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GROUP 18 CENTERED PERIODIC TABLE WITH ENHANCED INTERPRETATIONS IN CHEMICAL, PHARMACEUTICAL AND LIFE SCIENCES

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ABSTRACT

The periodic table was dissected between groups 12 and 13 followed by realigning groups 1 and 18 next to each other while ensuring proper sequencing of atomic numbers. The table now assumed a peak form. All the important elements in chemical, pharmaceutical and life sciences were captured around the peak within a v-shaped area near the table center. A useful bilateral feature emerged with elements having broadly different properties lying on either side of group 18. The new periodic table was found to represent a replica of a cross section of the earth's crust and to some extent advanced animal forms. A well-defined position was identified for atomic number 0 assigned with symbol ^{0}Ec. The scope for new interpretations in chemical, pharmaceutical and life sciences are possible to a greater depth and clarity.

Keywords: Biological elements basket, deuterium, quasi atom, atomic number 0.

INTRODUCTION

The modern periodic table had been designed on the basis of the dictates of the structure of elements that has denied any degree of flexibility and it may be considered to represent the alphabet of chemistry. In any visual image, photograph or picture the main objects are focused at the center. Therefore the principle objective of the study was to remodel the table in order to bring the most reactive elements constituting the groups 1, 2 and 16, 17 closer to each other as they exist in nature. Typical such examples include NaCl, KI, H_2O and $MgCl_2$.

Shuttling between groups 1to18 across the vacant valley shaped space at the top of the modern periodic table tends to make a slip in the thinking process in the connectivity of the elements. This is particularly the case since the elements with atomic numbers 1-20 that are responsible for bulk of the regular work in chemistry and pharmaceuticals lie at the two extremes of the popular table. Groups 1, 2 and 16, 17 lying far apart as if elements in these groups repel each other have a similar effect since these are positioned counter to the natural reactive forces of the constituent elements. The position of hydrogen is relegated to that of a forsaken isolation from the elements of its favorite affiliations.

It was evident that a remodeled periodic table could be applied with greater impact in pharmaceutical and other sciences. The first thought therefore was to bring these groups with highly reactive elements closer to each other. The new layout was arrived at by two simple realignments of the groups and periods. Another objective was to keep major principles and the standard parameters applicable to the elements of the modern 18 group periodic table undisturbed as far as possible. On this account those who are familiar with the current periodic table have no difficulty in adopting the new table. The popular symbols of the elements in current periodic tables were used throughout the text wherever applicable.

Following remodeling, the elements have positioned in a most surprisingly useful order in the table.

Difficulties encountered in the evolution process of the modern 18 group periodic table are reflected in the time taken spanning over two centuries [1]. An attempt is made here to present the table in a format that facilitates speedy reflection on many aspects of the elements in relation to health, pharmaceutical and chemical sciences. Apart from generating a periodic table with a novel format, three unique features could be identified in the new table. First is that the group 18 assuming prominence at the left center giving the table a bilateral nature. The second is the formation of a peak at the table top around which the majority of the elements routinely used in chemistry, pharmaceuticals and life sciences are crowded together. The third is the identification of an undisputed position for the long awaited atomic number 0 (Fig 1). It was assigned with symbol ^{0}Ec, pronounced 'easy' for convenience. It is meant to collectively represent in the periodic table all forms of energy, wave forms and the concept of non-matter devoid of mass which are gaining increasing significance currently. The wide spectrum of chemical compounds that one come across in pharmaceutical sciences together with the historical contribution to the development of the periodic table by a pharmacy professional, Johann Wolfgang Dobereneir of 'Triads' fame prompted the author to undertake the present exercise [2, 3].

Periodic table is a rich source of information on the nature of pharmaceuticals. Many elements of pharmaceutical significance are scattered across the periodic table mostly in periods 2, 3 and 4. In the periods further down one can find elements such as Tc, Ag, Sb, I, Ba, Pt, Au and Hg that have some limited medicinal uses together with their compounds. They are employed in radiation therapy, as antimicrobials, in Kala-azar, as X-ray screening agents and are constituent atoms of drug molecules such as those of cisplatin and antirheumatics. Simple colored compounds of Fe, Co and Cu belonging to period four are recommended as mixtures of fixed proportions to yield reference color solutions for color comparison tests in official compendia [4]. Even in situations remotely related to pharmacy such as in preparing 'show globes' that are considered as the standard symbols of pharmacy, colored compounds of Cr, Co, Ni and Cu have been used for the purpose[5]. When kept hermetically sealed they yield colored solutions with distilled water that are stable for decades. Following remodeling it was possible to formulate many other hitherto unrealized concepts with regard to pure elements and their compounds.

MATERIALS AND METHODS

The current periodic tables of the International Union of Pure and Applied Chemistry and the Royal Society of Chemistry were examined with a view to design a periodic table with groups representing most reactive elements closer to each other. This was to allow for the natural attractive forces between the elements to be better represented.

***Construction of group 18 centered periodic table*:** The 18 group standard periodic table was sliced between groups 12 and 13 separating *p*- block elements from the combined *s*, *d* and *f*- blocks so that the individual blocks are not fragmented. First section with *s* and *d*- blocks containing groups 1 to 12 was moved to the right hand side (RHS) of the second section so that group 1 elements were aligned against group 18. However when period one elements He and H were kept in line, sequence of the atomic numbers of elements between the now aligned group 18 and group1were disrupted. This was rectified by moving the section with groups 13 to 18 constituting the left hand side (LHS) of the new table one level down so that H stands alone and He is in line with Li and Be. All of the atomic numbers throughout the table 1-118 now read in the correct sequence. Group 18 consisting of noble gases standing at the left center of the new layout should be considered as the 'central core', like the spiral binding of a book in the enhanced interpretation of the new layout of the periodic table.

As usual the periods begin at group 1. The abbreviated column heading Gr.1 for group 1 is indicated with a bold text for easy identity of the starting points of the periods (Fig 1, 2). At the end of a period at the far RHS, one has to move to the far LHS end one level down, to continue reading the same period. For instance in period 2 starting from group 1, read Li and Be, then read on the LHS one level down along B, C, N, O, F and Ne ending in group 18. For the period 1 with only two elements, start with H ending on LHS one level down at He. Slicing and moving the *s* and *d* -blocks of the current table to the right side of *p*- block and thereafter moving the *p*-block elements one level down are the two major changes in the new layout. In the process the *d*- block had been move to RHS of the table. The *f*- block elements were placed at the bottom of the table as usual.

The grid consisting of squares that cage the elements were drawn with porous broken lines to represent the openness in which the elements exist in the planet earth exposed and suspended in the outer space. Elements naturally existing in gaseous phase are positioned on the top left side of the table except hydrogen positioned at the tip of the peak. Together with their simple gaseous compounds mostly formed by reacting among themselves they are represented in a manner as if ready to escape into the outer space and move back and forth. This led to the realization that a similar relationship exists in the mechanism of exchange of gases that operates in the respiratory system of higher animals and in the case of higher plants, the exchange of gases through the stomata.

***Assigning atomic number 0 and symbol ^{0}Ec*:** There had been few earlier attempts to introduce atomic number zero to the periodic table based on mass. The present attempt was to base atomic number zero on non-matter devoid of mass. The symbol ^{0}Ec with atomic number zero was inserted at the top of group 18 in the newly appeared 'period zero' of the table in order to reflect the increasing significance of non-matter, wave forms, all forms of energy and entities without mass.

