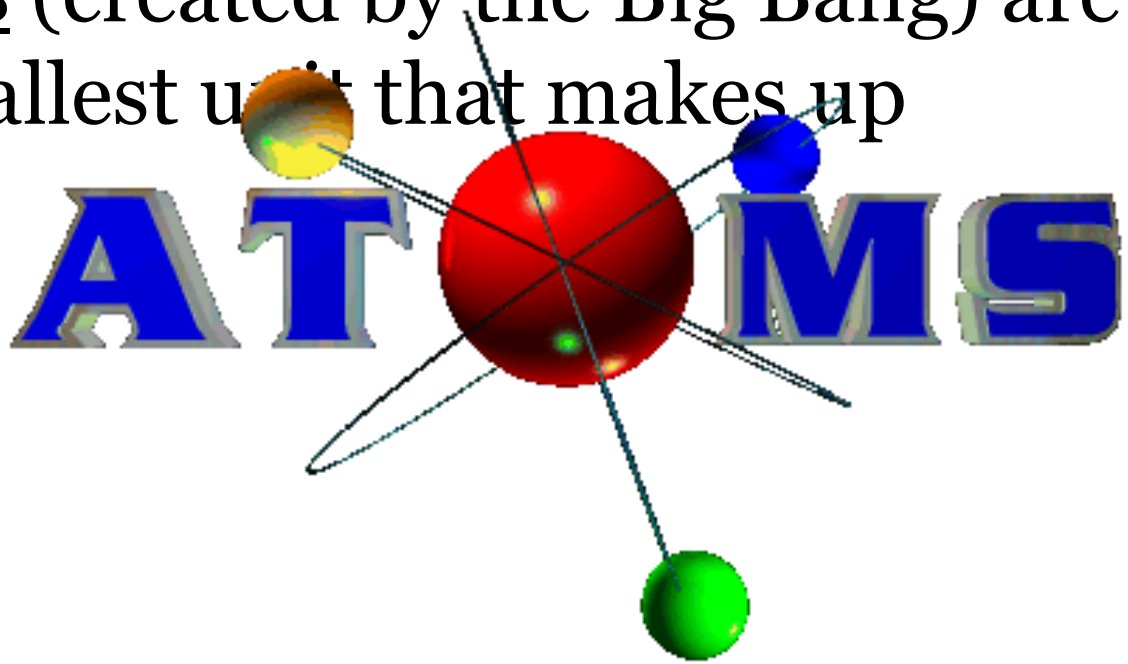
History of the atom

Atoms: What are they?

- **<u>Atoms</u>** (created by the Big Bang) are the smallest unit that makes up matter



Atoms

- *All life, whether in the form of trees, whales, mushrooms, bacteria or amoebas, consists of cells.*

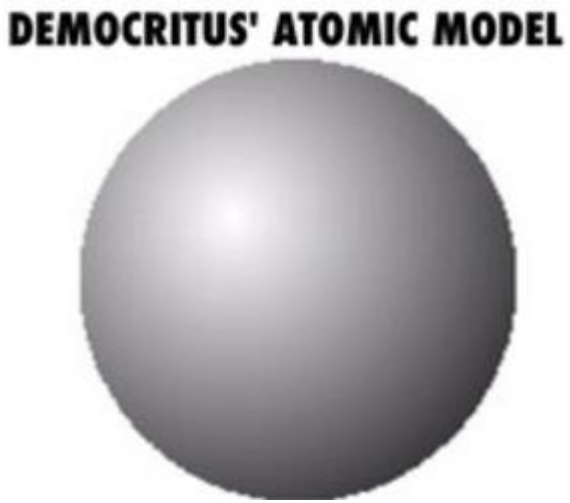
- *Similarly, all matter, whether in the form of aspirin, gold, vitamins, air or rocks,*

consists of atoms.

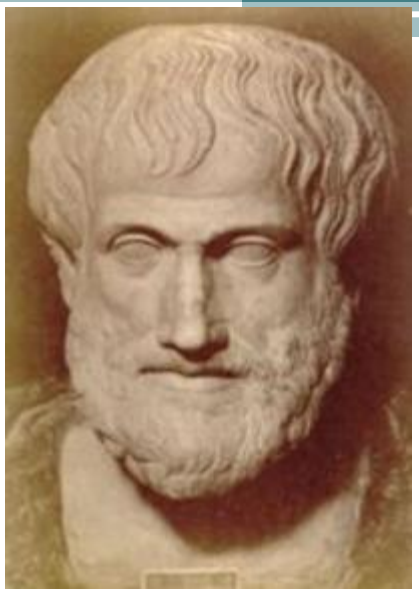
- *Regardless of size, atoms are made up of the same basic units.*

History of the atom : Democritus

- **Democritus (b. *c. 460 BC; d. c. 370 BC)* *postulated the existence of invisible atoms,*** characterized only by quantitative properties: size, shape, and motion. Imagine these atoms as indivisible spheres, the smallest pieces of an element that still behave like the entire chunk of matter.

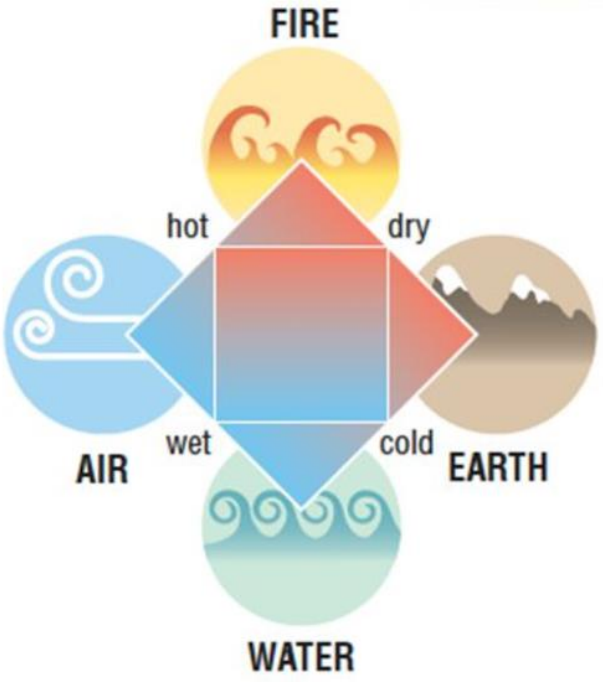


Aristotle



- Emphasized that nature consisted of four **elements: air, earth, fire, and water**. He thought these are bearers of fundamental properties, dryness and heat being associated with fire, heat and moisture with air, moisture and cold with water, and cold and dryness with earth.

