Supporting Information
for
Integrating Social Responsibility and Diversity, Equity, and Inclusion into the Graduate Chemistry Curriculum

Course Handouts

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Note: the authors encourage the use and adaptation of the included materials for teaching similar courses at other institutions or in other disciplines. With the use of these materials, please acknowledge this publication and its authors, and the Scientific Responsibility and Citizenship course taught in the UC Berkeley Department of Chemistry. The corresponding authors (K.T.X. and A.M.B.) can be contacted for further questions.

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Class 1 Handout
Critical Race Theory and Science Research
Chem 299: Scientific Responsibility and Citizenship 2022

Critical Race Theory (CRT) has become a buzzword lately, but what does it actually mean? CRT is a *theoretical framework* (a theory that helps us understand certain social phenomena). It was first proposed in 1989, with roots in earlier ideas from the 1960s and 1970s, and is based on the following main ideas, called tenets:

1. Race is socially constructed and not biologically natural – *race has no scientific genetic basis, but rather is a result of socially imposed and learned phenomena*
2. Racism is normal, not aberrational – *racial bias is ingrained in our societal structures; it is not rare; we have become normalized to it so we often don't notice*
3. Societal structures serve the interests of dominant White groups – *the system is set up to benefit White people legally, financially, and socially, due to effects of capitalism and imperialism; theories that analyze the reasons for this include "interest convergence" and "material determinism"*
4. "Differential racialization" – *stereotypes are constructed in the media and popular culture to oppress people of color and serve the interests of White people*
5. Intersectionality (or "anti-essentialism") – *no individual can be adequately identified with a single group; multiple aspects of a person's identity affect their lived experience*
6. Voices of Color – *people of color are uniquely qualified to speak on the experiences of other members of their group(s) regarding racism; scholarship cannot replace lived experiences*

A related theoretical framework is **White Institutional Presence** (WIP), which describes the dominance of White culture in institutions of higher education. WIP has four attributes:

1. White ascendancy – *a sense of superiority, a sense of entitlement, domination over racial discourse, and White victimization, which results from White mainstream authority and advantage*
2. Monoculturalism – *the expectation that all individuals conform to one "scholarly" worldview, which stems from beliefs in the superiority and normalcy of White culture*
3. White blindness – *belief that the race of a person is and ought to be immaterial to any decision-making process, and that equality can be achieved this way; color blindness protects White identity and obscures White privilege*
4. White estrangement – *the physical and social distancing of Whites from people of color; structural diversity within higher education by itself does not bring about heterogeneous interactions*

Note that neither of these theoretical frameworks are directly criticizing "Whiteness." Rather, they state that the default culture we live in contains an inherent bias toward "Whiteness." To become more equitable and inclusive to a diverse population, we need to recognize that these biases exist, and consider who is being left out. In academic science, inherent biases may exist not only in terms of race, but also, to varying degrees, in terms of gender, sexual orientation, socioeconomic class, national origin, etc. If you are in a position of privilege, you can **be an ally** by acknowledging the advantages afforded to you by these existing biases in our "default" state, and by **actively** helping your peers who are excluded from this default feel more valued and included.

How do these theoretical frameworks relate to science?

We don't often consider these social theories in scientific research, but we do see numerous examples of the impacts of scientific research inequitably benefiting or harming different communities (related to tenet 3 of CRT). We can conclude that there must be biases inherent in the research that we do, the ways that we do it, and the applications we use it for– i.e. science does not exist in a vacuum of pure objective reason, but interacts with society and its inequities and biases. When looking at historical examples of "what went wrong," note that many cases don't involve "bad actors" with malicious intent, but rather a complex and nuanced situation that *systematically* disadvantages certain groups. Preventing harm requires **active choices to do good**, rather than just not doing things that are obviously bad. The existing system already contains a bias that we need to actively counteract. It is important that we recognize that **science is not purely objective**, and that these social issues are **directly relevant to doing good science**. We need to first understand the biases in the system in order to correct for them – like a baseline correction or background correction you might do for a measurement.

Of course, we shouldn't stop just at recognizing the problem! The specific actions that can be taken will vary depending on your field and your career stage. You won't always be able to take direct action, but by being aware and thoughtful, we can be ready to take action when we have the opportunity. It could be as small as a personal interaction with someone, or as large as a paradigm shift in your whole field!

What does it mean to be an ally?

An ally is a person from a dominant group (usually having multiple dominant group identities, such as White, heterosexual, cisgender, etc.) who takes action to end oppression. In recent years, "ally" has also become a buzzword and is often used by people in positions of privilege to deflect attention from their privilege. Allyship should be centered on one's **actions**, not one's identity as an ally. A true ally for social justice needs to:

1. Acknowledge one's own privileged identity and the *systemic* nature of their privilege
   - *Common pitfalls*: seeing privilege and oppression as results of biased individuals or individual actions, rather than a systemic bias; being uncomfortable acknowledging one's own association with privilege
2. Have self-awareness about *systemic* oppressions; feel a sense of **solidarity**
   - *Common pitfalls*: seeing oneself as a "savior" to oppressed groups; dwelling on feelings of guilt – guilt should not be the primary motivation; centering allyship on helping individuals rather than addressing systems
3. Develop a sense of agency and feel capable and responsible for helping to create change
   - *Common pitfalls*: performative allyship, lip service without real action; feeling "fragile" or afraid of criticism while engaging in allyship; placing the burden on oppressed groups to educate dominant groups on the nature of their oppression; "tone policing" (criticizing the emotional tone of delivery of a message instead of its content)
4. Continually re-examine and re-evaluate one's own identity and one's actions
   - *Common pitfalls*: becoming too comfortable with one's identity as an ally; allyship is an evolving process, not a single state or status – be open to growth and recognize your limitations

This handout gives simplified summaries of CRT, WIP, and Allyship. We encourage you to read more on these topics to gain a more nuanced and detailed understanding. There is no single correct answer to improving social justice, and having an active discussion on these topics is the first step to recognizing their importance. Consider starting an ongoing conversation in your lab or with your peers on how we can counteract systemic biases as scientists.

Further Reading:

On Critical Race Theory:

- The Encyclopedia Britannica article on CRT is a useful overview:

https://www.britannica.com/topic/critical-race-theory

- In an educational context:

  Yosso, Tara J. "Whose culture has capital? A critical race theory discussion of community cultural wealth." *Race Ethnicity and Education*, **2005**, *8*(1), 69. DOI: 10.1080/1361332052000341006

- Studies have shown that students from historically excluded groups are interested in ways that their scientific work can make a contribution to or serve their communities:

  Thoman, D. B., Brown, E. R., Mason, A. Z., Harmsen, A. G., & Smith, J. L. (2015). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience*, *65*(2), 183-188.

  Jackson, M. C., Galvez, G., Landa, I., Buonora, P., & Thoman, D. B. (2016). Science that matters: The importance of a cultural connection in underrepresented students' science pursuit. *CBE—Life Sciences Education*, *15*(3), ar42.

  McGee, E. O., White, D. T., Jenkins, A. T., Houston, S., Bentley, L. C., Smith, W. J., & Robinson, W. H. (2016). Black engineering students' motivation for PhD attainment: Passion plus purpose. *Journal for Multicultural Education*.

  Boucher, K. L., Fuesting, M. A., Diekman, A. B., & Murphy, M. C. (2017). Can I work with and help others in this field? How communal goals influence interest and participation in STEM fields. *Frontiers in psychology*, *8*, 901.

  Data from our Chemistry Department climate survey are in agreement with these findings. Students from historically excluded groups are not any less interested in the scientific context and impact of their work, but have additional values related to prosocial goals and impacts. If science has not historically served their communities, these impacts may not feel intrinsic to their research pursuits.

