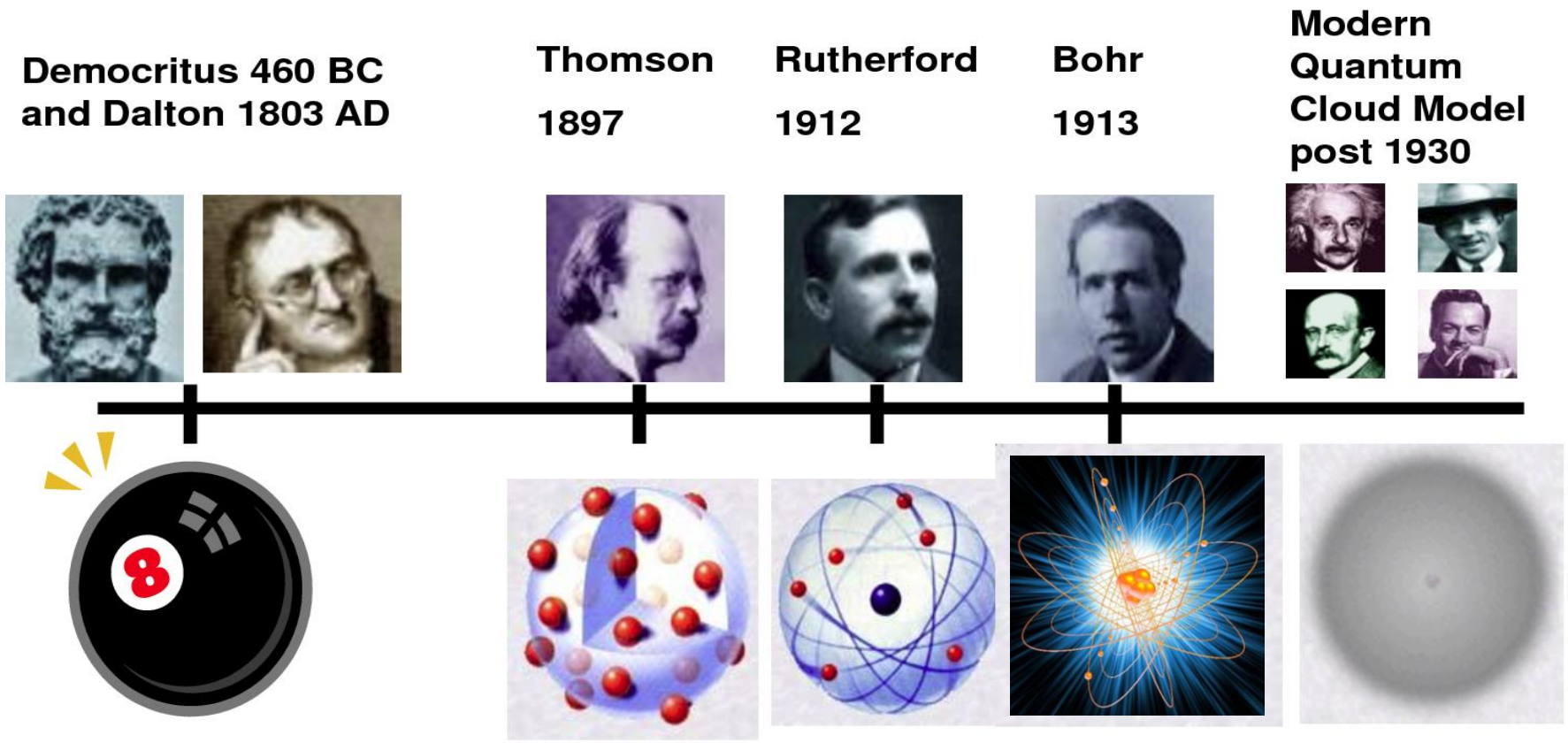
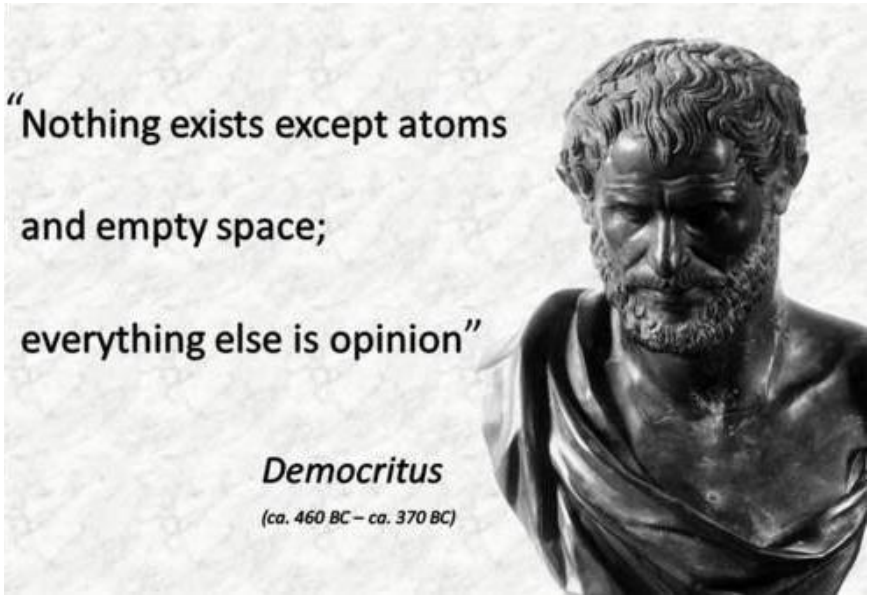
Atomic Theory Development



Born as early as 400 BC, it took more than 2000 years before Science was ready to accept the idea of atomic structure of matter…*and another 150 years to develop a good model!*

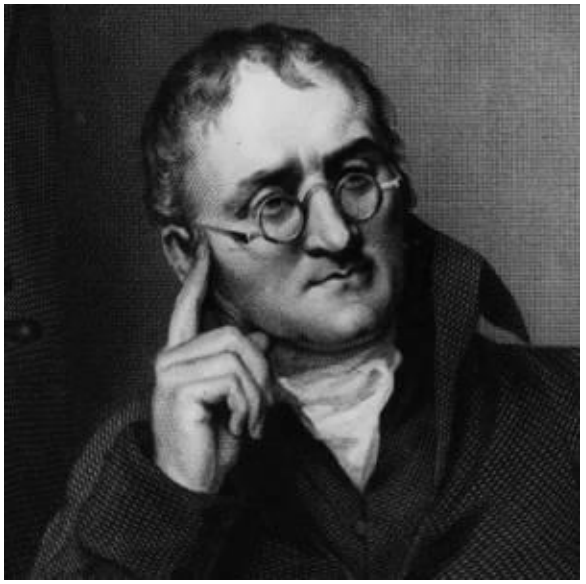
Democritus
~400 BC



"atomos"="not to be cut"

- **Matter could not be divided into smaller and smaller pieces forever, eventually the smallest possible piece would be obtained.**
- **This piece, atomos (atom), would be indivisible.**
- **Between atoms, there would be empty space.**
- **To Democritus, atoms were small, hard particles of different shapes and sizes that were all made of the same material.**
- **Atoms were infinite in number, always moving and capable of joining together.**

John Dalton
early 1800s



The first truly scientific theory of the atom: conclusions were reached by experimentation and examination of the results in an empirical fashion.

- **All elements are composed of atoms.**
- **Atoms are indivisible and indestructible particles.**
- **Atom model: a billiard ball or a *marble*.**

HOW ?

- **Atoms of the same element are exactly alike.**
- **Atoms of different elements are different.**

- **Compounds are formed by the joining of atoms of two or more elements.**

Mass…

Atomic weight!

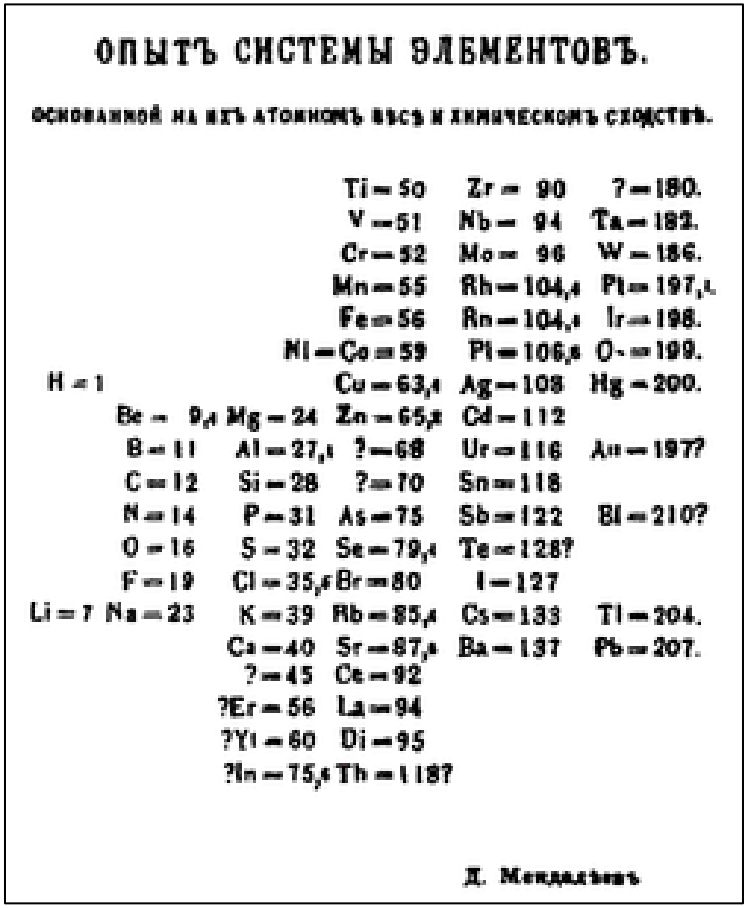
John Dalton

- **1803-1805**: first *list* of relative atomic weights containing just 6 elements, namely *hydrogen* (conventionally assumed to weigh 1), *oxygen, nitrogen, carbon, sulfur,* and *phosphorus*.

- **1808**: expanded list of elements

Dmitri Mendeleev

- **1869**: periodic *table* of 66 elements ordered and grouped according to their atomic weight.



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

			Ti = 50	Zr = 90	? = 180.	
			V = 51	Nb = 94	Ta = 182.	
			Cr = 52	Mo = 96	W = 186.	
			Mn = 55	Rh = 104,4	Pt = 197,1.	
			Fe = 56	Ru = 104,4	Ir = 198.	
			Ni = Co = 59	Pl = 106,6	O = 199.	
H = 1			Cu = 63,4	Ag = 108	Hg = 200.	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,5	Br = 80	I = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

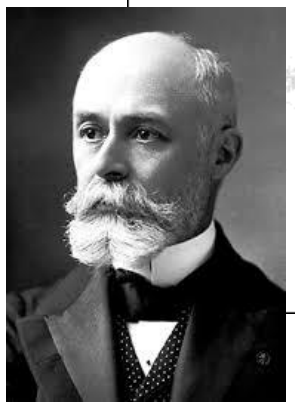
Д. Менделѣевъ

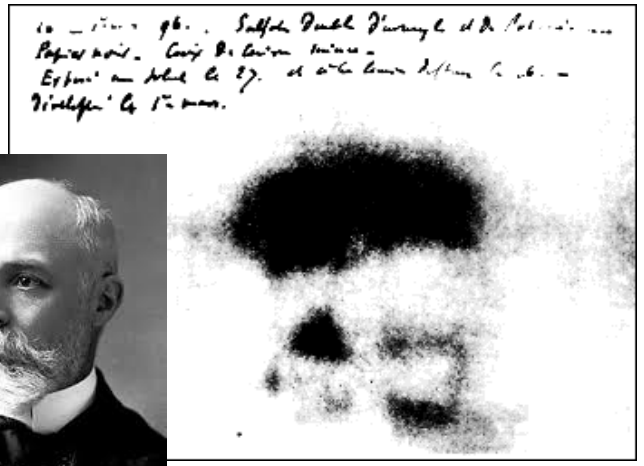
How can we study *the inside* of atom?

