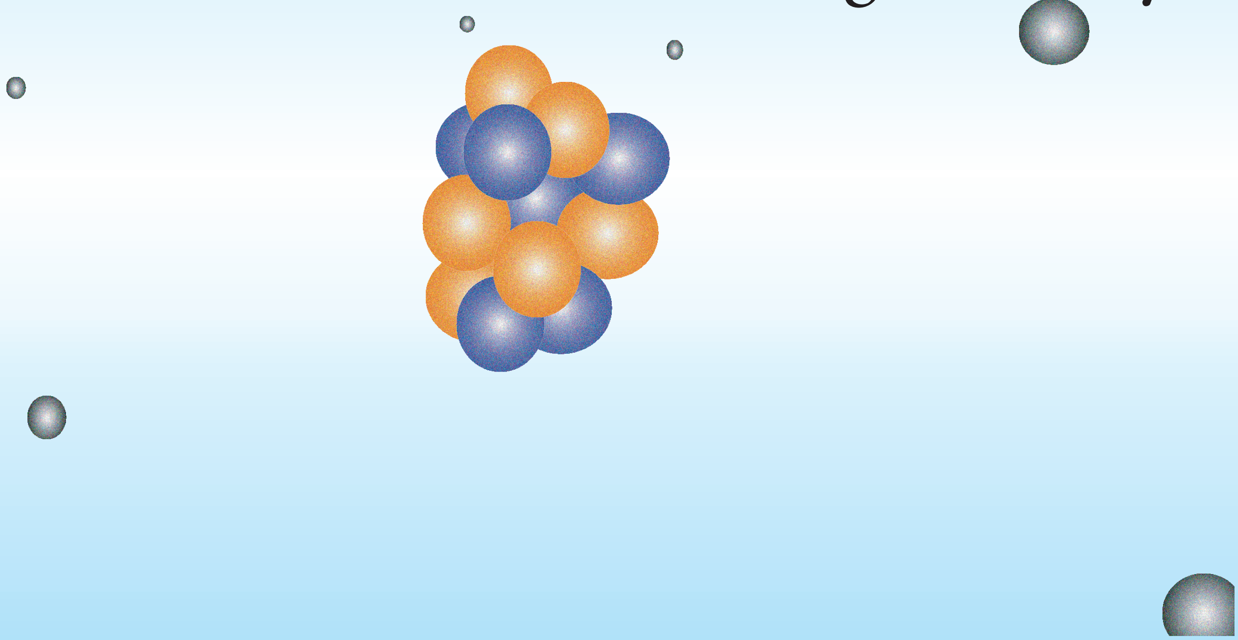
Atomic Theory

A View of the Atom Through History



By David Roth

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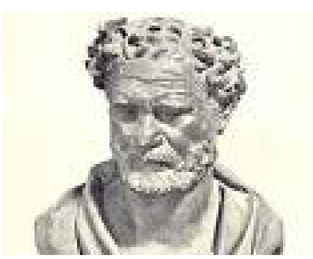
THE ATOM

Atoms are everywhere. In the clothes we wear, food we eat, ground we walk on, in the light that allows us to see, atoms are even in you and me. Lets face it atoms are everywhere and they make up everything. Atoms are the smallest unit of an element that retains the properties of that element and may not be broken down into smaller units by natural chemical means. As you are aware atoms are very small so small that it would take about a million hydrogen atoms to match the thickness of this page. This statement leads to the question of, "how do we know so much about the atom?" In this manual you will explore this question and many more as you journey through the history of atomic theory.

Atomic theory is the leading school of thought for what the atom is and how it behaves. All the evidence gathered by scientists for hundreds of years lend support to this theory yet as you know it wasn't always a theory. Like all scientific theories atomic theory started out as a mere observation, a thought really, made by one of the greatest philosophers of all time. Democritus made observations without the help of sophisticated scientific instruments that launched scientists on a journey that spanned over two-thousand years. In fact, thanks to advancements in science and technology, we are still fully engaged in this journey to explain what atoms are and how they behave.

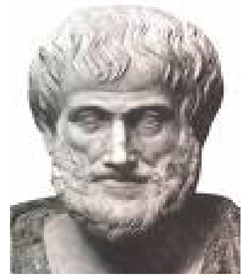
DEMOCRITUS



(460B.C.- 370 B.C.)