On White Institutional Presence:

Gusa, D. L. "White Institutional Presence: The Impact of Whiteness on Campus Climate." *Harvard Educational Review*, **2010**, *80*(4), 464. DOI:10.17763/haer.80.4.p5j483825u110002

On Allyship:

Bourke, B. "Leaving behind the rhetoric of allyship." *Whiteness and Education*, **2020**, *5*(2), 179-194, DOI:10.1080/23793406.2020.1839786

Class 2 Handout
Timeline to the Development of Nuclear Weapons

Read over the timeline and mark:

1. The earliest point at which you think there is clear ethical wrongdoing
2. The point at which a scientist could and should have intervened to prevent or correct the ethical wrongdoing

The timeline is adapted from https://www.atomicheritage.org/history/timeline with some additions from https://nuclearprinceton.princeton.edu/
If you are interested in learning more about the impacts of nuclear research on indigenous populations, we encourage you to check out the Nuclear Princeton Website.

November 8, 1895 German physicist Wilhelm Conrad Röntgen discovers x-rays.
1896 French physicist Henri Becquerel discovers radioactivity.
1898 Marie and Pierre Curie discover polonium and radium.
1911 Ernest Rutherford articulates his model of the atom, at the center of which exists a nucleus containing the majority of the atom's mass and all of its positive charge.
June 3, 1920 Ernest Rutherford speculates on the possible existence and properties of the neutron in his second Bakerian Lecture, London.
May 1932 British physicist James Chadwick discovers the neutron.
September 12, 1933 Leo Szilard conceives the idea of using a chain reaction of neutron collisions with atomic nuclei to release energy. He also considers the possibility of using this to make bombs. This predates the discovery of fission by more than six years.
Mid-January, 1934 Irene Joliot-Curie and Frederic Joliot conduct the first demonstration of artificial radioactivity.
May 1934 Enrico Fermi and his team in Rome bombard elements with neutrons and split uranium but do not realize it.
July 4, 1934 Szilard files a patent application describing the use of neutron-induced chain reactions to create explosions and the concept of the critical mass.
September 1934 Ida Noddack publishes a paper in Zeitshrift fur Angewandte Chemie arguing that the anomalous radioactivities produced by neutron bombardment of uranium may be due to the atom splitting into smaller pieces.
October 22, 1934 Enrico Fermi discovers the principle of neutron moderation, and the enhanced capture of slow neutrons.
October 8, 1935 The British War Office rejects Leo Szilard's offer to turn over to them his patents of nuclear energy for free, an offer made to bring them under British secrecy laws.
December 1935 James Chadwick wins the Nobel Prize in Physics for discovery of the neutron.
February, 1936 The British Admiralty accepts Leo Szilard's offer to turn over his patents.
January 29, 1938 J. Robert Oppenheimer hears about the discovery of fission. Within a few minutes, he realizes that excess neutrons must be emitted, and that it might be possible to build a bomb.
December 21, 1938 Otto Hahn submits a paper to Naturwissenschaften conclusively showing the production of radioactive barium from neutron irradiated uranium.

December 24, 1938 Otto Frisch and his aunt Lise Meitner correctly interpret Hahn's results as evidence that the uranium nucleus had split in two (Fission).
Mid-January, 1939 Leo Szilard hears about the discovery of fission from Eugene Wigner. He immediately realizes that the fission fragments, due to their lower atomic weights, would have excess neutrons that must be shed.
January 13, 1939 Otto Frisch observes fission directly by detecting fission fragments in an ionization chamber. With the assistance of William Arnold, he coins the term "fission".
January 26, 1939 Niels Bohr publicly announces the discovery of fission at an annual theoretical physics conference at George Washington University in Washington, DC.
January 28, 1939 Physicists recreate fission experiment at the Carnegie Atomic Physics Observatory in Washington D.C.
February 5, 1939 Niels Bohr realizes that uranium-235 and uranium-238 must have different fission properties, uranium-238 could undergo fission by fast neutrons but not slow ones, and that uranium-235 accounted for observed slow fission in uranium.
March 1939 Enrico Fermi and Herbert Anderson find that there are about two neutrons produced for every one consumed in fission.
April 22, 1939 Frederic Joliot and his group publish their work on the secondary neutrons released in nuclear fission. This demonstrates that a chain reaction is indeed possible.
August 2, 1939 Pres. Roosevelt receives "The Einstein Letter" warning about the prospect of an atomic bomb.
August 31, 1939 Niels Bohr and John A. Wheeler publish a theoretical analysis of fission. This theory implies that uranium-235 is more fissile than U-238, and that the isotope of the undiscovered element 94 (plutonium) with 239 nucleons is also very fissile. These implications are not immediately recognized.
September 1, 1939 Nazi Germany invades Poland, beginning World War II.
October 21, 1939 The first meeting of the Advisory Committee on Uranium in Washington, DC, which was created at President Roosevelt's order. The physicists argue for urgent government attention, but Adamson is hostile. Teller requests $6,000 for research on preliminary uranium-graphite slow neutron experiments, which is grudgingly approved.
February 1940 Otto Frisch and Rudolf Peierls, living in the United Kingdom, consider the possibility of fast fission in uranium-235. Based on a theoretical estimate of the fast fission cross section they estimate the critical mass of pure uranium-235 at "a pound or two", and that a large percentage could be fissioned before explosive disassembly. They also estimate the likely effects of the bomb, and possible assembly methods, as well as estimates of the feasibility of isotope separation.
March, 1940 After much prodding by Leo Szilard, Lyman Briggs, head of the Uranium Committee, finally releases a promised $6,000 budgeted for conducting neutron experiments with Enrico Fermi at Columbia University.
March, 1940 Otto Frisch and Rudolf Peierls conclude that only one pound of highly enriched uranium is needed for a bomb.
March 2, 1940 The first direct measurements of the enormous slow fission cross section of uranium-235 are made by John Dunning at Manhattan, NY.
April 9, 1940 Germany invades Denmark and Norway.

April 10, 1940 First meeting of the British committee (later code-named the MAUD Committee) organized by Henry Tizard to consider Britain's actions regarding the "uranium problem". Research into isotope separation and fast fission is agreed upon.
April 27, 1940 Second meeting of Lyman Briggs' The Uranium Committee. Briggs' decision is that neither research on fast fission, nor work on building a critical uranium-graphite assembly, should begin until the small scale lab experiments, just getting underway, are finished.
May 1940 George Kistiakowsky suggests gaseous diffusion as a possible means for producing uranium-235 to Vannevar Bush during a meeting at Carnegie Institution.
May 10, 1940 Germany launches its assault on Western Europe, attacking Holland, Belgium and France.
May 27, 1940 Louis Turner mails Leo Szilard a manuscript arguing that the isotope of element 94 with 239 nucleons, not yet discovered, should be highly fissionable like uranium-235, and could be manufactured by bombarding uranium-238 with neutrons, to form uranium-239. The same day, Edwin McMillan and Philip Abelson submit the report "Radioactive Element 93" to Physical Review describing their discovery of element 93, neptunium, produced by bombarding uranium with neutrons. Britain subsequently protests the publication as a violation of wartime secrecy.
June 1940 The MAUD Committee acquires its name. Franz Simon begins research on isotope separation through gaseous diffusion.
June 27, 1940 The National Defense Research Committee (NDRC) is created to organize U.S. scientific resources for war including research on the atom and the fission of uranium.
July 1, 1940 The newly founded The National Defense Research Committee, headed by Vannevar Bush, takes over responsibility for uranium research.
November 1940 John Dunning and Nobel Prize winner Harold Urey begin investigating isotope separation techniques without U.S. government support.
November 1, 1940 The $40,000 contract from the NDRC finally comes through. Work begins at Manhattan, NY to assemble a large subcritical pile made of graphite and uranium oxide.
December 1940 The MAUD Committee issues a report on isotope separation authored by Franz Simon. The report concludes that manufacturing uranium-235 by gaseous diffusion is feasible on a scale suitable for weapons production.
February 1941 Philip Abelson begins working on uranium enrichment at the Naval Research Laboratory. He selects liquid thermal diffusion as the technique to pursue.
February 24, 1941 Glenn Seaborg and his research team discover plutonium.
March 1941 The Department of Terrestrial Magnetism (DTM) at the Carnegie Institution measures the fast cross-section of uranium-235. Using it, Rudolf Peierls, on the MAUD Committee, calculates a new critical mass for uranium-235 at 18 pounds as a bare sphere or 9 to 10 pounds when surrounded by a reflector. A memorandum is prepared by the MAUD Committee describing the importance of fast fission for bomb design and transmits it to the U.S. Briggs locks up the document on arrival and shows it to no one.
March 6, 1941 Glenn Seaborg and Art Wahl isolate the first pure neptunium-239 (0.25 micrograms). In a matter of days it decays into a (barely) visible speck of pure plutonium.
March 28, 1941 Joseph Kennedy, Glenn Seaborg and Emilio Segre show that the plutonium sample undergoes slow fission, which implies it is a potential bomb material.

