

Chemical introduction

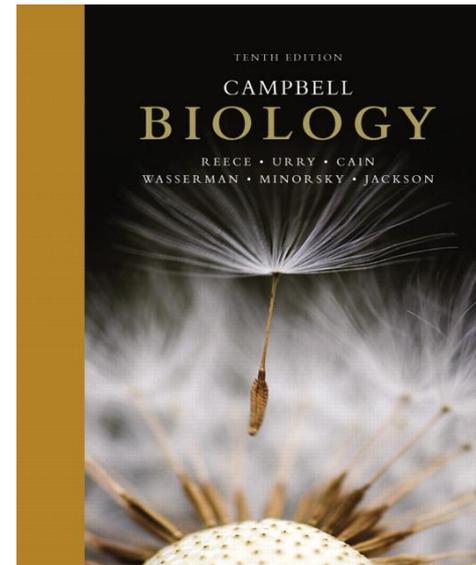
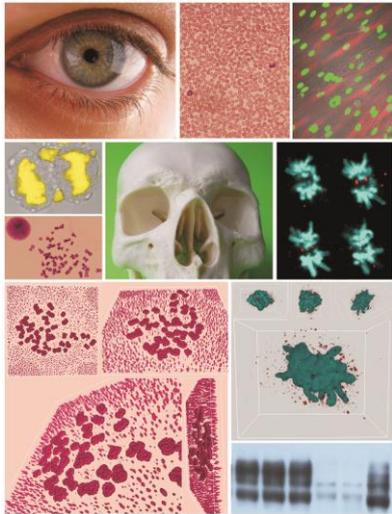
Katalin Kiss

Topic list

1. Chemical basis of life 1 (atoms, biological elements)
2. Chemical basis of life 2 (functional groups, bonds, water, pH)
3. Lipids and Carbohydrates
4. Amino acids, Proteins, Biochemical reactions, Enzymes
5. Nucleosides, nucleotides, nucleic acids
6. Discovering the genetic material; DNA replication
7. Synthesis of RNAs: Transcription
8. Flow of genetic information: Genetic code
9. Synthesis of Proteins: Translation
10. Mid-term test (multiple choice type)
11. Structure of cells I: pro-and eukaryotic cells, viruses, fungi, plant cells
12. Structure of cells II: nucleus, nucleolus, cell wall, cell membrane, transport
13. Structure of the cells III: ERs, Golgi, vesicles, lysosomes, cytoplasm, cytoskeleton
14. Mitochondria, the production of ATP
15. Organization of the genetic material, chromosomes, chromatids
16. Cell division: Mitosis and meiosis
17. Mendelian genetics
18. Tissues and cell types
19. Final test (multiple choice type)
20. Basics of immunology

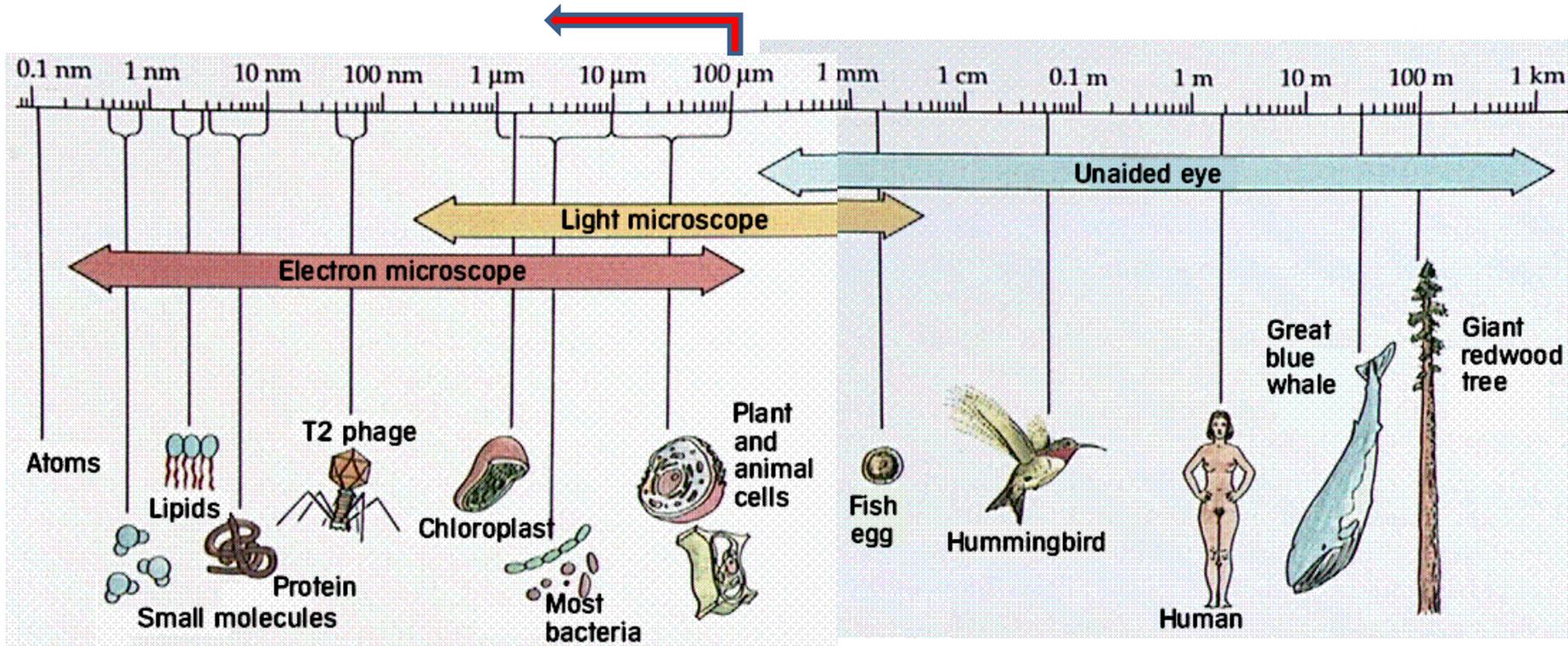
Recommended books

- BIOLOGY A TEXTBOOK FOR PRE-MEDICAL COURSE STUDENTS (by University of Pécs Medical School)
- Campbell: BIOLOGY



