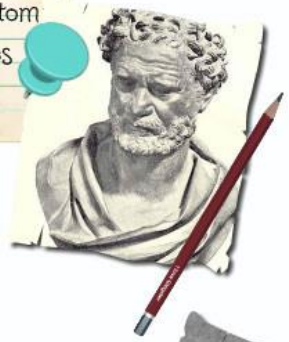
What is Atom?

Part 2

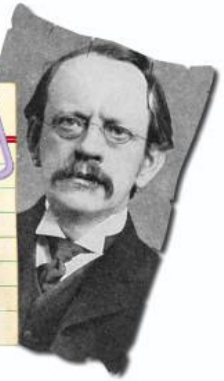
Democritus said that all atom are small, hard particles



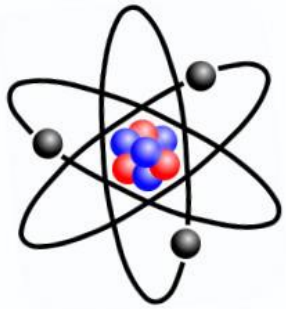
John Dalton developed his atomic theory from observations of many experiments

Glogster

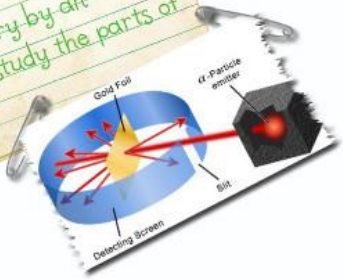
J.J Thomson discovered that there are small particles inside the atom.



Schodinger and Heisenberg further explained the nature of electrons in the atom



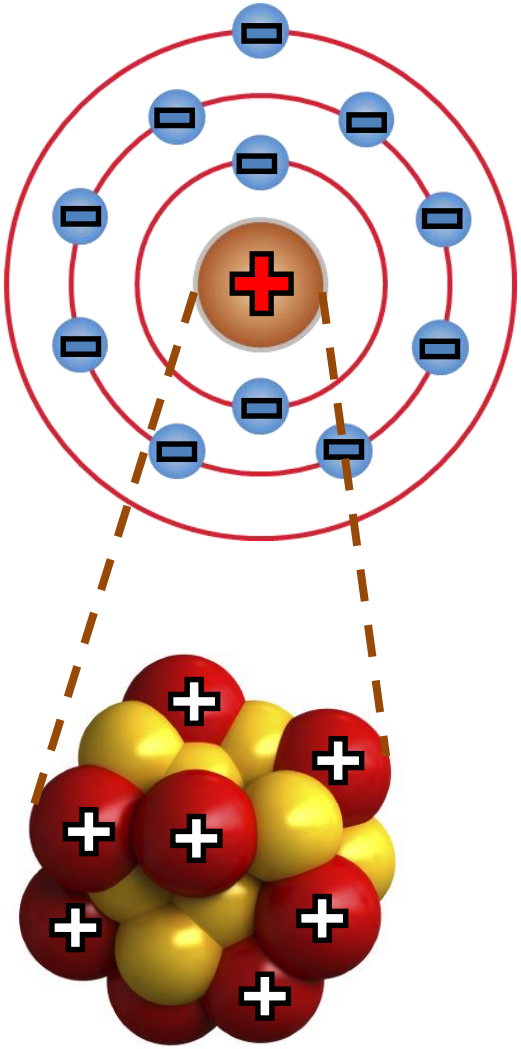
Rutherford decided to test Thomson's theory by an experiment to study the parts of an atom



