Alternative periodic tables

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[Theodor Benfey's periodic table](https://en.wikipedia.org/wiki/Alternative_periodic_tables#Two-dimensional_spiral_.28Benfey.2C_1964.29) (1964)

|  |
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**Alternative periodic tables** are tabulations of [chemical elements](https://en.wikipedia.org/wiki/Chemical_element) differing in their organization from the [traditional depiction of the periodic system](https://en.wikipedia.org/wiki/Periodic_table_(standard)).[[1]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-1)[[2]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-2)

Over a thousand have been devised, often for [didactic](https://en.wikipedia.org/wiki/Didactic) reasons, as not all correlations between the chemical elements are effectively captured by the standard periodic table.



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Major alternative structures[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=1)]

**Left-step periodic table (Janet, 1928)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=2)]

[Charles Janet](https://en.wikipedia.org/wiki/Charles_Janet)'s left-step periodic table[[3]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-3) is the most widely used alternative to the traditional depiction of the periodic system. It organizes elements according to an idealized orbital filling (instead of [valence](https://en.wikipedia.org/wiki/Valence_(chemistry))).[[4]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-4) For example, the elements Sc to Zn are shown as a 3d block implying orbital occupancy [Ar] 4s2 3dx, although it is now known that Cr actually has orbital occupancy [Ar] 4s1 3d5 and Cu has [Ar] 4s1 3d10.

