وزارة التعليم العالي والبحث العلمي
الجامعة التقنية الشمالية
اسم التشكيل :- المعهد التقني الدور

الحقيبة التعليمية

قسم تقنيات المختبرات الطبية

اسم المقرر:	الكيمياء الحياتية
المرحلة / المستوى:	الثاني
الفصل الدراسي:	الاول
السنة الدراسية:	٢٠٢٥ / ٢٠٢٦

معلومات عامة

اسم المقرر:	الكيمياء الحياتية						
القسم:	تقنيات المختبرات الطبية						
الكلية: المعهد	المعهد التقني الدور						
المرحلة / المستوى	الثاني						
الفصل الدراسي:	الاول						
عدد الساعات الاسبوعية:	نظري	١	عملي	٢			
عدد الوحدات الدراسية:	٣						
الرمز:	MLT٢٠٨						
نوع المادة	نظري		عملي		كلهما	*	
هل يتوفر نظير للمقرر في الاقسام الاخرى	كـلا						
اسم المقرر النظير	-						
القسم	-						
رمز المقرر النظير	-						
معلومات تدريسي المادة							
اسم مدرس (مدرسي) المقرر:	د. مها الطيف جاسم						
اللقب العلمي:	أستاذ						
سنة الحصول على اللقب	٢٠٢٦						
الشهادة :	دكتوراه						
سنة الحصول على الشهادة	٢٠١٢						
عدد سنوات الخبرة (تدريس)	١٦						

الوصف العام للمقرر

الكيمياء الحيوية: هي علم دراسة المواد الكيميائية والعمليات الحيوية داخل جسم الكائن الحي .وتركز على تركيب ووظيفة الجزيء الحيوي.

الاهداف العامة

- **تدريس الطالب كيفية التعرف على المركبات الكيميائية.**
- **تزويده بمعلومات كافية تمكنه من فهم ما يجري من فعاليات حيوية في جسم الانسان على المستوى الجزيئي.**
- **تطبيقها بدروس عملية وتبيان الطرق المستخدمة في تشخيص بعض الامراض.**

الأهداف الخاصة

- ترتبط بمقرر دراسي معين أو بوحدة دراسية محددة .
- تمتاز بأنها أهداف قصيرة الأمد إلى حد ما، تحدد بدقة توضح ما يجب أن يتعلمه المتعلم من دراسة مقرر معين أو القيام بنشاط معين .
- تكون صياغة الأهداف التعليمية أكثر تحديداً وتخصيصاً من الأهداف التربوية .
- تصف سلوك نوعي يحدد الأداء النهائي الذي يصدر عن المتعلم الذين ينجحون في تعلم السلوك المرغوب .

أمثلة الأهداف التعليمية .

تزويد الطلاب بأساس واسع ومتوازن من المعرفة والمهارات العملية في الكيمياء الحياتية والعلوم الأساسية ذات الصلة .تنمية القدرة لدى الطلاب على تطبيق معارفهم ومهاراتهم الكيميائية في حل المشكلات النظرية والعملية في الكيمياء الحياتية والتي تخدم اهداف التنمية المستدامة..

الأهداف السلوكية او نواتج التعلم

- **تطبيق المهارات العلمية والتحليلية المختلفة لحل المشكلات المختلفة**
- **تحليل وضع الحلول النهائية للمشاكل والتحليلات المرضية .**
- **تصميم وتحليل النظم التحليلية المختلفة**
- **تكامل المعرفة بين القيم العملية المختلفة لإيجاد حلول مميز**

((أمثلة أهداف تدريسية)) :- بعد الانتهاء من الدرس (المحاضرة) سيكون الطالب قادرا على ان

- ماهية العمليات الحياتية واصنافها وكيفية توليد الطاقة
- يميز ويعرف الكيمياء الحيوية وعلاقتها بالطب والعلوم الاساسية الاخرى.

المتطلبات السابقة

- لايوجد

الأهداف السلوكية او مخرجات التعليم الأساسية		
ت	تفصيل الهدف السلوكي او مخرج التعليم	آلية التقييم
١	تطبيق المهارات العلمية والتحليلية المختلفة لحل المشكلات المختلفة	• المحاضرات . • الواجبات الفردية والمشاركة . • حلقات النقاش والاختبارات .
٢	تحليل وضع الحلول النهائية للمشاكل والتحليلات المرضية .	• البحث وتطوير المهارة من خلال الابحاث في المختبرات
٣	تصميم وتحليل النظم التحليلية المختلفة	• مشاريع فردية او جماعية . • اختبارات .
٤	تكامل المعرفة بين القيم العملية المختلفة لإيجاد حلول مميز	• مشاريع فردية او جماعية . • اختبارات .

أساليب التدريس (حدد مجموعة متنوعة من أساليب التدريس لتناسب احتياجات الطلاب ومحتوى المقرر)

الاسلوب او الطريقة	مبررات الاختيار
١-المحاضرات النظرية والعملية من خلال الشرح	محدد وواضح ويطبق بسهوله وهو التقليدي
٢. التعلم التفاعلي والمتبادل	التفاعل بين الطلبة
٣. المناقشة في نهاية المحاضرة	تقديم الخلاصة والفهم للموضوع

المقرر الدراسي :- الكيمياء الحياتية المستوى الدراسي الثاني – الفصل الأول

الاسبوع	الساعات	مخرجات التعلم المطلوبة	اسم الموضوع	طريقة التعلم	طريقة التقييم
١	٣	المعرفة والتطبيق العملي	Introduction, collection and handing of blood samples, anti-coagulant protein receipt ant kinds, urine compassion, urine collection methods urine preservative.	عملي + نظري	الاختبارات والتقارير
٢	٣	المعرفة والتطبيق العملي	Electrolyte (Na+, K+, pb-٣, Fe+٣,٤)	عملي + نظري	الاختبارات والتقارير
٣	٣	المعرفة والتطبيق العملي	Trace element [cu, co, zn, mg], disease appeared in abnormal metabolism of these metals.	عملي + نظري	الاختبارات والتقارير
٤	٣	المعرفة والتطبيق العملي	Acid base balance in body disease appeared in disturbance of acidity and alkanty of blood, types of buffer system in body.	عملي + نظري	الاختبارات والتقارير
٥	٣	المعرفة والتطبيق العملي	Carbohydrate.	عملي + نظري	الاختبارات والتقارير
٦	٣	المعرفة والتطبيق العملي	Digestion, absorption in normal condition and abnormal condition.	عملي + نظري	الاختبارات والتقارير
٧	٣	المعرفة والتطبيق العملي	Glucose Tolerance test in normal condition and in D.M.	عملي + نظري	الاختبارات والتقارير
٨	٣	المعرفة والتطبيق العملي	Glucose metabolism, No. of hormones reside glucose level, hormone decrease blood glucose level.	عملي + نظري	الاختبارات والتقارير
٩	٣	المعرفة والتطبيق العملي	Types of D.M., canoes, ketosis, glucose urea.	عملي + نظري	الاختبارات والتقارير
١٠	٣	المعرفة والتطبيق العملي	Proteins.	عملي + نظري	الاختبارات والتقارير
١١	٣	المعرفة والتطبيق العملي	Digestion and absorption of proteins in normal and abnormal condition.	عملي + نظري	الاختبارات والتقارير
١٢	٣	المعرفة والتطبيق العملي	Abnormal proteins types and the disease appeared with this protein.	عملي + نظري	الاختبارات والتقارير
١٣	٣	المعرفة والتطبيق العملي	Protein metabolism, types of metabolism, protein function.	عملي + نظري	الاختبارات والتقارير
١٤	٣	المعرفة والتطبيق العملي	Electrophoresis of plasma protein types of blood protein, disease accompanied with these proteins.	عملي + نظري	الاختبارات والتقارير
١٥	٣	المعرفة والتطبيق العملي	Protein urea, causes disease accompanied with it.	عملي + نظري	الاختبارات والتقارير

A: Over view

١- Target population:

This educational package is designed to the second-class students in the Department of Medical Laboratory Technology at Al-Dour Technical Institute.

٢- Rationale:

This (Unit) will aid those who want to learn the basic clinical biochemistry concepts that apply to the health field. It is also intended for students who have little or no science background.

There is a need for a "simplified "clinical biochemistry unit that presents the major concepts clearly for people entering the health occupations.

The student will discover, the concise nature of this unit has made each sentence significant. Thus, the reader will be intellectually challenged to learn each new concept as it is presented.

٣-Central ideas:

٣-١: General view of clinical biochemistry
٣-٢: Function of clinical biochemistry
٣-٣: Constituent of blood
٣-٤: Constituent of urine

٤- Instructions:

٤-١: Study the over view carefully.
٤-٢: Learn briefly the modular unit of this package.
٤-٣: Perform the pre-test of this unit:

- If you get (٨) degree, or more. You will not need to learn this modular unit. In this case you must contact with your teacher to inform him about your results.
- But when you get less than (٨) degree in this test, you will need to continue learning this modular unit.

٤-٤: After you studying this modular unit.
The post-test you must do it.

- If you get (٨) degree or more, you must go to learn the second modular unit.
- In case you get less than (٨) degree, you Must return to the same unit in order to learn and understand the steps which you need.
- After you complete the studying, perform
  The post-test examination for checking.

B: Performance Objectives:

After studying this modular unit, you should be able to:

١- Define clinical biochemistry.

٢- Define normal values.

٣- Enumerate function of clinical biochemistry.

٤- Differentiate between the plasma and serum.

٥-Define urine.

Pre-test :

❖ Put a circle in front of right sentence:

١- Biochemistry is the science which deals with the studying of.

a- living tissues. b- Change in energy.

c- Chemical composition. d-chemical processes in living tissues.

٢-whole consist of:-

a-blood cell . b-plasma.

c-serum. d-blood cell &plasma.

٣-serum is one composition of :-

a-whole blood. b-plasma .

c-blood cell. d-white cell.

٤-blood anticoagulants as a:-

a- $Na^{2}CO^{3}$ b-EDTA

b- NaCl d-HCl

٥-heamolysis is a destruction of:-

a-WBCs b-RBCs

c-platelet d-fibrinogen

C: The Modular unit of this Package:

Clinical Chemistry:

Is the science that deals with the study and measurement of the chemical constituents of human body. These constituents are either organic substances like sugar, urea, cholesterol, uric acid, ….etc. or inorganic substances like Na+, K+, Ca++, Cl-, … etc. or may be enzymes or hormones.

Clinical Biochemistry Function :

The Function of clinical biochemistry labs are :

١. To perform quantitative and qualitative tests of body fluids such as blood , urine , CSF , Etc.
٢. To diagnosis and treatment of disease .
٣. The tests must be down as accurate as possible .

Types of specimen:

The common lab. Specimen that be examined in clinical lab are :

١-Blood ٢-Urine . ٣-Stool. ٤-Gastric fluid. ٥-CSF. ٦-Saliva . ٧-sweat .

Blood:

Blood could be obtained from three different sources:

١- Capillary blood:

It is obtained from finger of thumb after cleaning with spirit. Sufficient pressure is used to force out the blood which is allowed to run in suitable pipette. The pipette should be dry and clean. Not more than ٠,٢ ml of blood could be obtained by this source. Such sample is used for hematological analysis like RBC & WBC count, Hb …… etc.

٢- Arterial blood:

It is restricted for blood gases analysis i.e. for CO_2, O_2, HCO_3, pH…. Etc.

٣- Venous blood:

Used for analysis of all chemical constituents in blood, like Glucose, Urea, Cholesterol…etc. Tourniquet is used which aid in the identification of vein and in the rapid removal of blood . sample should be well preserved from the time of collection to the time of starting analysis.

Types of blood fractions :

١. Whole blood , for tests of glucose , Hb , Urea .
٢. Plasma for tests of chloride , Vit C , Fibrinogen , Bicarbonate .
٣. Serum for tests of total protein , albumin , globulin , cholesterol (Free , ester) Creatinine , Uric acid , enzymes .

The method used to obtain plasma or whole blood:

If whole blood or plasma is desired, an anticoagulant must be added to the specimen, than the sample centrifuged for ١٠ min at ٣٠٠٠xg to obtain plasma. The technologist must be certain that the anticoagulant used does not affect the chemical analysis.

The method used to obtain serum:

When blood is drawn from a patient, it is transferred to a clean and dry tube after the needle has been removed. The blood is than allowed to clot for at least (١٠ – ١٥) min. at room temperature. The clot may adhere to the wall of the tube, so that making a gentle sweep around the inside walls of the tube with a wooden stick should be performed before centrifugation. However, during this time glycolysis takes place and there can be a shift of substance from cells to serum. After the blood has clotted, the tube is centrifuged and the supernatant serum removed.

Note: centrifugation was about ١٠ min. ٣٠٠٠xg.

Anticoagulants:

Chemical agents that prevent coagulation are routinely used when whole blood or plasma is required.

- If the anticoagulant is present as sodium or potassium salt and electrolytes are being analyzed a significant error can occur.
- In the case of using oxalate, and calcium are being analyzed, oxalate removes calcium from serum by forming an insoluble salt.
- Oxalate has been reported to inhibit lactate dehydrogenase (LDH), acid phosphatase (ACP) and amylase.
- Fluoride if present in very high concentration inhibits urease but may activate amylase.

Types of anticoagulant :

١. Heparin :

Advantages : Ideal anticoagulant .

Disadvantage : High Cost , Temporary action , effected by its salt like Na, K , NH_4 , Li .

Action : Ant thrombin prevent the transformation of prothrombin to thrombin .

٢. Oxalate :

Advantages : Low cost , easy to handle .

Disadvantages : Interfere with some chemical analysis salts : Na , K , Li , NH_4 ,

Action : Complexion with ($Ca^{+٢}$) ion .

٣. EDTA :

Advantages : Low cost , Low period action .

Disadvantages : Inhibited to some enzyme .

Salts : Na,K,Li,NH_4 .