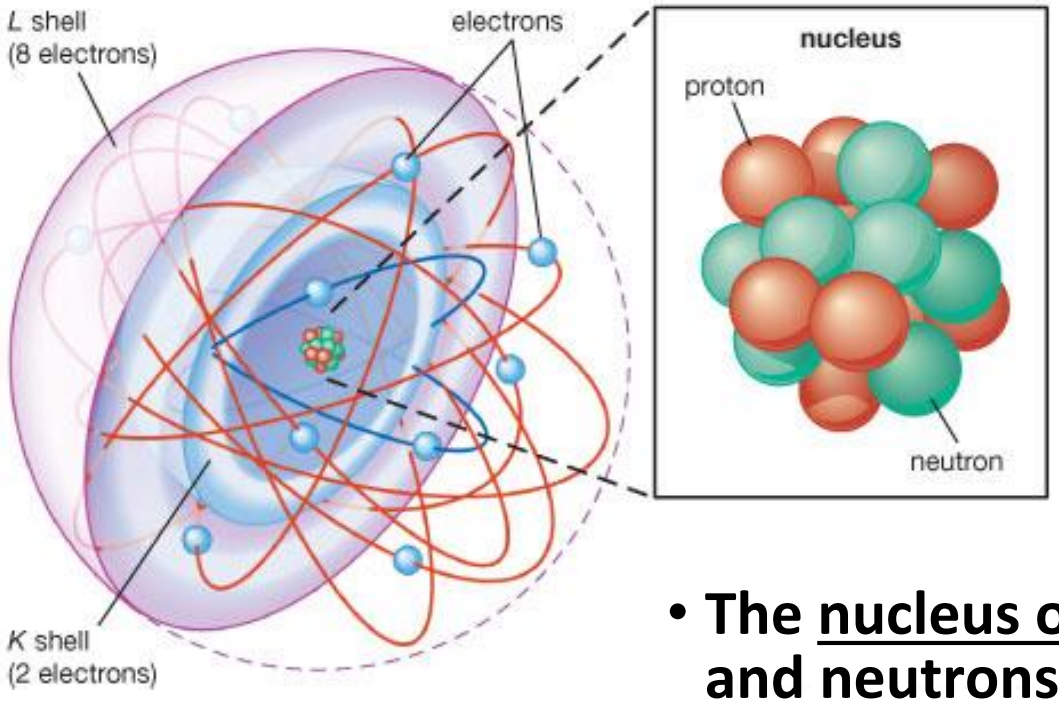
Bohr's results led him to propose that electorns move around nucleus in certain paths or energy levels.

Atomic Structure Summary

- **All atoms have:**
  - a positively charged nucleus
  - and negatively charged electrons moving around within atomic orbitals
- **Atomic nucleus consists of:**
  - positively charged protons
  - and neutrons that have no electric charge



What Holds an Atom Together?

