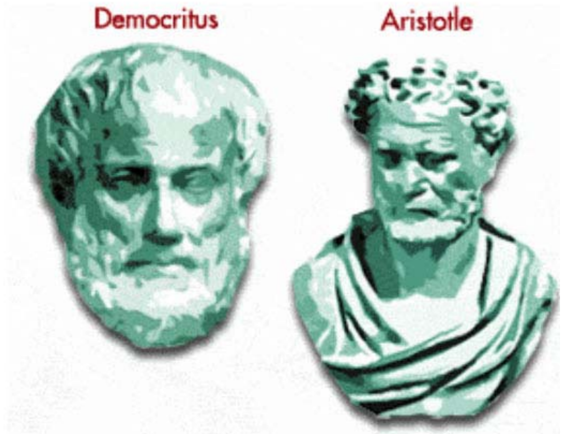
Atomic Basics : In the Beginning

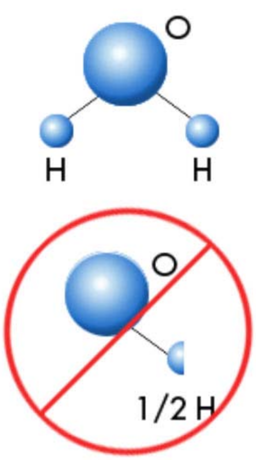


Today we know quite a bit about atoms. But how did we ever know about atoms in the first place?

The earliest known concept of the atom came from the Greek philosopher/scientist Democritus between 460 and 370 BCE. **Democritus** thought of the world as being composed of very tiny "uncuttable" particles, which he called "atomoz" or atoms. These tiny, invisible particles were thought to be separated by voids -- empty space. He explained differences in materials as caused by differences in the sizes of the particles and the amount of empty space between them. The ideas of Democritus provided a good foundation for the development of modern atomic theory.

After the death of Democritus, however, the great philosopher **Aristotle** (384-322 BCE) argued persuasively against the concept of atoms. Aristotle thought the earth was composed of matter, which he believed was made up of four elements: earth, air, fire, and water. He explained the differences in different types of matter as arising from the proportion, form, and qualities of the four basic elements that each type of matter contained. Aristotle's concept of matter was very different from that of today's chemists.

For a long time, Aristotle's ideas about matter held sway in the Western world. So how did scientists get back to the idea of atoms?



Molecules can only form whole number ratios. There is no such thing as "half an atom."

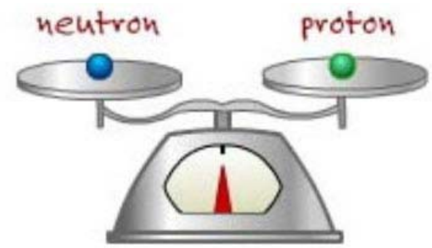
The concept of atoms was once again introduced to the scientific world by John Dalton in his 1808 book, *A New System of Chemical Philosophy*. Dalton put forth the concept of all matter being composed of small particles, atoms, which varied in weight and size. An element was a substance that contained only one particular type of atom. The atoms of one element are different from the atoms of any other element. The atoms of elements combine in small whole number ratios to form the many chemical compounds found on earth and in the rest of the universe.

All atoms are composed of a given set of subatomic particles: protons, neutrons, and electrons. These particles have definite arrangements for any given element. The important thing to remember is that the protons, electrons, and neutrons of one element are exactly the same as the protons, electrons, and neutrons of any other element. It is their number and arrangement that make the elements different.

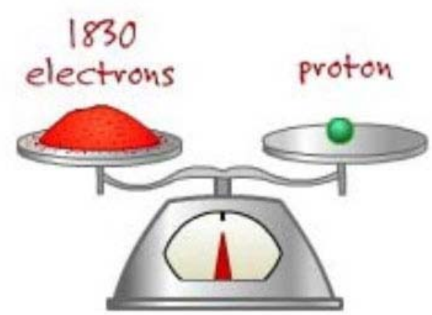
But what are these "protons, electrons, and neutrons"?

The basics of atomic structure are as follows:

- **Protons** are positively charged particles, weighing 1 atomic mass unit (1.67×10^{-24} grams) and located in the nucleus.
- **Neutrons** are neutrally charged particles, weighing approximately 1 atomic mass unit and located in the nucleus.



Electrons are negatively charged particles weighing zero atomic mass units and located in the various orbitals of the energy levels outside the atomic nucleus. The electron actually weighs 9.11×10^{-28} grams. This means it would take about 1,830 electrons to equal the mass of one proton. Since the heaviest naturally occurring element has only 92 electrons in its normal state, we do not count the mass of the electrons in calculating the mass of the atom.



Almost all of the weight of an atom comes from the protons and neutrons.

So an atom is composed of protons, neutrons, and electrons, but what makes an atom of one element different from the atoms of every other element? The answer starts with something called **Periodicity**.

What is Periodicity?

In studying the characteristics of various elements, the early chemists started to list various properties. John Dalton devised a means to determine a relative mass for the atoms of the elements. This would later allow us to arrange the elements in a table. This table, initially set up by the Russian scientist **Dmitri Mendeleev**, is the single most important tool of chemists everywhere in the world. In about 1868, Mendeleev arranged the 60 elements he knew of at the time in order of each element's increasing mass. This showed him a repeating pattern of other characteristics of the elements. The tendency to show a regular repeating pattern is known as **periodicity**.

Atomic Number

One important thing to note about Dmitri Mendeleev's first table is that there were blank spaces left. Mendeleev believed that there were elements yet undiscovered and actually predicted some of their properties based on their position in his table. Later, in 1913, Henry Moseley corrected some problems with the first table by rearranging the elements according to their atomic number rather than mass. You probably remember that the **atomic number** of an element is equal to the number of protons in the nuclei of its atoms. This rearrangement solved some irregularities in the periodicity of the original table, this new rearrangement of the Periodic Table of the Elements became rapidly accepted.

Ions and Isotopes
An **ion** is an atom in which the number of protons differs from the number of electrons. If an atom has more electrons than protons, the ion is known as an **anion**; if it has fewer electrons than protons, it is known as a **cation**. An **isotope** is an atom in which the number of protons and neutrons differ."

Importance of Protons
This orderly arrangement by number of protons makes sense on a basic level of logic. The number of electrons in an atom may be changed by adding or subtracting electrons to form positive or negative ions of the element. The number of neutrons in the nucleus of an atom may also be changed to create various isotopes of an element (some more stable than others). But add or subtract even one proton from an atom of any element and you no longer have the original element in any form. Now you have a different element! **The number of protons in an atom determines what element it is.**

Take a look at the **Periodic Table**.

The table is read just like any other written piece of information, from left to right and top to bottom. The first and simplest element is hydrogen, found in the extreme upper left corner of the table. It has an atomic number of 1. This means there is only one proton in the nucleus of any hydrogen atom. The next element in the table is located in the extreme right top corner of the table. This is helium. Helium has an atomic number of 2. There are two protons located in the nucleus of each and every helium atom or ion. In following the pattern described, you must look down one row and to the left side of the table to find the next element -- lithium. This is the same as looking back to the left side of the page and down one line to read this complete sentence.

By definition, an atom of any element has no overall charge. So as you add the protons one at a time, you are also forced to add electrons one at a time to balance the electrical charge of the atom. There are some very strict rules as to how and where these electrons have to be added to the atoms. We will be going over the rules for electron placement in the next chapter, **It's Elementary.**

Periodic Table of the Elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr