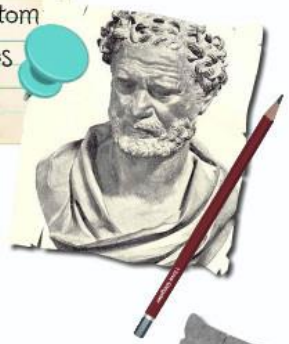
What is Atom?

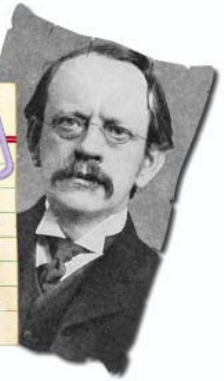
Democritus said that all atom are small, hard particles



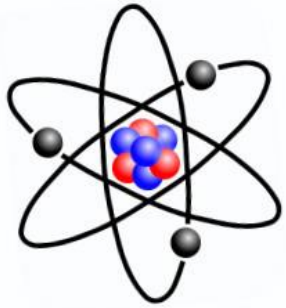
John Dalton developed his atomic theory from observations of many experiments

Glogster

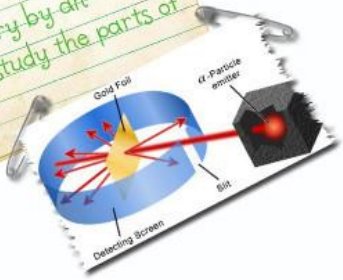
J.J Thomson discovered that there are small particles inside the atom.