- He did not believe in discontinuous or separate atoms but felt that matter was continuous

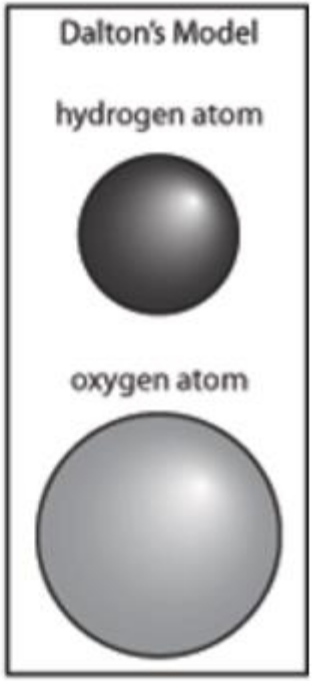


BONUS

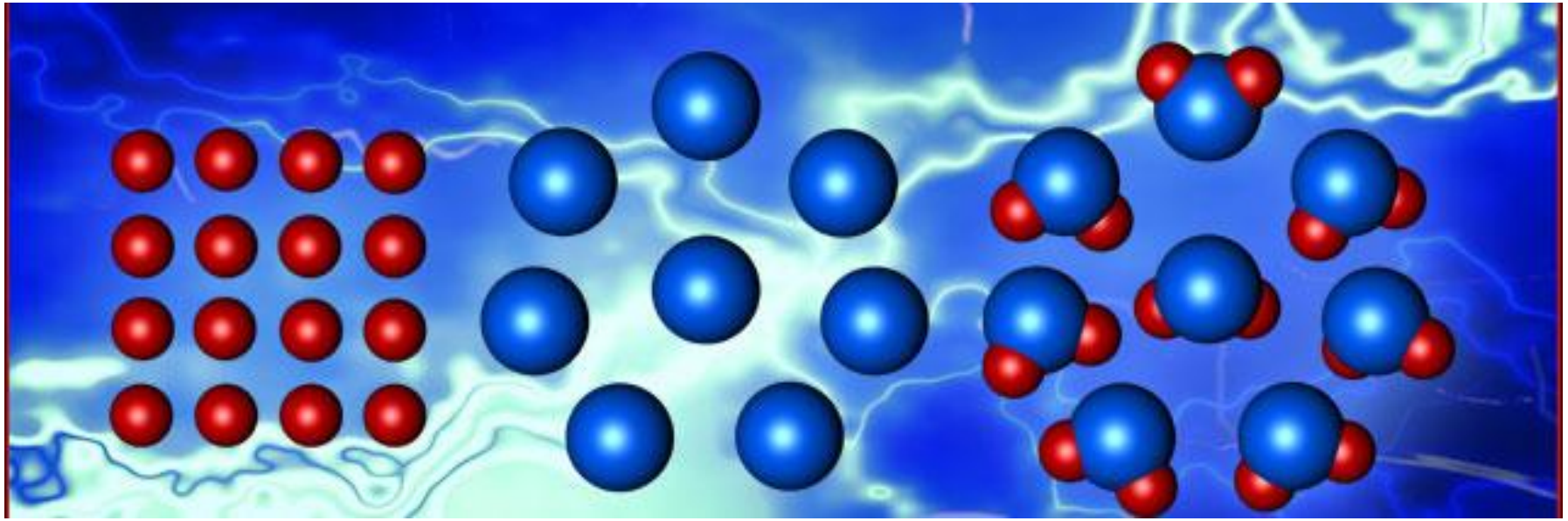
- Describe 2 different models of the atom (differences and similarities) and give the name of the person that first came up with the model.

John Dalton

- **Dalton (1766 - 1844)**
- **Deduced the law of multiple proportions (atoms combine in simple, whole number ratios to form compounds)**
- **Theorized that all matter is made up of tiny particles called atoms. No other smaller particles exist (same as Democritus)**
- **Atoms of the same element are identical. Atoms of different elements are different**

