Lecture 3- The Bomb and WW II

Recount history briefly:

- theoretical knowledge for the bomb goes back to Einstein
- that it was physically possible to do this was known in 1938
- the bomb was ready to be dropped in 1945

- Einstein believe that small amounts of matter could be changed into large amounts of energy
  - $e=mc^2$
  - c = 186,000 miles/second, so e is very large
  - small amounts of matter -> large amounts of energy
  - key is finding a way to release

Road to the knowledge that produced the bomb (the science)

- early 20th C. knew that atom had positive center, electrons in orbit around
- 1919, Rutheford discovered the positively charged particle, the proton
- 1932, James Chadwick, discovered another particle with no charge, the neutron
- Fermi (Italian) tried neutrons instead, neutral particles
- 1938, Otto Hahn and Fritz Strassmann, working in Berlin, found out what was happening to Uranium
- by 1939, the concept of "fission" (splitting atom) and "chain reaction" had been born

The technical problems were much more difficult than at first anticipated

- U-235 promising, but problems
- U-238 also had problems
- challenges thus presented to scientists:
  1. what fuel to use in the bomb
  2. if U-235, how to separate U-235 from U-238
  3. if U-238, how to get it to break apart
  4. some other fuel possible?

Government Response:

- January 1939, results of German work circulating in Washington D.C.
- August 2, 1939, Einstein wrote to Roosevelt, bringing problem of fission to his attention
- October 1939, Uranium Committee set up
- June 1940, National Defense Research Committee under Vannevar Bush
- June 1941, Bush named head of Office of Scientific Research and Development (OSRD)
- by 1942, has become Manhattan Engineering District Operation or Manhattan Project

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Intellectual Problems and their solution:

- first focus was on isotope separation
- three ways had been proposed:
    - eletromagnetic method (Alfred O. Nier, Minnesota); will become cylotron work of Lawrence Laboratory at Berkeley
    - gaseous diffusion (John R. Dunning, Columbia, and England)
    - Centrifuge (Jesse W. Beams, University of Virginia)
- also begin to look at graphite to slow neutron
- note: many questions to answer
    - which separation method
    - how to produce a chain reaction
- consequence, project remains in the research and development state
- November 1942, report says:
    - 100 kilograms of U-235 will produce a bomb
    - $50-$100M to separate that much U-235

Move to Production, Summer 1942:

- agreed to put the production under a branch of the military
    - Army Corp of Engineers choosen
    - General Leslie R. Groves eventually put as head
- research scientists, on S-1, continue to direct research
- military now takes over the logistics of production, and most of the budget
- by September 1942, now called the Manhattan Project
- December, 1942, Roosevelt gives approval for production, at the level of $500M (will eventually be $2B)
- note, time was so important, could not find out what worked; had to pursue every possible approach
- also December, Fermi achieved first sustained fission reaction in a pile under the stadium at the University of Chicago

Overview of the scale of the project and its characteristics:

- hard to imagine the size and impact of the project
    - would construct three new towns, in Tennessee, New Mexico, and Washington
    - end of War, Oak Ridge five largest town in Tennessee, the Clinton Engineering works consumed 1/7th of the nation's power
    - $2.2B is over half of the total war research effort, which is about $4B
- Clinton Engineering Works, Oak Ridge, Tennessee
    - purhased 59,000 acres of land
    - population 50,000
    - three cites: Y-12 for electromagnetic plant; X-10 for plutonium pile; and K-25 for gaseous diffusion
- Hanford, Washington
    - selected as major Plutonium production cite

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- note: Plutonium had been identified in 1941 as a fissionable material; could be produced in a pile and separated chemically
- purchase 500,000 acres of land on Columbia River
- population again 50,000, in tents, barricks, etc.

- Los Alamos, third cite, for atomic bomb production
- work continues as well at universities on parts of the projects

Final design problem - how do you build a bomb?

- two models to achieve critical mass
  - gun model, fire one mass into another to achieve critical mass (Plutonium version called thin man, after Roosevelt)
  - implosions model, put mass in the middle of an explosion which will compact it (plutonium version called fat man, after Churchill
  - also had a uranium gun, called Little Boy, Thin Man's Brother

Decision to drop the bomb:

- Roosevelt dies in April, 1945, Truman is told about the Bomb
- status of the War
  - German has been defeated (May 8, 1945)
  - Japan is very near defeat
  - US is bombing mainland at will
  - March, 1945 firebombing of Tokyo killed 100,000
  - May, 1945 firebombing of Tokyo killed 83,000
- In June, Committee formed to discuss proper and future use of the bomb - agree:
  - we should retain a monopoly over the bomb as long as possible (Russia was through to be 3-10 years away from having a bomb)
  - demonstration bombing discussed and rejected: might be a dud, Japanese might kill prisoners of war, etc.
  - recommendation, attack and drop without warning
  - committee of scientists were not sure, but were rejected
- July 16, Trinity Test
- Truman was in Potsdam and peace conference with Stalin and allied leaders
- July 25, Stimson (Sec of Def) gives order to drop the bomb

The bomb is dropped:

- August 6, 1945, Enola Gay, piloted by Colonel Paul Tibbets, flies mission
  - Little Boy detonated at 1900 ft. above city (uranium gun bomb, had not been tried before)
  - 70,000 killed instantly, another 70,000 died the first year, total reached 200,000 in five years

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- August 9, Bock's Car drops bomb on its secondary target, Nagasaki
    - Fat Boy (plutonium implosion bomb)
    - yield, 21,000 tons TNT
    - 40,000 killed instantly, 140,000 total toll after five years

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