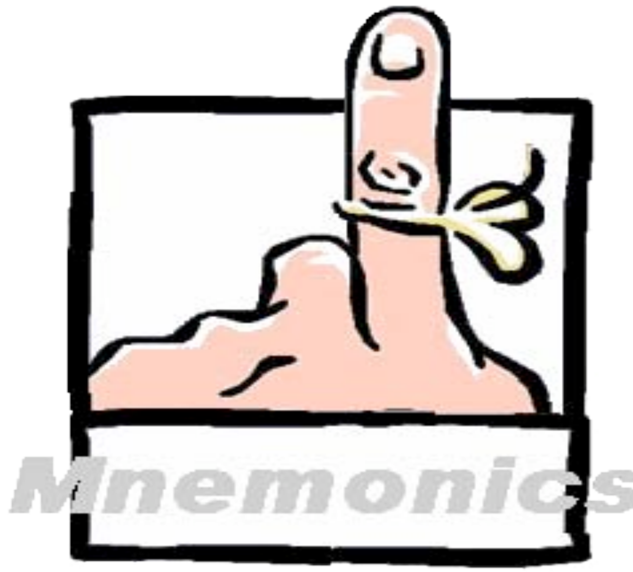
Mnemonics (Memory Aids):

for General Chemistry, Organic Chemistry, and Biochemistry
(including Greek and Latin roots and how to remember the periodic table)
Mnemonics meant to remember long term (not to dispose of next week).



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Chem West at North Central College, 3/16/2010

How to make a better mnemonic

How to make a better mnemonic:

1.) Make the remembered sentence more easily remembered: shorter, more logical, or more funny or more silly. If this sentence is too difficult to remember, you might as well just recite the actual set of words that you want to remember.

2.) Each word reminds you of a word to remember. Instead of matching just the first letter, match two or more letters, better yet make it rhyme or echo the set of words to be remembered.

3.) Perhaps add a picture, to visualize the idea.

Example: For remembering Methane, Ethane, Propane, and Butane

use: Meet Ethan, Professional Butler.

MEeT ETHANe PROpane BUTane

Alternate mnemonic: Me Eat Peanut Butter (Me Go to College, Learn Big Words.)

Another alternative: Mary Eats Peaches But Paul Has Had Only Nine Donuts.

For the first ten alkanes: Methane, Ethane, Propane, Butane, Pentane,

Hexane, Heptane, Octane, Nonane, and Decane

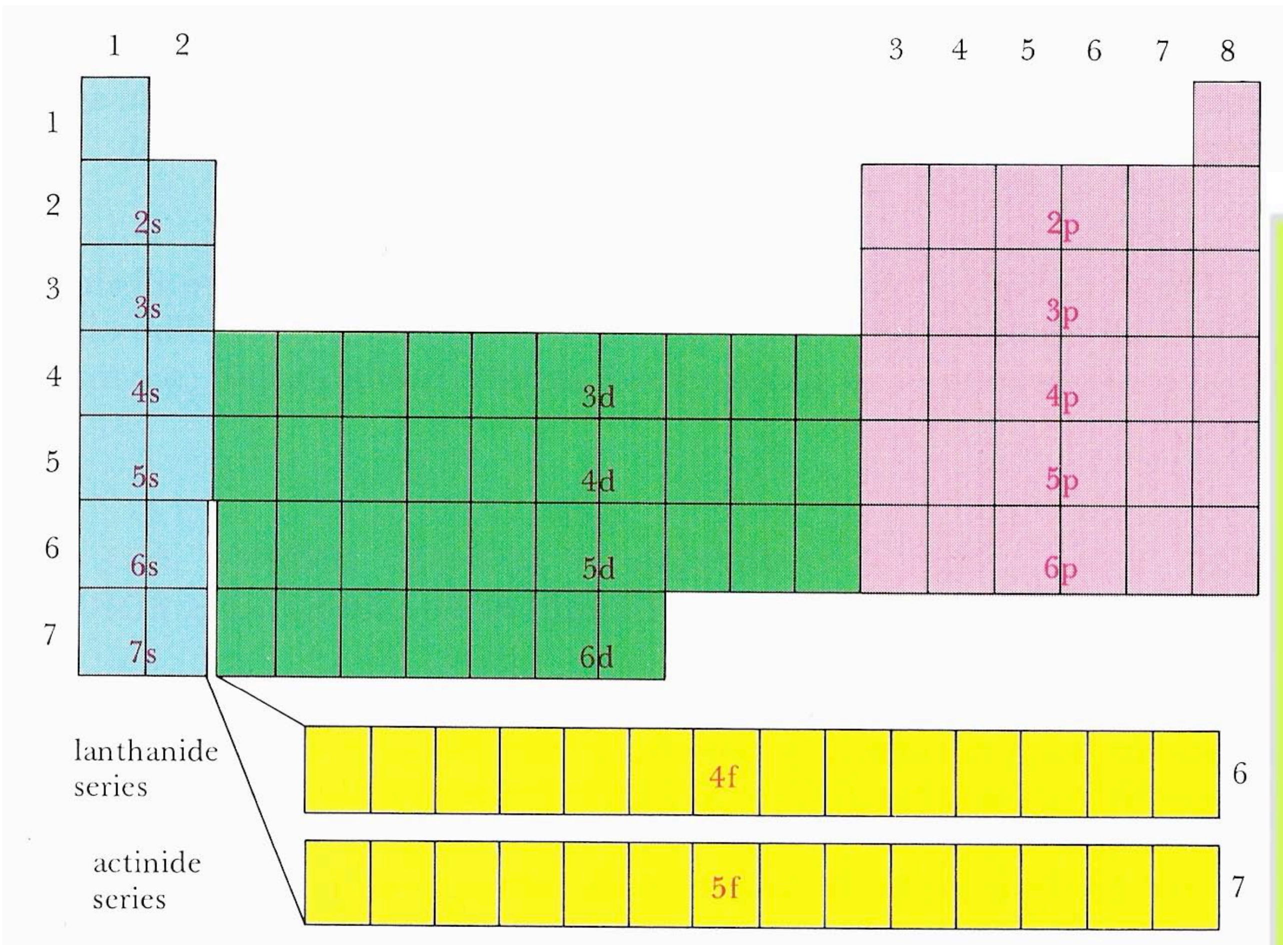
Memorize the Elements by Pronouncing Them in Periodic Table Order

- Students are often afraid that their introductory chemistry class will have a test question with a blank periodic table where they are asked to fill in the blanks. This is an inappropriate task for beginners as even experts don't see examples of many of the elements and the experts look up the rarer elements when needed. However, as a chemistry major progresses higher in the chemistry curriculum, it is natural to learn most of the table by familiarity. In an advanced inorganic chemistry course, where each of the Groups are studied in detail, a good general question could be:
- Given a blank periodic table, fill in the blanks. Give the atomic number, symbol, and name. Question for Chem 316 (Advanced Inorganic Chemistry)
- **Pronouncing the Periodic Table**
- A way to learn the order of the symbols (to complement the study of the reactions) is to pronounce the symbols (with a few vowel sounds added).

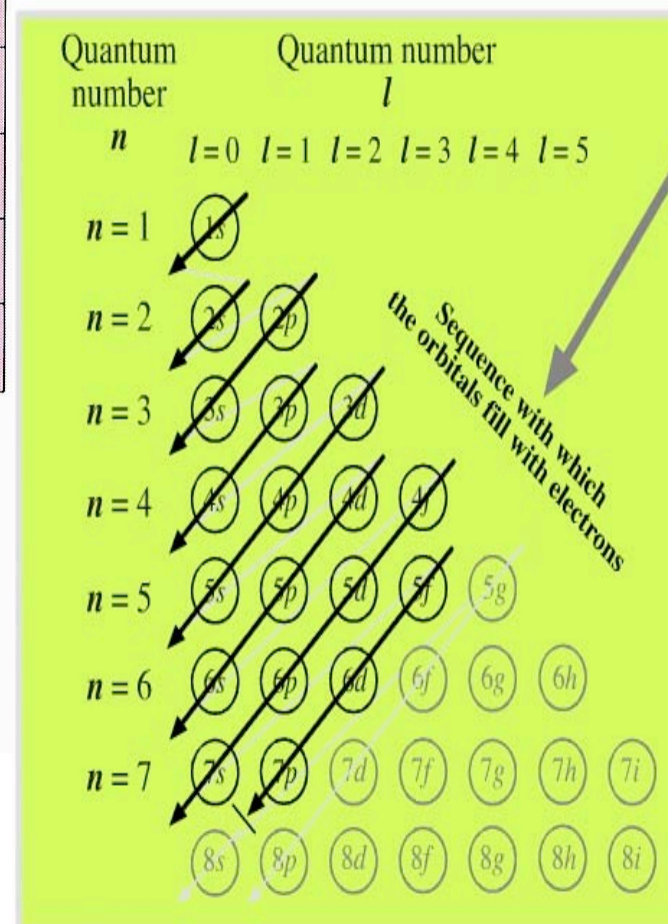
Heh	Hee																
Lih	Bee											Buh	Cah	N	O	F	Nee
Nah	Mig											Al	Si	P	S	ClAr	
Kuh	Cah	Scuh	Ti	V	Crr	Min	Fee	Coh	Nee	Cuu	Zin	Gah	Gee	Ahs	See	Brr	Ker
Rib	Sir	WhY	Zirr	Nib	Moe	Tick	Ruu	Ruh	Puhd	Agg	Cid	Inn	Sin	Sibb	Tee	Ih	Xee
Ciss	Bah	Lah	Haf	Ta	W	Ree	Oss	Irr	Pit	Au	Hig	Till	Pibb	Bi	Poh	At	Rin
Firr	Rah																
	Ceh	Pirr	Ned	Pim	Sim	Euu	Gad	Tib	Dye	Hoe	Err	Tim	Yibb	Luu			
	The	Pah	U	Nip	Puu	Am	Cim	Bek	Caf	Ess	Fam	Med	No	Lar			

- Make each of the elements a "sound" or "pronounced group", like a phoneme.
- From linguistics, a phoneme (pronounced Foh-Neem) is one of a group of distinctive sounds that make up the words of a language.

