**Chapter I: Physical Chemistry**

**ACIDS AND BASES**

**Acid:** is a Substance that gives hydrogen ions when dissolved in water (also it is defined as potential proton donor ) e.g. sulfuric and carbonic acids.

**Alkali:** is a substance that gives hydroxyl ions when disso­lved in water (also it is defined as a proton acceptor e.g. sodium hydroxide (Na OH).

**NEUTRAL SOLUTION** : Which contains equal number of hydro­gen and hydroxyl ions, as in pure water.

**pH**

 **PH Definition** : It is defined as minus log of hydrogen ion concentration

**BUFFERS AND BUFFERING**

**Definition** : buffers are systems that tend to keep their pH constant in spite of addition of ***moderate amounts***  of acid or alkali.

**Composition** : They are formed of a mixture of a ***weak acid and its salt*** with a strong base e.g. H2 CO3 and NaHCO3 or ***a weak base and its salt*** with a strong acid e.g. ammonium hydroxide (NH4OH) and ammonium chloride (NH4C1).

**Mechanism of Action :**

When an acid is added to blood it will be corrected by the basic part of the buffer,while adding a strong base will be corrected by acidic part of the buffer.

A. By addition of strong acid e.g. HC1 :

1. HCL + NaHCO3 NaCl + H2CO3 (weak acid)
2. HCL + Na2HPO4 NaCl + NaH2PO4 (weak acid)
3. HCL + Na proteinate NaCl + Proteinic acid (weak acid)

These weak acids do not affect much the pH of solutions.

B. By addition of strong base e.g. sodium hydroxide :

1. NaOH + H2CO3  H2O +NaHCO3 (weak base )

*2.* NaOH + NaH PO4 H2O + Na2HPO4 (weak base )

3. NaOH + Proteinic acid Na proteinate + H2O

Thus, the OH of NaOH is neutralized to form H2O with no change in pH.

**PHYSIOLOGICAL BUFFER SYSTEMS**

Enzymes control the homeostasis in the body. They are sensitive to changes to in the PH.So, any acid or base formed inside the body should be rapidly and effectively buffe­red .This is the function of the physiological buffer systems.

**The important physiological buffer systems** present in various tissues and body fluids are:

***1) Bicarbonate 2) Phosphate 3)Protein Systems*** including albumin and globulins.

***Bicarbonate buffer is the most important system in the body :***

The ratio of components in Bicarbonate system (H CO3 /NaHCO3 ) is 1/20. Bicarbonate system is **termed as the alkali reserve** because:

a) It is easily produced from CO2 of metabolic reactions.

b) It is easily excreted by action of carbonic anhydrase in lung as CO2 and H2O.

c) It is present in high concentrations

**BLOOD BUFFERS :**

The hemoglobin and oxyhemoglobin systems are responsible for the buffering of most of the CO2 added to the blood by tissues.

**RBCs buffers are; 1)**bicarbonate 2)phosphate 3) heamoglobin

Difference between buffers in plasma and buffers in RBCs

|  |  |  |
| --- | --- | --- |
|  | **Plasma buffers** | **RBCs buffers** |
| Type of cation | They Contain sodium | They Contain potassium |
| Chief buffer following bicarbonate | Plasma proteins | Heamoglobin  |

The normal pH of arterial blood is kept around: (7.35 to 7.45).

Disturbances in buffering system produce either acidosis or alkalosis.

**ACIDOSIS**

**Definition** : It is a condition in which pH of blood tends to decrease due to increase ratio of H2 CO3 / BHCO3 .

It results from the formation or absorption of acids at a rate exceeding that of their neutralization and elimina­tion.

Acidosis may be classified from the clinical point of view into two types:

Respiratory Acidosis and Metabolic Acidosis.

**• Metabolic Acidosis** : is caused by a decrease in the bicarbonate fraction, with either no change or a re­latively smaller change in the carbonic acid fraction . This is the most common classical type of acidosis.

**Causes :**

**A. Increased production of acids** e.g.

* Excessive intake of protein causes increased production of phosphoric, sulfuric and uric acids.
* Sever muscular exercise is accompanied by increase in lactic acid production.
* Ketosis as in :
* Low carbohydrate diet.
* Starvation.

- Diabetes mellitus.

B. **Failure of exceretion of acids**: as in renal failure.

C. **Increased loss of bases:**

* Severe diarrhea.
 - Hyperkalaemia.

 **• Respiratory Acidosis** : Respiratory acidosis is cau­sed by an increase in the carbonic acid relative to bicarbonate. This may occur in any disease which impairs res­piration such as :

1. Depression of respiratory centre by drugs as morphia.

1. Obstruction of air passages : as bronchial asthma
2. Pulmonary diseases: lobar pneumonia.
3. Excessive breathing of carbon monoxide (CO)

**How can the body correct acidosis**

**The role of lungs** **Rapid compensation** increase the rate of respiration leading to increase of carbonic acid excretion as CO2. It is mainly for metabolic acidosis.

**The role of the kidney :Slow compensation** increase in EXCRETION OF ACIDs, hydrogen ion excretion in urine With increase NaHCO3 REABSORPTION

**Diagnosis**

Arterial blood samples show low (acidic) PH.

***Treatment***

1. **Respiratory acidosis** is treated by improving lung functions. Drugs open airways treat asphyxia and emphysema. Severe cases need mechanical ventilation.
2. **Metabolic acidosis:** diabetes is treated by need to control diabetes with insulin.

 **Dialysis** improves acidosis for impaired kidney functions.

**ACIDEMIA** :it is a condition with increase in H+ in blood, which is a fatal con­dition.

**ALKALOSIS**

**Definition** It is a condition in which pH of the blood tends to increase due to decreased ratio of H2CO3 /BHCO3 -.

Two types of alkalosis are recognized: metabolic and respiratory alkalosis. Primary alkali excess or increase in alkali reserve is the most frequent cause of clinically observed alkalosis.

**. Metabolic Alkalosis** : Occurs when there is an incre­ase in the bicarbonate fraction, with either no change or relative smaller change in the carbonic acid fraction.

 **Causes of metabolic alkalosis:**

 Decrease in carbonic acid fraction relative to bicarbonate:

1. Increase fruits and vegetables intake.
2. Treatment of peptic ulcer by excess intake of bicarbonate.
3. Decrease renal blood flow (as in dehydration or heamorrhage due to increase Na reabsorption)
4. Hypokalemia due to:

(a)shift of hydrogen intracellular

(b) it stimulates H+ \K+ ATPase with reabsorption of potassium and bicarbonate and excretion of Hydrogen leading to alkalosis)

1. Severe vomiting loss of HCL (LOSS OF ACIDS).

**. Respiratory Alkalosis**: Occurs when there is a decrease in the carbonic acid fraction with no corresponding change in bicarbonate.

