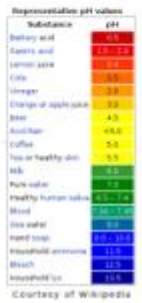
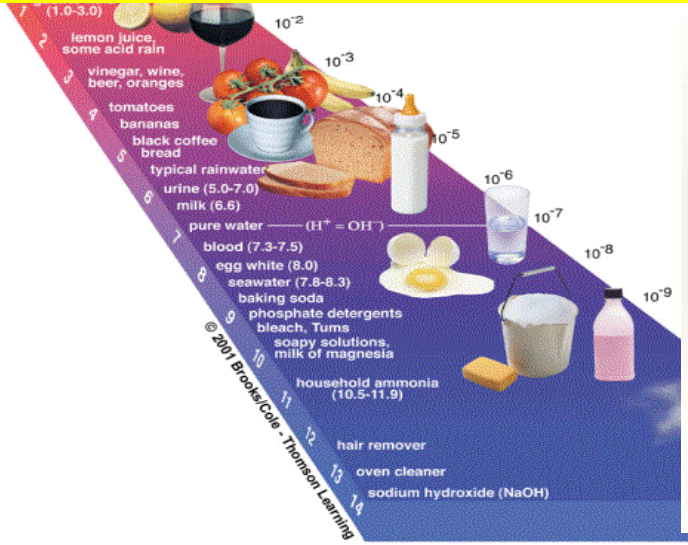
Acids, Bases, and pH of water solutions



OH^-

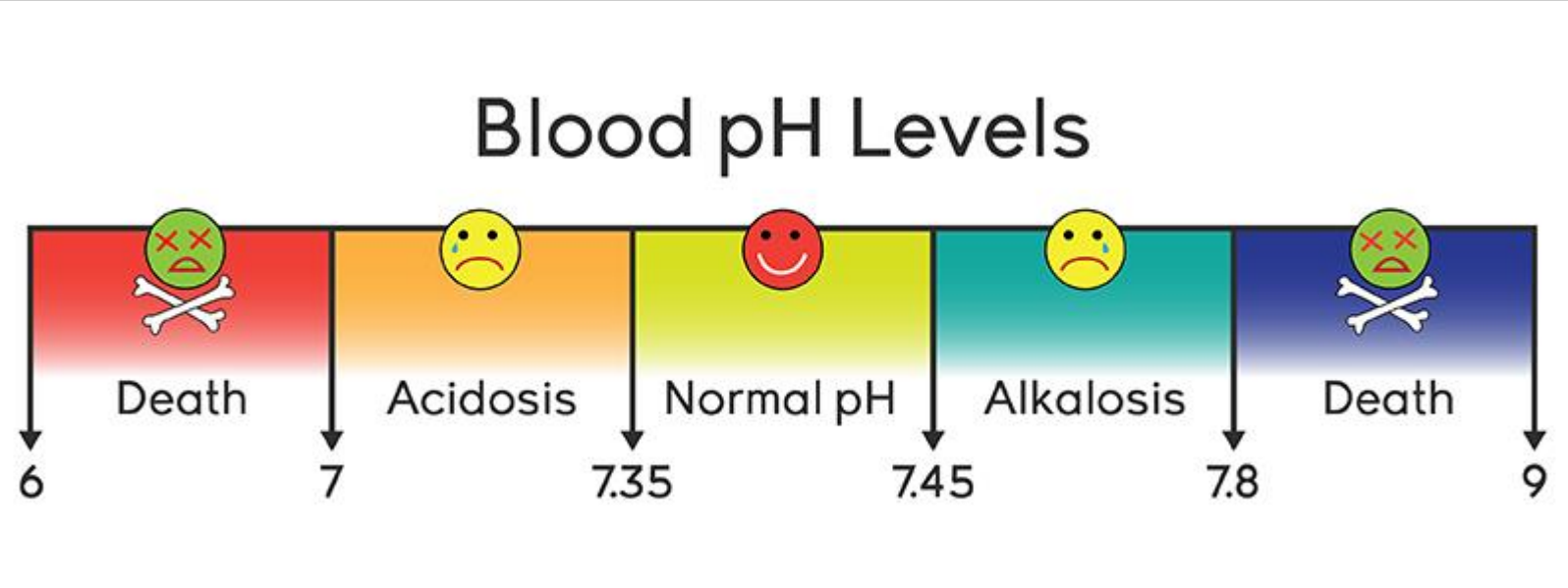


We learned previously that 400 billions reactions take place in one second in our organisms….

→many of these reactions MUST TAKE place in strict composition of solutions.

→For example, the food must be decomposed in Conditions of STRONG ACIDITY in the stomach

→reactions in blood take place in almost so-called NEUTRAL conditions…



Arrhenius –theory of acids and bases

Arrhenius, Svante August

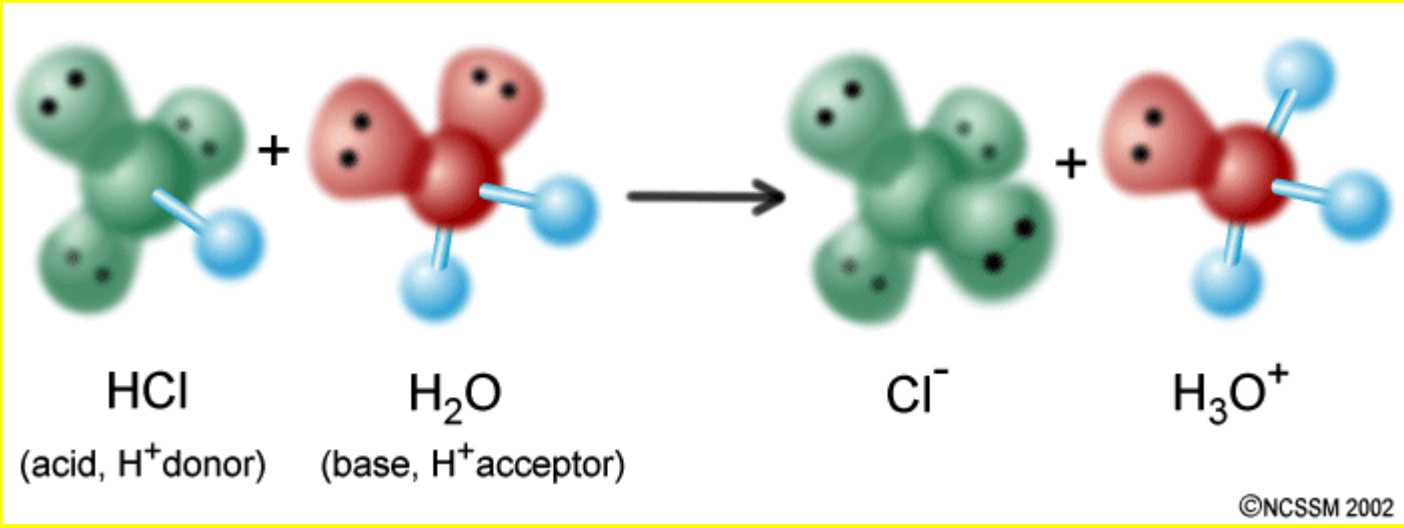
Acid–a substance that is a DONOR of protons or H^+ ions

$HCl \rightarrow H^+ + Cl^-$

Base – a substance that is a DONOR od hydroxide OH^- ions

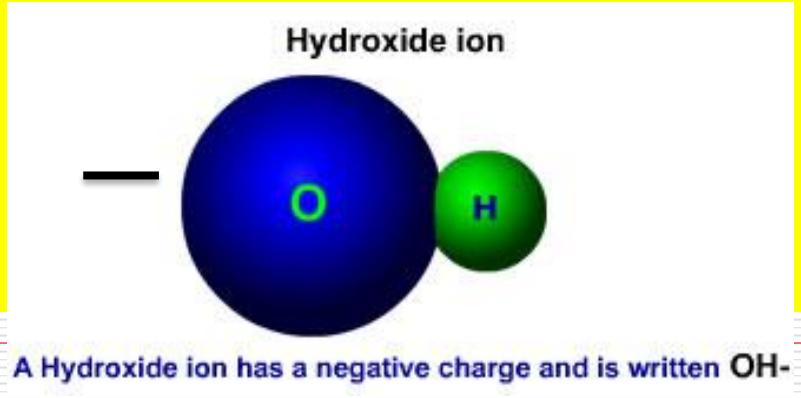
$NaOH \rightarrow Na^+ + OH^-$

WE SHOULD BE AWARE THAT the "ACIDITY" of solutions Originates from the so-called "free" H^+ (or H_3O^+) proton ions



…..while

The "free" OH- hydroxide ions contribute to the alkalinity of water solutions



Definition: **STRONG ACIDS** are those acids that are COMPLETELY DISSOCIATED in WATER and give equivalent number of protons (H+ ions)

→ STRONG BASES are those acids that are COMPLETELY DISSOCIATED in WATER and give equivalent number of hydroxide OH- ions

6 Strong Acids		6 Strong Bases	
$HClO_4$	perchloric acid	LiOH	lithium hydroxide
HCl	hydrochloric acid	NaOH	sodium hydroxide
HBr	hydrobromic acid	KOH	potassium hydroxide
HI	hydroiodic acid	$Ca(OH)_2$	calcium hydroxide
HNO_3	nitric acid	$Sr(OH)_2$	strontium hydroxide
H_2SO_4	sulfuric acid	$Ba(OH)_2$	barium hydroxide

This is the table of STRONG ACIDS and STRONG BASES..

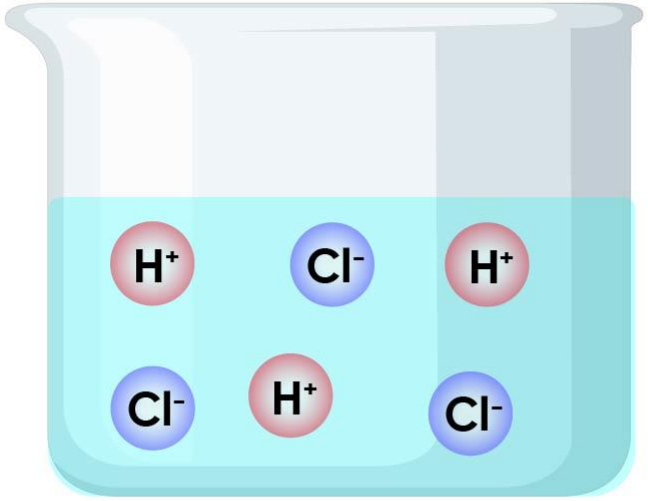
YOU MUST KNOW THE NAMES of these strong acids and strong bases!!!

DIFFERENCE between STRONG and WEAK ACIDS

teachoo

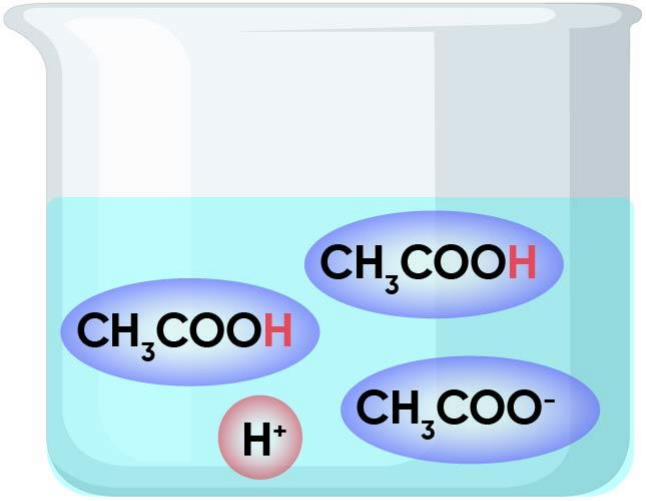
STRONG AND WEAK ACID

Strong Acid



HCl Strong Acid

Weak Acid



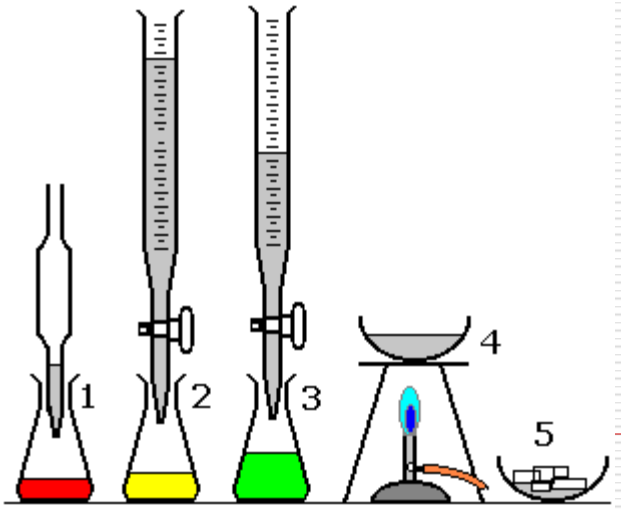
CH_3COOH Weak Acid

PROPERTIES OF SOME **STRONG ACIDS**

In reaction of neutralization, acids react with bases

Acid + base---> “salt” + water

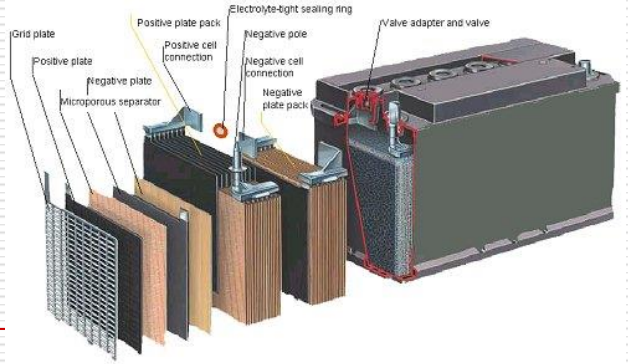
$HCl + NaOH \rightarrow NaCl + H_2O$



Barbie Soap

C. Ophardt, c. 2003

Sulfuric Acid

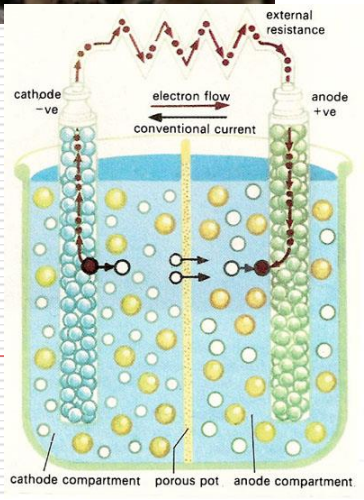


$$SO_3 + H_2O \text{ -----> } H_2SO_4$$

Attention: Very Dangerous!!!

