TOPIC: *STRUCTURE AND PROPERTIES OF MONOSACCHARIDE*

INTRODUCTION

- Carbohydrates include a large group of compounds commonly known as starches or sugars, widely distributed in plants & animals.
- Chemically, they are described as polyhydric alcohols, having potentially active aldehyde & ketone groups.
- In general, carbohydrates are white solids, freely soluble in water with the exception of certain polysaccharides.
- Carbohydrates of lower molecular weight have a sweet taste.

FUNCTION

- Carbohydrates in the body is that of a fuel. When carbohydrates are oxidized in the body they liberate carbon dioxide, water with and energy.
- They supply the major portion of energy required by living cells.
- Certain products of carbohydrate metabolism, as will be seen later, act as catalysts to promote oxidation of foodstuffs.
- Certain carbohydrates can be used as the starting material for the biological synthesis of compounds such as fatty acids and amino acids.

OCCURANCE

- Carbohydrates are widely distributed in natural in plants and animals. The most important carbohydrate found in plants is starch.
- It occurs abundantly in the roots, tubers, leaves, vegetables and grains. The carbohydrate found in animals is glycogen.
- It forms the storage form of carbohydrate in animals and is found abundantly in the liver and muscles.
- Both starch and glycogen are polysaccharides having high molecular weight – carbohydrates having lower molecular weight are also found in nature.
- They come under the groups of monosaccharides and oligosaccharides which are white crystalline substances, sweet to taste.
- They are generally known as sugars and are consumed with food.

MONOSACCHARIDE

- monosaccharides are nothing but the simplest form or classification of carbohydrates. They are hence known as the most basic unit of carbohydrates.
- They are defined as any carbohydrates (or sugars) that cannot be hydrolysed any further to give simpler sugars.

STRUCTURE

- The chemical formula that most monosaccharides have is Cx (H2O) y, where generally x≥ 3. The molecule is always formed by three elements and three elements only: Carbon (C), Hydrogen (H) and Oxygen (O).
- The molecule of monosaccharides is very small and compact in size. This is another reason we call monosaccharides simple sugars.

DIOSE

- The simplest compound to be classed as a carbohydrate is the diose, glycolaldehyde(CH2OH.CHO).
- it is classified as diose, because it contains two carbon atoms.
- It contains an aldehyde group and therefore it is referred as aldose. Thus, glycolaldehyde is an aldodiose.
- It differs from the higher aldoses in that it is not polyhydroxylic and for this reason, some authors do not include this compound among the true carbohydrate.

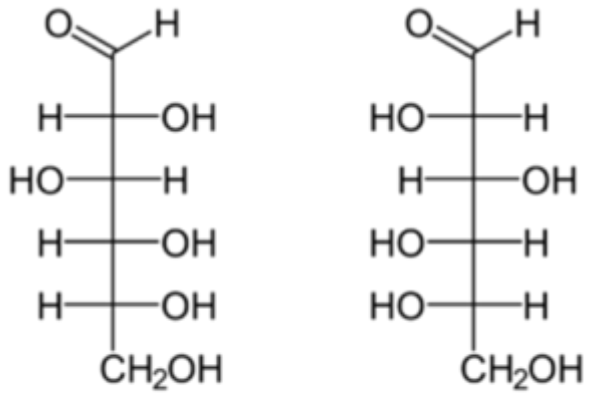
TRIOSE

- A triose contain 3 carbon, and ketotriose contains a ketone functional group.
- A ketotriose has no chiral center and one stereoisomers.
- An example of ketotriose is Dihydroxyacetone. Dihydroxyacetone has many uses, and it is non-toxic.
- Many creams had Dihydroxyacetone as an active ingredient.
- Dihydroxyacetone is also known as DHA.
- It is also use for sun tanning.

TETROSE

- Erythrulose A Tetrose is a monosaccharide that contains 4 carbon atoms.
- A Keto-tetrose is a tetrose that has a ketone functional group attached to Carbon 2 of the straight chain.
- A ketotetrose has 2 stereoisomers because it has one chiral center.
- An example of a ketotetrose is Erythrulose. Erythrulose has the chemical formula of C4H8O4.
- It is often used in self-tanning products

GLUCOSE



D-Glucose L-Glucose

- The most abundant monosaccharide found in nature is in fact glucose.
- It is the most abundant organic compound on earth.
- We can find glucose in varies fruits, honey and even in starch and cane sugar.
- We obtain a large part of the energy in our bodies from glucose through the foods we eat.
- It is an aldohexose, which means it has six carbon atoms in its molecule. Its chemical formula is $C_6H_{12}O_6$

- glucose mainly from two sources which are starch and sucrose.
- On a large and commercial scale glucose is prepared from hydrolysis of starch by boiling it with dilute H2SO4. The chemical reaction is as follows

(C6H10O5) + n (H2O) ————-> n (C6H12O6)

Starch Glucose

- Also, another way of preparing glucose, with fructose as a joint or by-product, is to boil sucrose in dilute HCl or even H2SO4 in an alcoholic solution. This chemical reaction is as follows

C12H22O11 + H2O ————> C6H12O6 + C6H12O6

Sucrose Glucose + Fructose

PROPERTIES OF GLUCOSE

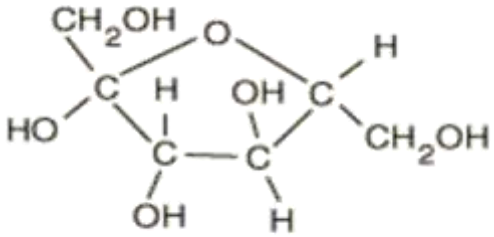
PHYSICAL PROPERTIES:

- Can be solid or liquid
- Melting Point: 294.8˚F(146˚C)
- Density: 1.54 g/cm³
- Weight: 180.16 g/mol
- Soluble in water and acetic acid
- has a sweet taste
- has no odour
- all forms of glucose are colourless and is also clear

CHEMICAL PROPERTIES:

- not toxic
- highly combustible (powdered glucose is highly flammable and)
- finely dispersed particles can become explosive when they are exposed to air
- Can emit heat when it burns.

FRUCTOSE



Fructose

- Fructose is a simple ketonic monosaccharide.
- We mostly find fructose in plants and their fruits, flowers and root vegetables, hence earning it a moniker of fruit sugar.
- It is also abundantly present in honey and corn syrup.
- The chemical formula of fructose is also C6H12O6 but the bonding of fructose is very different than that of glucose.
- Fructose has a cyclic structure.
- The structure is an intramolecular hemiacetal.
- It has its carbonyl group at its number two carbon (it's a ketone function group).
- In its cyclic form, it (generally) forms a five-member ring which we call a Furanose ring.

PROPERTIES OF FRUCTOSE

CHEMICAL PROPERTIES OF FRUCTOSE:

- Fructose is a 6-carbon polyhydroxy ketone. Crystalline fructose adopts a cyclic six-membered structure owing to the stability of its hemiketal and internal hydrogen-bonding. This form is formally called D-fructo pyranose.

REACTIONS:

FRUCTOSE AND FERMENTATION:

- Fructose may be anaerobically fermented by yeast or bacteria.
- Yeast enzymes convert sugar (glucose, or fructose) to ethanol and carbon dioxide.
- The carbon dioxide released during fermentation will remain dissolved in water, where it will reach equilibrium with carbonic acid, unless the fermentation chamber is left open to the air.
- The dissolved carbon dioxide and carbonic acid produce the carbonation in bottled fermented beverages.

DEHYDRATION:

- Fructose readily dehydrates to give hydroxymethylfurfural ("HMF").
- This process, in the future, may become part of a low-cost, carbon-neutral system to produce replacements for petrol and diesel from plants.

PHYSICAL AND FUNCTIONAL PROPERTIES:

SWEETNESS OF FRUCTOSE:

- It is the sweetest of all naturally occurring carbohydrates. The relative sweetness of fructose has been reported in the range of 1.2–1.8 times that of sucrose. However, it is the 6-membered ring form of fructose that is sweeter; the 5-membered ring form tastes about the same as usual table sugar. Warming fructose leads to formation of the 5-membered ring form. Therefore, the relative sweetness decreases with increasing temperature. However, it has been observed that the absolute sweetness of fructose is identical at 5 °C as 50 °C and thus the relative sweetness to sucrose is not due to anomeric distribution but a decrease in the absolute sweetness of sucrose at lower temperatures

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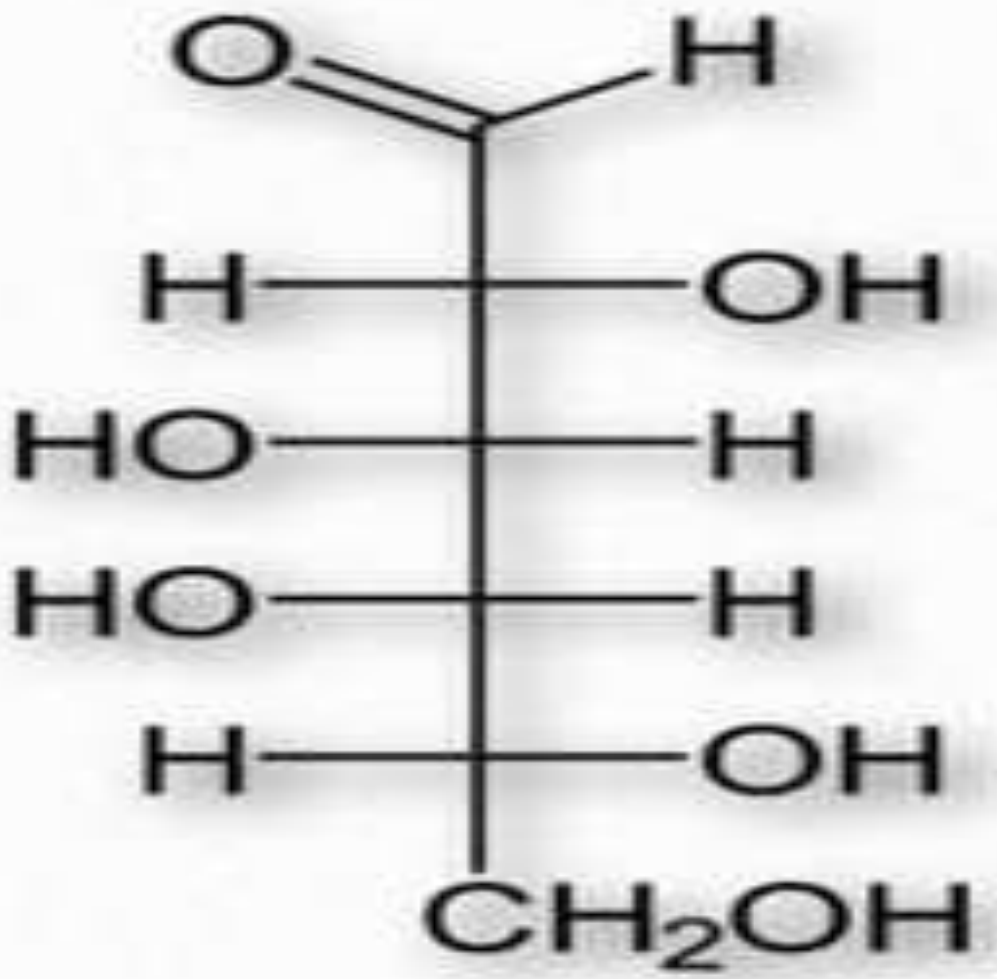
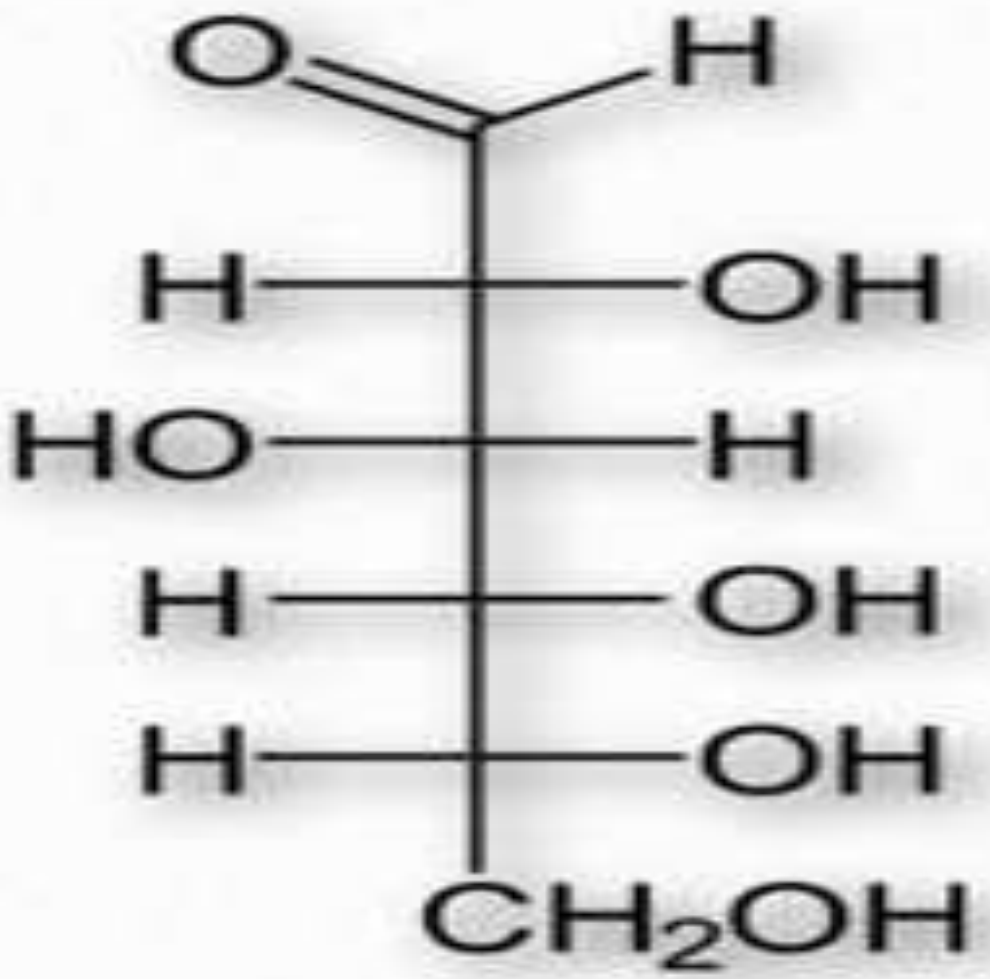
FREEZING POINT:

- Fructose has a greater effect on freezing point depression than disaccharides or oligosaccharides, which may protect the integrity of cell walls of fruit by reducing ice crystal formation.
- However, this characteristic may be undesirable in soft-serve or hard-frozen dairy desserts.

GALACTOSE



D-Galactose



D-Glucose

- Galactose, a member of a group of carbohydrates known as simple sugars (monosaccharides).
- It is usually found in nature combined with other sugars, as, for example, in lactose (milk sugar). Galactose is also found in complex carbohydrates (see polysaccharide) and in carbohydrate-containing lipids called glycolipids, which occur in the brain and other nervous tissues of most animals.

PROPERTIES GALACTOSE

- ***Product Name-*** D-Galactose
- ***Synonyms-*** (3R,4S,5R,6R)-6-(Hydroxymethyl) oxane-2,3,4,5-tetrol
- D-Glucopyranose
- ***CAS- 59-23-4 Formula-*** C6H12O6
- ***Molecular Weight-*** 180.2
- ***EINECS-*** 200-416-4
- ***RTECS-*** LW5490000
- ***RTECS Class-*** Reproductive Effector
- ***Merck-*** 13,4356
- ***Beilstein/Gmelin-*** 1724619
- ***Beilstein Reference-*** 4-01-00-04336

PHYSICAL AND CHEMICAL PROPERTIES

- ***Appearance-*** White powder.
- ***Solubility in water-*** 680 g/L
- ***Melting Point-*** 163 - 169
- ***Boiling Point-*** 527
- ***Vapor Pressure-*** 3E-13 (25 C)
- ***Density-*** 1.616 g/cm3 (15 C)
- ***PKA/PKB-*** 12.45 (PKA)
- ***Partition Coefficient-*** 3.17
- ***Heat Of Vaporization-*** 92.2 kJ/mol
- ***Heat Of Combustion-*** 2792 kJ/mol
- ***Usage-*** Considered a nutritive sweetener because it has food energy.
- ***Vapor Density-*** 6.2

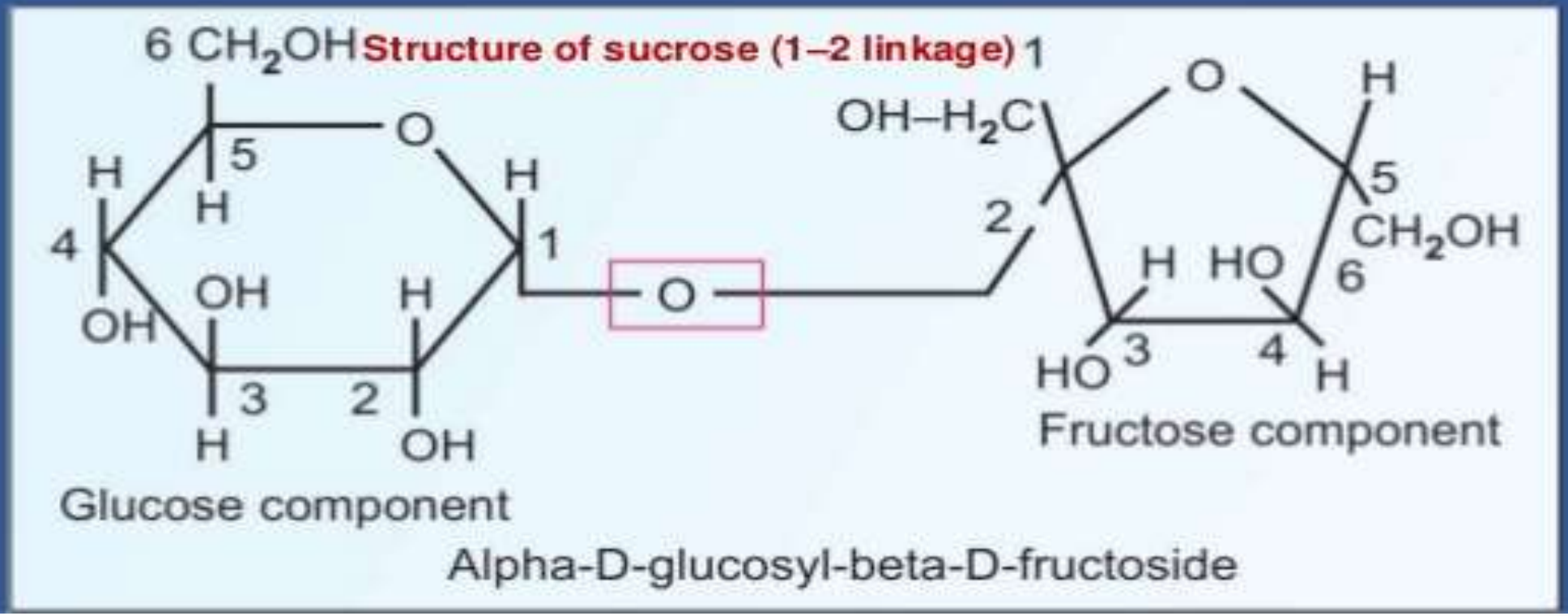
DISACCHARIDES

DISACCHARIDES

- When two monosaccharides are combined together by glycosidic linkage, a disaccharide is formed.
- The important disaccharides are:
  - 1. Sucrose
  - 2. Maltose and isomaltose
  - 3. Lactose

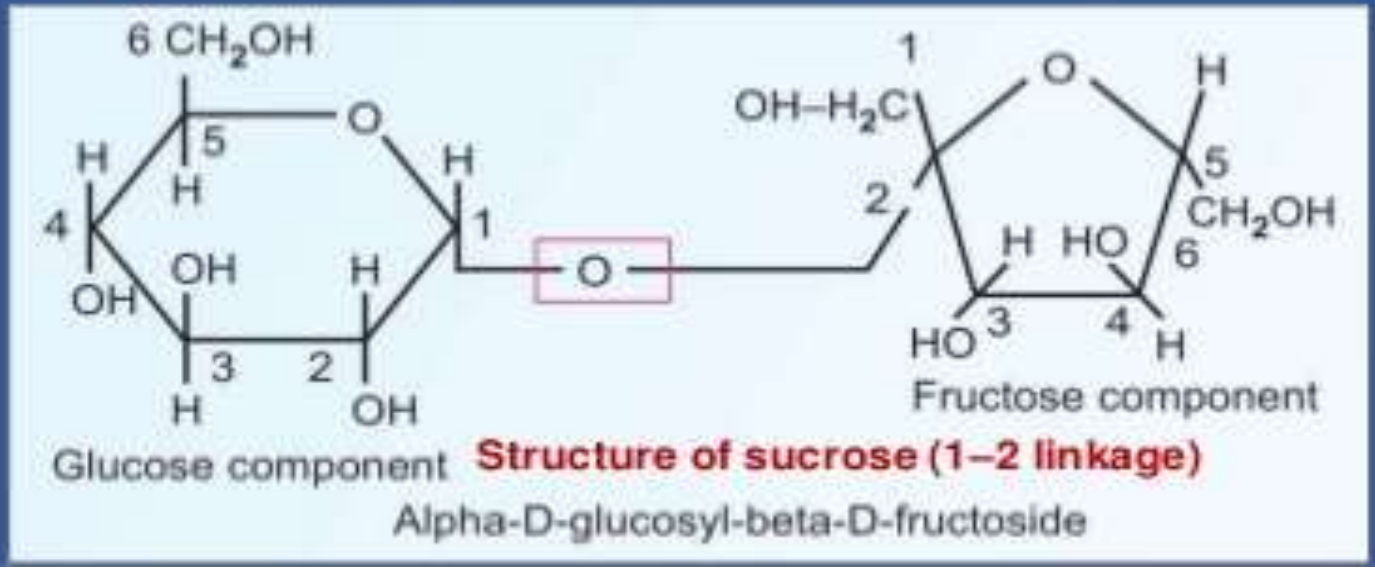
Sucrose

- It is the sweetening agent known as cane sugar. It is present in sugarcane and various fruits.



Sucrose

- Sucrose contains glucose and fructose. Sucrose is **not a reducing sugar**; and it will not form osazone. This is because the linkage involves first carbon of glucose and second carbon of fructose, and free reducing groups are not available.



Sucrose

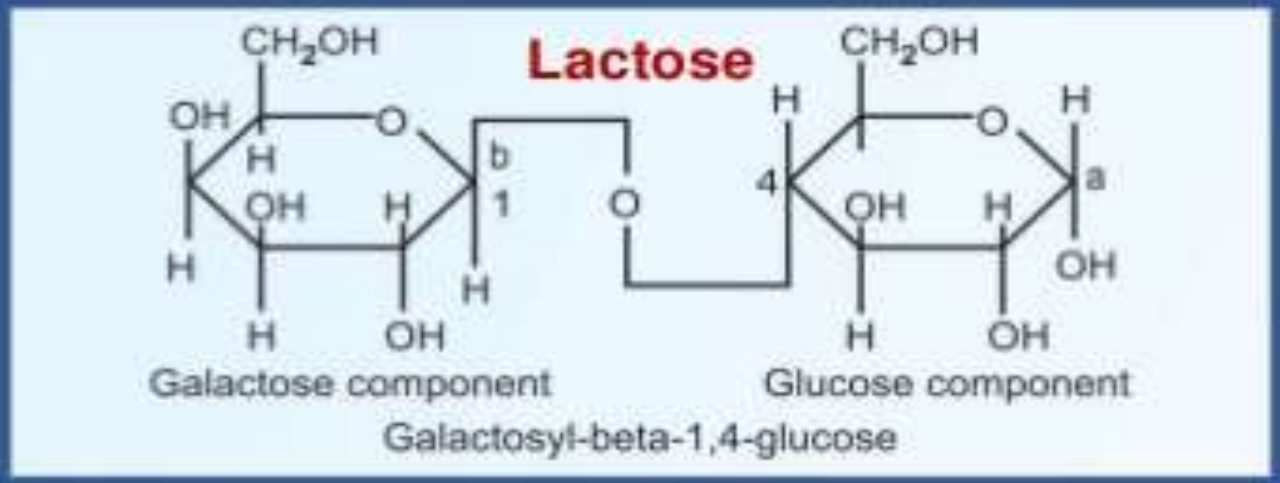
- When sucrose is hydrolyzed, the products have reducing action.
- A sugar solution which is originally non-reducing, but becomes reducing after hydrolysis, is inferred as sucrose (**specific sucrose test**).

Benedict's test is positive for glucose. Test is negative for sucrose; but when sucrose is hydrolyzed, the test becomes positive (specific sucrose test)

Sucrose

- Hydrolysis of sucrose (optical rotation +66.5°) will produce one molecule of glucose (+52.5°) and one molecule of fructose (–92°). Therefore, the products will change the dextrorotation to levorotation, or the plane of rotation is inverted.
- Equimolecular mixture of glucose and fructose thus formed is called **invert sugar**. The enzyme producing hydrolysis of sucrose is called **sucrase or invertase.**
- Honey contains invert sugar. Invert sugar is sweeter than sucrose.

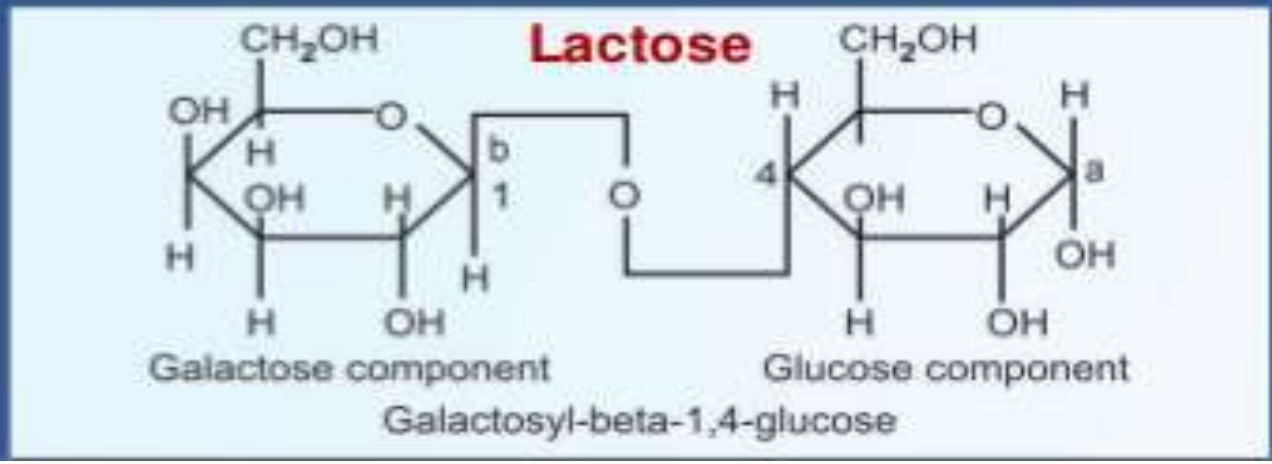
Lactose



- It is the sugar present in milk.
- It is a **reducing disaccharide.**
- On hydrolysis lactose yields glucose and galactose.
- **Beta glycosidic linkage** is present in lactose.

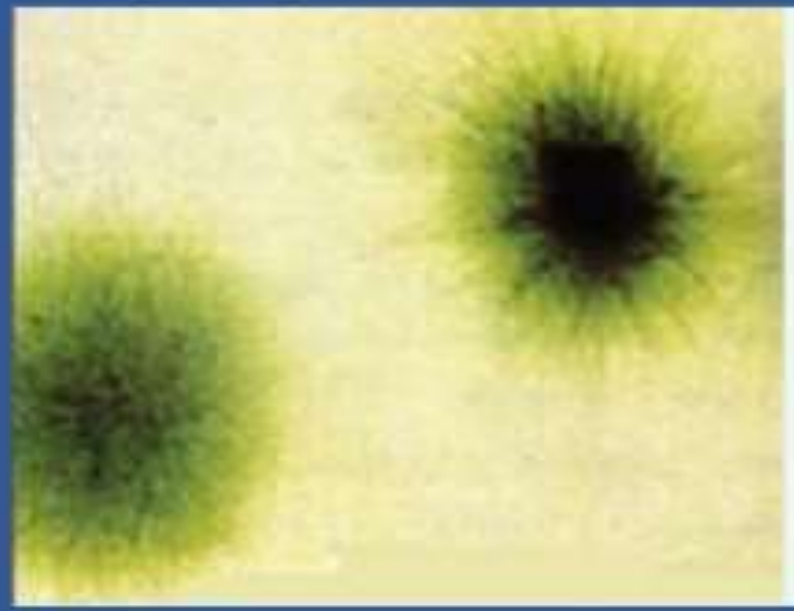
Lactose

- The structure is given in Figure. The anomeric carbon atom of beta-galactose is attached to the 4th hydroxyl group of glucose through beta-1,4 glycosidic linkage.
- The lactose may be alpha or beta variety, depending on the configuration of 1st carbon of glucose moiety.



Lactose

- Lactose forms osazone which resembles "pincushion with pins" or "**hedgehog**" or flower of "touch-me-not" plant.



Hedgehog or "pincushion with pins" or flower of "touch-me-not-plant"
Lactososazone

Lactose

- Lactose and lactate should not be confused.

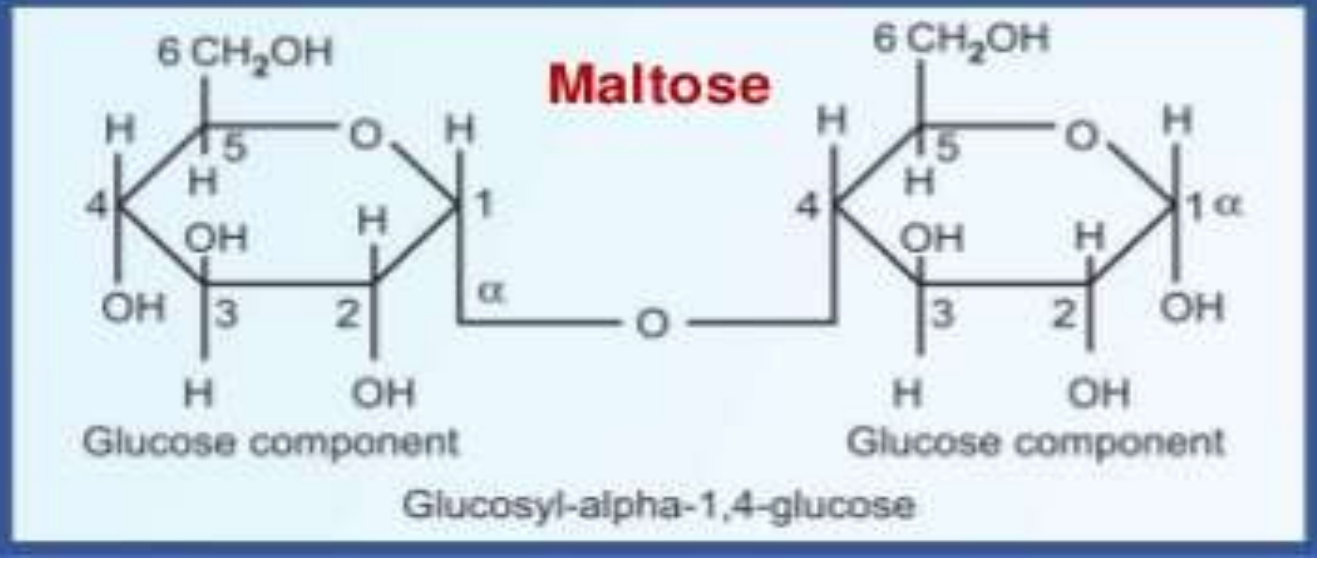
Box 6.2: Lactose and lactate are different

Lactose is the milk sugar; a disaccharide made of galactose and glucose.

Lactate or Lactic acid is a product of anaerobic metabolism of glucose.

Maltose

- Maltose contains two glucose residues.
- There is alpha-1,4 linkage, i.e. the anomeric 1st carbon atom of one glucose is combined with 4th hydroxyl group of another glucose through alpha-glycosidic linkage. Structure is shown in Figure.



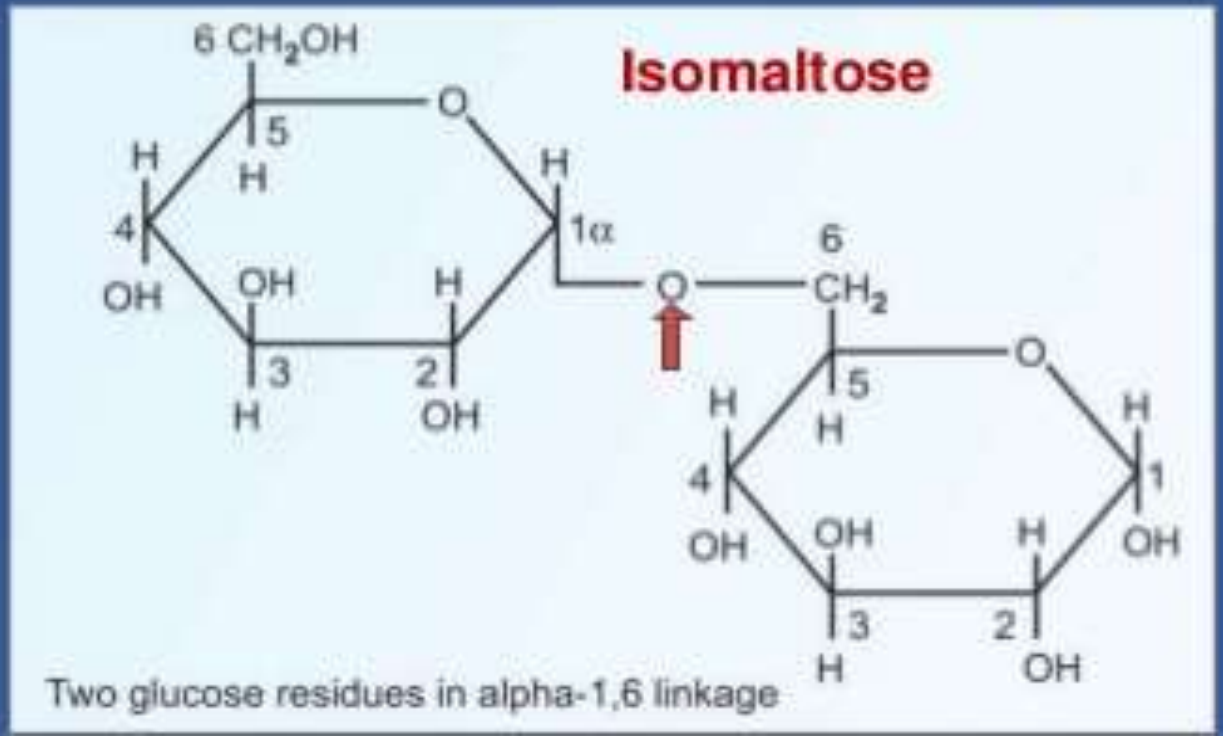
Maltose

- Maltose may be alpha or beta depending on the configuration at the free anomeric carbon atom.
- It is a **reducing disaccharide**. It forms **petal-shaped crystals** of maltose-osazone.

Sunflower-shaped or petal-shaped crystals of Maltosazone

Isomaltose

- It is also a **reducing** sugar. It contains 2 glucose units combined in alpha-1, 6 linkage. Thus first carbon of one glucose residue is attached to the sixth carbon of another glucose through a glycosidic linkage.



Two glucose residues in alpha-1,6 linkage

Isomaltose

- Partial hydrolysis of glycogen and starch produces isomaltose.
- The enzyme oligo-1,6-glucosidase present in intestinal juice can hydrolyze isomaltose into glucose units.

The salient features of important sugars are shown in Box

Box 6.3: Salient features of important sugars

Monosaccharides

Glucose	Aldohexose
Galactose	4th epimer of glucose
Mannose	2nd epimer of glucose
Fructose	Ketohexose

Disaccharides

Glucose + Galactose = Lactose (reducing)

Glucose + Glucose = Maltose (reducing)

Glucose + Fructose = Sucrose (non-reducing)

POLYSACCHARIDES

POLYSACCHARIDES

- Simply glycans.
- Repeat units of monosaccharides or their derivatives,held together by glycosidic bonds.
- Linear as well as branched polymers.
- Two types-

1. Homopolysaccharides
2. Heteropolysaccharides

Classifications of Polysaccharides

Homopolysaccharides

polymers of a single monosaccharide

- Starch
- Cellulose
- Dextrins
- Dextran

Heteropolysaccharides

polymers of more than one type of monosaccharide

- Gums
- Mucilages
- Agar
- Algin
- Pectic substances

1.HOMOPOLYSACCHARIDES

Homopolysaccharides are polymers composed of single type of sugar units.

GLUCOSANS / GLUCAN

❖ STARCH (storage polysaccharide):-

- Homopolymer composed of D-glucose units held by α-glycosidic bonds.
- Two polysaccharide units –

a. Amylose (15-20 percent)

b. Amylopectin (80-85 percent)

a) AMYLOSE :-

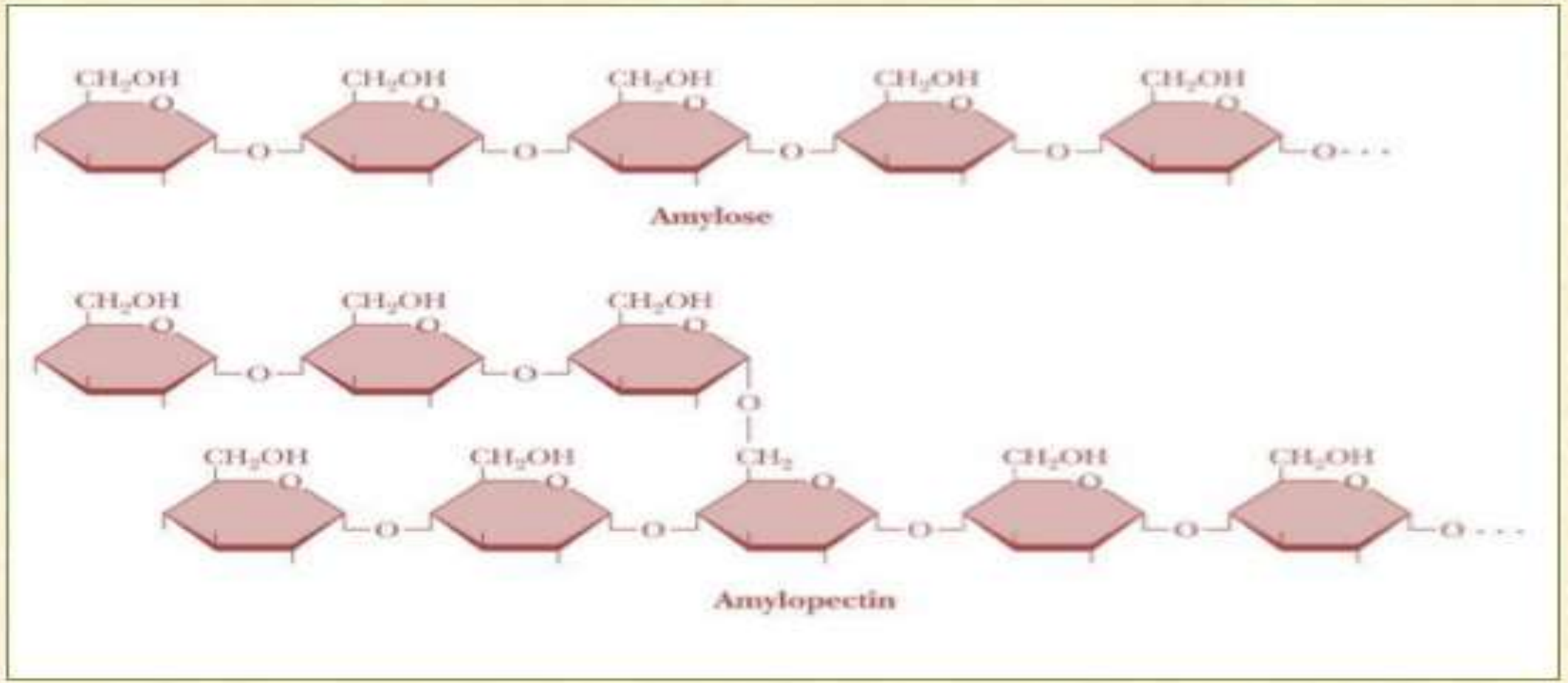
- Long unbranched chain
- 250-300 D-glucose units held by α(1-4) glycosidic linkages.

b) AMYLOPECTIN:-

- Branched chain with α(1-6) glycosidic bonds at the branching points and α(1-4) linkages everywhere else.
- Contains few thousand glucose units looks like a branched tree (20-30) glucose units per branch.