**Causes of respiratory alkalosis:**

Decrease in carbonic acid and increase in respiratory rate as in:

1-During fever

2-High altitude

3-Salycilate poisoning

**How can the body correct alkalosis**

 **The role of lungs:** **Rapid compensation** decrease the rate of respiration leading to accumulation of carbonic acid in blood

**The role of the kidney** : **Slow compensation** decrease in hydrogen ion excretion in urine, increase excretion of NaHCO3

**Diagnosis**

Arterial blood samples show increased blood alkalinity

**Treatment of alkalosis**

It includes administration of HC1 by mouth, inhalation of C02, ammonium chloride injection.

**alkalemia is a fatal condition and irreversible PH increases**

***Comparison of different laboratory findings in acidosis and alkalosis***

|  |  |  |  |
| --- | --- | --- | --- |
|  | **PCO2 mmHg** | **HCO3- mmol/ L** | **PH** |
| **Normal Range** | **35-45** | **22-26** | **7.35-7.45** |
| **Respiratory acidosis** | Increased | Normal or Partially Increased | Decreased |
| **Metabolic acidosis** | Normal or Partially decreased | Decreased | Decreased |
| **Respiratory alkalosis** | Decreased  | Normal or Partially Decreased | Increased |
| **Metabolic alkalosis** | Normal or Partially increased | Increased  | Increased |

**Chapter II**

**Amino Acids and Proteins Chemistry**

**Classification of amino acids according to chemical nature of radical group (R)**

**1)Aliphatic**

* **Neutra**l (no acidic or basic) ;glycine ,alanine
* **Branched** : valine ,leucine and isoleucine
* **Hydroxy containing**; serine, threonine,hydroxylysine, tyrosine and hydroxyproline
* **Sulfur containing amino acids**;cysteine,cystine, homocysteine and methionine.
* **Acidic;{polar negative}**  **glutamic and aspartic** contain two carboxyl groups
* **Basic;{polar positive}arginine, lysine and hydroxylysine (contain 2 NH3).**

**2)Aromatic**

They contain ring and include: **phenylalanine ,tyrosine and tryptophan.**

**3)Heterocyclic:** contain imidazole ring **( Histidine)**

**4) Imino acids** includeproline and hydeoxyproline

**5)Amino acid derivative not present in protein** *:*

They includehomocysteine ,homoserine and ornithine

**5)Selenocysteine** is a new amino acid present in some enzymes and is like cysteine but the sulfur is replaced by selenium.

 **Metabolic classification of amino acids**

**1- Ketogenic amino acid leucine is the only pure ketogenic amino acid**

**2-Mixed glucogenic and ketogenic**(give glucose and ketone) are **phenylalanine ,tyrosine ,tryptophan,isoleucine and lysine.**

**Glucogenic** amino acids (give glucose) any amino acid other than mentioned in 1&2.

**Nutritional classification**

**According to the nutritional value of amino acids they are classified into: Essential** **amino acids:**

phenylalanine , tryptophane, methionine,Threonine,valine ,leucine and isoleucine.They can’t be formed in our bodies .

**Non- Essential amino acids;**

 They can be formed in the body. So, it is not essential to be taken in diet. They include rest of amino acids

**Semi - Essential amino acids;**They are essential for children (due to their rapid rate of growth) ,but they are formed in enough amounts in adults ; they include **histidine and arginine.**



**Properties of Amino Acids**

Physical properties of amino acids:

 The amino acids derived from proteins are α amino acids. All amino acids are optically present in mainly in the L Forms.

 **1 -Optical activity** ;

 ALL amino acids are optically *active except glycine*, because it has no asymmetric carbon atom.

 2 - **Solubility:**

Most of amino acids are soluble in water.

 **3 - Amphoteric property of amino acids**

Amino acids can react in both acidic and alkaline PH due to presence of amino and carboxyl groups.

**In acidic pH** amino acids carry positive charge at amino group -NH3+

**In alkalinepH** amino acids carry negative charge at carboxyl group -COO -

**In isoelectric point (IEP) zwitterion**

Amino acids carry equal amounts of negative and positive charge (around pH 6) at this pH amino acids can’t migrate in electric field and can be precipitated (ZWITTER ION)

**Examples of peptides and proteins of medical importance**

1. **Oligopeptides (are formed of amino acids range from 2-10 a.a.)**

**1-Glutathione:**

It is formed of (*hydrolytic product*) **; glutamic ,cystiene and glycine** it acts as a hydrogen carrier (anti-oxidant).

**2-Thyrotropin releasing hormone:**

it isformed of **glutamic, histidine and proline** secreted from hypothalamus and regulates the action of thyroid gland.

**3-Vasopressin:**

It is an oligopepetide formed from 9 amino acids it is secreted in case of dehydration

1. **Polypeptides (from 11-49a.a.)**

**1-Glucagon** consisted from 29 a.a. it increases blood glucose by action on the liver

**2-Calcitonin** formed from 32 a.a. it lowers blood calcium

1. **Proteins (50 a.a. and more)**

**1-Insulin** it is a protein hormone formed from 51 amino acids in two chains A and B chains. It lowers blood glucose to normal level.

**2-Parathyroid hormone** it is formed of 84 a.a. it elevates blood calcium level by increasing calcium mobilization from bones and reabsorption from intestine and reabsorption from kidneys

**Structure of Protein**

A protein molecule may be composed of one or more polypeptide chains which are usually folded in a regular manner that gives the molecule a specific shape. The internal struc­ture of proteins could be considered at four levels.

 **1ry structure of protein**

It is the **number, type and sequence of** amino acids in the protein.

It begins at the N terminus of the protein at the left side and ends at the C terminus on the right side. The peptide bond is responsible to keep its structure.



It localizes the position of cysteine for disulfide bond.

 **2ry structure of the protein**

It is either **α helical or β pleated sheets.(single polypeptide chain)**

Helical structure is held by *hydrogen bonds* where 1st amino acid binds the 4th one.

The protein has a *right handed* helical shape its diameter is 0.54nm ***example*** as myosin, fibrinogen and keratinof unstretched hair*.*



**Many factors disturb the right handed helical structure:**

1. proline amino acid (*the proline ring allows left handed helix*)
2. Excess acidic or basic amino acids.
3. Presence of bulky amino acids as leucine.

**β pleated sheets**

 It may be parallel or anti-parallel. Example as *keratin of stretched hair*



**Tertiary structure of protein ( single polypeptide chain)**

The protein takes a globular shape with the polar groups in the outer surface and the hydrophobic groups in the inner side. Example as *Myoglobin*

**Factors stabilizing the tertiary structure of protein**

1) hydrogen bonds 2) hydrophobic bonds 3) disulfide bonds 4) electrostatic bonds

**Quaternary structure of protein( many polypeptide chains)**

**Factors stabilizing Quaternary structure of protein**

1) Hydrogen bonds

 2) Hydrophobic bonds

3) Disulfide bonds

4) Electrostatic bonds

**Best Example of quaternary structure is:**

 Hemoglobin

**Isolation of a mixture of protein**

*1)Salting out 2)precipitation 3)dialysis 4)ultracentrifugation 5) chromatography*

**Proteins are either globular or fibrous according to their axis:**

**I- globular protein**

Spherical protein (axial ratio: length\ width is less than (10 ).