See what "comes out"!

- **Electric current – originates within matter; can flow through matter but also…in vacuum!**
  - **<u>Cathode rays, 1869</u>: streams of *something travelling in straight lines* observed in vacuum tubes when voltage is applied across the evacuated tube equipped with two electrodes.**
- **Radioactivity (alpha, beta, gamma)**
  - **<u>Henri Becquerel, 1896</u>:**

    - radioactivity was first discovered in uranium salts during his work on phosphorescence.
- **Light** (later!)



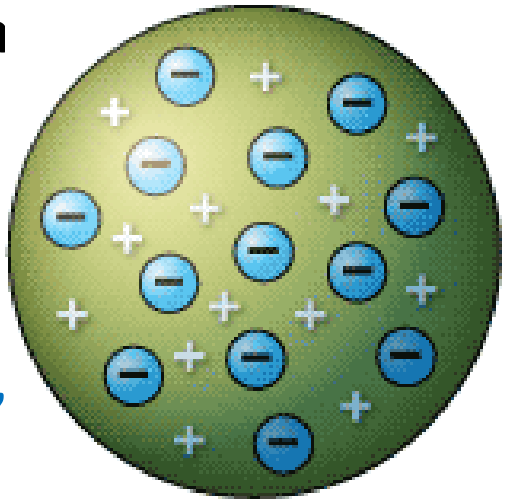


Discovery of Electron

Joseph John Thomson

1897: Studying cathode rays, Thomson detected charged particles that were around 1800 times lighter than the lightest atom, hydrogen. Therefore they were not atoms, but a new particle, the first subatomic particle to be discovered. Originally it was called "corpuscle" but was later named *electron*.

- **many elements were shown to emit electrons…**
- **…all atoms must contain electrons as universal building blocks**
- **atoms are neutral, so there must be a balancing "cloud" of opposite charge**



Plum Pudding Model, 1904

1906 Nobel prize in Physics

Radioactivity

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

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

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

- 4 years later, discovered an even more intensely radioactive substance, *radium*.

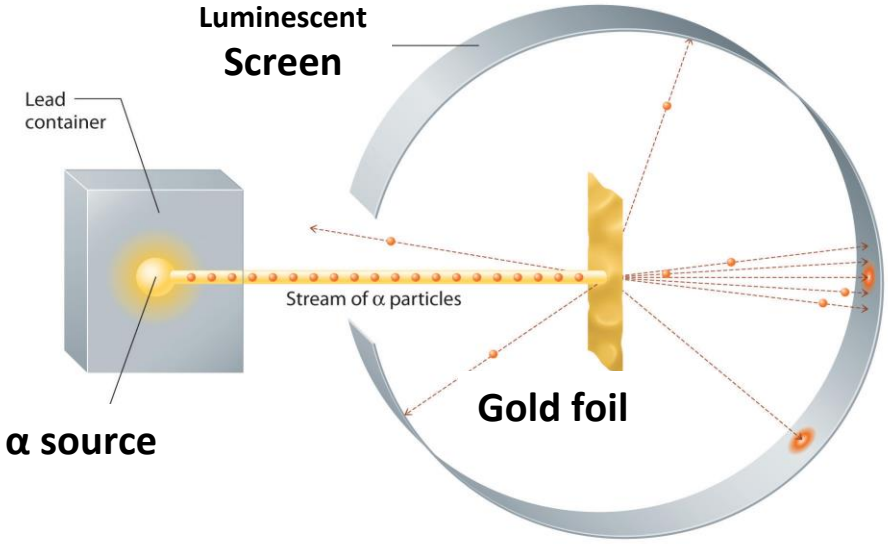
- **Ernest Rutherford and Frederick Soddy, 1899-1903:**

