

## EXAM 2

## 1. Function of pentose.

- **Ribose:**
  - Enter in the structure of **nucleic acids** (RNA and DNA.)
  - Enters in the structure of **ATP, GTP** and other high energy phosphate compounds.
  - Enters in the structure of coenzymes **NAD, NADP** and **flavoproteins**.
- **Ribose phosphate and ribulose phosphate are CHO:**
  - Intermediates in pentose phosphate pathway (minor pathway for glucose oxidation).
- **Arabinose and xylose:**
  - Are constituents of **glycoproteins** in plants and in animals.
- **Lyxose: is a constituent of a lyxoflavin isolated from human heart muscle.**
- **Xylulose: is an intermediate in uronic acid pathway** (a minor pathway for glucose oxidation).

## 2. Essential fatty acids.

- Definition:

- a) These are fatty acids that **cannot be synthesized in the body**. They must be obtained from the diet.
- b) They include fatty acids that contain more than one double bond (**polyunsaturated fatty acids**) e.g. **linoleic, linolenic, arachidonic acids**.
- c) The human body has enzyme system that can form only **one double bond** at the **ninth** carbon atom.

- Sources:

- a) **Vegetable oils** e.g. corn oil, soya bean oil, safflower oils, sunflower, linseed oil and cotton seed oil.
- b) **Fish oils:** shark liver oils, which particularly contain the  $\omega^3$  polyunsaturated fatty acids.

- Importance:

- a) Normal growth.
- b) They enter in the structure of phospholipids and cholesterol esters.
- c) They enter in the structure of **cell membranes** and are required for the fluidity of membrane structure.
- d) They protect against **atherosclerosis** and **coronary heart disease** by **decreasing** free

## 3. Tertiary structure of ptn (Definition, forms &amp; Bonds responsible)

- **Definition:** This is the **final arrangement** of a **single** polypeptide chain resulting from spatial relationship of more distant amino acid residues.

- **There are two forms of tertiary structures:**

- a) **Fibrous:** which is an extended form e.g. keratin, collagen and elastin.
- b) **Globular:** which is a compact form and results from folding of polypeptide chain e.g. myoglobin.

- **Bonds responsible for tertiary structure are:**

- a) **Hydrogen bonds:** within the **chain** or between **chains**
- b) **Hydrophobic bonds:** between the **nonpolar side chains (R)** of **neutral** amino acids.
- c) **Electrostatic bonds: (salt bonds):** between **oppositely charged groups** in the side chains of amino acids e.g. **amino group** of lysine and **carboxyl group** of Aspartate.
- d) **Disulfide bonds:** between **residues** within the chain.

#### 4. Optical activity.

- It is the ability of substance to rotate plane polarized light either to the right or to the left.
- 1- If the substance rotates plane polarized light to the right so it is called: dextrorotatory or d or (+).
- 2- If it rotates it to the left so it is called: levorotatory or l or (-).
- 3- Glucose is dextrorotatory, so it is sometimes named dextrose.
- 4- Fructose It is levorotatory, so it is sometimes called: Levulose.

#### 5. TAG properties.

##### A. Physical properties:

- a. **Solubility:** All triacylglycerols are insoluble in water, soluble in fat solvents.
- b. **Melting point:**
  - Triacylglycerols rich in unsaturated F.A. are **liquid** at room temperature. "Oils".
  - Triacylglycerols rich in saturated F.A. are **solid** at room temperature "Fats".
- c. **Specific gravity:** It is **less** than **one**. Specific gravity of water is one Therefore triacylglycerol float on the surface of water.
- d. **Grease stain test:** All Triacylglycerols give **+ve** grease stain test.

