THE BIOGRAPHY OF A PERIODIC SPIRAL: FROM CHEMISTRY MAGAZINE, VIA INDUSTRY, TO A FOUCAULT PENDULUM

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Introduction

Biographies have been written of people, chemicals, and devices like zippers. Here is the biography of a periodic table. The spiral table in the student magazine *Chemistry* was introduced in 1964 to emphasize the complex yet beautiful periodicity in the properties of the chemical elements. It was modified as new elements were discovered or predicted. The laboratory equipment company, Instruments for Research and Industry, added color when it used the spiral in its calendar. The table began appearing in textbooks and was included in a history of chemistry. Franklin Hyde, creator of silicones, modified it to emphasize the central significance of carbon and silicon. It found its way to a Max Planck Institute in Germany under the swings of a Foucault pendulum.

In 1963 the American Chemical Society, having acquired from Science Service a magazine *Chemistry,* of the size of the old *Readers Digest,* asked me to serve as editor. The reason for the acquisition was mainly to prevent any one else from owning a magazine with that name. What to do with it was left to be decided. On October 4, 1957, the Soviet Union had launched Sputnik, spurring the United States vastly to improve its science education. By 1963 two national curricular programs for high school chemistry had been underwritten by the US National Science Foundation, first The Chemical Bond Approach Project (CBA), and soon thereafter, since CBA seemed to some too radical, The Chemical Education Materials Study (CHEMS). It was then felt that high school chemistry students and teachers, once raised to a new level of interest and competence, deserved an extracurricular tool purely for their enjoyment and continuing stimulation. For this purpose the ACS's *Chemistry* was to be dedicated and I was asked to design and edit it. The magazine was to be pitched to the top 40% of high school chemistry students and their teachers, but I insisted that its aim be broader, speaking to the abler beginning college chemistry student as well. I also requested that I spend the first year of my editorship in Washington at ACS headquarters. This was generously granted, and it allowed me to work closely with Richard L. Kenyon, director of publications, and with Joseph Jacobs, art director, who took personal responsibility for the overall layout and for the individual artwork for each issue of the new monthly magazine in its enlarged format.

Periodicity

The periodic law and table are at the heart of all of chemistry—comparable to the theory of evolution in biology (which succeeded the concept of the Great Chain of Being) and the laws of thermodynamics in classical physics. However, the standard periodic table as displayed in classrooms and used in textbooks always seemed to me thoroughly unsatisfactory. With its mammoth gaps in the first and second periods and the unattached collections of lanthanides and actinides floating below the table, the last impression a student would gain would be a sense of element periodicity. It was therefore with great excitement that I came across an oval periodic table resembling a football field (1), which showed no gaping holes or floating strings of elements. All elements had their place in a continuous spiral from hydrogen inside to the outer loop. The only annoyance I felt was that the lanthanides were all squeezed in a space elsewhere reserved for just three elements. The *Life* table appeared as a two-page spread (pp 82-83) in an unsigned section of its issue entitled "The Atom: A Layman's Primer on what the World is made of." It is a carefully multi-colored rendition of a black and white diagram published by John D. Clark (2). (Fig. 1) *Life* states that it received assistance for the article from William F. Meggers, Glenn T. Seaborg, and Clark. Since the lanthanide compression occurred in the outer loop, I decided it should not be difficult to give these elements a decent space simply by creating a protrusion – the resulting shape not surprisingly being nicknamed that of a snail. My unhappiness with the conventional table was probably not superficial. I had always been interested in geometry as well as in the arithmetic patterns often discovered in nature. The ancient Pythagoreans already had been fascinated by numbers which they felt were at the basis of all physical reality, and Johannes Kepler was clearly guided to his laws by his belief that God thought as a mathematician. In the 1960s I was teaching at Earlham College in Indiana and for some years Reino Hakala was a chemistry colleague. He developed one of the early diagrams showing the amazingly orderly progression in the filling of the *s, p, d, f* electronic subshells. Eric Scerri includes a similar diagram in an article on Mendeleev's legacy (3).

