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In the Classroom

Mnemonics for the Entire Periodic Table

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A mnemonic for the entire periodic table of the elements recalls the names and abbreviations of all the elements, their basic electron structures, and some properties. Elements are presented in chemically useful groupings with a method that allows one to position an element without recreating the entire table. With two additional lines one can derive all the major elements and the trace elements required by humans. Another verse identifies anomalies in orbital filling. The mnemonic and explanations can be fit on one double-sided page to provide a one-page reference.

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The periodic table is the foundation of most of the physical and life sciences. The elements however, were not named on this basis and it is not easy to remember their positions or even the names of less common elements. Although one hopes that the error of substituting gallium (Ga) for gadolinium (Gd) in the description of the containment efforts at the crippled Chernobyl reactor [1] could never occur at the actual site, this

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example shows how, even in the scientific community, just the names of the elements can be a problem.

At a recent seminar I could not relate lead to other elements, yet I was able to recall all the d- and f-group elements from a mnemonic that I devised 25 years earlier. I was surprised by this reappearance of so much long unused chemistry; after my undergraduate studies, I worked in biochemistry and the periodic table is not a feature of biochemistry laboratories. This demonstration of the long term retention that is possible with mnemonics led me to extend this approach to the rest of the table. The mnemonic presented below provides an acoustic link [2] between the words of the mnemonic lines and the names of the elements. It uses the imagery incited by these lines[2] to recall a number of chemical concepts. While such a devise can be expected to increase long-term retention and the enthusiasm for learning in most students [2], based on past studies of the teaching of the periodic table [3], one can expect that some students will still prefer the traditional presentation of the periodic table. Lectures should therefore not reach the point where one is teaching the mnemonic. The mnemonic is simply another learning aid that may be of use to some students. It can be inexpensively distributed to students as most of the information, including the basic instructions and all the endnotes, can be fit on one double-sided sheet of paper (see Appendix I).

The mnemonic considers elements in the traditional groupings. It builds up from the most common elements so that the lines can be gradually presented as the periodic table is studied. An individual familiar with the common elements can consider only the lines for the unfamiliar elements. Since many chemical and biological properties can be related to these lines (Endnotes), a lecturer can reinforce the mnemonic lines throughout a course as these properties are encountered. The organization of the mnemonic allows one to position an element in the table without regenerating the entire table.

To obtain the names of elements, one adds “-ium” or “-dium” to the first one or two syllables of each word (underlined in the mnemonic). This directly gives the name of many rarer elements; trying various pronunciations will recall the names of most elements.

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Difficult abbreviations are emphasized as hyphenated words; with some noted exceptions[3,7,8,11,13], the first letter after the hyphen is the second letter of the abbreviation. If one knows the abbreviation for an element, the second word can be omitted. Elements that are actually named in the text (shown in italics) usually have a one letter or unusual abbreviation. When one learns five other one letter abbreviations (B, S, F, I, U), a simple rule gives perfect abbreviations for the rest of the natural elements: one takes the first two letters of each name, or the next unused letter if the second letter has already been used. Appropriate pronunciation (next paragraph) will readily identify three exceptions among the transuranides (Cf, Es, Md).

Short clarifications appear in parentheses in the mnemonic. Endnotes give longer explanations, other memory aids and properties and ideas that a lecturer could relate to the mnemonic line. Words that do not code for elements (&, the, to) are in brackets; many of these words can also be eliminated when the meaning of a line is understood. Abbreviations are in bold type. For easy learning, give words a pronunciation that resembles the names and put the emphasis (often shown by hyphens) on the letters that give the abbreviation. One's scientific background will improve however one's English will deteriorate.

Text of the Mnemonic:

Hi,..... **He**ro![1],
Bear-illy:.....**B**oring **C***arbon*, **N***itrogen* & **O***xygen* **F**loor.[2]

↓ **H**ide **Li**ght *Sodium* & *Potassium*; **R**a-**b**idly **C**ea-**s**es **Fr**ance.[3]

↓ **He**ro **Nee**ds **Ar**guable **Kr**yptic **Xe**s. **R**ight-o**n**![4]

↓ **Be**ar **Mag***nesium* & **Ca***lcium*$^{\rightarrow Sc}$; **S**trong-**r**ain$^{\rightarrow Y}$ **Bar**s$^{\rightarrow La}$ **Ra**diation$^{\rightarrow Ac}$. [5]

↓ **B**oring **Al***uminum* **Ga**lley's **In**digestible **T**ally-**l**ist.[6]

↓ **C***arbon* & **Si***licon*'s **Ge**rmane [to] *ti***nS**- & *lead*-**P**ro**b**s![7]

↓ **N***itrogen* & **P***hosphorus* **A**re-**s**cenic ante-**money** **Bi**smarks.[8]

↓ **O***xygen***s** **S**uffer, **Se**aling **Te**lls **Po**lls.[9]

↓ **F**leeing **C***hlorine*-**l**ayers & **Br***omine*, **I**'d **As**tonish.[10]

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$^{Ca}\rightarrow$**Sc**ant **Ti**tans **V**end-aid [to] **C**hromatic-**r**ow **M**angy-**n**eeds,

Ferociously **Co**bble **Ni**cks, & C*opper*-**u**p **Z***inc*-**n**etworks.[11]

$^{Sr}\rightarrow$**Y** (Why) **Z**e-**R**econ **N**eo-**b**odies **Mo**llify **Tec**hniques?[12]

Ruthless **Rh**oads (roads) **P**ale-**d**e (the) *Silver*y **Ca**d**d**s.