STRUCTURE OF STARCH

(AMYLOSE & AMYLOPECTIN)



Amylose

1) Soluble in water

2)Gives Blue colour with dilute iodine solution

3)Structure –unbranched

4)250 to 300 D-glucose units linked by alpha 1→4 linkages

5)Mol. wt approx.60000

6)Occurs at the extent of 15 to 20%

Amylopectin

1)Insoluble in water

2)Gives reddish colour with iodine solution

3)Structure – highly branched

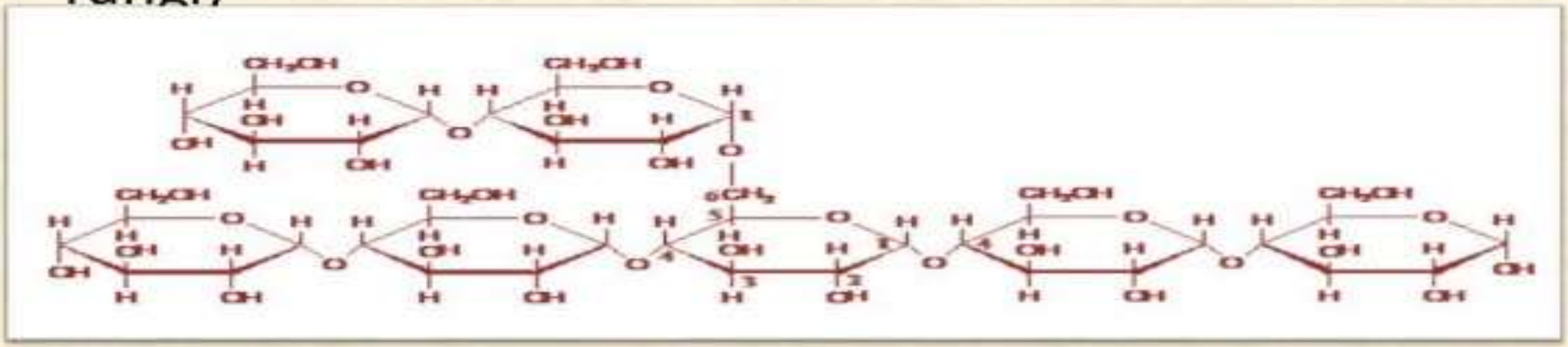
4)Units joined together by Alpha 1→4glycosidic bond and at branch point with alpha 1→6 glycosidic linkages

5)Mol. wt. approx 500000

6)Occurs at 80 to 85%

❖ GLYCOGEN:-

- ➢ Animal starch.
- ➢ Present in high concentration in liver followed by muscle, brain.
- ➢ Present in plants with no chlorophyll (eg.yeast , fungi)



- Structure of glycogen is similar to that of amylopectin with more number of branches.
- Glucose is the repeating unit in glycogen joined together by α(1-4) glycosidic bonds,and α(1-6) glycosidic bonds at branching points.
- Present in cells as granules with high molecular weight.
- Complete hydrolysis yields glucose.

- In the liver, glycogen synthesis and degradation are regulated to maintain blood-glucose levels . Glycogen serves as a buffer to maintain blood glucose level.
- In contrast, in muscle, these processes are regulated to meet the energy needs of the muscle itself.
- The concentration of glycogen is higher in the liver than in muscle , but more glycogen is stored in skeletal muscle overall because of its much greater mass.

❖ CELLULOSE:-

- Polymer of glucose.
- On heating with high concentrations of acids yields disaccharide cellobiose and D-glucose.
- Cellobiose is made up of two molecules of D-glucose linked together by β -Glucosidic linkages between C1 and C4 of adjacent glucose units.
- Most abundant of all carbohydrates.
- Very stable insoluble compound.

- Herbivorous animals utilise cellulose with the help of bacteria.
- Human beings lack any enzyme that hydrolyzes the β (1→ 4) bonds, and so cannot digest cellulose. It is an important source of "bulk" in the diet, and the major component of dietary fiber stimulating peristalsis and elimination of indigestible food residues.

β-1,4-Linked D-glucose units

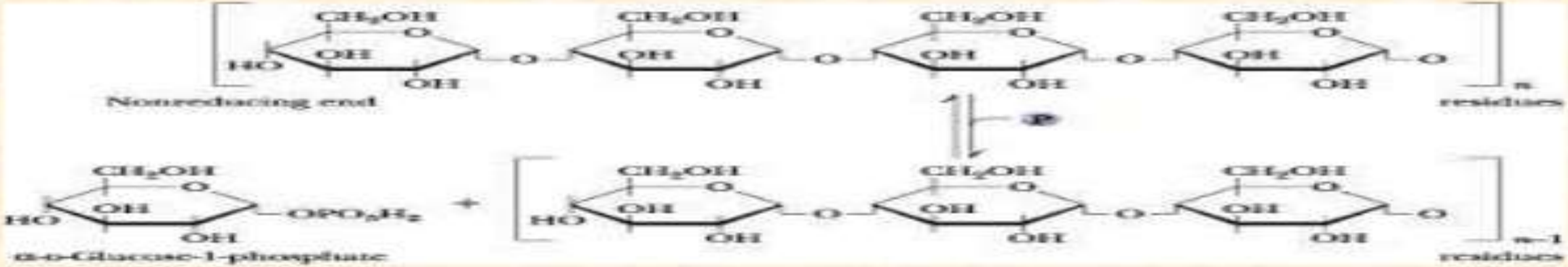
❖ CHITIN:-

- It is linear homopolysaccharide composed of N-acetyl glucosamine residues in b-linkage.
- Only difference from cellulose is the replacement of the hydroxyl group at C-2 with an acetylated amino group.
- Principal component of the hard exoskeleton of arthopods.
- Second most abundant in nature.

❖ DEXTRINS:-

- Produced by the partial hydrolysis of starch along with maltose and glucose.
- Dextrins are often referred to as either amylodextrins, erythrodextrins or achrodextrins.
- Used as mucilages (glues).
- Used in infant formulas .

- Indigestible dextrin are developed as soluble fiber supplements for food products.
- Also Used as thickening agents in food processing



❖ DEXTRANS:-

- Polymer of D-glucose.
- Synthesised by the action of Leuconostoc mesenteroides.
- Exocellular enzyme produced by the organisms bring about polymerisation of glucose moiety of sucrose molecule DEXTRANS.
- They differ from dextrins in structure.

- Contains α (1,4), α(1,6) and α (1,3) linkages.
- Molecular weight : 40,000; 70,000; 75,000
- Used as plasma expanders .

❖ Disadvantage:-

- ➢ It interferes with grouping and cross matching.

FRUCTOSANS

❖ INULIN:-

- ➢ Polymer of D-fructose.
- ➢ Low molecular weight -5000
- ➢ Occurs in tubers of the Dehlia, in the roots of Jerusalem artichoke, dandelion and in the bulbs of onion and garlic.

- β-(1,2) linked fructofuranoses.
- Linear ,no branching.
- Hydrolysis yields fructose.
- Used for the evaluation of glomerular filtration rate.
- It has no dietary importance in human beings as inulinase is absent.

GALACTOSANS

❖ AGAR:-

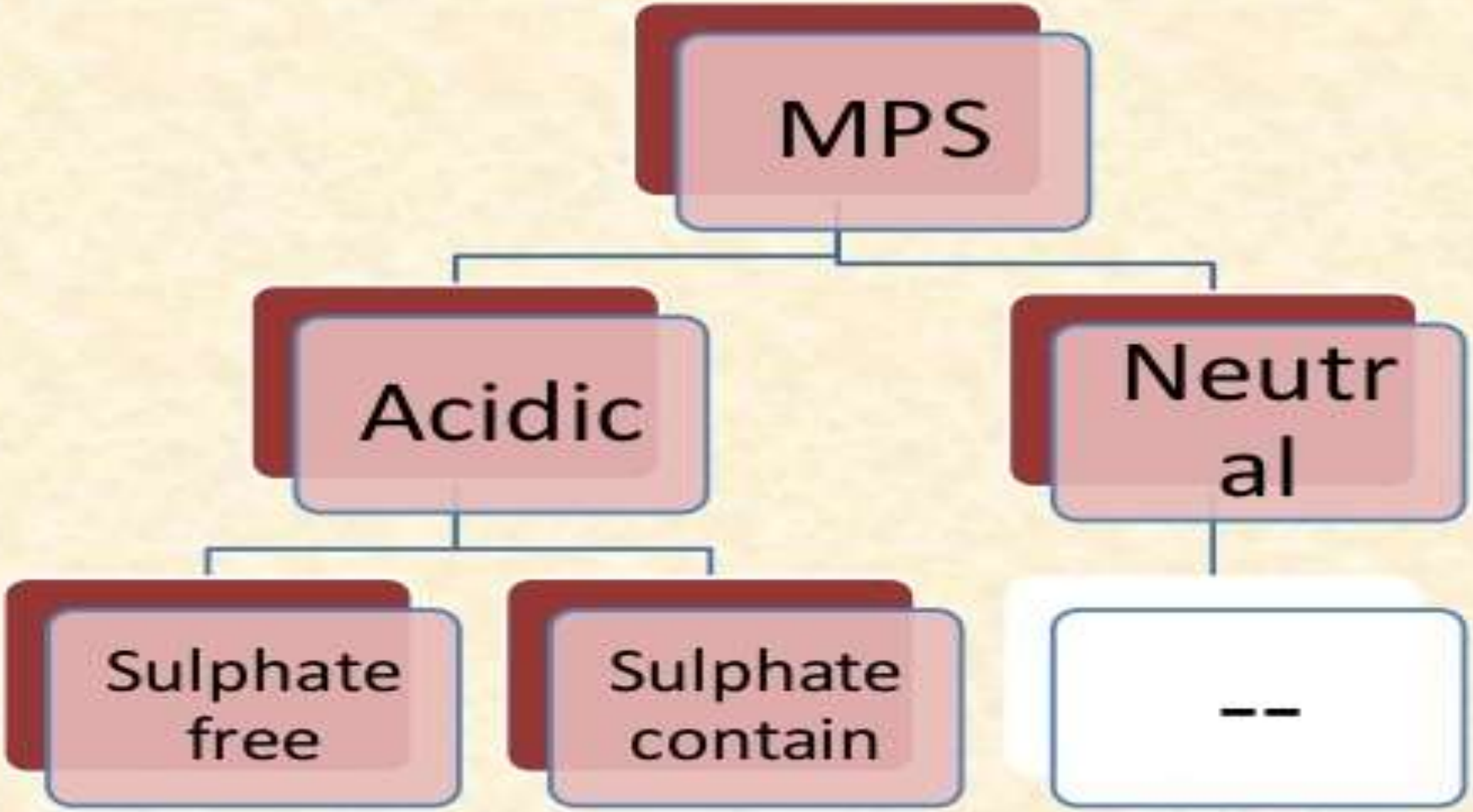
- Agar is a galactose polymer.
- Obtained from the cell walls of some species of red algae (*Sphaerococcus Euchema*) and species of Gelidium.
- Dissolved in hot water and cooled, agar becomes gelatinous.
- Used in microbiology .

- As laxative.
- A vegetarian gelatin substitute.
- A thickener for soups, jellies, ice cream and Japanese desserts.
- As a clarifying agent in brewing, and for sizing fabrics.

HETEROPOLYSACCHARIDES/ HETEROGYLCANS

- Mucopolysaccharides/Glycosaminoglycans(GAGS)
- Amino sugar +ss uronic acid units.
- Some contain amino sugar and monosaccharide units without the presence of uronic acid.
- Amino group is generally acetylated.
- Carbohydrate content more than 4% -Mucoproteins.
- Carbohydrate content less than 4% -Glycoproteins.

CLASSIFICATION

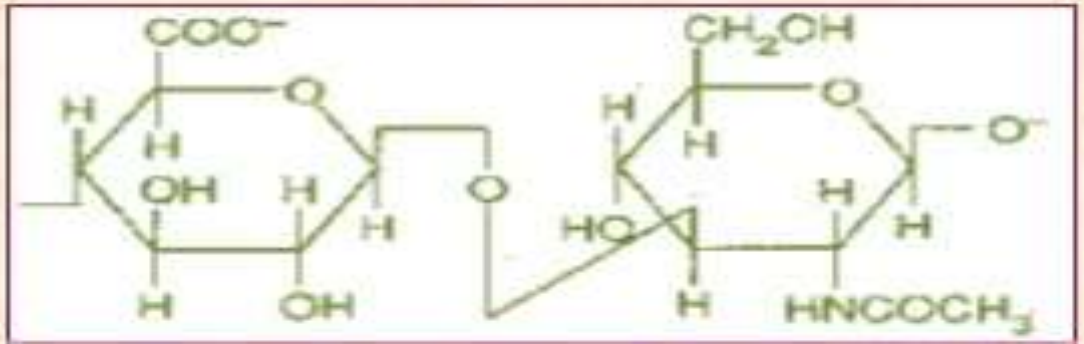


ACIDIC SULPHATE FREE MPS

1. Hyaluronic Acid
2. Chondroitin

1.HYALURONIC ACID:-

- Composed of N-acetyl glucosamine and D-Glucoronic acid.
- On hydrolysis yields equimolecular quantities of D-Glucosamine, D-Glucoronic acid & acetic acid.



- Occurrence:- Synovial fluid, ECM of loose connective tissue. Serves as a lubricant and shock absorber.
- HYALURONIDASE –An enzyme catalyses the depolymerisation of hyaluronic acid and by reducing its viscosity facilitates diffusion of materials into tissue spaces.
- Clinically the enzyme is used to increase the efficiency of absorption of solutions administered by clysis.

2.CHONDROITIN

-Another Sulphate free acid mucoplosaccharide.

-It is found in cornea and also in cranial cartilages.

- N-acetyl galactosamine +D-Glucoronic acid.

ACIDIC SULPHATE CONTAIN

1.Chondroitin sulphate

2.Keratan sulphate

3.Heparin

4.Heparitin sulphate

1.CHONDROITIN SULPHATE

- It is a principle MPS in ground substance of mammalian tissues and cartilages.
- It is a sulphate containing MPs.
- Four chondroitin sulphate are isolated which are chondritin Sulphate A,B,C,D.

- **1.Chondritin Sulphate A** - Consists of repeating units of N-acetyl-D-Galactosamine and D-Glucuronic acid. N-Acetylgalactosamine is esterified with sulphate in position 4 of galactosamine .
- It is present in cartilages ,bone and cornea.

2.Chondroitin Sulphate B:-

- It is present in skin ,cardiac valve and tendon.
- It has L-iduronic acid in place of glucuronic acid which is found in other chondritin sulphate.
- L-iduronic acid is an epimer of D-Glucuronic acid.
- It consist of repeating units of L-iduronic acid and N-acetyl galactosamine at c4 sulphate moity present.
- It has weak anticoagulent property.
- Sometimes it is found in skin hence called as

3.Chondroitin sulphate C

- It is found in cartilage and tendon.
- Structure of chondritin sulphate c is similar to chondritin sulphate A. Except that sulphate group is present at position 6 of galactosamine molecule instead of position 4.

4.Chondroitin Sulphate D

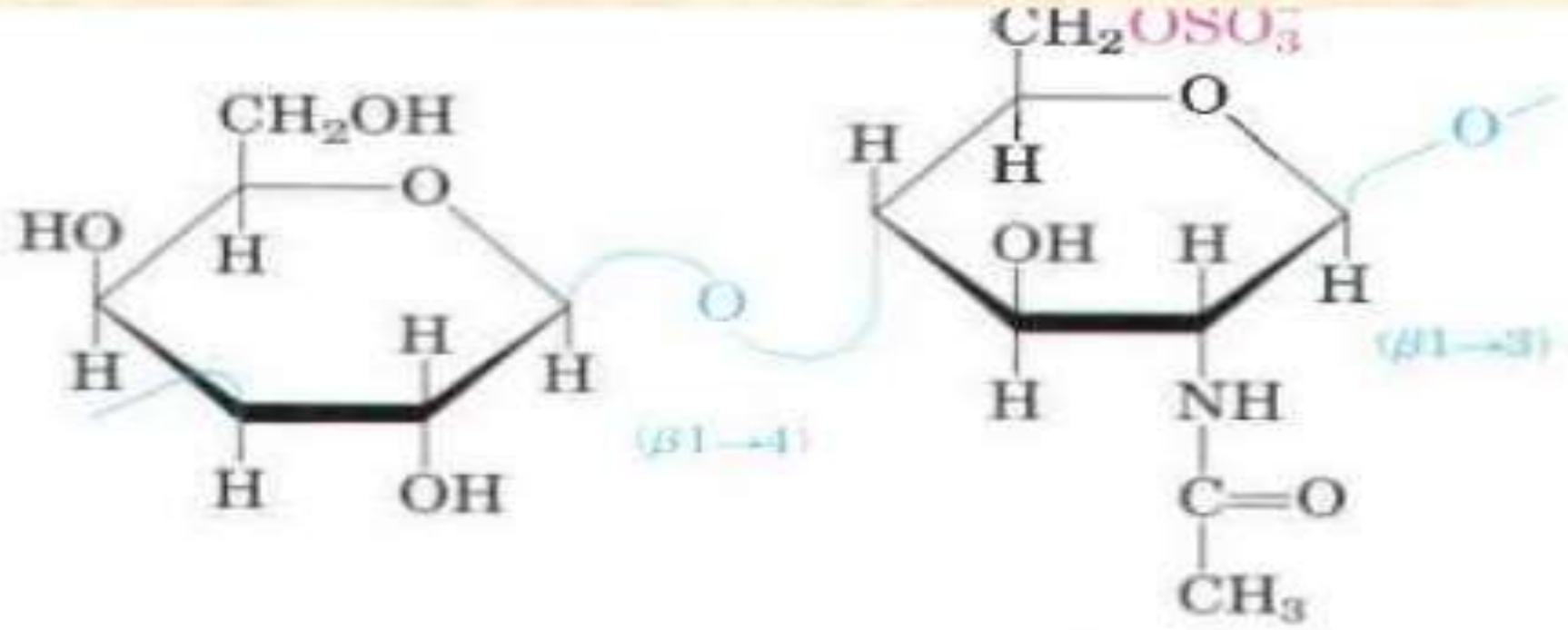
- It is isolated from cartilage of shark
- It resembles in structure to chondroitin sulphate C,except that it has second SO_4 attached at carbon 2 or 3 of uronic acid.

2.KERATAN SULPHATE

- It is a sulphate containg acid MPS.
- Found in costalcartilage,cornea,aorta,nucleus pulposus.
- KERATAN SULPHATE - It consist of repeating diassacharide units of N-aceyl glucosamine and galactose.
- No uronic acids in molecule.

Keratan sulfate

~25



Gal GlcNAc6S

- There are 2 types as follows -
- **Keratan Sulphate type 1-** found in cornea.In this type linkage are between N-acetylglucosamine and aspargine.
- **Keratan Sulphate type 2-** found in skeletal muscle. In this type linkage to protein is through –OH group on serine and threonine residue of protein.

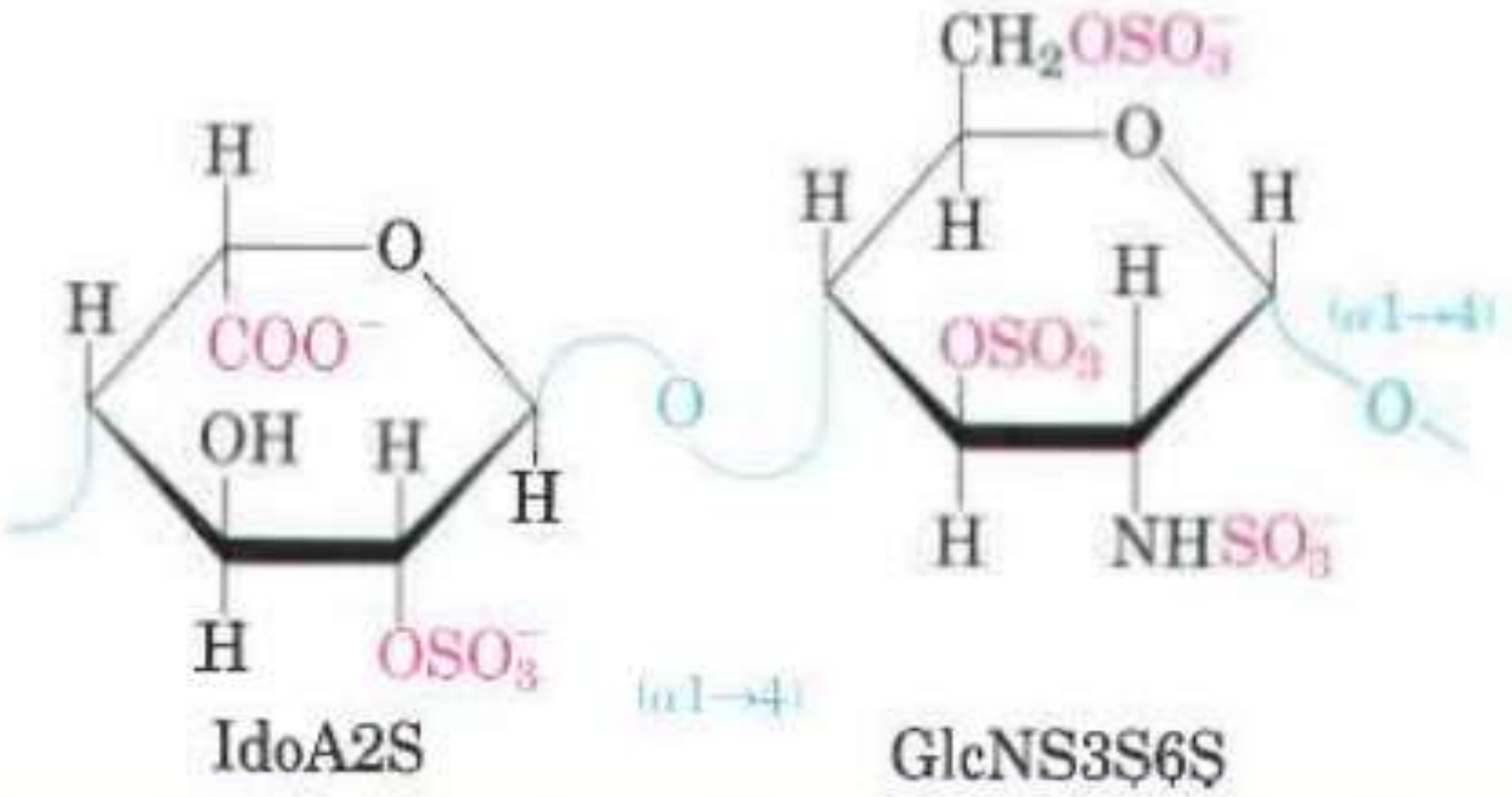
3.HEPARIN

- Has Molecular weight 17000 to 20000.
- It is anticoagulant present in liver produced by mast cells present in liver .
- It is found in lungs ,thymus,spleen,walls of large arteries ,skin ,blood.
- It is a polymer of repeating diasaccharide unit of D-Glucosamine and either of the two uronic acid –D-Glucuronic acid and L-Iduronic acid.
- In fully formed heparin molecule 90% or more of uronic acid residues are L-Iduronic acid.

Heparin

Heparin

15–90



4.HEPARITIN SULPHATE

- It is isolated from amyloid liver and spleen of pts with Hurler's syndrome.
- It has negligible anticoagulant activity.
- Unlike heparin it's predominant uronic acid is D-Glucuronic acid.
- Some of the amino group carry acetyl groups and % of $-SO_4$ group are smaller.
- Recent study shows that it is present on cell surface as proteoglycans and is extracellular.
- It has low molecular weight.

NEUTRAL MPS

- Found in Pneumococci capsule.
- Act as blood group substances. Four monosaccharides , Galactose, Fucose, Galactosamine(Acetylated) and Acetylated Glucosamine are present in all types of blood group substances.
- Also found in egg protein- ovalbumin.

PROTEOGYLCANS

Proteoglycans are conjugate proteins.

- Proteins called ‘core’proteins are covalently linked to glycosaminoglycans.
- Amount of carbohydrates in proteoglycans are 95% more as compared to glycoproteins.
- LINKAGES – Three types
- 1) O-glycosidic linkage-formed between N-acetyl glucosamine and serine or threonine. seen in keratan so4 .

2)N-glycosylamine linkage –formed between N-acetyl glucosamine and amide N of aspargine of core protein.

- seen in keratan so4and N-linked glycoprotein

3) O-Glycosidic linkage – formed between xylose and serine of protein.This bond is unique to proteoglycans.

FUNCTIONS

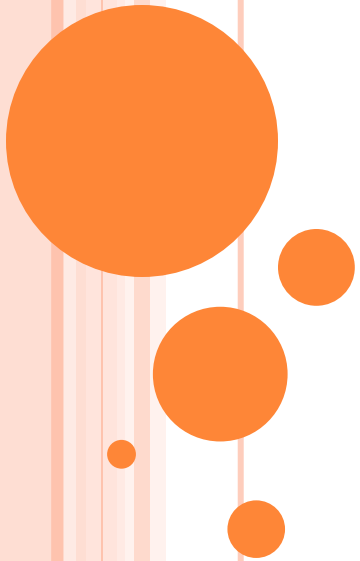
- It acts as a costituent of extracellular matrix or ground substances .
- Proteoglycans acts as barrier in tissue..

- Proteoglycans play a vital role in release of hormones.
- It plays a essentiel role in cell migratio of embryonic tissues.
- It is useful in glomerular filtration rate
- It acts as anticoagulent.
- It acts as coenzyme.
- It acts as receptor for cells.
- It plys a role in compressibility of cartilage.
- It plays a role in sclera of eyes

MUCOPOLYSACCHARIDOSES (MPS)

- **Mucopolysaccharides** (glycosaminoglycans) are structural molecules integral to connective tissues such as cartilage.
- Degradation occurs within **lysosomes**, requiring specific enzymes.
- Patients with **MPS** appear normal at birth and usually present with developmental delay in the first year.
- The features of storage become more obvious with time.

Protein



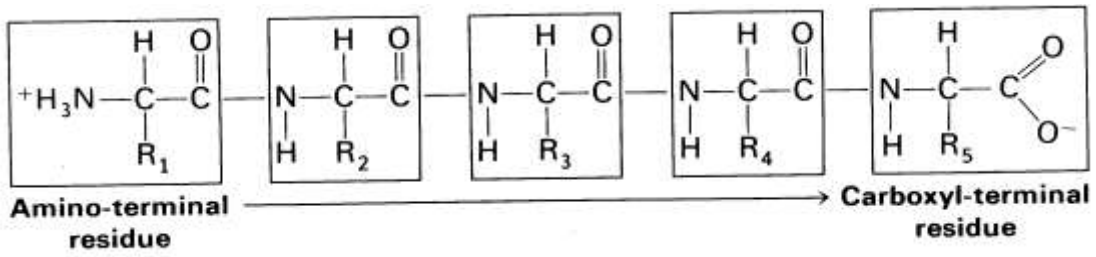
Introduction

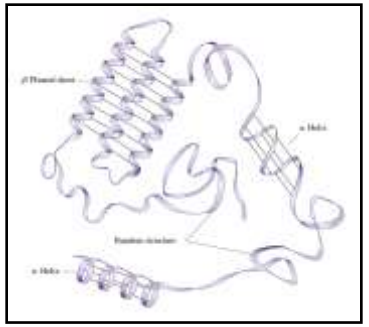
- Are most abundantly distributed organic compounds
- 70 kg man= protein weight constitute 12 kg
- Skeleton and connective tissue contains half
- Body protein and other half is intracellular

Protein Digestion

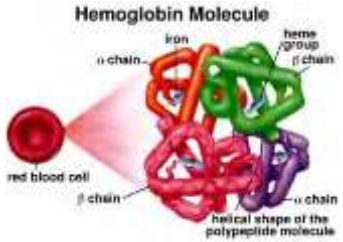
Protein breakdown begins in the **stomach**.

No protein hydrolyzing enzymes are found in saliva.





Hydrolysis (10% of peptide bonds) & **denaturization** by pepsin enzyme & HCl acid produce **short chain polypeptides** in the stomach.



Trypsin, chymotrypsin, & carboxypeptidase from Pancreatic juices,

and **Aminopeptidase** from cells in the small intestine Brush Zone create “free” **amino acids**.

Free amino acids are absorbed thru intestinal wall via active transport.
Enter bloodstream and are brought to cells.

The total supply of free amino acids available is called: the **Amino Acid Pool**.

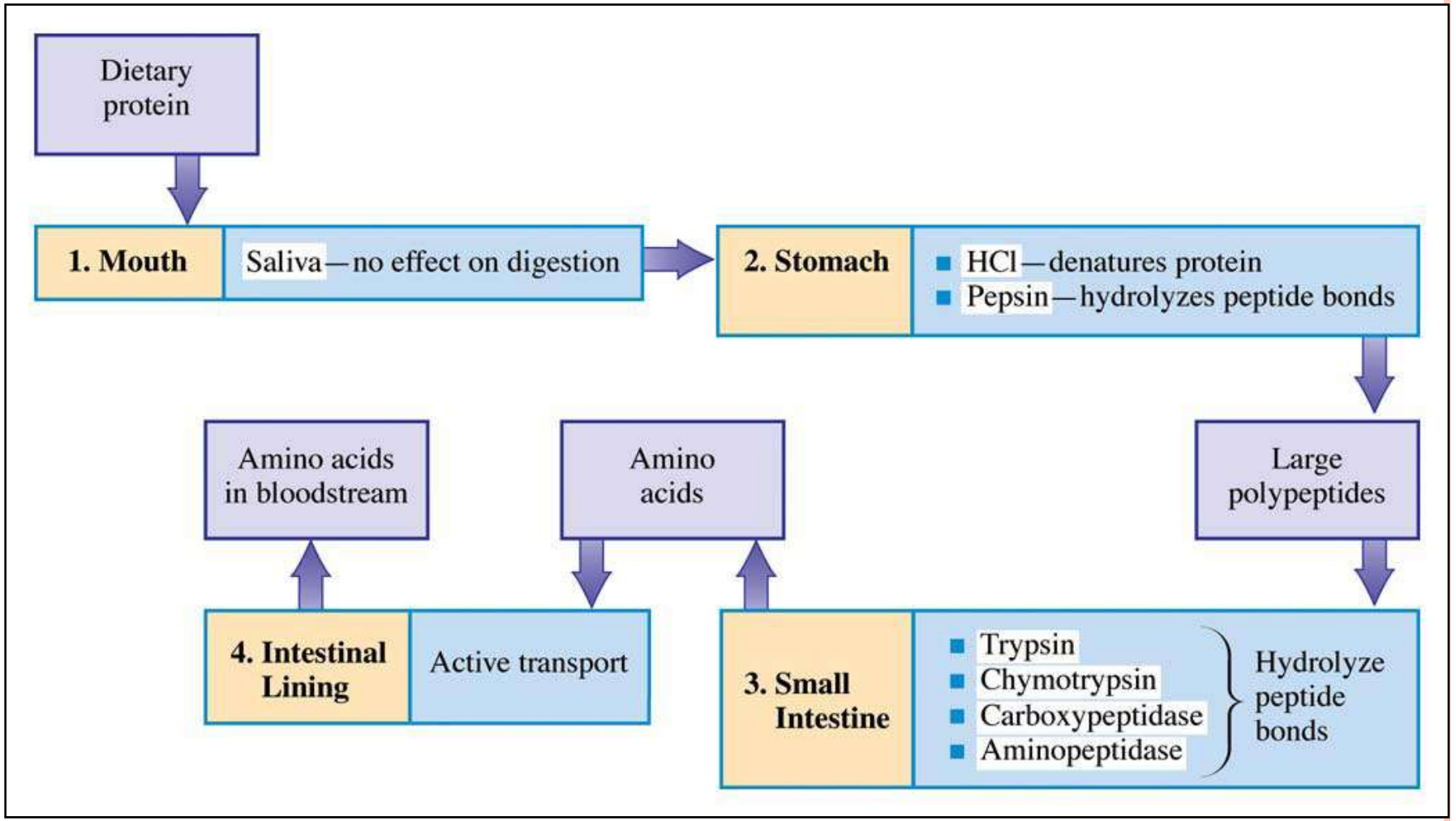
<u>3 sources of "free" amino acids:</u>

1. Dietary protein breakdown
2. Biosynthesis of amino acids in the Liver
3. Protein turnover (I prefer apple turnovers)

Protein turnover is the breakdown & re-synthesis of body protein:

- Old tissues
- Damage
- Recycling enzymes & hormones

Summary of protein digestion in the human body.Possible fates for amino acid degradation products.



Transamination and **Oxidative Deamination:**

Two steps in degrading amino acids

1) remove α-amino group
2) breakdown & process carbon skeleton

Release of an **amino group** is also two steps:

1) **Transamination**
2) **Oxidative deamination**

Central role of glutamate:

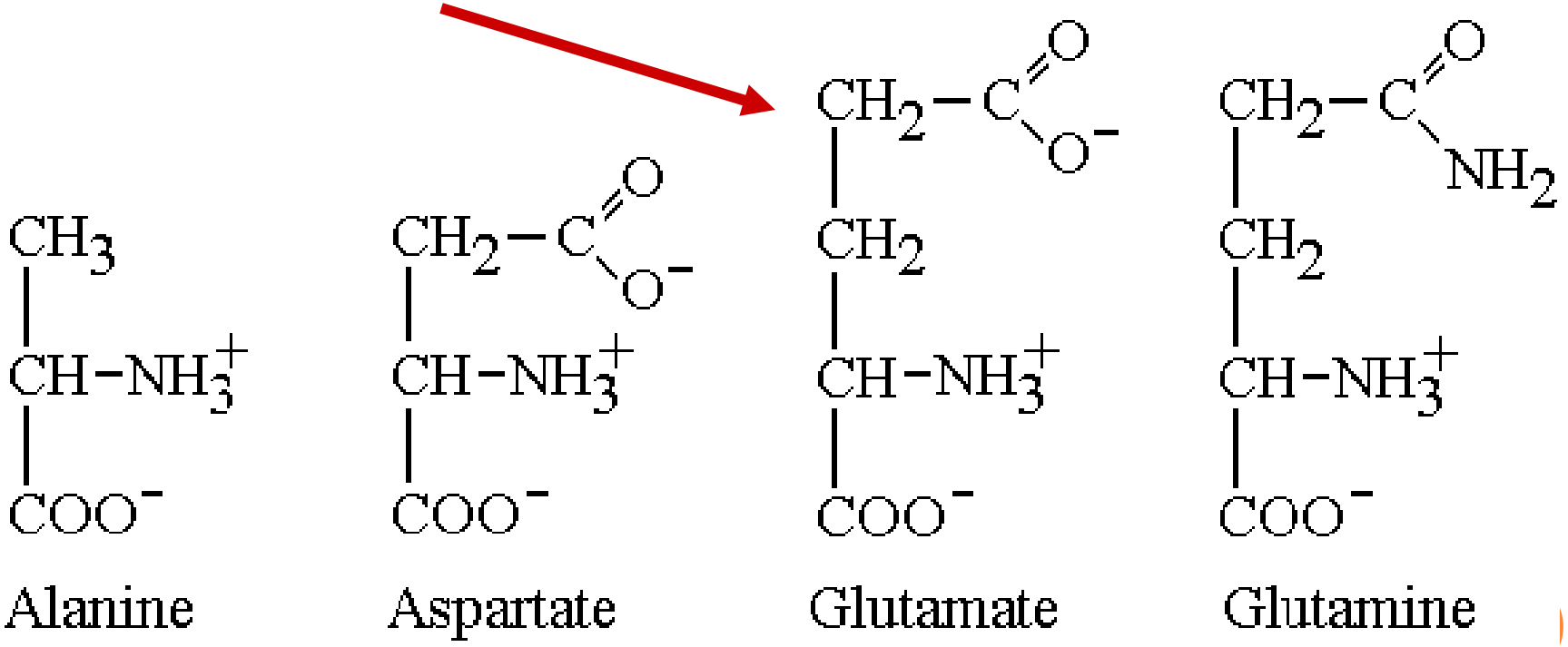
Amino acids:

Glutamate, **aspartate**, **alanine** & **glutamine**

present in higher concentrations in mammalian cells.

Have metabolic functions as well as roles in proteins.

Glutamate is the most important, metabolically.

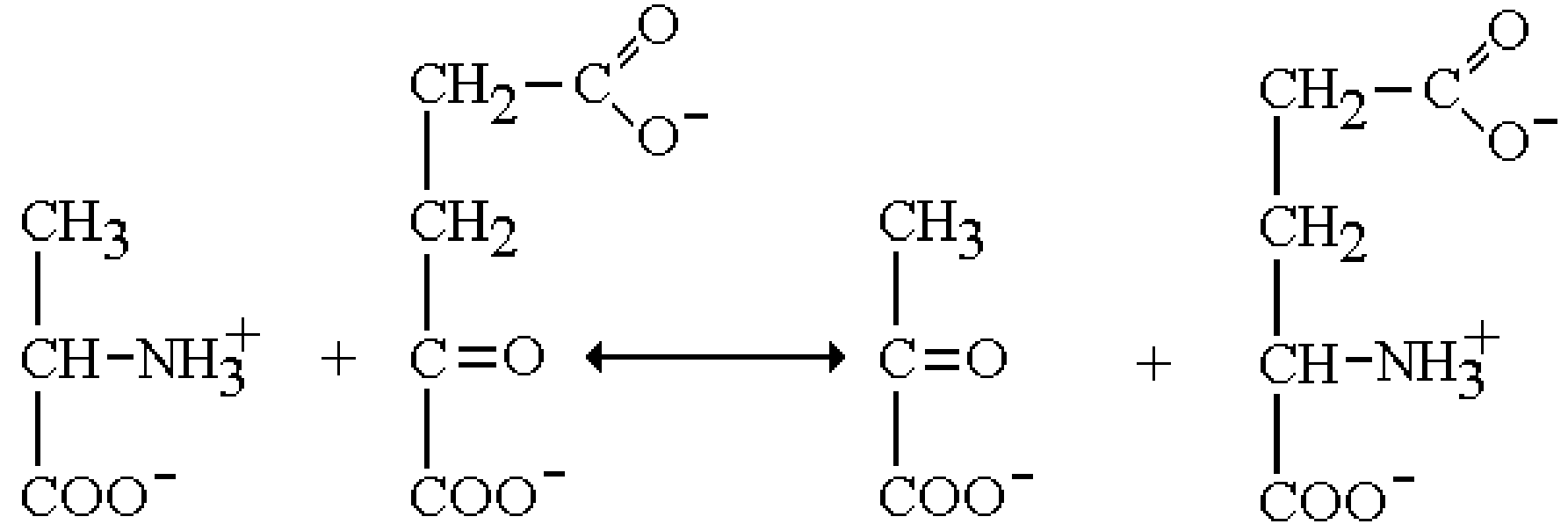


Some **transaminases** are used for diagnosing disorders:

enzyme **alanine aminotransferase**

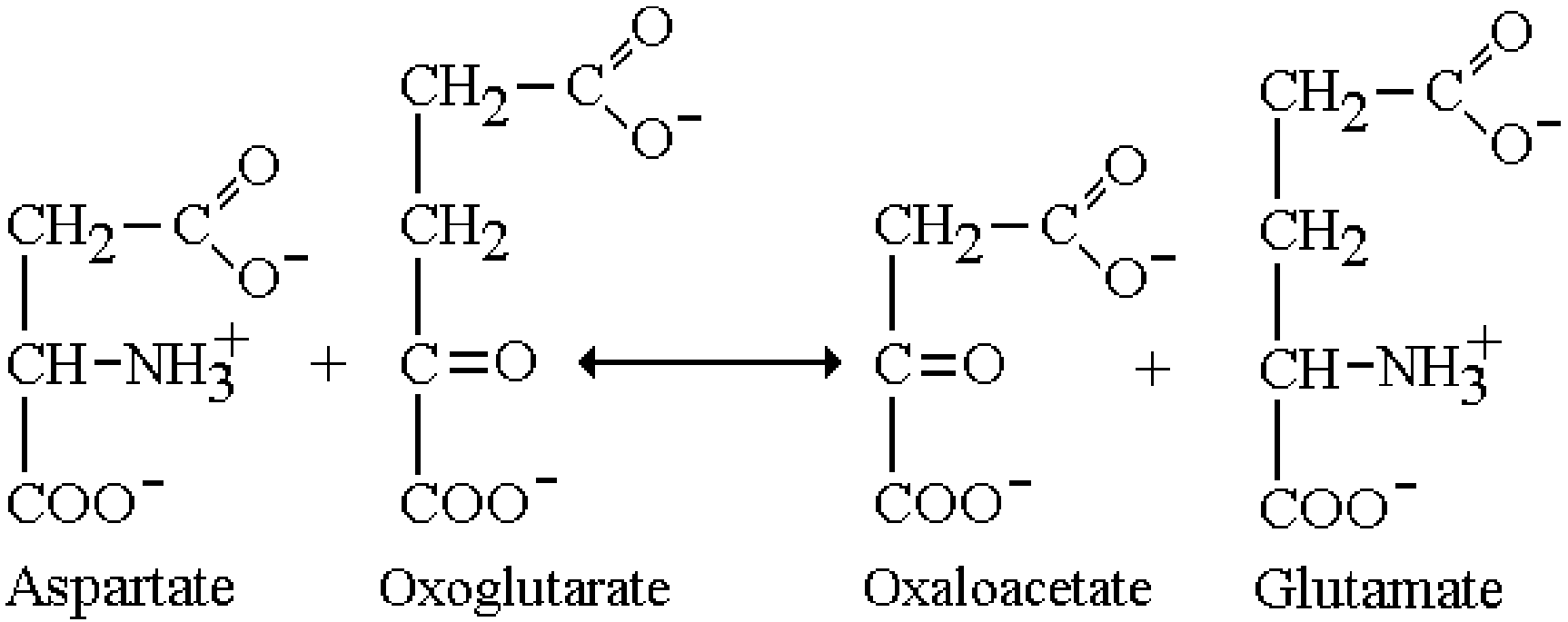
Escapes in large amounts from dead or dying liver tissue.