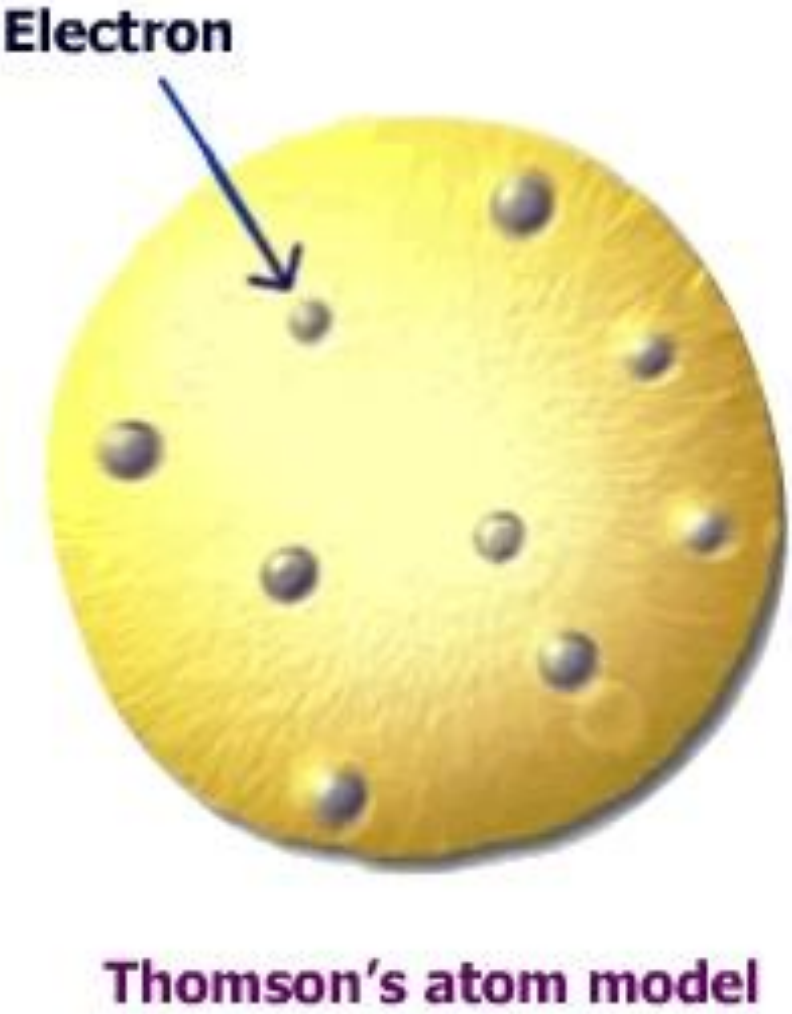


- **Atoms cannot be made or destroyed**
- **All atoms of the same element are identical**
- **Different elements have different types of atoms**

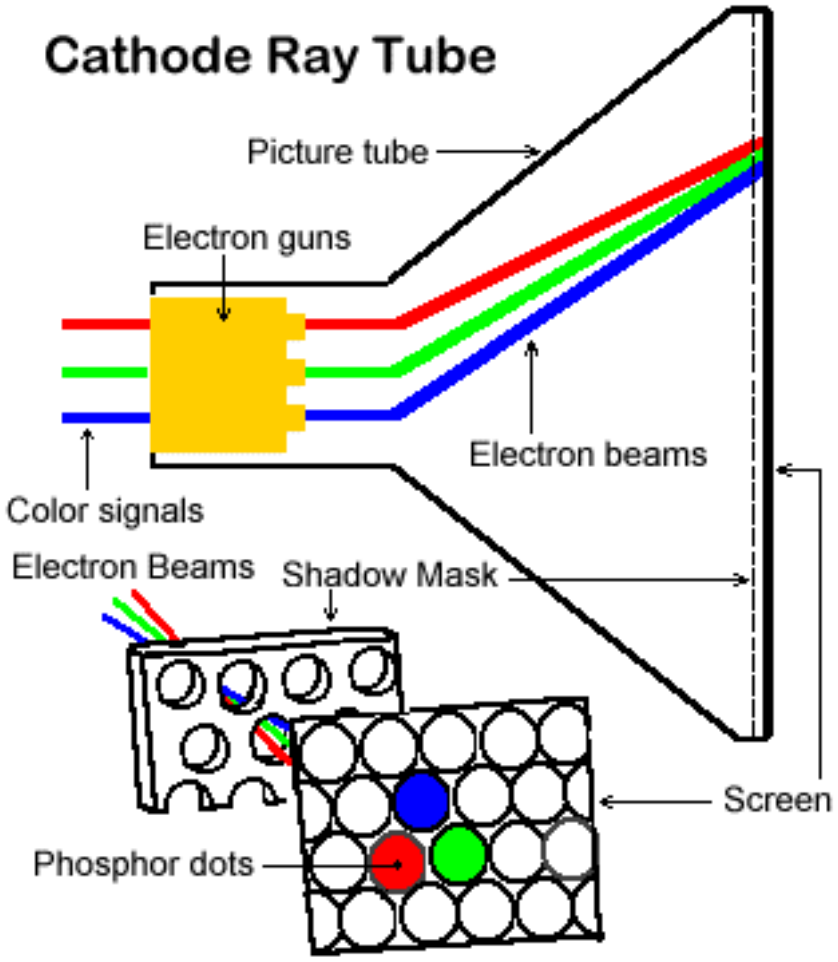


J. J. Thomson

- **J.J. Thomson** (1856 - 1940)
- Played with **cathode ray tubes** and found that the atom was divisible!
- He discovered that atoms consisted of both + and – charges.
- "Plum Pudding" model or "Watermelon" model of the atom:

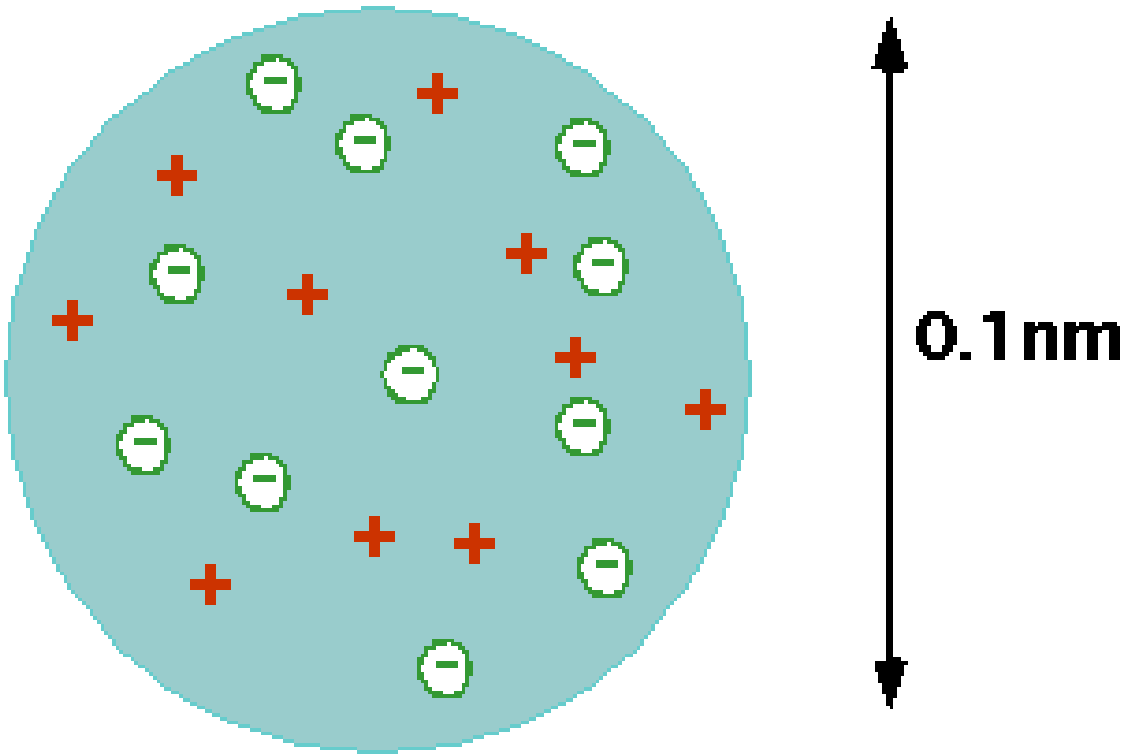


Cathode ray tube

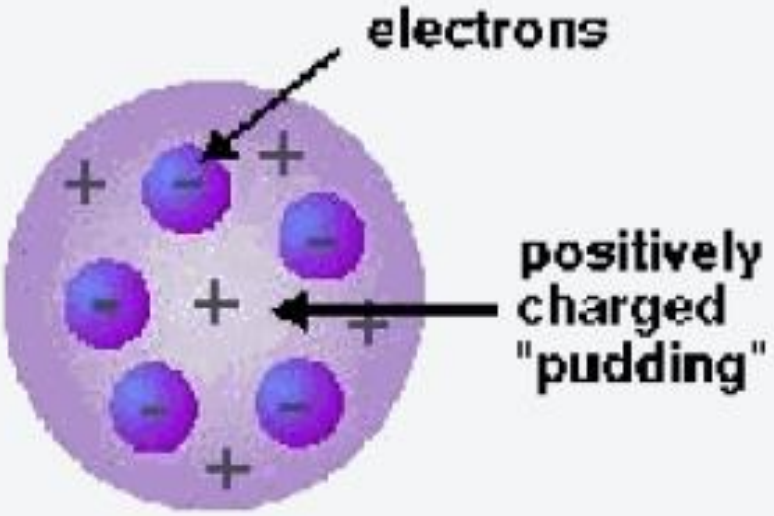


J. J. Thomson

- Later on he discovered a positively charged particle (proton) and adapted his model:

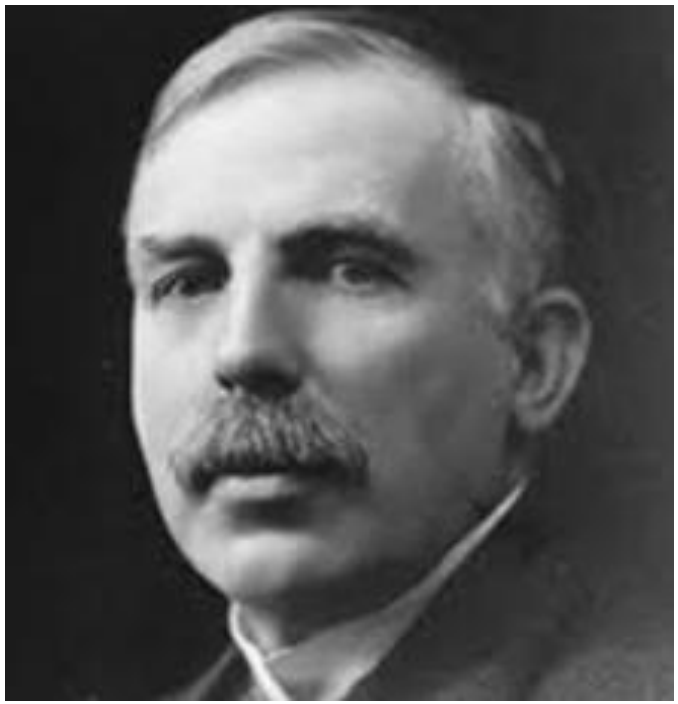


J.J. Thomson's Plum Pudding Model of the Atom (1897)