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

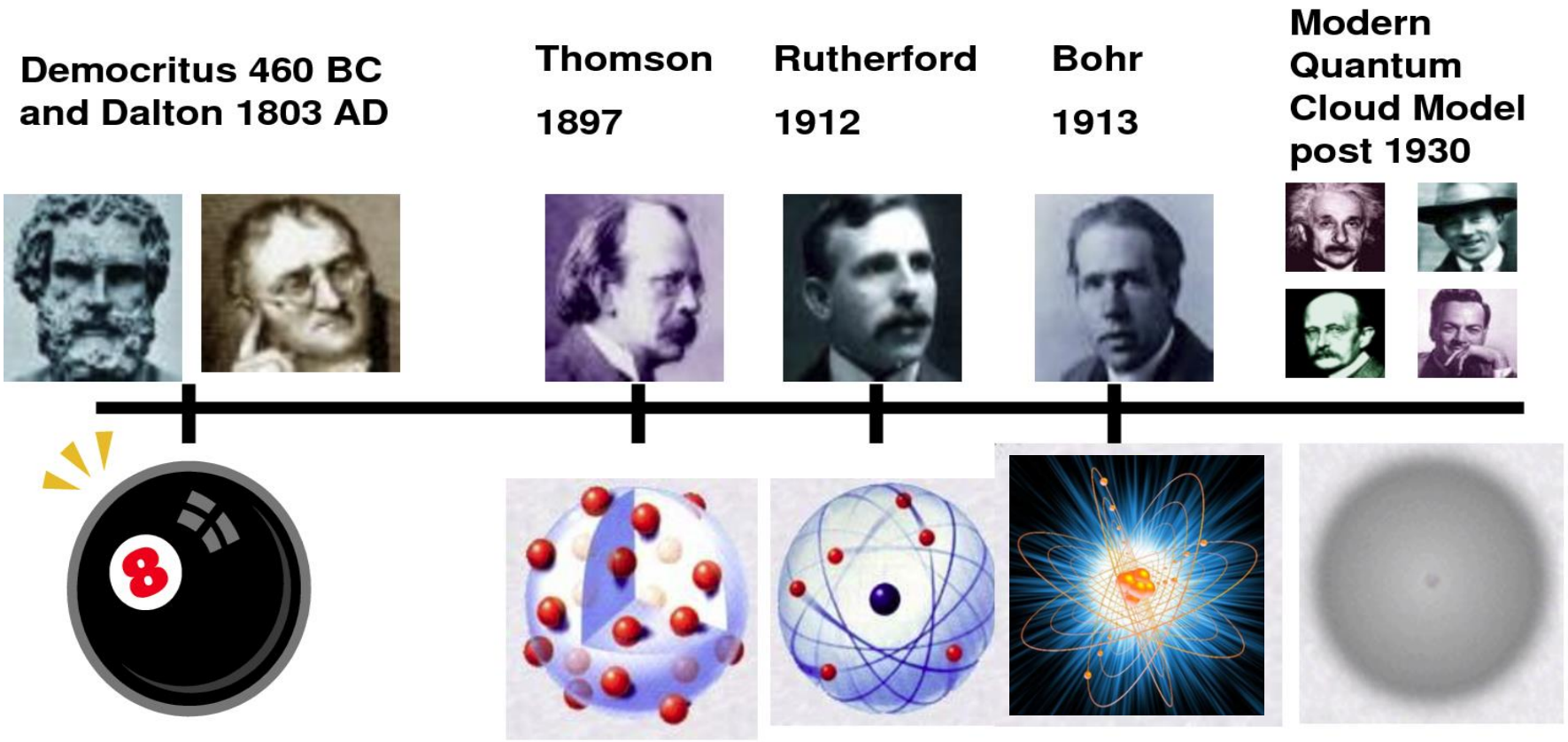


Rutherford decided to test Thomson's theory by an experiment to study the parts of an atom



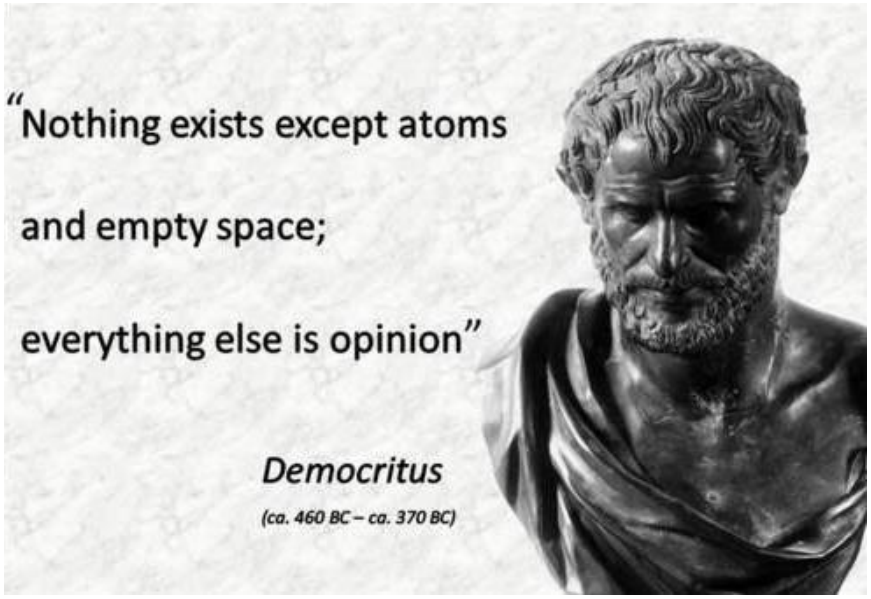
Bohr's results led him to propose that electorns move around nucleus in certain paths or energy levels.

Atomic 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!*

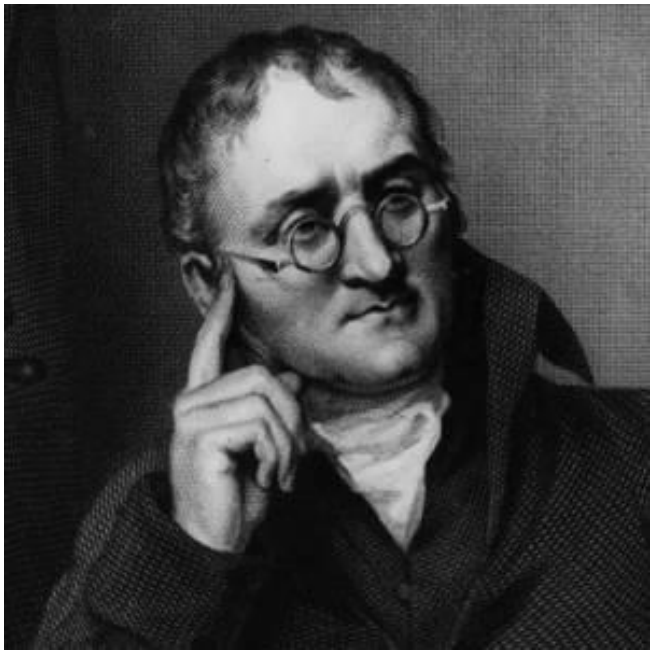
Democritus
~400 BC



"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?