May 1941 After months of growing pressure from scientists in Britain and the U.S. (particularly University of California at Berkeley's Ernest O. Lawrence), Vannevar Bush at The National Defense Research Committee decides to review the prospects of nuclear energy further and engages Arthur H. Compton and the National Academy of Sciences for the task. The report is issued May 17 and treats military prospects favorably for power production, but does not address the design or manufacture of a bomb in any detail. At this same time, Bush creates the larger and more powerful Office of Scientific Research and Development (OSRD), which is empowered to engage in large engineering projects in addition to research, and becomes its director.
May 1941 Tokutaro Hagiwara at the University of Kyoto delivers a speech in which he discusses the possibility of a fusion explosion being ignited by an atomic bomb, apparently the first such mention.
May 18, 1941 Emilio Segre and Glenn Seaborg determine that the slow cross-section of plutonium-239 is 170% of that of uranium-235, proving it to be an even better prospect for a nuclear explosive.
June 22, 1941 Nazi Germany invades the Soviet Union.
June 28, 1941 The Office of Scientific Research and Development (OSRD) is established. Vannevar Bush is put in charge.
July 1941 Emilio Segre and Glenn Seaborg measure the fast fission cross-section of plutonium-239, finding a high value.
July 15, 1941 The MAUD Committee approves its final report and disbands. The report describes atomic bombs in some technical detail, provides specific proposals for developing them, and includes cost estimates. Although the contents of The MAUD Report reach Vannevar Bush at The Office of Scientific Research and Development immediately, he decides to wait for the report to be transmitted officially before taking any further action on fission development. In short, the report concludes that an atomic bomb is indeed feasible.
August to September, 1941 Enrico Fermi and his team at Manhattan, NY begin assembling a subcritical experimental pile containing 30 tons of graphite and 8 tons of uranium oxide. It gives a projected k value of 0.83, indicating that purer materials are needed.
September, 1941 Enrico Fermi muses to Edward Teller whether a fission explosion could ignite a fusion reaction in deuterium. After some study, Teller concludes that it is impossible.
September 3, 1941 With PM Winston Churchill's endorsement, the British Chiefs of Staff agree to begin development of an atomic bomb.
October 3, 1941 The MAUD Report reaches the US through official channels.
October 9, 1941 Vannevar Bush brings The MAUD Report to President Roosevelt for his consideration. FDR asks Bush to determine the cost of an atomic bomb and to explore Army construction needs.
October 12, 1941 Peter L. Kapitza, one of the leaders of Soviet physics, remarked at an international "anti-Fascist" meeting of scientists in Moscow that the recent discovery of nuclear energy could be useful in the war against Germany and that the theoretical prospects of a uranium bomb seemed promising. The Soviet Union would later launch its own atomic program.
October 21, 1941 Arthur H. Compton holds a meeting in Schenectady, NY with Ernest O. Lawrence, J. Robert Oppenheimer, George Kistiakowsky, and James B. Conant reviewing

The MAUD Report and the most recent US work. The meeting ends by concluding that an atomic bomb could be made.
November 1, 1941 Arthur H. Compton issues the final NAS report, highlighting the importance of conducting further research on the feasibility of a U-235 bomb. The report is delivered to FDR by Vannevar Bush on November 27.
November 1, 1941 John Dunning and Eugene Booth at Manhattan, NY demonstrate the first measurable U-235 enrichment through gaseous diffusion.
December 6, 1941 Vannevar Bush holds a meeting in Washington to organize an accelerated research project. Arthur H. Compton remains in charge. Harold Urey is appointed to develop gaseous diffusion and heavy water production at Manhattan, NY; Ernest O. Lawrence will investigate electromagnetic separation at the University of California at Berkeley; and Eger Murphree will develop centrifuge separation and oversee engineering issues. James B. Conant advocates pursuing Pu-239, but no decision on this is made.
December 7, 1941 Japan attacks Pearl Harbor.
December 8, 1941 The US declares war on Japan.
December 11, 1941 The US declares war on Germany and Italy following their declaration of war on the US.
December 18, 1941 The first meeting of the S-1 project is held, sponsored by the OSRD. S-1 is dedicated to the full scale research development of fission weapons.
January 19, 1942 Pres. Roosevelt approves the production of an atomic bomb. Arthur H. Compton creates the Metallurgical Laboratory at the University of Chicago to act as a consolidated research center. He transfers work on "uranium burners" (reactors) to it. J. Robert Oppenheimer organizes a program on fast neutron theoretical physics at the University of California at Berkeley.
February 1942 Arthur H. Compton asks Gregory Breit to coordinate physics research on fast neutron phenomena. At this time available experimental data on all aspects of fast neutron reactions and fission is extremely limited and imprecise. Theoretical techniques are also rudimentary.
April 1942 Enrico Fermi relocates to the Chicago Met Lab. He builds an experimental pile in the Stagg Field squash courts with a projected k value of 0.995, then begins planning the construction of the world's first man-made critical pile, to be called CP-1. Fermi's efforts now shifts from demonstrating feasibility to securing graphite and uranium of adequate purity and in sufficient quantity to build the reactor.
April 1942 Glenn Seaborg arrives in Chicago and starts work on developing an industrial-scale plutonium separation and purification process. Percival Keith of the Kellogg Co. begins designing a gaseous diffusion pilot plant.
May 18, 1942 Gregory Breit, who has been coordinating physics research on fast neutron phenomena, quits, leaving the neutron physics effort without leadership. Arthur H. Compton asks J. Robert Oppenheimer to take over in his place.
May 19, 1942 Robert Oppenheimer writes Ernest O. Lawrence that the atomic bomb problem was solved in principle and that six good physicists should have the details mostly worked out in six months. His optimism is based on the belief that gun assembly would suffice for both uranium and plutonium.

May 23, 1942 S-1 program leaders discuss priorities. James B. Conant urges proceeding with *all* options for producing fissionable material simultaneously: gaseous diffusion, centrifuge, Electromagnetic Separation, and plutonium breeding using both graphite and heavy water reactors. He argues that redundant development will reduce the time to successful production to the shortest possible time, regardless of cost.
June 1942 J. Robert Oppenheimer leads an effort on fast neutron physics, and prepares an outline for the entire neutron physics program. Production of plutonium through marathon irradiation by cyclotron begins. Chicago Met Lab engineering council begins developing plans for large scale plutonium production reactors. President Roosevelt approves a plan for spending $85 million for a weapon development program.
June 18, 1942 Due to continuing and increasing organizational problems, Col. James Marshall is ordered by Brig. Gen. Wilhelm Styer to organize a U.S. Army Corps of Engineers District to take over and consolidate atomic bomb development.
July to September, 1942 Oppenheimer assembles theoretical study group in Berkeley to examine the principles of bomb design. Included are J. Robert Oppenheimer, Hans Bethe, Edward Teller, John Van Vleck, Felix Bloch, Robert Serber, and Emil Konopinski. During the summer the group develops the principles of atomic bomb design, and examines the feasibility of fusion bombs. Oppenheimer emerges as a natural leader. The group estimates the mass of U-235 required for a high yield detonation at 30 kg (estimated at 100 Kt), megaton range fusion bombs are also considered highly likely. During this period Richard C. Tolman and Robert Serber discuss the idea of using explosives to collapse a shell of fissile material in place of the gun assembly method. Serber reports that they co-authored a short paper on the subject, although this paper has not been found. At this time Enrico Fermi and his staff are busy arranging for the materials required for Chicago Pile 1.
July 27, 1942 First shipment of irradiated uranium arrives at the Chicago Met Lab (300 lb.).
Mid-August 1942 Enrico Fermi's group demonstrates an experimental pile with a projected k value of close to 1.04. Achieving a chain reaction is now certain.
August 13, 1942 The Manhattan Engineer District is formally established.
August 20, 1942 Glenn Seaborg isolates pure plutonium through a separation process suitable for industrial scale use.
August 29, 1942 A status report by James B. Conant is relayed to the Secretary of War by Vannevar Bush indicating the very positive results of Oppenheimer's group. Bush adds his concerns about the organization and leadership of the project, requesting new leadership be appointed.
May 15, 1942 President Franklin D. Roosevelt signs into law legislation creating the Women's Army Auxiliary Corps (converted into the Women's Army Corps in 1943).
Sept 13, 1942 The S-1 Executive Committee recommends building a pilot plant based on Ernest O. Lawrence's cyclotrons to separate uranium isotopes in Tennessee.
Sept 15, 1942 Starting on this date, and continuing until November 15, Enrico Fermi's group receives shipments of uranium and graphite for CP-1 and prepares them for assembly.
Sept 17, 1942 Col. Leslie Groves is notified at 10:30 a.m. by Gen. Brehon Somervell that his assignment overseas has been canceled and that he will take another assignment - command of the Manhattan Engineer District. Groves' previous assignment had required overseeing ten billion dollars’ worth of construction projects, including the construction of the Pentagon.