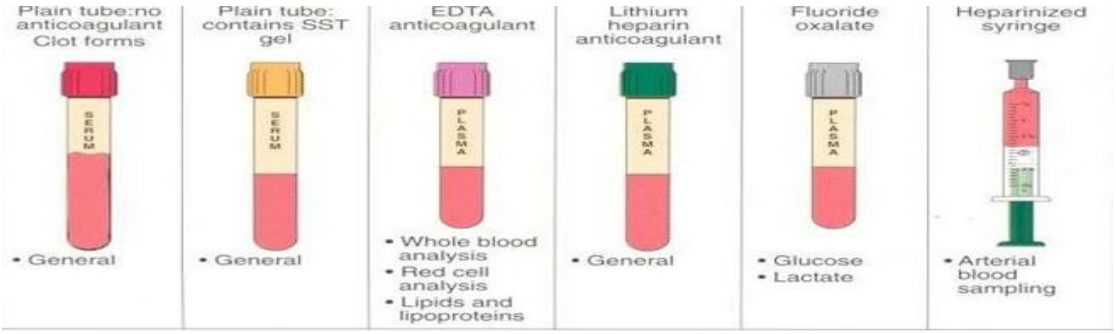
Action : Chelating agent with $Ca^{+٢}$ ion .

٤. Sod – Fluoride :

Advantages : good for glucose .

Disadvantages : Weak anticoagulant .

Action : Enzymatic inhibited .



Source of error :

Several factors causes faults in determination of certain chemical substances presents in blood sample among these factors.

١- **Hemolysis** : The erythrocyte release its content in the sample so that the color change in colorimetric analysis and makes interference with specific chemical like bile determination Na, K.

and to avoid hemolysis by :

- Needle and syringes must be dry .
- Tubes & flasks must be dry and chemically clean and clear .
- Minimum movement on arm patient Should be applied .
- Mixing of blood with anticoagulant should be done with gentle rotation and not shakes .
- Separation of plasma or serum should be done immediately with centrifugation for (٥ – ١٠) Min .
- The clot must be done with stick and removed out the tube .

٢- **Concentration Change** : The change in the original Conc. of blood sample due :

١. Diluting of sample .
٢. Using of anticoagulant .
٣. Evaporation of sample .
٤. Prolong stand of blood in open container .

٣- **Composition Change** : Its change by :

١. Bacterial .
٢. Enzymatic change .
٣. Heat .
٤. Light .

To avoid Composition Change :

١. Sterilizing blood sample .
٢. Promote separation of cells from plasma or serum .
٣. Storage the sample at (٤ – ٦ C^{o}) until analyzed .
٤. Freezing at ٢٠ C^{o} for long period of time .
٥. Avoid the light in some sample like bile .

٤- **Blood Gas lost :** Lost of $CO_{٢}$ From blood sample and to minimize that by :

١. Filling the original Container to capacity with blood .
٢. Tightly closed of blood sample container .

٥- **Biological Factors effecting the interoperations of results** :

١. Sex .
٢. Age .
٣. Diet .
٤. Timing .
٥. Stress .
٦. Posture .
٧. Effect of exercise
٨. Medical history.

Urine

It is an ultra-filtrate fluid from the blood, the filtration occurs in the kidney and excreted outside the body through urinary tract. Urine is a good media for bacterial growth that is why the sample should be collected in clean, sterilized vessels and should be examined within half an hour after its collection. Otherwise its kept in refrigerator till the time of examination, this sample should be warmed before analysis.

Urine Samples

Many different samples of urine could be collected:

١- **Random sample**: This sample may differ from person to another depending on physical, pathological and dietary condition taken at any time and kept in covered vessel.
٢- **Moring sample**: Usually the most concentrated of any other time of collection and is the most uniform from day to day, that is why it is preferred for analysis than any other sample.
٣- **Timed sample**: Are needed when quantitative estimation is to be carried out, used for measuring the kidney function. The sample may be ٢٤ hr. ٣hr., ….etc collected in suitable container containing preservative like benzoic acid, toluene, ….. can be used for measuring the total urinary excretion per day.
٤- **Catheterized sample:** Collected in cases of anuria (total suppression of urine excretion) using a catheter.
٥- **Bacteriological sample**: Collected in sterilized, clean test tube, mid-stream is preferred for such analysis, the tube should be closed directly after urine has been put in.

Collection of 24 hour Urine sample:

A ٢٤ – hour sample may be collected between ٨,٠٠ on Monday and ٨,٠٠ on Tuesday, The procedure is therefor as follows:

١- At ٨,٠٠ on Monday the bladder is emptied completely, whether or not the patient feels the need. Discard the specimen.
٢- Collect all urine passed until.
٣- At ٨,٠٠ on Tuesday the bladder is emptied completely, whether or not the patient feels the need. Add the specimen to the collection.

The shorter the period of collection, the greater the error if this procedure is not followed.

Urine Preservatives :

١. Formalin : Its useful for preserving Cellular element and cast in urine .
٢. Thymol : Used for quantitative analysis For (٢٤) hr urine sample .
٣. Boric acid : Its useful for all purpose .
٤. Toluene : Its useful for glucose determination .
٥. HCL : Used for analysis total nitrogen A.A , Catecholamine .

Note:-

If you are finished the first modular unit. Please check your knowledge by: Performing the post-test.

Post-test

☒ Put a circle in front of right sentence: -

١-when a centrifuge blood with EDTA produced

a-plasma b-serum

c-fibrinogen d-platelet

٢-the process of destruction of RBCs is called

a-hemoglobin b-hemolysis

c-glycolysis d-dehydration

٣-when increase in urine amount the person may be cause by:-

a-nephritis b-kidney failure

c-diabetic mellitus d-dehydration

٤-if urine color is brownish or greenish that's mean the urine contain

a-RBCs b-antibiotic drugs

c-Bilirubin d-pus

٥-the patient when intake the drug of glucose laboratory tests result: -

a-glucose normal but acetone hyper

b-glucose abnormal but acetone hypo

c-glucose normal but acetone hyper

d-glucose abnormal but acetone hyper

Electrolytes

Electrolytes are distributed in solution through all the body fluids, the cation (positively charged) of these electrolytes are Na, K, Ca & Mg. the chief cation of plasma and other extracellular fluid is Na and in the intracellular fluid is K.

Among the anion of body fluids are Cl, HCO_3, H_2PO_4, HPO_4, SO_4 & protein. The chief anion of plasma and other extracellular fluids is Cl and in the intracellular fluids is HPO_4 and protein.

Trace Element

are (Fe , Cu , Mn , Cr , Cd , Zn , Br , I) the trace element occur in the body in a minute quantity and present as not free element but its combination with protein .

Function of electrolyte and trace element :

١. Regulation of the most metabolic path way in the body .
٢. Maintain of osmotic pressure and hydration of the various body fluid compartment .
٣. Maintain of the proper body PH .
٤. Regulation of the proper function of heart and muscles .
٥. Involvement in oxidation – Reduction reaction .
٦. Participation as essential part of Co-Factor of Enzyme .

Sodium (Na^+)

Body content – Distribution :

١. Sodium ion consider as the major cation of extracellular fluid .
٢. It is present as(١,٠٩gm) of (Na^+) per Kg of body weight in adult
٣. In new born present as (١,٨٧gm) per Kg of body weight .
٤. The average amount in the body is about (٦٥ g) of Na present in extracellular bone .

Function :

١. Maintain proper (PH) and acid base balance .
٢. Maintain the osmotic pressure of the body fluid .

Metabolism :

١. The amount of Na as NaCl is ingested daily .
٢. ٩٥٪ of this quantity is excreted in urine according to the body requirement .
٣. It is completely absorbed by G.I.T .
٤. Kidney are regulated the Na Content by partially filtration from glomerular .
٥. ٨٥٪ is reabsorbed in proximal tubules and the re absorption controlled by aldosterone hormone .

Clinical Significance :

N.V. for Na^+ in serum = ١٣٥ – ١٤٨ m.mole/L .
N.V. for Na^+ in urine = ١٤٣ – ٢١٧ m.mole/L .

Hyponatremia :-

١. Sever poly urea (as in diabetes insipidus)
٢. Metabolic acidosis .
٣. Addison's disease . (decrease aldosterone hormone) .
٤. Diarrhea .
٥. Renal tubular disease .

Hypernatremia :

١. Hyperadrenalism (Cushing syndrome) .
٢. Severe dehydration (Water loss).
٣. Certain type of brain injury .
٤. Diabetic coma after insulin therapy .
٥. Excessive treatment with Na^+ salt .

Potassium (K^+)

Body content – distribution :

١. Potassium is consider as major intracellular cation .
٢. N.V of serum K^+ =٣,٥ – ٥ m.mole/L .
٣. Concentration on cell = ١٥٠ m.mole /L .
٤. Concentration in RBC = ١٠٥ m.mole/L .
٥. The intracellular Conc. is (٢٣) times higher than the extracellular Conc.
٦. The body Content of (K^+) In adult = ٢,٦٥ g/kg fat free and ١,٩٠ g/kg of the new born .

Functions :

١. Effect neuromuscular excitation and respiration .
٢. Important in cell action (it is intracellular action) .
٣. Important in myocardial function .
٤. Normal daily intake is (٨٠ – ٢٠٠) m.mole / day .

Absorption:

Absorption directly from intestine and excreted with urine, the capacity of the kidney to excrete K is so great so hyperkalemia will not occur. Aldosterone hormone increases excretion of K.

Clinical significance :

Hypokalemia :

١. Prolong diarrhea and vomiting .
٢. Cushing syndrome (↑Aldosterone hormone)
٣. Low in take (K) .
٤. Muscle weakness & paralysis .
٥. Effect cardiac contradiction .
٦. Renal function .
٧. Alkalosis will lead to hypokalemia .

Hyperkalemia :

Serum (K^{+}) is more than ٥ m.mole/L

١. Acute sever chronic renal failure .
٢. Hypoaldesronism .
٣. Metabolic acidosis .
٤. Insulin deficiency .
٥. Urinary obstruction .

N.V. of Serum K = (٣,٥ – ٥) m.mole /L .

Urine K = (٢٥ – ١٢٠ m.mole/L .

Phosphorous

Body Content and distribution :

١. (P) Is present in every cell of the body .
٢. Total body (P) is (٥٠٠ – ٨٠٠)g , ٨٥ – ٩٠٪ present in skeleton , daily requirement is (١,٩) g/day .
٣. Total plasma (P) is about ١٢ mg / dL with ٢/٣ of this total is organic comps. And the remaining is inorganic Phosphorous (Pi) mostly (PO_4 , HPO_4) .
٤. The amount interring the bone is ٣ mg / kg / d , with equal amount leaving via reabsorption .

٨٠٪ of total (P) with Ca^{+2} in bone and teeth .
١٠٪ of total (P) with protein , CHO .
١٠٪ of total (P) with chemical comps ATP .

Function of (P) :

١. Integral Compds. Of vital molecule such as nucleic acid , Nucleotides , (NAD , NADP) phospholipids and some protein .
٢. Integral part of bone with Ca contribute in the buffering system of blood HPO_4 , H_2PO_4 in ratio ٤:١ at PH ٧,٤ .

٣. Essential components of ATP they form of energy transport and storage in the living cell .

Absorption :

١. Phosphate absorbed in jejunum by Active and passive diffusion .
٢. phosphate absorption is proportional to dietary intake .
٣. Phosphate absorption increased by present (VitD) and the synthesis of (VitD) increased when Serum (P) decreased .
٤. Deposition of phosphate as hydroxyl apitate in bone in regulated by (PTH) .
٥. ٨٥ – ٩٠ of plasma Phosphate is filtered by glomerular filtration and ٩٠ – ٩٥ of filtrate (Pi) is reabsorbed by (VitD) .
٦. (P) Like (Na) have renal threshold limit . ٤٠ % of excreted (Pi) in the feces and ٦٠٪ in the urine (Unlike $Ca^{+٢}$) .
٧. It is favored at the following factors: Acidic pH, Vitamin D, Low serum calcium.

CLINICAL SIGNIFICANCE :

Hyperphosphatemia :

١. Hyper vitaminosis .
٢. Hypoparathyroidism .
٣. Renal Failure .
٤. In normal children due to secretion growth hormone .
٥. Diabetic ketosis .

Hypophosphatemia :

١. Rickets .
٢. Hyperparathyroidism .
٣. Fancony syndrome .
٤. Acute alcoholism .
٥. Osteomalicia .

N.V of S. phosphorous

١st year of Life = ٤ – ٧ mg / dL .
Children = ٤,٥ – ٦,٥ mg/dL .
Adult = ٣ – ٤ mg / dL .
Pi in Urine = ٠,٤ – ١,٣ g/d .

Iron ($Fe^{+2,+3}$)

Body content and distribution :

١. Normal adult contains (٣ – ٤) g Fe .
٢. Hemoglobin = ٦٥٪ .
٣. Myoglobin = ١٠ %
٤. Enzymes + Transferrin = ١٪

} **Physiological Active Fe ٧٥٪ .**

٥. Enzymes :- Catalase , Cytochrome , peroxidase , hydroxlyase .
٦. Ferritin = ١٠٪
٧. Hemosidrin = ٩٪

} **Storage place of Fe = ٢٥٪ .**

٨. Liver , Spleen , Bone marrow = ٥٪

Fe can be stored in body as :

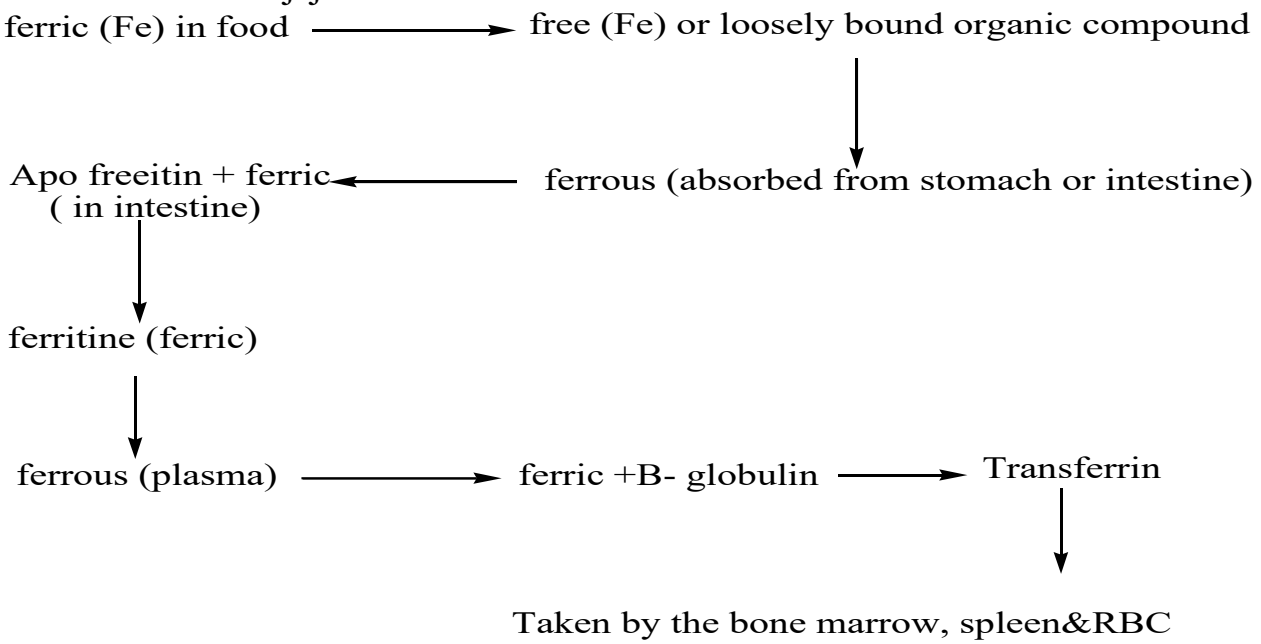
١. Iron stored in ferritin as ferric hydroxide – ferric phosphate .
٢. Iron Stored in hemosiderin as iron oxide granules .
٣. Iron Stored in liver , spleen and bone marrow as sub microscopic particles .

