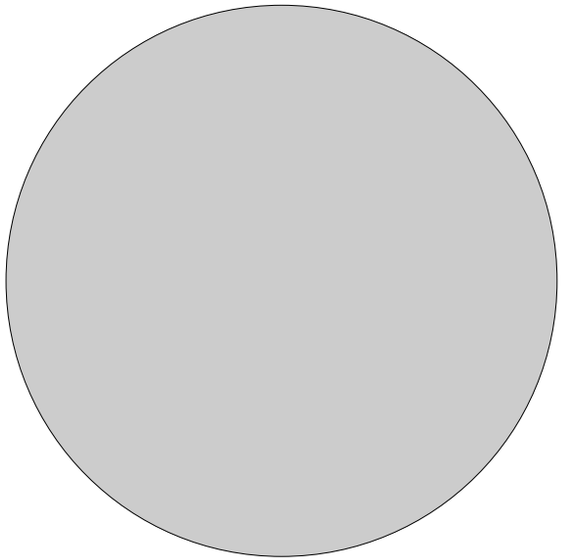
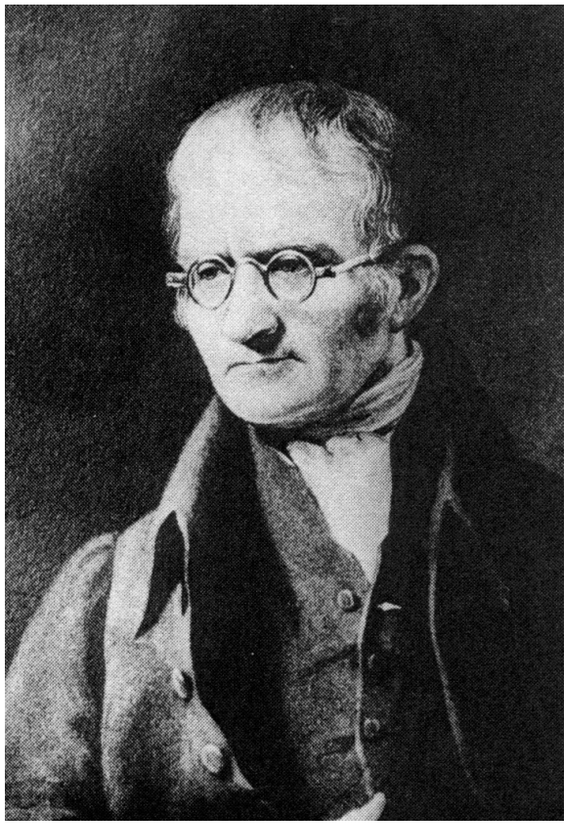
Dalton's Atom (1808)

- Atoms are indivisible spheres.

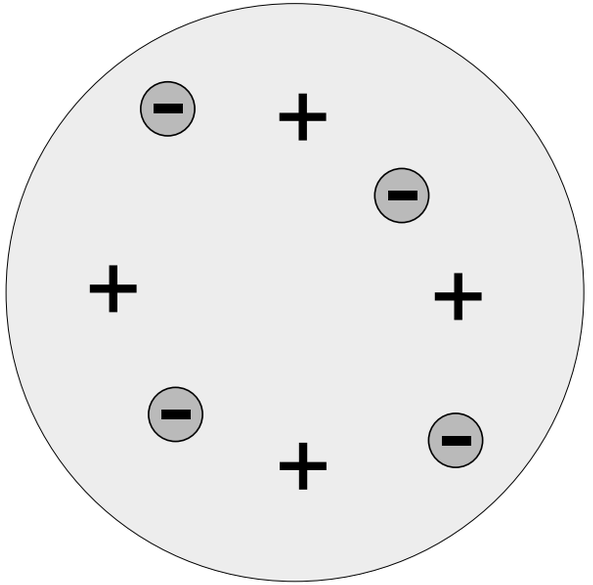


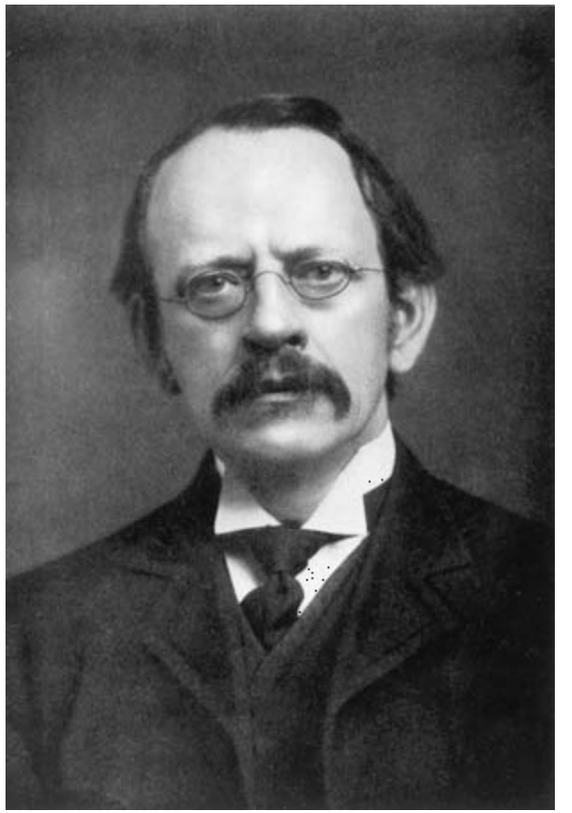


John Dalton
(1766-1844)

