

The Many Looks of the Periodic Table

By Gary Katz

H 1																	He 2														
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10														
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18														
K 19	Ca 20											Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36				
Rb 37	Sr 38											Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54				
Cs 55	Ba 56	La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Uub 112	Uut 113	Uuq 114	Uup 115	Uuh 116	Uus 117	Uu8 118

Figure 1. All known chemical elements are grouped in a table called the periodic table. Elements in the same column share similar chemical properties. The four blocks of elements (blue, orange, yellow, and green) also arrange elements that share similar properties.

Everything is made up of simple chemical substances called chemical elements. For the past two centuries, scientists have painstakingly separated and identified these simple substances, leading to a current total of 117 elements.

Scientists also have discovered that many chemical elements share similar properties. So they displayed these elements in the form of a table in which elements that had common properties were grouped in columns. This table, called the periodic table of the elements, was developed over the course of a century and a half and is now seen in chemistry textbooks and wall charts around the world.

The periodic table was not the only way by which the elements were represented. At various times during the past century, scientists created alternative representations in the form of circles, spirals, and other curves. But the table has prevailed as the most widely accepted way of displaying the chemical elements.

During the past few decades, scientists, educators, and designers have continued to propose new and ingenious ways of representing the chemical elements. These new representations, they claim, address major flaws and weaknesses of the current periodic table, and they may, one day, gain wide acceptance among chemists.

This article reviews some of the most interesting alternatives to the traditional periodic table. As you read about them, you may want to guess which one might one day replace the conventional periodic table. You may also come up with a totally new way of organizing the chemical elements!

The traditional periodic table

The traditional periodic table lists the elements in order of increasing atomic number, which is the number of protons—one of the fundamental particles making up atoms—going horizontally in rows from left to right and from top to bottom. Fig. 1 shows one of the two forms—called the long form—of the traditional periodic table.

Vertically, the elements are arranged in columns, or groups, and all the elements of a group share similar properties. Horizontally, the rows are organized in pairs, except for the first row (hydrogen and helium).

Each row starts with the same types of elements. They all begin with an element from alkali metal group (hydrogen (H), lithium (Li), etc.), followed by an element from the alkaline earth metals (beryllium (Be), magnesium (Mg), etc.), and so on. This is what is meant by the “periodicity” of the table—that elements with similar properties reappear at pre-

cise intervals while going through the list of elements from top to bottom. For this reason, the rows are also called periods.

Also, the columns are grouped in blocks because elements from neighboring columns share common properties with one another. These blocks, labeled *s*, *p*, *d*, and *f*, are represented in Fig. 1 in blue, green, yellow, and orange, respectively.

Scerri's periodic table

Eric Scerri, a lecturer in chemistry and philosophy of science at the University of California, Los Angeles, recently proposed to make changes to the periodic table to maximize the number of groups of three elements called triads.

A triad consists of three elements arranged in a vertical column and in which the middle element has an atomic number that is the average of the two elements above and below it. For example, by looking at neighboring elements from periods 1, 2, and 3, such as helium, neon, and argon, the atomic numbers of helium (2) and argon (18) can predict that of neon (10) by making a simple average: $(2 + 18)/2 = 10$.

Such triads occur because the periodic table consists of varying period lengths in which each period—with the exception of the first—repeats once. In the examples above,

helium, argon, and neon form a triad because there are seven elements between helium and argon and seven elements between argon and neon. But, for example, nitrogen, phosphorus, and arsenic don't form a triad because nitrogen and phosphorus are separated by seven elements, while phosphorus and arsenic are separated by 17 elements.

Scerri, who published an award-winning book titled *The Periodic Table: Its Story and Its Significance*, noticed that hydrogen (1), fluorine (9), and chlorine (17) define a perfect triad, but hydrogen is not located above fluorine—as would be required to make a triad. So Scerri suggested moving hydrogen to the second-to-last column of the table to obtain a new triad (consisting of hydrogen, fluorine, and chlorine).

