakia should cede to Germany all areas where the population is more than 50% German. Hitler tells Chamberlain that this is the last of his territorial ambitions. The Czechs and French mobilize their armies. Chamberlain, French Premier Edouard Daladier, Mussolini and Hitler meet at Munich on September 29 and agree to Czech evacuation of the Sudentenland (part of Czechoslovakia that Hitler wants) within 10 days. Hitler and Mussolini discuss Italian participation in the planned invasion of Britain. Chamberlain returns to Britain, reads the joint declaration from the Prime Minister's window to the crowd below, and concludes, "I believe it is peace in our time." (page 246) Future Prime Minister Winston Churchill is disgusted at this surrender to the Nazi threat of force.

Hahn and Strassman continue their experiments with slow neutron bombardment of uranium, finding they have created radium (element 88,) thorium (element 90,) and actinium (element 89.) Fermi buys his wife a fur coat and stuffs the lining with expensive watches and other valuables that did not have to be registered. The evening news reports additional limitations on the civil status of Jews in Italy. While the passports of Jews have already been marked, Fermi has kept his wife's clear. The German *Kristallnacht*, the night of glass, has taken place the night before. A Jewish student assassinates the third secretary of the German Embassy on November 7, instigating a general German anti-Semitic riot. Mobs torch synagogues, destroy business and stores, drag Jewish family from their homes and beat them in the street. The plate glass shattered across the Germany and Austria equals half the annual production of Belgian glass. The German secret police arrests 30,000 wealthy Jewish men and packs them into concentrations camps at Buchenwald, Dachau, and Sachsenhausen, for ransoming by their families. Not all are.

The Fermis leave for Stockholm to receive the Nobel Prize. Lise Meitner is alone and miserable in Sweden. Hahn and Strassman continue their work at the Kaiser Wilhelm Institute to isolate uranium isotopes. Otto Frisch is in Copenhagen, his mother is in Vienna, and his father is incarcerated at Dachau. Frisch and Meitner go for a walk and theorize the division of a nucleus. They use Einstein's famous equation, *E = mc2* to calculate the mass of a proton released by such division. They understand the energy issues but can not imagine a chain reaction.

In Germany, Frisch uses a cloud chamber to look for atom fragments that would prove the nucleus has split. He finds them. He receives a telegram that his father has been released from concentration camp. His parents will move to Stockholm and live with his aunt, Lise Meitner. The next day, William A. Arnold and George de Hevesy observe Frisch's experiments. Frisch calls the division process "fission." Bohr sails to the United States. He decides that the atomic nucleus' splitting into two parts is a question of probabilities. Two fragments were greatly more probable than many. At Princeton, Bohr writes a paper to *Nature* giving credit for fission to Meitner and Frisch. Szilard learns of uranium's fission during a visit to Princeton. He immediately envisions the possible chain reaction. Szilard talks to Fermi about secreting this information from the Germans.

The scientists meet at a Washington conference in 1939. Bohr announces that a neutron can split uranium. Fermi's presentation is more elegant and informative, revitalizing the possibility of atomic power. Robert Oppenheimer reads the materials and decides that fission is real. He then draws a crude plan for an *atomic bomb* on his blackboard. Fermi also concludes the bomb is real.

Chapter 9 "An Extensive Burst" Analysis

As more respected European nuclear scientists leave the countries ruled by Hitler and Mussolini, work continues on nuclear fission until Otto Frisch (in Germany) proves the nucleus has split. Lise Meitner, Frisch's aunt, is now in exile in Stockholm, Sweden. The theoretically resulting nuclear chain reaction makes production of the atomic bomb possible. The true genius of Robert Oppenheimer is seen, when he reads their reports and draws a crude model of the atomic bomb. The reader should remember that everything beyond Frisch's cloud chamber is still theory in the minds of the nuclear scientists, including Bohr, Szilard, Fermi, and Oppenheimer.

Kristallnacht is commemorated by Jewish communities worldwide on November 9th or 10th as the Night of the Broken Glass. The assassination incident was used by the German Nazi leaders to launch their violent, organized attack against German Jews. Nazi storm troopers and secret police went on a rampage through Jewish neighborhoods in Germany and Austria, breaking into Jewish homes and businesses and smashing the windows. They entered synagogues, set them on fire, and destroyed sacred Torah scrolls. This event and date is widely acknowledged as the start of the Holocaust.

Chapter 10 "Neutrons"

Chapter 10 "Neutrons" Summary

Leo Szilard, sick with a cold in January 1939, is determined to prevent news about a chain reaction in uranium from reaching German physicists. He talks with his friend, Isador Isaac Rabi, Nobel laureate in physics in 1944, who tells him Fermi discussed the possibility of a chain reaction at Washington the week before. Rabi talks with Fermi, who discounts fission in natural uranium. Szilard cables Oxford to ship him the cylinder of beryllium he left at the Clarendon so he can do his own neutron-emission experiment. He convinces Lewis Strauss to become his patron. Szilard must rent radium to combine with his beryllium and needs financial support.

Szilard meets with the Tellers in Washington to discuss keeping nuclear fission secret from the Nazis. Szilard also talks with Eugene Wigner at Princeton. Neils Bohr, at Princeton, talking with colleagues, abruptly understands fission and draws charts for thorium's changing response to bombardment by neutrons of increasing energy, for U238, and for the uranium isotope U235. Both thorium and U238 theoretically fission with "fast neutrons," but U235 will fission if hit by slow neutrons. When U238 absorbs a neutron it becomes a nucleus of odd mass number - U239, and accrues energy toward fission because of this change of mass. Any neutron at all, slow or fast will fission U235. U238 requires the energy of a fast neutron before it will fission, because its fission energy threshold requires that amount of energy. Bohr publishes his findings in *Physical Review*. Left unanswered is the question of what will happen if U235 and U238 are separated. Szilard pursues a chain reaction in natural uranium.

Vannevar Bush, President of Carnegie Institute, a New England Yankee, inventor and former dean of the engineering school at MIT, is reluctant to invest in chain-reaction experiments. Fermi and Szilard continue on their own. Szilard finds abundant neutron emission in beryllium. Hitler threatens to bomb Prague, Czechoslovakia, which becomes a German protectorate. Wigner, Szilard, and Fermi meet with George Pegram in his New York office. The scientists want to tell the U.S. Government of their discoveries. Pegram, Associate Professor of physics at Columbia, brought Einstein, Rabi and Fermi to that University. He knows the Undersecretary of the Navy. Pegram calls Washington and gets Fermi an audience with Admiral Hooper, assistant to the Chief of Naval Operations. This will be the first direct contact between nuclear physicists and the United States government. Wigner and Szilard return to Princeton to meet with Niels Bohr. They want Bohr to join their plan to keep American progress secret and isolate German nuclear physics research from their information. Bohr is torn by the need to shape physics into a model international community and the growing menace of Nazi Germany. He speaks of the doom of Europe in apocalyptic terms.

The next afternoon, Fermi goes to the Navy Department for his appointment with Admiral Hooper and several others. He speaks for over an hour about neutron physics. The Navy will remain in contact. The French group publishes a paper in *Nature* about chain-reaction possibilities of uranium. Scientists in Berlin read the article too and contact the German War Office. Hans Geiger pursues atomic research in Germany.

American nuclear physicists discuss and argue about which uranium isotope to use for a chain reaction and how to separate them. Fermi works on a chain reaction in natural uranium. Debate continues on the nature of the "moderator," the substance that slows down neutrons and allows control of the chain reaction. Water is proposed first. Szilard wants to use carbon. If carbon is unsuitable, the next guess is "heavy water," and they will need a few tons of this scarce and expensive liquid. Szilard writes Fermi about layering uranium and carbon. If a chain reaction will work in graphite (carbon) and uranium, the Americans can produce a bomb. Szilard realizes he cannot save the world. Nazi scientists must have come to the same conclusions.

Szilard talks with Teller and Wigner. Wigner believes they must inform the Roosevelt administration and atomic fission and keep the Belgium government from selling uranium to Germany. Szilard remembers Albert Einstein has met Queen Elizabeth of Belgium, and Einstein is summering on Long Island. Wigner and Szilard drive to Einstein's residence and present the possibility of a chain reaction. Einstein sees the implications and will assume responsibility for sounding the alarm. He wants to write a friend in the Belgium cabinet. The three decide to send a letter through the U.S. State Department. Einstein dictates a letter in German.

Szilard's friend Gustav Stolper has talked with Dr. Alexander Sachs, vice president of the Lehman Corporation. Dr. Sachs is the economist, who wrote Roosevelt's economic speeches and is his personal friend. Sachs hears Szilard and decides they must tell Roosevelt. He will take a letter to the President. Szilard prepares a second draft letter for Einstein to sign. Teller again drives Szilard to Einstein's house on Long Island in his 1935 Plymouth. Einstein proposes that the letter be delivered to the President by the financier Bernard Baruch, or the President of MIT, Karl T. Compton, as possible alternatives. Szilard takes the letter in English to Sachs along with his own memorandum. The scientists still hope for world government and world peace, conditions they imagine atomic bombs might enforce. Hitler invades Poland and World War II begins. Britain and France declare war on Germany on September 3. Roosevelt appeals to the warring countries not to bomb civilians. Roosevelt is too busy that week to meet with Sachs.

The German War Office consolidates German fission research under its authority. Hans Geiger, Walther Bothe, Otto Hahn, and others are pressed into research service. Heisenberg presents two ways to harness fission's energy and the Germans plan to layer uranium and a moderator - heavy water. The War Office takes over the Kaiser Wilhelm Institute of Physics which is equipped and well-funded. The German atomic bomb project begins.

Alexander Sachs goes to Washington the next week to meet with Roosevelt. He presents the first authoritative report on the possibility of the atomic bomb and recommends obtaining uranium supplies from Belgium. Roosevelt does not want the Nazis to blow up the U.S. He sets up a committee consisting of the director of the

Bureau of Standards (the nation's physics laboratory with Dr. Lyman J. Briggs as director) an Army and a Navy representative. Briggs sets the first meeting of the Advisory Committee on Uranium for October 21 in Washington. The attendees include Briggs, an assistant, Sachs, Szilard, Wigner, Teller, Roberts, Adamson for the Army, and Hoover for the Navy. Szilard presents the possibility of a chain reaction in a uranium-graphite system. Wigner supports him. Sachs participates actively and enthusiastically. Teller supports Szilard. Commander Hoover asks how much money they want, catching Szilard by surprise. He says $6,000 for the graphite, which he gets. The Uranium Committee's report for the President is read and kept "on file." The war is still a European war.

Chapter 10 "Neutrons" Analysis

While Rhodes provides an extensive biography of Albert Einstein and discusses the importance of his letters to President Roosevelt, he never provides the reader with a copy of any of Einstein's four letters dictated in German, translated into English, typed by Leo Szilard and Edward Teller, and returned to Einstein on Long Island for his signature. Einstein is not sufficiently fluent in English to write in English. This is a remarkable event - two well-known nuclear physicists taking dictation from Albert Einstein, translating his words into English, typing the letters on a manual typewriter, and returning them to him for signature. The letters are available on the Internet using search terms, "Einstein's letters to Roosevelt."

The reader should note that while President Roosevelt immediately understands the importance of the atomic bomb, Dr. Lyman Briggs, the government's chief physicist, does not, and keeps putting important correspondence from the scientists in his safe. Vannevar Bush's role continues through several chapters. At this time there is a viable German atomic bomb project.

Chapter 11 "Cross Sections"

Chapter 11 "Cross Sections" Summary

Before the war begins, Otto Frisch (in Hamburg, Germany) would run experiments by day and think about physics into the night. He feels war coming in 1939 and is depressed. In Copenhagen, his aunt Lise Meitner, worries about her isolation in Stockholm, and Frisch worries about his vulnerability. Mark Oliphant, who directs the physics department at the University of Birmingham, hires him as auxiliary lecturer. In the safety of Britain he thinks about physics again and is intrigued by fission. He considers Bohr's theoretical work as the German's invade Poland. Two staff physicists are developing the cavity magnetron, an electron tube that can generate intense microwave radiation for ground and airborne radar. It's the most valuable English innovation in the war. Russia invades Finland.

Frisch reviews his research into four possible mechanisms for an explosive chain reaction in uranium. He realizes nobody has studied fast-neutron fission of U235, and he begins to calculate the amount of the isotope needed for a chain reaction. It turns out to be a pound or two. He and Rudolf Peierls roughly calculate the explosive power of such a bomb and are staggered. An atomic bomb is possible. They forward their calculations to Mark Oliphant, who is concerned that the Germans are also developing a bomb. The scientists see this as the *beginning of the nuclear arms race*.

Werner Heisenberg sends his conclusions to the German War Office in December 1939. He proposes to use heavy water or very pure graphite as a suitable moderator. Germany does not have its own heavy water plant. The only plant in the world is the Norsk Hydro-Electric Plant which produces the rare liquid as a byproduct of hydrogen electrolysis for producing synthetic ammonia. The Germans first try to buy the plant, but a French bank controls a majority interest in it. While the French are prepared to pay for the water, the Norwegians donate it to the British. Both the Russians and the Japanese also begin work towards a working atomic bomb.

Neils Bohr returns to Copenhagen to help refugees flee the coming European apocalypse. The Germans invade Norway and Denmark. The Norwegians fight back so their King, court, and parliament can go into exile. Bohr stays in Norway to burn the files of the refugee committee that helped people escape. He takes the Nobel Prize medals that Max Von Laue and James Franck gave him for safekeeping and dissolves them in acid. They sit out the war in unmarked jars on a laboratory shelf. After the war, the Nobel Foundation recasts them for their owners.

The British Uranium Committee meets but is not enthusiastic about the reports from Frisch, Peierls, and Lindemanm. Henry Tizard, Oxford chemist and chairman of the British Committee on the Scientific Survey of Air Defense, retains the second Frisch-Peierls report in *his* safe. Szilard is upset that they hear nothing from Washington. He goes to Princeton to see Einstein, and they prepare a letter for Einstein's signature. This letter is also "held" by Lyman Briggs. The Uranium Committee meets again and determines to await the outcome of Fermi's graphite measurements now that his project is funded.

Graphite bricks arrive at Pupin Laboratory at Columbia University. The physicists carry them to the seventh floor and go home at night covered with graphite. They compute how far neutrons from a radon-beryllium source set in paraffin on the floor under the graphite column would travel without the graphite slowing their progress. The farther the neutrons travel, the better the moderator. The Columbia experiments ruled out slow-neutron fission in U235 but not in U235 but not U238. Nobody notices the omission.

Edward Teller believes that Hitler will conquer the world unless a miracle happens. On May 10, 1940, Germans invade Belgium, the Netherlands, and Luxembourg with 77 divisions and 3500 aircraft. Teller decides to speak to President Roosevelt. Roosevelt speaks at the Pan American Scientific Congress in Washington, and offers absolution in advance to scientists for war work. Vannevar Bush makes a similar choice. He leaves his MIT vice presidency for the Carnegie Institute to position himself closer to the sources of government authority. His experiences with inventions in World War I convinced him of the need for proper liaison between the military and civilians in weapons development.

Bush gathers fellow scientists, including James Bryant Conant, Karl Compton and others, and they devise a national organization to do this. Bush wants independent authority with the President, and he arranges an introduction to Harry Hopkins to pitch his idea. Harry Hopkins is Roosevelt's closest adviser and aide. Bush takes his plan for the N.D.R.C. (National Defense Research Council) to the President. It immediately absorbs the Uranium Committee and eliminates Lyman Briggs from a position of authority. The NDRC gives nuclear fission research an articulate lobby within the executive branch.

Winston Churchill becomes Prime Minister of Britain the day Germany invades the Lowlands. The nuclear physicists in Britain become energized and work on isotope separation. They form a group nicknamed the "MAUD" committee from an anagram in a cable from Lise Meitner indicating that the Germans were taking all the radium they could. The war crosses the channel in the air and the Battle of Britain begins in mid-August. Neither side yet attacks civilians. On August 24, German bombers strike central London. Churchill immediately retaliates on Berlin, causing little physical damage but inciting Hitler to hysterical revenge. Radar does not exist. Hitler prizes terror as a weapon and begins the Blitz bombing of Britain.

The Germans collect radium. Heisenberg and von Weizsacker design a wooden laboratory on the grounds of the Kaiser Wilheim Institute for Biology, next to the physics institute, where they intend to build a sub-critical uranium burner. Germans has access to the world's only heavy-water factory and to thousands of tons of uranium ore in Belgium and the Belgian Congo. Germany has superb chemical plants and competent physicists, chemists, and engineers. It has no cyclotron. With the Fall of France on June 14, Germany obtains use of Joliot's cyclotron. The Germans must decide between two moderator materials: graphite and heavy water. In January, they are left with one because of miscalculations by physicist Walther Boethe, an anti-Nazi, who concludes graphite will not work. They must depend on heavy water.

Japan decides it has access to enough uranium deposits to make further study feasible, and the Imperial Army Air Force authorizes research towards development of an atomic bomb.

Leo Szilard happens on a letter from a Princeton physicist in the *Physical Review* titled "Atomic energy from U238," discussing indirect release of the fission energy of that isotope and bombardment of U235 with neutrons to produce other fissionable isotopes. Berkeley scientists are already working on this. Szilard does not realize how small a quantity of pure fissile material is needed to form a critical mass. A British team works out the computations and presents them to the MAUD Committee in 1941. Churchill sends Henry Tizard to America with the cavity magnetron developed in Mark Oliphant's laboratory and a high powered microwave generator. Laura and Enrico Fermi move from Manhattan to a Washington suburb. Segre travels to Indiana and visits the Fermis. They discuss how and whether to separate uranium isotopes. Lawrence at Berkeley opts for cyclotron irradiation. Another young Berkeley scientist, Glenn T. Seaborg, has begun work towards isolating elusive element 94. On the day that Field Marshal Erwin Rommel, commander of Germany's Afrika Korps, opens a major offense in North Africa, Seaborg and Segre isolate plutonium.

Chapter 11 "Cross Sections" Analysis

Even Otto Frisch leaves Germany to work under Mark Oliphant, who directs the physics department at the University of Birmingham, England. Oliphant will be a driving force behind the American atomic bomb project. The Germans and the Japanese have their own atomic bomb projects. Rhodes continues to mix scientific discoveries and technical information with the activities of the scientists, politics, and events of World War II. The reader should be fascinated with the scope of the combination. Of particular note is how Neils Bohr preserves 2 Nobel Prize medals for recasting by dissolving the gold in acid and leaving unmarked bottles on a laboratory shelf. They remain untouched for the duration of the war.

Walther Boethe, one of the scientists working on Germany's atomic bomb project, himself anti-Nazi, effectively sabotages Germany's plans, intentionally or accidentally, by miscalculations showing that graphite is not moderator material. It will not let them control the speed of neutrons. Germany must depend on heavy water instead, and there is no heavy water plant in Germany. It is in Norway, and it is destroyed. The ferry carrying heavy water from Norway to Germany is sunk.

Chapter 12 "A Communication from Britain"

Chapter 12 "A Communication from Britain" Summary

James Bryant Conant, President of Harvard University, goes to London in the winter of 1941 to open a liaison office between the British government and the American National Research Council, of which he is a member. He is the first American scientist of administrative rank to visit Britain. Conant has long opposed American isolationism and believes in using advanced technology in war. He lunches twice with Prime Minister Churchill, has an audience with the King, and picks up an honorary degree at Cambridge. He meets with a French scientist, who complains of inaction on uranium-heavy water research and tries to talk about fission studies.

