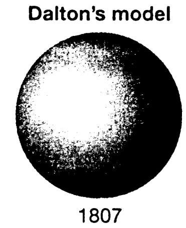
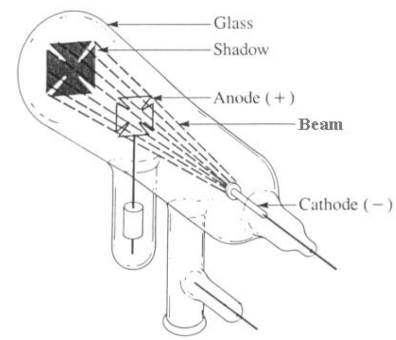
HISTORY OF THE ATOMIC MODEL



JOHN DALTON, British Schoolteacher (1807)

- developed the first atomic theory
- Dalton's Atomic Theory—the **Rubber Ball Model**
    1) An atom is an indivisible, uniformly dense, solid sphere (the smallest form of matter)
    2) All atoms of a given element have the same unique set of properties (e.g. size, shape, reactivity, mass, etc.)—they differ from the properties of all other elements.
    3) A chemical reaction merely consist of a reshuffling of atoms from one set of combinations to another. The individual atoms themselves, however, remain intact. (The Law of Conservation of Matter)
    4) Atoms of different elements always combine in fixed number ratios to produce specific compounds. (The Law of Definite Composition)

SIR WILLIAM CROOKES, British Scientist (1870's)

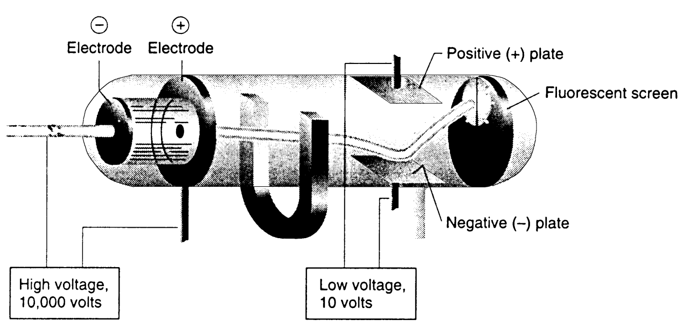


- Experimented with a cathode ray tube (CRT) filled with a gas of some sort.
- When an electric current passed through the CRT, a glowing greenish beam was produced. To figure out what the beam was made of, Crookes:
    1) held a magnet to it and deflected the beam
    2) noticed a shadow behind the anode

  Since the beam bent with the magnet, it couldn't be light. For the shadow to appear behind the anode (the positive electrode) the beam had to come from the cathode (the negative electrode)
- **CONCLUSION**: The beam was made up of negatively charged particles.

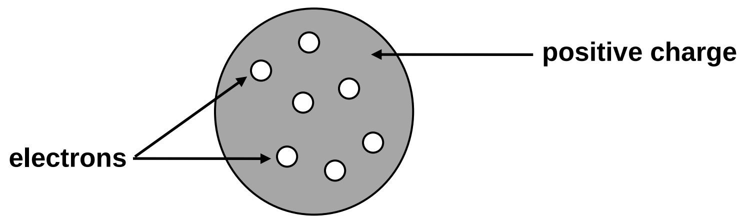
JJ THOMSON, British Scientist (1897)

- Thomson modified Crookes' CRT experiments by having a disk with a small hole in it for the anode along with a fluorescent screen at the end of the CRT behind the anode.



- Thomson used a magnet and electric plates (one positive and one negative plate) to deflect the beam and measured the amount of deflection. The beam bent towards the positive electric plate proving the beam consisted of negatively charged particles.
- The amount of deflection depends upon:
    1) the mass of the particle—the heavier the particle the less it can be bent
    2) the velocity of the particle—the faster the particle the less it can be bent
    3) the electric charge of the particle—the higher the charge the more it can be bent
    4) the strength of the magnet—the stronger the magnet the more the beam can be bent
    5) the amount of charge in the plates—the stronger the charge the more the beam can be bent plus the beam will move in the direction of the oppositely charged plate
- Thomson determined the charge to mass ratio (e/m) of the particles from the data and found the ratio to be the same high number regardless of the type of gas in the tube and the metal used for electrodes.
- **CONCLUSION**: Atoms have a negatively charged particle in them called **electrons.**

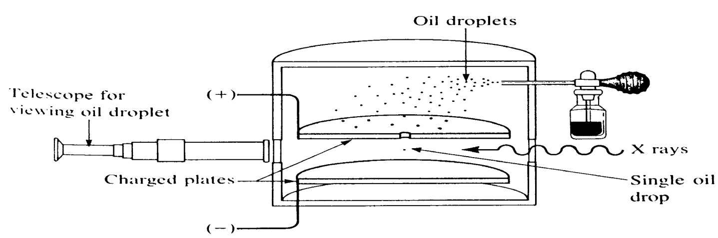
- Thomson did further studies in which he found beams of positive particles also formed in the CRT. When using H_2 gas at a very low pressure a beam was found moving in the opposite direction of the electron beam. Therefore this beam had to be positively charged. He reasoned that when the high voltage was applied to the gas, the H_2 broke down into two oppositely charged particles—the electrons and positively charged hydrogen ions. Since H_2 is electrically neutral, Thomson concluded the H^+ ion must be equal to, but opposite that of the electron.
- Thomson found that, unlike electrons, this positive beam varied in the amount of deflection depending upon the gas used in the CRT. Since the H^+ ion had the most deflection, it had to have the smallest of these positive ions.
- **CONCLUSION**: The positive ion formed from H_2 was a single particle with a charge equal to but opposite the electron. William Thomson (also known as Lord Kelvin) revised Dalton's model of the atom with the **Plum Pudding Model**.