Thomson's Plum Pudding Model (1904)

- Based on his discovery of the electron in 1897.
- The atom is mostly a sphere of positive charge.
- Tiny, negatively charged "electrons" circulate in this sphere.
- The positive and negative charges balance – atom is neutral.

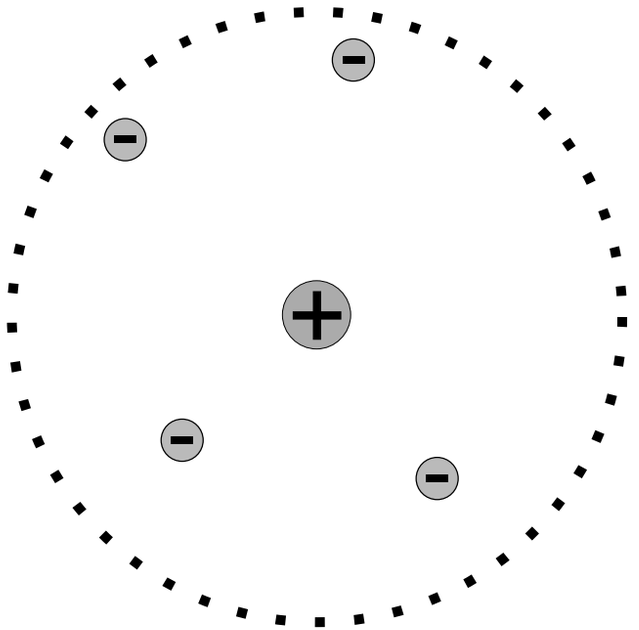




J. J. Thomson
(1856-1940)

Rutherford's Nuclear Model (1911)

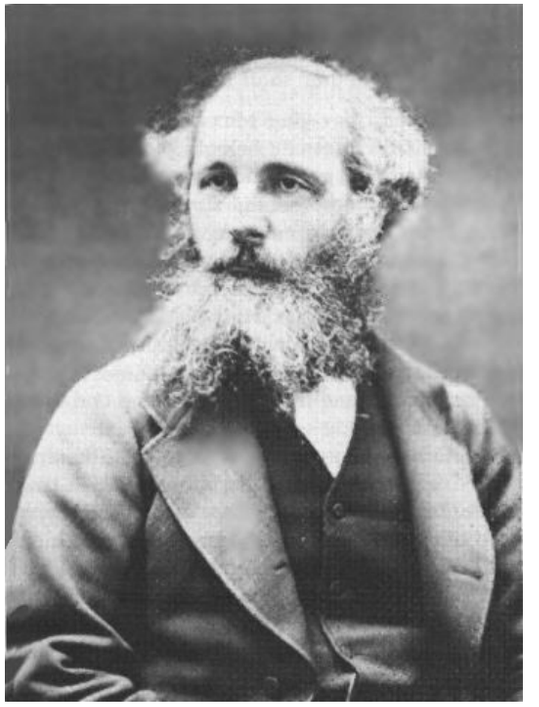
- Based on the results of the gold-foil experiment.
- Most of the atom is empty space.
- Atom's mass is concentrated in a tiny positive nucleus.
- Electrons are located in the space surrounding the nucleus.



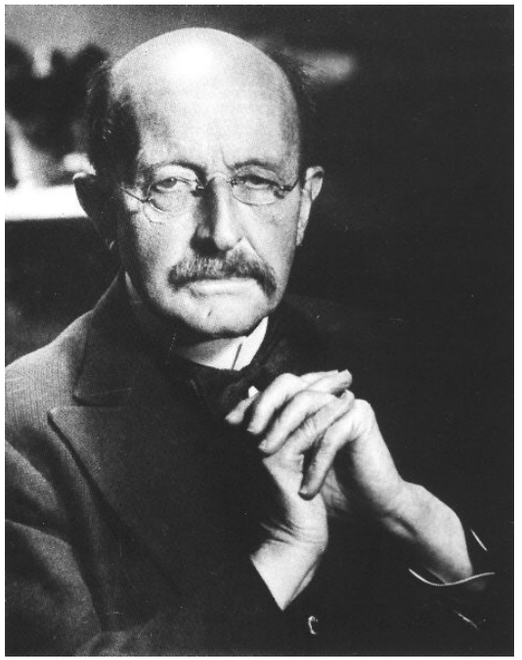
Ernest Rutherford
(1871-1937)

Thomas Young
(1773-1829)

- Light shows wave interference.
- Light behaves like a wave.
- Light is an electromagnetic wave.



