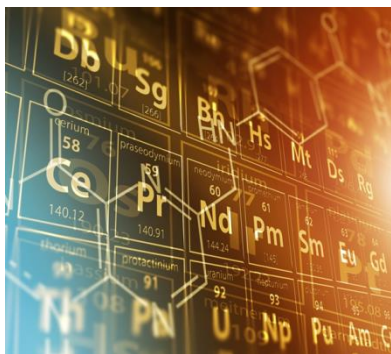


**1869** is considered as the year of discovery of the Periodic System and therefore **2019** will be the **150<sup>th</sup>** anniversary of its discovery.

## The Periodic Table of Chemical Elements

is a unique tool enabling scientists to predict the appearance and properties of matter on Earth and in the Universe

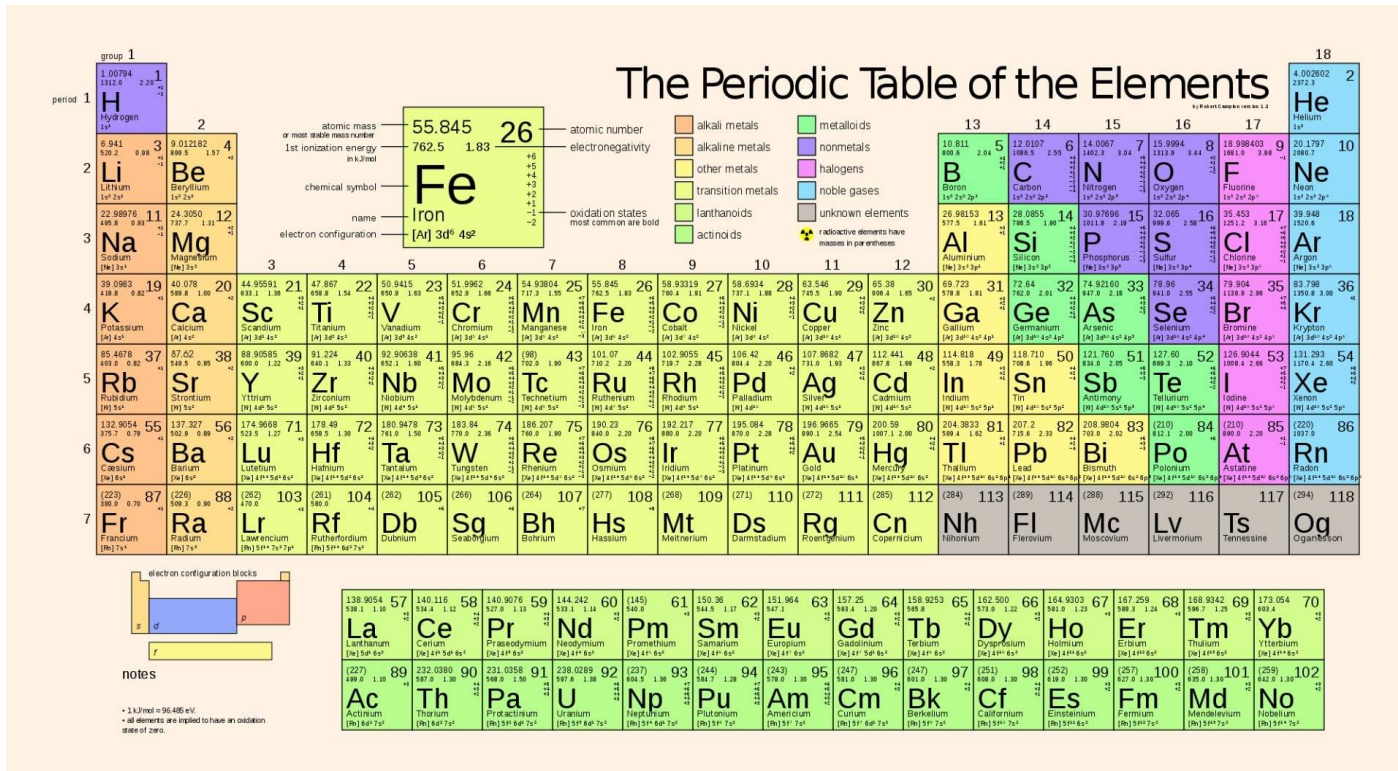
It is one of the most significant achievements in science, capturing the essence not only of chemistry, but also of physics and biology



# The Periodic Table of Chemical Elements is a Language for Science

The Periodic Table enabled to order the chemical knowledge







Each element box evidences symbolic, microscopic and macroscopic characteristics: the three levels of Chemistry



# Related Scientific Disciplines

## The Periodic Table has broad implications in Astronomy

### The Origin of the Solar System Elements

1 H	big bang fusion 											cosmic ray fission 						2 He				
3 Li	4 Be	merging neutron stars? 						exploding massive stars 						5 B	6 C	7 N	8 O	9 F	10 Ne			
11 Na	12 Mg	dying low mass stars 						exploding white dwarfs 						13 Al	14 Si	15 P	16 S	17 Cl	18 Ar			
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					
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					
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
87 Fr	88 Ra																					
		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	Very radioactive isotopes; nothing left from stars														



# The Periodic Table has broad implications in Biology

## THE PERIODIC TABLE FOR BIOLOGISTS

I	II
1 1.01 H hydrogen	2 4.00 He
3 6.94 Li	4 9.01 Be
11 22.99 Na sodium	12 24.31 Mg magnesium
19 39.10 K potassium	20 40.08 Ca calcium
37 85.47 Rb	38 87.62 Sr
55 132.91 Cs	56 137.33 Ba
73 223.02 Fr	74 226.03 Ra

The most commonly occurring elements in living organisms are:

6 C carbon	1 H hydrogen	8 O oxygen	7 N nitrogen
------------------	--------------------	------------------	--------------------

Other common elements are shaded in green.

relative atomic mass      atomic number

1.01 1 H hydrogen
----------------------------

element name

transition-metals

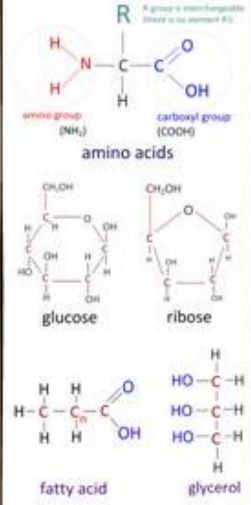
21 44.96 Sc	22 47.90 Ti	23 50.94 V	24 52.00 Cr	25 54.94 Mn manganese	26 55.85 Fe iron	27 58.93 Co cobalt	28 58.71 Ni nickel	29 63.55 Cu copper	30 65.38 Zn zinc
39 88.91 Y	40 91.22 Zr	41 92.91 Nb	42 95.94 Mo	43 98.91 Tc	44 101.07 Ru	45 102.91 Rh	46 106.42 Pd	47 107.87 Ag	48 112.41 Cd
72 178.49 Hf	73 180.95 Ta	74 183.85 W	75 186.21 Re	76 190.23 Os	77 192.22 Ir	78 195.09 Pt	79 196.97 Au	80 200.59 Hg	

Lanthanide and actinide elements (and 104 - 109) have been left off.

III	IV	V	VI	VII	VIII
5 10.81 B	6 12.01 C carbon	7 14.01 N nitrogen	8 16.00 O oxygen	9 19.00 F	10 20.18 Ne
13 26.98 Al	14 28.09 Si	15 30.97 P phosphorus	16 32.06 S sulphur	17 35.45 Cl chlorine	18 39.95 Ar
31 69.72 Ga	32 72.59 Ge	33 74.92 As	34 78.96 Se	35 79.91 Br	36 83.80 Kr
49 114.82 In	50 118.69 Sn	51 123.75 Sb	52 127.60 Te	53 126.90 I iodine	54 131.30 Xe
81 204.37 Tl	82 207.19 Pb	83 208.98 Bi	84 210.00 Po	85 209.99 At	86 222.02 Rn

**Organic Compounds** contain **carbon** and are found in **living organisms**.

Some examples include:



Some exceptions are:

CO oxides of carbon      CO<sub>2</sub>      CO<sub>3</sub><sup>2-</sup> carbonates

HCO<sub>3</sub><sup>-</sup> hydrogen carbonates      CaCO<sub>3</sub>      Na<sub>2</sub>CO<sub>3</sub>

Resources used:

Kent, M. *Advanced Biology*. Oxford University Press, 2000.

Allott, A & Minderoff, D. *Biology Course Companion*. Oxford University Press, 2007.

Designed for the IB Biology course by Stephen Taylor

More resources: <http://ib-biology.net>  
Twitter: @BiologyStephen

Some elements are used universally in nature—though their uses can be diverse.

<p>7 N nitrogen</p> <ul style="list-style-type: none"> <li>Amino group of amino acids (the monomers of proteins)</li> <li>Also used in chlorophyll.</li> </ul>	<p>16 S sulphur</p> <ul style="list-style-type: none"> <li>Source of energy for chemosynthetic bacteria in hydrothermal vents.</li> <li>Found in the R-Group of cysteine, an amino acid, and can form disulfide bridges in protein folding.</li> </ul>	<p>11 Na sodium</p> <ul style="list-style-type: none"> <li>Generate resting and action potentials in neurons.</li> <li>Used in maintaining osmosis. Sodium is the main cation (positive ion) in blood plasma, potassium in cytoplasm.</li> <li>Sodium-potassium pump is an example of active transport</li> </ul>
<p>26 Fe iron</p> <ul style="list-style-type: none"> <li>Has a high affinity for oxygen</li> <li>Used in hemoglobin and myoglobin to carry oxygen in blood and muscles</li> <li>Used in ferredoxin in photosynthesis</li> <li>electron carrier in some bacteria</li> </ul>	<p>15 P phosphorous</p> <ul style="list-style-type: none"> <li>Phospholipids make up the plasma membrane.</li> <li>Sugar-phosphate backbone of DNA structure.</li> <li>Bonds between phosphate ions store energy in ATP.</li> </ul>	<p>19 K potassium</p> <ul style="list-style-type: none"> <li>Extracellular component of bone matrix</li> <li>Forms exoskeletons</li> <li>Stimulates synaptic transmission between neurons</li> <li>Used in muscle contraction</li> </ul>

Condensation reactions create bonds between organic molecules, making **polymers**.

Hydrolysis reactions break bonds.

example:

amino acids (monomers)

hydrolysis      condensation

hydrolyase used      polymerase used

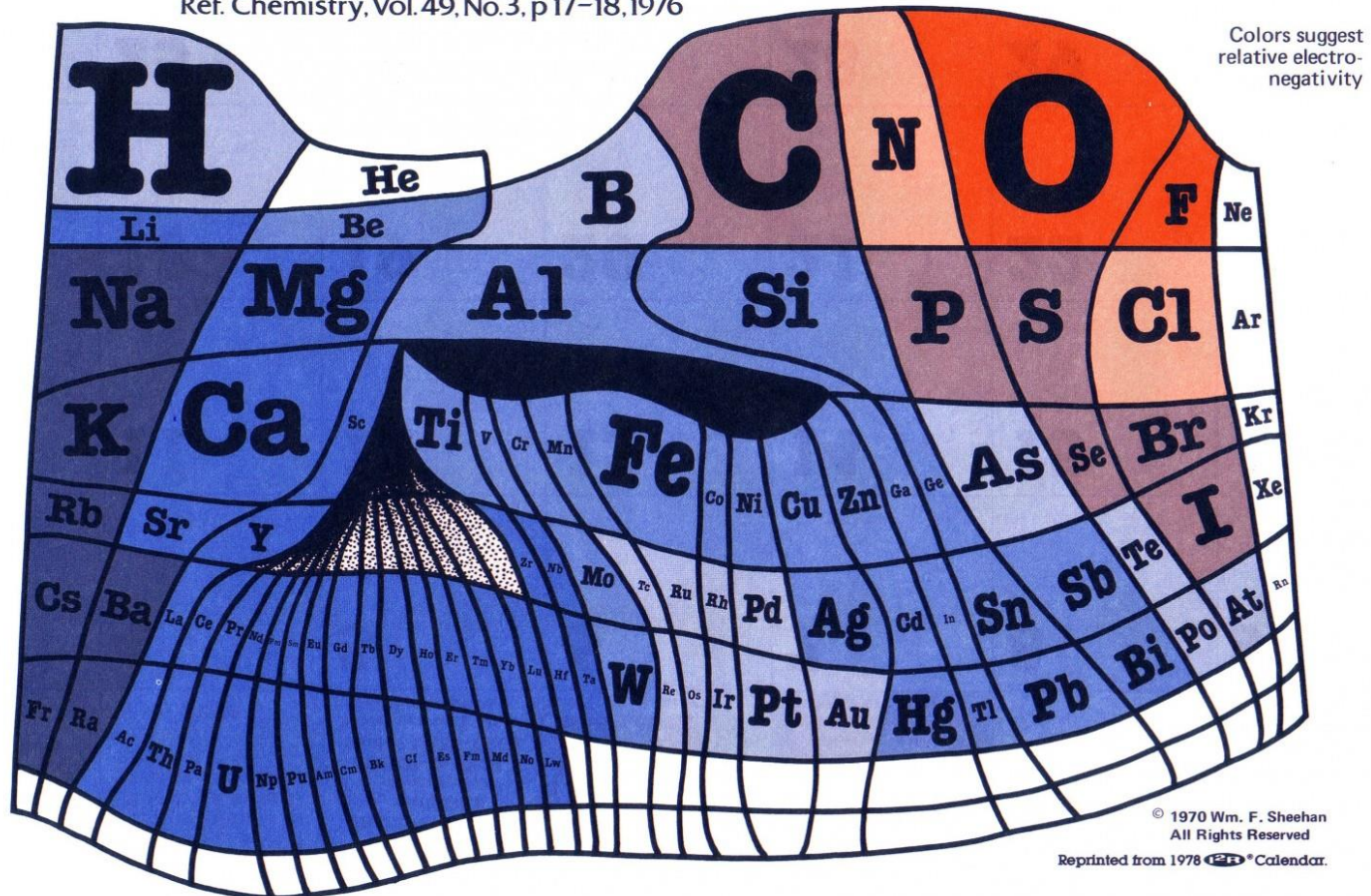
water in      water out

dipeptide (polymer)