Ernest Lawrence, now a California physicist, encourages the search for plutonium, and designs a means for uranium isotope separation by an industrial scale mass spectrometer. He pitches his plan to Conant, back from Britain, and Karl Compton and Alfred Loomis at MIT. Conant telephones Vannevar Bush, who invented and heads the NDRC (National Defense Research Council.) Compton phones Vannevar Bush that the British and Germans are ahead of the Americans in fission research. Loomis is cousin to Henry L. Stimson, the influential Secretary of War. Bush sees the scientists' reactions as a challenge to his authority. In 1940 Bush recruits Kenneth Bainbridge, a nuclear physicist, from Harvard to work on radar at MIT. He goes to London and attends a MAUD Committee meeting. The members understand critical mass and bomb assembly mechanism and think that they can create an atomic weapon in three years. Bush, pressured by Lawrence and Bainbridge, asks for help from noted nuclear scientists even though governmental authorities are still skeptical of plutonium's fissionability.

As the U.S. program bogs down in bureaucratic doubt, Hitler's war machine begins Operation Barbarossa, its invasion of Russia and opening of the Eastern front. Hitler wants to crush Russia in a quick campaign before the conclusion of the war against England, pushing to the Urals before winter to commandeer Russia's industrial and agricultural base. His armies use the same roads as Napoleon's did. The U.S. program is saved, only because Lawrence proposes to use plutonium to make a bomb. A group of British scientists has already concluded that it is feasible to make a bomb out of uranium 235. Meanwhile, Fritz Houtermans, a German experimental physicist, works with the Germans and pursues uranium research separately from Heisenberg and the War Office. By August he has worked out the basic ideas for a bomb, which he discusses in a thirty-nine page report.

Mark Oliphant pushes the American program into action. He comes to the United States from Britain to work on radar. He discovers the British reports were sent to Lyman Briggs, who put them in his safe and never showed them to his Committee. Oliphant meets with the Uranium Committee, talks about "bomb," and tells the members that

Britain does not have the money or manpower to develop it. Oliphant wires Ernest Lawrence and flies to Berkeley. After they talk, Lawrence calls Compton in Chicago to tell him that an atomic bomb will determine the outcome of the war. Edward Teller and his wife become American citizens, as does Hans Bethe. The Tellers move to Manhattan. Teller theorizes that an atomic bomb might heat a deuterium mass sufficiently to start thermonuclear fusion and works on the challenge. Teller understands the atomic bomb and moves on to develop the hydrogen bomb.

Japanese physicist Tokutaro Hagiwara of the University of Kyoto has followed world fission research with studies of his own. He understands an explosive chain reaction depends on U235 and understands the need for isotope separation. There is not yet major support in either Japan or America for an atomic bomb.

Conant pushes Lawrence to devote years of his life to development of fission bombs. Oliphant convinces Lawrence, and Lawrence convinces Compton. George Kistiakowsky, Harvard NDRC explosive expert, convinces Conant, who believes Compton's and Lawrence's attitudes count heavily with Bush. Bush carries these opinions and the British report to President Roosevelt. Roosevelt wants policy considerations limited to the "Top Policy Group" - Vice President Wallace, Secretary of War Stimson, Army Chief of Staff Marshall, Bush and Conant. This leaves the scientists with the choice of whether or not to help. Most are motivated by fear - fear of Germany's winning the war and establishing a Thousand-Year Reich made invulnerable with atomic bombs.

It is a race against time. President Roosevelt preemptively decides that the United States is committed to exploring the building of the atomic bomb. Eugene Wigner, at Princeton, clarifies for Compton the difference between fast- and slow-neutron fission and endorses Fermi's graphite system for producing uranium 94. Fermi, almost in tears, urges Compton to get the atomic program rolling. Fermi has lived in Europe and knows the Nazis well. He fears they will make the bomb first. Lawrence adds Oppenheimer to his group.

In September, German physicist Heisenberg receives the first forty gallons of heavy water from Norsk Hydro and prepares another chain-reaction experiment in an aluminum sphere filled with alternating layers of heavy water and 300 pounds of uranium oxide arranged around a central neutron source. The sphere is immersed in water in a laboratory tank. Heisenberg finds some increase in neutrons, enough to compute eventual success. He talks to Bohr and passes him a drawing of his experimental heavy water reactor at risk of his own life. Bohr reacts badly and hears only that the Germans know that atomic bombs can be built.

There is no document signed by President Roosevelt authenticating his decision to expedite research toward the atomic bomb. Roosevelt scribbles a note to Bush with "OK." The Uranium Committee meets on December 6, 1941, to reorganize work. Harold Urey will develop gaseous diffusion at Columbia. Lawrence will pursue electromagnetic separation at Berkley. Standard Oil of New Jersey will supervise centrifuge development and engineering. Comptom in Chicago will design the bomb.

Early the next day, Sunday, December 7, 1941, the Japanese bomb Pearl Harbor. Their goal is to continue their expansion into Manchuria and China with a new supply of aviation fuel, steel and scrap iron from the captured islands. They destroy the American battleships *Arizona*, *West Virginia, Oklahoma, California, West Virginia,* and *Nevada.* They sink eight battleships, three light cruisers, three destroyers and four other ships, damage 292 aircraft, kill 2,403 Americans, and wound 1,178 others in an unprovoked attack. The following afternoon, President Roosevelt addresses a joint session of Congress and receives a declaration of war against Japan, Germany, and Italy. The Japanese Commander's attack is designed to win his country six months to a year to establish its Greater East Asia Co-Prosperity Sphere and dig in. The specially modified torpedoes used were made in Kyushu, three miles from Nagasaki.

Chapter 12 "A Communication from Britain" Analysis

This chapter details the historical pushes and shoves necessary to start the American atomic bomb building project. British scientists are upset with Hitler's invasion of Russia, since that is known to be Germany's prelude to an invasion of Britain. President Roosevelt OK's the project the day before the Japanese bomb Pearl Harbor on December 7, 1941. The reader will note that the American project is jump-started by James Bryant Conant, President of Harvard, and Mark Oliphant, who directs the physics department of the University of Birmingham in England even as the war expands greatly in scope.

The German invasion of Russia fails as did Napoleon's, both caught up in the harsh Russian winter with substantial below-zero conditions.

Chapter 13 "The New World"

Chapter 13 "The New World" Summary

In 1941, Enrico Fermi's Columbia University team (Fermi, Szilard, Anderson and others) works to develop nuclear fission through a slow-neutron chain reaction in uranium while the United States Government debates funding for the atomic bomb. Scientists at Berkeley isolate plutonium. Szilard, now on the Columbia payroll, works to procure supplies of purified uranium and graphite. That summer, the Columbia team assembles the largest uranium-graphite lattice ever devised. They have yet to determine how much natural uranium plus the graphite moderator are necessary to create a self-sustaining chain reaction. Fermi names the structure a "pile" (page 395,) synonymous with heap.

Many of nuclear science's standard terms are developed during this time period. They move their huge experiment to Schermerhorn Hall and enlist Columbia's football players to stack the 50 and 100 pound packs of graphite and uranium into a cubical lattice. The impure materials cause Szilard's continued quest for better qualities. The project leaders adopt code terms for their materials and project a timetable for production of plutonium. The project is moved to Chicago, where it can be expanded. Soviet forces consisting of well-fed, warmly clad, and fresh Siberians fully equipped for winter fighting, counter-attack the German Army thirty miles from Moscow, where the Germans are embedded in the snows and below zero temperatures of Russian winter. The German army retreats.

The Germans, led by Heisenberg, know how to make a plutonium bomb, but they lack necessary money and materials. Heisenberg admits it will take two years to make a bomb. The concept of an atomic bomb strains Hitler's intellectual capacity (page 404), so the Germans turn to developing nuclear energy sources.

President Roosevelt pushes American atomic bomb development because of suspected German progress. Glenn Seaborg goes from Berkeley to Chicago to discuss ways to extract plutonium from irradiated uranium, simultaneously with Jimmy Doolittle's morale raid and bombing of Tokyo and three other Honshu cities in the Pacific War. Seaborg explores how to make plutonium in concentrated solutions without a pile. He seeks out Professor Anton Alexander Benedetti-Pichler, who has pioneered ultramicrochemistry, a technology for manipulating extremely small quantities of chemicals. When he returns to Chicago, Edward Teller joins the Chicago project. Robert Oppenheimer visits for a briefing on Seaborg's fast-neutron studies at Berkeley. The scientists confront the issue of how to cool the big piles. Water is corrosive to uranium. Liquid bismuth is a possibility. There is a general agreement to use helium even though a water-cooled system could be built in a much shorter time.

The group is concerned about German creation of an atomic bomb. President Roosevelt orders use of the Army Corps of Engineers to build the production plant. The Chicago scientists resist, because they would lose control of the project. Szilard sends a memorandum to Vannevar Bush complaining that nuclear scientists do not want to be absorbed into the totalitarian structure of the Army and reminding him that the scanty information they had about German progress was not reassuring.

Three hundred pounds of irradiated UHN (uranyl nitrate hexahydrate) - yellowish crystals like rock salt - arrive by truck. The chunks are surrounded by a layer of lead bricks. Scientists carefully carry the parcels to the fourth floor for extraction of plutonium 239. Pure plutonium is extracted for the first time on August 20, 1942. Robert Oppenheimer gathers theoretical physicists together at Berkeley to design an atomic bomb. He snares Hans and Rose Bethe, Edward and Mici Teller, and others. Teller calculates how to build a fission bomb and wants to use it to ignite deuterium in a hydrogen bomb. The scientists meet in Oppenheimer's office and name the anticipated hydrogen bomb the "Super." Bethe rethinks some of Teller's assumptions in his calculations to cool thinking that use of an atomic bomb might trigger the explosion of nitrogen in the atmosphere of all the hydrogen in the ocean. Oppenheimer proceeds with plans for the Super. By summer's end, the group of scientists concludes that development of an atomic bomb will be a major scientific and technical effort.

This conclusion is conveyed to Washington in a status report and to the Secretary of War. The Chicago scientists rebel against authority and responsibility. Szilard writes another long memorandum detailing his frustrations. The Army has been involved in the bomb project since June. Colonel Marshall of the Army Corps of Engineers, who works out of an office in Manhattan hiding the building of the atomic bomb behind the name Manhattan Engineering District, has been unable to drive the project ahead of other national military priorities. General Brehon Somervell, in charge of the Army Services of Supply, solves the problem by appointing forty-six-year-old General Leslie R. Groves to direct the project. Groves is currently deputy chief of construction for the entire U.S. Army and has just finished building the Pentagon. He is promoted to Brigadier General to help with authority over the academic scientists. Groves is almost six feet tall jowly with curly chestnut hair, a sparse mustache and sufficient girth to balloon over his belt above and below its buckle. His father was a lawyer turned minister, who enlisted as an Army Chaplain. Groves graduated fourth in his class at West Point. Although considered a loner, he is married with a thirteen-year-old daughter and a plebe son at West Point.

Groves is a capable individual, with an ego second to none, and tireless energy. He has absolute confidence in his decisions and is ruthless in how he approaches a problem to get it done. Groves goes to work on the nicknamed "Manhattan Project" immediately, tackles his worse problems, and solves them. First, he acquires 1,250 tones of pitchblende - uranium oxide - stored in two thousand steel drums on Staten Island. Then he approves a directive for the purchase of 52,000 acres at Site X in Tennessee. His promotion to Brigadier General comes through and he meets with Secretary of War Stimson and describes how he plans to operate under a three-man supervisory committee. Groves next goes to inspect Site X in Tennessee.

In May 1942, Enrico Fermi begins planning a full-scale chain reacting pile for the Chicago Met Lab facilities. General Groves appears as the technical council is debating cooling systems again. He tells them that if there is a choice between two methods, one good and one promising, build both. He wants the cooling-system decision by Saturday night. Groves goes to Berkeley. He has already convinced du Pont, the Delaware chemical and explosive manufacturers, to build and run the plutonium production piles by telling them that the atomic bomb will shorten the war and save tens of thousands of American casualties.

When the subcontractors workers strike, Fermi builds his plant at the University of Chicago's squash court. He alternates a layer of graphite with two layers of bricks containing uranium with slots lined up for ten cadmium covered wood control-rod channels passing completely through the pile. Fermi's crew halts work at the 57th layer as the control rods are removed one by one. The neutron count at that stage suggests the pile will go critical, when the last rod is removed.

As the pile waits for Fermi on December 2, 1942, two million Jews have perished in Europe and five million more are in danger. The Germans are planning a counterattack in North African. American Marines are fighting the Japanese at Guadalcanal. Fermi and his scientists work slowly and carefully to run the pile and control the release of energy from the atomic nucleus. At 3:53 P.M., it has run for 4.5 minutes, and the chain reaction was no longer "moonshine." All are ecstatic except for Szilard.

Chapter 13 "The New World" Analysis

The American atomic bomb program stagnates until General Leslie R. Groves is put in charge. He coordinates all construction and selects the sites and recruits the necessary scientists. The reader should note that the technical term "atomic pile" originated as a "heap" or "large mound." Leo Szilard realizes that his fears of an atomic weapons race are indeed possible as it appears that several countries are building atomic bombs. General Leslie Groves, together with Dr. Robert Oppenheimer, are able to keep the scientists from several countries and different scientific training, working together in teams (to the extent possible) for the construction of the atomic bomb that will end World War II. A plutonium bomb is also promised. Theory is becoming reality. The German scientists realize that their Jewish friends and relatives left in Europe are perishing in the Holocaust.

Chapter 14 "Physics in Desert Country"

Chapter 14 "Physics in Desert Country" Summary

Robert Oppenheimer, thirty-eight in 1942, is a respected theoretician in the world of physics. He is tall and intent, his hair wispy, black and curly, with blue eyes showing depth and disarming candor. He resembles both a young Einstein and an overgrown choir boy. Oppenheimer is also self-destructive - a chain smoker with a persistent cough, ravaged teeth, and an appearance of emaciation from addition to martinis and spiced food. He is embarrassed by his body. He lived in a small apartment until marriage, when he buys an elegant house in the Berkeley hills. Women adore him. Oppenheimer's mother died of leukemia in late 1931, his father of a heart attack in 1937. These two deaths cause him to realize the extent of suffering in the world. He is furious about the treatment of Jews in Germany, where he has relatives. In 1936 he met and became involved with Jean Tatlock, daughter of a Berkeley history professor. Their stormy relationship involved him in numerous leftwing organizations, including the Communist Party, the cause of the Loyalists in the Spanish Civil War, and the plight of migrant workers in California. He read Engels and Marx, but Communist theory never made sense to him.

He meets his wife Kitty in 1939 in Pasadena. Her first husband died fighting in the Spanish Civil War. He was a Communist Party official and Kitty a party member for a while. When they meet, Kitty is not engaged in any political activity and is totally disappointed in the Community Party. Oppenheimer disconnects from his earlier political commitments to beat the Nazis to a practical atomic bomb. Oppenheimer has created the greatest school of theoretical physics in the United States at Berkeley in California. He buys a ranch in the Pecos Valley high in the Sangre de Cristo Mountains of northern New Mexico.

Oppenheimer and General Groves meet in 1942, when Groves comes to Berkeley. Oppenheimer pitches the need for a central laboratory devoted to development of the atomic bomb. Groves now considers Oppenheimer, a genius and a hard worker, his first choice as the new laboratory's director, even though Oppenheimer has a considerable left wing background and Groves does not yet have control of the Manhattan Project. The Military Policy Committee balks at choosing Oppenheimer until Groves asks for better suggestions. Oppenheimer and Groves discuss the appointment while on a train to Washington to meet with Vannevar Bush. The next problem is the location of the laboratory and staffing. The laboratory has to be located where the anticipated prima donna scientists and their families would be satisfied with their working and living conditions. Oppenheimer proposes use of a boys' school in New Mexico called Los Alamos. Oppenheimer has combined his two great loves, physics and desert country, and the Manhattan Project acquires this scenic laboratory site.

Groves contracts with the University of California to operate the installation. They build cheap, barracks-like buildings with coal-burning stoves and no sidewalks. Oppenheimer begins to attract his scientists, including the Bethes in Chicago and Edward Teller. Security issues are settled between Groves and Oppenheimer, with the Army making the facility itself secure and Oppenheimer being responsible for the laboratory. Oppenheimer obtains scientific freedom of speech in a government facility surrounded by barbed wire fences. British saboteurs destroy the Norwegian heavy-water installation in February 1943, blowing up the plant and spilling a half ton of heavy water into the drains. The Japanese scientists researching nuclear power for propulsion are switched to more valuable research on radar.

Oppenheimer and aides move to Santa Fe in March 1943. The boys' school is quickly modified to include laboratories and a building for the cyclotron. By April there are thirty scientists. Oppenheimer prepares his *Los Alamos Primer* that, in twenty-four pages, defines the laboratory's program to build the first atomic bomb, a practical military weapon, in under two years. The Japanese decide that no country can produce an atomic bomb in two years. They underestimate U.S. industrial capacity and American dedication. General Groves is intellectually insecure around so many distinguished scientists, who like to discuss their ideas during hikes in the desert. A young experimental physicist, Seth Neddermeyer, imagines an "implosive" device to fire the "gun" with a three-dimensional inward squeeze. This would have higher velocity and a shorter path of assembly. Another scientist points out that the weight of the cannon the physicists are planning can be reduced, because it only has to work one time.

The British start heavy bombing attacks on German cities and industry to reduce German morale. Night bombing pre-radar development is imprecise. Sir Arthur Harris takes over Bomber Command. He saw the German blitz of London and hates the Germans for starting and continuing two world wars. He orders a thousand-bomber raid on Cologne. Churchill and Roosevelt affirm the British plan at the Casablanca Conference in late January 1943. Hamburg is the next target. Churchill gives the bombers further advantage with a radar-jamming device known as "windows," or bales of strips of aluminum foil pushed out of bombers on route to disperse on the wind and cloud German radar.

The British use incendiary bombs on Hamburg. Those bombs combine with summer heat and low humidity to create an unstoppable firestorm that burns eight square miles of the city and kills at least 45,000 Germans. This is but one atrocity in the European war. The German Army captures two million Soviet soldiers and interns them in camps without food or shelter. The vast Nazi program to eliminate the Jews in their midst begins. The British and Americans become enraged over Japanese brutality and Nazi torture - the Bataan Death March and the incomprehensible horror of death camps.

The Los Alamos review committee subordinates plans for a thermonuclear bomb to fission bomb work. Ordnance development and engineering begins at Los Alamos immediately. Naval Captain William S. "Deke" parsons is assigned to field test the proximity fuse at Los Alamos and designs the plutonium gun. The B-29 bomber is redesigned to carry the atomic bomb internally. Seth Neddemeyer continues to experiment with implosion. By squeezing a hollow shell of plutonium to a solid ball, implosion can effectively "assemble" the bomb much faster at a critical mass. Violent implosion can squeeze plutonium to such unearthly densities that a solid sub-critical mass could serve as a bomb core. Pre-detonation problems will be eliminated and implosion will deliver a more reliable bomb more quickly. B-29 test bombing starts in the fall. Parsons and Ramsey select two external bomb shapes and weights. For security reasons, these are called "Thin Man" and "Fat Man." This lets the Air Force officers converse, as if the plane is carrying Roosevelt (thin man) and Churchill (fat man.)

Neils Bohr, still in Copenhagen, is invited to England. If the atomic bomb is possible, Bohr wants to go. If not, he wants to stay to help Danish resistance to the Germans. The Nazis left Denmark alone for access to its agricultural supplies of meat and butter and did not intern their Jewish people. When the Germans surrender at Stalingrad in 1943 and Mussolini resigns the following summer, the Nazis reoccupy Copenhagen, disarm the Danish Army, blockade the royal palace, and imprison the King. Hitler is now infuriated that the Danish Jews have been exempted from the Final Solution.

