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THE TRILINEAR CHART OF NUCLIDES— A UNIQUE TECHNICAL PUBLICATION

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The Trilinear Chart of Nuclides (formerly Trilinear Chart of Nuclear Species) was conceived and initiated by William H Sullivan in 1946. It represents an attempt to satisfy conflicting requirements, primarily between chemists and physicists, for the graphical representation of nuclear data. The usual method of showing nuclear properties graphically by physicists uses rectilinear coordinates and plots Z (atomic number) vs $N = A\text{-}Z$ (neutron number) or N vs Z on the ordinate and abscissa, respectively. Another system, using rectilinear coordinates, plots Z (atomic number) vs $A\text{-}2Z = I$ (isotopic number or isodiaphere).

As the cyclotron was developed into an increasingly useful tool, starting in the late 1930's, physicists began to recognize that the chemist's term C.P. (chemically pure), was useful primarily for chemists but that radioactivation was sometimes a more sensitive indicator of chemical purity than chemical analysis. Accordingly, chemists became increasingly involved in nuclear physical and nuclear chemical matters and were depended on more and more for conducting appropriate chemical spearations in the burgeoning new field of nuclear physics (i.e., artifical radioactivity).

Since the chemist had to separate one element from another he naturally became interested in the relationships and transitions between (or among) elements as the result of radioactive transformations from one element to another after being produced in the cyclotron. In a similar manner, the chemist also became interested in reducing his data to a graphical form where he could see what happened when a particular element was "bombarded" in the cyclotron. Thus, chemists plotted graphically, A (mass number) vs Z, or Z vs A, on ordinate and abscissa, respectively.

With the "marriage" of chemistry and physics on the Manhattan "atomic bomb" Project, the desirability of having a graphical form that would unite these somewhat divergent requirements of chemists and physicists became evident. Thus, trilinear coordinate graph paper, which has been used for many years by chemists and metallurgists interested in "phase diagram" studies, was considered to be the most logical graphical form for the purpose.

In 1949, the First Edition of the Trilinear Chart of Nuclear

Species was printed in four colors so that some features of the interrelationships among nuclides could be seen dramatically at a glance. Its publication by the John Wiley and Sons, Inc. was a first attempt by the printing industry. With the Chart (16' long, if stretched out, but it could be fitted within a 9½" x 11" looseleaf binding when bound and accordian-folded), the advantages of plotting simultaneously, with equal emphasis, A vs Z, Z vs N, and A vs N were realized. An additional feature of such a graphical plot was that it is possible to exhibit isodiapheres (Z vs I or Z-2Z).

In 1957, the Second Edition of the Trilinear Chart of Nuclides (vs Trilinear Chart of Nuclear Species) was published by the US Government Printing Office. The Chart was enlarged somewhat for clarity of the type (the new Chart is 17' long when stretched out but fits within a 10" x 12" three-post binder, similar to that for the First Edition). Since its publication date, two additional printings (over thirteen thousand copies total) have been made. This shows that trilinear coordinates have been accepted as a useful graphical form, despite the fact that such coordinates are foreign to some in the scientific community.

One new publishing technique for bringing the Trilinear chart up to date involves the use of "gummed stamps." Each issue of hexagonally-shaped stamps contains up to a maximum of forty-nine stamps. In this way, the stamps may be used to up-date the Chart piece-by-piece, as desired, after the orginal publication. Figure I shows a section of the Chart (approximately ⅔ of printed size), with its system of trilinear coordinates, and examples of the "gummed stamps" in place. Because the gummed stamps match in texture and tint the paper used for the Chart, the easiest way to tell where they are located is to look for the date of issue of the stamp in the lower right-hand corner of the rectangular area, known as the "name plate" (see Figure I, 7 and 19). Although these gummed stamps represent a new and rather radical departure from standard publishing practice, the technical details for producing and using them have been worked out so that the problems for the user, whomever and wherever he may be, are at a minimum.