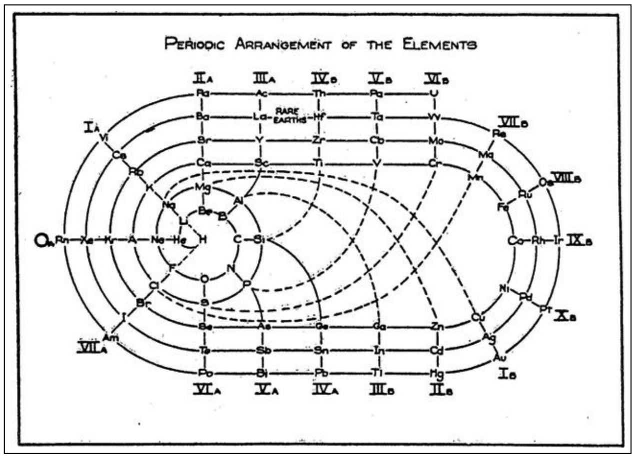

***Figure 1**. The Clark oval, the basis for the Life magazine periodic table. Used with permission of the Journal of Chemical Education. Copyright © Division of Chemical Education, Inc.*

I outlined the significance of Pythagorean thinking in the ordering of elements, at the Boston AAAS meeting as part of the Mendeleev commemorative symposium Decermber 29, 1969, but it was only published more than twenty years later (4).

I took my sketch of the modified *Life* oval to the ACS design department, and Joe Jacobs proceeded to convert it into a publishable image which after discussions and modifications appeared in *Chemistry* in 1964. (Fig. 2) It was first used to highlight the position of plutonium in the periodic table within a Seaborg article (5) on that element. My concern at the time was purely pedagogic. I needed a design that showed periodic patterns more clearly than in the tables students were used to. Jacobs, a professional artist still today, contributed the aesthetic appeal.

From the time of the spiral's first appearance, whenever we carried an article dealing with an element or a group of related elements, we published a section of the spiral, often a pie slice, in the margin where we often added comments that looked as if scribbled in pencil.

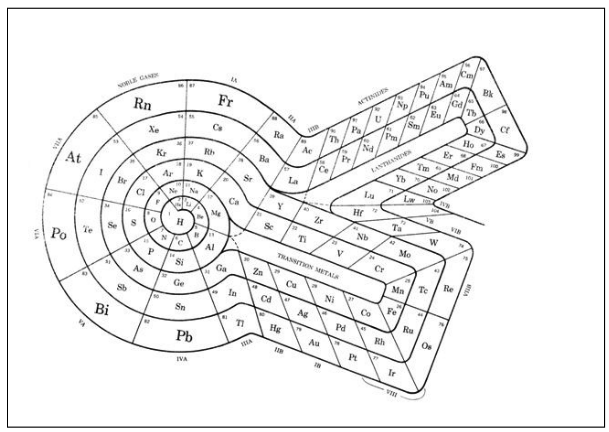

***Figure 2**. First image of the periodic snail in Chemistry.*

In correspondence with Philip Stewart I learned that I was not alone in starting on my quest when I saw the *Life* oval. For the Festival of Britain in 1951, the artist Edgar Longman based his large mural on it, and this in turn inspired Stewart's 'Chemical Galaxy' (6). All three spirals are shown by Scerri (3). Scerri also included Stewart's and my spiral in an article on newer developments in depicting the elements (7).

Glenn Seaborg

Chemistry reprinted or commented on several speeches Seaborg had given while heading the U.S. Atomic Energy Commission, as well as articles he published, and we were particularly interested in his speculations as to the expansion of the periodic table to accommodate new transuranic elements as they were being discovered. An unsigned Research Reporter piece (8) summarized and commented on an article by Seaborg (9), in which he suggested where the transuranics would appear in future tables. He placed elements 93 to 103 (neptunium to lawrencium) to complete the actinide series, elements 104 to 121 as new members of existing groups, and then placed elements 122 to 126 as the beginnings of a third group of 14 elements analogous to the lanthanides and actinides. We accordingly expanded our spiral table with the extra elements clinging to our previous design with no new protrusion. This prompted one of *Chemistry*'s readers, a high school student Herbert Weiner, to object. In a letter to the editor (10) he pointed out that the rules for introducing new subshells (*s, p, d, f, g*, etc.) demand that a new subshell be introduced after two cycles containing a previous subshell. Thus after two periods of eight elements (containing *s* and *p* subshells) there are two periods of 18 (*s, p*, and *d*) followed by two of 32 (*s, p, d, f*). The next period should contain 2 + 6 + 10 + 14 + 18, or 50 elements and involve a new *g* subshell of 18 elements. If we follow earlier patterns, the 18 *5g* elements should precede a new lanthanide/actinide series and should begin with element 121, contrary to Seaborg's earlier placement of this element. To follow this suggestion we modified our spiral table further, introducing a second protrusion, thereby producing a black and white version of the spiral as currently known and widely reproduced. (Fig. 3) We published this with the Weiner letter, but we first sent the letter to Seaborg, whose answer appeared on the same page. Seaborg defended his earlier placement. He recognized the likely appearance of the *5g* series but felt doubtful that the g series would be completely filled before the *6f* series began. However, in 1969 Seaborg published in the Russian journal *Chemistry and Life* an article entitled "From Mendeleev to Mendelevium and Beyond," in commemoration of the hundredth anniversary of Mendeleev's formulation of the periodic table. The article was later reprinted in *Pravda* and in *Chemistry*, and in it he proposed the name "superactinide" for the 32-element combined series of 18 *5g* and 14 *6f* elements (11).