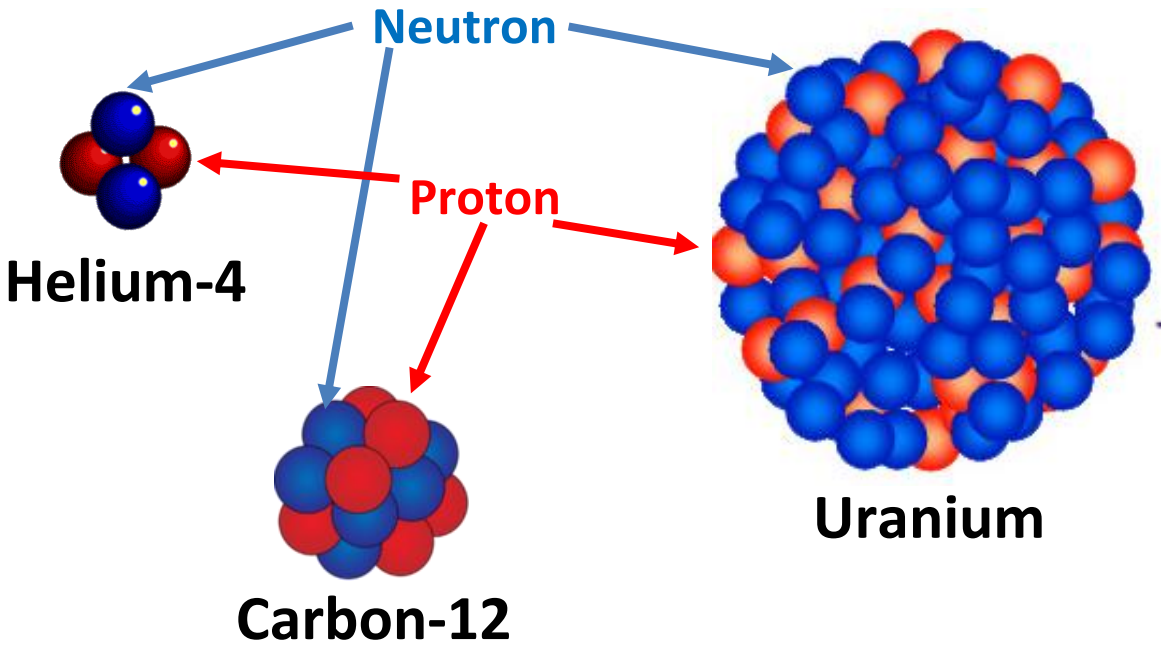


- **The <u>electrons</u> are kept in orbit around the nucleus due to an <u>electromagnetic field</u> of attraction between the positive (+) charge of the protons and the negative (-) charge of the electrons.**

- **The <u>nucleus of protons and neutrons</u> is kept together by the <u>nuclear (strong) force</u>, which *opposes and overcomes the electromagnetic repulsion when particles are very close to each other (~1 fm!)*.**

Binding Energy and Atom Stability

Nuclear (binding) energy is the energy associated with the **nuclear force.**

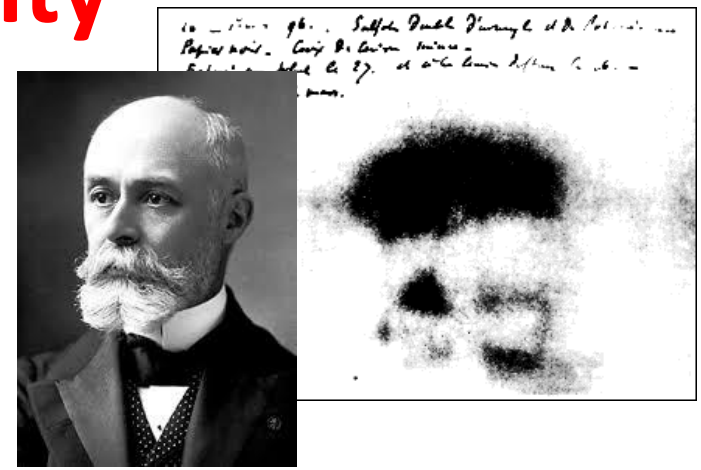


- An <u>unstable atom</u> does not have enough binding energy to hold the nucleus together permanently and <u>*will lose neutrons and/or protons*</u> as it attempts to become stable…

- A <u>stable atom</u> is an atom that has <u>enough binding energy</u> to hold the nucleus together permanently.

…radioactivity!

Discovery of Radioactivity



- **Henri Becquerel, 1896:**

  - radioactivity was first discovered in uranium salts during his work on phosphorescence.

- **Marie Sklodowska-Curie and Pierre Curie, 1898:**

  - conducted a systematic study to determine which other elements and compounds emitted "mysterious radiation" that they called "radioactivity",

  - isolated a new radioactive element, *polonium* (named in honor of Marie's home country),

  - four years later, discovered an even more intensely radioactive substance, which they called *radium*.

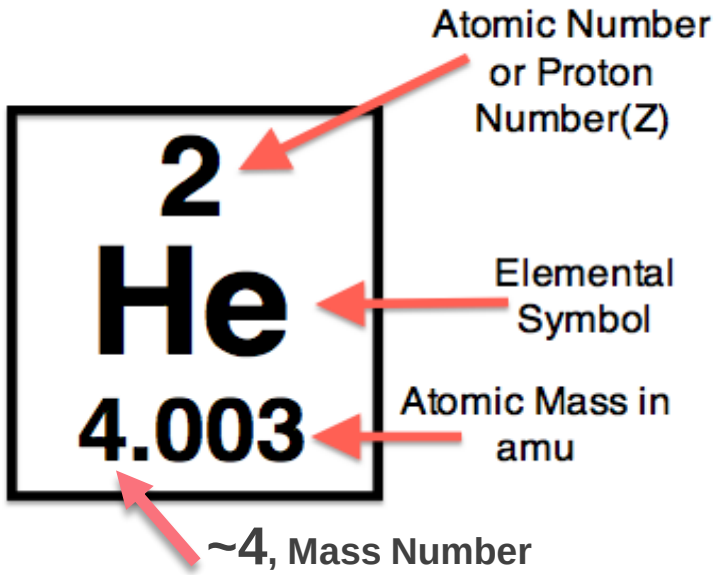
- **Ernest Rutherford and Frederick Soddy, 1899-1903:**

  - discovered three different types of radiation "rays" with very different powers of penetration, introduced the term "half-life", and proposed that atoms were not conserved in radioactive emissions.

