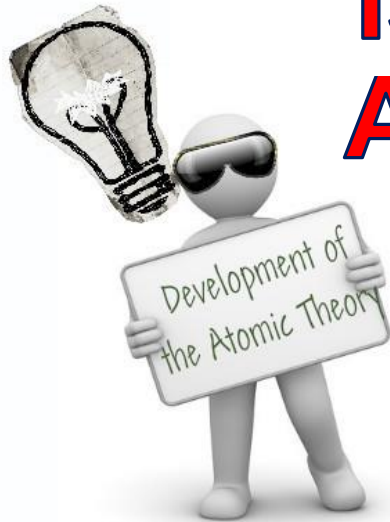
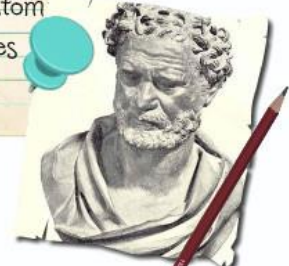


# What is Atom?

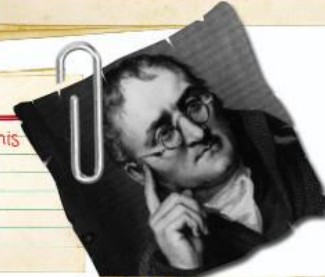
## Part 2



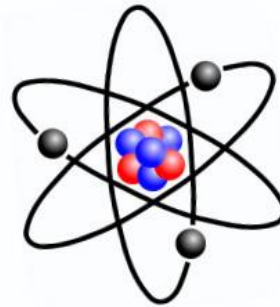
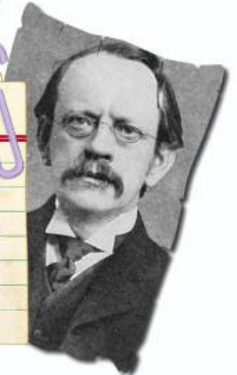
Democritus said that all atoms are small, hard particles.



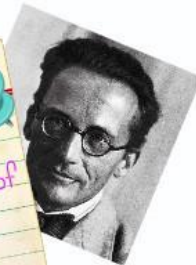
John Dalton developed his atomic theory from observations of many experiments.



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



Schrodinger 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.

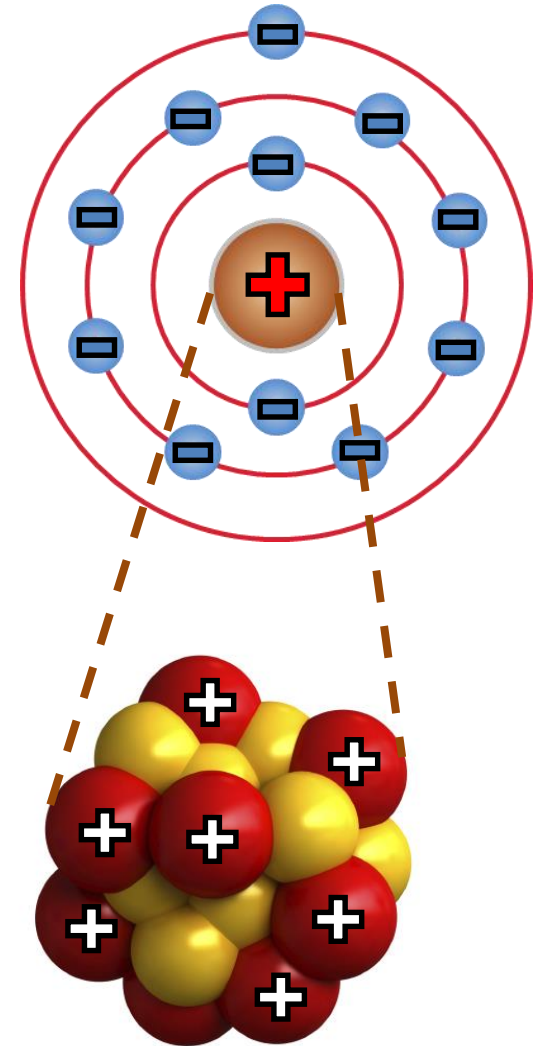


Bohr's results led him to propose that electrons move around the nucleus in certain paths or energy levels.