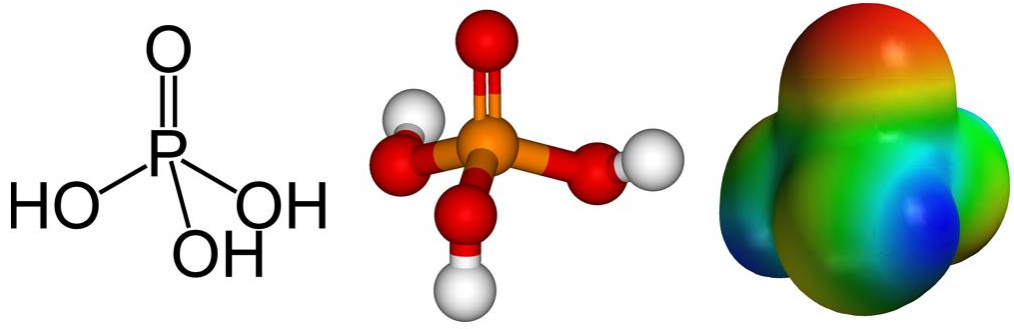
When we want to dissolve concentrated sulfuric acid in water

FIRST we PUT WATER and afterwards sulfuric acid in the container

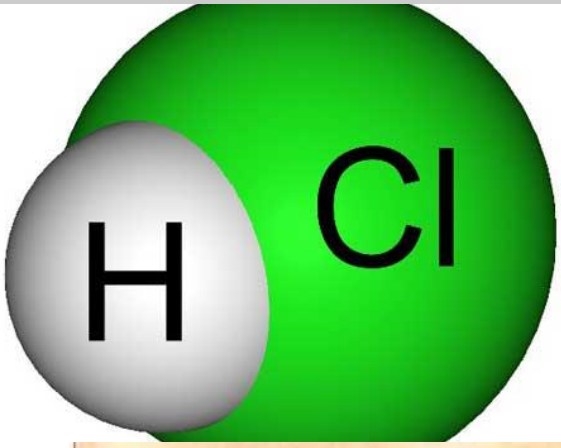


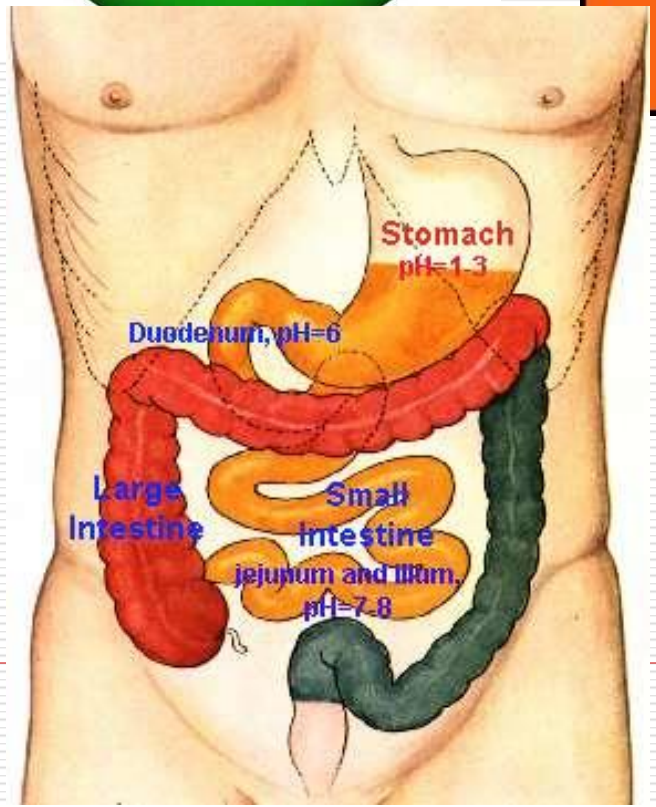
Phosphoric Acid---not very dangerous used in many cola-like beverages as a conservating substance

$$P_4O_{10(s)} + 6H_2O_{(l)} \text{ ---> } 4H_3PO_{4(aq)}$$

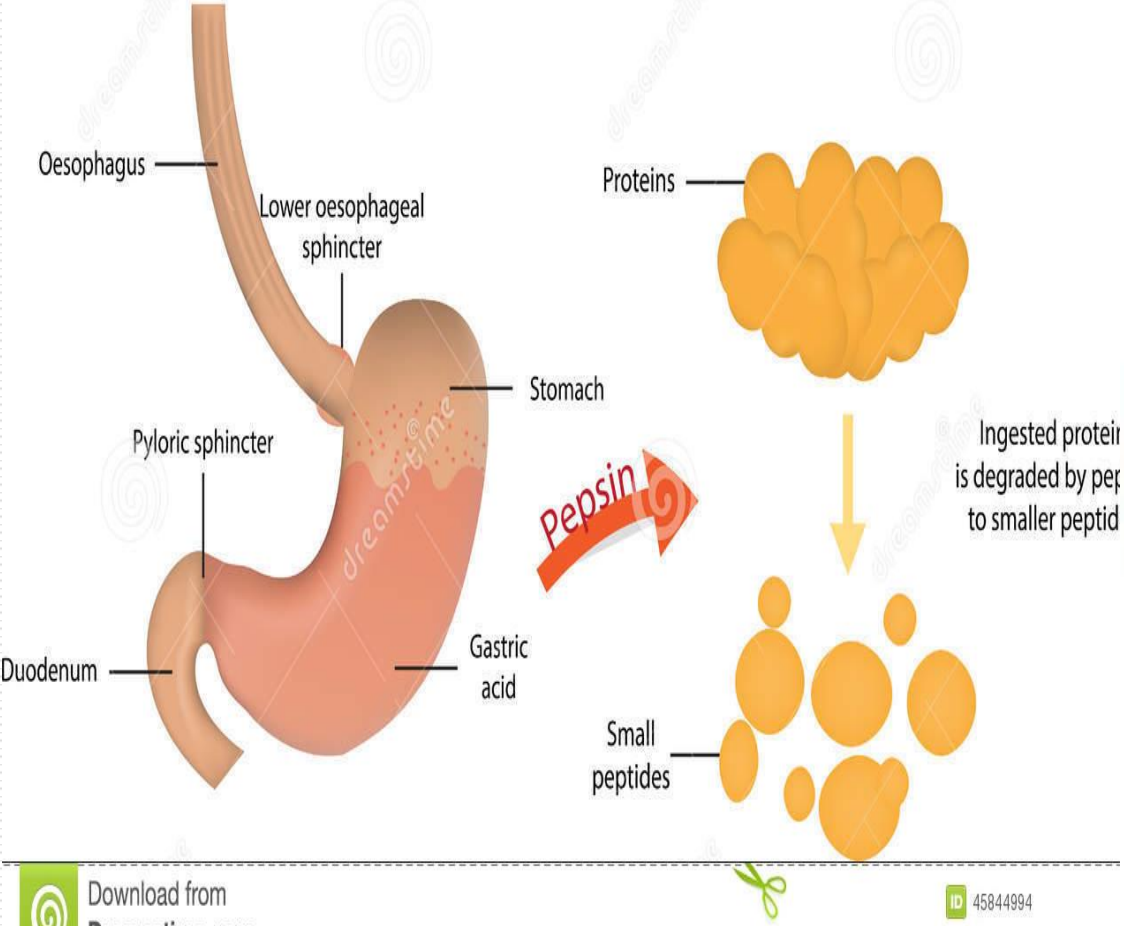


HCl-Hydrochloric Acid-very dangerous But VERY IMPORTANT

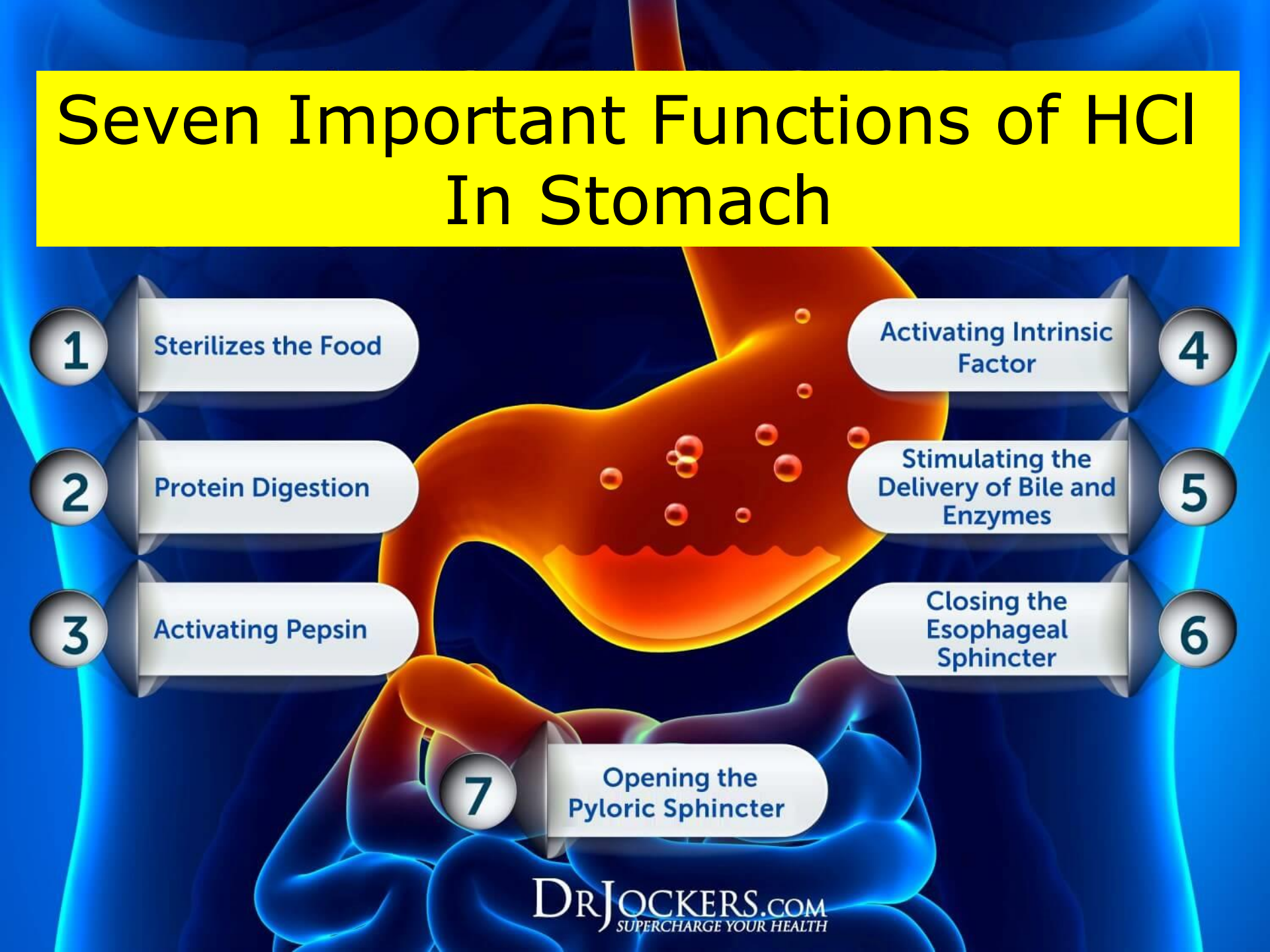


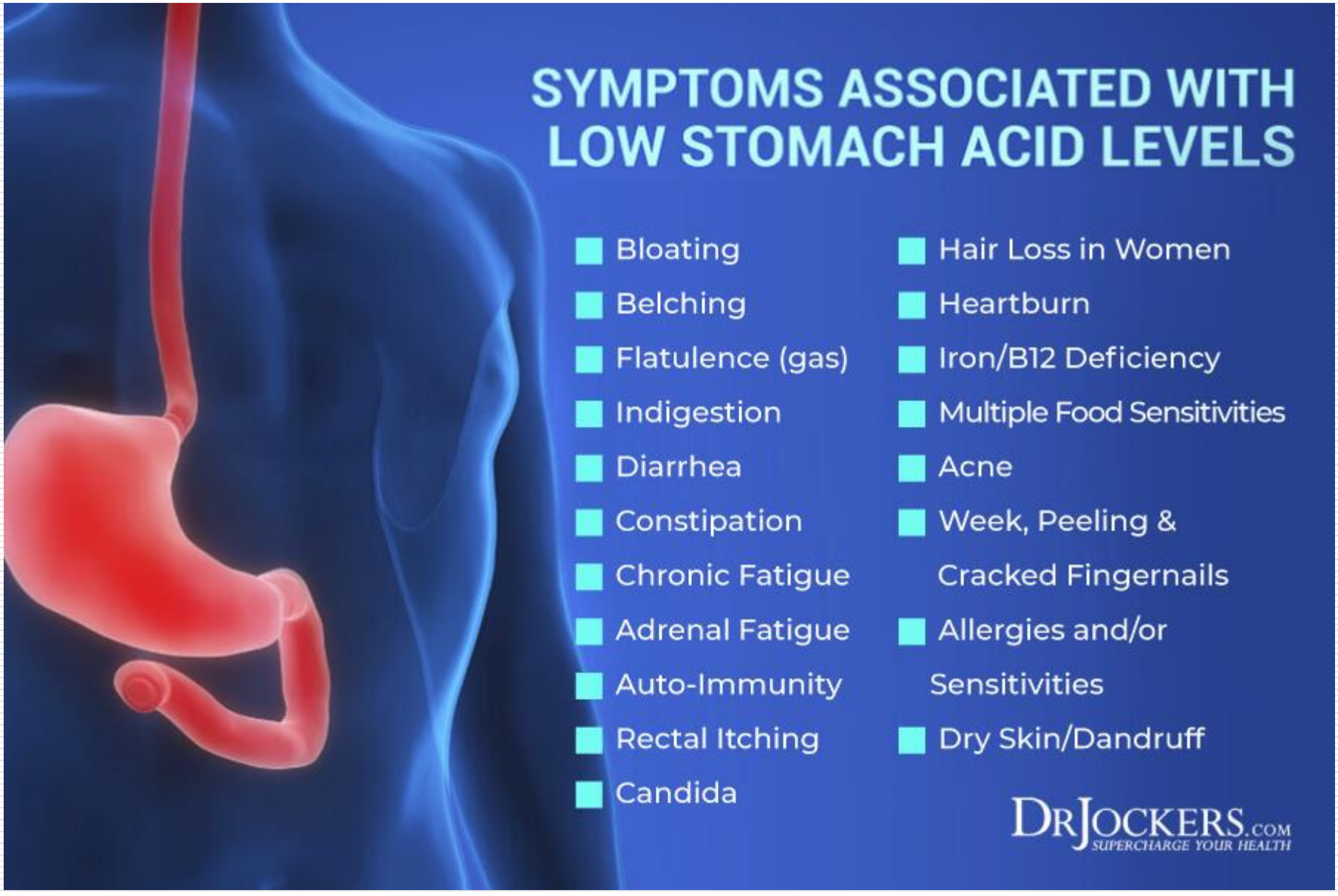


Digestion

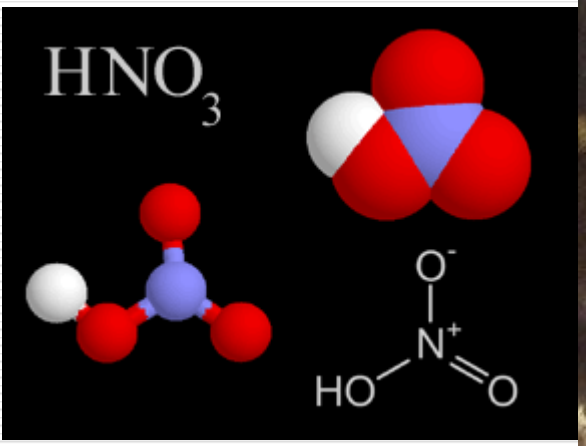


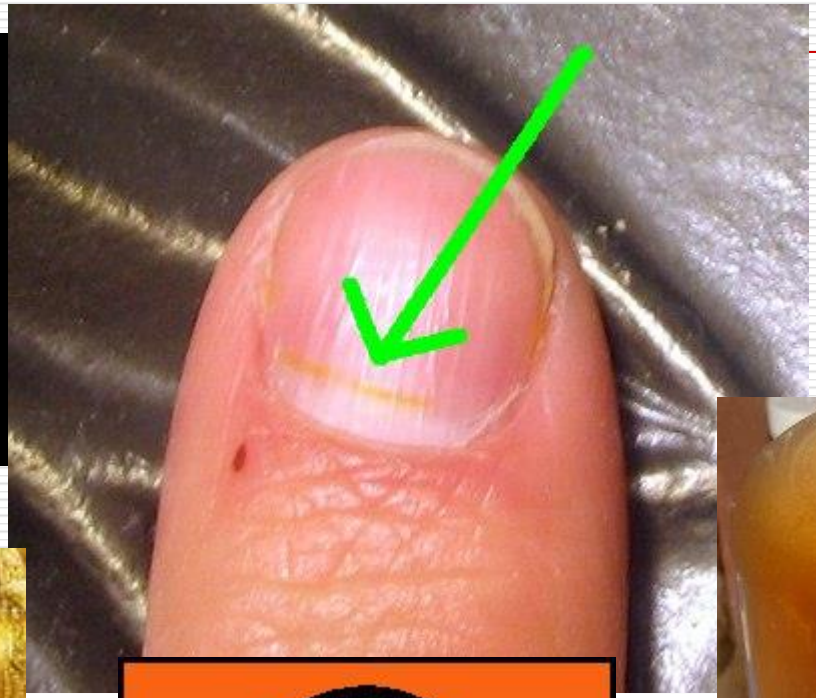
Seven Important Functions of HCl In Stomach

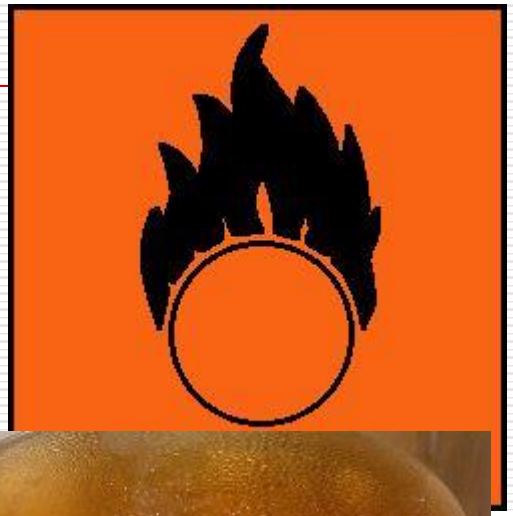



SYMPTOMS ASSOCIATED WITH LOW STOMACH ACID LEVELS
Bloating
Belching
Flatulence (gas)
Indigestion
Diarrhea
Constipation
Chronic Fatigue
Adrenal Fatigue
Auto-Immunity
Rectal Itching
Candida
Hair Loss in Women
Heartburn
Iron/B12 Deficiency
Multiple Food Sensitivities
Acne
Week, Peeling & Cracked Fingernails
Allergies and/or Sensitivities
Dry Skin/Dandruff
DRJOCKERS.COM
SUPERCHARGE YOUR HEALTH

