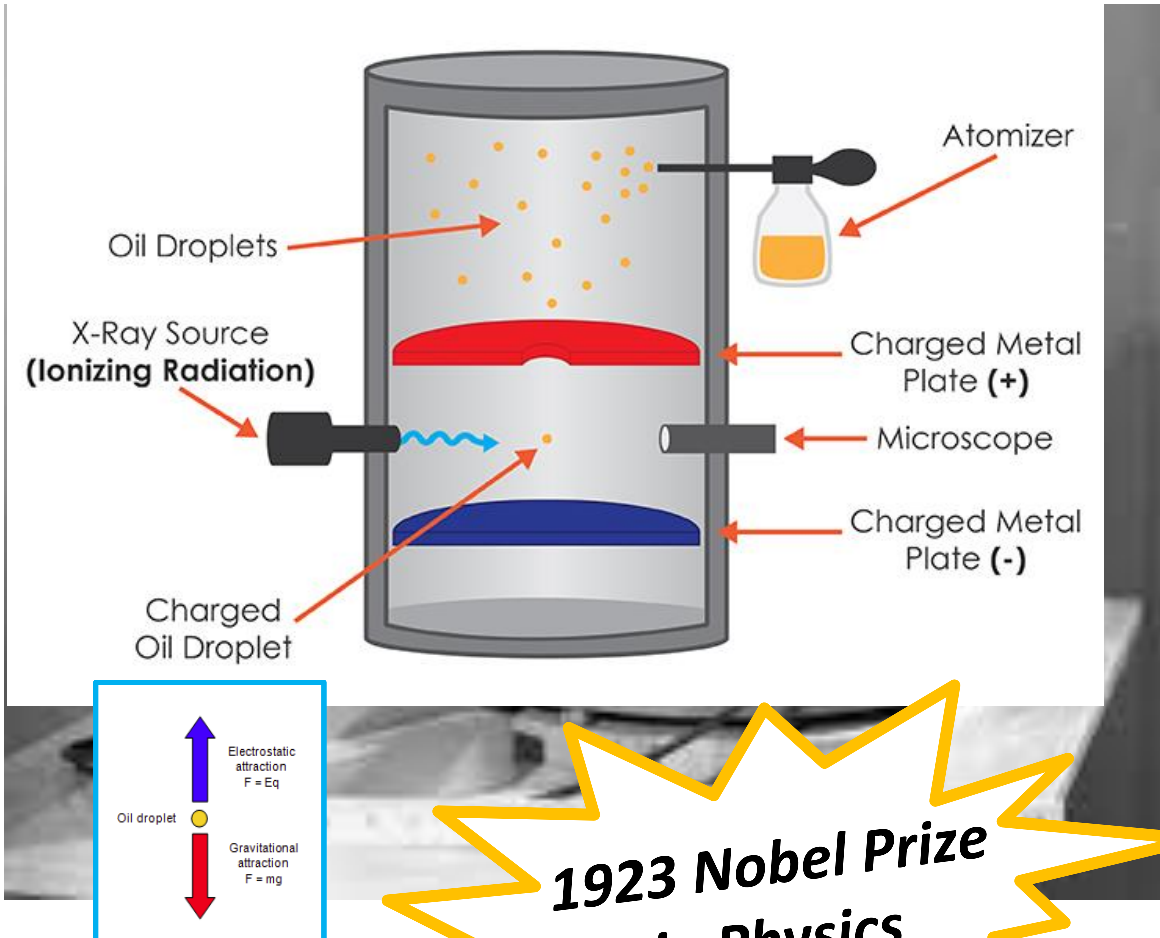
Oil-drop experiment

Robert Millikan, 1909

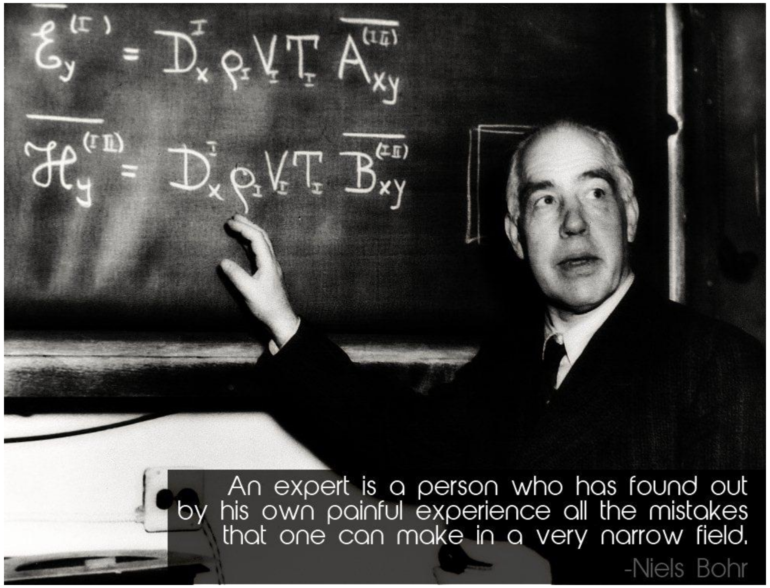


1923 Nobel Prize in Physics

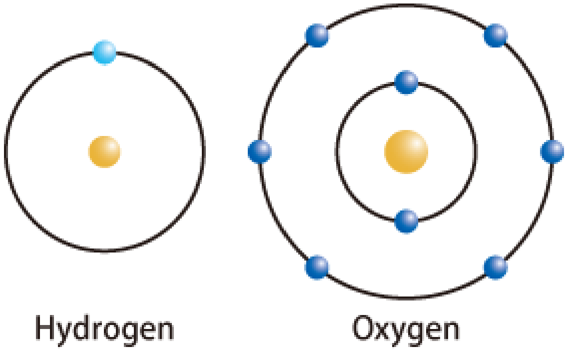
Measured the force on tiny charged droplets of oil between two metal electrodes and