In order to assure that the gummed stamps are "fool-proof", numerous tests were made, using male and female, technically trained (post-Ph.D.) and non-technically trained (clerks, stenographers, secretaries, etc.), and adult (maximum age 78) and child (minimum age 11). By asking the assistance of this diverse group of individuals, it was possible to obtain information about the extremes to which the sheets of "gummed stamps" would be subjected. In the summer of 1958, a subscription service for sheets of the "gummed stamps" at a charge of $1.00 was initiated by the Atomic Energy Commission through the Superintendent of Documents, Washington, 25, D. C. This is the same office from which the Chart itself may be ordered at a charge of $2.00. This "subscription service" thus represents a distinct change in the practices of an old and established government printing organization (Government Printing Office). Perhaps the real tribute to the persons and organizations supporting this endeavor is that "it works!".

As mentioned earlier, Figure I shows in greater detail, some of the more significant types of information presented on the Chart. These include:

1. The "bee-hive" pattern of hexagonal spaces for the stable (12) and radioactive (11) nuclides.
2. The fact that each different "area-shape" has a specific meaning and is not repeated. For example, a rectangle (7) gives the element symbol and mass number of a nuclide; a parallelogram (1) gives the mass number of any given nuclide decay, an equilateral triangle (9) shows that chemistry was performed to identify the element, etc.
3. Stable (12) Xe^{136} and radioactive naturally-occurring nuclides (e.g., La^{138}) are differentiated from those produced artificially, such as I^{135} (11) by means of the heavy border around the hexagon.
4. In addition to some original type, fourteen different type faces in Gothic-Regular are used to illustrate visually the decreasing importance of some types of data (e.g., overall, the relative isotopic abundance of a stable nuclide is considered more important than its cross-section value). Although there are other examples of systematics that are used to depict nuclear data, the examples cited above and examined in Figure I should suffice to show the blending of science and printing.

In Figure II, Mrs. Juanita Bowden, seated at the right and holding a copy of the Chart, shows how the publication may be used, its size, its cover and the way in which the accordian folds may be opened so that a region comprising some forty-five mass numbers may be viewed easily at one time.

One important phase of the work on the Trilinear Chart of Nuclides, in order to keep it up-to-date is the Nuclear Data Collection partly illustrated also in Figure II. Some of the more than 500 notebooks, containing reprints, preprints, photoprints, reports, etc., from the original literature, are shown on the shelves behind the table. One of the notebooks containing some of the "Master Data Sheets" is being used by Mrs. Frances Hurley (seated at the left).

This Nuclear Data Collection, which comprises many thousands (thirty-one thousand) of reprints, etc., is available for the use of any person at the Laboratory or in the surrounding area (e. g., ORINS, AEC, U. of Tenn., etc.), as well as for the use of the compiler for keeping up-to-date with the original literature in the field. The data for a given nuclide are arranged system-