NITRIC ACID-Highly dangerous acid and oxidizing agent!!!
It damages easily the skin very if in contact
It is harmful for the lungs

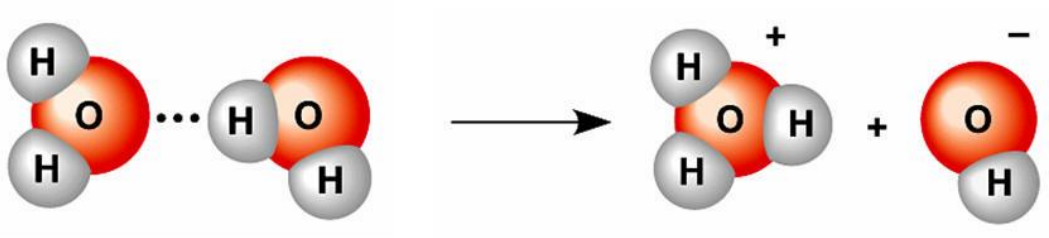






Equilibrium in water and concept of pH

→water is a very weak electrolyte, but it dissociates and gives equal amounts of H+ and OH- ions



$$H_2O + H_2O <=> H_3O^+ + OH^-$$

$$K = \frac{c[H_3O^+]c[OH^-]}{c^2[H_2O]}$$

$$\mathbf{K_w} = K\, c^2[H_2O] = c[H_3O^+] \times c[OH^-] =$$

$$\mathbf{= 1.0 \times 10^{-14}\ mol^2dm^{-6}}$$

So, in PURE WTAER, it holds that $[H_3O^+]=[OH^-]$

...и ако ова се замени во изразот претходен за K_w, добиваме дека

$c[H_3O^+]c[H_3O^+] = K_w = 1.0 \times 10^{-14}\ mol^2dm^{-6}$ or

$c^2[H_3O^+] = 1.0 \times 10^{-14}\ mol^2dm^{-6}$

Or $c[H_3O^+] = 1.0 \times 10^{-7}\ moldm^{-3}$

...if we make "-log()" operation from both sides of last equations, we get

$-\log([H_3O^+]) = -\log(1.0 \times 10^{-7})$

$pH = -\log([H_3O^+]) = 7.00$ →for pure water

REMEMBER

$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}\ mol^2dm^{-6}$

If we make –log from both sides of last equation, we get

$-\log(Kw) = -\log[H_3O^+] - \log [OH^-]$

If we define that: -log(Kw) = pKw; or **pKw =-log(10^{-14}) = 14**

…and if we define

pH = -log[H_3O^+]; while

pOH = –log [OH^-];

Remember that pH + pOH = 14

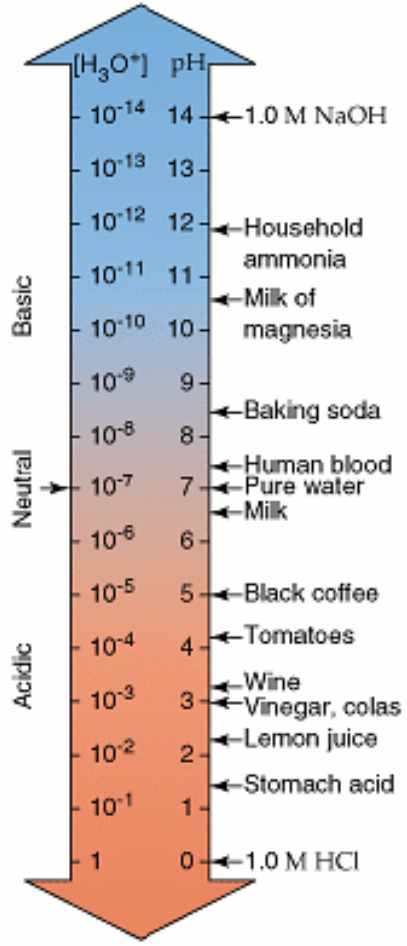
1. if **pH = pOH**, neutral solutions; then, it holds that **c[OH^-] = c[H_3O^+]**

2. If **pH < pOH** then **c[H_3O^+]) > [OH^-] and we have ACIDIC MEDIUM**

3. **If pH > pOH**, then it holds that **c[OH^-] > c[H_3O^+] and we have ALKALINE (basic) medium**

A SCALE of pH of water solutions→
→REMEMBER these expressions for estimating of pH!!!!

pH Scale



$[H^+][OH^-] = 1x10^{-14}$ **pH + pOH = 14**

$pH = -\log[H^+]$

$[H^+] = \text{antilog}(-pH) = 10^{-pH}$

$pOH = -\log[OH^-]$

$[OH^-] = \text{antilog}(-pOH) = 10^{-pOH}$

Acidic solution: $pH < 7$

Neutral solution: $pH = 7$

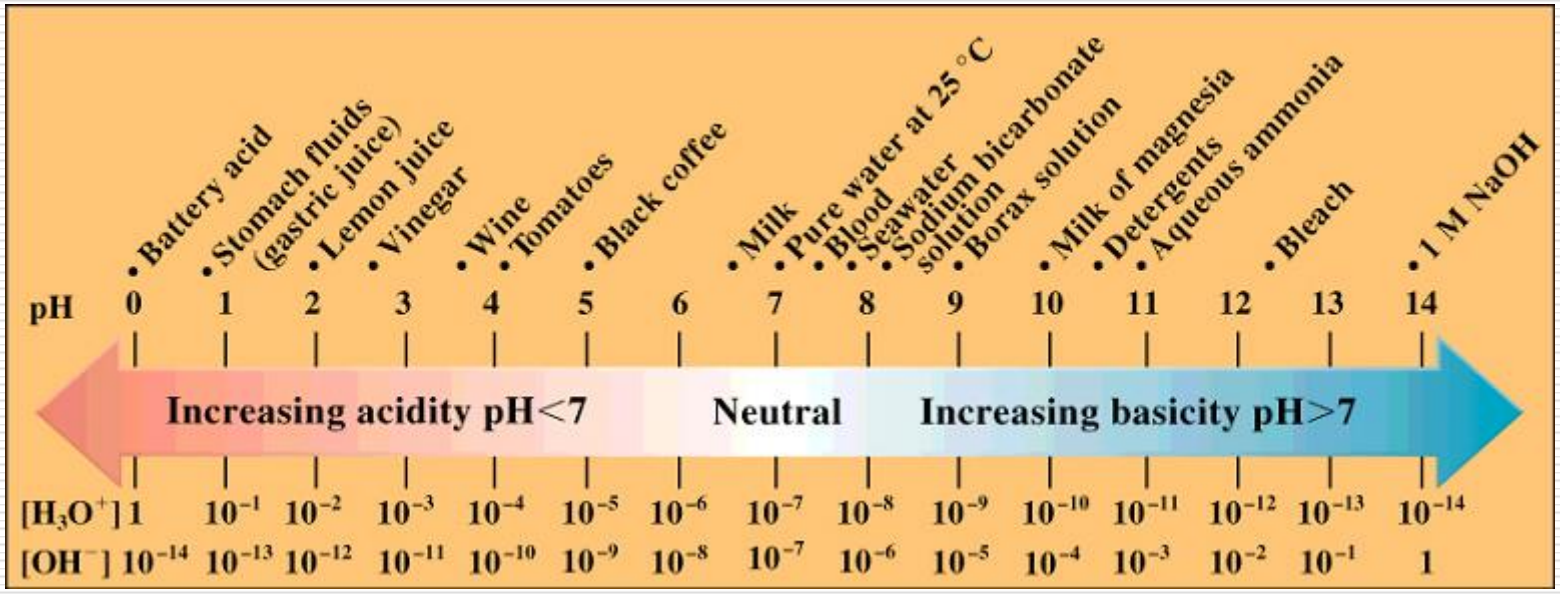
Basic solution: $pH > 7$

„[]" – is a symbol of equilibrium molar concentration„c„

pH + pOH = 14

$[H^{+1}]$	$[OH^{-1}]$	pH	pOH
10^{0}	10^{-14}	0	14
10^{-1}	10^{-13}	1	13
10^{-2}	10^{-12}	2	12
10^{-3}	10^{-11}	3	11
10^{-4}	10^{-10}	4	10
10^{-5}	10^{-9}	5	9
10^{-6}	10^{-8}	6	8
10^{-7}	10^{-7}	7	7
10^{-8}	10^{-6}	8	6
10^{-9}	10^{-5}	9	5
10^{-10}	10^{-4}	10	4
10^{-11}	10^{-3}	11	3
10^{-12}	10^{-2}	12	2
10^{-13}	10^{-1}	13	1
10^{-14}	10^{0}	14	0

pH SCALE!!!!



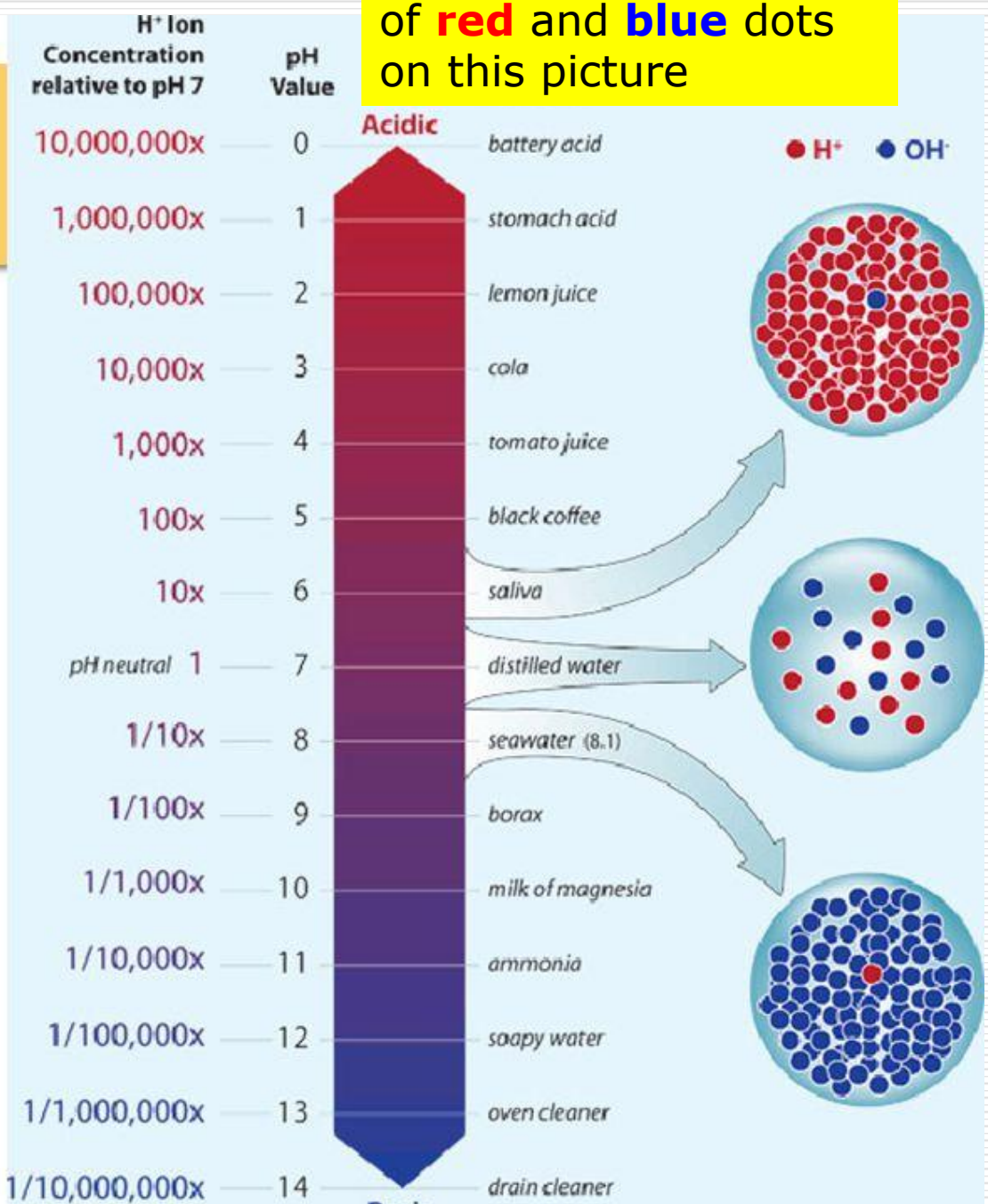
if pH goes from 7 to 1, ACIDITY of solutions is INCREASED;
if pH goes from 7 to 14, ALKALINITY of solutions INCREASES

pH

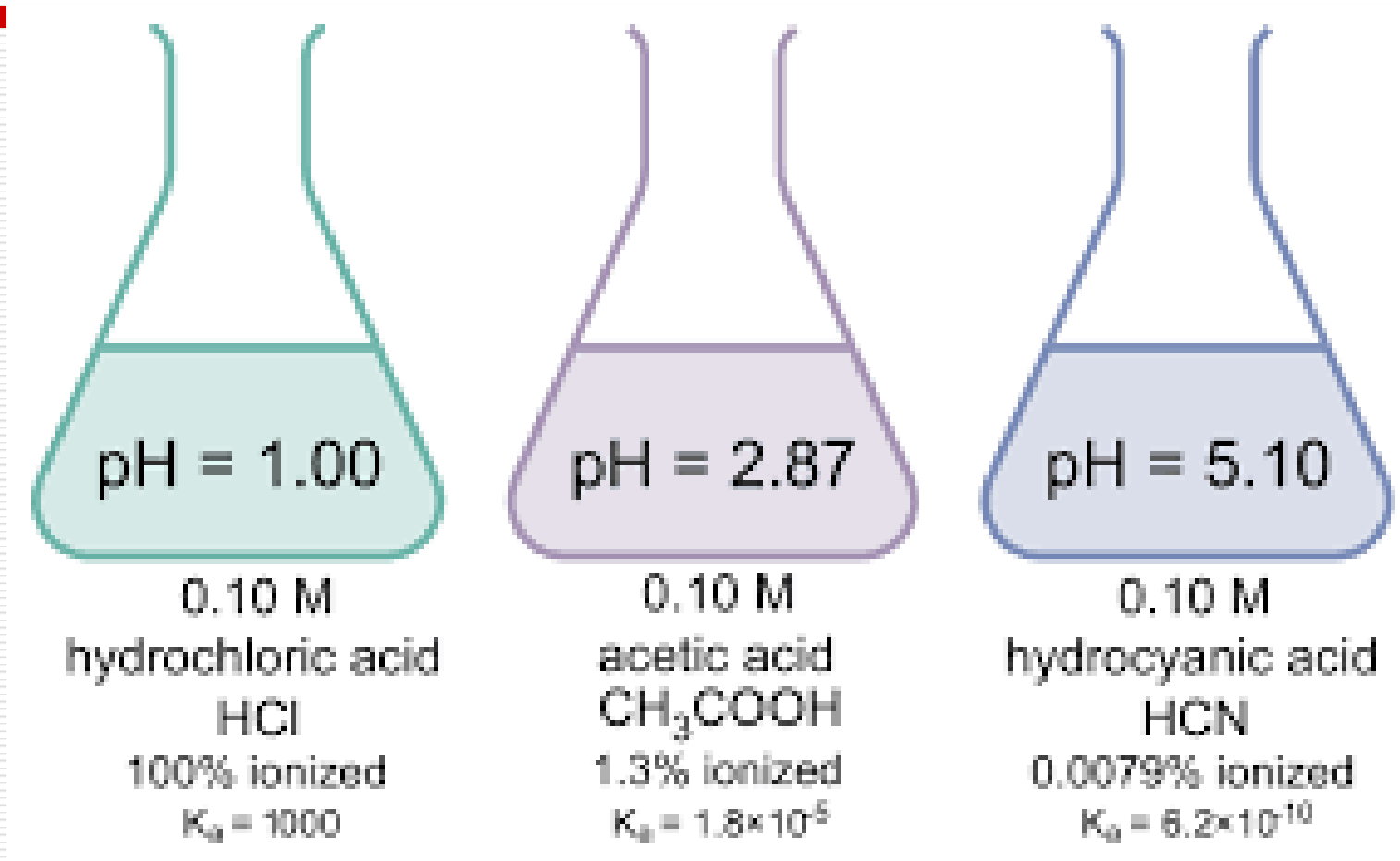
#10. • **pH scale**- measure of H^+ ions (acidity); "**p**ower of **h**ydrogen"

H + = hydronium ion
OH- = hydroxide ion

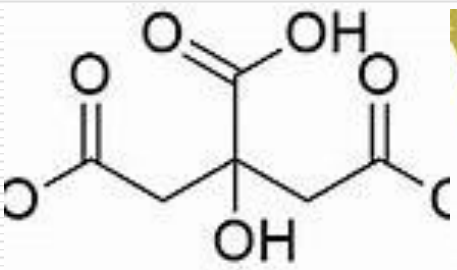
Take a look to the ratio of **red** and **blue** dots on this picture



STRONG vs WEAK ACIDS…
→imagine we have same concentrations of one **strong** (HCl), one weak (CH3COOH) and one very weak (HCN) acids…
All are dissolved in water → take a look in pH of those solutions!!!



