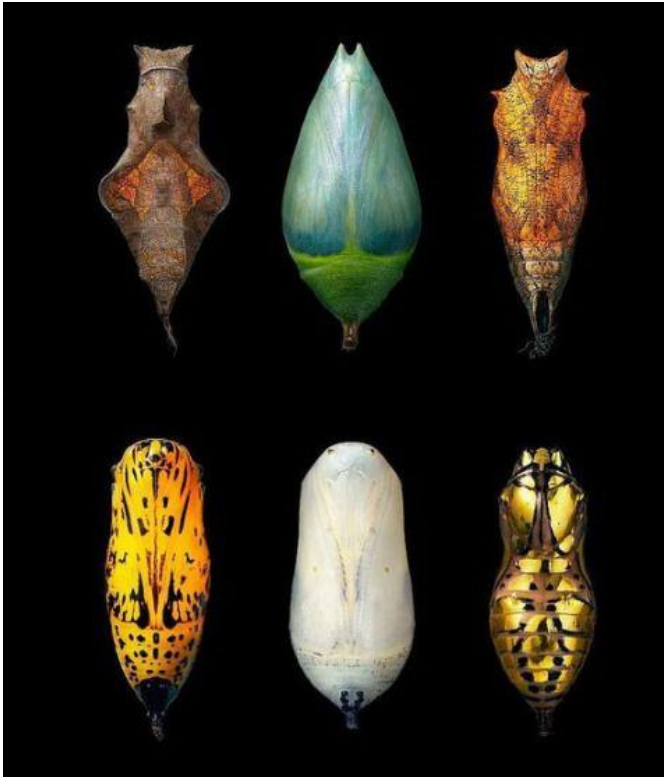


How do we  
learn *what*  
*is inside?*



See what “comes out”!

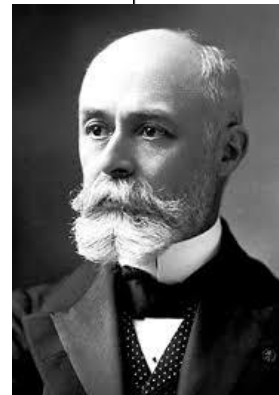
# How can we study *the inside* of atom?

## See what “comes out”!

- Electric current – originates within matter; can flow through matter but also...in **vacuum**!
  - Cathode rays, 1869: 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)
  - Henri Becquerel, 1896:
    - radioactivity was **first discovered** in uranium salts during his work on phosphorescence.
- Light (later!)



10 - 11 - 96. Sulfide Double Phosphor of the Phosphorescence  
Papier noir - Geig. & Carter's tubes -  
Exposé au soleil le 27. et a été placé dans le tube -  
Nicolson & Co. man.



