The periodic table

The periodic table is the single most important document for chemists. Scientists have attempt to organize the elements in some sort of logical order for centuries. The most important chemist in history was Dmitri Mendeleev as he was the first scientist who made the periodic table look as the one we are use today.

The French chemist Antione- Laurent de Lavoisier(1743-1794) compiled the first extensive list of elements in 1789. The list of element included oxygen, nitrogen, hydrogen, phosphorus, zinc mercury and sulphur. Before Antione-de Lavoisier people have known about basic chemical elements such as gold, silver, and copper from antiquity, as these can all be discovered in nature in native form and are relatively simple to mine with primitive tools. Aristotle, a greek philosopher, theorised that everything is made up of a mixture of one or more of four elements. They were earth, water, air, and fire. This was more like the four states of matter: solid, liquid, gas, and plasma, though he also theorised that they change into new substances to form what we see.

In the nineteenth century the first recognizable Periodic Table was pieced together by comparing properties of different elements. At least 47 elements were discovered, and scientists began to see patterns in the characteristics. In 1828 Jakob Berzelius published a table of atomic weights and introduced letter-based symbols for elements. Johann Wolfgang proposed his `law of triads` in 1829, stating that: ` Nature contains triads of elements where the middle element has properties that are on average of the other two members of the triad when ordered by the atomic weight.' Wolfgang discovered that strontium had similar chemical properties to calcium and barium and that its atomic weight fell midway between the two. He also discovered the halogen triad of chlorine, bromine and iodine and the alkali metal triad of lithium ,sodium and potassium. In 1863 English chemist John Newlands divided the than discovered 56 elements into 11 groups, based on characteristics he was the first person who did this. Two years later Newlands proposed his `law of octaves` which states that 'Any given element will exhibit analogous behaviour to the eight element following in the table.` Newlands listed the 60 known element at that time (there are over 100 now) in order of their atomic weight putting their position in this sequence alongside the symbol. He did not give a name to this position number.

H 1	F 8	Cl 15	Co/Ni 22	Br 29	Pd 36	I 42	Pt/Ir 50
Li 2	Na 9	K 16	Cu 23	Rb 30	Ag 37	Cs 44	Tl 53
Gl 3	Mg 10	Ca 17	Zn 25	Sr 31	Cd 34	Ba/V 45	Pb 54
Bo 4	Al 11	Cr 18	Y 24	Ce/La 33	U 40	Ta 46	Th 56
C 5	Si 12	Ti 19	In 26	Zr 32	Sn 39	W 47	Hg 52
N 6	P 13	Mn 20	As 27	Di/Mo 34	Sb 41	Nb 48	Bi 55
O 7	S 14	Fe 21	Se 28	Ro/Ru 35	Te 43	Au 49	Os 51

The pattern was perfect up to calcium then became less convincing as some metals appeared unlike the non-metals to their left. However a further seven elements later there was a greater similarity. Then Newlands was forced to sometimes put two elements in the same box so that after this similar elements would be in the same horizontal line. Di stood for didymium, which we now know as a mixture of two elements. Four years later in 1869 the Russian chemist Dimitri Mendeleev started the development of the periodic table, arranging chemical elements by atomic mass. He predicted the discovery of other elements, and left spaces open in his periodic table for them. Mendeleev`s version is widely regarded as one of the most important developments in chemistry

Mendeleev's table was nine tenths of the way there, but needed one important modification before it became the modern periodic table. Mendeleev ordered his elements in order of their relative atomic mass which gave him some problems. For example, iodine has a lower relative atomic mass than tellurium, so it should come before tellurium in Mendeleev's table - but in order to get iodine in the same group as other elements with similar properties such as fluorine, chlorine and bromine, he had to put it after tellurium, so breaking his own rules

The final modern periodic table arrangement was finally proposed by Henry Moseley in 1913 by ordering elements by their atomic number instead of their mass. Using atomic number instead of atomic mass as the organizing principle was first proposed by the British chemist Henry Moseley in 1913, and it solved anomalies like this one. Iodine has a higher atomic number than tellurium. Even though he didn't know why, Mendeleev was right to place it after tellurium after all.

