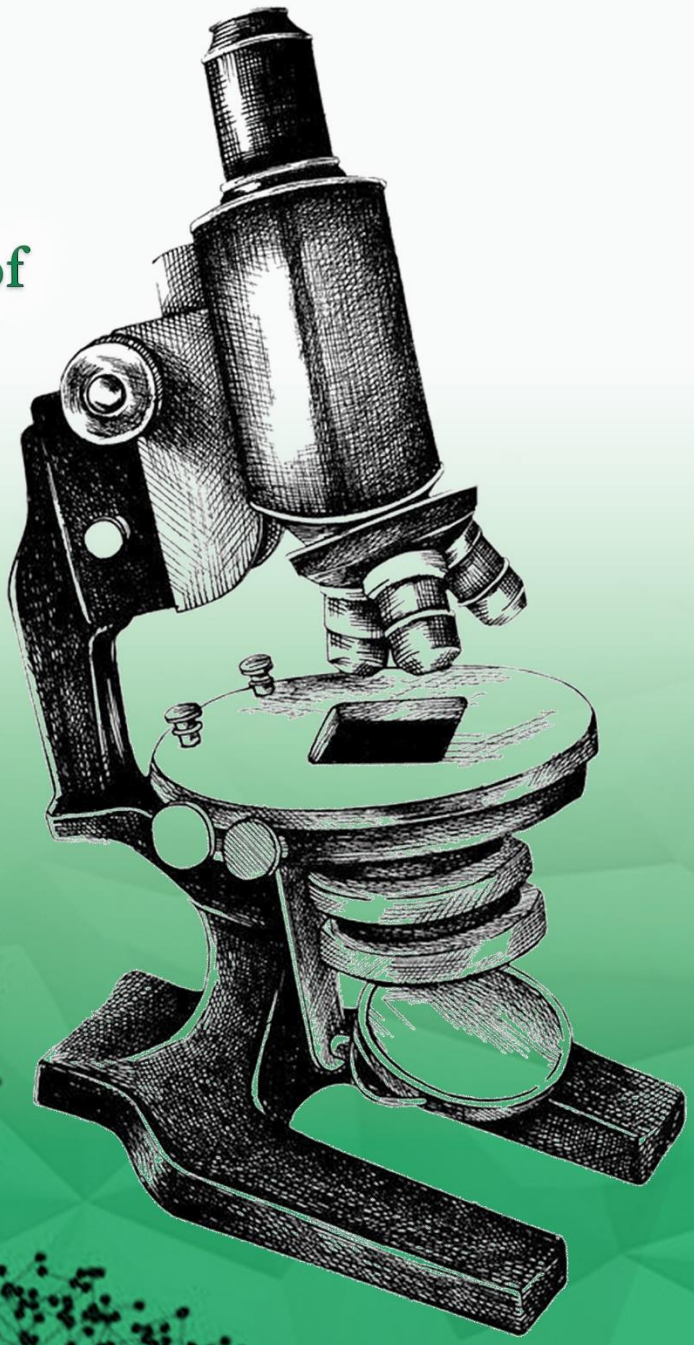
MASTERING BIOCHEMISTRY
A Comprehensive Guide to MCQs, Essays, and OSPEs

Uva Wellassa University

- Cell biochemistry
- Biomolecules
- Functional aspects of protein



Published by,
Department of Biochemistry
Faculty of Medicine
Uva Wellassa University

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- **Cell biochemistry**
- **Biomolecules**
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Authored by:

Department of Biochemistry

Faculty of Medicine

Uva Wellassa University

Mastering Biochemistry

A Comprehensive Guide to MCQs, Essays & OSPEs

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Message from the Vice Chancellor

Dear Students,

It is with great pleasure that I extend my heartfelt congratulations and sincere appreciation to the Faculty of Medicine, Uva Wellassa University of Sri Lanka including Senior Professor Muditha Vidanapathirana, the Founder Dean of the Faculty of Medicine, for this remarkable initiative of publishing “Mastering Biochemistry: A Comprehensive Guide to MCQs, Essays & OSPEs”.