hide

* [v](https://en.wikipedia.org/wiki/Template:Periodic_table_(left_step))
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**Left-step periodic table (by Charles Janet)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  | [f1](https://en.wikipedia.org/wiki/F-block) | f2 | f3 | f4 | f5 | f6 | f7 | f8 | f9 | f10 | f11 | f12 | f13 | f14 | [d1](https://en.wikipedia.org/wiki/D-block) | d2 | d3 | d4 | d5 | d6 | d7 | d8 | d9 | d10 | [p1](https://en.wikipedia.org/wiki/P-block) | p2 | p3 | p4 | p5 | p6 | [s1](https://en.wikipedia.org/wiki/S-block) | s2 |
| 1s |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | [H](https://en.wikipedia.org/wiki/Hydrogen) | [He](https://en.wikipedia.org/wiki/Helium) |
| 2s |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | [Li](https://en.wikipedia.org/wiki/Lithium) | [Be](https://en.wikipedia.org/wiki/Beryllium) |
| 2p 3s |  | | | | | | | | | | | | | | | | | | | | | | | | [B](https://en.wikipedia.org/wiki/Boron) | [C](https://en.wikipedia.org/wiki/Carbon) | [N](https://en.wikipedia.org/wiki/Nitrogen) | [O](https://en.wikipedia.org/wiki/Oxygen) | [F](https://en.wikipedia.org/wiki/Fluorine) | [Ne](https://en.wikipedia.org/wiki/Neon) | [Na](https://en.wikipedia.org/wiki/Sodium) | [Mg](https://en.wikipedia.org/wiki/Magnesium) |
| 3p 4s |  | | | | | | | | | | | | | | | | | | | | | | | | [Al](https://en.wikipedia.org/wiki/Aluminium) | [Si](https://en.wikipedia.org/wiki/Silicon) | [P](https://en.wikipedia.org/wiki/Phosphorus) | [S](https://en.wikipedia.org/wiki/Sulfur) | [Cl](https://en.wikipedia.org/wiki/Chlorine) | [Ar](https://en.wikipedia.org/wiki/Argon) | [K](https://en.wikipedia.org/wiki/Potassium) | [Ca](https://en.wikipedia.org/wiki/Calcium) |
| 3d 4p 5s |  | | | | | | | | | | | | | | [Sc](https://en.wikipedia.org/wiki/Scandium) | [Ti](https://en.wikipedia.org/wiki/Titanium) | [V](https://en.wikipedia.org/wiki/Vanadium) | [Cr](https://en.wikipedia.org/wiki/Chromium) | [Mn](https://en.wikipedia.org/wiki/Manganese) | [Fe](https://en.wikipedia.org/wiki/Iron) | [Co](https://en.wikipedia.org/wiki/Cobalt) | [Ni](https://en.wikipedia.org/wiki/Nickel) | [Cu](https://en.wikipedia.org/wiki/Copper) | [Zn](https://en.wikipedia.org/wiki/Zinc) | [Ga](https://en.wikipedia.org/wiki/Gallium) | [Ge](https://en.wikipedia.org/wiki/Germanium) | [As](https://en.wikipedia.org/wiki/Arsenic) | [Se](https://en.wikipedia.org/wiki/Selenium) | [Br](https://en.wikipedia.org/wiki/Bromine) | [Kr](https://en.wikipedia.org/wiki/Krypton) | [Rb](https://en.wikipedia.org/wiki/Rubidium) | [Sr](https://en.wikipedia.org/wiki/Strontium) |
| 4d 5p 6s |  | | | | | | | | | | | | | | [Y](https://en.wikipedia.org/wiki/Yttrium) | [Zr](https://en.wikipedia.org/wiki/Zirconium) | [Nb](https://en.wikipedia.org/wiki/Niobium) | [Mo](https://en.wikipedia.org/wiki/Molybdenum) | [Tc](https://en.wikipedia.org/wiki/Technetium) | [Ru](https://en.wikipedia.org/wiki/Ruthenium) | [Rh](https://en.wikipedia.org/wiki/Rhodium) | [Pd](https://en.wikipedia.org/wiki/Palladium) | [Ag](https://en.wikipedia.org/wiki/Silver) | [Cd](https://en.wikipedia.org/wiki/Cadmium) | [In](https://en.wikipedia.org/wiki/Indium) | [Sn](https://en.wikipedia.org/wiki/Tin) | [Sb](https://en.wikipedia.org/wiki/Antimony) | [Te](https://en.wikipedia.org/wiki/Tellurium) | [I](https://en.wikipedia.org/wiki/Iodine) | [Xe](https://en.wikipedia.org/wiki/Xenon) | [Cs](https://en.wikipedia.org/wiki/Caesium) | [Ba](https://en.wikipedia.org/wiki/Barium) |
| 4f 5d 6p 7s | [La](https://en.wikipedia.org/wiki/Lanthanum) | [Ce](https://en.wikipedia.org/wiki/Cerium) | [Pr](https://en.wikipedia.org/wiki/Praseodymium) | [Nd](https://en.wikipedia.org/wiki/Neodymium) | [Pm](https://en.wikipedia.org/wiki/Promethium) | [Sm](https://en.wikipedia.org/wiki/Samarium) | [Eu](https://en.wikipedia.org/wiki/Europium) | [Gd](https://en.wikipedia.org/wiki/Gadolinium) | [Tb](https://en.wikipedia.org/wiki/Terbium) | [Dy](https://en.wikipedia.org/wiki/Dysprosium) | [Ho](https://en.wikipedia.org/wiki/Holmium) | [Er](https://en.wikipedia.org/wiki/Erbium) | [Tm](https://en.wikipedia.org/wiki/Thulium) | [Yb](https://en.wikipedia.org/wiki/Ytterbium) | [Lu](https://en.wikipedia.org/wiki/Lutetium) | [Hf](https://en.wikipedia.org/wiki/Hafnium) | [Ta](https://en.wikipedia.org/wiki/Tantalum) | [W](https://en.wikipedia.org/wiki/Tungsten) | [Re](https://en.wikipedia.org/wiki/Rhenium) | [Os](https://en.wikipedia.org/wiki/Osmium) | [Ir](https://en.wikipedia.org/wiki/Iridium) | [Pt](https://en.wikipedia.org/wiki/Platinum) | [Au](https://en.wikipedia.org/wiki/Gold) | [Hg](https://en.wikipedia.org/wiki/Mercury_(element)) | [Tl](https://en.wikipedia.org/wiki/Thallium) | [Pb](https://en.wikipedia.org/wiki/Lead) | [Bi](https://en.wikipedia.org/wiki/Bismuth) | [Po](https://en.wikipedia.org/wiki/Polonium) | [At](https://en.wikipedia.org/wiki/Astatine) | [Rn](https://en.wikipedia.org/wiki/Radon) | [Fr](https://en.wikipedia.org/wiki/Francium) | [Ra](https://en.wikipedia.org/wiki/Radium) |
| 5f 6d 7p 8s | [Ac](https://en.wikipedia.org/wiki/Actinium) | [Th](https://en.wikipedia.org/wiki/Thorium) | [Pa](https://en.wikipedia.org/wiki/Protactinium) | [U](https://en.wikipedia.org/wiki/Uranium) | [Np](https://en.wikipedia.org/wiki/Neptunium) | [Pu](https://en.wikipedia.org/wiki/Plutonium) | [Am](https://en.wikipedia.org/wiki/Americium) | [Cm](https://en.wikipedia.org/wiki/Curium) | [Bk](https://en.wikipedia.org/wiki/Berkelium) | [Cf](https://en.wikipedia.org/wiki/Californium) | [Es](https://en.wikipedia.org/wiki/Einsteinium) | [Fm](https://en.wikipedia.org/wiki/Fermium) | [Md](https://en.wikipedia.org/wiki/Mendelevium) | [No](https://en.wikipedia.org/wiki/Nobelium) | [Lr](https://en.wikipedia.org/wiki/Lawrencium) | [Rf](https://en.wikipedia.org/wiki/Rutherfordium) | [Db](https://en.wikipedia.org/wiki/Dubnium) | [Sg](https://en.wikipedia.org/wiki/Seaborgium) | [Bh](https://en.wikipedia.org/wiki/Bohrium) | [Hs](https://en.wikipedia.org/wiki/Hassium) | [Mt](https://en.wikipedia.org/wiki/Meitnerium) | [Ds](https://en.wikipedia.org/wiki/Darmstadtium) | [Rg](https://en.wikipedia.org/wiki/Roentgenium) | [Cn](https://en.wikipedia.org/wiki/Copernicium) | [Nh](https://en.wikipedia.org/wiki/Nihonium) | [Fl](https://en.wikipedia.org/wiki/Flerovium) | [Mc](https://en.wikipedia.org/wiki/Moscovium) | [Lv](https://en.wikipedia.org/wiki/Livermorium) | [Ts](https://en.wikipedia.org/wiki/Tennessine) | [Og](https://en.wikipedia.org/wiki/Oganesson) | [119](https://en.wikipedia.org/wiki/Ununennium) | [120](https://en.wikipedia.org/wiki/Unbinilium) |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | [f-block](https://en.wikipedia.org/wiki/F-block) | | | | | | | | | | | | | | [d-block](https://en.wikipedia.org/wiki/D-block) | | | | | | | | | | [p-block](https://en.wikipedia.org/wiki/P-block) | | | | | | [s-block](https://en.wikipedia.org/wiki/S-block) | |