Measured in blood samples for diagnostic purposes.



Alanine Oxoglutarate Pyruvate Glutamate

Transaminase enzyme **aspartate aminotransferase**
very active enzyme inside heart cells.
Also escapes in large amounts from dead or dying heart tissues & enters bloodstream.
Measured in blood for diagnosing myocardial infarction.

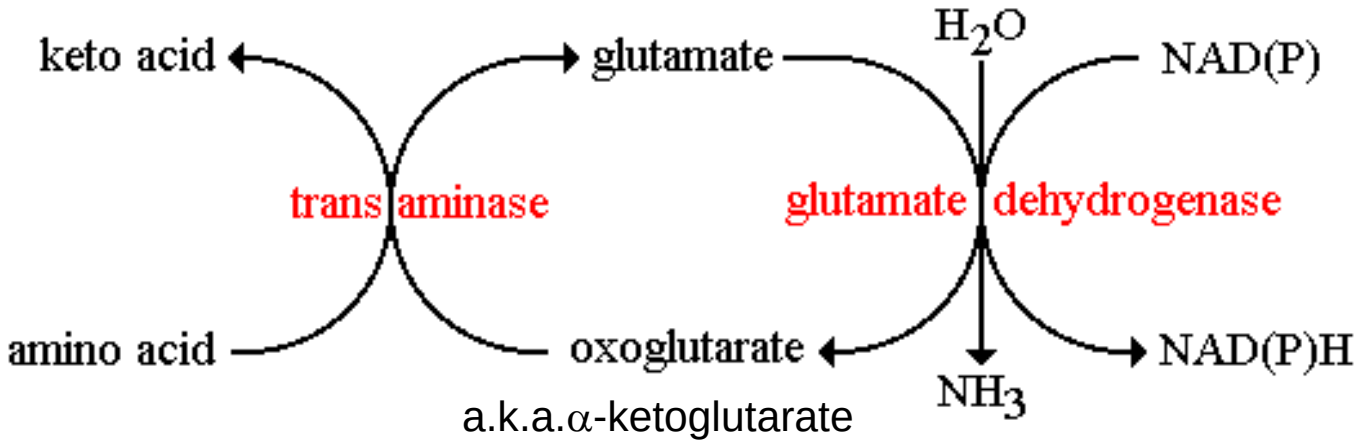


Trans-deamination (sum it up)

Most **transaminases** share a common substrate and product (oxoglutarate and glutamate) with the enzyme **glutamate dehydrogenase**.

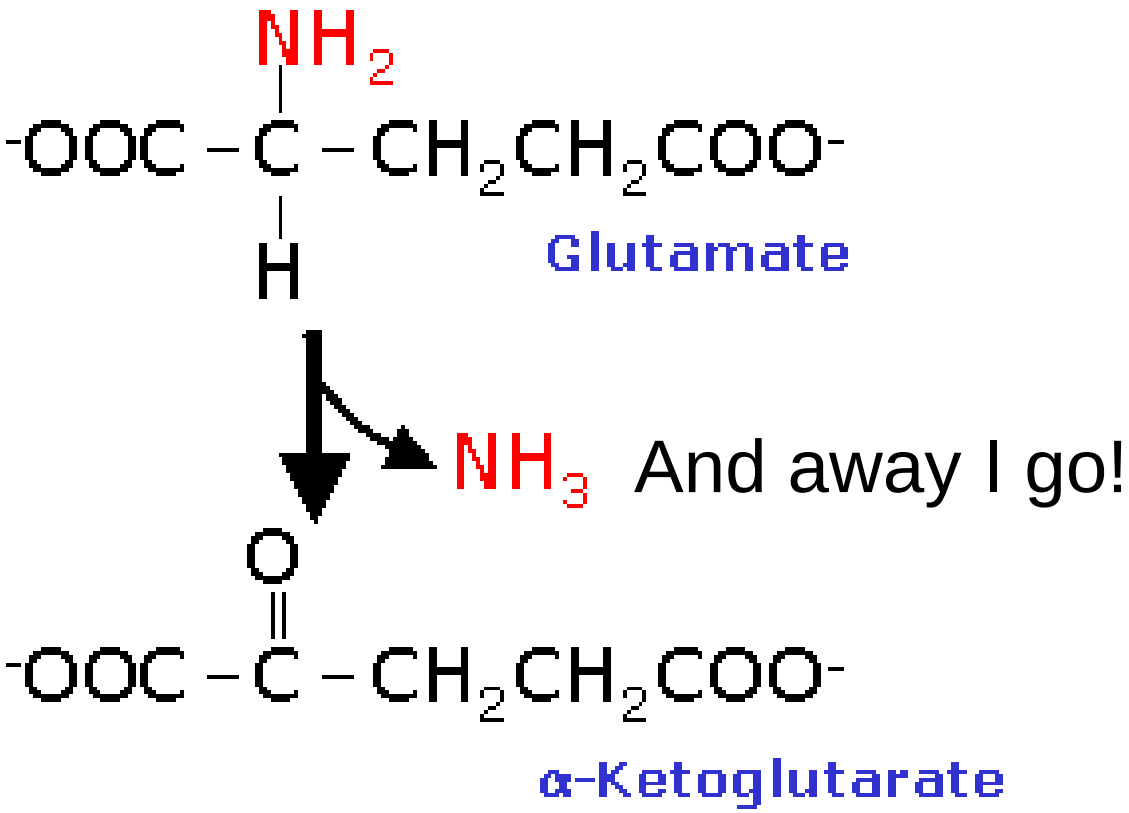
This permits a ***combined*** N excretion pathway for individual amino acids: "trans-deamination."

Glutamate has a central role in the overall control of nitrogen metabolism.



Oxidative Deamination

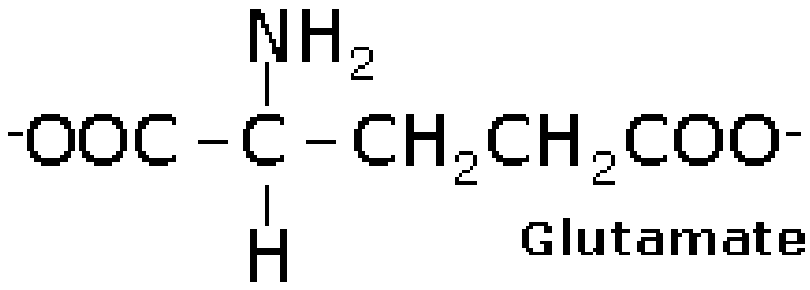
The **glutamate** produced from the transamination step is then deaminated by **oxidative deamination** using the enzyme **glutamate dehydrogenase**:

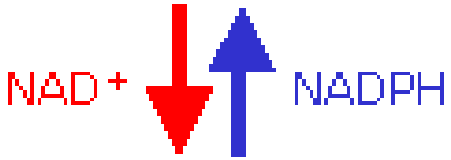


Recycles back to a ketodiacid & releases ammonia

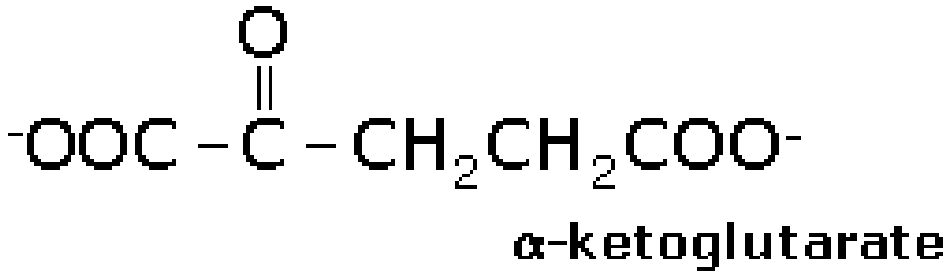
Glutamate dehydrogenase [GluDH]
will reversibly convert
glutamate to **α-ketoglutarate**
and **α-ketoglutarate** to **glutamate**.

Deamination reaction uses **NAD^+**





reverse reaction uses **NADPH**



Uses ***both*** **NAD^+** and **NADPH** – how to regulate it?

Urea cycle:

Ammonium salts (NH_4^+) are toxic compounds.

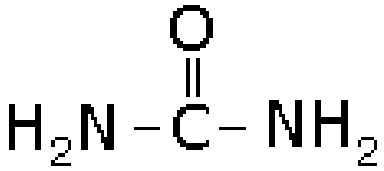
Oxidative deamination converting glutamate to α-ketoglutarate is an easily shifted equilibrium reaction.

Ammonium ions building up favors the synthesis of excessive amounts of glutamate, decreasing the Krebs cycle intermediate

α-ketoglutarate.

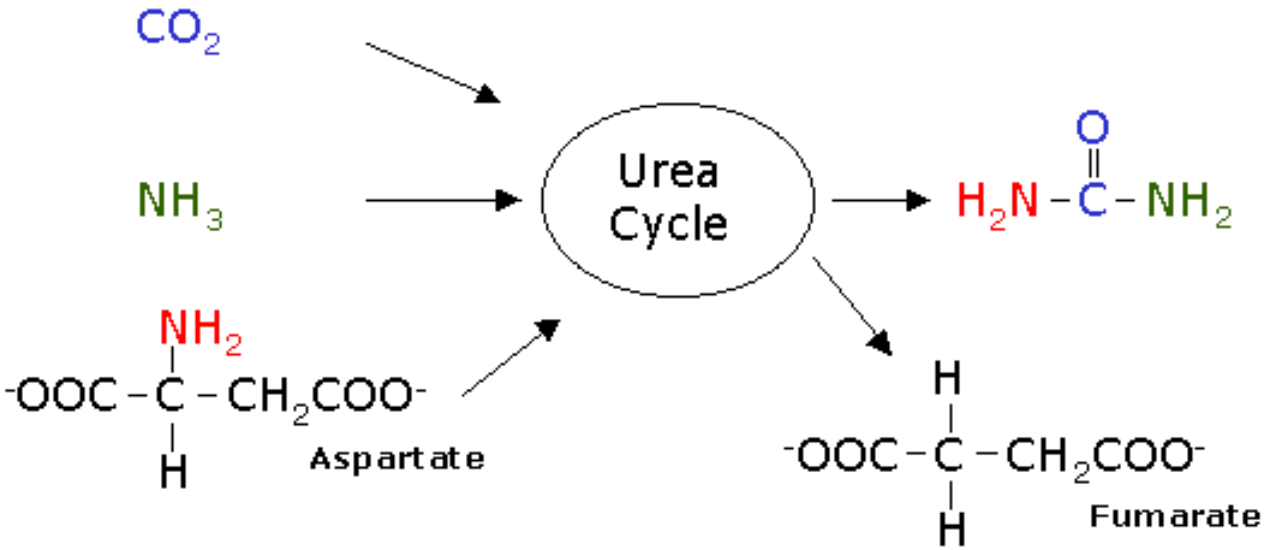
This in turn decreases **ATP production**, and that affects the nervous system.

The answer is Urea:



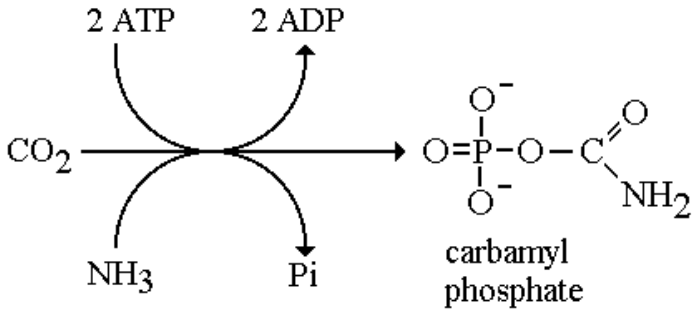
The **inputs** to the urea cycle are NH_3, CO_2 and aspartic acid and ATP.

The **outputs** are urea, ADP and fumaric acid.

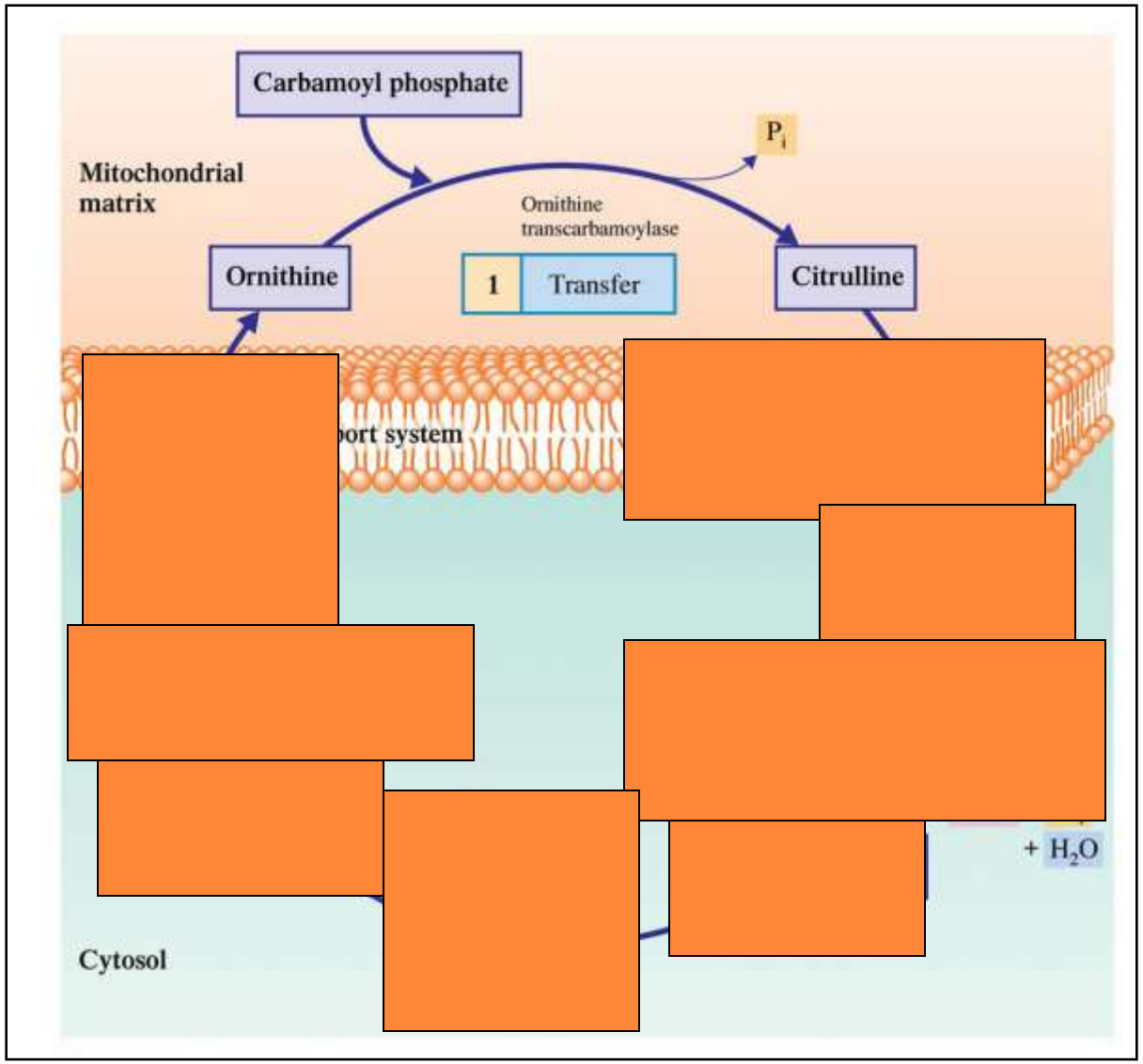


The carbonyl group of urea is derived from **CO_2**

Ammonia contributes one of the amine groups on urea

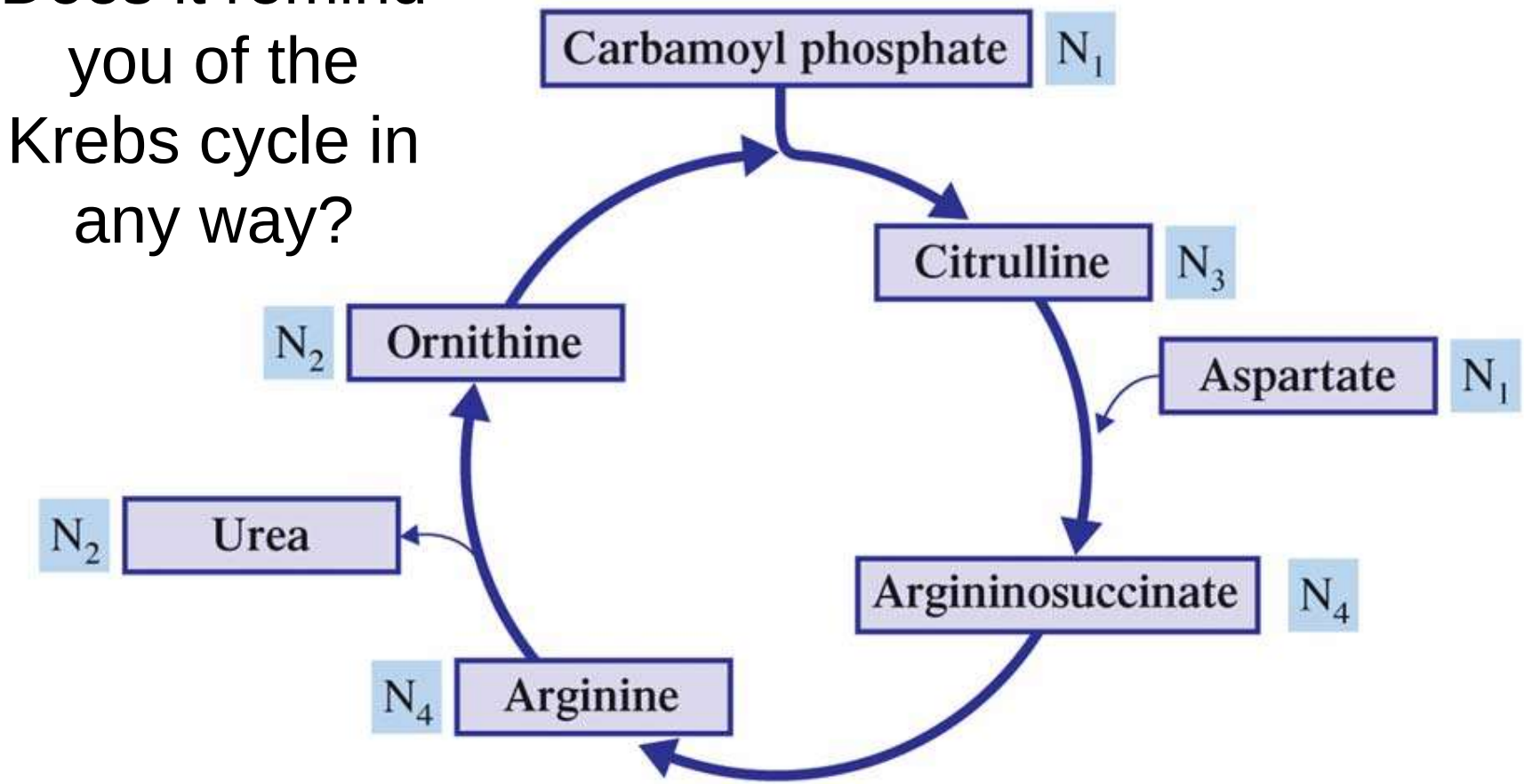


THE FOUR-STEP UREA CYCLE IN WHICH CARBAMOYL PHOSPHATE IS CONVERTED TO UREA.

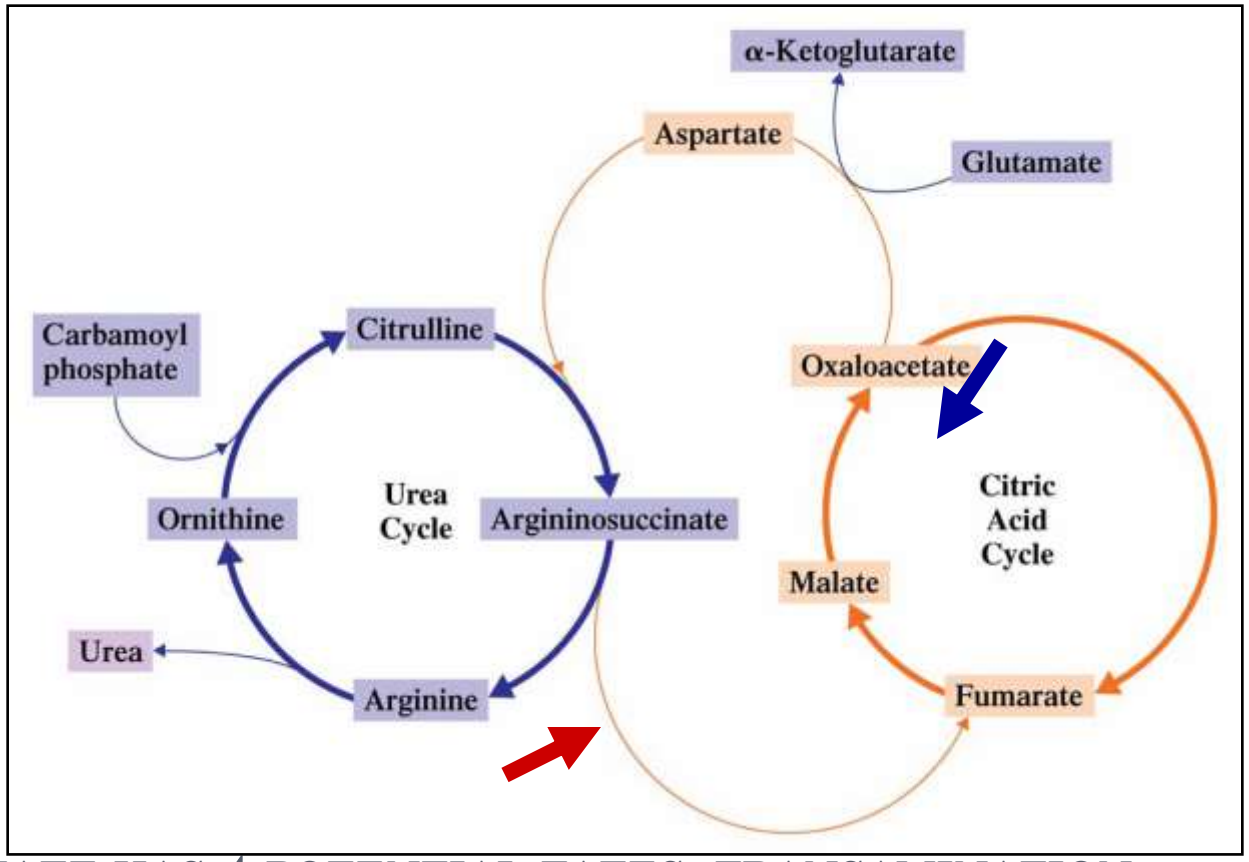


The nitrogen content of the various compounds that participate in the urea cycle.

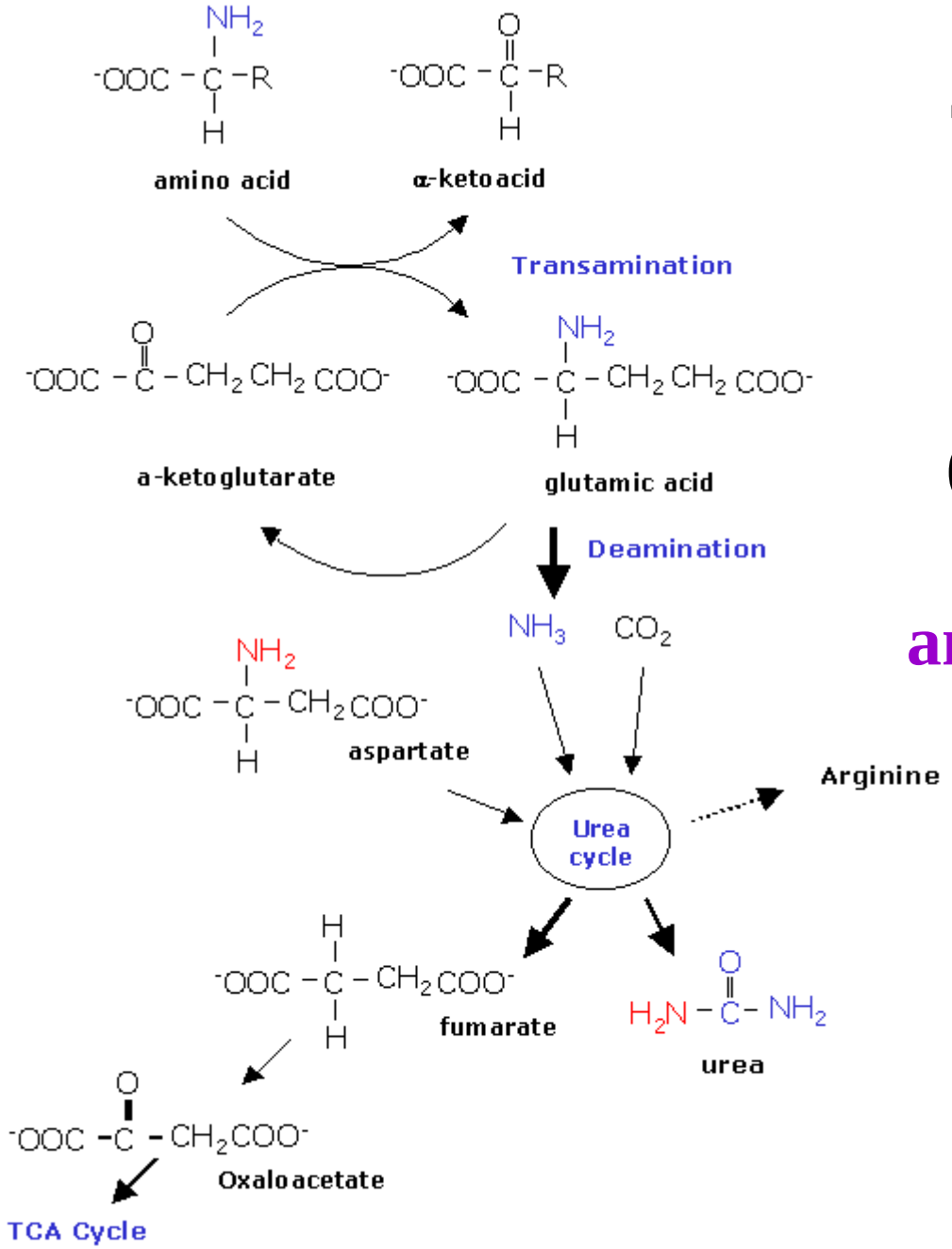
Does it remind you of the Krebs cycle in any way?



KREBS CYCLE. **ASPARTATE** PRODUCED FROM **OXALOACETATE** OF THE KREBS CYCLE ENTERS THE UREA CYCLE.



OXALOACETATE HAS 4 POTENTIAL FATES: TRANSAMINATION; CONVERSION TO GLUCOSE; FORMATION OF CITRATE; CONVERSION TO PYRUVATE



Summary:

Transamination takes off amine groups from amino acids and forms **glutamate** (ionized glutamic acid)

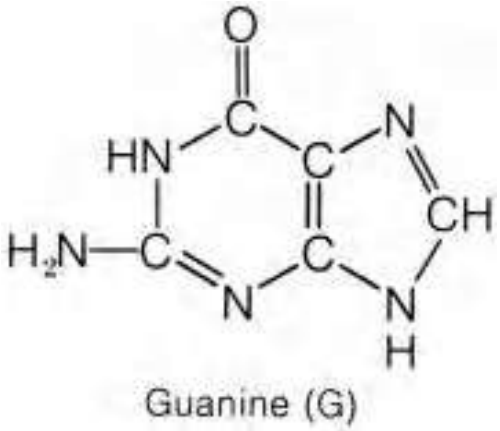
Amine groups form **ammonia** when removed in **deamination**

This combines with **CO_2** & **Aspartate**.

Forms **urea**, **Arginine**, & **Fumarate**

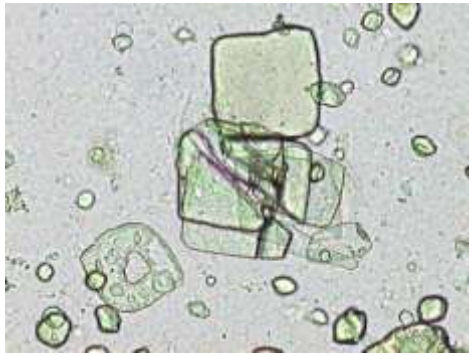
Alternative methods of nitrogen excretion

Aquatic species excrete free **ammonia** through gills.
Terrestrial critters produce **Urea** - very soluble - still needs water for removal via kidneys.
Imposes a minimum daily water requirement.
Spiders excrete **guanine**,
5 nitrogen atoms in a small molecule.

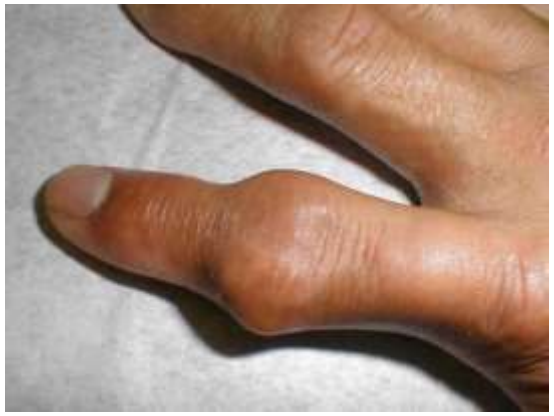


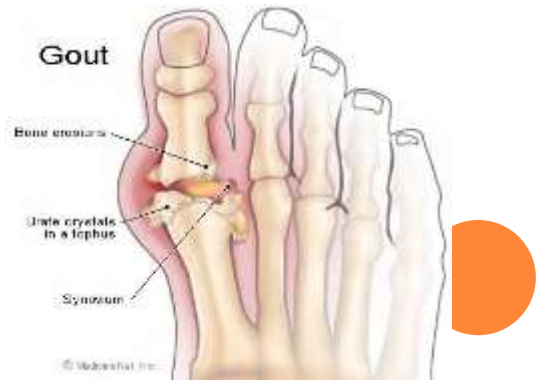
Guanine (G)

Reptiles & birds excrete **uric acid** – very ***insoluble*** purine compound – forms supersaturated solutions. Concentrated urine, supersaturated with uric acid, goes from cloaca into hindgut – uric acid crystalizes & water is reabsorbed.



In humans uric acid deposits crystals & causes gout.





Amino Acid Biosynthesis

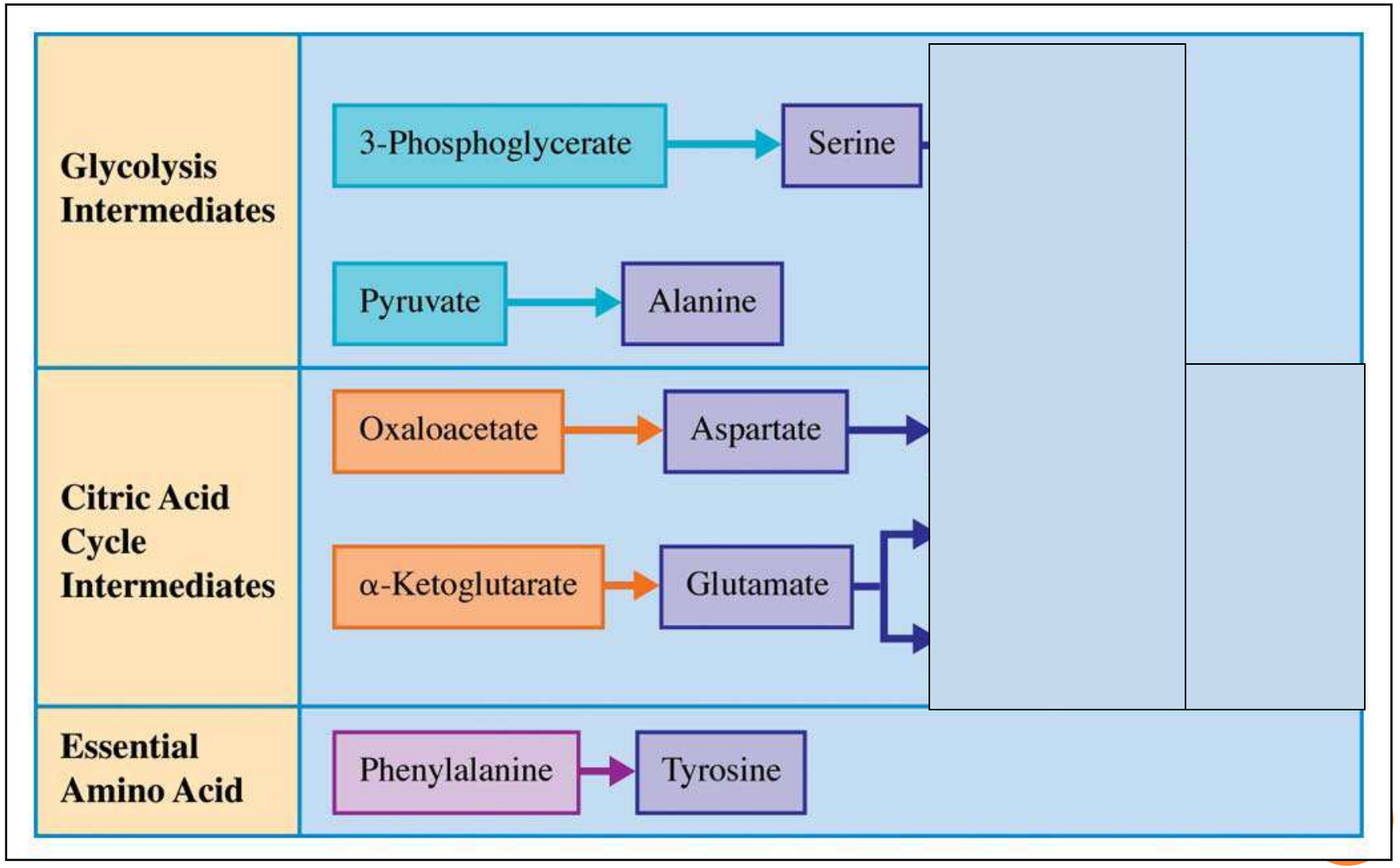
Essential amino acids can be made by plants & bacteria in 7 to 10 steps.
We obtain these amino acids by eating plants.

11 Non-essential amino acids synthesized in 1 to 3 steps.

Use glycolysis intermediates:
3-phosphoglycerate & pyruvate

Krebs cycle intermediates:
Oxaloacetate & **α-ketoglutarate**

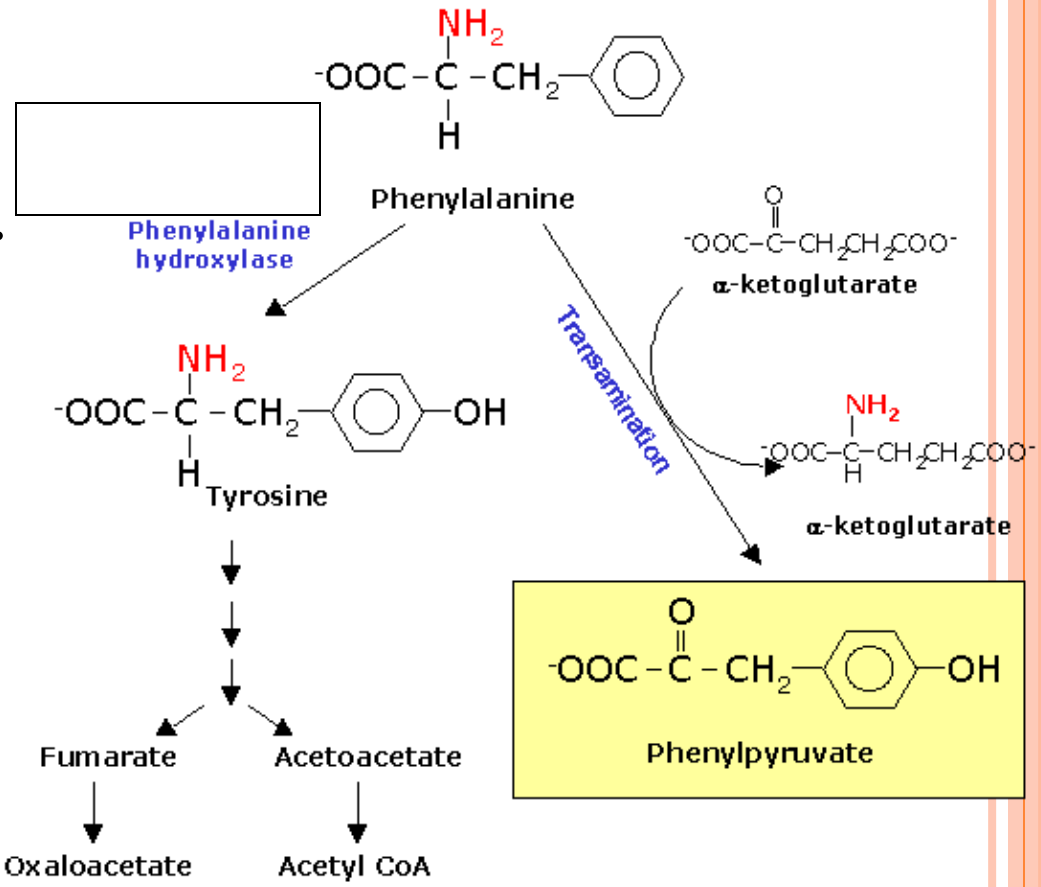
STARTING MATERIALS FOR BIOSYNTHESIS OF 11 **NONESSENTIAL** AMINO ACIDS: 1 STEP, 2 STEPS, OR 3 STEPS



Alanine, aspartate, & glutamate use transamination

Phenylalanine & tyrosine degradation:

Degradation of phenylalanine starts with conversion to tyrosine catalyzed by phenylalanine hydroxylase. Fumarate & acetoacetate are formed. Fumarate is converted to **oxaloacetate** for TCA cycle & acetoacetate is converted to **acetyl CoA**.



Phenylketonuria (PKU):

Defective phenylalanine hydroxylase – **phenylalanine** accumulates in body.

Phenylalanine is transaminated to **phenylpyruvate**.

Accumulation of phenylpyruvate leads to severe mental retardation in infants.

Persons suffering from phenylketonuria should not consume foods containing high levels of phenylalanine, such as aspartame.

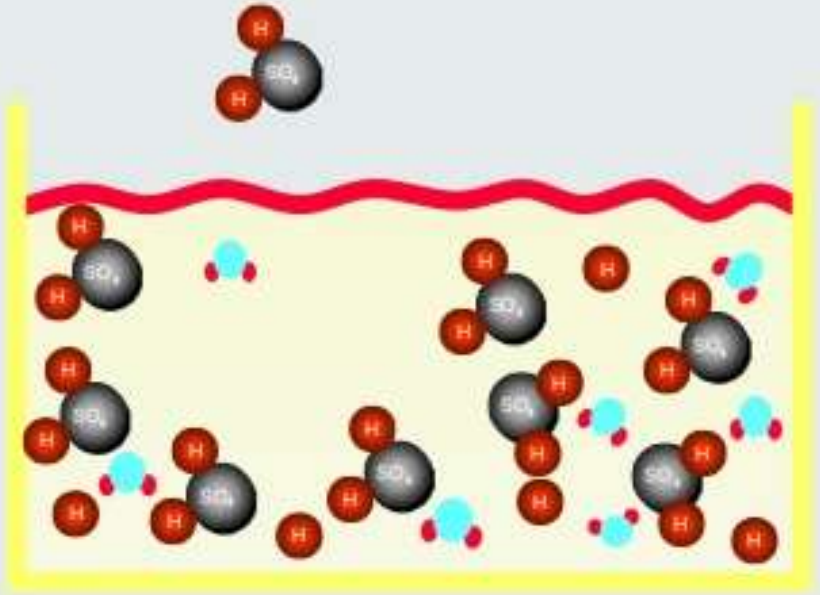
ACID-BASE BALANCE

BY: Mrs. C. Sathyalakshmi

Associate Professor Department of FSN

ACIDS

- Hydrogen containing substances which dissociate in solution to release H^+
- Any ionic or molecular substance that can act as a proton (H^+) donor.
  - Strong acid : HCl, H_2SO4, H_3PO4.
  - Weak acid : H_2CO3, CH_3COOH.



Metabolic Sources of Acids

- **VOLATILE ACIDS (20,000mEq/day):**

➢ Produced by oxidative metabolism of CHO,Fat,Protein

➢ Average **15000-20000** mmol of CO_2 per day

➢ Excreted through **LUNGS** as CO_2 gas

- **FIXED ACIDS (1 mEq/kg/day)**

➢ Acids that do not leave solution, once produced they remain in body fluids until eliminated by **KIDNEYS**

Eg: Sulfuric acid, Phosphoric acid, Organic acids

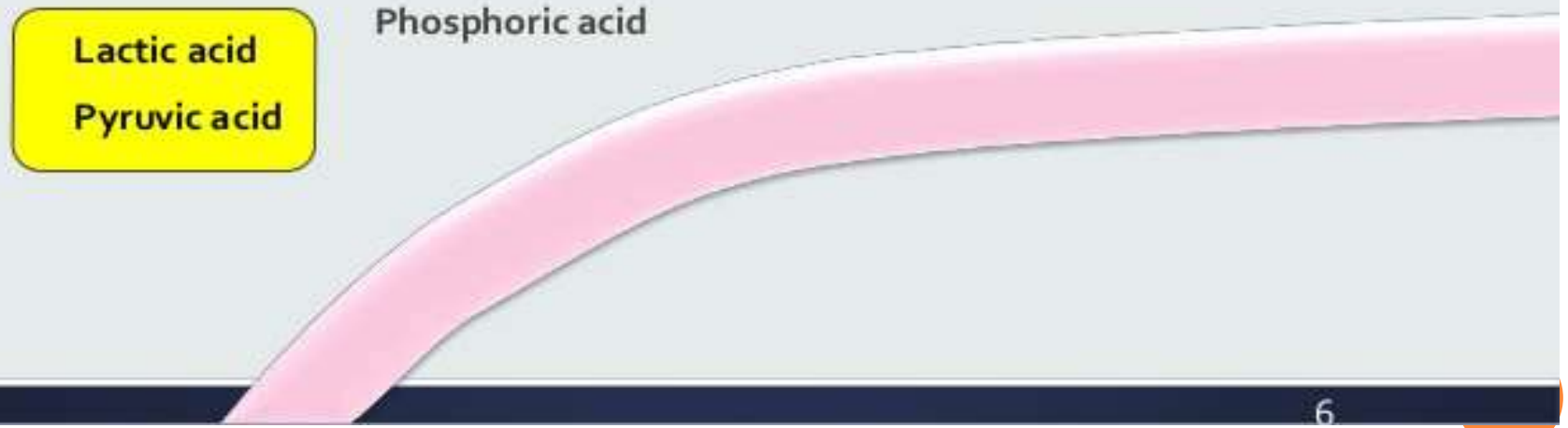
✓ Are most important fixed acids in the body

✓ Are generated during catabolism of:

- amino acids(oxidation of sulfhydryl groups of cystine, methionine)
- Phospholipids(hydrolysis)
- nucleic acids

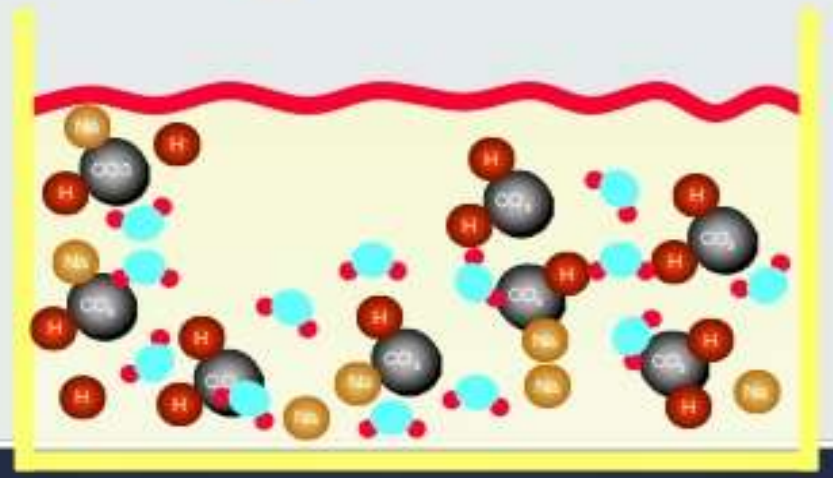
ACIDS

- *Physiologically important acids include:*
  - Carbonic acid (H_2CO_3)
  - Phosphoric acid (H_3PO_4)
  - Pyruvic acid ($C_3H_4O_3$)
  - Lactic acid ($C_3H_6O_3$)



Bases

- Bases can be defined as:
  - ♥ A proton (H^+) acceptor
  - ♥Any ionic or molecular substance that can act as a proton acceptor.
    - ♥Strong alkali : NaOH, KOH.
    - ♥Weak alkali : $NaHCO_3$, NH_3, CH_3COONa.



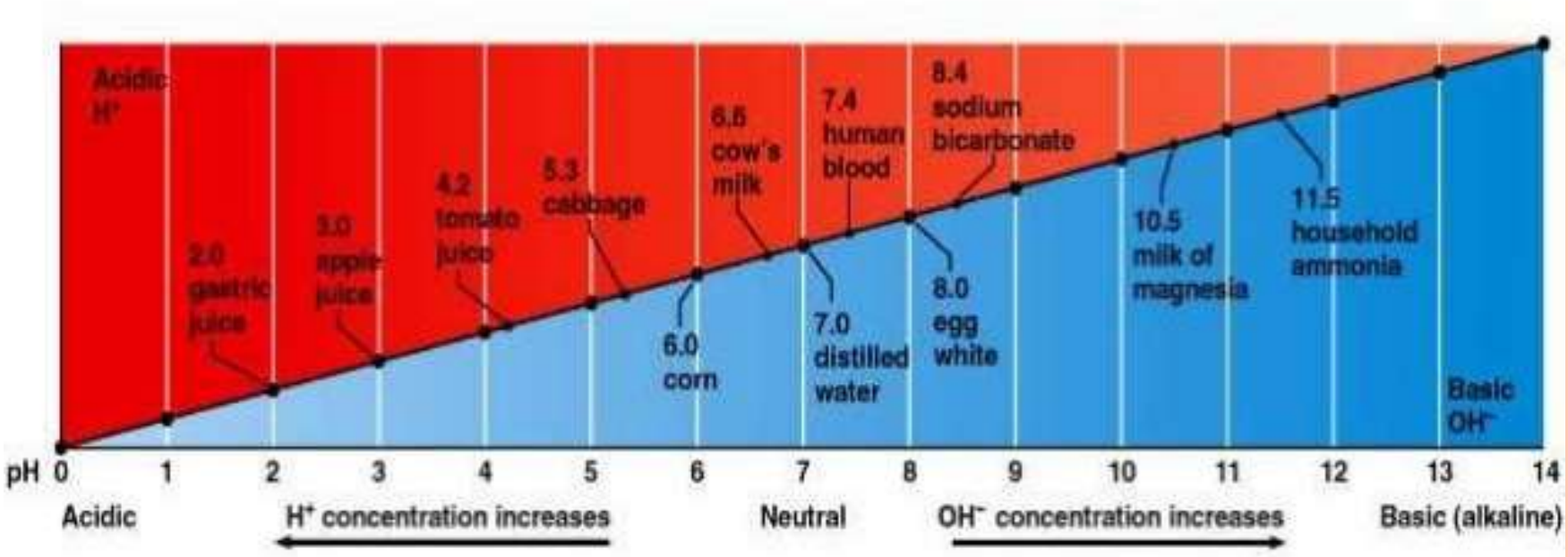
Bases

- *Physiologically important bases include:*
  - Bicarbonate (HCO_3^-)
  - Biphosphate (HPO_4^{-2})

Buffer

- Ability of an acid-base mixture to resist sudden changes in pH is called its buffer.
- Buffer is a solution of weak acid and its corresponding salt.
- Buffer resists a change in pH when a small amount of acid or base is added to it.
- By buffering mechanism a strong acid (or base) is replaced by a weaker one.

pH


Acidic
H+
2.0
gastric
juice
3.0
apple
juice
4.2
tomato
juice
5.3
cabbage
6.5
cow's
milk
7.4
human
blood
8.4
sodium
bicarbonate
10.5
milk of
magnesia
11.5
household
ammonia
6.0
corn
7.0
distilled
water
8.0
egg
white
Basic
OH-
pH 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Acidic
H+ concentration increases
Neutral
OH- concentration increases
Basic (alkaline)

pH

- pH is the negative log of hydrogen ion concentration.

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

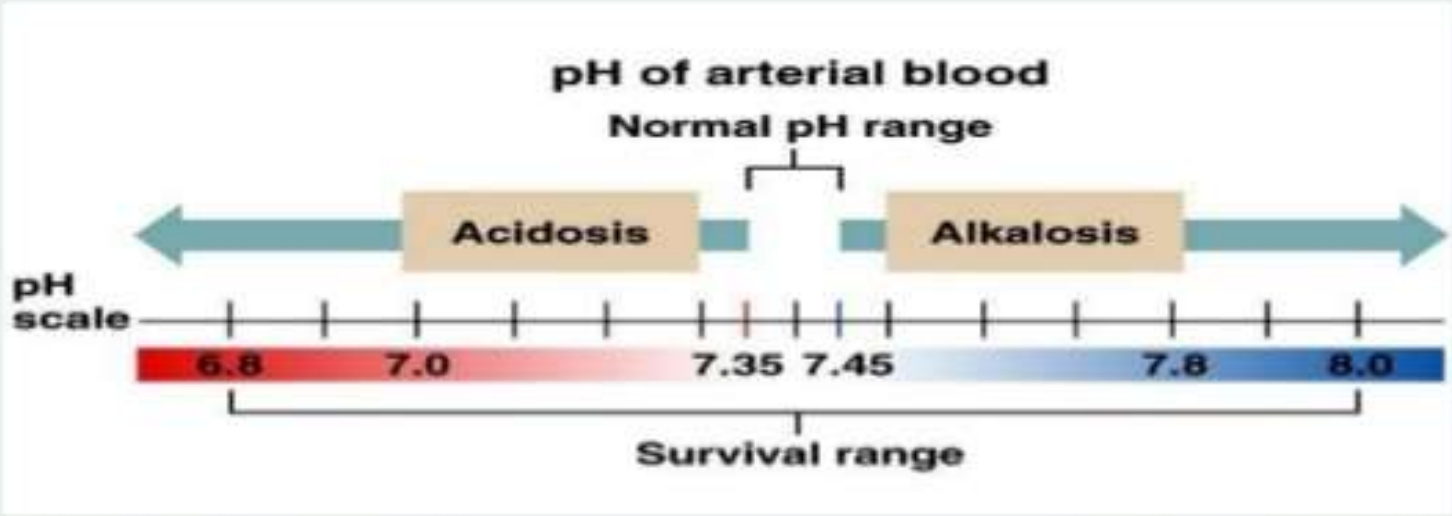
- If $[H^+]$ is high, the solution is acidic; pH < 7
- If $[H^+]$ is low, the solution is basic or alkaline ; pH > 7

Table 2.5 Hydrogen Ion Concentrations and pH

Grams of H^+ per Liter	pH	
0.00000000000001	14	↑ Increasingly basic
0.0000000000001	13	
0.000000000001	12	
0.00000000001	11	
0.0000000001	10	
0.000000001	9	
0.00000001	8	
0.0000001	7	Neutral–neither acidic nor basic
0.000001	6	
0.00001	5	
0.0001	4	
0.001	3	Increasingly acidic ↓
0.01	2	
0.1	1	
1.0	0	

The Body and pH

- Homeostasis of pH is tightly controlled
- Extracellular fluid = 7.4
- Blood = 7.35 – 7.45
- < 6.8 or > 8.0 death occurs
- Acidosis (acidemia) below 7.35
- Alkalosis (alkalemia) above 7.45



- Two types of acids are produced in the body:

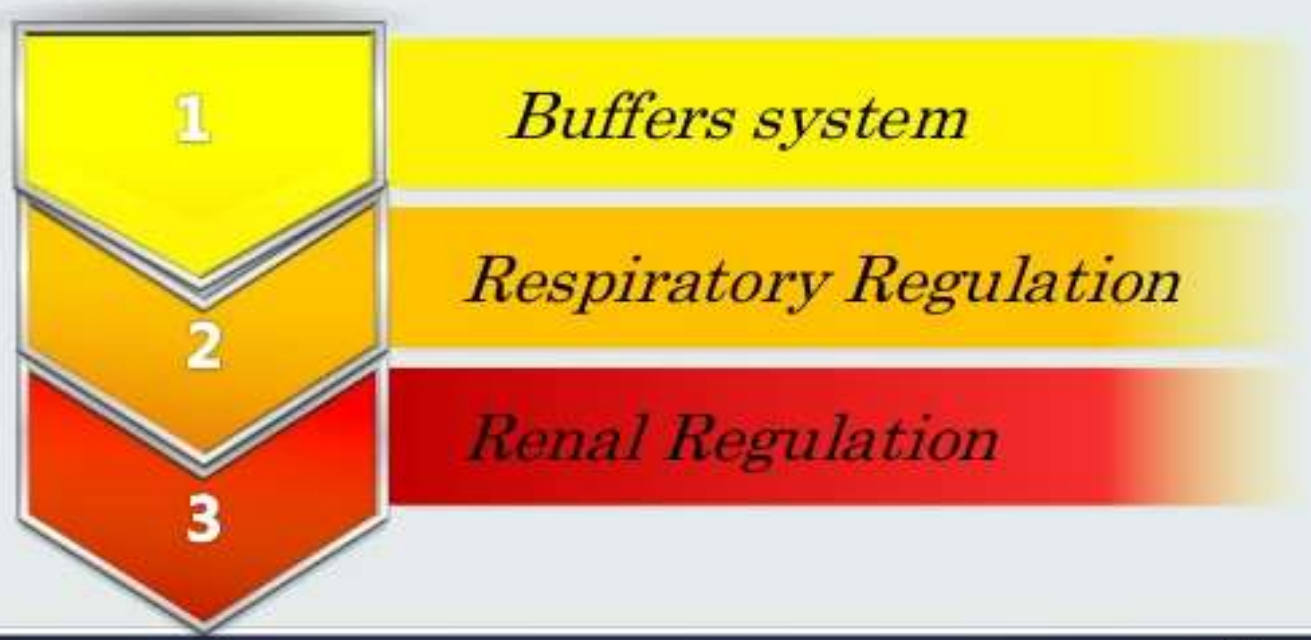
✓ **Volatile acids :** Carbonic acid formed from CO_2

✓ **Non-volatile acids:** metabolism of protein, CHO, lipids

e.g. lactic acid, keto acid, sulphuric acids

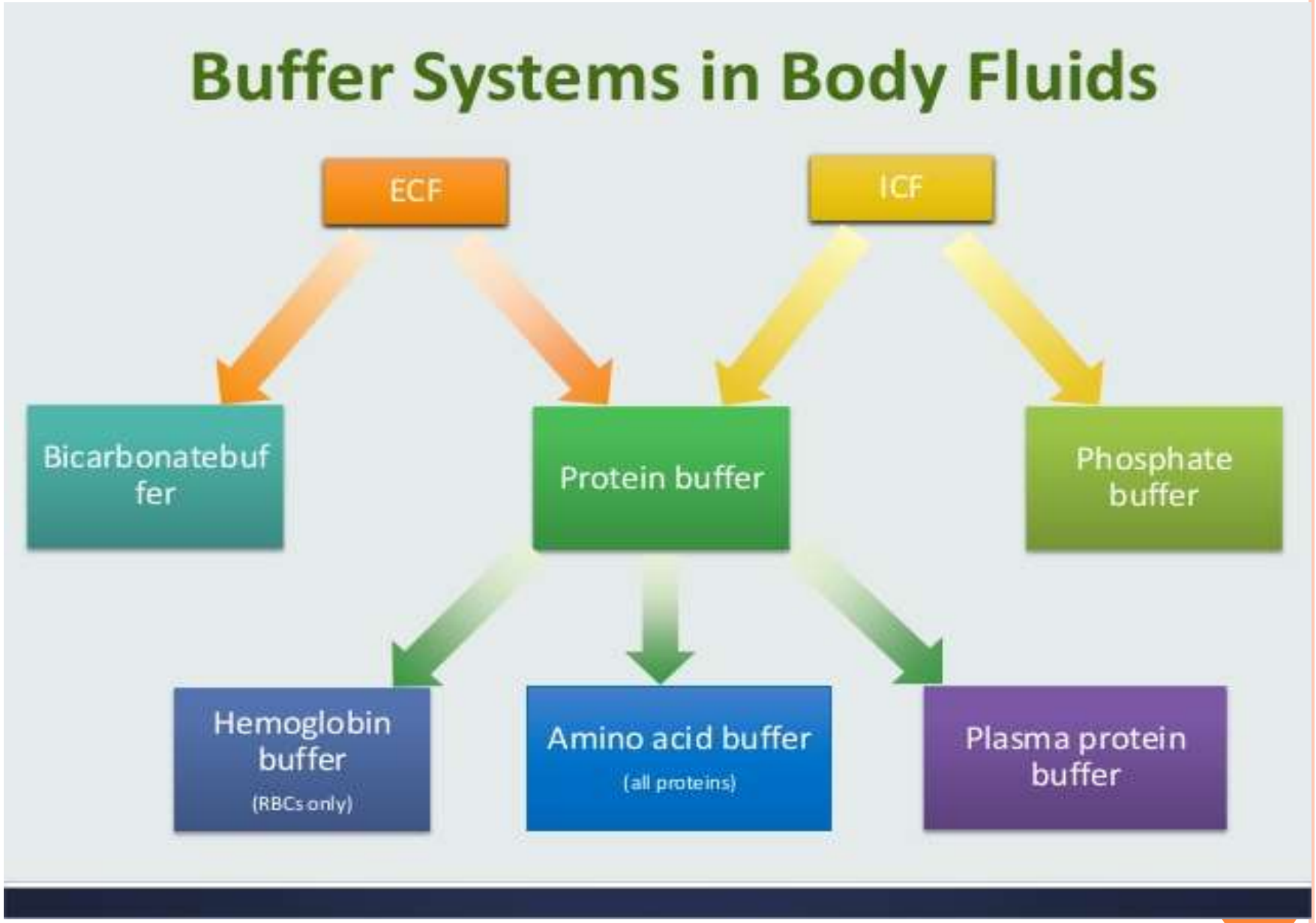
Regulation of blood pH.

- To maintain the blood pH at 7.35 –7.45, there are three primary systems that regulate the hydrogen ion concentration in the body fluids.
- These are:



Buffer system

- These are the first line of defense against pH change
- React very rapidly within seconds.
- The buffer systems of the blood, tissue fluids and cells; immediately combine with acid or base to prevent excessive changes in pH.
- It do **not eliminate** hydrogen ions from the body or add them to the body but only keep them tied up until balance can be re-established.
- Three major chemical buffer systems
  - Bicarbonate buffer
  - Phosphate buffer
  - Protein buffer


Buffer Systems in Body Fluids
ECF
ICF
Bicarbonatebuf fer
Protein buffer
Phosphate buffer
Hemoglobin buffer
(RBCs only)
Amino acid buffer
(all proteins)
Plasma protein buffer

Bicarbonate Buffer System ($NaHCO_3^-/H_2CO_3$)

- Bicarbonate Buffer is the most important extracellular fluid buffer.
- Bicarbonate Buffer constitute, Sodium bicarbonate ($NaHCO_3$-) and carbonic acid (H_2CO_3).
- Carbonic acid dissociates into hydrogen and bicarbonate ions.
- Under normal circumstances there is much more bicarbonate present than carbonic acid (the ratio is approximately 20:1).

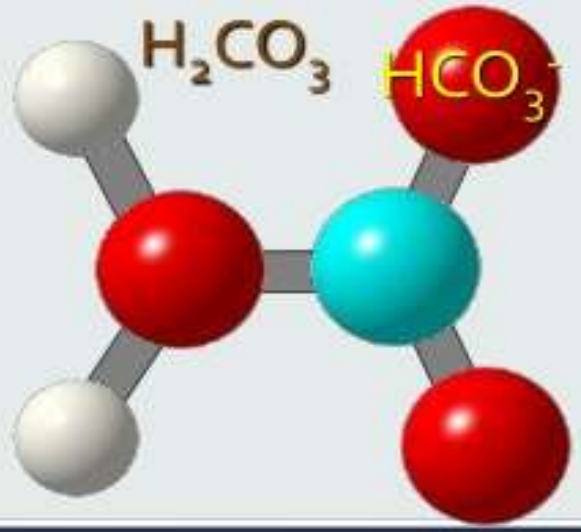
$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Mechanism of action of bicarbonate buffer

- When pH is rising….

$$H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons CO_2 + H_2O$$

- Hydrogen ions *generated* by metabolism or by ingestion react with bicarbonate base to form more carbonic acid

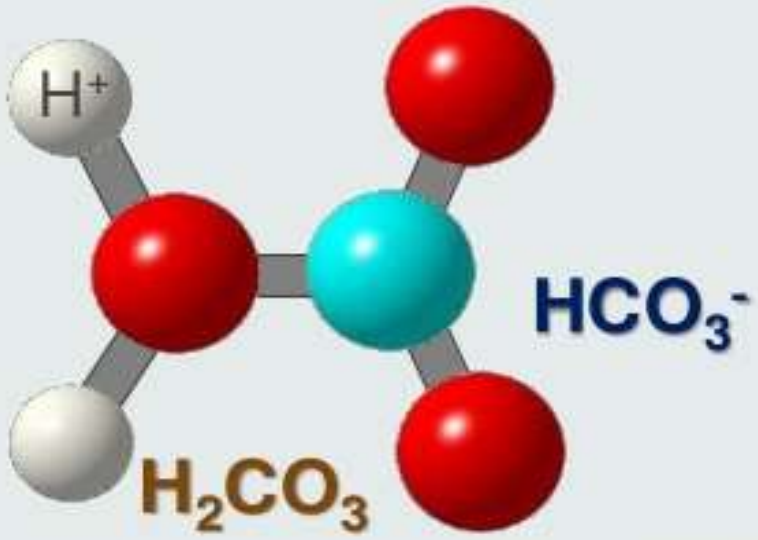


Mechanism of action of bicarbonate buffer

- When pH is falling….

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

♠Hydrogen ions *generated* by metabolism or by ingestion react with bicarbonate base to form more carbonic acid



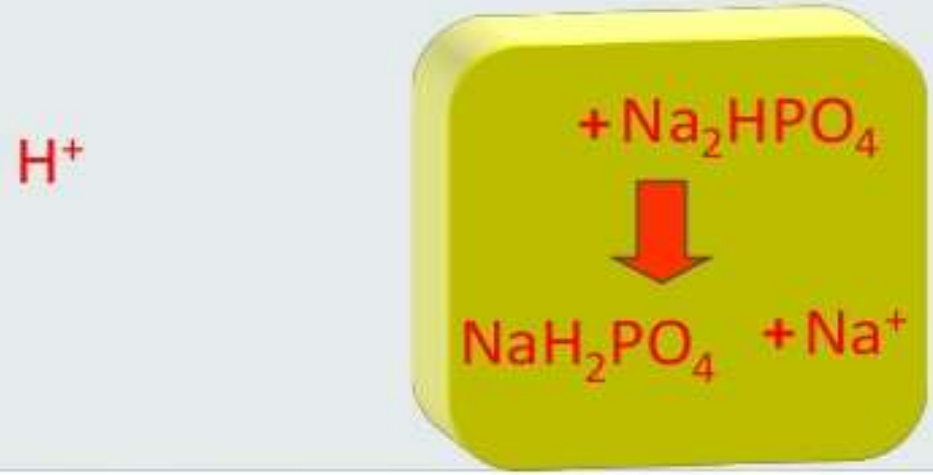
Importance of Bicarbonate Buffer

- Present in high concentration – (accounts 40-50%)
- Have alkali reserve – (ratio of HCO_3^- to H_2CO_3 is 20:1)
- Concentration of component can be regulated by
  - The base constituent, bicarbonate (HCO_3^-), is regulated by the kidney
  - While the acid part, carbonic acid (H_2CO_3), is under respiratory regulation

PHOSPHATE BUFFER SYSTEM (Na_2HPO_4/ NaH_2PO_4)

$$Na_2HPO_4 + H^+ \rightleftharpoons NaH_2PO_4 + Na^+$$

- It is not important as blood buffer.
- It plays a major role in buffering **renal tubular fluid** and the **intracellular fluid.**
- The normal ratio of Na_2HPO_4 and NaH_2PO_4 in plasma is 4:1 and this is kept constant by the help of kidneys for which phosphate buffer system is directly related to the kidneys.



PHOSPHATE BUFFER SYSTEM

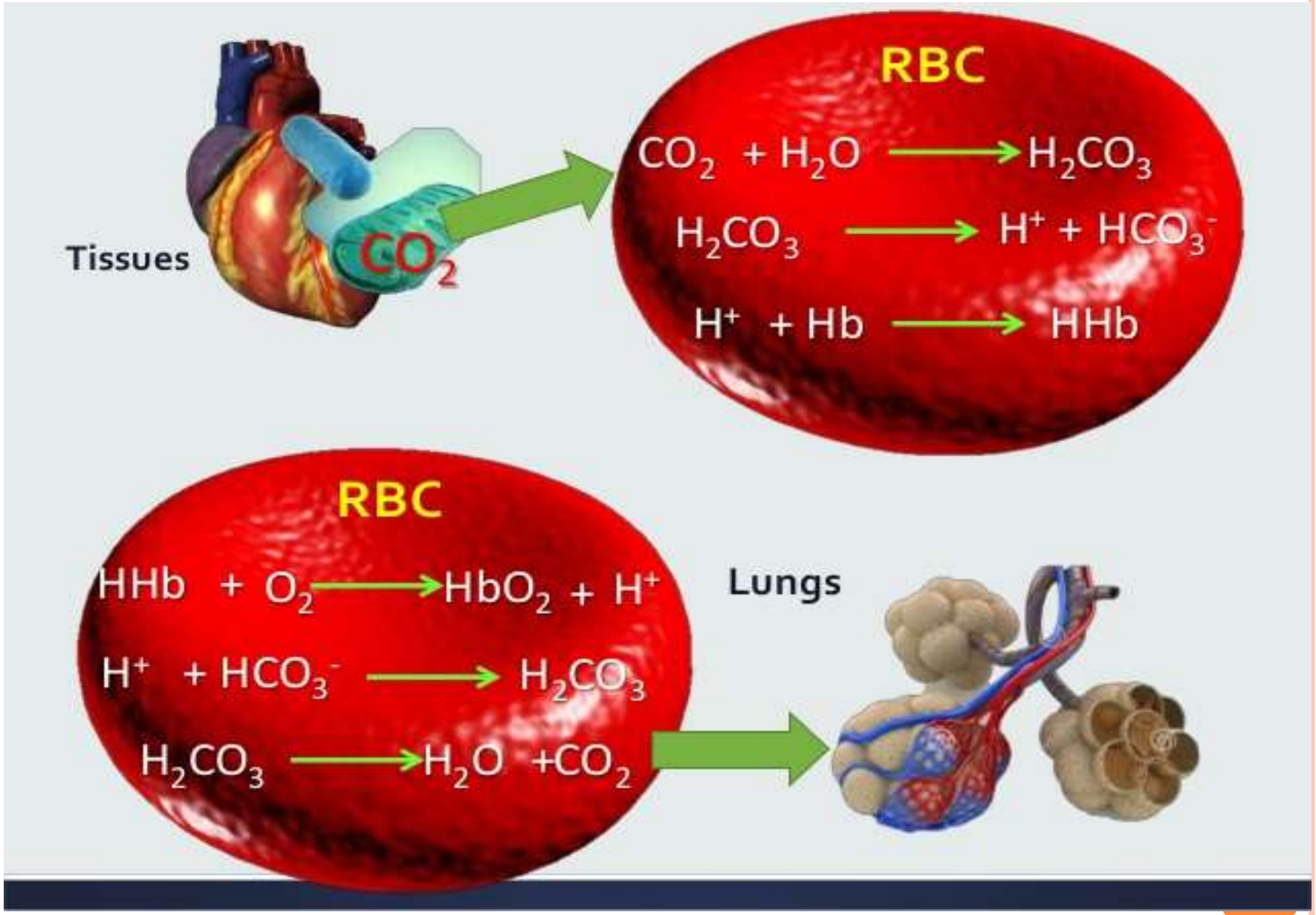
- Regulates **pH** within the cells and the urine
- Phosphate concentrations are higher intracellular and within the kidney tubules.
- More phosphate ions are found in tubular fluids
- More powerful than bicarbonate buffer system

PROTEIN BUFFER SYSTEM

- In the blood, plasma proteins especially albumin act as buffer because:
- – It contain a large number of dissociable
  - acidic (COOH) &
  - basic (NH_2) groups.
- – In acid solution, NH_2 accept excess H+
- – In basic solutions, COOH give up H+
- – Other important buffer groups of proteins in the physiological pH range, are the **imidazole groups of histidine**.

Hemoglobin buffer

- Hemoglobin buffers in RBC plays an important role in **respiratory regulation** of pH.
- It helps in **transport of metabolically** produced **CO_2** from cell to lungs for excretion.
- As hemoglobin releases **O_2** it gains a great affinity for **H^+**


Tissues
CO_2
RBC
$CO_2 + H_2O \rightarrow H_2CO_3$
$H_2CO_3 \rightarrow H^+ + HCO_3^-$
$H^+ + Hb \rightarrow HHb$
RBC
$HHb + O_2 \rightarrow HbO_2 + H^+$
$H^+ + HCO_3^- \rightarrow H_2CO_3$
$H_2CO_3 \rightarrow H_2O + CO_2$
Lungs

FLUID AND ELECTROLYTES BALANCE

CONTENTS:

- Introduction
- Normal Anatomy and Physiology
- Regulation of water intake
- Electrolyte balance
- IV Fluids

INTRODUCTION:

- When unicellular organisms evolved into multicellular organism, they faced several physiological challenges including the maintenance of water and salt balance in an environment.

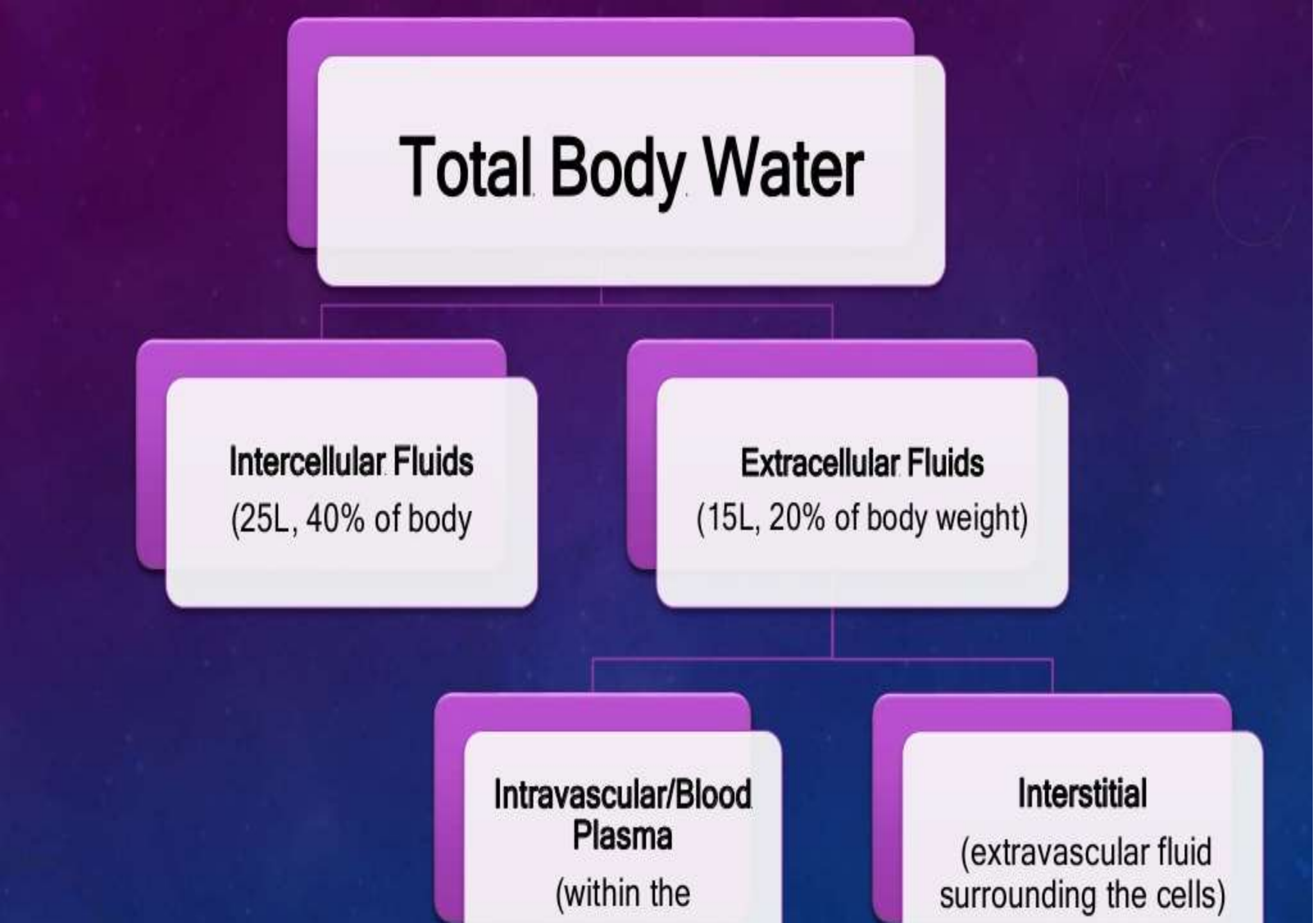
- Rather than being surrounded by an external sea, they carried their own internal sea or Extracellular Fluid (ECF), in which their cells could bathe in a constant chemical environment, which the great French physiologist Claude Bernard called the 'milieu interieur'.

Normal anatomy and physiology

- Water comprises 60%(40L) of the body weight of an average adult.
- the percentage is lower in obesity, since adipose tissue contains less water than lean tissue.

- Fluid balance refers to the proper levels of water and electrolytes being in the various body compartments according to their needs.

- Osmotic pressure (created by the dissolved electrolytes in body fluids) and hydrostatic pressure (created by the water in body fluids) are the main forces behind any molecular movement between body compartments.


Total Body Water
Intercellular Fluids
(25L, 40% of body
Extracellular Fluids
(15L, 20% of body weight)
Intravascular/Blood Plasma
(within the
Interstitial
(extravascular fluid surrounding the cells)

ICF	Rich in K^+, Mg^{++}, HPO_4^{2-}, SO_4^{2-}, and protein anions.
ECF	Rich in Na^+, Cl^-, HCO_3^-, and Ca^{++}.

Key to fluids:

= Blood plasma

= Interstitial fluid

= Intracellular fluid

Key to symbols:

Na^+ = Sodium

K^+ = Potassium

Ca^{2+} = Calcium

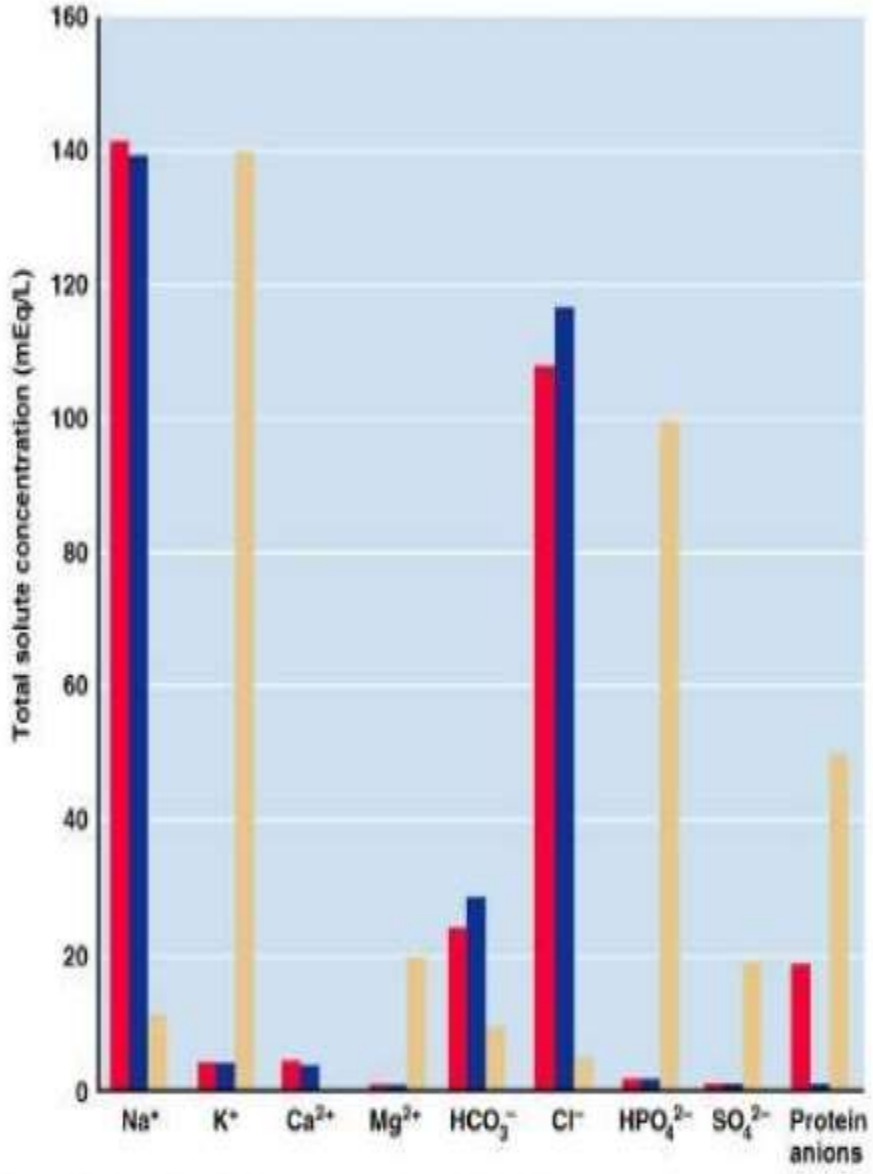
Mg^{2+} = Magnesium

HCO_3^- = Bicarbonate

Cl^- = Chloride

HPO_4^{2-} = Hydrogen phosphate

SO_4^{2-} = Sulfate



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WATER BALANCE

Intake (ml)		Output (ml)	
Water from beverages	1200	Urine	1500
Water from solid food	1000	Insensible losses from skin and lungs	900
Metabolic water from oxidation	300	Faeces	100

Excess water loss

- Fever : 100 ml / degree fever / day
- Tracheostomy (unhumidified air) : >1.5 L / day
- Children - 1.5 to 2 L/m2

REGULATION OF WATER INTAKE

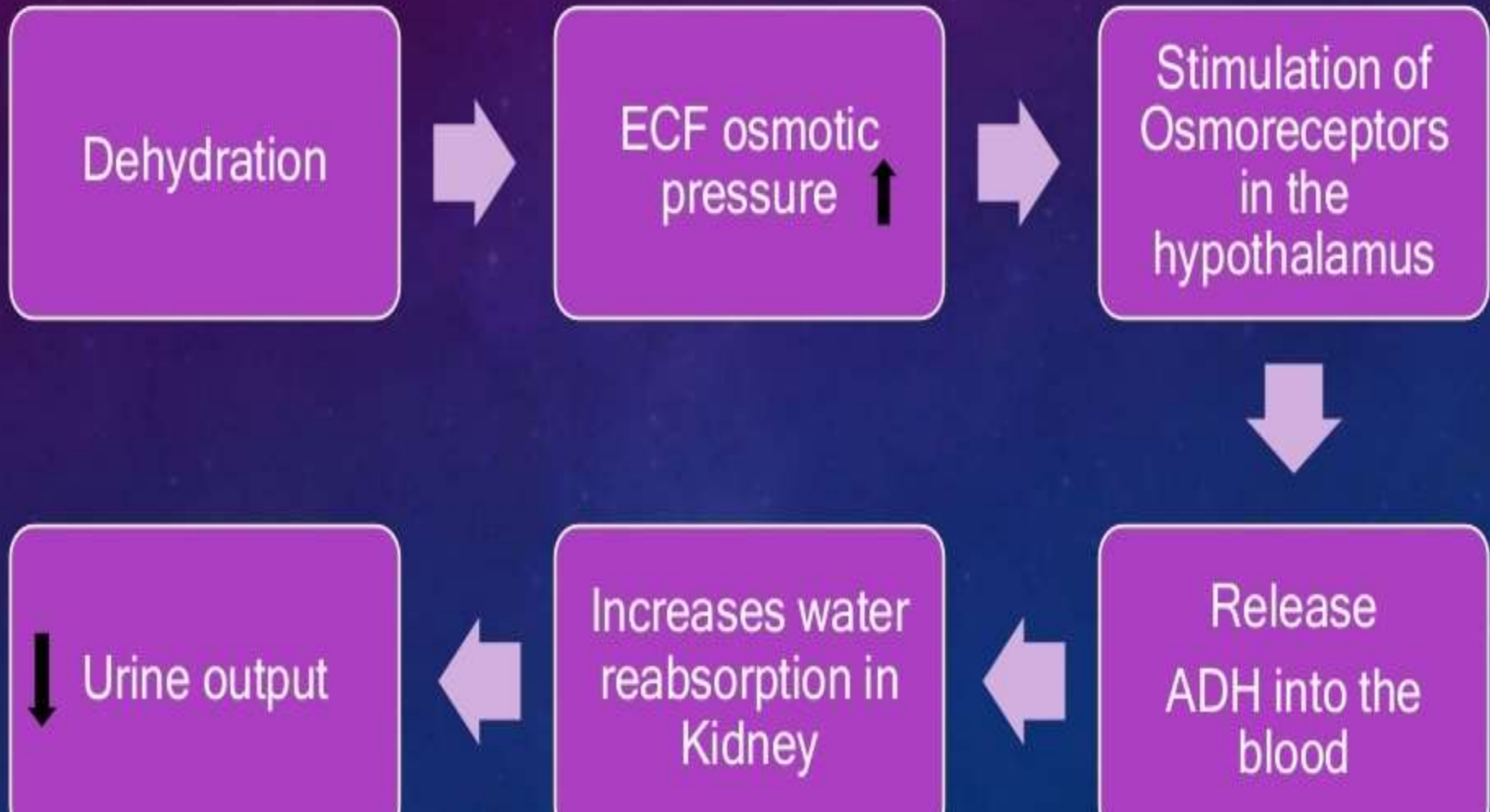
- The body loses as little as 1% of its water.
- An increase in osmotic pressure of extracellular fluid due to water loss stimulates osmoreceptors in the thirst center (hypothalamus).
- Activity in the hypothalamus causes the person to be thirsty and to seek H2O.