This book is an invaluable resource, offering immense benefits not only to MBBS undergraduates of Uva Wellassa University but also to medical students across the country.

I encourage you to take full advantage of the excellent resources developed by the Faculty of Medicine to enhance your academic journey. Resources such as this guide can make your studies more effective, efficient, and rewarding.

Wishing you all the very best in your academic and professional pursuits.

Senior Professor Kolitha B. Wijesekara
B.Sc. (Hon.) (Peradeniya), M.Phil. (Peradeniya), Dr. Sc. Agr. (Gottingen, Germany), M.Biol.
Vice Chancellor
Uva Wellassa University
06.01.2025



Message from the Dean

As the Founder Dean of the Uva Wellassa Medical Faulty, it is with great pride and enthusiasm that I present to you “Mastering Biochemistry: A Comprehensive Guide to MCQs, Essays, and OSPEs.” This publication represents a significant milestone in our ongoing commitment to enhancing the educational experience for our students.

In the ever-evolving field of medicine, a thorough understanding of Biochemistry is foundational to your future success. This guide has been meticulously crafted to provide you with a comprehensive resource that not only covers a wide range of question formats MCQs, essays, and OSPEs but also offers detailed answers and explanations to reinforce your learning.

Our aim with this book is to equip you with the tools necessary to excel in your examinations and to deepen your grasp of anatomical concepts. We believe that this guide will serve as an invaluable asset in your academic journey, offering clarity, confidence, and a robust framework for your studies.

I extend my heartfelt gratitude to the faculty members and contributors who have dedicated their expertise and effort to make this resource possible. It is our hope that you will find this guide to be a source of support and inspiration as you navigate your medical education.

Wishing you every success in your studies and future medical career.

Sincerely,

Senior Professor Muditha Vidanapathirana,
Founder Dean,
Faculty of Medicine,
Uva Wellassa University



Message from the Head of the Department

Dear Students,

As the Head of the Department of Biochemistry, it is both an honor and a privilege to be part of the team behind the publication of "Mastering Biochemistry: A Comprehensive Guide to MCQs, Essays, and OSPEs." This publication has been meticulously designed to align with the Biochemistry curriculum for Year 1, Semester 1, as offered by the Department of Biochemistry, Faculty of Medicine, Uva Wellassa University of Sri Lanka.

As aspiring medical professionals dedicated to excellence, this guide aims to support your academic journey by serving as a resource to prepare effectively for your examinations. It provides detailed insights into the components of MCQs, essays, and OSPEs, helping you navigate these formats with confidence. Furthermore, the publication is structured to assist in testing your comprehension and reinforcing the knowledge acquired through the curriculum.

I extend my heartfelt gratitude to Snr. Prof. Muditha Vidanapathirana, Founder Dean of the Faculty of Medicine, Uva Wellassa University, for conceptualizing this initiative and offering steadfast guidance throughout its development. My sincere appreciation also goes to all contributors who played a role in creating this valuable resource.

I hope this publication serves as a reliable guide and inspires you to excel in your academic endeavors.

Warm regards

Dr. Gayathri Rathnayake

Head, Department of Biochemistry

Faculty of Medicine

Uva Wellassa University

BIOCHEMISTRY MCQ (T/F & SBA) QUESTIONS

Q1. The plasma membrane is one of the fundamental structures of cellular evolution. Which of the statements regarding plasma membranes are true?

A. It is present in both eukaryotes and prokaryotes.
B. Its main function is to generate metabolic energy in the cell
C. The Phospholipid bilayer of the plasma membrane is permeable to most water-soluble molecules
D. The main components in it are lipids and nucleic acids.
E. The passage of ions and most biological molecules across the plasma membrane is mediated by proteins

Q2. A protein is a naturally occurring, complex substance that consists of amino acid residues joined by peptide bonds. Which of the following is true regarding the degradation of proteins?

A. It is an irreversible process
B. It alters iso-electric pH
C. Primary structure is destroyed in this process
D. It increases the solubility of protein
E. Biological activity of protein is lost in this process

Q3. Which of the following are true regarding the Iso electric point of a protein?

