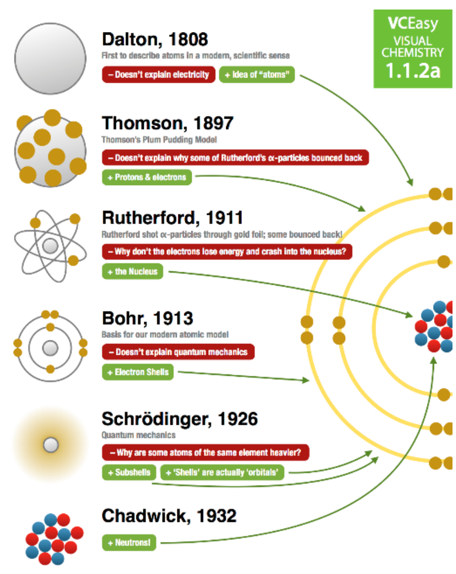
History of Atomic Theory

“Never trust an atom, they make-up everything”

The atomic theory is a model developed to explain the properties and behaviors of atoms. As with any scientific theory, the atomic theory is grounded on scientific evidence available at any given time. This means it has changed a great deal as we have learned more about the humble atom. It has changed remarkably in the most recent 100 years.



atomic theory - historical development of the model of atomic theory with contributions from Dalton to Chadwick

The origin story of the atom, and no I am not talking about the popular DC comic book hero, can be traced back to the Greekphilosopher, Democritus. (c. 470-380B.C.)

Democritus came up with the atom, or atomos, by pondering what made up the world, or matter. Atomos is a Greek word meaning “uncuttable” essentially meaning the smallest particle in existence.

Dalton’s (marble) Theory: You may think that Democritus got the ball rolling so we have been learning all about atoms ever since he named them. However, this is not true. It was not until the early 1800’s that the world started learning more about the atom. John Dalton was a chemist who revitalized the atomic movement. He was the first to propose the modern atomic theory. It is called modern as it contained ideas and statements that could be scientifically tested. His theory had 5 main components: 1) All matter is composed of very small particles called atoms. 2) All atoms of a given element are identical. 3) Atoms cannot be created, destroyed, or subdivided. 4) In chemical reactions, atoms combine with or separate from other atoms. 5) In chemical reactions, atoms combine with earth other in simple, whole-number ratios to form combined atoms (molecules).

What made Dalton’s theory so important was that every statement he made ended up being *correct*. In addition, every statement he made could be quantified and tested. This opened the door to other scientists to test.his ideas.

Plum-Pudding Theory: One such scientist was the physicist J. J. Thompson. In 1897 he discovered that atoms are not inseparable, meaning they can in fact be broken into smaller portions. He did this by exciting atoms using an electrical current. This caused the atoms to break down into parts. The most notable of these parts has a negative charge and was named an electron.

Once Thomson made his discovery he needed to devise a way to explain it. Thomson proposed a new model of the atom. It is commonly known as the plum-pudding model. The name originates from the traditional English pudding. Plums are embedded in the pudding (see image last page) and represent electrons. Whereas the "pudding" portion represents the positive areas of the atom.

The Nuclear Atom: Thomson's plum-pudding model did not survive long however, as it was soon put to the test by the English chemist and physicist, Ernest Rutherford in 1906.

Rutherford studied the effect of bombarding this gold foil with alpha particles. Alpha particle are helium atoms that have lost their electrons. Because they have lost their electrons this makes them positively charged. Rutherford's logic was that the way these particles interacted with the gold foil would allow him to inquire about the actual structure of the atoms in the gold foil. Simply speaking, the alpha particles would trace out the structure if the atoms.

Rutherford discovered two important things with his experiment. 1) Most of the particles traveled straight through the gold foil without any deflection. This told Rutherford that most of the space in gold atoms was empty. 2) A small amount of the alpha particles deflected sharply. This told Rutherford that there must be a dense, isolated area in the atom that contained positive charges. He named this the nucleus.

The Planetary Atom: One part of Rutherford's model proved to be correct, the nucleus. The main issue with his model was his placement of the electrons. This was something that even Rutherford acknowledge. The problem was that electrons cannot remain stationary in an atom; as the plum-pudding model suggests. If they were stationary they would be attracted to the nucleus and become a part of it (recall that positive and negatives attract).

In contrast, the electrons could not be spinning around the nucleus either. According to a well-established law of physics, any charged particles that travel through space give off energy. Moving electrons would eventually lose energy, speed, and ultimately fall into the nucleus. In Rutherford's model electrons, could neither be at rest or in motion (confusing I know).

This rather complicated problem was eventually solved by a truly brilliant Danish physicist, Niels Bohr. His new theory (The Planetary Atom) suggested that places exist in the atom where electrons can travel without losing energy. These are similar to the rotation of planets, and are what give this theory it name.

Bohr's Planetary Atom was flabbergasting to most physicists. Bohr was implying that atoms ignored accepted principles of physics. It came across as if Bohr was making up rules as he went. Simply put, people thought he was cheating.

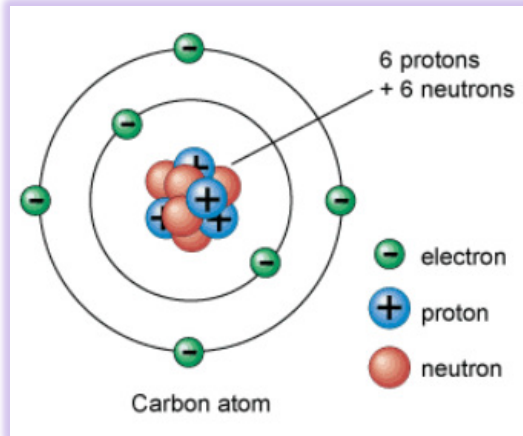
Of course, with a theory as dramatic as this is was promptly put to the test. To many people's surprise, it held up under the scrutiny of tests it was subjected too. By 1930 Bohr's model was the accepted model of an atom. It contained two parts: a nucleus whose positive charge was known to be caused by particles known as protons, and one or more electrons arranged in distinct orbits around the nucleus.