SIZE-SCALE

Metric = in meter/in metre



Millimeter= mm 1 mm=10⁻³m

Mikrometer=μm 1 μm=10⁻⁶m

Nanometer=nm 1 nm=10⁻⁹m

Centimeter=cm 1 cm=10⁻²m

Kilometer=km 1 km=10³m

Microscopes

Magnification

- Light microscope: 1000x
- Electron microscope: 500 000x

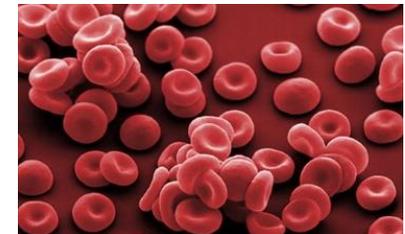
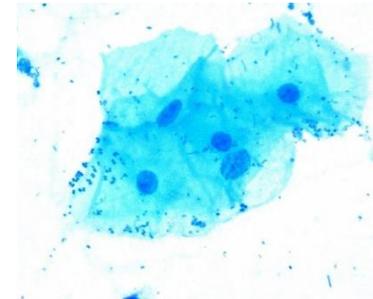
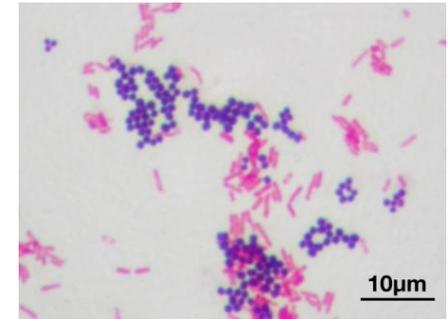
Resolution

limits of resolution:

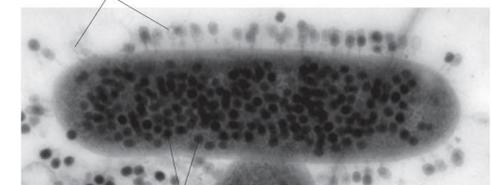
- Human eye: 1 mm
- Light microscope: 1 μm
- Electron microscope: 1 nm
- High resolution microscope

Contrasting

- Light microscope: dyes
- Electron microscope: metal particles

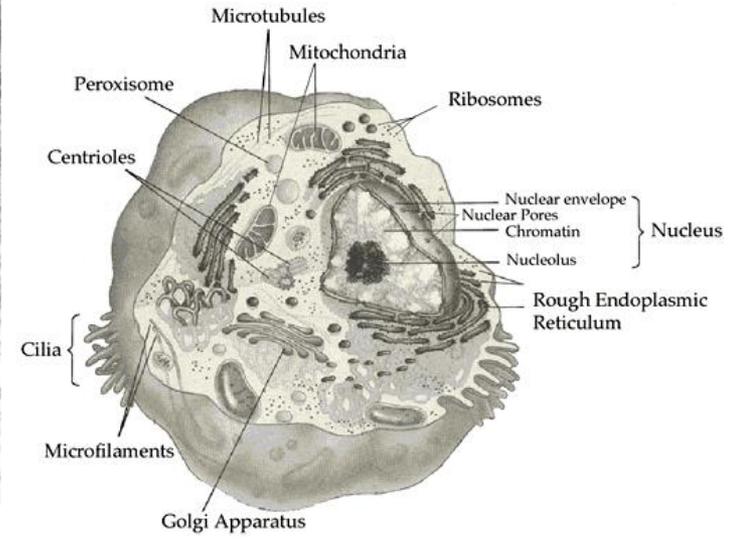
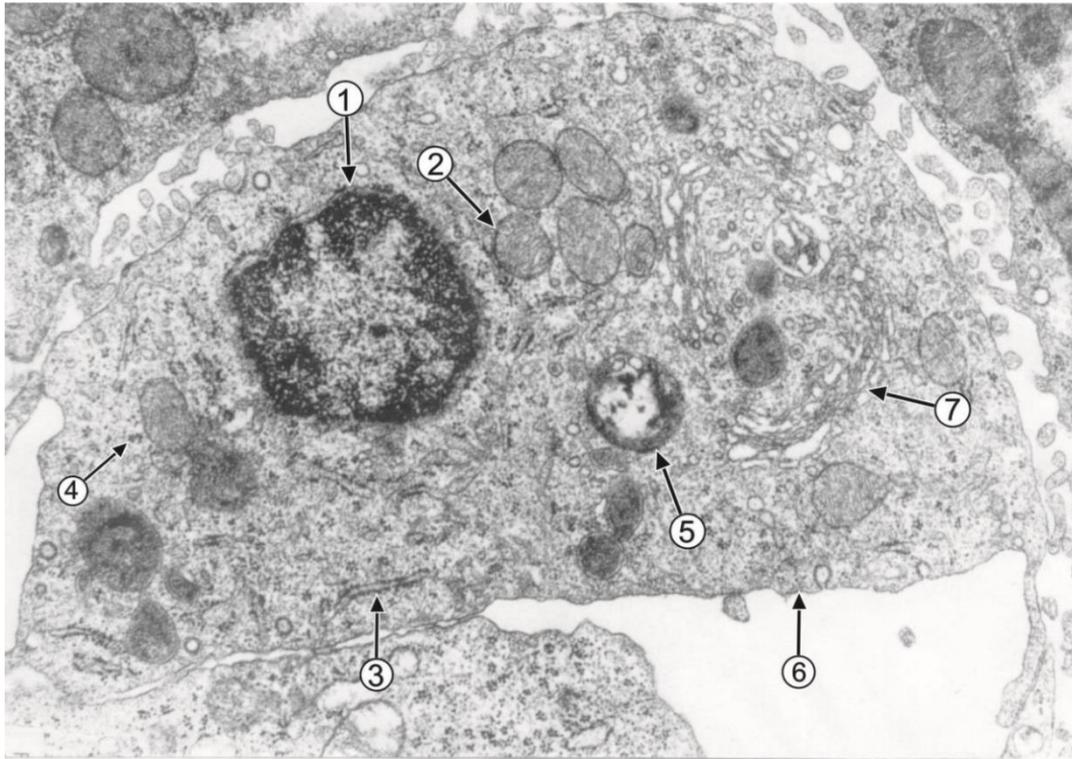