- Drinking and the resulting distension of the stomach by water stimulants nerve impulses that inhibit the thirst center.

- water is absorbed through the wall of the stomach, small intestine, and large intestine.

- The osmotic pressure of extracellular fluid returns to normal.

EVENTS IN REGULATION OF WATER OUTPUT



ELECTROLYTE BALANCE

- Electrolytes are chemical substances that release cations (positively charged ions) and anions (negatively charged ions) when they are dissolved in water.

- The most important electrolytes include Na^+, K^+, Cl^-, Ca^{+2}, and HPO_4.

BODY FLUID & ELECTROLYTES DISTURBANCES

VOLUME CHANGES	CONCENTRATION CHANGES	COMPOSITION CHANGES
• Hypovolemia • Hypervolemia	• Hyponatremia • Hypernatremi	• Potassium Abnormalities • Calcium Abnormalities • Magnesium Abnormalities

VOLUME CHANGES

HYPOVOLEMIA

- diminished **ECF.**
- **CAUSES :-**
- GI losses from vomiting,
- nasogastric suction,
- diarrhea,
- fistula drainage
- soft-tissue injuries

HYPERVOLEMIA

- INCRESED **ECF.**
- **CAUSES :-**
- Iatrogenic or Secondary to renal insufficiency
- Cirrhosis

HYPOVOLEMIA

- **SIGNS**
- Dry oral mucus membrane
- Tachycardia
- Dry axilla
- Diminished skin turgor

HYPERVOLEMIA

- **SIGNS**
- **CVS:** elevated JVP, venous distension - pulmonary edema.
- **GI:** edema of bowel
- **Tissue:** pitting edema - ascites

HYPOVOLEMIA

- **MANGAEMENT**
- Haemorrhage - whole blood transfusion 1st line of choice.
  - 6% dextran
  - 6% hetastarch
  - 5% albumin
  - 3.5% urea-bridged gelatin
  - 1lt of ringer's lactate
- Burn - 4ml/kg/% of body area

HYPERVOLEMIA

- **MANAGEMENT**
- Prevention is the best way
- Diuretics
- Increase oncotic pressure: or albumin infusion (may followed by diuretics)
- Dialysis

CONCENTRATION CHANGES

HYPERNATRIUM

- Asymptomatic
-
- Symptomatic (**Na>160 mEq/L**)

HYPONATRIUM

- Na^+ is the most abundant positive ion of ECF compartment and is critical in determining the ECF and ICF osmolality.
- Normal amount **135-145 mEq/l.**
- Sign & symptoms : **<120 mEq/l.**

HYPERNATRIUM

- **SIGNS & SYMPTOMS**
- CNS: Restlessness, ataxia, irritability, tonic spasms, delirium, seizures, coma
- Musculoskeletal: Weakness
- CVS: Tachycardia, hypotension, syncope

HYPONATRIUM

- **SIGNS & SYMPTOMS**
- CNS: confusion, lethargy, headache, seizure, coma
- GI: nausea, vomiting
- Skeletal system : muscle twitches
- **TREATMENT**
- Diuretics like Frusemide

COMPOSITION CHNAGES

POTTASIUM ABNORMALITIES

HYPOKALEMIA

- Serum K^+ < 3.5 mEq /L

Etiology :

- Excessive potassium excretion
- Hyperaldosteronism

Treatment :

- KCl 10 mEq/L/hr IV - pripherally
- KC1 20 mEq/L/hr IV - centrally

HYPERKALEMIA

- Serum K^+ > 5.1 mEq /L

Etiology :

- Blood transfusions
- Acidosis
- Impaired excretion of potassium

Treatment :

- IV Dextrose 50gms
- Sodium bicarbonate 50-100mmol

CALCIUM ABNORMALITIES

- Majority of the 1000 to 1200gm of calcium in the average-sized adult is found in the bone .
- Normal daily intake of calcium is 1 to 3 gm.
- Normal serum level = 8.8-10.5 mg/dl
- Ionized portion (1.2 mg/dl) is responsible for neuromuscular stability
- Most is excreted via the GI tract

HYPOCALCEMIA

- Serum calcium level <8.8 mg/dl

CAUSES:

1) Acute pancreatitis,
2) Massive soft-tissue infections
3) Acute and chronic renal failure,
4) Pancreatic and small-bowel fistulas,
5) Hypoparathyroidism

HYPERCALCEMIA

- Serum calcium level >10.5mg/dl

CAUSES:

1) Hyperparathyroidism
2) Cancer - PTH-like peptide in malignancies

HYPOCALCEMIA	HYPERCALCEMIA
1. Hypotension	1. Hypertension & Bradycardia
2. Anxiety	2. Constipation & Anorexia
3. Psychosis	3. Nausea & Vomiting
4. Paresthesia	4. Pain
5. Laryngeal Spasm	5. Psychosis
6. Numbness And Tingling Tetany With Carpopedal Spasm, Convulsions	6. Weight Loss, Thirst, Polydipsia, And Polyuria
7. Chvosteck & Trousseau's Signs	7. Easy Fatigue, Weakness, Coma

TREATMENT :-

1. IV calcium – 1gm in D5 or NS
2. Oral calcium & vitamin D

MAGNESIUM ABNORMALITIES

- Total body content of magnesium 2000 mEq, about half of which is incorporated in bone.
- Normal daily dietary intake of magnesium is approximately 240 mg
- Normal serum level = 1.5- 2.4 mg/dl
- Deficiency causes impaired repletion of Na^{+} & CA^{2+}

HYPOMAGNESEMIA

- Plasma level less than 1mmol/l

CAUSES:

  - starvation,
  - malabsorption syndromes,
  - GI losses,
  - prolonged IV with magnesium-free solutions
  - Drugs - aminoglycosides.

- **Sign & symptoms** - similar to that of hypocalcemia
- **Treatment** :- IV 49.3% $MgSO_4$ 5-10ml

ACID-BASE BALANCE

- pH - 7.4
- Three primary system regulates acid-base balance in our body :-
  a) Chemical acid-base buffer systems of the body fluids.
  b) Respiratory centre
  c) Kidneys.
- A pH < 7.4 - Acidosis
- A pH > 7.4 - alkalosis

SIGNS AND SYMPTOMS

- **Acidosis** -
  a) Increased respiratory rate
  b) Increased in heart rate
  c) Cyanosis
  d) Fruity smell
- **Alkalosis** -
  a) Decreased respiratory rate

TREATMENT

- **Acidosis** :-
  a) 7.5% sodium bicarbonate iv
  b) Sodium lactate
  c) Sodium gluconate
- **Alkalosis** :-
  a) Ammonium chloride
  b) Lysine monohydrochloride

THANK YOU

"Thanks for inviting me to dinner -
It's really great!"

NUTRITIONAL BIOCHEMISTRY

SUBMITTED BY;

VIJILA.K

2ND MSC(DFM)

CLASSIFICATION , PROPERTIES AND FUNCTIONS OF LIPIDS.

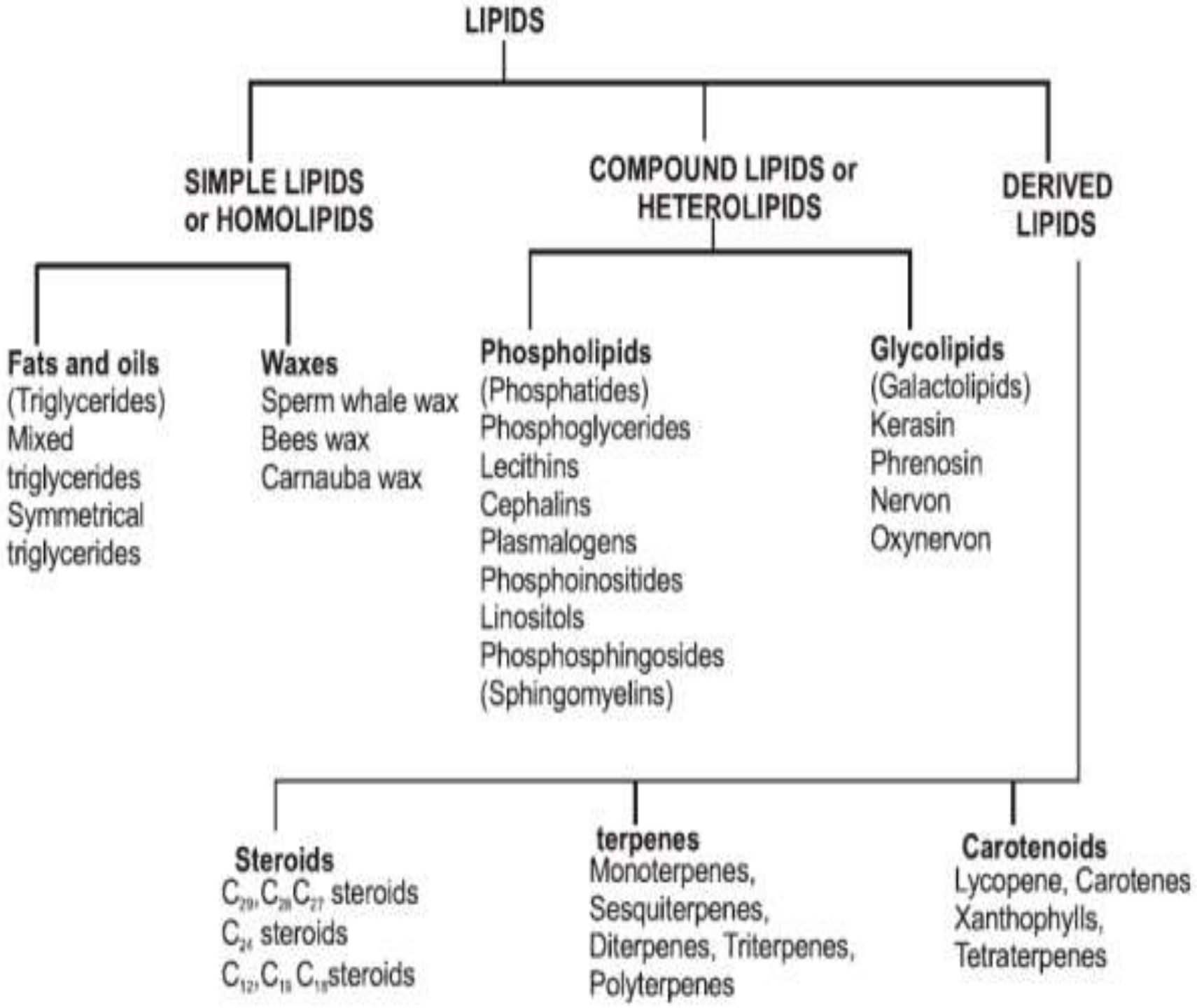
INTRODUCTION

- Lipids defines substances as oils, fats and waxes.
- coming from plant and animal origin.
- Insoluble in water but soluble in organic solvents such as chloroform, ether, benzene, acetone and
- Formed of long-chain hydro carbon groups(carbon and hydrogen)

LIPIDS CLASSIFICATION

- Lipids are classified into mainly 3 types.

- simple lipids
- compound lipids
- derived lipids


LIPIDS
SIMPLE LIPIDS or HOMOLIPIDS
COMPOUND LIPIDS or HETEROLIPIDS
DERIVED LIPIDS
Fats and oils
(Triglycerides)
Mixed triglycerides
Symmetrical triglycerides
Waxes
Sperm whale wax
Bees wax
Carnauba wax
Phospholipids
(Phosphatides)
Phosphoglycerides
Lecithins
Cephalins
Plasmalogens
Phosphoinositides
Linositols
Phosphosphingosides
(Sphingomyelins)
Glycolipids
(Galactolipids)
Kerasin
Phrenosin
Nervon
Oxynervon
Steroids
C_{29}, C_{28} C_{27} steroids
C_{24} steroids
C_{12}, C_{18} C_{19} steroids
terpenes
Monoterpenes,
Sesquiterpenes,
Diterpenes, Triterpenes,
Polyterpenes
Carotenoids
Lycopene, Carotenes
Xanthophylls,
Tetraterpenes

PROPERTIES OF LIPIDS

- physical properties of lipids
- chemical properties of lipids

PHYSICAL PROPERTIES

- They are energy rich organic molecules
- Lipids may be either liquids or non crystalline solids at room temperature.
- Soluble in organic solvents like alcohol, chloroform, acetone, benzene, etc..
- Pure fats and oils are colorless, odorless and tasteless.

- Insoluble in water.
- Form emulations when agitated with water in the presence of soap or either emulsifier.
- Poor conductor of heat ad electricity efficient insulator animal body.
- Color of fat is due to other substances

  yellow color of butter is due to keratin.

CHEMICAL PROPERTIES

- Hardening of oils
- Unsaturated triglycerides(oils)are liquid at room temperature.
- Hydrogenation – water is passed in presence of metal catalyst.
- Saturated triglycerides(fats)are produced which are semisolids.

FUCNTIONS OF LIPIDS

- Storage form of energy.
- Supply essential fatty acids.
- Structural components of cell membranes.
- Electrical insulation.

- Protect body form cold.
- Mechanical protection of internal organs.
- Metabolic regulators(hormones).
- Help transport fat soluble vitamins

BIOLOGICAL FUNCTIONS OF LIPIDS

- Triglycerides provide energy storage in adipocytes.
- As an energy sources, lipids provide 9 k/cal of energy per gram.
- Phosphoglycerides, sphingolipids and steroids are structural components of cell membranes.

- Steroid hormones are critical inter cellular messengers.
- Dietary fat acts as a carrier of lipid soluble vitamins into cells of small intestine.
- Provide shock absorption and insulation.


Thank you!

VITAMIN

VITAMINS

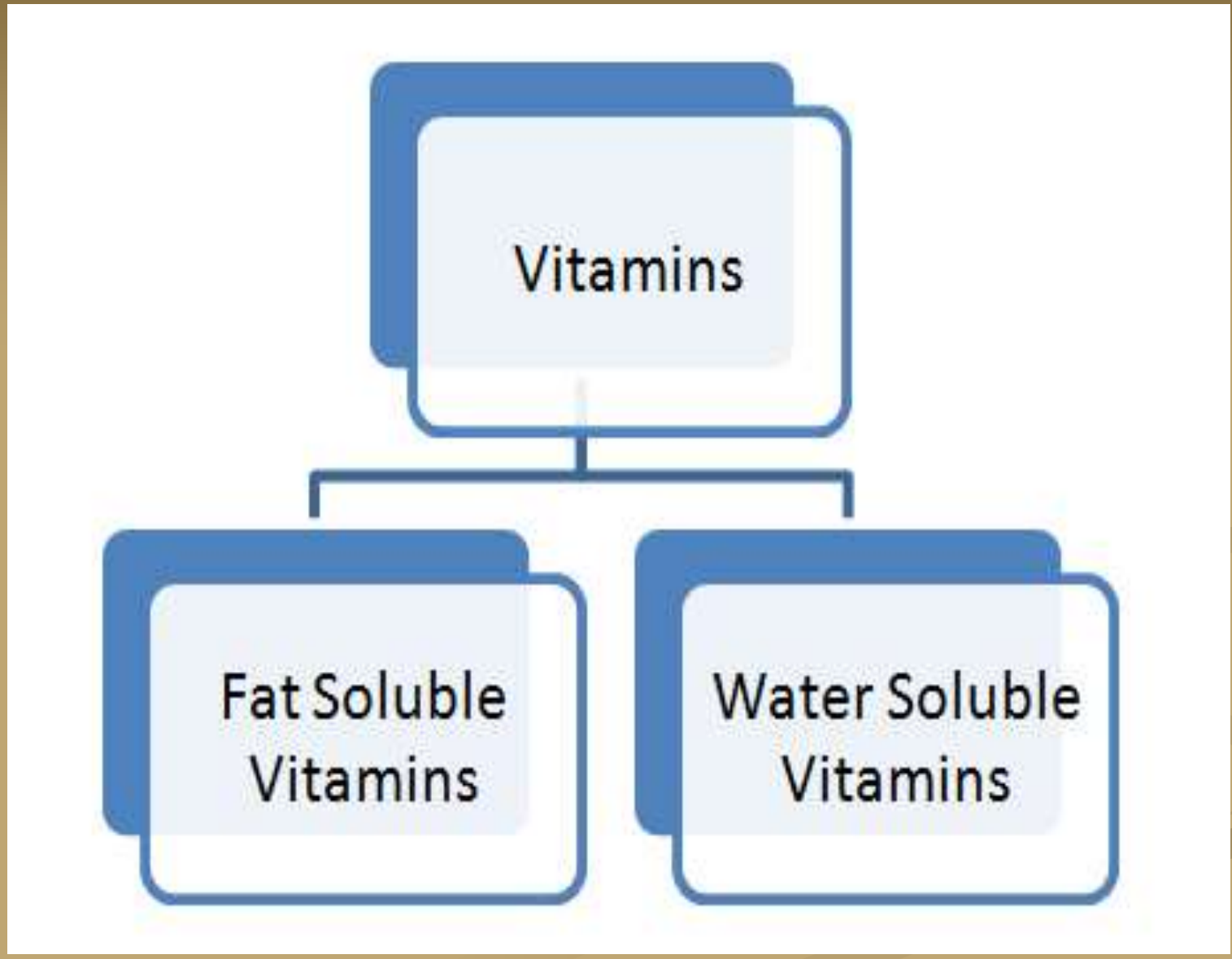
- Vitamins are made up of carbon, hydrogen and oxygen.
- Vitamins are called micronutrients because they are needed in only very small quantities. They all have chemicals names but they are usually referred to by letters.

What are Vitamins?

- It is an organic compound, required in small amounts by an organism to obtain cellular functions.
- It is called vitamin, when it can not be synthesized in sufficient quantities by the organism, and must therefore be supplied by the diet.

History of Vitamins

- In ancient Egypt: Feeding of patients with liver to prevent night blindness (now known as vitamin A deficiency)
- In 1749, the prevention of scurvy by citrus foods, was first discovered by the Scottish surgeon James Lind.
- In the Orient: Beriberi was common (a disease caused by the deficiency of Vitamin B1), because of polished white rice.


Vitamins
Fat Soluble Vitamins
Water Soluble Vitamins

WATER SOLUBLE VITAMINS

WATER-SOLUBLE VITAMINS

- Dissolve in water
- Generally readily excreted
- Subject to cooking losses
- Function as a coenzyme
- Participate in energy metabolism
- 50-90% of B vitamins are absorbed
- Marginal deficiency more common

B Complex Vitamins

- Co-enzymes (activate enzymes)
- Found in the same foods
  - Single deficiency rare
- Act together in metabolism
  - Metabolic pathways used by protein, carbohydrate, and fat

B Complex Digestion

- Broken down from coenzyme form into free vitamins in the stomach and small intestine
- Absorbed, primarily in the small intestine (50%-90%)
- Once inside cells, coenzyme forms are

B Complex Primary Functions

- Energy metabolism
  - Thiamin (B-1), Riboflavin (B-2), Niacin (B-3), Pyridoxine (B-6), Biotin, Pantothenic Acid
- Red blood cell synthesis
  - Folate, B12
- Homocysteine metabolism
  - Folate, B12, B6

Enrichment

- Many nutrients lost through milling process of grains
- Grain/cereal products are enriched
- Thiamin, riboflavin, niacin, folate, iron
- Whole grains contain original nutrients
- Enriched grains still deficient in B-6,

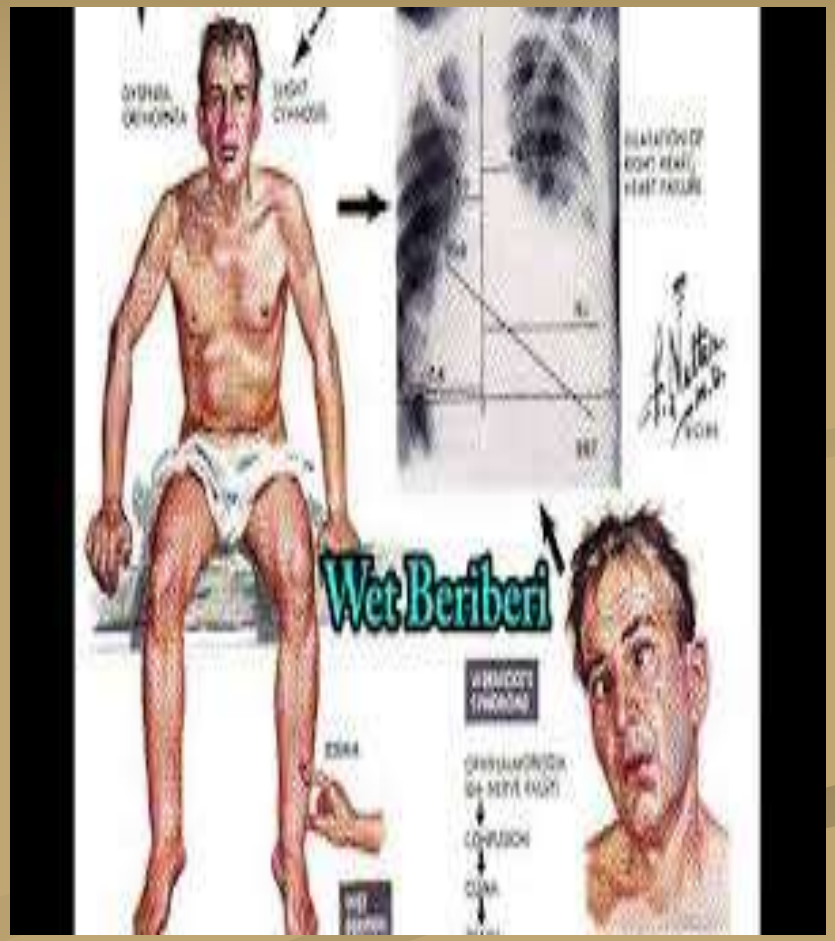
Thiamin (B1)

- Contains sulfur and nitrogen group
- Destroyed by alkaline and heat
- Coenzyme
  - Releases energy from carbohydrate
  - CO2 is released from a larger molecu
  - Glucose metabolism

Deficiency of Thiamin

- Occurs where polished rice is the only staple
- **Beriberi (I can't I can't)**
  - Weakness, nerve degeneration, irritability, poor arm/leg coordination, loss of nerve transmission
  - Edema, enlarged heart, heart failure
  - Symptoms due to poor metabolism of glucose
  - Depression and weakness can be seen after only 10 days on a thiamin-free diet

Wet and Dry BeriBeri



Food Sources of Thiamin

- Wide variety of food
- Red meat, unpolished cereal
- Enriched breads and grains/ whole grains
- Green beans, milk, orange juice, organ meats, peanuts, dried beans and seeds
- **Thiamine's** found in raw fish
  - Destroys thiamin

RDA For Thiamin

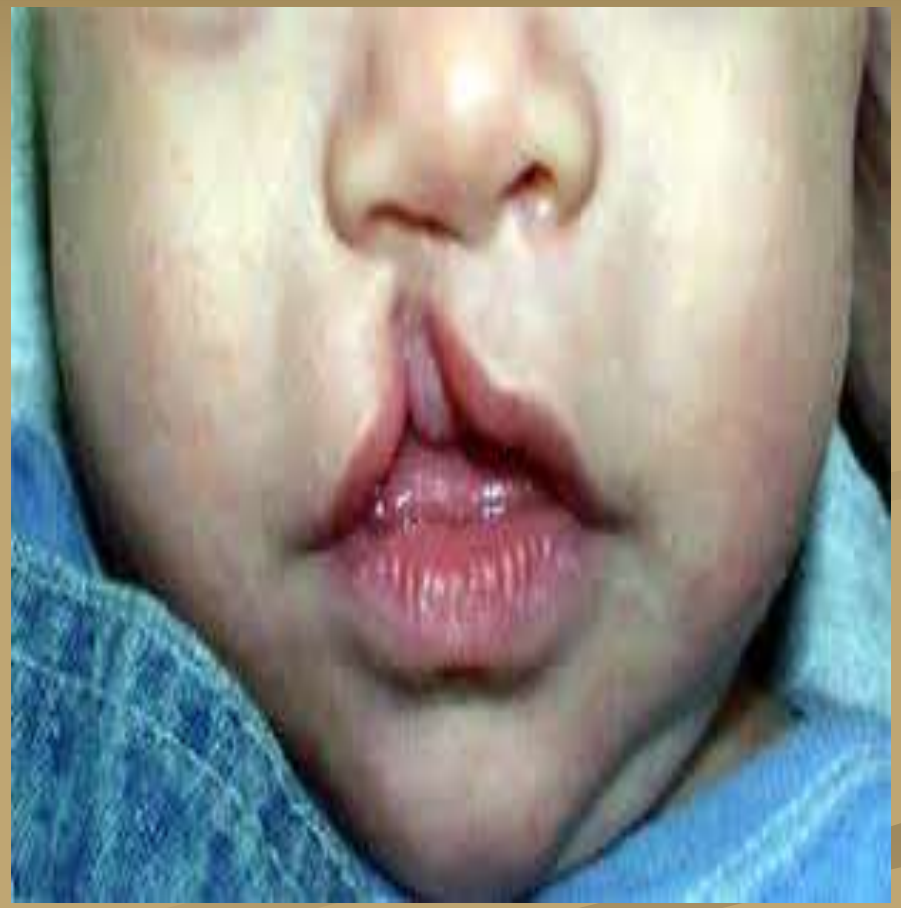
- 1.1 mg/day for women
- 1.2 mg/day for men
- Daily Value on food label is 1.5 mg
- Most exceed RDA in diet

Riboflavin (B2)

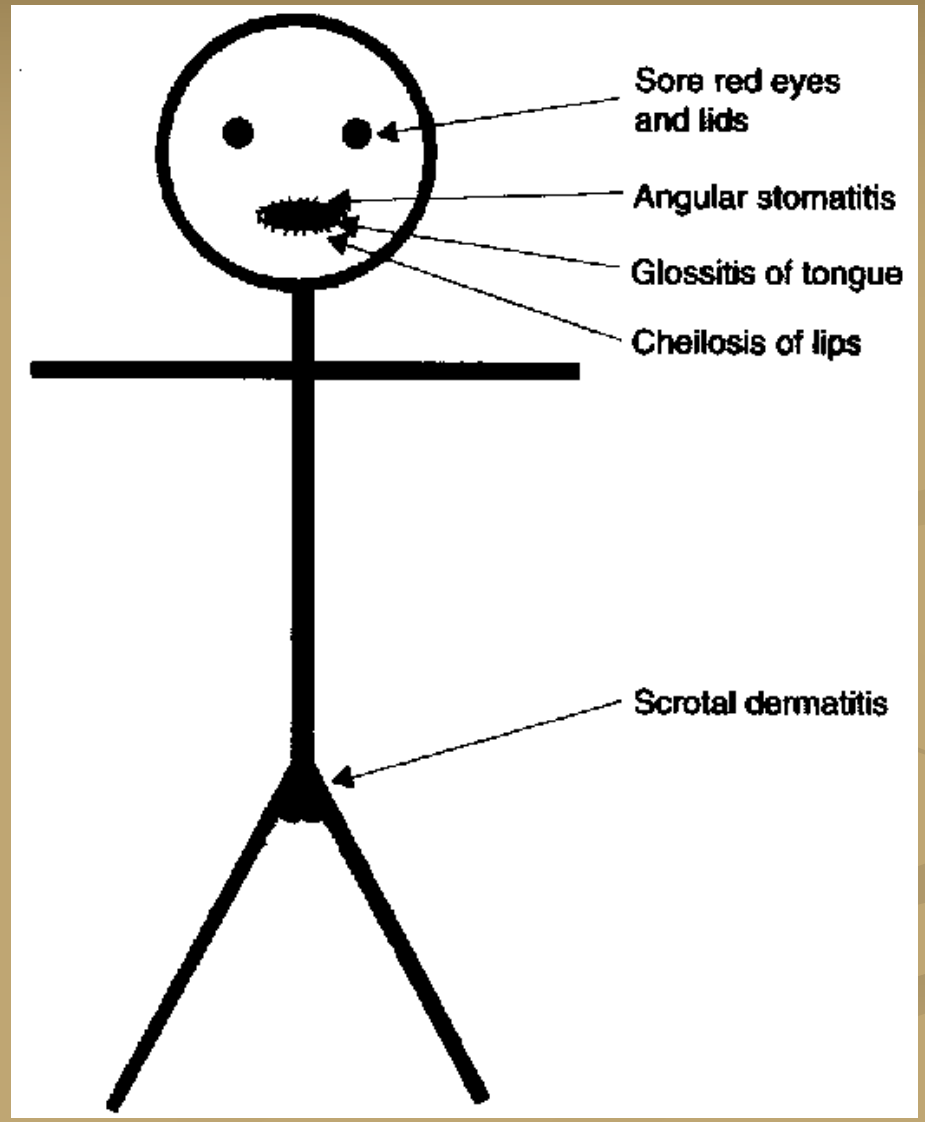
- Coenzymes
- Participate in many energy-yielding metabolic pathways
  - Fatty acids broken down and burned for energy

Deficiency of Riboflavin

- **Ariboflavinosis**
  - Glossitis, cheilosis, seborrheic dermatitis, stomatitis, eye disorder, throat disorder, nervous system disorder
- Occurs within 2 months
- Usually in combination with other deficiencies



Ariboflavinosis



Food Sources of Riboflavin

- Milk/products
- Enriched grains
- Ready to eat cereals
- Liver
- Oyster
- Brewer's yeast
- Vegetables (asparagus, broccoli, greens)
- Sensitive to uv radiation (sunlight)
- Stored in paper, opaque plastic containers

RDA for Riboflavin

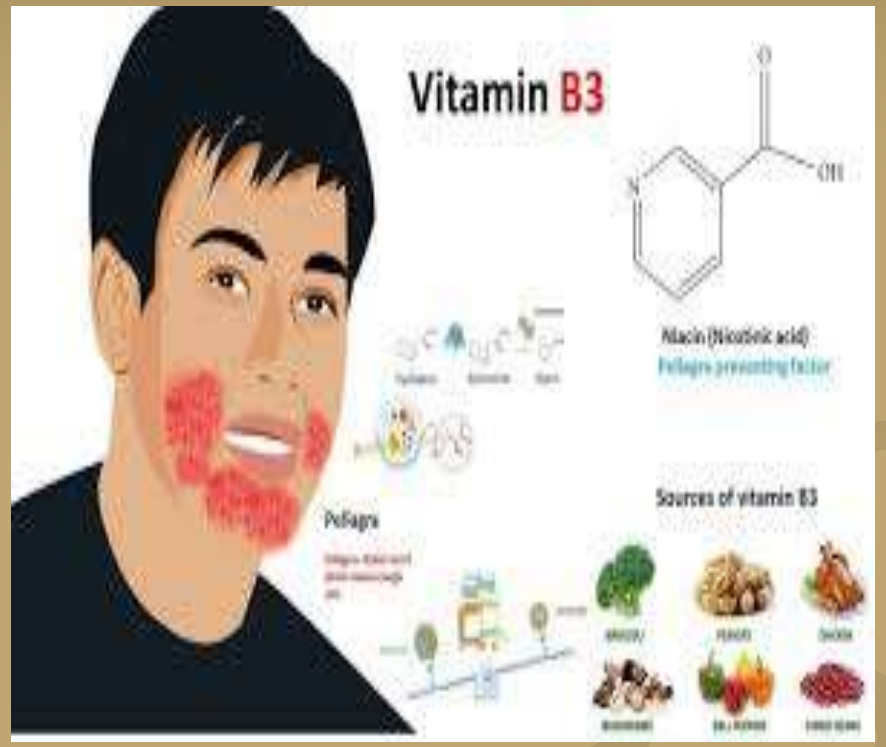
- 1.1 mg/day for women
- 1.3 mg/day for men
- Average intake is above RDA
- Toxicity not documented
- No upper level

Niacin (B3)

- Nicotinic acid and nicotinamide
- Coenzymes
- Needed when cell energy is being utilized
- Synthetic pathways require niacin, especially fatty acid synthesis

Deficiency of Niacin: Pellagra

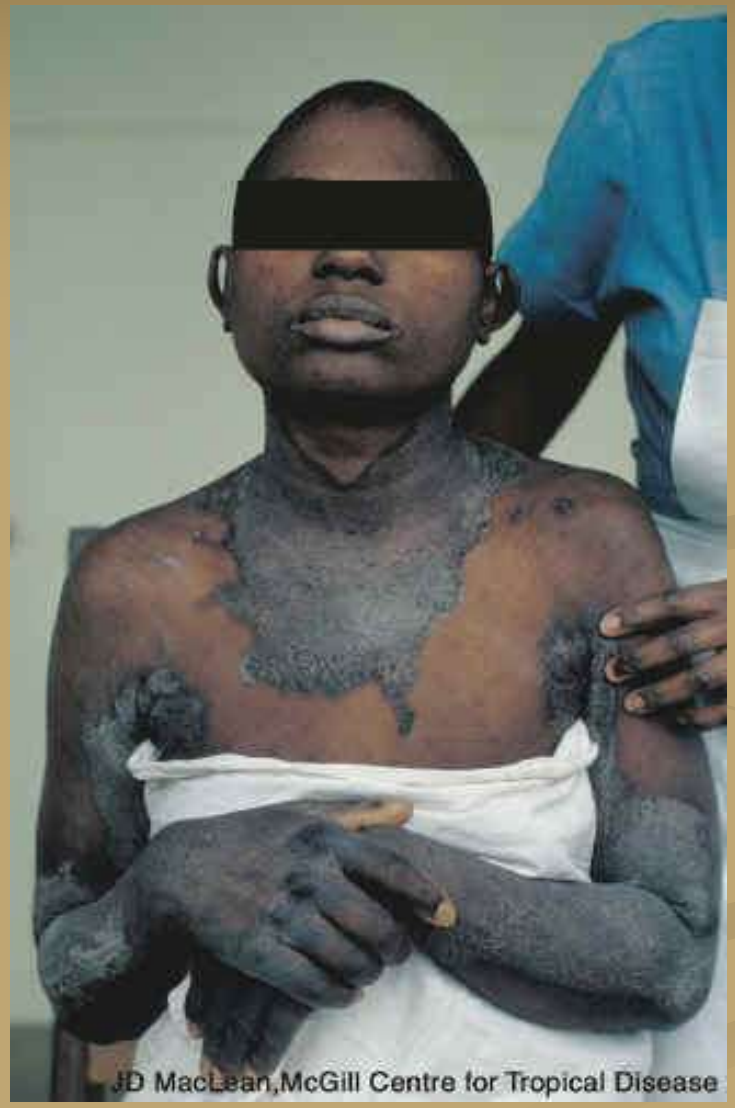
- 3 Ds
  - Dementia
  - Diarrhea
  - Dermatitis (worse with sun exposure)
- Occurs in 50-60 days
- Poor appetite, weight loss, weakness



Pellagra

- Prevented with an adequate protein diet
- Became epidemic in southern Europe in early 1700s when corn became a staple food (poor source)
- Reached epidemic proportions in the southeastern U.S from late 1800s to 1930s
  - Only dietary deficiency disease to reach epidemic proportions in the US

Pellagra



Food Sources of Niacin

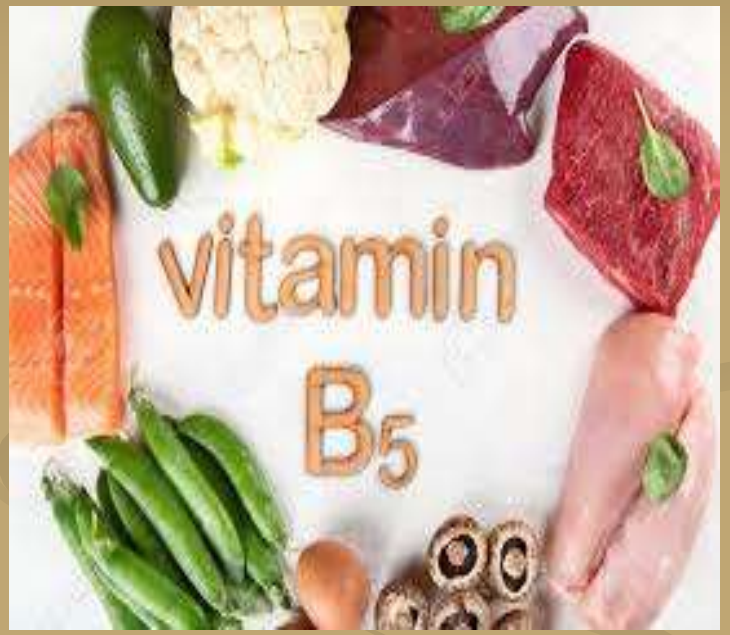
- Enriched grains, ready to eat cereals
- Beef, chicken, turkey, fish
- Asparagus, peanuts
- Heat stable; little cooking loss
- 60mg tryptophan can be converted into 1 mg niacin; meets 50% of our needs
- Niacin in corn is bound by a protein
  - Soaking corn in alkaline solution, like lime water releases niacin
  - Hispanic people soak corn in lime water before making tortillas

RDA for Niacin

- 14 (mg) NE/day for women
- 16 (mg) NE/day for men
- Daily Value on labels is 20 mg
- Upper Level is 35 mg
- Toxicity S/S: headache, itching, flushing, liver and GI damage
- Megadose can lower LDL and TG and increase HDL

