U B
Li Br Ar Y

The Order of the Elements

1789 **Lavoisier** defines the chemical element:

> ***We apply the term* elements *to express our idea of the last point which analysis is capable of reaching.***

Lavoisier

Dalton

1803 **Dalton** proposes the atomic theory, associates a defined weight to the atoms of each element and organizes them according to such weights.

1807 **Davy** applies electrolysis to the isolation of elements from their compounds: K, Na, Mg, Sr, Ca and Ba.

1815 **Prout** publishes the hypothesis that elements are constituted by hydrogen atoms and that atomic weights are integer numbers.

Ampère

1816 **Ampère** proposes an ordering of the elements *Annales de Chimie et Physique*, 2, 5, 108 (1816).

H. Davy
1778-1829

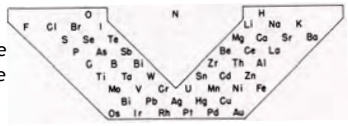
J. W. Döbereiner
1780-1849

1829 **Döbereiner** organizes the elements in triads.

1843 **Gmelin** proposes a classification of the elements.

1858 **Cannizzaro** distinguishes atomic and equivalent weights and establishes correct atomic weights.

Pettenkofer, **Dumas, Odling, Hinrichs** and **Strecker** contribute towards the organization of the elements in groups and analyze numerical relationships between their atomic weights.



Gmelin

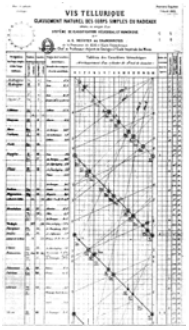
S. Cannizzaro
1826-1910

G. R. Kirchhoff
1824-1887

R. W. Bunsen
1811-1899

A. B. de Chancourtois
1820-1886

J. A. R. Newlands
1838-1898



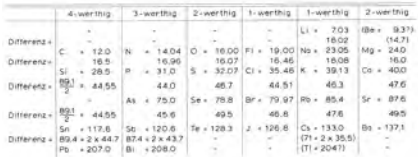
Chancourtois

Julius Lothar **Meyer**
1830-1895

1860 **Bunsen** and **Kirchhoff** identify Rb and Cs with the help of the spectroscope triggers the discovery of more new elements.

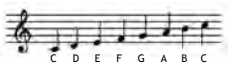
1862 **Chancourtois** orders the elements in a helical way.

1864 **Meyer** organizes 27 known elements of the main groups in a table of his book *Die modernen Theorien der Chemie*.



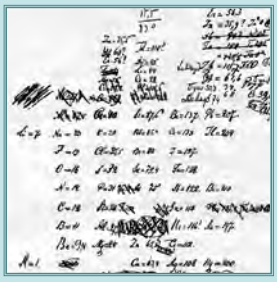
Meyer

1865 **Newlands** organizes in a table 61 elements according to their atomic weights and proposes the law of octaves:



members of the same group stand to each other in the same relation as the extremities of one or more octaves in music.

1869

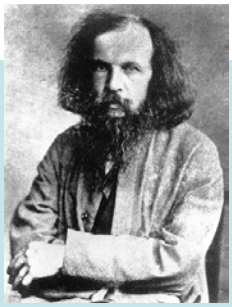


February: He gives to print a leaflet titled ***Essay of a system of the elements, based on their atomic weights and chemical affinities***, 150 copies in Russian and 50 in French.

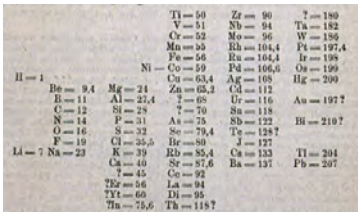
March: Nikolai Menshutkin presents the periodic system to the Russian Chemical Society in the absence of its author, who was supervising cooperatives of cheese producers.

April: Mendeleev publishes in a brief communication in German the periodic system with 62 elements, *Zeitschrift für Chemie*, 12, 405-406 (1869), and a more extense paper in Russian in *Zhurnal Russkoe Fiziko-Khimicheskoe Obschchestvo*, 1, 60-77 (1869).

He publishes the first volume of his book *Osnovi Khimii* (*Principles of Chemistry*).



Dmitri Ivanovich **Mendeleev**
1834-1907



Mendeleev, 1869

1870 Mendeleev publishes a paper in Russian in which he predicts new elements and proposes changes for some atomic weights.

Meyer publishes a table similar to Mendeleev's with 54 elements *Liebigs Annalen der Chemie, Supplementband* 7, 354-364 (1870).

1871 Mendeleev publishes a more detailed paper in German, similar to the one published in Russian in 1869: *Liebigs Annalen der Chemie, Supplementband* 8, 133-229 (1871).