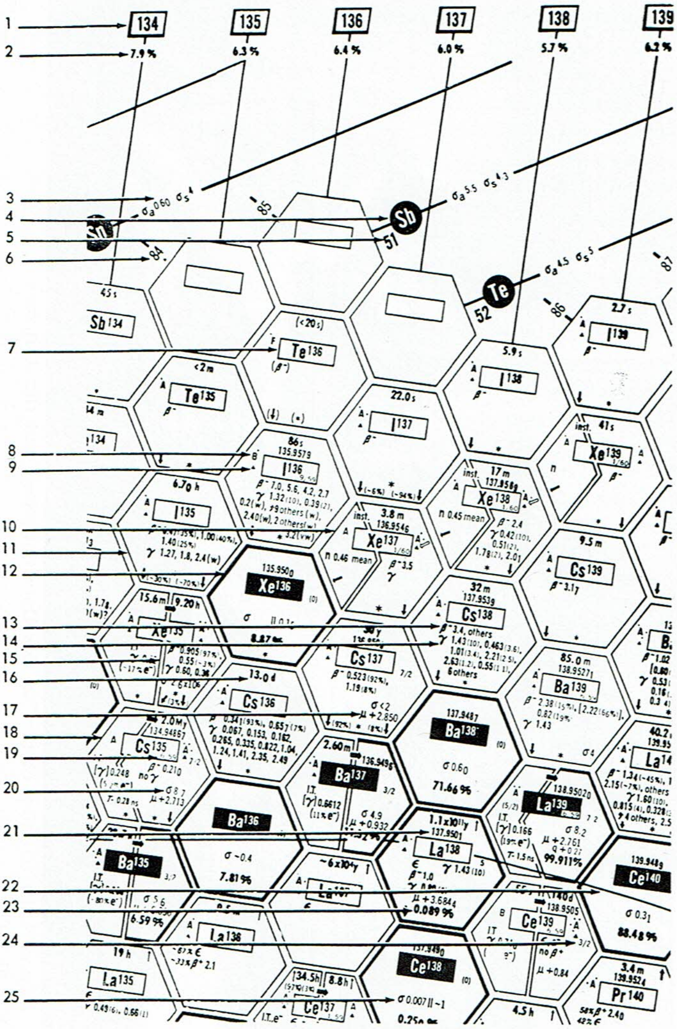

Figure I. Section of Trilinear Chart of Nuclides

1. Mass number (A)
2. U^{235} thermal neutron fission yield
3. Whole element thermal neutron cross section
4. Element symbol
5. Atomic number (Z)
6. Neutron number (A-Z)
7. Name-plate (element symbol and mass number)
8. Certainty of nuclide assignment
9. Chemistry done to identify element
10. n, p, and α emitter (diamond)
11. Artificially produced nuclide
12. Naturally-occurring nuclide (stable)
13. Nuclear disintegration (α, β−, β+, ϵ)
14. Electromagnetic radiation (γ or I.T.)
15. Nuclear isomers (split field)
16. Half-life ($t_{1/2}$)
17. Magnetic dipole moment (μ)
18. Short-lived isomeric transition (chevron)
19. Issue date of revision stamp
20. Isotopic thermal neutron cross section (σ)
21. Atomic mass value
22. Line of beta stability
23. Relative natural abundance
24. Nuclear spin (angular momentum)
25. Isotopic cross sections for isomers