empty capsids following infection



nascent viruses

1 μm



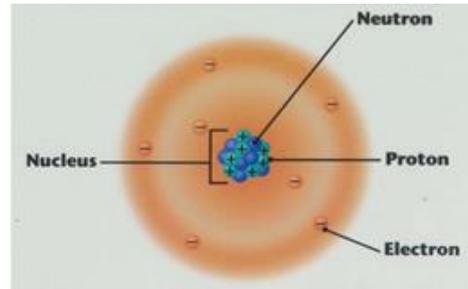
Levels of organization in human body

- Biogenic elements
- Molecules, macromolecules
- Cells (viruses), cellular organelles
- Tissues
- Organs
- Organic systems

atom, ion, isotope, element, molecule

1. A substance composed of atoms with the same atomic number; it cannot be broken down in ordinary chemical reactions.
2. The smallest indivisible particle of matter that can have an independent existence.
3. Two or more atoms which are chemically combined to form a single species.
4. An atom that has lost or gained electrons from its outer shell and therefore has a positive or negative charge, respectively; symbolized by a superscript plus or minus sign and sometimes a number, e.g., H^+ , Na^+ , O^{2-} , Cl^- .
5. Atoms with the same atomic number but different numbers of neutrons; indicated by adding the mass number to the element's name, e.g., carbon 12 or ^{12}C .

Atom, subatomic particles



www.csmate.colostate.edu

- **2 parts of an atom: nucleus** and electron **cloud** („1cm/100m“)
- Electron **orbital**: space of one electron
- Electron **shells**
 - composed of orbitals
 - determine the size of the atom
 - 4 major shells (K: 2 electrons, L: 8 electrons, M: 18 electrons, N: 32 electrons)
- Number of protons=number of electrons
- Atom is neutral=uncharged
- **Atomic number**: number of protons
- **Atomic mass/weight = mass number**: number of protons + number of neutrons

Subatomic particles

Name	Charge	Location	Mass	Atomic mass
Proton	+1	atomic nucleus	1.6726×10^{-27} kg	1Dalton
Neutron	0	atomic nucleus	1.6750×10^{-27} kg	1Dalton
Electron	-1	electron orbital	9.1095×10^{-31} kg	negligible (1/1800Da)

Dalton = Da = unit of mass/weight (NOT METRIC!)

1 Dalton = mass/weight of 1 Hydrogen ion (H⁺)

1 Dalton = mass/weight of 1/12 Carbon atom

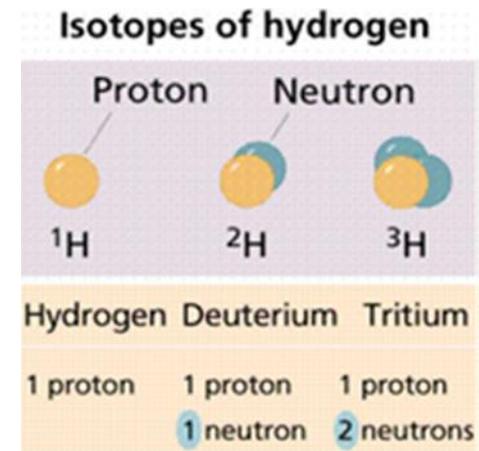
Mass/weight of proteins, eg. 60 000Da=60kDa

Kilodalton (kDa)= 10^3 Dalton

Ions

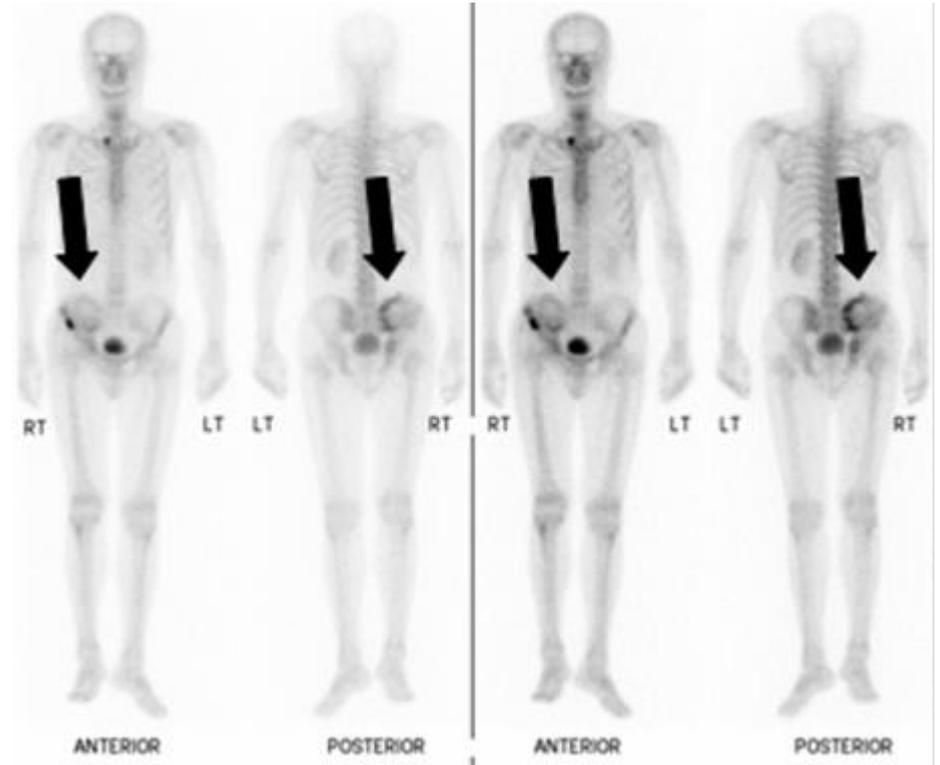
- **more or less electrons than protons**
- charged
- types:
 - cation** (+ charge) : 1st and 2nd groups tend to lose 1 or 2 electrons
eg. Na⁺, Mg²⁺
 - anion** (- charge) : 6th and 7th groups tend to gain 2 or 1 electrons
eg. Cl⁻, O²⁻
- ionic bond formation (between a cation and an anion)