Example: albumin and globulins

**II-Fibrous Protein** (axial ratio is more than (10 ).

Example: collagen C.T.

**Chemical classification of proteins**

**I-Simple proteins**

**Albumin and globulin**

***They are responsible*** for :

1) **buffer in plasma** (proteinate buffer).

 2) They **act as carrier for minerals and hormones**

3) Globulins responsible for **immune reactions.**

4- **Osmotic pressure** is regulated by albumin and globulins (their deficiency leads to edema).

They are high biological value protein .they are coagulated by heating

Albumin is precipitated by full concentration of ammonium sulfate globulin is precipitated by half conc. Ammonium sulfate

 Albumin is a regulator of the osmotic pressure, albumin is soluble in water. It runs faster than globulin in electrophoresis

**Protamines and histones**

They are basic proteins rich in histidine, lysine and arginine amino acid and react with the negative charged phosphate in DNA.

They are soluble of water.

They help packing of proteins

***Sclereproteins***  they are rich in cystiene amino acid.keratin is aform of helical protein . the increase in disulfide bonds leads to increase in toughness of protein

**Β keratin** is present in silky hair.

***Conjugated proteins***

 ***1)Phosphoproteins*** as casinogen of milk and vittelin of wheat.

 ***2)\*\*Lipoproteins***

Chylomicrons(transmit lipids from intestine to blood) ,very low density lipoprotein (VLDL) (transmits lipids from liver to blood),low density lipoprotein(LDL) (transmits cholesterol from liver to blood) and high density lipoprotein (HDL) (transmits lipids from blood to liver)

 ***3) Glycoprotein***

They are either N-linked (carbohydrates bind to asparagines of protein) or O-linked (carbohydrates bind to serine or threonine)

***Importance of glycoprotein***

*1-it enter in structure of cell membrane* ***2-*** *they form immunoglobulin*

*3****-*** *Many hormones are glycoprotein in nature as TSH and FSH*

*4-* *They are forming collagen and fibronectin*

*5- They form* ***mucin:****1) (lubricant in the respiratory system, lubricant in the digestive system.) 2) it is protective for the respiratory and digestive and urinary systems 3) many cancer cells secrete mucin on their surface to protect them from immunity*

***4) metalloproteins***

***a-Iron containing proteins***

***Non heam iron containing proteins***

***Ferritin:*** *it is used for storage of iron*

***Transferrin****: it is for the transport of iron in plasma*

***Hemosidren****: for carrying of iron overload or toxic iron.*

***Heam iron containing proteins***

Heamoglobin,Myoglobin,catalase,peroxidase,cytochromes, cytochrome oxidase, nitric oxide synthase

***b-Cupper containing proteins***

***Ceruloplasmin***  *it is a globin protein, transports cupper in plasma, it can carry 6 atoms of cupper*

***Super oxide dismutase*** *it removes the free radicals in the Cytosol or mitochondria*

***Cytochrome oxidase*** *it is present in the mitochondria for energy synthesis.*

***c-Magnesium containing proteins :*** It is present in kinase and phosphates and chlorphyll

***d-Manganese containing proteins*** (arginase and carboxylase)

***e-Zinc containing proteins include:*** carbonic anhydrase and carboxypeptidase

*Chromoproteins are either metallpchromoproteins or non metallochromoproteins.*

***Non metallochromoproteins****: carotenoids, flavoporteins and melanoporteins.*

**Extracellular matrix proteins**

 **I-Collagen**

It is the most common protein in the extracelluar matrix. The name collagen comes from the Greek kolla meaning glue and suffix -gen denoting producing. It makes 25-30% of total body proteins. It is secreted by fibroblasts. There are 20 types of collagen ,the most common one is type 1 .the unit forming collagen is tropocollagen (formed of 3 polypeptide chains) it is 300 nm in length and 1.5 nm in diameter .

**Synthesis of collagen**;

***The precursor of collagen is* preprocollagen**:

* it has 2 extensions one at the N terminus and the other at C terminus
* It has a signal peptide at the N terminus.

**Conversion to procollagen :**

Preprocollagen is converted to procollagen by :

* Removal of signal peptide
* Glycosylation and hydroxylation of lysine and proline a.a.
* Oxidation of cystiene a.a. to form disulfide bonds.

**Conversion of procollagen to tropocollagen** *by:*

* removal of extension peptides ,
* stabilization of collagen by interchain covalent bonds and parallel quarter staggered form

**Primary structure of collagen;**

It is formed of approximately1050 a. a. It has a distinctive regular arrangement of amino acids.

The sequence often follows the pattern [Gly](http://en.wikipedia.org/wiki/Glycine)-[Pro](http://en.wikipedia.org/wiki/Proline)-X or Gly-X-[Hyp](http://en.wikipedia.org/wiki/Hydroxyproline), where X may be any of various other amino acid residues.

Hydrolytic product of collagen is : (Glycine,lysine, proline and hydroxyproline or hydroxylysine) and 10% Alanine.

**Secondary structure of collagen**;

Each chain is turned in **left handed helix (due to the presence of proline ring**  and each turn contains only 3 a.a..The 3 chains are coiled over each other in right handed direction .triple helix are arranged in parallel quarter staggered form

**

***chemical properties of collagen*** *;it is glycoprotein. It is of low biological value it is poor in essential a.a. On boiling it gives gelatin.*

 **Causes of strength of collagen**

 *1) the presence of 3 a.a.* ***only*** *per turn 2)glycine forms a point of intersection between the triple helix*

 *3)amino group of hydroxylysine form covalent cross link between fibers*

 *4)each turn is left handed and they all form a right handed shape. 5) Bundles are staggered.*

|  |  |  |
| --- | --- | --- |
|  | *collagen* | *elastin* |
| *Number of chains* | *3 chains* | *4 chains* |
| *glycosylation* | *present* | *absent* |
| *structure* | *fibrous* | *Fibrous and globular* |
| *desmosine* | *absent* | *Present* |
| *type* | *20 types* | *1 type* |
| *structure* | *αhelix*  | *αhelix and globular* |

***II- Fibronectin ;***it is a glycoprotein formed of 2 identical polypeptide chains connected by disulfide bonds.It helps the adhesion of molecules to extracellular matrix.

***III- Integrin ;***it is present in the cell membrane it interact with collagen in the outside and actin in the cell.

***Aggrecan***

It is a complex GAG present in cartilage formed of **hyaluronic acid** long chain , attached to **link protein** to a **core protein** and giving it a brush bottle shape .GAG side chain negatively charged attracts water and formed of ***chondroitn sulfate (***long chain***) and small amount of keratan sulfate(***short chain ***)***

***By aging*** keratan sulfate increases and replaces chondoitin sulfate .leading to decrease in the size of cartilage and its collapse

**CHAPTER III: LIPID CHEMISTRY**

**Lipids are classified into:**

**Simple lipids *:*** Simple lipids are formed of alcohol (glycerol or high alcohol) and fatty acids. (glycerol is colorless and odorless present in L-form).