showed that the **total charge on the droplet** could be described as **integer multiples of a common value** - the **charge of a single electron**.

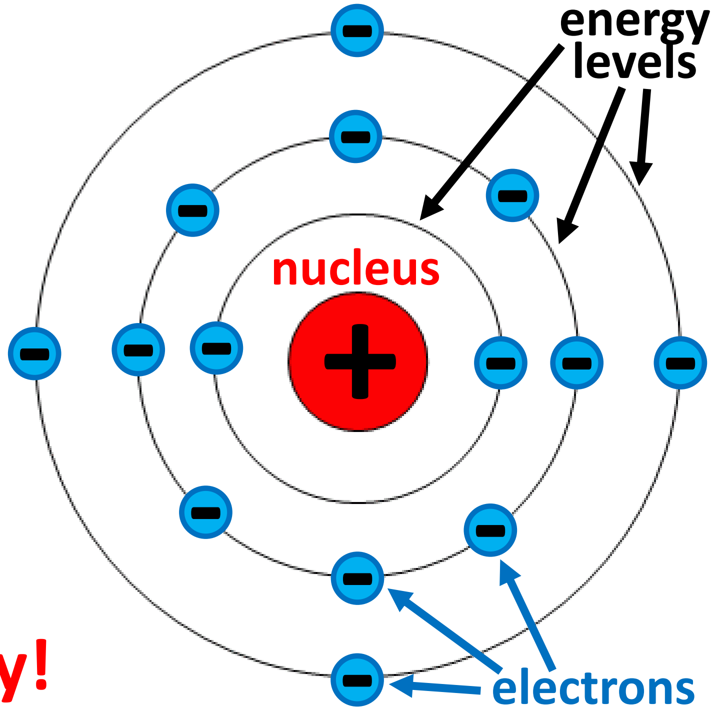
Planetary Model
Niels Bohr, 1913

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.