The best mnemonic device for the Aufbau order of orbitals is the periodic table itself



Why use this?



Electronegativity: Pronounce the mnemonic, FONClBrISCHP

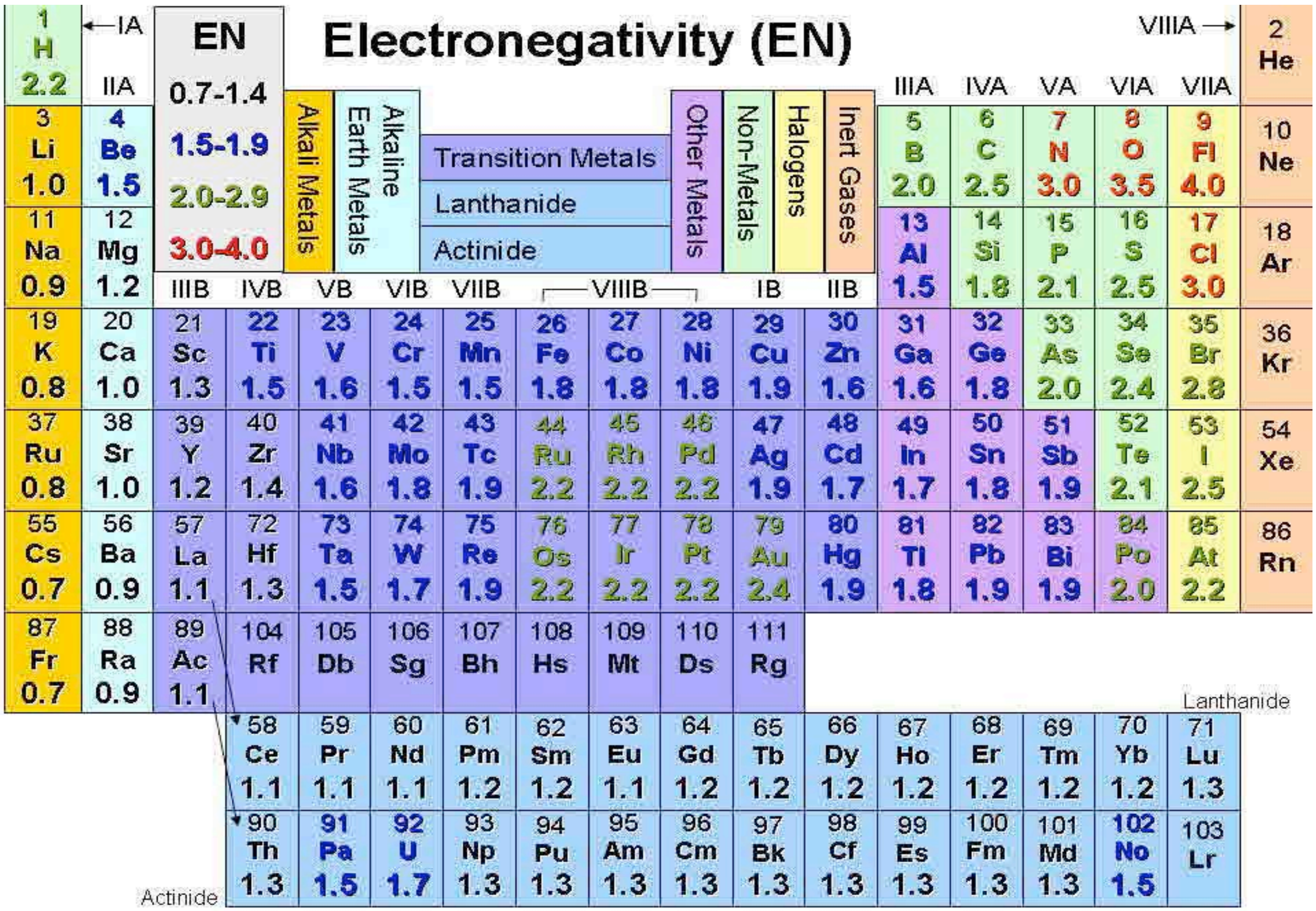
The only essential ones after that are Boron, Silicon, and the metals.

The second period lets all majors remember some standard values:

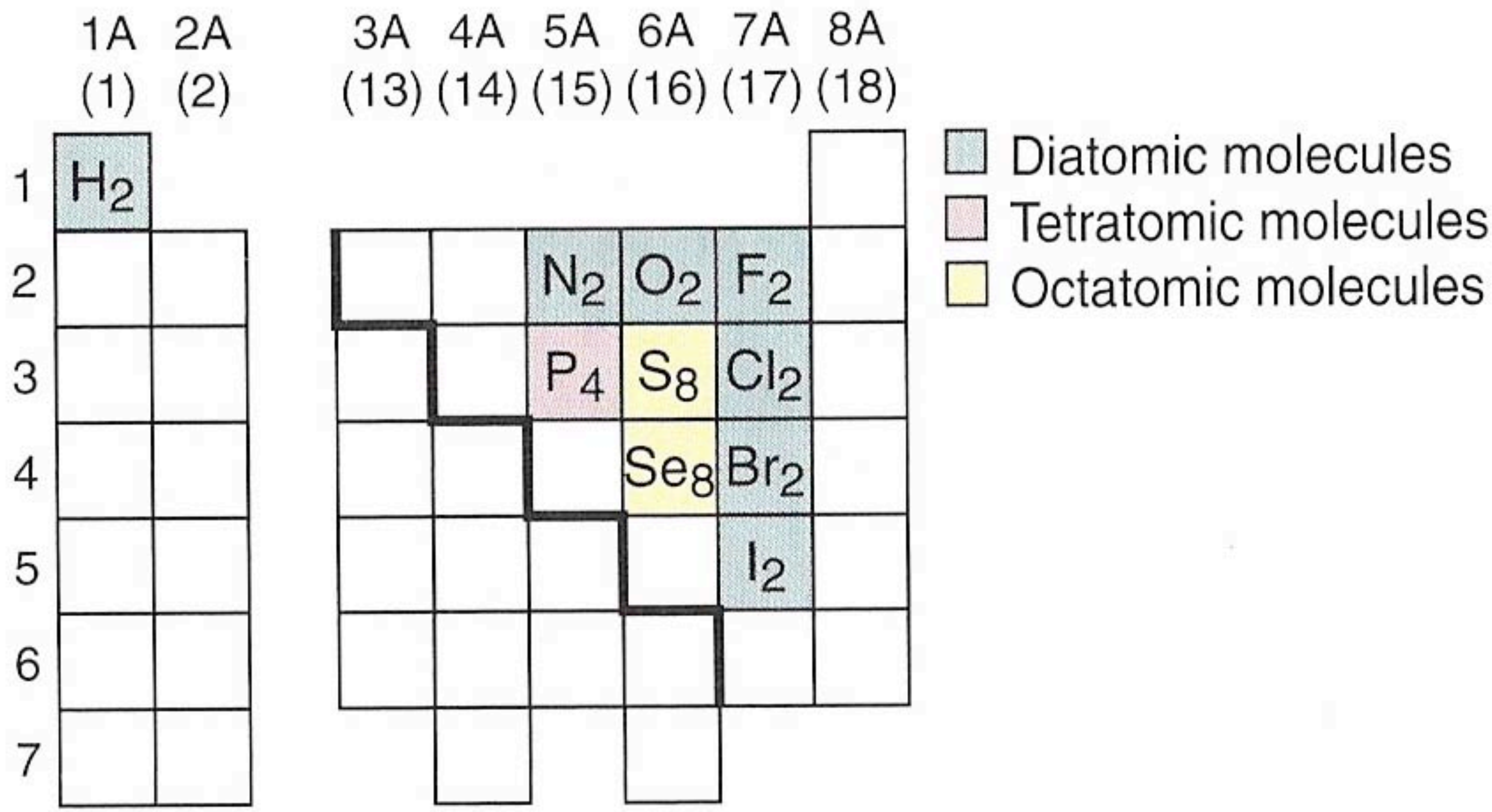
Li (1.0), Be (1.5), B (2.0), C (2.5), N (3.0), O (3.5), F (4.0),

also H and P have coincidentally, nearly the same value, 2.1

Thus, the only bonds polar enough to have Hydrogen bonding are H-F, H-O, and H-N.



Mnemonic for diatomic molecules: FONClBrIH



Even-numbered isotopes dominate over odd

Illustration of the fact that elements with odd numbers of Z (i.e., atomic number) usually have only one or two stable isotopes and elements with even values of Z have several stable isotopes. (Indicating that even numbers of protons [and even numbers of neutrons] somehow make the nucleus more stable.)