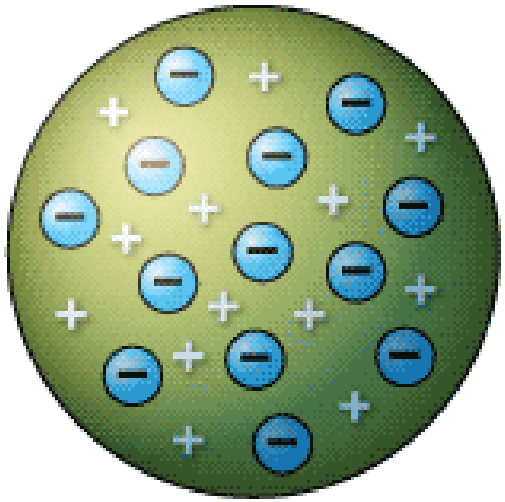
- **Atoms of the same element are exactly alike.**
- **Atoms of different elements are different.**
- **Compounds are formed by the joining of atoms of two or more elements.**

Discovery of Electron

Joseph John Thomson

1897: 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 balancing "cloud" of opposite charge



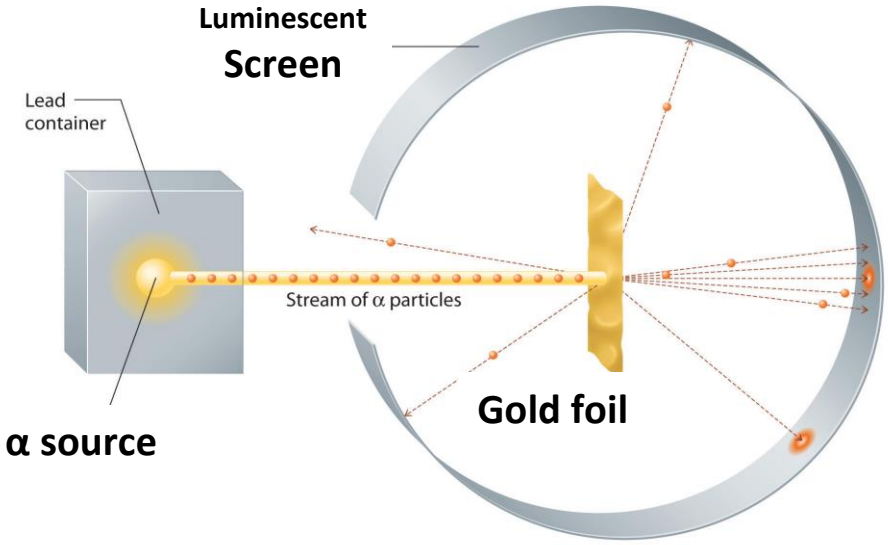
Plum Pudding Model, 1904