Functions :

١. The major used of iron for oxygen transport in hemoglobin .
٢. integral part of hem protein and enzymes .
٣. participate in oxidation – reduction reaction .

Absorption & Metabolism :

Small amount of iron is absorbed from the stomach, while most of absorption takes place in the duodenum and jejunum of the intestinal tract.



That's why iron is said to circulate in closed circulation as it cannot be excreted in urine because it has been combined with high M. wt. β- globulin and it is stored in the form of ferritin in mucosal cells of the stomach and intestine.

Clinical Significance :

High serum Iron Level :

١. Hemolytic anemia .
٢. Lead poisoning .
٣. Necrotic hepatitis .
٤. Pernicious anemia .
٥. Hemochromatosis , Hemosidrosis .
٦. Hodgkin disease .

Low Serum Iron :

١. Decrease Iron In take or absorption .
٢. Chronic blood loss , nephrosis .
٣. Pregnancy .
٤. lactation , Menstation .
٥. Infection .

Transferrin
Is a compound of iron in serum bound to β-globulin. Normally, about ١/٣rd of transferrin is combined with iron, while the other ٢/٣rd need to combine with iron.

Unsaturated iron binding capacity (UIBC)
The part of transferrin which is not combined with iron.

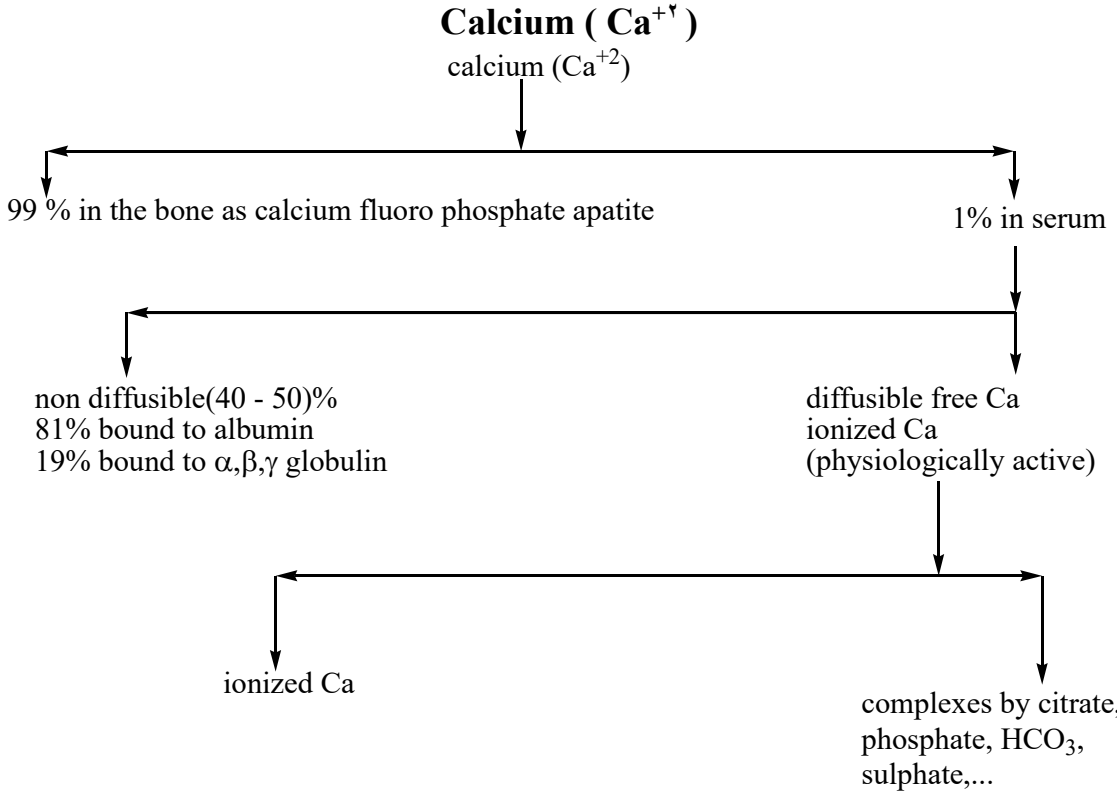
Total iron binding capacity (TIBC)
It is the total amount of iron circulating in the plasma plus the iron that could be bound. It is used to estimate the transferrin level in serum.

TIBC increased in:
١- Chronic iron deficiency.
٢- Liver necrosis.

TIBC decreased in:
١- Liver cirrhosis.
٢- Hemochromatosis.
٣- Nephrosis.
٤- Malignancy.

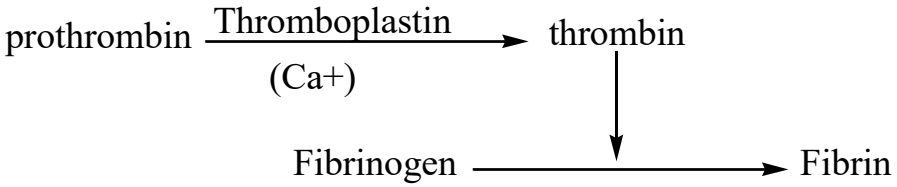
Calcium ($Ca^{+٢}$)

It is an essential cationic component of all living matter. The adult human body contain about ١١٠٠g of ($Ca^{+٢}$).



($Ca^{+٢}$) Functions :

١. Decrease neuromuscular excitability.
٢. Participate in blood coagulation



٣- Activate some enzymes.
٤- Transferring inorganic ions across cell membrane.
٥- Regulate heart function.

Metabolism:

It is mostly absorbed from the upper small intestine (duodenum), it is need acid pH, vitamin D and parathyroid hormone.

Factors affecting calcium level:

١- Acidic pH: absorption increase in acid media and decrease in alkaline.
٢- Vitamin D: Increase absorption of calcium.
٣- Parathyroid hormone: direct influence on calcium absorption.
٤- Serum protein: any decrease in serum protein will affect serum level of calcium, it affect only the diffusible from of Ca.
٥- Serum phosphorus: There appears to be a reciprocal relationships between Ca & P.

Clinical significance :

Hypercalcemia

١. Hyperparathyroidism .
٢. Hyper vitaminosis D .
٣. Multiple myeloma .
٤. Bone disease (Esteopoisis) bone cancer .

Hypocalcaemia :

١. Hypoparathyroidism .
٢. Chronic renal failure .
٣. low in take ($Ca^{+٢}$) and ($VitD^{٣}$) .
٤. Nephrosis and Nephritis .
٥. Pancreatitis .

N.V of S.Ca = ٤,٥ – ٥,٥ meq/L
= ٢,٢٥ – ٢,٧٥ m.mole / L .
= ٩ – ١١,٥ mg / ١٠٠ml .

Chloride (Cl^{-})

Is major extracellular anion consists about ١٠٣ m.mloe/L of the total anion Concentration .

Functions :

١. Maintain proper water distribution .
٢. Maintain normal osmotic pressure .
٣. Maintain anion and cation balance in extracellular fluid .

Metabolism :

١. Completely absorbed by G.I.T .
٢. Removed from blood by glomerular filtration .
٣. Reabsorbed passively by proximal tubules .
٤. Lost through excessive sweating .
٥. Plasma (Cl^-) decrease slightly after meal .

Clinical significance :

Hypochloremia :

١. Nephritis .
٢. Addison's disease .
٣. Metabolic acidosis . (Diabetic acidosis renal failure) .
٤. Vomiting .

Hyperchloremia :

١. Congestive heart failure .
٢. Primary hyperparathyrodism .
٣. Excessive intake of chloride .
٤. Sever renal tubular pathology .

N.V. of S. Cl^- = ٩٨ – ١٠٦ m.mole/L .

Urine = ١١٠ – ٢٥٠ M.mole / L .

Trace element

Trace element : They have found in the body a trace amount extremely small in living system essential to the life , they contain (١٣) element (٤) of them are nonmetal such as (Si , F, I , Se) and the other are metal. They are generally measured by atomic absorption.

Fluoride (F)

It is found in bone and teeth .

Selenium (Se)

Selenium Metabolism:

It is one of the important elements inside the body and is a semi-metals atomic weight ٧٨,٦٩ and the number of atomic ٣٤ deposited in the liver, kidneys, cardiovascular and skeletal muscle at a very low concentration in the body because it easily turns into a toxic element causing a lot of diseases inside the body. The average rate in the body is ١٥ µg.

selenium metabolic functions

١- Proteins form the structure of the so-called seleno- protein.

٢- enters in important clinical enzymes within the body, the most important enzyme glutathione peroxidase, which makes up a rate of ٣٤٪ and this enzyme is concentrated in the thin films of red blood cells and any defect in selenium leads to a deficiency in this enzyme which leads to rupture of the membranes of red blood cells by a process called hemolytic anemia.

٢- Selenium is an anti-oxidant where it breaks free radicals and turn them into neutral molecules and any deficiency of selenium in muscle cells leads to the

accumulation of free radicals as in the heart leads to enlargement of the heart or myocardial infarction.

٣- prevents the growth of cancer cells where it prevents the formation of free radicals and thus prevents the occurrence of cancer

$$٢GSH + H_٢O_٢ \quad GSSG + ٢H_٢O_٢$$

$$٢GSH + ROOH \quad GSSG + ROH + H_٢$$

Selenium is found in Brazilian tuna and pistachio at a high rate and any increase in the percentage of selenium turns into a toxic substance causing selenosis.

Absorption of selenium

It is absorbed by the small intestine and binds to a specific protein and goes with its blood to the body tissues

Subtraction of selenium is carried out in two ways:

١- Through urine

Urine →Tri methyl selenite

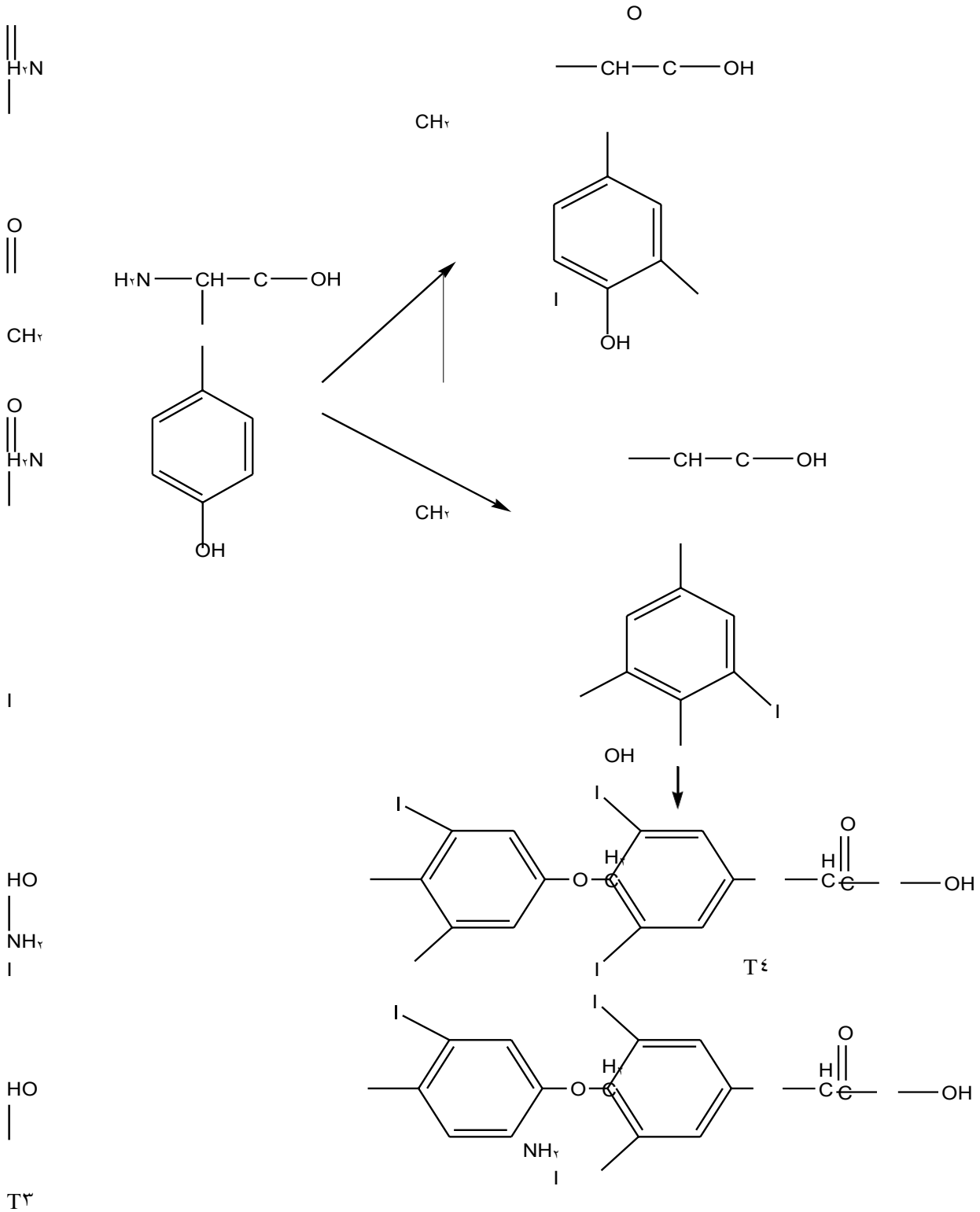
٢- put through breathing means the presence of a high percentage of selenium within the body

Breath →Di methyl selenite

Iodine (I)

Iodine metabolism

It is an important trace element and is very rarely so should pay attention to iodine-containing salts It maintains the balance of thyroid hormones T٣, T٤ and helps to manufacture them from the body of iodine to ٢٥ micrograms and its concentration in the normal blood serum ٤-١٠ micrograms found in the body linked with proteins Is called Protein bond iodin.