A. It is the point where the solubility of protein is lowest
B. It is the pH value when the net charge of the protein is zero
C. It is the point where the denaturing of the protein begins
D. It is the voltage in which the protein migrates from negative to positive electrodes.
E. It is the optimum pH value for the protein.

Q4. Glycolysis, Krebs Cycle, and Electron Transport chain are the steps in cellular respiration. Which of the following is true regarding cellular respiration?

A. Energy is stored as NADH/FADH2
B. In the process of the Krebs cycle, glucose is converted to pyruvic acid
C. Electron transport chain occurs in the inner mitochondrial membrane
D. NADH produced in glycolysis must be transported to the lysosomes for the Krebs cycles.
E. Carbohydrates, fat, and amino acids are utilized in this process of generating energy.

Q5. Haemoglobin is a protein constituting 1/3 of red blood cells which helps in transporting 0_2 and CO_2. Which of the following is true regarding Haemoglobin?

A. Haem and Globin parts are synthesized in the same cell location to produce Haemoglobin.
B. The Hb-oxygen dissociation curve shifts to the right with high CO2 in the cell.
C. Hb-oxygen dissociation curve shifts to the left with High 2,3-DPG.
D. Sickle Cell disease is a genetic disorder of the Beta globin chain of Haemoglobin.
E. Methemoglobin increases the capacity for oxygen binding and transport in the cell.

Q6. Which of the following is true regarding Hemoglobin structure?

A. It has 4 porphyrin rings.
B. One molecule composed of four types of globin chains.
C. There is one ferrous ion at the center of the Hemoglobin molecule.
D. It is tetrameric in its quaternary structure.
E. Has allosteric proteins.

Q7. A 5-month-old infant presented to the pediatric ward with difficulty in feeding and poor weight gain. On examination, the child had severe pallor, tachypneic, and hepatosplenomegaly. Which of the following investigations will be helpful in the diagnosis?

A. Hemoglobin Level
B. Blood picture
C. MCH (Mean corpuscular Hemoglobin)
D. MCV (Mean corpuscular Volume)
E. HPLC

Q8. Which of the following causes the right shift of the normal Oxygen-Hemoglobin dissociation curve?

A. Exercises
B. Decreased temperature
C. Acidosis
D. 2,3-BPG
E. Fetal hemoglobin

Q9. Which of the following are true regarding the structure and function of mitochondria?

A. It is surrounded by a double membrane.
B. It plays a major role in generating ATP by oxidative phosphorylation.
C. The outer membrane of mitochondria forms numerous cristae.
D. The inner membrane contains a mitochondrial genetic system.
E. Mitochondria are unique among cytoplasmic organelles as they contain their own DNA.

Q10. Which of the following is true regarding glycolysis?

A. It is the first step of energy production in human cells.
B. There are three rate-limiting steps.
C. It is a process that occurs in Mitochondria.
D. It is regulated by insulin and glucagon.
E. It is the major energy-providing pathway for RBC.

Q11. An infant presented with poor growth and refusal of feeding was diagnosed with cystathione deficiency. Which of the following components is likely to be increased in his blood?

A. Cysteine
B. Methionine
C. Homocysteine
D. Serine
E. Phenylalanine

Q12. A buffer is a solution that can resist pH change upon the addition of acidic or basic components. Which of the following is the best statement regarding pH and buffers?

A. Amino acids function as buffers around physiological pH
B. Buffers act best around pH 7
C. The buffering capacity of a buffer depends upon the concentration of the buffer.
D. HCO3- H2CO3 system is the main buffer in urine
E. Buffering capacity depends on the pK of the buffer acid or base.

Q13. Albumin is a plasma protein made by the liver. Which of the following is true regarding Albumin?

A. Act as a transport carrier for various biomolecules
B. Contribute to oncotic pressure in cells
C. Oedema develops when albumin level increases in the blood
D. Hypoalbuminemia can be physiological
E. Albuminuria is always a physiological

Q14. Which of the following are true regarding lysosomes,

A. Are bags of hydrolytic enzymes
B. Are formed by Golgi
C. Involve in protein synthesis
D. Involve in the inactivation of foreign bodies
E. pH of lysozymes is acidic

Q15. Which of the following are true regarding eukaryotic cells?