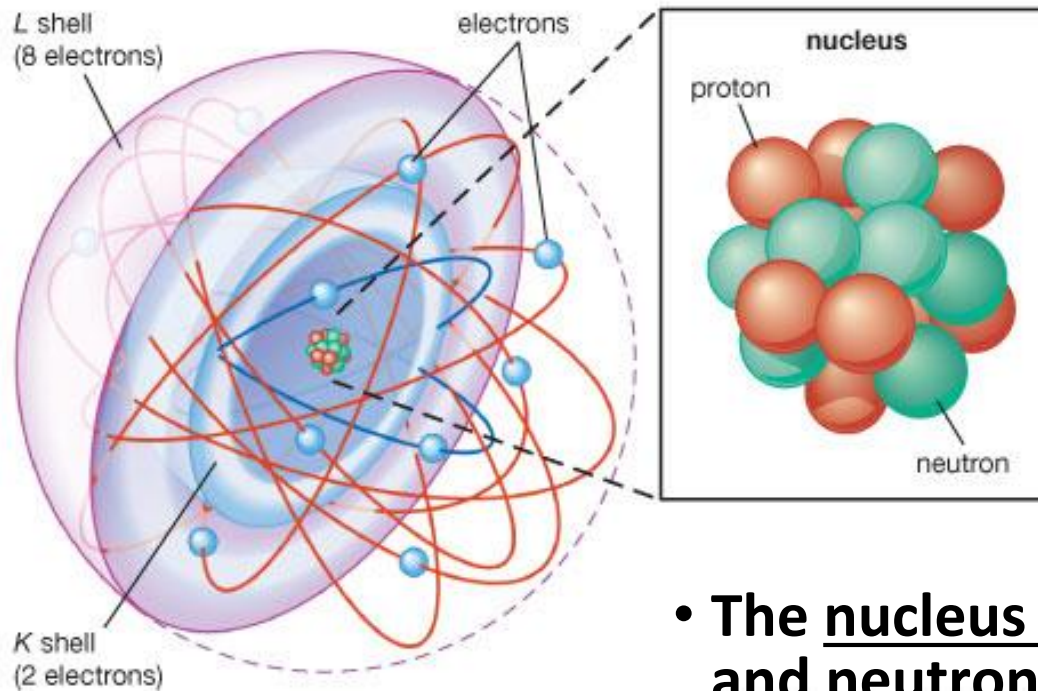


# Atomic Structure Summary

- 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?