**Conjugated lipids:** lipid part and *non lipid part* (e.g.carbohydrates,proteins or phosphate).

**Derived lipids**: by hydrolysis of simple or conjugated lipids

**Classifications of fatty acids *;*** **Short chain Fatty** acid from 2 – 8 carbons **Examples:**

acetic acid formed of 2 carbons Butyric Acid formed of 4 carbons

**Long chain fatty acid** 12-24 carbons , **Examples:**

palmitic acid formed of 16Carbon atoms Stearic acid formed of 18 Carbon atoms.

Fatty acids are either ***saturated or unsaturated*** fatty acids:

 **monounsaturated = monoethenoid** contain 1 double bond ,**examples:** Palmitoleic 16 carbon atoms.

**Oleic acid 18 carbon atoms.**

 poly unsaturated fatty acids **PUFA** = polyethenoids

 ***ω 3PUFA*** : linolenic (18;3;ω3) ***ω6PUFA*** :linoleic (18;2;ω6) and arachidonic (20;4;ω6)

**(sources of PUFA: they are present in oils )**

**Oils** are rich in unsaturated fatty acids while **fats** are rich with saturated fatty acids and solid at room temp.

 **Essential fatty acids are linoleic and linolenic**.(they are essential as being needed to be taken in diet for normal growth)

**Eicosanoids**

They are substances ***contain 20 carbons*** derived from ***(arachidonic acid)***

1. ***cyclic compmerounds;***

1)prostaglandins 2)prosatcyclins 3)thromoxans

1. ***oxy compounds:***

1)leucotrienes2) lipoxenes**.**

***Importanceof eicosanoids***

**I-Prostaglandins;**

 1-They induce smooth muscles contraction in the wall of bronchi and blood vessels

 2-They stimulate uterine contraction and help the induction of labor

 3-They mediate the increase cyclic adenosine monophosphate (cAMP) in certain endocrine glands as pituitary, thyroid, and suprarenals leading to increased hormonal secretion.

 4-They decrease cAMP in stomach lead to decreased secretion of gastric HCL .

**ll-Prostacyclins**:

* PGI2 are formed by the endothelial cells lining the blood vessels.
* They produce vasodilatation.
* They inhibit platelet aggregation by increasing cAMP in platelets.

**III-Thromboxanes**;

* They are formed by platelets (thrombocytes) and help thrombus formation and control of bleeding decreasing cAMP in platelets.
* They produce vasoconstriction of blood vessels.
* They promote platelet aggregation**.**

**IV-Leukotrienes**;

* They are formed by leukocytes and they help the migration of polymorphnuclear leukocyte to the sites of inflammation.
* They are responsible for, broncho-spasm, vasodilatation of blood vessels and the drop of blood'pressure.
* They are released during severe allergic reaction (anaphylactic shock).

**V-Lipoxins**

* They are important for inflammatory process.

***Phospholipids***

Phospholipids are either glycerophospolipids or sphingomyelin

***A) Glycerophospholipids***



They contain both polar and non polar components.

**They include:**

1.**phosphatidic acid [**glycerol +2 fatty acids +phosphate]

2) **lecithin**=**Phosphatidyl choline**  [glycerol +2 fatty acids +phosphate +choline ]

3)**Cephalin**=**Phosphatidyl-ethanolamine** [glycerol +2 fatty acids +phosphate + ethanolamine ]

4)**Phosphatidyl serine** [glycerol +2 fatty acids +phosphate +serine]

5)**Phosphatidyl inositol** [glycerol +2 fatty acids +phosphate +inositol]

6)**plasmalogen** [glycerol + fatty acids + fatty alcohol +phosphate +chloline]

7)**cardiolipin** [ 3 glycerol + 4 fatty acids + 2 phosphate]

**Hydrolysis of phospholipids by:**

* phospholipase A1:it cuts the fatty acid in position number 1.
* phospholipase A2: it cuts the fatty acid in position number 2.
* phospholipase B : it cuts the fatty acid in position number 1&2.
* phospholipase C : it cuts the phosphate and nitrogenous base.
* phospholipase D : it cuts the nitrogenous base bond to phospholipids.

**Lysolecithin is a type of Lysophospholipid** , formed by the **action of phospholipase A2** enzyme.Snake venom contains lecithinase enzyme.

**B)sphingolipids**

**1-Ceramide [sphigosine +fatty acid attached to its carbon number 2]**

**2-Sphingomyeline** is formed of [**sphingosine** +fatty acid +(phosphate +**choline attached to carbon number 1 of sphingosine**]

**(**it is present in lungs and myelin sheath**)**

**Importance Of Phospholipids**

1. They enter in the structure of every **cell membrane**.
2. They are important for formation of **plasma lipoprotein,as they are present between lipids and proteins**
3. They enter in the formation of **lung surfactant (dipalmityl lecithin)**.
4. They are important as the main factor responsible for **Emulsification** of dietary lipids
5. **They are important for Prevention of cholesterol stones**.
6. Phospholipids share in the synthesis of **Eicosanoids** through Arachidonic acid attached to their carbon number 2
7. They are needed for **blood clotting as they are one of the platelet activating factors**

8. They may act as a **2nd messenger of hormones. phospholipids act as 2nd messenger of hormones** is phosphstidyl inositol biphosphate.

***Glycolipids***

**Glycolipids are lipids formed of sphongosine and carbohydrates attached to 1st carbon. They are cerebrosides,sulfolipids and gangliosides**

**glycolipids are formed of ceramide + (galactose or glucose).**

***1-cerebrosides are named*** according to fatty acids they contain .

1. Cerebron contains (fatty acid cerebronic ).
2. Nervon contains (fatty acid nervonic ).
3. Kerasin contains (fatty acid lignoceric ),

**2-sulfolipids :it is formed of sphingosine ,Galactose and sulfate.**

**3rd carbon of sphingosine binds sulfate through Galactose.**

**3-gangliosides they are formed of sphingosine** with galactose, glucose and N- acetyl neuraminic acid (NANA).

**Importance of Glycolipids**

*1-*Recognition of molecules in plasma membranes.

2-They enter in structure of Myelin sheath and nervous tissues.

3-They enter in components of RBCs membrane and blood group antigen.

**Derived lipids**

*Fatty acids \ alcohols(glycerol or sphongosine) \ steroids \ carotenoids \ fat soluble vitamins A,D,E,K.*

\***Steroids containing compounds** *are sterols\ bile acids \ steroids containing hormones*

\***Steroids containing hormones** *are sex hormones and corticoids*

**Cholesterol**

**Importance and derivatives of cholesterol**

1) It enters In the structure of ***cell membranes***

2) it enters in Synthesis of ***bile acids***

3) it enters in the Formation of ***vitamin D***3.