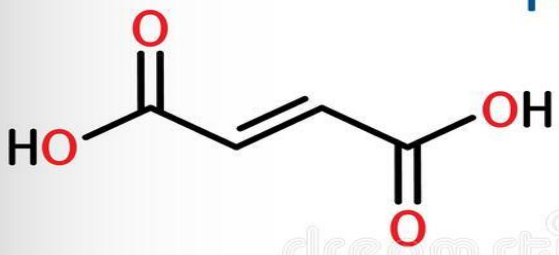
Some important Acids in Medicine

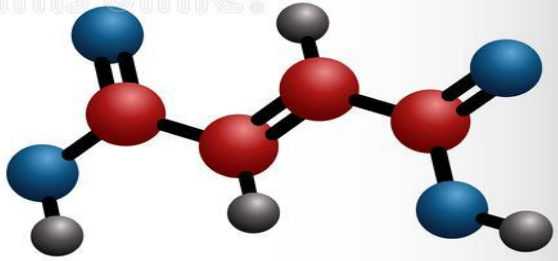


Citric acid

Lemon Juice

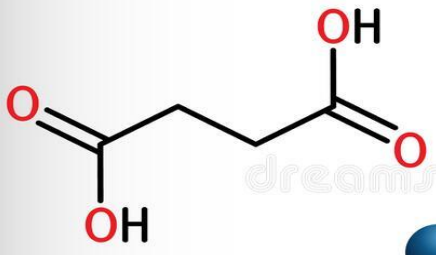
Fumaric acid

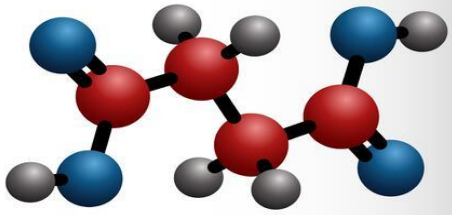




$C_4H_4O_4$

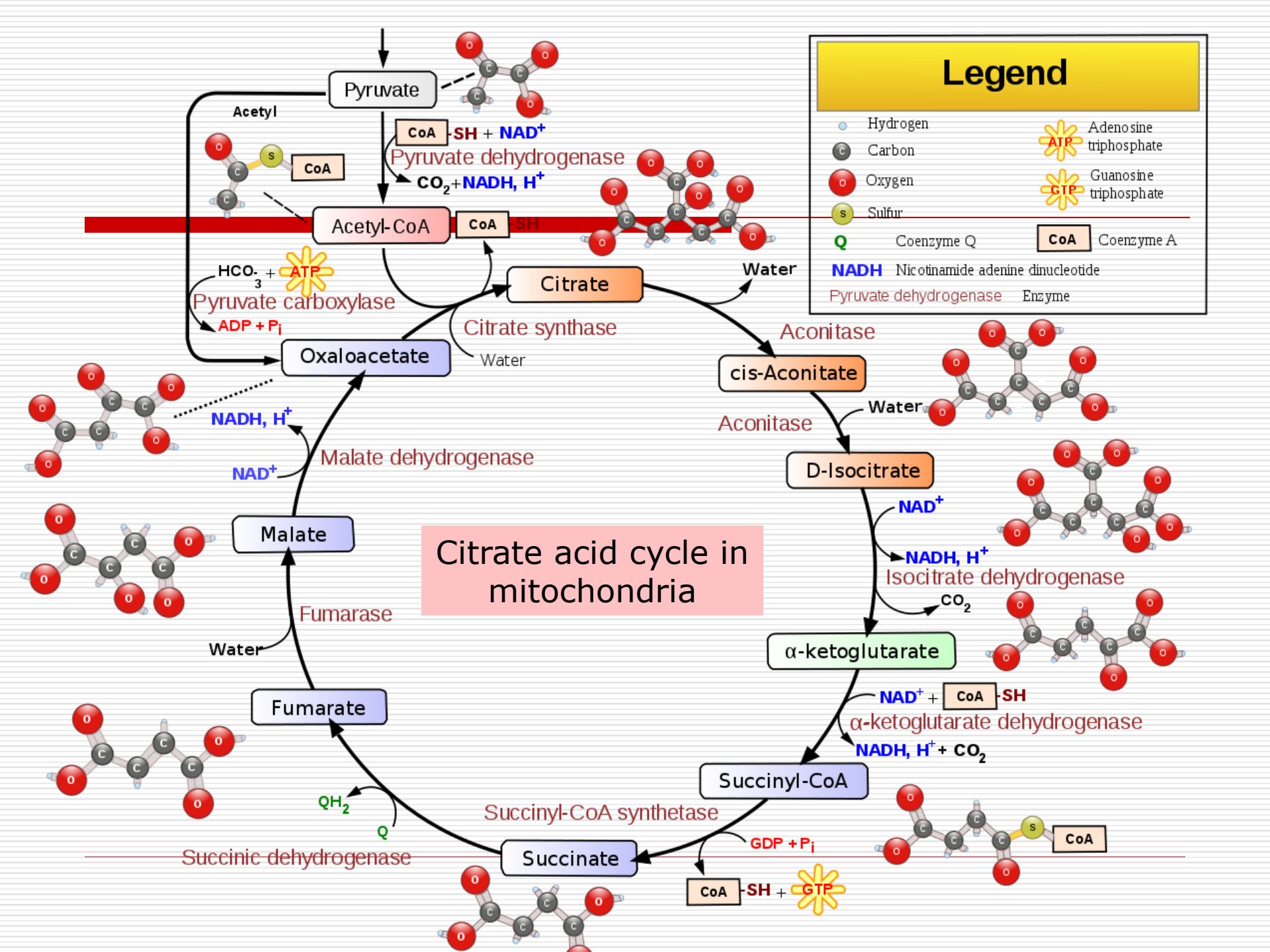
сукцинатна киселина



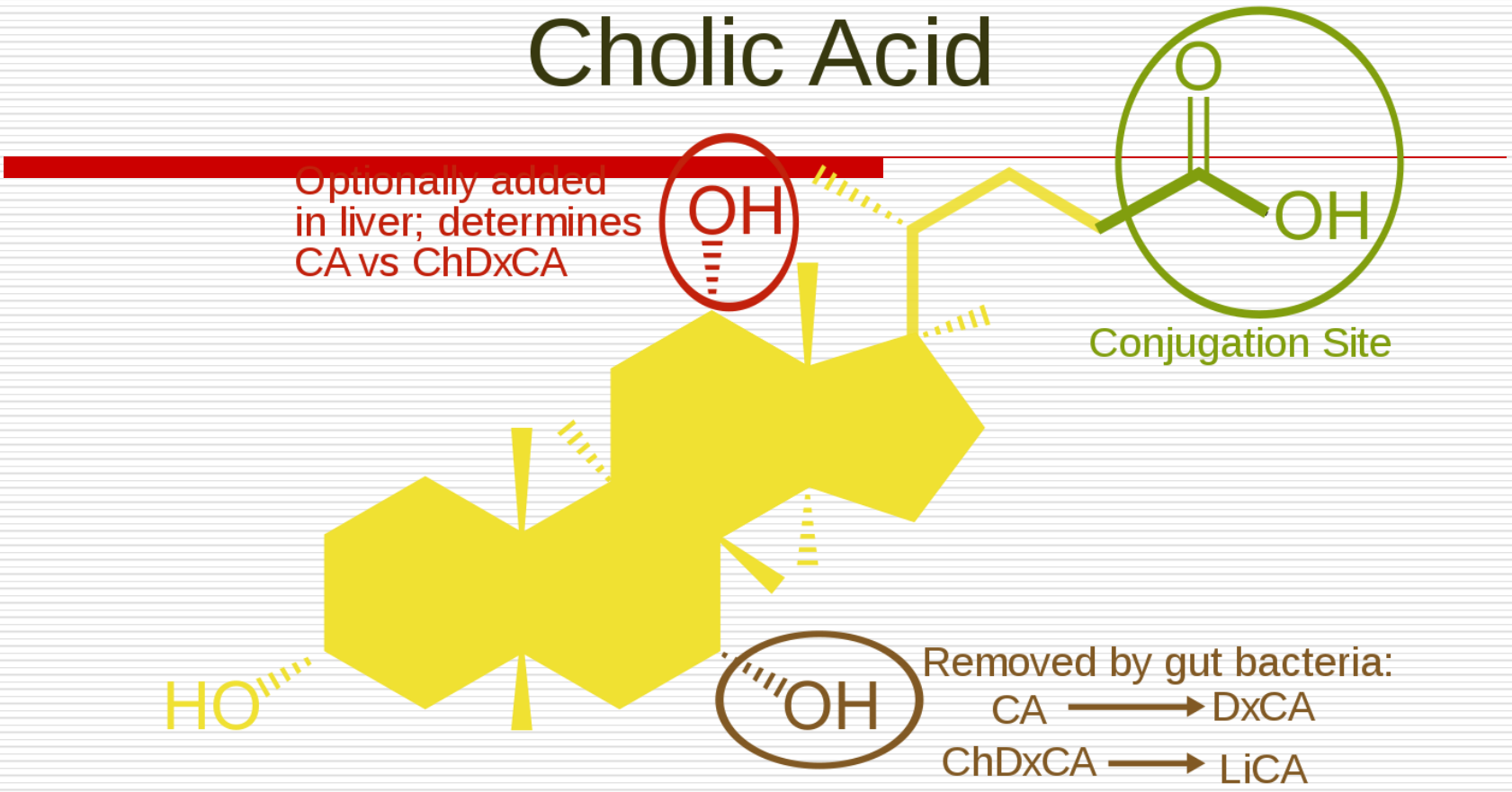


$C_4H_6O_4$

These acids are contribuents in ATP production in the cells

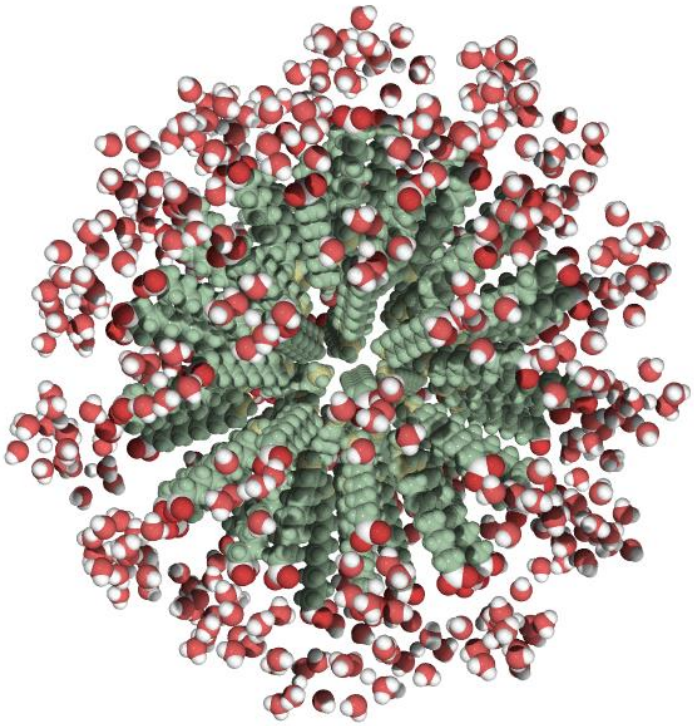

Legend
Hydrogen
Carbon
Oxygen
Sulfur
Coenzyme Q
Nicotinamide adenine dinucleotide
Pyruvate dehydrogenase
Enzyme
Adenosine triphosphate
Guanosine triphosphate
Coenzyme A
Citrate acid cycle in mitochondria
Pyruvate
Acetyl
CoA
Acetyl-CoA
Pyruvate dehydrogenase
Pyruvate carboxylase
Oxaloacetate
Citrate
Citrate synthase
Water
Aconitase
cis-Aconitate
D-Isocitrate
Isocitrate dehydrogenase
α-ketoglutarate
α-ketoglutarate dehydrogenase
Succinyl-CoA
Succinyl-CoA synthetase
Succinate
Succinic dehydrogenase
Fumarate
Fumarase
Malate
Malate dehydrogenase

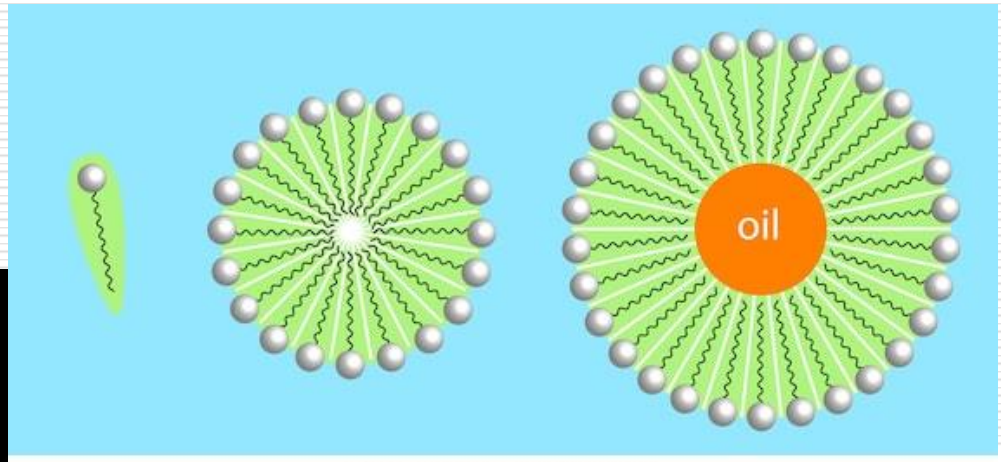
Bile Acids-Cholesterol Derivatives

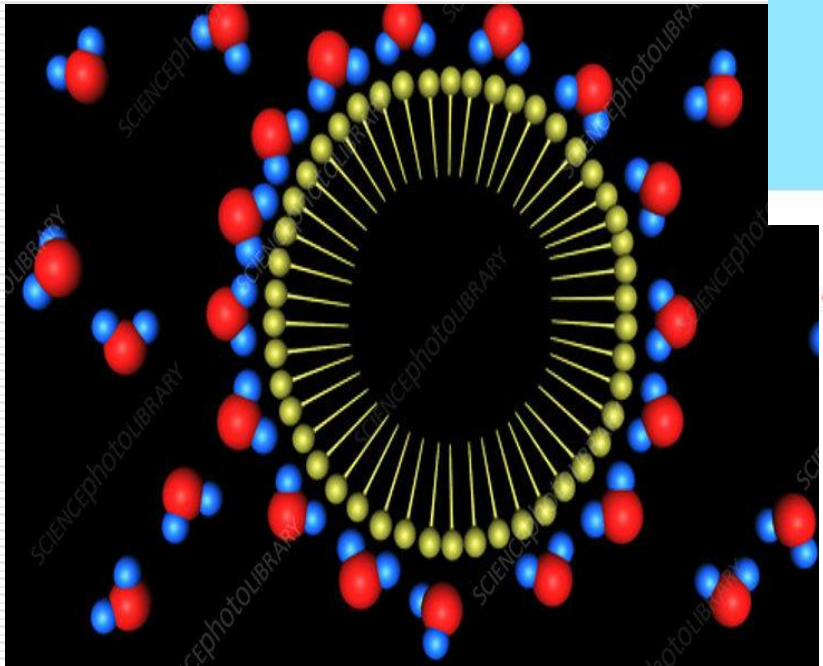


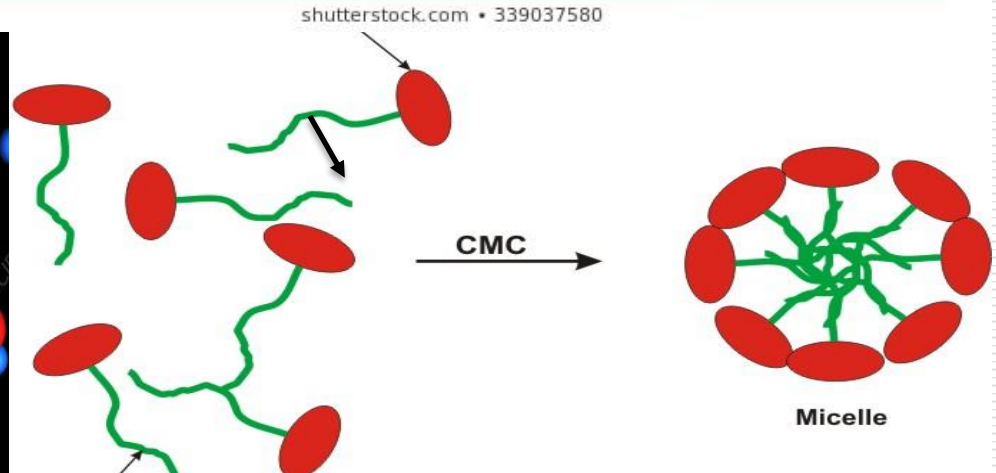
They are synthesized in the LIVER
They help in transferring of lipophilic substances across CELL MEMBRANES via making specific structures so-called MICELLES