# The Periodic Table has broad implications in Geology

## The Elements According to Relative Abundance

A Periodic Chart by Prof. Wm. F. Sheehan, University of Santa Clara, CA 95053  
Ref. Chemistry, Vol. 49, No. 3, p 17-18, 1976



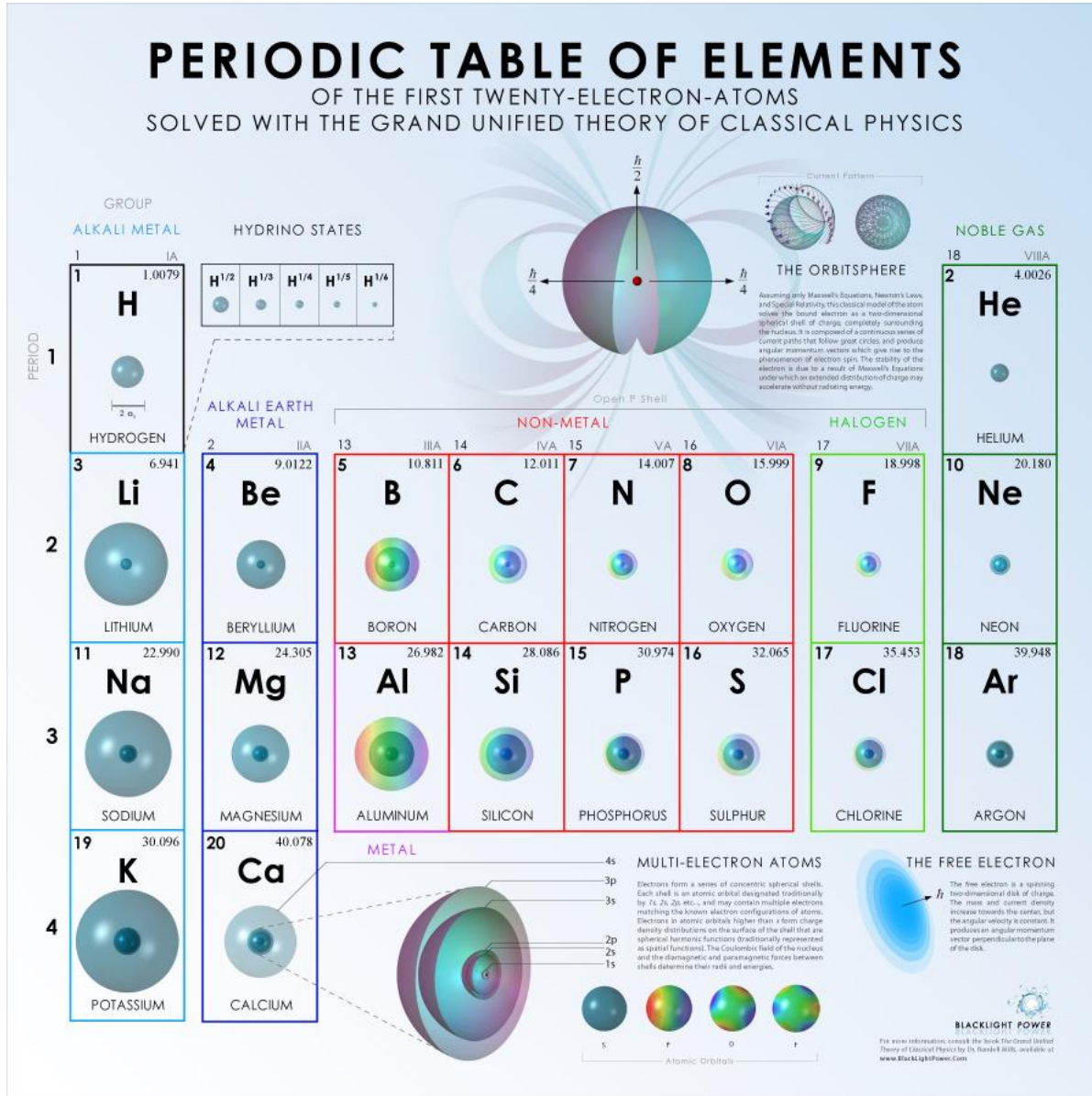
Roughly, the size of an element's own niche ("I almost wrote square") is proportioned to its abundance on Earth's surface, and in addition, certain chemical similarities (e.g., Be and Al, or B and Si) are sug-

gested by the positioning of neighbors. The chart emphasizes that in real life a chemist will probably meet O, Si, Al, . . . and that he better do something about it. Periodic tables based upon elemental abundance would, of course, vary from planet to planet. . . W.F.S.

NOTE: TO ACCOMMODATE ALL ELEMENTS SOME DISTORTIONS WERE NECESSARY, FOR EXAMPLE SOME ELEMENTS DO NOT OCCUR NATURALLY.



# The Periodic Table has broad implications in Physics



# The Periodic Table has also implications in Mathematics

## Mathematical Expression of Mendeleev's Periodic Law

By Valery Tsimmerman

February 15, 2012

Mendeleev's dream of finding mathematical expression of his Periodic Law has finally come true. Here it is:

$$\text{Periodic Law: } Z=A+g$$

Where **A** represents atomic numbers of alkaline earth metals that can be expressed by following formula:

$$A = \left( \frac{p^3 + 3p^2 + 2p}{6} \right) \left| \cos \frac{p\pi}{2} \right| + \left( \frac{p^3 + 3p^2 + 5p + 3}{6} \right) \left| \sin \frac{p\pi}{2} \right|$$

and **g** is an integer representing groups of elements that has following boundaries:  $(1 - L) \leq g \leq 0$

Term **L** represents period lengths and can be found from the following formula:

$$L = \left( \frac{p^2}{2} \right) \left| \cos \frac{p\pi}{2} \right| + \left( \frac{p^2 + 2p + 1}{2} \right) \left| \sin \frac{p\pi}{2} \right| \quad \text{representing period lengths.}$$

Term  $p=1,2,3,4,\dots$  represents periods in all formulae.

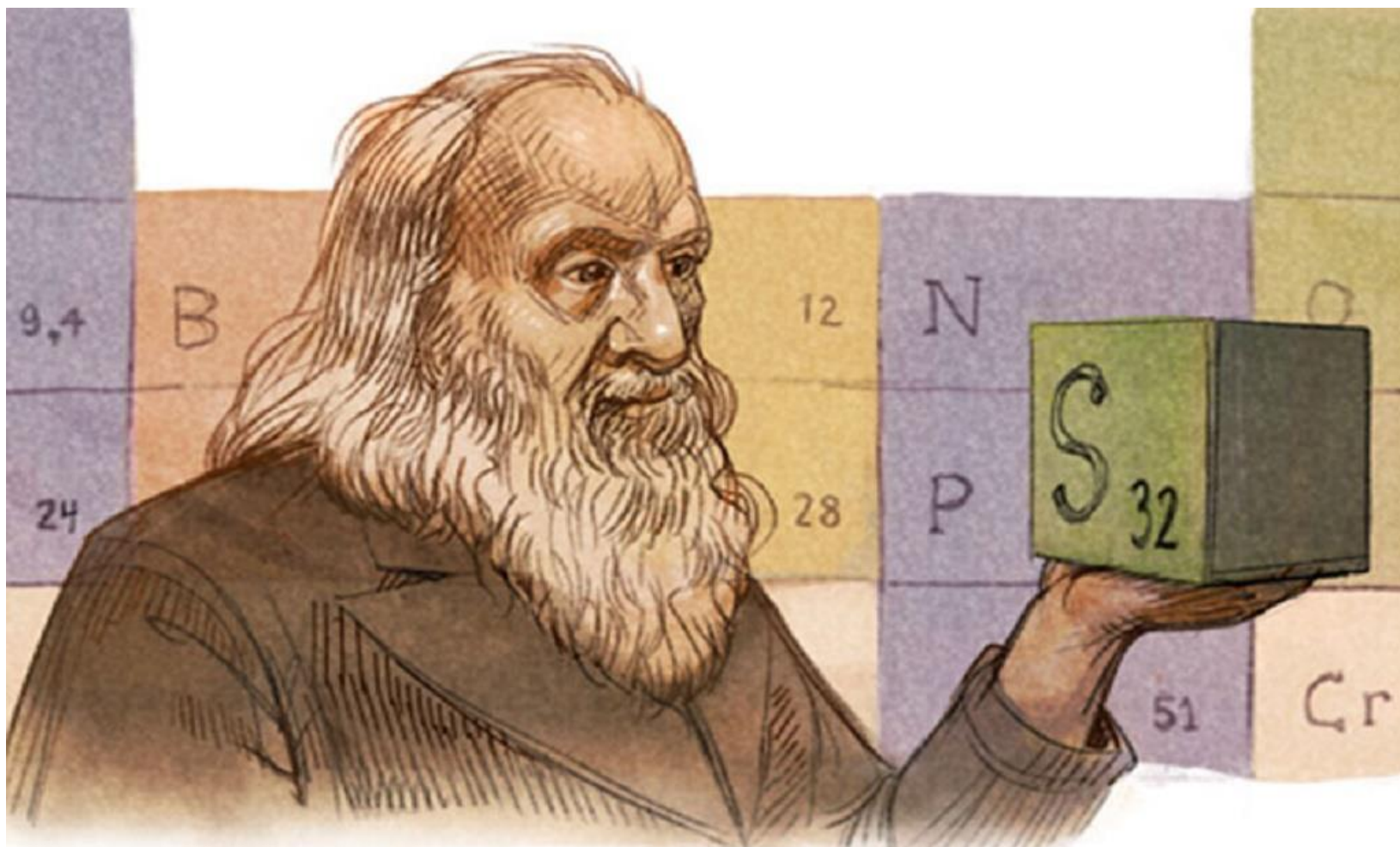
Formula  $Z=A+g$  assigns He(2) with Alkaline Earth metals. Helium could be treated as a special case and assigned with noble gases if lower boundary of term **g** was violated:  $g=(-L)$  for  $p=2$ . Similarly, Mg could be placed next to Zn if  $g=(-L)$  and  $p=4$ . Therefore, placing Helium in the same group with Ne, Ar, Kr, etc. is an example of a special case that can be regarded as Periodic Law violation.