Iodine absorption

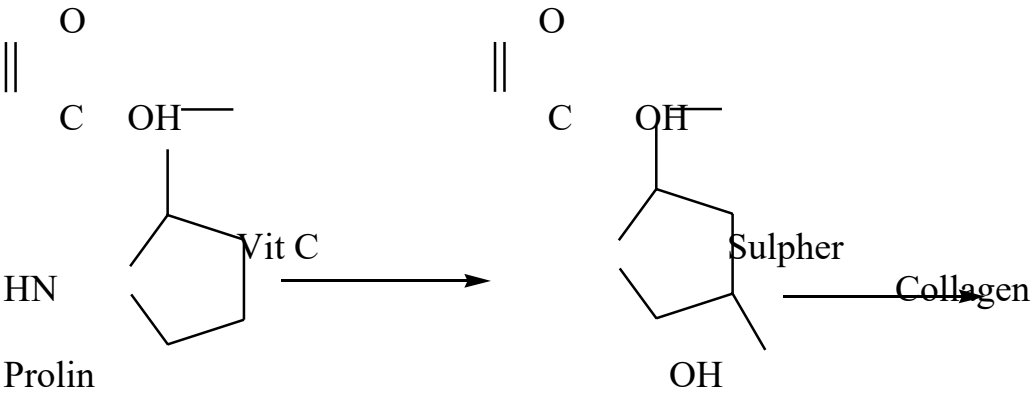
Iodid is absorbed in the form of iodid through the small intestine and is carried by Protein to the thyroid gland and turns into iodonium and goes to a protein in the thyroid gland called Thyroglobuline, an essential component of the thyroid gland containing an important amino acid, which is tyrosine. Iodination occurs and the different iodine atoms are distributed on the tyrosine sites and we get thyroid hormones T٣, T٤ by rearranging.

Sulfur (S)

Sulfur .. Its importance and metabolic functions

١- Includes in the synthesis of many amino acids such as methionine, sixty and the genders

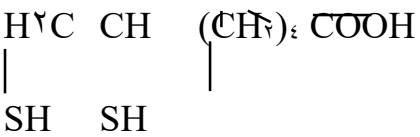
٢- Sulfur is an essential material for the manufacture of collagen, where it enters the synthesis of skin tissue and body cells, hair and nails.



٣- enter into the composition of heparin

٤- Includes in the composition of many enzymes such as Glutathion and vitamins such as Thiamine

٥ - enters into the installation of enzyme facilities such as



Lipoic acid (Co-enzyme)

Copper (Cu)

Daily intake by adult is ٢,٥mg. , Infant and children require about ٠,٠٥mg/kg body weight. This is easily supplied in diet, which contain (٢,٥ – ٥) mg of Cu. It is necessary for normal function of all living cells.

Dietary sources: Grains, Meat, Cocoa and fish.

Absorption: Cu is absorbed mainly from duodenum.

Excretion: Cu is excreted in intestine. It is not excreted in urine because copper in the plasma is largely bound to protein.

Functions

١- Copper is a constituent of certain enzymes (cytochrome, cytochrome oxidase, catalase, monoamine oxidase, ascorbic acid oxidase, uricase).
٢- It is necessary for Hb synthesis.
٣- In mucosal cell its bind with a protein and called metallothionin .
٤- In plasma its bind with histidine and albumin .
٥- Copper hemostat is maintained and eliminated by biliary excretion .
٦- Copper helps in protection from (UV) rays .

Hypocuperemia:

١- Anemia in infants.
٢- Malnourished infants.
٣- Nephrosis.

Hypercuperemia:

١- Cute cupper poisoning.
٢- Leukemia.
٣- Thalassemia.
٤- Rheumatoid.

Cobalt (Co)

Functions:

١- Essential component of (Vit B١٢) .
٢- Cobalt absorption increased in liver disease .
٣- Cobalt is excreted primary in the Urine .
٤- It has Low order of toxicity .

Manganese(Mn)

Sources: Grains, Coffee, Tea.

Functions:

١- It is necessary for synthesis of oligosaccharides, glycoprotein
٢- Essential for bone and tissue formation .
٣- Integral part of many enzyme such as hydrolase , kinase decarboxylase .

Excretion: Mainly in intestine.

Manganese toxicity: inhalation of large amount of Mn dust.

Zinc (Zn)

Functions

١- It is a structural and functional component of the enzyme carboxy peptidase and it participate directly in, its catalytic activity.
٢- Zn is also associated with several other enzyme involving carbonic anhydrase and alcohol dehydrogenase which contain one atom Zn/mole of enzyme protein.
٣- Insulin is known to contain Zn and the pancreas of diabetics contain only about half the normal amount of Zn.
٤- Zinc is contained in WBC, their content of Zn decreased in leukemia.
٥- Deficiency of Zn in children lead to an impaired taste acuity.
٦- Normal liver function and synthesis of DNA .
٧- Human body contain (٢ – ٣)mg. of Zn .

Magnesium (Mg)

Occurrence:
٧٠٪ of it is found in the bone in combination with Ca and PO_4.
٣٠٪ in body fluids and soft tissue.
Its deficient lead to tremor and convulsion. Mg distributed widely in food. It has the same metabolism of calcium and phosphorus.
Normal Value (٢ – ٤)mg/dl.

Water and Their Disturbance

١. H_2O is the most abundant component in body and makes about ٦٠٪ of the body weight in male and ٥٠٪ in female .
٢. ٦٦٪ of the water present inside the cells and ٣٣٪ in the intracellular Fluid .

Sources of H_2O :

١. Drinking water (٠,٥ – ٥) Liter each day .
٢. Food containing water .
٣. Metabolic reaction in body produced (٣٠٠ – ٥٠٠) mls/day .

Sources of H_2O loss :

١. Loss of H_2O vapor by expiratory air .
٢. loss of H_2O with in the urine (٠,٥ – ٤) l/day .
٣. Loss of H_2O from kidney by sweating (٥٠٠ – ٨٥٠) Mls/day .
٤. Loss of H_2O with feces .

Buffer System :

It's a mechanism against acid base disturbance , which quick mechanism to prevent change of (PH) , it controls of PH by large excreted (PCO_2) and kidney excreted nonvolatile acid .

The Body Contains a number of buffers against any change in (H^+) production , protein act as buffers , hemoglobin in erythrocyte has high capacity for binding (H^+)

In the (ECF) , bicarbonate buffer is most important in the buffer system , bicarbonate (HCO_3^-) combines with (H^+) to form carbonic acid (H_2CO_3) this buffer system in unique in that the (H_2CO_3) can Dissociate to water and CO_2 . The reaction is accelerated by an enzyme . carbonic anhydrase which is present in the erythrocyte and kidney .

Some Sources of [H]

١. Protein = - From amino acid .
٢. CO_2 formed from metabolism of tissue .
٣. Lactic acid = During exercise .
٤. Keto acid = Acetone , acetoacetic acid , B – butyric acid .
٥. Ingestion of acidifying salt (as NH_4Cl or $CaCl_2$)
٦. Renal Failure and diabetic Keto acidosis .

Some alkaline sources in body

١. Fruits = The main dietary source of alkaline .
٢. ingestion of large amount of $NaHCO_3$ or $KHCO_3$.
٣. Vomiting of gastric juice rich HCl .

Buffer solution : it is a mixture of weak acid and its salt or weak base and its salts .

The Principle of buffering system of the body :

١. **Intestinal Fluid** :

Bicarbonate = H_2CO_3 $H^+ + HCO_3^-$ ⟷ (Buffer)

٢. **Intracellular Fluid** :

a) Protein Buffer : H – Prot ⟷ $H^+ + Prot^-$

b) Dibasic phosphate Buffer : $H_2PO_4^-$ ⟷ $H^+ + HPO_4^{-2}$

٣. **Kidney** :

a) Bicarbonate Buffer .

b) Dibasic Buffer .

c) Ammonia Buffer

Glutamic acid ⟷ $2HCO_3^- + 2NH_4^+$

Disturbance of Acid – Base Balance

Disturbance of acid – base balance are divided in to acidosis and alkalosis

Acidosis → Accumulation of excesses acid or depletion of base in body .

Alkalosis → Accumulation of base or depletion of acid in the body .

It occurs if there is increasing in

[HCO_3] / PCO_2 in ECF

Plasma (PH) Stay around (٧,٤) disturbance of acid base balance which are due to respiratory abnormally are called (Respiratory Acidosis or alkalosis) .

All others are called metabolism abnormally (Metabolic Acidosis or Alkalosis)

So Acid – Base disturbance divided in to :-

١. **Respiratory disorder** :

a) Respiratory acidosis → ↑ Co_2 It is due to many disease such as :

١. Voluntary breath holding like asthma , chronic bronchitis .

٢. Paralysis of respiratory center in brain .

b) Respiratory alkalosis → ↓ Co_2

١. Hyper ventilation → Like hysteria .

٢. Fever .

٢. **Metabolic disorder** :

a) Metabolic acidosis → ↓ [HCO_3^-] Occur in many disease .

١. Diarrhea .

٢. Diabetic keto acidosis .

٣. NH_4Cl ingestion ⟷ $HCl + NH_4^+$

٤. Renal failure .

b) Metabolic alkalosis : ↑ [HCO_3^-] occurs in :

١. Vomiting .

٢. Cushing syndrome .

٣. Hypokalemia

The PH of some common body fluid

١. Gastric Juice = (١ – ٣) Acidic media
٢. Blood plasma = Slightly basic (٧,٤) .
٣. Urine = has a wide (PH) range it can be acidic , basic , neutral , due to many acidic or base substances that be removed from the body to maintained the (PH) of blood .

Carbohydrates (CHO)

Are the major food supply and energy sources they occurs in grain , starch , vegetable and ligaments .

Definition Of CHO : They are depend as the aldehyde and keton derivatives of the polyhydric alcohol the ratio of H:O is the same ratio of water .

EX: The Simple (CHO) are the following :

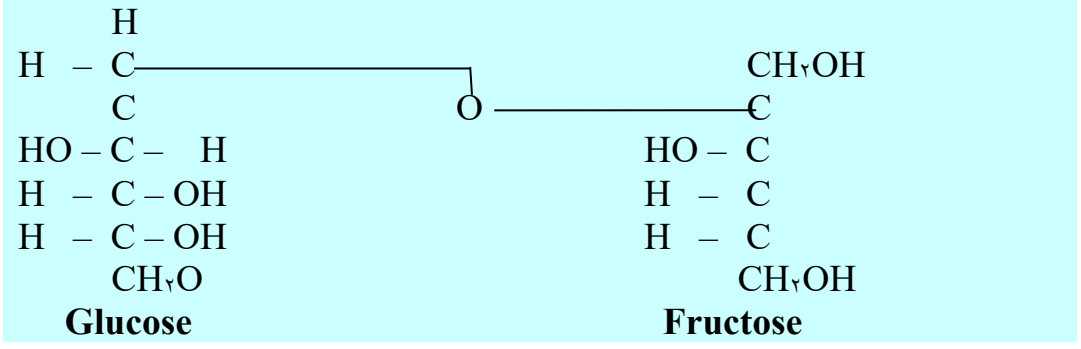
H – C = O	CH_2OH
HO – C – H	C = O
CH_2OH	CH_2OH
Glyceraldehyde	**Dihydroxy acetone**
Aldehyde Group	**Keton Group**

Classification of (CHO) :- Simple Sugar

١. Monosaccharide :- Its having the following properties :
   a) Cannot be hydrolyzed by any matter .
   b) Are called (Trioses , Tetroses , Pentoses , Hexoses) Depending on the number of carbon atom (٣,٤,٥ …….Etc) .
   c) They called (aldoses or ketosis) depending to their oxidized functional group .

٢. Disaccharide : A compounds of two monosaccharide molecules (either the same or different unit) Linked together by O – glycoside bond .
   Maltose → Glucose + Glucose .
   Lactose → Glucose + Galactose .
   Sucrose → Glucose + Fructose .

٣. Oligosaccharide : It Contains up to (١٢) unit :
   a) Monosaccharide molecules linked together by O – glycoside bond .
   b) The glycoside bond in disaccharide linked between the aldehyde group of one monosaccharide with carbon atom (No.٤) of the other monosaccharide (Lactose , Maltose) or the linkage between aldehyde group of the other monosaccharide to form disaccharide .

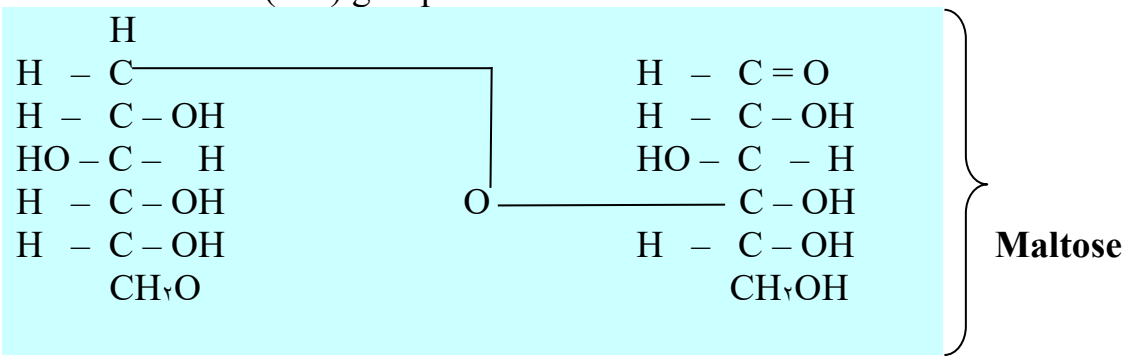


Glucose **Fructose**

Sucrose

In this case there is no reducing properties because there is no free aldehyde or keton group

c) If the aldehyde or keton group of one monosaccharide is linked to the (OH) group of the other monosaccharide as the follow :



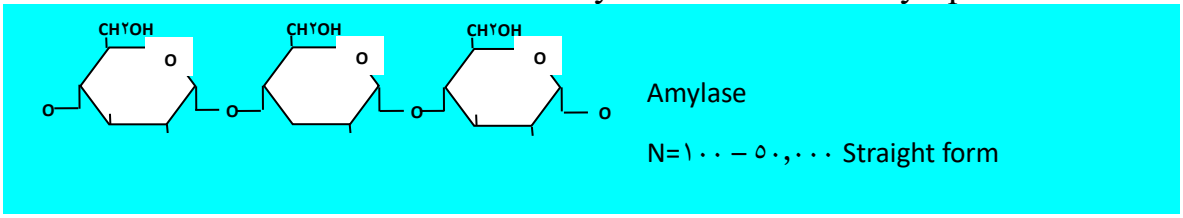
In this Case the disaccharide (Maltose) had a reducing properties because having free carbonyl group (Ald.) .