Reading in the sequence of reducing atomic numbers, the proposed position for the atomic number zero was identified as follows. The relative atomic weights of elements starting from around ^{20}Ca (At. wt. 40) to ^{2}He (At. wt. 4) are nearly twice that of their respective atomic numbers so that their proportion is 2: 1. According to the sequence of reducing atomic numbers the position next to He is valid for isotope deuterium with an atomic weight of 2 and an atomic number 1due to the presence of one proton and one neutron in the nucleus. It retains the proportion 2: 1common to all elements considered here. This trend is disrupted by having hydrogen instead, which has a deficient nucleus to that of deuterium. Hydrogen possesses only a proton but no neutron resulting in an atomic weight of 1. The depletion of hydrogen atomic nucleus becomes obvious when the ratios of atomic weight to atomic number of helium (4: 2) or (2: 1), deuterium (2:1) and hydrogen (1: 1) are compared. According to this ratio pattern, the position presently occupied by hydrogen should rightfully belong to deuterium in which 2: 1 ratio is retained. On account of the deficiency, though hydrogen is indispensable, it should be considered as a form of 'quasi atom'. In the direction of reducing atomic numbers, the position next to H could be expected to wear off the remaining single proton from the already quasi atom, justifying the installation of the weightless entity with atomic number zero ^{0}Ec. The alpha-numeral symbol is derived from atomic number 0 and the two quantities E and c that does not represent mass from the Theory of Relativity equation $E = m.\ c^2$.

Despite the exchange of the groups in the new table format, the sequence of increasing atomic numbers was retained intact. The new layout brought the atomic numbers 1 to 20 crowded together at the peak with H standing alone. A potential empty slot in the grid was observed bordering H and He (Fig 1). This prompted the possibility of introducing symbol ^{0}Ec with the atomic number 0 to the table, ahead of H which has the atomic number 1. The well-defined new position at the head of group 18 is to represent all the forces in nature, other than 'matter' that is related to the atomic mass. It was thought appropriate to assign the symbol ^{0}Ec extracted from the Theory of Relativity equation $E = m\ c^2$.

RESULTS AND DISCUSSION

The remodeling resulted in a convenient form of the table that has retained all the basic features of the modern periodic table. It has brought in to view several novel features that were otherwise not visible in the periodic table. Although not clearly visible as in the remodeled table, certain discussion materials are common to standard periodic table as well.

***Design features of the new periodic table*:** The new layout of the periodic table has the elements positioned in a pattern that gives greater visibility, freedom and meaning to their interrelationships. It has brought the elements that matter most in chemistry and in life sciences such as pharmacy closer together and their relevance to each other easier to fathom. The *d*- block elements had been moved from the formerly central position to the RHS of the table contributing to this freedom and bringing to prominence the peak form of the table. The formation of the v-shaped 'biological basket of elements' around the peak of the new format is a significant development (Fig 2).

The new table resonates well with the natural tendencies where elements with greatest attractions lie closer to each other. It was in a sense animated with the introduction of a position for atomic number 0 with the symbol ^{0}Ec representing non-matter and all forms of energy ahead of the atomic number 1.

The new layout has assumed a significant asymmetric LHS-RHS bilateral nature to the table at group 18. The LHS elements C, N, O, P and S can present themselves in two forms, either organic or as inorganic oxyanions whereas the RHS elements exists only in the inorganic form. The bilateral division of elements having broadly different properties on either side of group 18 is clearly visible in the new layout. This arrangement could be used as a new tool in interpreting the chemistry of the elements.

Biologically significant elements C, O, N, S, P, F, Cl and I on the LHS of the centrally placed group 18 were found to be lying in close proximity to biologically significant inorganic elements such as alkali metals Na, K and alkaline earths Mg and Ca together with H on the RHS of the new table (Fig 2). In a new development the most significant elements in living matter were found to be represented in the periodic table lumped together as a result of remodeling. It is ever puzzling as to why the vast majority of the medicinal compounds too consist of the very same basket of biological elements that constitute the living organisms.

The focal point of the newly laid out periodic table is the group 18. It can be visualized that the *p*- block elements in a given period shed one electron each starting from group 17 as one move down to group 13 on the LHS of the table. On the RHS one electron each is added to the elements in a given period as one move up from group 1 to 12. It appears that the least reactive group 18 (formerly group 8) has now assumed a central 'reference point' standing as an anchor for the rest of the groups in the new format of the table. This is a phenomenon that deserves greater attention.