Conclusion:

All groups and periods of the periodic system of chemical elements can be mathematically recreated by solving the above equations for  $p=1,2,3,\dots$

Valery Tsimmerman

Date: 02/14/2012



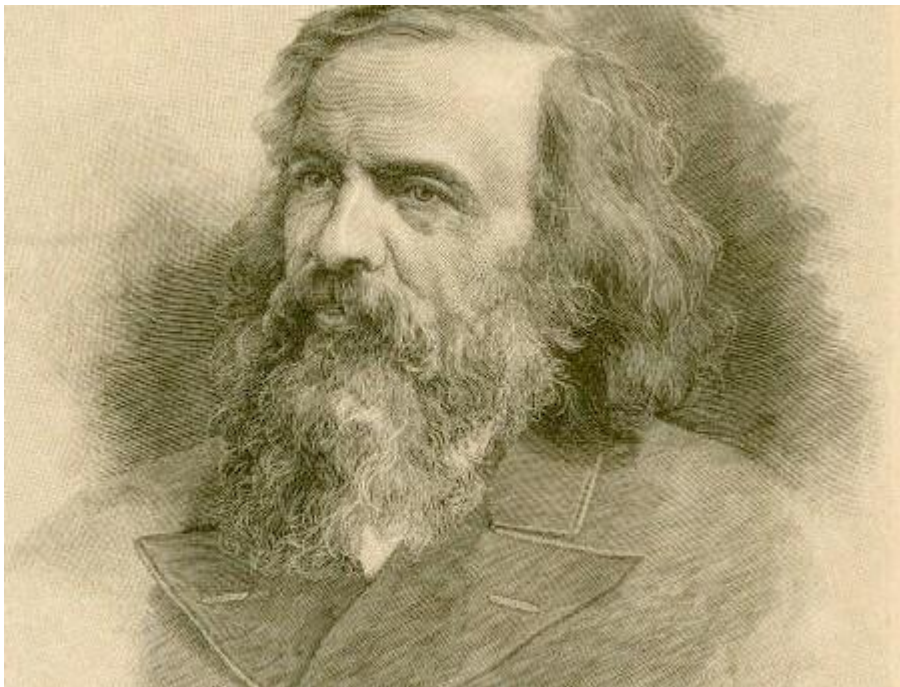
**Dmitry Mendeleev is considered the father of the Periodic Table (at the beginning called Periodic System)**



# Dmitry Mendeleev

- He was born on February 8, 1834 in Verkhnie Aremzyani, in the Russian province of Siberia
- In 1856 he was awarded a master's degree in chemistry at the University of St. Petersburg
- He spent most of the years 1859 and 1860 in Heidelberg, Germany, where he had the good fortune to work for a short time with Robert Bunsen at Heidelberg University
- In 1864 he became professor of Technical Chemistry at St. Petersburg University
- In 1867 he was transferred to the professorship of General Chemistry at St. Petersburg University
- In 1869 he published the first version of his Periodic table
- He died on February 2, 1907 in Saint Petersburg, killed by influenza

At his funeral in St. Petersburg, his students carried a large copy of the Periodic Table of the elements as a tribute to his work



Dmitry Mendeleev is considered the father of the Periodic Table (at the beginning called Periodic System)

Historical and Public Figures Collection  
New York Public Library Archives

The construction of the Periodic Table required time and the involvement of several scientists

# 1836: Berzelius' Electronegativity Table

## Electrochemische Theorie.

Sauerstoff,	Palladium,
Schwefel,	Quecksilber,
Stickstoff,	Silber,
Fluor,	Kupfer,
Chlor,	Uran,
Brom,	Wismuth,
Jod,	Zinn,
Selen,	Blei,
Phosphor,	Cadmium,
Arsenik,	Kobalt,
Chrom,	Nickel,
Vanadium,	Eisen,
Molybdän,	Zink,
Wolfram,	Mangan,
Bor,	Cerium,
Kohlenstoff,	Thorium,
Antimon,	Zirconium,
Tellur,	Aluminium,
Tantal,	Yttrium,
Titan,	Beryllium,
Kiesel,	Magnesium,
Wasserstoff.	Calcium,
	Strontium,
	Barium,
Gold,	Lithium,
Osmium,	Natrium,
Iridium,	Kalium.
Platin,	
Rhodium,	



# 1843: Gmelin's System

		O		N		H			
F	Cl	Br	I			Li	Na	K	
	S	Se	Te			Mg	Ca	Sr	Ba
	P	As	Sb			Be	Ce	La	
	C	B	Bi			Zr	Th	Al	
		Ti	Ta	W		Sn	Cd	Zn	
			Mo	V	Cr	U	Mn	Ni	Fe
				Bi	Pb	Ag	Hg	Cu	
			Os	Ir	Rh	Pt	Pd	Au	

# 1850: Dobereiner's Triads

Johann Dobereiner found 'triads', namely sequences of three similar elements, where the middle element has a mass equal to the average of the least and most massive

Atomic Mass (1850)

Li	7	} → $\frac{7 + 39}{2} = 23$
Na	23	
K	39	
Ca	40	} → $\frac{40 + 137}{2} = 88.5$
Sr	87	
Ba	137	
P	31	} → $\frac{31 + 122}{2} = 76.5$
As	75	
Sb	122	
S	32	} → $\frac{32 + 128}{2} = 80$
Se	78	
Te	128	
Cl	35.5	} → $\frac{35.5 + 127}{2} = 81.25$
Br	80	
I	127	

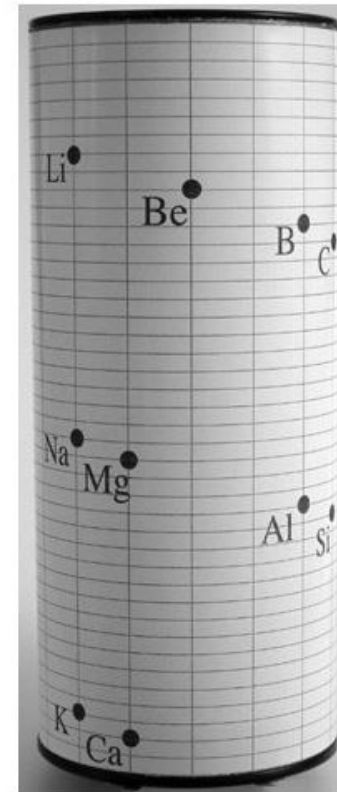
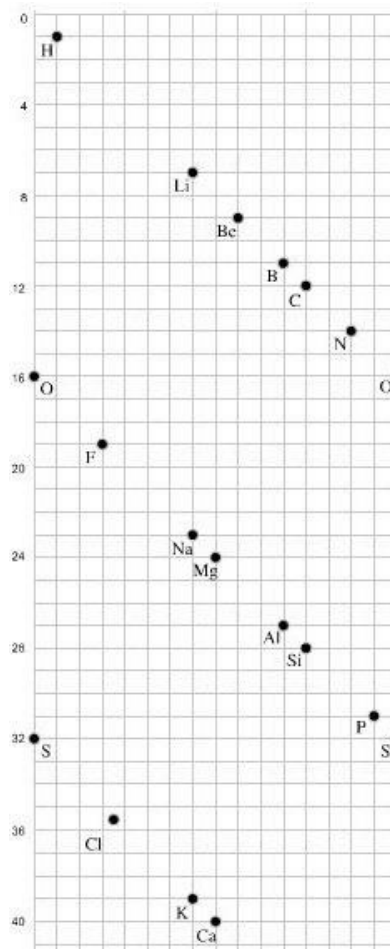
Atomic Number

Li	3	} → $\frac{3 + 19}{2} = 11$
Na	11	
K	19	
Ca	20	} → $\frac{20 + 56}{2} = 38$
Sr	38	
Ba	56	
P	15	} → $\frac{15 + 51}{2} = 33$
As	33	
Sb	51	
S	16	} → $\frac{16 + 52}{2} = 34$
Se	34	
Te	52	
Cl	17	} → $\frac{17 + 53}{2} = 35$
Br	35	
I	53	

H						He	
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn

# 1862: Alexandre-Émile Béguyer de Chancourtois

The first attempt to make use of atomic weights to produce a classification of periodicity. He drew the elements as a continuous spiral around a metal cylinder divided into 16 parts. Tellurium was situated at the centre, prompting *vis tellurique*, or *telluric helix*





# 1862: Meyer's Table

Lothar Meyer devised a partial periodic table consisting of 28 elements arranged in order of increasing atomic weight in which the elements were grouped into vertical columns according to their chemical valences

*Eric Scerri: The Periodic Table: A Very Short Introduction*

	4 werthig	3 werthig	2 werthig	1 werthig	1 werthig	2 werthig
	---	--	---	---	Li = 7.03	(Be = 9.3?)
Differenz =	---	---	---	---	16.02	(14.7)
	C = 12.0	N = 14.04	O = 16.00	Fl = 19.0	Na = 23.05	Mg = 24.0
Differenz =	16.5	16.96	16.07	16.46	16.08	16.0
	Si = 28.5	P = 31.0	S = 32.07	Cl = 35.46	K = 39.13	Ca = 40.0
Differenz =	$\frac{89.1}{2} = 44.55$	44.0	46.7	44.51	46.3	47.6
	---	As = 75.0	Se = 78.8	Br = 79.97	Rb = 85.4	Sr = 87.6
Differenz =	$\frac{89.1}{2} = 44.55$	45.6	49.5	46.8	47.6	49.5
	Sn = 117.6	Sb = 120.6	Te = 128.3	I = 126.8	Cs = 133.0	Ba = 137.1
Differenz =	89.4 = 2 x 44.7	87.4 = 2 x 43.7	---	---	(71 = 2 x 35.5)	---
	Pb = 207.0	Bi = 208.0	---	---	(Tl = 204?)	---

# 1864: Newland's Octaves

Newland noticed that if he broke up his list of elements (arranged by atomic weight) into groups of seven - starting a new row with the eighth element - the first element in each of those groups had similar chemistry

H Li Be B C N O F Na Mg Al Si P S Cl

Cl K Ca Cr Ti Mn Fe Cobalt/Nickel something is wrong! Al Si P S Cl

Mendeleev was said to have been inspired by the card game known as solitaire, and "patience"



The Mendeleev's study located in the Twelve Collegia building of St. Petersburg State University

Mendeleev said:

I saw in a dream a table where all the elements fell into place as required. Awakening, I immediately wrote it down on a piece of paper



The Periodic Table was also born for didactic reasons  
Mendeleev was convinced that the difficulty in understanding chemistry was the lack of any clear system for classifying the known elements:  
“Without one, only particulars about specific building blocks of matter can be offered to the students, but no framework that would explain the relationships between different substances”

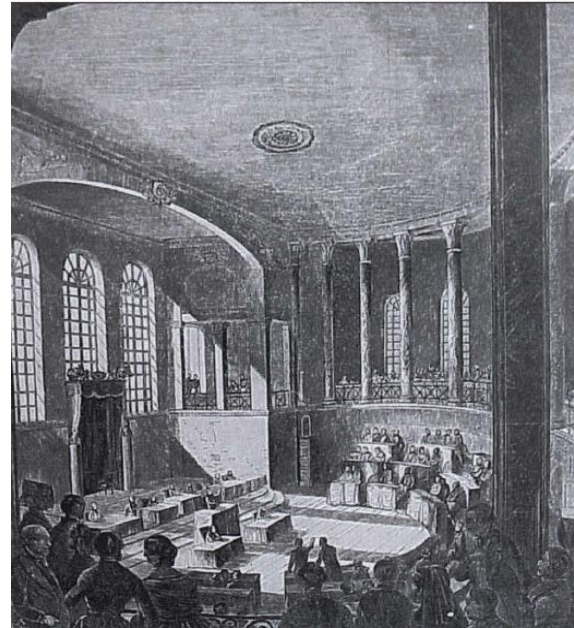


Some Mendeleev's Chemistry books

**Mendeleev's participation in the First International Chemistry Congress held in September 1860 at Karlsruhe (Germany), where he met Cannizzaro, was of fundamental importance for his work of constructing the Periodic Table**



**Ständehaus (right) where the Chemical Congress of 1860 was held**



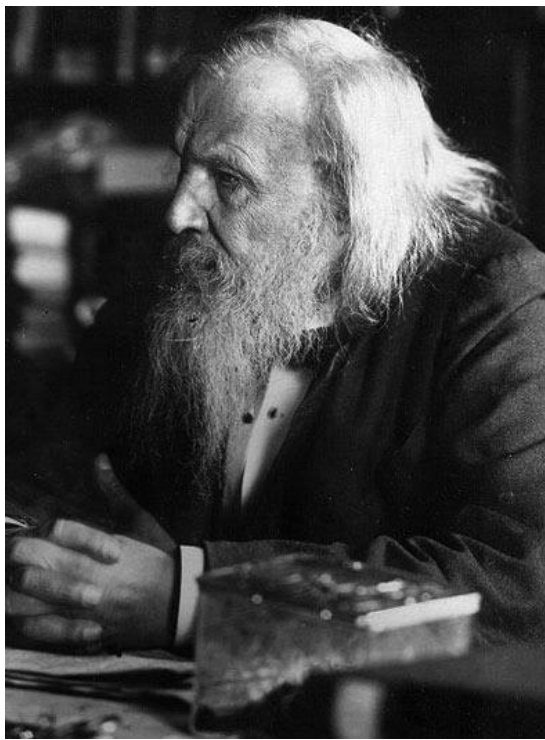
**The meeting hall where the Chemical Congress of 1860 was held**



## Dmitry Mendeleev is considered the father of the Periodic Table

He used the table to accurately predict the existence and properties of unknown elements. For example, Mendeleev used his table to predict an element one row down from silicon. He denoted this with Sanskrit digit for "1" ("eka") and thus named the element "ekasilicon." The properties he predicted would eventually be proved to be incredibly accurate, and we now know this substance as "germanium."





