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Nuclear Primer

* **Atoms, Elements, and Isotopes**
  + Atoms are the basic building blocks of elements – they are comprised of protons, neutrons, and electrons.
    - Atoms have an inner, dense nucleus, comprised of protons and neutrons, and an exterior cloud of electrons.
  + Atoms have a specific number of protons, which is matched by its number of electrons. This number is called the atom’s *Atomic Number*.
    - Atomic Number determines what *element* an atom is. For example, Hydrogen has an Atomic Number of 1, so it has a single proton and a single electron.
    - As such, the only thing that determines what element an atom is is the number of protons in its nucleus.
  + Neutrons have no electric charge, so they do not contribute to Atomic Number.
    - Because of this, atoms of with varying numbers can still be considered the same element. We call these atoms with differing numbers of neutrons *Isotopes*.
    - Isotopes, despite being considered the same element, can behave very differently in various circumstances.
  + Some super heavy elements are unstable, and release radiation over time in various forms (alpha, beta, and gamma radiation). These elements are considered *radioactive.*
    - Alpha radiation consists of 2 protons and 2 neutrons which are then ejected from the nucleus. These are effectively positively charged helium ions.
    - Beta radiation consists of electrons or positrons (positively charged particles similar to electrons) being ejected from the atom; this type of radiation is more dangerous than alpha radiation as it is much smaller, and thus can inflict more damage.
    - Gamma radiation consists of high energy electromagnetic waves – these are the most dangerous.
    - Over time these particles decay into nothing. The time it takes half of the material to decay is called, appropriately, the element’s *half-life.*
* **Nuclear Fission**
  + Fission is the basis for current nuclear energy and weaponry.
    - During fission, neutrons are fired at very heavy elements (particularly Uranium, which is Atomic Number 92, and Plutonium, which is Atomic Number 94), which splits the atoms’ nuclei, and sends out more neutrons, which can split more nuclei.
    - This reaction creates tons of energy, which can be harnessed for power, or expelled for destruction.
  + A ton of research throughout the Cold War and beyond has been about improving the efficiency, safety, and size of nuclear equipment capable of fission.
  + Fission can reach a “critical mass”, when the fission reaction becomes self-sustaining – if the neutrons firing out of reacting atoms are enough to start more reactions, such that the entire amount of material reacts, the mass is considered critical.
    - Increasing density is the best way to achieve critical mass. As such, technology related to compressing these superheavy materials at a specific moment has become very important to efficient nuclear fission reactions.
* **Nuclear Fission Weapons**
  + Two important types of Fission Weapons are “gun types” and “implosion types.”
    - Gun types induce fission by launching two pieces of subcritical fission fuel at each other. One part of the fuel forms a hollow “bullet”, and the other forms a “spike” that impales the hollow bullet. Upon impact, they induce fission.
      * These forms are relatively easy to create, if given the fuel.
      * However, these types of weapons are very inefficient, producing a relatively small yield for a large amount of fuel.
      * The *Little Boy* bomb dropped on Hiroshima was a gun type weapon.
    - Implosion types induce fission by detonating powerful explosives in a sphere around a mass of subcritical fuel. They create a perfect sphere of pressure which compresses the fuel into a critical mass, which induces lots of fission and detonates. =
      * These types are much harder to create than gun types and take lots of research and calculation to ensure success.
      * Implosion types also produce much more yield for much less fuel, when compared to gun types.
      * The *Fat Man* bomb dropped on Nagasaki was an implosion type weapon.
* **The effects of nuclear weapons**
  + Upon detonation, a number of things happen in a very quick succession:
    - The point of detonation reaches millions of degrees celcius – around the temperature of the sun’s core.
    - A large blast wave and heat wave launch out from the detonation point. Depending on whether the weapon was detonated in the air or on the ground, different distributions of force impact different radii around ground zero. These forces are typically enough to level buildings and have a fatality level ranging from 50-90%.
    - As radioactive material “falls out” of the mushroom cloud, the area experiences nuclear fallout. The exact spread of fallout will be determined by wind and nature in general.
      * Exposure to fallout entails hair loss, internal bleeding, comas, and worse. There is no real treatment, and death is all but guaranteed within the next two weeks.
      * Low levels of exposure still increases risk, and death rate remains high, but it is more survivable.
  + Even long after detonation, effects still linger:
    - Birth defects and cancers are highly correlated with radiation exposure. An area irradiated by a nuclear weapon is effectively uninhabitable for years to come.
    - Several nuclear weapons could cause permanent global environmental damage, impacting food production especially.