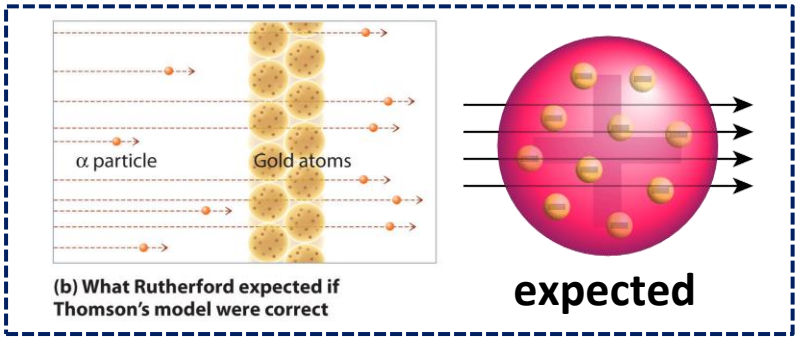
- discovered three different types of radiation "rays" with very different properties and proposed that atoms were not conserved in radioactive emissions.

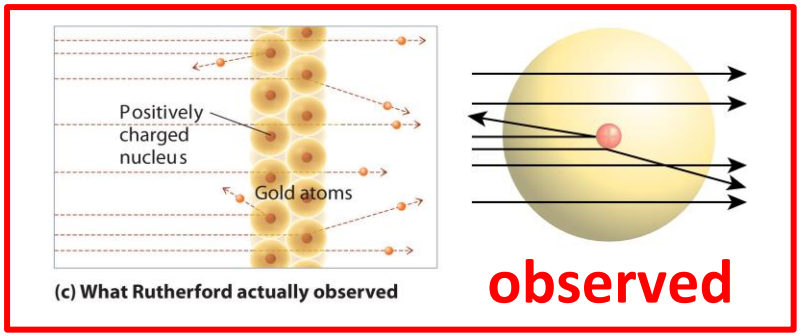
Discovery of the Nucleus

Rutherford (Geiger–Marsden), 1908-1913: Gold Foil Experiment

- **"Father of nuclear physics"**
- **Bombarded a thin metal foil with alpha particles. A majority of the particles passed through the sheet, but a small percentage were deflected.**

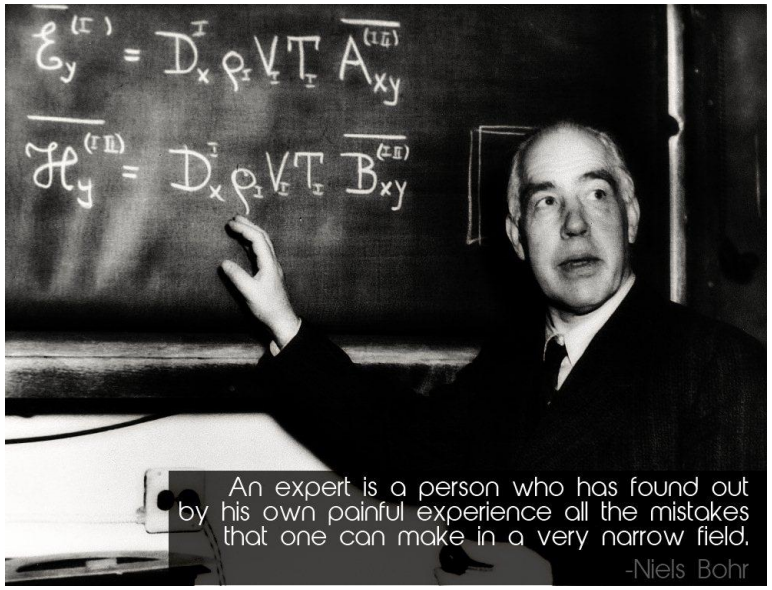






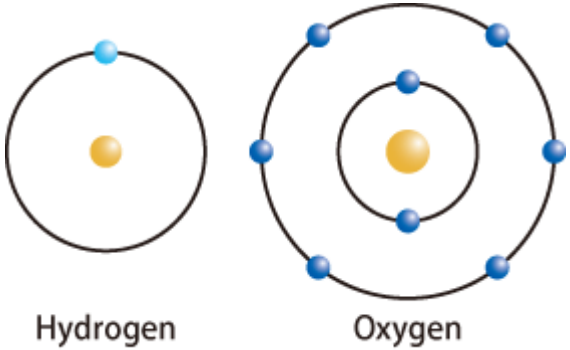
- **Rutherford's conclusion:** "the **greater part of the mass** of the atom was concentrated **in a minute nucleus**… carrying a charge".