Isotopes

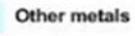
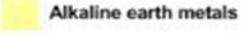
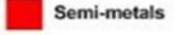
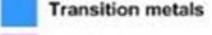
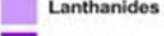
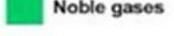
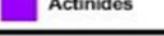


www.csmate.colostate.edu

- Same number of protons but different number of neutrons = **Same atomic number** but **different mass number**
- Types: **stable** and **unstable =radioactive** (nuclear splitting)
- Role in research and medicine: change of molecular density or energy emission
 1. to trace molecules, biochemical processes in cells (eg. Hershey –Chase experiment; Meselson-Stahl experiment)
 2. nuclear medicine: scanning the structure and function of organs with radioisotope eg. Technetium-99m labeled organ specific molecules
 - skeletal scintigraphy/bone scan (bone metastasis!, inflammation)
 - thyroid gland (hormone production) Tc 99 or iodine 131
 - heart (blood supply, muscle activity)
 - secretion by kidney



Periodic Table of the Elements

Color Legend									
 Alkali metals	 Other metals								
 Alkaline earth metals	 Semi-metals								
 Transition metals	 Nonmetals								
 Lanthanides	 Noble gases								
 Actinides									

5 B Boron					
Atomic number					
Symbol					
Element name					

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulphur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57-71 Lanthanides see below	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89-103 Actinides see below	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Uu Ununnilium								

Lanthanides	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
Actinides	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

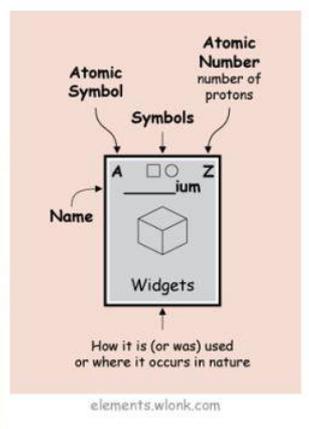
H Hydrogen 1
Sun and Stars

Li Lithium 3
Batteries

Be Beryllium 4
Emeralds

Na Sodium 11
Salt

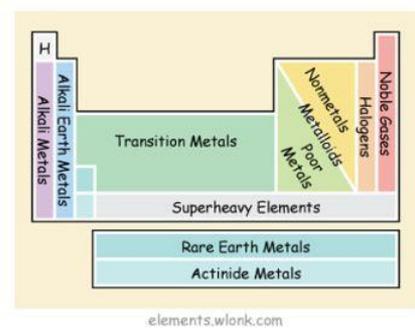
Mg Magnesium 12
Chlorophyll



Legend:

- Solid
- Liquid
- ☁ Gas at room temperature
- ♀ Human Body top ten elements by weight
- 🌍 Earth's Crust top eight elements by weight
- ⚡ Magnetic ferromagnetic at room temperature
- 👑 Noble Metals corrosion-resistant
- ☄ Radioactive all isotopes are radioactive
- ⚗ Only Traces Found in Nature less than a millionth percent of earth's crust
- ✖ Never Found in Nature only made by people

Examples: ■ metallic solid, ● red liquid, ☁ colorless gas



He Helium 2
Balloons

B Boron 5
Sports Equipment

C Carbon 6
Basis of Life's Molecules

N Nitrogen 7
Protein

O Oxygen 8
Air

F Fluorine 9
Toothpaste

Ne Neon 10
Advertising Signs

Al Aluminum 13
Airplanes

Si Silicon 14
Stone, Sand, and Soil

P Phosphorus 15
Bones

S Sulfur 16
Egg Yolks

Cl Chlorine 17
Swimming Pools

Ar Argon 18
Light Bulbs

K Potassium 19 Fruits and Vegetables	Ca Calcium 20 Shells and Bones	Sc Scandium 21 Bicycles	Ti Titanium 22 Aerospace	V Vanadium 23 Springs	Cr Chromium 24 Stainless Steel	Mn Manganese 25 Earthmovers	Fe Iron 26 Steel Structures	Co Cobalt 27 Magnets	Ni Nickel 28 Coins	Cu Copper 29 Electric Wires	Zn Zinc 30 Brass Instruments	Ga Gallium 31 Light-Emitting Diodes (LEDs)	Ge Germanium 32 Semiconductor Electronics	As Arsenic 33 Poison	Se Selenium 34 Copiers	Br Bromine 35 Photography Film	Kr Krypton 36 Flashlights
Rb Rubidium 37 Global Navigation	Sr Strontium 38 Fireworks	Y Yttrium 39 Lasers	Zr Zirconium 40 Chemical Pipelines	Nb Niobium 41 Mag Lev Trains	Mo Molybdenum 42 Cutting Tools	Tc Technetium 43 Radioactive Diagnosis	Ru Ruthenium 44 Electric Switches	Rh Rhodium 45 Searchlight Reflectors	Pd Palladium 46 Pollution Control	Ag Silver 47 Jewelry	Cd Cadmium 48 Paint	In Indium 49 Liquid Crystal Displays (LCDs)	Sn Tin 50 Plated Food Cans	Sb Antimony 51 Car Batteries	Te Tellurium 52 Thermoelectric Coolers	I Iodine 53 Disinfectant	Xe Xenon 54 High-Intensity Lamps
Cs Cesium 55 Atomic Clocks	Ba Barium 56 X-Ray Diagnosis	71 - 71	Hf Hafnium 72 Nuclear Submarines	Ta Tantalum 73 Mobile Phones	W Tungsten 74 Lamp Filaments	Re Rhenium 75 Rocket Engines	Os Osmium 76 Pen Points	Ir Iridium 77 Spark Plugs	Pt Platinum 78 Labware	Au Gold 79 Jewelry	Hg Mercury 80 Thermometers	Tl Thallium 81 Low-Temperature Thermometers	Pb Lead 82 Weights	Bi Bismuth 83 Fire Sprinklers	Po Polonium 84 Anti-Static Brushes	At Astatine 85 Radioactive Medicine	Rn Radon 86 Surgical Implants
Fr Francium 87 Laser Atom Traps	Ra Radium 88 Luminous Watches	89 - 103	Rf Rutherfordium 104	Db Dubnium 105	Sg Seaborgium 106	Bh Bohrium 107	Hs Hassium 108	Mt Meitnerium 109	Ds Darmstadtium 110	Rg Roentgenium 111	Cn Copernicium 112	Nh Nihonium 113	Fl Flerovium 114	Mc Moscovium 115	Lv Livermorium 116	Ts Tennessine 117	Og Oganesson 118