Bohr learns that he is slated for arrest. He contacts the underground, escapes to Sweden by boat, and then leaves his wife in southern Sweden to wait for their sons, while he rushes to Stockholm to appeal to the Swedish government for help. There, he learns that the Swedes have offered to intern the Danish Jews. In the meantime, the Danes hide their Jewish citizens, leaving 284 elderly nursing home residents to be seized. The Swedish coast guard helps 7,220 Jews to safety with Bohr's intervention. Bohr and his son Aage go first to England and then to America to work with Oppenheimer.

Chapter 14 "Physics in Desert Country" Analysis

The scientists are discussing the use of a gun-type configuration to make the two types of atomic bombs. The simplest proposal for the bomb's design uses a gun concept to project one subcritical mass of fissionable material into another mass producing a supercritical mass that explodes. This is the design used in the Thin Man bomb dropped on Hiroshima. The other method, implosion, directs the blast of conventional high explosives into a quantity of fissionable material. The force of the blast squeezes the material together to critical mass and detonation. This is the design used in the Fat Man bomb delivered against Nagasaki. Since neither have been used before, there is no existing prototype.

Groves and Oppenheimer begin working together to create the atomic bomb before the project has government approval and despite Oppenheimer's considerable left-wing involvement in his younger days. Oppenheimer is too valuable to the project for his political views to be an impediment.

The reader should note that the British bombing of Germany changes to incendiary bombing of cities and civilians as other atrocities of war increase. The Holocaust begins. News of Japanese atrocities such as the Bataan Death March and the incomprehensible horror of death camps reaches the outside world.

Chapter 15 "Different Animals"

Chapter 15 "Different Animals" Summary

General Leslie Groves acquires 59,000 acres of Appalachian semi-wilderness in eastern Tennessee on which the Army's Oak Ridge facility will be built the futuristic factories needed to separate U235 from U238 to build the atomic bomb. The Army first must build a town, highways, and install adequate communications. The entire reservation, fenced with barbed wire and controlled through seven guarded gates, is named the "Clinton Engineer Works," nicknamed "Dogpatch." General Groves plans to build electromagnetic isotope separation plants and a gaseous-diffusion plant there to produce plutonium. Ernest Lawrence's electromagnetic isotope separation method using a cyclotron is farthest along but too slow for the Army's needs.

At Berkeley, Fermi is separating isotopes by gaseous diffusion through an enormous interconnected assemblage of pipes and pumps. General Groves begins building a plant at Oak Ridge without knowing what to build. He works from the general to the particular. His first problem is a critical national shortage of copper used to wind the coils of electromagnets. Since it can be recovered, the Treasury makes silver bullion available in copper's stead. 395 million troy ounces of silver (13,540 short tons) go from the West Point Depository to be cast into cylindrical billets. The billets are then rolled into 40 foot strips and wound onto iron cores. The silver is worth more than $300 million dollars at the time. General Groves accounts for it, ounce by ounce. A gaseous diffusion plant is designed, an enormous interconnected assemblage of pipes and pumps in an oval configuration nicknamed a "racetrack." Groves initially approves three buildings to house five race tracks (Alpha.) He then approves a second (Beta) that will enrich the U235 production.

Alpha and Beta buildings cover more area than twenty football fields. The "racetracks" themselves are on the second floor of the buildings. The first floors hold gigantic pumps to exhaust the tanks to high vacuum. Ernest Lawrence is awed. When an experimental Alpha unit operates in August, Lawrence urges Groves to double the plant. New estimates from Los Alamos are that an efficient uranium gun would require 88 pounds of the rare uranium isotope being produced, and such doubling will permit production of a 50 kilogram bomb core around the beginning of 1945. The contracted employees of Eastman Kodak operate the plant 24 hours a day, 7 days a week.

Unanticipated problems cause the magnets to short, and Alpha plant is shut down. There are two major problems and the unit must be rebuilt. The design placed the heavy current-carrying silver bands too close together. Rust and other dirt particles got into the circulating oil. These bridged the gap between the silver bands and caused shorting. When the Alpha plant was designed, no practical material barrier between the circulating oil and the tubes of gas existed. Columbia University designs barrier material of a new kind of plastics later patented as *Teflon*. All the pipe interiors will be nickel plated. Groves' change of barrier material to continue gaseous diffusion confirms the commitment of the United States through the Manhattan Project to the urgent and narrow goal of beating the Germans to use of an atomic bomb.

Groves must locate a plutonium production site with plentiful electricity and water and few people. He finds a promising location in south-central Washington State, named the Hanford Engineer Works, to be built by DuPont. The DuPont engineers first have to decide how to cool the plutonium production piles (reactors.) Eugene Wigner and Enrico Fermi's new calculations made water cooling practical. The camp has recruiting problems from severe labor shortages and the unwillingness of scientists, family members, and workers to camp out on scrubland far from any major city. Dust storms are common. A project recruiting pamphlet recommends workers bring padlocks, towels, coat hangers, and a thermos bottle. Since there is nothing for the workers to do after work except fight, DuPont builds saloons with hinged windows for easy tear-gar lobbing. Eventually 5,000 workers struggle in the desert dust, and DuPont builds more than 200 barracks. Meat and other rationed food are plentiful.

The Hanford Plant is gigantic. The scale reveals how ambitiously the nation is moving to build the bomb, claim the prize, and deny it to others - even the British - until Churchill talks with Roosevelt in Quebec in August 1943 during the planning of the invasion of Normandy. Work towards an atomic bomb begins in Russia in 1939. Russian physicists realize in 1940 that the United States' must be pursuing the bomb, when the names of prominent scientists who would be involved in such a project vanish from scientific journals. Secrecy itself gives the secret away. When Germany invades Russia in June 1941, the Russian project stops as priorities are rearranged. Radar is first place, naval mind detection second, and atomic bombs a poor third. The scientist working on the bomb is assigned to study naval mine defenses. Work resumes in 1943 without means of producing a bomb.

General Groves must cope with Leo Szilard, mercurial with brilliant ideas, who delights in baiting brass hats. Szilard's latest proposal is that Army compartmentalization rules should be ignored in the interests of completing the bomb. This argument ends in a stalemate, when Groves realizes how many of the important scientists are long-standing Szilard colleagues. Now Szilard further angers Groves by asking for compensation for his pre-project inventions. The issue is not money but representation. Szilard wants to remove the process of decision making from government restraints and return it to the atomic scientists.

Groves decides that Szilard, the troublemaker, must be a foreign government agent and has him followed. The resulting reports are comical. Szilard next retains a patent attorney. Szilard negotiates with Lieutenant Colonel John Landsdale, Jr., Groves' chief of security, who tells Szilard he can trade his patent rights for the privilege of working to beat the Germans to the bomb. This does not happen, but Szilard is paid over $15,000 for the 20 months he worked unpaid at Columbia plus attorneys' fees. Szilard turns his attention to the use of the atomic bomb and the impending nuclear arms race. Enrico Fermi approaches Oppenheimer about using radioactive fission products to poison the German food supply. Oppenheimer discusses Fermi's idea with Groves and Edward Teller.

The British are much more concerned about the possibility of a radioactive attack of some kind coming from a desperate Germany. British scientist believe they have found a way to separate light from heavy water five times faster and fear the Germans have done the same. The High Concentration Plant in Norway is still operable. Neils Bohr escapes from Stockholm to Scotland in 1943 with Heisenberg's drawing of an experimental heavy-water reactor. The Nazis have increased security at the plant. American B-17's bomb the plant, destroying power stations and damaging the unit supplying hydrogen, effectively shutting down the plant. The Norwegian underground reports the Germans will transport the heavy water to Germany. Norwegian saboteurs sink the ferry carrying the heavy water, ending Germany's race to the bomb.

Despite Japan's bombing attack on Pearl Harbor, the United States does not concentrate its attention on the Pacific War. The former U.S. Ambassador to Japan tries desperately to change official opinion. He urges that the Japanese are united, frugal, fanatical, and totalitarian. They are convinced they can and will win. They are counting on U.S. underestimates, disunity, and unwillingness to sacrifice, endure and fight. The same information comes from Marine General Vandegrift, whose troops have engaged the Japanese in the Solomons at Guadalcanal. He writes the Marne Commandant in Washington that the Japanese refuse to surrender. The wounded wait for Americans to examine them and then blow themselves and the other man to death with a hand grenade. *Time-Life* reporter John Hershey adds that the war in the Pacific is frightening. Germans react like human beings. The Japanese are like animals. "You have to get used to their animal stubbornness and tenacity. They take to the jungle as if they had been bred there, and like some beasts you never see them until they are dead." (page 519)

Whether bestiality, fanaticism, or heroism, the refusal of Japanese soldiers to surrender requires new warfare tactics. The Japanese build fortresses on islands and refuse to exit. As Japanese resistance improves, Allied casualty figures grow. The United States uses flamethrowers to burn Japanese soldiers from their caves. Talk begins of firebombing Japan's matchbox cities. Roosevelt and Churchill meet at Casablanca and issue a joint statement. Unconditional surrender becomes official Allied policy.

Chapter 15 "Different Animals" Analysis

Note that the tactics used in war have escalated and become more gruesome than before. The scientists, including the otherwise peaceful Oppenheimer, want to use radioactivity to poison the German's food supply. We are introduced to the bloodiness and loss of lives in the Japanese war in the Pacific, created by the Japanese determination never to surrender. All Japanese are willing to die before surrendering their homelands. American and British policy changes to unconditional surrender by Germany, Italy, and Japan.

Teflon is invented. Leo Szilard, also a genius at harassing the military, now wants payment for his English patents concerning the chain reaction. The reader must be amazed at the patience exhibited by General Groves with some of the activities of the scientists.

Chapter 16 "Revelations"

Chapter 16 "Revelations" Summary

In November 1943, James Chadwick asks Otto Frisch if he would like to work in America. Within a week, the British clear the scientists picked by General Groves to review barrier development as well as those going to Los Alamos for relocation to America. These include Frisch, Rudolph Peierls, George Placzek, Klaus Fuchs, Chadwick, and others. Some travel by train to Los Alamos, greeted by Robert Oppenheimer, smoking a pipe and wearing a pork-pie hat: "Welcome to Los Alamos, and who the devil are you?" (page 523) Neils Bohr and his son Aage join them. They discuss Heisenberg's drawing of a heavy-water reactor. Oppenheimer wants the experts, on the last day of 1943, to turn an atomic pile into a weapon. Oppenheimer appreciates Bohr's presence, since he makes the enterprise hopeful. Bohr reveals later he traveled to Los Alamos not to help them build a bomb but to work out the revolutionary consequences of the existence of an atomic bomb.

While he and Aage lived in Washington, Bohr renewed his acquaintance with Associate Supreme Justice Felix Frankfurter a Vienna-born, agnostic, Zionist Jew and close friend of President Roosevelt. Frankfurter has heard about the project, and the two men talk about the potential of the bomb for both good and evil and the inevitable nuclear arms race after World War II if the Russians develop their own weapons. At the end of March 1944, Bohr has a mandate from President Roosevelt to talk to Prime Minister Churchill about nuclear proliferation and the coming arms race with Russia. Bohr wants to invite the Russians to collaborate in planning for international control. Churchill will have none of this. He is busy with preparations for the Normandy invasion. Bohr stays in London and is there on D-Day, Tuesday, June 6, 1944. Bohr returns to the United States and reports his failure to Justice Frankfurter. President Roosevelt is amused to hear yet another account of Churchill's stubbornness.

While in Washington, Bohr writes a detailed analysis of the nuclear arms race to come, starting with the phrase "We are in a completely new situation that cannot be resolved by war." (page 532) He analyzes the changes that will come about in the world's situation and change all future conditions of warfare. Nobody will be able to *win*. Before the bomb, international relations swung between war and peace. With the advent of the atomic bomb, war between nations will be self-defeating. The pendulum will swing between peace and national suicide. The countries of the world will have to open up to each other as to whether or not they have atomic bombs. The Soviet Union will be reluctant. Scientists will have to lead in the exchange of information.

Bohr sends his untitled memorandum to Justice Felix Frankfurter, who recognizes its merit. This document is still the only comprehension and realistic charter for a post nuclear world (page 536.) Frankfurter gives it to Roosevelt. Roosevelt is more optimistic about the Russian response than is Churchill, and talk begins of Bohr's being sent to

Russia to explore matters. When Churchill learns of these preparations, he vetoes them. Bohr does not go to Russia.

Edward Teller and wife Mici arrive at Los Alamos in April of 1943 with their two indispensable items - his grand piano and her new Bendix automatic washer. The Steinway nearly fills the living room of their assigned apartment. Although Teller helped Oppenheimer organize Los Alamos and recruit its staff, he receives no administrative appointment. He wants to lead a division working towards a thermonuclear fusion weapon, a "Super," but no such division is created. Fission and a working atomic bomb take priority. Teller helps Bethe develop ways to calculate critical mass and nuclear efficiencies of various bomb designs.

At Berkley, Emilio Segre measures the rate of spontaneous fission in uranium and plutonium. He moves away from the Los Alamos mesa to protect his measuring instruments from radiation generated by other experiments and discovers a better method to fission U235 so that the "gun" or triggering mechanism setting off the bomb's critical mass can be shorter and lighter. The scientists are still working on the plutonium gun, and George Kistiakowsky is brought from Harvard to Los Alamos to assist. Kistiakowsky quickly discovers that team members and leaders are working at cross purposes and are not always cordial. Bethe brings in new scientists to fill in for Teller, working on fission development. Personality conflicts continue among the opinionated scientists, who are using for the first time IBM punch card sorters to calculate the critical mass of oddly shaped bomb cores. Oppenheimer reassigns work to the warring geniuses with Kristiakowsky in charge of implosion work as an associate division leader under Parsons.

Meanwhile, the Oak Ridge pilot-scale reactor reaches critical mass at 5:00 A.M. on November 4, 1943. Comptom and Fermi are rousted out of bed to witness the event. The pile is a graphite cube twenty-four feet on each side drilled with 1,248 channels that can be loaded with canned uranium-metal slugs cooled by fans. Irradiated uranium begins to be produced at the plant. By the end of the summer of 1944, plutonium nitrate in gram qualities arrives at Los Alamos and is used in more than 2000 separate experiments by summer's end. Segre's spontaneous fission rate measurements for plutonium signals catastrophe for a plutonium gun since the bullet and target will melt down and fizzle before the two parts join and set off the bomb. While Parsons works on the uranium gun's design, Oppenheimer and his team solve the implosion problem.

The island war advances in the Pacific. The United States wants the Marianas as bases for further advances, including Saipan and Tinian for the new B-29 Superfortresses temporarily deployed in China. The Marianas campaign (Operation Forager) begins in mid-June with heavy bombing of the island airfields. On Eniwetok, the Marines face mountains and caves fortified by the Japanese. The Marines advance onto Saipan, fighting Japanese frontal assaults called "banzai charges," and set up artillery fired on Tinian. By the time Saipan is taken 22,000 Japanese civilians jumped from two sea cliffs high about jagged rocks so that the surf turns red with blood. The Americans learn though this mass suicide that both soldiers and civilians will choose death before surrender. There are 100 million Japanese on their home islands.

The Hanford, Washington, plutonium production plant went critical in December 1944. Plutonium production in quantity begins. Groves reports to General George Marshall that he expects to have 18 plutonium bombs ready the second half of 1945. It becomes clear that atomic bombs will be dropped the following summer.

Chapter 16 "Revelations" Analysis

After the war, Klaus Fuchs was convicted of communicating information to the Russians about American atomic research. He began doing so while working on the Manhattan Project. The author never makes this clear.

The mass suicide of 22,000 Japanese civilians on Saipan, convinces the American leadership that the Japanese soldiers and civilians will die before they surrender their home lands. This will mean an enormous loss of life for the Americans should they invade Japan. The military is more convinced than ever to find an alternate to such invasion. In the meantime, the atomic bombs are being built under General Groves' supervision.

Neils Bohr wants to involve the Russians in discussions of limiting the post-war nuclear arms race and is willing to go to Russia. Prime Minister Churchill in England vetoes the plan once more. The reader should note that the nuclear arms race did start at the end of World War II between the Americans and the Russians. The American concerns about Russians learning of their discoveries become mute, when Klaus Fuchs' activities are revealed, showing that the Russians have full knowledge of American inventions.

Chapter 17 "The Evils of This Time"

Chapter 17 "The Evils of This Time" Summary

Bush and Conant agree that the gun method of detonation is as certain to work as any new procedure. Oppenheimer continues to work on the implosion method. Bush and Conant also write Secretary of War Stimson concerning the need for an arms control treaty somehow including the Soviet Union. Their letter causes President Roosevelt concern that Felix Frankfurter and Neils Bohr have breached Manhattan Project security. The Fermis, now American citizens, move to Los Alamos in September 1944 into a fourplex apartments on the Hill. Rudolph Peierl and wife Genia live below them. Parties are developed for Saturday nights, including Westernized square dancing. Baby making is a main activity. Some of the scientists travel on Sundays to see New Mexico's legendary sights. They discuss physics at 12,500 feet on the Sangre de Cristos. Others seek the Stone Lions prehistoric lifesize effigies of crouching carved mountain lions beside a ruined pueblo. Neils Bohr admires a skunk. A family cat is diagnosed with radiation poisoning.

While Oppenheimer, still under constant surveillance, loses himself in his work, his wife Kitty responds to the stress of living at isolated Los Alamos by drinking heavily. In March 1944 the scientists begin planning for a test of an implosion weapon. Oppenheimer proposes the code name "Trinity" for this test, named after *Holy Sonnets* by John Donne, a poem which explores the theme that destruction might also redeem. Oppenheimer wants to balance his bringing total destruction to the world with the possibility of detachment and peace. The scientists at Los Alamos develop diagnostics necessary for implosion. John von Neumann has theoretically developed an implosion lens for Fat Man, but they need a way to mix polonium and beryllium in the core of the bomb. Polonium is a strange isotope that tends to migrate on its own, so the scientists learn to look for it embedded in the walls of shipping containers. Japanese progress towards an atomic bomb becomes futile and impractical.

The United States begins testing dummy bombs dropped from specially modified B-29's at Muroc Army Air Force Base in California on in March 1944. The Air Force orders seventeen more modified B-29's and plans to train a special group to deliver the first atomic bomb. The 393rd Bombardment Squadron, based at Fairmont, Nebraska, under Lieutenant Colonel Paul W. Tibbets, twenty-nine years old, will drop the bomb. Tibbets is the best bomber pilot in the Air Force. He led the first B-17 bombing mission from England into Europe and also carried General Eisenhower to his Gibraltar command post before the invasion of North Africa.

Tibbets flies to Second Air Force headquarters in Colorado Springs in September 1944 and is briefed and ordered to put together an outfit to deliver the weapon. The delivery program is nicknamed "Silverplate," with the highest priority in the service. The Air Force chooses Wendover Field, Utah, as home base. The 393rd moves there in September, becomes the 509th Composite Group, and begins receiving the modified B-29's. The B-

29 was a revolutionary aircraft built by Boeing as the first intercontinental bomber. As originally designed, their powerful engines were delivering bright orange Fat Man imitations called Pumpkins.