##### B. Chemical properties:

##### 1. Hardening (Reduction):

**Def:** Hydrogenation of oils to form solid fat or margarine

**As:** USFA are converted to SFA

##### 2. Hydrolysis of TAG:

##### a. Alkaline Hydrolysis (Saponification):

- **Def:** Hydrolysis of TAG using alkalis
- **Produces:** Glycerol & Soap
- **Soap:** Alkaline salt of FA



##### b. Enzymatic Hydrolysis:

TAG by lipase enzyme gives glycerol & 3 FAs

#### 6. Denaturation of ptn.

##### A. Definition: unfolding and loss of secondary tertiary and quaternary structure.

- Does not affect primary structure **i.e.** not accompanied by hydrolysis of peptide bond.
- Denaturation may be **reversible** (in rare cases)

##### B. Effect of protein denaturation:

1. **Loss of biological activity:** **e.g.** insulin loses its activity after denaturation.
2. Denaturated protein are often **insoluble**.
3. Denaturated protein are **easily precipitated**.

##### C. Denaturing factors include:

1. **Heat:** causes coagulation and precipitation of certain proteins like albumin.
2. **Organic solvents:** They interfere with **hydrophobic bonds** of proteins.
3. **Detergents:** They contain both hydrophobic and hydrophilic groups **i.e.** amphipathic. They interfere with hydrophobic bonds of proteins.

4. **Strong acids or bases:** They lead to change in pH which affects the charges on polypeptide chains. As a result, hydrogen and electrostatic bonds will be disrupted.
5. **Heavy metals:** as **lead** and **mercury** salts:
6. **Enzymes:** e.g. **Digestive** enzymes.

## 7. Mutarotation.

- It is a gradual change of specific rotation of any optically active substance having free aldehyde (-CHO) or ketone (C=O) group.
- $\alpha$  Glucose dissolved in water, has specific rotation of +112.
- $\beta$  Glucose when freshly dissolved in water, has specific rotation of -19.
- When both anomers are left for sometimes,  $\alpha$  and  $\beta$  sugars slowly change into an equilibrium mixture which has specific rotation of + 52.5.

## 8. Waxes.

Ñ **Def:** Esters of long chain FA **with** long chain alcohols contain **one (-OH)** group.

Ñ **Site:** Trunks of trees & fur of animals

Ñ **Function:** Acts as a protective coat

Ñ **Examples:**

1. **True wax (Bee's wax):** Esters of **palmitic** acid e' **mericyl** alcohol (C30)
2. **Lanolin (in hair):** Esters of cholesterol derivatives
3. **Vit A (Retinol)** esters                      4. **Vit D (Calciferol)** esters

Ñ **Properties:**

1. They have the same physical properties as fat.
2. They give negative **Acrolein** test because they contain no glycerol.
3. They are not digested by lipase enzyme. Thus they are not utilized.

## 9. Enumerate Scleroproteins & compare between 2 of them.

They include: keratin, collagen, elastin and reticulin.

### 1. Keratins:

- a) **Location:** They are found in hair, nail, enamel of teeth, and outer layer of skin.
- b) **Structure:** They are  **$\alpha$ -helical polypeptide** chains. They are rich in **cysteine** (which provides **disulfide bonds** between adjacent polypeptide chains).
- c) **Solubility:** It is **insoluble** due to their high content of **hydrophobic a.a**

### 2. Collagen

#### a) Types of collagens:

- There are more than **12** types of collagen. Type **I** is the most common in human body (**90%**) of cell collagens.
- Collagens form about **30%** of total body proteins.

#### b) Functions and Location:

- It is the protein of connective tissue present in **skin, bones, tendons** and **bl. vessels**.
- Bones and teeth are made by adding **mineral** crystals to the collagen.
- Collagen may be present as a **gel** e.g. in **extracellular matrix** or in **vitreous humour of the eye**.

**c) Structure:**

- 1) **Collagen molecules** are simple protein; consist of **3** polypeptide chains called  **$\alpha$ -chains**. They are twisted around each other forming triple helix molecule.
  - i- The 3 polypeptide chains are held together by hydrogen bonds
  - ii- each chains about 300 nm length and 1 .5nm in diameter.
  - iii- Each chain is formed of 1050 amino acids.
- 2) **Amino acids composition acid sequence:**
  - i- Amino acids composition: Collagen contains **33%** glycine (the smallest amino acid), **10%** proline, **10%** hydroxy proline and **1%** hydroxylysine.
  - ii- Amino acids sequence: Every **third** amino acid in the  **$\alpha$ -chain** is glycine. The repeating sequence is glycine-X-Y, where X is frequently proline and Y is often hydroxy-proline or hydroxylysine.
- 4) **Glycosylation:** Collagens are present in the form of glycoprotein. Glucose and galactose are commonly attached to collagen
- 5) **Collagen molecule has very firm structure due to:**
  - i- Each helical turn contains only 3 amino acids. For other proteins, each turn contains 3.6 amino acids.
  - ii- **Glycine** (the smallest amino acid) forms 33% of total molecule. This makes the polypeptide chains **compact**.
  - iii- The high content of hydroxyproline and hydroxylysine increase the number of hydrogen bonds.