1942 Sept 18 Col. Leslie Groves buys 1250 tons of high quality Belgian Congo uranium ore stored on Staten Island.

1942 Sept 19 Col. Leslie Groves selects Oak Ridge, TN as the site for the pilot plant. He buys Site X, 52,000 acres of land on the Clinch River. Preliminary construction work begins soon after. The Oak Ridge National Laboratory sits on the homelands of the Cherokee people, whose tribe was fractured into three independent and distinct tribal nations, the Cherokee Nation, the Eastern Band of Cherokee Indians, and the United Keetoowah Band of Cherokee Indians.

1942 Sept 19 At Col. Leslie Groves' insistence the Manhattan Project is granted approval by the War Production Board to use the highest emergency procurement priority in existence (AAA) when needed.

1942 Sep 23 Col. Leslie Groves is promoted to Brigadier General.

1942 Sept 29 J. Robert Oppenheimer proposes that a "fast-neutron lab" to study fast neutron physics and develop designs for an atomic bomb be created. The idea at this point is for the lab to be a small research institution that would not be involved in the engineering and production of nuclear weapons.

1942 Oct Gen. Leslie Groves puts DuPont in charge of the plutonium production project.

1942 Oct James B. Conant recommends to Vannevar Bush that information exchange with Britain, already largely one-way (UK --> US), be sharply restricted. Bush passes this recommendation to President Roosevelt. As a result the US loses access to British work in gaseous diffusion, which seriously delays successful plant completion.

1942 Oct Centrifuge separation is abandoned due to technical problems.

1942 Oct 5 Gen. Leslie Groves visits the Chicago Met Lab and meets the key scientists, including J. Robert Oppenheimer. He orders key engineering decisions for plutonium production, under debate for months, be made in 5 days.

1942 Oct 15 Gen. Leslie Groves asks J. Robert Oppenheimer to head Project Y, planned to be the new central laboratory for weapon physics research and design.

1942 Oct 19 Vannevar Bush approves J. Robert Oppenheimer's appointment in meeting with Oppenheimer and Gen. Leslie Groves.

1942 Nov 3 Glenn Seaborg reports that due to plutonium's high alpha activity, slight amounts of light element impurities can cause a serious problem with neutron emission from alpha -> n reactions. This issue caused major concern with many project leaders, including Leslie Groves and James B. Conant, not only due to its own significance, but because it raised apprehension about the impact of other unexplored phenomena. (This issue later became moot due to the problems with Pu-240 contamination). Later in the month the Lewis Committee is formed to review progress and make recommendations.

1942 Nov 12 The Military Policy Commission decides to skip the pilot plant stages and go directly from research to industrial-scale production.

1942 Nov 16 Enrico Fermi's group begins constructing Chicago Pile-1 at Stagg Field using round-the-clock shifts. Also, Groves and Oppenheimer visit the Los Alamos, NM mesa in New Mexico and select it for "Site Y."

1942 Nov 25 General Leslie Groves selects Los Alamos, NM as the site for a scientific research laboratory, codenamed "Project Y". J. Robert Oppenheimer is selected as laboratory director.

1942 Dec During this month the work on gaseous diffusion is reorganized. On the strength of the Lewis Committee's recommendation, gaseous diffusion is chosen as the principal enrichment approach. Kellex Corporation, a subsidiary of Kellog is created to build a plant, Percival Keith is put in charge. Contracts are put in place, and hiring begins for plant construction. Kellex immediately begins work on a process for producing usable barrier material on an industrial scale.
1942 Dec Vannevar Bush provides Roosevelt with an estimate placing the total cost for the Manhattan Project at $400 million (almost 5 times the previous estimate). Roosevelt approves the expenditure.
1942 Dec Plans and contracts are made for the construction of an experimental reactor, plutonium separation plant, and Electromagnetic separation facility at Oak Ridge, TN.
1942 Dec 1 After 17 days of work, Enrico Fermi's group completes Chicago Pile-1. It contains 36.6 metric tons of uranium oxide, 5.6 metric tons of uranium metal, and 350 metric tons of graphite. Construction is halted sooner than planned when Fermi projects that a critical configuration has been reached.
1942 Dec 2 At 3:49 p.m., CP-1 goes critical. It demonstrates a k value of 1.0006, and is allowed to reach a thermal output of 0.5 watts (ultimately it operates at 200 watts maximum). This is the first sustained nuclear fission chain-reaction with the Chicago Pile-1 (CP-1).
1942 Dec 6 M. M. Sundt Company is appointed contractor to build Los Alamos Laboratory in a handshake deal. Sundt begins construction immediately, without plans or blueprints in order to finish as quickly as possible. Between 1942 and 1985, Navajo tribal land was contaminated through the mining of more than thirty million tons of uranium ore, first for the Manhattan Project and later for the Atomic Energy Program. Valerie Kuletz explains that uranium booms "transformed these Indian lands (almost overnight) from a pastoral to a mining-industrial economy, resulting in a mining-dependent population." The non-Indian-owned mining companies installed Navajos in the least protected jobs as miners, jobs that were also the lowest paid. Later, at the encouragement of mining officials, many Navajo homes were built from uranium-mine debris, with six hundred Navajo homes continuing to pose a significant threat of uranium contamination to its inhabitants and visitors. Traci Voyles explains that Navajo "interests and agency were consistently undermined by the racism inherent to settler colonial power."
1943 Jan 16 General Leslie Groves selects Hanford, WA as a site for plutonium production. This location - the Hanford Site - sat on the lands of the Wanapum Tribe, Nez Perce, the Confederated Tribes of the Yakama Nation, and the Confederated Tribes of the Umatilla Indian Reservation. With the US government's decision to occupy this land, they forced the removal of both American Indian and non-Indian residents. The US government gave residents around a few months to relocate themselves. Residents were provided compensation for their relocation. However, often properties were greatly undervalued and the compensation was greatly insufficient. The Hanford reactors generated exorbitant amounts of nuclear and other waste, many of which were improperly stored and spilled into the land, water, and groundwater. To this day, the Hanford Site is extremely contaminated. Remediation efforts are ongoing.
1943 Feb The Soviet Union secretly launches its own atomic program under the direction of Igor Kurchatov. The program was extremely limited throughout the war and included no more than fifty personnel.