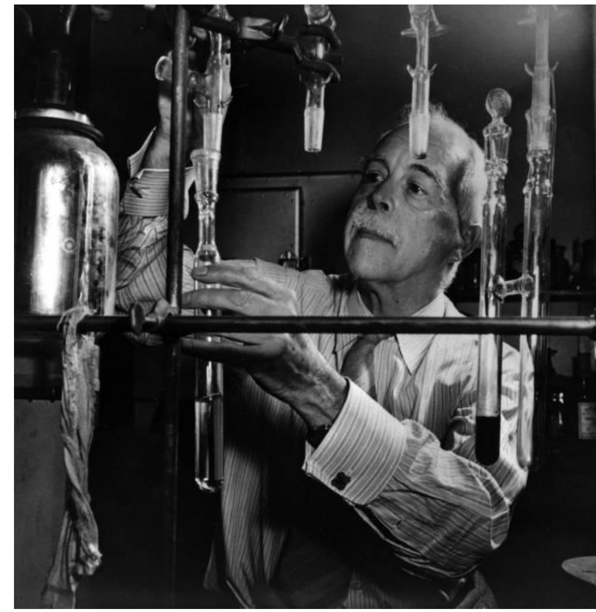
- Electrons can jump between levels emitting (or absorbing) energy…

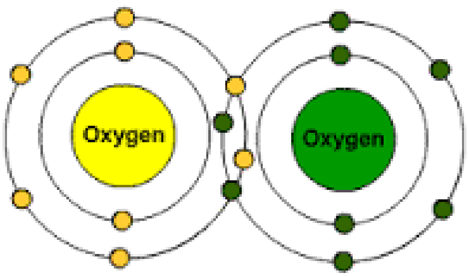
…here comes Quantum Theory!

Chemical Bond Explained

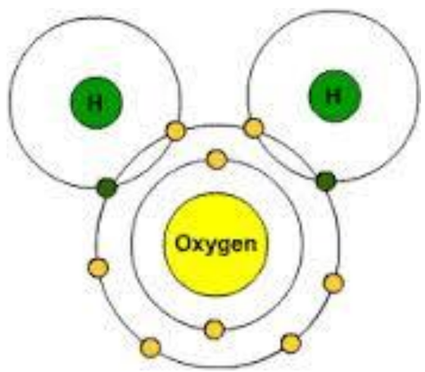
Gilbert Newton Lewis, 1916:

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

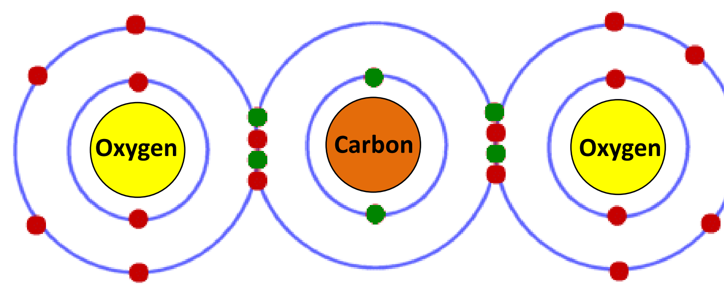




Oxygen molecule



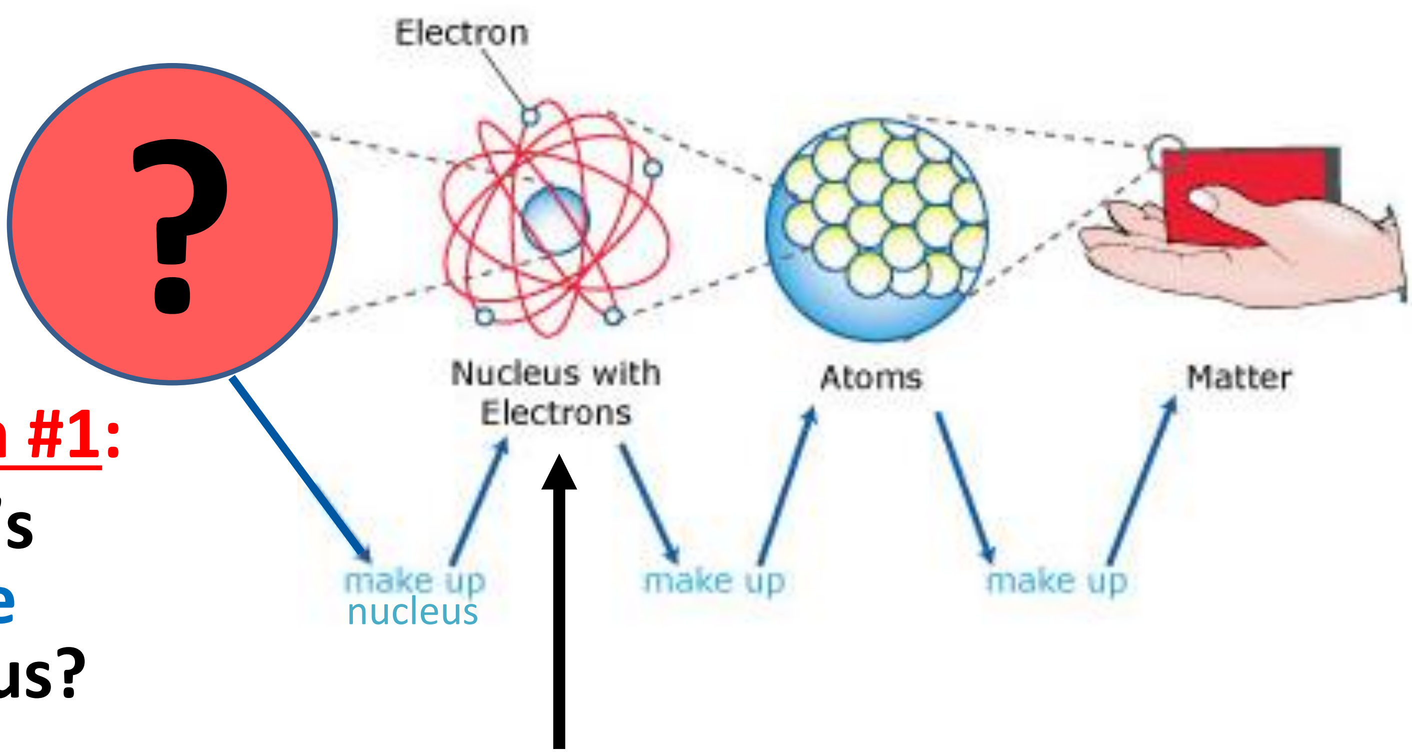
Water



Carbon dioxide

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

Summary: Structure of Matter



<u>Question #1</u>:

What's inside a nucleus?

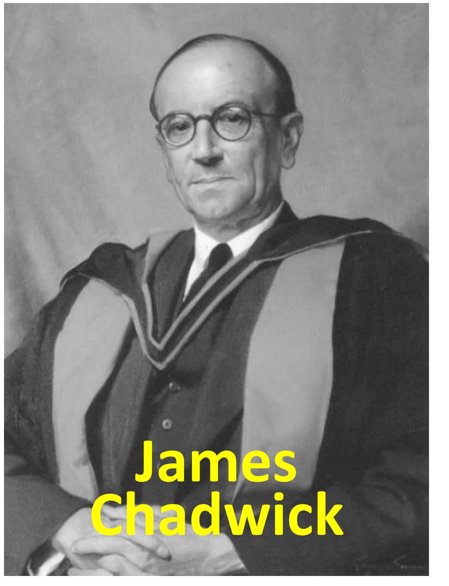
<u>Question #2</u>: Is planetary model of the atom *good enough* to explain all experimental observations?