Pantothenic Acid

- Part of Coenzyme-A
- Essential for metabolism of CHO, fat, protein
- Deficiency rare
- Usually in combination with other deficiencies
- No known toxicity



Food Sources of Pantothenic acid

- “From every side”
- Meat
- Milk
- Mushroom
- Liver
- Peanut
- Eggs
- Adequate Intake = 5 mg/day
- Daily Value 10 mg
- Average intake meets AI

Biotin

- Free and bound form
- Metabolism of CHO and fat
- Assists the addition of CO2 to other compounds
- Synthesis of glucose, fatty acids, DNA
- Help break down certain amino acids

Biotin Deficiency

- Raw egg whites avidin bind biotin → deficiency
- Requires large amount
- Scaly inflamed skin, tongue, and lip changes
- Poor appetite, nausea, vomiting
- Anemia

Muscle pain and weakness

Poor growth

Food Sources of Biotin

- Cauliflower, yolk, liver, peanuts, cheese
- Intestinal synthesis of biotin
- Biotin content only available for a small number of foods
- Unsure as to bioavailablity of synthesized biotin
- We excrete more than we consume

Biotin Needs

- Adequate Intake is 30 ug/day for adults
- This may overestimate the amount needed for adults
- Deficiency rare
- No Upper Level for biotin
- Relatively nontoxic

Pyridoxine (B6)

- 3 compounds
- Coenzyme
- Activate enzymes needed for metabolism of CHO, fat , protein
- Synthesize nonessential amino acid via transmutation
- Synthesize neurotransmitters
- Synthesize hemoglobin and WBC

Food Sources of Vitamin B-6

Well absorbed

- Meat, fish, poultry
- Enriched cereals
- Potatoes
- Milk

Less well absorbed

- Fruits and vegetables: Banana, spinach, avocado

Heat and alkaline sensitive

B6 Deficiency

Widespread symptoms

- Depression
- Vomiting
- Skin disorders
- Nerve irritation
- Impaired immune system

B6 Toxicity

- Nerve damage
- Difficulty walking
- Numbness in hands/feet

RDA for Vitamin B-6

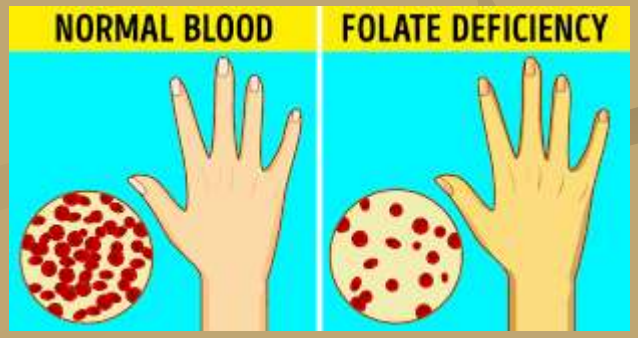
- 1.3 mg/day for adults
- 1.7 mg/day for men over 50
- 1.5 mg/day for women over 50
- Daily Value set at 2 mg
- Average intake is more than the RDA
- Athletes may need more
- Alcohol destroys vitamin B6

Folate

- Coenzyme
- DNA synthesis
  - Anticancer drug methotrexate
- Homocysteine metabolism
- Neurotransmitter formation

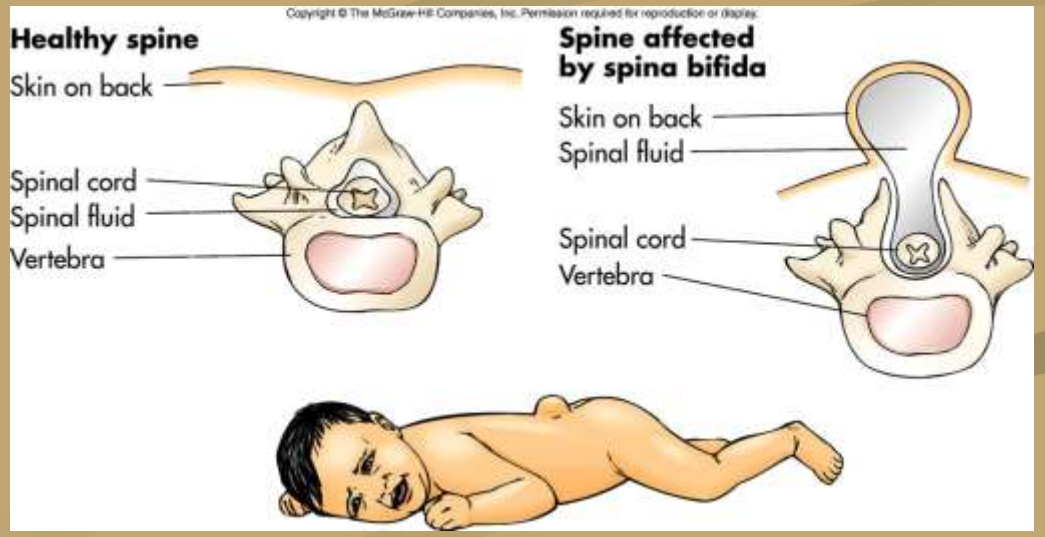
Deficiency of Folate

- Similar signs and symptoms of vitami… deficiency
- Anemia
  - RBC grow, cannot divide
  - Megaloblast: large, immature RBC
- Pregnant women
- Alcoholics
- Megaloblastic Anemia



Neural Tube Defects

- Neural tube closes first 28 days of pregnancy
- Forms brain and spinal cord
- By the time pregnancy is confirmed, damage is done



Food Sources of Folate

- Liver
- Fortified breakfast cereals
- Grains, legumes
- Foliage vegetables
- Susceptible to heat, oxidation, ultraviolet light
- Synthetic form better absorbed

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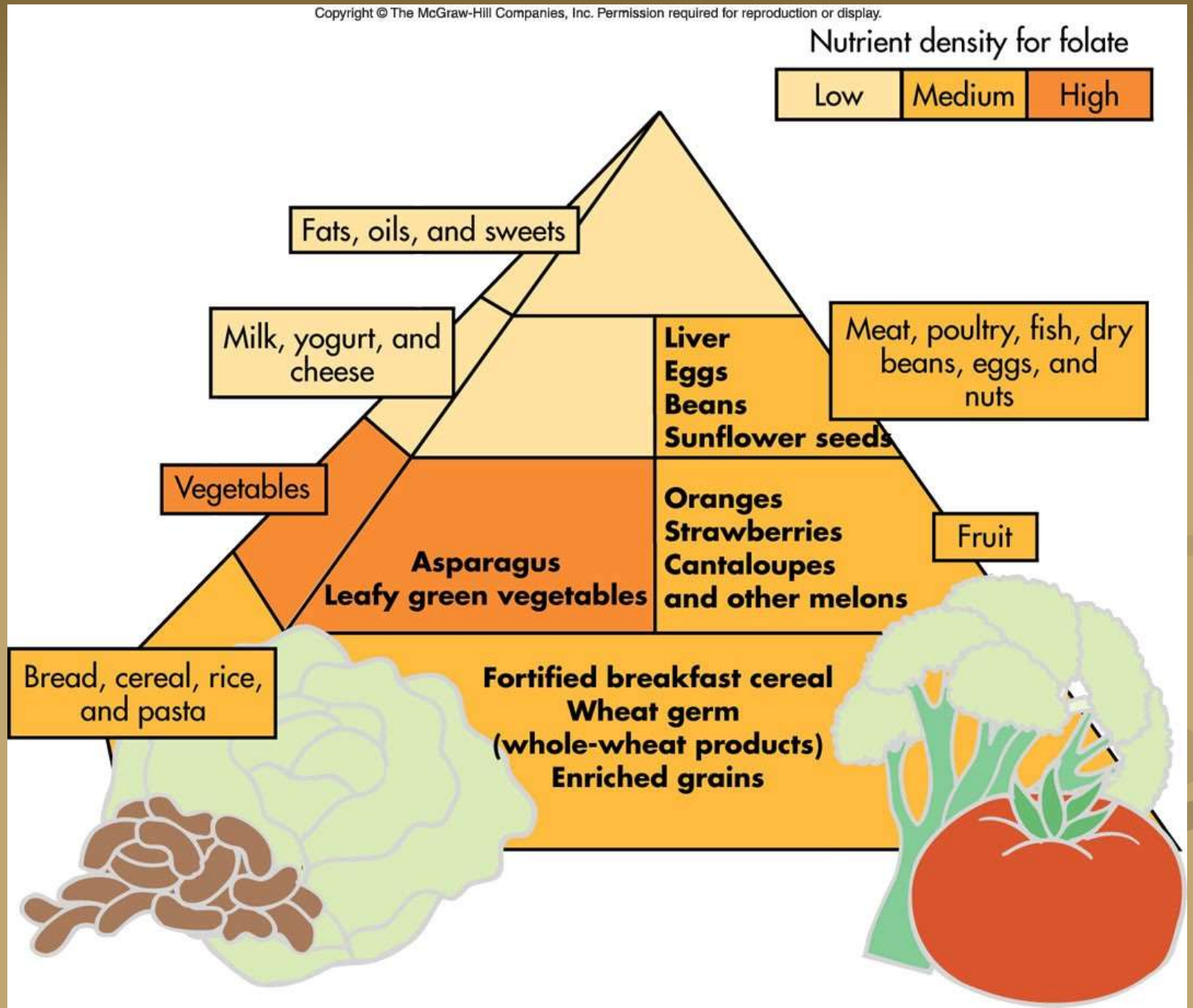


RDA for Folate

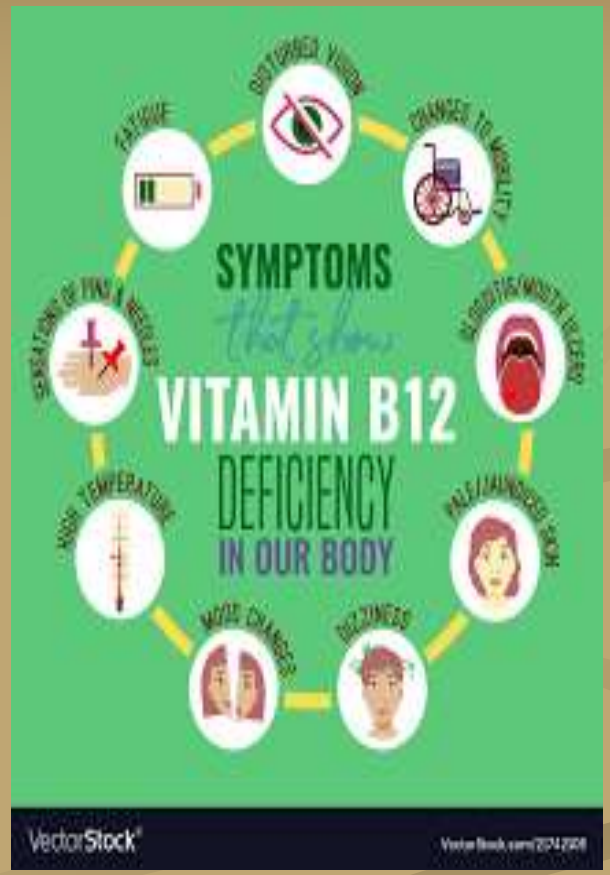
- 400 ug/day for adults
- (600 ug/day for pregnant women)
- Average intake below RDA
- FDA limits nonprescription supplements to 400 ug per tablet for non-pregnant adults
- OTC Prenatal supplement contains 800 ug
- Excess can mask vitamin B-12 deficiency
- Upper Level set at 1 mg

Vitamin B-12

- Compounds containing the mineral cobalt
- Synthesized by bacteria, fungi and other lower organisms
- Role in folate metabolism
- Maintenance of the myelin sheaths
- RBC formation
- Pernicious anemia (associated with nerve degeneration and paralysis)

Deficiency of Vitamin B-12

- **Pernicious anemia**
  - Nerve degeneration, weakness
  - Tingling/numbness in the extremities (parasthesia)
  - Paralysis and death
  - Looks like folate deficiency
- Usually (95%) due to decreased absorption ability
- **Achlorhydria** especially in elderly
- **Injection** of B-12 needed
- Takes ~20 years on a deficient diet to see nerve destruction



Food Sources of Vitamin B-12

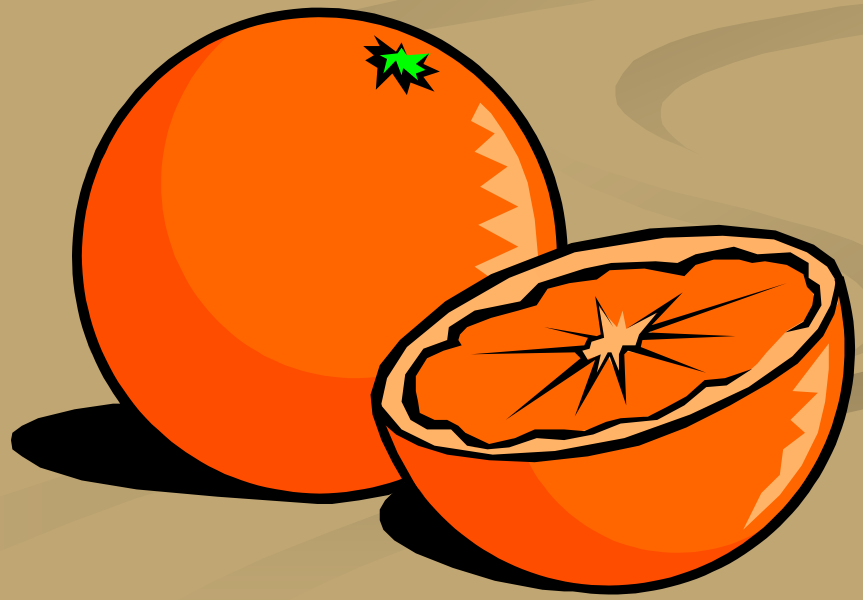
- Synthesized by bacteria, fungi and algae
- (Stored primarily in the liver)
- Animal products
- Organ meat
- Seafood
- Eggs
- Hot dogs
- Milk

RDA for Vitamin B-12

- 2.4 ug/ day for adults and elderly adults
- Average intake exceeds RDA
- B-12 stored in the liver
- Non-toxic (no Upper Level)

Vitamin C

- Synthesized by most animals (not by humans)
- Decrease absorption with high intakes
- Excess excreted



Functions of Vitamin C

- Reducing agent (antioxidant)
- Iron absorption (enhances)
- Synthesis of collagen
- Immune functions
  - Does not prevent colds, but may reduce duration of symptoms by a day or so
- Wound healing

Antioxidant

- Can donate and accept hydrogen atoms readily
- Water-soluble
- Needs are higher for smokers
- May prevent certain cancers (esophageal, oral, stomach cancer, cardiovascular disease, cataracts)

Vitamin C Deficiency: History of Scurvy

- Sailors on long sea voyages suffered horribly from scurvy
- Jacques Cartier and his exploring party suffered from scurvy in Canada during the winter of 1535-6. Local Indians showed them how to brew a tea from evergreens
- On Vasco da Gama's voyage to the East Indies in 1497, 100 out of 160 men were lost from the disease.
- Scurvy was also seen in the Great Potato Famine, in soldiers during the Civil War, and in California Gold Rush communities

Scurvy in the British Royal Navy

- James Lind published his Treatise on the Scurvy in 1754. Lim juice was made mandatory on Britis Navy sailing ships 4 years later

Deficiency of Vitamin C

- **Scurvy**
  - Deficient diet for 20-40 days
  - Fatigue, pinpoint hemorrhages
  - Bleeding gums and joints. Hemorrhages
  - Associated with poverty; macrobiotic diet
- Rebound Scurvy
  - Sudden halt to high levels of vitamin C supplements

Scurvy

Scorbutic Rosary

Follicular Hemorrhages

Food Sources of Vitamin C

- Citrus fruit
- Potato
- Green pepper
- Cauliflower
- Broccoli
- Strawberry
- Romaine lettuce
- Spinach

- Easily lost through cooking
- Sensitive to heat
- Sensitive to iron, copper, oxygen

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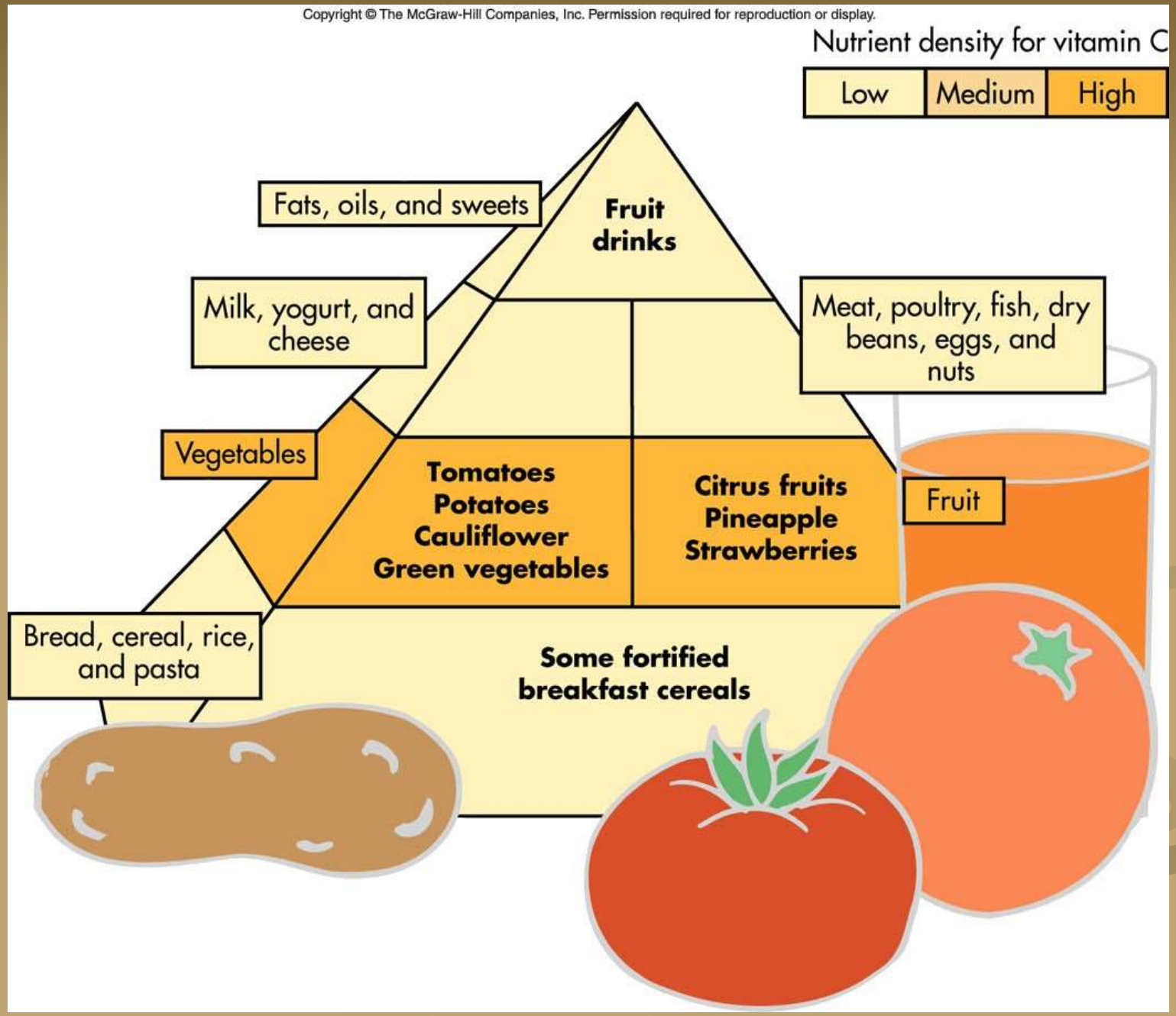
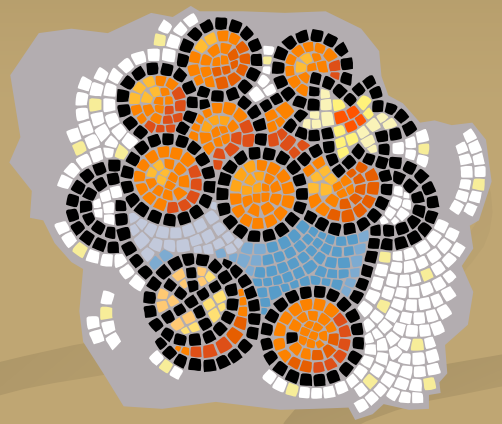


RDA for Vitamin C

- 90 mg/day for male adults
- 75 mg/day for female adults
- +35 mg/day for smokers
- Average intake ~72 mg/day
- Daily Value is 60 mg
- Fairly nontoxic (at <1 gm)
- Body is saturated at intake of 200 mg/day
- Upper Level is 2 g/day



Vitamin C Excess

- Hemochromatosis
  - Vitamin C enhances iron absorption
- Oxalate kidney stones
- Erodes tooth enamel

Vitamin C Deficiency

- In the U.S., deficiency is seen mostly in alcoholic persons with poor diets and older persons who eat poorly (no fresh fruits and vegetables)

Choline

- Newest essential nutrient
- All tissues contain choline
- Precursor for acetylcholine (neurotransmitter)
- Precursor for phospholipids
- Some role in homocysteine metabolism

Food Sources of Choline

- Widely distributed
- Milk
- Liver
- Eggs
- Peanuts
- Lecithin added to food
- Deficiency rare

Needs for Choline

- Adequate Intake is 550 mg/day for adult males
- Adequate Intake is 425 mg/day for adult females
- Normal consumption is ~700-1000 mg/day
- High doses associated with fishy body odor, vomiting, salivation, sweating, hypotension, GI effects
- Upper Level is set at 3.5 g/day (3500 mg/day)

Vitamin-Like Compounds

- Choline
- Carnitine
- Inositol
- Taurine
- Lipoic acid
- Synthesized in the body at the expense of amino acids and other nutrients

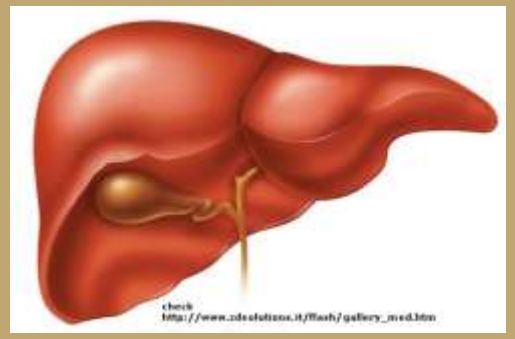

Thanks

Fat soluble vitamins

Vitamin D, E & K

Vitamin D


Vitamin D
The body itself makes vitamin D when it is exposed to the sun
Cheese, butter, margarine, fortified milk, fish, and fortified cereals are food sources of vitamin D
A.D.A.M.




Vitamin A
Vitamin B
Folic acid
Vitamin C
Vitamin D
Vitamin E
Vitamin K
Minerals

Vitamin D

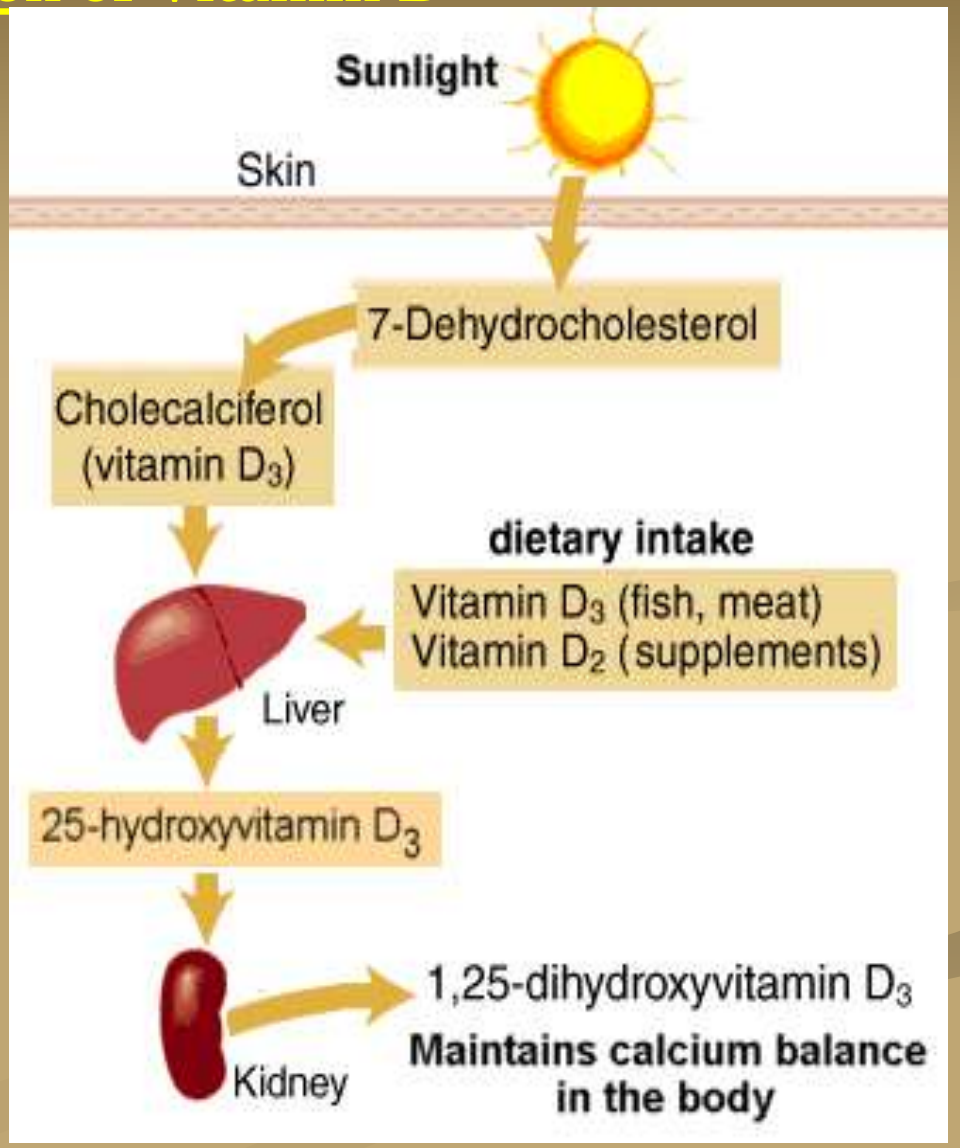
- The term “Vitamin D” refers to a family of related compounds biosynthesized from cholesterol and ergosterol. Both have equal acitivitys

- Vitamin D3 (cholecalciferol) is synthesized from 7-dehydrocholesterol in sun-exposed skin and found naturally in animal products such as eggs, fish and liver.

- Vitamin D2 (ergocalciferol) is another form of vitamin D synthesized by certain fungi and is used in many supplements.

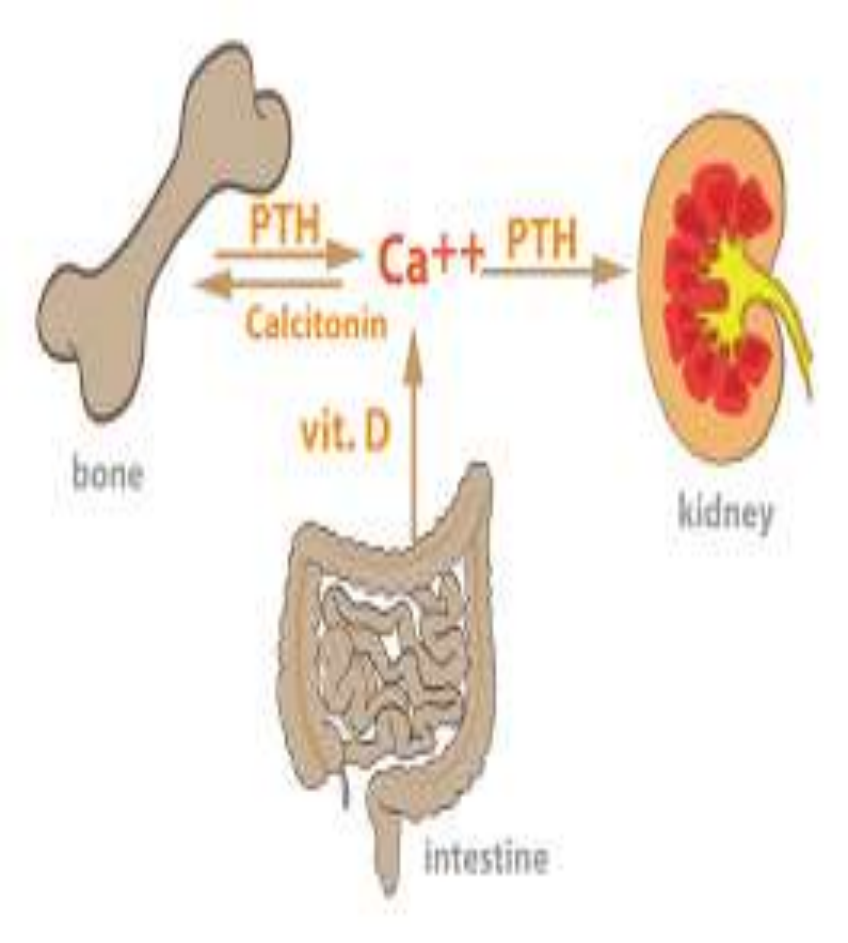
(Cholecalciferol) VITAMIN D_3	(Ergocalciferol) VITAMIN D_2
❖Synthesized in the body	❖Found in plant life
❖Naturally derived supplement	❖Synthetically derived supplement
❖Significantly increases vitamin D levels in the body	❖Moderately increases vitamin D levels in the body
❖Recommended by experts for optimal bone and immune support	❖Alternative form appropriate for vegetarians

Daily Requirements = 10mg vitamin D = 400 IU vitamin D.
Pergnancy = 15mgs Activation of Vitamin D



FUNCTIONS OF VITAMIN D

- Role in calcium and phosphate homeostasis
- The site of action are intestine, kidney and bones.
- Intestine: absorption of calcium and phosphorous and thus increases blood calcium and phosphate level.
- Kidney: promote the reabsorption of cal, phos by renal tubules and thus reducing excretion of cal and phos
- Bone : bone reabsorption



Bone Mineralization And Formation

- **Essential for normal bone growth during childhood** and for maintaining bone density and strength during adulthood
- **Integrated function with parathyroid hormone**
- **Regulation of cell growth and development**

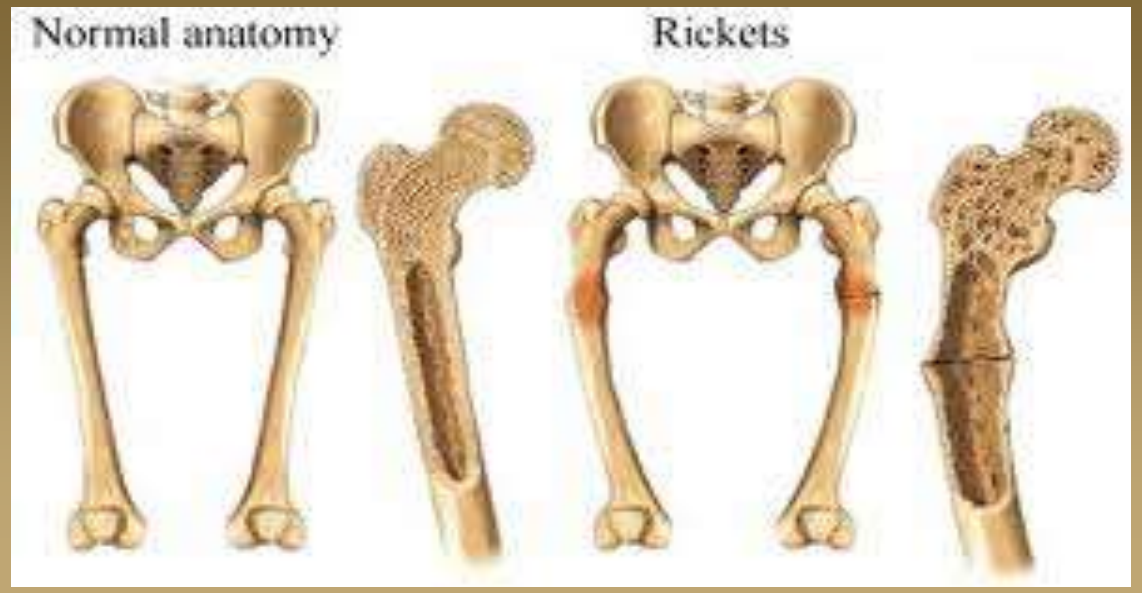
DISEASES CAUSED BY VITAMIN D DEFICIENCY

Vitamin D deficiency causes several bone diseases, including:

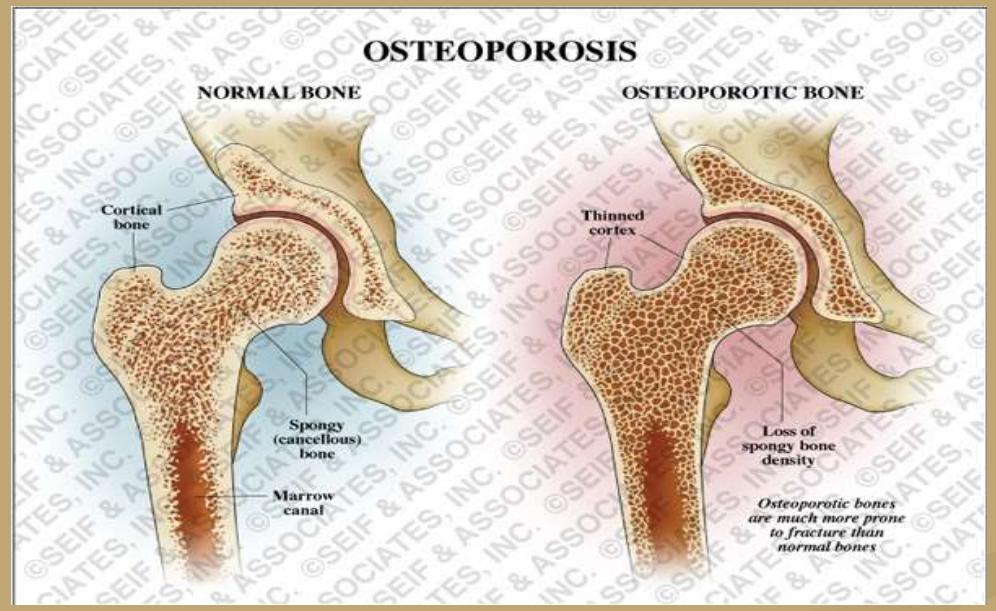
Rickets: a childhood disease characterized by failure of growth and deformity of long bones.

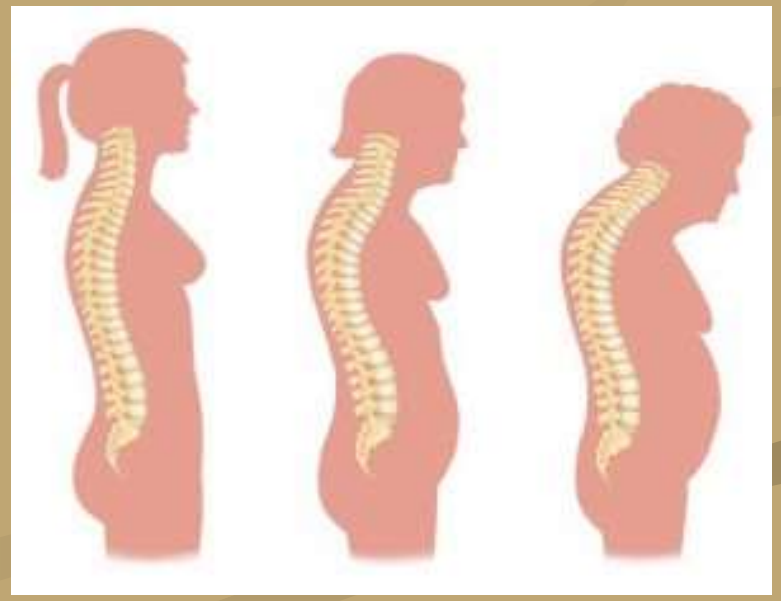
Osteoporosis: a condition characterized by fragile bones due to decreased bone density. fragile bone ⟶ easily fractured.

Osteomalacia: (adult version of Rickets) is a case of softening of bones due to defective bone mineralization and characterised by proximal weakness and bone fragility.



Rickets





Osteoporosis

Osteomalacia

Toxicity

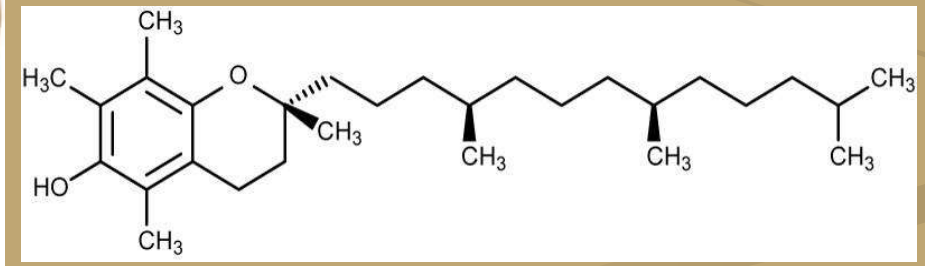
- Excess consumption of vitamin D leads toxicity condition

INTERACTIONS WITH VITAMIN D

1. **The absorption of vitamin D is improved** by calcium, choline, fats, phosphorus, vitamins A and C.
2. **Drugs as Rifampin, H2 blockers, barbiturates, heparin, cholestyramine, carbamazepine, phenytoin, fosphenytoin, and phenobarbital** reduce serum levels of vitamin D and increase its metabolism.
3. **Overuse of mineral oil** and stimulant laxatives may **deplete vitamin D**.
4. Osteoporosis and hypocalcaemia can result from prolonged use of corticosteroids. It is necessary to take of **calcium and vitamin D together with corticosteroid drugs.**

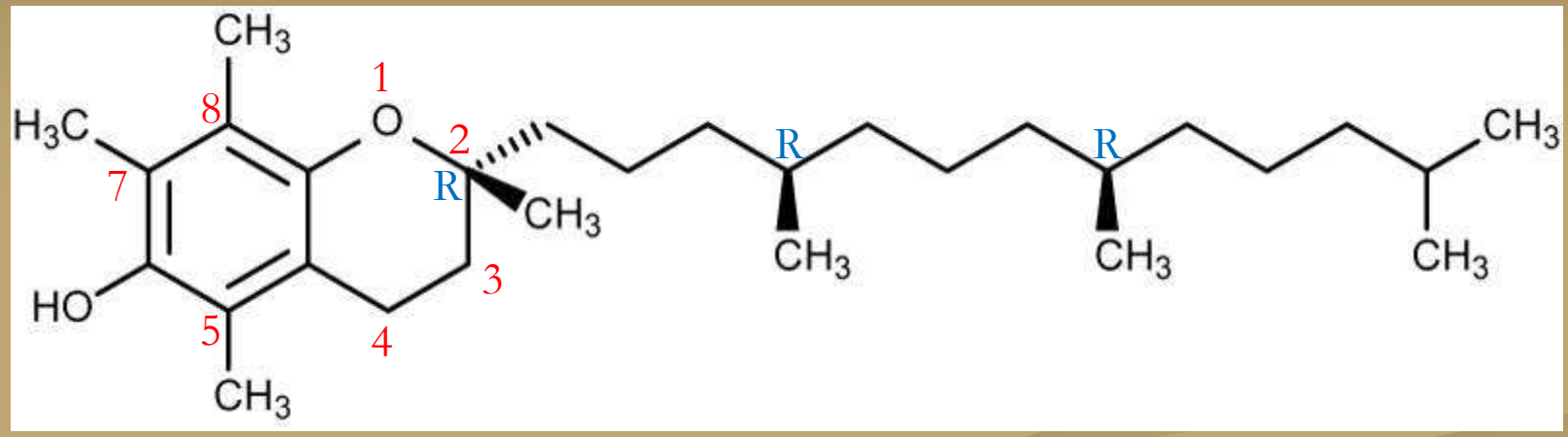
Fat Soluble Vitamins

VITAMIN E



Vitamin E

- **Vitamin E is a general term used for a group of compounds (α, β, γ, and δ-tocopherols) having a chromanol ring and phytyl side chain.**



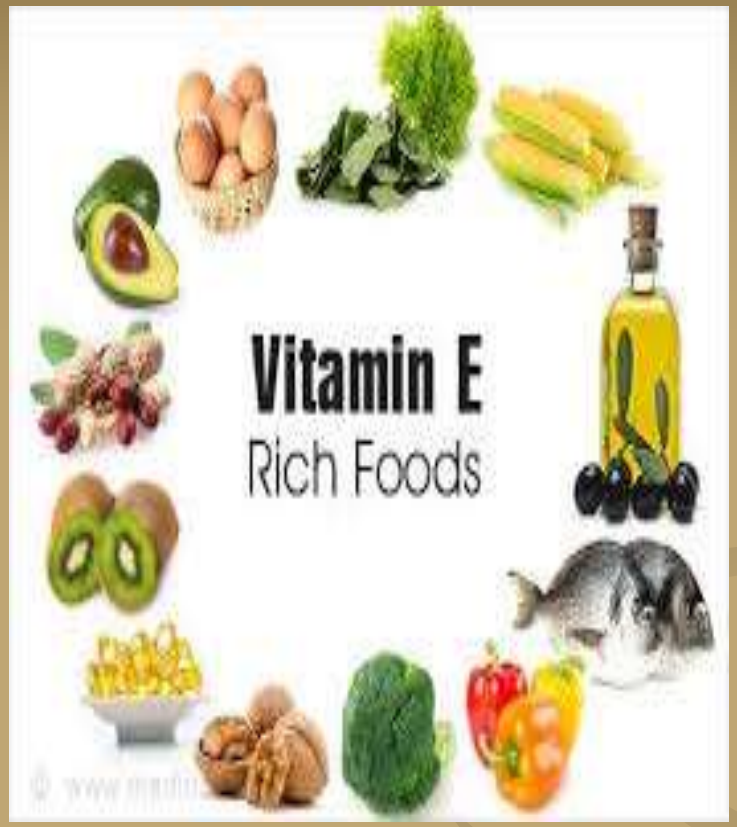
Chromanol Group

Phytyl side chain

- The most abundant and active form of vitamin E is α-tocopherol (α-*RRR-tocopherol).*
- The relative activities of the tocopherols vary considerably and thus vitamin E activity should referred to α-tocopherol.
- For example, soybean oil has a higher total tocopherol content than sunflower oil.