1943 Feb 18 Construction begins at Oak Ridge, TN on buildings for the Y-12 Plant -- the electromagnetic U-235 separation plant.
1943 Mar The original construction program nears completion, and staff begins arriving at Los Alamos, NM to begin operations. From this point on the site grows non-stop through the end of the war.
1943 Mar 27 Richard Tolman writes J. Robert Oppenheimer about using explosives to collapse a shell into a critical mass. This is the earliest surviving reference to the idea of implosion (although this term was not used).
1943 April Los Alamos, NM provides its scientists introductory lectures on nuclear physics and bomb design.
1943 April At the beginning of the month the original building plan for Los Alamos, NM is 96% complete. It is already apparent that the original construction program is inadequate to meet needs.
1943 April A series of staff conferences among the roughly 100 scientific staff members are held at Los Alamos, NM. These include indoctrination lectures by Robert Serber (later published as The Los Alamos Primer) on April 5, 7, 9, 12, and 14; and meetings to plan the laboratory's work from April 15 through May 6. The laboratory's initial organization and leadership is worked out.
1943 April Seth Neddermeyer begins research on implosion, seeking to compress hollow metal assemblies.
1943 April Hans Bethe is selected over Edward Teller to head the theoretical division. Teller is soon placed in charge of lower priority research on fusion weapons.
1943 April J. Robert Oppenheimer projects that 100 g of 25% enriched U-235 will be produced by Electromagnetic Separation by 1 Jan. 1944.
1943 April By the end of the March planning sessions, the necessity of including ordnance development activity at Los Alamos was apparent. This greatly expanded the scope of work undertaken at the laboratory to engineering development, and eventually acting as prime contractor for weapon production, and manufacturer of key weapon components (including all nuclear components, and the implosion system).
1943 April 1 Fencing of the reservation completed -- Oak Ridge, TN is closed off to public access. Also, construction begins on plant for manufacturing gaseous diffusion barriers in Decatur, IL although no barrier materials of usable quality have yet been produced.
1943 April 20 A contract is concluded with the University of California to manage Los Alamos, NM acting as paymaster, accountant, and procurement agency. This contract (back dated to Jan. 1 for work already performed) served as the basis for University of California management of both the Los Alamos and Lawrence Livermore laboratories.
1943 May 10 The Los Alamos, NM review committee approves the laboratory's research program.
1943 May 31 Surveying begins for the K-25 Plant, the gaseous diffusion uranium enrichment plant at Oak Ridge, TN.
1943 June K-25 Plant construction begins in Oak Ridge, TN.
1943 June Navy Capt. William Parsons arrives at Los Alamos, NM as Ordnance Division leader to begin directing gun assembly research.

1943 June 24 Working with cyclotron produced plutonium, Emilio Segre determines that the spontaneous fission rate is 5 fissions/kg-sec. This is well within the assembly speed capability of a high speed gun.
1943 July 4 Seth Neddermeyer conducts first explosion in the implosion research program (currently consisting of Neddermeyer, and 3 informal assistants).
1943 July 10-15 The first nuclear physics experiment is conducted at Los Alamos, NM (the measurement of Pu-239 fission neutron yield), inaugurating it as a functioning laboratory.
1943 Aug Despite the efforts of more than 1000 researchers at Kellex and Columbia University, no suitable gaseous diffusion barrier material has yet been developed.
1943 Aug Due to lagging progress on gaseous diffusion, and continuing uncertainties about the required amount of U-235 for a bomb, General Leslie Groves decides to double the size of the Y-12 Plant.
1943 August The first Alpha Electromagnetic Separation unit for uranium begins operation. Construction staff at Oak Ridge, TN now exceeds 20,000. Also, construction begins on the cooling systems for the production reactors at Hanford, WA. Construction staff is about 5,000.
1943 Aug President Franklin Roosevelt and Winston Churchill sign the Quebec Agreement.
1943 Sept 8 Italy surrenders to Allied forces.
1943 Sept 17 First shot fired in gun assembly research program at Los Alamos, NM. The focus at this point is on developing a high velocity gun for plutonium since a uranium gun would be much easier to make.
1943 Sept 20 John von Neumann arrives on a visit to Los Alamos, NM and points out the potential for high compression from implosion. This is a clear advantage for the technique which would make a bomb more efficient, and require a smaller critical mass. Edward Teller and Hans Bethe begin investigating the subject theoretically, J. Robert Oppenheimer and General Leslie Groves become very interested in its potential, and efforts to accelerate the program begin. John von Neumann agrees to work on the physics of implosion in his spare time.
1943 Sept 23 J. Robert Oppenheimer suggests recruiting George Kistiakowsky, the leading explosives research director at The Office of Scientific Research and Development, to aid an expanded implosion effort.
1943 Oct The first Alpha racetrack (containing 96 units) is completed. A work force of 4800 to run the Y-12 Plant has been assembled. Startup is unsuccessful due to unexplained shorts in the magnets.
1943 Oct Project Alberta, the full scale atomic bomb delivery program, begins. Norman Ramsey appointed to select and modify aircraft for delivering atomic bombs.
1943 Oct 4 DuPont engineers release reactor design drawings for the first Hanford, WA plutonium production pile, 100-B, allowing construction to begin.
1943 Oct 10 Site preparation starts for the B-100 plutonium production reactor, B Reactor, at Hanford, WA.
1943 Oct 21 First concrete is poured for the K-25 Plant building at Oak Ridge, TN.
1943 Nov The top experts in England on fission weapons, many former members of the MAUD committee, depart England for the US to assist the atomic bomb project. Included are Niels Bohr, Otto Frisch, Rudolf Peierls, James Chadwick, William Penney, George Placzek, Philip B. Moon, James Tuck, Egon Bretscher, and Klaus Fuchs.

1943 Nov The Navy approves Philip Abelson's plan to build a liquid thermal diffusion pilot plant for enriching uranium, the S-50 Plant.
1943 Nov The world's first sample of plutonium in metal form is produced by reducing PuF_4 with Ba at the Chicago Met Lab.
1943 Nov 4 The X-10 Graphite Reactor pile goes critical at Oak Ridge, TN. This air-cooled experimental pile begins producing the first substantial (gram) amounts of plutonium to assist research into its properties. The world supply of plutonium at this time is 2.5 mg, produced by cyclotrons. Also, a Manhattan Project Governing Board meeting approves an ambitious implosion research program, intended to develop it to the point of usability in six months.
1943 Nov 29 The first B-29 modifications begin at Wright Field, Ohio to adapt it for carrying atomic bombs.
1943 Dec After attempts to bring the first Alpha racetrack into operation fail, the Y-12 Plant is shut down for equipment rebuilding.
1943 Dec Emilio Segre measures the spontaneous fission rate of U-235 at Los Alamos, NM, and finds it lower than expected. This allows a substantial reduction in performance of the planned gun assembly method for uranium.
1943 Dec Chemical separation of reactor-produced plutonium begins, using fuel from the X-10 Graphite Reactor pile.
1944 Jan Philip Abelson, after learning about the problems with the Manhattan Project's gaseous diffusion plant, informs J. Robert Oppenheimer about the progress in his research on liquid thermal diffusion technology. This eventually leads to the construction of the S-50 Plant at Oak Ridge.
1944 Jan General Leslie Groves and J. Robert Oppenheimer decide to plan for a fission bomb test (none was envisioned before this). Groves stipulates that the active material must be recoverable if a fizzle occurs, so the construction of Jumbo, a 214 ton steel container (25 ft x 12 ft), is authorized.
1944 Sept 16 The S-50 Plant begins partial operation at Oak Ridge, TN, but leaks prevent substantial output.
1944 Jan George Kistiakowsky arrives at Los Alamos, NM to assist Seth Neddermeyer in implosion research. It becomes increasingly clear that Neddermeyer's academic research style is unsuited to directing a rapidly expanding research and engineering program.
1944 Jan 11 An implosion theory group is set up with Edward Teller as head.
1944 Feb 16 George Kistiakowsky becomes a full-time Los Alamos staff member, replacing Seth Neddermeyer as leader of implosion research.
1944 Mar Emilio Segre has improved his spontaneous fission estimates in cyclotron plutonium (essentially pure Pu-239) to 11 fissions/kg-sec. This is still acceptable for gun assembly, but greatly narrows the margin of security.
1944 May Six months after the start of accelerated implosion research, little progress towards successful implosion has been made. Inadequate diagnostic equipment prevent accurate measurement of implosion process, and no scheme to avoid asymmetry has yet shown promise. The current approach is to use many simultaneous detonation points over the surface of a sphere, and try different methods of inert spacers or gaps to suppress the shaped charge-like jets that form when detonation waves from adjacent initiation points

merge. Spalling (the ejection of fragments) from the interior surface of the hollow core is a serious problem, as is simply getting precise simultaneous detonation.