## Dmitry Mendeleev is considered the father of the Periodic Table

In devising his table, Mendeleev did not conform completely to the order of atomic mass: he swapped some elements around

Although he was unaware of it, Mendeleev had actually placed the elements in order of increasing "atomic number"



# 1871: Mendeleev's Table II

Reihen	Gruppe I. — R <sup>0</sup>	Gruppe II. — R <sup>0</sup>	Gruppe III. — R <sup>0</sup> <sup>3</sup>	Gruppe IV. RH <sup>4</sup> R <sup>0</sup> <sup>2</sup>	Gruppe V. RH <sup>5</sup> R <sup>0</sup> <sup>3</sup>	Gruppe VI. RH <sup>6</sup> R <sup>0</sup> <sup>3</sup>	Gruppe VII. RH R <sup>0</sup> <sup>7</sup>	Gruppe VIII. — R <sup>0</sup> <sup>4</sup>
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	—
9	(—)	—	—	—	—	—	—	—
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	—
12	—	—	—	Th=231	—	U=240	—	—

# 1871: Mendeleev's Table II

Естественная система элементовъ Д. Менделѣева.

Периодъ	Группы I-VIII								II=I HX		
	Группа I	Группа II	Группа III	Группа IV	Группа V	Группа VI	Группа VII	Группа VIII (переходъ къ I)			
Высшій окиселъ образующій соли:	R <sup>o</sup> H=1 H <sup>o</sup> , NH, HCl, H <sup>o</sup> N, H <sup>o</sup> C, ROH.	R <sup>o</sup> O <sup>2</sup> или RO	R <sup>o</sup> O <sup>3</sup>	R <sup>o</sup> O <sup>4</sup> или RO <sup>2</sup>	R <sup>o</sup> O <sup>5</sup>	R <sup>o</sup> O <sup>6</sup> или RO <sup>3</sup>	R <sup>o</sup> O <sup>7</sup>	R <sup>o</sup> O <sup>8</sup> или RO <sup>4</sup>			
Типичес. Рядъ	Li=7 LiCl, LiOH, Li <sup>2</sup> O, LiX, Li <sup>2</sup> CO <sup>2</sup>	Be=9, <sup>1</sup> BeCl, BeO, Be <sup>2</sup> Al <sup>3</sup> Si <sup>4</sup> O <sup>10</sup>	B=11 BCl, B <sup>2</sup> O <sup>3</sup> , B <sup>2</sup> N <sup>3</sup> , B <sup>2</sup> Na <sup>2</sup> O, BF <sup>3</sup>	C=12 CH <sup>4</sup> , C <sup>2</sup> H <sup>4</sup> , C <sup>2</sup> H <sup>2</sup> , CO, CO <sup>2</sup> , CO <sup>2</sup> M <sup>2</sup>	N=14 NH <sup>3</sup> , NH <sup>4</sup> Cl, N <sup>2</sup> O, <sup>Δ</sup> NO, NO <sup>2</sup> , N <sup>2</sup> M, CNM.	O=16 OH, H <sup>2</sup> O, O <sup>2</sup> , O <sup>3</sup> , OM <sup>2</sup> O <sup>2</sup> R, HO <sup>2</sup> R.	F=19 FH, BF, SiF <sup>4</sup> , CaF <sup>2</sup> , KF, KHF <sup>2</sup> .	* Тѣло твердое, малорастворимое въ водѣ. Δ Тѣло газообразное или летучее. M=K, Ag, ... M <sup>2</sup> =Ca, Pb, ... X=Cl, ONO, OH, OM, ... X <sup>2</sup> =SO, CO <sup>2</sup> , O <sup>2</sup> , S, ...			
Рядъ 1.	Na=23 NaCl, NaHO, Na <sup>2</sup> O, Na <sup>2</sup> SO <sup>4</sup> , Na <sup>2</sup> CO <sup>3</sup>	Mg=24 MgCl, MgO, MgCO <sup>2</sup> , MgSO <sup>4</sup> , MgNH <sup>2</sup> PO <sup>4</sup>	Al=27, <sup>3</sup> Al <sup>3</sup> Cl, Al <sup>3</sup> O <sup>2</sup> , KAIS <sup>2</sup> O <sup>2</sup> 12H <sup>2</sup> O.	Si=28 SH, SiCl, SiH <sup>4</sup> , <sup>+</sup> KAIS <sup>2</sup> O <sup>2</sup> SiO <sup>2</sup>	P=31 PH, PCl, PCl <sup>3</sup> , P <sup>2</sup> O <sup>3</sup> , P <sup>2</sup> O <sup>5</sup> , Ca <sup>3</sup> P <sup>2</sup> O <sup>7</sup>	S=32 SH, SM, S <sup>2</sup> M, <sup>1</sup> SO, SO <sup>2</sup> , X, Ba <sup>2</sup> SO <sup>4</sup>	Cl=35, <sup>5</sup> ClH, ClM, ClCl, ClOH, ClO <sup>2</sup> H, AgCl.				
Рядъ 2.	K=39 KCl, KOH, K <sup>2</sup> O, KNO <sup>3</sup> , K <sup>2</sup> PcCl <sup>2</sup> , K <sup>2</sup> SiF <sup>6</sup>	Ca=40 CaSO <sup>4</sup> , CaO, CaCO <sup>2</sup> , CaCl, CaO, CaCO <sup>2</sup>	744—Eh <sup>7</sup>	Ti=48(50) <sup>7</sup> TiCl, TiO <sup>2</sup> , Ti <sup>2</sup> O <sup>3</sup> , FeTiO <sup>2</sup> , TiOSO <sup>4</sup>	V=51 VOCl, V <sup>2</sup> O <sup>3</sup> , VO <sup>2</sup> , Pb <sup>2</sup> V <sup>2</sup> O <sup>7</sup> , VO <sup>2</sup>	Cr=52 CrCl <sup>2</sup> , CrCl <sup>3</sup> , Cr <sup>2</sup> O <sup>3</sup> , CrO <sup>2</sup> , K <sup>2</sup> CrO <sup>4</sup> , Cr <sup>2</sup> O <sup>3</sup> Cl <sup>2</sup>	Mn=55 MnK <sup>2</sup> O, MnKO <sup>2</sup> , MnCl, MnO, MnO <sup>2</sup>	Fe=56 FeK <sup>2</sup> O, FeS <sup>2</sup> , FeO, Fe <sup>2</sup> O <sup>3</sup> , FeK <sup>2</sup> Cy <sup>2</sup>	Co=59 CoX, CoX <sup>2</sup> , CoX <sup>2</sup> 5NH <sup>2</sup> , CoK <sup>2</sup> Cy <sup>2</sup>	Ni=59 NiX, NiO <sup>2</sup> , NiSO <sup>4</sup> 5H <sup>2</sup> O, NiK <sup>2</sup> Cy <sup>2</sup>	Cu=63 CuX, CuX <sup>2</sup> , CuH <sup>2</sup> , Cu <sup>2</sup> O, CuO <sup>2</sup> , CuKCy <sup>2</sup>
Рядъ 3.	Cu=63 CuX, CuX <sup>2</sup>	Zn=65 ZnCl, ZnO, ZnCO <sup>2</sup> , ZnSO <sup>4</sup> , ZnEt <sup>2</sup>	768—EIP	772—Es <sup>7</sup> , 71E, Es <sup>2</sup>	As=75 AsH <sup>3</sup> , AsCl, As <sup>2</sup> O <sup>3</sup> , As <sup>2</sup> O <sup>5</sup> , As <sup>2</sup> S <sup>2</sup>	Se=78 SeH <sup>2</sup> , SeO, SeO <sup>2</sup> , SeM <sup>2</sup> , SeM <sup>3</sup> O <sup>3</sup>	Br=80 BrH, BrM, BrO <sup>2</sup> M, BrAg <sup>2</sup>	Ru=104 RuO, RuCl <sup>2</sup> , RuO, RuCl <sup>2</sup> , RuO, RuCl <sup>2</sup>	Rh=104 RhCl, RhCl <sup>2</sup> , Rh <sup>2</sup> O, RhX <sup>2</sup> , RhK <sup>2</sup> Cy <sup>2</sup>	Pd=106 PdH, PdO, PdI, PdCl <sup>2</sup> , PdK <sup>2</sup> Cy <sup>2</sup>	Ag=108 AgNO <sup>2</sup> , AgX, AgCl, Ag <sup>2</sup> O, AgKCy <sup>2</sup>
Рядъ 4.	Rb=85 RbCl, RbOH, Rb <sup>2</sup> PcCl <sup>2</sup>	Sr=87 SrCl, SrO, SrH <sup>2</sup> O <sup>2</sup> , SrSO <sup>4</sup> , SrCO <sup>2</sup>	788—YI(92), 7YI <sup>2</sup> O <sup>2</sup> , YIX <sup>2</sup>	Zr=90 ZrCl, ZrO <sup>2</sup> , ZrX <sup>2</sup>	Nb=94 NbCl, Nb <sup>2</sup> O <sup>3</sup> , Nb <sup>2</sup> O <sup>5</sup> , NbOK <sup>2</sup> F <sup>2</sup>	Mo=96 MoCl, MoS <sup>2</sup> , MoO <sup>2</sup> , M <sup>2</sup> Mo <sup>2</sup> O <sup>2</sup> nMo <sup>2</sup> O <sup>2</sup>	100	Ru=104 RuO, RuCl <sup>2</sup> , RuO, RuCl <sup>2</sup> , RuK <sup>2</sup> Cy <sup>2</sup>	Rh=104 RhCl, RhCl <sup>2</sup> , Rh <sup>2</sup> O, RhX <sup>2</sup> , RhK <sup>2</sup> Cy <sup>2</sup>	Pd=106 PdH, PdO, PdI, PdCl <sup>2</sup> , PdK <sup>2</sup> Cy <sup>2</sup>	Ag=108 AgNO <sup>2</sup> , AgX, AgCl, Ag <sup>2</sup> O, AgKCy <sup>2</sup>
Рядъ 5.	Ag=108 AgX, AgCl <sup>2</sup>	Cd=112 CdCl, CdO, CdS, CdSO <sup>4</sup>	In=113 InCl, In <sup>2</sup> O <sup>2</sup>	Sn=118 SnCl, SnCl <sup>2</sup> , SnO <sup>2</sup> , SnX <sup>2</sup> , SnNa <sup>2</sup> O <sup>2</sup>	Sb=122 SbH, SbCl, Sb <sup>2</sup> O <sup>3</sup> , Sb <sup>2</sup> O <sup>5</sup> , Sb <sup>2</sup> S <sup>2</sup> , SbOX	Te=125(128) <sup>7</sup> TeH, TeCl, TeO <sup>2</sup> , TeO <sup>2</sup> M <sup>2</sup> , TeM <sup>2</sup>	127 IH, IAg, IHO <sup>2</sup> , IHO <sup>2</sup> , HgI, KI				
Рядъ 6.	Cs=133 CsCl, CsOH, Cs <sup>2</sup> PcCl <sup>2</sup>	Ba=137 BaCl, BaH <sup>2</sup> O, BaO, BaSO <sup>4</sup> , BaSiF <sup>6</sup>	7188—La <sup>7</sup> —Df(144), 7La <sup>2</sup> O <sup>2</sup> , LaX <sup>2</sup>	Ce=140(138) <sup>7</sup> CeCl, Ce <sup>2</sup> O <sup>2</sup> , CeO <sup>2</sup> , CeX <sup>2</sup> , CeX <sup>2</sup> , CeK <sup>2</sup> X <sup>2</sup>	142	146	148	150	151	152	153
Рядъ 7.	153	158	160	162	164	166	168				
Рядъ 8.	175	177	717—Er(109), 7Er <sup>2</sup> O <sup>2</sup> , ErX <sup>2</sup>	7180—Df—La(187), 7DfO <sup>2</sup> , DfX <sup>2</sup>	Ta=182 TaCl, Ta <sup>2</sup> O <sup>2</sup> , Tak <sup>2</sup> F <sup>2</sup>	W=184 WCl, WCl <sup>2</sup> , WO <sup>2</sup> , K <sup>2</sup> WO <sup>2</sup> , nWO <sup>2</sup>	190	Os=193 OsO, OsH <sup>2</sup> O <sup>2</sup> , OsCl, OsCl <sup>2</sup> , OsK <sup>2</sup> Cy <sup>2</sup>	198 <sup>7</sup> Ir=195 K <sup>2</sup> IrCl <sup>2</sup> , IrCl, IrCl <sup>2</sup> , Ir <sup>2</sup> O <sup>2</sup> , IrK <sup>2</sup> Cy <sup>2</sup>	Pt=197 PtCl, PtO <sup>2</sup> , PtCl <sup>2</sup> , Pt <sup>2</sup> X <sup>2</sup> , PtK <sup>2</sup> Cy <sup>2</sup>	Au=197 AuCl, AuCl <sup>2</sup> , Au <sup>2</sup> O <sup>2</sup> , Au <sup>2</sup> O, AuKCy <sup>2</sup>
Рядъ 9.	Au=197 AuX, AuX <sup>2</sup>	Hg=200 HgCl, HgCl <sup>2</sup> , Hg <sup>2</sup> O <sup>2</sup> , HgO, HgX <sup>2</sup> , nHgO	Tl=204 TlCl, Tl <sup>2</sup> O, Tl <sup>2</sup> O <sup>2</sup> , Tl <sup>2</sup> SO <sup>4</sup> , TlCl <sup>3</sup>	Pb=207 PbCl, PbO, PbO <sup>2</sup> , PbEt <sup>2</sup> , PbSO <sup>4</sup> , PbK <sup>2</sup> O <sup>2</sup> , BiX <sup>2</sup> , BiOX, BiNO <sup>2</sup> (HO) <sup>2</sup>	210	212					
Рядъ 10.	220	225	227	Th=231 ThCl, Th <sup>2</sup> O, ThX <sup>2</sup> , ThSO <sup>4</sup>	235	U=240 UCl, UO <sup>2</sup> , UO <sup>2</sup> X <sup>2</sup> , UO <sup>2</sup> M <sup>2</sup> O <sup>2</sup>	245	246	248	249	250