Sources of Vitamin E

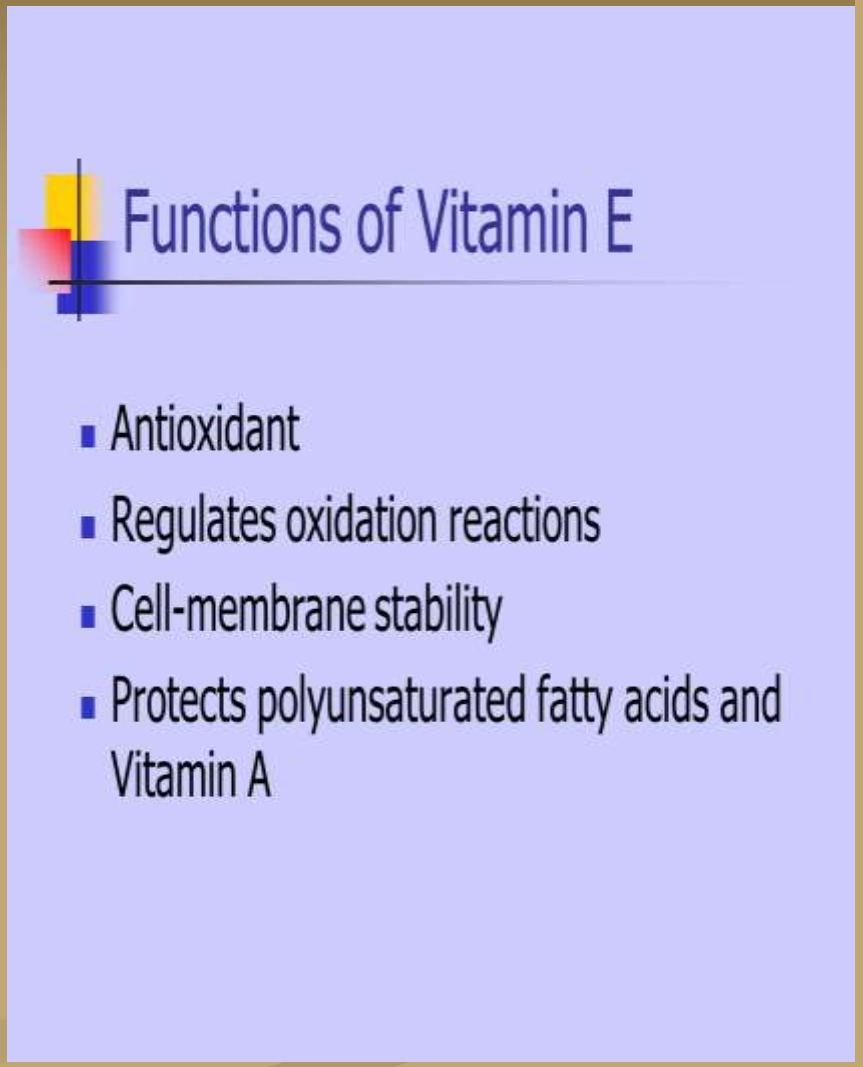
- Natural sources of vitamin E (d-RRR-α-tocopherol)
  - Vegetable oils from seeds (Sunflower, Cottonseed)
  - Lettuce.
  - Nuts.
  - Unprocessed grains.



Functions of Vitamin E

1. Antioxidant action:

- Tocopherols (Vitamin E) interrupt free radical chain reactions. This imparts to them their antioxidant properties.
- Therefore, vitamin E protects the cells, with other nutrient (e.g. Vitamin C and Selenium) against the harmful free radicals formed during metabolism of fatty acids.



2. Antithrombotic action:

Vitamin E slows down the action of thrombin (a blood clotting protein) and reduces platelet aggregation by inhibiting thromboxane. Although vitamin E is a natural “blood thinner” it does not increase risk of bleeding in healthy people.

Deficiency

- Vitamin E deficiency can **cause** nerve and muscle damage that results in loss of feeling in the arms and legs, loss of body movement control, **muscle weakness**, and vision problems

Toxicity and side effects

- **Vitamin E is well-tolerated**, and side effects are rare even at doses of (up to 2000 mg/day).

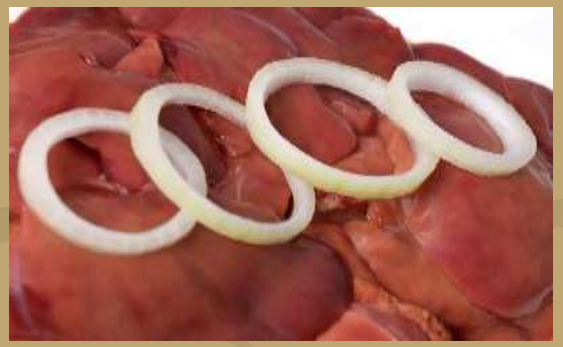
- However, in some individuals who are vitamin K deficient, vitamin E may increase the risk for hemorrhage or bleeding.

- People taking anticoagulant drugs should also be cautious with high doses.

- People with diabetes should be cautious when starting high doses of vitamin E because it may enhance the action of insulin but, rarely.

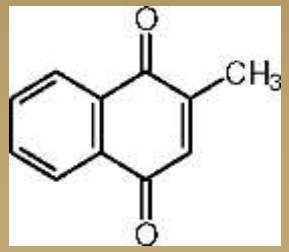

Vitamin K
Food sources of vitamin K include cabbage, cauliflower, spinach and other green, leafy vegetables, as well as cereals

VITAMIN K



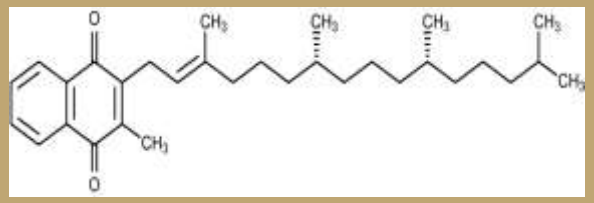
VITAMIN K

- A group of compounds derived from 2-methyl-1,4-naphthoquinone that act as antihemorrhagic factor in birds and mammals. There are three forms of vitamin K:

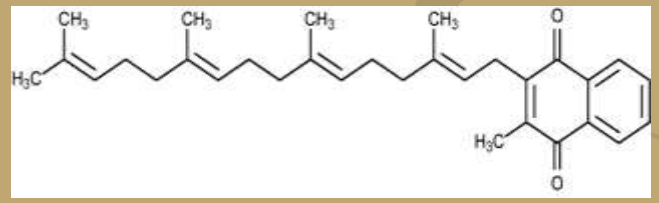


2-methyl-1,4-naphthoquinone

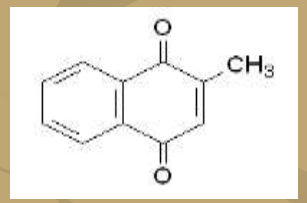
a) Vitamin K1 (Phylloquinone) found in plant foods.
b) Vitamin K2 (Menaquinone) from animal and bacterial sources.
c) Synthetic Vitamin K3 (Menadione).



Vit. K_1 (**Phylloquinone**)



Vit. K_2 (**Menaquinone**)



Vit. K_3 (**Menadione**)

Commercial infant formula contain 50- 125 µg/day

Recommended Daily amount →
New born: 500- 1000 µg once
1- 6 Months: 5 mg/day
6- 12 Months: 15 mg/day
Adult: 80 mg/Kg (body weight) / day

Sources of Vitamin K

Foods rich in Vitamin K:

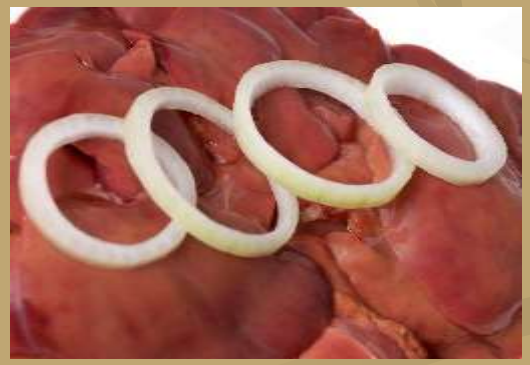
Spinach, Green cabbage, Turnip, Parsley, lettuce, beef liver, green tea (in decreasing order) etc.

Spinach

Green cabbage

Turnip

Parsley



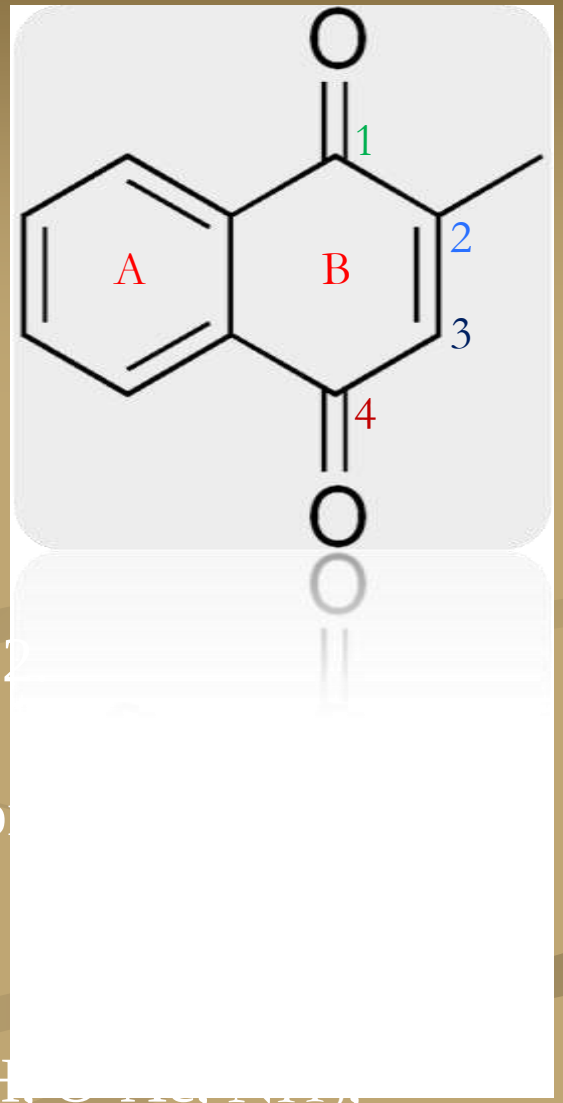
Beef liver

Green tea

Structure Activity Relationship

1. **Activity is maximum when:**

   - ❖Ring A and Ring B are aromatic.
   - ❖Ring A is not substituted.
   - ❖Methyl group at C-2.
   - ❖Unsaturation of phytyl side chain at C-3.



2. **Activity is decreased when:**

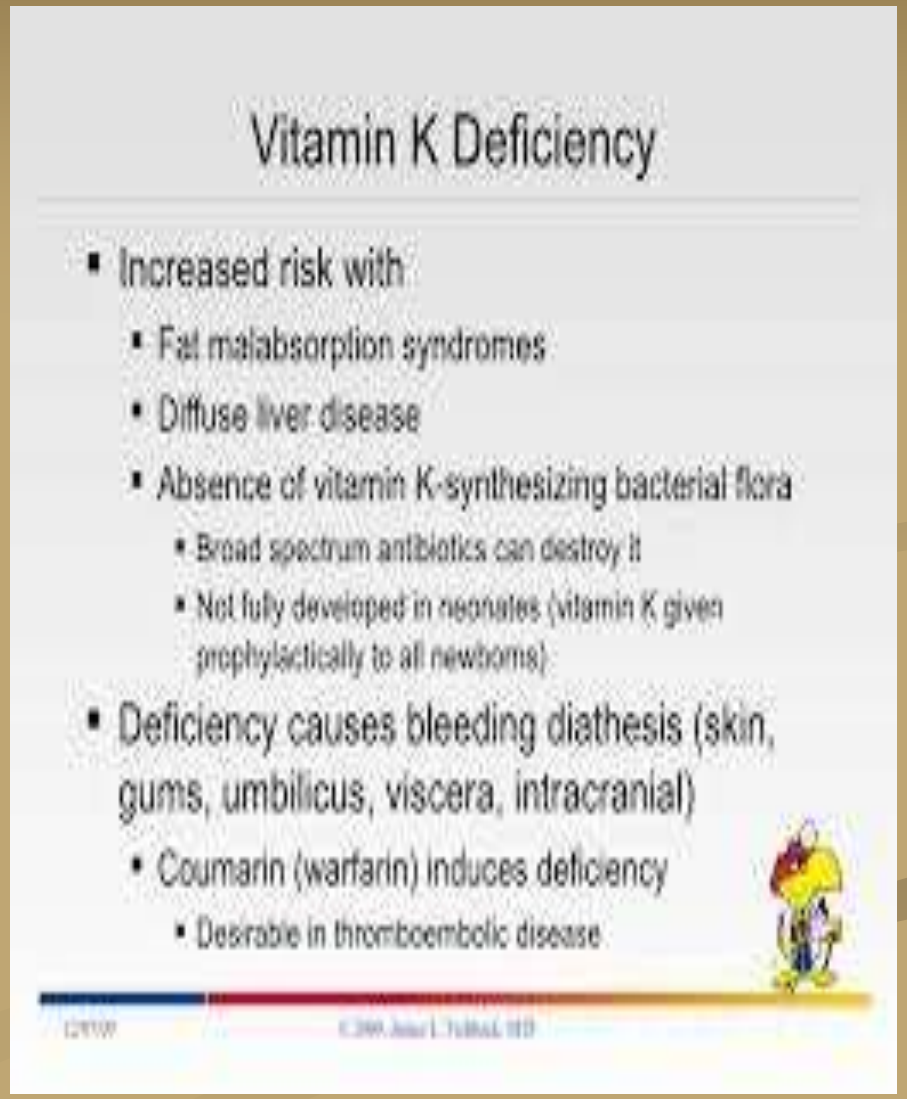
   - ❖Alkyl group larger than Methyl at C-2
   - ❖Hydroxyl group at C-3.
   - ❖Hydroxylation or saturation or cis-co
     of the phytyl side chain at C-3.

Activity not affected:

if positions 1 and 4 are substituted with OH, NH_2, OCH_3, OC_2H_5, C=O

Symptoms of Vitamin K deficiency

1. Uncontrolled internal bleeding.
2. Cartilage calcification and malformation of developing bone.
3. Deposition of insoluble calcium salts in the arterial vessel walls.



The basic factors needed to prevent vitamin K deficiency:

a) A normal diet containing the vitamin.
b) The presence of bile in the intestine.
c) A normal intestinal uptake or absorption.
d) A normal liver i.e. no interference with vitamin K metabolism or use of vitamin K antagonists therapeutically or accidently.
e) Heavy alcohol consumption impairs the liver's ability to produce vitamin K-dependent coagulation factors and impair recycling of vitamin K.

Symptoms of Vitamin K Toxicity

- Vitamins K1 and K2 are non-toxic in large doses.
- Vitamin K3 (the synthetic one) is toxic in doses three time more than the usual dose.

Toxicity manifestations:

- Hyperbilirubinemia.
- Severe Jaundice.
- Anemia.

Drug Interaction with Vitamin K

A. Some interactions may increase the need for vitamin K:

1. **Antibiotics:** Prevent absorption and kill normal bacterial folra.
2. **Anticonvulsants** e.g. Phenytoin : Affect Vit K metabolism.

Functions of Vitamin K

Vitamin K is involved as a cofactor in the carboxylation of certain glutamate residues in proteins to form **γ- carboxyglutamate residues (Gla-residues).** Gla-residues are usually involved in binding calcium and are essential for the following biological activities:

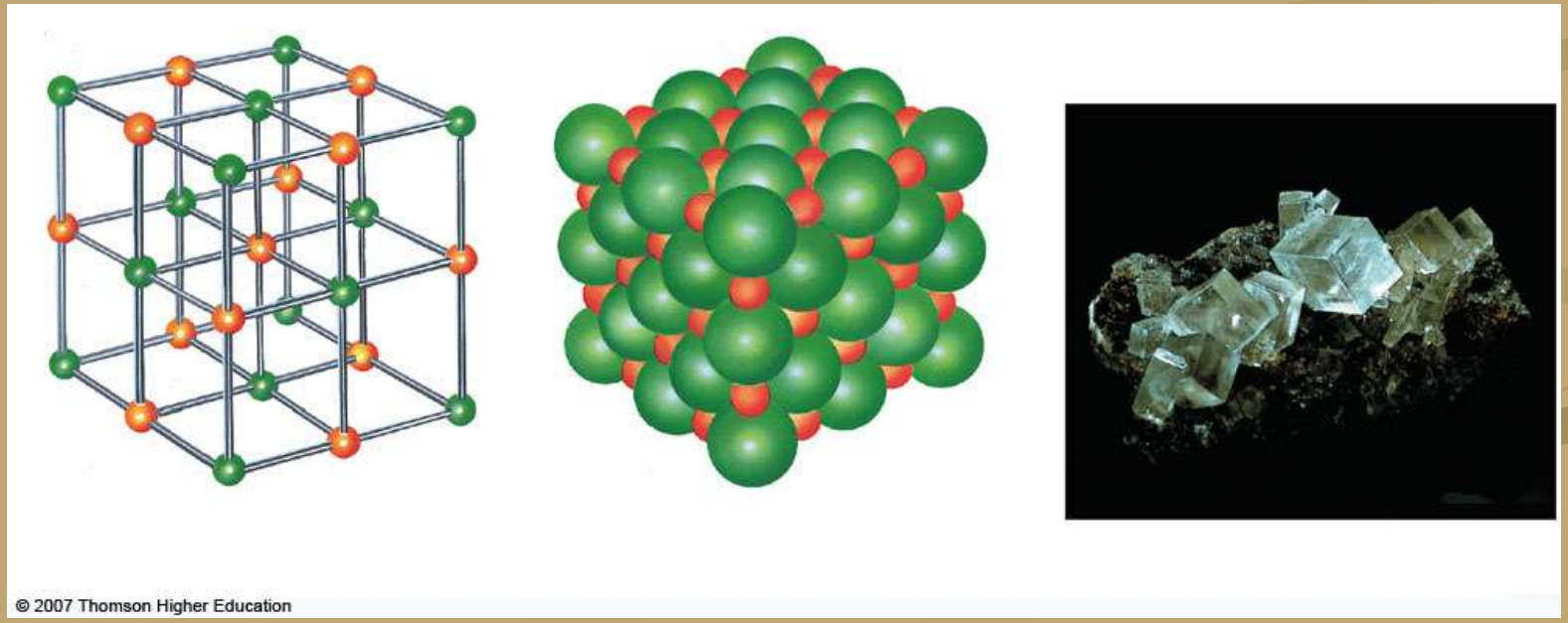
1. **Blood coagulation**
   Production of proteins that are part of the coagulation cascade in the blood. Several proteins promote coagulation (prothrombin, VII, IX, X) while others slow it down (proteins C and S). Thus, activity of vitamin K balances the two opposing sides of coagulation system in blood.
2. **Bone metabolism**
   •Bone Gla-protein (Osteocalcin): Regulate incorporation of calcium Phosphate into bones.
   •Matrix GLA protein (MGP): Clearance of extracellular Calcium to protect against soft tissue calcification.

MINERALS

What is a mineral?

- Naturally occurring
- Inorganic
- Crystalline structure

Halite, salt, sodium chloride



Humans cannot survive without minerals

- 16 minerals needed for humans to survive
- .03% of what we eat but we would not survive without the minerals
- Sodium, potassium, calcium, magnesium, copper, phosphorous

Macro & Micro Minerals

- Macro
- Salt (NaCl)
- Calcium (Ca)
- Phosphorous (P)
- Magnesium (Mg)
- Potassium (K)
- Sulfur (S)

- Micro
- Copper (Cu)
- Selenium (Se)
- Zinc (Zn)
- Manganese (Mn)
- Cobalt (Co)
- Iron (Fe)
- Chromium (Cr)
- Molybdenum (Mo)
- Iodine (I)
- Nickel (Ni)

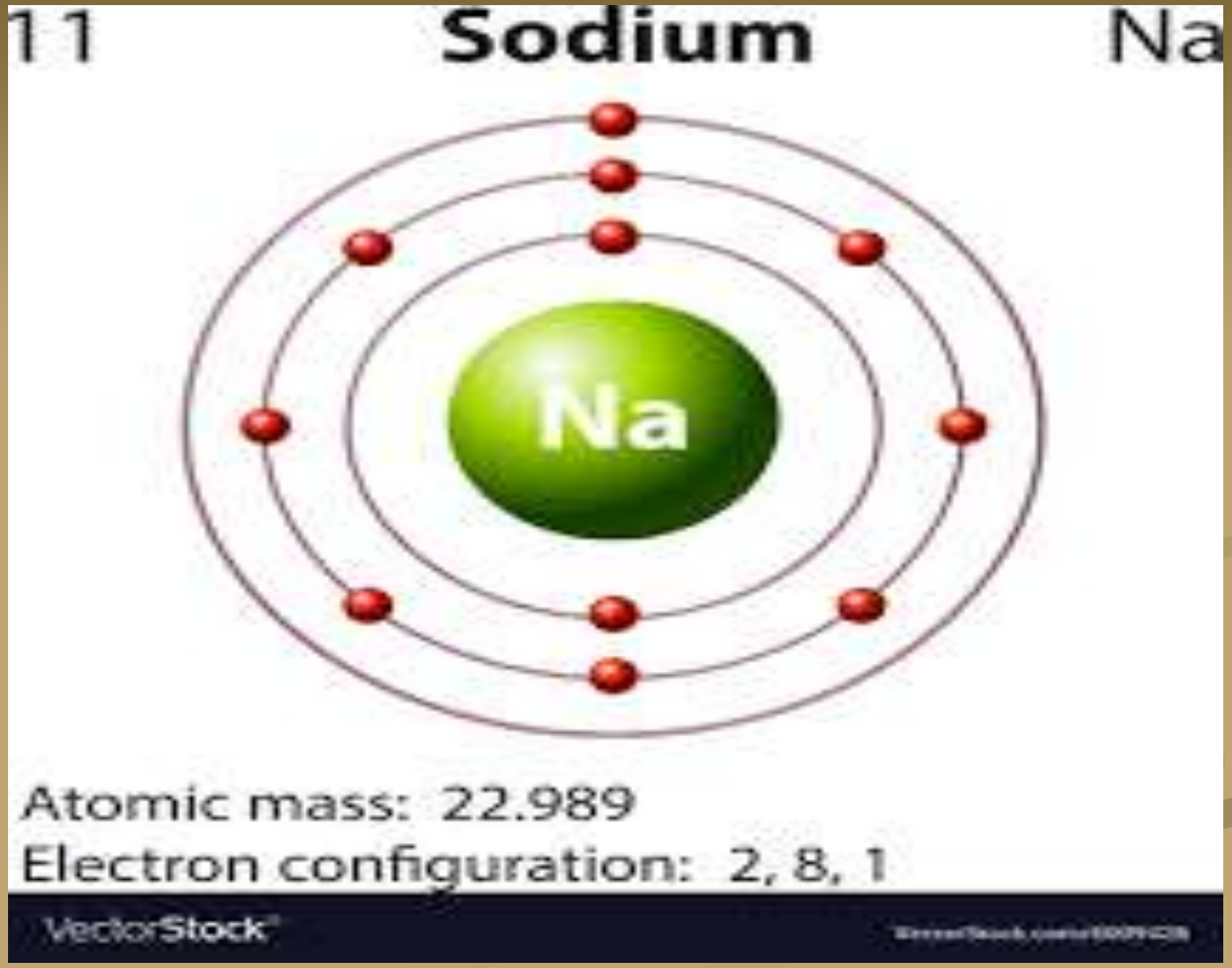
Minerals

- Are inorganic regulators needed for different functions inside the body.

- Do not provide energy but involved in generation of energy through their metabolic function
- provide a good medium for the protoplasmic activities (permeability of cells membrane and normal functioning of the cell, irritability of muscle and nerve cells
- maintaining body fluid balance (osmotic pressure)
- regulation of acid-base balance
- for structural units (bones and teeth
- haemoglobin and thyroxin formation
- some are cofactors in the enzymatic reactions

Functions of Minerals

- Formation of bones and teeth — Ca
- Mg — Cofactors for metabolic enzymes
- Transportation of Oxygen — Fe
- K — Regulate heart beat, membrane potential
- Boost body immunity and heal wounds — Zn
- Cl — Produce hydrochloric-acid in stomach
- Produce thyroid hormones — I
- P — Synthesis of DNA and bones
- Regulate body fluids, maintain pH balance — Na
- Cu — Metabolism of Iron and enzymes
- Functioning of antioxidant enzymes — Se


11
Sodium
Na
Na
Atomic mass: 22.989
Electron configuration: 2, 8, 1
VectorStock

SODIAM RICH FOODS

Milk

Kale

Cherry tomatoes

Cantaloupe

Broccoli

Salmon

yogurt

Sweet potato

Spinach

Sodium

- RDA = 1,500 mg/day, same as for non-pregnant women
- Excess: fluid retention, bloating, high blood pressure
- Increased body fluids are a normal and necessary part of pregnancy
- Some sodium needed for fluid balance

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Regulation of Sodium Balance: Aldosterone

- Low aldosterone cause Na excretion and water will follow it
- High aldosterone levels will cause Na absorption. For the water to be absorbed ADH must also be present
- Adrenal cortical cells are also directly stimulated to release aldosterone by elevated K^+ levels in the ECF
- Aldosterone brings about its effects (diminished urine output and increased blood volume) slowly

Absorption and excretion

- Sodium is absorbed by sodium pump situated in basal and lateral plasma membrane of intestinal and renal cells.
- Na-pump actively transports Na into extracellular fluid.
- There is normally little loss of these ions through the skin (sweat) and in the faeces.

Biochemical Functions

- Sodium (as sodium bicarbonate) regulates the body **acid base balance.**
- Sodium regulates **ECF volume**:
  - Sodium pump is operating in all cells, so as to keep Sodium **extracellular**.
  - This mechanism is **ATP dependent**.

Function of sodium

- **Provides 92% of ECF osmolarity & maintains internal environment**
- **Is concerned with**
- **RMP, AP & neuromuscular/ tissue excitability**
- **Maintenance of electrolyte & fluid balance**
- **Cardiac rhythmicity & contractility**
- **Exocrine secretion**
- Maintenance of blood volume & BP

DEFICIENCY & TOXICITY

Sodium

- Sodium Deficiency
  - ✓ Sodium and water must be replaced after vomiting, diarrhea or heavy sweating.
  - ✓ Symptoms are muscle cramps, mental apathy, and loss of appetite.
  - ✓ Salt tablets without water induce dehydration.
  - ✓ Be careful of hyponatremia during ultra-endurance athletic activities.
- Sodium Toxicity and Excessive Intakes
  - ✓ Edema and acute hypertension
  - ✓ Prolonged high intake may contribute to hypertension.

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Sodium

Function

- Needed to regulate body fluids
- Needed for energy release
- Needed for proper functioning of nerves and muscle contraction

Sources

- Smoked fish, soy sauce, ham, bacon, olives, processed foods and table salt

Effects of deficiency

- As sodium is found in small amounts in many foods and is particularly high in processed foods, most people have a higher sodium intake than they need. High sodium intake has been linked to high blood pressure and strokes

RDA

- RDA met by a high intake of processed foods

MINERLS

CALCIUM

Distribution

- 1 to 1.5kg- total content of calcium in the body
- Present in bone and teeth
- Rest ECF (blood)
- Normal blood level of ca is 9 to 11mg

Dietary sources

- Milk and milk product
- Egg , fish, mutton, dates and vegetable
- Cereals , millets

RDA

- Adult – 0.4g per day
- Children -0.6 g per day
- Pregnancy and lactation – 1g per day

Absorption of calcium

- Calcium is absorbed in duodenum against concentration gradient
- Absorptions requires calcium binding protein
- Which requires energy

Factors facilitating calcium absorptions

- Calcitriol
- PTH
- Lactose
- Amino acids (lysine and arginine)
- gastric acidity

Factors decreasing calcium absorption

- Phytates
- Oxalates
- Fatty acids
- High phosphate
- Alkaline condition

storage

- Bones,teeth and muscle stores calcium
- Teeth calcium can not used to maintain blood calcium level
- Excretion -500 mg of calcium is excreted in the urine

Functions of calcium

- Bones and teeth formation
- blood coagulation
- Muscle contraction
- Transmissions of nerve impulse
- Neuromuscular excitability
- Hormone action
- Release of hormone
- Activation of enzyme
- Membrane integrity and cell permeability
- Cell to cell contact.

Dietary deficiency

- Children : impaired growth negative calcium balance
- Adult : osteoporosis
- Toxicity : risk of kidney and decreased absorption of minerals

Calcium homeostatis

- Vitamin D : intestine , kidney,bones
- PTH
- Calcitonin

Phosphorus

distribution

- Adult body has about 1kg of phosphorus
- 85% - combination with calcium in t bones and teeth
- 15% - various chemical compounds of the body

sources

- Milk , egg, fish, cereals , pulses, nuts , oil seeds, leafy vegetables meet and soft drinks.
- Bio - availability of P from plant sources is much lower as they contain phytates which decreases phosphorus absorption

RDA

- Adult – 400 mg
- Children – 500mg
- Pregnancy and lactating – 1000mg

Absorption

- Phosphorous is mainly from jejunum.
- Calcitrol increases phosphorous absorption.
- PTH also facilitates phosphorous absorption.

Storage

- Phosphorous is mainly stored in teeth, bone and muscles.
- Excretions – 500mg

Functions

- Formation of bone and teeth
- Production of high energy phosphate
- Synthesis of nucleoside co enzymes
- Nucleic acid synthesis
- Formation of phosphate esters
- Enzyme activation
- Phosphate buffer system

Dietary deficiency of phosphorous

- Osteomalacia
- Growth retardation
- Toxicity – bone resorption

Megnesium

Distribution

- 25g – total amount
- 60% - bone
- Mg one of the major intra cellular caution
- Normal level of Mg is 5 milliequivelant per liter

sources

- Green leafy vegetables, milk, meat, sea foods , cereals, nuts, beans and fruits.
- RDA –male (350 mg), female (300mg) per day

absorption

- Mg is absorbed from intestines with a help of specific carrier.
- Increased amount of calcium, phosphate decrease the absorption of Mg.

functions

- Constituent of bones and teeth
- Magnesium serves as cofactor for many enzymes
- Magnesium is required for proper neuromuscular functions
- Magnesium has a role in insulin sensitivity
- Amino acids for protein synthesis

Dietary deficiency

- Only in combination with PEM, alcoholism, diarrhea and vomiting
- Toxicity - renal in sufficiency

TOPIC: CO-ENZYMES AND ITS FUNCTIONS

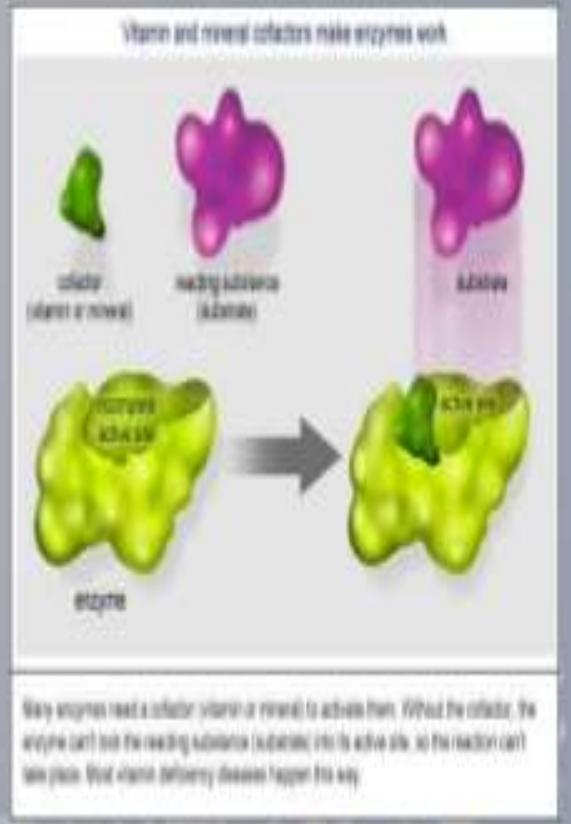
PRESENTED BY,
C.SATHYALAKSHMI,
ASSOCIATE PROFESSOR OF HOMESCIENCE COLLEGE

What Are Enzymes?

- **Enzymes** are large biological molecules responsible for thousands of metabolic processes that sustain life.
- They are highly selective catalyst, greatly accelerating both the rate and specificity of metabolic reactions.
- Some enzymes require no chemical groups for activity other than their amino acid residues. Other require an additional chemical component called a **cofactor** for the required activity.

Co-factor

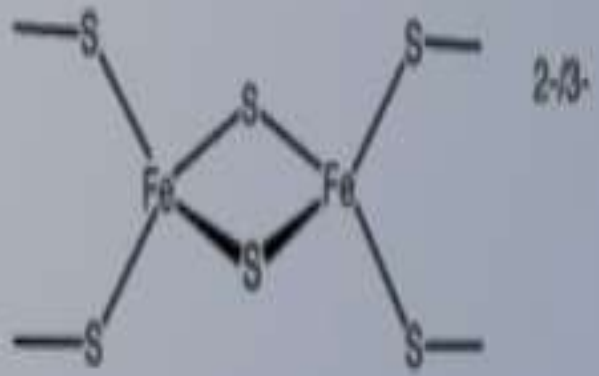
- A **cofactor** is a non-protein chemical compound that is required for the protein's biological activity. These proteins are commonly enzymes, and cofactors can be considered "helper molecules" that assist in biochemical transformations.
- Cofactors can be divided into two broad groups: **organic cofactors**, such as flavin or heme, and **inorganic cofactors**, such as the metal ions Mg^{2+}, Cu^{+}, Mn^{2+}, or iron-sulfur clusters.



Inorganic cofactor

Metal Ions

Ion	Examples of enzymes containing this ion
Cupric	Cytochrome oxidase
Ferrous or Ferric	Catalase Cytochrome (via Heme) Nitrogenase Hydrogenase
Magnesium	Glucose 6-phosphatase Hexokinase DNA polymerase



A simple $[Fe_2S_2]$ cluster containing two iron atoms and two sulfur atoms, coordinated by four protein cysteine residues.

Organic cofactor

- Organic cofactors are small organic molecules (typically a molecular mass less than 1000 Da) that can be either loosely or tightly bound to the enzyme and directly participate in the reaction.

Cofactor	Vitamin	Additional component	Chemical group(s) transferred	Distribution
NAD^+ and $NADP^+$	Niacin (B_3)	ADP	Electrons	Bacteria, archaea and eukaryotes
Coenzyme A	Pantothenic acid(B_5)	ADP	Acetyl group and other acyl groups	Bacteria, archaea and eukaryotes
Ascorbic acid	Vitamin C	None	Electrons	Bacteria, archaea and eukaryotes
Flavin mononucleotide	Riboflavin (B_2)	None	Electrons	Bacteria, archaea and eukaryotes

Coenzyme

- loosely bound cofactors termed **coenzymes**
- Any of a number of freely diffusing organic compounds that function as cofactors with enzymes in promoting a variety of metabolic reactions.
- Coenzymes are a type of cofactor and they are bound to enzyme's active sites to aid with their proper functioning.
- Coenzymes which are directly involved and altered in the course of chemical reactions are considered to be a type of secondary substrate.

Coenzymes as vitamins

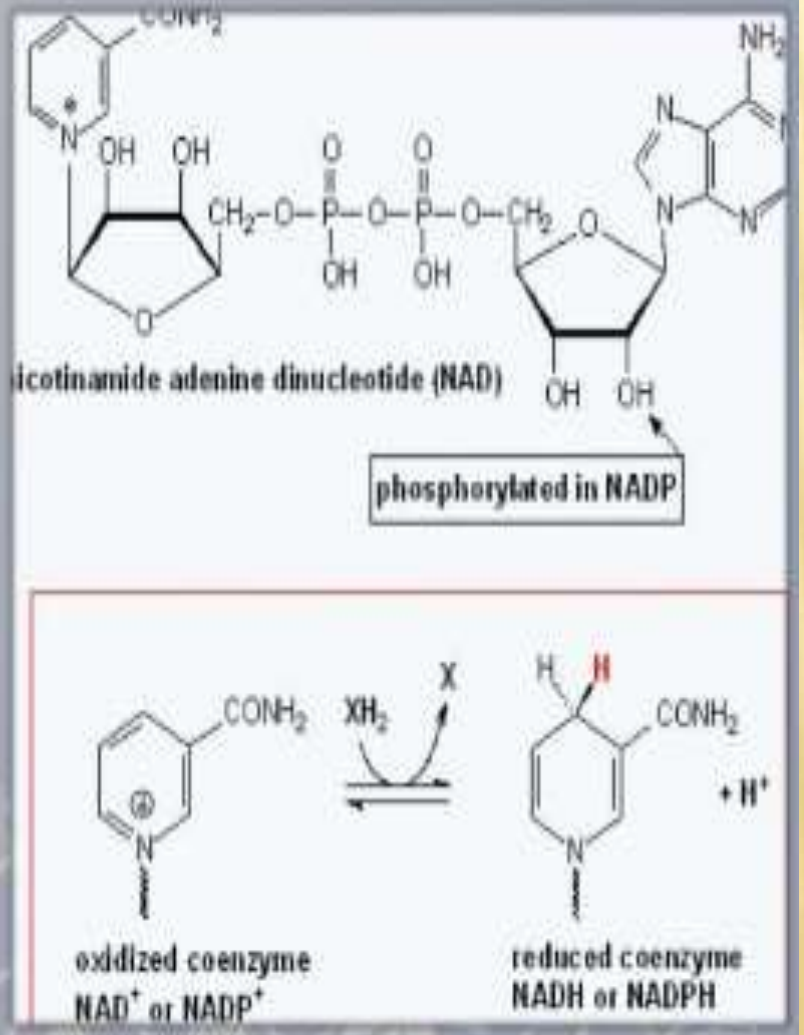
- Many coenzymes are closely related to vitamins. Some of them are important growth factors.
- Coenzymes are the precursors of vitamins.
- A vitamin is a main component of an coenzyme endowed with bio catalytic functions.
- Coenzymes involved in transfer of hydrogens are called hydrogen transferring enzymes and those which transfer a specific group are known as group transferring coenzymes.

coenzymes in Hydrogen transfer reaction

- **Nicotinamide nucleotide**
- These coenzyme involved in hydrogen transfer reaction and form essential components of dehydrogenase.