**d) Collagen synthesis:**

1. Collagens are formed by **connective tissue** cells called **fibroblasts**.
2. **Intracellular location:** The polypeptide chains of procollagen are synthesized on the rough endoplasmic reticulum, where **procollagen** is cleaved → **Procollagen** + Signal (**pre**) sequence.
3. Proline and lysine residues are **hydroxylated** by a reaction that requires **O<sub>2</sub>** and **vitamin C**
4. Glycosylation by glucose and galactose that added to hydroxylysine residues.
5. The Procollagen (in the form of triple helix) is secreted from the cell and cleaved → **Collagen**
5. **Cross links** are produced.

**e) Solubility and denaturation:**

- 1) **Solubility:** Collagen is **insoluble** in **all solvents**. It is protein of low biological value and **not** digestible.
- 2) **Denaturation:**
  - When collagen is heated, it loses all of its structure. The triple helix unwinds and the chains are separated. Then when this Denaturated mass cools down, it soaks up all of the surrounding water like sponge, **forming Gelatin**.
  - **Gelatin** is **soluble** in water and **digestible**.
  - **Gelatin** is given for patients during **convalescence** (in the form of **jelly**).

**f) Collagen diseases: (Scurvy):**

- i- It is due to a **deficiency** in ascorbic acid (**vitamin C**). See vitamins.

### 3. Elastin:

#### a) Characters:

- It is connective tissue protein. It is **rubber** like **i.e.** it can be stretched to several times as their normal length, but **recoil** to their original shape when the stretching force is **relaxed**

#### b) Location:

It is present in **lungs**, the **walls of large blood vessels** and **elastic ligaments**.

#### c) Structure:

- 1) Elastin is formed of **4** polypeptide chain.
- 2) Elastin is similar to collagen, being rich in glycine (**1/3 of its a.a**) and **proline**. It is poor in hydroxyproline hydroxylysine.
- 3) The 4 polypeptide chains are interconnected through their lysine residues. The 4 lysine residues are linked together form a cyclic structure termed: **desmosine**.

Elastin is capable of undergoing 2 way stretch, due to its content of desmosine.

#### Role of $\alpha$ 1-antitrypsin ( $\alpha$ 1-AT) in : elastin degradation:

- 1)  $\alpha$ 1-antitrypsin is an enzyme produced mainly by **liver**. It is also produced by blood cells **monocytes** and **macrophages**.
- 2) It is present in blood and other body fluids.
- 3) It inhibits a number of enzymes and destroys proteins.
- 4) Role of  $\alpha$ 1-AT in the lungs: In the normal lung, the alveoli are exposed to low levels of **elastase enzyme** released from **neutrophils**. Their proteolytic activity can destroy the elastin in alveolar walls: This elastase enzyme activity is inhibited by  $\alpha$ 1-antitrypsin.
- 5) Deficiency of  $\alpha$ 1-AT: Leads to destruction of connective tissue of alveolar walls by neutrophils elastase. This leads to lung disease called: **emphysema**.

	collagen	Elastin
<b>Number of chains</b>	3	4
<b>Amino acids</b>	1/3 glycine, rich in proline, more hydroxyproline,	1/3 glycine, rich in proline, less hydroxyproline and free from hydroxylysine
<b>Structure</b>	Fibrous	* <b>Fibrous</b> in extended form * <b>Globular</b> in relaxed form
<b>Direction of stretch</b>	One direction	2 Directions due to presence of desmosine

## 10. Disaccharides.

- definition of (disaccharides):