Periodic table

- **D. I. Mendeleev**
- **symbols of elements** (element: a substance composed of atoms with the same atomic number) carbon:C; nitrogen: N; calcium: Ca etc.
- rows=**periods**: elements with the same major quantum number/same major electron shell (K, L, M, N)
- columns=**groups**: elements with the same versatile/unpaired electrons
- **size of elements** increases from top to bottom and from right to left.
- **electron affinity**=the amount of energy *released* or *spent* when an electron is added to a neutral atom or molecule in the gaseous state to form a negative ion.
Electron affinity of elements increases from bottom to top, and from left to right.
The highest electron affinities are possessed by fluorine (F) and chlorine (Cl).
- **relative atomic mass = molar mass** : gram/mole , mole: 6×10^{23}

Molecules

- 2 or more **atoms bound to each other** through covalent bond(s)
- **central atom**
- **stable** compound
- **shape** determined by electronpairs and the electron attraction by atomic nuclei
eg. Linear (H-H, O-C-O), V-saped (H-O-H)
- **polarity** determined by the electronegativity of atomic nuclei
apolar (eg. H-H) or polar (eg. H-Cl) molecules

Chemical bonds in organic chemistry

1. Primary/Covalent bonds:

- Electrons are shared by the bound atoms (bonding electrons)
- Strong
- Inside molecules=intramolecular
- Types:
 - Single (H-H, C-C, H-O-H), Double (C=O, C=C), Triple (C≡C, N≡N)
 - Non polarized, polarized

2. Disulfide-bond/Disulfide-bridge: -S-S- (inside molecules, between molecules)

3. Ionic bond: between ions (eg. between Na⁺ and Cl⁻)

4. Secondary/Non-covalent bonds:

- Electrons are not shared by the bound atoms
- Weaker than covalent bonds
- Between molecules =intermolecular
- Types:
 - Van der Waals=London forces (between apolar molecules)
 - Dipole-dipole bonds (between polar molecules)
 - Hydrogen bond

Hydrogen bond

- is a secondary bond
- **between a H atom covalently attached to an electronegative atom** (atom with a high affinity for electrons) eg O, N, **and an electronegative atom of another molecule or another part of the same molecule**
- weaker than covalent bonds
- between water molecules, inside protein molecules, nucleic acids

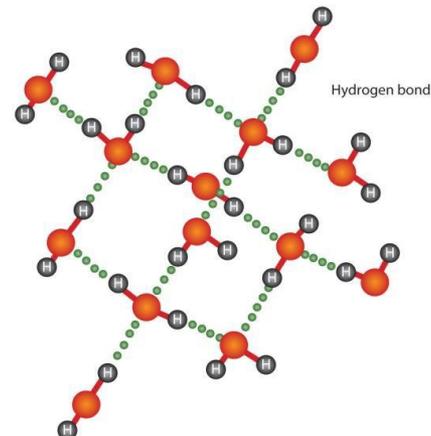


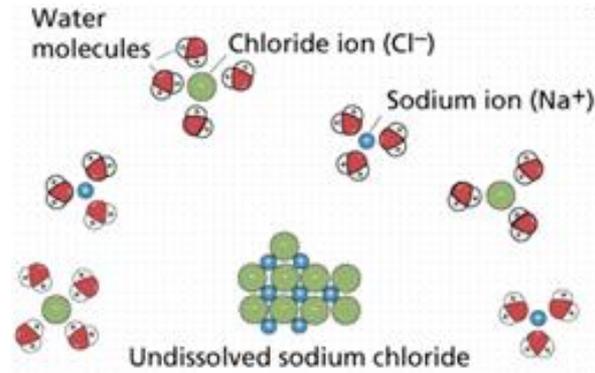
Figure 2-3. The hydrogen bond in water. <http://www.flatworldknowledge.com/>

Water

chemistry

- 1) H-O-H („V” shape)
- 2) Polar (slightly negative and positive sites because of different affinities for electrons)
- 3) H-bond formation (1water/4 neighbouring water or with other molecules)
- 4) Solvent of ions and polar substances (hydrophilic substances) eg. Glucose, NaCl, alcohols,... (hydrophilic functional groups)
- 5) Tendency to dissociate into H^+ and OH^- in liquid state
- 6) Existence in all three states of matter (gas, liquid, solid)
- 7) Expansion upon freezing due to crystal formation (stabilized by H-bonds)
 - leading to lower density