٤. Polysaccharide : Many monosaccharide molecules are linked together to form polysaccharide molecule Ex. Starch , glycogen and cellulose , a molecule of polysaccharide may contain (٢٥ – ٢٥٠٠) glucose unit linked together by (١ – ٤) linkage or (١ – ٦) linkage glycoside bond or both of them like starch .

Polysaccharide is homoploysaccharide or hetropolysaccharide , So that its polymers formed from monosaccharide D – Glucose is the most common monosaccharide found in nature , most of it stored as food for plant and animal , its less soluble in water .

Homopolysaccharide :

Starch : The storage form of glucose and the major source of (CHO) in the human diet it is a mixture of ٢٠٪ of amylase and ٨٠٪ of amylopectin .



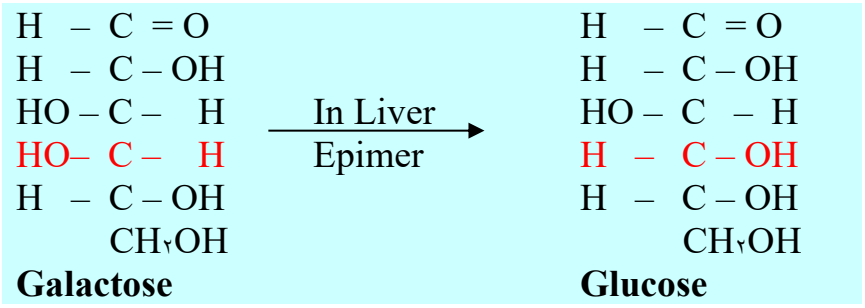
Glycogen : The reverse of CHO in animals , it has similar structure as amylopectin but it is more highly branched and more compact . Glycogen Is hydrolyzed to glucose as needed by the body during fasting or between .

Functions of CHO :

١. This primary energy source for nervous system and brain , each (١gm) of CHO release ٤Kcal. of energy .
٢. Acts as structural components of cell wall and cell membrane .
٣. Acts as metabolic intermediate . e.g. glucose – ٦ – phosphate (G٦P) .
٤. Are component of nucleotide that form DNA and RNA .

Asymmetric or chiral : Carbon atoms that have four different group bounded to it :

Ex:



Metabolism of Carbohydrates (CHO)

Digestion of carbohydrates

١. **In mouth** : When starch and glycogen are ingested by mouth , they are digested by **salivary amylase** action by break (α ١,٤) linkage between glucose residue with in chain to form α – dextrin the major product .

Starch or glycogen $\xrightarrow{\textbf{Salivary amylase}}$ dextrin + maltose

٢. **In stomach** : No metabolism of CHO can be taken place in stomach because the amylase activity inhibited by the acidic PH of stomach media .

٣. **In small intestine** :

a) **Digestion by pancreatic enzyme** : The pancreas secreted **α – amylase** in small intestine and pancreatic juice , this raised the (PH) of intestine and help to complete the metabolism of the remaining starch and glycogen . The action of pancreatic **α – amylase** like **salivary amylase** cleaves (١– ٤) linkage between glucose polymers . The product of pancreatic **α – amylase** are disaccharide maltose, tri saccharide and small oligosaccharide .

Dextrin $\xrightarrow{\text{Pancreatic α – amylase}}$ Maltose + trisaccharide

+ Oligo saccharide (١ , ٦) & (١,٤) linkagse

b) **Digestion by enzymes of intestinal cells** : The enzymes produced by intestinal epithelial cells and the digestive process by

١. **α – glycosidase** : It cleaves glucose residue from non-reducing end of oligosaccharide and cleaved α (١ – ٤) linkage of maltose resulting two glucose residue .

٢. **α – dextrinase** : it cleaves ١ , ٦ linkage releasing glucose residue from branch oligosaccharide .

٣. **Dietary disaccharide** : are also digested by enzyme in the brush border of intestinal epithelial cell .

Absorption :

Glucose, fructose and galactose are the final product generated by digestion of dietary CHO .

١. The monosaccharide are absorbed by intestinal epithelial cells , they are transported in the cell on carriers (Glucose and galactose) are absorbed activity by helping of (Na) ions .

٢. Fructose is only one that absorbed passively without energy and (Na) ions pumps .

٣. Carbohydrate that cannot be digested is polysaccharide such as cellulose .

Transport of Monosaccharide :

After absorption the monosaccharide are transported by portal vein to the liver cells and other cells depending on the needs of the body , they may converted and stored as glycogen on the liver on metabolized completely to [CO_2 +H_2O + Energy] or converted to amino acid or converted to a fat and stored in adipose tissue .

Metabolism

Is the sum of all enzymatic reaction occurring in the cells, controlled for the following:

١- To obtain chemical energy.
٢- To convert exogenous nutrients in to building of macromolecule.
٣- To assemble those building blocks in to protein, lipid, nucleic acids,…..,etc.

Metabolism in the sum of two pathways:

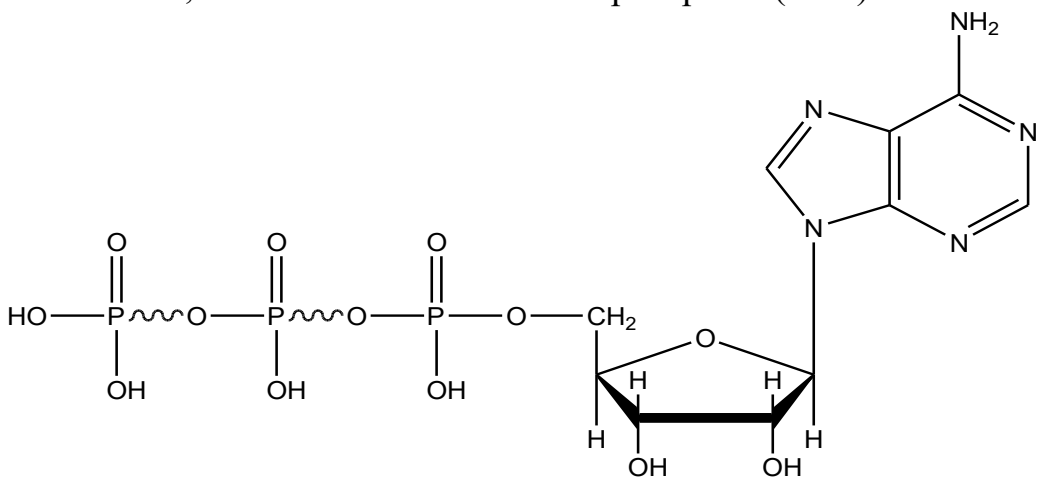
- ☒ **Catabolism:** Large and complex nutrient molecule coming from the cells are degraded to yield smaller and simpler molecule such as acetyl Co A, pyruvate,….,etc. chemical energy is released and stored in the form of energy transferring molecule ATP.
- ☒ **Anabolism:** It is the biosynthetic phase metabolism when macromolecule are built from their building units, energy is required for this synthetic work and is derived from that generated from catabolism.

Energy transferring molecule Adenosine Tri Phosphate (ATP)

Living cells require a continual input of free energy for three major purposes:

١- The performance of mechanical work in muscle contraction.
٢- The active transport of molecules and ions.
٣- The synthesis of macromolecules from simple precursors.

The free energy derived from the oxidation of foodstuffs is partly transformed in to a carrier, this carrier is adenosine tri phosphate (ATP)



Adenosine tri phosphate (ATP)

ATP is a nucleotide consisting of an adenine, ribose and phosphate unit,
it has the following properties:

١- Each phosphate bond when hydrolyzed release ٧,٣ Kcal/mol

$$ATP \underset{+7.3\ Kcal/mol}{\overset{-7.3\ Kcal/mol}{\rightleftharpoons}} ADP + PO_4 \underset{+7.3\ Kcal/mol}{\overset{-7.3\ Kcal/mol}{\rightleftharpoons}} AMP + PO_4$$

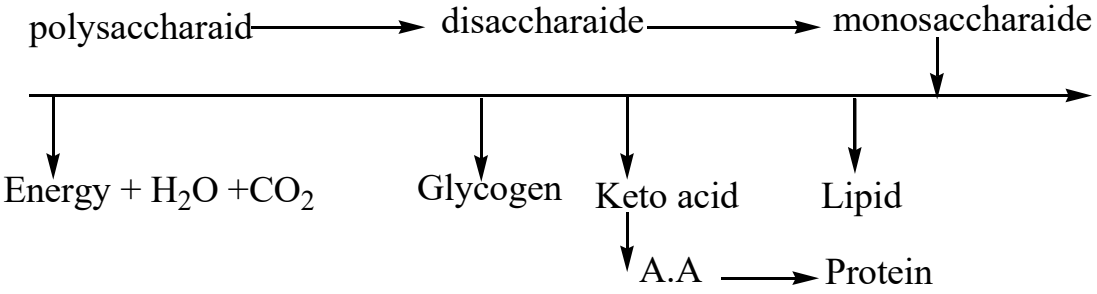
٢- Phosphate bond cleavage need an activation by a specific enzyme called kinase which depend on the need of the body.

٣- Phosphate bond cannot be hydrolyzed in aqueous medium.

Carbohydrate metabolism:

Following absorption of monosaccharaides in to portal vein, they are transported to the liver depending on the need of the body.

Monosaccharaides may be inter one of the following path ways:



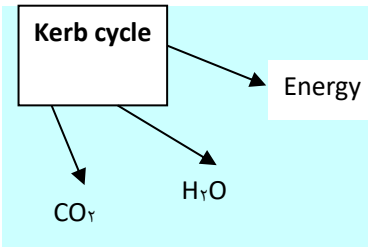
Terms Used in CHO metabolism :

The metabolism of carbohydrate may be subdivided as follows:

١. **Glycolysis** : Is the conversion of glucose to pyruvate or lactate , it is divided in to :

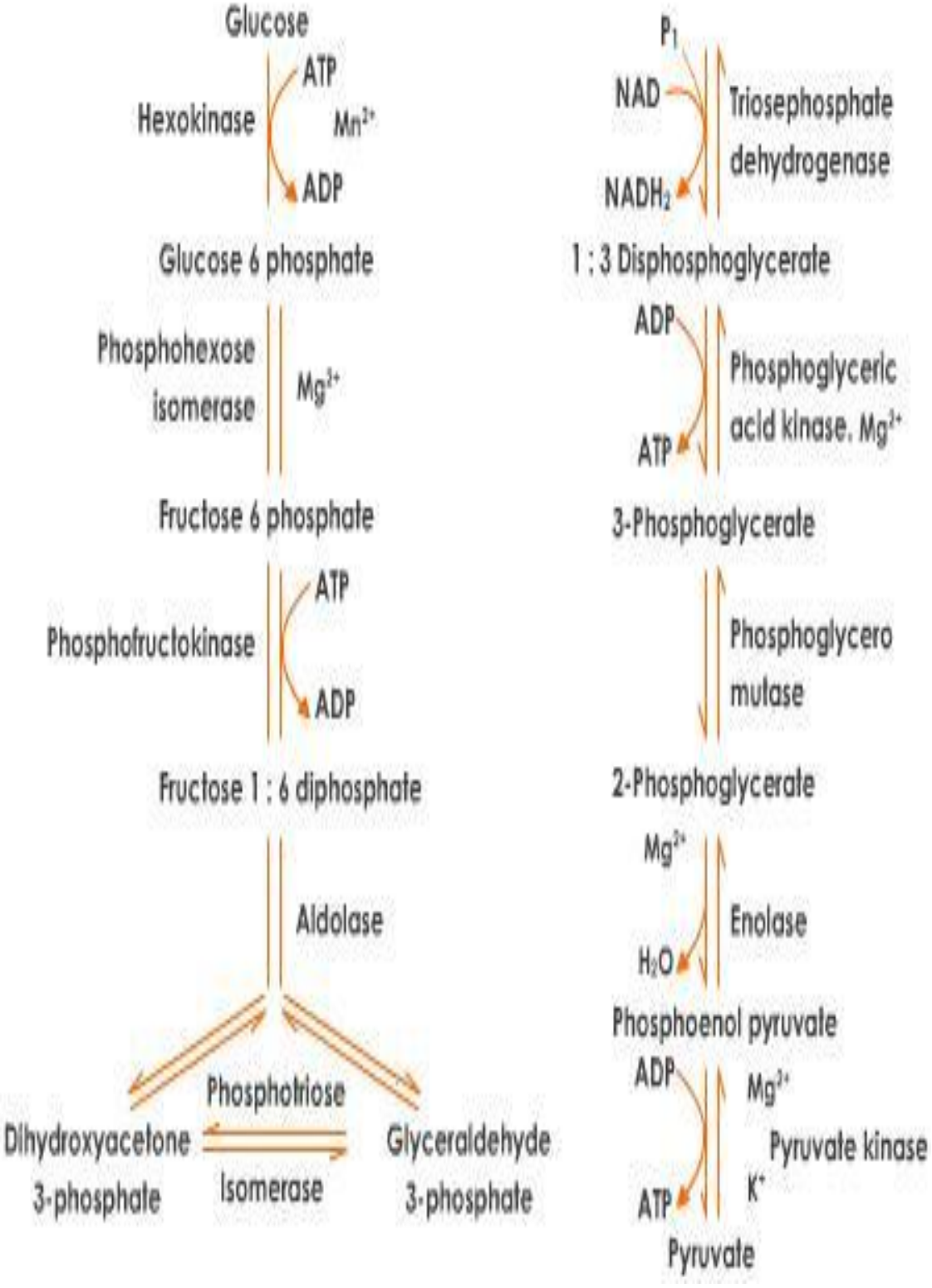
a) **Aerobic glycolysis** : Is the conversion of glucose to CO_2 and H_2O and energy .