Scerri also suggested moving the last two columns to the left of the table, so that the first period disappears and the table is now made of pairs of periods, each pair being of similar length. This new periodic table is shown in Fig. 2.

The Periodic Spiral

Jeff Moran, a graphic designer and the owner of Electric Prism, a software company based in Woodstock, N.Y., has produced a representation called the Periodic Spiral, in which the elements are ordered in spirals.

The Periodic Spiral (Fig. 3), in which the elements are represented as hexagons (instead of squares), starts in the middle

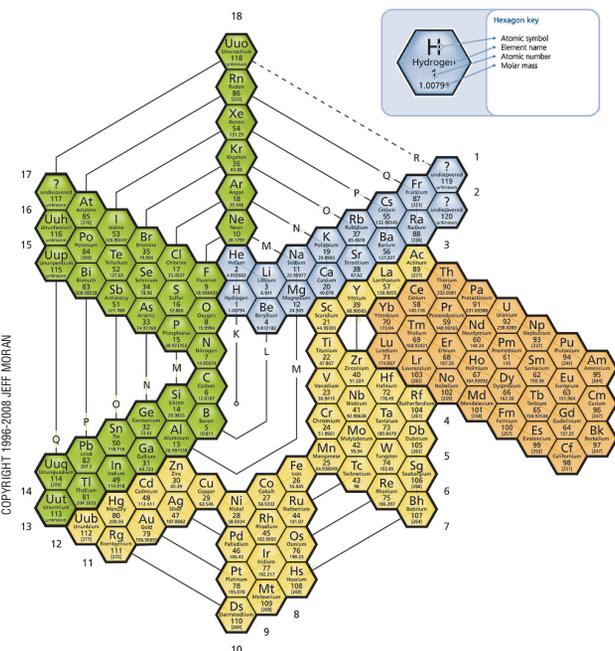


Figure 3. In the Periodic Spiral, the elements start in the middle with hydrogen and spiral clockwise from the inside out.

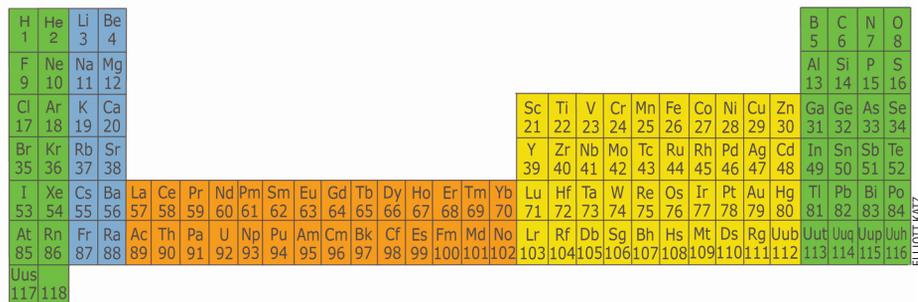


Figure 2. The long form of Scerri's periodic table is more symmetric than the traditional periodic table. The elements are grouped in four-column blocks on each side of the table and (except for the last element, Uus), the number of same-length rows are grouped in pairs (one pair of rows with eight elements each, another pair of rows with 18 elements each, and a third pair of rows with 32 elements each).

with hydrogen and moves in circles clockwise from the inside out. Other than for the first two elements (hydrogen and helium) and the *f* block, a full loop corresponds to a row in the traditional periodic table.

According to Moran, the Periodic Spiral addresses three “serious flaws” in the periodic table. “First, hydrogen has unique properties unlike any other element in the table, so, in essence, it belongs to none of the 18 columns of the table,” Moran says. “Second, the elements from each period of the *f* block—called lanthanides and actinides—have similar properties yet they are not displayed in columns in the table. Third, the table's column-and-row design doesn't show the continuity between the elements, which is better illustrated with a spiral.”

To address these issues, Moran started working on a spiral representation of the elements in 1991 and published it as a Web-based application six years later (available at www.periodic-spiral.com/spiral.html).