Understanding Elements

The number of protons and neutrons in the nucleus give the atoms their specific characteristics.

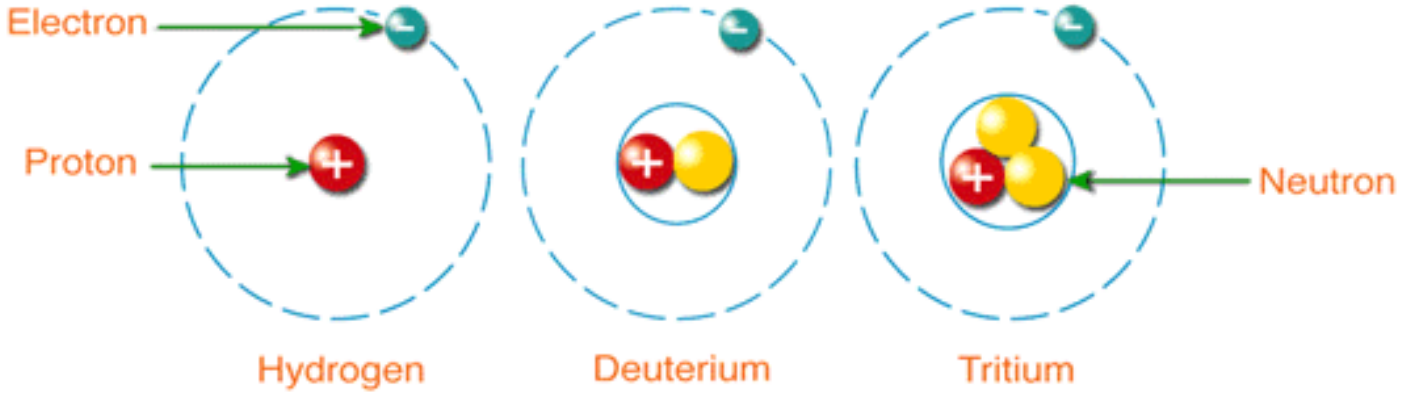
- **All atoms of the same chemical element contain the same number of protons, defined by a unique atomic number of that element.**
- **For example, all helium atoms, and only helium atoms, contain two protons and have an atomic number of 2.**



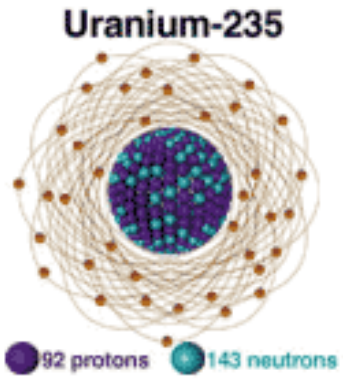
- **Atoms are also characterized by:**
  - **mass number, which is a sum of the number of protons and the number of neutrons in the nucleus (number of *nucleons*)**
  - **atomic mass, "relative isotopic mass" in *unified atomic mass units*, which is roughly (within 1%) equal to the whole mass number (since the mass of a proton and the mass of a neutron are almost the same and the mass of the atom's electrons is negligibly small)**

What is Isotope?

<u>Isotopes</u> are different forms of a given element that have the same number of *protons* in each atom but differ in number of *neutrons*.