This form of periodic table is congruent with the order in which electron shells are ideally filled according to the [Madelung rule](https://en.wikipedia.org/wiki/Aufbau_principle#Madelung_energy_ordering_rule), as shown in the accompanying sequence in the left margin (read from top to bottom, left to right). The experimentally determined ground-state electron configurations of the elements differ from the configurations predicted by the Madelung rule in twenty instances, but the Madelung-predicted configurations are always at least close to the ground state. The last two elements shown, elements 119 and 120, have not yet been synthesized.

Left to right: s-, f-, d-, p-block in the common periodic table presentation; for sufficiently high [principal quantum numbers](https://en.wikipedia.org/wiki/Principal_quantum_numbers), these blocks fill out in the order of s, p, d, and f. The left-step periodic table is organized according to a reversal of this order, so that the true order is maintained through a proper reading.

Compared to the common layout, the left-step table has these changes:

* Helium is placed in group 2 (not in group 18).
* Groups 1 and 2 (the s-block), including elements 119 and 120 in extended period 8, are moved to the right side of the table.
* The s-block is shifted upwards one row, and all elements not in the s-block are now one row lower than in the standard table. For example, most of the fourth row in the standard table is the fifth row in this table.

In the result, the order is still consistently by [atomic number](https://en.wikipedia.org/wiki/Atomic_number) (*Z*), 1–120.

**Two-dimensional spiral (Benfey, 1964)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=3)]

In [Theodor Benfey](https://en.wikipedia.org/wiki/Otto_Theodor_Benfey)'s periodic table the elements form a two-dimensional spiral, starting from hydrogen, and folding their way around two peninsulas, the [transition metals](https://en.wikipedia.org/wiki/Transition_metal), and [lanthanides](https://en.wikipedia.org/wiki/Lanthanide) and [actinides](https://en.wikipedia.org/wiki/Actinide). A [superactinide](https://en.wikipedia.org/wiki/Superactinide) island is already slotted in.[[5]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-5)