This positive particle was identified and called a **proton** by the 1920's.

ROBERT MILLIKAN, American Scientist (1909)

- Millikan did his famous "Oil Drop Experiment" in which he determined the size of the electric charge of an electron, the mass of the electron and the proton.
- The experiment consisted of suspending a charged oil drop between two electric plates. By knowing the charge of the plates, Millikan was able to determine the charge of the electron (1.602×10^{-19} coulombs—the SI base unit for electric charge). From the e/m ratio of the electron as determined by Thomson, Millikan was able to determine the mass of the electron (9.11×10^{-28} g)
- Millikan also determined the e/m ratio for the proton by using positively charged oil drops. Since the charge of the proton is the same as the electron (but opposite), he than determined the mass of the proton to be 1.67×10^{-24} g (1836 times heavier than the electron).



- Millikan received a Nobel Prize for his work on these particles.

HENRI BECQUEREL, French Scientist (1896)

- Becquerel accidentally discovered radiation when doing experiments with uranium. When his experiment was delayed, he placed a photographic plate in a drawer with some uranium. Later when he developed the plate, he found images on the plate that could only be caused by particles emitted by the uranium.

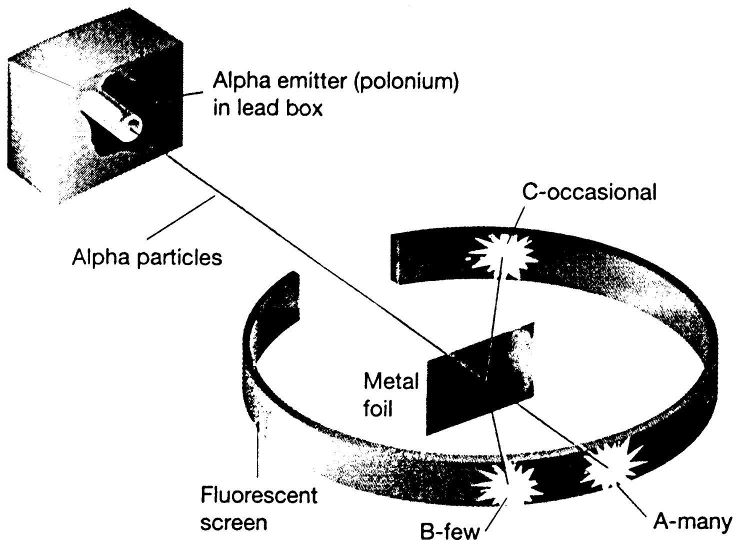
MARIE and PIERRE CURIE, French Scientist (late 1800's - early 1900's)

- This married couple discovered other radioactive elements—radium and polonium. Because of their work, along with others, 3 different types of radiation were discovered.

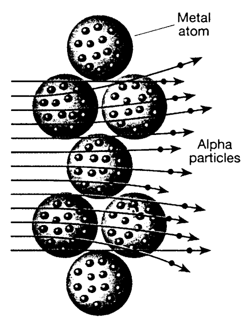
1) alpha radiation (α)—fast moving (1/10 the speed of light) positively charged He ions with no electrons, ${}^4_2He^{2+}$; has the least penetrating power (can be stopped by a sheet of paper)
2) beta radiation (β)—fast moving electrons (almost the speed of light)
3) gamma radiation (γ)—a form of electromagnetic radiation with no mass nor charge and moves at the speed of light; has the strongest penetrating power (it takes several cm of lead or even thicker concrete to stop it)

ERNEST RUTHERFORD, New Zealand Scientist (1909)

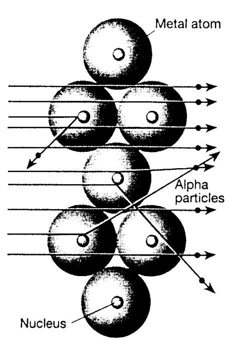
- Rutherford did his famous "Gold Foil Experiment" in which he used α radiation to probe the atom.



- Rutherford shot α particles at a sheet of gold foil in which he expected the α particles to pass more or less straight through.

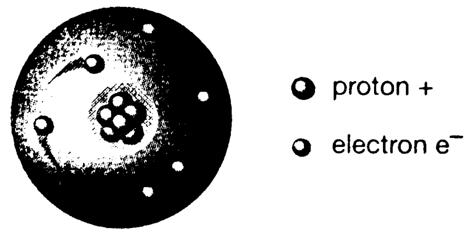


As shown in the diagram above, (A) shows many of the α particles did pass straight through and some (B) were deflected a little as expected. However, there were cases where the α particles bounced backwards (C)—this was not expected. In Rutherford's words this "was like firing a 15 inch shell at toilet paper and it came back at you".



- **CONCLUSION**: There exist in the center of the atom a very small and extremely dense region called the **nucleus**. Rutherford revised the atomic model to show that the nucleus also contained the protons and the electrons traveled around the nucleus. Furthermore, most of the mass of the atom was in the nucleus.

Rutherford's model



1911

IRENE and FREDERIC JOLIOT-CURIE, French Scientists (1932)

- When bombarding Be with α particles, they found that a neutral radiation was emitted. This radiation then was able to knock off protons from H atoms. They incorrectly assumed this radiation was gamma radiation.

JAMES CHADWICK, British Scientist (1932)

- Continuing on with Joliot-Curie's experiment, Chadwick determined the neutral radiation they found had a mass. Therefore, it couldn't be gamma radiation.
- **CONCLUSION**: The neutral radiation was formed by a neutral particle called a **neutron**. The neutron has about the same mass as a proton and is also located in the nucleus.

1930'S MODEL OF THE ATOM