Bioavailability of many lipophilic substances
Is restricted and only in form of
micelles they can enter into the cells

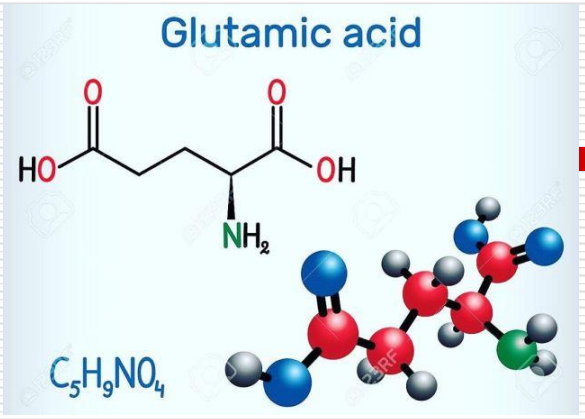


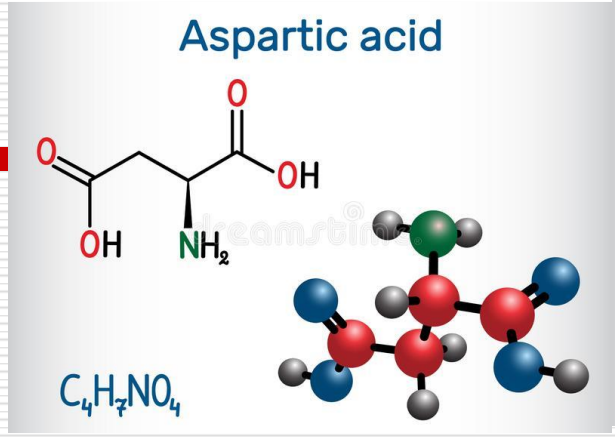


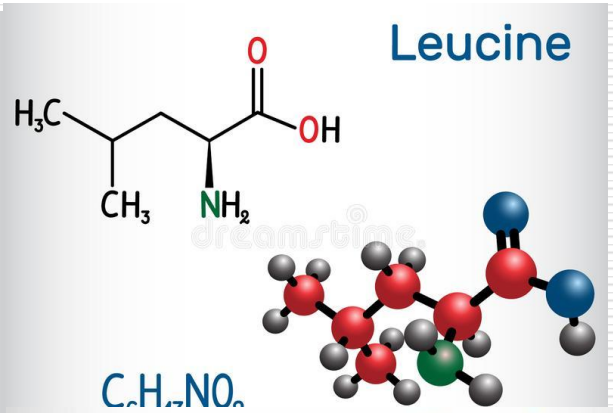


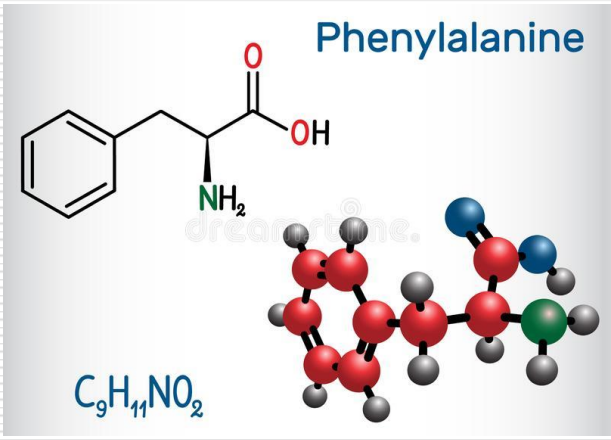


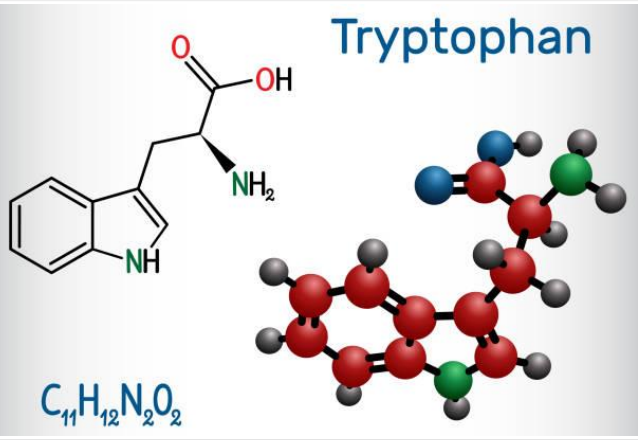
AMINOACIDS-MAJOR CONSTITUENTS of PROTEINS

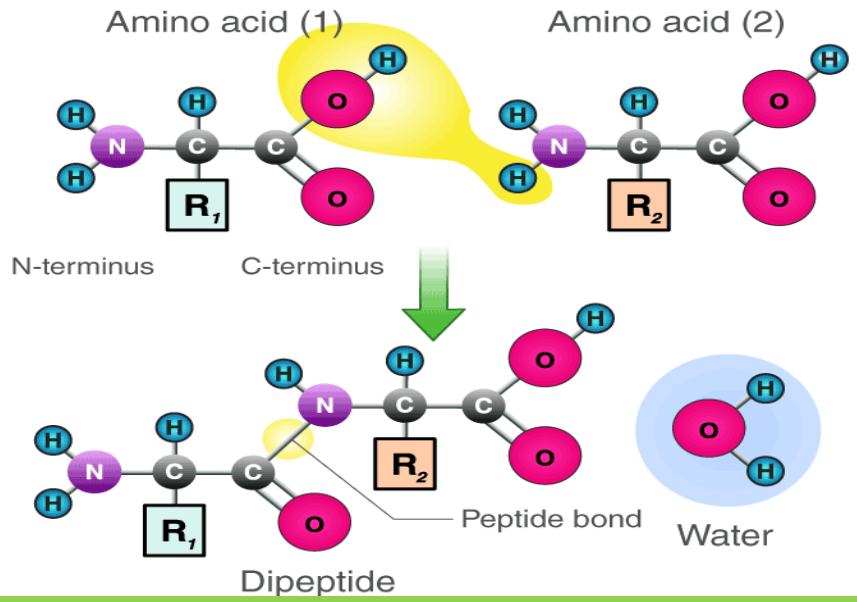


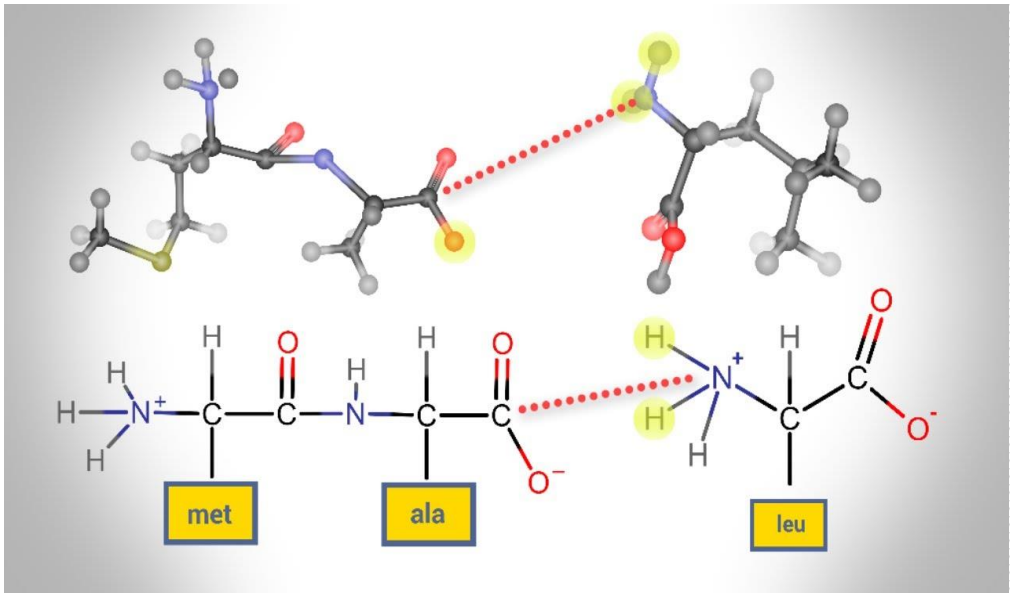




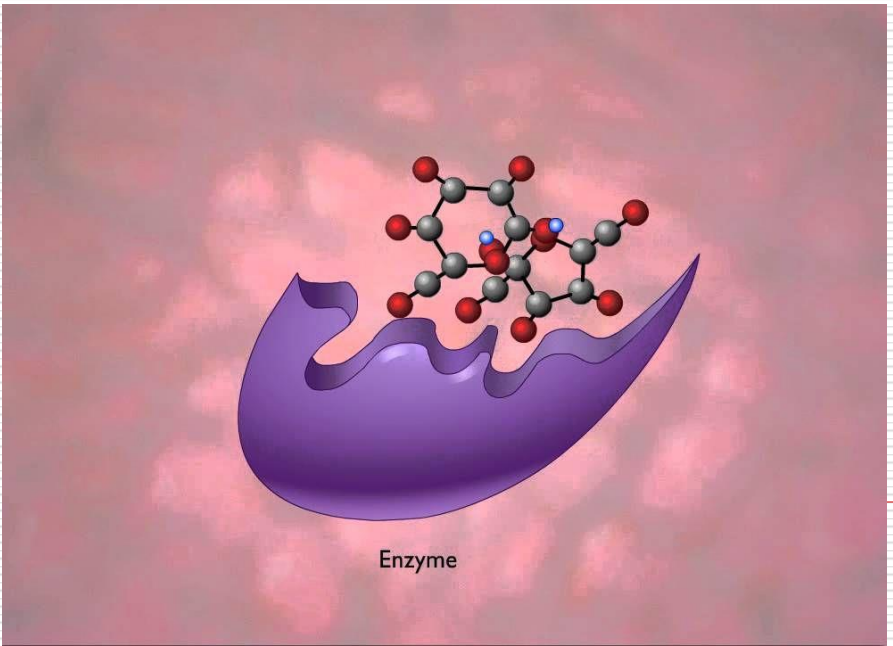


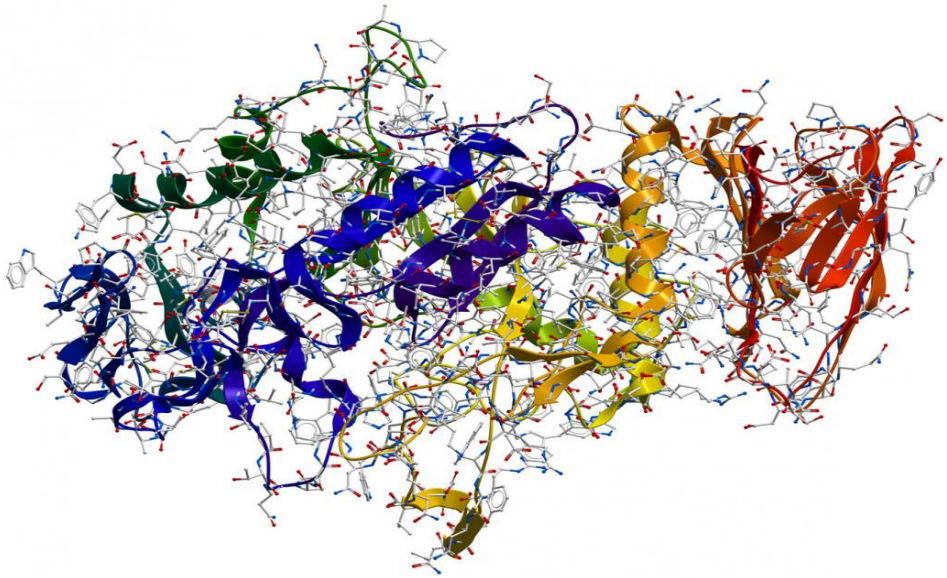




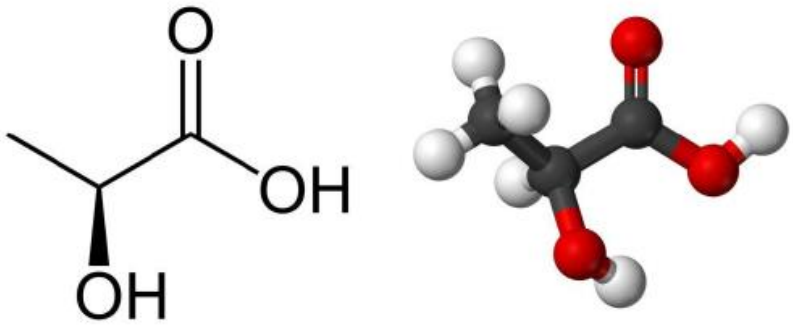


All Enzymes that Catalyze billions of chemical reactions in the cells are made **of AMINOACIDS**





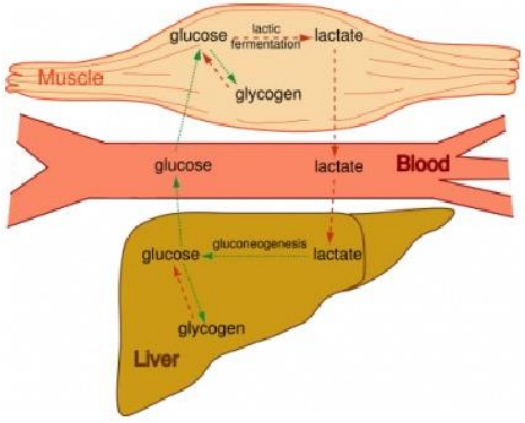
-LACTIC ACID



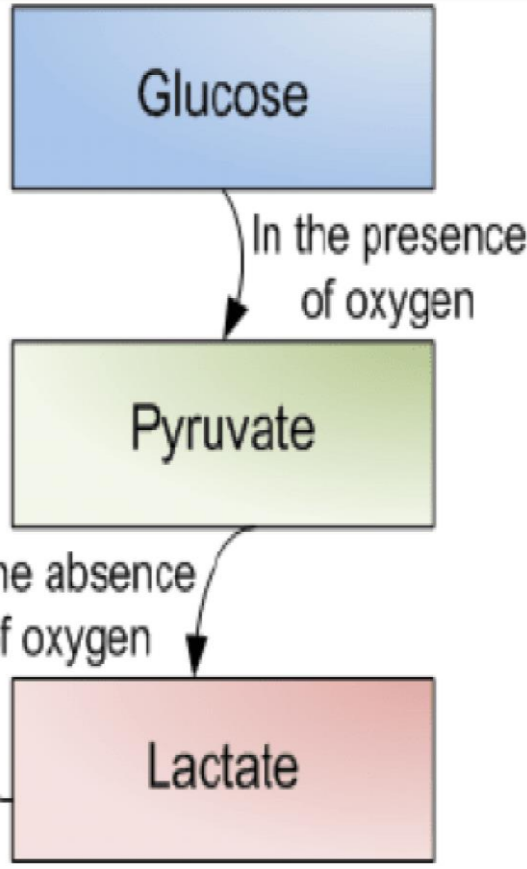
Lactic Acid

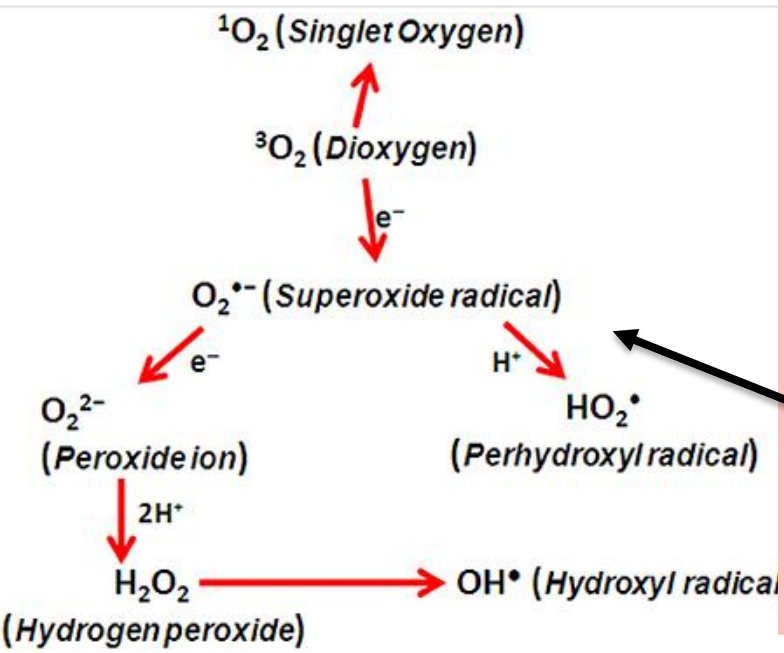
Lactic Acid Fermentation

- Lactic acid build up in muscle is what causes muscle ache / pain
- Carried to liver where it can be converted back to pyruvate