Water as solvent

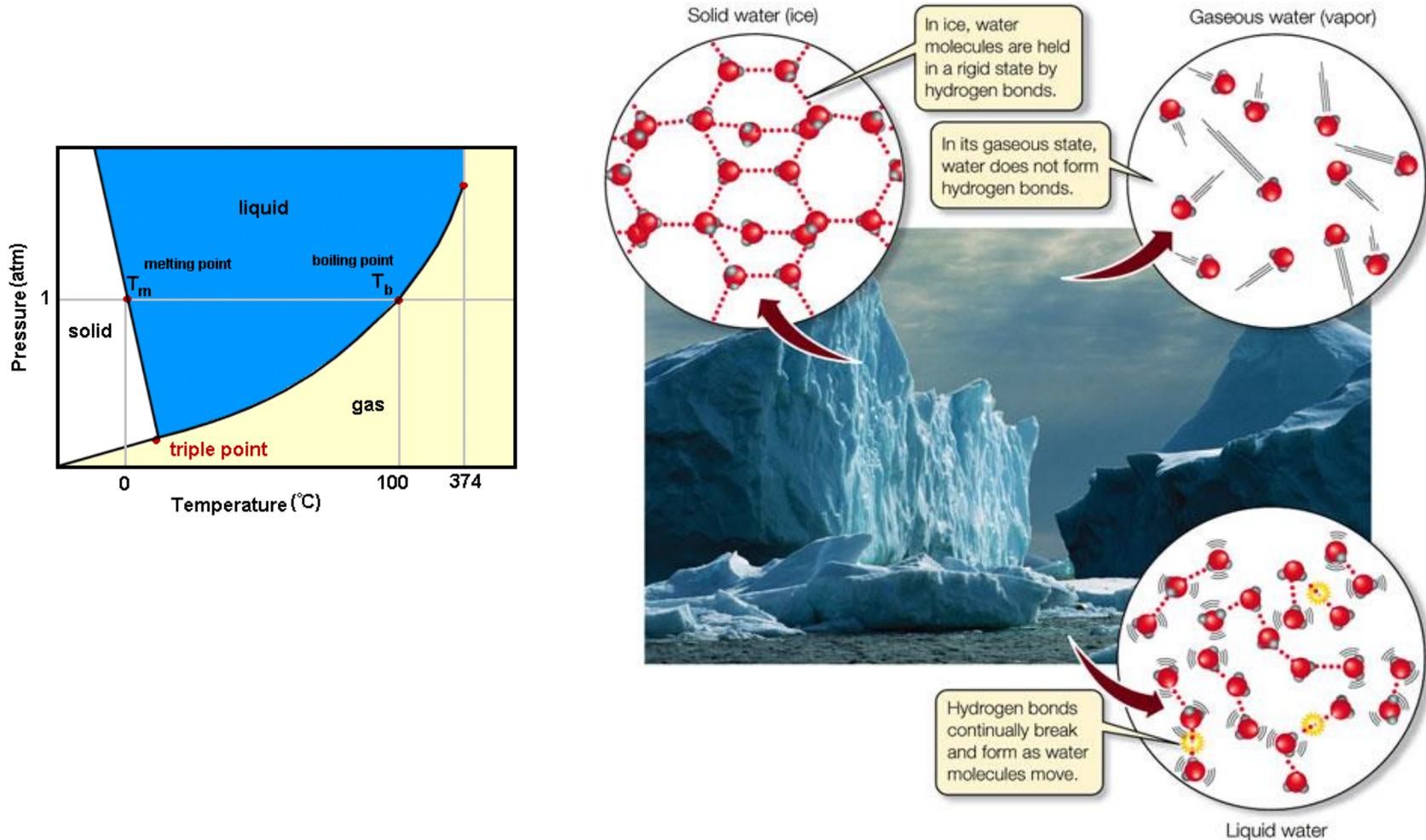


Solution: a homogeneous mixture of two or more substances. A solution may exist in any phase.

Solute is the substance that is dissolved in a solution (eg. NaCl).

Solvent is the substance in which the solute is dissolved (eg. water). The solvent is present in greater amount than the solute.

States of matter of water



LIFE 8e, Figure 2.14

Water

role in biology

- 1) environment for life
 - a. cohesive behavior (H-bonds!)
 - b. stabilisation of temperature
 - c. expansion upon freezing
 - d. dissolving capability
 - e. weak viscosity (medium for transport, reactions)
 - f. transparency
- 2) partner in biochemical reactions as either substrate or endproduct
 - a. condensation (dehydration)
 - b. hydrolysis (hydration)
- 3) role in photosynthesis (photolysis of water)
- 4) free movement through biological membranes without energy requirement (osmosis)
- 5) pH

pH, pH scale

pH = negative logarithm (to the base 10) of H⁺ concentration in a water based solution

pH value can be any between 0 and 14 because of the concentration of H⁺ ranging between 10⁰ and 10⁻¹⁴ mole/liter

[H⁺]x [OH⁻] = 10⁻¹⁴ mole/liter = CONSTANT

pH=7 concentration of H⁺ equals to concentration of hydroxide ions (**neutral** solution)

pH<7 concentration of H⁺ is more than concentration of hydroxide ions (**acidic** solution)

pH>7 concentration of H⁺ is less than concentration of hydroxide ions (**basic** solution)

Concentration of Hydrogen ions compared to distilled water	1/10,000,000	14	Liquid drain cleaner, Caustic soda	Examples of solutions and their respective pH
	1/1,000,000	13	bleaches, oven cleaner	
	1/100,000	12	Soapy water	
	1/10,000	11	Household Ammonia (11.9)	
	1/1,000	10	Milk of magnesium (10.5)	
	1/100	9	Toothpaste (9.9)	
	1/10	8	Baking soda (8.4), Seawater, Eggs	
	0	7	"Pure" water (7)	
	10	6	Urine (6) Milk (6.6)	
	100	5	Acid rain (5.6) Black coffee (5)	
	1,000	4	Tomato juice (4.1)	
	10,000	3	Grapefruit & Orange juice, Soft drink	
	100,000	2	Lemon juice (2.3) Vinegar (2.9)	
	1,000,000	1	Hydrochloric acid secreted from the stomach lining (1)	
	10,000,000	0	Battery Acid	

Acid, Base, Buffer

Acid: lowers pH

- substance that **increases the H^+ concentration** of an aqueous solution
- by **dissociating into H^+**
- eg. HCl , H_2CO_3

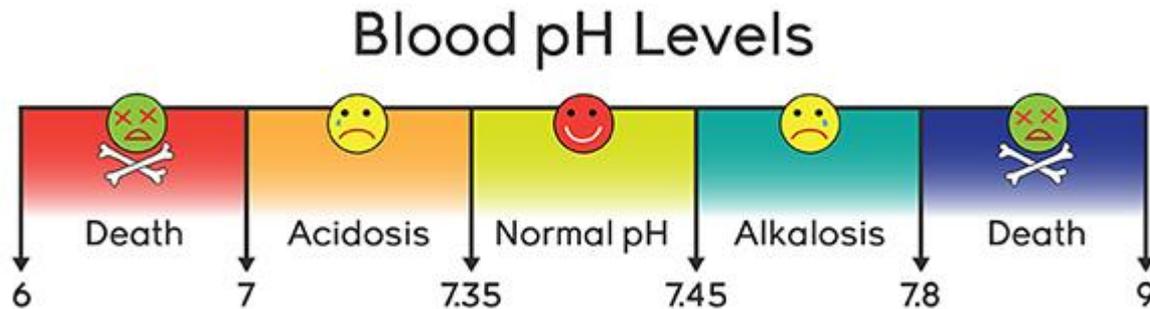
Base: increases pH

- substance that **decreases the H^+ concentration** of an aqueous solution
- by **accepting H^+ or by dissociating into OH^-**
- eg. $NaOH$, NH_3

Buffer: minimizes changes of pH („pH regulator“)

- substance easily shifting between its H^+ dissociated and H^+ accepted forms
- weak acid and its corresponding base
- eg. H_2CO_3 and HCO_3^-

Blood pH



Maintenance of blood pH mainly by $\text{H}_2\text{CO}_3/\text{HCO}_3^-$ buffer system:

- chemical shifting between H_2CO_3 and HCO_3^-
$$\text{H}_2\text{CO}_3 = \text{HCO}_3^- + \text{H}^+$$
- elimination or retain of CO_2 by lungs
- elimination of H^+ or retain of HCO_3^- by kidneys

Functional groups / chemical groups in organic chemistry

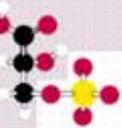
A **complex** of covalently joined atoms (minimum 2 atoms are coupled to each other).