Compounds formed by combination of the group 17 halogens and group 1 alkali metals lying closer to each other on either side of the central group 18 form highly polar freely soluble salts. Halogens do the same with group 2 alkaline earth metals but with a lesser intensity. So does the reaction pattern of RHS groups 1 and 2 elements with oxyanions formed by the elements S, N, P and C with O on the LHS. Following the new layout, it appears that oxygen transforms these LHS biological elements to counter parts of RHS elements in the formation of electrolytes. This property of aiding water solubility of electronegative elements by O has not been discussed widely as a concept. Innumerable C back-bone water insoluble compounds, some including N, O, P and S, all of which belong to elements in the LHS are drawn in to aqueous media by group 1 elements Li, Na and K of the RHS of the table.

Relating the table to pharmaceuticals and health sciences**:** The positions of elements in their characteristic spheres of health care applications can be located around certain areas of the table. There are many pharmaceutically useful pure elements such as He, F, Cl, O and S as well as many simple compounds such as those of Li, Na, K, Mg, Ca, N, O and S derived from the 'biological basket of elements' at the top of the table center. At the RHS extreme of the new table one can find lined together in period 4 some of the most useful elements Cr, Mn, Fe, Co, Cu and Zn. These are micronutrients and complex forming elements as in the case of macromolecules heamoglobin, zinc insulin hexamer and in cynocobalamin. For instance according to the molecular formulae, four Fe atoms combine with 9268 atoms belonging to other elements in hemoglobin, two Zn atoms combine with 4728 atoms in Zn insulin hexamer [6] and one Co with 182 atoms in cyanocobalamin.

Lying on to the LHS of the peak is the trio B, Al and Si that provides some useful medicinal compounds such as intravenous calcium boro-gluconate (veterinary), aluminium hydroxide, magnesium trisilicate and semithicone. The insignificant role they play in the formation of living organisms are extended to the medicinal compounds of Si and Al. They merely act locally within the gastrointestinal tract without getting absorbed into systemic circulation. Their non-medicinal pharmaceuticals include excipients, devices and packaging materials including soda lime glass, borosilicate glass, silicones, silica gel, aluminium tubing and foil. It is strange that the second and third most abundant elements on earth Si and Al have no major role to play in living organisms. There is a RHS counterpart trio consisting of Sc, Ti and V. Though interposed between life science and micronutrient elements, their pharmaceutical applications are minimal. An exception is the excipient white pigment $Ti\ O_2$. Antimicrobials and medicinal compounds have been derived from elements lying further down the table such as those of Ag, Pt, Au, Hg and Bi. Examples include silver nitrate, cisplatin, antiarthritics and phenyl mercuric nitrate.

It is interesting to note that the elements such as F, Cl, Br, I and Li, Na, K, Mg and Ca that can substitute H from organic and medicinal compounds are placed on either side adjacent to group 18 mostly around the peak of the table. All of the chain, ring, plate, sphere, lattice and branch forming elements mainly C, Si and to a lesser extent N, O, P and S lie on the LHS of the table. All these features can be easily figured out in the newly laid out periodic table due to close proximity and greater visibility of elements that are significant in life sciences and chemistry.

There are elements occurring in the deeper layers of the table that are generally not conceived to have any curative properties. However through a unique process of potentization of serial dilutions either 1in 10 or 1in 100, the homoeopathic system of medicine [7, 8] has developed some of these elements including Pd, Sn, Te, Os, Pt, Tl and Pb in to useful therapeutic agents [9]. The British Pharmacopoeia has a section and monographs on the subject. They are serially diluted 30, 200 or 1000 times well past the exhaustion of the material drug as per Avogadro's constant.

***Relationship of the new periodic table, earth's crust, higher animal and plant forms*:** A remarkable finding is that the formation of the peak at the upper margin of the new table has brought in to view a primordial representation of the three phases of matter that exist in the natural world into the table. The gaseous atmosphere, surface liquid bodies and the solid earth crust can be identified from the peak above to the deeper layers of the table. Since no element in the life science basket exists in liquid form, the liquid bodies are represented by their simple compounds such as water, ethyl alcohol and acetic acid. The table also remotely represents three phases found in the structure of higher animals with their respiratory, body fluid and skeletal tissues representing gas, liquid and solid phases. Same could be figured out remotely in higher plants when related to physiology involving the stomata, xylem vessels in sapwood and solid heartwood.