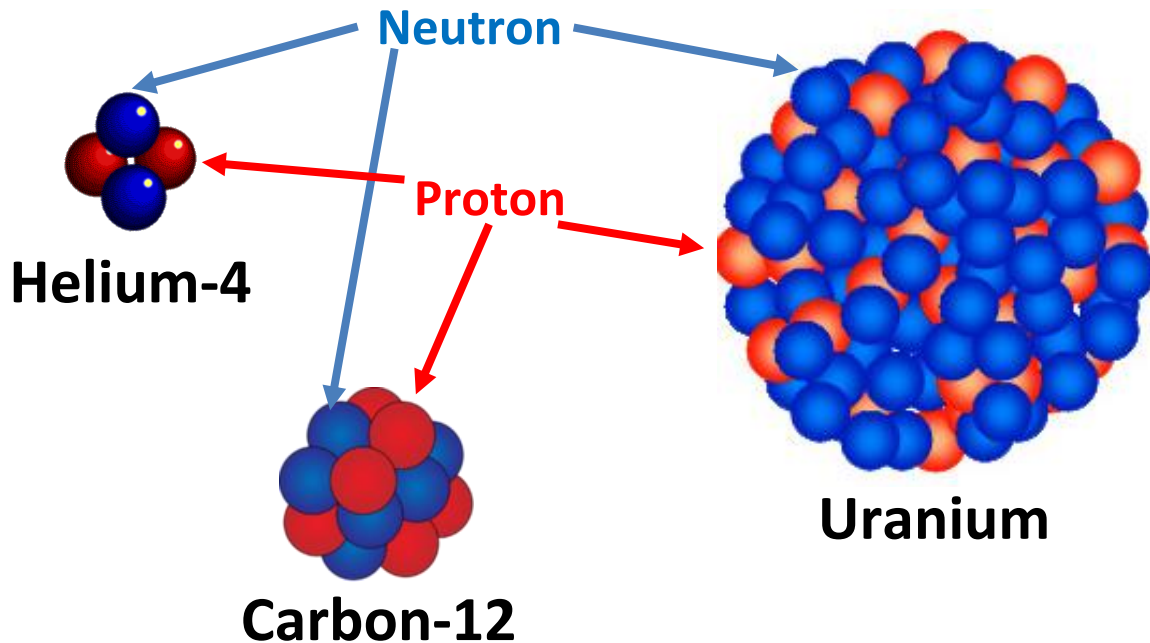


- The electrons are kept in orbit around the nucleus due to an electromagnetic field of attraction between the positive (+) charge of the protons and the negative (-) charge of the electrons.

- The nucleus of protons and neutrons is kept together by the nuclear (strong) force, 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 unstable atom does not have enough binding energy to hold the nucleus together permanently and will lose neutrons and/or protons as it attempts to become stable...

- A stable atom is an atom that has enough binding energy 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:

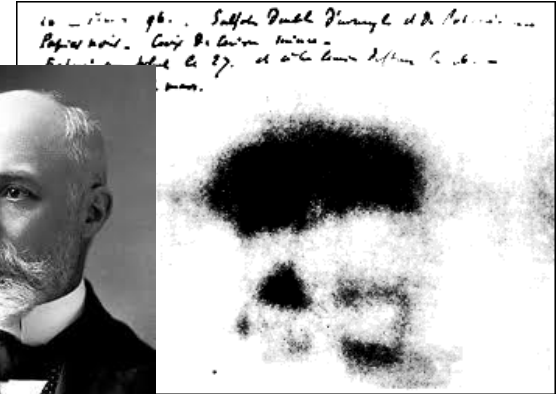
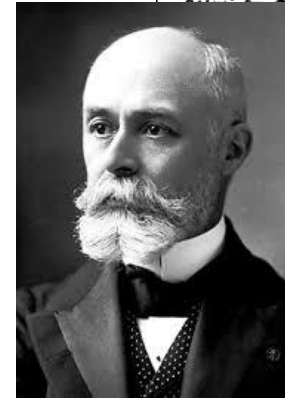
- conducted a **systematic study** to determine which other elements and compounds emitted “mysterious radiation” that they called “radioactivity”,

- 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:

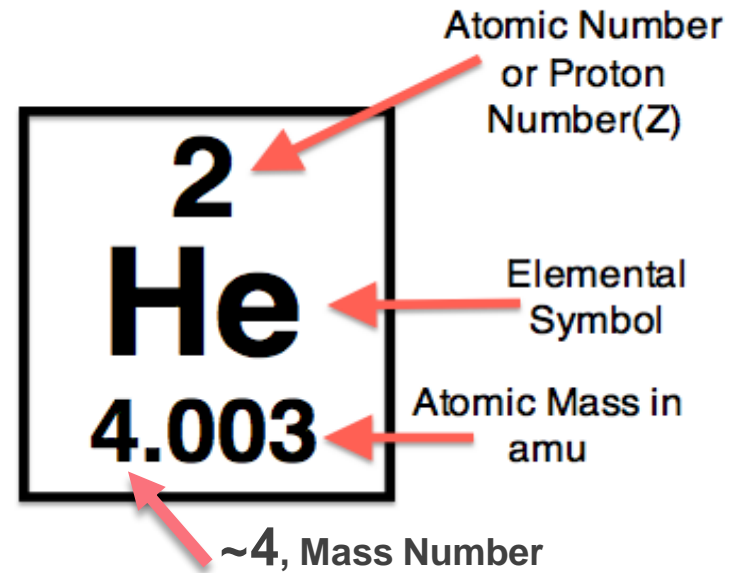
- discovered **three different types of radiation** “rays” with very different powers of penetration, introduced the term “half-life”, and **proposed that atoms were not conserved in radioactive emissions.**