1944 Mar 3 Drop tests of dummy atomic bombs begin from specially modified B-29s at Wendover, Utah.

1944 Apr IBM calculating equipment arrives at Los Alamos, NM and is put to work on implosion research.

1944 Apr James Tuck suggests idea of using explosive lenses to create spherical converging implosion waves.

1944 April Monsanto at Dayton, OH begins delivering polonium for initiator research. The rate is initially 2.5 curies/month.

1944 Apr 5-15 On April 5 the first sample of reactor produced plutonium arrives from Oak Ridge, TN. Emilio Segre immediately begins monitoring its spontaneous fission rate. By April 15 he makes a preliminary estimate of a spontaneous fission rate of over 50 fissions/kg-sec (due to Pu-240 contamination), far too high for gun assembly. The report is kept quiet due to limited statistics, and observations continue.

1944 May Two British scientists join Los Alamos, NM, and prove to have important impacts on the implosion program. Geoffrey Taylor (arrived May 24) points out implosion instability problems (especially the Rayleigh-Taylor instability), which ultimately leads to a very conservative design to minimize possible instability. James Tuck brings the idea of explosives lenses for detonation wave shaping (2-D lenses for plane wave generation originally proposed by M. J. Poole in England, 1942), but suggests developing 3-D lenses to create a spherical implosion.

1944 May Edward Teller is removed as head of the implosion theory group, and also from fission weapon research entirely, due to conflicts with Hans Bethe and his increasing obsession with the idea of the Super (hydrogen bomb).

1944 May 9 The 50 milliwatt Water Boiler reactor goes critical at Los Alamos, NM. Holding 565 g of U-235 (in the form of 14.7% enriched uranyl sulfate), dissolved in a 12" sphere of water, this is the world's first reactor to use enriched uranium, and the first critical assembly constructed at Los Alamos.

1944 May 28 First test of the exploding wire detonator, used to achieve precise, reliable simultaneous detonation for implosion.

1944 June J. Robert Oppenheimer replaces Seth Neddermeyer with George Kistiakowsky as director of implosion research.

1944 June Hans Bethe and Rudolf Peierls work on developing explosive lens concept.

1944 June John von Neumann provides design breakthrough for the slow component for focusing.

June 3, 1944 After visiting the uranium enrichment pilot plant at the Naval Research Laboratory, a team of Manhattan Project experts recommends that a liquid thermal diffusion plant be built to feed enriched material to the electromagnetic enrichment plant at Oak Ridge, the S-50 Plant.

1944 July Experiments with explosive lens designs begin by mid-month when 2-D models are fired.

1944 July The design for the gun gadget neutron initiator is completed.

1944 June 6 Allied forces launch the Normandy invasion.

1944 July Scientists at the Chicago Met Lab issue the "Prospectus on Nucleonics," which concerns the international control of atomic energy.
1944 July 4 J. Robert Oppenheimer reveals Emilio Segre's spontaneous fission measurements to the Los Alamos, NM staff. The neutron emission for reactor-produced plutonium is too high for gun assembly to work. The measured rate is 50 fissions/kg-sec, the fission rate in Hanford, WA plutonium is expected to be over 100 times higher still. The discovery of the high spontaneous fission rate of reactor-produced plutonium was a turning point for Los Alamos, NM, the Manhattan Project, and eventually for the practice of large-scale science after the war. The planned plutonium gun had to be abandoned, and J. Robert Oppenheimer was forced to make implosion research a top priority, using all available resources to attack it. A complete reorganization of Los Alamos Laboratory is required. With just 12 months to go before expected weapon delivery a new fundamental technology, explosive wave shaping, has to be invented, made reliable, and an enormous array of engineering problems had to be solved. During this crisis the many foundations for post-war science were laid. Scientist-administrators (as opposed to academic or research scientists) came to the forefront for running large scale research efforts. Automated numerical techniques (as opposed to manual analytical ones) were applied to solve important scientific problems, not just engineering applications. The dispersal of key individuals after the end of the war later carried these insights, as well as the earlier organizational principles developed at Los Alamos throughout American academia and industry.
1944 Aug A. Francis Birch takes over the uranium gun project.
1944 Sept At this point the K-25 Plant is half built, but no usable diffusion barriers have been produced. The Y-12 Plant is operating at only 0.05% efficiency. The total production of highly enriched uranium to date is a few grams.
1944 Sept During the fall Robert Christy suggests the "Christy gadget", the use of a solid core that is raised to supercriticality solely by compressing the metal to twice normal density. This conservative implosion design avoids instability and spalling problems, but the period of maximum compression is brief and requires a "modulated initiator" (a neutron generator that emits a burst at a precise moment). Earlier shell designs could have relied on spontaneous fission and still achieved reasonable efficiency.
1944 Sept President Franklin Roosevelt and British Prime Minister Winston Churchill sign the Hyde Park aide-memoire, pledging to continue researching atomic technology.
1944 Sept 22 The first RaLa implosion test shot is made in Los Alamos, NM. This diagnostic technique used 100 curies of radiolanthanum produced by the X-10 Graphite Reactor at Oak Ridge, TN to provide an intense gamma source for making observations of implosion (essentially an internal x-ray generator). This is the largest radioisotope source ever assembled in the world up to this time.
1944 Sept 26 Loading uranium into the first full scale plutonium reactor, the B Reactor, at Hanford, WA is completed. This reactor contains 200 tons of uranium metal, 1200 tons of graphite, and is cooled by 5 m^3 of water/sec. It designed to operate at 250 megawatts, producing some 6 kg of plutonium a month. Fermi supervises reactor start-up.
1944 Sept 27-30 After several hours of operation at 100 megawatts, the B Reactor pile inexplicably shuts down, then starts up again by itself the next day. Within a few days this is determined to be due to poisoning by the highly efficient neutron absorber Xenon-135, a radioactive fission product. The reactor must be modified to add extra reactivity to overcome this effect before production can begin.

1944 Oct 12 The first B-29s arrive in the Mariana Islands to begin bombing Japan. Japan has so far remained free from air attacks (except for the symbolic Doolittle raid in 1942).
1944 Oct 27 J. Robert Oppenheimer approves plans for a bomb test in the Jornada del Muerto valley at the Alamagordo Bombing Range. General Leslie Groves approves 5 days later, provided that the test be conducted in Jumbo.
1944 Dec Work begins on an implosion initiator for the solid core bomb, it is not clear at this point if one can be made.
1944 Dec First successful explosive lens tests conducted at Los Alamos, NM, establishing the feasibility of making an implosion bomb.
1944 Dec 8 Polish Physicist Joseph Rotblat resigns from the Manhattan Project upon learning that an American atomic bomb will not be used against Nazi Germany.
1944 Dec 22 First Fat Man bomb assembly is completed as production gets underway. Explosive lenses and nuclear material are not yet available, the bomb assemblies are used for airdrop and ground handling practice.
1945 Jan 18 The Dragon experiment conducted by Otto Frisch, in which a U-235 hydride slug is dropped through a barely subcritical U-235 hydride assembly, creates the world's first assembly critical through prompt neutrons alone (prompt critical). The largest energy production for a drop is 20 megawatts for 3 milliseconds (the temperature rises 6 degrees C in that time).
1945 Jan 31 Robert Bacher reports to Oppenheimer that a Po-210/Be-9 implosion initiator (still to be designed) is possible.
1945 Feb Uranium gun design is completed and frozen. Only planning for deployment and combat use once the U-235 is delivered is now required.
1945 Feb Initiator tests begin. Demand for polonium from Dayton, OH rises to 100 curies/month.
1945 Feb Admiral Nimitz, Commander in Chief, Pacific Ocean Areas, is notified of the nature of the atomic bomb project.
1945 Feb 19 Marines land on Iwo Jima, a Japanese observation post for the B-29 raids. Over the next two months 6,281 marines are killed, and 21,865 are wounded in capturing the island from 20,000 defenders.
1945 Feb 28 A meeting between J. Robert Oppenheimer, General Leslie Groves, George Kistiakowsky, James B. Conant, Richard Tolman, Hans Bethe, and Charles Lauritsen is held to fix the design approach for the plutonium bomb. A schedule for completing research, development, engineering, and testing is also established.
1945 Mar 9-10 General Curtis LeMay launches an all-out low altitude firebomb raid on Tokyo with 334 B-29s. Flames engulf 15.8 square miles of the city, killing about 100,000 people and injuring 1,000,000 (41,000 seriously).
1945 Mar 11-18 During these eight days fire raids with similar tactics are launched on Nagoya, Osaka, and Kobe; the second, third, and fourth largest cities in Japan. An additional 16 square miles of city are burned, killing more than 50,000 people.
1945 Apr 11 Robert Oppenheimer reports that George Kistiakowsky has achieved optimal performance with implosion compression in sub-scale tests.
1945 Apr 12 Otto Frisch completes criticality and "zero-yield" experiments with U-235 at Los Alamos, NM. Also, President Roosevelt dies and Harry S. Truman become president.