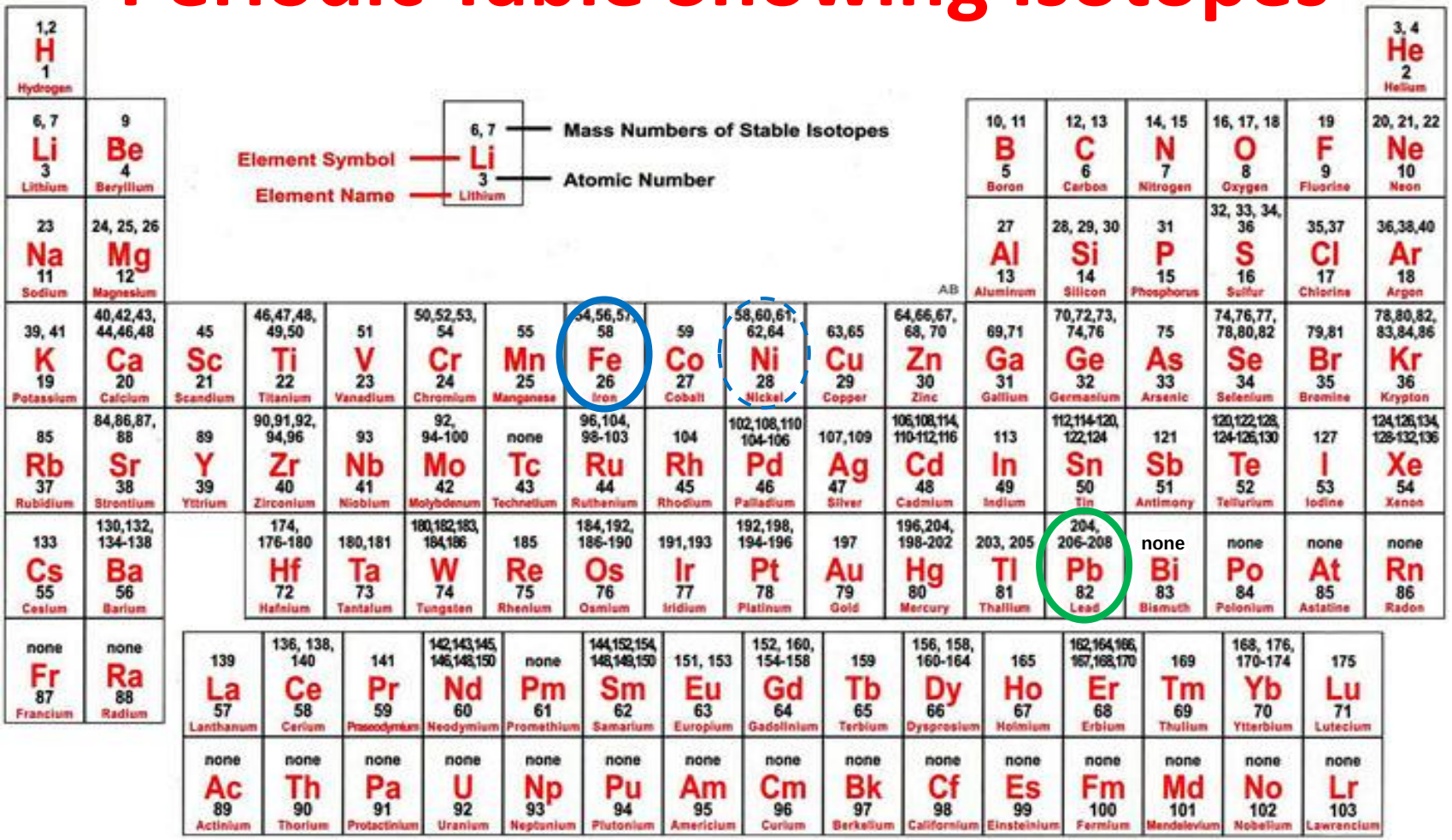
Most elements have more than one isotope.



There are 20 Plutonium isotopes, all of them unstable!