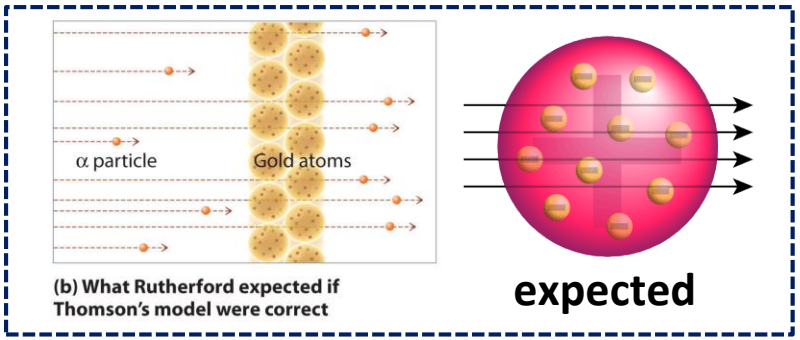
1906 Nobel prize in Physics

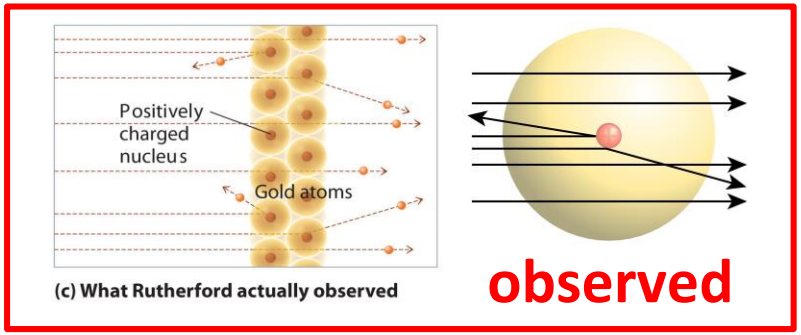
Discovery of the Nucleus

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.**

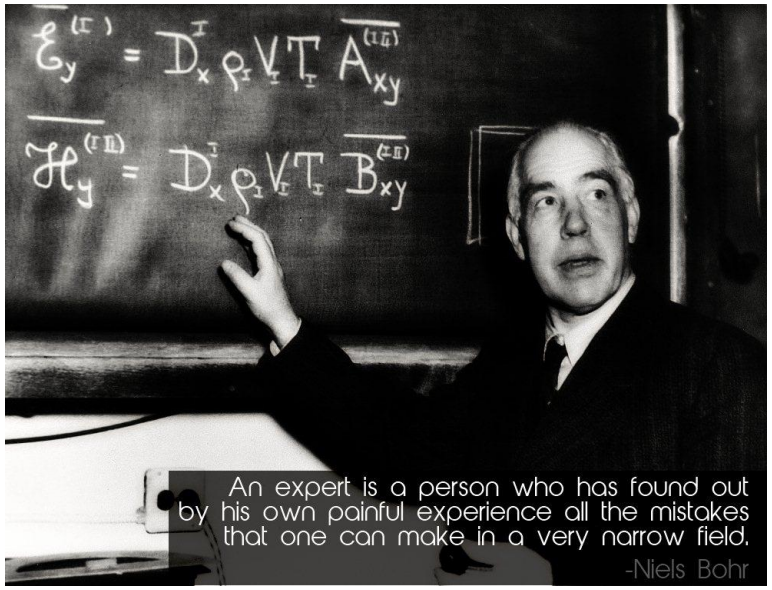






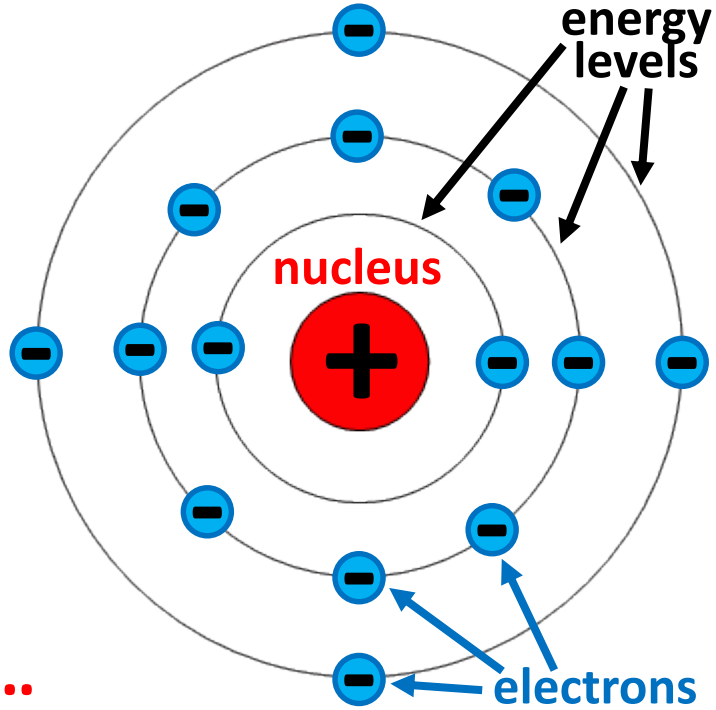
- **Rutherford's conclusion:** "the **greater part of the mass** of the atom was concentrated **in a minute nucleus**… carrying a charge".