Z		Number of stable isotopes	Z		Number of stable isotopes	Z		Number of stable isotopes	Z		Number of stable isotopes
1	H	2	21	Sc	1	41	Nb	1	61	Pm	0
2	He	2	22	Ti	5	42	Mb	7	62	Sm	3
3	Li	2	23	V	2	43	Tc	0	63	Eu	2
4	Be	1	24	Cr	4	44	Ru	7	64	Gd	6
5	B	2	25	Mn	1	45	Rh	1	65	Tb	1
6	C	2	26	Fe	4	46	Pd	6	66	Dy	7
7	N	2	27	Co	1	47	Ag	2	67	Ho	1
8	O	3	28	Ni	5	48	Cd	8	68	Er	6
9	F	1	29	Cu	2	49	In	2	69	Tm	1
10	Ne	3	30	Zn	5	50	Sn	10	70	Yb	7
11	Na	1	31	Ga	2	51	Sb	2	71	Lu	2
12	Mg	3	32	Ge	5	52	Te	7	72	Hf	5
13	Al	1	33	As	1	53	I	1	73	Ta	2
14	Si	3	34	Se	6	54	Xe	9	74	W	5
15	P	1	35	Br	2	55	Cs	1	75	Re	2
16	S	4	36	Kr	6	56	Ba	7	76	Os	7
17	Cl	2	37	Rb	2	57	La	2	77	Ir	2
18	Ar	3	38	Sr	4	58	Ce	4	78	Pt	5
19	K	2	39	Y	1	59	Pr	1	79	Au	1
20	Ca	6	40	Zr	5	60	Nd	7	80	Hg	7
									81	Tl	2
									82	Pb	4
									83	Bi	1

Beyond Bismuth (Z=83) there are no stable nuclei. So far, but island of stability followers are hoping that will change. Again, notice the rhythm of odd and even values - the evens usually have the higher number of stable isotopes.

This implies that being paired is as important for nucleons as being paired is for electrons.

Tin has ten

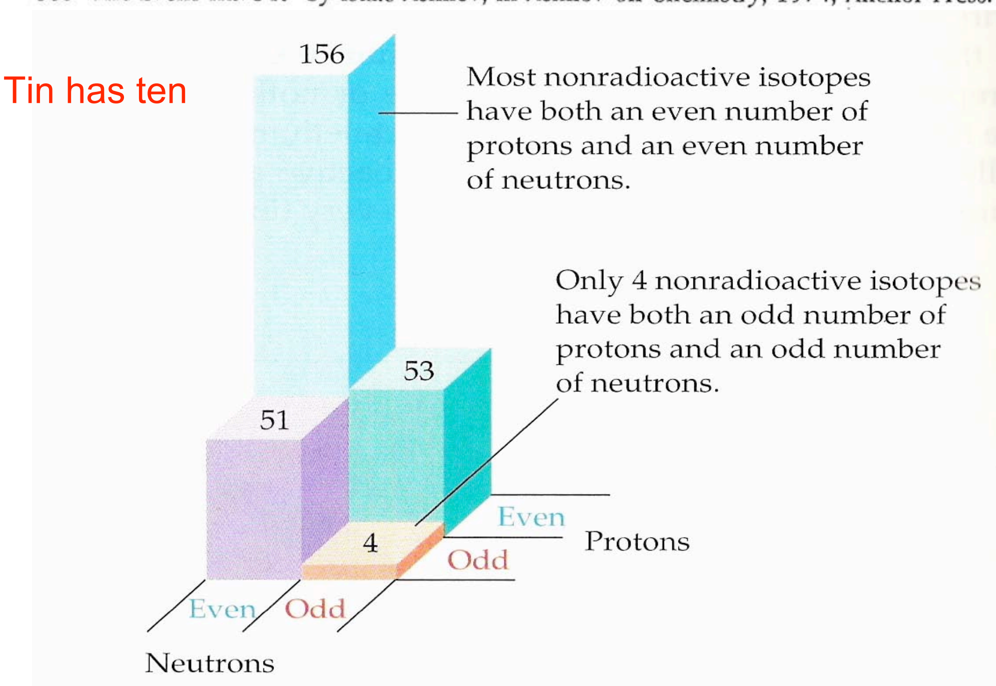
Odd or Even? The evens have greater stability.

The arithmetic of the components of the nucleus affects its stability:
Why? We don't have a complete answer, yet. But, this phenomenon is evidence that nucleons pair their spins like electrons pair spins by the Pauli exclusion principle.
So, pairs are more stable than unpaired nucleons.

			Examples	% abundance of this class in Earth's crust
even # of p^+,	even # of n	162 stable nuclei	^{12}C, ^{16}O, ^{206}Pb	85.63 %
even # of p^+,	odd # of n	56 stable nuclei	^{3}He, ^{9}Be, ^{13}C,	13.11 %
odd # of p^+,	even # of n	52 stable nuclei*	^{19}F, ^{23}Na, ^{27}Al, ^{31}P	1.25 %
odd # of p^+,	odd # of n	4 stable nuclei	^{1}H, ^{6}Li, ^{10}B, and ^{14}N,	0.01 %
				100.00 % total

* There are 20 examples of elements that have only one stable isotope. They are: ^{9}Be, ^{19}F, ^{23}Na, ^{27}Al, ^{31}P, ^{45}Sc, ^{55}Mn, ^{59}Co, ^{75}As, ^{89}Y, ^{93}Nb, ^{103}Rh, ^{127}I, ^{133}Cs, ^{141}Pr, ^{159}Tb, ^{165}Ho, ^{169}Tm, ^{197}Au, ^{209}Bi. All but one (^{9}Be) of those elements is of the odd p/even n class.

See "The Evens Have It" by Isaac Asimov, in *Asimov on Chemistry*, 1974, Anchor Press.



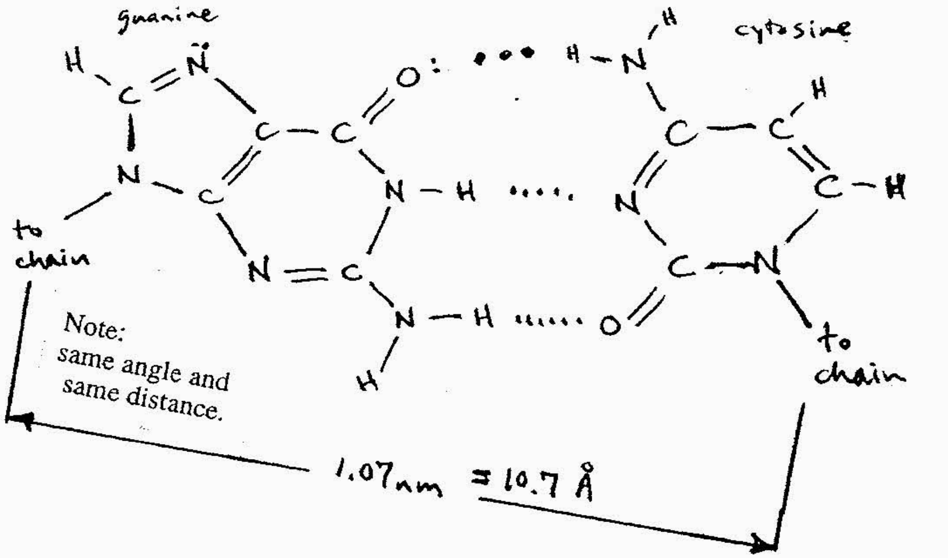
Essential Amino Acids (through evolution, we have lost the enzymes needed to make these, so we must get them in diet)

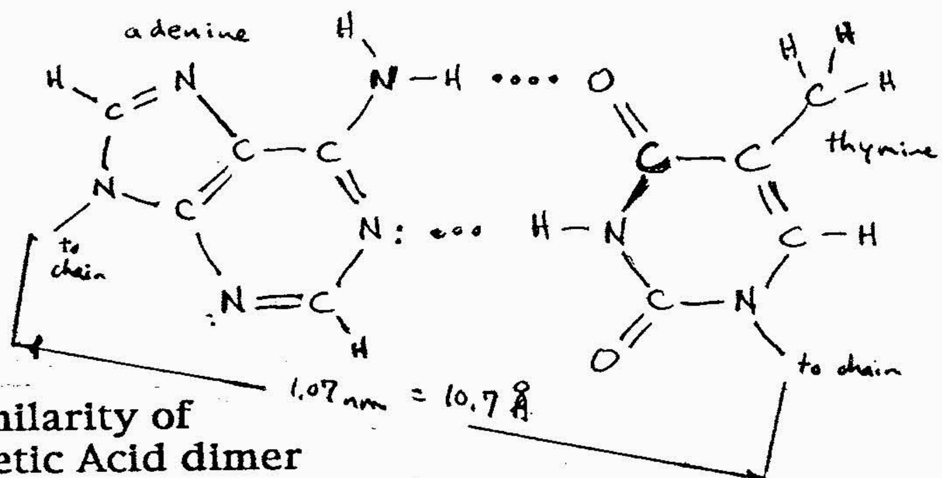
These amino acids have lengthy synthetic paths requiring many enzymes for their biosynthesis.

So, evolution eliminated those enzymes, since these amino acids are usually in our diet already. Note: many microbes can still make all twenty!