One of Tibbets' chosen pilots had earlier trained Major General Curtis LeMay, who took over the 20th Bomber Command that was attempting to bomb Japan from India. LeMay was a wild man, a tough, smart bomber pilot, who stated bluntly (after the war), "I'll tell you what war is about. You've got to kill people, and when you've killed enough they stop fighting." (page 586)

General Henry "Hap" Arnold needs someone in the Pacific theater, who will use the B-29's successfully in bombing raids. The first B-29 to arrive in the Marianas lands on Saipan on October 12, 1944, flown by Brigadier General Haywood S. Hansell, Jr., Arnold's Chief of Staff, who helped create the doctrine of precision bombing and believes that wars can be won by selectively destroying the enemy's key industries of war. A stream of new bombers follows General Hansell to the Marianas. The first U.S. Aircraft to fly over Tokyo since the Doolittle raid of 1942 was a B-29 on photoreconnaissance mission on November 1. Hansell teaches his men to navigate together and fly in formation. Their first raid on November 24 hits the Musashi aircraft engine factory north of Tokyo - 10 miles north of the Imperial Palace. The planes quite unexpectedly encountered *jet stream* winds for the first time - a 140 mile per hour wind at 30,000 feet. This wind greatly increases their air speed and causes bombing errors.

General LeMay is still with the 20th Bomber Command out of India and China supporting the military campaigns of Chiang Kai-shek. General Claire Chennault wants LeMay to load his aircraft with incendiaries and bomb from 20,000 feet and strike Hankow, the riverside city from which Japan supplies its Asian mainland armies. The incendiary firebombing destroys the city and fires rage out of control for three days.

Leaders met in Oppenheimer's office in Los Alamos to approve a simpler design of Fat Man that will be ready in three days, by December 22. General Groves vetoes test bombing and further test bombing of pumpkins. Parsons finally convinced Groves that there are major differences between the "gun gadget" and the "implosion gadget" in terms of final assembly (page 590) and that additional practice is essential. Precision bombing of Japan is not succeeding, and General LeMay is sent to Guam. LeMay has to contend with the jet stream, terrible Japanese weather with the Russians not cooperating with weather predictions as promised, B-29 engines that overheat and burn up, and indifferent bombing. LeMay trains his crews and radar units became available. He also notices no intelligence reports of low altitude flak from the Japanese. In response to the German counter-offensive at the Battle of the Bulge, Winston Churchill approves the Allied fire-bombing raid on Dresden using high explosives and incendiaries to create a firestorm visible 200 miles away.

General LeMay watches the intensity and ferocity of Japanese resistance increasing as American forces fight their way towards the home islands. The latest "hellhole" is Iwo Jima which supports two Japanese airfields. The Japanese have prepared their defense of Iwo Jima for months, and 15,000 men have turned the island into a fortress of bunkers, ditches, trenches, tunnels, pillboxes, fortified cave entrances, and blockhouses with thick concrete walls. These emplacements are armed with the largest concentration of artillery the Japanese have assembled to that day. The Japanese commander taught his men to fight from cover as long as possible and defend the island to the end, making the conquest so costly that the Allies will not invade Japan. Each man is to kill ten enemy before dying. The American invasion begins on February 19th. Slow, cruel fighting continues for a month as shell and artillery fire changed the landscape. Victory cost 6,821 Marines killed and 21,000 wounded of 60,000 committed, a casualty rate of 2 to 1. 20,000 Japanese defenders died, and only 1,063 allowed themselves to be captured.

LeMay vows to repay their debt of deaths, because so many Marines died on Iwo Jima to protect his B-29 crews. 172 planes with incendiaries fly over Tokyo on February 23 burning a square mile of the city made of wood. LeMay now wants to change to low-altitude fire bombings. His first target will be 12 square miles of workers' houses adjacent to the northeast corner of the Imperial Palace in central Tokyo, which he justifies as where they made shell fuses at home. The Fifth Air Force backs him by saying that the Japanese government is mobilizing civilians to resist American invasion of Japan. The entire population of Japan becomes a military target. LeMay drops two kinds of incendiaries - 100 pound oil-gel bombs and 6 pound gelled-gasoline bombs, with a few high explosives in the mix. General Norstad, now General Arnold's Chief of Staff, approves LeMay's plan. The Japanese vow to fight until they all eat stones. They will continue to fight until every man, woman, and child lies face downward on the battlefield, and they create a war of total extermination.

LeMay's planes arrives over Tokyo after midnight on March 10th and drop their incendiaries. The 20 mile per hour wind whips the fire into a conflagration, an extended wall of fire preceded by a pillar, a mass of burning vapors close to the ground. An extended fire sweeps over 15 square miles in 6 hours and creates air turbulence that affects the departing B-29 bombers. The area of the fire is totally burned. The rivers boil. The firestorm at Dresden killed more people but not so quickly. LeMay pushes on. His planes firebomb Nagoya, Osaka, Kobe, and Nagoya again. LeMay runs out of bombs. He wants to end the war without an invasion of Japan.

Back in the United States, at the Oak Ridge plant, Ernest Lawrence's monumental effort has succeeded. The U235 needed for Little Boy will be ready by mid 1945. Early in 1945 Oak Ridge ships bomb-grade U235 to Los Alamos with couriers traveling by train. Plutonium is produced at DuPont's Hanford Plant with Glenn Seaborg in charge. Seaborg's team develops two separation processes to take advantage of the different chemistries of plutonium's several different valence states. DuPont builds three huge poured-concrete separation plants. Each building is 800 feet long, 65 feet wide, and 80 feet tall. The separation cells are surrounded by concrete walls 7 feet thick covered with 6 feet of concrete. The resulting plutonium yields started at 60 to 70 per cent efficiency and reached 90 per cent in February 1945. The resulting small batches are carefully packed in convoys of Army ambulances to Los Alamos.

American intelligence did little during World War II to find out the extent of German progress towards atomic bomb development. General Groves authorizes a security unit called "Alsos," Greek for Grove, headed by Lieutenant Colonel Boris T. Pash. Pash has previously investigated Ernest Lawrence's Berkely staff and Robert Oppenheimer about their Communist ties. Groves likes his determination and drive. Pash goes to London in 1944 and into Paris after the Normandy invasion, ending at the Radium Institute on Rue Pierre Curie to drink champagne with Frederic Joliot. Joliot knows nothing about German uranium research, so Pash goes on to Strasbourg and a German physics lab. He studies available papers and determines that Germany has no atom bomb and is not likely to develop one.

Groves then directs Pash to locate the 1200 tons of Union Miniere uranium ore the Germans took from Belgium. He finds 31 tons stored in Toulouse. The rest of the ore is in a factory in northern Germany close to the Red Army. General Omar Bradley orders the immediate removal of that 1100 tons of ore stored in barrels to the rail yards. Alsos verified there is no German atom bomb, prevents the Soviet Union from acquiring the Belgium uranium ore, and ships that ore to Oak Ridge for use in Little Boy. At Los Alamos, Otto Frisch determines how much uranium Little Boy will really need. By April, Oak Ridge has produced enough U235 to make the bomb. When LeMay firebombs Tokyo, he destroys the Japanese atomic bomb project.

On April 12, 1945, President Franklin Delano Roosevelt has a massive stroke and dies in Warm Springs at age sixty three. Oppenheimer announces the news to Los Alamos, and the nation grieves. Between Roosevelt's death on Thursday and his memorial service on Sunday, Otto Frisch delivered to Oppenheimer his report on his first experimental determination of the critical mass of pure U 235.

Chapter 17 "The Evils of This Time" Analysis

As the Americans finish the atomic bomb, General Curtis LeMay's 20th Air Force bomber group begins incendiary bombing of Japanese cities and is quite successful until he literally runs out of bombs. LeMay intends to burn Japan to the ground. He plans to drop 100,000 bombs a month by the end of 1945. He is motivated by the nature of the Japanese attacks on Iwo Jima and other islands and by the Japanese vow never to surrender their home islands. He wants to destroy Japan so no invasion by American troops will be necessary. LeMay's bombs destroy what is left of the Japanese atomic bomb project as well as a number of cities that were considered targets for the American atomic bombs.

By now all the scientists realize the nature of their creation. Even Robert Oppenheimer wants to balance his bringing possible total destruction to the world with the possibility of detachment and peace. Oppenheimer names the test of an implosion weapon "Trinity" from *Holy Sonnets* by John Donne, a poem which explores the theme that destruction might also redeem. All of the scientists realize what they have created, and its many horrible implications.

President Roosevelt dies on April 12, 1945, and is succeeded by Vice President Harry Truman, who will make the decision to drop the atomic bomb on Japan.

Chapter 18 "Trinity"

Chapter 18 "Trinity" Summary

Harry Truman learns about the atomic bomb immediately on President Roosevelt's death. He already knew about the "Manhattan Project," but Secretary of War, Henry Lewis Stimson (now 77 years of age) and James Frances "Jimmy" Byrnes, who unofficially ran the country while Roosevelt ran the war, provide details. Byrnes believes the bomb will put the United States in a position to dictate terms at the end of the war. Truman asks Byrnes to transcribe his shorthand notes on the Yalta Conference. Truman then names Byrnes Secretary of State, and he is given a free hand in domestic affairs. Roosevelt promised Byrnes he would be his Vice President in the 1948 elections, guaranteeing him the Presidency. Roosevelt named Truman instead, deeply hurting his friend. Truman needs Byrnes' help. State was the most powerful office he had to offer.

Neils Bohr seeks to convince the American government to forestall an arms race once the existence of the bomb is known, by early discussions with the Russians. He uses Justice Felix Frankfurter as his emissary. Bohr is convinced that an open world modeled on the republic of science can answer the challenge of the atomic bomb. Frankfurter talks to Stimson, who talks to Roosevelt. When Roosevelt dies, they try to talk to Truman. Averell Harriman, Ambassador to Moscow, returns to Washington to brief President Truman that Stalin is breaking his agreements. Russia intends to take over its neighbors and install the Soviet system of government, including secret police and state control.

In April, delegates arrive in San Francisco to formulate the United Nations' charter. Russian Foreign Minister Molotov comes to the United States. Truman tells Harriman he intends to continue with the San Francisco plans and the Russians can join or go to Hell. General George Marshall urges patience, because Truman cannot tell the Russians to go to Hell if he needs them to finish the Pacific war. Truman and Molotov meet and discuss the postwar government of Poland. The Russians want Poland; Truman wants the free elections agreed on at Yalta. Russia stands firm on its demands for a Polish government friendly to Russia.

President Truman and his advisors decide what to tell other nations about the atomic bomb. General Groves brings a report on the status of the Manhattan Project, and a Target Committee under Groves' authority meets at the Pentagon to discuss potential targets. Groves wants to bomb places that will most adversely affect the will of the Japanese people to continue the war, sites that are military in nature. Hiroshima will be the largest yet-untouched target. Tokyo was bombed and burned out by General LeMay's relentless firebombing. LeMay's 20th Air Force is systematically bombing cities so as not to leave one stone lying on another. If the Japanese are prepared to eat stones, the Americans are prepared to supply them. General LeMay advises that the 20th Air Force will increase conventional bombing until it drops 100,000 bombs a month by the end of 1945. The group selects 17 potential targets and adjourns. The Target Committee will meet again in mid May in Oppenheimer's Los Alamos' office.

On May 1, German radio announces Adolf Hitler's suicide in Berlin's rubble. Truman has not announced Byrnes' appointment as Secretary of State, because the current Secretary heads the United States' delegation to the United Nations conference in San Francisco. Supreme Allied Commanded Dwight D. Eisenhower celebrates the European victory on national radio on Tuesday, May 8, 1945, V-E Day. Eisenhower watches Colonel General Alfred Jodel sign the act of military surrender in Rheims in the Supreme Headquarters Allied Expeditionary Force in the early morning hours of May 7. Eisenhower tries to draft an appropriate report to the Americans and finally says only, "The mission of this Allied force was fulfilled at 0241, local time, May 7, 1945." (page 630) Twenty million Soviet soldiers and civilians have died; eight million British and Europeans died or were killed; plus another five million Germans. The Nazis murdered six million Jews in ghettos and concentration camps. There remains the brutal conflict in the Pacific that Japan refuses to surrender, despite increasing destruction of Japan and its cities.

The Target Committee meets on May 10th and 11th in Oppenheimer's office at Los Alamos. Oppenheimer takes control by devising the agenda. Those in attendance discuss progress with the atomic bombs. The Target Committee narrows the names of cities to be bombed, and the list still includes both Hiroshima and Nagasaki. Bohr's proposal to discuss matters with Russia becomes now a question of whether or not to tell Russia after the first bomb is dropped but before the second one is. Leo Szilard becomes involved. He prepares a memorandum for President Roosevelt and travels to Princeton to obtain aid from Albert Einstein. Einstein has been left out of the atomic bomb projects because of his pacifism and his ardent Zionism. He does give Szilard a letter of introduction to President Roosevelt.

Szilard approaches Roosevelt through his wife but does not speak to the President before his death is announced. Szilard speaks with Vice President Truman's Appointments' Secretary, who refers him to South Carolina and Jimmy Byrnes. Szilard raises the question about the impending danger of a nuclear arms race between the United States and Russia. Byrnes takes an immediate dislike to Szilard and demonstrates the dangers of his lack of firsthand knowledge of politics. Szilard is flabbergasted by Byrnes' assumption that rattling the bomb will make Russia more manageable.

Colonel Tibbets and his crew in the 509th Composite Group go to Cuba for training with radar and flying over water. General Curtis LeMay's Twentieth Air Force continue fire bombing Japanese cities. Availability of future Japanese targets may be a problem for the Manhattan project. General Groves removes Kyoto, the Rome of Japan, founded in 793 and a center of the Buddhist and Shinto religious with hundreds of historic temples and shrines, from the target list.

The scientists continue to agonize over and discuss how to negotiate a way beyond the mutual danger the new weapons will install in the world. Oppenheimer finds an ally in

General George Marshall, who wants to forge a combination among like minded power and force Russia to fall in line. Oppenheimer does not see how this will work in the days of the atomic bomb, but Marshall wants to invite two prominent Russian scientists to witness the Trinity Test. Jimmy Byrnes refuses this proposal. The discussion shifts to the Japanese city structure, which, according to General LeMay, is that the Japanese work at home, as families. It is their system of dispersal of industry. Jimmy Byrnes recommends the bomb be used against Japan as soon as possible on a war plant surrounded by workers' homes. President Truman sides with Byrnes.

All agree that the design for Little Boy will work, but they must test it in a desolate area. Trinity will be the largest physics experiment ever attempted. Kenneth T. Bainbridge, a Harvard experimental physicist, is assigned to find the Trinity test site. He selects a flat scrub region 60 miles northwest of Alamogordo between the Rio Grande and the Sierra Oscura. Oppenheimer sets the test shot's target date as July 4. The military constructs observatory and residential buildings and towers, including one at ground Zero.

Truman agrees to meet with Stalin and Churchill in the Berlin suburb of Potsdam during the summer. Truman wants more time. He might not need a Soviet invasion of Manchuria to challenge the Japanese and therefore have to trade away less in Europe.

The scientists at Los Alamos continue building the test bomb. The parts ride with soldiers in sedans and jeeps to the test site where they will be assembled and tested. In the meantime, Little Boy minus uranium target pieces is trucked from Los Alamos to Albuquerque and shipped to Tinian on board the U.S.S. *Indianapolis.* The bomb Arming Party arrives at the Trinity site. At 5:30 A.M. the firing circuit closes, and the test bomb works. The plutonium core collapses into itself, becoming an eyeball. The chain reaction begins. The fireball, an isothermal sphere invisible to the world, a cooling wave moving inward toward that spear, and a shock front moving into undisturbed air, is created. Men at base camp see a bright light lasting two seconds followed by an enormous ball of fire that grows and rolls, changing colors from yellow, to scarlet, and green. The visible results fit into no one's predictions. Four hours later, the *Indianapolis* sails with its cargo.

Chapter 18 "Trinity" Analysis

Now that the atomic bomb is a reality, Neils Bohr again tries to forestall an arms race through discussions with the Russians. He is convinced that having an open scientific world will prevent it. He does not know that the Russians have been receiving information from Klaus Fuchs. Leo Szilard and other scientists continue trying to convince the U.S. Government to take steps to prevent the impending nuclear arms race with Russia. The scientists at Los Alamos test the atomic bomb, and it works spectacularly. The War in Europe ends with Hitler's suicide and Germany's surrender on May 8, 1945.

Stalin's failure to keep his agreements becomes obvious to government leaders, so no discussions about stopping a nuclear arms race take place with Russia. Oppenheimer wants the other major powers to force Russia somehow to fall in line with their plans and the creation of an open scientific world, which is an idea shared by some members of Truman's administration.

Chapter 19 "Tongues of Fire"

Chapter 19 "Tongues of Fire" Summary

At the end of March 1945, Colonel Elmer E. Kirkpatrick, an Army engineer, tours the Marianas to find a location for the 509th Composite Group. The SeaBees (Navy construction battalion) will build buildings and dig pits from which the bombs will be lifted into the bomb bays of Tibbets' B-29's on Tinian Island. Tibbets' combat crews will fly specially modified new B-29's - lightweight with fuel-injection systems to replace carburetors, quick closing pneumatic bomb doors, fuel flow meters, reversible electric propellers, and redesigned interiors to hold Fat Man. In the meantime, General Curtis LeMay's bombers continue firebombing Japanese cities. The armed forces have already converted Tinian Island into the biggest airport in the world.

President Truman and Secretary of State Jimmy Byrnes leave Potsdam in an open car to tour Berlin on July 16, 1945, while awaiting Stalin's arrival.

Secretary of War Henry Stimson reviews Japan's situation for Truman and recommends a carefully timed warning. He is then willing to let Japan's existing government continue under a constitutional monarchy. The Japanese ambassador to Russia is also trying to get the Russians to mediate a Japanese surrender. As long as the United States and England insist on unconditional surrender, Japan is going to fight for survival and honor.

President Truman is told of the success of the Trinity shot. Secretary Byrnes agrees to delay the warning statement to the Japanese which will not include any commitment about the Emperor and the Japanese government. The warning would be delivered, when the atomic bombs were ready. Now, General Groves requests permission from General George Marshall to brief General Douglas MacArthur about the availability of the atomic fission bomb scheduled for use in early August. The 509th is flying practice missions over Japan. General Marshall tells President Truman that previous airpower has been insufficient to put Japan out of the war. The Japanese have demonstrated they will not surrender. They will fight to the death. He expects resistance in Japan to be worse. They must end the war to save American lives. General Eisenhower becomes depressed about using the bomb, because he believes Japan to be ready to surrender, and he does not want the United States to be first to use the bomb. He stays out of the debate, because his war in Europe is over.

The Pacific commanders list possible Japanese targets, not yet including Nagasaki. Truman and Byrnes discuss what to tell Stalin, who already knows about the Trinity test. Stalin appears not to be impressed, but Russian troops are assembling at the Manchurian border to attack Japan. President Truman is writing apocalyptic, biblical visions in his diary. Truman decides not to drop the bomb on the Old Capital or the New. General Groves drafts the historic directive releasing the atomic bomb for use. Marshall and Stimson approve it at Potsdam. Truman's staff releases the Potsdam Declaration offering on behalf of the President of the United States, the President of Nationalist

China, and the Prime Minister of Great Britain, to give Japan an opportunity to end the war. The terms include unconditional surrender of all Japanese armed forces, with the alternative being prompt and utter destruction.

The Japanese leaders debate the meaning of the message all day and recommended immediate rejection. Japan intended to fight on. The United States Senate ratifies the United Nations Charter. Three Fat Man preassembled bombs arrive at Tinian air base. The *U.S. Indianapolis* sails to Guam after unloading the Little Boy gun and bullet at Tinian and then on to the Philippines, where the men will join forces training for the November 1 invasion of Kyushu. A Japanese submarine sinks it. 318 sailors survive of the 850 men, who escape the sinking.

Hiroshima will be the first target since it does not have an allied prisoner of war camp. The bomb will prove to the Japanese that the Potsdam Declaration meant business and shock them to surrender. The Japanese militarists have decided to arm the people with bamboo spears and set them against any major invasion force to fight to the death to preserve Japan. The American people are impatient to end the war. Little Boy is ready on July 31. The crews wait for good weather for the flight to Japan. Tibbets (now thirty years old) forbids his men to write letters home or to discuss the mission among themselves. He says that the use of the bomb will shorten the war by at least six months. The mission will be on August 6, and the bomb will drop, when the plane lowers to 7000 feet. Tibbets gives his plane his mother's name, Enola Gay, because she assured him he would not be killed flying. All preparations are complete by dinnertime on the 5th. Nobody can sleep.

At take off, the *Enola Gay* weighs 65 tons. The 7,000 gallons of fuel and a four ton bomb make it 15,000 pounds overweight. Tibbets and crew take off. At 3:00 A.M. two weaponeers enter the unpressurized, unheated bomb bay to finish assembling the bomb. At 5:52 A.M. they approach Iwo Jima, and Tibbets climbs to 9,000 feet to rendezvous with the observation and photography planes. Little Boy is fully armed at 7:30 A.M. The primary target will be Hiroshima. As they cross the Aioi Bridge over the Ota River in central Hiroshima, the bomb is dropped. Four tons lighter, the B-29 jumps and Tibbets dives away.

The first shock wave hits the men, when they are 11 ? miles away from the target. When the second wave hits, they turn back to look at Hiroshima and see the boiling, terribly tall, mushroom cloud. The tail gunner and cameraman see the mushroom as a bubbling mass of purple-gray smoke with a red core, as if everything is burning inside. Lava or molasses covers the whole city, flowing upwards into the foothills. Fires are everywhere.

The temperature at the site of the explosion reached 5,400 degrees F. All living creatures within half a mile of the fireball flash burn. The thermal flash and blast start firestorms until the entire city burns. The next day, people coming into the city to help see nothing but ashes and ruins. The river banks are covered with dead and wounded. Cadavers still burn. Of 76,000 buildings in Hiroshima, 70,000 are damaged or destroyed, 48,000 totally. The city hall, fire departments, police stations, railroad stations, post offices, telegram and telephone offices, broadcast station, and schools are totally destroyed. Those who did not die immediately experience radiation sickness, involving nausea, vomiting, loss of appetite, bloody diarrhea, ulceration of the mouth and gums, and loss of hair. They die. Internal body organs have sustained massive tissue damage and decay before the person dies. The atomic bomb also destroys community. The common world shared at Hiroshima as human organizations and interrelations disappeared. The whole of society is gone. Estimates are that 200,000 people died from the bomb and its effects.

President Truman, en route home from Potsdam, calls this the greatest day in history. General Groves calls Oppenheimer to congratulate him. Leo Sziland feels terrible. Otto Hahn, interned with German scientists in England, is shattered. Others in Los Alamos celebrated the success.

Japan's civilian and military leaders continue to argue about surrender. Due to the total destruction of Hiroshima, they have not received any communications about what happened. Stalin accelerates his war plans and tells the Japanese ambassador that Russia will consider itself at war with Japan the next day. The troops waiting in readiness on the Manchurian border then attack Japan an hour after midnight. The Navy and Air Force print leaflets and drop 6 million over 47 Japanese cities. Fat Man is being assembled at Tinian to be used on August 10th and is readied for use. Major Charles W. Sweeney's plane, *Bock's Car*, is loaded, with the primary target being Kyushu, the secondary being Nagasaki, the San Francisco of Japan, where the torpedoes used at Pearl Harbor were made.

Bock's Car takes off at 3:47 A.M. on August 9, in the rain. The primary target is obscured by heavy ground haze and smoke. They make a radar approach on Nagasaki. The clouds open long enough to give the bombadier a visual sighting on a stadium upriver from their target. Fat Man drops and explodes 1,650 feet above the city on August 9, 1945. The steep hills surrounding the city contain the larger explosion, and it causes less damage and less loss of life. 70,000 people die in 1945, and 140,000 during the next 5 years.

The military leaders of Japan do not agree to surrender. Emperor Hirohito forces the issue and accepts the Potsdam Declaration except for any demand that prejudices his own sovereignty. Truman and Byrnes draft a reply that requires the Emperor and the Japanese High Command to sign the surrender terms. Truman stops further atomic bombing. American incendiary attacks continue, destroying two more cities. Despite a last minute attempt at a military coup in Japan, loyalty prevails. The Emperor broadcasts the surrender to his weeping nation on August 15th.

Chapter 19 "Tongues of Fire" Analysis

President Truman and Secretary of State Byrnes tour the remains of Europe and Berlin, and Truman describes some of the horrors and the remains of Berlin in his diary. The Japanese will not agree to the Allies' description of "unconditional surrender." General

Groves drafts the memorandum authorizing the use of the first atomic bomb. Truman's staff releases the Potsdam Declaration offering Japan an opportunity to end the war. The terms include unconditional surrender of all Japanese armed forces, with the alternative being prompt and utter destruction. Japanese military and civilian leaders debate the meaning of this declaration and determine to continue the war.

The "Little Boy" bomb assembly is loaded on the *Enola Gay,* flown by Colonel Paul Tibbetts, who will drop it on Hiroshima, the only Japanese city without a prisoner of war camp. None of his crew can sleep the night before the bombing, which succeeds too well. It destroys all of Hiroshima, cutting off communications from Japanese high command, preventing it from realizing the power of the new American weapon. Japan's civilian and military leaders continue to argue about surrender as Russia declares war on Japan and invades Manchuria. The second bomb loaded on Major Charles W. Sweeney's plane, *Bock's Car,* is dropped on Nagasaki, where the mountainous geography contains the ensuing damage. Emperor Hirohito of Japan forces the civilian and military leaders to surrender as Truman stops further atomic bombing but LeMay's forces drop incendiary bombs on two more cities. The Emperor broadcasts his surrender to what is left of his country on August 15.

Epilogue

Epilogue Summary

Effects of the atomic bombing of Hiroshima and Nagasaki horrify Leo Szilard, who believes the United States should assume full responsibility for making total world devastation possible. The United States government publishes a detailed report on how the atomic bomb was developed to forestall further information leaks by defining what is public and secret information about the development program. From this the Soviets learn which approaches to isotope separation not to pursue. The day after Nagasaki is bombed, Ernest Lawrence flies to New Mexico to work with Oppenheimer on postwar planning and finds him weary, guilty, and depressed, wondering if the dead at Hiroshima were not luckier than the survivors. Lawrence sees the positive side that the bomb might be the weapon to end all wars.

Members of the Interim Committee Scientific Panel, Lawrence, Oppenheimer, Compton, and Fermi, begin to rethink national policy and advocate free interchange of science and scientists and a form of world government. They are unsuccessful at influencing policy from outside the political process. The scientists meet again at the University of Chicago and decide that if the Russians start making atomic bombs, the world will have a durable armed peace. Permanent world peace could only come with world government. They expect a Third World War with the victor making a world government. Leo Szilard leaves nuclear physics and goes into biology. H. G. Wells, deeply pessimistic about the fate of the world, dies at eighty on August 13, 1946, after the bombings of Hiroshima and Nagasaki. Edward Teller and Enrico Fermi continue work on thermonuclear ignition.

When Japan surrenders, hydrogen bomb studies at Los Alamos stop, because General Groves is unclear about his mandate to continue. Teller, a vehement anti-communist, disagrees, because he fears Russia will soon be an enemy. Bethe returns to Cornell. Oppenheimer returns to California. Fermi joins the faculty at the University of Chicago.

Norris Bradbury, the Navy physicist who organized the assembly of the Trinity bomb, replaces Oppenheimer as director at Los Alamos. Bradbury asks Teller to continue as head of the Theoretical Division, but Teller will agree only if there is a great effort to build a hydrogen bomb in a short time or new models of fission explosives. There is no government support for either program, because the work needs congressional authorization and funding. Teller's wife is expecting their second child. He packs his grand piano and moves to a physics professorship at the University of Chicago.

General Leslie R. Groves returns to Los Alamos to present a certificate of appreciation to the laboratory from the Secretary of War. The entire population of the camp assembles on Oppenheimer's last day as director. Oppenheimer decides to spend the rest of his life encouraging the peoples of the world to unite in spirit, law, conception and feeling. Others return to university positions. The British Mission returns to Great Britain with much information. Neils Bohr settles in the Carlsberg House of Honor in Copenhagen, Denmark.

The War Department learns that the Soviets are taking all German plans, parts, models, and formulas on the use of atomic energy, rocket weapons, and radar from the Czechoslovakian army. The Russians are determined to get the atomic bomb. Edward Teller chairs a secret conference at Los Alamos in April 1946. Klaus Fuchs is one of those present. They examine designs for a thermonuclear weapon, the "classical Super" with 10 megatons explosive force. The United States needs to produce plutonium and improve a fission bomb design during a time of conflict with the Russians. As Teller ages, he sees no defense against atomic weapons, and he begins to urge world government.

In 1949, Teller returns to Los Alamos at Oppenheimer's encouragement. The Russians take over Czechoslovakia, and the Communist Party takes over Hungary. Teller's father, mother, sister and nephew are in Budapest. Teller is there, when President Truman announces the explosion of the first Russian atomic bomb in 1949. Now Congress approves a program to expand production of uranium and plutonium. On January 31, 1950, President Truman announces he wants the H-bomb developed. The next month, Washington learns that Klaus Fuchs passed secret information to the Russians from 1942 to 1949. Stanislaw Ulam and Teller continue working on the "Super" bomb until they become angry with each other and create a new concept of fission called the "Teller-Ulam" configuration, a different mechanism of arming the bomb. Teller becomes increasingly angry and leaves Los Alamos, which builds the first experimental thermonuclear device, coded "Mike." This is the bomb tested at Eniwetok on November 1, 1952, which vaporized the island and left a crater ? mile deep and 2 miles wide in its place. Mike is too big for practical use, so its designers create a hydrogen bomb that can be delivered by aircraft. The Russians test theirs on November 23, 1955.

Gil Elliot writes the *Twentieth Century Book of the Dead* examining how many humans have died by man-made violence in the Twentieth Century. He observes that no part of society, whether church, political party, custom, or body of law, has the strength to resist the new man-made creations for organized death.

The author suggests that the world is now divided into nations with geographical boundaries, replacing the hierarchical feudal system. There is now no system to mediate between nations as the Church once did, and the death organization is the nation-state itself. The "republic of science" has evolved in parallel to the nation states. It was founded in openness and international in scope. Science limits its sovereignty to observable natural phenomena, which does not interest the nation states. This conflict and parallel development of science and the nation-states has continued since 1945. The author believes that the pre-eminent trans-national community in our times is science.

Epilogue Analysis

The author discusses the emotional effects of the creation of the atomic bombs on scientists, who still want a scientific trans-national community to contain the effects of the bomb's creation. The scientists depart for different post-war positions. Stanislaw Ulam and Edward Teller create the devastating hydrogen bomb tested by the Americans at Eniwetok Island in 1952. The Russians test theirs in 1955. The author leaves the future open ended with the hope of creation of some kind of multi-national system to resist the destruction of the world.

Characters

Niels Bohr

Niels Bohr (1885-1962) was a Danish physicist known as the first to apply quantum theory to the study of atomic and molecular particles. He is also known for proposing the liquid model of the atomic nucleus and for formulating the Bohr theory of the atom. Bohr received a doctoral degree from the University of Copenhagen in 1911. He studied under J. J. Thomson at Cambridge University in England, but, when he learned that Thomson was not interested in his work, Bohr left to work under Ernest Rutherford in Manchester, England. There, Bohr distinguished himself by formulating the Bohr atomic model. He returned to Copenhagen in 1912 and in 1921 was named director of the Institute for Theoretical Physics. Under his direction, the Institute soon gained an international reputation for research in quantum theory and atomic physics. Bohr's principle of complementarity offered a theoretical basis for quantum physics, which became widely accepted among many scientists, although Albert Einstein continued to dispute it. Bohr's ground-breaking "liquid drop" model of the atomic nucleus and his "compound nucleus" model of the atom led other scientists to the discovery of nuclear fission. With the outbreak of World War II, Nazi Germany invaded Denmark, as a result of which Bohr and his family fled the country for England and then the United States. He worked on the Manhattan Project in Los Alamos, New Mexico, which developed the first atomic bomb. However, Bohr expressed concern throughout his life about the threat to humanity posed by nuclear warfare.

Sir James Chadwick

James Chadwick (1891-1974) was an English physicist credited with the discovery of the neutron, for which he received a Nobel Prize in 1935. Chadwick worked with Ernest Rutherford at the Cavendish Laboratory in Cambridge, England, in researching properties of the atomic nucleus. In 1945, he received the honor of being knighted for his accomplishments.

Arthur Compton

Arthur Compton (1892-1962) was an American physicist who shared the Nobel Prize for Physics in 1927 for his research on X rays. Compton received his doctorate from Princeton University in 1916. In 1920, he was made head of the department of physics at Washington University in St. Louis, Missouri. Compton's research helped to make legitimate Einstein's quantum theory, which was not yet widely accepted among scientists. In 1923, Compton became professor of physics at the University of Chicago, a post that he retained until 1945. He became the chairman of the committee of the National Academy of Sciences that in 1941 conducted research into the potential development of nuclear weapons, ultimately organizing the Man-hattan Project.

Compton worked on the Manhattan Project as the director of the University of Chicago Metallurgical Laboratory from 1941 to 1945.

Albert Einstein

Albert Einstein (1879-1955) was a German-Jewish physicist whose theories of relativity forever changed scientific approaches to space, time, and gravity. Einstein was awarded the Nobel Prize for physics in 1921. After Hi tler came to power in 1933, Einstein fled Nazi Germany, eventually taking a post at the Institute for Advanced Study at Princeton University in New Jersey, where he remained for the rest of his life. In 1939, Niels Bohr alerted Einstein to the possibility that Germany could develop an atomic bomb. Bohr asked Einstein to write a letter to President Franklin D. Roosevelt, suggesting that the United States initiate research on an atomic bomb. Einstein, however, was not involved in the research carried out by the Manhattan Project and was not even aware of the successful development of the atomic bomb until after it was dropped on Hiroshima. In the wake of this event, Einstein became a vocal advocate for world peace and the prevention of further nuclear warfare.

Enrico Fermi

Enrico Fermi (1901-1954) was an Italian-born physicist who won the Nobel Prize for physics in 1938 for his research on nuclear fission. Fermi earned a doctoral degree at the University of Pisa for his research on X rays. In 1926, he became a professor of theoretical physics at the University of Rome, where he was instrumental in developing a community of brilliant young physicists. On the pretext of traveling to Sweden to receive his Nobel Prize, Fermi fled fascist Italy with his family and settled in the United States. In New York City, Fermi met with other nuclear physicists, eventually becoming a part of the Manhattan Project. Based at the University of Chicago, he developed the first self-sustained nuclear chain reaction, which quickly lead to the making of the first atomic bomb. He became an American citizen in 1944 and, in 1946, was named professor of Nuclear Studies at the University of Chicago.

Richard Feynman

Richard Feynman (1918-1988) was an American theoretical physicist who received the Nobel Prize for physics in 1965 for his work on the theory of quantum electrodynamics. Feynman received his doctorate from Princeton University in 1942. From1941 to 1942, he worked on the Manhattan Project in Princeton, joining the laboratory at Los Alamos, New Mexico, in 1943. Feynman was among the youngest scientists to hold a leadership position at Los Alamos. From 1945 to 1950, he worked as an associate professor at Cornell University, and from 1950 until his retirement he worked as aprofessor of theoretical physics at the California Institute of Technology. Feynman is considered one of the most brilliant scientific minds of the twentieth century.

Otto Frisch

Otto Frisch (1904-1979) was an Austrian-born physicist who worked on the Manhattan Project at Los Alamos, New Mexico. Frisch earned his doctorate degree at the University of Vienna in 1926. He worked with his aunt, the physicist Lise Meitner, together discovering and naming uranium fission in 1939. After the War, Frisch became director of the nuclear physics department of the Cavendish Laboratory at Cambridge University in England.

Brigadier General Leslie R. Groves

In September 1942, Brigadier General Leslie R. Groves (1896-1970) was named head of the Manhattan Engineer District, in charge of all army activities concerned with the Manhattan Project. Groves was responsible for contracting independent building industries to construct the facilities at the various research and production sites that made up the Manhattan Project, such as a gaseous diffusion separation plant and a plutonium production facility.

Otto Hahn

Otto Hahn (1879-1968) was a German chemist who won the Nobel Prize for chemistry in 1944 for his discovery (along with Fritz Strassmann) of nuclear fission. Hahn received a doctorate degree from the University of Marburg in 1901. At the University of Berlin, he conducted research on radioactivity and in 1911 joined the Kaiser Wilhelm Institute for Chemistry. During World War I, he was instrumental in developing chemical warfare. Although his research was instrumental to the development of the atomic bomb, throughout the remainder of his life he opposed the further development of nuclear weapons.

Lise Meitner

Lise Meitner (1878-1968) was a Jewish Austrian-born physicist whose collaborative research withOtto Hahn, Fritz Strassmann, and her nephew Otto Frisch resulted in the discovery and naming of uranium fission. Meitner received her doctorate from the University of Vienna in 1906. In 1907, she began working with Hahn in Berlin on research in radioactivity. In 1938, she fled Nazi Germany for Sweden.

Robert Oppenheimer

Robert J. Oppenheimer (1904-1967) was an American theoretical physicist most widely known as the director of the Los Alamos laboratory of the Manhattan Project, which developed the first atomic bomb. Upon graduating from Harvard, Oppenheimer studied atomic physics under Lord Rutherford at the Cavendish Laboratory at Cambridge. He received his doctoral degree from Göttingen University in 1927, after which he taught physics at the University of California at Berkeley and the California Institute of Technology. His collaboration with a team of scientists on the Manhattan Project lead to the first nuclear explosion test in 1945 at Alamogordo, New Mexico. In 1947, Oppenheimer took a post as head of the Institute for Advanced Study at Princeton University. From 1947 to 1952, he was chairman of the General Advisory Committee of the Atomic Energy Commission. In 1953, during the Red Scare in which many intellectuals were accused of treason, Oppenheimer was put on trial for suspicion of having leaked military secrets, based on his earlier sympathies with communism. He was found not guilty, but his position with the Atomic Energy Commission was terminated. The Federation of American Scientists, however, supported Oppenheimer. In 1963, President Lyndon B. Johnson presented Oppenheimer with the Enrico Fermi Award of the Atomic Energy Commission, thus officially retracting all public denunciation of the scientist.

Sir Rudolf Peierls

Rudolf Peierls (1907-1995) was a German-born physicist whose theoretical work was instrumental in the development of the atomic bomb. Peierls worked with Otto Frisch at the University of Birmingham, in England, where they collaborated on a memo explaining the theories that suggested the possibility of creating an atomic bomb. He became a British citizen in 1940 and in 1943 joined the team of British scientists who moved to Los Alamos, New Mexico, to work on the Manhattan Project. After the war, he returned to his post as a professor at Birmingham. In 1963, he left Birmingham to become a professor at the University of Oxford. Peierls was knighted in 1968.