A. They are surrounded by plasma membrane
B. DNA replication takes place in cytoplasm
C. Translation of RNA into proteins takes place in ribosomes
D. Mitochondria is found in almost all cells
E. Only some eukaryotes contain a nucleus in them

Q16. Which of the following is a key difference between eukaryotic and prokaryotic cells?

A. Eukaryotic cells have membrane-bound organelles, while prokaryotic cells do not.
B. Eukaryotic cells are smaller in size compared to prokaryotic cells.
C. Prokaryotic cells contain a nucleus, while eukaryotic cells do not.
D. Eukaryotic cells have a cell wall made of peptidoglycan, while prokaryotic cells have a cell wall.
E. Eukaryote cells typically undergo binary fission for cell division.

Q17. Which of the following statements regarding glycolysis is correct?

A. Glycolysis occurs in the cytoplasm of all cells and is the primary pathway for glucose metabolism
B. Glycolysis occurs in the mitochondria and is primarily involved in the production of ATP
C. Glycolysis is an aerobic process that requires oxygen to proceed efficiently
D. Glycolysis produces a net gain of 4 molecules of ATP per molecule of glucose.
E. The enzyme hexokinase catalyzes the conversion of glucose to glucose-6-phosphate in the first

Q18. Which of the following are true regarding actions to be taken to avoid laboratory accidents?

A. Listing to news on TV while laboratory procedures undergo
B. Opening laboratory windows
C. Removing leftover chemicals via the sink
D. Wearing protective shoes
E. Letting patients into the hospital laboratory

Q19. Which of the following statements accurately describes a key function of the electron transport chain (ETC) in cellular respiration?

A. It synthesizes glucose from pyruvate in the presence of oxygen.
B. It produces ATP directly through substrate-level phosphorylation.
C. It generates a proton gradient across the mitochondrial membrane.
D. It converts lactic acid into pyruvate to replenish ATP stores.
E. It occurs in the plasma membrane of Eukaryotes.

Q20. Which of the following statements are correct regarding Hemoglobin?

A. Hemoglobin primarily transports carbon dioxide in the blood.
B. Hemoglobin consists of four subunits, each containing a heme group.
C. The binding of oxygen to hemoglobin decreases its affinity for carbon monoxide.
D. Hemoglobin exists primarily in the reduced state in venous blood.
E. During the degradation of Heme, Bilirubin is released into the blood.

Q21. Which of the following best describes methemoglobinemia?

A. Increased production of oxygen-carrying hemoglobin in red blood cells
B. Decreased oxygen affinity of hemoglobin due to iron deficiency
C. Oxidative conversation of hemoglobin to a non-function form
D. Accumulation of carbon dioxide in red blood cells
E. Impaired production of red blood cells due to genetic mutations

Q22. Which of the following statements accurately describes the characteristics of the eukaryotic nucleus?

A. It contains DNA only in the form of a linear chromosome
B. It is surrounded by a double membrane
C. It has an association with ribosomes involved in protein synthesis
D. It is not involved in regulation of gene expression
E. It undergoes division during the cell cycle

Q23. Which of the following statements about polysaccharides is correct?

A. Cellulose is a storage polysaccharide found in animals.
B. Glycogen is primarily stored in the liver and skeletal muscles.
C. Chitin consists of glucose monomers linked by β-1,4 glycosidic bonds.
D. Amylopectin is a linear polymer of glucose units connected by α-1,4 glycosidic bonds.
E. Cellulose provides rigidity and strength to plant cell walls.

Q24. Which of the following statements about Golgi bodies (Golgi apparatus) is correct?

A. They are responsible for cellular respiration.
B. They primarily synthesize proteins.
C. They modify, sort, and package proteins and lipids for secretion or delivery to
D. They are found only in plant cells.
E. They store genetic information.

Q25. Which of the following accurately describes the role of lipoprotein lipase in lipid metabolism?