# Discovery of Electron

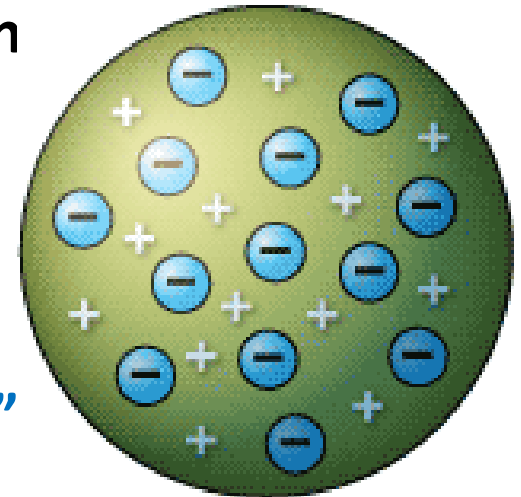


Joseph  
John  
Thomson



**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.

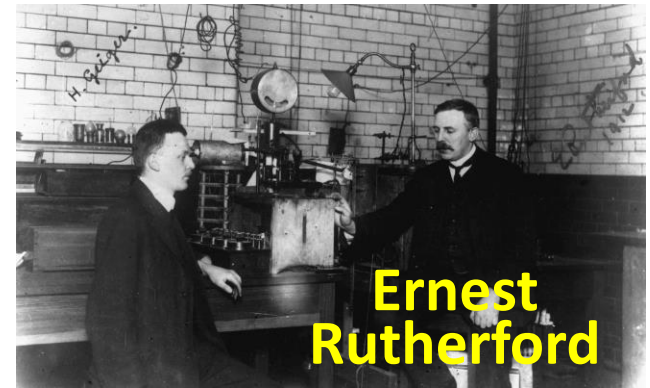


- Ernest Rutherford and Frederick Soddy, 1899-1903:

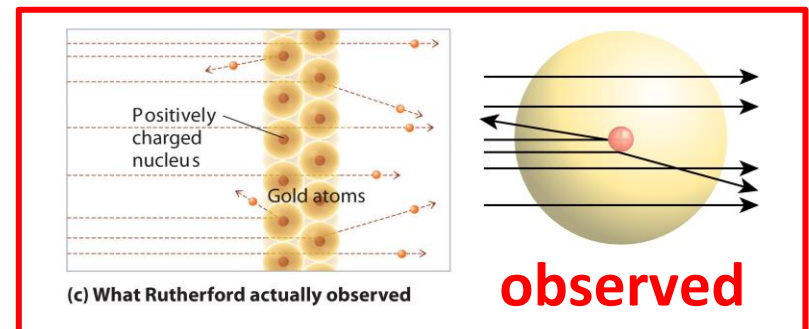
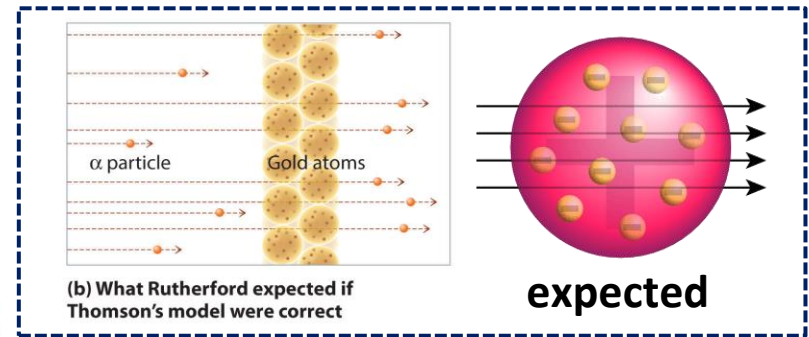
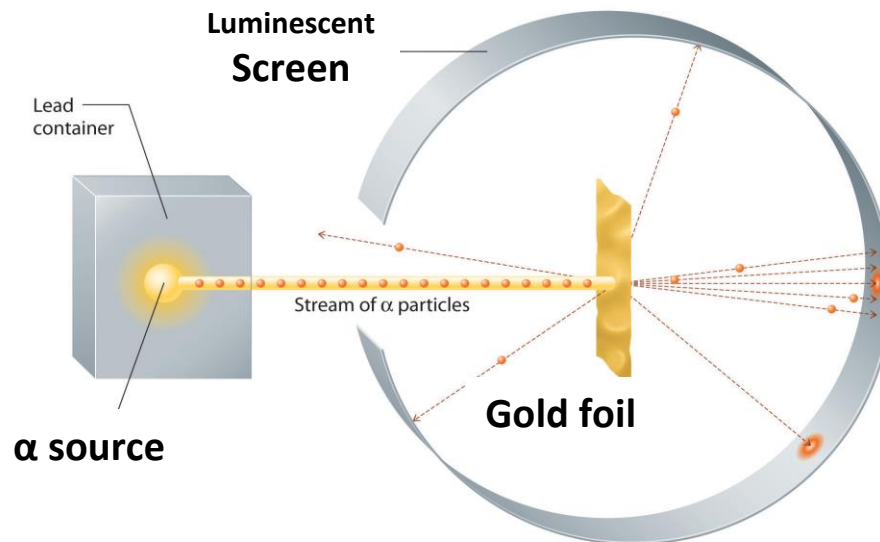
- discovered **three different types** (named  $\alpha$ ,  $\beta$ ,  $\gamma$ ) of radiation "rays" with very different properties and **proposed that atoms were not conserved in radioactive emissions.**