Max Planck

Max Planck (1858-1947) was a German theoretical physicist who was awarded the 1918 Nobel Prize for physics for his formulation of quantum theory. Planck earned his doctoral degree in 1879 from the University of Munich. In 1892, he became a professor at the University of Berlin, a position that he held throughout his life. Although it was not immediately recognized as such by the scientific community, his quantum theory eventually revolutionized theoretical physics. While Einstein was instrumental in championing Planck's achievement, Planck was instrumental in calling attention to the significance of Einstein's theory of relativity. Although Planck was openly opposed to Hitler's racist policies, he remained in Germany throughout World War II to continue his research.

President Franklin Roosevelt

President Franklin Delano Roosevelt (1882-1945) was in his third term of presidency when the United States entered World War II. In 1939, he received a letter from Einstein alerting him to the potential for developing an atomic bomb, but he failed to see the true significance of this information until the United States entered the war in 1941. Roosevelt died in office on April 12, 1945, several months before the dropping of the first atomic bombs and ending of World War II.

Sir Ernest Rutherford

Ernest Rutherford (1871-1937) was a New Zealand-born British physicist awarded the Nobel Prize for chemistry in 1908 for his research that led to the development of nuclear physics (also referred to as atomic physics). In 1895, Rutherford came to the Cavendish Laboratory at Cambridge, in England, where he studied under J. J. Thomson. In 1898, Rutherford took a post as a professor of physics at McGill University in Montreal, Canada. He moved back to England in 1907 to work at the University of Manchester. Rutherford's most important accomplishment was his nuclear theory of atomic structure, called the Rutherford atomic model. In 1914, he was knighted for his many accomplishments. In 1919, he became head of the Cavendish Laboratory.

Major Charles Sweeney

Major Charles W. Sweeney piloted the B-29 bomber, named the Great Artiste, which dropped the atomic bomb over Nagasaki on August 9, 1945.

Leo Szilard

Leo Szilard (1898-1964) was a Hungarian physicist who was a key figure in the formation of the Manhattan Project. Szilard earned his doctoral degree from the University of Berlin in 1922. He worked as a staff member at the Institute of Theoretical Physics at the University of Berlin until 1933, when Hitler came to power, and he left Germany. Szilard worked for several years at the college of St. Bartholomew's Hospital in England, before moving to the United States to occupy a post at Colombia University. From 1942to 1945, Szilard worked on the Manhattan Project with Fermi's research team at the University of Chicago. After the war, he accepted a position as professor of biophysics at the University of Chicago. Following the war, Szilard became a strong advocate of the use of atomic energy for peaceful purposes and supported limitations on the nuclear arms race.

Edward Teller

Edward Teller (1908-) was a Hungarian-born Jewish nuclear physicist who worked on the Manhattan Project. Teller worked with Enrico Fermi at the University of Chicago before joining the research team at Los Alamos, New Mexico. However, Teller was more interested in research into the development of a hydrogen bomb, which was considered a lesser priority during World War II. After the war, however, Teller became a leading proponent of United States efforts to create a hydrogen bomb, which was potentially more powerful than the atom bomb. In 1951, Teller collaborated with Stanislaw Ulam in a major breakthrough for research on the hydrogen bomb known as the Teller-Ulam configuration. Teller was thus dubbed the "father of the H-bomb."

Sir J. J. Thomson

J. J. Thomson (1856-1940) was an English physicist who discovered the electron in 1897. Thomson began research at the Cavendish Laboratory of Cambridge University in 1880 and in 1884 was made chair of the physics department there. For his accomplishments, Thomson was granted the Nobel Prize for physics in 1906 and was knightedin 1908. Thomson was an influential teacher at Cavendish, and many of his students, including Ernest Rutherford, were awarded Nobel Prizes.

Colonel Paul Tibbets

Colonel Paul W. Tibbets, Jr. was the pilot who flew the B-29 bomber, named Enola Gay, which dropped the atomic bomb on Hiroshima, in Japan, on August 6, 1945.

President Harry Truman

Harry S. Truman (1884-1972) was the thirty-third president of the United States. He took office on April 12, 1945, the day of President Roosevelt's death. Upon being sworn into office, Truman was apprised of the developments of the Manhattan Project, about which he had known little up to that point. While he attended the Potsdam Conference to discuss peace negotiations between the Allies and a defeated Germany, he received notice that the first atomic bomb had been successfully tested by the Manhattan Project on July 16. From Potsdam, a message was sent to Japan, threatening the use of a devastating new weapon unless they agreed to unconditional surrender.When Japan refused this offer, Truman ordered the dropping of the atomic bomb on Hiroshima on August 6, 1945, and on Nagasaki on August 9, 1945.

H. G. Wells

H. G. Wells (1866-1946) was an English writer known today primarily for his classic science fiction novels such as *The Time Machine (1895), The Island of Doctor Moreau (1896), The Invisible Man (1897),* and *The War of the Worlds (1898).* Wells' novel *The World Set Free* (1914) was prophetic in essentially predicting atomic warfare.

Eugene Wigner

Eugene Wigner (1902-1995) was a Hungarian-born physicist who shared the 1963 Nobel Prize for physics for his work on nuclear physics. Wigner received his doctoral degree in 1925 from the Institute of Technology in Berlin. In 1938, he became a professor of mathematical physics at Princeton University, a position that he held until

1971, when he retired. In 1939, Wigner, with Leo Szilard, helped to convince Albert Einstein to draft a letter to President Roosevelt, alerting him of the possibility of developing an atomic bomb. Wigner worked withEnrico Fermi at the University of Chicago Metallurgical Laboratory, part of the Manhattan Project.

Themes

Scientific Community

Rhodes devotes almost the entire first third of *The Making of the Atomic Bomb* to introducing the international community of scientists whose work contributed to the development of the first atomic bomb. Rhodes provides biographical background on scientists from Denmark, Germany, Italy, Austria, Hungary, Great Britain, and the United States. Even before the Manhattan Project formally brought these men and women together, many of them were either familiar with one another's work, had communicated with one another, studied with one another, or collaborated on their research. For instance, several of them worked or studied at the Cavendish Laboratory at Cambridge University in England. Further, the oppressive conditions in Germany under Hitler led many of these scientists who were Jewish to flee Nazi Germany, often settling in the United States or Britain. Rhodes explains in detail the ways in which the research, discoveries, and theoretical developments pioneered by each scientist or team of scientists drew from and added to the work of other scientists. Further, several scientists met informally in New York City and in Chicago, before the formulation of the Manhattan Project, to discuss strategies for alerting the United States government to the importance of developing an atomic bomb before Germany achieved the same end. For instance, several of them worked together at various points to draft letters to United States officials, explaining the urgency of the matter. Finally, the Manhattan Project itself, carried out simultaneously in several locations throughout the United States, represents the collaborative efforts of some of the most brilliant scientists of the twentieth century (many of whom were Nobel Prize winners in physics and chemistry).

Weapons of Mass Destruction

Rhodes is particularly concerned with the implications of nuclear warfare on the fate of the human race. Scientists working on the Manhattan Project were painfully aware of the potentially apocalyptic consequences of developing a weapon of mass destruction. Throughout their research, they debated and discussed the fate of world politics in the wake of atomic warfare. They had no doubt that the knowledge and resources to create nuclear weapons would be within the reach of many nations before long and that this could potentially result in mutual mass destruction by warring nations—the self-immolation of the human race. However, others felt convinced that, because such a universally horrific outcome could result from nuclear warfare, it might in fact be the cause of world peace. Some even believed that the potential for nuclear warfare would inevitably result in a new organization of world politics, whereby all nations would become one, and war would be completely abolished. Others were more cynical, foreseeing the horrors of implementing such a weapon. Rhodes spends considerable time quoting from interviews of victims of the bombing of Hiroshima, making vivid and visceral the effects of the bomb on human lives. He provides extensive descriptions of the aftermath of the bombing in which the charred flesh of the survivors, their skin hanging from their bodies like rags, is perhaps the most prominent image. Rhodes thus attempts to provide the reader with an idea of the deeply felt moral and ethical dilemmas of the scientists responsible for the bomb and the pure horror of the human suffering that resulted from their efforts.

Style

Research and Sources

As a work of nonfiction, Rhodes' success in writing *The Making of the Atomic Bomb* is largely due to the thoroughness and skill with which he conducted his research. Rhodes spent five years researching and writing this history, which combines information from a variety of sources. One of his sources was classified government documents, such as the FBI files that include the record of a secret investigation of Szilard, one of the scientists on the Manhattan Project. Another source was first-person accounts by Japanese survivors of the bombing of Hiroshima, describing in graphic detail the devastation caused by the bomb. Another source was reproductions of important correspondence between scientists and politicians, such as the letter written by Einstein to the United States government, warning of the possibility of Germany building an atomic bomb. Yet another source of material Rhodes incorporates into his narrative are anecdotalaccounts of private conversations between scientists involved in the Manhattan Project.

Nonfiction Genres

Drawing from a wide variety of source materials, Rhodes' narrative also combines elements of a variety of genres, or categories, of nonfiction. His book is part biography, in the sense that he provides extensive biographical background on many of the scientists whose work lead up to the making of the first atomic bomb. It is partly a political history, as Rhodes describes the political and diplomatic significance of historical events surrounding the development of the bomb. It also falls into the category of history of science, as Rhodes traces the series of scientific developments, beginning in the mid-nineteenth century, which made it possible to create an atomic bomb.

Narrative Voice

Rhodes' success with *The Making of the Atomic Bomb* can also be attributed to his capacity for encompassing a massive accumulation of data and several nonfiction genres into a single, coherent, accessible narrative. Rhodes covers a century of history, and an entire globe of political, sociological, and scientific events with a smoothly flowing, comprehensible, as well as comprehensive, third-person narrative voice.

Epigraphs

Rhodes makes use of epigraphs□short, pithy quotations□at the beginning of each of the three parts of the book and facing the table of contents. The very first of these quotes is by Robert Oppenheimer, director of the Los Alamos, New Mexico, branch of the Manhattan Project; it reads: "Taken as a story of human achievement, and human blindness, the discoveries in the sciences are among the great epics." Such a reference to mythological or biblical tales of human heroism and folly is entirely apt as an opening to Rhodes' arguably "epic" nine-hundred page history of the atomic bomb. This quote captures Rhodes' attitude toward the development of the first nuclear weapon, as both a monument to scientific "achievement," and as a testament to a certain moral "blindness" to the horrors that were to result from this achievement. A second opening quote is from Emilio Segré. In this comment, Segré emphasizes a certain element of luck in the various political and scientific efforts that went into the making of the bomb. In offering this quote, Rhodes indirectly comments upon theextent to which minute facts of physical reality□ "solid numbers based on measurement"□can potentially determine the fate of human history.

Historical Context

World War II was waged between the Allied forces and the Axis forces in the years 1939 to 1945. The first use of the atomic bomb was instrumental in determining the outcome of the war.

World War II began on August 31, 1939, when Germany, under Adolph Hitler, invaded Poland. As a result, Great Britain and France declared war on Germany on September 3. Soviet troops invaded Poland's eastern border on September 17, and Germany and the Soviet Union agreed to divide a defeated Poland between them. By October 10, Soviet forces easily established themselves in Estonia, Latvia, and Lithuania. Meanwhile, skirmishes between British naval forces and German U-boats (submarines) took place in September and October of that year.

In February 1940, the Soviet Union attacked Finland, achieving victory by March 6. In April, Germany successfully invaded and occupied both Denmark and Norway. In May, Germany successfully invaded and occupied Belgium. From there, German troops invaded northern France, beating back French and British troops. On June 10, Italy, under Mussolini, aligned itself with Germany by declaring war on France and Great Britain. The French government surrendered to both Germany and Italy, agreeing to a partitioning of France into an occupied zone and an unoccupied zone. In July, the occupied French government, known as the Vichy, consented to the creation of a new French nation under German rule. Accordingly, France ended its alliance with Great Britain against Germany.

Having broken the French-British alliance, Germany began attacks on British air and naval forces in an extended conflict known as the Battle of Britain. When German bombing attacks moved further into British territory, Great Britain retaliated by bombing Berlin. Hitler responded to this offensive with the bombing of London and other British cities. Germany continued air raids over Great Britain into April 1941; however, the British ultimately held off a German invasion with Britain's superior radar technology that allowed them to detect and shoot down many German planes.

In October 1940, Italy began a war against Greece. In April and May 1941, Germany successfully invaded and occupied both Yugoslavia and Greece. As a result, Yugoslavia was broken into several separate states, and Greece was divided between German and Italian occupation zones. On June 22, 1941, German troops invaded Russia.

Up to this point, the United States had remained officially neutral with regard to the war. However, on December 7, 1941, Japanese forces bombed the United States naval base at Pearl Harbor in a surprise attack. As a result, on December 8, the United States declared war on Japan. Japan had invaded China in the years previous to World War II, and, immediately after the United States declared war on Japan, China declared war on Italy, Germany, and Japan. On April 18,1942, the United States bombed Tokyo in an air raid using conventional explosives. With the United States at war, preparations for the secret Manhattan Project to develop the first atomic bomb were made by United States government and military officials.

In January 1943, Roosevelt and Churchill met at the Casablanca Conference, as a result of which Roosevelt announced a request for the unconditional surrender of Germany, Italy, and Japan. On July 25 of that year, Mussolini resigned his rule in Italy, after which the new Italian government secretly negotiated with the Allies. In August, the Allies took Sicily. In September, the Allies landed in Italy, which soon surrendered. On October 13, Italy, now aligned with the Allies, declared war on Germany.

The decisive event of the war was the invasion of German occupied Normandy by American, British, and Canadian troops on June 6,1944, known as D day. When, in April 1945, Allied troops made their way into Germany and surrounded Berlin, Hitler committed suicide. On May 8, 1945, Germany officially surrendered to the Allies.

Meanwhile, war continued on the Pacific front between the Allies and Japan. The Potsdam Conference, in which the leaders of the Allied forces met in a suburb outside Berlin, was held from July 17 to August 2, 1945. During this time, Truman was notified of the successful testing of the first atomic bomb, named Trinity, by members of the Manhattan Project. At this point, Stalin was informed of theUnited States' possession of an atomic bomb. The Allies had made much progress in defeating Japanese forces in the Pacific theater of war, and, on July 26, a declaration was sent from Potsdam to Japan, calling for unconditional surrender and warning of reprisals if this demand was not met.

As Japan refused to surrender, the United States dropped an atomic bomb on the city of Hiroshima on August 6. Japanese government authorities did not entirely comprehend the degree of devastation caused by the new weapon and did not surrender until a second atomic bomb was dropped on the city of Nagasaki on August 9. On August 10, Japan communicated its acceptance of an unconditional surrender, officially surrendering to the Allies on August 14. On September 9, Japan formalized their surrender to China, thus ending World War II.

Critical Overview

Upon publication, *The Making of the Atomic Bomb* enjoyed both critical acclaim and popular success. Rhodes was rewarded for his years of meticulous research when he won the 1987 National Book Award, the 1988 Pulitzer Prize for General Nonfiction, and the 1988 National Book Critics Circle Award for General Nonfiction.

Critics praise Rhodes for his exhaustive research, comprehensive scope, even-handed reportage, and narrative skills in rendering a nearly overwhelming array of historical information into a dramatic story, successfully integrating clear explanation of complex scientific concepts with a humanizing account of the scientists, military officials, and political figures involved in the Manhattan Project.

Solly Zuckerman, in a 1988 review in the *New Republic,* calls it "a monumental study," and, echoing the widespread praise Rhodes received, asserts:

Rhodes' book richly deserves the acclaim that it has already been accorded. He has taken infinite trouble to understand and to outline in simple language the principles of nuclear physics that are the foundation on which the story of the bomb rests. The personalities who move through his book come to life in a way that they are unlikely to have done had they been depicted by a scientist's pen.

Zuckerman further observes, ' T have no doubt that his book will stand for years to come as an authorita tive account of the way our nuclear age started," adding, "Above all, lengthy as it is, it will be enjoyed as a magnificent read."

In addition to his narrative skills, Rhodes is praised for his balanced treatment of controversial subject matter. David Bennett, in *Dictionary of Literary Biography,* notes that *The Making of the Atomic Bomb* "draws much of its strength and vigor from Rhodes' reporting prowess." He observes, "Despite his own feelings about the subject, Rhodes largely remains a dispassionate narrator, an objective historian, never taking sides on the nuclear debate, giving equal space to myriad points of view."

Rhodes' sequel to *The Making of the Atomic Bomb,* entitled *Dark Sun: The Making of the Hydrogen Bomb* (1995), was named one of the best books of 1995 by *Publishers Weekly.* Critical response to *Dark Sun* expresses praise for Rhodes on similar grounds to that of the earlier book. Richard Stengel, in a review in *Time* magazine, calls it "epic and fascinating." A review in *The Economist* states, "Readers of Mr. Rhodes' s magnificent *The Making of the Atomic Bomb* ... could not wish for a better chronicler for the subsequent installment. The insight, learning and narrative skill displayed in that first volume are gathered here again." A reviewer in *Publishers Weekly* expresses the response of many critics to both books by stating, "Rhodes makes history work as drama."

In addition to *The Making of the Atomic Bomb* and *Dark Sun,* Rhodes has written a wide variety of fiction and nonfiction books that demonstrate the broad scope of his research and writing abilities. In 1973, he published *The Ungodly,* a well-researched fictionalized narrative of the Donner Party, a group of Pioneers who, stranded in the mountains by a snowstorm, resorted to cannibalism to survive. *Farm: A Year in the Life of an American Farmer* (1989), was the culmination of a year spent researching the daily activities and financial struggles of a family of farmers. *A Hole in the World: An American Boyhood* (1990) is Rhodes' autobiographical account of the abuse he and his brother experienced as boys. *Nuclear Renewal* (1993) argues for the expanded use of nuclear power plants, which has come to be largely discounted as an unviable energy source. In *How to Write: Advice and Reflections* (1995), Rhodes offers advice to aspiring writers, based on his own experience. *Trying to Get Some Dignity: Stories of Childhood Abuse* (1996), written with third wife Ginger Rhodes, is based on interview material with survivors of childhood abuse.

Criticism

Critical Essay #1

Brent has a Ph.D. in American Culture, specializing in film studies, from the University of Michigan. She is a freelance writer and teaches courses in the history of American cinema. In the following essay, she discusses themes of anti-Semitism and Jewish identity in Rhodes' account of the making of the first atomic bomb.

Rhodes devotes considerable attention to the impact of anti-Semitism and Jewish identity on the careers of many of the scientists who contributed to the Manhattan Project. Because of the rise of fascism and anti-Semitism in Germany and other parts of Europe during the 1930s, many Jewish scientists fled to England and the United States where they generally found posts at prominent universities. Jewish nuclear physicists who fled Nazism included Niels Bohr, Albert Einstein, Enrico Fermi, Lise Meitner, Leo Szilard, Edward Teller, and Eugene Wigner, all of whose efforts were essential to the creation of the first atomic bomb. As prominent Jewish scientists, many of these men and women had been particularly vulnerable as targets for assassination by Hitler.

The rise of Hitler in Germany had a cataclysmic effect on the lives of many prominent German-Jewish scientists in the years preceding World War II. Hitler came to power as chancellor of Germany in 1933, at which time he immediately initiated anti-Semitic policies, both official and unofficial. Soon after coming into power, Hitler organized a national boycott of Jewish businesses, which was accompanied by random acts of public violence committed against Jews. A week later, the Law for the Restoration of the Professional Civil Service determined that all non-Aryan, particularly Jewish, university faculty were to be fired from their posts. This was a devastating blow to both the Jewish and the scientific communities of Germany. According to Rhodes, some 16,000 university faculty members lost their jobs, including eleven current or future Nobel Prize winners. A third of the faculty of both the University of Berlin and the University of Frankfurt were let go. Over one hundred physicists, fully one fourth of the physicists in Germany, were fired.