James Maxwell
(1831-1879)



Max Planck
(1858-1947)

- Light from hot objects is emitted as discrete packets of energy (quanta).
- The energy of a quantum depends on the frequency of the light.

$$E = hf$$

- Light is absorbed as quanta (explains the photoelectric effect).
- The energy of a quantum depends on the frequency of the light.

$$E = hf$$

PHOTONS

Albert Einstein
(1879-1955)

Bohr's Quantum Atomic Model (1913)

- Electrons orbit the nucleus only at specific allowable energy levels (stationary states).
- While in an stationary state, electrons do not emit energy.
  - electrons cannot spiral into the nucleus
- An electron can change to a higher energy level by absorbing a photon with energy exactly equal to the difference between the energy levels.
  - explains the absorption spectra (dark-line spectra) of elements
- An electron can change to a lower energy level by emitting a photon with energy exactly equal to the difference between the energy levels.
  - explains the emission spectra (bright-line spectra) of elements

Niels Bohr
(1885-1962)

De Broglie's Matter Waves (1924)

- Hypothesizes that all particles (including electrons) have wave properties.
- Later supported by observed wave interference patterns produced by electrons.

Louis de Broglie
(1892-1987)

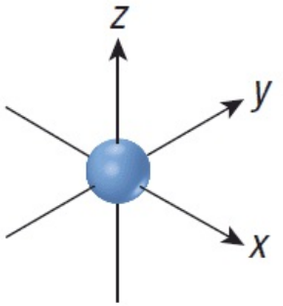
Schrödinger's Wave Mechanics (1927)

- Applies wave equations to the electrons in an atom.
- Solutions describe probability distributions for the electrons called orbitals.
- An orbital is a three-dimensional region in which an electron is most likely found.
- The orbital does not give the exact position of the electron or the motion of the electron.

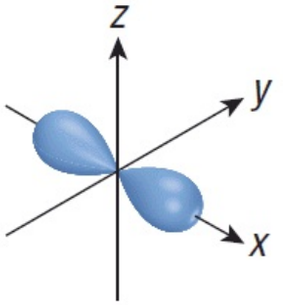
Erwin Schrödinger
(1887-1961)

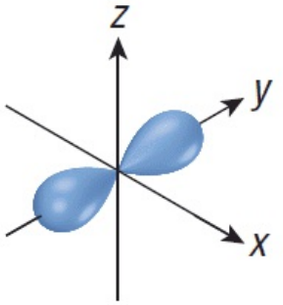
Orbitals

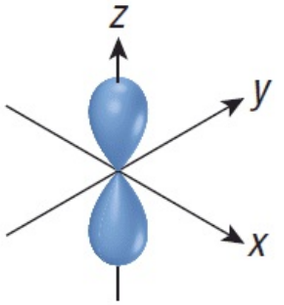
s orbitals



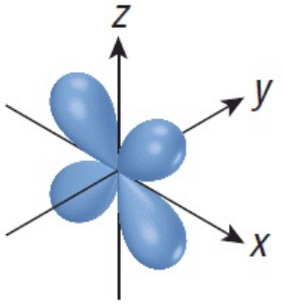
p orbitals

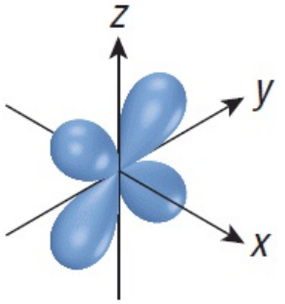


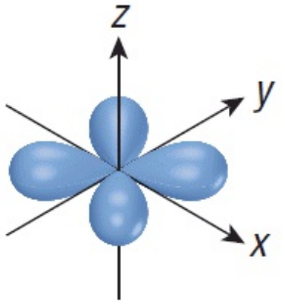


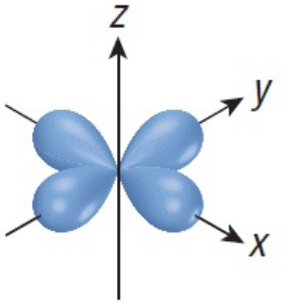


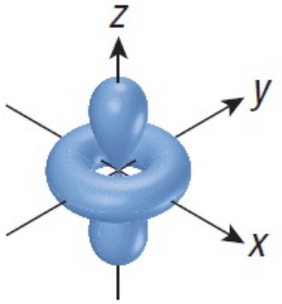
d orbitals











Heisenberg's Uncertainty Principle (1927)

- The exact position and motion of an electron (or any particle) cannot be known.

Werner Heisenberg
(1901-1976)

Electron-Energy-Level Diagram