4) It is responsible for Synthesis of ***all steroid hormones.***

 5) It is excreted in the form of 7 dehydrocholesterol

**Bile acids -Cholic acid**

***Primary bile acids*** {formed in the liver }are ***cholic*** and ***chenodeoxycholic***

***Secondary bile acids*** {formed in the intestine } are ***deoxycholic*** and ***lithocholic***

**Bile salts are**

1-sodium taurocholate and sodium glycocholate

2-Potassium taurocholate and Potassium glycocholate

**Importance of bile acids;**

1. they are the *main excretory form of cholesterol*
2. they have *choleretic effect* [reabsorbed from intestine and return back to liver after their action]

*With phospholipids they have*

1. Emulsification of dietary lipids
2. Prevention of cholesterol stones

**Adrenocortical Hormones**

**MALE SEX HORMONES**

They include:

1-Dihydroteststerone **(the most potent one)**

2- Testosterone

**FEMALE SEX HORMONES**

They include:

A) Hormones for female sex character

B) Hormones released with pregnancy.

Group 1 hormone for female sex characters

**1-estradiol*****(the most potent)***

2-estrone

3-estriol

Group 2 hormones released with pregnancy include:

**progesterone**

**GLUCOCORTICOID**

Glucocorticoids include:

1-cortisol (the most potent)

2- cotison

3- corticosterone

**Prolonged intake of corticoids or (cortisol) predispose to diabetes due to** increase blood glucose by different mechanisms:

1-decrease glucose oxidation by tissues .

2-increase glucose synthesis from non carbohydrate sources (gluconeogenesis) .

3- increases glycogenolysis in the liver

4-Also it stimulates protein and fat breakdown*.*

**Mineralocorticoids**

**They include:**

**1-Aldosterone (The most potent)**

2- 11- deoxycorticosterone

**Chapter IV**

**Carbohydrates Chemistry**

**Definition:**

Carbohydrates are organic substances consist of carbon ,hydrogen and Oxygen.They are polyhydroxaldehydes or polyhydroxyketones.

**Classification:**

One of the classifications of carbohydrates depends on the yield of hydrolysis:

* Monosaccharides.
* Disaccharides.
* Oligosaccharides.
* Polysaccharides.

 Monosaccharides are simple sugars .They can’t be hydrolyzed to more simple sugar.

They have different classifications:

**1st classification according to active group**

The active group is either aldehyde or ketol group or according to this the sugar is either aldose or ketose.

* The simplest aldose is glyceraldehyde which is formed of 3 carbon atoms and its active group is the aldehyde group.

It has only one asymmetric carbon atom,so it has optical activity and it rotates the the light to the right side

 It is considered as the mother compound of any aldose.

* The simplest ketose is dihydroxyacetone which is formed of 3 carbon atoms and its active group is the ketol group.

It has no asymmetric carbon atom,so it has no optical activity. It is considered as the mother compound for all ketoses.

**2nd classification according to number of carbon atoms**

 Trioses :

They contain 3 carbon atoms.  ***Aldotriose*** is glyceraldehydes ***ketotriose*** is dihydroxyacetone

 Tetroses

They contain 4 carbon atoms.***Aldotetrose*** is erythrose. ***ketotetrose*** is erythrulose

 Pentoses

They contain 5 carbon atoms.**Aldopentose** : They include ribose and deoxyribose

k**etopentose** They include ribulose and xylulose

 Hexoses

They contain 6 carbon atoms.

**Aldohexoses include:** 1) **Glucose 2) Galactose 3)Mannose**

 **ketohexose** :Fructose

All monosaccharides are optically ***active except*** *dihydroxyacetone as it has* no asymmetric carbon atom.

***3) Isomerism***

They are compounds have the same molecular structure but differ in the configuration.

**Structural isomerism** they differ in the **functional group** e.g. glucose and fructose

**Stereoisomerism**  compounds differ in the asymmetric carbon atom

**Types of stereoisomerism**

**Epimers** they are compounds differ in the configuration around one carbon atom examples :

1-Glucose and galactose 2- glucose and mannose 3- ribulose and xyluose

**Anomers** they are α and β forms of the isoformsin the ring structure

**Chemical properties of monosaccharides:**

* **Oxidation :**

**a) Mild oxidation** : glucose gives gluconic acid.

1. **Moderate oxidation:** glucose glucuronic acid.
2. **Strong oxidation:** concentrated nitric acid, oxidize both the aldehydic and primary alcohol groups of sugar forming (dicarboxylic acid).

From glucose we get (saccharic acid) .

from galactose galactaric acid (mucic acid).

* **Reducing ability**:

Monosaccharides are reducing agents due to the presence of free aldehyde or ketol group. Both can re­duce cupric hydroxide of Fehling

* **Esterification** ;

Alcohol groups of sugars can be esterified with phosphoric acid to form sugar phosphate. It is the primary step in the metabolism of glucose in cells.

**Monosaccharide Derivatives**

**1-Amino Sugars** are sugars in which the hydroxyl group of the second carbon is replaced by an amino group e.g. glucosaminef galactosamine and mannosamine. They are present in N—acetyl derivatives in mucopolysaccharides and gangliosides.

**2-Aminosugar Acids**:

These are formed by the addition of acids to aminosugars, e.g. pyruvic acid added to mannosamine gives neuraminic acid, and lactic acid added to glucosamine gives muramic acid.

The N-acetyl derivatives of the aminosugar acids are called Sialic acids.

They are components of mucopolysaccharides and gangliosides.

Muramic acid = lactic acid *+* glucosamine.

Neuraminic acid = pyruvic acid + mannosamine.

**Sialic acid** ; It is formed of acetic acid and mannosamine and pyruvic acid.

Functions; 1) it is present as a cell receptor 2) It is important in cell membrane for cell recognition.

**3-Sugar acids**

**Mild oxidation of sugars** as Gluconic acid and L-ascorbic acid (vitamin C)

**Uronic acids** as glucuronic acid (***important for*** detoxication of compounds - conjugation of steroids and bilirubin)

**4-Sugar alcohols : *Ribitol*** ;alcohol of ribose / ***sorbitol*** ; alcohol of glucose / ***inositol*** ;prevent absorption of minerals from intestine

**5-Deoxysugars**

***Deoxyribose*** in DNA

***L –fucose*** in cell membrane and important for blood group

**Glycosides**

Glycosides are formed by reaction of active carbonyl group with alcohols or phenols.

 It is either formed by reaction of sugar with sugar or sugar with non sugar.

 **Examples** glycosides formed **between disaccharide units** (sugar and sugar)to form oligosaccharides and polysaccharides with removal of a molecule of water.

**Sugar with non sugar:**

 **1- Digitalis*:***

It is formed bycombination of galactose and steroid.

It is used in heart failure treatment.

**2- Phlorrhizin**:

It is formed by combination of glucose and phloritin (it inhibits glucose absorption from intestine and kidneys).

3 - **Nucleosides**

They are formed by combination of pentose (either ribose or deoxyribose ) with nitrogenous base.

**OLIGOSACCHARID ES**

They are formed of 2-6 sugar units. According to the number of sugar units, oligosaccharides are classified into disaccharides, trisaccharides....etc.

**DISACCHARIDES**

**REDUCING DISACCHARIDES:**

MALTOSE **(**Malt sugar**)**

* It is formed by the condensation of a molecule of glucopyranose with a molecule of D-glucose through α1- 4 glucosidic linkages. It is a reducing sugar, as there is a free reducing group.