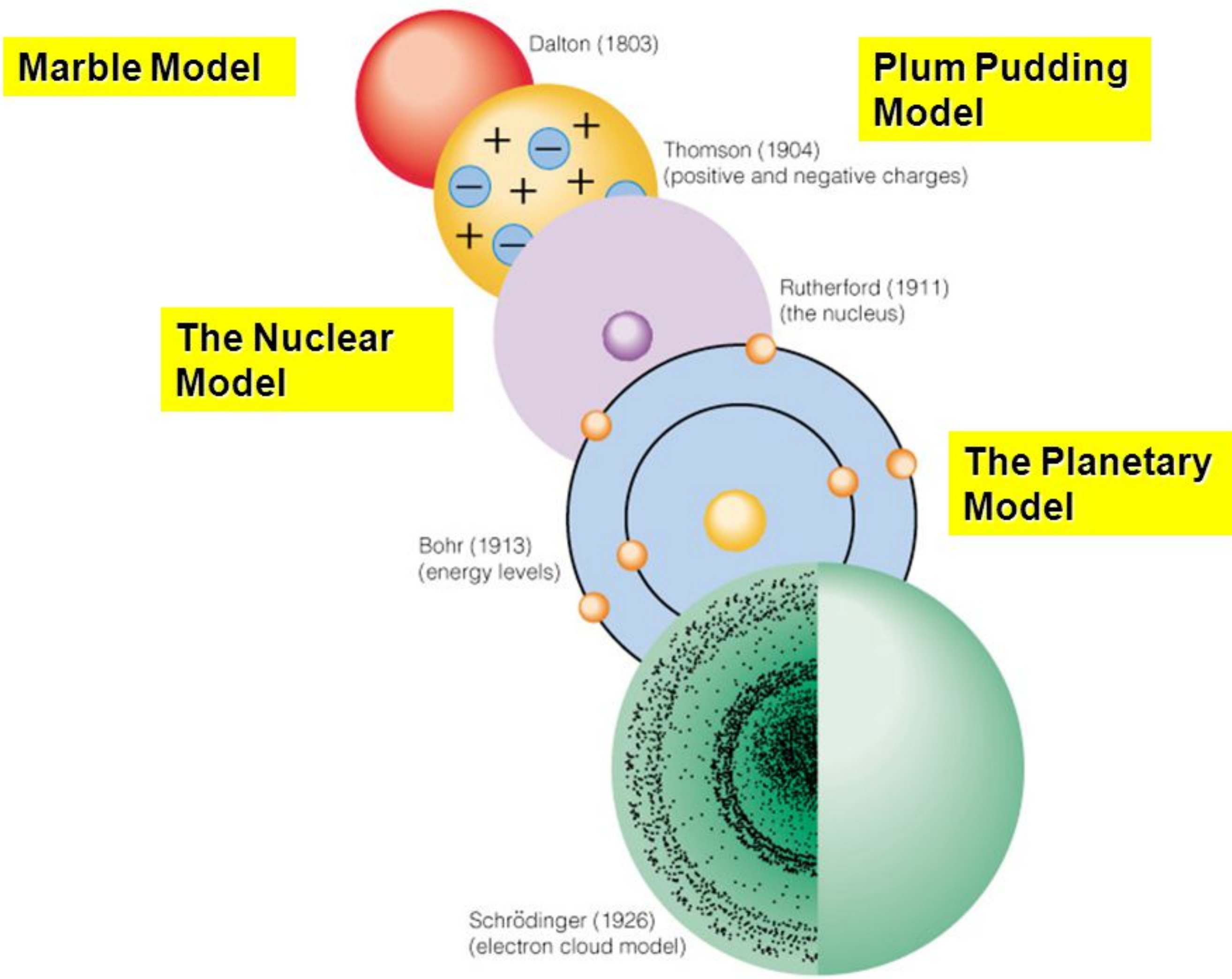
Quantum Mechanical Model: In 1926 an Austrian physicist by the name of Erwin Schrödinger improved Bohr's model by adding detail to the orbits. He used complex mathematics which allowed him to map out the location and shape of the orbits of atoms.

The Neutron: As you may have figured out by now, this model was eventually improved upon. No current model could explain the mass of an atom. At this time if you added up the total number of electrons and protons in an atom it was nowhere near the actual mass of the atom. The solution came in 1932.

Physicist James Chadwick found that the nuclei (plural of nucleus) of the atoms contained a particle with no electric charge. This particle was appropriately named, the neutron.

The outcomeof Chadwick's discovery was a model of the atom that was fairly simple to understand. The core of the atom is the atomic nucleus, where the proton(s) can be found and the nucleus. Outside of the nucleus the electrons move in specific orbits.


6 protons
+ 6 neutrons
electron
proton
neutron
Carbon atom


Marble Model
Dalton (1803)
Plum Pudding Model
Thomson (1904)
(positive and negative charges)
Rutherford (1911)
(the nucleus)
The Nuclear Model
The Planetary Model
Bohr (1913)
(energy levels)
Schrödinger (1926)
(electron cloud model)