Essential Amino Acids	Symbols	Pronunciation	Discoverer	Date	Etymology of Name (Gr. for Greek, Lat. for Latin)
Tryptophan	Trp, W	TRIP-toe-fane	Hopkins, Cole	1901	released from protein by TRYPsin, tryptic Gr. PHAiNo = appear
Valine	Val, V	VAY-leen	Fischer	1901	alpha-amino isoVALeric acid = valine
Threonine	Thr, T	THREE-oh-neen	Rose	1935	like THREOse (amino acid of that sugar)
Isoleucine	Ile, I	eye-so-LOO-seen	Ehrlich	1903	ISOmer of **leucine**
Leucine	Leu, L	LOO-seen	Braconnot	1820	white crystals (Gr. leukos = white)
Lysine	Lys, K	LYE-seen	Drechsel	1889	a hydrolysis product of casein
Phenylalanine	Phe, F	fee-nul-AL-uh-neen or fen-nul-AL-uh-neen	Schultze, Barbiere	1881	PHENYL structure added to ALANINE
Methionine	Met, M	meh-THIGH-oh-neen	Meuller	1922	METHyl-THIO ether (Gr. theion = sulfur)
Arginine (essential for infants)	Arg, R	ARJ-uh-neen	Schultze Hedin	1886 1895	forms complexes with metal ions, such as silver(I), Ag^+ (Lat. ARGentum)
Histidine (essential for children and some adults)	His, H	HISS-tuh-deen	Hedin, Kossel	1896	HISTo = tissue, Gr. histon = woven

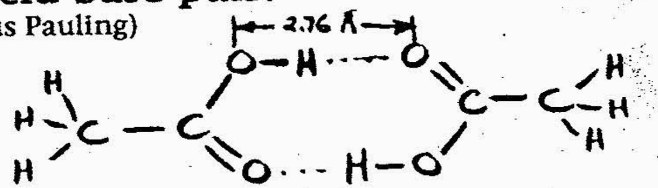
Mnemonic: TV TILL PM AH





Similarity of Acetic Acid dimer to nucleic acid base pair:

(as noted by Linus Pauling)

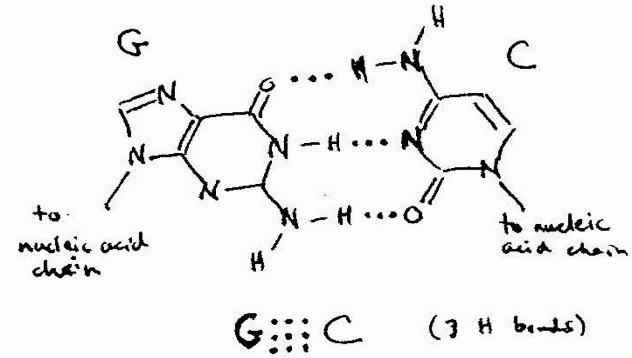


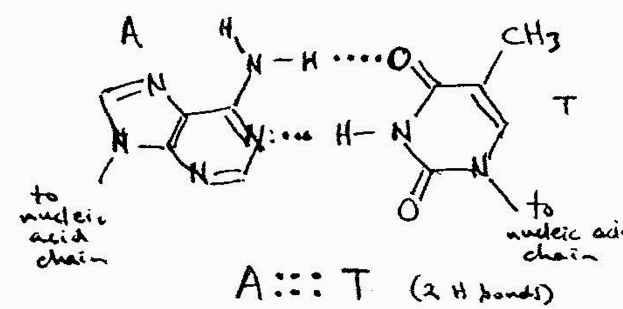
Acetic acid dimer

[observed molar mass, M = 120 g/mole (in liquid)]

Complementary Base Pairing

Rather than pairing between similar bases the pairings are by complementary bases.





Adenine goes steady with Thymine and

Guanine has a long-term monogamous relationship with Cytosine

Complementary bases

Mnemonic:

All Together, Go Chicago! (AT, GC)

CUT the pyr rim.

Biochemistry: Krebs' Cycle

- Krebs' cycle (Citric acid cycle, Tricarboxylic acid cycle)
- Remember: Caesar's Armies Invaded Other Kingdoms Searching For Many Oranges.
- Citrate, Aconitate, Isocitrate, Oxalosuccinate, alpha-Ketoglutarate, Succinate, Fumarate, Malate, Oxaloacetate
- Also, see the structures, they are the logical next reactions when you know organic mechanisms.

- Pericyclic reactions (use Woodward-Hoffman rules)
  - Electrocyclic reactions
  - Remember : TOC for

Thermal, Even (number of electron pairs) → Conrotatory

Photochemical, Even → Disrotatory

Photochemical, Odd → Conrotatory

Thermal, Odd → Disrotatory

In each row leave one factor the same, the other two must change, because if you change orbital symmetry (odd/even), you must change the way it reacts.

Greek and Latin roots

The Greeks Had a Word for It

Knowledge of the Greek and Latin etymology of scientific words is widely recognized as a useful skill to help remember and identify unfamiliar words. But students often have a different view of the value of roots. When presented with the new term "sarcoplasmic reticulum", they are sometimes told in parentheses that (Gr. sarco = flesh). So, now to help remember the term they never heard of, their book has provided an etymological root that they do not know from a language that they have never studied! It is no wonder that many students learn to ignore etymology as they view it as further unnecessary impediment.

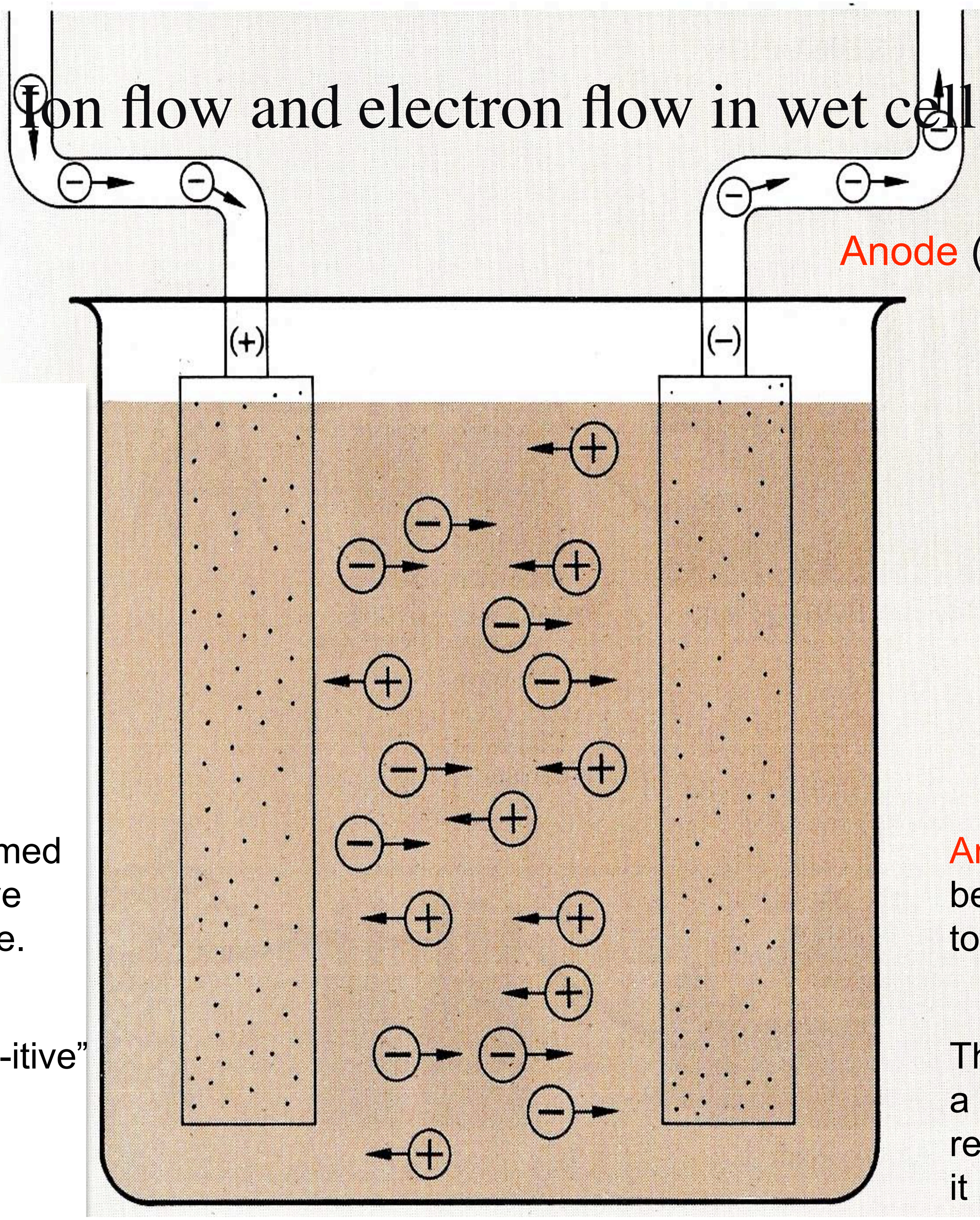
I think that the root should be presented with other words that use the same root, especially using words that are likely to be familiar to the student. Then it is obvious to the student that knowledge of the roots allows them to make use of a few roots to decipher or remember many words.

Some excellent books on etymology list some other words having the same root, but they do not give any definitions. So, unless the reader has a spectacular vocabulary, they must use a good dictionary to appreciate the value. This will work fine for the most motivated students, but for many it leaves a barrier seeming as high as the one for "sarcoplasmic reticulum." I give a short definition, that often emphasizes the connection to the etymology.