The Chemical Galaxy

Philip Stewart, a retired teacher of ecology at the University of Oxford in the United Kingdom, created an artistic representation of the chemical elements, called the Chemical Galaxy, (Fig. 4).

Stewart's representation, on which he worked during three summers, from 2003 to 2005, looks like a galaxy to reflect the fact that chemical elements are produced in stars. The spokes of the

galaxy link elements with similar properties, acting like the groups in the periodic table.

In the Chemical Galaxy, each element is represented with a circle of a different color. Stewart's choice of colors runs through the entire color spectrum, from violet for the alkali metals (the group that includes lithium) to red for the halogens (the group that includes chlorine). Colorless grey was used for the noble gases (the group that includes neon), which participate very little in chemical reactions, if at all.

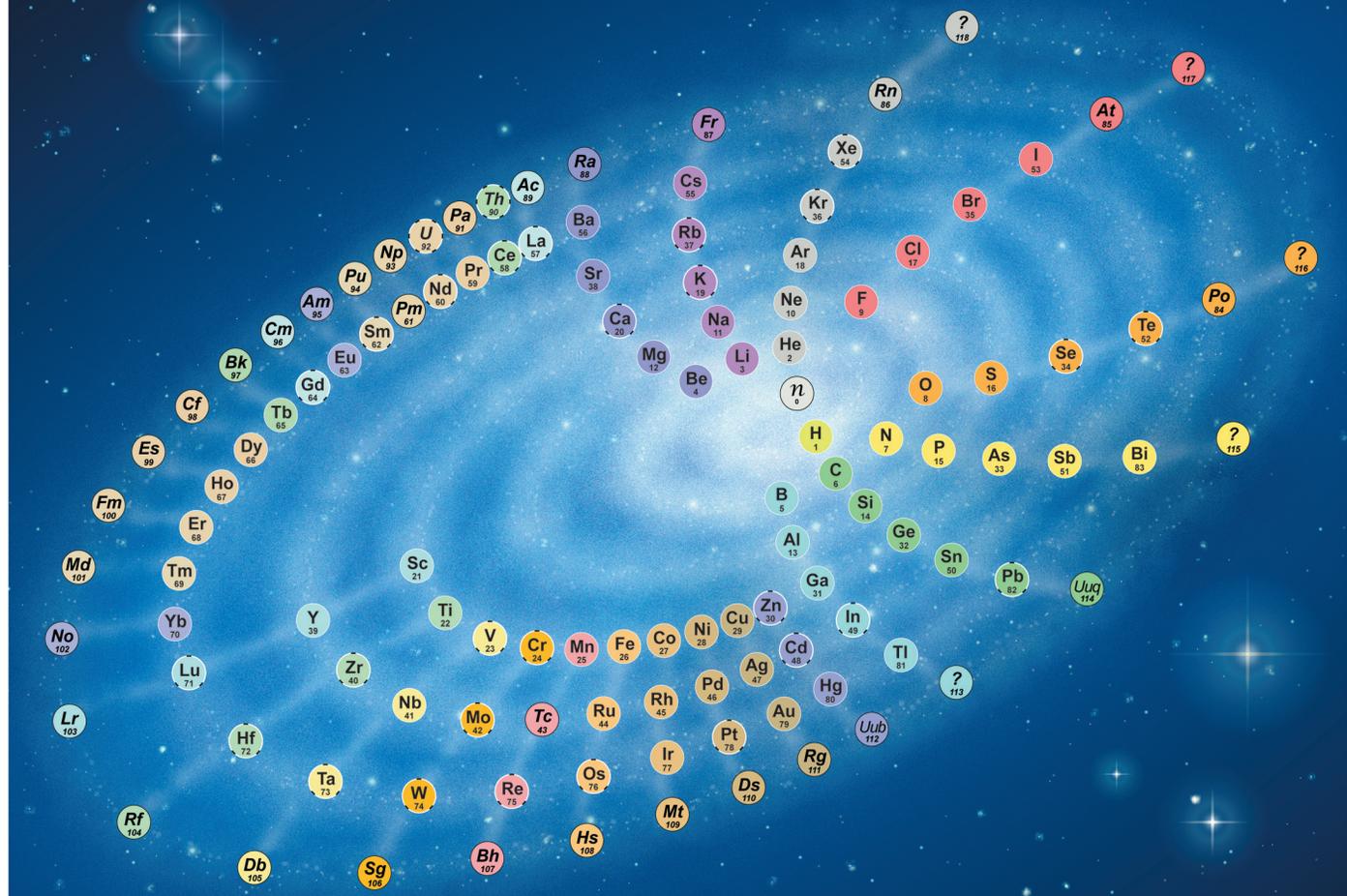
In the middle of the Chemical Galaxy, Stewart placed an additional element called the neutronium, in which there are neither protons nor electrons, but only neutrons. Scientists have speculated that the neutronium may be present inside very dense stars called neutron stars.