Jewish and non-Jewish scientists in England and the United States quickly founded organizations for the specific purpose of aiding German-Jewish scientists fleeing Nazi Germany. Szilard and Rutherford organized the Academic Assistance Council in England. John Dewey in the United States organized the Faculty Fellowship Fund at Colombia University. Similarly, the Institute for International Education organized the Emergency Committee in Aid of Displaced German Scholars in the United States. Britain and the United States, therefore, harbored a majority of the displaced scientists. Rhodes notes that some one hundred Jewish physicists settled in the United States between 1933 and 1941.

By the 1920s, Einstein, living in Berlin, was among the most celebrated physicists alive. As a Jew, his international prominence marked him as a thorn in the side of Nazi Germany. Einstein had become an outspoken and highly regarded figure of Jewish pride. In a tour of the United States in 1921, where he was warmly received by American Jews, he raised money for a Hebrew university in Palestine (now Israel). As

Rhodes observes, Einstein "was now not only the most famous scientist in the world but also a known spokesman for Jewish causes." Einstein's outspoken pacifism during World War I added to anti-Semitic prejudices against him on the part of German nationalists. As Rhodes comments, "It rankled German chauvinists, including rightist students and some physicists, that the eyes of the world should turn to a Jew who had declared himself a pacifist during the bloodiest of nationalistic wars and who spoke out for internationalism now." An anti-Jewish organization, the Committee of German Scientists for the Preservation of Pure Scholarship, met publicly to criticize Einstein's theory of relativity as, according to Rhodes, "a Jewish corruption." In the spring of 1933, Einstein, under the impending threat of assassination by Nazi forces, fled Germany and renounced his German citizenship. He was offered a position at Princeton University, in New Jersey, where he remained throughout the rest of his life.

Bohr, a Danish-Jewish physicist, fled his native Copenhagen in 1943, after it was invaded by Hitler. While Hitler wished to "eliminate" Danish Jews, the Danish population rallied in support of its Jewish inhabitants, successfully hiding many of them from Nazi officials. Bohr and his son, himself a promising physicist, were specifically targeted by Hitler as prominent scientists. They escaped to Sweden, however, where Bohr made efforts to convince Swedish authorities to publicly announce their willingness to harbor Jews escaping Nazi-occupied Denmark. Rhodes points out that "Niels Bohr played a decisive part in the rescue of the Danish Jews." However, even in Stockholm, Bohr was in danger of assassination by German agents and was secretly flown out of the country in a flight during which he almost died from lack of oxygen. Bohr arrived in England in time to join the British team of scientists who traveled to Los Alamos to work on the Manhattan Project.

Meitner, an Austrian born Jewish physicist, became vulnerable to Nazi persecution after Hitler took Austria in 1938, making it a province of the Third Reich. Meitner contacted a colleague in Holland, who arranged with government officials for her entry into Holland without a visa or passport. Traveling by train from Berlin to Holland, Meitner was in fear for her safety; Rhodes quotes Meitner's explanation that " 'I knew that the Nazis had just declared open season on Jews, that the hunt was on.'" With Bohr's help, Meitner was given a post at the Physical Institute of the Academy of Sciences in Stockholm, Sweden, and provided with a grant from the Nobel Foundation.

Although Fermi himself was not Jewish, his wife Laura was. In 1938, they began to make plans for fleeing fascist Italy, then occupied by German forces. Fermi took advantage of the opportunity to travel to Sweden in order to accept his Nobel Prize, cleverly convincing Italian authorities to allow him to bring his wife with him. He had already accepted a position at Colombia University.

Rhodes discusses the noteworthy phenomenon that "seven of the twentieth century's most exceptional scientists" were Hungarian Jews. Among such notable figures were Leo Szilard, Eugene Wigner, and Edward Teller, all of whom were instrumental in the Manhattan Project. Rhodes explains that the Hungarian Revolution of 1918, known as the Red Terror, was put down in 1919 and replaced with a fascist regime known as the White Terror. What resulted was, as Rhodes describes it, "a selective but unrelenting anti-Semitism that drove tens of thousands of Jews into exile." Szilard fled to Vienna in 1933, then on to London in 1934, arriving in the United States in 1937, where he taught at Colombia University. Teller arrived in the United States in 1935, where he took a post at George Washington University, in Washington, D.C. In 1941, he became a U.S. citizen and relocated to the University of Chicago, where he worked with Fermi, then to the University of California at Berkeley, where he worked with Oppenheimer. Wigner, also a refugee from anti-Semitic Hungary, was hired by Princeton in 1930.

As refugees from Nazi Germany, now working at such institutions as Colombia and Princeton Universities, they were in a unique position to meet and discuss the political implications of recent breakthroughs in the field of nuclear physics. Their sense of urgency in attempting to alert the United States government was in part motivated by a realistic fear that German scientists were coming to the same conclusions and that Nazi Germany, if it developed an atomic bomb before the United States, could succeed in dominating Europe, if not the world. In 1939, Szilard and Wigner were the first scientists to make serious efforts to contact the United States government in regard to the idea of the atomic bomb. Together, they visited Einstein at his home in Princeton, where they explained recent developments in nuclear physics and their implications for atomic warfare. Although he had not been aware of these developments, Einstein immediately understood them and agreed to draft a letter to President Roosevelt. As foreigners, however, these brilliant scientists encountered obstacles in their attempts to communicate with American officials. Einstein's written English was not perfect, so he drafted the letter in German for translation into English; but even a letter from the celebrated Einstein was not enough to convince authorities in Washington. Fermi later traveled to Washington to present their findings before a group of military and government officials. However, having recently escaped fascist Italy, he was met with American prejudice when someone announced his arrival by referring to him as a "wop," a derogatory term for an Italian.

Distrust of Jewish foreigners on the part of United States officials persisted even throughout the Manhattan Project. Einstein himself, due to his lifelong commitment to world peace, was considered a security risk and not informed of the existence of the Manhattan Project; he in fact was not made aware of work on the atomic bomb until after the bombing of Hiroshima. Absurdly, Szilard, the most ardent and persistent in his repeated attempts to inform the United States of the importance of the atomic bomb, came under suspicion and was followed by secret agents during the course of the Manhattan Project. Rhodes observes that reports derived from "the surveillance of an innocent but eccentric man" were essentially comedic; official reports included such information as the fact that Szilard, a Hungarian Jew, occasionally spoke in a foreign language, that most of his friends were "of Jewish extraction," and that he frequently shopped at delicatessens.

Anti-Semitism and the Jewish identity of many of the world's most brilliant physicists played a significant role in the series of events that led up to the creation of the first atomic bomb. The rise of Nazism in Europe resulted in the emigration of many scientists to the United States and England. The status of these scientists as refugees from the persecution of Hitler's Germany increased their sense of urgency in desiring that the

United States create an atomic bomb before German scientists achieved the same end. As foreigners, however, their vocal and ardent devotion to an Allied victory in World War II did not place them above suspicion in the eyes of the United States government.

Source: Liz Brent, Critical Essay on *The Making of the Atomic Bomb,* in *Nonfiction Classics for Students,* The Gale Group, 2001.

Critical Essay #2

Patnode is an instructor of American history and the history of medicine. In this essay, he evaluates Rhodes' book with regard to the history of science and the relationship of science to society.

Rhodes' *The Making of the Atomic Bomb* is a well-crafted book with prose that is clear, understandable, and very engaging. Indeed, the book is hard to put down at times. No wonder it was received with almost universal critical acclaim and won three major book awards: the National Book Award, the National Book Critics Circle Award, and the Pulitzer Prize. Rhodes gathers a fascinating cast of characters from the past and tells their stories in a lively, captivating style.

However, this focus on individuals is also one of the weak points of the book. In focusing on personalities, Rhodes gives short shrift to the role of culture and institutions in the historical drama that unfolds. For example, he underestimates the significance of the blind faith Americans had in science during the 1930s and 1940s. This has led society to an overly optimistic belief in the redemptive powers of experts, both historically and in the present. In short, Rhodes' book puts an overly optimistic spin on the relationship between science and society.

One of the cultural influences on science that Rhodes does briefly explore is science fiction. Leo Szilard, one of the developers of the bomb and a central actor in the book, was heavily influenced by the work of H. G. Wells. In particular, Szilard was inspired by *The Open Conspiracy,* which refers to Wells' vision of a public trust of science-minded businessmen and financiers who establish a type of global republic. Their mission is nothing less than the salvation of the world. Rhodes continues, "Szilard appropriated Wells' term and used it off and on for the rest of his life." Indeed, Szilard was so inspired by the idea of the "Open Conspiracy" that he tried to create one several times (a clear example of science fiction influencing science practitioners).

The theme of the "Open Conspiracy" is an important one; it recurs throughout the book and provides an excellent illustration of the hubris of scientists during this period. This points toward the weakest element of the book: Rhodes' uncritical acceptance of the point of view that dominated the physical sciences during the 1940s. Physicists like Szilard and Niels Bohr (another prominent physicist who thought that the atomic bomb would make war obsolete) believed that science could create a better world. Or, as Rhodes puts it, "discoveries Szilard made in literature and utopianism opened his mind to new approaches to world salvation." The literature in question is actually H. G. Wells' *The World Set Free.* According to Szilard, the novel envisions "the liberation of atomic energy on a large scale forindustrial purposes, the development of atomic bombs, and a world war." In turn, this book informed Szilard's vision of what the agenda for physicists should be.

Even prior to this, Szilard attempted to create an "Open Conspiracy" of his own in Germany in the form of *Der Bund,* which Rhodes translates as "the order, the confederacy or, more simply, the band." This group was comprised of young physicists that Szilard organized in 1930. One of the fine things Rhodes does throughout the book is use extensive quotes from primary sources (in other words, the original documents written by the historical actors he is studying). Thus, he quotes Szilard's own ideas regarding the *Bund,* which is meant to be "a closely knit group of people whose inner bond is pervaded by a religious and scientific spirit." Szilard believed that this group should be able to influence public affairs even if it had no formal power. Or perhaps the *Bund* might even "take over a more direct influence on public affairs as part of the political system, next to government and parliament, or in the place of government and parliament." This quote is indicative of the kind of presumption found among many scientists during the 1930s and 1940s and serves as a cautionary flag for the critical reader.

However, this is not to say that all scientists were bent on a monolithic conspiracy to take over the world. In fact, many of the scientists involved in weapons work had deep-seated misgivings about the moral implications of their work. For example, scientist Edward Teller (who was involved with the development of both fission and fusion bombs) had deep reservations about the morality of his work with weapons. Rhodes quotes him, "To deflect my attention from physics, my full-time job which I liked, to work on weapons, was not an easy matter." Indeed, Teller agonized over the decision for "quite a time." Here Rhodes has an opportunity to explore the internal workings of a scientist who is debating the course that his discipline has charted during the 1930s and 1940s.

Even though Rhodes includes some of this scientific soul-searching, he downplays its significance. For example, he quickly glosses over Teller's dilemma with a brief story about a speech delivered by Franklin Delano Roosevelt to an audience that included the physicist. In the course of this speech, Roosevelt flatly declared that scientists were not responsible for the terrible destruction of the war. In fact, he says, "What has come about has been caused solely by those who would use, and are using, the progress that you have made along lines of peace in an entirely different cause." In effect, Roosevelt was absolving scientists of any guilt and, moreover, insisting it was their duty to develop weapons. Stirred to action, Teller resolved immediately to focus on weapons work. Rhodes quickly moves on to another subject, never having explored the broader implications of Teller's internal dialogue.

In fact, Rhodes seems to ignore the fact that several of the individuals he discusses actually laid the foundation for the much larger critiques of science that emerged during the latter half of the twentieth century. For example, regarding James B. Conant (a chemist and president of Harvard who was involved with the development of the atomic bomb as well as chemical weapons in World War I), Rhodes simply remarks, "[He] was a patriot who believed in the application of advanced technology to war." This assertion ignores the fact that Conant was directly linked to some of the biggest critics of twentieth century science.

Specifically, Conant helped found one of the programs at Harvard that gave rise to the suspicion of science that followed World War II. As James G. Hershberg recounts in the biography *James B. Conant: Harvard to Hiroshima and the Making of the Nuclear Age,* Conant began teaching a course at Harvard in the early 1940s that was intended for nonscientists and emphasized the "cultural, intellectual, and political contexts of major advances in scientific knowledge and theory." This course led to "thoughtful criticism" and became the training ground for preeminent historians of science like Thomas S. Kuhn.

In turn, Thomas Kuhn gained notoriety for his book *The Structure of Scientific Revolutions,* which suggested that science was not as objective as previously thought. Rather, Kuhn argues that scientific achievements are framed by the cultural circumstances that produce them, suggesting that scientific "truth" is far more relative than previously believed. In other words, science is not merely scientific but always has a cultural and political dimension to it as well. If this is the case, then do people need to accept scientific assertions as absolute truth, or are they open to interpretation as products of the culture that created them? This is a shortcoming in Rhodes' book: he disregards the critics of science who have spent the last fifty years questioning the validity of scientific claims and examining the moral implications of scientific achievements like the atomic bomb.

Rhodes' unquestioning acceptance of the scientific worldview comes across most clearly in the epilogue of his book. He notes, "Science is sometimes blamed for the nuclear dilemma." However, he insists this criticism is misplaced. "[Physicists] Otto Hahn and Fritz Strassmann did not invent nuclear fission; they discovered it." Here and elsewhere, Rhodes completely accepts the scientific worldview□the idea that the universe is a static system governed by universal laws that scientists simply need to discover. For example, he asserts that sometimes even other scientists have a hard time remembering that nuclear bombs were developed "not only as weapons of terrible destruction. They were also, as [Italian physicist Enrico] Fermi once said, 'superb physics.'" In this respect, Rhodes presents a very utilitarian interpretation of history, which holds that the events of the twentieth century were preordained.

Again, this completely discounts the importance of the cultural milieu and historical events that framed the "discovery" of the atomic bomb. The discovery of nuclear fission cannot possibly be removed from the events that surrounded it□namely, World War II. These developments were intrinsically linked to the armed conflict. The war framed nuclear fission as a weapon, a tool for total war. Without the conflict, fission may very well have been conceived as an industrial power source; or conversely, it might never have advanced beyond the planning stages because of a lack of initiative from the government and universities that developed it. However, Rhodes' acceptance of the scientific worldview extends beyond simply repeating what the historical actors in his book said.

Rhodes concludes the book by echoing Leo Szilard's ideas regarding the Open Conspiracy. He posits that the dominant organization of political power in the world today, the nation-state, has become nothing but a "death machine." The onlything that can resist this organization is the "republic of science." This refers to the larger scientific community, which is "founded on openness" and is "international in scope." For two hundred years, these two systems, the nation-state and the republic of science, coexisted. But then, Rhodes concludes, "In 1945 science became the first living organic structure strong enough to challenge the nation-state itself." The liberation of nuclear energy brought these two systems into direct opposition□science finally produced a weapon that was so terrible, war was no longer possible. Consequently, the nation-state could no longer use war as a means of settling disputes. In other words, the republic of science was the only thing that could save the world from the "death machine" of the modern nation-state by forming an Open Conspiracy of its own.

Rhodes expands this argument, implying that the scientists who invented the nuclear bomb were the true American patriots. He asserts that the intention of the American Revolution was to create an open society. This vision of utopia was not unlike the one that physicist Niels Bohr proposed with his "open world." Bohr believed that the coming of the atomic bomb meant the existing political order of the 1940s would have to be replaced with one based on diplomacy and mutual security. Bohr's "openworld" can be read as another inflection of the idea Szilard borrowed from Wells: the Open Conspiracy.

Rhodes goes on to suggest that the American Revolution and Bohr's "open world" have much in common, "in part because the framers of that revolution and the founders of the republic of science drew from a common body of Enlightenment ideas." The Enlightenment refers to an eighteenth century philosophical movement, which argued that the methods of natural science could be used to discover the laws of nature and human cultures in the interest of creating better societies. By this reasoning, the scientists who invented the bomb were the true patriots; the politicians who stymied their vision of the open world were, in fact, traitors to America's founding fathers.

The problem with this interpretation of history has to do with the distinction that Rhodes draws between the nation-state and the republic of science. Again, science cannot be analyzed apart from its cultural context. In other words, the distinction between science and politics represents a false dichotomy. They are not mutually opposed to one another. Rather, they both form part of a larger process of power relations in American society. Indeed, Rhodes even hints at this himself, noting at one point that "industrial technology and applied science enormously amplified the nation-state's power." Rhodes tries to draw a distinction between two social institutions that cannot be separated.

In conclusion, Richard Rhodes has written a fine book. He makes excellent use of primary sources, has synthesized a vast amount of material, and writes about his subjects with a lively, engaging style. Unfortunately, the focus on individuals is a weak point of the book. It serves to reinforce the beliefs of the scientists that he studies. Rhodes neither offers a critical reflection on the role of science in society nor explores the moral dilemmas of the atomic bomb with sufficient depth. In other words, Rhodes ends up endorsing the scientific worldview of the 1940s without considering the subsequent decades of scholarship that have called it into question. This is the only substantial shortcoming in an otherwise excellent book.

Source: Stephen Raymond Patnode, Critical Essay on *The Making of the Atomic Bomb,* in *Nonfiction Classics for Students,* The Gale Group, 2001.

Critical Essay #3

In the following review, Wang calls The Making of the Atomic Bomb "*a most up-to-date and surely most readable version of the exciting story."*

This Pulitzer and National Book Prize-winning work (for 1987) by Richard Rhodes is an exceptionally well-written account of the building and use of the first nuclear weapons. Rhodes presents an extensive historical exploration of the scientific and political background to the bomb that focuses on people□the scientists, engineers, and administrators. He synthesizes a large amount of material, most of it published, and ably weaves various lines of development together to render a most up-to-date and surely most readable version of the exciting story.

Starting with Ernest Rutherford's 1911 discovery of the atomic nucleus, the first third of the book is mostly devoted to the history of nuclear physics before World War II. By narrating the milestone events in the field up to the discovery of nuclear fission in 1938, Rhodes does more than provide the necessary scientific framework within which the bomb was created. Scientists' faith in and practice of openness are well illustrated. Scientists are also shown interacting far beyond their national boundaries. Making full use of biographies, Rhodes introduces prominent scientists such as Niels Bohr, Leo Szilard, Albert Einstein, Werner Heisenberg, James Chadwick, Enrico Fermi, Otto Hahn, J. Robert Oppenheimer, Ernest Lawrence, Edward Teller, and many others, when he describes their discoveries. These men eventually became the central figures in the atomic bomb projects on the two sides of World War II.

The American efforts apparently originated in "the Hungarian Conspiracy" led by Szilard. Always concerned about the fate of the world, Szilard, in the days after fission's discovery, was alarmed by thepossibility of an atomic bomb and particularly of its being in Nazi hands first. Together with Eugene Wigner and Teller, two fellow Hungarian refugee scientists, he went to see Einstein to encourage him to write what became the famous letter that brought the matter to President Roosevelt's attention. Although given some support in 1939, for bureaucratic and technical reasons the bomb project did not receive full impetus until 1941. Then, a more optimistic feasibility report on the bomb from Britain reached America, and Pearl Harbor brought the nation into war. Thereafter, under the general administration of Vannevar Bush, James Conant, and, more directly, General Leslie Groves, by 1945 the Manhattan Project succeeded, and Hiroshima and Nagasaki were devastated.