The group is **covalently linked to** the carbon backbone (skeleton) of a **molecule**.

The group is responsible for

- the **chemical properties** of the molecule (eg. solubility, polarity, charge, acidic/basic feature...)
- the **chemical interactions** (bond forming capability) of the molecule.

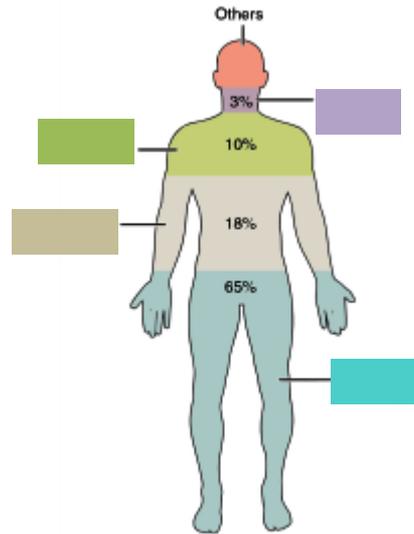
Functional groups in organic chemistry

Functional group	Class of compounds	Structural formula	Example	Ball-and-stick model	Water solubility	Acid/Base	Charge	Molecules	Bonds
Hydroxyl -OH	Alcohols	$R-OH$	$\begin{array}{c} H & H \\ & \\ H-C & -C-OH \\ & \\ H & H \end{array}$ Ethanol		yes	no	no	Carbohydrates	ester
Carbonyl -CHO	Aldehydes	$R-C(=O)H$	$\begin{array}{c} H & O \\ & \\ H-C & -C-H \\ & \\ H & \end{array}$ Acetaldehyde		yes	no	no	Carbohydrates eg. glucose	
Carbonyl -CO-	Ketones	$R-C(=O)R$	$\begin{array}{c} H & O & H \\ & & \\ H-C & -C & -C-H \\ & & \\ H & & H \end{array}$ Acetone		yes	no	no	Carbohydrates eg. fructose	
Carboxyl -COOH	Carboxylic acids	$R-C(=O)OH$	$\begin{array}{c} H & O \\ & \\ H-C & -C-OH \\ & \\ H & \end{array}$ Acetic acid		yes	weak acids (protein buffers)	negative	Organic acids, eg. citric acid; Aminoacids, proteins	ester, peptide
Amino -NH ₂	Amines	$R-NH_2$	$\begin{array}{c} H & H \\ & \\ H-C & -N-H \\ & \\ H & H \end{array}$ Methylamine		yes	bases	positive	Aminoacids, proteins	peptide
Phosphate -OPO ₃ ²⁻	Organic phosphates	$R-O-P(=O)(O^-)_2$	$\begin{array}{c} HO & O \\ & \\ H-C & -C-OH \\ & \\ H & -O-P(=O)(O^-)_2 \\ & \\ H & \end{array}$ 3-Phosphoglyceric acid		yes	weak acids (phosphate buffers)	negative	Nucleotides Nucleic acids Phospholipids	ester, phosphoanhydride (macroerg)
Sulfhydryl -SH	Thiols	$R-SH$	$\begin{array}{c} H & H \\ & \\ H-C & -C-SH \\ & \\ H & H \end{array}$ Mercaptoethanol		yes	no	no	Aminoacids eg. cysteine	disulfide

Biogenic elements

- elements present in living systems
- 25
- types:
 - primary**
 - secondary**
 - tertiary =trace**

4 elements compose 96% of human body



Elements of human body

primary, secondary, tertiary (trace)

1. Oxygen (65%)
2. Carbon (18%)
3. Hydrogen (10%)
4. Nitrogen (3%)
5. Calcium (1.5%)
6. Phosphorus (1.0%)
7. Kalium/Potassium (0.35%)
8. Sulfur (0.25%)
9. Natrium/Sodium (0.15%)
10. Magnesium (0.05%)
11. Copper, Zinc, Selenium, Molybdenum, Fluorine, Chlorine, Iodine, Manganese, Cobalt, Iron (0.70%)
12. Lithium, Strontium, Aluminum, Silicon, Lead, Vanadium, Arsenic, Bromine ($\leq 0,5\%$)

Elements of human body

oxygen: 2 valences, electronegative

- in water
- in CO₂
- in all organic molecules, in many functional groups
- in H-bond formation
- oxygenates H into water during ATP (energy) synthesis
= oxidant

carbon: 4 valences

- formation of carbon backbone=skeleton of organic molecules (central atom)
 - formation of complex and diverse molecules
 - formation of single, double, triple bonds
 - formation of linear, and ring-like backbones
- in many functional groups
- in CO₂
- is oxidized during breakdown processes (eg. glucose breakdown)

hydrogen: 1 valence

- in water
- in all organic molecules, in many functional groups
- in H-bond formation
- is reduced into water during ATP (energy) synthesis

Elements of human body

nitrogen: 3 valences, electronegative

- in aminoacids and proteins
- in nucleotides and nucleic acids (purine, pyrimidine bases)
- (in a few lipids, carbohydrates)
- in amino group
- in H-bond formation

calcium:

- bones, teeth (rigidity)
- blood coagulation
- muscle contraction

phosphorous:

- bones, teeth (rigidity)
- in nucleotide, nucleic acids
- in phosphate functional group

Elements of human body

natium=sodium and kalium=potassium:

- membrane potential, action potential

sulfur:

- in thiol functional group
- in a few aminoacids, proteins

magnesium:

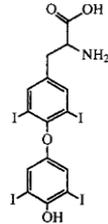
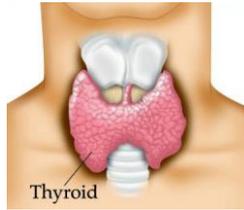
- in enzyme function
- in muscle cell and nervous system function

iodine:

- in thyroid gland hormone (thyroxine)

iron:

- in haemoglobin (O₂ gas transport in blood)



FORMULA 1 L- AND D- THYROXINE

Hypothyroidism

Easy to diagnose and treat -- if you think of it.