Stewart hopes that the Chemical Galaxy will be seen as a piece of art that conveys the beauty and wonder of the universe. “I am confident that other people will find other ways of expressing ideas about the chemical elements.”

Periodic table in three dimensions

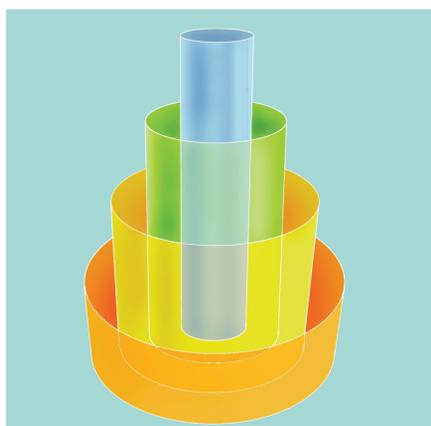
In 1977, I patented a version of the periodic table in three dimensions called the Periodic Round Table. In creating this table, I used a modified version of the traditional periodic table that addresses some of the issues mentioned above.

The first scientist who modified the periodic table this way was Charles Janet, a French engineer and polymath. In 1929, he proposed to move helium to the top of the second column and then move the first two columns (the *s* block) to the right and shift them up one row (Fig. 5). Janet's table has eight rows, the first two consisting of a pair of two elements each.



PHILIP STEWART

Figure 4. The Chemical Galaxy looks like a galaxy to reflect the fact that chemical elements are produced in stars.



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Figure 6. The Periodic Round Table consists of cylinders formed by rolling up the four colored blocks of Janet's periodic table.

To go from the two-dimensional table of Janet to the Periodic Round Table, one simply rolls up each block of elements into a tube (Fig. 6). The four tubes are nested together around a common central axis, creating a set of four concentric cylinders. The cylindrical version is then sliced horizontally into eight disks, each disk corresponding to one period of the two-dimensional table.

A hardwood version of the Periodic Round Table (Fig. 7) is available and consists of a stack of disks stamped with the symbol and atomic number of each element. By removing and replacing the disks on top of one another, people can appreciate the symmetry and

Figure 5. Charles Janet's periodic table contains four blocks that contain (from right to left) a decreasing number of rows: eight rows for the blue block, six rows for the green block, four for the yellow block, and two for the orange block.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uu8	Uu9	Uu10	Uu11	Uu12	Uu13	Uu14	Uu15	Uu16	Uu17	Uu18	Uu19	Uu20
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Figure 7. Periodic Round Table.

beauty that characterize the fundamental relationships of the chemical elements.

A different periodic table in the future

Efforts by scientists, educators, and others to produce alternatives to the conventional periodic table have been ongoing since the table was first published in 1869. Although

most of these alternatives haven't succeeded in supplanting the periodic table, maybe one of them will replace it in the future. Who knows? Maybe you are witnessing the last few years of the conventional periodic table before an alternative version becomes the periodic table of tomorrow. ▲

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