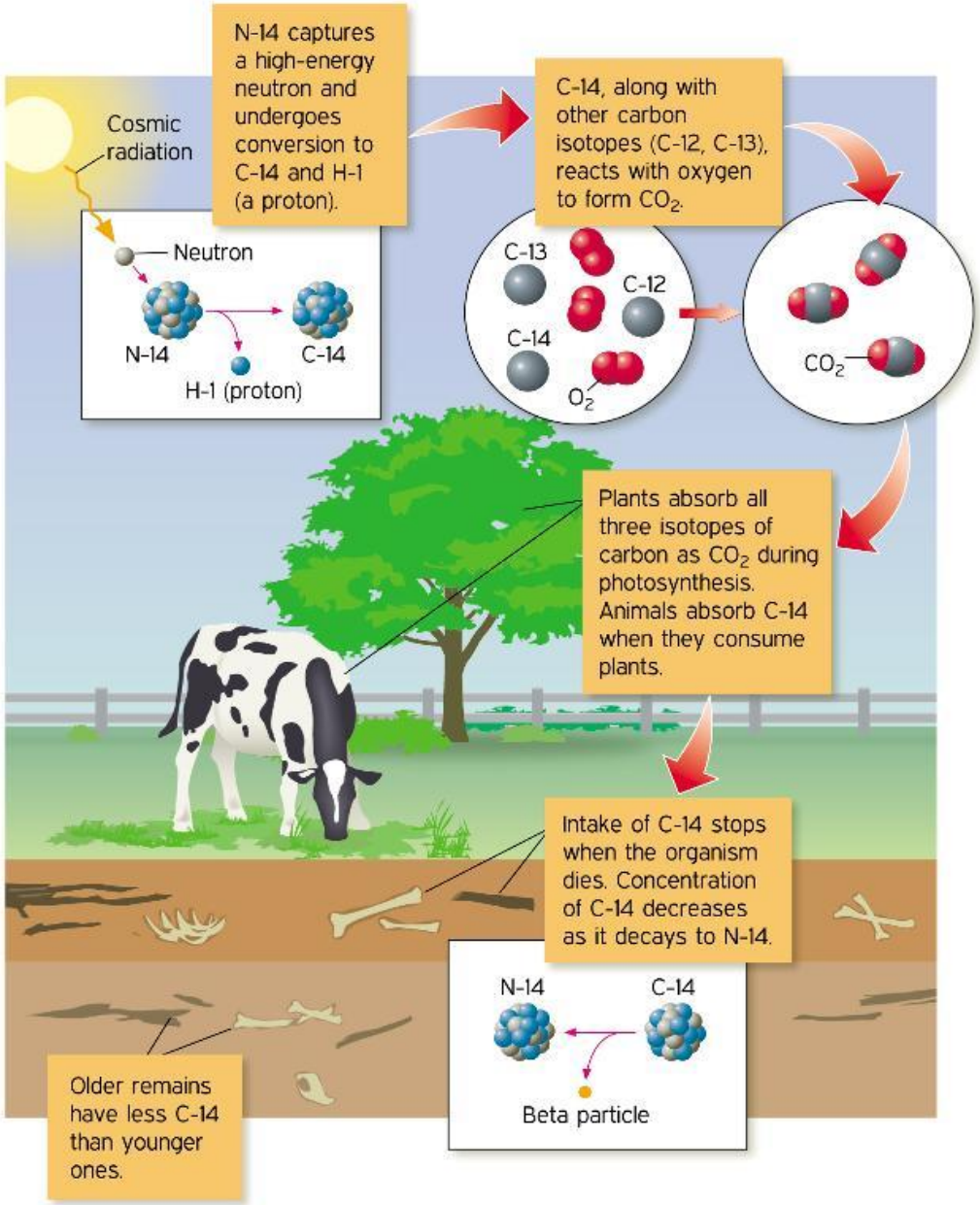
Pu^{228} ⟹ Pu^{247}

Periodic Table Showing Isotopes



- **The nucleus of an iron isotope with mass number 56 is more stable than any other element's nucleus (the farther from 56 an element's mass number is, the more unstable that element's nucleus tends to be).**
- **The heaviest element that still has stable isotopes is Lead.**

Carbon Dating



^{12}C	^{13}C	^{14}C
12.00000	13.00335	14.0
98.89%	1.11%	$t_{1/2}$ = 5715yrs
Stable	Stable	Radioactive Cosmogenic/ anthropogenic

- **A method of determining the age of an object by measuring the radioactive emissions of radiocarbon (C-14), a radioactive isotope of carbon.**
- **Invented by Willard Libby in the late 1940s and soon became a standard tool for archaeologists.**
- **Applicable only to matter which was once living and presumed to be in equilibrium with the atmosphere.**
- **The oldest dates that can be reliably measured by carbon dating are around 50,000 years ago.**