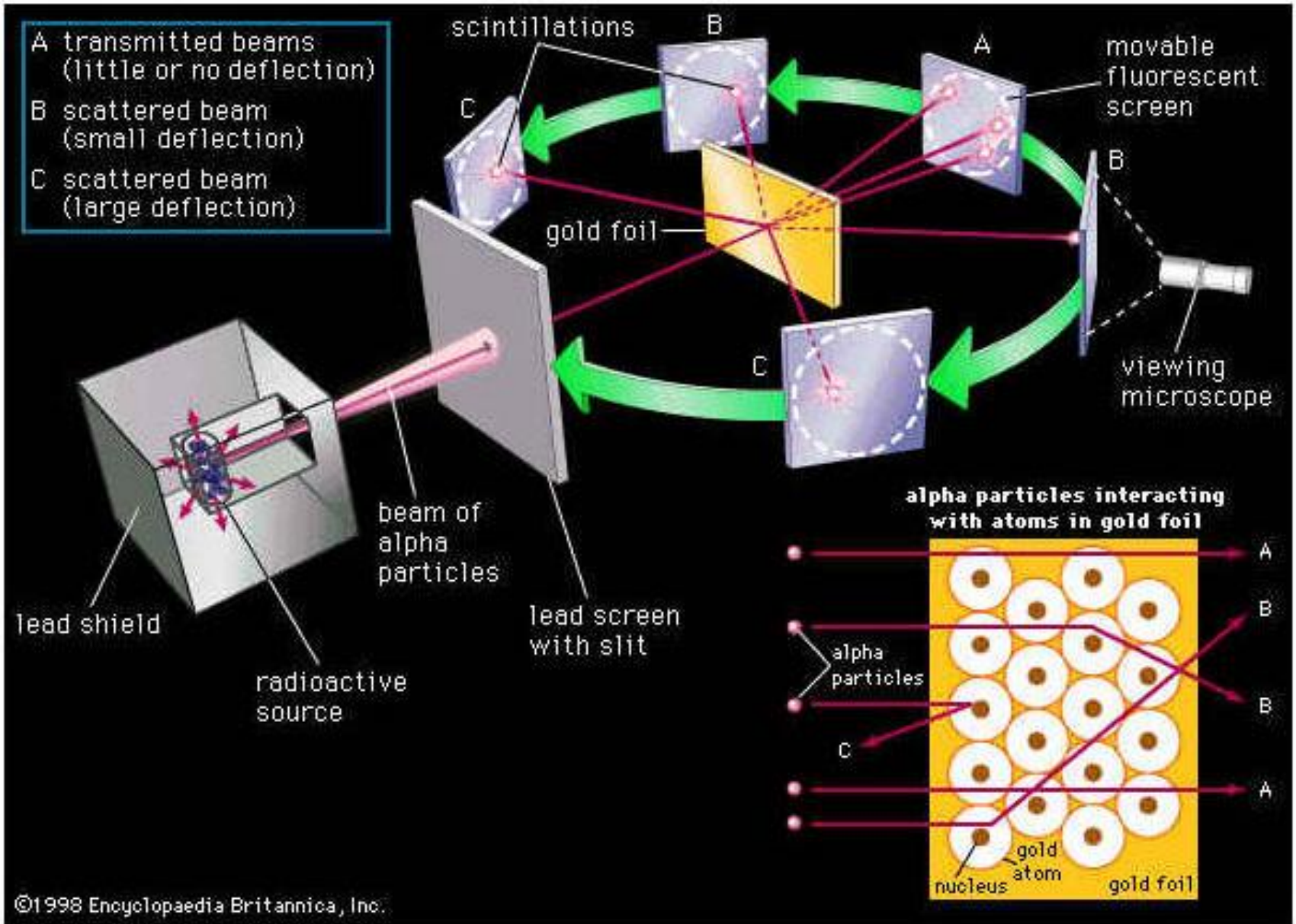


Ernest Rutherford (1871- 1937)

- Performed the “gold foil experiment”, in which he discovered that the atom is made up of mostly empty space.
- Most of the mass of an atom is concentrated in a tiny nucleus that has a positive charge.
- Electrons orbit the nucleus like planets in the solar system



Gold foil experiment



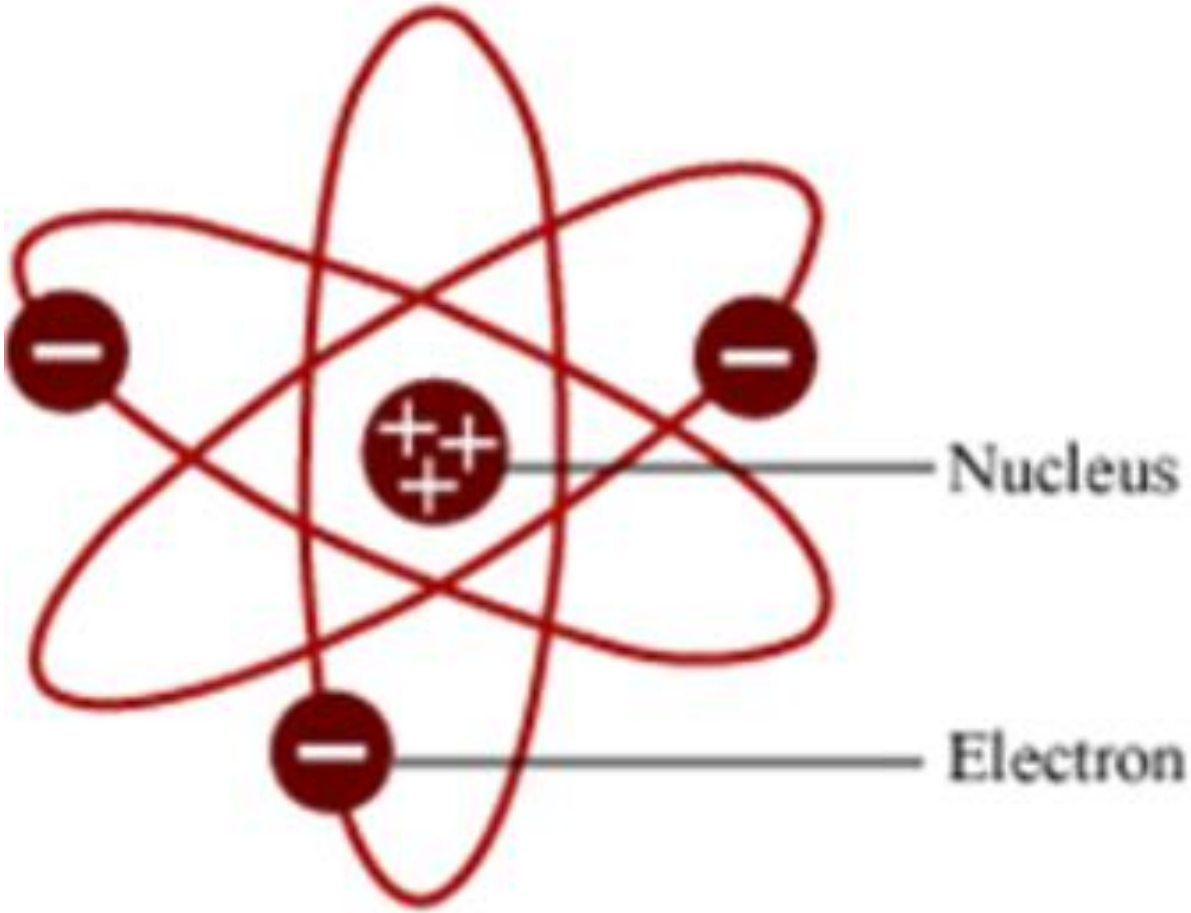
Rutherford's Observations and Consequent Conclusions