Though few engineers are named in the book, engineering was largely at the center of the project. Oppenheimer headed the Los Alamos Laboratory, where the bombs were designed and tested. The problems his people faced, highlighted well by the author, were at least as much technological as scientific. Ordnance experts, applied mathematicians, and engineers from numerous fields worked alongside physicists to understand and perfect the mechanism of implosion.

Industrialists were also an important part of the story. Production of bomb-quality uranium-235 and plutonium meant much more than merely an enlargement of laboratory-size apparatus. It figuratively demanded no less than "turning the whole country into a factory," as predicted by Bohr. Du Pont, Kellex, Union Carbide, and many other industrial giants built plants in Oak Ridge, Tennessee, and Hanford, Washington, under the Army Corps of Engineers. In fact, the Hanford plutonium project was the largest plant Du Pont had ever constructed and operated.

Although this impressive achievement testified to the effectiveness of the collaboration between science and government, Rhodes hardly ignores any of the clashes between the two. Barbed wire at Los Alamos disgusted Edward Condon, a prominent physicist. For questioning the hierarchical structure and military control of the project, and Groves's "compartmentalization" policy, Szilard was almost interned by the general. He was, in any case, under continuous army surveillance. So was Oppenheimer, because of his prewar connection with left-wing organizations. Bohr came close to the same position. He tried to convince Roosevelt and Winston Churchill of both the great danger and the opportunity the new bomb would bring to the world and urged them to consider international control of nuclear weapons. Churchill, suspicious of Bohr's activities, warned his advisers that "Bohr ought to be confined" to avoid "leakage of information particularly to the Russians." Rhodes highlights these instances to illustrate one of his themes, that "democratic" science conflicts with the "authoritarian " nation-state.

The military use of the atomic bomb also troubled a good many scientists working on the project. When the bombs were nearly ready, Truman's advisers, the Interim Committee, decided to drop them on Japanese cities. While the scientific consultants to this committee saw no other options, a group of Chicago scientists, including Szilard, disagreed. Led by James Franck, they produced the Franck Report, which surprisingly is not mentioned in the book, and suggested a nonmilitary demonstration of the bomb to better the chance for postwar international agreement on the control of nuclear weapons. But the bombs were dropped, and the nuclear arms race was under way.

There was never any serious questioning of the bomb's use on moral grounds. Atrocities in warfare since World War I, so keenly described by Rhodes, had "the long grave already dug." The use of chemical gases and bombing of civilians terrified people. But the Holocaust in the Nazi concentration camps, the Hamburg, Dresden, and Tokyo firebombings, and the December 1937 massacre of Nanjing where Japanese troops killed 300,000 Chinese, all emphatically proclaimed the darker nature of modern warfare. The apt adoption by all belligerents of new military technologies and the strategy of attrition war prepared the stage for the use of atomic weapons. It was merely a "bigger" bomb, as Churchill and many others saw it.

This failure to recognize the revolutionary nature of the new weapons, against which there is no protection except massive retaliation, Rhodes concludes, misled the politicians and brought us to today's confrontational world. The way out of the problem is to negotiate an open world with nuclear arms under international control. This, Rhodes argues, is a direct consequence of science's challenge to the traditional power of nation-states.

Source: Zuoyue Wang, Review of *The Making of the Atomic Bomb,* in *Technology and Culture,* Vol. 30, No. 4, 1989, pp. 1078-1081.

Adaptations

The Making of the Atomic Bomb, by Richard Rhodes, was recorded on audiocassette by Books on Tape in 1992.

Topics for Further Study

Learn more about the development of methods for harnessing nuclear power as an energy source for peaceful purposes. What scientific research resulted in the construction of nuclear power plants? When was the first nuclear power plant constructed? What types of opposition arose to the development of nuclear power plants? What is the status of nuclear energy as a peacetime power source in the United States today? What about in other nations?

The research of many scientists throughout the first half of the twentieth century led up to the realization that an atomic bomb was possible. Pick one of these scientists from the Key Figures list in this entry, and learn more about his or her research up to 1942 when the Manhattan Project was organized. How did this scientist's research contribute to the creation of the first atomic bomb?

Learn more about the impact of the atomic bomb on Japan. How did the Japanese government and people respond to the horrors of Hiroshima and Nagasaki in the post-war years?

What is the status of nuclear weapons in the world today? To what extent does nuclear warfare continue to be a threat to the populations of the world?

Compare and Contrast

1949: The North Atlantic Treaty Organization is founded to create an alliance between the United States and nations of Western Europe in opposition to the military might of the Soviet Union in much of Eastern Europe.

1955: The Warsaw Pact forms a military alliance between the Soviet Union and other Eastern European nations.

1963: The Nuclear Test Ban Treaty, signed by the United States, the Soviet Union, and the United Kingdom, bans the testing of nuclear weapons in the earth's atmosphere, in outer space, and underwater; it limits the testing of atomic weapons to underground sites.

1967: The Outer Space Treaty is signed by the United States, the Soviet Union, the United Kingdom, and other nations; it declares that space exploration be conducted for peaceful purposes only and that no nation may claim sovereignty over the moon or any other region of outer space.

1968: The Nuclear Non-Proliferation Treaty, signed by the United States, the Soviet Union, the United Kingdom, and many other nations, claims that no nation shall aid another nation that does not possess a nuclear arsenal in the development or build up of nuclear weapons.

1987: The Intermediate Range Nuclear Forces (INF) Treaty is signed between the United States and the Soviet Union, resulting in the dismantling of some 2,600 missiles and granting each side the right to verify and inspect compliance with the terms of the treaty. This is the first treaty to completely dismantle a particular category of nuclear weapons system.

1945: Over the next forty-five years, the buildup of nuclear arms in the context of the Cold War between the United States and the Soviet Union results in an arms race with the potential to result in mutual mass-destruction.

1947: The term Cold War is first used to characterize the chilly status of international relations between the United States and the Soviet Union.

1962: During the Cuban Missile Crisis, the United States learns that the Soviets have installed nuclear missiles in Cuba. In the course of a diplomatic standoff between President John F. Kennedy and Soviet Premier Nikita Khrushchev, both sides are on the brink of initiating global nuclear warfare. However, Khrushchev backs down, agreeing to remove all nuclear weapons from Cuba in exchange for a United States promise never to invade Cuba.

1972: The Strategic Arms Limitations Talks (SALT), held between the United States and the Soviet Union, result in the signing of the Anti-Ballistic Missile Treaty (ABM). The

ABM Treaty places limitations on the build up of weapons designed to destroy incoming nuclear weapons.

1979: SALT II negotiations result in the proposal of a treaty to limit nuclear weapons, but neither side signs the treaty. However, both sides subsequently adhere to the limitations set by the treaty.

1983: President Ronald Reagan announces his proposal for the development of a Strategic Defense Initiative (SDI), which would include the build up of nuclear weaponry in outer space. However, the "Star Wars" initiative remains controversial throughout the 1980s and is essentially abandoned with the break up of the Soviet Union from 1989-1991.

1989-1991: The collapse of the Soviet Union into fifteen independent, sovereign nations effectively ends the Cold War.

1991-1992: The Strategic Arms Reduction Talks (START) between the United States and the Soviet Union resume the SALT I and SALT II negotiations. With the collapse of the Soviet Union and effective end of the Cold War, both sides agree to significant reduction (of 10-15 percent) in their nuclear arsenal by the dismantling of many existing weapons.

What Do I Read Next?

Farm: A Year in the Life of an American Farmer (1989), by Richard Rhodes, is based on the year Rhodes spent chronicling the daily activities and financial struggles of a Missouri farm family.

A Hole in the World: An American Boyhood (1990), by Richard Rhodes, is Rhodes' autobiographical account of the years of abuse he and his brother suffered at the hands of their stepmother.

Dark Sun: The Making of the Hydrogen Bomb (1995), by Richard Rhodes, is Rhodes' celebrated sequel to *The Making of the Atomic Bomb,* in which he chronicles the research leading to the development of the first hydrogen bomb.

Picturing the Bomb: Photographs from the Secret World of the Manhattan Project (1995), by Rachel Fermi and Esther Samra, is a photographic account of the research and testing done by the Manhattan Project during the development of the first atomic bomb.

Hiroshima: Why America Dropped the Atomic Bomb (1995), by Ronald Takaki, is an analysis of the social, political, and historical context of the American decision to drop the first atomic bomb on Hiroshima, Japan.

Weapons for Victory: The Hiroshima Decision Fifty Years Later (1995), by Robert James Maddox, provides a discussion of the impact of the dropping of the first atomic bomb, in 1945, on politics and international relations in the late twentieth century. This book also offers a discussion of the moral and ethical issues raised by the United States decision to drop the bomb on Hiroshima.

Further Study

Allen, Thomas B., and Norman Polmar, *Code-Name Downfall: The Secret Plan to Invade Japan and Why Truman Dropped the Bomb,* Simon & Schuster, 1995.

Allen and Polmar discuss United States military strategy in respect to President Truman's decision to drop the atomic bomb on Hiroshima.

Alperovitz, Gar, *The Decision to Use the Atomic Bomb and the Architecture of an American Myth,* Knopf, 1995.

Alperovitz presents a critical historical perspective on the United States military strategy and international relations with the Allied nations during World War II in respect to the dropping of the atomic bomb on Hiroshima.

Larsen, Rebecca, *Oppenheimer and the Atomic Bomb,* F. Watts, 1988.

Larsen provides a biography of Robert J. Oppenheimer, a leading scientist in the Manhattan Project, which developed the first atomic bomb.

Lifton, Robert Jay, and Greg Mitchell, *Hiroshima in America: Fifty Years of Denial,* Putnam, 1995.

Lifton and Mitchell discuss the moral and ethical implications of the ways in which the bombing of Hiroshima has been represented in American history.

Rhodes, Richard, *Deadly Feasts: Tracking the Secrets of a Terrifying New Plague,* Simon & Schuster, 1997.

Rhodes discusses the potential threat to humans from a category of infectious diseases known as "mad cow disease" in its bovine form.

________, *How to Write: Advice and Reflections,* Morrow, 1995.

Rhodes offers advice to the aspiring writer, based on his personal experience as a journalist, novelist, and nonfiction writer.

________, ed., *Visions of Technology: A Century of Vital Debate About Machines, Systems, and the Human World,* Simon & Schuster, 1999.

Visions of Technology provides a collection of articles that address the social, historical, and ethical impact of various technological developments throughout the twentieth century.

Rhodes, Richard, and Ginger Rhodes, *Trying to Get Some Dignity: Stories of Triumph Over Childhood Abuse,* W. Morrow, 1996.

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Review in *The Economist,* Vol. 337, No. 7935, October 7, 1995, p. 99.

Review in *Publishers Weekly,* Vol. 242, No. 40, October 2, 1995, p. 40.

Rhodes, Richard, *The Making of the Atomic Bomb,* Simon and Schuster, 1986

Stengel, Richard, Review in *Time,* Vol. 146, No. 8, August 21, 1995, p. 66.

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Introduction

Purpose of the Book

The purpose of Nonfiction Classics for Students (NCfS) is to provide readers with a guide to understanding, enjoying, and studying novels by giving them easy access to information about the work. Part of Gale's□For Students□ Literature line, NCfS is specifically designed to meet the curricular needs of high school and undergraduate college students and their teachers, as well as the interests of general readers and researchers considering specific novels. While each volume contains entries on

□classic□ novels frequently studied in classrooms, there are also entries containing hard-to-find information on contemporary novels, including works by multicultural, international, and women novelists.

The information covered in each entry includes an introduction to the novel and the novel's author; a plot summary, to help readers unravel and understand the events in a novel; descriptions of important characters, including explanation of a given character's role in the novel as well as discussion about that character's relationship to other characters in the novel; analysis of important themes in the novel; and an explanation of important literary techniques and movements as they are demonstrated in the novel.

In addition to this material, which helps the readers analyze the novel itself, students are also provided with important information on the literary and historical background informing each work. This includes a historical context essay, a box comparing the time or place the novel was written to modern Western culture, a critical overview essay, and excerpts from critical essays on the novel. A unique feature of NCfS is a specially commissioned critical essay on each novel, targeted toward the student reader.

To further aid the student in studying and enjoying each novel, information on media adaptations is provided, as well as reading suggestions for works of fiction and nonfiction on similar themes and topics. Classroom aids include ideas for research papers and lists of critical sources that provide additional material on the novel.

Selection Criteria

The titles for each volume of NCfS were selected by surveying numerous sources on teaching literature and analyzing course curricula for various school districts. Some of the sources surveyed included: literature anthologies; Reading Lists for College-Bound Students: The Books Most Recommended by America's Top Colleges; textbooks on teaching the novel; a College Board survey of novels commonly studied in high schools; a National Council of Teachers of English (NCTE) survey of novels commonly studied in high schools; the NCTE's Teaching Literature in High School: The Novel;and the Young Adult Library Services Association (YALSA) list of best books for young adults of the past twenty-five years. Input was also solicited from our advisory board, as well as educators from various areas. From these discussions, it was determined that each volume should have a mix of □classic□ novels (those works commonly taught in literature classes) and contemporary novels for which information is often hard to find. Because of the interest in expanding the canon of literature, an emphasis was also placed on including works by international, multicultural, and women authors. Our advisory board members□educational professionals□ helped pare down the list for each volume. If a work was not selected for the present volume, it was often noted as a possibility for a future volume. As always, the editor welcomes suggestions for titles to be included in future volumes.

How Each Entry Is Organized

Each entry, or chapter, in NCfS focuses on one novel. Each entry heading lists the full name of the novel, the author's name, and the date of the novel's publication. The following elements are contained in each entry:

- Introduction: a brief overview of the novel which provides information about its first appearance, its literary standing, any controversies surrounding the work, and major conflicts or themes within the work.
- Author Biography: this section includes basic facts about the author's life, and focuses on events and times in the author's life that inspired the novel in question.
- Plot Summary: a factual description of the major events in the novel. Lengthy summaries are broken down with subheads.
- Characters: an alphabetical listing of major characters in the novel. Each character name is followed by a brief to an extensive description of the character's role in the novel, as well as discussion of the character's actions, relationships, and possible motivation. Characters are listed alphabetically by last name. If a character is unnamed□for instance, the narrator in Invisible Man-the character is listed as □The Narrator□ and alphabetized as □Narrator.□ If a character's first name is the only one given, the name will appear alphabetically by that name. □ Variant names are also included for each character. Thus, the full name □Jean Louise Finch□ would head the listing for the narrator of To Kill a Mockingbird, but listed in a separate cross-reference would be the nickname □Scout Finch.□
- Themes: a thorough overview of how the major topics, themes, and issues are addressed within the novel. Each theme discussed appears in a separate subhead, and is easily accessed through the boldface entries in the Subject/Theme Index.
- Style: this section addresses important style elements of the novel, such as setting, point of view, and narration; important literary devices used, such as imagery, foreshadowing, symbolism; and, if applicable, genres to which the work might have belonged, such as Gothicism or Romanticism. Literary terms are explained within the entry, but can also be found in the Glossary.
- Historical Context: This section outlines the social, political, and cultural climate in which the author lived and the novel was created. This section may include descriptions of related historical events, pertinent aspects of daily life in the culture, and the artistic and literary sensibilities of the time in which the work was written. If the novel is a historical work, information regarding the time in which the novel is set is also included. Each section is broken down with helpful subheads.
- Critical Overview: this section provides background on the critical reputation of the novel, including bannings or any other public controversies surrounding the work. For older works, this section includes a history of how the novel was first received and how perceptions of it may have changed over the years; for more recent novels, direct quotes from early reviews may also be included.
- Criticism: an essay commissioned by NCfS which specifically deals with the novel and is written specifically for the student audience, as well as excerpts from previously published criticism on the work (if available).

- Sources: an alphabetical list of critical material quoted in the entry, with full bibliographical information.
- Further Reading: an alphabetical list of other critical sources which may prove useful for the student. Includes full bibliographical information and a brief annotation.

In addition, each entry contains the following highlighted sections, set apart from the main text as sidebars:

- Media Adaptations: a list of important film and television adaptations of the novel, including source information. The list also includes stage adaptations, audio recordings, musical adaptations, etc.
- Topics for Further Study: a list of potential study questions or research topics dealing with the novel. This section includes questions related to other disciplines the student may be studying, such as American history, world history, science, math, government, business, geography, economics, psychology, etc.
- Compare and Contrast Box: an □at-a-glance□ comparison of the cultural and historical differences between the author's time and culture and late twentieth century/early twenty-first century Western culture. This box includes pertinent parallels between the major scientific, political, and cultural movements of the time or place the novel was written, the time or place the novel was set (if a historical work), and modern Western culture. Works written after 1990 may not have this box.
- What Do I Read Next?: a list of works that might complement the featured novel or serve as a contrast to it. This includes works by the same author and others, works of fiction and nonfiction, and works from various genres, cultures, and eras.

Other Features

NCfS includes □The Informed Dialogue: Interacting with Literature,□ a foreword by Anne Devereaux Jordan, Senior Editor for Teaching and Learning Literature (TALL), and a founder of the Children's Literature Association. This essay provides an enlightening look at how readers interact with literature and how Nonfiction Classics for Students can help teachers show students how to enrich their own reading experiences.

A Cumulative Author/Title Index lists the authors and titles covered in each volume of the NCfS series.

A Cumulative Nationality/Ethnicity Index breaks down the authors and titles covered in each volume of the NCfS series by nationality and ethnicity.

A Subject/Theme Index, specific to each volume, provides easy reference for users who may be studying a particular subject or theme rather than a single work. Significant subjects from events to broad themes are included, and the entries pointing to the specific theme discussions in each entry are indicated in boldface.

Each entry has several illustrations, including photos of the author, stills from film adaptations (if available), maps, and/or photos of key historical events.

Citing Nonfiction Classics for Students

When writing papers, students who quote directly from any volume of Nonfiction Classics for Students may use the following general forms. These examples are based on MLA style; teachers may request that students adhere to a different style, so the following examples may be adapted as needed. When citing text from NCfS that is not attributed to a particular author (i.e., the Themes, Style, Historical Context sections, etc.), the following format should be used in the bibliography section:

Night. Nonfiction Classics for Students. Ed. Marie Rose Napierkowski. Vol. 4. Detroit: Gale, 1998. 234-35.

When quoting the specially commissioned essay from NCfS (usually the first piece under the Criticism subhead), the following format should be used:

Miller, Tyrus. Critical Essay on Winesburg, Ohio. Nonfiction Classics for Students. Ed. Marie Rose Napierkowski. Vol. 4. Detroit: Gale, 1998. 335-39.

When quoting a journal or newspaper essay that is reprinted in a volume of NCfS, the following form may be used:

Malak, Amin. Margaret Atwood's The Handmaid's Tale and the Dystopian Tradition, Canadian Literature No. 112 (Spring, 1987), 9-16; excerpted and reprinted in Nonfiction Classics for Students, Vol. 4, ed. Marie Rose Napierkowski (Detroit: Gale, 1998), pp. 133-36.

When quoting material reprinted from a book that appears in a volume of NCfS, the following form may be used:

Adams, Timothy Dow. Richard Wright: Wearing the Mask, in Telling Lies in Modern American Autobiography (University of North Carolina Press, 1990), 69-83; excerpted and reprinted in Novels for Students, Vol. 1, ed. Diane Telgen (Detroit: Gale, 1997), pp. 59-61.

We Welcome Your Suggestions

The editor of Nonfiction Classics for Students welcomes your comments and ideas. Readers who wish to suggest novels to appear in future volumes, or who have other suggestions, are cordially invited to contact the editor. You may contact the editor via email at: ForStudentsEditors@gale.com. Or write to the editor at:

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