Glucose → Pyruvate → Acetyl CoA →



Occur Under Highly Oxygenated Environment

b) **Anaerobic glycolysis**: Is the Conversion of Glucose → Pyruvate → Lactate (Hypoxic condition) The body derived ٨٠٪ of its energy from the glucose in normal condition , The glucose is an important energy source for the brain and RBC , these are called glucose dependent organ , during starvation , these organs take the energy from the lipid .


Glucose
ATP
Hexokinase
Mn^{2+}
ADP
Glucose 6 phosphate
Phosphohexose
isomerase
Mg^{2+}
Fructose 6 phosphate
ATP
Phosphofructokinase
ADP
Fructose 1 : 6 diphosphate
Aldolase
Phosphotriose
Dihydroxyacetone
3-phosphate
Isomerase
Glyceraldehyde
3-phosphate
P_i
NAD
$NADH_2$
Triosephosphate
dehydrogenase
1 : 3 Disphosphoglycerate
ADP
ATP
Phosphoglyceric
acid kinase. Mg^{2+}
3-Phosphoglycerate
Phosphoglycero
mutase
2-Phosphoglycerate
Mg^{2+}
H_2O
Enolase
Phosphoenol pyruvate
ADP
ATP
Mg^{2+}
Pyruvate kinase
K^+
Pyruvate

٢. **Glycogensis**: Is the conversion of glucose to glycogen , the process take place only in liver , glycogen is stored in the liver and muscles and other body tissue .
٣. **Glycogenolysis**: The breakdown of glycogen, glucose is the end product of this path way in the liver while pyruvate and lactate are the main product in muscles.
٤. **Gluconeogenesis**: Is the conversion of non-carbohydrate source such as amino acid or glycerol , lactate , and pyruvate to glucose during the starvation , the brain can be derived energy from Keton body which are converted to acetyl CoA , synthesis of glucose from three or four carbon atom precursors is essentially are a reversal of glycolysis .
٥. **Citric acid cycle**: the final common path way of oxidation of carbohydrate, fat and protein through which acetyl CoA is completely oxidized to CO_2 & H_2O.

Blood Glucose:

Glucose is supplied to blood from three different sources, they are:

١- From the carbohydrate of foodstuffs.
٢- By process of glycogenolysis in which glycogen is hydrolyzed to glucose.
٣- From process of gluconeogenesis in which glucose is formed from non – carbohydrate sources.

Normal value of fasting blood glucose is (٦٥ – ١١٠) mg/dl. After a meal rich in carbohydrate content the level of glucose in blood rise to (١٤٠ – ١٥٠) mg/dl.
Fasting Blood Sugar (**FBS**): (٦٥ – ١١٠) mg/dl
Post Prandial Blood Sugar (**PPBS**): less than ١٤٠ mg/dl.
Blood glucose level affected by many factors:

a. Liver tissues.
b. Hormonal factor.
c. Tissues, which are far from liver, like pancreas, kidney & brain.

Regulation of blood glucose level:

In the fasting state, the level of blood glucose is maintained by drawing upon the glycogen stores of the liver, and a slight amount may also be derived from the kidney.
Both of these organs contain enzyme (glucose – ٦ – phosphatase) which is necessary for the conversion of glu – ٦ – p to glucose.

Glycogenolysis:

$$\text{Glycogen} \longrightarrow \text{glu-1-p} \longrightarrow \text{glu-6-p} \xrightarrow{\text{Glucose -6- phosphatase}} \text{Glucose}$$

As blood glucose level increases usually by absorption of carbohydrate from the intestine, glycogenolysis is stopped and replaced by glycogenesis, where blood glucose is converted in to glycogen in liver and muscle.

Number of hormones is important in the regulation of blood glucose concentration:

١- **Insulin**: It produced by β cells of Langerhans is lets in pancreas gland , it decrease blood glucose level by :
   a) Promote glycogenesis .
   b) Promote lipogensis (formation of fat from CHO)
   c) Increase permeability of cell to glucose

٢- **Growth Hormone (GH) and Adrenocortical trophic hormone (ACTH)**: They are secreted by anterior pituitary gland , they are antigens to insulin function , they are increased blood glucose level by decrease of permeability of cell to glucose and decrease glycolysis .

٣- **Hydrocortisone**: It secreted by adrenal cortex it increased glucose level by increasing gluconeogenesis .

٤- **Epinephrine**: It secreted from adrenal medulla , it is increasing blood glucose level by increasing glycogenolysis .

٥- **Glucagon**: It secreted by the α – cell of the islet of Langerhans of pancreas , it increased glucose level by glycogenolysis .

٦- **Thyroxin**: It secreted by the thyroid gland it is increased blood glucose level by increase glycogenolysis and increased the rate of absorption of glucose from the intestine .

Disorder of glucose metabolism:

Hyperglycemia: it is increasing in glucose level above the normal value :

- In the hyperglycemia, the fasting glucose level is (١١٠mg/١٠٠ml), this level should be taken from (٦ – ١٢ hr.) .
- In random glucose level also hyperglycemia is > ١٤٠mg/١٠٠ml .

Causes of Hyperglycemia:

١. Relative deficiency of insulin .
٢. Absolute deficiency of insulin .
٣. Defect on the action of insulin .
٤. increase in hormones that increase blood glucose level .

Glucose level increased:

١- diabetes.
٢- Hyperthyroidism.
٣- Hyperpituitarism.
٤- Nephritis.
٥- Infections.
٦- Pregnancy.

Hypoglycemia: When the level of blood glucose to decrease to very low concentration usually ٤٠mg/١٠٠ml or below .

Glucose level decreased:

١- Hyperinsulinism.
٢- Hypothyroidism.
٣- Hypopituitarism.
٤- Hepatic disease.
٥- Addison disease.
٦- Starvation.

Glycosuria: A condition when glucose appear in urine when blood glucose concentration exceeds the RTH for glucose (١٨٠ mg/dl).

Causes of glycosuria:

١- Diabetes mellitus.
٢- Renal glycosuria (low RTH) occur in the absence of any pathological condition.
٣- Alimentary glycosuria occur after a meal rich in carbohydrate content.

Renal threshold (RTH)

The kidney has the ability to balance the quantity of glucose in blood, as it help to return the filtered amount of glucose to blood again (phosphorylation of Glu to Glu-٦-P).

When the level of glucose in blood passes (١٨٠ mg/dl) the kidney losses its ability to return the filtered amount to blood again and some glucose is excreted in urine, the presence of glucose in urine is known as glycosuria. The blood glucose level at which glycosuria occurs is usually ١٨٠ mg/dl. This is known as RTH.

RTH: defined as the concentration of glucose in venous blood at which level it appears in urine.

Glucose Tolerance Test (GTT)

If glycosuria occurs and the physician suspects diabetes he may request a glucose tolerance test.

The technician gives glucose to the patient and measure blood glucose levels at specific intervals, the diabetic takes longer to remove the sugar from the blood than a normal individual.

GTT: It means the ability of human to metabolize the carbohydrate.

Procedure:

١- The patient fasts overnight for at least ١٠ hr.
٢- A venous sample is withdrawn for plasma glucose estimation and urine specimen collected.
٣- The equivalent of ٧٥ gm. Of anhydrous glucose (for children ١,٧٥g/kg B.wt.) is given dissolved in ٣٠٠ml of water.
٤- Further blood and urine samples are taken at two hours after the dose.

The plasma glucose concentration is measured and the urine samples tested for glucose.

Interpretation

Venous plasma glucose mmol/l (mg/dl)

	Fasting	٢ hours
Diabetic unlikely	٥,٥ (١٠٠) or less	٧,٨ (١٤٠) or less
Impaired glucose tolerance	٥,٥ to ٧,٨	٧,٨ to ١١,١
Diabetic	٧,٨ (١٤٠) or more	١١,١ (٢٠٠) or more

Diabetic Ketoacidosis (DKA) or Ketosis:

Defined as accumulation of keton body in blood Aceto acetic acid, B – Hydroxy butyric acid and acetone.

In insulin deficiency the intracellular glucose deficiency is due to impaired entry of high extracellular glucose in to the cell, therefore fat stores will became the main energy source, triglyceride is converted to free fatty acids (FFA) and glycerol by lipolysis.

Most tissues other than brain use FFA as an energy source after conversion to acetyl CoA, acetyl CoA converted to aceto acetic acid, which is reduced to β-hydroxy butyric acid or decarboxylated to acetone.

The H produced with ketones buffered by plasma bicarbonate. In severe condition more H may be produced than can be buffered with bicarbonate, so plasma HCO_3 fall down and a state of acidosis appear.

When the concentration of ketones exceeds RTH they will appear in urine this condition called **Ketonuria**.

There are two cases associated with Ketosis:

١. **Diabetes Millets**: In this case there is an increase of blood glucose but the body cannot utilize the glucose for the production of energy , the body utilize fat , For production of energy , because of deficiency of insulin as resulting of using Fat , Keton body accumulation in blood .

٢. **Starvation**: In this case Keton bodies also accumulation in blood because there is no enough (CHO) and glucose in food , so body uses fats that are stored in the body for production energy . Ketosis usually associated with acidosis because Keton bodies are acid , this occur in the advanced case of diabetes .

Diabetes Mellitus

It is a metabolic disorder In carbohydrate oxidation due to reduce in insulin function , this state diagnosis by excessive Urine secretion , elevated glucose in plasma and excessive thirst.

Diabetes is characterized by an elevated level of glucose in the blood and in the urine, glucose is excreted in the urine when the blood glucose levels exceeds the reabsorptive capacity of the renal tubules.

It's a disease caused by absolute or relative deficiency of insulin. This disease is of many types:

١- **Primary diabetes mellitus**:

These patients are those in whom there is no obvious cause for the development of diabetes.

a. Insulin dependent diabetes mellitus (IDDM)

This condition is so named because insulin is required to normalize blood glucose levels, and prevent progression of the metabolic disorder to keto acidosis. It has been called **Juvenile onset diabetes** in the past because most cases developing before the age of ٤٥ years.

b. Non-insulin dependent diabetes mellitus (NIDDM)

It is also called **Maturity onset diabetes**. It is the commonest form of diabetes. Most cases occur after the age of ٤٥ years, it varies widely different communities but is usually common in obese, physically inactive populations and uncommon in lean.

Insulin is not indicated for initial control of this type of diabetes. Patient with NIDDM do not become ketoacidosis.

٢- **Secondary diabetes mellitus**:

This small group includes patient in whom there is a clear cut factor associated with the development of diabetes depending on the severity of insulin deficiency or antagonism. The patient may require insulin, although most patient are not ketoses prone.

The condition being precipitated by the causative factor.

a. **Pancreatic disease**: like pancreatitis, hemochromatosis, fibrocystic,….etc.
b. **Diabetes and endocrine disease**: excessive production of insulin antagonistic hormone (growth hormone, glucocorticoid, glucagon, catecholamine's) occurs in acromegaly, Cushing syndrome, glucagonoma, is responsible for the high incidence of diabetes in these conditions.
c. **Stress diabetes**: Hyperglycemia seen in predisposed individuals subject to a variety of stresses (metabolic or physiological) is in part due to increased secretion of insulin antagonistic hormones and usually resolves when the stress is withdrawn. Example of stresses myocardial infarction, gangrene & severe infection.
d. **Gestational diabetes**: pregnancy is a diabetogenic stress. Since hormones which are secreted is increased amounts in pregnancy (Estrogen, progesterone, corticosteroid,….etc.) may antagonize the action of insulin and promote hyperglycemia, most patients return to pre pregnant state after delivery.
e. **Drug associated diabetes**: Thiazide diuretics and phenytoin may impair insulin secretion, and estrogen induces a state of insulin resistance.

Genetic disturbance of CHO metabolism :

١. **Galactose intolerance**: It is a condition in which an increase in galactose and decrease in glucose . The condition become appeared after milk has been added to the diet of infant , this due to the deficiency of enzyme that convert

galactose to glucose defect in (galactose – ١ – puridyl transferrase and galactose Kinse) .

Treatment: Galactose should be elimated from Food .

Complication: Mental disturbance and Cataract .

٢. **Fructose intolerance**: The Symptoms of this disease appear in infant when they begin to drink sucrose and fruit juice , so glucose decrease in blood leading to nausea and vomiting with enlargement of liver , the decrease in glucose may be due to inhibition of glycogenlysis and also the formation of glucose from (F – ١ – P) which accumulate as result of deficiency of the enzyme which convert (F – ١ – P) to ٣ – Carbon sugar . It is lack of fructose Kinase and fructose ١,٦ biphosphate result in paired hepatic glycogensis

٣. **Glycogen Storage Disease**: A condition in Which there is an increase in glycogen and decrease in glucose in blood this due to the deficiency of the enzyme responsible for the glycogenolysis , so glycogen accumulated in the (Liver , Kidney , heart and Muscle) .

Treatment: Take frequent meals to maintain plasma glucose level and prevent accumulation of glycogen

Proteins

Proteins it is organic compounds contained C,H,O and N may be contain sulfur or iodine. The average nitrogen content is about ١٦٪ , its most important for life because its present in all living cells such as muscle, bone, blood, tissue, tendon, cartilage, …..etc. Proteins has high molecular weight and composed of high number of simple molecular named α – Amino acid which is linked together by peptide bond. Proteins can be hydrolyzed by acids , alkaline and enzymes to form (α – Amino acids).

α – Amino acid (α – A. A) : its organic acid has (COOH) group which donate proton (Proton donating) and the (NH_2) which accept proton (Proton accepting) in the Alpha position .

proteine play an important role in all biological processes, their functions are:

١- **Enzymatic catalysis**: All biological systems are catalyzed by specific macromolecules called enzymes, and all known enzymes are proteins, they usually enhance reaction rate by at least a million fold.

٢- **Transport and storage**: Many small molecules and ions are transported by specific proteins for example Hemoglobin transport oxygen in erythrocytes, iron is carried in the plasma of blood by transferrin.

٣- **Coordinated motion**: Proteins are the major component of muscles, the sliding motion of two kinds of protein filaments accomplishes muscle contraction.

٤- **Mechanical support**: The high tensile strength of skin and bone is due to the presence of collagen, a fibrous protein.

٥- **Generation and transmission of nerve impulses**: Receptor proteins mediate the response of nerve cells to specific stimuli.