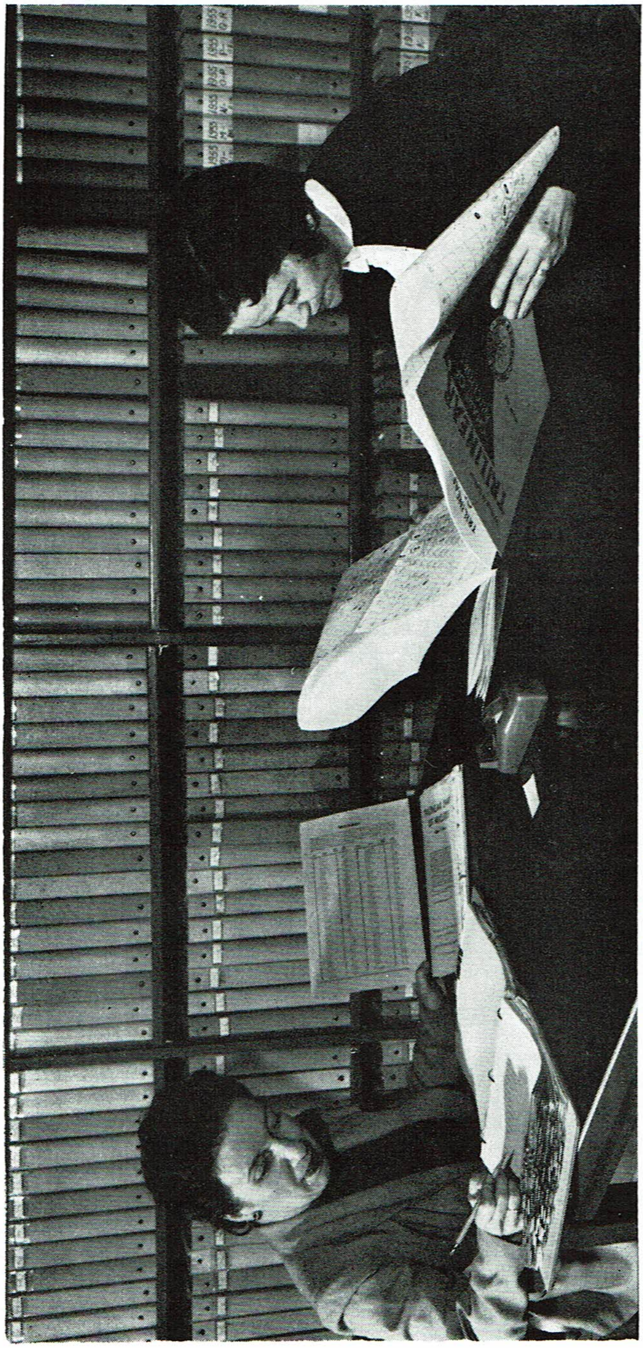

Figure II. Partial view of the Nuclear Data Collection and the Trilinear Chart in use.

atically in three-ring 8½" x 11" notebooks; first by Z (atomic number) and then within a given set of Z books, by A (nucleon number). The system of reference coding permits a user to examine the original references on any given static nuclear constant with ease, and in a fraction of the time he might normally spend in the library. The present limitations of manpower have curtailed the accumulation of data in the burgeoning field of dynamical nuclear constants. However, as a correlative adjunct for use with data to be placed on the Trilinear Chart or on the "gummed stamps", the Nuclear Data Collection is invaluable and permits the compiler to judge, together with other tabulations and compilations, what the best results appear to be for any given nuclide.

Although work on the Trilinear Chart of Nuclide has been supported by several different organizations as subcontractors of the Atomic Energy Commission, the work being carried on at present at the Oak Ridge National Laboratory is for the Technical Information Division of the Atomic Energy Commission. Its support has been manifested by displays at Geneva, Switzerland, in 1958, at Cairo, Egypt, in 1960, and Buenos Aires, Argentina, in 1960.

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matched by the University; to Charles E. Farrell and D. Franklin Farrar, Jr., $24,000 for a study of the biophysics of a bird flight; from NIH to Ilda McVeigh, $42,000 for research on the factors affecting the growth of *Histoplasma capsulatum*.

Under Title IV of the National Defense Education Act, Vanderbilt has been awarded a graduate training program in the combined areas of plant taxonomy and ecology, with R. B. Channell serving as Director. Special emphasis is being placed on the value of such a combined approach in studies of the mechanisms of evolution among higher plants. During the fall semester, W. H. Wagner, University of Michigan, H. G. Baker, University of California, and J. J. Friauf, Vanderbilt University, participated in a seminar series, specifically designed for this program in which special topics related to plant evolution are discussed by visiting specialists. Each speaker presented a total of five lectures over a period of one week, during which time he was otherwise available for individual student consultation. This seminar series is expected to continue for a period of three years.

The Kentucky-Tennessee Branch of the Society of American Bacteriologists, with Ilda McVeigh of the VU Department of Biology, serving as President, met at Vanderbilt University Oct. 28 and 29. New offices elected for 1960-61 at this meeting were: Dr. R. F. Wiseman, University of Kentucky, President; Dr. Raymond Beck, University of Tennessee, Secretary-Treasurer.

The Department of Chemistry of Tennessee Polytechnic Institute has received a grant of $2,012.00 from the Atomic Energy Commission for the purchase of instruments for use in undergraduate training in the use of isotopes.

Professor Miser Richmond has been made Acting Head of the Deparment of Biology at Tennessee Polytechnic Institute, replacing Dr. G. B. Penne-

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