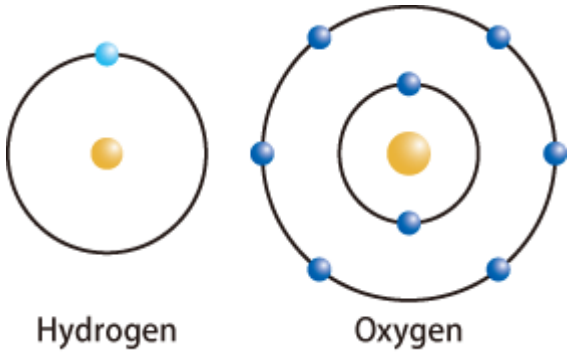
Planetary Model
Niels Bohr, 1913



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.**



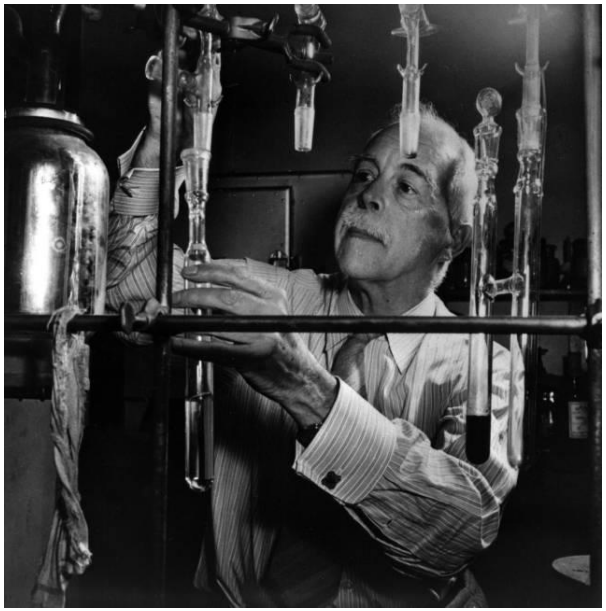


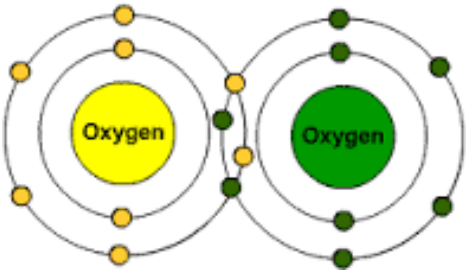
Here comes Quantum Theory…

Chemical Bond Explained

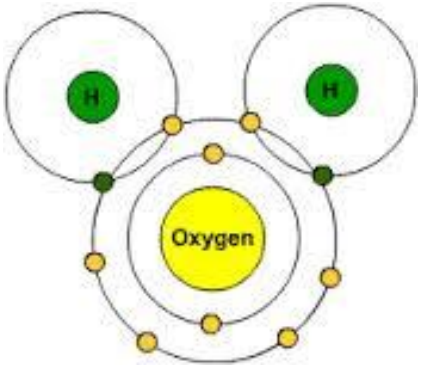
Gilbert Newton Lewis, 1916:

a covalent bond between two atoms is maintained by a pair of electrons shared between them.