Chemical Heritage Foundation



# Scientists continued and still continue to adjust the Periodic Table as new elements are found and/or created

IUPAC Periodic Table of the Elements

1 <b>H</b> hydrogen 1.008 [1.0078, 1.0082]																	2 <b>He</b> helium 4.0026
3 <b>Li</b> lithium 6.94 [6.938, 6.997]	4 <b>Be</b> beryllium 9.0122	Key: atomic number <b>Symbol</b> name conventional atomic weight standard atomic weight										13 <b>B</b> boron 10.81 [10.806, 10.821]	14 <b>C</b> carbon 12.011 [12.009, 12.012]	15 <b>N</b> nitrogen 14.007 [14.006, 14.008]	16 <b>O</b> oxygen 15.999 [15.999, 16.000]	17 <b>F</b> fluorine 18.998	18 <b>Ne</b> neon 20.180
11 <b>Na</b> sodium 22.990	12 <b>Mg</b> magnesium 24.305 [24.304, 24.307]	3	4	5	6	7	8	9	10	11	12	13 <b>Al</b> aluminium 26.982	14 <b>Si</b> silicon 28.085 [28.084, 28.086]	15 <b>P</b> phosphorus 30.974	16 <b>S</b> sulfur 32.06 [32.059, 32.076]	17 <b>Cl</b> chlorine 35.45 [35.446, 35.457]	18 <b>Ar</b> argon 39.948
19 <b>K</b> potassium 39.098	20 <b>Ca</b> calcium 40.078(4)	21 <b>Sc</b> scandium 44.956	22 <b>Ti</b> titanium 47.867	23 <b>V</b> vanadium 50.942	24 <b>Cr</b> chromium 51.996	25 <b>Mn</b> manganese 54.938	26 <b>Fe</b> iron 55.845(2)	27 <b>Co</b> cobalt 58.933	28 <b>Ni</b> nickel 58.693	29 <b>Cu</b> copper 63.546(3)	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.723	32 <b>Ge</b> germanium 72.630(8)	33 <b>As</b> arsenic 74.922	34 <b>Se</b> selenium 78.971(8)	35 <b>Br</b> bromine 79.904 [79.901, 79.907]	36 <b>Kr</b> krypton 83.798(2)
37 <b>Rb</b> rubidium 85.468	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.906	40 <b>Zr</b> zirconium 91.224(2)	41 <b>Nb</b> niobium 92.906	42 <b>Mo</b> molybdenum 95.95	43 <b>Tc</b> technetium	44 <b>Ru</b> ruthenium 101.07(2)	45 <b>Rh</b> rhodium 102.91	46 <b>Pd</b> palladium 106.42	47 <b>Ag</b> silver 107.87	48 <b>Cd</b> cadmium 112.41	49 <b>In</b> indium 114.82	50 <b>Sn</b> tin 118.71	51 <b>Sb</b> antimony 121.76	52 <b>Te</b> tellurium 127.60(3)	53 <b>I</b> iodine 126.90	54 <b>Xe</b> xenon 131.29
55 <b>Cs</b> caesium 132.91	56 <b>Ba</b> barium 137.33	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.49(2)	73 <b>Ta</b> tantalum 180.95	74 <b>W</b> tungsten 183.84	75 <b>Re</b> rhenium 186.21	76 <b>Os</b> osmium 190.23(3)	77 <b>Ir</b> iridium 192.22	78 <b>Pt</b> platinum 195.08	79 <b>Au</b> gold 196.97	80 <b>Hg</b> mercury 200.59	81 <b>Tl</b> thallium 204.38 [204.38, 204.39]	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 208.98	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	113 <b>Nh</b> nihonium	114 <b>Fl</b> flerovium	115 <b>Mc</b> moscovium	116 <b>Lv</b> livermorium	117 <b>Ts</b> tennessine	118 <b>Og</b> oganesson



57 <b>La</b> lanthanum 138.91	58 <b>Ce</b> cerium 140.12	59 <b>Pr</b> praseodymium 140.91	60 <b>Nd</b> neodymium 144.24	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.36(2)	63 <b>Eu</b> europium 151.96	64 <b>Gd</b> gadolinium 157.25(3)	65 <b>Tb</b> terbium 158.93	66 <b>Dy</b> dysprosium 162.50	67 <b>Ho</b> holmium 164.93	68 <b>Er</b> erbium 167.26	69 <b>Tm</b> thulium 168.93	70 <b>Yb</b> ytterbium 173.05	71 <b>Lu</b> lutetium 174.97
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.04	91 <b>Pa</b> protactinium 231.04	92 <b>U</b> uranium 238.03	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium

For notes and updates to this table, see [www.iupac.org](http://www.iupac.org). This version is dated 28 November 2016.  
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Its shape is used to order very different "things"

# The Periodic Table of Meat

1 B Bacon															2 H Hamburger						
3 P Pork chops	4 Bb Baby back ribs															5 Bk Blackened fish	6 Gf Grilled fish	7 Bf Baked fish	8 Ff Fried fish	9 Mb Meatballs	10 Sg Sausage
11 Pl Pork loin	12 Sr Spare ribs															13 Sh Sashimi	14 Im Shrimp	15 Sl Shellfish	16 Sq Squid	17 Ci Chili	18 Sj Sloppy joe
19 Cu Pork cutlet	20 Hh Hamhock	21 Ha Sliced ham	22 Ca Capicola	23 Cd Corned beef	24 Tp Beef tri-tip	25 Bs Beef sausage	26 R Beef ribs	27 Kb Kobe	28 Rt Pot roast	29 Cr Crab	30 Tu Tuna	31 Lb Lobster	32 Pg Chicken parmigiana	33 Tm Chicken tempura	34 Fg Chicken fingers	35 Ng Chicken nuggets	36 Fr Fried chicken				
37 Ro Pork roast	38 Cz Chorizo	39 Ch Christmas ham	40 Mr Mortadella	41 Rb Roast beef	42 He Head cheese	43 Td Beef tenderloin	44 S T-bone steak	45 Fm Filet Mignon	46 Sf Stroganoff	47 St Beef stew	48 Cb Chicken coq au vin	49 C Grilled chicken	50 Gt General Tso's chicken	51 Ty Teriyaki chicken	52 Jm Jamaican jerk	53 W Buffalo wings	54 Q BBQ chicken				
55 Pp Pulled pork	56 Ap Al pastor	57 Z Zungenwurst	58 Rs Prosciutto	59 Pm Pastrami	60 Cw Cow tongue	61 Pr Pepper steak	62 Tt Steak Tartare	63 Si Strip steak	64 Md Mandarin beef	65 Bt Brisket	66 Cs Chicken casserole	67 Re Robbiano chicken	68 Tr Tandoori	69 K Kabobs	70 Gb Gumbo	71 Sp Spam	72 Pe Pepperoni				
73 Gr Ground pork	74 Ct Carnitas	75 Fe Pig's feet	76 Pt Panostia	77 Gy Gyro	78 Fi Steak fingers	79 Sy Salisbury steak	80 Cf Chicken fried steak	81 Ry Ribeye	82 Sw Shawarma	83 J Beef jerky	84 D Duck	85 Th Thanksgiving turkey	86 T Sliced turkey	87 Sm Summer sausage	88 Bg Bologna	89 Lf Pimento loaf	90 Hd Hot dogs				
91 Bn Bison	92 Ek Elk	93 L Lamb	94 Go Goat	95 Kl Roadkill	96 Bh Bushmeat																
97 Dr Deer	98 Ra Rabbit	99 Wb Wild boar	100 O Ostrich	101 E Emu	102 G Gator																

Red Meat
  Seafood
  The Noble Meats

Cold Cuts
  Poultry
  Mixed

Steaks
  Gamey

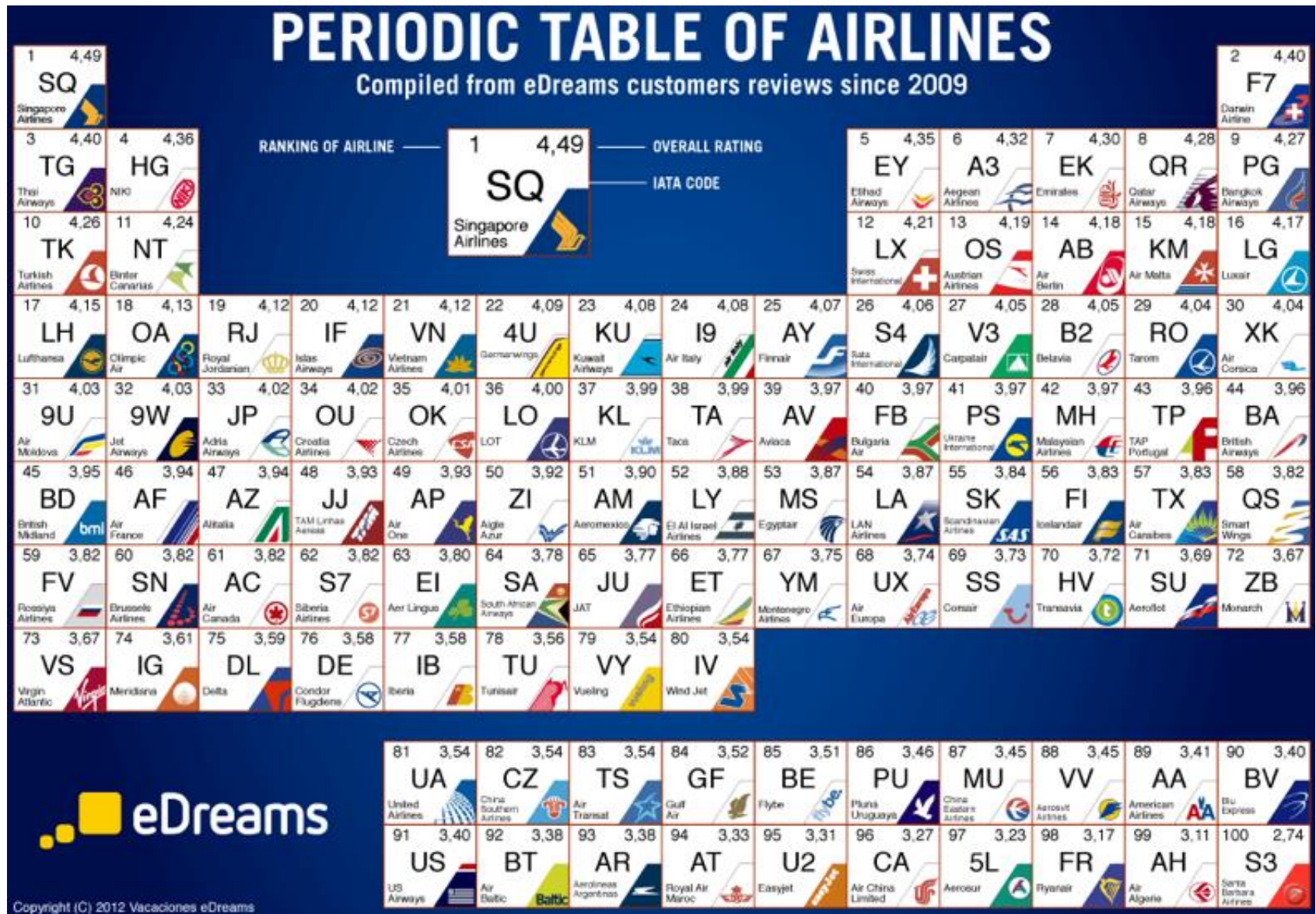
## Key Meat Facts:

- Bacon is the "meat of life." Without bacon, life on earth as we know it could not exist
- Noble Meats are named as such because they rate the highest on the Glanburg "Yumminess Scale." Lowest-ranking meats include Pig's feet, Spam and Roadkill
- Meats occur in two basic forms: boned and boneless
- Basic chemical formulas: H<sub>2</sub>B = Bacon Double Cheeseburger; ThReD = Turducken; HaRbT = Cold Cut Trio; HdQH = A Barbeque, FrCiB = Heart attack

91 Bn Bison	92 Ek Elk	93 L Lamb	94 Go Goat	95 Kl Roadkill	96 Bh Bushmeat
97 Dr Deer	98 Ra Rabbit	99 Wb Wild boar	100 O Ostrich	101 E Emu	102 G Gator



# Its shape is used to order very different "things"



# Various types of the Periodic Table

## The Non Scientist's Concept of the Periodic Chart of the Elements

by John T. Hortenstine, Jr.  
of R.W. Johnson Pharmaceutical Research Institute

<b>H</b> 1 Hydrogen in hydrogen bombs																	<b>He</b> 2 Helium in party balloons
<b>Na</b> 11 Sodium in table salt	<b>Mg</b> 12 Magnesium in stomach medicine											<b>C</b> 6 Carbon diamonds "a girl's best friend"	<b>N</b> 7 Nitrogen in fertilizer	<b>O</b> 8 Oxygen in air	<b>F</b> 9 Fluorine prevents tooth decay	<b>Ne</b> 10 Neon in signs	
<b>K</b> 19 Potassium in bananas	<b>Ca</b> 20 Calcium in bones	<b>Ti</b> 22 Titanium in house paint	<b>Cr</b> 24 Chromium on car bumpers	<b>Fe</b> 26 Iron used in making steel	<b>Co</b> 27 Cobalt blue pigment	<b>Ni</b> 28 Nickel in 5¢ coins	<b>Cu</b> 29 Copper wire & pennies	<b>Zn</b> 30 Zinc buckets & wash tubs	<b>Al</b> 13 Aluminum in pots & pans	<b>Si</b> 14 Silicon in "Silly Putty"	<b>P</b> 15 Phosphorus in making matches	<b>S</b> 16 Sulfur in rotten eggs	<b>Cl</b> 17 Chlorine in swimming pools	<b>Ar</b> 18 Argon in fluorescent bulbs			
<b>Ba</b> 56 Barium nasty drink before X-Rays	<b>Zr</b> 40 Zirconium in fake diamonds	<b>Mo</b> 42 Molybdenum in kitchen knives	<b>W</b> 74 Tungsten in light bulbs	<b>Pd</b> 46 Palladium theater in London	<b>Ag</b> 47 Silver name of a horse & fillings for teeth	<b>Cd</b> 48 Cadmium yellow pigment	<b>Sn</b> 50 Tin in roofs & cans	<b>Ge</b> 32 Germanium a flower	<b>As</b> 33 Arsenic and Old Lace	<b>Br</b> 35 Bromine in stomach remedy	<b>Kr</b> 36 Krypton planet of Superman	<b>I</b> 53 Iodine used on cuts & scrapes	<b>Pb</b> 82 Lead in old paints	<b>Rn</b> 86 Radon gas in cellars			
<b>Ra</b> 88 Radium used in cancer therapy																	
																<b>U</b> 92 Uranium in nuclear reactors	

**DAD... WHAT DO YOU THINK Pr MEANS?**

**I DON'T KNOW - PUBLIC RELATIONS I GUESS??**

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# Various types of the Periodic Table

## The Alchemical Table of Symbols

**Elements**

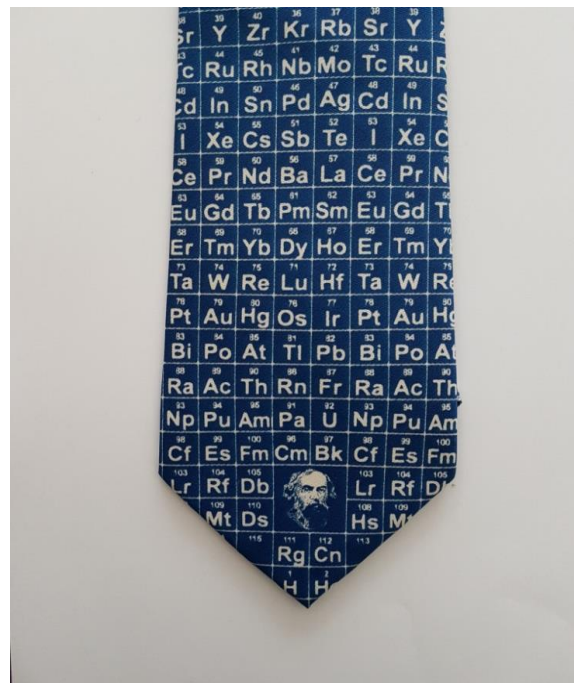
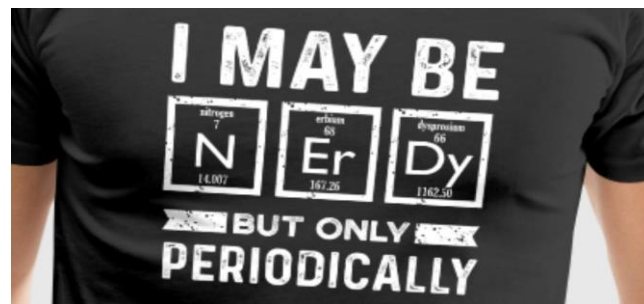
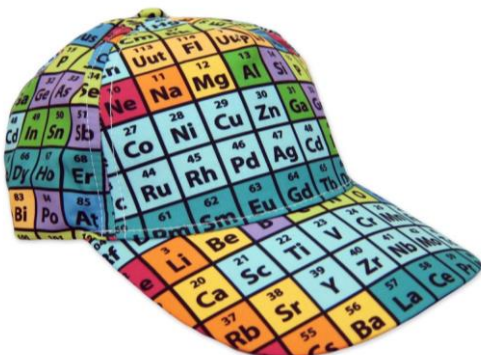
fire	water
air	earth

**Zodiac Signs  
and Processes**

**Other  
Processes**

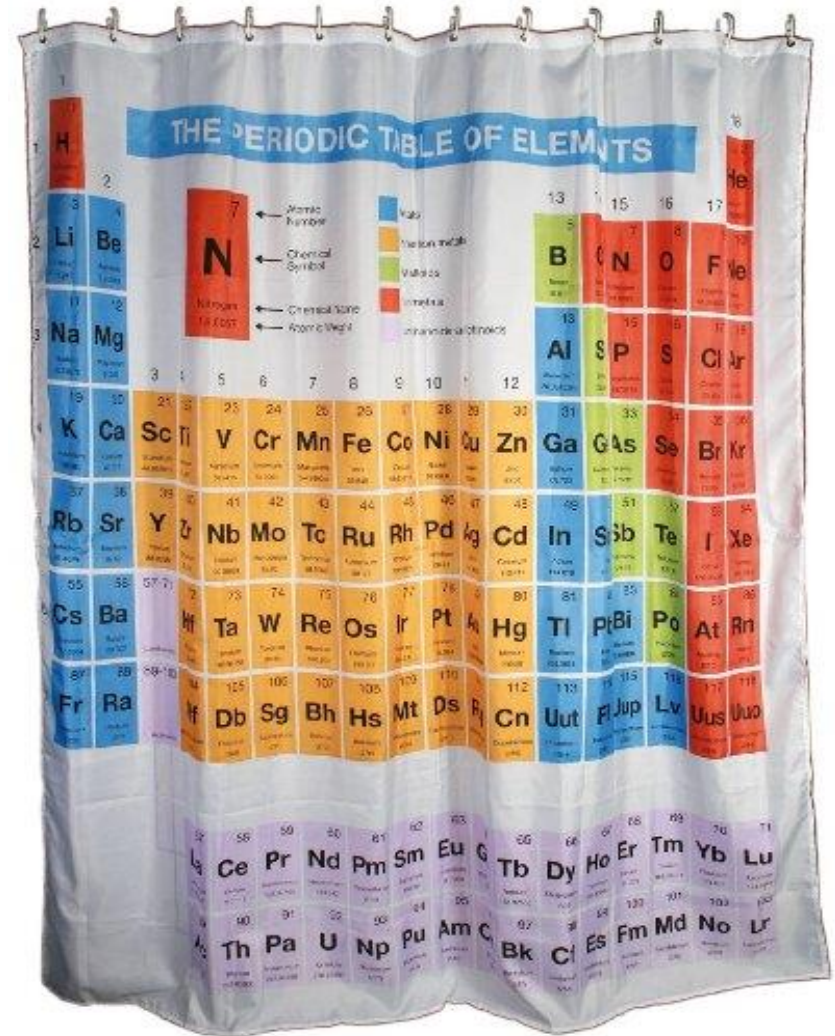
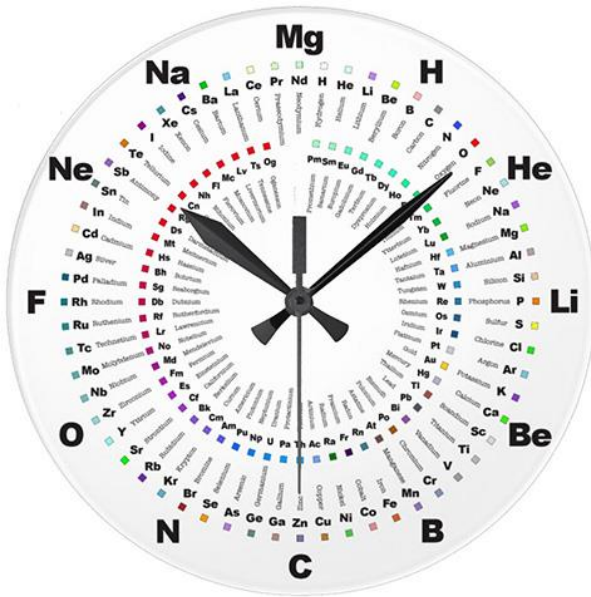
aries	taurus	gemini	cancer	leo	virgo	libra	scorpio	sagittarius	capricorn	aquarius	pisces
calcination	congelation	fixation	solution	digestion	distillation	sublimation	separation	ceration	fermentation	multiplication	projection
compose	rot	boil	solve	amalgamation	tube	purify	distill	filter	precipitate	sublimate	pulverize