# 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**.



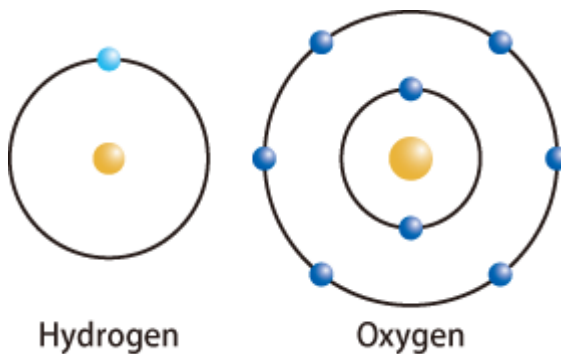
- Rutherford's conclusion: “the **greater part of the mass** of the atom was concentrated **in a minute nucleus**... carrying a charge”.

# Planetary Model

## Niels Bohr, 1913

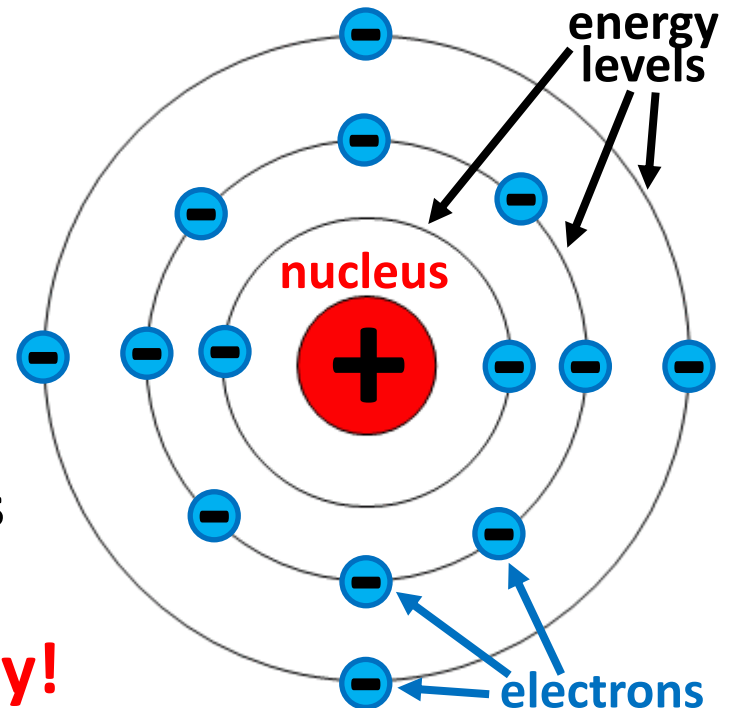
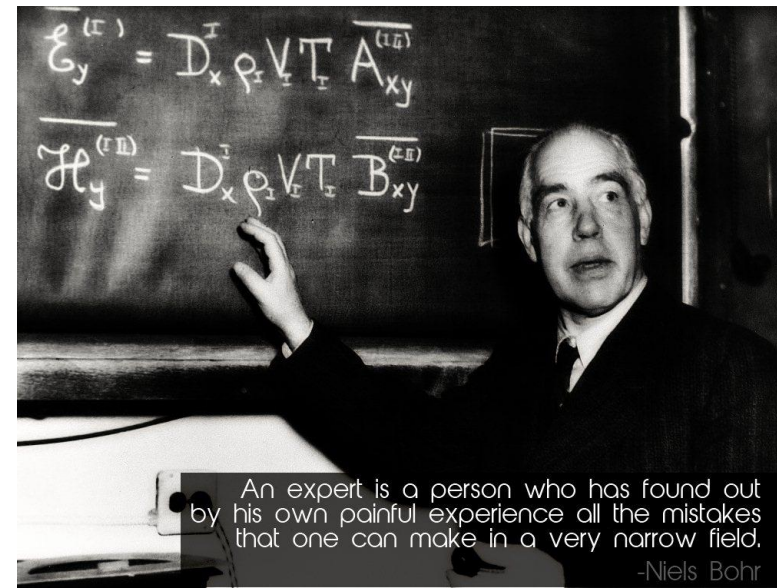
Electrons move in definite orbits around the nucleus, **much like planets circle the Sun.**