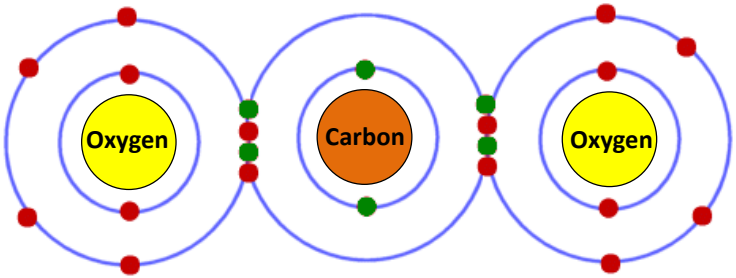




Oxygen molecule



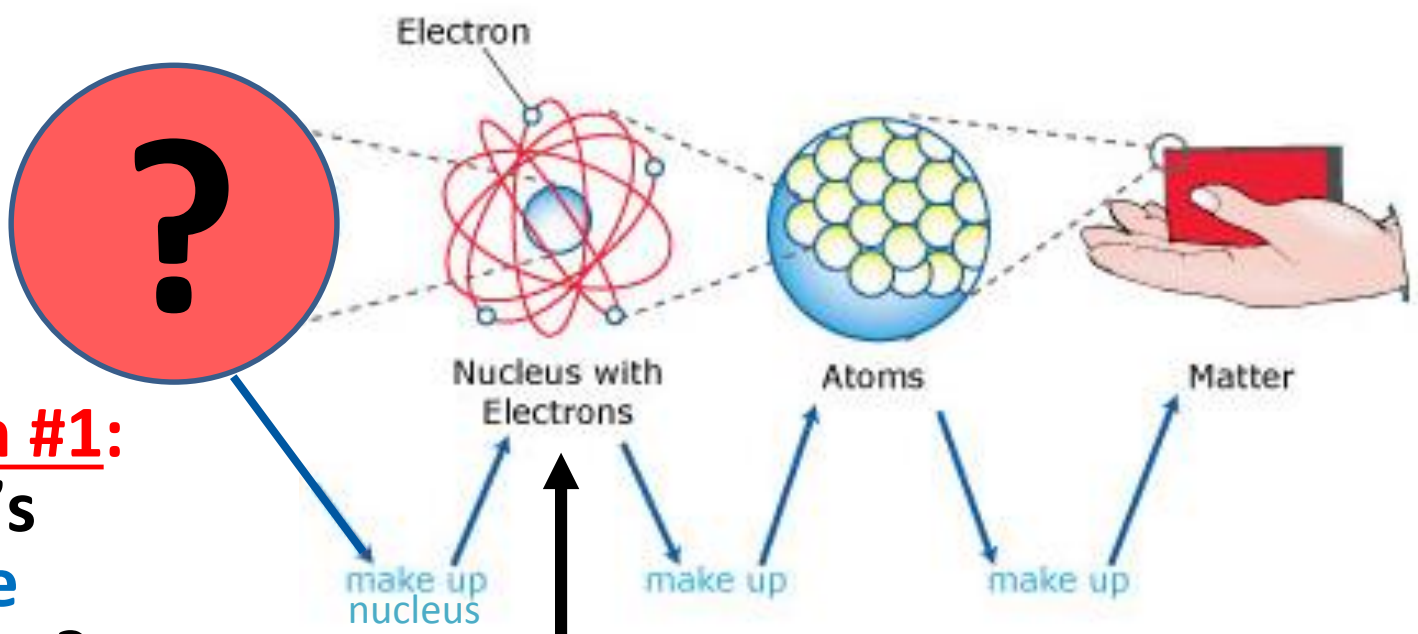
Water



Carbon dioxide

Although nominated 35 times (!), Lewis *never won* the Nobel Prize in Chemistry…

Summary: Structure of Matter

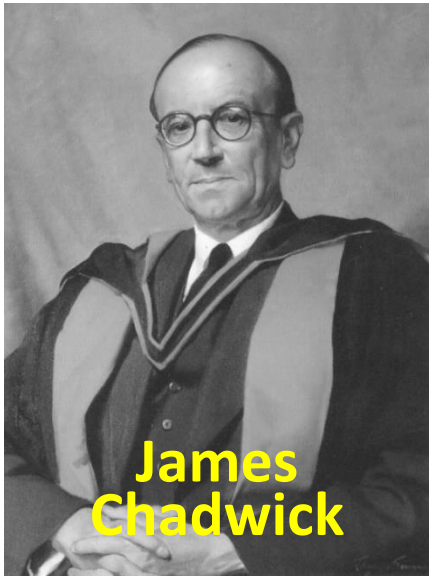


Question #1:
What's inside a nucleus?