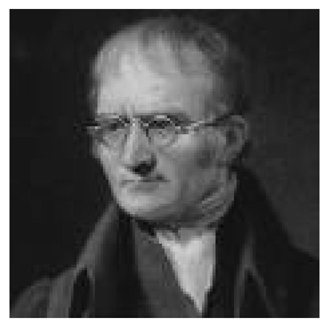
Our journey begins around the year 420 B.C. with the greek philosopher Democritus. Democritus observed the world around him and believed that everything was made of tiny invisible particles that could combine into solid forms creating the world around him. Democritus called these tiny invisible particles ATOMOS. This loosely translates into two words. (A) meaning negative or not and (Tomos) meaning divisible. When put together the word atom means non divisible.

ARISTOTLE



Aristotle did not hold the same views as Democritus. To Aristotle everything in the world was designed for a specific purpose and there was no way that living objects, such as people, could be made of the same stuff as non living objects, such as rocks. He also reasoned that there was no direct evidence for the existence of atoms or the "glue" that could hold them together. Aristotle, of course, also argued that the Earth was at the center of an unchanging universe. But hey, you decide who's ideas made more sense.

JOHN DALTON



(1766-18440)

Dalton was an English school teacher and chemist who studied the work of Democritus and established what we now call Atomic Theory in the year 1803. Dalton was interested in how elements combine during chemical reactions and made precise observations about the ratios in which elements combined as well. According to Dalton the atom was spherical in shape and solid through and through just like a marble.

Activity: Complete the following.

1. In what year did Dalton make his discovery?

2. What was Dalton's discovery?

3. In the space below draw a picture of Dalton's atom:

Benjamin Franklin

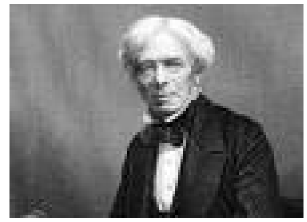
(1706-1790)

Besides taking part in the formation of the United States of America Ben Franklin was a brilliant inventor. Did he deliberately work on the development of atomic theory? No he did not, however, like many other scientists Franklin's discoveries helped others to discover the structure and behavior of the atom. Franklin's part started one dark and stormy day.....

As the story goes Old Ben Franklin was constructing a device that would warn of an impending lightning storm. Franklin thought that an increase of static electricity, in the atmosphere, was a precursor to a lightning storm. Franklin also believed that static electricity had something to do with positive and negative charges. So one dark and stormy afternoon old Ben put together a kite not unlike any other kite except he wanted to gather evidence that these positive and negative charges would be attracted to metal so he attached a metal key to the string connecting him to the kite. Without much of a stretch of the imagination lightning came down from the sky, passed through the metal key and into Old Ben Franklin.

This is of Course how the story went. Considering that even with our current state of medical technology people tend to die more often than survive a direct blast of lightning..... You be the judge. But be assured that Benjamin Franklin did champion the idea of positive and negative charges that would intrigue future scientists on future quests to explain the atom.

Michael Faraday



(1791-1867)

Michael Faraday was a scientist and inventor who spent considerable time in the laboratory working with electricity. Faraday started out as a book binder but had an interest in science. Specifically Faraday was interested in electricity and gained a position as an apprentice working in a laboratory mainly as a chemist. Investigating the phenomena of electricity Faraday was able to transmit electrical currents through metallic wires which led to the discovery of the first electric motor. Further work on electromagnetism led to the discovery that somehow electricity was related to the structure of the atom.

J.J. Thompson

(1856-1940)

While experimenting with the phenomenon of electricity J.J. Thompson made one of the greatest discoveries of all time. Passing an electrical current through a cathode ray tube Thompson noticed that the compressed gas began to glow as the electrical current passed from the anode (+ charged electrode) to the cathode (- charged electrode). From his observations he concluded that the gas began glowing due to negatively charged particles traveling between electrodes and he called them electrons. The mass of the electron was later calculated to be: e- = 9.1 x 10-28g. Thompson also used this discovery to improve upon the model of the atom originally constructed by Dalton. According to Thompson the atom was spherical but was not solid through and through as Dalton concluded. Instead the atom had an internal structure that was like a positive and negative soup.

How else has JJ Thompson affected society? As you recall Thompson discovered the electron by passing an electrical current through a cathode ray tube containing compressed gas. The result was that the compressed gas glowed as a result of electrons becoming excited and jumping from one energy level to the next. This discovery led to the discovery of the television set which produces images by passing electrical currents through cathode ray tubes.