Biochemical function

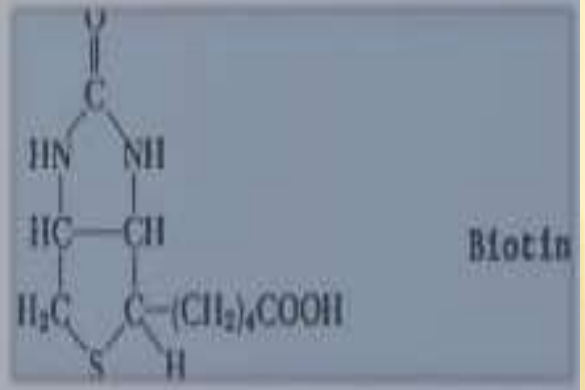
- These NAD+ and NADP are coenzymes of a number of dehydrogenases catalyzing oxidation-reduction reaction.
- All reaction catalyzed by them reversible



coenzymes involved in group transfer

- **BIOTIN**

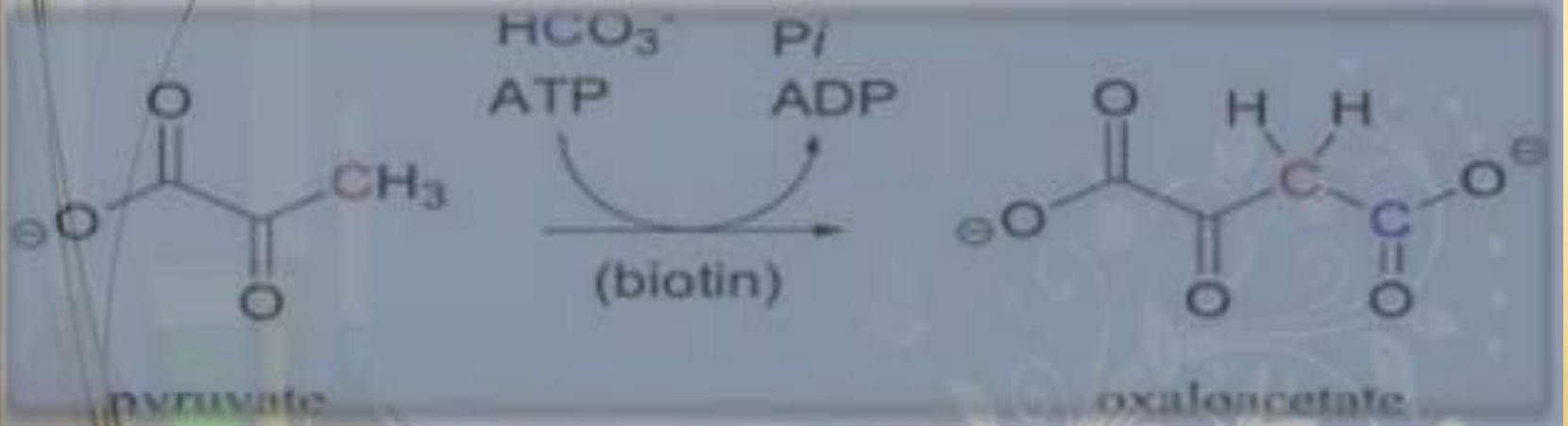
biotin is a coenzyme belonging to vitamin B2 group which is an essential growth factor for yeast and other microorganism, but is also required by higher organism.



Biotin

Biochemical function

Biotin is a water soluble vitamin and participate in transfer of carboxyl group.



Role of coenzyme

- The function of coenzymes is to transport groups between enzymes.
- Chemical groups include hydride ions which are carried by coenzymes such as NAD,
- phosphate groups which are carried by coenzymes such as ATP
- acetyl groups which are carried by coenzymes such as coenzyme A.
- Coenzymes which lose or gain these chemical groups in the course of the reaction are often reformed in the same metabolic pathway.

For example NAD+ used in glycolysis and the citric acid cycle is replaced in the electron transport chain

Function of coenzyme

- The coenzyme is essential for the biological activity of the enzyme.
- A coenzyme is a low molecular weight organic substance, without which the enzyme cannot exhibit any reaction.
- One molecule of the coenzyme is able to convert a large number of substrate molecules with the help of enzyme.

Salient features of coenzyme

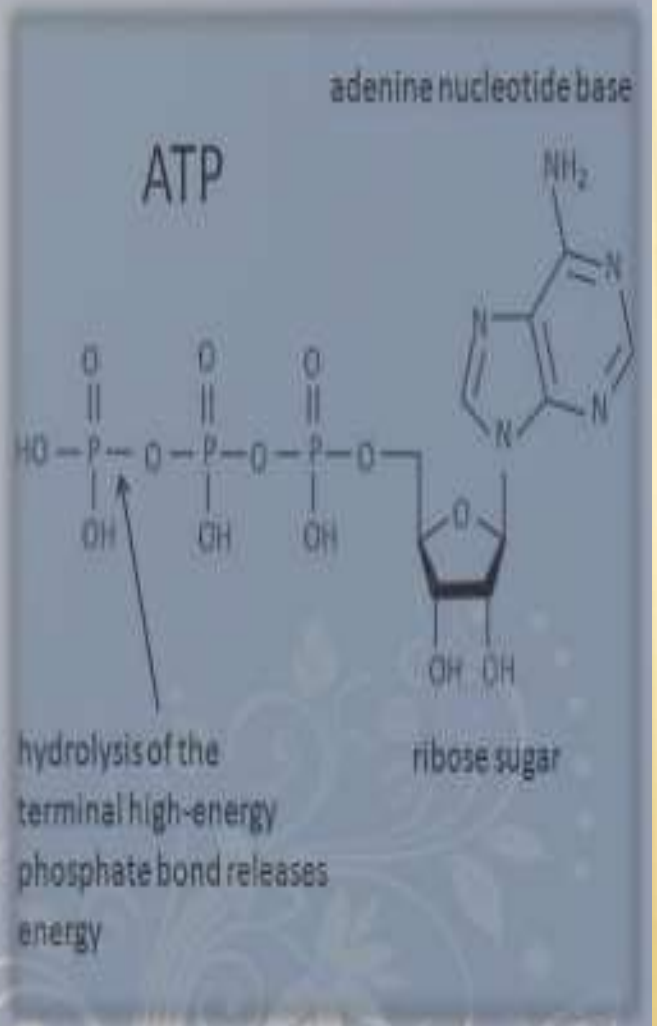
- Coenzymes are heat stable.
- They are low-molecular weight substances.
- The coenzymes combine loosely with the enzyme molecules and so, the coenzyme can be separated easily by dialysis.
- When the reaction is completed, the coenzyme is released from the apo-enzyme, and goes to some other reaction site.

Important coenzyme

- Alcohol dehydrogenase
- Coenzyme A
- Flavin adenine dinucleotide (FAD)
- Nicotinamide adenine dinucleotide (NAD)
- Adenosine triphosphate (ATP)

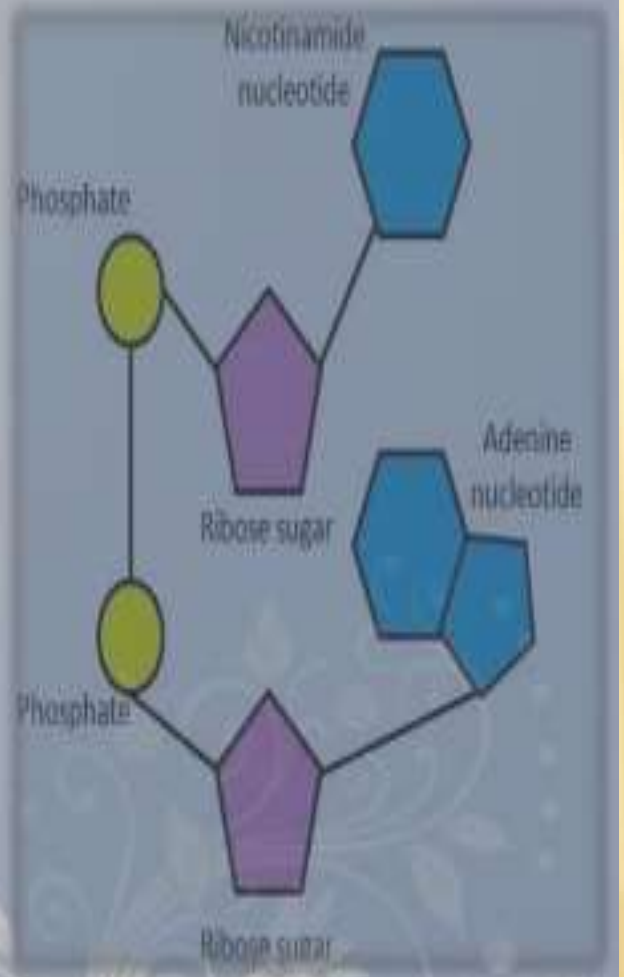
Adenosine triphosphate (ATP)

- The function of ATP is to transport chemical energy within cells for metabolism.
- ATP is often referred to as the energy currency of cells.
- Adenosine triphosphate is composed of an adenine nucleotide base, a ribose sugar and three phosphate groups.
- Energy can be released from ATP when the terminal phosphate group is released in a hydrolysis reaction. This is because the energy of ATP is held in the bonds between the phosphate groups and when the bonds are broken it is accompanied by a release of energy.



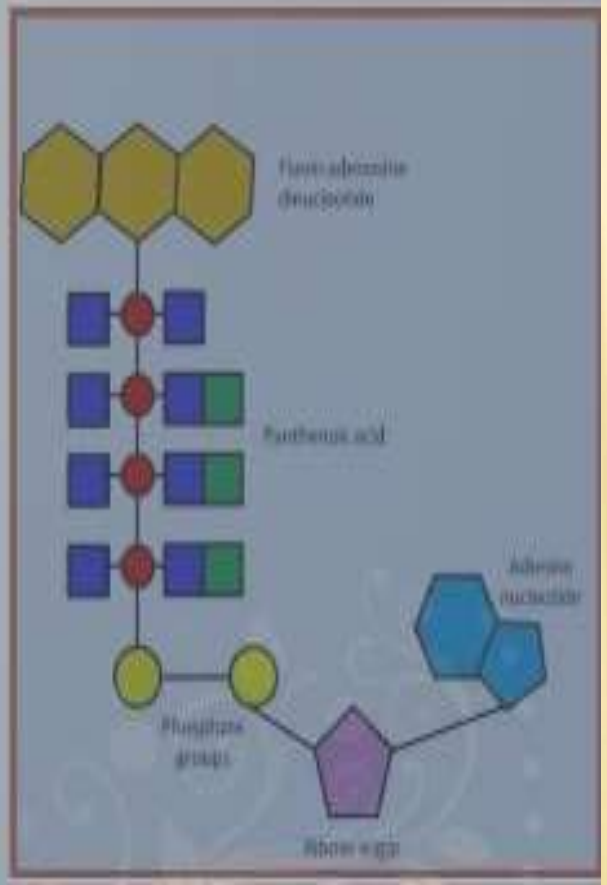
Nicotinamide adenine dinucleotide (NAD)

- NAD is composed of two nucleotides, adenine and nicotinamide.
- The nucleotides are held together by a pair of phosphate groups which act as a bridge and are also bonded to a ribose sugar each.
- The function of NAD is to carry electrons from one enzyme controlled reaction to another.
- NAD is involved with redox reactions because substrates are either oxidized , in which they lose electrons or are reduced in which they gain electrons.
- NAD is either found as NAD+, which is an oxidizing agent and is involved with accepting electrons from other molecules.
- NADH which is used as a reducing agent to donate electrons to other molecule



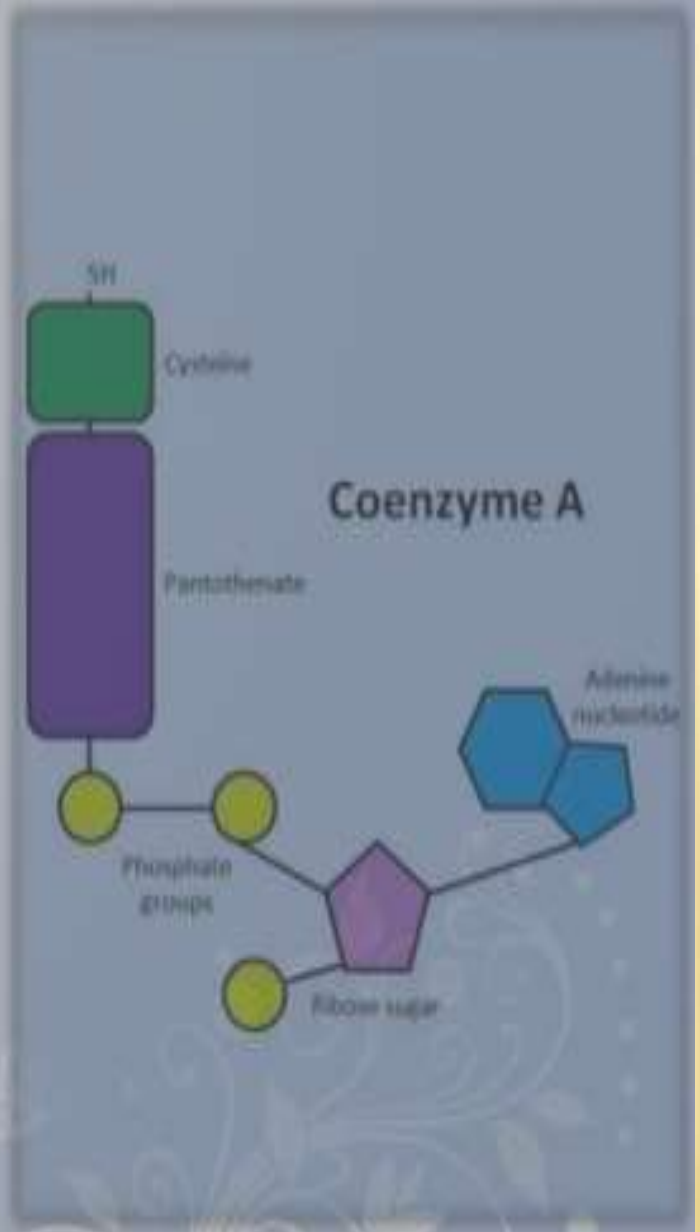
Flavin adenine dinucleotide (FAD)

- FAD is composed of an adenine nucleotide, a ribose sugar and two phosphate groups.
- FAD can also exist as a monophosphate and is called flavin adenine monophosphate (FMN).
- FAD is involved with redox reactions.
- like NAD, FAD can exist in two redox states FAD and FADH.



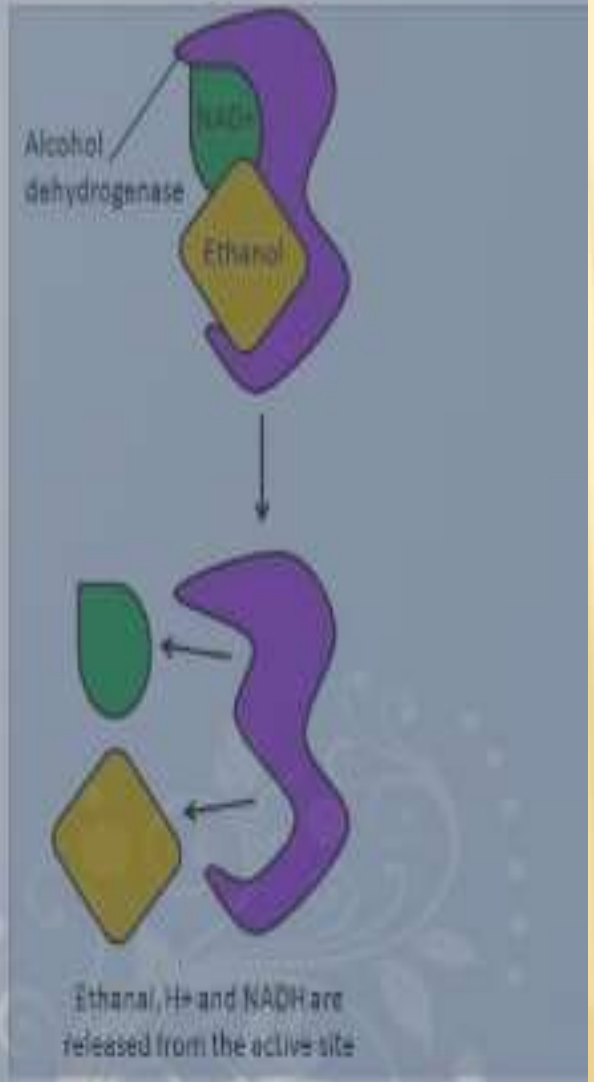
Coenzyme A

- Coenzyme A is a prominent coenzyme of living organism which transfers the acyl group of carboxylic acid.
- It plays an important role in the metabolism of proteins, carbohydrates and fats which are important reactions that allow the energy from food to be released. For example coenzyme A is required for the oxidation of pyruvate in the citric acid cycle.
- Coenzyme A is also important in the synthesis of cholesterol and steroid hormones, and is required for the detoxification of a range of harmful drugs that can accumulate in the liver.



Alcohol dehydrogenase

- Alcohol dehydrogenase (ADH) is an enzyme which uses NAD+ as a coenzyme.
- ADH has two binding regions, one where the primary substrate, ethanol binds and one where the coenzyme, NAD+ is able to bind.
- The enzyme is responsible for the conversion of ethanol to ethanal. The reaction is an oxidation-reduction reaction and results in the removal of two hydrogen ions and two electrons from ethanol. The hydrogen ions and electrons are added to NAD+ which converts the coenzyme to NADH + H+. This is the first reaction involved with the metabolism of ethanol.



DNA AND RNA
PROTEIN SYNTHESIS

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DNA:

- **DNA** is basically a long molecule that contains coded instructions for the cells.

- Everything the cells do is coded somehow in DNA - which cells should grow and when, which cells should die and when, which cells should make hair and what color it should be Our DNA is inherited from our parents.

- We resemble our parents simply because our bodies were formed using DNA to guide the process - the DNA we inherited from them.

- We may resemble our parents, but we are never exactly like them. This is because each child gets only some of the DNA each parent carries.

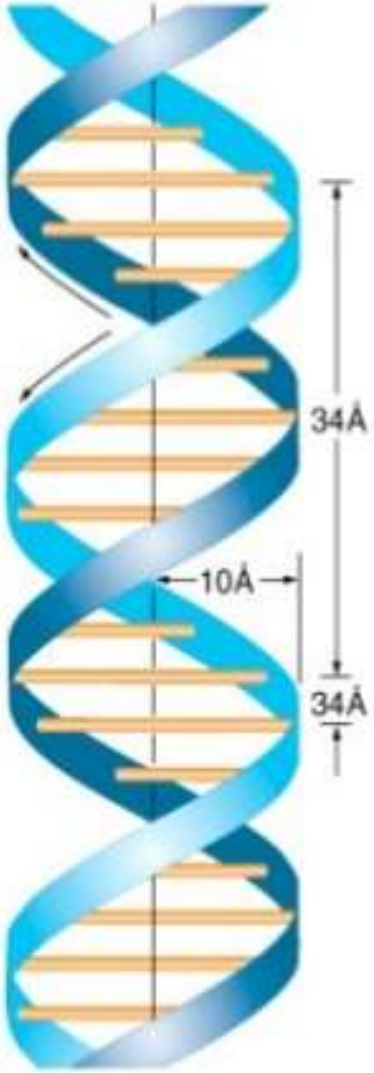
- About half our DNA comes from our mother, and half comes from our father.

- Which pieces we get is basically random, and each child gets a different subset of the parents' DNA.

- Thus, siblings may have the same parents, but they usually do not have exactly the same DNA.

DNA STRUCTURE

- helical structure of DNA
- major & minor groves
- 10Å radius & 20Å diameter
- 3.4Å between nucleotide base pairs
- 34Å / 360° turn
- 10 nucleotide base pairs / 360° turn



STRUCTURE

- DNA is made up of molecules called nucleotides. Each nucleotide contains a phosphate group, a sugar group and a nitrogen base. The four types of nitrogen bases are adenine (A), thymine (T), guanine (G) and cytosine (C).

- Dna is a polymer. The monomer of dna is called a neucleotide. Dna molecule has shape of a double helix.We all know that the DNA is made up of three components as I said in the definition.

- Structurally, the DNA is a kind of spirally coiled molecule having minor and major grooves.

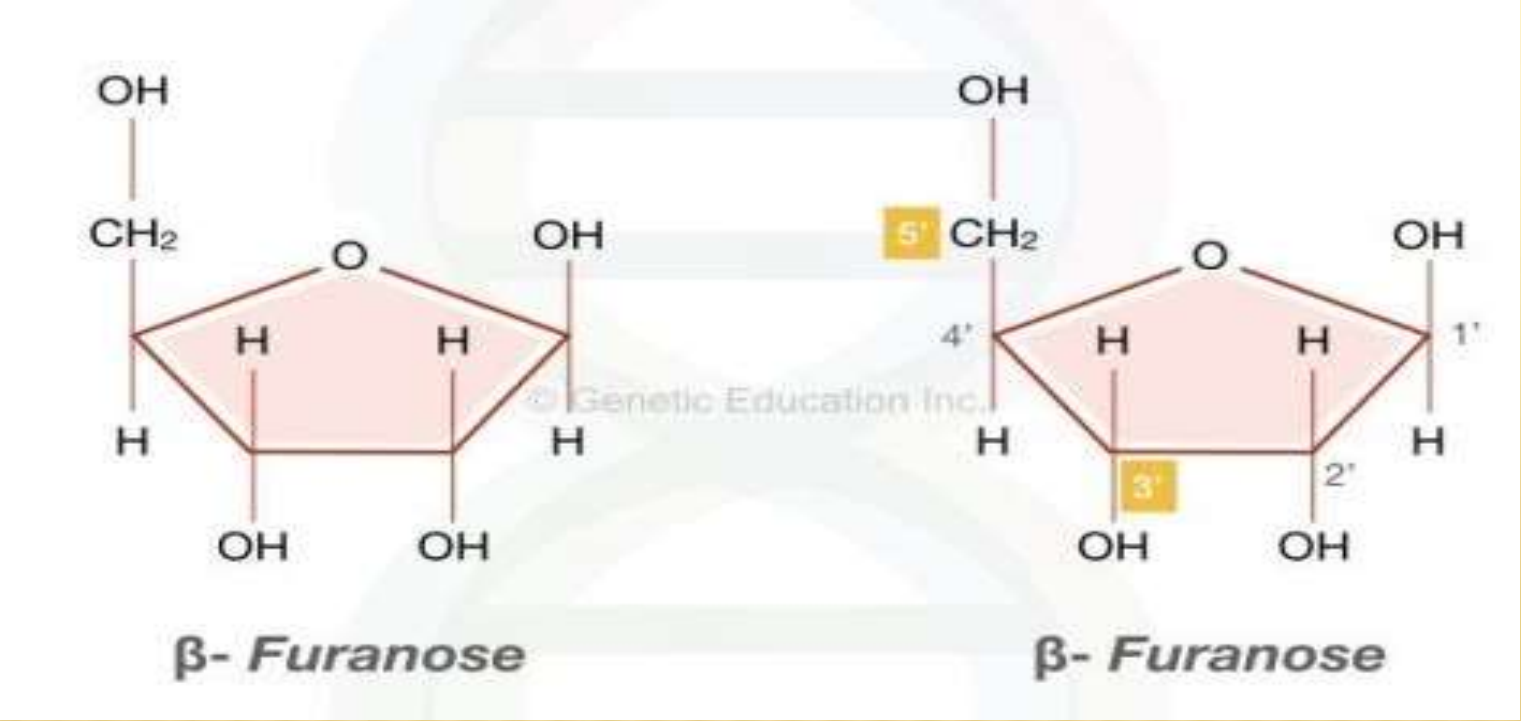
- These chromosomes are made up of thousands of shorter segments of DNA, called genes. Each gene stores the directions for making protein fragments, whole proteins, or multiple specific proteins.

THE MOLECULAR STRUCTURE OF DNA

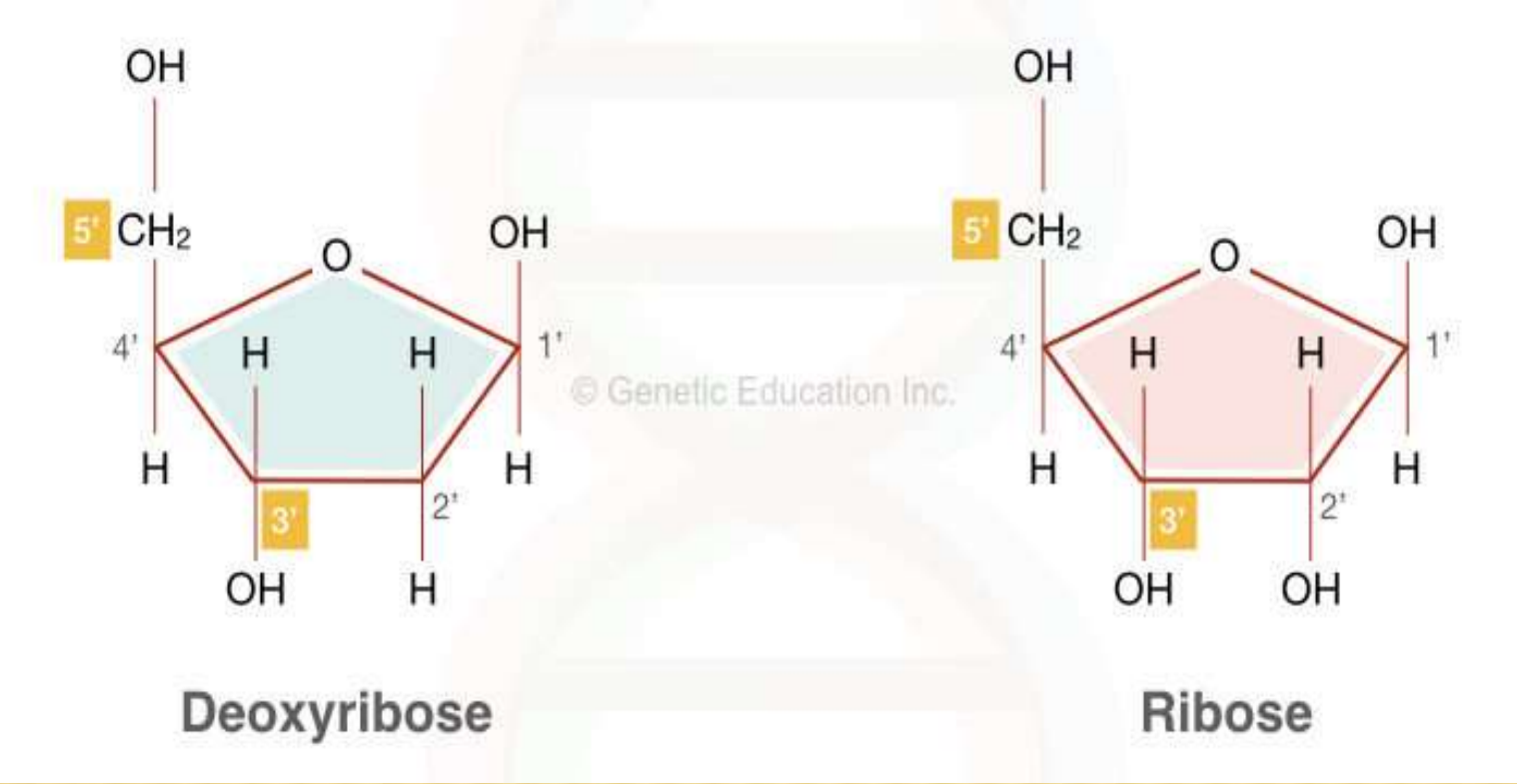
- In order to understand the biological function of DNA, you first need to understand its molecular structure. This requires learning the vocabulary for talking about the building blocks of DNA, and how these building blocks are assembled to make DNA molecules.

- DNA is the information molecule. It stores instructions for making other large molecules, called proteins. These chromosomes are made up of thousands of shorter segments of DNA, called genes.

- **Ribose:**
- The ribose, a pentose sugar is one of the primary units of the DNA. Both types of nucleic acid viz DNA and RNA are made up of the pentose sugar. The DNA is made up of deoxyribose, 2’-deoxy D- ribose while the RNA is made up of ribose or D-ribose only.
- The ribose present in both the nucleic acid are pentose (having five-carbon) and in beta- furanose form. The structure of the beta-furanose is given below,



- Even if the DNA has some uracil, 2’-deoxy D- ribose makes it DNA likewise even if thymine is present in RNA, D-ribose makes it RNA. The identity of each nucleic acid is because of the difference in the pentose sugar, not because of the bases. See the image below,



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FUNCTIONS OF STRUCTURE

- In a simple language, we can say, the function of DNA is to store and transfer information just like our computer. Scientifically, DNA code for various proteins and regulates gene expression.

- The DNA forms a long chain of amino acid and hence by doing this, it creates different types of proteins for different function and structural support. Three major events happened to do so; replication, transcription and translation.

REPLICATION

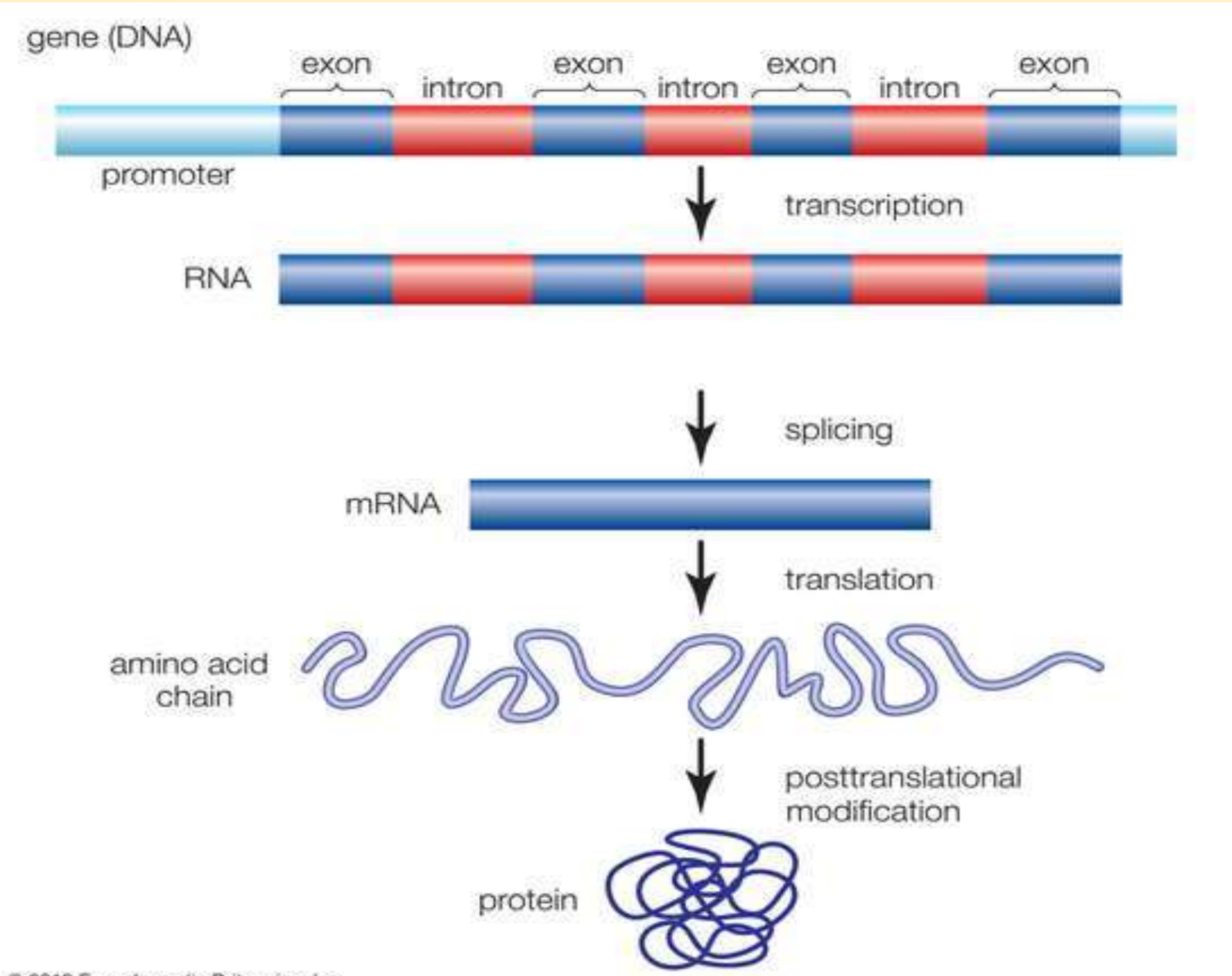
- The replication is a process in which a DNA molecule becomes doubled through the enzymatic reactions.

- Briefly, the helicase unwinds the dsDNA, the primase settled RNA primer on the leading strand and a polymerase synthesise a new DNA from it.

TRANSCRIPTION

- **Transcription**, the synthesis of RNA from DNA. Genetic information flows from DNA into protein, the substance that gives an organism its form. This flow of information occurs through the sequential processes of transcription and translation. Transcription occurs when there is a need for a particular gene product at a specific time or in a specific tissue.

- From the replicated DNA, a messenger RNA is generated in the process called transcription. The RNA polymerase synthesises an mRNA molecule from the single-stranded DNA and stores all the information for a gene to expression.



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RNA STRUCTURE

- RNA typically is a single-stranded biopolymer. However, the presence of self-complementary sequences in the RNA strand leads to intrachain base-pairing and folding of the ribonucleotide chain into complex structural forms consisting of bulges and helices.

- The three-dimensional structure of RNA is critical to its stability and function, allowing the ribose sugar and the nitrogenous bases to be modified in numerous different ways by cellular enzymes that attach chemical groups (e.g.,methyl groups) to the chain.

- Such modifications enable the formation of chemical bonds between distant regions in the RNA strand, leading to complex contortions in the RNA chain, which further stabilizes the RNA structure. Molecules with weak structural modifications and stabilization may be readily destroyed.

- RNAs can also form complexes with molecules known as ribonucleoproteins (RNPs). The RNA portion of at least one cellular RNP has been shown to act as a biological catalyst, a function previously ascribed only to proteins.

FUNCTIONS OF RNA

- Mrna(messsenger) – insructions protein
- Trna(transfer) – carriers that match amino acids to codons during translation
- Rrna(ribosomal) – part of the ribosomes- ribosomes are rna puls protein
- Rna has many functions but most rna molecules are involved in protein synthesis only.

TYPES OF RNA

- In both prokaryotes and eukaryotes, there are three main types of RNA – messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA). These 3 types of RNA are discussed below.

RNA(mrna):

- mRNA accounts for just 5% of the total RNA in the cell. mRNA is the most heterogeneous of the 3 types of RNA in terms of both base sequence and size.

- It carries complimentary genetic code copied, from DNA during transcription, in the form of triplets of nucleotides called codons.

- Each codon specifies a particular amino acid, though one amino acid may be coded for by many different codons.

- Although there are 64 possible codons or triplet bases in the genetic code, only 20 of them represent amino acids. There are also 3 stop codons, which indicate that ribosomes should cease protein generation by translation.

- part of post-transcriptional processing in eukaryotes, the 5’ end of mRNA is capped with a As guanosine triphosphate nucleotide, which helps in mRNA recognition during translation or protein synthesis.

- Similarly, the 3’ end of an mRNA has a poly-A tail or multiple adenylate residues added to it, which prevents enzymatic degradation of mRNA. Both the 5’ and 3’ end of an mRNA imparts stability to the mRNA.

RNA(rRna):

- rRNAs are found in the ribosomes and account for 80% of the total RNA present in the cell. Ribosomes are composed of a large subunit called the 50S and a small subunit called the 30S, each of which is made up of its own specific rRNA molecules.

- Different rRNAs present in the ribosomes include small rRNAs and large rRNAs, which belong to the small and large subunits of the ribosome, respectively.

- rRNAs combine with proteins and enzymes in the cytoplasm to form ribosomes, which act as the site of protein synthesis.

- These complex structures travel along the mRNA molecule during translation and facilitate the assembly of amino acids to form a polypeptide chain.

- They interact with tRNAs and other molecules that are crucial to protein synthesis. the structure and function of ribosomes is largely similar across all species.

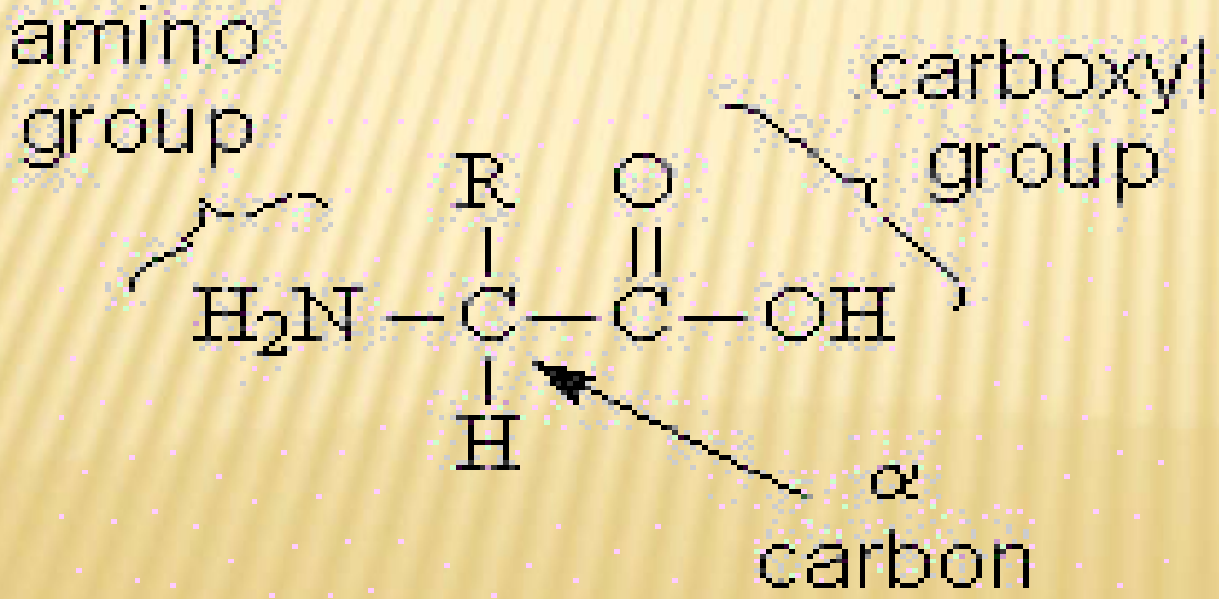
- RNA (TRNA):

- tRNAs have a clover leaf structure which is stabilized by strong hydrogen bonds between the nucleotides. They normally contain some unusual bases in addition to the usual 4, which are formed by methylation of the usual bases. Methyl guanine and methylcytosine are two examples of methylated bases.

- Each of the 20 amino acids has a specific tRNA that binds with it and transfers it to the growing polypeptide chain. tRNAs also act as adapters in the translation of the genetic sequence of mRNA into proteins. Thus, they are also called adapter molecules.

PROTEINS

- A protein is a long train of amino acids linked together. Proteins have different functions;they can provide structure (ligaments, fingernails, hair), help in digestion (stomach enzymes), aid in movement (muscles), and play a part in our ability to see (the lens of our eyes is pure crytalline protein). There are twenty amino acids that are commonly found in proteins. Each amino acid has a similar, yet unique structure.



PROTEIN STRUCTURE

- Protein structure is broken down into four levels:
- Primary structure refers to the "linear" sequence of amino acids.
- Secondary structure is "local" ordered structure brought about via hydrogen bonding mainly within the peptide backbone. The most common secondary structure elements in proteins are the *alpha (a) helix* and the *beta (b) sheet* (sometime called b pleated sheet).

FUNCTIONS OF RNA IN PROTEIN SYNTHESIS

- Cells access the information stored in DNA by creating RNA to direct the synthesis of proteins through the process of **translation**.

- Proteins within a cell have many functions, including building cellular structures and serving as enzyme catalysts for cellular chemical reactions that give cells their specific characteristics.

- The three main types of RNA directly involved in protein synthesis are **messenger RNA (mRNA)**, **ribosomal RNA (rRNA)**, and **transfer RNA (tRNA)**.

- Ribosomes are composed of rRNA and protein.

- As its name suggests, rRNA is a major constituent of **ribosomes**, composing up to about 60% of the ribosome by mass and providing the location where the mRNA binds.

- The rRNA ensures the proper alignment of the mRNA, tRNA, and the ribosomes; the rRNA of the ribosome also has an enzymatic activity (**peptidyl transferase**) and catalyzes the formation of the peptide bonds between two aligned amino acids during protein synthesis.

CONCLUSION

- Genetic information is encoded in the base sequence of dna molecules as series of genes.
- Gene expression is the term used to describe how cells decode the information to synthesize proteins required for cellular function.
- The expression of a gene involves the synthesis of a complementary rna molecules whose sequence specifies the amino acid sequence of a protein.
- The dna sequence of the gene is collinear with


Thank
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