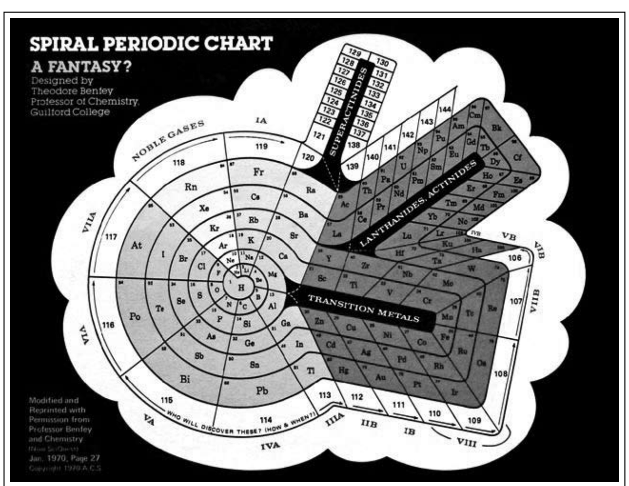

Figure 3. *Final shape of snail in a colored version as it appeared in an I²R calendar*

After we had developed our own spiral design, we found that E. G. Mazurs had published a spiral with a separate protrusion for the lanthanides (12) which, under the image, he misleadingly ascribed to Charles Janet in 1928, the same year that Janet had published a simple circular form also shown by Mazurs. The Mazurs diagram with the lanthanide protrusion was reprinted in *Chemistry* (13). However, Stewart informed me that the Mazurs figure bears no resemblance to the Janet diagram he indicated nor to any other of his designs (14). Detailed references given a few pages later by Mazurs suggested correctly that the spiral derives from Stedman (15) and is so identified and depicted by van Spronsen (16). The Mazurs diagram is a mirror image of the Stedman spiral, updated to include elements discovered since 1947.

Enter the Calendar

Instruments for Research and Industry (I^2R), a company specializing in safety equipment for the chemical sciences laboratory, was founded in 1957 by Daniel Conlon. He had become dissatisfied with the scant recognition he received for innovations he had introduced while working at Rohm and Haas. Early in the new company's history, a suggestion was made for publicizing the company through a calendar. This bore fruit when the theme was identified as humorous scenes in the laboratory, a cartoonist was located, and the decision was made that each cartoon would show use of one or more of the company's products. However, one of Conlon's friends sought to publicize a new periodic table through the calendar. It was used as the September illustration because September was the school year's beginning. The search was on for periodic tables for future Septembers. Conlon was a Quaker interested in Quaker education and not infrequently donated minutely defective and hence not sellable versions of his company's offerings to Earlham and other Quaker college chemistry departments. In my teaching at Earlham I thus became acquainted with such I^2R products as curved shields, glove bags, and lead doughnuts for steadying Erlenmeyer flasks. At the same time Conlon must have become acquainted with *Chemistry*, and hence with the spiral table, the periodic snail. As a result the table, expertly colored by his company's artists, appeared in the 1966 I^2R calendar, and it reappeared in various forms in subsequent years, once together with one of Janet's circular versions, more than once in its expanded form with the extra "feeler" accommodating the superactinides (Fig. 3). Single copies of the September periodic tables were offered free of charge on request and could also be purchased in class-size quantities. Also the spiral table was offered as a 22" x 24" wall chart, silk screened on PVC. In addition to the 30,000 or so recipients of *Chemistry* magazine, a large new community of chemists and others on the company's mailing list were now exposed to the spiral snail.

The snail of course was not the only periodic table appearing on the calendar's September pages. Many alternative, often humorous versions such as the Boron

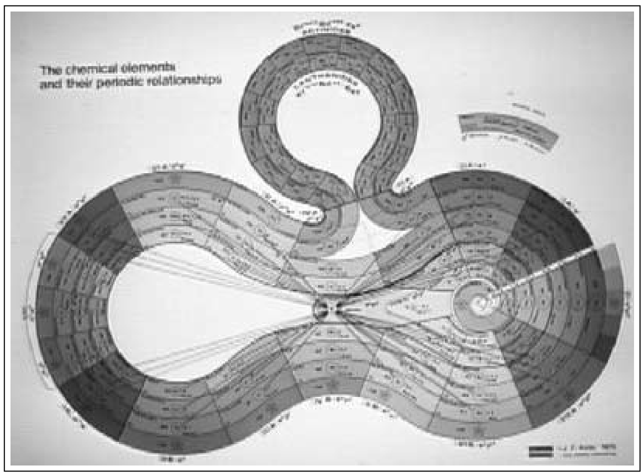

***Figure 4**. Franklin Hyde's periodic table highlighting the pivotal importance of carbon and silicon. Copyright Dow Corning*