Activity: Complete the following.

1. In what year did Thompson make his discovery?

2. What was Thompson's discovery?

3. In the space below draw a picture of Thompson's atom:

Ernest Rutherford

(1871-1937)

Earnest Rutherford was intrigued by alpha particles, positively charged particles, and studied their properties by attempting to pass them through a sheet of gold foil. According to Thompson, the atom was a soup of evenly mixed positive and negative charges within a solid shell. If this model were accurate Rutherford predicted that the alpha particles, when fired through the gold foil, would be deflected because they would collide with the uniformly distributed positive charges within the gold atoms. Surprisingly this did not happen and most of the alpha particles passed directly through the gold atoms. Rutherford concluded that the Thompson model was inaccurate and then proceeded to change it. To Rutherford, the alpha particles could pass directly through only if the positive charges, within the atom, were located within a nucleus. Rutherford's new model of the atom pushed the positively charged protons inside of the nucleus leaving a jumbled mess of electrons flying around it. This sounded good at the time except that a physicist working for Rutherford couldn't use this model to predict or explain the chemical properties of the elements. Within the next few years Bohr improved upon his model with addition of neutrons within the nucleus.

Activity: Complete the following.

1. In what year did Rutherford make his discovery?

2. What was Rutherford's discovery?

3. What was the problem with Rutherford's model of the atom?

4. In the space below draw a picture of Rutherford's atom:

Niels Bohr

(1885-1962)

Niels Bohr was a physicist working with Rutherford when he made his discoveries of the behavior of alpha particles. The problem Bohr had was that Rutherford's model could not explain the behaviors of the elements. Rutherford was on the right track, however, the problem must have been not within the nucleus of the atom but outside of the nucleus within the jumble of electrons. In 1913 Bohr hypothesized that the chemical behavior of the atom was due to electrons occupying specific energy levels in orbit around the nucleus. Bohr concluded that a model of the atom would resemble a model of the solar system. Using this model the nucleus would be like the sun in the center of the solar system and the electrons would orbit the nucleus within specified orbits just as planets orbit the sun.

Each atom has a ground state which means that electrons naturally occupy specific energy levels in an electrically stable atom. When energy is added to an atom its electrons may become excited and bounce from one energy level to the next. If you are trying to imagine what this is like for the atom just imagine giving a small child a whole bunch of sugar and then watch them bounce off of the walls. Electrons are like small children with the exception that they do not enjoy being in an excited state. When an electron jumps from one energy level to the next it must, eventually, move back to its ground state. In order to go back to its ground state the electron must give up the additional energy it gained. Electrons give up, or emit, this additional energy in the form of photons which may be detected in the form of light.

Activity: Complete the following.

1. In what year did Bohr make his discovery?

2. What was Bohr's discovery?

3. In the space below draw a picture of Bohr's atom:

Erwin Schroedinger

(1887-1961)

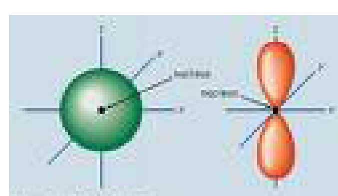
The last stop we will make on our journey to discover the nature of the atom is with a physicist by the name of Erwin Schroedinger the year 1926. Schroedinger was an Austrian physicist who was also interested in the chemical behavior of the atom. Schroedinger saw a problem with the Bohr model of the atom because even though it could explain the chemical behavior of some of the elements it could not explain the behaviors of all the elements. Schroedinger solved this problem by treating electrons as waves of energy instead of particles. If electrons were waves of energy rather than particles then they would seem to be in multiple locations at the same time. Just like the Bohr model Schredinger's model kept the protons and neutrons within the nucleus while the electrons were now confined to specific orbitals around the nucleus. This model is called the quantum mechanical model of the atom and according to this model electrons move freely within a specified orbital depending upon their assigned energies. Visually this model would differ from Bohr's in that the electrons would not have definite orbits but instead have shaded areas in which they may be found at any given moment.

Activity: Complete the following.

1. In what year did Schroedinger make his discovery?

2. What was Schroedinger's discovery?

4. Below is a picture of different shaped orbitals. The nucleus is located at the center of each diagram. the sphere on the right is the (p) orbital and the sphere the left is the (s) orbital. Electrons may be located at any point within the shaded areas at any given time.



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