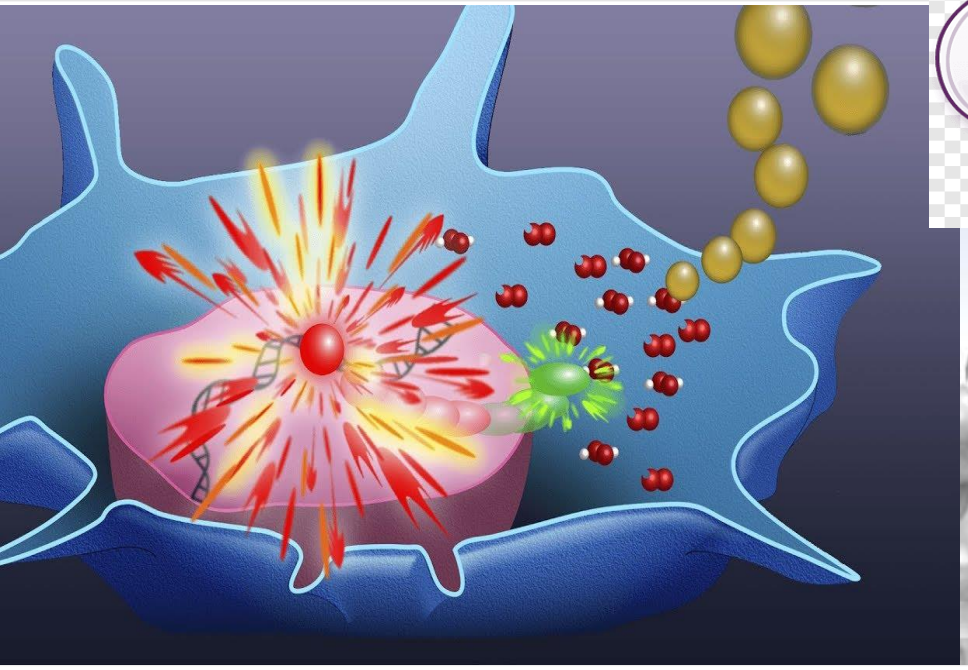


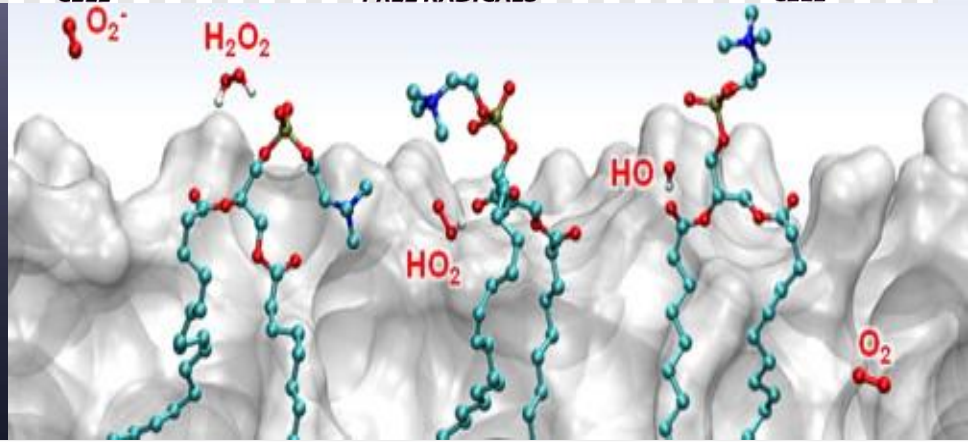
Continuous production of Lactate accumulate lactic acid in muscles

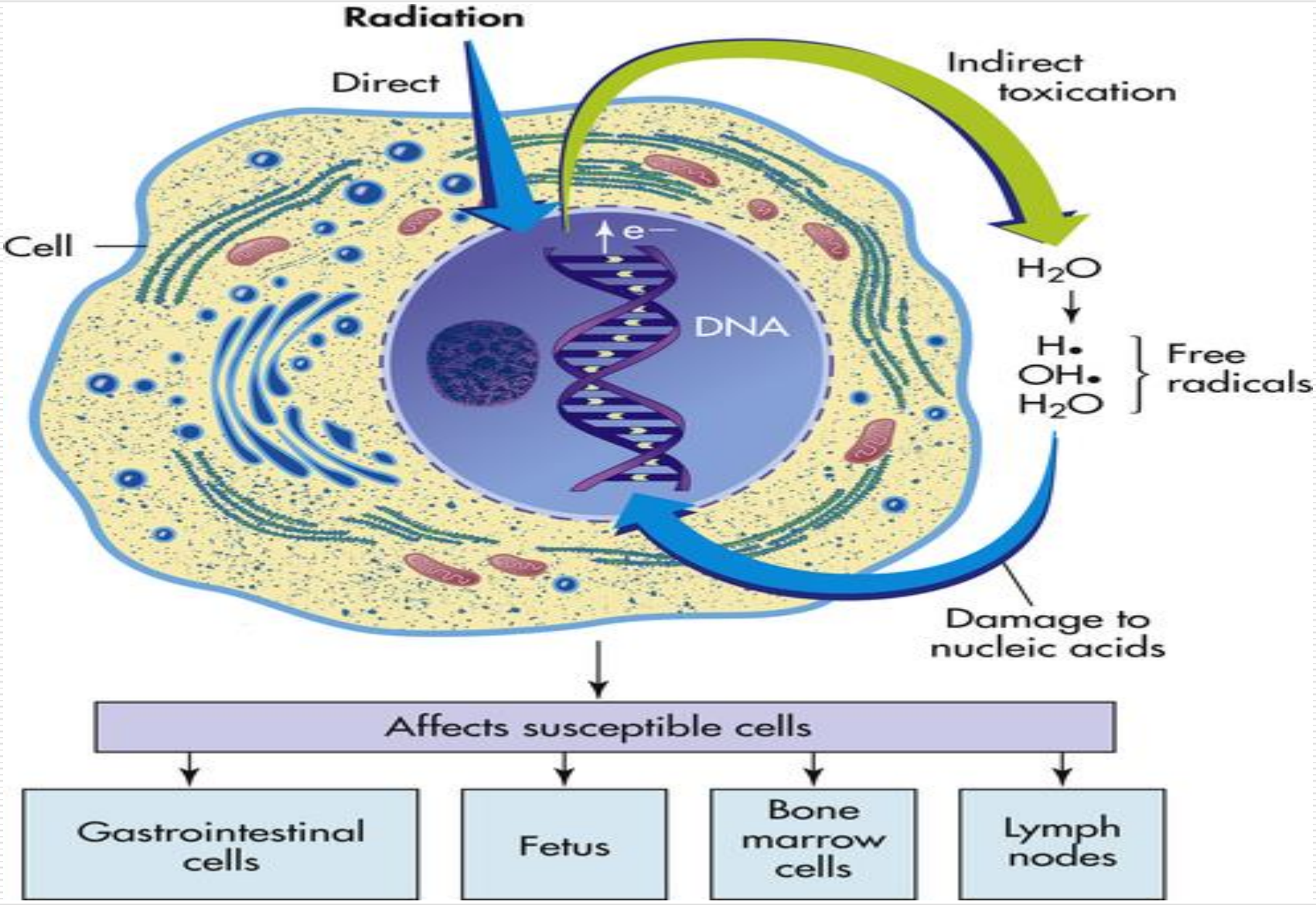




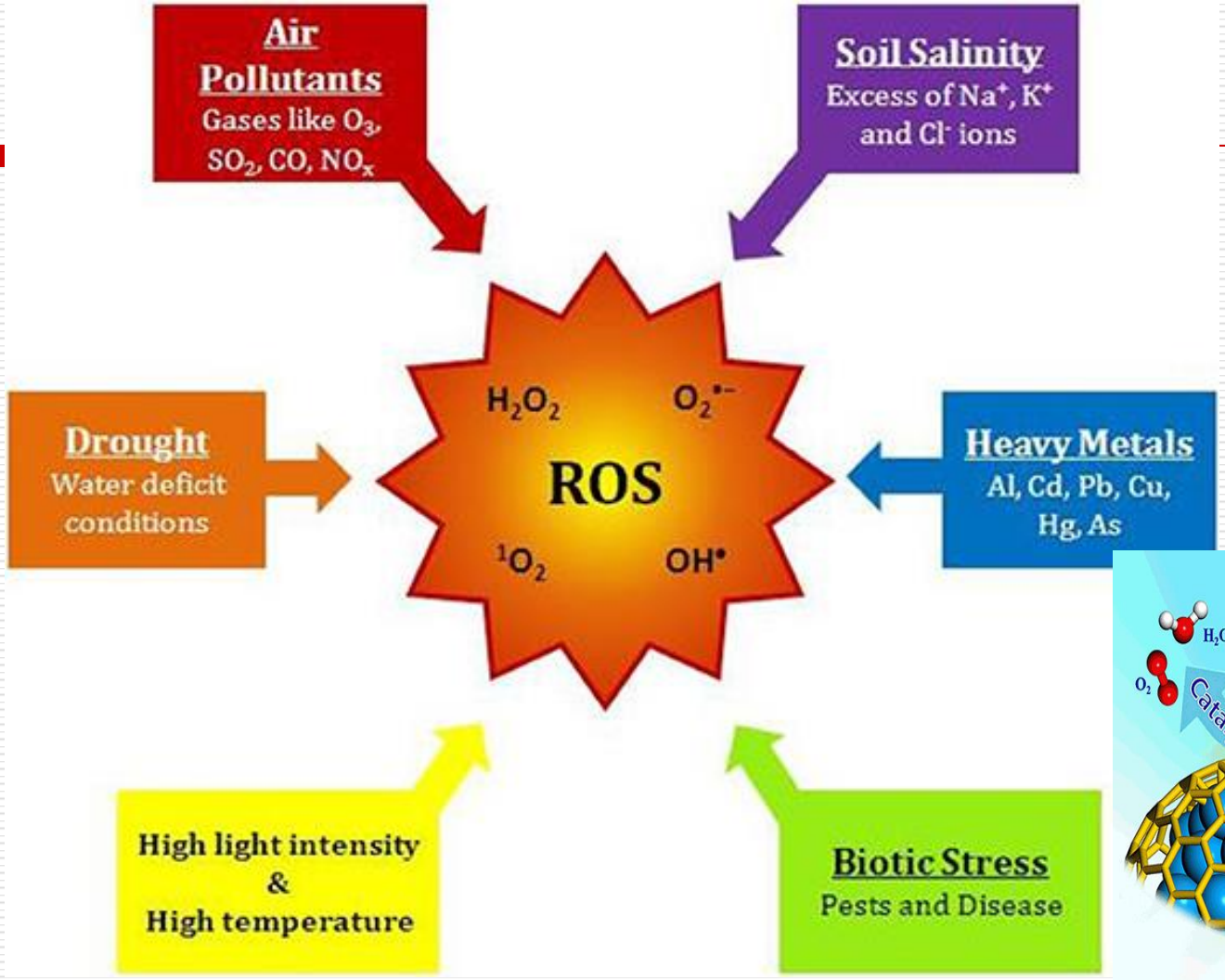
Oxygen means LIFE, but
Molecular Oxygen O2 is major sources of
Producing HIGHLY REACTIVE
REACTIVE OXYGEN SPECIES ROS'es or
FREE RADICALS
→**ROS'es are hydroxide radical, superoxid**
Radical, hydrogen peroxide
→all these Reactive Oxygen Species
Attack cell membranes and produce so-called
LIPID PEROXIDATION i.e. destruction of
Cell MEMBRANES

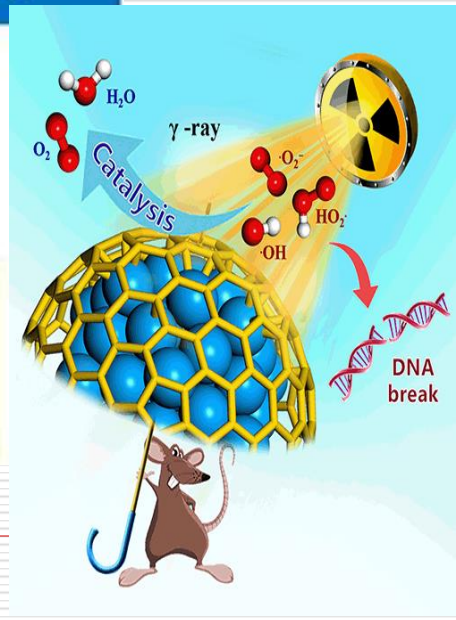




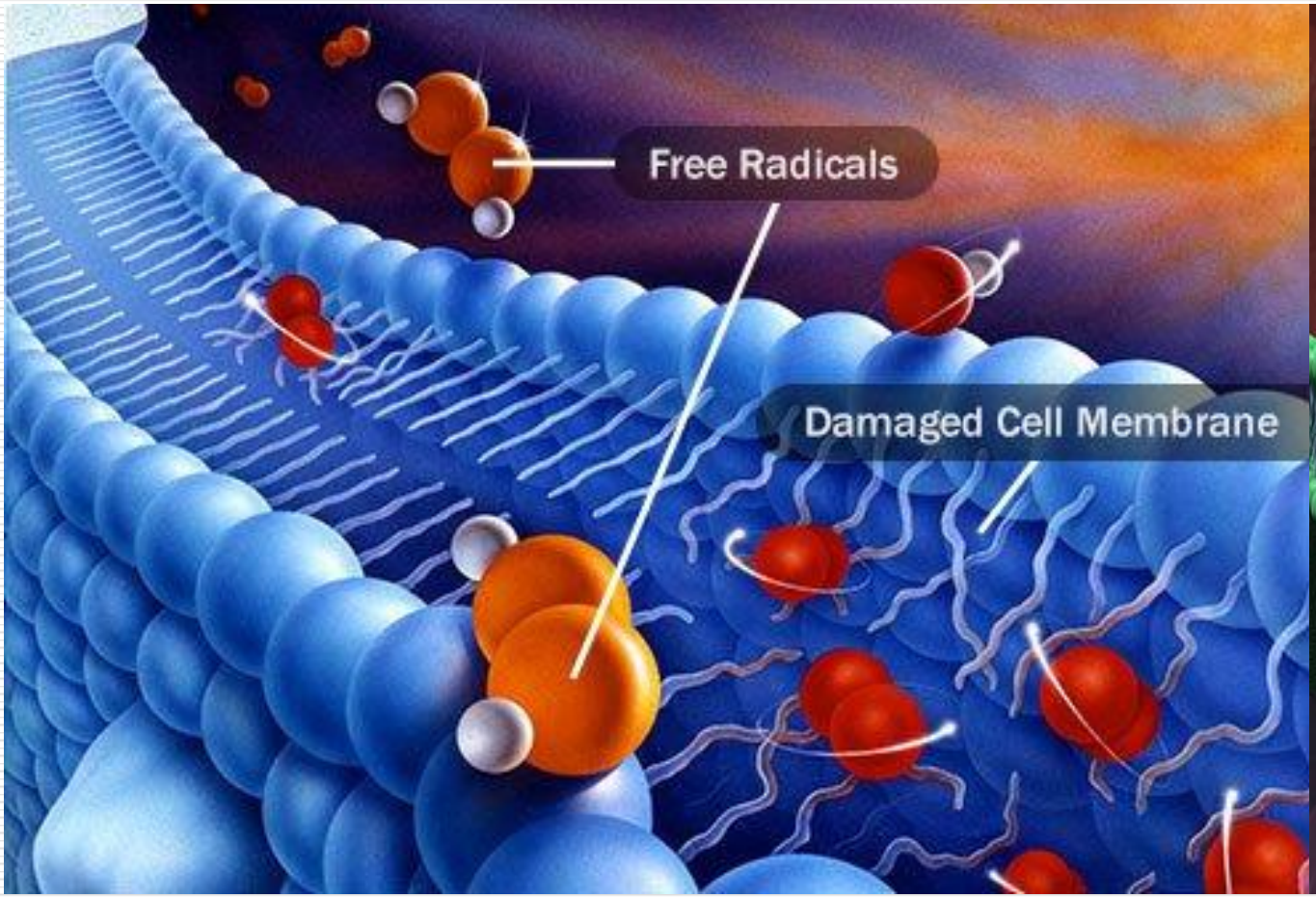

Radiation
Direct
Indirect toxication
Cell
e⁻
DNA
H_2O
H•
OH•
H_2O
Free radicals
Damage to nucleic acids
Affects susceptible cells
Gastrointestinal cells
Fetus
Bone marrow cells
Lymph nodes

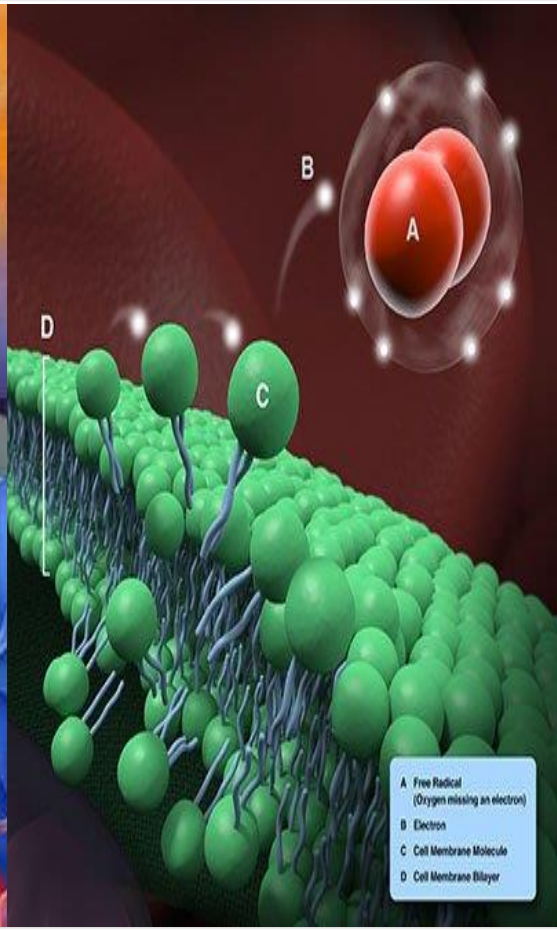
Which processes produce Reactive Oxygen Species in Our Body?