Chemist's Concept which unduly blew up the space for boron, Industry's view which made Fe enormous with further attention to other industrially important elements, the organic chemist's chart with C at the center and with only elements prominent in the biosphere attached, and charts that could be cut and pasted to make cubic blocks ("of particular interest to cement chemists"), pyramids, and fancier helices. Some of us became unofficial scouts and consultants, seeking new tables, advising as to their suitability, and suggesting modifications (17). I^2R was acquired by the Glas-Col company in 2005.

The Hyde Spiral, Silicones, and Dow Corning

J. Franklin Hyde is widely considered the father of silicones. At Corning Glass Works he had created fumed silica used in fiber-optic cables, spaceship windows, and for sophisticated telescope lenses such as in the Hubble. Threatened by the mushrooming plastics industry, Corning asked Hyde whether there was a way to compete through the combination of properties of silicon with the diverse possibilities available among organic chemicals. Silicones resulted as well as the creation of Dow Corning as a joint venture of Dow Chemical and Corning Glass. Silly Putty was a minor by-product. Hyde's immersion in silicone chemistry made him realize the remarkable properties of carbon and silicon because of their centrally located position in the fourth group of the periodic table, between electropositive and electronegative elements. Whereas carbon is the essential element of the biosphere, silicon is central to the lithosphere. Having seen the spiral snail, no doubt through the I^2R calendar, he proceeded to modify it by creating a horizontal axis originating with hydrogen and going through carbon and silicon. It was printed by Dow Corning and was published in *Chemistry* (18). (Fig. 4). Aesthetically, it is a signal improvement over the lowly snail.

Subsequent History

The questioning of the final authority of the rectangular periodic table has slowly made its way into high school chemistry textbooks. Davis, Metcalfe, Williams, and Casca, authors of *Modern Chemistry* (successor to the classic Dull, Metcalfe, and Williams texts) chose the periodic snail as the opening image for its Chapter 5, "The Periodic Law" (19). It reached a spectacular display at the college level by appearing on the front and back hard covers of *Descriptive Inorganic Chemistry* by Rayner-Canham (20). It was ushered into chemical history by being the only periodic table shown among the 23 photographs between pages 360 and 361 in The Fontana/Norton History of Chemistry by Brock (21). Brock chose it because it clearly shows the location of the superactinides.

Finale: The Snail under a Foucault Pendulum

In 2003, an email brought news that the spiral had been installed in place of a simple circle or compass rose under a German Foucault Pendulum. Wolfgang Hönle, of the Max Planck Institute for Chemical Physics of Solids in Dresden, wrote that his institute had received a Foucault pendulum as a gift from another MPI and looked for a chemical form to place under the seemingly circling bob. He found the spiral snail easily enough at the website of Chris Heilman, Phoenix College, Arizona [*chemlab.pc.maricopa.edu*] by searching the internet under "periodic table." However, other than my name no indication as to source was given. Via the literature, the Deutsches Museum, and the Chemical Heritage Foundation, he tracked down the source. The pendulum is 11.50 m (37.7 feet) long in the entrance hall of the MPI. I trust the periodic snail is content, resting on a revolving piece of earth under the periodic swings of a pendulum. (Fig. 5).

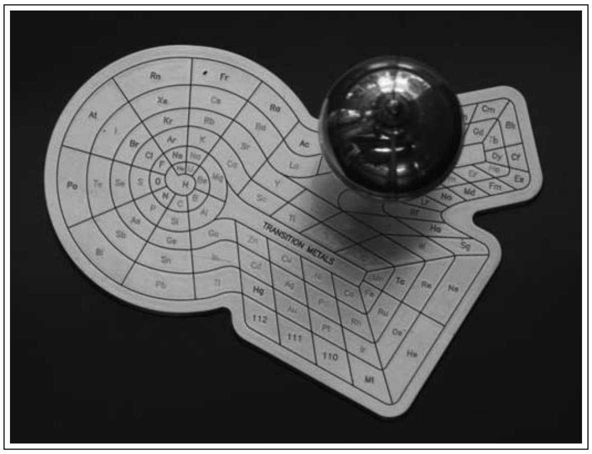

***Figure 5**. The periodic snail under the Dresden Foucault pendulum. Courtesy Max Planck Institute for Chemical Physics of Solids, Dresden, Germany*

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