ISOMALTOSE

-It is formed by condensation of a molecule of glucopyranose with a molecule of D-glucose through α1- 6 glucosidic linkage.

LACTOSE

 It is formed by condensation of a molecule of D glucose and D Galactose by β1-4 Galactosidic bond. It is present as the sugar of milk.

CELLOBIOSE

* On hydrolysis yields twoto3-glucose units.
* Repeating units in cellulose of plants.
* The linkages involved are β-1-4 glucosidic linkage.
* It is a reducing disaccharide.
* It results from the careful hydrolysis of cellulose.

**NON REDUCING DISACCHARIDES**

SUCROSE **(**Canesugar)

It is formed by the condensation of a molecule of α-D-glucose with a molecule of β-D-fructose through α- l-2-glucosidic linkage Non reducing, since the two carbonyl atoms form the glucosidic linkage; thus no reducing group is present in the molecule.

* Fermentable.

— Sucrose is dextrorotatory, and on hydrolysis gives a levorotatory mixture of equal amounts of glucose and fructose. This mixture is called invert sugar , and the enzyme producing hydrolysis is called invertase

*2.* **TRISACCHARIDES :** contain 3 monosaccharide units e.g. Raffinose = galactose + glucose + fructose.

3. **TETRASACCHARIDES** : contain 4 monosaccharide units e.g,

Stachyose = 2 galactose + glucose + fructose.

**POLYSACCHARIDES**

They are carbohydrates containing more than six monosaccha­ride units. They are classified into two major classes according to the hydrolytic products they yield.

**I. HOMOPOLYSACCHARIDES**

 On hydrolysis they yield the same type of monosaccharide units.

They are either :

1. **Glucans** : On hydroylsis give only glucose units e.g, starch, dextrins, glycogen and cellulose.

**2) Fructans** : On hydrolysis yield only fructose units e.g. inulin.

**STARCH AND DEXTRINS**

- Present in plant only (nutritional reservoir of plant cells).repeating unit is glucose Non reducing as there is no free aldehyde or ketone group. Composed of alpha-glucose units linked by 2 types of linkagesα1, 4 and α1,6 glucosidic link. The starch granule consists of 2 components, amylose (inner part) and amylopectin (outer part).

**Amylose**:

It forms less than 20% of starch granule.

It has along chain, linear polymer.

It contains α-l-4 glucosidic linkages.

It gives blue colour with iodine.

**Amylopectin** :

Forms about 80% of starch granule branched polymer.

It is formed of *20* to 30 glucose residues per chain.

The point of branching is α 1,6 glucosidic linkage , and gives red to violet colour with iodine.

* **Starch hydrolysis:**

1) Acid (HCL) hydrolysi gives D-glucose units.

2) Enzymatic hydrolysis with amylase enzyme yields the di-saccharides maltose and isomaltose.

* **Comparison between starch subunits (amylase and amylopectin)**

|  |  |  |
| --- | --- | --- |
|  | **Amylose** | **Amylopectin** |
| **Site** | Inner | Outer |
| **Percent/ Granule** | 15% | 85% |
| **Shape** | Linear | Branched |
| **bonds** | α1-4 glucosidic | α1-4 glucosidic and (α1-6 glucosidic in branching points) |
| **Color with iodine** | Blue | Violet |

**CELLULOSE :**

- Present in plants..

- Linear polymer of glucose.

- Composed of D-glucose units connected together by β-1- *4* glucosidic linkages.

* Not digested (as its linkage is *β*glucosidic linkage).— 300 - 2500 glucose residues/molecules.
* Being rough and has βbonds it is not digested by amylase enzyme and it stimulates peristalsis of intestine ,it Prevents constipation as it forms the main bulk of the stool s

- It is a medium for intestinal flora which is important for vitamin B and vitamin K formation.

**GLYCOGEN :**

* Nutritional reserve present in liver and muscle of animals.
* Branched chain polymer (resembling amylopectin) with 8-12

glucose residues for chain

- On hydrolysis it gives α -D-glucose units.



**Comparison between linear polysaccharides (amylase and cellulose)**

|  |  |  |
| --- | --- | --- |
|  | **Amylase** | **Cellulose** |
| **Bond** | α1-4 glucosidic bond | β1-4 glucosidic bond |
| **Solubility in water** | Soluble | Insoluble |
| **Molecular Weight** | Lower | Higher |
| **Effect of Amylase Enzyme** | Digested | No effect |
| **Partial Hydrolysis** | Maltose | Cellobiose |

**Comparison between branched Polysaccharides (Amylopectin and Glycogen)**

|  |  |  |
| --- | --- | --- |
|  | **Amylopectin** | **Glycogen** |
| **Sources** | plants | Animals |
| **Type of Bonds**  | α1-4 and α1-6 glucosidic bonds | α1-4 and α1-6 glucosidic bonds |
| **Color with Iodine** | Violet  | Red |
| **Number of Branches**  | Less branched  | More branched |
| **Molecular Weight**  | Lower  | Higher |

**Fructans**

**1) Inulin :** Present in plants.

- On hydrolysis it gives β-D-fructose units.
- Linear polymer of fructose.

* Non digestable, and if injected intravenously, it is not metabolized.
* Medical uses of inulin ;
1. It measures the glomerular filteration rate as it is not absorbed by the renal tubules.
2. The diluted inulin can be used to measure the extracellular fluid volume. ( it is a polymer does not penetrate the cells ).

II. **HETEROPOLYSACCHARIDES (MUCOPOLYSACCHARIDES) (Proteoglycans)**

**GLYCOSAMINOGLYCANS (GAGS)**

They are big molecules on hydrolysis, they give monosaccharide and other compounds. They are either:

1- **Acidic Heteropolysaccharides** :

1. **Sulfate containing heteropolysaccharides** : e.g. Dermatan sulfate, heparin, chondroitin sulfate and heparin sulfate.
2. **Sulfate free heteropolysaccharides** e.g. hyaluronic acid.

**2- Neutral Heteropolysaccharides : e.g.** blood group substances and the prosthetic group of hormones as TSH.

**Hyaluronic acid :**

* Highly viscous solution.
* Present in connective tissue, synovial fluid, umbilical cord ... etc.

- On hydrolysis it yields **N-acetylglucosamine** **and glucuronic acid.**

*N.B.: Spreading Factor:* The invasive power of certain bacteria is due to their content of the enzyme hyaluronidase, (spreading factor) which hydrolyzes the hyaluronic acid in connective tissue.

1-It is present in the head of sperm to facilitate the fertilization of ovum.

2- It is present in certain bacteria to spread in the subcutaneous tissue.

**Heparin:**

* It is present in mast cells.
* On hydrolysisit yields: **glucuronic acid sulfate, L-iduronic acid sulfate and glucoseamine bisulfate**
It acts as:
* Anticoagulant, it inhibits factor II ,VII IX and X.
* It acts as an activator for plasma lipoprotein lipase enzyme which helps to clear lipemic plasma, after hydrolysis of its fat contents and hence it is named *the clearing factor*.