My work to organize scientific roots started about 35 years ago when I began collecting roots and terms by pencilling them into the margins of my copy of "Dictionary of Scientific Word Elements" by William Mullen, 1969, Littlefield, Adams. After 40 years of reading and teaching chemistry, my copy is now loaded with extra words and connections.

In the tables I present the roots with Greek and Latin side-by-side in the useful style of Lancelot Hogben, in "The Vocabulary of Science", 1970, Stein and Day. Unlike Hogben, I provide short definitions as an aid to those who don't yet have an enormous vocabulary. Here, the students see the root in use in other words, including some words they probably already know. There are also some words which they may have seen a few times and some words that are more obscure, but are perhaps still worth knowing. Everyone can learn something new and leverage their knowledge of a few roots to the wide range of combinatorial possibilities.

Ion flow and electron flow in wet cells



Cathode
(Greek for
"down-way")

Anode (Greek: "up-way")

Compare:
catabolism
(breaking down),
catapult

Compare:
Anabolism as
in anabolic
steroids
(building up),
Analysis
(breaking up)

Cations are so named
because they move
toward the cathode.

Anions are so named
because they move
toward the anode.

Cations are "paws-itive"
(positive) because
cats have paws.

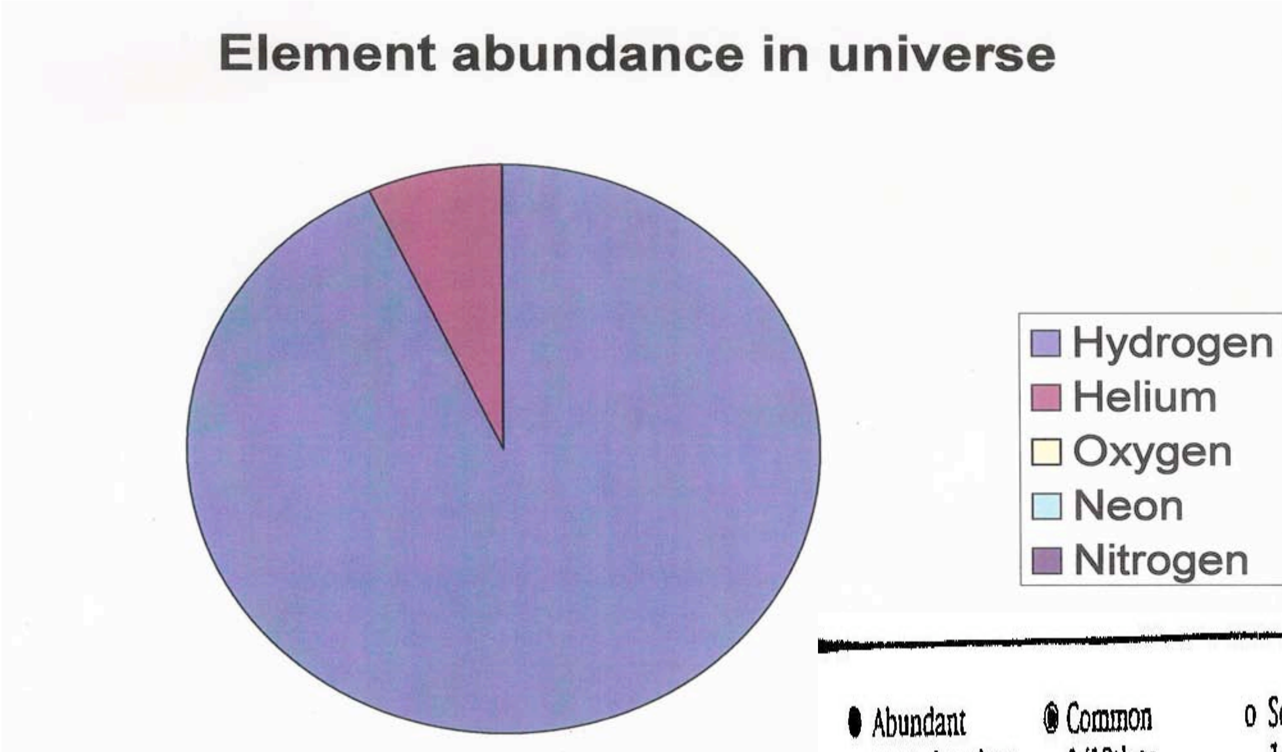
The name anion has
a hard "n" sound,
reminding you that
it is negative.

Greek and Latin roots for nucleus and nucleic acids (and examples in the English language)

	Greek with English word examples	Latin with English word examples
Nucleus	καρυον (karyon) = nut eukaryote (cell having a nucleus) prokaryote (primitive cell, w. no nucleus) karyotype (organized set of chromosomes) karyomere (small nucleus from abnormal mitosis) caryophylaceae (Pink family, chickweeds, bouncing bet [soapwort], sandworts, etc.) caryophyllene (from oil of cloves) caryophyllous (clove-like) caryopsis (seedlike, nut-appearing fruit) caryopsis (small one-seeded dry fruit) caryota (palm genus; has large nuts)	nux, nucis = nut, kernel nucleus (1. center of atom, 2. center of biological cell, 3. center of comet, 4. central part of organic molecule) nucleation (forming a center for phase change) nucleon (particle of nucleus: proton or neutron) nuclide (general name for any isotope of any element) enucleate (to remove the nucleus, usually biological cell) nucleolus (body within biological cell nucleus) nucleoplasm (protoplasm inside nuclear membrane) nucleic acids (polynucleotides: DNA or RNA) nucleotides (monomer of base-ribose sugar-phosphate) nuclease (an enzyme that hydrolyses nucleic acids)
Change:	αλλασσο (allasso)	mutare = to change, muto = change mutation (sudden alteration, genetically transmissible) mutant (modified gene or genetically-modified organism) mutagen (substance that may cause mutation) mutase (enzyme to change substrate to isomer) commutate (reverse every half-cycle in motor) commutative (math operation order can be reversed) permutation (process of rearranging in all possible ways) transmutation (change from one form to another; Alchemy) transmutation (as in transmutation of axes)
Bring to Life	τοχετος (toketos), τοχος (tokos)= birth tocopherol (Vitamin E was named because a deficiency of Vit. E led to fetal death) oxytocin ("sharp birth", this molecule leads to "sharp" quick birth) tocometer (measures birth contractions of pregnant mother) tocolytic (stops birth contractions)	oxygen (named acid-forming; non-metal oxides are acids) hydrogen (water-forming) genesis (origin, beginning of life) endogenous (produced within) eugenics (plan to allow only "good births") geneology (study or table showing progenitors & ancestors) generation (a begetting) genetics (inherited genes & characteristics of an organism) homogeneous ("origin alike", thus uniform, same) progeny (lat. progenitus = lineage, offspring) regeneration (formed anew, re-created, born again) congenital (not inherited, but acquired during fertilization) genus (grouping of organisms above species, below family)
Fold (replica)	απλοος (haploos) = one fold διπλοος (diploos) = double, two-fold diploma ("paper folded twice") diploid (having two sets of chromaosomes) haploid (having only one set of chromaosomes)	plico, plicate- = to fold replication (process of copying DNA) complex (having many "folds", complicated) explicit (all folds are laid out, easy to see) simple (only one "fold", easy) multiple (many "folds", several repeats) multiplication, ply, plywood implicate (folded into the accusation), accomplish, pliers, perplex, duplicity

Greek and Latin roots for thermodynamics (and examples in the English language)

	Greek with English word examples	Latin with English word examples
Heat	θερμοτη s (thermotes) θερμος = hot thermodynamics (study of heat & energy) thermometer (measures temperature) thermostat (controls, regulates temp.) thermocouple (measures temp. electronically) exothermic (releasing heat to surroundings) endothermic (absorbing heat from surroundings) isothermal (under conditions of constant temperature) diathermal wall (allows heat to go in or out) thermophilic (organisms preferring heat) thermotropism (organisms turning toward heat) thermotaxis (movement toward heat by life) thermite (Al & iron oxide mix for producing great heat for field welding, etc.)	calor calorie (unit of heat energy in cgs unit system) calorimeter (instrument for measuring heat flow) calorescence (incandescence caused by infrared [heat]) cauldron (a large kettle or boiler) calenture (tropical fever with delerium & hallucinations) calescence (condition of growing warmer; increasing warmth) nonchalant (via French: not warm, cool, indifferent) scald (to burn with hot water or steam) isocaloric (providing the same number of calories) rigor caloris (a form of rigor mortis induced by heat)
Power	δυναμις (dynamis) dynamics dyne (unit of force in the cgs unit system) dynamite (powerful explosive of nitroglycerine in absorbent) dynamo (converts mechanical to electrical E) dynasty (long period of power by same group)	potentia = power potent (powerful) potential (capacity for power, stored power) potentiometer (measures electrical potential, voltage) Potentilla (genus of herbs of rose family, including cinquefoils) potentate (a sovereign; one having great power)
Work	εργαζομαι (ergazomai), εργον (ergon) erg (unit of work in the cgs unit system) energy (literally work within; the capacity to do work) argon (a-erg => no work, lazy, inert [element]) allergy (lit. other work; not the intended immune reaction) synergy (works together) , synergetics synergids (co-workers) ergatogyne (female worker [ant]; Biol. term) exert, exertion, exercise ergonomics surgery (short for cheir-urgy = hand work)	laboro laboratory (place for scientific work, controlled experiments) laborious (toilsome, requiring much work) labored (difficult, painful, performed laboriously) labor (pain and stress of childbirth) opus, opera operate, operation operon (gene controlling use of other genes) opuscule (small work, unimportant work) opera (a musical drama or its music)
Turn	τροπη (trope) entropy (lit. turning, change within; measure of disorder) allotrope (other form of an element) troposphere (lower atmosphere with churning weather) tropic (where the sun turns at solstice) atropo-isomers (isomers due to inability to rotate, like chiral hindered biphenyls) Atropos (Greek fate who comes to cut the thread of life; means "cannot be turned away") atropine (toxic drug from Atropa belladonna) Atropa belladonna (deadly nightshade plant) Heliotrope (genus of sunflower; turns toward sun) phototropism (tendency to turn toward light) geotropism (tendency to turn toward Earth's gravity) trophy (prize of a victory where the enemy was turned away) isotropic (same in all directions) anisotropic (not same in all directions, like a crystal)	verto, vertere avert (turn away, ward off, prevent) inverse (reversed or inverted) reverse, reversible, revert transverse, transversal (line intersecting a system of lines) vertex (point of intersection of sides of an angle), vertical controversy (lit. turn against) diversion (turn aside, distraction), version universe (all turned into one) vertigo, versus, pervert, vertebra flecto (= bend) deflect, deflection, flexible, inflect reflect, reflection, reflex, reflexive
Stable (stand)	στατος (statos) astatine (unstable, radioactive element) metastasis (cancer moving beyond one place) statics (vs. dynamics in physics) electrostatics (study of non-moving charges) hydrostatics (study of pressure and equilibrium of fluids, especially water)	stabilis stability metastable (temporarily seems stable)