1945 Apr 13 President Harry Truman learns of the existence of atomic bomb development from Secretary of War Henry Stimson.
1945 Apr 27 The first meeting of the Target Committee to select targets for atomic bombing. Seventeen targets are selected for study: Tokyo Bay (for a non-lethal demonstration), Yokohama, Nagoya, Osaka, Kobe, Hiroshima, Kokura, Fukuoka, Nagasaki, and Sasebo (some of these are soon dropped because they had already been burned down).
1945 Apr 30 Initiator Committee (Hans Bethe, Enrico Fermi and Robert Christy) selects the most promising design for fission initiator (neutron generator) to be used in the implosion bomb. The "Urchin" design is favored, and work on initiator fabrication begins. Also, first batch of supplies for the atomic bomb deployment leaves for Tinian Island from Wendover, Utah.
1945 May 31 Critical mass tests with plutonium begin at Los Alamos, NM.
1945 May Little Boy is ready for combat use, except for the U-235 core. It is estimated sufficient material will be available by 1 August.
1945 May 2 The first Raytheon Mark II X-Unit arrives for detonation testing.
1945 May 7 The 100-ton test is conducted. 108 tons of TNT, laced with 1000 curies of reactor fission products, are exploded 800 yards from Trinity ground zero to test instrumentation for The Trinity Test. This is the largest instrumented explosion conducted up to this date. Also, Nazi Germany surrenders to the Allies.
1945 May 9 General procedures for atomic bombing are completed by D.M. Dennison, under Deak Parsons.
1945 May 10-11 Target Committee reconvenes. On the committee now are J. Robert Oppenheimer, John von Neumann, Deak Parsons, and Hans Bethe. Meeting discusses issues combat employment of atomic bombs (e.g. proper burst height, etc.). Target list is shortened to Kyoto, Hiroshima, Yokohama, and Kokura Arsenal (Niigata is considered).
1945 May 25 464 B-29s raid Tokyo again, burning out nearly 16 square miles of the remaining city. Only a few thousand are killed, urban inhabitants have learned to flee fire bomb attacks quickly and escape the flames.
1945 June Curtis LeMay estimates that the Twentieth Air Force will finish destroying the 60 most important cities in Japan by Oct. 1. Also, the T-5 group in the Los Alamos T (Theory) Division estimates The Trinity Test explosion yield at 4-13 Kt.
1945 June Scientists begin circulating Franck Report, which urges demonstration of the bomb prior to military use.
June 1945 The Interim Committee, organized to guide the final conduct of the war and the post-war reconstruction and led by Secretary of State Designate James Byrnes, issues the recommendations that the atomic bomb be dropped as soon as possible, that an urban area be the target, and that no prior warning be given.
June 16, 1945 The Scientific Panel of the Interim Committee, which includes Enrico Fermi, J. Robert Oppenheimer, Arthur Compton, and Ernest Lawrence, reports that it sees "no acceptable alternative" to the use of an atomic weapon against Japan. Oppenheimer’s subsequent refusal to expedite Leo Szilard’s petition to Truman, signed by 70 Manhattan Project scientists opposing the bomb’s use, ensured that it would arrive too late to matter.
1945 June 21 The Interim Committee rejects The Franck Report.
1945 June 21 The first implosion initiator is ready.

1945 June 24 Otto Frisch confirms that the implosion core design is satisfactory after criticality tests.
1945 June 27 General Leslie Groves meets with J. Robert Oppenheimer and Deak Parsons to plan delivery of atomic bombs to the Pacific theater.
1945 July 11 Assembly of Gadget, the first atomic bomb begins. Also, Japanese Foreign Minister Shigenori Togo cables Ambassador Naotake Sato in Moscow advising him to explore using the USSR as an intermediary in surrender negotiations.
1945 July 16 At 5:29:45 a.m., as part of The Trinity Test, Gadget is detonated in Alamogordo, NM in the first atomic explosion in history. The explosive yield is 20-22 Kt (initially estimated at 18.9 Kt), vaporizing the steel tower.
1945 July 19 J. Robert Oppenheimer suggests to General Leslie Groves that the U-235 from Little Boy be reworked into uranium/plutonium composite cores for making more implosion bombs (4 implosion bombs could be made from Little Boy's pit). Groves rejects the idea since it would delay combat use.
1945 July 23 Secretary of War Henry Stimson, in Potsdam for meeting between President Truman and Soviet Premier Stalin, receives current target list. In order of choice it is: Hiroshima, Kokura, and Niigata. He also receives an estimate of atomic bomb availability: Little Boy should be ready for use on Aug. 6, second Fat Man-type by Aug. 24, 3 should be available in September, and more each month - reaching 7 or more in December. Also, first A-bomb test unit dropped by 509th at Tinian, and combat hemispheres for Fat Man are fabricated.
1945 July 26 President Truman issues the Potsdam Declaration, which warns Japan of "prompt and utter destruction" and requires unconditional surrender of the Japanese armed forces. USS Indianapolis delivers Little Boy bomb units, and the U-235 projectile to Tinian Island. Five C-54 transport planes leave Kirtland Air Force Base, Albuquerque with: the Little Boy U-235 target (its final component); the Fat Man plutonium core, and its initiator.
1945 July 29 The Japanese government rejects the Potsdam surrender demand. Also, the five C-54 transports arrive at Tinian. All components for Little Boy are now on site, but no Fat Man bomb assemblies have yet arrived.
1945 Aug 6 Little Boy is released at 31060 feet above Hiroshima, Japan. Little Boy explodes at an altitude of 1850 feet, 550 feet from the aim point, the Aioi Bridge, with a yield of 12.5-18 Kt (best estimate is 15 Kt). Japan suffers 20,000 military deaths and 70,000-126,000 civilian deaths. Continued contamination and health consequences persist for decades.

Class 3 Handout
Applying a Model of Feminist Inquiry to a Drug Development Case Study

What is Feminist Science?

Feminists have written about the historical exclusion of non-male scientists from the practice of science, and the lack of recognition for the contributions of non-male scientists. Science has also been slow to study women's lives, bodies, and experiences, often even using male subjects to study treatments intended for women. Hence, science has not served women (and people who are not cis-men) satisfactorily. Feminist perspectives on science encompass more than equity issues, however, and feminist science has also critiqued scientific methodology (how we do research), epistemology (how we generate knowledge), and ontology (how we define the meaning of things). These investigations sometimes reveal how scientific practice has failed to meet standards of good science. Most generally, feminists are united in urging recognition of the social contexts in which scientific research takes place and scientific knowledge is received.
(Adapted from the Stanford Encyclopedia of Philosophy.
Read more at: https://plato.stanford.edu/entries/feminist-science/)

In this course, we will use the term "feminist" to refer to **intersectional feminism**, which considers not only gender but also factors such as race, class, ethnicity, national origin, ability, and all the other diverse aspects of human identity and difference.