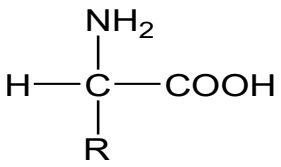
٦- **Immune protection**: Anti bodies are highly specific proteins that recognize and combine with viruses, bacteria and cells from other organisms.

٧- **Control of growth and differentiation**: Controlled sequential expressions of genetic information is essential for the orderly growth and differentiation of cells.

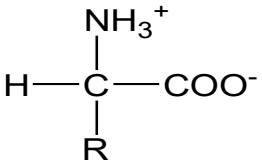
Proteins are built from amino acids

Amino acids (A.A) are the basic structural units of proteins, an A.A consist of an amino group, a carboxyl group, a hydrogen atom, and R group bonded to a carbon atom, which called **α-carbon**.

An R group is referred to as a side chain, A.A in solution at neutral pH are predominantly (**Dipolar ions**) or (**Zwitter ion**) rather than unionized molecules.



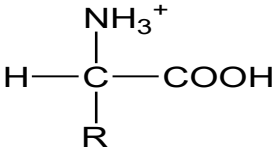
Unionized from of A.A



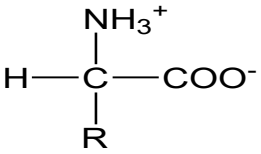
Dipolar ion (Zwitter ion) of A.A

(Note: R is a side chain)

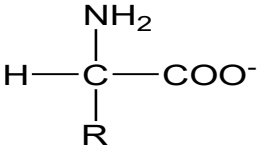
In the dipolar from of A.A the amino group is protonated (-NH٣) and the carboxyl group is dissociated (-COO) the ionization state of an A.A varies with pH.



at pH= 1
acidic



at neutral pH



at pH= 11
basic

"Ionization state of A.A as a function of pH"

With a single exception (Glycine) each A.A has at least one asymmetric carbon atom and hence is optically active, that is it can rotate the plane of polarized light, two mirror image forms are called the L- isomer and the D- isomer, only L- isomer are constituent of proteins.

Twenty kind of side chain varying in size, shape, hydrogen bonding, capacity and chemical reactivity are commonly found in proteins.

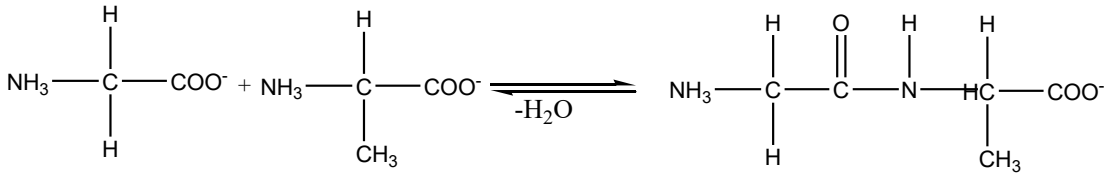
Classification of amino acids:

No.	Amino acids	٣-letter	١-letter	Side-chain class	Side-chain polarity	Side-chain charge pH
١	Alanine	Ala	A	aliphatic	nonpolar	neutral
٢	Arginine	Arg	R	basic	basic polar	positive
٣	Asparagine	Asn	N	acid/amide	polar	neutral
٤	Aspartic acid	Asp	D	acid/amide	acidic polar	negative
٥	Cysteine	Cys	C	sulfur-containing	nonpolar	neutral
٦	Glutamic acid	Glu	E	acid/amide	acidic polar	negative

٧	Glutamine	Gln	Q	acid/amide	polar	neutral
٨	Glycine	Gly	G	aliphatic	nonpolar	neutral
٩	Histidine	His	H	basic	basic polar	positive(١٠٪) neutral(٩٠٪)
١٠	Isoleucine	Ile	I	aliphatic	nonpolar	neutral
١١	Leucine	Leu	L	aliphatic	nonpolar	neutral
١٢	Lysine	Lys	K	basic	basic polar	positive
١٣	Methionine	Met	M	sulfur-containing	nonpolar	neutral
١٤	Phenylalanine	Phe	F	aromatic	nonpolar	neutral
١٥	Proline	Pro	P	cyclic	nonpolar	neutral
١٦	Serine	Ser	S	hydroxyl-containing	polar	neutral
١٧	Threonine	Thr	T	hydroxyl-containing	polar	neutral
١٨	Tryptophan	Trp	W	aromatic	nonpolar	neutral
١٩	Tyrosine	Tyr	Y	aromatic	polar	neutral
٢٠	Valine	Val	V	aliphatic	nonpolar	neutral

Amino acids are linked by peptide bond to form poly peptide chain:
In proteins, the α-carboxyl group of one A.A is joined to the α-amino group of another A.A by peptide bond (also called amide bond) as define: covalent bond linkages amino group with carboxyl group has the properties:

١- Polar properties in structure.
٢- Partial double bond character.



١- **Dipeptide** : Are two amino acid links together by peptide bond
٢- **Tri peptide** : Are three amino acid linked together by peptide bond .
٣- **Residue** : Residue main any amino acid with in poly peptide chain .
٤- **Essential A.As** : Which cant by synthesized in body are required in diet . Ex :- Isoleucine , Leucine , Valine , threonine , Methionine , Phenyl alanine , tryptophan , Arginine , Histidine .
٥- **Non – Essential Amino acid** : They can be synthesized in human body . Ex : Glutamine , Glutamate , praline , Aspargine , Alanine , Glycin , serine , tyrosin , cystine .
٦- **Complete Protein** : Is the protein Contains essential and non-essential (A.A) ex : like animal protein .
٧- **Incomplete Protein** : Is the protein missing one or more of the Essential A.A (ex) Plant protein , Vegetable .

Classification of protein :

١- **Simple proteins**: These contain only L-α-amino acid or there derivatives and include the following groups: albumin, globulin, prolamines, albuminiod, histones & protamines.
٢- **Conjugated protein**: Those which contain some non-protein substance (the prosthetic group) linked by forces other than ionic attraction.
   a- Nucleoproteins: Compounds of one or more of several molecules of proteins with nucleic acids.
   b- Glycoproteins: Compounds with carbohydrate, ex. Mucin.
   c- Phospho proteins: Compounds with a phosphorous-containing radical other than phospholipid & N.As., ex. Casein.
   d- Chromo proteins: Compounds with a chromophoric group in conjugation ex. Hemoglobin.
   e- Lipoproteins: Conjugated to neutral fats (triglyceride) or phospholipid & cholesterol.
   f- Metallo proteins: Binding a metal as copper or ion.

Protein structures

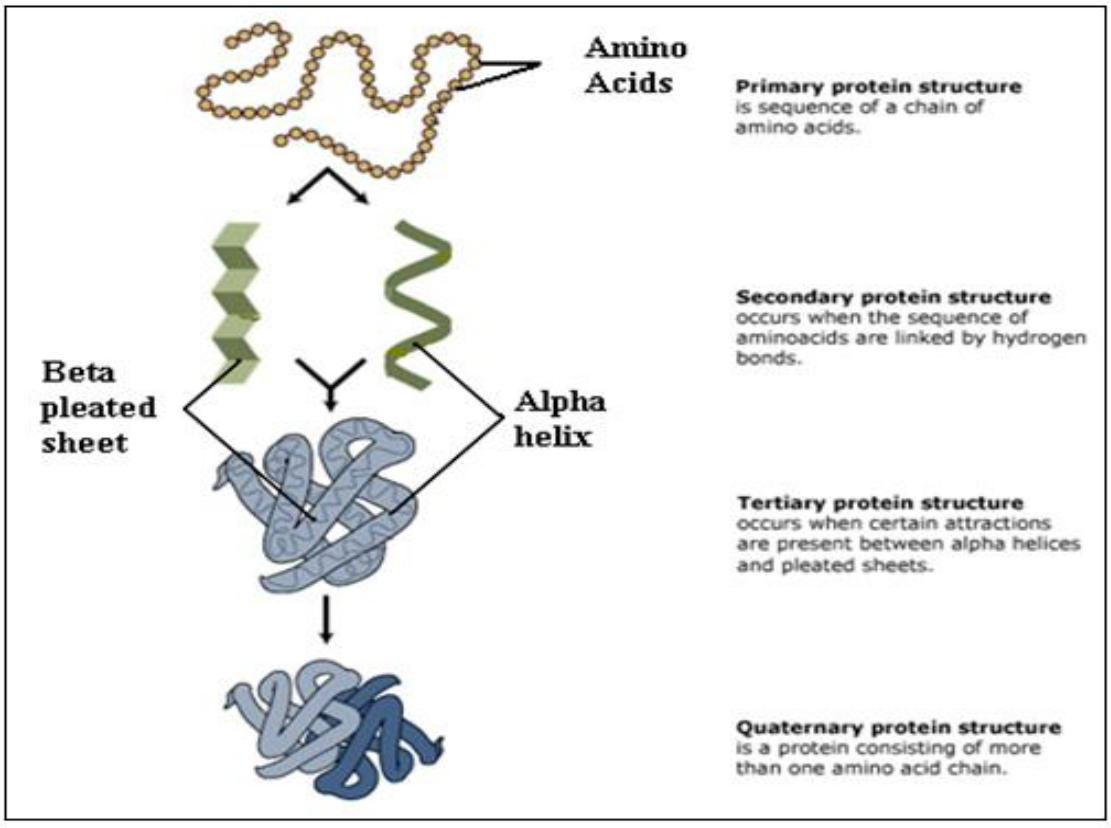
There are four various levels of protein structures:

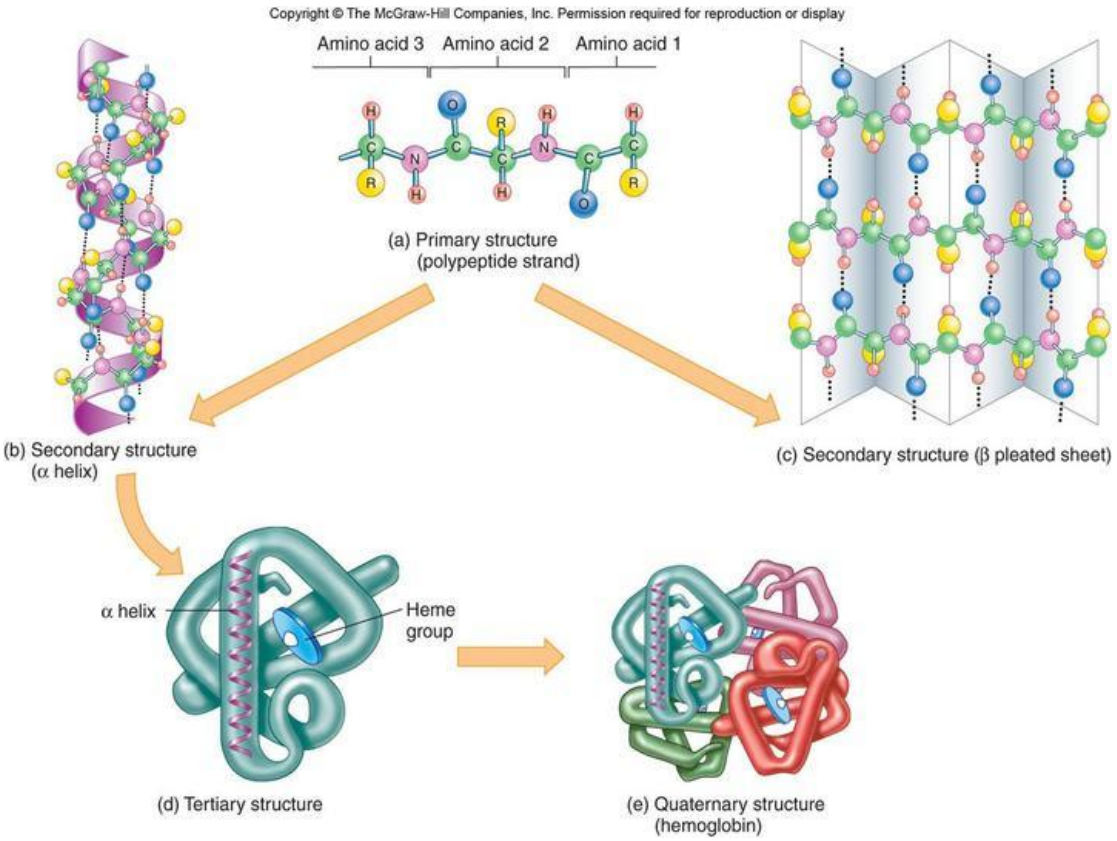
١- **Primary structure**: It refers to the sequence of individual A.As in the poly peptide chain or chains that comprise the proteins and the location of disulphide bonds if they are present.

٢- **Secondary structure**: It have two aspects, the first is the way in which the protein chain is folded and bent that is (α-helix or β-pleated sheet); the second is the nature of the linkages and bond which stabilize this structure.

٣- **Tertiary structure**: The spatial position of all the atoms in three dimensions, including those of the side chains. It concern with stabilization of protein by bonds in addition to H-bond such as ionic, non-polar (hydrophobic), covalent and Vander walls linkage.

٤- **Quaternary structure**: The arrangement of poly peptide subunits to form superstructures.

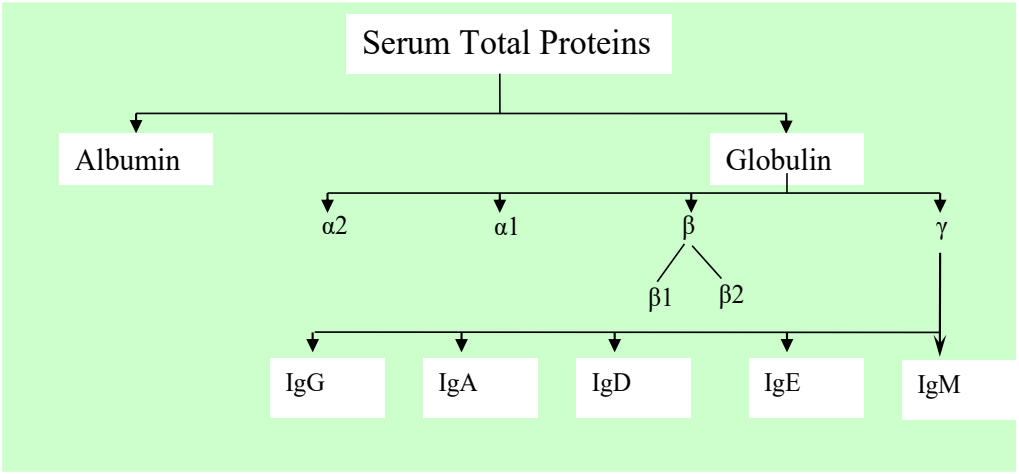




Denaturation: Loss in secondary, tertiary and quaternary (if present) structures of protein on heating. It results in loss of biological activity of the proteins.

plasma proteins:

The total protein of the plasma is about (٦,٢ – ٨,٢) gm/dl, thus the plasma protein comprise the major part of the solids of the plasma. Plasma protein are classified to albumin , globulin and fibrinogen. Serum protein differ from plasma protein serum does not contains fibrinogen as in the following diagram .