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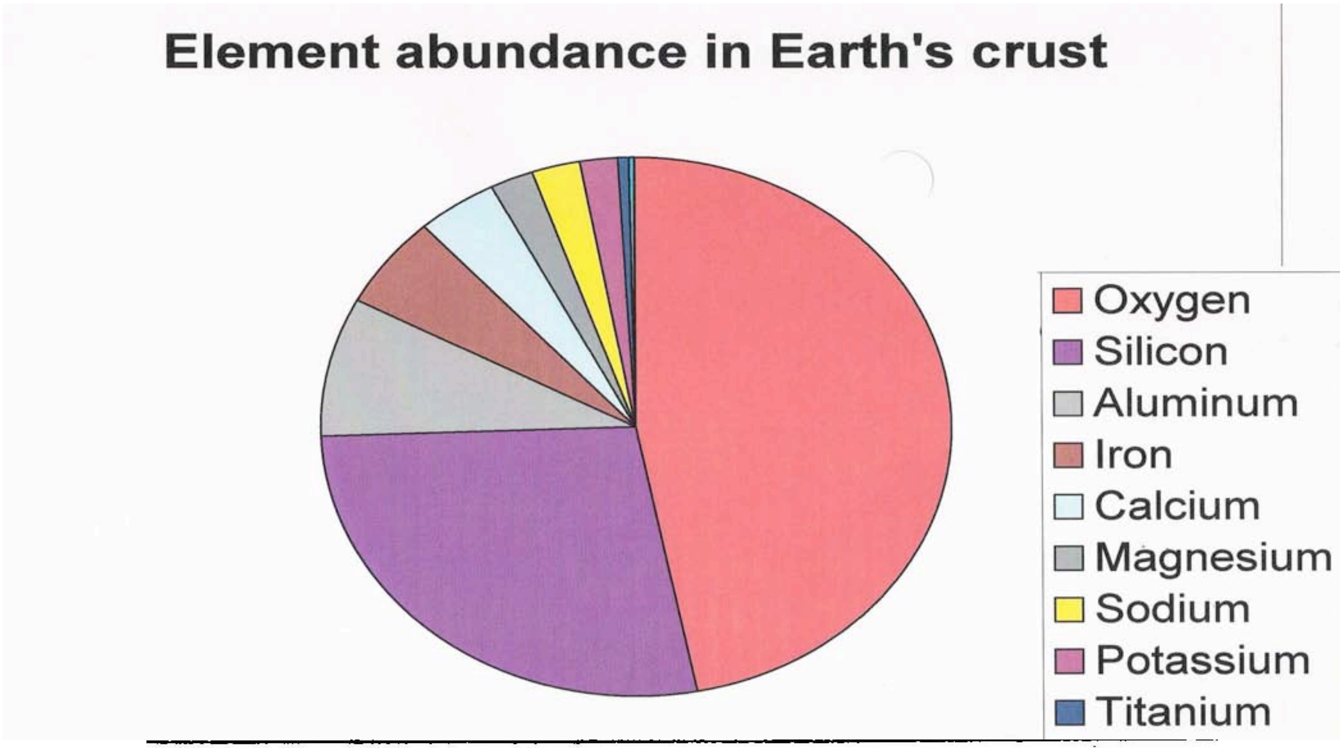
● Abundant	◉ Common	o Scarce	· Rare
most abundant to 1/10 of that	1/10th to 1/100th	1/100th to 1/1000th	less than 1/1000 of the most abundant

Relative Abundance of the elements in the UNIVERSE:
(from spectra of stars and analysis of meteorites)
Abundance by number of atoms, relative to Si = 20 000 atoms

● Hydrogen	H	800 000 000		Sodium	Na	880
⊙ Helium	He	60 000 000		Argon	Ar	800
Oxygen	O	430 000		Nickel	Ni	670
Neon	Ne	172 000		Aluminum	Al	441
Nitrogen	N	132 000		Chlorine	Cl	180
Carbon	C	70 000		Chromium	Cr	146
Silicon	Si	20 000		Titanium	Ti	48
Magnesium	Mg	18 200		Potassium	K	35
Iron	Fe	12 000		Zinc	Zn	10
Sulfur	S	7 500		Copper	Cu	4
Calcium	Ca	980		All others	total less than 0.1 %	

Some things to notice from this table:
1.) Element #1 (Hydrogen) is number one in abundance in the universe. (about 90 %)
2.) Element #2 (Helium) is number two in abundance in the universe. (about 10 %)
3.) All other (non H, He) atoms total to less than 1%. but among that trace, ...
4.) The elements essential for life are among the next most abundant (C, N, O)
Neon is among those next most abundant, but it is completely unreactive (inert).
5.) Elements of even atomic number are more abundant than those with odd atomic numbers. Notice how the abundance graph zig-zags up and down with atomic number.
6.) There is a general decline in abundance after oxygen. That decline is especially pronounced after iron (Fe). The stars that build elements higher than O are rare and short-lived. After iron, nuclei cannot be built by fusion, but only by less efficient methods.
7.) These abundance numbers are due to at least three factors:
a.) the original composition of the universe formed by the big bang, and
b.) the rate of element construction in the stars (stellar nucleosynthesis).
c.) the stability of the nucleus of each element.

"Important Elements"
by P. G. Nelson,
J. Chemical Education,
Sept. 1991, p.732.



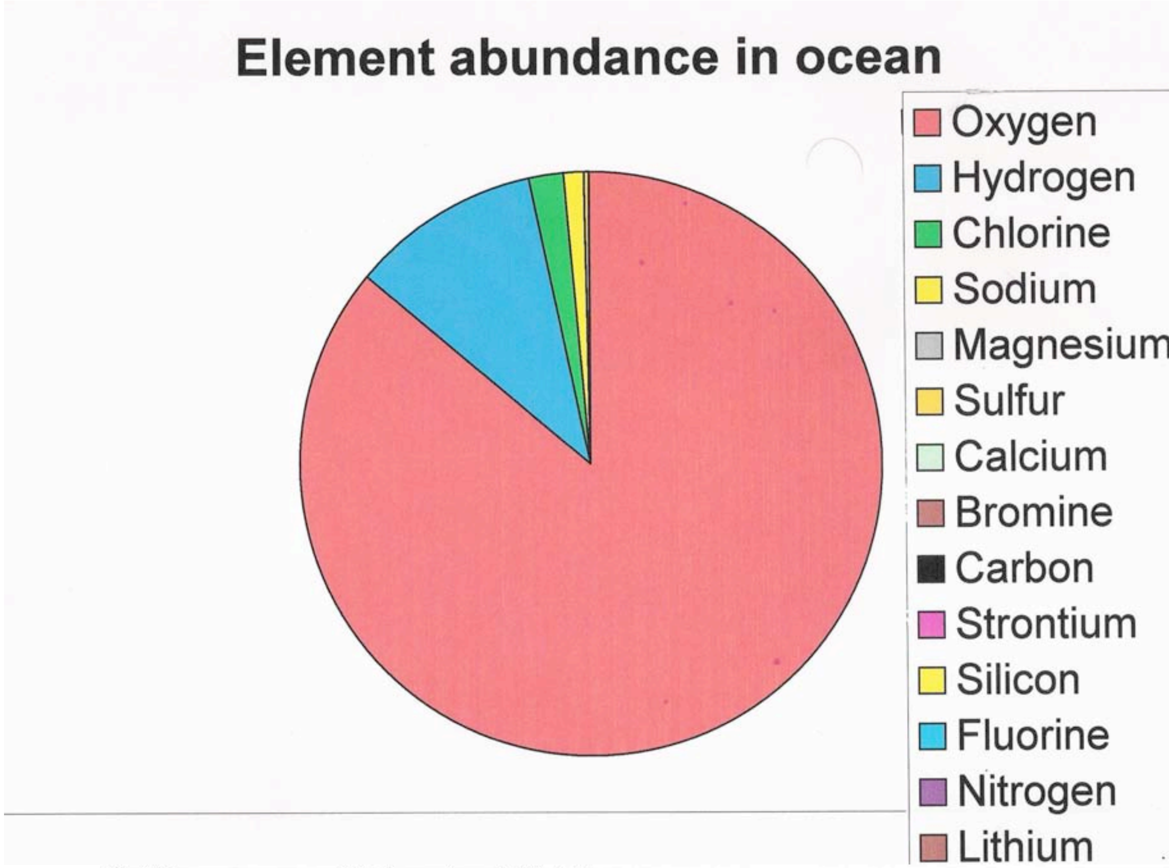
Relative Abundance of the elements in the EARTH'S CRUST:
(Also called Earth's Lithosphere or Terrestrial crust)
Abundance in a hypothetical "average" rock or "typical" rock
in grams per ton (= ppm)