A Model of Feminist Inquiry

(Deboleena Roy. "Feminist Theory in Science: Working Toward a Practical Transformation." *Hypatia*, **2004**, *19*(1), 255–279. Access at: https://muse.jhu.edu/article/53927)
Roy proposes using a model of feminist inquiry, adapted from the social sciences, to conduct scientific research in a way that will lead to more equitable research processes and impacts. The methodology consists of four steps:

I. Locating the *Origins of Problematics*
   Feminist research would originate from efforts to improve the quality of life for all who live on this planet. Concerns about what is wrong with society, such as violence, poverty, sexual abuse, and the misuse of power over people and resources, are placed at the center of a feminist approach, in contrast to conventional scientific motivations, such as the accrual of knowledge for its own sake, the advancement of capitalism, or personal ambition.
   By starting here, a scientist is forced to think not only about their hypothesis but about **what factors have influenced them to arrive at this particular hypothesis**. The factors that influence a scientist depend on who they are.
II. Uncovering the *Purposes of Inquiry*
   In scientific discourse, the term "purpose" is often used interchangeably with the term hypothesis. The two words do not share the same meaning in the context of a feminist inquiry. In a scientific experiment, the assumption is often made that a purpose for the research obviously exists, even if it goes unsaid. At other times, the purpose is stated by way of referencing a particular subject area, thus suggesting that the research conducted contributes to knowledge in that field, and that the accrual of knowledge is

the sole purpose of the research. By not having to state a defined purpose for the particular scientific experiment, researchers are not required to reveal the social forces prompting their research, or the biases that may exist in their reasoning for conducting the research in the first place. In terms of a feminist model of inquiry, this is unacceptable.

In this feminist methodology, the process of defining the *Purposes of Inquiry* in a scientific experiment forces the scientist to consider the impact of their research in a broader context. The scientist would then be required to investigate what would be **the totality of effects of a scientific intervention would be, prior to its widespread application**. The point here is that even if the totality of effects cannot be fully realized, at least an attempt to consider all the effects, whether desirable or not, should be made on the part of the researcher. This requirement can only improve the current standard of scientific experimentation.

III. Interpreting the *Hypothesis and Evidence*

In a feminist inquiry there would be no claims to pure objectivity. But at the same time, we cannot dismiss objectivity all together. For when objectivity implies quantitative research, statistics, and accuracy, there may still be something to gain from its practice. Of course, feminist science would also strive for accuracy but would not assume that this could be achieved by pure objectivity alone. Therefore, instead of dismissing objectivity completely, Margrit Eichler argues that "it seems useful to think of objectivity as an asymptotically approachable but unreachable goal."

This tension may be resolved if one were to approach the scientific inquiry with **strong objectivity: extending the notion of scientific research to include systematic examination of powerful background beliefs**—it must do so in order to be competent at maximizing objectivity. Therefore, by examining the ideological assumptions built into the actual *Hypothesis* itself, the feminist scientist only increases the level of objectivity in their inquiry, thereby increasing the accuracy in the interpretation of their *Evidence*.

IV. Establishing a *Relationship between the Inquirer and the Subject of Inquiry*

One of the tenets of feminist scholarship is that the researcher should be in the same "critical plane" as the subject matter. By making their **conceptual framework** (i.e. the lens of prior knowledge and theories through which you are approaching your research) clear, the researcher places themself on a mutual footing with the material. This helps to make visible the researcher's actual relationship to the information and interpretations of the research and promotes a **self-reflexive search for researcher bias**, something that is rarely considered necessary in conventional research.

This component of the methodology asks the researcher to state their own beliefs and values, and how this shapes their approach to their research. Included in this should be **a reckoning of the limitations that come with the researcher's approach**. Every approach has limitations, and by acknowledging these, we can identify what gaps remain in our collective knowledge.

Applying the Feminist Model to a Case Study

Imagine you were to design a new research project to investigate the development of birth control today. How can you avoid or ameliorate inequities in your research and broader impact by using this feminist methodology instead of our current Scientific Method? What considerations are missing in the way we currently approach medical research?

I. Locating the *Origins of Problematics*
   A From what motivations does my thesis originate? Does my thesis originate in the material and political concerns of efforts to improve the quality of life for those who are oppressed?
   B How do we come to understand what areas of research are important/exciting or not? Is this an objective or subjective process? How can we counteract the biases in this process?

II. Uncovering the *Purposes of Inquiry*
   A Is it a central purpose of my inquiry to eliminate constraints based on gender (or race, or class, or ability, etc.) in order to change society for the better?
   B Will my inquiry improve the quality of life for people by correcting inaccuracies and distortions of biased paradigms and worldviews?
   C How can we be more inclusive and equitable in the research we do? How can we apply our research to more diverse applications?

III. Interpreting the *Hypothesis and Evidence*
   A Do my *Hypothesis and Evidence* incorporate dynamics of culture that shape both behavior and biology?
   B Am I examining my background beliefs and biases to work toward strong objectivity?

IV. Establishing a *Relationship between the Inquirer and the Subject of Inquiry*
   A How can I as the researcher make my conceptual framework clear and place myself on a mutual footing with the material I used? Did I recognize my limitations as a researcher, and the limitations of my conceptual framework?
   B Whose voices and opinions have the most sway in the research process? Who has the most at stake (both in terms of benefits and harms)? Do these two populations overlap?
   C How can we give the affected communities more agency in the research process?

Optional Additional Reading:

On the history of the development of birth control:

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Watkins, E. S. (1998). *On the pill: A social history of oral contraceptives, 1950-1970.* Baltimore: Johns Hopkins University Press.

On the burden of contraceptive responsibility on women:

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Bertotti, A. M. (2013). Gendered divisions of fertility work: Socioeconomic predictors of female versus male sterilization. *Journal of Marriage and Family*, 75, 13-25.
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Ruhl, L. (2002). Dilemmas of the will: Uncertainty, reproduction, and the rhetoric of control. *Signs*, 27(3), 641-663. doi: 10.1086/337940

On the future of birth control research:

Layne, L. L., Vostral, S. L., & Boyer, K. (Ed.) (2010). *Feminist technology*. Chicago: University of Illinois Press.

Kean, S. (2012). Reinventing the pill: Male birth control. *Science*, 338(6105), 318-320.
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Class 4 Handout

The following article was used as optional further reading for Class 5:

Martin, A.; Iles, A. The Ethics of Rare Earth Elements over Time and Space. *Hyle – Int. J. Philos. Chem.* **2020**, *26*, 5–30. https://doi.org/10.1142/9789811233548_0012.

Class 5 Handouts

The following articles were used as optional further reading for Class 6:

Schummer, J. The Chemical Prediction of Stratospheric Ozone Depletion: A Moral Model of Scientific Hazard Foresight. *Hyle – Int. J. Philos. Chem.* **2020**, *26*, 31–54. https://doi.org/10.1142/9789811233548_0013.

Martin, A.; Iles, A.; Rosen, C. Applying Utilitarianism and Deontology in: Managing Bisphenol-A Risks in the United States. *Hyle – Int. J. Philos. Chem.* **2016**, *22*, 79–103. https://doi.org/10.1142/9789811233548_0010.

Scott, D. Ethics of Climate Engineering: Chemical Capture of Carbon Dioxide from Air. *Hyle – Int. J. Philos. Chem.* **2018**, *24*, 55–77. https://doi.org/10.1142/9789811233548_0014.

Iles, A.; Martin, A.; Rosen, C. M. Undoing Chemical Industry Lock-Ins: Polyvinyl Chloride and Green Chemistry. *Hyle – Int. J. Philos. Chem.* **2017**, *23*, 29–60. https://doi.org/10.1142/9789811233548_0011.