**Chondroitin Sulfate**:

* It is present in cartilage and bones as shock absorbant.
* On hydrolysis it yields: **N-acetylGalactoseamine6- sulfate and D- Glucuronic acid.**

**Keratan Sulfate:**

* It is present in cornea and cartilage.
* On hydrolysis it yields: **D-Galactose and N-acetylglucoseamine 6 sulfate .**

**Dermatan Sulfate:**

* It is present in the skin heart valves and sclera of the eye
* On hydrolysis it yields:**L-iduronic and N-acetylGalactoseamine 4 sulfate.**

**Heparan Sulfate:**

* It present as plasma membrane receptor.
* On hydrolysis it yields:

**N-acetylglucoseamine 6 sulfate, Glucuronic acid and Galactose.**

**Aggrecan**

is a complex GAG present in cartilage formed of **hyaluronic acid** long chain , attached to **link protein** to a **core protein** and giving it a brush bottle shape .GAG side chain negatively charged attracts water and formed of **chondroitn sulfate (**long chain**) and small amount of keratan sulfate(**short chain **).**

.



**By aging:**

 **keratan sulfate** increases and replaces chondroitin sulfate . This leads to decrease in the size of cartilage and its collapse.

It will lead to pain and deformities in joints known as osteoarthritis.

**Table of Important Heteropolysaccharide (GAGS) proteoglycan**

|  |  |  |
| --- | --- | --- |
| **Name** | **Function** | **Hydrolytic product** |
| 1. **Hyaluronic acid (only sulfate free)**
 | Present in C.T., vitreous of the eye, synovial fluid of joints, cell differentiation / eneters in ***aggrecan***, / ***hyaluronidase***  | N- acetylglucoseamine & glucuronic A. |
| 1. **Chondroitin sulfate**
 | Bone and cartilage acts as shock absorption | N- acetylglucoseamine 4-sulfate & glucuronic A |
| 1. **Dermatan sulfate**
 | Skin &heart valves & sclera  | N- acetylgalctoseamine6 sulfate & iduronic  |
| 1. **Keratan sulfate**
 | Cornea and cartilage  | N- acetylglucoseamine6sulfate & galactose  |
| 1. **Heparin**
 | Anticoagulant &lipoprotein lipase(clearing factor) | Glucose amine sulfate + glucuronic sulfate + L –iduronic A  |
| 1. **Heparan sulfate**
 | Plasma membrane and membrane receptor | N- acetylglucoseamine 6sulfate & galactose + glucuronic |

**CHAPTER 5 : MINERALS**

**Calcium**

Sources: milk and its products.

It is absorbed from small intestine with calcium binding proteins (CBP).

Its level (8.5-10.5 mg\dl) . It is either diffusible (ionized)or non diffusible.

Acidosis favors the diffusible fraction .

**Factors affecting calcium level**

**Factors increase calcium level in blood**

1) ***calcitriol (vit D3)***

a-It increases calcium absorption in the brush border of intestine and m RNA for calcium binding protein

b-it increases reabsorption of calcium from kidneys and deposition in bones.

**2) *parathormone*** increase calcium absorption from kidneys and intestine through Vit D3 and increase calcium mobilization from bones.

**Factors decrease calcium level**

1-calcitonin by increase mineralization of bones and decreases its reabsorption by kidneys.

**Importance of calcium**:

formation of bones and teeth,

generation of nerve impulse,

 muscle contraction,

formation of calmodulin and

 blood clotting.

**Phosphorus**

absorbed with calcium and needs Vit.D3.

**Importance** energy transfer,phsophorylation and dephosphorylation of enzymesformation of phosphoproteins and nucleosides.

**Magnesium**

**factors affecting its absorption** :

1-high fat diet diminishes its absorption.

2-both alkalosis and calcium diminish its absorption from upper intestine. **Distributionand importance**:

1) it acts as an activator of kinase and phophorylase

2) bone formation

 3)it plays role in neuromuscular irritability.

**Sodium**

**importance**:

1)present in bones 2) extracellular fluids 3)acid base balance 4)osmotic pressure

**Chloride**

It is essential for synthesis of gastric HCL.

Its conc. ishigher in CSF than plasma.

**Potassium**

**It is important for regulation of:**

**-**acid base balance

– intracellular fluid

– muscle activity.

**Sulfur**

 **Importance**

 in GAGS , sulfolipids ,sulfur containing amino acids,

**vitamins containing sulfur** (thiamine- biotin - lipoic) ,

it is present in biologically active compounds like :

1- PAPS

**2- Ethereal sulfate used for detoxication** of compounds.

**IRON**

It is absorbed from the intestine in the ferrous state (reduced from).

Reducing substances like lemon juice convert ferric iron into ferrous and increase its absorption from stomach and duodenum.

**Absorption of Iron**

**Mucosal block theory** in mucosa ferrous ions are oxidized into ferric and combined with apoferritn to form ferritin.

 when all apoferritin is consumed no more iron is absorbed.

**MORE RECENT THEORY** :

Iron is absorbed by a carrier and needs ferritin for its storage.

**IRON CONTAINING PROTEINS** ;

HEAMOGLOBIN ,MYOGLOBIN, CATALASE ,PEROXIDASE,TRYPTOPHAN PYROLLASE.IRON ABSORPTION DEPENDS ON THE IRON BLOCK THEORY FROM THE INTESTINE

**NON HEAM- IRON CONTAINING PROTEINS**

FERRITIN (STORAGE OF IRON)

TRANSFERRIN (TRANSPORT OF IRON)

 HEMOSIDERIN(CARRY TOXIC IRON)

**Transport of iron** :

1 – **transferring** bind 2 iron molecules

2 - **Ceruloplasmin** Is a ferroxidase enzyme helps transfer of iron.

Ceruloplasmin also convert ferrous into ferric. it carries also cupper.

minerals important for bone formation

calcium, phosphorus, fluoride ,magnesium ,copper and sodium.

 Vitamins important for bone:Vit D3 &Vit K &Vit C

**Copper**

It is important for heam synthesis- bone formation- myelin sheath-cytochrome oxidase- superoxide dismutase (antioxidant)

**Zinc**

It is essential for normal growth and storage of insulin in B cells of the pancreas.

**Iodine**

**It**  is important for synthesis of thyroxin(T3&T4) hormone so its deficiency in oasis leads to Goiter

**Fluorine**

**Fluoride is important for**

 1- **normal bone growth** (floroapatite salt) resistant to bacteria,it also

2**- inhibits enolase of** **glycolysis**.so it is added to tooth paste and prevent dental caries

**Autonomic nervous system**

**DIFFERENTIATE BETWEEN SOMATIC NERVOUS SYSTEM & ANS and true and false**

SOMATIC NERVOUS SYSTEM:

-act on voluntary muscles

ANS:

-act on involuntary muscles

-supply smooth muscles ( viscera)

-2 TRANSMITTERS

-it has 2 nerves supply the muscle

- END IN GANGLIA or ORGAN

PREGANGLIONIC NERVE----BEFORE THE GANGLIA

 THIN MYELINATED AXONS

POSTGANGLIONIC NERVE---UNMYELINATED FIBERS

**mention divisions of ANS and their origin and true and false:**

The ANS is divided into

Sympathetic parasympathetic

nervous system nervous system

Origin: arise from origin: arise from

lateral horn cells of

1-All Thoracic segments 1-cranial nerves 3,7,9,10

2-upper 3 lumber segments 2-sacral segments 2,3,4

Sympathetic nervous system dominates during Parasympathetic nervous

Exercise, stress, fear, fight, flight rest, feeding

**DEFINE GANGLIA AND DISCUSS THE AUTONOMIC GANGLIA.**

DEF: it is collection of neurons outside the CNS

Function: act as distributing center

Types:

1-paravertebral ganglia---(lateral ganglia.)