**Three-dimensional, flower-like (Paul Giguère, 1966)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=4)]

[Paul Giguère](https://en.wikipedia.org/wiki/Paul_Gigu%C3%A8re)'s 3-D periodic table consists of four connected billboards with the elements written on the front and the back. The first billboard has the [group 1 elements](https://en.wikipedia.org/wiki/Group_1_element) on the front and the [group 2 elements](https://en.wikipedia.org/wiki/Group_2_element) at the back, with hydrogen and helium omitted altogether. At a 90° angle the second billboard contains the groups 13 to 18 front and back. Two more billboards each making 90° angles contain the other elements.[[6]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-6)[[7]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-7)

**Three-dimensional, physicist's (Timothy Stowe, 1986)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=5)]

Timothy Stowe's physicist's periodic table is three-dimensional with the three axes representing the [principal quantum number](https://en.wikipedia.org/wiki/Principal_quantum_number), [orbital quantum number](https://en.wikipedia.org/wiki/Orbital_quantum_number), and orbital [magnetic quantum number](https://en.wikipedia.org/wiki/Magnetic_quantum_number).[[8]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-8)[[9]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-9) Helium is again a [group 2 element](https://en.wikipedia.org/wiki/Group_2_element).

**Elements repeating (Ronald L. Rich, 2005)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=6)]

Ronald L. Rich has proposed a periodic table where elements appear more than once when appropriate.[[10]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-10) He notes that hydrogen shares properties with [group 1 elements](https://en.wikipedia.org/wiki/Group_1_element) based on [valency](https://en.wikipedia.org/wiki/Valence_(chemistry)), with [group 17 elements](https://en.wikipedia.org/wiki/Group_17_element) because hydrogen is a non-metal but also with the [carbon](https://en.wikipedia.org/wiki/Carbon) group based on similarities in chemical bonding to transition metals and a similar [electronegativity](https://en.wikipedia.org/wiki/Electronegativity). In this rendition of the periodic table [carbon](https://en.wikipedia.org/wiki/Carbon) and [silicon](https://en.wikipedia.org/wiki/Silicon) also appear in the same group as [titanium](https://en.wikipedia.org/wiki/Titanium) and [zirconium](https://en.wikipedia.org/wiki/Zirconium).

**ADOMAH (Valery Tsimmerman, 2006)**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=7)]

The ADOMAH periodic table reflects electron configurations of atoms.[[11]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-11)

The ADOMAH table is an adaptation of the left step table.[[12]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-12) Each strictly vertical column of the table has the same value of the principal quantum number *n*. For example, *n* = 3 for Fe. Each block of elements has the same value of the secondary quantum number *l.* For example, *l* = 2 for Fe. Each element entry together with all preceding elements corresponds to the [electron configuration](https://en.wikipedia.org/wiki/Electron_configuration) of that element (with 20 exceptions out of 118 known elements). For example, the electron configuration of Fe is determined by starting at H, which is 1s1, and counting in atomic number order. This gives a configuration of 1s2 2s2 2p6 3s2 3p6 4s2 3d6 or, in short form, [Ar] 4s2 3d6.

The four [blocks](https://en.wikipedia.org/wiki/Block_(periodic_table)) of the Adomah table can be rearranged such that they fit, equidistantly spaced, inside a regular [tetrahedron](https://en.wikipedia.org/wiki/Tetrahedron). The latter, in turn, fits into a cube.[[13]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-13)

**Other**[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=8)]

A chemists' table ("Newlands Revisited") with an alternative positioning of hydrogen, helium and the lanthanides was published by EG Marks and JA Marks in 2010.[[14]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-14)

Variants of the classical layout[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=9)]

From Mendeleev's original periodic table, elements have been basically arranged by valence (groups in columns) and the repetition therein (periods in rows). Over the years and with discoveries in atomic structure, this schema has been adjusted and expanded, but not changed as a principle.

Mendeleev's 1871 periodic table in VIII columns. Nowadays, roughly spoken, pairs of *Reihen* are shown as grouplabels A, B ([for example](https://en.wikipedia.org/wiki/Periodic_table#Further_development): Reihen 4, 5 are written as period 3 and [groups](https://en.wikipedia.org/wiki/Group_(periodic_table)#Group_names) (columns) IA–VIIIA, IB–VIIIB).

The oldest periodic table is the **short form** table (columns I–VIII) by [Dmitri Mendeleev](https://en.wikipedia.org/wiki/Dmitri_Mendeleev), which shows secondary chemical kinships. For example, the [alkali metals](https://en.wikipedia.org/wiki/Alkali_metals) and the [coinage metals](https://en.wikipedia.org/wiki/Coinage_metals) (copper, silver, gold) are in the same column because both groups tend to have a valence of one. This format is still used by many, as shown by this [contemporary Russian short form table](http://flerovlab.jinr.ru/flnr/dimg/Periodic_Table.jpg), which includes all elements and element names until [roentgenium](https://en.wikipedia.org/wiki/Roentgenium).