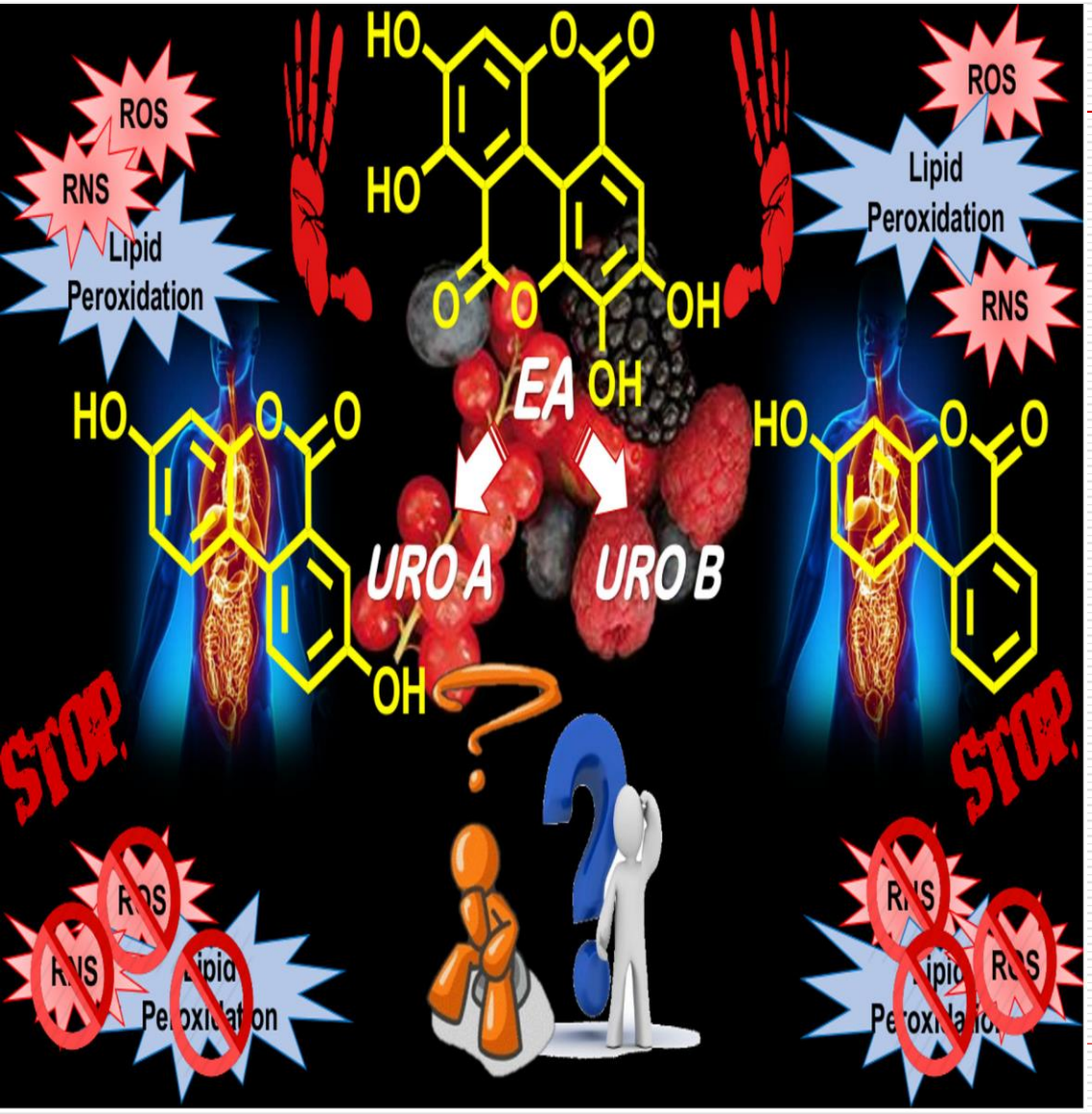


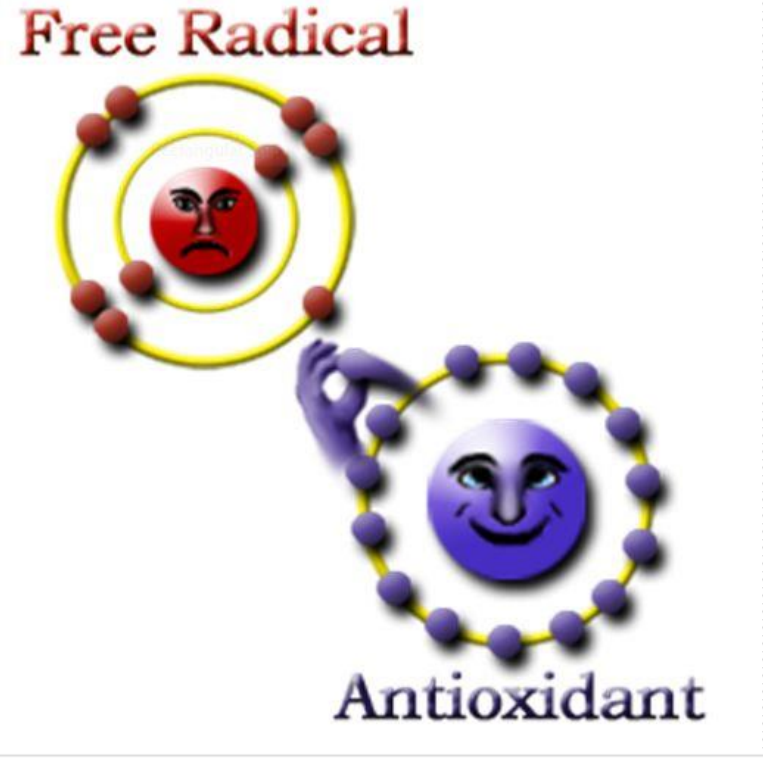
Scheme of how ROSes Damage the Cell Membrane….



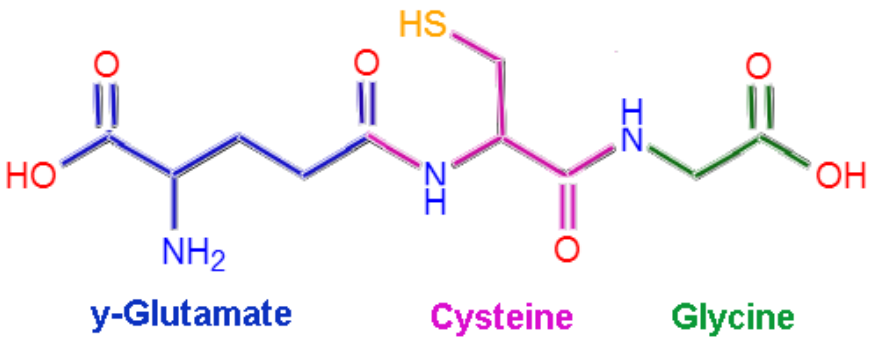


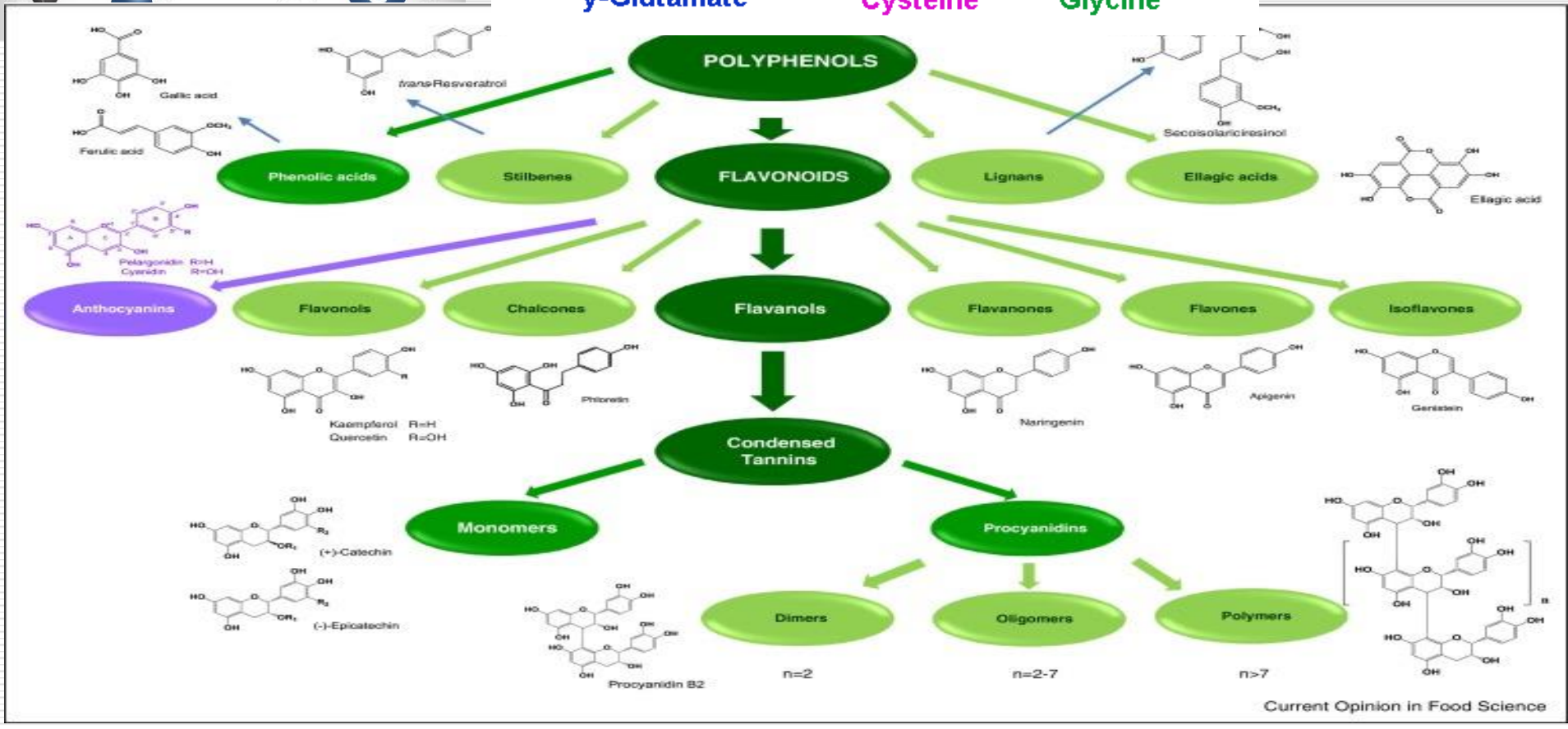
Antioxidants—mainly weak acids such as Vitamin C, Polyphenols, Glutathione…are major DEFENDERS agains Reactive Oxygen Species



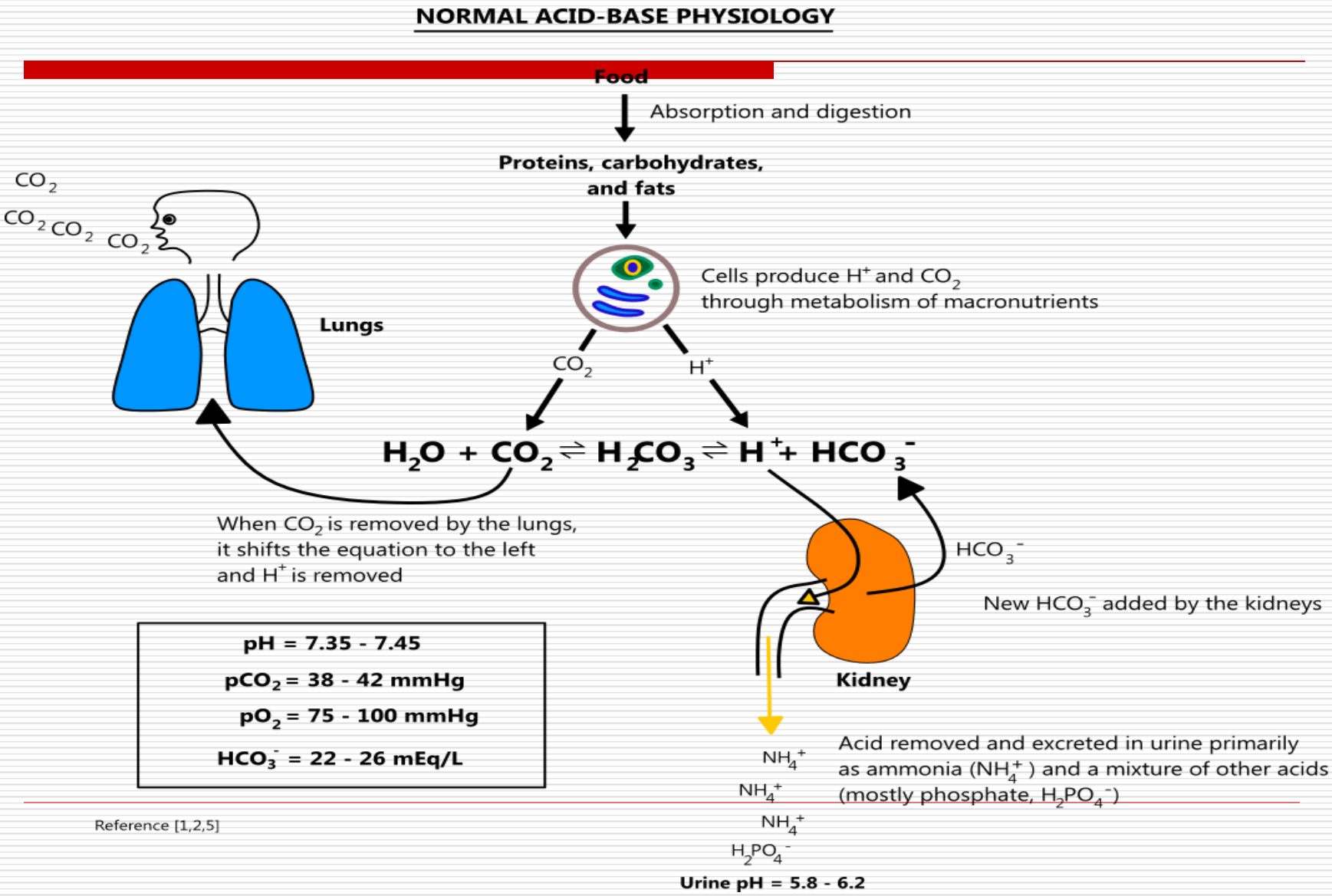


Vitamin A;
Vitamin C, glutathione, Polyphenols
Major defenders against ROS→present in fruits