$^{Ba}\rightarrow$**La**and$^{\rightarrow Ce}$... & **H**ave-**f**un **Ta**ntalize *tungsten*-**W**olfram,

Renal **Os**mosis **Ir**ritates **P**la-**t**onic *Gold*en *Mercury*[13].

Laand$\rightarrow$ **Ce**remonies: **Pr**esiding **N**eo-**d**imwits **P**ro**m**ise **S**ome-**m**ere **Eu**ropean **G**od-**d**ole,

Tur-**b**id **Dy**sproteinemia **Ho**les **Er**ban (urban) **T**ool-**m**ans **Y**ear-tear-**b**ook **Lu**cidly.

Radiant$\rightarrow$ **Ac**ting **Th**oroughly **P**rot**a**cts (protects) **Ur** (your)[14] **Nep**otism, **P**lu-**u**tocratic **Am**erica

Cures-**m**e & **B**er**k**eley **C**ali-**f**ornia, **E**in-**s**tein **F**ir**m**ly **M**en-**d**ed **No**ble **L**aw-**r**eins...

Lines for identifying nutritional requirements:

Hi Carbon-to-Bones: **V**end-aid-to-**Zi****n**c[15]

For all traces,[16] REPEAT **B**oring **C**arbon,

ADD: **I**'d **F**lee **Mo**llified **C**a**d**s, **Si**lly-cons & *Arsenic* **Se**alings.

Lines for identifying anomalies in orbital filling:

When the first low ds steal a stabilizing s to get a full or half full rack,[17]

then **N**eo**b**odies all steal one up to the d ten PAC,[18]

after just the PAC basement steals just one electron back.

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Land f orbitals all contract d one, but two return it to get a stable run.[19]

Hot fs are d two thieves, that steal each one in steps of threes,

Return policy's the same, as in the lanthanide game.[20]

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Endnotes

[1] **.** Basics: The superabundant elements (of the universe) stem from the **s**ingle shell with the **s**ingle electron pair in the **s**pherical **s**-orbital. The **p**redominant **p**edestrian elements populate the **p**ear-shaped, **p**erpendicular **p** orbitals. A **d**ecade of **d**eluxe, **d**ense elements found in *scant* **d**eposits derive from the so highly **d**eveloped shapes of **d** orbitals (so highly **d**eveloped for energy that electrons first occupy the next s orbital); *Scant* recalls the line that starts them[5,11] and that they come after the s orbitals of Ca. **F**ourteen fringe, **f**leeting or **f**ake elements form from the so **f**ormidable **f** orbitals (so **f**ormidable that electrons only occupy them after starting on the next d orbitals[19,20]). "New shell, new orbital with two more pairs" recalls that a new orbital appears with each shell number and that each new type holds two more electron pairs than the previous type. The line "Starting period develops further" states that some shells are only filled at later periods and it recalls the abbreviations for the orbitals (first letter of each word), the shell number at which each type of orbital first appears (position of word in line) and how many periods later a given d or f orbital is actually used (position of word after "starting period").

[2] **.** Tolerate the boring elements that constitute the foundation of the universe, the body[15] and the periodic table. The punctuation provides the framework of the table, the words recall the lines for each column.[3–10] Used in reverse, this system gives the position of an element in the table: counting on one's fingers as one goes down a column[3–10] will give the outer shell number of an element when the name of the element is reached and the electron configuration can then be determined as in[1]. As "Bore-in", B recalls that this is the element that starts the diagonal that *bores down* through the table to split it into metals and non metals.

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[3]. "Hide" these low density reactive metals! With its short half life, Fr *rapidly* ceases to exist.

[4]. Algebra clues are Xes. "-on!" is needed for the names after He and the abbreviation for Rn ends o**n n**!

[5]. You carry these major body constituents.[16] Rain removes atmospheric Sr derived from nuclear tests. The pause recalls that when the major body constituents end,[15] the *Scant*[1,11] transition elements start. From Ca, this column *bears* extensions (leads to another line) at every word; "Scant. Why?[12] Land's[13] radiant.[14]" recalls the other lines. Use this column to rapidly determine the outer shell number of any d or f element.[2]

[6]. "Indigestible": all these elements are not required by humans.[16] "Boring" in chemistry.[10]

[7]. "germane" *to chemistry* (recall the valence of C in Sn and Pb "prob[lem]s") and *to biology* (the named elements are essential[16]). The abbreviations (**S**ta**n**nous, **P**lum**b**ic) are also "probs."