# Various kinds of objects reproducing the Periodic Table





# Various kinds of objects reproducing the Periodic Table



Shower curtain

# Various kinds of objects reproducing the Periodic Table

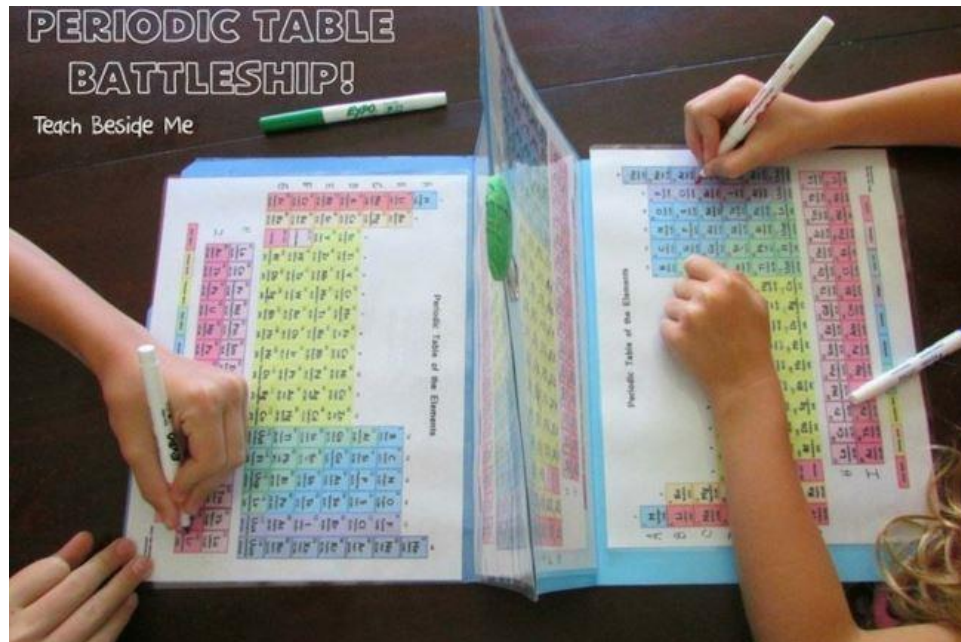




# Various kinds of objects reproducing the Periodic Table



Playing cards



# Various kinds of objects reproducing the Periodic Table



You can eat a sweet Periodic Table

You can also eat on the Periodic Table

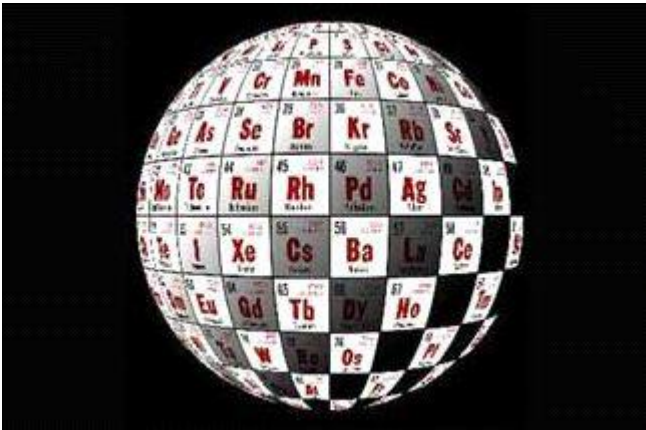




# Various shapes of the Periodic Table

## Spherical Periodic Table

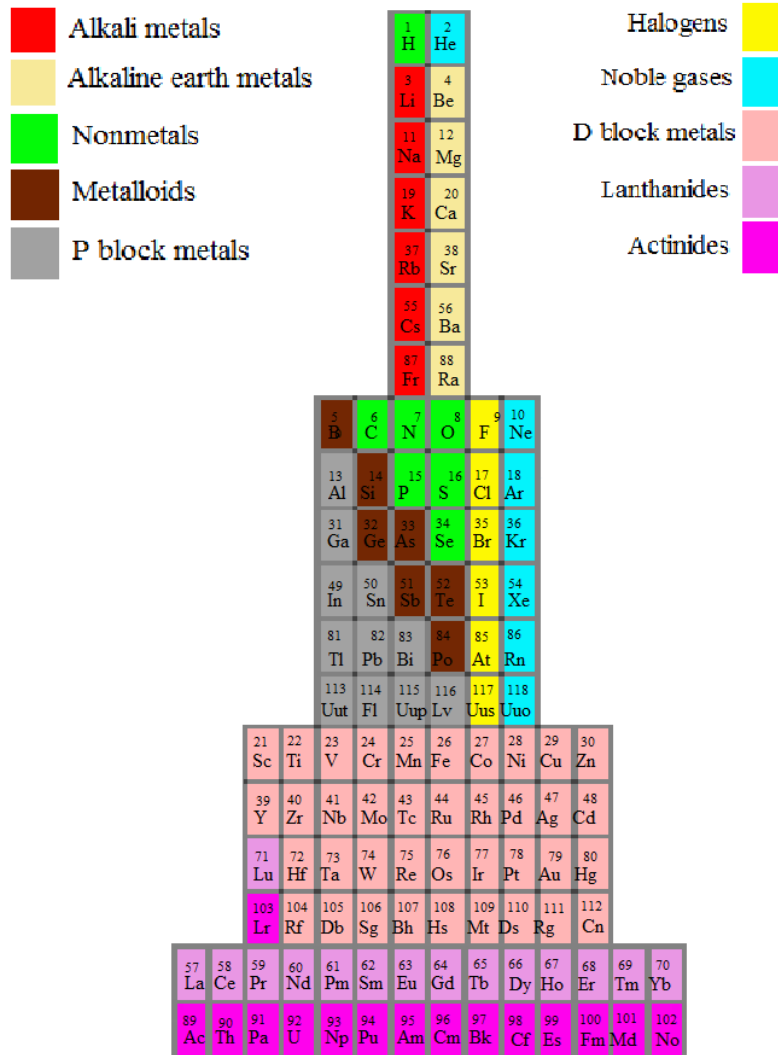
Unfortunately, this wonderful formulation from a **Union Carbide** advertisement (1960) does not work; it is *not* (in this author's opinion) possible to wrap the Periodic Table onto a sphere





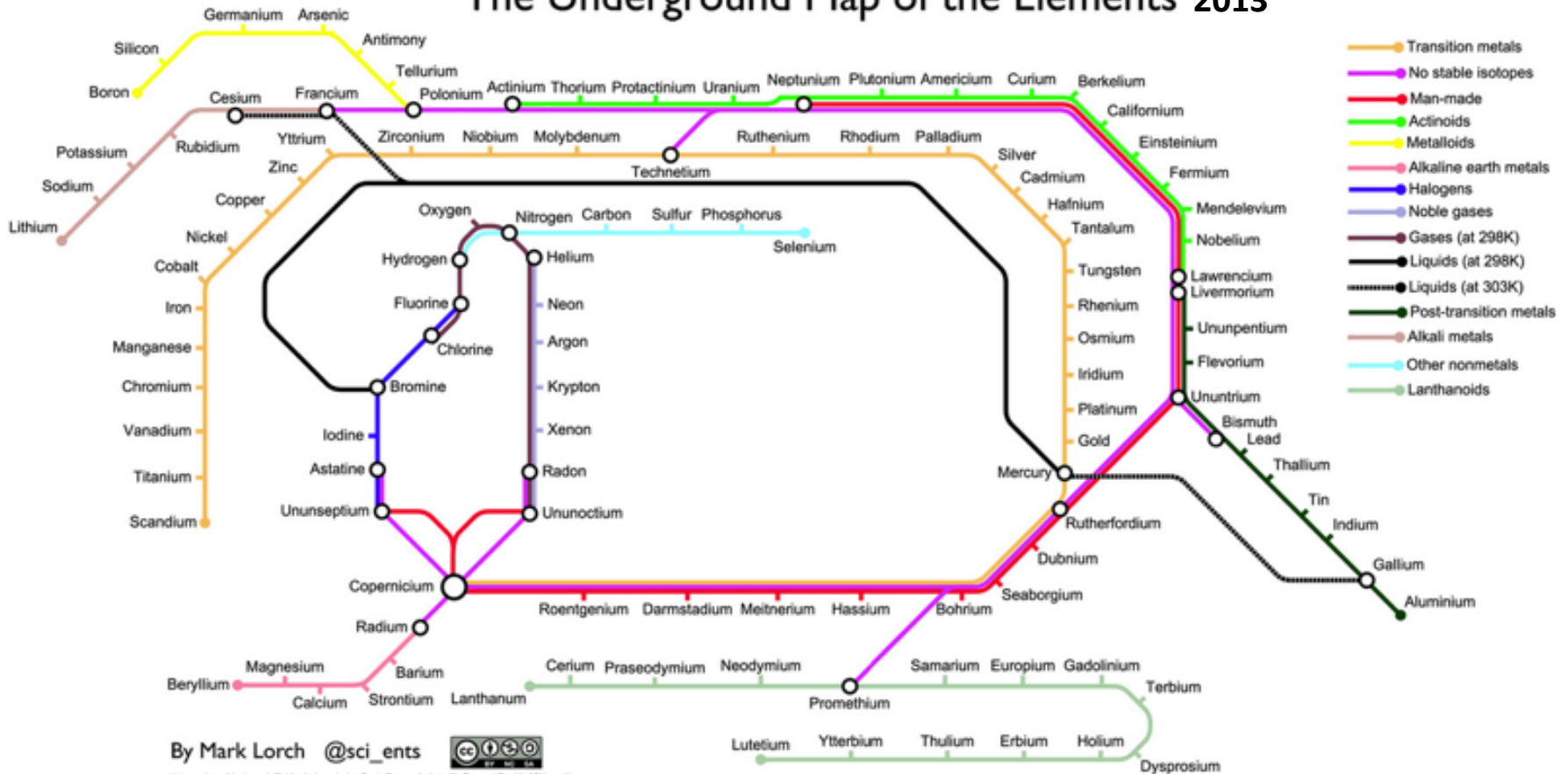
# Various shapes of the Periodic Table

## Pyramidal periodic table 2012



# Various shapes of the Periodic Table

## The Underground Map of the Elements 2013



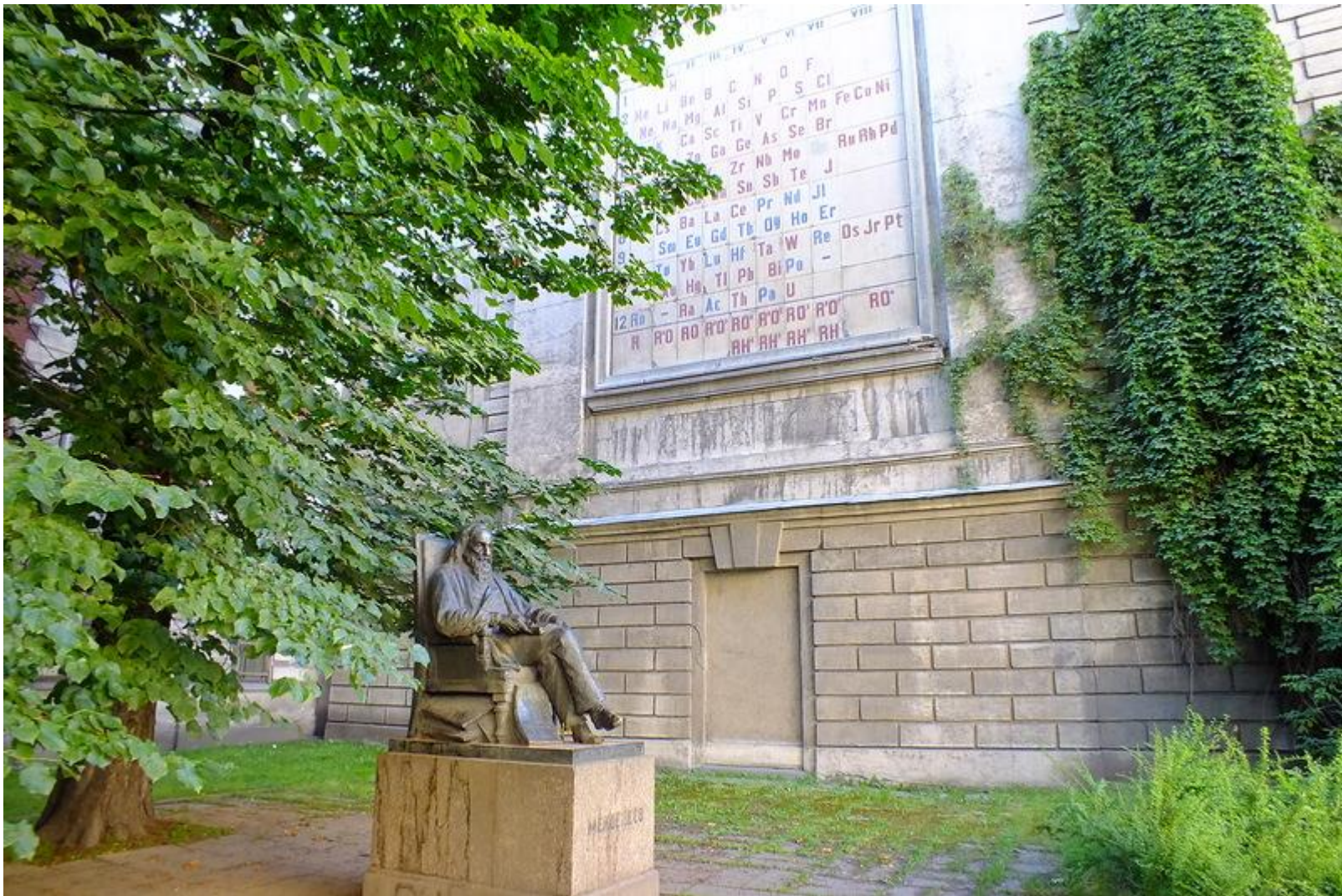
# Real-life Periodic Tables



University of Iowa (USA)



# Periodic Table Monuments



St. Petersburg



# Periodic Table Monuments



Bratislava, Slovakia



# Very big Periodic Tables



Murcia, Spain



# Very big Periodic Tables



Daley Center, Chicago (USA)