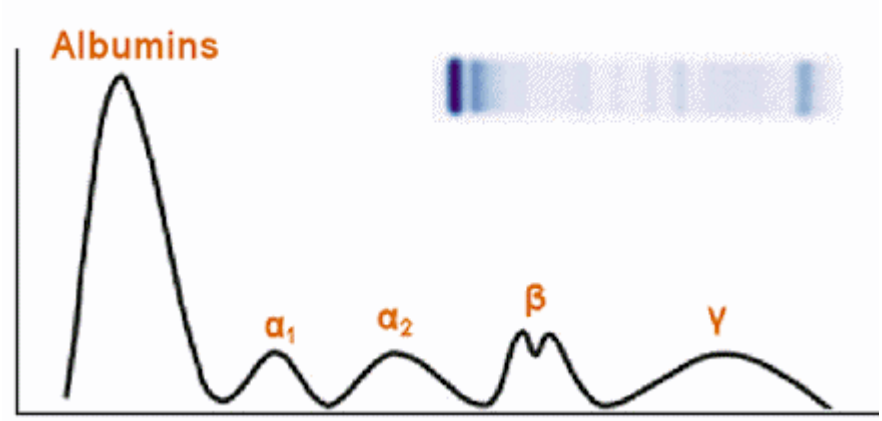


Types of plasma proteins:

The three major fractions of plasma proteins are known as **Albumin, globulin** and **Fibrinogen.** On a finer resolution by electrophoresis, these fractions are separated as follows:

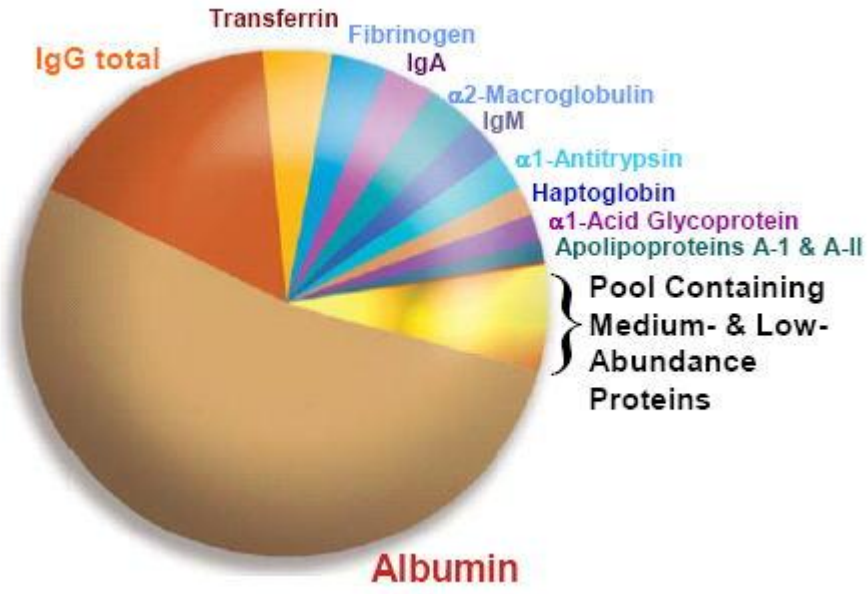
- **Albumin**: ٥٥,٢٪
- **α١-Globulin**:٥,٣٪ (α١-Antitrypsin, TBG, Transcortin, etc)
- **α٢-Globulin**:٨,٦٪(Haptoglobulin, ceruloplasmin, α٢-macroglobulin, etc)
- **β-Globulin**:١٣,٤٪ (β١-transferin, β-lipoprotein, etc)
- **γ-Globulin**:١١,٠٪ (Antibodies, etc)
- **Fibrinogen**:٦,٥٪

Normal electrophoretic graph and Blood Proteins



Albumin:

This is the most abundant class of plasma proteins (٢,٨ to ٤,٥ gm/١٠٠ml) with highest electrophoretic mobility. It is soluble in water ad is precipitated by fully saturated ammonium sulphate. Albumin is synthesized in liver and consists of a single polypeptide chain of ٦١٠ amino acids having a molecular weight of ٦٩,٠٠٠. It is rich in some essential amino acids such as lysine, leucine, valine, phenylalanine, threonine, arginine and histidine. The acidic amino acids like aspartic acid and glutamic acid are also concentrated in albumin. The presence of these residues makes the molecule highly charged with positive and negative charge. Besides having a nutritive role, albumin acts as a transport carrier for various biomolecules such s fatty acids, trace elements and drugs.. Another important role of albumin is in the maintenance of osmotic pressure and fluid distribution between blood and tissues.



Globoulin:

By electrophoresis plasma globulins are separated into α١, α٢,β and γ-globulins are synthesized in liver, whereas γ-globulins are formed in the cells of reticula-endothelial system. The average normal serum globulin (total) concentration is ٢,٥ gm / ١٠٠ ml (Howe method) or ٣,٥٣ gm/١٠٠ ml by electrophoresis.

α١-Globulins:

This fraction includes several complex proteins containing carbohydrates and lipids. These are, orosomucoid, α١-glycoprotein and α-lipoproteins. The normal serum level of α١-globulin is ٠,٤٢ gm/١٠٠ ml.

Orosomucoid is rich in carbohydrates. It is water-soluble, heat stable and has a molecular weight of ٤٤,٠٠٠. It serves to transport hexosamine complexes to tissues.

Lipoproteins are soluble complexes which contain non-covalently bound lipid. These proteins act mainly as transport carrier to different types of lipids in the body.

α٢-Globulins:

This fraction also contains complex proteins such as α٢-glycoproteins, plasminogen, prothrombin, haptoglobulin, ceruloplasmin (transports Cu) and α٢-macroglobulin. The normal serum value of this fraction is ٠,٦٧ gm/١٠٠ml.

Plasminogen and prothrombin are in the inactive precursors of plasmin and thrombin respectively. Both these proteins play an important role in blood clotting.

Haptoglobulins are also glycoproteins having a molecular weight of ٨٥,٠٠٠. These are synthesized in liver and can bind with any free hemoglobin that may arise in plasma due to lysis of erythrocytes and thus prevent excretion of Hb and iron associated with it.

Ceruloplasmin is a glycoprotein synthesized in liver and is an important component of copper metabolism in the body. Nearly ٩٥٪ of plasma copper is bound to this protein.

β-Globulins:
This fraction of plasma proteins contain these different β-lipoproteins which are very rich in lipid content. It also contains transferrin (siderophilin) which transports non-heme iron in plasma. The normal serum value of β-globulins is ٠,٩١ gm/١٠٠ml.
Transferrin is an iron transport protein. In plasma it can be saturated even up to ٣٣٪ with iron. It has a low content of carbohydrate.

γ-Globulins:
These are also called as Immunoglobulins and possess antibody activity. On the basis of their electrophoretic mobility they are classified as IgG, IgA and IgM.

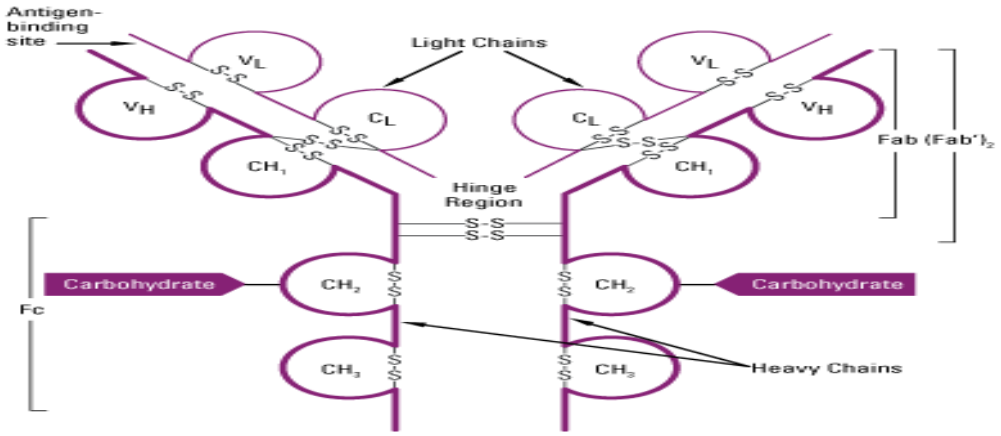
Fibrinogen:
It is a fibrous protein with a molecular weight of ٣٤٠,٠٠٠. It has ٦ polypeptide chains which are held together by disulphide linkages. Fibrinogen plays an important role in clothing of blood where it is converted to fibrin by thrombin.
In addition to the above mentioned proteins, the plasma contains a number of enzymes such as *acid phosphatase* and *alkaline phosphatase*which have great diagnostic value.

Origin of plasma proteins

Most plasma proteins are synthesis in the liver except γ – globulin which are synthesis in reticule endothelial system (Spleen , Bone morrow) .

Immunoglobulin's:
It is the γ-globulin fraction of plasma proteins, it has antibody activity.

Structure:
The basic immunoglobulin is Y – shaped molecule depicted as follows:



Function of plasma proteins:

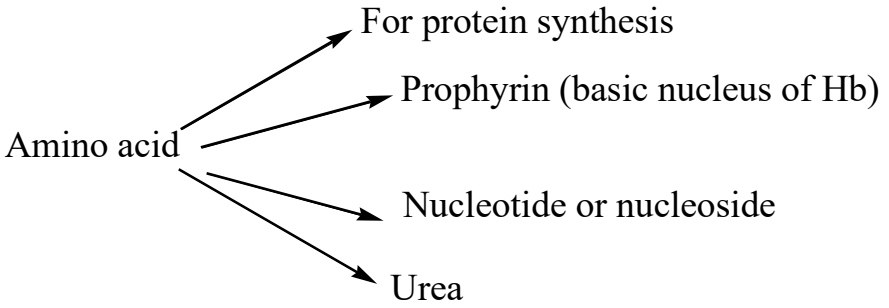
١. **Protein Nutrition:** Plasma proteins act as a source of protein for the tissues, whenever the need arises.
٢. **Osmotic Pressure and water balance:** Plasma proteins exert an osmotic pressure of about ٢٥ mm of Hg and therefore play an important role in maintaining a proper water balance between the tissues and blood. Plasma albumin is mainly responsible for this function due to its low molecular weight and quantitative dominance over other proteins. During the condition of protein loss from the body as occurs in kidney diseases, excessive amount of water moves to the tissues producing edema.
٣. **Buffering action:** Plasma proteins help in maintaining the pH of the body by acting as ampholytes. At normal blood pH they act as acids and accept captions.
٤. **Transport of Lipids:** One of the most important functions of plasma proteins us to transport lipids and lipid soluble substances in the body. Fatty acids and bilirubin are transported mainly by albumin, whereas cholesterol and phospholipids are carried by the lipoproteins present in β-globulins also transport fat soluble vitamins (A, D, K and E)
٥. **Transport of other substances:** In addition to lipids, plasma proteins also transport several metals and other substances α٢-Globulins transport copper (Ceruloplasmin), bound hemoglobin (haptoglobin) and thyroxine (glycoprotein) and non-heme iron is transported by transferrin present in β-globulin fraction. Calcium, Magnesium, some drugs and dyes and several cations and anions are transported by plasma albumin.
٦. **Blood Coagulation:** Prothrombin present in α٢-globulin fraction and fibrinogen, participate in the blood clotting process as follows.
Prothrombin -> Thrombin (Presence – Thromboplastin)
Fibrinogen -> Fibrin (Clot) (Presence –Thrombin)

Digestion and absorption of Protein :

Protein is degradation start in the stomach under the action of the enzyme pepsin PH (٣ – ٤) . In the small intestine (Jejunum , duodenum) pepsin is inactive at (PH ٦,٥) , but protein digestions continue on the actions of the enzyme from pancreatic juice , trypsin , chymotrypsin and elastase all are named end peptidase . End peptidase means an enzyme that cleaves the interior peptide .The carboxyl peptidase of the pancreas and the amino peptidase , that hydrolysis , the amino acid at the carboxy and amino end of poly peptidase . Some free amino acid are liberated by this digestion in the intestinal lumen others are di , and tri peptidase which hydrolyzed on the brush border by the enzyme , lipopeptidase another protein of di and tri peptidase are activity absorbed and hydrolyzed with in the mucosal cells by cytoplasm peptidase to free (A.A) .

Absorption of amino acids

An active process (mean energy expenditure) absorbs them by portal vein, they reach to the liver where they are utilized for the following pathways:



Metabolism of protein

١. **Decarboxylation :** they caused formation of biogenic amine which is very important and very dangerous to the brain .

$$R-CH(NH_2)-COOH \xrightarrow{-CO_2} RCH_2NH_2 + CO_2$$

٢. **Deamination :** Oxidation of amino acid to form α – Keto acid

$$R-CH(NH_2)-COOH \xrightarrow{[O]\ oxidation} R-C(=O)-COOH$$

NH_3 is very toxic comps. , So it is converted to less toxic Comps. That is urea .

NH_3 → Glutamine → Urea

Urea is formed from (NH_3) in the liver according to the above equation and urea excreted through kidney with urine

N.V of urea = ٢٠ – ٤٠ mg/١٠٠ml Urine serum .

N,V of NH_3 = ١٠mg/ ١٠٠ml Urine

Urea is not toxic , very soluble and excreted by kidney .

٣. **Transamination :** Formed by :

١. Amination .

٢. Deamination .

$$R-CH(NH_2)-COOH + R-C(=O)-COOH \rightarrow R-C(=O)-COOH + R-CH(NH_2)-COOH$$

Keto acid

α – A.A

References

١- AL-Mothafr sami
(Biochemistry) ١stEdition
Baghdad University, ١٩٨٤
٢-David T Plummer
(An introduction to biochemistry)٢nd Edition
McGR-Hill Book company (UK) Limited, ١٩٧٨