- Most of the alpha particles pass through the gold foil without being deflected → **An atom is mostly empty space**

- Some alpha particles are strongly deflected or bounce back

→**An atom contains a very dense and very small nucleus**

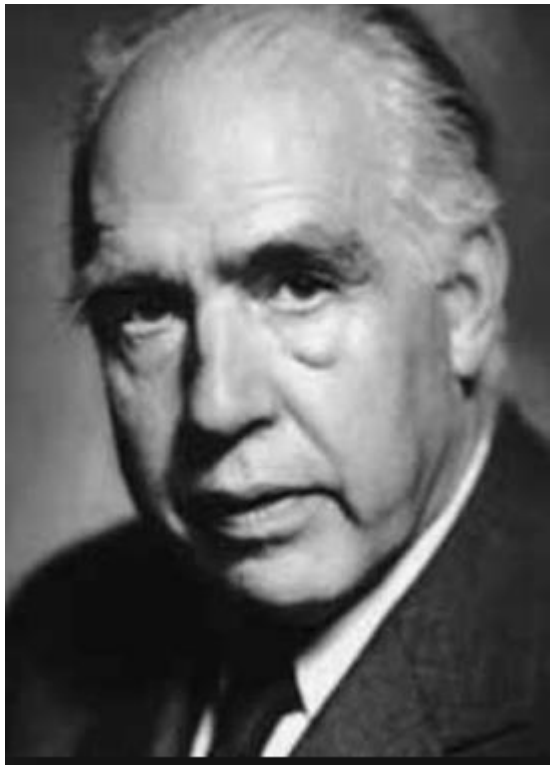
→**The nucleus of an atom is positively charged**



Rutherford's atomic model

Niels Bohr (1885 – 1962)

- Discovered that electrons exist around the nucleus in specific energy levels or electron shells.
- Different levels have different sizes and capacities.
- They are numbered 1 – 7, with level 1 closest to the nucleus.
- Electrons prefer to be close to the nucleus, but some levels fill up fast, and some may only fill partially.
- The maximum number of electrons that a given shell can hold can be calculated:

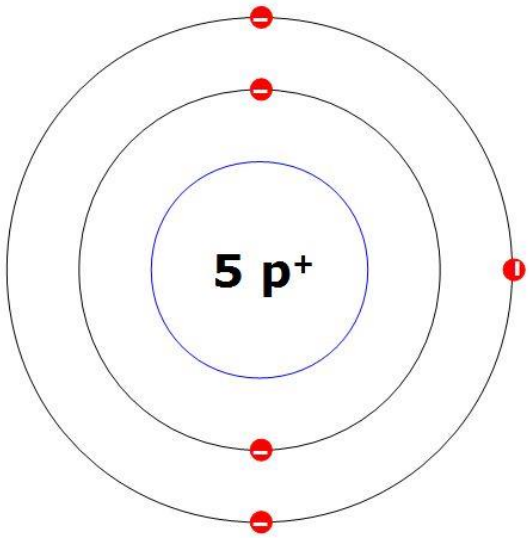


Niels Bohr

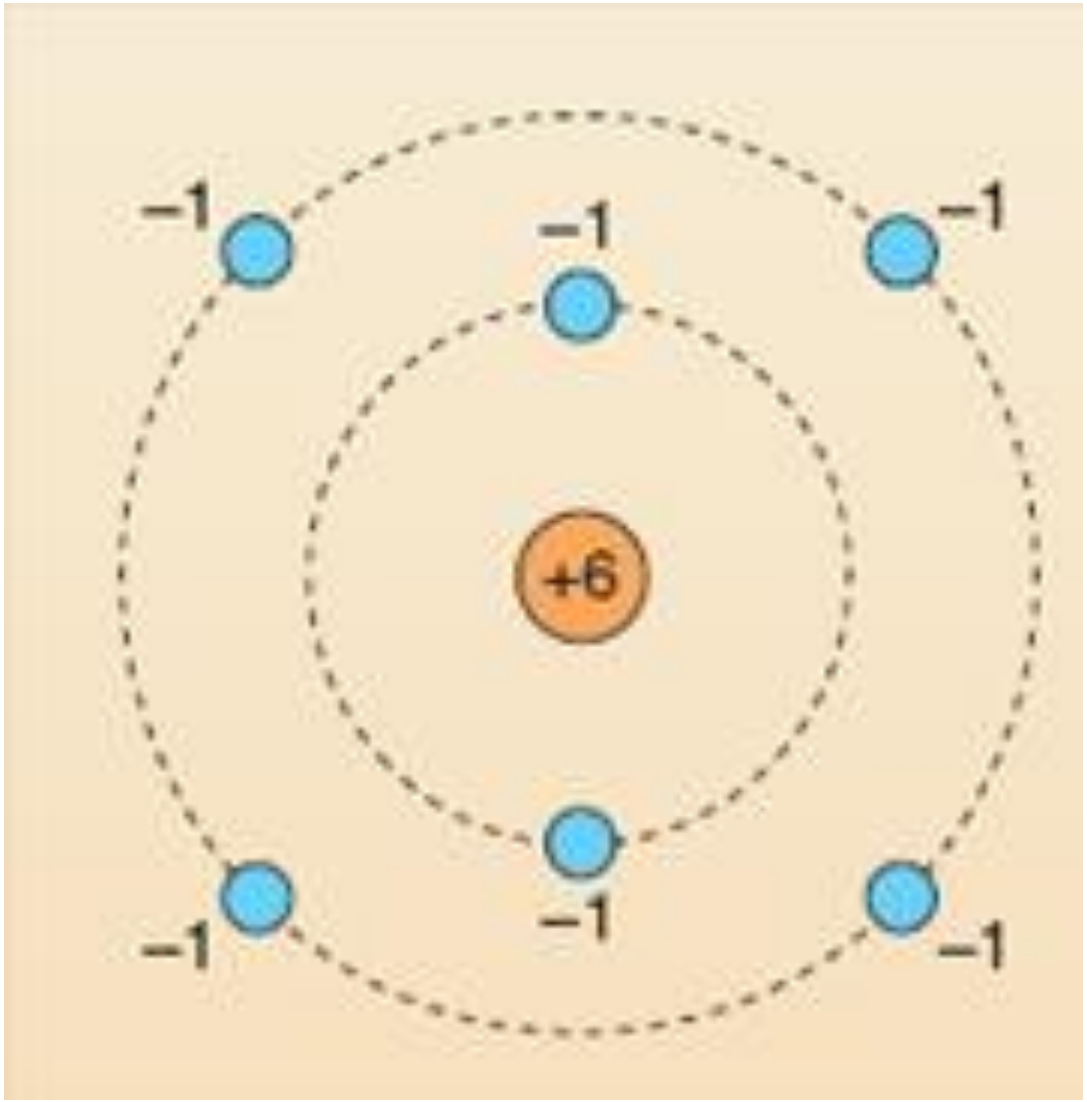
Level (n)	Capacity ($2n^2$)
1	2 e^-
2	8 e^-
3	18 e^-
4	32 e^-

The Bohr-Rutherford Model of the Atom

- An element is defined by the number of protons it contains.
- To remain electrically neutral, it must contain the same number of protons and electrons.
- The number of neutrons can vary in an element.
- Because electrons are so small, nearly all the mass of an atom is contained in it's nucleus.
- The nucleus is very small and dense compared to the whole atom



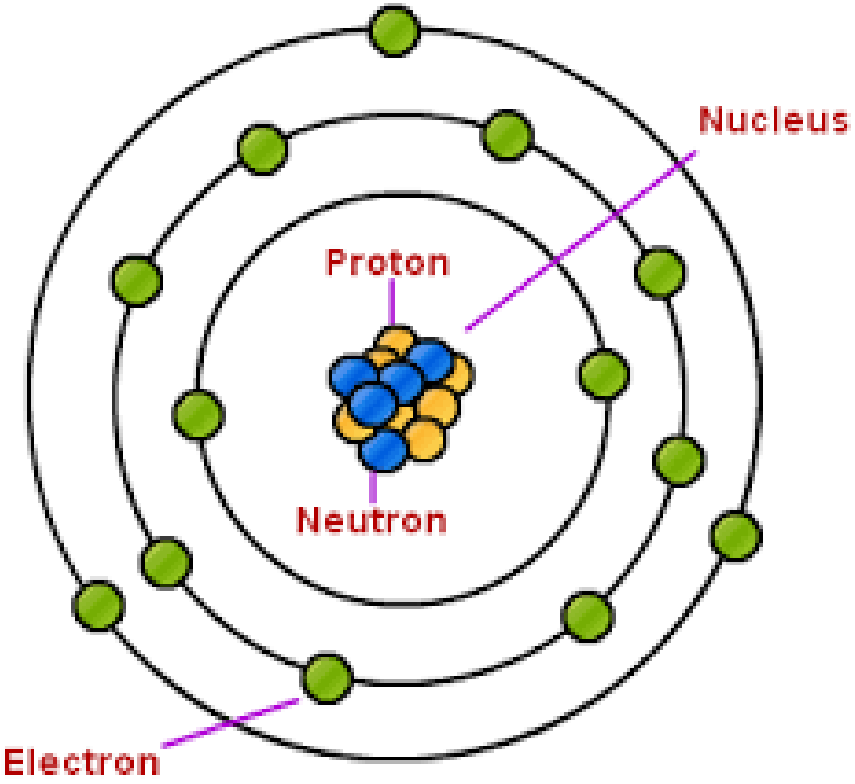
Drawing: Carbon Atom Rutherford-Bohr Model

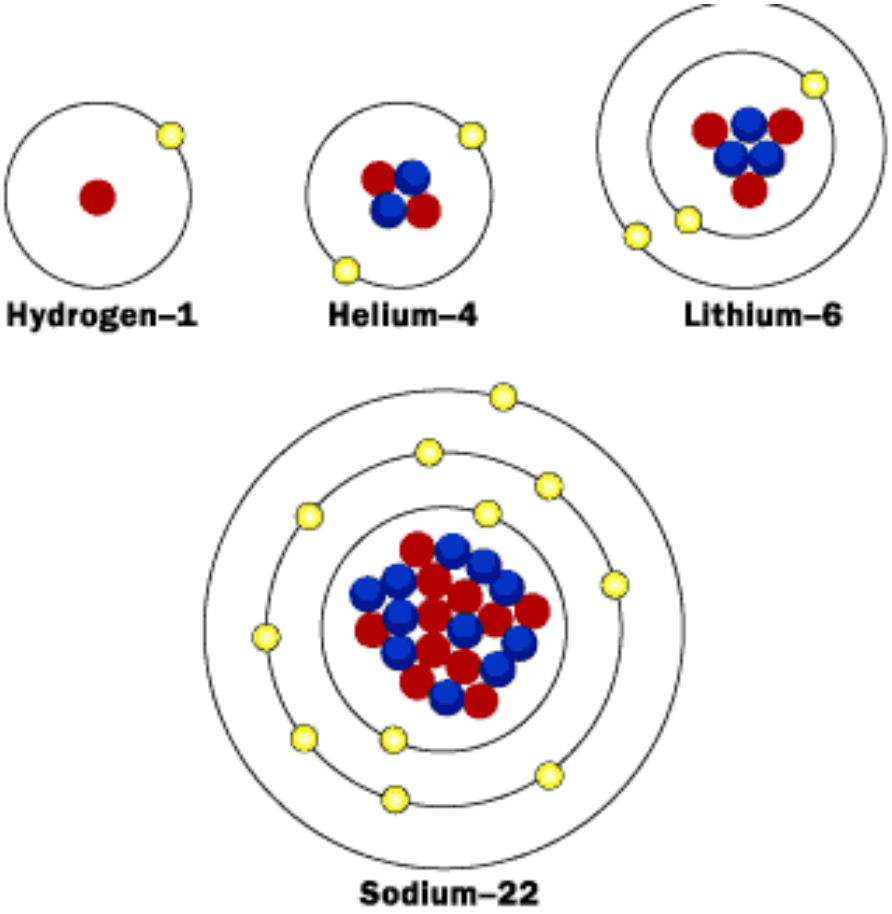


James Chadwick (1891 – 1974)

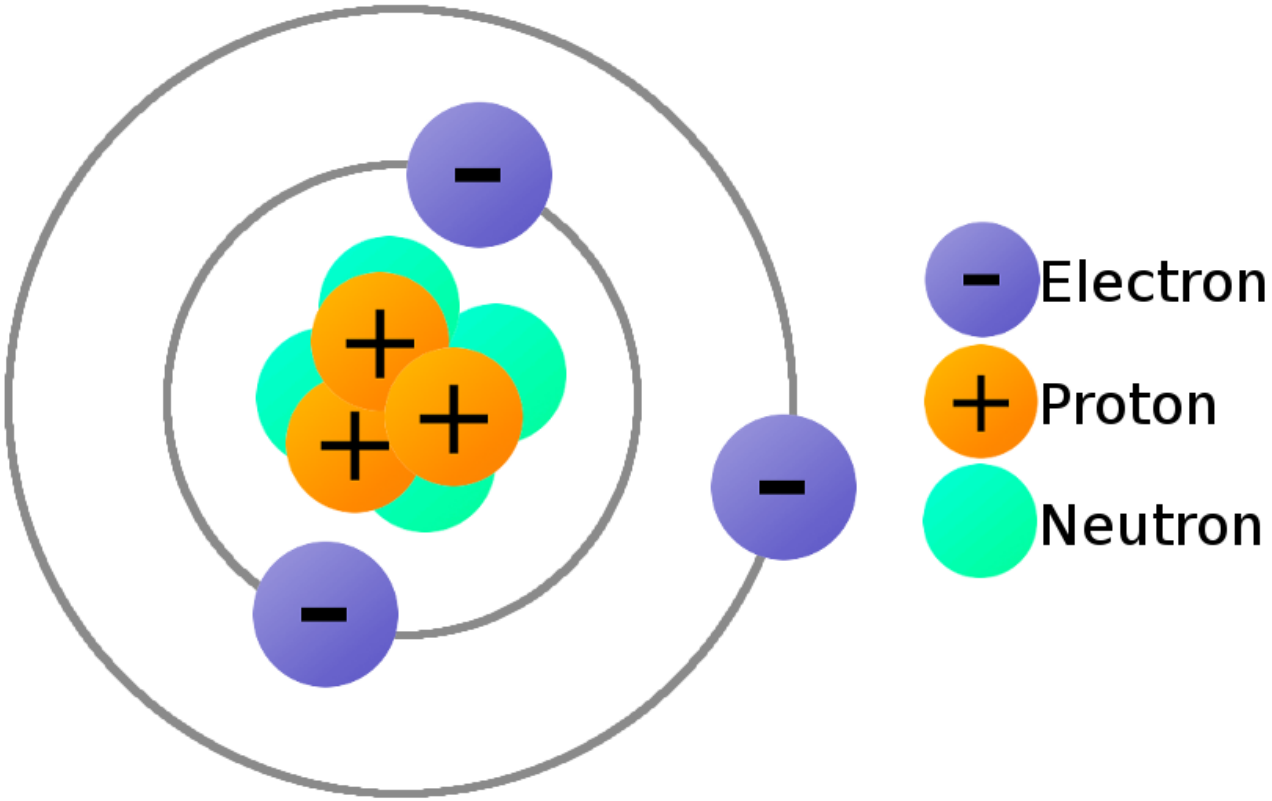
- Discovered the neutron

- The neutron: One of the particles that makes up an atom. With the proton, it forms the nucleus. It has no electrical charge, so it is neutral.




Hydrogen–1
Helium–4
Lithium–6
Sodium–22
Neutron
Proton
Electron

The simplified atomic model



The Rutherford-Bohr Model of the Atom

Subatomic Particles

Particle	Mass		Charge	Location
	kg	*amu*		
Proton	1.672×10^{-27}	1	+	Inside the nucleus
Electron	9.109×10^{-31}	1/1837	-	outside the nucleus
Neutron	1.674×10^{-27}	1.008	neutral	Inside the nucleus

Drawing: Carbon Atom
Simplified atomic model

Carbon

$p = 6$

$e^- = 6$