The relationship of the quartet consisting of the periodic table, a cross section of the earth, the higher animal structure and the plant structure is bound to have a far reaching impact on the interpretations relating to all studies concerning life sciences. It has the potential for identifying many new concepts in relating chemistry to life sciences that may not be visible at present. Animals and the plants are essentially built up with 'biological basket of elements' together with their compounds that were initially in gaseous or liquid form prior to anabolic conversion in to solids. There is a mass transfer of these elements between the environment, plants and animals mainly during photosynthesis and respiration with great natural harmony.

When the earth is dug up for coal, fossil oils, minerals and radio-active material and brought to the surface the natural interplay between the 'biological basket of elements' and living organisms is disrupted leading to malfunctioning and deformities of the biological structures. Mining in a sense is like dislocating period 5 and 6 elements and placing them among periods 2, 3, and 4 of the periodic table bringing about chaos to the natural order. Also when substances existing in natural proportions are disturbed as with the cases of excess of greenhouse gases or depletion of ozone layer, adverse effects leading to far reaching outcomes such as climate changes or health hazards such as skin cancer can be the result. It is to be noted that gaseous form of elements are positioned around the peak of the new table. They include H, N, O, F and Cl as well as other elements that combine with them to form simple gaseous compounds such as H_2O (vapor), NH_3, CO_2, SO_2 and CH_4. Same group of elements form compounds in liquid phase such as H_2O (liquid), ethanol, acetone, glycerol, fatty acids and oils all of which are of immense importance to the pharmaceutical processes. The elements on the RHS appear destined to remain in solid form except H and Hg that exist in gas and liquid phases respectively.

Elements further down the table more or less may be equated with the insoluble earth's crust. Embedded in these layers are the radio- active isotopes useful in nuclear pharmacy. The living tissue formed by the 'biological basket of elements' at the top of the table appear to be inimical to elements lying further down the table so that most of these are insidiously toxic and destructive to living matter chemically or in some of the worst elements through radio-activity. For instance radio-active iodine (RAI) isotope I_{131} belonging to period 5 of the table is employed in controlled ablation of the thyroid gland in hyperthyroidism.

With the increasing incidences of antibiotic resistance, the pharmaceutical industry need to have a fresh look at element based antiseptics and antimicrobials however arduous, for appropriate formulation in the lines of povidone iodine and silver sulfadiazine. No microbial resistance to antibacterial activity of some of the elements had been found despite prolonged large scale use. Examples are O (hydrogen peroxide), Cl (chlorination) and I (tincture iodine, povidone iodine). Other similar elements include Zn (zinc oxide plaster, dusting powder, calamine lotion), Ag (silver nitrate) and Cu (copper sulfate).

Elements in the *f*-block lanthanides and actinides have very little physiological and pharmacological uses. However gadolinium organic complexes administered intravenously are used in magnetic resonance imaging (MRI) diagnostic contrast media since ionic Gd is extremely toxic [10].

There does not seem to be a role for both ^{3}Li and ^{4}Be in living organisms and for the latter in therapeutics despite their position among basket of life science elements. Same is the case with ^{21}Sc and ^{23}V given their positions among the biologically useful elements (Fig. 2). Viewed from the new layout of the periodic table of elements more light may be shed on chemistry, physics and the life sciences beyond what was understood up to now.