Rutherford Transmutation Experiments

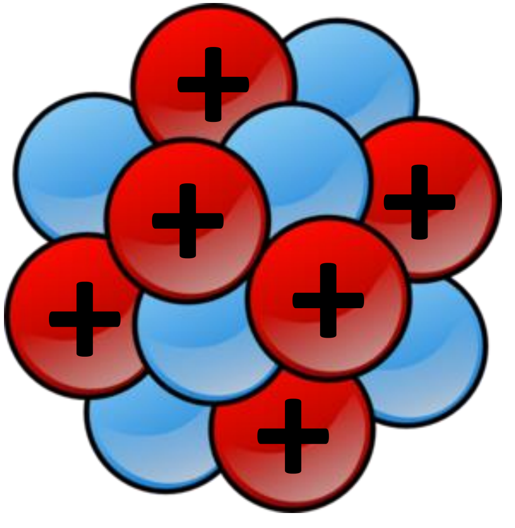
- **1919**: "splitting the atom" - it is possible to change one element into another by striking it with energetic alpha particles.
- **Early 1920's**: a number of experiments, *transmuting* one atom into another (examples -)
  - Observation #1: in every case, hydrogen nuclei were emitted in the process.
  - Therefore hydrogen nucleus must play a fundamental role in atomic structure.
  - Observation #2: the positive charge of any nucleus could be accounted for by an integer number of hydrogen nuclei.
  - Observation #3: the total mass of any given atomic nucleus IS LARGER than the total mass of the number of hydrogen nuclei corresponding to its charge.
  - Therefore the nucleus must also contain a neutral particle.

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).



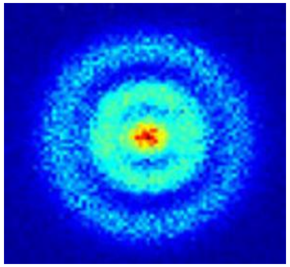
Atomic Nucleus Structure



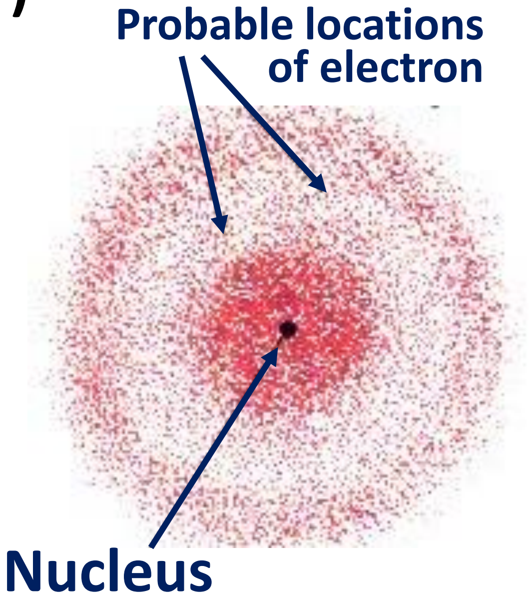
Atom ~10^{-10}m

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

Wave Model of the Atom
(contemporary model)

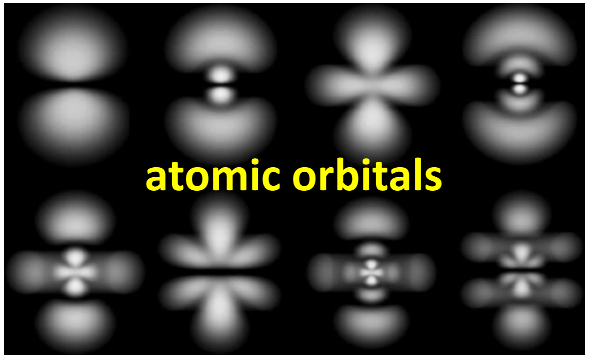


Atom has a small positively charged nucleus surrounded by a large region (*"electron cloud"*) in which there are enough electrons to make an atom neutral.