[8]. Bismark united Germany; before money existed, N united proteins and P linked DNA. **money**: the dollar sign is S on top of b = **Sb**.

[9]. Atmospheric **Se**aling tells pollsters about the suffering of "[ozone] oxygens."

[10]. "...[those ignorant of these colourful vapours]". Compare lines at this point to note that the mnemonic reminds that chemical reactivity increases as one goes from the middle of the table ("Boring.."[6]) to the sides ("Hide..",[3] "Flee.."[10]) until "kryptic"[4] inert full orbitals are achieved. This overview can note that density decreases from the "Dense"[1] elements in the middle to the "light"[3] elements on the left and the gases on the right.[2,10] The mnemonic notes that very heavy nuclei are unstable (Fr[3], Ra[5]).

[11]. These "Scant[1] Titans" of the industrial age: (1) give help to man as essential trace elements[15,16] ("mangy-needs") of the d row ("chromatic-row"); (2) they mend "nicks" in their electron shells (their basic chemistry) so "ferociously" that anomalies in orbital filling occur;[17,18] (3) they copper coat Zn networks (metallurgy: this gives the brasses). Associate Fe with the prefix for iron: ferro. Generalize these observations (e.g., all transition elements form alloys) and expand the key words: "Chromatic row" notes that transition metals add colour to compounds (Cr is the red of rubies, Fe is the red of blood). Human dietary needs for trace elements are "mangy" (mediocre): they are in the m ranges (milligrams to micrograms per day); a deficiency in one of these usually gives a "mangy" appearance (a skin condition and/or anemia). These essential trace elements *sell their help* since they usually function as redox cofactors. But, expand "vend-aid" to "vent-aid" (aerate) and move the comma over by one word, to recall that Fe must be in the ferrous form in hemoglobin. "Vent-aid" also recalls that increasing the Cu in brasses improves their resistance to corrosion. Expand "mangy-needs" to "magnetic-needs" to recall the importance of magnetism in these chemistries: the last word of each section then gives the principle of paramagnetism: "needs nicks [in electron] networks" (i.e., unpaired electrons). For the principle of ferromagnetism, atoms "ferociously cobble nicks" (to keep them aligned); this explanation gives the names of the only three elements that exhibit ferromagnetism (Fe, Co, Ni).

[12]. "Why do the new recruits sent on reconnaissance..." The pronunciation of Y (and Yb) comes from their Scandinavian origin.

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[13]. Land (stretch pronunciation) stretches to the lanthanides. The kidney increases the toxicity ("irritates") of chemically quite inert ("platonic"), Au-dissolving ("golden"), Hg. Use **H**idden-**g**as for the abbreviation to caution that Hg gives off a tasteless toxic gas.

[14]. "Nothing exists after you (U)" reminds that the transuranides are synthetic and stresses the abbreviation. A "**Te**c**h**nique" and a "Neo-dimwit's **P**ro**m**ise" are also not found in nature!

[15]. Man starts life as carbon and ends as bones. Taking hydrogen, and going from carbon to calcium [phosphate *bones*] in the table encompasses all the major dietary elements. *Sell* elements going from V to Zn as about a half of the essential trace elements.[16]

[16]. "For all trace [elements], REPEAT [the] Carbon [line[6]]" to include Sn and Pb as trace elements and ADD the indicated elements to complete the list of essential trace elements.[15] "*For all traces* [of error in the major elements], REPEAT [the] Boring" line"[7] to eliminate Al as a required nutrient; compare with the trace element list to conclude that Si is only a

[17]. The "low[er shell[1]]" d orbitals "steal" an s electron to attain the more stable half (Cr) or completely (Cu) filled configuration.

[18]. In the next row ("then"), from Nb, elements that are not half filled[17] "all steal one ... up to the" d^{10} *pack* ("PAC"= **P**d-**A**g-**C**d); Pd must "steal" both s electrons to attain d.[10] In the last row, only the elements under PAC "steal [and they steal] just one electron".

[19]. Lanthanides are thieves[17,18] of *Lanthanum's-hide* (the characteristic $5d^1$ electron[1]) but Gd and Lu return it to attain a more stable[17] configuration. "Contract" replaces steal to recall the lanthanide contraction (This principle also explains "Dense"[1,10]).

[20]. The radioactive ("hot") f elements steal after two electrons are in d orbitals ("d^2 thieves") and they "steal each one [of the $6d^2$ electrons] in steps of threes" (at the third element, Pa, and at the sixth, Pu). As with lanthanides[19], they "return" an electron for more stable configurations (Cm, Lw).