# Understanding Elements

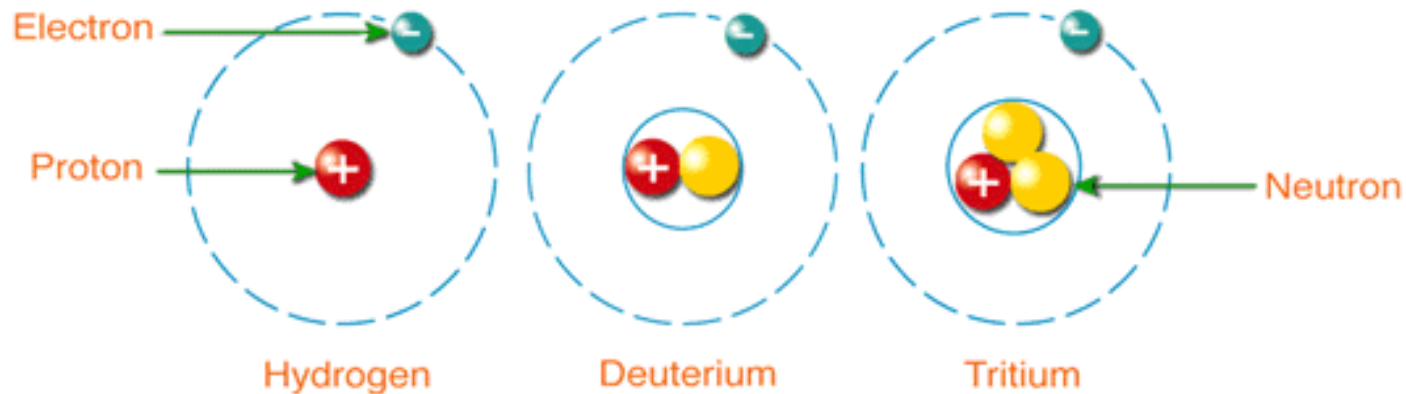
The number of protons and neutrons in the nucleus give the atoms their specific characteristics.

- 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)