H. G. Deming used the so-called **long periodic table** (18 columns) in his textbook "General Chemistry", which appeared in the US for the first time in 1923 (Wiley), and was the first to designate the first two and the last five main groups with the notation "A", and the intervening transition groups with the notation "B".

The numeration was chosen so that the characteristic oxides of the B groups would correspond to those of the A groups. The iron, cobalt, and nickel groups were designated neither A nor B. The noble-gas group was originally attached (by Deming) to the left side of the periodic table. The group was later switched to the right side and usually labeled as group VIIIA.

Extension of the periodic table[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=10)]

In the [**extended periodic table**](https://en.wikipedia.org/wiki/Extended_periodic_table), suggested by [Glenn T. Seaborg](https://en.wikipedia.org/wiki/Glenn_T._Seaborg) in 1969, yet unknown elements are included up to [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 168. Theoretical periods above regular period 7 are added.

In the research field of [superatoms](https://en.wikipedia.org/wiki/Superatoms), clusters of atoms have properties of single atoms of another element. It is suggested to extend the periodic table with a second layer to be occupied with these [cluster compounds](https://en.wikipedia.org/wiki/Cluster_compound). The latest addition to this multi-story table is the [aluminium](https://en.wikipedia.org/wiki/Aluminium) cluster ion Al−  
7, which behaves like a multivalent [germanium](https://en.wikipedia.org/wiki/Germanium) atom.[[15]](https://en.wikipedia.org/wiki/Alternative_periodic_tables#cite_note-15)

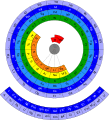
Gallery[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=11)]

Spiral periodic table (Robert W Harrison)

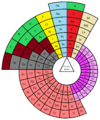
*The Ring Of Periodic Elements* (TROPE)

* [](https://en.wikipedia.org/wiki/File:The_chemical_elements_and_their_periodic_relationships.svg)

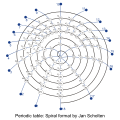
Curled ribbon periodic table (J. F. Hyde)

* [](https://en.wikipedia.org/wiki/File:Circular_form_of_periodic_table.svg)

Circular periodic table

* [](https://en.wikipedia.org/wiki/File:Alternative_circular_periodic_table.png)

Alternative circular periodic table

* [](https://en.wikipedia.org/wiki/File:Periodic_table_(spiral_format).SVG)

Spiral periodic table (Jan Scholten)

* [](https://en.wikipedia.org/wiki/File:Mendeleev_flower.jpg)

Mendeleev's Flower (Flower periodic table)

* [](https://en.wikipedia.org/wiki/File:Periodic_table_in_binary_electron_shells_layout,_designed_by_Eric_William_McPherson.jpg)

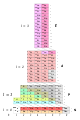
Binary electron shells periodic table

* [](https://en.wikipedia.org/wiki/File:Periodic_system_Stowe_format.svg)

"Stowe" periodic table

* [](https://en.wikipedia.org/wiki/File:Periodic_system_Zmaczynski%26Bayley.svg)

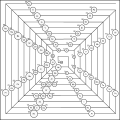
"Zmaczynski & Bayley" periodic table

* [](https://en.wikipedia.org/wiki/File:ADOMAH_periodic_table_-_electron_orbitals_(polyatomic).svg)

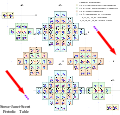
ADOMAH periodic table (V. Tsimmerman)

* [](https://en.wikipedia.org/wiki/File:MARKSBROSPT(2010).jpg)

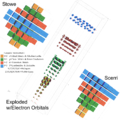
Newlands revisited

* [](https://en.wikipedia.org/wiki/File:Periodic_system_Pyramid_format.svg)

Pyramidal periodic table

* [](https://en.wikipedia.org/wiki/File:Stowe-Janet-Scerri_PeriodicTable.svg)

Stowe–Janet–Scerri with 3D electron orbitals

* [](https://en.wikipedia.org/wiki/File:4DPeriodicTable.png)

4D Stowe–Janet–Scerri periodic table

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Further reading[[edit](https://en.wikipedia.org/w/index.php?title=Alternative_periodic_tables&action=edit&section=13)]

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