●	Oxygen	O	474 000	○	Fluorine	F	700
●	Silicon	Si	277 000	○	Sulfur	S	520
●	Aluminum	Al	85 600		Strontium	Sr	450
●	Iron	Fe	56 300		Carbon	C	320
◉	Calcium	Ca	41 000		Chlorine	Cl	200
◉	Magnesium	Mg	23 300		Chromium	Cr	200
◉	Sodium	Na	23 000		Nickel	Ni	80
◉	Potassium	K	21 000		Zinc	Zn	65
○	Titanium	Ti	4 400		Nitrogen	N	46
○	Hydrogen	H	1 400		Lithium	Li	30

What to notice from this table:

1.) Silicon and oxygen are by far the most abundant as the silicate rocks are the most common (granite and others).
2.) Silicate minerals generally require a positive metal ion and the abundant metals on earth are Al, Fe, Ca, Na, K, and Mg.
3.) Crust abundances are similar to whole Earth abundances except that we think most of the siderophile metals (especially heavy metals) have been separated to the core of the Earth.

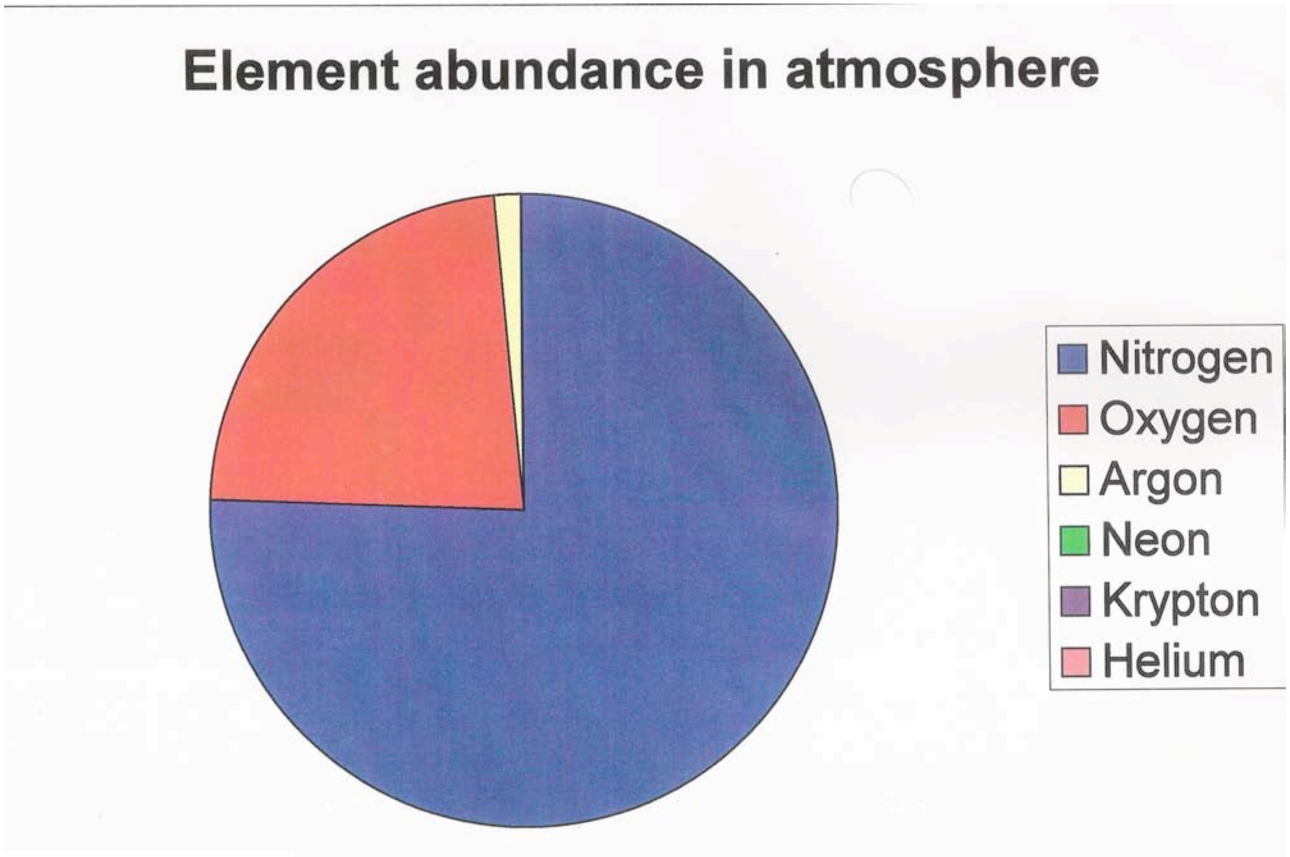
The order of these abundant & common elements in the crust can be remembered by pronouncing the mnemonic: Oh, see, Al, fee, Cah, Mig, NacK.
to represent the elements: O Si Al Fe Ca Mg Na K
These eight elements compose more than 99% of the Earth's crust.



Relative Abundance of the elements in SEAWATER:
(Also called Earth's Hydrosphere, the oceans)
in grams per ton (= ppm)

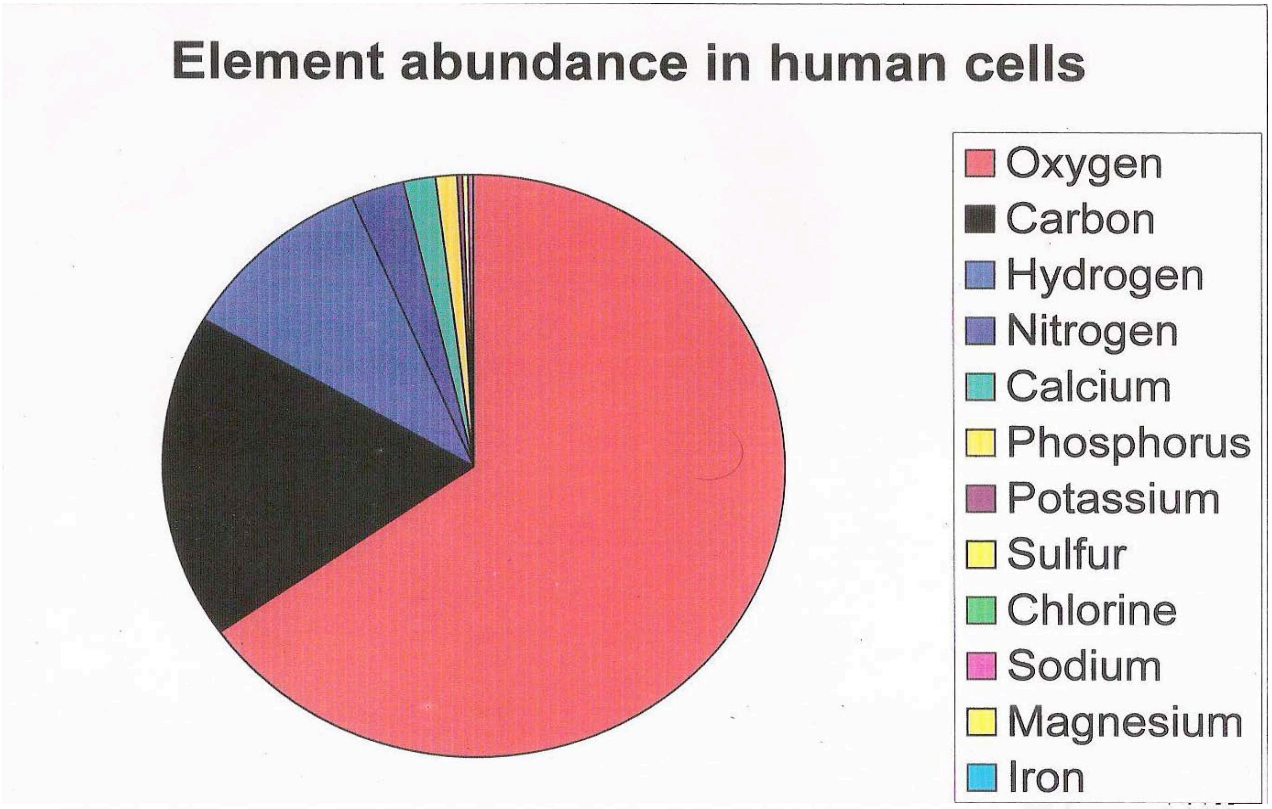
●	Oxygen	O	864 000	Bromine	Br	65
●	Hydrogen	H	108 000	Carbon	C	28
⊙	Chlorine	Cl	18 980	Strontium	Sr	13
⊙	Sodium	Na	10 560	Silicon	Si	4
○	Magnesium	Mg	1 270	Fluorine	F	1.4
	Sulfur	S	884	Nitrogen	N	0.7
	Calcium	Ca	400	Lithium	Li	0.1

What to notice from this table:
1.) The most abundant elements in seawater are obviously those in water (H & O)
2.) The next most abundant elements in saltwater are those of salt (Na & Cl).
3.) All the rest of the elements (non-H,O) here are obviously those whose compounds are most soluble in water.