A. It synthesizes triglycerides from glycerol and fatty acids in adipose tissue.
B. It hydrolyzes triglycerides from circulating lipoproteins, releasing fatty acids for cellular.
C. It converts cholesterol into bile acids in the liver, aiding in lipid digestion.

D. It facilitates the transport of lipids across cell membranes during lipid absorption.
E. The liver is a central organ for lipid metabolism.

Q26. Which of the following statements about pH and buffers is correct?

A. A pH of 7.0 indicates an acidic solution.
B. Buffers resist changes in pH by releasing or absorbing protons (H+) or hydroxide ions (OH-).
C. Increasing temperature always decreases the effectiveness of a buffer solution.
D. Buffers are ineffective in biological systems due to constant changes in pH.
E. Decreasing temperature will always decrease the effectiveness of a buffer.

Q27. An enzyme catalyzes the conversion of substrate S to product P. Which of the following statements are true regarding enzyme activity?

A. Enzyme activity is highest when substrate concentration is lower than the enzyme concentration
B. Competitive inhibitors decrease enzyme activity by binding irreversibly to the enzyme substrate.
C. Increasing temperature always increases enzyme activity. leading to faster reactions.
D. pH affects enzyme activity primarily by altering the ionization states of amino acid side chains.
E. Enzyme activity is independent of cofactors and coenzymes.

Q28. Cyanide is poisonous because of its,

A. Formation of a complex with Hemoglobin
B. Combination with the erythrocyte membrane
C. Inhibition of cytochrome oxidase
D. Inhibition of myoglobin
E. Blockage of oxygen transport in blood

Q29. In the context of plasma proteins, which of the following statements regarding fibrinogen is correct?

A. Fibrinogen is primarily synthesized in the liver
B. It is an enzyme that catalyzes the conversion of fibrin to fibrinogen during blood clotting
C. It is an acute-phase protein that increases during inflammation and infection
D. It works in the immune response by binding to antigens & their clearance from circulation
E. It is crucial for maintaining osmotic balance in the blood

Q30. In competitive inhibition,

A. The apparent concentration of active enzyme molecules is reduced
B. Vmax is increased
C. The concentration of active enzyme molecules is unchanged
D. The apparent Km is increased
E. The apparent Km is decreased

Q31. Which of the following statements accurately describes the role and characteristics of ribosomal RNA (rRNA) in eukaryotic cells?

A. rRNA is synthesized in cytoplasm & functions in the regulation of mRNA stability & translation
B. In eukaryotes, it is transcribed in the nucleolus
C. It serves as a template for DNA replication & is primarily found in the mitochondria of eukaryotes

D. rRNA acts as a carrier molecule for amino acids in protein synthesis & is synthesized in the nucleus
E. rRNA is a structural component of the ribosome

Q32. A patient was brought to the hospital with an acute intoxication of wood alcohol. Inhibition of which enzyme is the most beneficial in his management.

A. Lactate dehydrogenase
B. Alcohol dehydrogenase
C. Acetyl Co A synthase
D. Acetaldehyde dehydrogenase
E. Glyceraldehyde 3- phosphate dehydrogenase

BIOCHEMISTRY MCQ (T/F & SBA) ANSWERS

Q1. The plasma membrane is one of the fundamental structures of cellular evolution. Which of the statements regarding plasma membranes are true?

(A) T - All prokaryotes and eukaryotes have a cell membrane.
(B) F - Mitochondrias' main function is to generate metabolic energy in the cell.
(C) F - The basic structure of the cell membrane is the phospholipid bilayer. It is impermeable to most water-soluble molecules.
(D) F - The main components in the cell membrane are lipids and proteins.
(E) T - The passage of ions and most biological molecules across the plasma membrane is mediated by proteins, as the lipid bilayer is impermeable to most water-soluble molecules