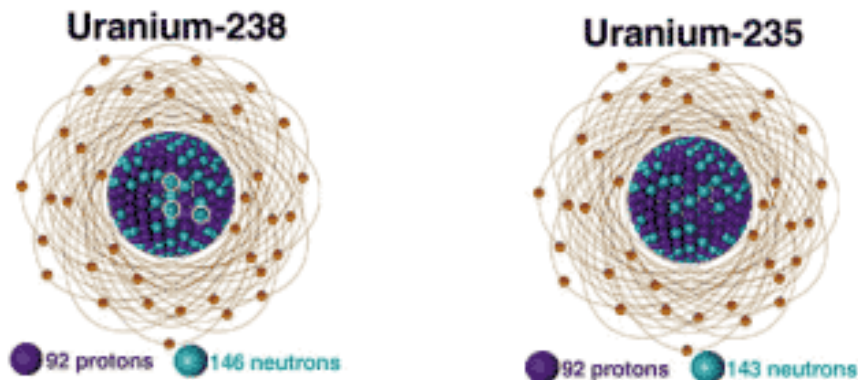


# What is Isotope?

Isotopes 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!**



# Periodic Table Showing Isotopes

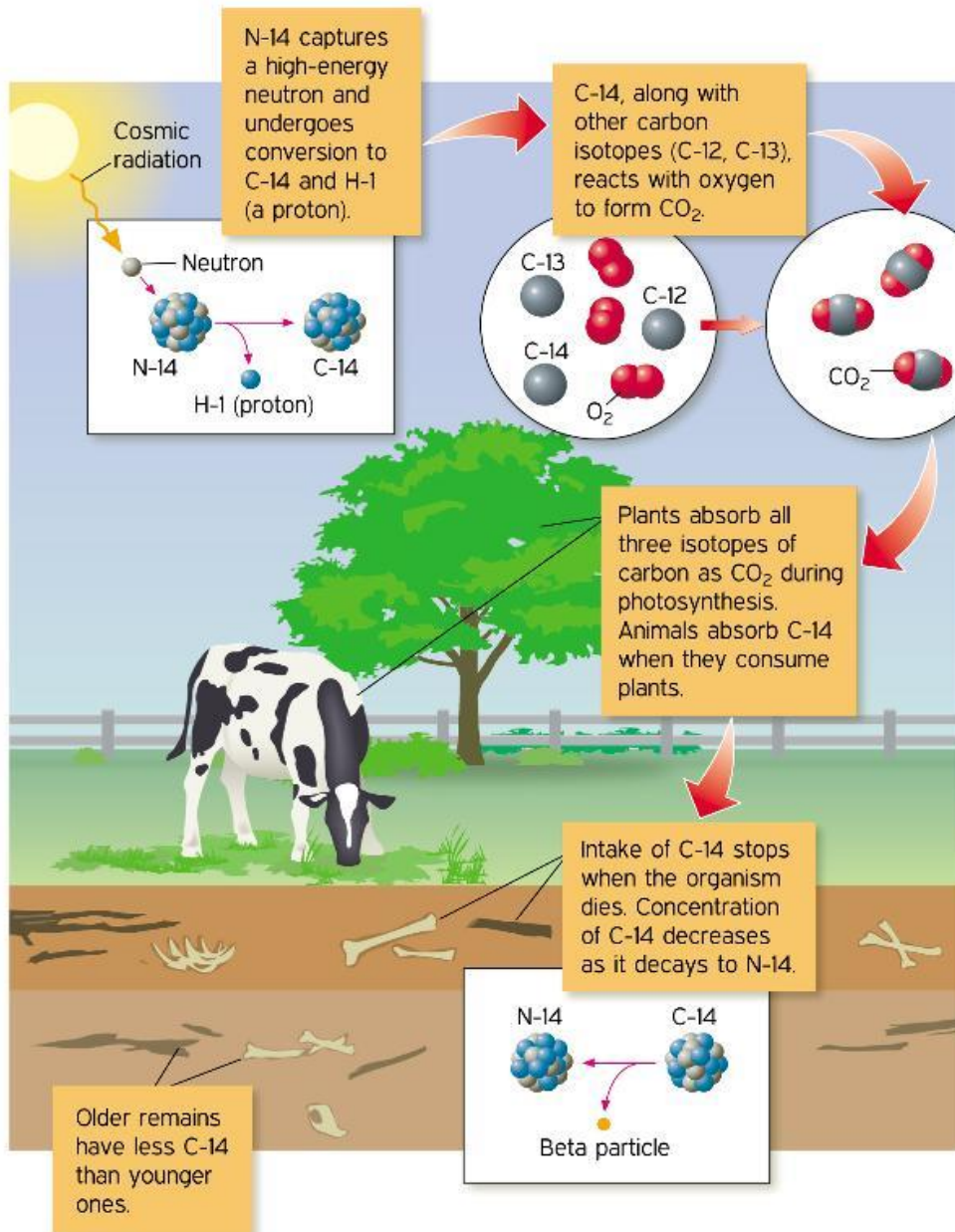
1,2 <b>H</b> 1 Hydrogen																	3, 4 <b>He</b> 2 Helium															
6, 7 <b>Li</b> 3 Lithium	9 <b>Be</b> 4 Beryllium																	10, 11 <b>B</b> 5 Boron	12, 13 <b>C</b> 6 Carbon	14, 15 <b>N</b> 7 Nitrogen	16, 17, 18 <b>O</b> 8 Oxygen	19 <b>F</b> 9 Fluorine	20, 21, 22 <b>Ne</b> 10 Neon									
23 <b>Na</b> 11 Sodium	24, 25, 26 <b>Mg</b> 12 Magnesium																	27 <b>Al</b> 13 Aluminum	28, 29, 30 <b>Si</b> 14 Silicon	31 <b>P</b> 15 Phosphorus	32, 33, 34, 36 <b>S</b> 16 Sulfur	35, 37 <b>Cl</b> 17 Chlorine	36, 38, 40 <b>Ar</b> 18 Argon									
39, 41 <b>K</b> 19 Potassium	40, 42, 43, 44, 46, 48 <b>Ca</b> 20 Calcium	45 <b>Sc</b> 21 Scandium	46, 47, 48, 49, 50 <b>Ti</b> 22 Titanium	51 <b>V</b> 23 Vanadium	50, 52, 53, 54 <b>Cr</b> 24 Chromium	55 <b>Mn</b> 25 Manganese	54, 56, 57, 58 <b>Fe</b> 26 Iron	59 <b>Co</b> 27 Cobalt	58, 60, 61, 62, 64 <b>Ni</b> 28 Nickel	63, 65 <b>Cu</b> 29 Copper	64, 66, 67, 68, 70 <b>Zn</b> 30 Zinc	69, 71 <b>Ga</b> 31 Gallium	70, 72, 73, 74, 76 <b>Ge</b> 32 Germanium	75 <b>As</b> 33 Arsenic	74, 76, 77, 78, 80, 82 <b>Se</b> 34 Selenium	79, 81 <b>Br</b> 35 Bromine	78, 80, 82, 83, 84, 86 <b>Kr</b> 36 Krypton															
85 <b>Rb</b> 37 Rubidium	84, 86, 87, 88 <b>Sr</b> 38 Strontium	89 <b>Y</b> 39 Yttrium	90, 91, 92, 94, 96 <b>Zr</b> 40 Zirconium	93 <b>Nb</b> 41 Niobium	92, 94-100 <b>Mo</b> 42 Molybdenum	none <b>Tc</b> 43 Technetium	96, 104, 98-103 <b>Ru</b> 44 Ruthenium	104 <b>Rh</b> 45 Rhodium	102, 108, 110, 104-106 <b>Pd</b> 46 Palladium	107, 109 <b>Ag</b> 47 Silver	106, 108, 114, 110-112, 116 <b>Cd</b> 48 Cadmium	113 <b>In</b> 49 Indium	112, 114-120, 122, 124 <b>Sn</b> 50 Tin	121 <b>Sb</b> 51 Antimony	120, 122, 123, 124-126, 130 <b>Te</b> 52 Tellurium	127 <b>I</b> 53 Iodine	124, 126, 134, 128-132, 136 <b>Xe</b> 54 Xenon															