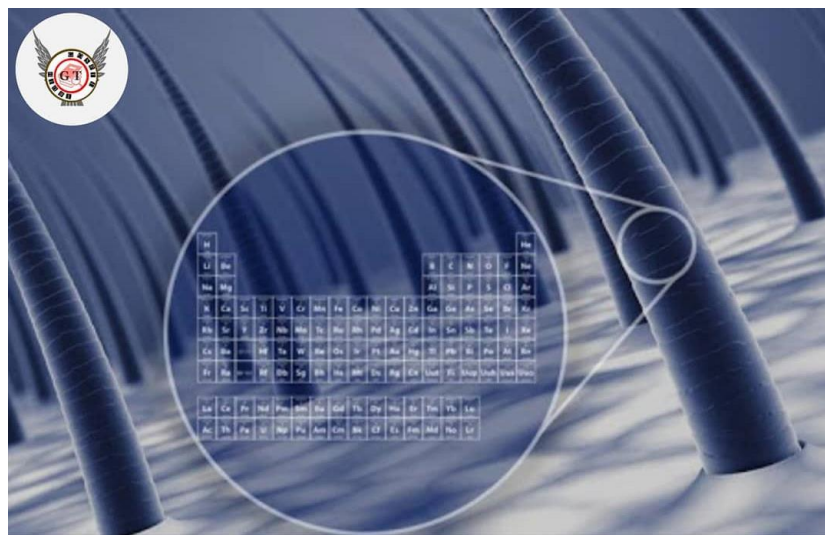
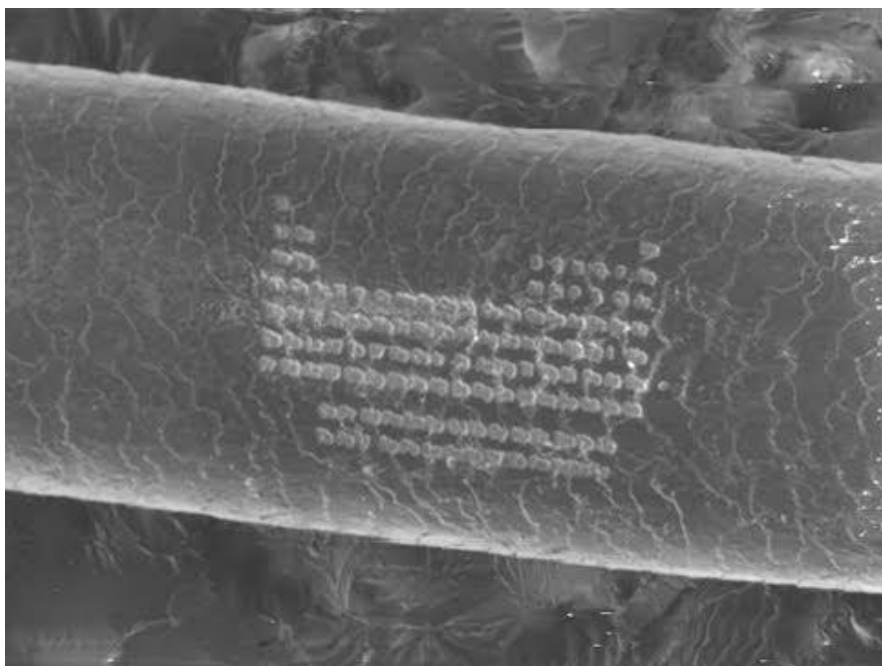






# Very small Periodic Tables

The world's smallest periodic table was also one of the world's smallest birthday gifts: it was a present to Prof. Martyn Poliakoff for his birthday in December 2010. Scientists used an ion beam and an electron microscope to etch the table onto one of his hairs, creating a table that was 89.67 microns wide and 46.39 microns tall



World's smallest periodic table was created on a strand of hair at the University of Nottingham. In this periodic table, each symbol measures about 4 millionths of a meter across.



Contents lists available at ScienceDirect

Polyhedron

journal homepage: [www.elsevier.com/locate/poly](http://www.elsevier.com/locate/poly)



Review

Row 7 of the periodic table complete: Can we expect more new elements; and if so, when?



Jan Reedijk

Two questions are arising:

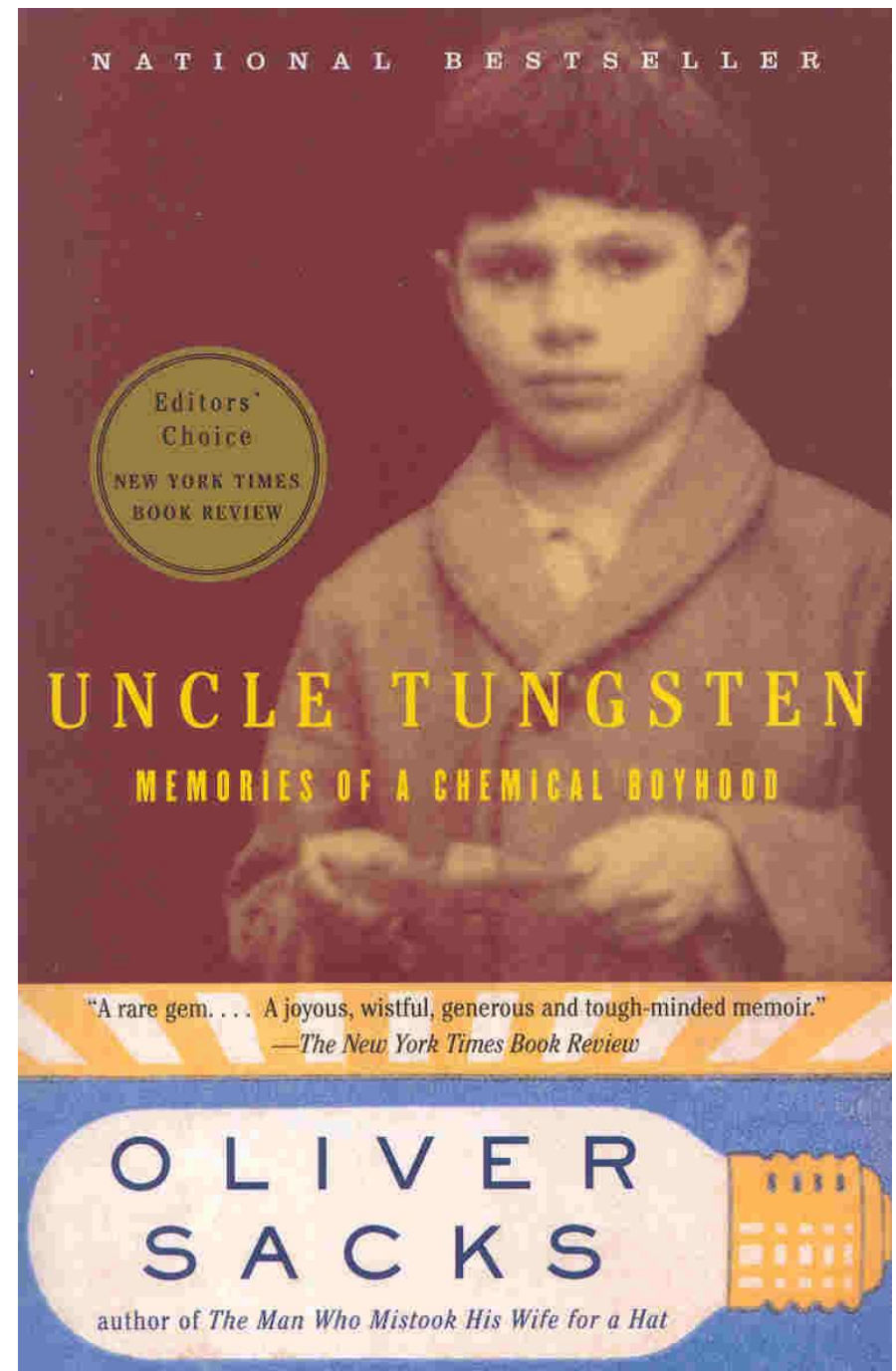
- 1) How many elements can be added? Is the Periodic Table an infinite document?
- 2) Because the last elements exhibit properties quite different from those of the related elements in the preceding rows (for example Oganesson is more reactive than the noble gases), will the current concept of periodicity end? Will the Periodic Table collapse?



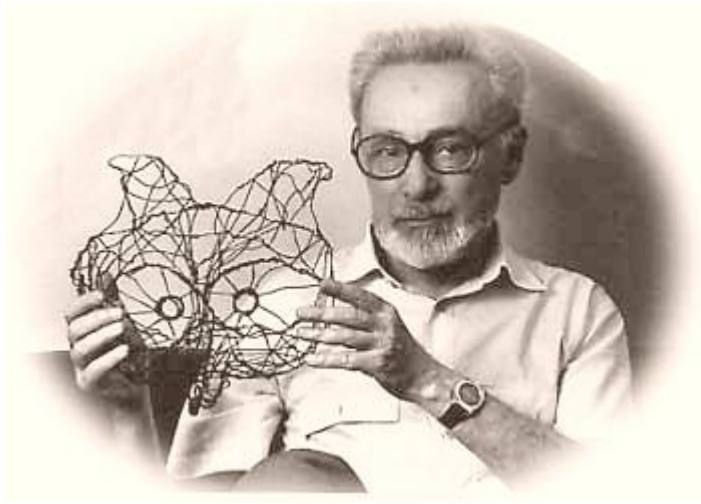
Oliver Sacks said

*"The Periodic Table is the most important discovery in the history of Science: everything in its place"*

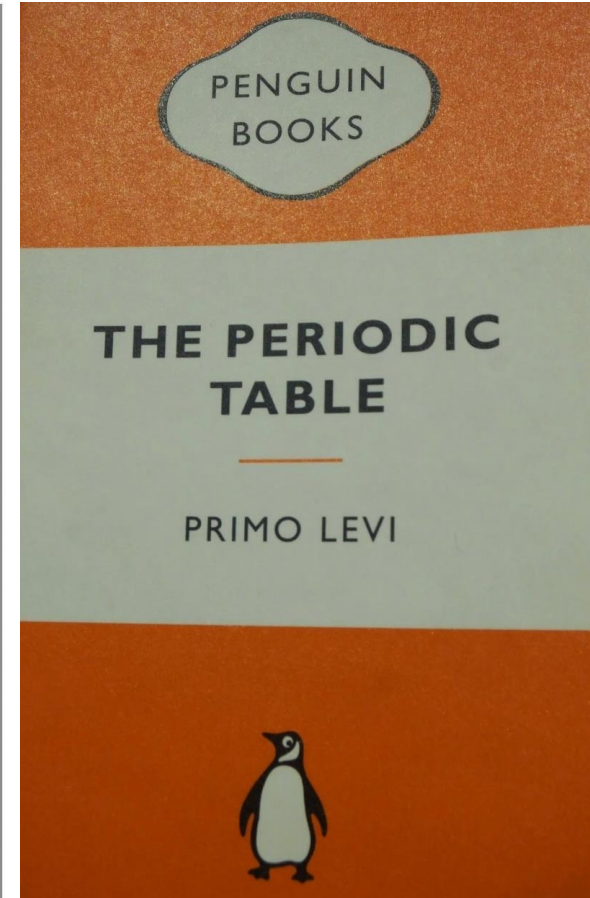
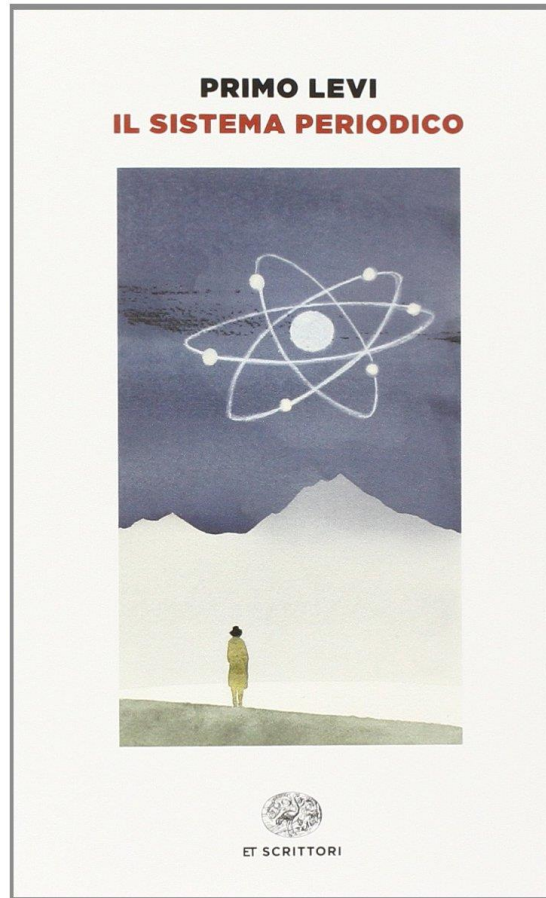
New York Times, April 18, 1999



1975



Primo Levi (1919 - 1987)



2019 is also the 100th anniversary  
of the birth of Primo Levi