Planetary Model
Niels Bohr, 1913



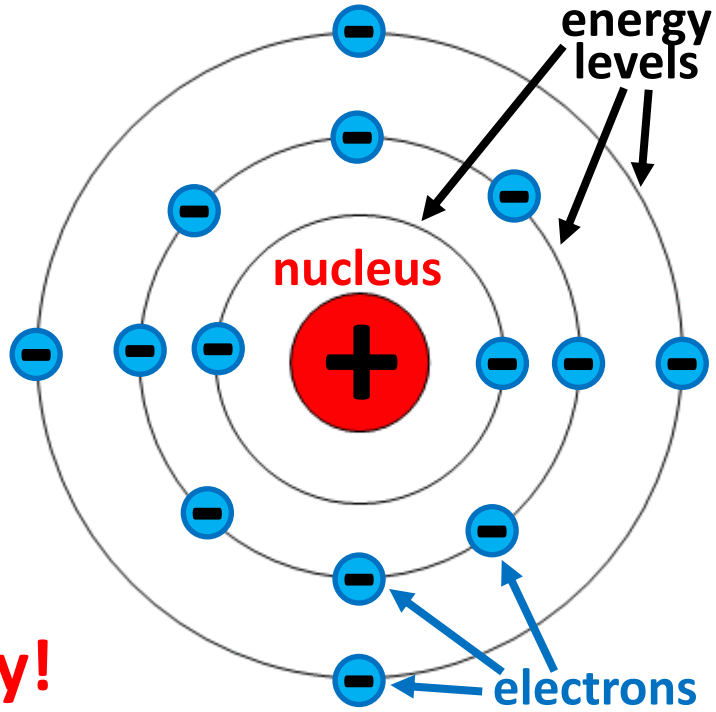
Electrons move in definite orbits around the nucleus, much like planets circle the Sun.

- **These circular orbits, or energy levels, are located at certain distances from the nucleus.**