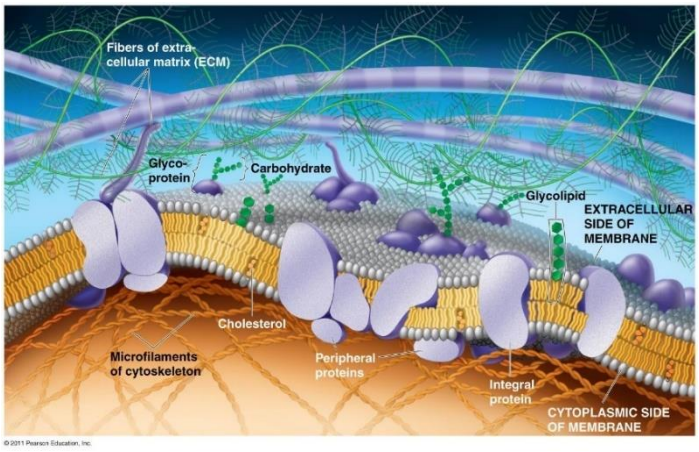


Figure 1-Structure of plasma membrane (http://anatomyandphysiologyi.com/the-plasma-membrane-structure/)

Q2. A protein is a naturally occurring, complex substance that consists of amino acid residues joined by peptide bonds. Which of the following is true regarding the degradation of proteins?

(A) T - Protein denaturation is irreversible in most instances.

Ex: egg albumin

(B) F - Isoelectric pH is not affected in this process.
(C) F - Protein degradation destroys 2ry, tertiary, and quaternary structures but not the primary structure. Because covalent bonds are not cleaved.
(D) F - Denatured proteins have less or no solubility. It makes a Precipitate.

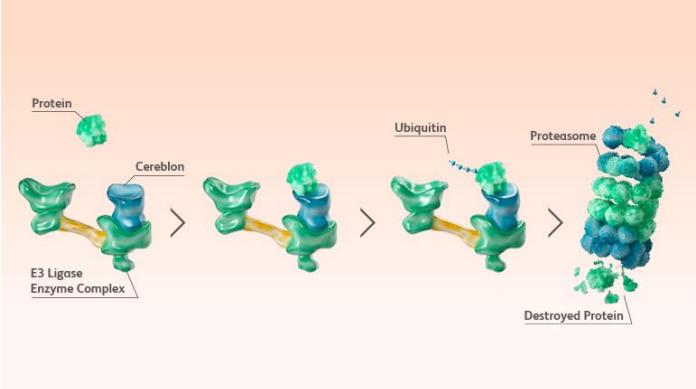


Figure 2-Protein degradation (https://www.bms.com/media/media-library/scientific-media-resources/protein-gegradation.html)

(E) T - Loss of biological activity due to the alternation of the 3D structure of a protein is denaturation. The 3D structure is needed to act as a protein. So once degraded, its biological activity is lost.

Q3. Which of the following are true regarding the Iso electric point of a protein?

(A) T - The isoelectric pH, coincides with the pH where the protein is least soluble. And it is most likely to precipitate out of the solution.
(B) T - The isoelectric point (pI) is the pH of a solution at which amino acids carry an equal number of positive and negative charges. So the net charge of a protein becomes zero.

(C) F - Protein denaturation results in the unfolding and disorganization of secondary and tertiary structures. Denaturing agents include heat, organic solvents, strong acids, bases, and heavy metals. But it does not begin at isoelectric Ph.

(D) F - As the net charge of protein becomes zero, in iso-electric pH, there's no mobility in an electric field. At pH greater than isoelectric pH, Amino acid exists deprotonated or negatively charged and moves towards positive electrodes.

(E) F - Proteins have minimum buffering capacity at iso-electric pH.

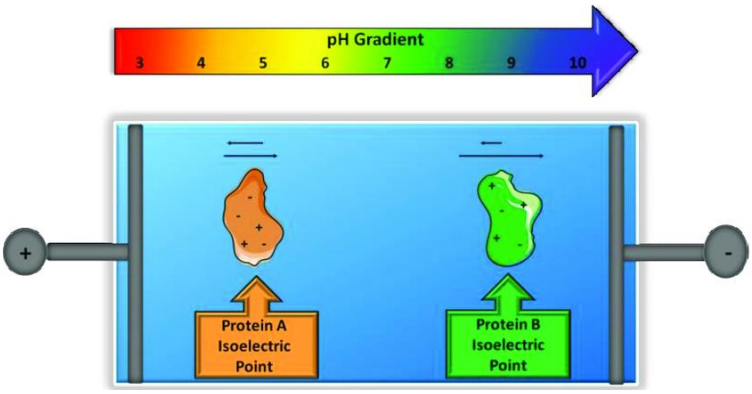


Figure 3-Isoelectric focusing of proteins (https://www.researchgate.net/publication/312924660_Isoelectric_Point_Separations_of_Peptides_and_Proteins)

