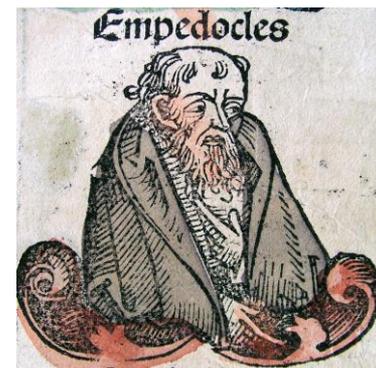


# Elements: History

The Big Idea: “everything” is made of a limited number of “elements” in a great variety of combinations.

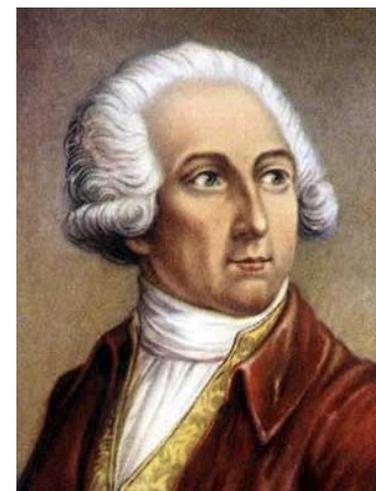
- Ancient philosophy:

- Empedocles’ (5<sup>th</sup> century BC) **earth, water, air, fire**.
- The term “**elements**” (*stoicheia*) was first used by the Greek philosopher **Plato** (4<sup>th</sup> century BC).
- Aristotle (350 BC) - a fifth element called “**aether**”.



- Robert Boyle, 1661: **corpuscularism** theory - analysis of matter as constituted by indecomposable *chemical elements*.

- Antoine Lavoisier, 1789: the **first modern list of chemical elements** (contained **33 elements** including *light* and *caloric*, “element” of heat).



# Atomic Weight

## John Dalton (1766–1844):

- Atoms of a given element are identical in size, mass, and other properties; atoms of different elements differ in size, mass, and other properties.
- Atoms of different elements combine in simple whole-number ratios to form chemical compounds (ex: two hydrogen atoms per one oxygen atom makes water).
- Chemical analysis of simple compounds like water, ammonia, carbon dioxide, etc. allows to determine relative atomic weights of the constituent elements.
- 1803-1805: Dalton published his **first table of relative atomic weights** containing **six elements**:  
*hydrogen* (conventionally assumed to weigh 1), *oxygen*, *nitrogen*, *carbon*, *sulfur*, and *phosphorus*.



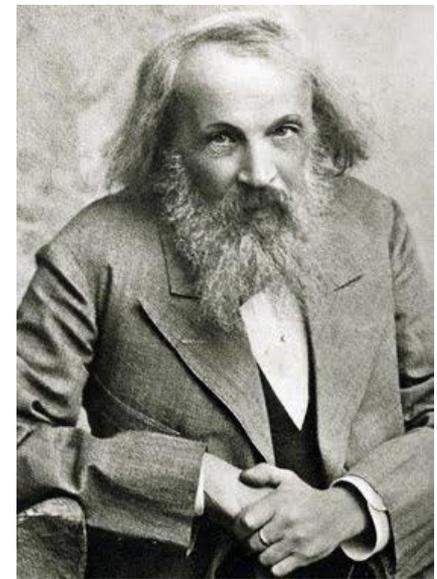
# Systematization of Elements

By 1818, atomic weights were determined for **45** out of **49 known elements** by careful studies of chemical reactions.

- **First attempts to organize elements:**
  - **1829**, Johann Wolfgang Döbereiner, *Law of Triades* (“3-in-a-row”)
  - **1862**, Alexandre-Emile de Chancourtois, the first notion of periodicity by increasing atomic weight, “screw” periodic table
  - **1864**, Julius Lothar Meyer, table based on *valency*
  - **1863-1866**, John Newlands, *Law of Octaves* (“8-in-a-row”)
  - **1867**, Gustavus Hinrichs, “spiral” periodic system based on atomic spectra and weight
  - **1870**, Meyer expanded his periodic table
- **Dmitri Mendeleev, 1869**: **periodic table** of **66 elements**.
- **Horace Deming, 1923**: the popular periodic table layout, also known as the **common** or **standard form**.

# Mendeleev's Table

- 1869, Dmitri Mendeléev: the **first accepted version** of the periodic table.
- Elements were **grouped according to their atomic weight**.



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.  
ОСНОВАННОЙ НА ВѢСЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

		Ti = 50	Zr = 90	? = 180.
		V = 51	Nb = 94	Ta = 182.
		Cr = 52	Mo = 96	W = 186.
		Mn = 55	Rh = 104,4	Pt = 197,4
		Fe = 56	Ru = 104,4	Ir = 198.
		Ni = Co = 59	Pd = 106,4	Os = 199.
H = 1		Cu = 63,4	Ag = 108	Hg = 200.
Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
B = 11	Al = 27,1	? = 68	Ur = 116	Au = 197?
C = 12	Si = 28	? = 70	Sn = 118	
N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
O = 16	S = 32	Se = 79,4	Te = 128?	
F = 19	Cl = 35,4	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133
		Ca = 40	Sr = 87,4	Ba = 137
		? = 45	Ce = 92	Pb = 207.
		?Er = 86	La = 94	
		?Yt = 80	Di = 95	
		?In = 75,4	Th = 118?	

Д. Менделѣевъ

- Gaps were left in the table when it seemed that the corresponding element had not yet been discovered (*predicted* elements).
- The order suggested by the atomic weights was occasionally ignored to *better classify* elements into chemical families (having similar physical/chemical characteristics and properties).
- With the development of theories of atomic structure, it became apparent that Mendeleev had *unintentionally* listed the elements in order of increasing atomic number or nuclear charge.

# Elements Discovery Timeline from Antiquity to 2012

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											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	-71	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	-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	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

Known in antiquity

also known when (akw) Levoisier published his list of elements (1789)

akw Mendeleev published his periodic table (1869)

akw Deming published his periodic table (1923)

akw Seaborg published his periodic table (1945)

also known (ak) up to 2000

ak to 2012