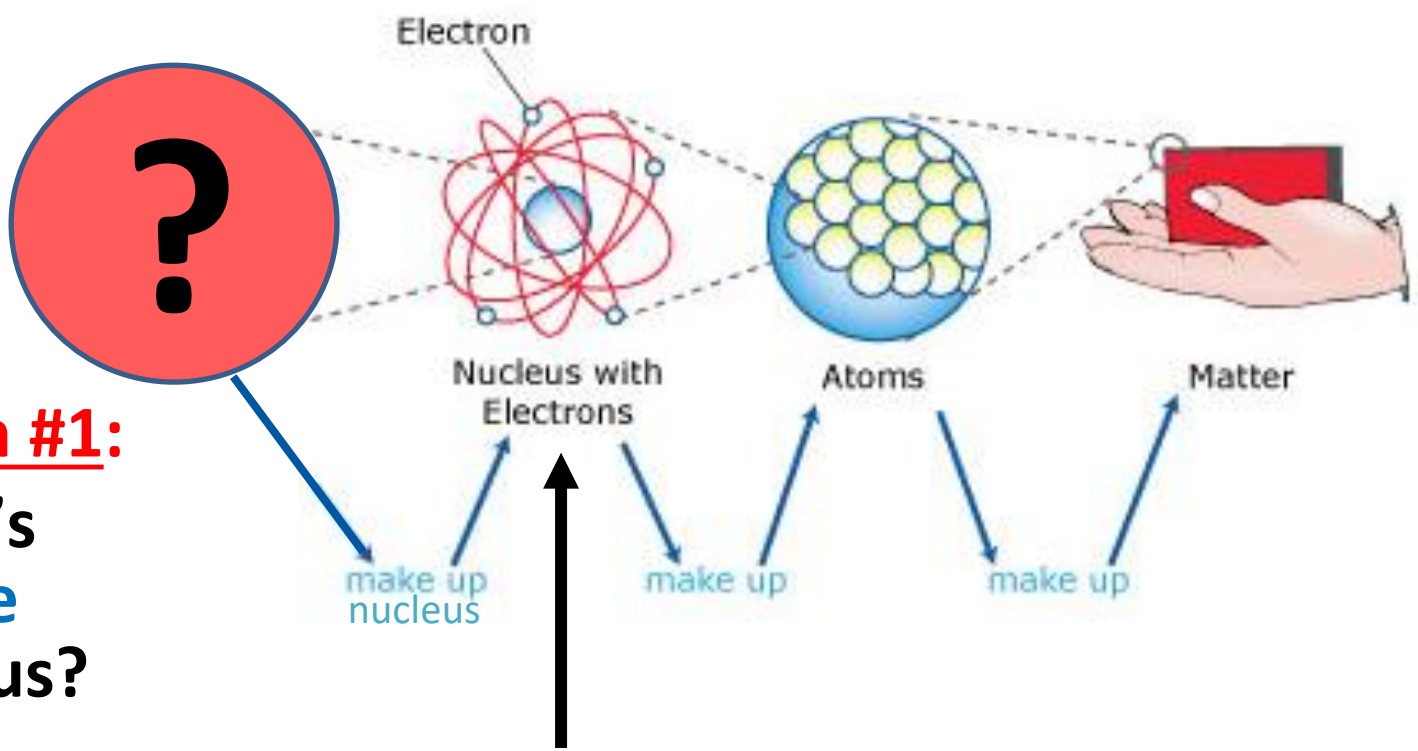


- **Electrons can jump between levels emitting (or absorbing) energy…**

…here comes Quantum Theory!



Summary: Structure of Matter



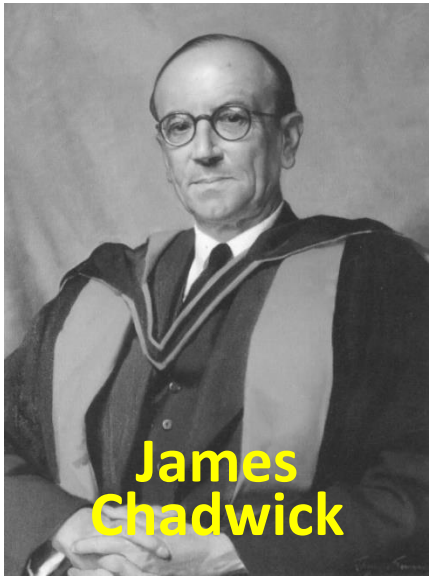
Question #1:

What's inside a nucleus?

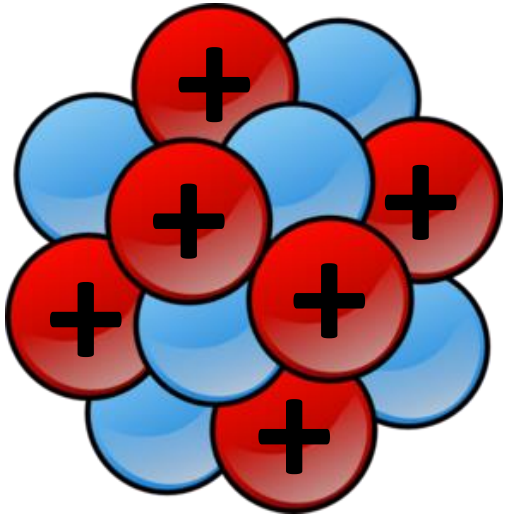
Question #2: Is planetary model of the atom *good enough* to explain all experimental observations?

Inside a Nucleus

- **Rutherford, 1920: discovery of a proton (Greek: "first"), a positively charged subatomic particle.**
- **1920-1932: search for a *neutral* particle.**
- **Chadwick, 1932: detected zero charged particles with about the same mass as the proton, eventually called neutron (1935 Nobel Prize in Physics).**



Atomic Nucleus Structure



Atom ~10^{-10}m

Nucleus ~10^{-14}m
Proton ~10^{-15}m
Neutron ~10^{-15}m