Week 2 - Building the Bomb

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1. Atomic Energy for Military Purposes Book
   - Released 3 days after the bombing of Nagasaki
     - *NOTE:* War was not yet over
   - Written during the Manhattan project
   - Translated to Russian and people were able to know about atomic bombs outside of their govt.
   - Groves (Major General, USA) in foreword:
     - This book contains everything we can say about the bomb
     - If you say anything else not in this book, then you will be punished by Espionage Act
     - Reason for releasing: If you give them something, then they won't go looking on their own accord
   - Mainly about theoretical physics since Smyth was a theoretical physicist
     - Missing chemistry, engineering, and other types of work
     - It's the least sensitive stuff about the bomb, and everyone mainly understood the ideas prior to the war
2. Timeline
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phase	**goal**	**methods**	**primary output**
exploratory	to see if a nuclear weapon program is feasible	small-scale experiments and theoretical studies	reports
pilot	to evaluate the feasibility of manufacturing methods	building medium-scale facilities	reports, plans, tacit knowledge, test samples
production	making actual nuclear weapons	building large-scale facilities, designing bombs, preparing for use	fissile material, atomic bomb

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country	**exploratory**	**pilot**	**production**
United States	1939	1941	1942
Germany	1939	1942 (reactor only)	x
UK	1940	x	x
USSR	1940	x	x
Japan	1941	x	x

   - You need a production program to get an atomic bomb
   - "Why did the United States make an atomic bomb?"
     - No one else made one
3. State of knowledge in 1939
   - U-238 (99%) and U-235 (<1%)
   - Only U-235 fissions from fast and slow neutron energies
     - U-235 is thus fissile (can sustain fission chain reactions in sufficient quantities)
   - U-238 will absorb slow neutrons without fissioning
     - Kills chain reaction
   - Both isotopes are chemically identical - can only be separated physically, but differ by only 3 neutrons
   - If you could separate U-235, you can make a bomb. But can you? If you can't, what are the options?
   - But nuclear reactors are very possible

  - Some confusion between a reactor and a bomb (out of control reactor)

4. Einstein-Szilard Letter, 1939
   - Written by Szilard but signed by Einstein for importance
   - Unsure about many characteristics of the bomb (ie. power, size, weight)
     - Undersold
     - Better to undersell than to oversell
   - This is a policy letter
     - Appoint a guy to keep an eye on the situation
   - FDR did not read this, he got a summary
     - Said: "make sure the Germans can't blow us up"
   - Asks to make a committee
5. Uranium Committee
   - Roosevelt created it in 1939
   - Used to coordinate the fission research with universities
   - Figure out if a bomb is worth worrying about
   - Gets absorbed in to the National Defense Research Committee
   - Office of science and research and development was eventually made as well
     - Was used to develop physical things (ie. camo stuff being put on planes from MIT)
6. James Conant, President of Harvard
   - Thought the innovation would take a long time
   - With other things to do (ie. camo), he doesn't want the scientists to waste their time on the bomb
     - Doesn't think it'll work
7. Atomic Piles
   - Bomb
     - Produces **exponential** chain reaction
     - Uses **fast** neutron reactions
     - Require **enriched** fuel (80-90% fissile material)
   - Reactor
     - Produces **stable** chain reaction
     - Uses **slow** neutron reactions
     - Uses **unenriched** or **lightly-enriched** fuel and a **moderator** to slow neutrons
   - When U-238 absorbs a neutron, it will (in several days) turn into plutonium-239 (relatively stable) which is **fissile**
     - Could use it as bomb fuel
     - Figured it out at 1941 and paved new path for the bomb
8. Other Programs
   - Germans though the bomb wasn't necessary for this war, for the next war
     - **Why did the United States decide to make the bomb?**
   - Japan kept program small and thought the US couldn't make an atomic bomb in time for the war
   - France was invaded by Germany by 1940 :(
   - USSR didn't have too many sources, so they just accumulated info for post war
9. United Kingdom
   - Physicist were figuring out how much material would be needed for the atomic bomb
     - only 5 kg of U-235 was necessary
10. United Kingdom/USA
    - UK committee (MAUD) goes to USA and says the bombs feasible but you need to do it because of resources

- US cleans house on the Uranium Committee and changes name to S-1 Committee
- It is then estimated at $400 million cost (5x under)
- It's actually much harder than expected, Germany, Japan, and USA were on the right path of saying it's too hard but the UK are dead-afraid and push the USA to think it's doable
  - The US has too much money already spent that they keep going
- FDR approves ARMY taking control over construction job with goal of **making an atomic bomb = Manhattan Project**

11. The Manhattan Project