-on both sides of the vertebral column

-each segment of spinal cord has 2 ganglia one on the right and one on the left except the 8 cervical segments hs only 3 on the right & 3 on the left

-it is only sympathetic

2-collateral ganglia

-mid way between spinal cord and viscera

-at origin of large arteries

-may be sympathetic or parasympathetic

3-Terminal ganglia:

-in the wall of viscera

-has very short post ganglionic nerve

-has very long preganglionic nerve

-it is only parasympathetic

**mention function of sympathetic nervous system on the head & neck may get only one organ and ask for its function (mention the effect of sympathetic on---- eye, pupil , sweat gland**

 Function of the sympathetic nervous system:

**Head and neck:**

\*pupil dilatation---(mydriasis)---contract DILATOR pupilae muscle

\*elevate upper eye lid.

\*Exophthalmus

\*decrease curvature of lens ---- lens become less convex----see far objects.

\*decrease tear secretion.

\*increase sweat secretion.

\*vasoconstriction of blood vessles.

\*decrease salivary secretion.

**mention horner syndrome**

* Horner syndrome:
* Lesion in the cervical sympathetic.
* It results in:
* Miosis-----constriction of the pupil,
* Ptosis-----drop of the upper eye lid
* Anhydrosis---decrease sweat secretion---dry skin.
* Warm skin---due to vasodilatation.

 **mention effect of sympathetic nervous system on thorax**

 Thorax:

* Heart and lungs:
* \*increase heart rate.
* \*increase force of contraction.
* \*vasodilation of the coronary artery.
* \*bronchodilatation.
* \*vasoconstriction of the bronchial vessles.

**mention function of greater splanchnic nerve and mention function of sympathetic nervous system on abdomen**

* Abdomen:greater splanchnic area:
* Supplied by the greater splanchnic nerve.
* \*liver----increase blood glucose.
* convert GLYCOGEN------GLUCOSE
* \*increase metabolic rate.
* \*increase fibrinogen
* \*contract spleen-----push RBCs to circulation.
* \*increase secretion of adrenaline, and noradrenaline.
* \*inhibit wall of the stomach.
* Contract sphincter.
* \*vasoconstriction of blood vessles.

**mention function of lesser splanchnic nerve and mention function of sympathetic nervous system on pelvis**

* Pelvis:
* (lesser splanchnic area)---supplied by lesser splanchnic nerve.
* \*inhibit wall of the urinary bladder.
* Contract sphincter-----inhibit micturation.
* \*inhibit wall of the rectum
* Contract sphincter----inhibit defecation.
* \*ejaculation---then shrink of penis.
* \*vasoconstriction of blood vessles

**mention function of parasympathetic nervous system on head & neck**

* Parasympathetic function:
* Head and neck:
* \*Pupil constriction-----Miosis.
* \*increase salivary secretion.
* \*vasodilate blood vessles of anterior 2/3 of tongue and posterior 1/3 of tongue.

 **mention function of vagus nerve**

 **mention function of parasympathetic nervous system on the thorax & abdomen**

* Thorax and abdomen:
* Supplied by the vagus nerve.
* Thorax:
* \*decrease heart rate.
* \*decrease coronary flow.
* \*decrease oxygen consumption.
* \*decrease atrial properties.
* \*constrict bronchi.
* \*Dilate pulmonary vessles.
* \*increase bronchial secretion.
* Abdomen:
* \*motor to G.I.T.
* relax sphincter.
* \*stimulate secretion of the glands.
* \*contract wall of the gall bladder.
* Relax sphincter.

**mention function of parasympathetic on pelvis (function of the pelvic nerve)**

1-contract wall of rectum & relax sphincter ----defecation

2-contract wall of bladder and relax sphincter ----micturation

3-vasodilation of blood vessles of penis ----erection

**mention sites of release of acetylcholine.**

Acetylcholine :

Formed at end of cholinergic fibers

Sites of cholinergic fibers:

1-all preganglionic sympathetic fibers

2-all preganglionic parasympathetic fibers

3-all post ganglionic parasympathetic fibers

4-NMJ

5-CNS

6-some postganglionic sympathetic fibers to

 \*sweat glands

 \*blood vessles of skeletal muscles

7-preganglionic fibers to adrenal medulla

 **mention methods of removal of acetylcholine( Fate )**

Methods of removal of acetylcholine:

1-split by acetylcholine estrase enzyme.

2- go between receptors

3- active uptake into vesicles

**mention cholinergic receptors**

Receptors which act on them acetylcholine are cholinergic Receptors.

Found at parasympathetic target organs.

Types of cholinergic receptors:

1-Muscarinic receptors

2-Nicotinic receptors.

* 1-Muscarinic receptors:
* \*on the effector organ, sweat gland , blood vessel of skeletal muscles
* \*stimulated by \*muscarine
* 2-Nicotinic receptors:
* \*found at ganglia on membrane of post ganglionic fibers
* \*stimulated by \*nicotine small dose

**mention sites of release of noradrenaline**

* Sites of the adrenergic fibers:
* 1-all post ganglionic sympathetic fibers except those to----\*sweat gland
* \*blood vessles of skeletal muscles.
* 2-adrenal medulla

 3-CNS

**mention methods of removal of noradrenaline**

* Methods of removal of noradrenaline:
* 1-active reuptake to nerve end.
* 2-diffuse to extra cellular fluid
* 3-destroyed by MAO, COMT.

**DISCUSS ADRENERGIC RECEPTORS**

-They are receptors act on the noradrenaline

-they are either alpha1, alpha 2 or beta1, or beta 2 receptors

Alpha 1 receptors act by increasing antracellular Ca++

Alpha 2 receptors act through inhibiting adenyl cyclase---decrease cAMP

Beta 1 & beta 2 ---produce effect by +++ adenyl cyclase ---increase cAMP

Alpha receptors form:

 vc ,dilate pupil , contract capsule of spleen , contract sphincters of GIT , contract seminal vesicle

They relax ----wall of GIT

Beta receptors:

-they cause relax blood vessles of skeletal muscles

-they relax bronchi

-relax uterus

-relax urinary bladder

Relax wall of intestine

-noradrenaline -------+++ mainly alpha receptors and beta to slight extent

Adrenaline -------+++ both alpha and beta equally