

1) **Manhattan project:**

- was composed of 3 main production facilities: Oak Ridge, Tennessee; Hanford, Washington; and Los Alamos, New Mexico

Oak Ridge:

Composed of 4 sub-sites;

- **“X-10”: Nuclear Graphite Reactor:**
 - the world's first production nuclear reactor, to demonstrate the production of plutonium
 - The X-10 Graphite Reactor supplied the Los Alamos laboratory with the first significant amounts of plutonium. Fission studies of these samples from the X-10 heavily influenced bomb design
- **“Y-12”: Electromagnetic separation:**
 - The facility began operating in November 1943, separating uranium-235 from natural uranium by using calutrons to perform electromagnetic isotope separation.
 - Y-12 produced some of the uranium-235 for Little Boy, the atomic bomb that was dropped on Hiroshima, Japan on August 6, 1945.
- **“K-25”: Gaseous Diffusion:**
 - located on the southwestern end of the Oak Ridge reservation, used the gaseous diffusion method to separate uranium-235 from uranium-238. Although producing minute amounts of final product measured in grams, gaseous diffusion required a massive facility to house the hundreds of cascades and consumed enormous amounts of electric power.
 - The U-shaped K-25 building measures half a mile by 1,000 feet and is larger than the Pentagon, and at the time was the biggest building in the world.
- **“S-50”: Thermal Diffusion:**
 - As problems with both Y-12 and K-25 reached crisis proportions in spring and summer 1944, the Manhattan Project received help from an unexpected source: the United States Navy.
 - During the winter of 1944-45, substantial progress was made on uranium enrichment at Oak Ridge thanks to improved performance at each of the major production facilities. S-50 was finished at the same time that the Y-12 racetracks were demonstrating increased efficiency.

The Hanford Site:

- It's purpose was to produce the plutonium necessary for the Manhattan Project, which was then used in test bombs and in the infamous “Fat Man” bomb dropped on Nagasaki, Japan.
- Scientists took a U-238 atom, placed it in a fuel slug and added to it a neutron, effectively producing a U-239 atom. The U-239 then undergoes a beta decay to give Np-239, which then undergoes another beta decay giving off a Pu-239. The irradiated fuel slugs were then transported to the plutonium processing canyons, and after a few chemical processing steps, a small amount of plutonium was produced and separated from the nuclear waste

- This plutonium was then sent to New Mexico, where bomb testing and construction was carried out.
- The site produced 54.5 metric tons of plutonium, which was roughly 60% of all plutonium production in the United States. It took one metric ton of uranium to produce 250 grams of plutonium.

Los Alamos:

- Founded during World War II as a secret, centralized facility to coordinate the scientific research of the Manhattan Project
- Known as Site Y
- Created 3 atomic devices
- The "Trinity" test was the first test of a nuclear weapon, conducted by the United States on July 16, 1945, The detonation was equivalent to the explosion of around 20 kilotons of TNT.
- Some predictions ranged from zero, a complete dud, to 18 kilotons of TNT (predicted by I. I. Rabi), to destruction of the state of New Mexico, to ignition of the atmosphere and incineration of the entire planet

2) **How nuclear bombs work:**

- Releasing the power of the atom- nuclear fission v. nuclear fusion. Both processes cause large amounts of heat and radiation to be released.
- What do you need to build a bomb?
 1. Fissionable/ Fusion able material,
 2. A trigger
 3. A method that ensures most of the fuel will fission or fuse prior to explosion
- Properties of Uranium when ^{235}U at 90%- (Induced Fission)
- Amount of energy in weapons grade uranium- One Pound of weapons grade uranium has the same amount of potential energy as one million gallons of gasoline.
- Critical mass- What is it? Why is it important to create sub-critical masses separate? What problems does this create, and in what ways have problems associated with them been solved?
- How can you combine these separate sub-critical masses?; gun-triggered fission bombs vs. implosion-triggered fission bombs vs. fusion bombs.
- What are the main differences in these bombs?

3) **The After Effects:** Post Manhattan project and U.S. nuclear bombings...

- **Nuclear Non-proliferation treaty (NPT)** – is an international treaty designed to limit the spread of nuclear weapons. There are three pillars: non-proliferation, disarmament, and peaceful use of nuclear weapons.

- **The nuclear club** – The 8 (9 including Israel) countries that have admitted to the possession of nuclear weapons. This list is informally known in global politics as the nuclear club: US, France, China, UK, Russia, (Pakistan, India, North Korea; these countries do not have signatures on the NPT), (Israel; considered a suspected nuclear state.)
- **The Veal Incident** – this was an unidentified flash of light over the Indian Ocean. It was detected by the US Vela satellite on September 22, 1979. It has been speculated that the flash was a result of a nuclear weapons test performed by Israel or South Africa.

Effects of Bombing:

- Radiation
- Thermal
- Blast
- EMP
- Other effects

Implications for the future:

- Stockpile stewardship refers to the United States program of reliability testing and maintenance of its nuclear weapons without the use of nuclear testing. Comprehensive Test Ban Treaty (CTBT).
- Reliable Replacement Warhead Programs (RRWP)

New Nuclear Weapons

- Robust Nuclear Earth Penetrator (RNEP) aka Bunker Buster*
- *Advanced Concepts Initiative (ACI): Agent defeat bombs*
- “Complex 2030”