Before and After Mendeleev

Al Ga **1875** — **Lecoq de Boisbaudran** discovers Ga, predicted by Mendeleev as *eka-Al*.

eB Sc **1879** — **Nilson** discovers Sc, predicted by Mendeleev as *eka-B*.

Si Ge **1886** — **Winkler** discovers Ge, predicted by Mendeleev as *eka-Si*.

P. E. Lecoq de Boisbaudran
1838-1912

L. F. Nilson
1840-1899

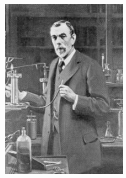
C. Winkler
1838-1904

Eka-Silicium	Predicted	Found
Atomic weight	72	72,6
Specific weight	5,5	5,35
Formula for its oxide	$ESiO_2$	GeO_2
Specific weight of its oxide	4,7	4,70
Its salts will be decomposed by water		Yes
Its chloride, $ESiCl_4$, will be a liquid		Yes
and its boiling point will be	90° C	83° C

Ramsay discovers argon. Mendeleev, who did not foresee it, refuses to accept it as a new element and interprets it as a new allotropic form of nitrogen, N_3, analogous to ozone. The same author discovers later He (1895), Kr, Ne and Xe (1898). **Dorn** discovers Rn the same year. In that way a new group makes its way into the periodic table.

1894 — He Ne Ar Kr Xe Rn

Po Ra **1898** — **Marie** and **Pierre Curie** discover Po and Ra.



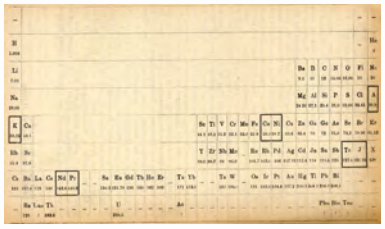
W. Ramsay
1852-1916

M. Curie
1867-1934

H. G. J. Moseley
1889-1915

He Ne **1900** — **Ostwald** incorporates noble gases to the periodic table in his book *Grundlinien der anorganische Chemie*.

1905 — **Werner** publishes the first long version of the periodic table.



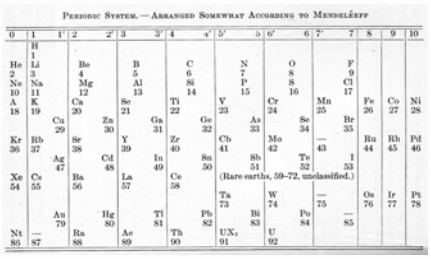
Werner

v Z **1913** — **Moseley** notes that the X ray emission frequencies of the elements depend on their position in the periodic system, defines the atomic number and explains the relationship between frequency and atomic number, based on the atomic model recently proposed by **Bohr**.

1918 — **Hildebrand** organizes the periodic table according to atomic numbers in the book *Principles of Chemistry*.

1919 — **Langmuir** presents the first table in which each element is associated to its number of valence electrons.

1925 — **Pauli** proposes the exclusion principle that, together with the spin quantum number proposed by **Uhlenbeck** and **Goudsmit**, provides a rationale for the existence of periods of different lenghts in the periodic table.



Hildebrand

Tc **1937** — **Perrier** and **Segré** obtain Tc, the first artificial element.

Np **1940** — Np, the first transuranium element, is obtained in Berkeley.

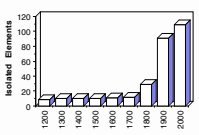
Actinids **1949** — **Seaborg** proposes to place elements heavier than actinium under the lanthanides and calls them *actinides*.

Lr **1961** — The actinide series is completed with the generation of Lr through bombardment of Cf and B in Berkeley.

Glenn T. Seaborg
1902-1997

Proposal of a periodic table that incorporates the nonexisting elements up to 168, based on the theoretically predicted electron configurations.

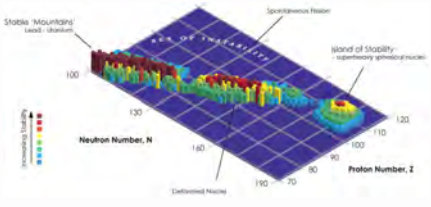
1996



Total number of elements isolated throughout the centuries.

Uub **1996** — The detection of two atoms of element 112 confirms the existence of the ***Island of stability*** predicted around 1970 for elements with Z = 112-114 and N = 184.

Rg **2006** — The last element to be given a name is Roentgenium, element 111. Confirmation of elements 113 to 118 still pending.



Island of Stability: combinations of numbers of protons and neutrons predicted to form stable nuclei.

Santiago Alvarez, Joaquim Sales, Miguel A. Seco, 2007