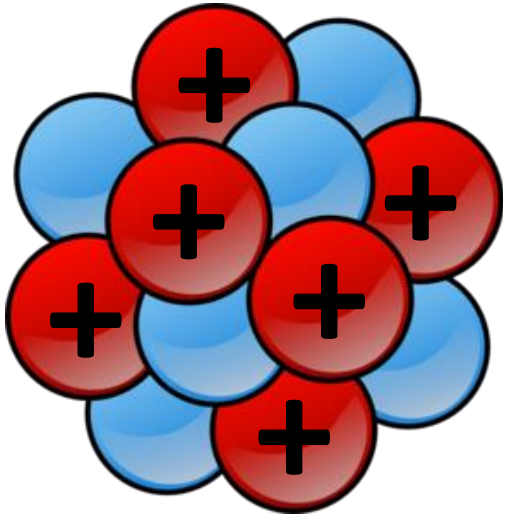
Question #2: Is planetary model of the atom *good enough* to explain all experimental observations?

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).**



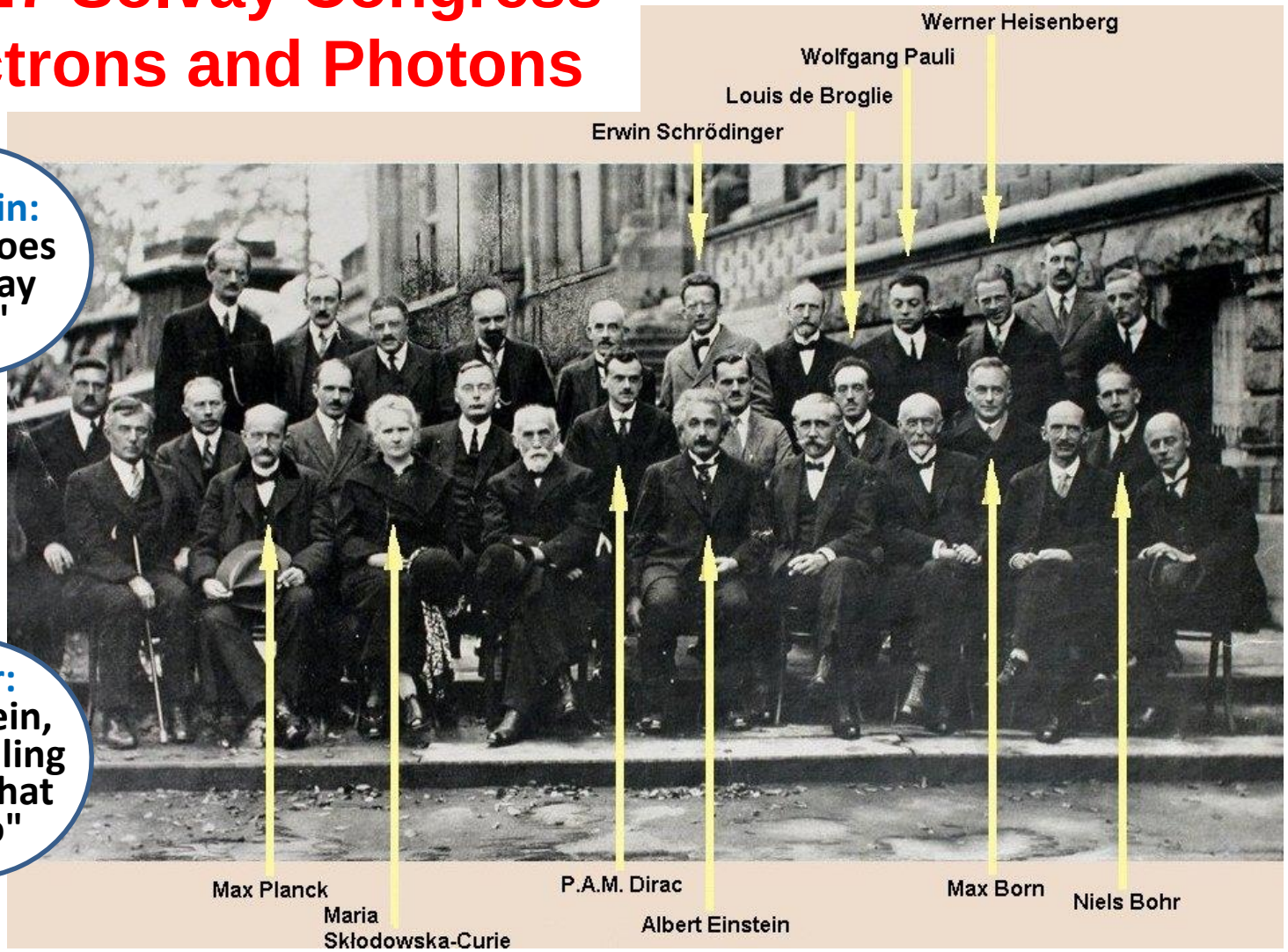
Atomic Nucleus Structure



Atom ~10^{-10}m

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

The 1927 Solvay Congress on Electrons and Photons

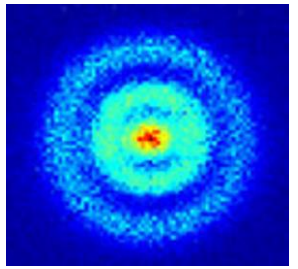


Einstein: "God does not play dice"

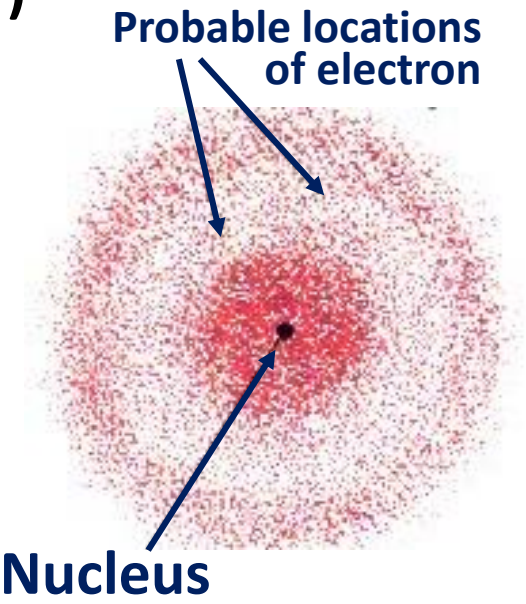
Bohr: "Einstein, stop telling God what to do"

In October 1927, the world's most notable physicists met to discuss the newly formulated quantum theory and subatomic makeup. 17 of the 29 attendees were or later became Nobel Prize winners.

Wave Model of the Atom (contemporary model)

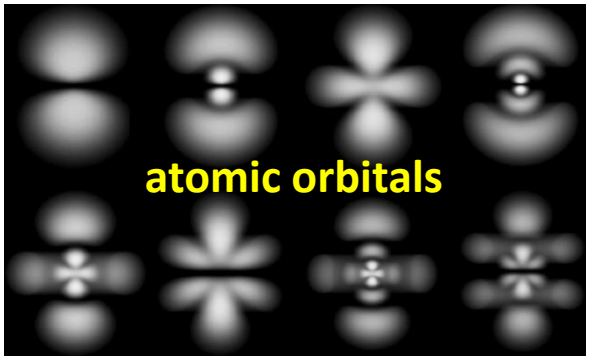


Atom has a small positively charged nucleus surrounded by a large region (*"electron cloud"*) in which there are enough electrons to make an atom neutral.



Quantum Theory states that the electrons inside an atom possess both particle- and wave-like properties:

- **There is always an integer number of electrons orbiting the nucleus.**
- **It is impossible to determine the exact location of an electron. Electrons do not have a definite path around the nucleus. The probable location of an electron is based on how much energy it has.**
- **The modern term "atomic orbital" refers to the physical region or space where the electron can be calculated to be present.**
- **Electrons whirl about the nucleus billions of times in one second and can jump between orbitals in a particle-like fashion, losing or gaining energy.**



Atomic Structure Summary

- **All atoms have:**
  - a positively charged nucleus
  - and negatively charged electrons around it

- **Atomic nucleus consists of:**
  - positively charged protons
  - and neutrons that have no electric charge