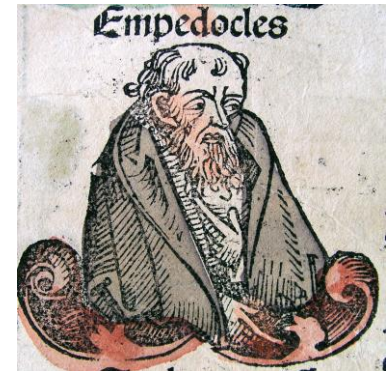


Elements: History

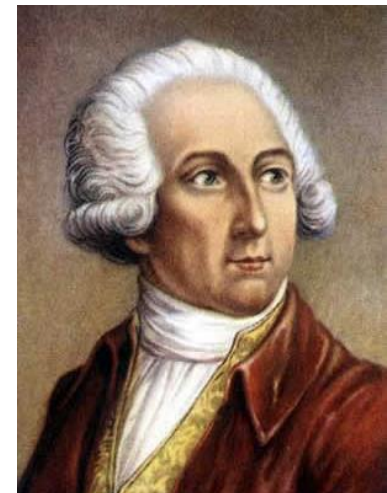
The Big Idea: “everything” is made of a limited number of “elements” in a great variety of combinations.

- Ancient philosophy:

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



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

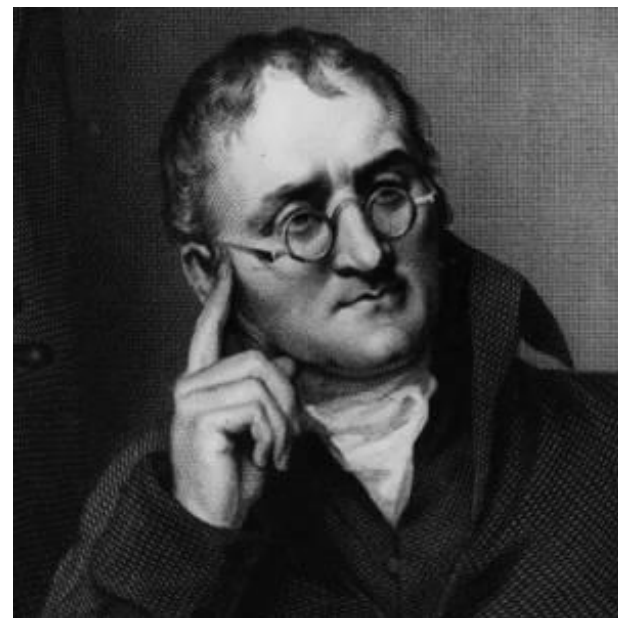


- Antoine Lavoisier, 1789: the **first modern list of chemical elements** (contained **33 elements** including *light* and *caloric*, “element” of heat).

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*.



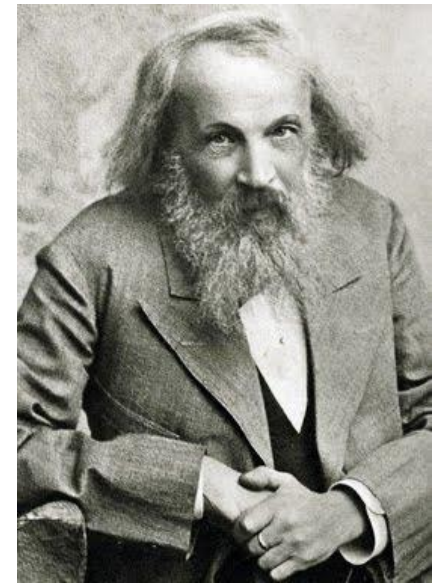
Systematization of Elements

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 ВЪСЪ 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. | |
| | | Cu=63,4 | Ag=108 | Hg=200. | |
| H=1 | Be=9,4 | Mg=24 | Zn=65,4 | Cd=112 | |
| B=11 | Al=27,4 | ?=68 | U=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 | Tl=204. |
| | | Ca=40 | Sr=87,4 | Ba=137 | Pb=207. |
| | | ?=45 | Ce=92 | | |
| | | ?Er=56 | La=94 | | |
| | | ?Yt=60 | 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 | 57 La | 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 | 89 Ac | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Ds | 111 Rg | 112 Cn | 113 Nh | 114 Fl | 115 Mc | 116 Lv | 117 Ts | 118 Og |

| | | | | | | | | | | | | | | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| 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