First he put elements into their correct places in the table. In some cases the relative atomic mass had been wrongly calculated by others. By correcting the relative atomic mass he put the element in the correct place.
At the time, relative atomic masses were laboriously determined using the formula
atomic weight = equivalent weight x valency
The combining (or equivalent) weights were generally accurate but sometimes an element was given the wrong valency. Thus beryllium, combining weight 4.6, was given the valency 3 because it was chemically similar to aluminium. This gave an atomic weight of 13.8, placing it between carbon and nitrogen where there was no space. Mendeleev said the valency was 2; the problem was solved - it fitted into the space between lithium and boron.
Secondly, Mendeleev sometimes decided that atomic weights must be wrong because the elements simply appeared in the wrong place. For example he placed tellurium before iodine although its atomic weight is greater simply because iodine’s properties are so similar to those of fluorine, chlorine and bromine and tellurium’s to those of oxygen, sulfur and selenium rather than the other way round. We now know that it is atomic number, not relative atomic mass that governs an element’s position in the Periodic Table but in most cases the two result in the same order.

There were two main faults. First chemists were not distinguishing between the weights of atoms and of molecules. Seven common elements exist as diatomic molecules (molecules containing two atoms, such as oxygen, O_2), of special importance being hydrogen, the original standard for atomic weights. If a *molecule* of H_2 is given a relative mass of 1 instead of 2, then when other elements are compared with it, their relative atomic masses are halved.

Second, at the time chemists used a term called equivalent, or combining weight. This was the number of grams of an element that combined with 8 g of oxygen (They used this because 8 g of oxygen combine with 1 g hydrogen so 8 g of oxygen was *equivalent* to 1 g hydrogen.) Chemists used this because it is in general easier practically to measure the weight of an element that combines with oxygen than the weight that combines with hydrogen. Atomic weights were then found from the equivalent weight using the relationship:

Equivalent weight x valency = atomic weight

where valency is the combining power of an element (the number of atoms of hydrogen that would combine with an atom of the element).

The greatness of Mendeleev was that not only did he leave spaces for elements that were not yet discovered but he predicted properties of five of these elements and their compounds. How foolish he would have seemed if these predictions had been incorrect but fortunately for him three of these missing elements were discovered by others within 15 years (*ie* within his lifetime). The first of these Mendeleev had called eka-aluminium because it was the one after aluminium (eka = 1 in Sanskrit) and was identified in Paris (1875) by Paul Emile Lecoq de Boisbaudran who named it gallium after the Latin name for France. Mendeleev was ecstatic when he heard of its properties which nearly matched his eka-aluminium. However de Boisbaudran's value for gallium's density (4.9 g/cm^3) differed from Mendeleev's prediction. Mendeleev told the Frenchman, who re-measured the density to find Mendeleev was right! It is interesting to speculate whether de Boisbaudran was pleased or irritated by this. The table compares Mendeleev's predictions with de Boisbaudran's discovery.

	Eka-aluminium (Ea)	**Gallium (Ga)**
Atomic weight	About 68	69.72
Density of solid	6.0 g/cm^3	5.9 g/cm^3
Melting point	low	29.78°C
Valency	3	3
Method of discovery	Probably from its spectrum	Spectroscopically
Oxide	Formula Ea_2O_3, density 5.5 g/cm^3. Soluble in both acids and alkalis.	Formula Ga_2O_3, density 5.88 g/cm^3. Soluble in both acids and alkalis.

Within the next ten years Swede Lars Nilson (1879) identified scandium, predicted by Mendeleev as eka-boron and German Clemens Winkler (1886) discovered germanium which he realised was Mendeleev's eka-silicon. These discoveries established the acceptance of the Russian's table, although two other elements whose properties were predicted were not discovered for 50 years.

One thing that Mendeleev did not predict was the discovery of a whole new Group of elements, the noble gases, by the Scot William Ramsay and co-workers during the last decade of the 19^{th} century. Mendeleev was at first dismayed by this but before he died in 1907 realised that Ramsay's discoveries were further proof of the Periodic Table, not a contradiction. Ramsay was awarded a Nobel Prize for discovering five elements. Mendeleev never received that honour. However, an element, atomic number 101, has been named after Mendeleev, an even rarer distinction. This is surely deserved by the original formulator of the Periodic Table.

References

http://www.rsc.org/education/teachers/learnnet/periodictable/pre16/develop/mendeleev.htm
http://www.wou.edu/las/physci/ch412/perhist.htm
http://members.aol.com/profchm/periodic.html
http://www.chemheritage.org/classroom/chemach/forerunners/lavoisier.html
http://www.chemistry.co.nz/mendeleev.htm