133 <b>Cs</b> 55 Cesium	130, 132, 134-138 <b>Ba</b> 56 Barium		174, 176-180 <b>Hf</b> 72 Hafnium	180, 181 <b>Ta</b> 73 Tantalum	180, 182, 183, 184, 186 <b>W</b> 74 Tungsten	185 <b>Re</b> 75 Rhenium	184, 192, 186-190 <b>Os</b> 76 Osmium	191, 193 <b>Ir</b> 77 Iridium	192, 198, 194-196 <b>Pt</b> 78 Platinum	197 <b>Au</b> 79 Gold	196, 204, 198-202 <b>Hg</b> 80 Mercury	203, 205 <b>Tl</b> 81 Thallium	204, 206-208 <b>Pb</b> 82 Lead	none <b>Bi</b> 83 Bismuth	none <b>Po</b> 84 Polonium	none <b>At</b> 85 Astatine	none <b>Rn</b> 86 Radon															
none <b>Fr</b> 87 Francium	none <b>Ra</b> 88 Radium																	139 <b>La</b> 57 Lanthanum	136, 138, 140 <b>Ce</b> 58 Cerium	141 <b>Pr</b> 59 Praseodymium	142, 143, 145, 146, 148, 150 <b>Nd</b> 60 Neodymium	none <b>Pm</b> 61 Promethium	144, 152, 154, 148, 149, 150 <b>Sm</b> 62 Samarium	151, 153 <b>Eu</b> 63 Europium	152, 160, 154-158 <b>Gd</b> 64 Gadolinium	159 <b>Tb</b> 65 Terbium	156, 158, 160-164 <b>Dy</b> 66 Dysprosium	165 <b>Ho</b> 67 Holmium	162, 164, 166, 167, 168, 170 <b>Er</b> 68 Erbium	169 <b>Tm</b> 69 Thulium	168, 176, 170-174 <b>Yb</b> 70 Ytterbium	175 <b>Lu</b> 71 Lutetium
none <b>Ac</b> 89 Actinium	none <b>Th</b> 90 Thorium	none <b>Pa</b> 91 Protactinium	none <b>U</b> 92 Uranium	none <b>Np</b> 93 Neptunium	none <b>Pu</b> 94 Plutonium	none <b>Am</b> 95 Americium	none <b>Cm</b> 96 Curium	none <b>Bk</b> 97 Berkelium	none <b>Cf</b> 98 Californium	none <b>Es</b> 99 Einsteinium	none <b>Fm</b> 100 Fermium	none <b>Md</b> 101 Mendelevium	none <b>No</b> 102 Nobelium	none <b>Lr</b> 103 Lawrencium																		

Element Symbol — **Li** — Mass Numbers of Stable Isotopes  
 Element Name — Lithium — Atomic Number

- 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



<sup>12</sup> C	<sup>13</sup> C	<sup>14</sup> C
12.00000	13.00335	14.0
98.89%	1.11%	t <sub>1/2</sub> = 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.