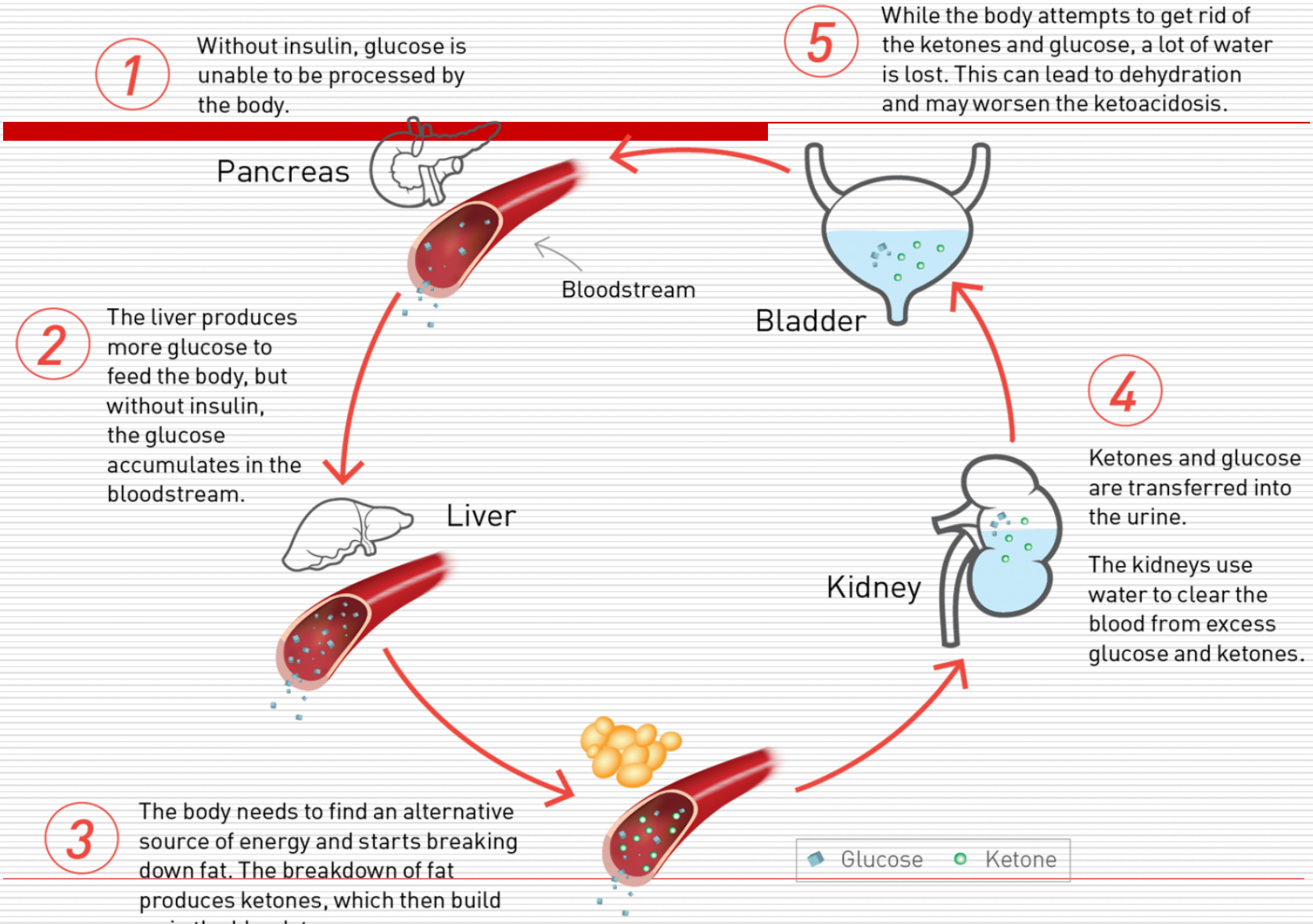


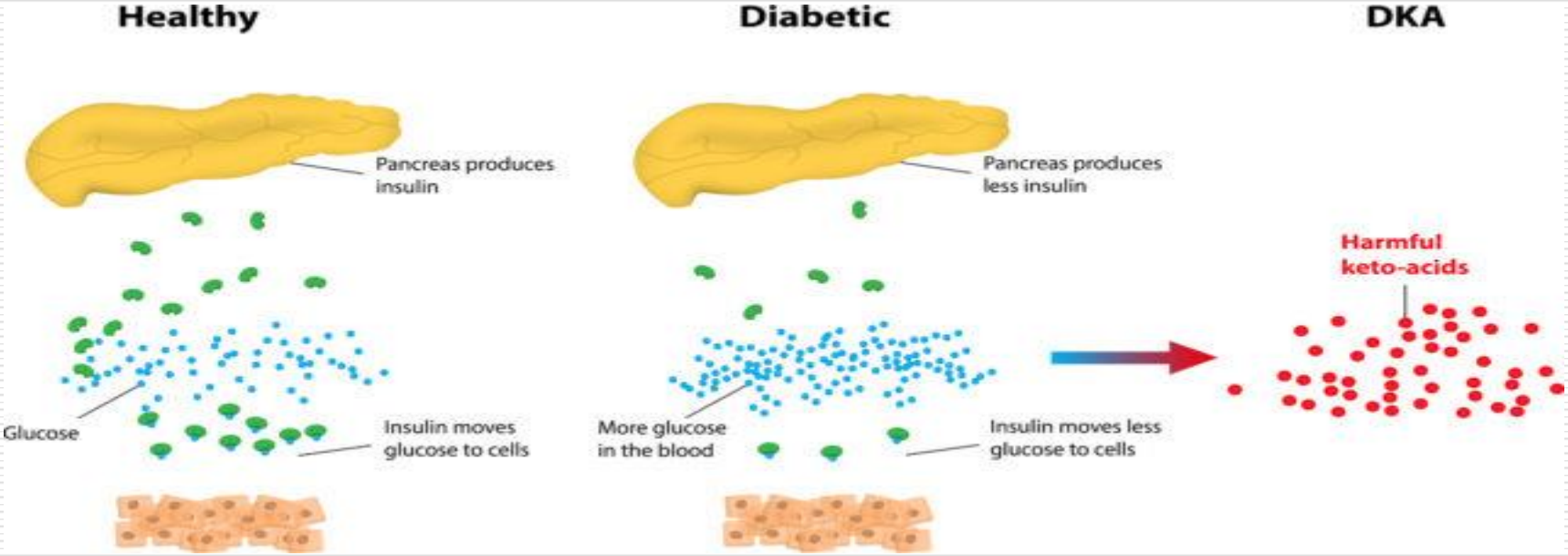


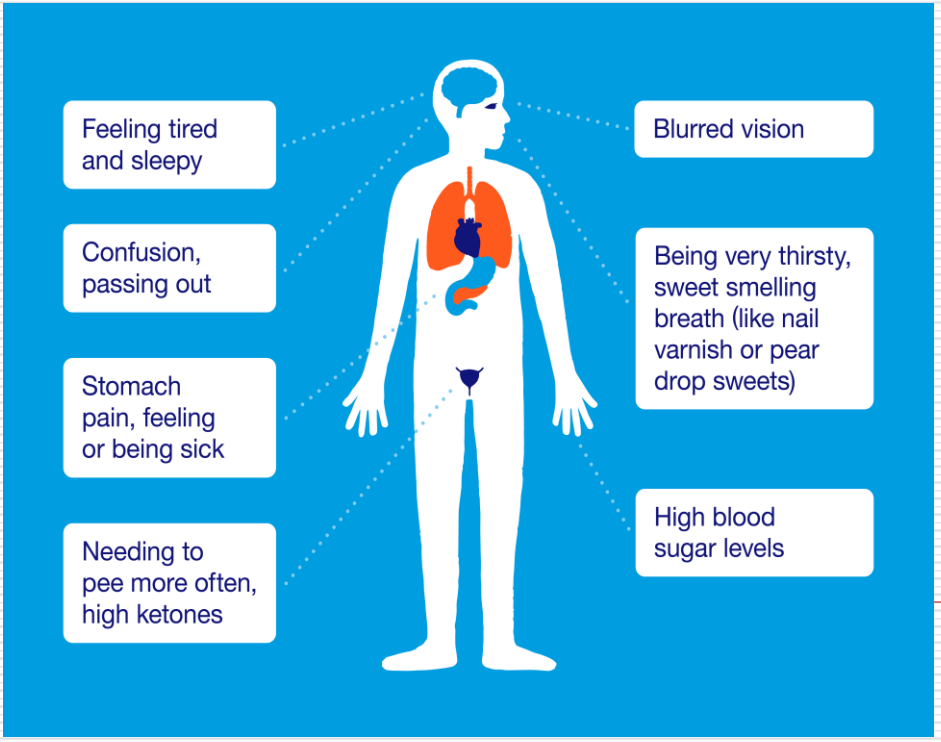
Carbonic acid H_2CO_3 (i.e. **HCO_3^-** ions or hydrogencarbonates)
Are very important for keeping pH constant in the blood
They are constitutents of so-called "carbonate buffer" in the blood

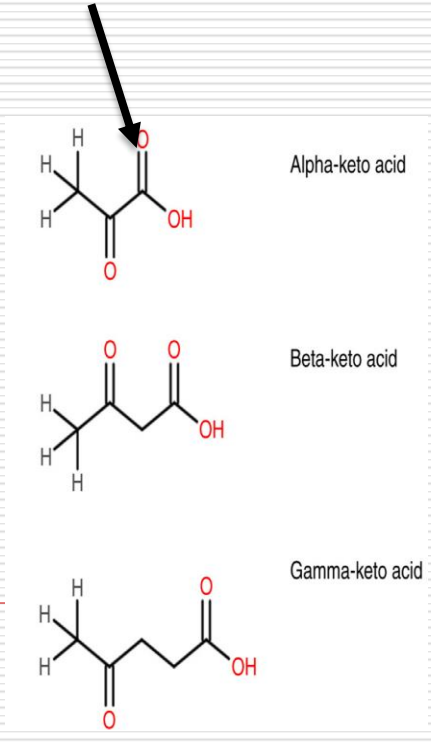


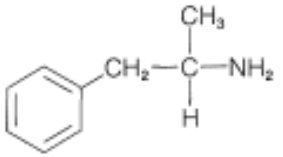
KETO-ACIDS—important systems that always emerge In PATIENT HAVING diabetes → excess of glucose in blood



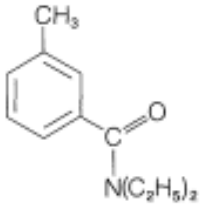

Healthy
Pancreas produces insulin
Glucose
Insulin moves glucose to cells
Diabetic
Pancreas produces less insulin
More glucose in the blood
Insulin moves less glucose to cells
DKA
Harmful keto-acids


Feeling tired and sleepy
Confusion, passing out
Stomach pain, feeling or being sick
Needing to pee more often, high ketones
Blurred vision
Being very thirsty, sweet smelling breath (like nail varnish or pear drop sweets)
High blood sugar levels

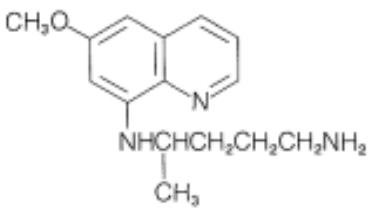

Alpha-keto acid
Beta-keto acid
Gamma-keto acid



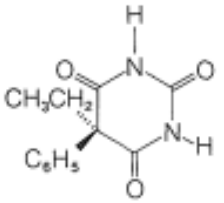
amphetamine
(stimulant, decongestant)
(Benzedrine)



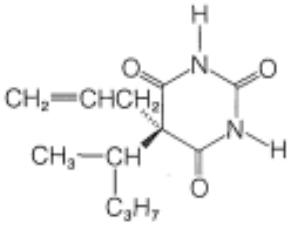
N,N-diethyl-
meta-toluamide
(mosquito repellant)



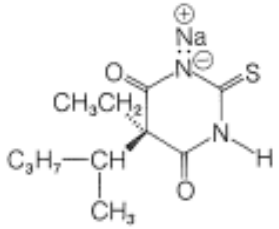
primaquine
(antimalarial)



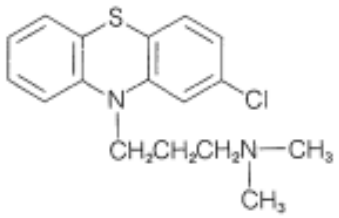
phenobarbital
(sedative, anticonvulsant)



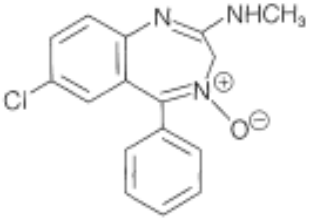
secobarbital
(seconal, soporific)



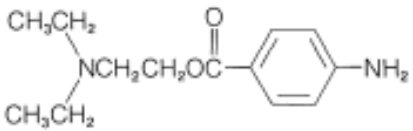
sodium pentothal
(anaesthetic)



chlorpromazine
(tranquilizer)

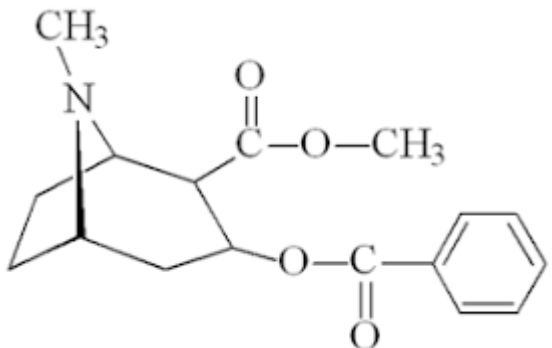


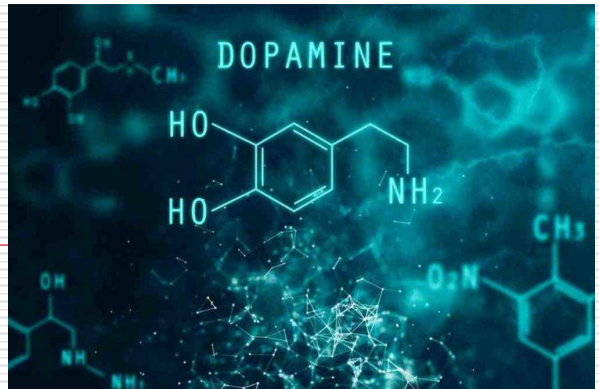
chlordiazepoxide
(tranquilizer)
(Librium)



procaine
(local anaesthetic)
(Novocaine)

Weak Bases
Amines R-NH_2
… Present in
Structure of
AMINO ACIDS…but
Many as adrenaline,
Dopamine
Drugs such as
morphine, codeine…are
Weak bases





…many drugs used in medical therapies are weak acids or bases
Here are some of those substances…

Table 2.5 pKa Values for Selected Drugs

Weak Acids	pKa	Weak Bases	pKb
Amoxicillin	2.4	Alprenolol	9.6
Acetazolamide	7.2	Allopurinol	9.4, 12.3
Ampicillin	2.5	Amphetamine	9.8
Aspirin	3.5	Atropine	9.7
Chlorothiazide	6.8, 9.4*	Chlorpheniramine	9.2
Ciprofloxacin	6.1, 8.7*	Cocaine	8.5
Cephalexin	3.6	Codeine	8.2
Ethacrynic acid	2.5	Diazepam	3.0
Furosemide	3.9	Diphenhydramine	8.8
Ibuprofen	4.4, 5.2*	Amoxicillin	7.4
Levodopa	2.3	Ephedrine	9.6
Methotrexate	4.8	Epinephrine	8.7
Methyldopa	2.2, 9.2*	Imipramine	9.5
Penicillamine	1.8	Lidocaine	7.9
Pentobarbital	8.1	Methadone	8.4
Phenobarbital	7.4	Methamphetamine	10.0
Phenytoin	8.3	Methyldopa	10.6
Propylthiouracil	8.3	Metoprolol	9.8
Salicylic acid	3.0	Morphine	7.9
Sulfadiazine	6.5	Nicotine	7.9, 3.1*
Sulfapyridine	8.4	Norepinephrine	8.6
Theophylline	8.8	Phenylephrine	9.8
Tolbutamide	5.3	Pilocarpine	6.9, 1.4*
Warfarin	5.0	Pseudoephedrine	9.8

* denotes more than one ionizable group

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5. R Gulaboski, V Mirčeski, S Mitrev, ***Food Chemistry*** 138 (2013) 116-121
6. P. Kokoskarova, R. Gulaboski, ***Electroanalysis*** 32 (2020) 333-344.
7. R. Gulaboski, K. Caban, Z. Stojek. F. Scholz, ***Electrochemistry Communications*** 6 (2004) 215-218