Relative Abundance of the elements in the Earth's ATMOSPHERE:
% by weight

Nitrogen	75.51	Neon	0.001 25
Oxygen	23.15	Krypton	0.000 29
Argon	1.28	Helium	0.000 072



DISTRIBUTION OF SOME ELEMENTS IN THE BIOSPHERE

(% Body Weight of typical organism, typical cell)

60% to 1 % (macro nutrient elements)	1% to 0.05% (micro nutrient elements)	Less than 0.05% (trace nutrient elements)	Concentrated by some organisms
Hydrogen	Magnesium	Boron*	Titanium
Carbon	Sulfur	Molybdenum	Vanadium
Nitrogen	Potassium	Silicon*	Bromine
Oxygen	Sodium†	Iron	Silver
Phosphorus	Chlorine†	Copper	Chromium
Calcium		Manganese	
		Zinc	
		Cobalt†	
		Iodine†	
		Selenium†	
		Nickel (in urease)†	

† Essential for animals
* Essential for plants

So, which elements should we know?

Answer: The most abundant of each of those classes. Also, the most useful ones.

How to remember the elements having Latin symbols.

The Elements of Chemistry

For each of the common elements in **bold print** below, Chemistry 100 students (UIC Chem 100) must know the name and symbol.

Actinium	*Ac*	*Hafnium*	*Hf*	*Praseodymium*	*Pr*
Aluminum	**Al**	**Helium**	**He**	*Promethium*	*Pm*
Americium	*Am*	*Holmium*	*Ho*	*Protactinium*	*Pa*
Antimony	*Sb*	**Hydrogen**	**H**	*Radium*	*Ra*
Argon	*Ar*	*Indium*	*In*	*Radon*	*Rn*
Arsenic	*As*	**Iodine**	**I**	*Rhenium*	*Re*
Astatine	*At*	*Iridium*	*Ir*	*Rhodium*	*Rh*
Barium	*Ba*	**Iron** (Ferrum)	**Fe**	*Rubidium*	*Rb*
Berkelium	*Bk*	*Krypton*	*Kr*	*Ruthenium*	*Ru*
Beryllium	*Be*	*Lanthanum*	*La*	*Samarium*	*Sm*
Bismuth	*Bi*	*Lawrencium*	*Lr*	*Scandium*	*Sc*
Boron	*B*	**Lead** (Plumbum)	**Pb**	*Selenium*	*Se*
Bromine	**Br**	**Lithium**	**Li**	**Silicon**	**Si**
Cadmium	*Cd*	*Lutetium*	*Lu*	**Silver** (Argentum)	**Ag**
Calcium	**Ca**	**Magnesium**	**Mg**	**Sodium** (Natrium)	**Na**
Californium	*Cf*	*Manganese*	*Mn*	*Strontium*	*Sr*
Carbon	**C**	*Mendelevium*	*Md*	**Sulfur**	**S**
Cerium	*Ce*	**Mercury** (Hydro-argyrum)	**Hg**	*Tantalum*	*Ta*
Cesium	*Cs*	*Molybdenum*	*Mo*	*Technetium*	*Tc*
Chlorine	**Cl**	*Neodymium*	*Nd*	*Tellurium*	*Te*
Chromium	*Cr*	*Neon*	*Ne*	*Terbium*	*Tb*
Cobalt	*Co*	*Neptunium*	*Np*	*Thallium*	*Tl*
Copper (Cuprum)	**Cu**	*Nickel*	*Ni*	*Thorium*	*Th*
Curium	*Cm*	*Niobium*	*Nb*	*Thulium*	*Tm*
Dysprosium	*Dy*	**Nitrogen**	**N**	**Tin** (Stannum)	**Sn**
Einsteinium	*Es*	*Nobelium*	*No*	*Titanium*	*Ti*
Erbium	*Er*	*Osmium*	*Os*	*Tungsten*	*W*
Europium	*Eu*	**Oxygen**	**O**	**Uranium**	**U**
Fermium	*Fm*	*Palladium*	*Pd*	*Unnilquadium*	*Unq*
Fluorine	**F**	**Phosphorus**	**P**	*Vanadium*	*V*
Francium	*Fr*	*Platinum*	*Pt*	*Xenon*	*Xe*
Gadolinium	*Gd*	*Plutonium*	*Pu*	*Ytterbium*	*Yb*
Gallium	*Ga*	*Polonium*	*Po*	*Yttrium*	*Y*
Germanium	*Ge*	**Potassium** (Kalium)	**K**	**Zinc**	**Zn**
Gold (Aurum)	**Au**			*Zirconium*	*Zr*

There are only twenty-seven elements to know and most of them are probably already familiar to you. These are the most common elements on Earth and the most important for life.

Here are a few ways that may help you to remember the elements whose symbols are based on ancient Latin words:

Iron, Fe Non-ferrous metals do not contain Fe. Ferrous metal alloys contain iron.
A ferrule is an iron or metal ring around the end of a cane or umbrella.

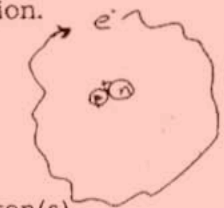
Mercury's symbol, Hg, comes from Greek hydroargyrum or Latin hydroargentum, which literally means "watery-silver" or quicksilver, which is an older name for mercury. "Quick" here means lively as in the phrase "the quick and the dead".

Lead, Pb A **plumber** is someone who repairs water pipes and sewer pipes. Those pipes often used to be repaired by lead solder. Lead is a metal having a low melting point temperature. Also, a **plumb-bob** was a lead weight attached to a string used to find a vertical line (also called a **plumb-line**).

The Three Particle Model of the Structure of Atoms

1. There are three primary subatomic particles. Although many other particles (muons, pions, quarks, etc.) have been found, we can usually ignore those details and treat atoms as if they were made only of p, n, & e. They are the standard, interchangeable parts of atoms; i.e., atoms seem to have a modular construction.

Subatomic particle	Charge	Mass (Weight)	Location in the atom
Proton, p or p^+	+ , positive	heavy, 1	in nucleus
Neutron, n or n°	0 , neutral	heavy, 1	in nucleus
Electron, e or e^-	- , negative	very light, = 1/2000	outside of nucleus



Note that although the mass of the electron is often negligible, the atom's size is due to the electron(s).

2. Each element of the periodic table has two main numbers associated with it. The larger (& non-integer) is the atomic weight (≈ mass number); the smaller is the atomic number. Simple calculations relate the atomic number and mass number to the number of protons and neutrons.

Mass number, A = # of protons + # of neutrons

Atomic number, Z = # of protons

Mass # - At. # = # of neutrons

Summary: Mass # = p + n = larger integer

Atomic # = p = smaller integer

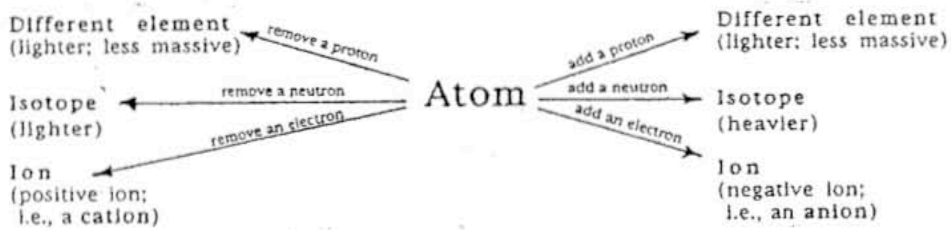
Mass #- At. # = n

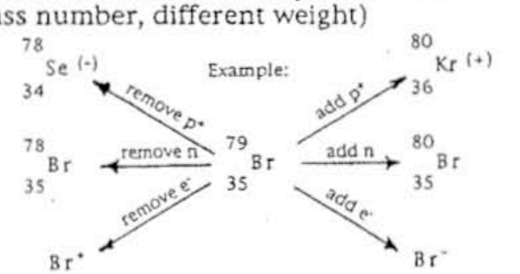
Note: Mass number and atomic number are both integers, while atomic weight is usually not exactly an integer.

3. If we could start with a neutral atom and make these changes, then:

IF WE CHANGE THE NUMBER OF:	THE RESULT IS CALLED A:	OBSERVED EFFECTS
protons	different element	new valence, new weight, new properties, (new charge)
neutrons	isotope	same element, essentially identical chemistry, but different weight, often radioactive (unstable nucleus)
electrons	ion	same element, essentially the same mass, but new properties (new chemistry), new size

An isotope (def.) has 1.) the same number of protons (thus same atomic number, same element), yet also has 2.) a different number of neutrons (thus different mass number, different weight)





“Do as you oughta’, add acid to watah.”