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



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

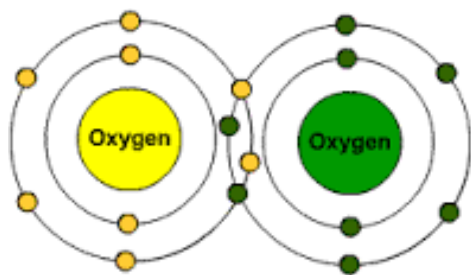
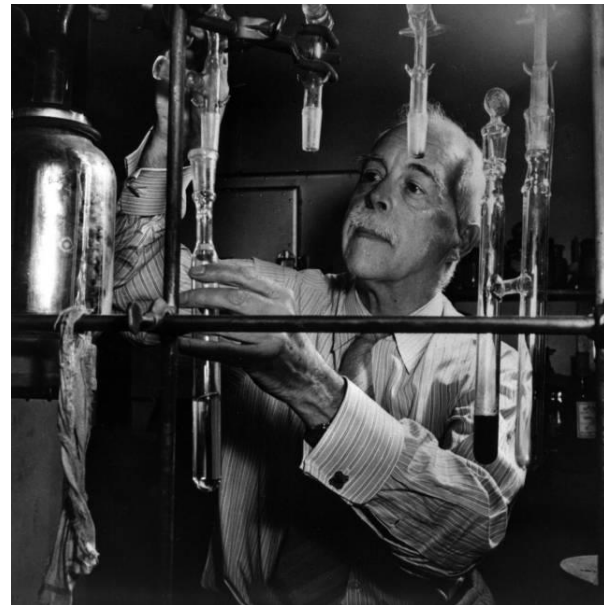
**...here comes Quantum Theory!**



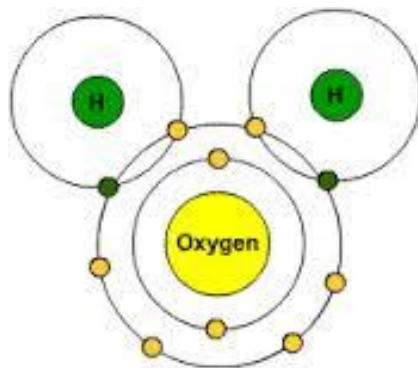
# Chemical Bond Explained

**Gilbert Newton Lewis, 1916:**

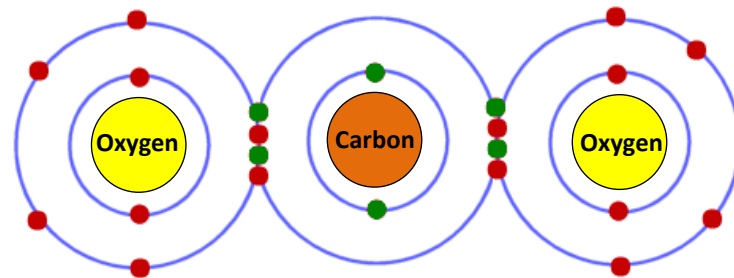
a **covalent bond** between two atoms is maintained by a **pair of electrons shared** between them.



**Oxygen molecule**



**Water**



**Carbon dioxide**

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