slowing of mind and body

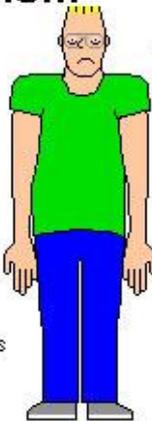
weak heartbeat

constipation

myxedema

high LDL

slow reflexes



hair thinning

depression
"schizophrenia"
irritability

big tongue

croaky voice

dry skin

cold skin

cold intolerance

Growth failure
Mental retardation

Flat back of head

Abnormal ears

Many "loops"
on finger tips

Palm crease

Special skin
ridge patterns

Unilateral or bilateral
absence of one rib

Intestinal blockage

Umbilical hernia

Abnormal pelvis

Diminished muscle tone

Broad flat face
Slanting eyes
Epicanthic eyefold
Short nose

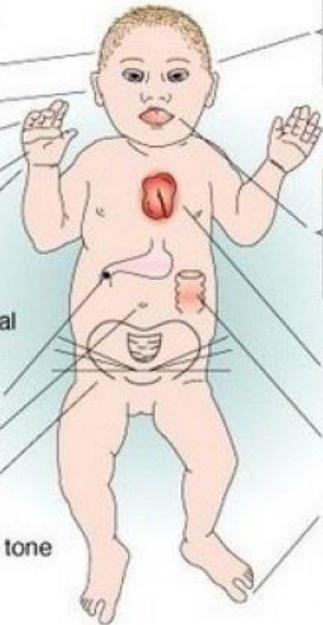
Short and
broad hands

Small and
arched palate
Big, wrinkled
tongue
Dental anomalies

Congenital heart
disease

Enlarged colon

Big toes widely
spaced



TOP 10 MAGNESIUM FOODS

DrAxe.com	
1 Spinach	157 MG (40% DV) 1 CUP
2 Chard	154 MG (38% DV) 1 CUP
3 Pumpkin Seeds	92 MG (23% DV) 1/8 CUP
4 Yogurt or Kefir	50 MG (13% DV) 1 CUP
5 Almonds	80 MG (20% DV) 1 CUP
6 Black Beans	60 MG (15% DV) 1/2 CUP
7 Avocado	68 MG (17% DV) 1 MED
8 Figs	50 MG (13% DV) 1/2 CUP
9 Dark Chocolate	95 MG (24% DV) 1 SQ. L.
10 Banana	32 MG (8% DV) 1 MED

TOP 10 POTASSIUM FOODS

DrAxe.com	
1 Avocado	1068 mg (30% DV) 1 WHOLE
2 Sweet Potato	952 mg (27% DV) 1 MEDIUM
3 Acorn Squash	899 mg (26% DV) 1 CUP
4 Spinach	839 mg (24% DV) 1 CUP
5 Dried Apricots	755 mg (22% DV) 1/2 CUP
6 Coconut Water	600 mg (17% DV) 1 CUP
7 Kefir or Yogurt	579 mg (15% DV) 1 CUP
8 White Beans	502 mg (15% DV) 1/2 CUP
9 Mushrooms	428 mg (12% DV) 1 CUP
10 Banana	422 mg (12% DV) 1 LARGE

TOP 10 IRON FOODS

DrAxe.com	
1 Beef Liver	5.6 mg (31% DV) 3 OZ.
2 Spinach	3.2 mg (18% DV) 1/2 CUP
3 Navy Beans	2.3 mg (13% DV) 1/2 CUP
4 Swiss Chard	2.0 mg (11% DV) 1/2 CUP
5 Artichokes	2.0 mg (11% DV) 1 CUP
6 Black Beans	1.8 mg (10% DV) 1/2 CUP
7 Beef Steak	1.8 mg (10% DV) 3 OZ.
8 Prunes	1.6 mg (8% DV) 1 CUP
9 Egg Yolk	0.46 mg (3% DV) 1 LARGE
10 Collard Greens	0.17 mg (1% DV) 1 CUP

TOP 10 CALCIUM FOODS

DrAxe.com	
1 Raw Milk	300 mg (30% DV) 1 CUP
2 Yogurt or Kefir	300 mg (30% DV) 6 OZ.
3 Kale (cooked)	245 mg (24% DV) 1 CUP
4 Cheese	224 mg (22% DV) 1 OZ.
5 Sardines (with bones)	217 mg (21% DV) 2 OZ.
6 Broccoli (cooked)	93 mg (9% DV) 1 1/2 CUPS
7 Okra	82 mg (8% DV) 1 CUP
8 Almonds	76 mg (8% DV) 1 OZ.
9 Bok Choy	74 mg (7% DV) 1 CUP
10 Watercress	41 mg (4% DV) 1 CUP

TOP 10 PHOSPHORUS FOODS

DrAxe.com	
1 Kefir or Yogurt	356 mg (36% DV) 6 OZ.
2 Salmon	280 mg (28% DV) 3 OZ.
3 Raw Milk	247 mg (24% DV) 1 CUP
4 Grass-fed Steak	209 mg (21% DV) 3 OZ.
5 Brazil Nuts	203 mg (20% DV) 1 OZ.
6 Hard Cheese (Cheddar, Parmesan)	197 mg (20% DV) 1 OZ.
7 Sunflower Seeds	186 mg (18% DV) 2 TBSP.
8 Lentils	178 mg (18% DV) 1/2 CUP
9 Navy Beans	131 mg (13% DV) 1/2 CUP
10 Pumpkin Seeds	59 mg (6% DV) 1 CUP

TOP 10 SODIUM FOODS

DrAxe.com	
1 Table Salt	2300 mg (96% DV) 1 TSP.
2 Bouillon Cubes	1200 mg (20% DV) 1 CUBE.
3 Soy Sauce	1005 mg (42% DV) 1 TBSP.
4 Beef Jerky	590 mg (24% DV) 1 OZ.
5 Olives	420 mg (17% DV) 10 OLIVES (KALAMATA)
6 Parmesan Cheese	390 mg (16% DV) 1 OZ.
7 Ham	320 mg (13% DV) 1 SLICE.
8 Salami	226 mg (9% DV) 1 SLICE.
9 Bacon	194 mg (8% DV) 1 SLICE.
10 Pickles	160 mg (6% DV) 1 LARGE.