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

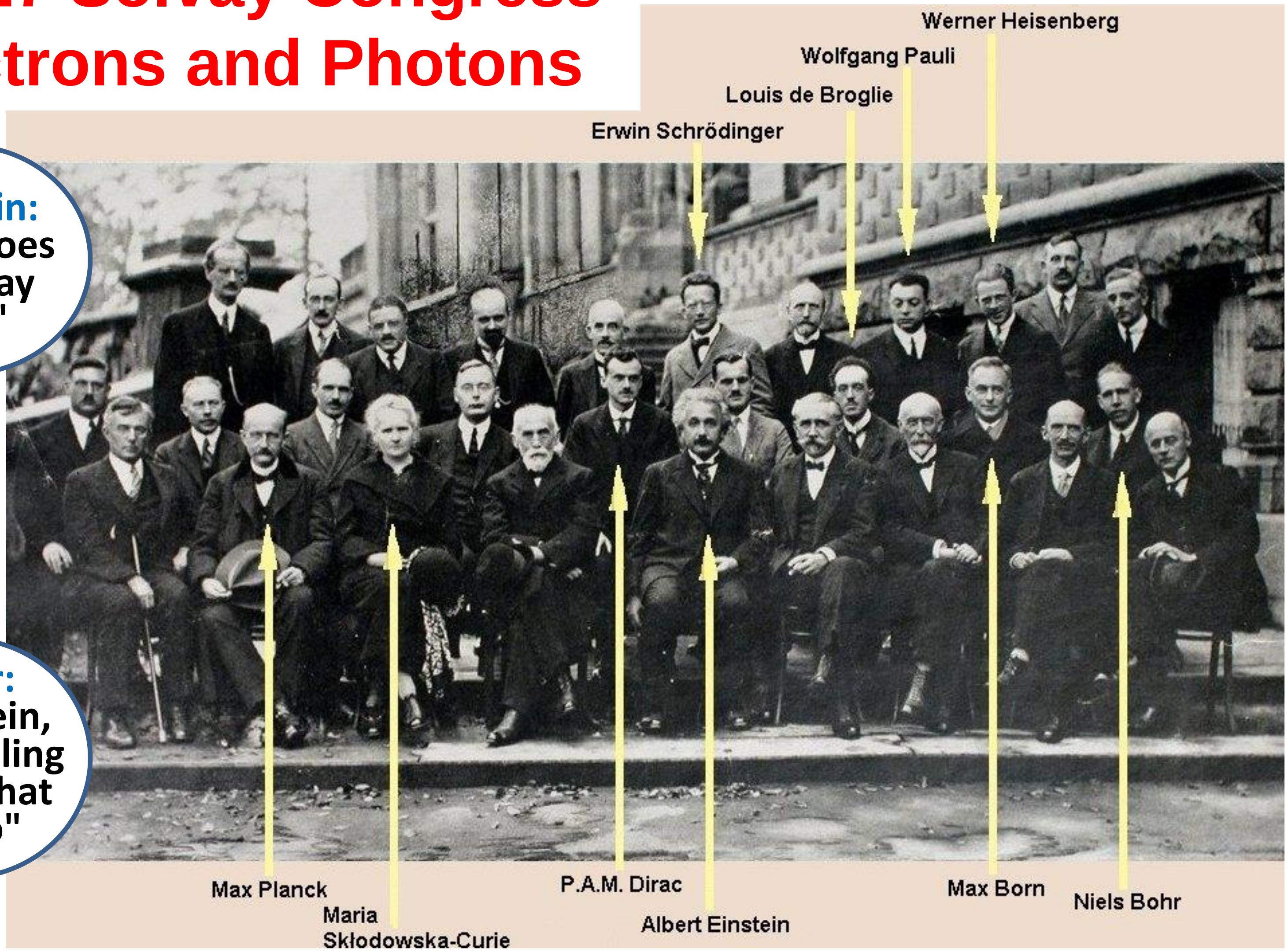
- **There is always an integer number of electrons orbiting the nucleus.**
- **It is impossible to determine the exact location of an electron. Electrons do not have a definite path around the nucleus. The probable location of an electron is based on how much energy it has.**
- **The modern term "atomic 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.**



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.