- These are formed by condensation of 2 molecules of monosaccharides bound together by glycosidic bond, Its general formula is  $C_n (H_2O)_{n-1}$

- What is the most important (disaccharides):

- $\{\alpha\text{-glucose} + \alpha\text{-glucose}\} : \rightarrow \alpha (1-1) \text{ glycosidic bond} \rightarrow \text{trehalose}$   
 $\rightarrow \alpha (1-4) \text{ glycosidic bond} \rightarrow \text{Maltose}$   
 $\rightarrow \alpha (1-6) \text{ glycosidic bond} \rightarrow \text{Isomaltose}$
- $\{\beta\text{-glucose} + \beta\text{-glucose}\} : \rightarrow \beta (1-4) \text{ glycosidic bond} \rightarrow \text{Cellobiose}$
- $\{\beta\text{-glucose} + \beta\text{-galactose}\} : \rightarrow \beta (1-4) \text{ galactosidic bond} \rightarrow \text{Lactose}$
- $\{\alpha\text{-glucose} + \beta\text{-fructose}\} : \rightarrow (\alpha1-\beta2) \text{ glycosidic bond} \rightarrow \text{Sucrose}$

Sugar	Source	Importance & Clinical Significance
<b>Trehalose</b>	<b>a)</b> It is present in fungi and yeast <b>b)</b> It is the major sugar of fungi and insect hemolymph	- Trehalose can be used as a sweetener and <b>preservative</b> for foods. - It can be also used in <b>organ</b> and tissue preservation solutions that provide improved viability of an organ such as a <b>heart</b> or <b>lung</b> .
<b>Maltose</b> "Malt sugar"	<b>a)</b> Malt. <b>b)</b> <b>Maltose</b> is produced during digestion of starch by amylase enzyme.	
<b>Isomaltose</b>	- <b>Isomaltose</b> is produced during digestion of starch and glycogen by amylase enzyme.	
<b>Cellobiose</b>	- It is obtained by partial hydrolysis of cellulose present in plants.	

Lactose "Milk sugar"	a) Milk. b) In human milk, its concentration is <b>7.4 g/dl</b> .	a) It may appear in urine in <b>late pregnancy</b> and <b>during lactation</b> . b) In <b>lactase deficiency</b> , malabsorption leads to diarrhea and flatulence.
Sucrose "Table sugar"	a) <b>cane</b> and <b>beet</b> sugar b) Pineapple and carrot.	In <b>sucrase deficiency</b> , malabsorption leads to diarrhea and flatulence.

• Give short account on (Invert Sugar) :

- Structure: It is a sugar that contains **equal** number of both **glucose** and **fructose** molecules (**unbound**).
- Sources: a) Bee honey  
b) By hydrolysis of sucrose by **sucrase** (invertase) enzyme
- Properties: the same properties Lactose and maltose  
N.B. It is called "invert sugar" because the strongly levorotatory fructose produces changes (inverts) the previous dextrorotatory action of sucrose.

## 11. Niemann Pick's disease.

• **Niemann Pick's disease:**

1. It is accumulation of large amounts of Sphingomyelin in liver due to deficiency of **sphingomyelinase** enzyme.
2. It leads to mental retardation and death in early life.

## 12. HbS.

**Sickle cell anemia:**

- a) The blood cells of these patients contain abnormal hemoglobin called hemoglobin S (**HbS**).
- b) A molecule of HbS contains 2 normal  $\alpha$ -chains and 2 mutants - chains in which glutamate at position six has been replaced by valine.

### 13. Cellulose.

<b>Cellulose</b>	<ul style="list-style-type: none"> <li>- Long <b>linear</b> chains of (<math>\beta</math>-D-glucopyranose) linked together by <b><math>\beta</math> 1-4</b> glycosidic bond.</li> <li>- The presence of cellulose in diet is important <u>because it</u> increases the <b>bulk of stool</b>. This <b>stimulates</b> intestinal movement and <b>prevents</b> constipation.</li> </ul>	<ul style="list-style-type: none"> <li>- <b>plants:</b> vegetables, cotton</li> </ul>	<ul style="list-style-type: none"> <li>- give NO color with <b>iodine</b>.</li> <li>- insoluble in water</li> <li>- <b>Cannot be</b> digested <u>due</u> to absence of digestive hydrolase enzyme that attacks <b><math>\beta</math>-linkage</b>.</li> </ul>
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### 14. Iron containing proteins (enumerate & discuss one).

