HST 415
Week 1

Splitting the Atom

History of the atom

X-rays invented by **Wilhelm Roentgen**

Through the right apparatus, x-rays could show things that were not shown before. **Henri Becquerel** discovered radioactivity in uranium in 1898. This was an accidental discovery. This was an indication that there are rays that are part of matter by itself.

Marie and Pierre Curie found radium (1898). Use chemistry to isolate the components. Uranium that Becquerel was using was not pure uranium. Curie found which part was from the radioactivity that is from the uranium. Isolated out the radium through chemistry. This glowed in the dark and is the amazing new substance. For every ton of uranium ore, you get .2 grams of radium.

The US raised funds so that Marie Curie could have one whole gram of radium.

Atomic Models

J.J. Thomson found the electron (1897). Thomson gave us a whole new atom. Atoms had a structure. Every atom was made up of electrons (he believed the plum-pudding model).

Ernest Rutherford found the planetary model (1905) and disproved Thomson's specific model. He found the Gold-foil experiment and he found that the atom has a nucleus. The atom is mainly loose and empty.

Transmutation and Popularization

Frederick Soddy won the nobel prize and he worked with Rutherford and they figured out transmutation. Radioactivity is a form of transformation. You are changing one element into another. A modern form of "alchemy". The radioactivity is the moving of protons in and out of the atom. This would change the way in which the electron behavior would work. *The Interpretation of Radium* (1909). Soddy did a lot of activity to make it more available to a broader audience.

Popularization

"This bottle contains about one pound of uranium oxide, and therefore fourteen ounces of uranium... Is it not wonderful to reflect that in this little bottle there lies a sleep and waiting to be evolved into the energy of about nine hundred tons of coal?" -*The Interpretation of Radium*

Soddy is where we have the beginning of unlocking the energy of the atom. Soddy never talked about bombs. He meant to talk about electricity.

Atomic Visions

H.G. Wells is the first to describe atomic bombs (*The World Set Free)* in 1914. He was a prolific science fiction writer. Wells is linking the scientific with the political. By the 1920s, this kind of thinking was popularly discussed. There is a headline: "Tinkering with angry atoms may blow up the earth". Atomic culture is evolving into a popular understanding. Soddy thinks about popularization while Rutherford did not think about popularization.

Through the 1930s, there was a pre-atomic age. This is where many people are talking about the power of the energy from uranium. It is evident through newspaper articles.

Analogy: Atomic bomb in 1945 is how we understand the warp drive today.

Winston Churchill: Read H.G. Wells and has a speech called "Shall We All Commit Suicide" in which he talks about the explosives. He read Wells and kept up-to-date with the atomic bomb. What does reading science fiction and talking in these terms get a person like this? What sort of ideas that Wells derives give these world leaders? These weapons will reorder the world/how they can dominate the world.

Atomic Fads

There was atomic energy for health. There was something called radium therapy (1910s) and you could buy radium water therapy. This would give you radioactive drinking water. There were radioactive chocolate bars. Radium is fairly expensive so anything cheap did not have any radium in it. The expensive stuff did have radioactivity in it which caused exposure for some people. People created radium watches. This would cause the watch to glow in the dark. This association with green in the dark is from this radium thing. A more informed color for radioactivity is blue. The radium on the paint was done by "**Radium Girls**" and they would have this radioactive paint and painted the numbers which led to major health problems because they were putting this radioactivity paint in their mouth to keep the fine tip. Many of them got mouth cancers and other problems from this. This became a major labor case. Employers could sue for occupational health hazards. This was done in New Jersey! This was settled in 1928.

Eben Byers consumed huge amounts of radium water to lethal qualities and his jaw fell off and died of radium poisoning. Mayor of New York drank 3 glasses of water with radium a day. These types of cases caused a pushback on radioactivity. There became a thing called "*radiophobia*" (someone afraid of anything with radioactivity) and "*radio mania*" (where everything is great with radioactivity).

Flourishing of physics

New theories are being developed in the 1910s with Quantum theory. The 1920s was Quantum Mechanics. In 1929, the Cyclotron was created. This allowed you to whip around a charged particle really fast and collide it with something to see the results. This is "splitting of the atom" which occurs in 1932. International communities started working on all of this.

Atomic Models

By 1932, they looked at the atom with the planetary model. The electron is no longer straightforward (sometimes wave, sometimes particles). The proton and neutron are in the nucleus. **James Chadwick** discovered the Neutron that has no electrical charge (found in 1932). They are very exciting because they help give understanding as to how the nucleus is stable and neutrons do not get repelled by protons or electrons. There is a strong force that protons and neutrons have which is why they are extremely attracted to one another.

Periodic Table

Atoms as you go down the periodic table, to keep them stable you have to have many more neutrons.
The elements are defined by the number of protons.
In 1934, the heaviest known atom was uranium.

Artificial Radioactivity

1934: **Frederic and Irene Joliot-Curie** found that if you can bombard non-radioactive atoms, you can make artificial radioactivity. This created more possibilities to radioactivity energy.

Chain Reaction?

Leo Szilard found a neutron-based chain reaction (1934). Rutherford had announced that atomic energy could not happen, he said it might be possible to make a nuclear chain reaction. If you shoot neutrons, you can penetrate the nucleus. So Szilard believed that you could undergo a nuclear reaction in which these neutrons would go off and do the same thing to other atoms. He created this hypothetical to create huge amounts of energy.

1934: **Enrico Fermi** found that slow neutrons are good at making things very radioactive.

Hahn and Meitner, 1938

Otto Hahn and Lise Meitner in 1938 in Berlin were conducting experiments similar to Fermi's and trying to figure out what is left over when you use slow neutrons and uranium? When Hitler came into power, all Jewish professors were fired. This resulted in a massive immigration to the United Kingdoms and this became a brain drain for Germany.

Meitner had to flee to Sweden so Hahn was doing the chemical work where they were radiating uranium and they had these stuff leftover where they used chemical techniques to remove elements. He found barium from this. This has an atomic number of 56. He sends his results to Meitner. The atom is splitting because the barium is about half the weight of uranium. They called this process **nuclear fission.** Two positive nuclei suddenly find themselves next to each other and then repel violently.

Self-Censorship

Szilard wanted to deny that this was possible to the Germans because they have their own scientists and it was assumed that they would be able to have this knowledge as well. He told **Fermi and Joliot** and we should keep everything we do in secret. Fermi was saying that there are so many unknowns from this to a working weapon. *If you are one day ahead, it is enough.*

Fermi agreed to keep quiet if everyone else agreed to keep quiet. Joliot did not understand why they did not want to publish (they asked him on April 1st) and he wanted the credit. He did end up publishing anyways.

Szilard's 1939 Experiment

Large-scale liberation of atomic energy was just around the corner. He realized that the "world was heading for grief".

Bohr and Wheeler explained why fission happened and why it does not happen often. Why doesn't the uranium blow up all the time? In their paper in 1939, they found out that there are two types of uranium (two different isotopes). 99% of uranium is U-238. All U atoms are fissionable, and will release 2+ neutrons. But only U-235 fissions from all (fast+slow) neutron energies, including neutrons produced by fission reactions. **So U-235 is fissile = can sustain exponential fission chain reactions.**

U-238 will absorb slow neutrons without fissioning so it stops chain reactions. To make a bomb, you need to get rid of U-238 or some other kind of fissile fuel. There is a 2% weight difference between the two (they differ by only three neutrons).