Suggested applications of symbol ^{0}Ec: Essentially it has fulfilled the long standing quest for the introduction of atomic number zero in to the periodic table. The symbol ^{0}Ec will grow more versatile with use and should be useful in overcoming the present void in relating chemistry to living organisms. The symbol Ec may be applied in situations where some form of energy changes take place or manifested. For instance, although chemically heterogeneous to the extreme, all of the compounds sucrose, saccharin, aspartame and lead acetate taste sweet. This phenomenon could be considered as a form of different levels of chemical energy. Therefore it comes under the representation of the symbol Ec that stands for entities and phenomena devoid of mass. The specific case here may be represented as $Ec_{\text{(taste, sweet)}}$. The contrary is also true where polymorphic forms of the same compound have different properties such as crystalline structure, melting points, solubility and color. Polymorphism occurs in an increasing number of drug molecules. Mebendazole has three polymorphs, with varying dissolution rates. Current dissolution criteria for the Mebendazole Tablets USP could be met only with a specific polymorph. In this instance the different energies of the same compound may be expressed as $Ec_{\text{(polymorhs)}}$. Different chemical compounds with similar smell may be represented as $Ec_{\text{(odor)}}$. The symbol ^{0}Ec could be applied in relation to many more events in chemistry such as exothermic reactions, endothermic reactions, density changes, reflection, refraction, luminescence, sublimation and phase changes.

CONCLUSION

Following remodeling, the biologically and pharmaceutically significant elements were lumped together in a limited space of 11 elements between atomic numbers 6-20, not counting ^{10}Ne, ^{13}Al, ^{14}Si and ^{18}Ar. Hydrogen is another significant element. They all could be viewed under minimum change of visual focus. A secondary life science series of elements consisting of micronutrients can be found between atomic numbers 24 – 30 with the exception of ^{28}Ni. Micronutrient Se and I however lie within the main life science basket of elements. The strongest electronegative elements F, O, Cl, N, S, C, H, I and P (4 to 2.1 Pauling scale) are also found in the life science basket, all on LHS except H [11]. The strongest electronegative element in the RHS is Ca with a scale of 1.

Bilateral nature of the table based on central group 18 separating broadly different elements is a new dimension with which properties of the elements and their compounds could be viewed. The subjects of biology, toxicology and chemistry including those of drugs could be analyzed and comprehended from an entirely new angle with the relationship identified between earth's crust, periodic table and higher life forms. A cautious statement may be made to the effect that nearly 65% of elements of the periodic table are biologically dead elements.

A well secured position for atomic number zero assigned with the symbol ^{0}Ec was identified. This was on the basis of reducing atomic numbers of elements from ^{20}Ca and an abrupt reduction in atomic weight: atomic number ratio at the position for H atom. Although its atomic number is 0, the symbol Ec ('Easy') could be considered as one of the most significant additions to the periodic table. The enormity of this development can be understood when one realizes the present trend in increasing significance attributed to non-matter in modern scientific pursuits.

The overriding conclusion is the realization that the new periodic table has assumed a structure representing the image of the cross section of the earth and that both the higher animal and plant forms carry a distance image of the new periodic table. Scientists from various fields are bound to benefit from the new points of view presented in the remodeled periodic table which are by no means limited to what is discussed.

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Gr 13	Gr 14	Gr 15	Gr 16	Gr 17	Gr 18	**Gr 1**	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12
					0 Ec	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	57-71	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	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn
113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo												

Lanthanide series	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
Actinide series	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

Fig. 1: Group 18 centered periodic table layout indicating the redistributed groups and the peak formation at the upper margin. Gr; Group, ^{0}Ec; symbol for atomic number zero. Standard symbols for the elements have been used in the table.

Gr 13	Gr 14	Gr 15	Gr 16	Gr 17	Gr 18	**Gr 1**	Gr 2	Gr 3	Gr 4	Gr 5	Gr 6	Gr 7	Gr 8	Gr 9	Gr 10	Gr 11	Gr 12
					0 Ec	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	57-71	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	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn
113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo												

Lanthanide series	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
Actinide series	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

Fig. 2: Group 18 centered periodic table indicating locations of elements of interest in life sciences. Solid shaded area indicates v- shaped biological basket of elements. Diagonal down shaded area shows three elements of pharmaceutical significance that are not absorbed systemically. Diagonal up shaded area shows three elements with minimum pharmaceutical significance lying among useful elements. Trellis shaded area on top right shows micronutrient elements. Gr; Group, ^{0}Ec; symbol for atomic number zero. Standard symbols for the elements have been used in the table.

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