#### Hemoproteins

- **Definition:** Hemoproteins are conjugated protein formed of protein part (globin) and nonprotein prosthetic part (Heme).

1. Hems containing iron (red in color). Thus hemoproteins are considered Metaloproteins.

2. Hemoproteins include many **biologically active compounds** as:

a) **Hemoglobin:** This carries oxygen.

b) **Myoglobin:** This stores oxygen in muscles.

c) **Respiratory enzymes:** These use oxygen.

- **Structure of Heme:**

1. Four Payrol rings are united together to form **protoporphyrin III**.

2. Iron in ferrous state ( **$\text{Fe}^{++}$** ) is incorporated in protoporphyrin III to form **heme**.

### 15. Bile acids & salts.

- Bile acids are hydroxyl derivatives of C24 steroid termed **cholanic acid**

Ñ **Types of bile acids:** Primary & Secondary bile acids

#### A. Primary bile acids

- Cholic acid (3, 7, 12 trihydroxy cholanic acid)
- Chenodexy cholic

#### B. Secondary bile acids

- **2<sup>ry</sup>** bile acids are formed from **1<sup>ry</sup>** bile acids by the action of intestinal bacteria (contain **7 $\alpha$**  dehydroxylase).

**2<sup>ry</sup>** bile acids are:

- Deoxycholic acid (3, 12 dihydroxy cholanic acid).
- Lithocholic acid (3 monohydroxy cholanic acid).

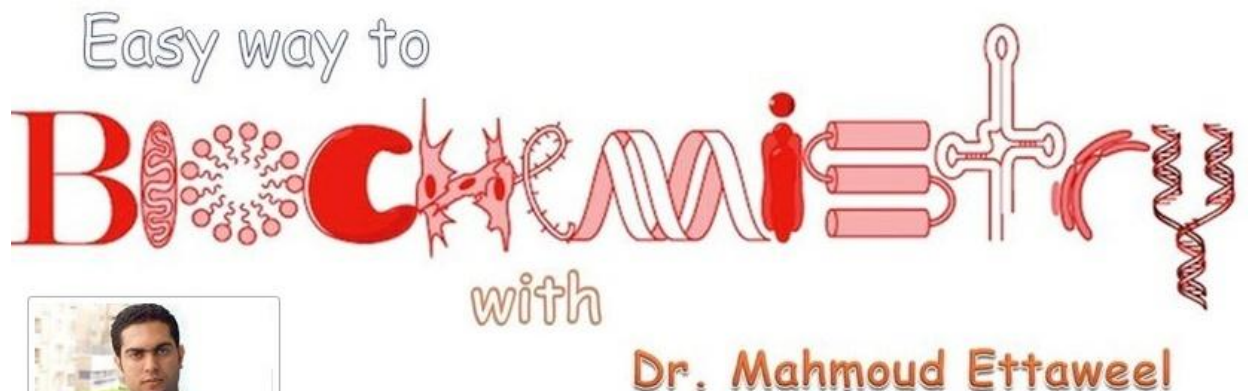


### C. Bile Salts

- Formed by & conjugation of bile acids with glycine or tourine then  $\text{Na}^+$  or  $\text{K}^+$  to form:
  - Na glycocholate
  - Na taurocholate
- Bile salts are excreted from **liver** & stored in **gall bladder**
- Bile salts pass to intestine during digestion of fat
- They are reabsorbed from intestine & back to liver (**Enterohepatic circulation**)

### Ñ Importance of bile salts: MDAPS

1. Main way for excretion of cholesterol.
2. Digestion of fat due to emulsification.
3. Absorption of fat due to formation of micelle.
4. Prevents precipitation of cholesterol & formation of cholesterol stones. S. Stimulates liver cells to secrete more bile (Choleretic effect).



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