Q4. Glycolysis, Krebs Cycle, and Electron Transport chain are the steps in cellular respiration. Which of the following is true regarding cellular respiration?

(A) T - Cellular respiration consists of Glycolysis, Krebs cycle, and electron transport chain, and the energy produced is stored as NADH/ FADH2

(B) F - Glucose is converted to pyruvic acid in the glycolysis. And it enters the Krebs cycle to produce Acetyl Co A.

(C) T - Glycolysis occurs in the cell cytoplasm and the Electron transport chain occurs in the inner mitochondrial membrane.

(D) F - NADH produced in the process of glycolysis must be transported to the mitochondrial matrix via the mitochondrial membrane to the electron transport chain to occur.

(E) T - Generating energy in human cellular respiration can be utilized for all three types: carbohydrates, fat, and amino acids.

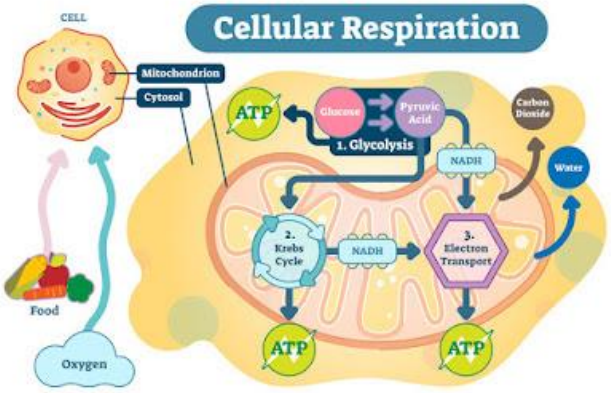


Figure 4-Cellular respiration (https://stock.adobe.com/lk/images/cellular-respiration-medical-vector-illustration-diagram-respiration-process-scheme/188848103)

Q5. Haemoglobin is a protein constituting 1/3 of red blood cells which helps in transporting 02 and CO2. Which of the following is true regarding Haemoglobin?

(A) F - Haem and globin are produced at two different sites in the cell. Haem in mitochondria & Globin in polyribosomes

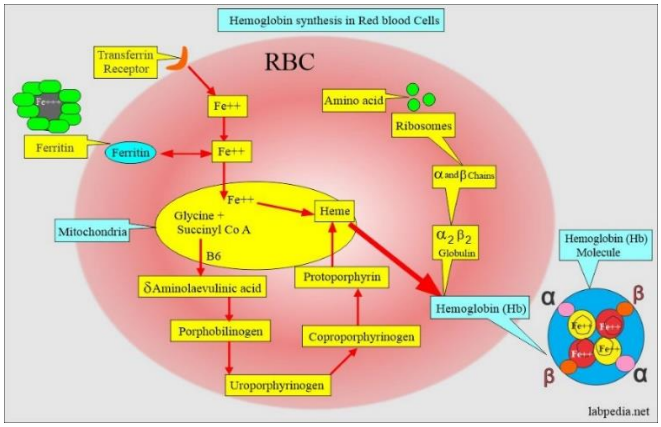


Figure 5-Haemoglobin synthesis in RBC
(https://labpedia.net/category/lab-tests/page/16/)

(B) T - The oxygen-hemoglobin dissociation curve shows the O2 carrying capacity of Hb at different PO2. It is shifted to the right by high 2,3 DPG, High H+, High CO2, and HbS.
(C) F - It is shifted to the left by low 2,3 DPG and HbF.
(D) T - Under Hemoglobinopathies, sickle cell is a genetic disorder of the beta-globin gene. Alpha globin chain synthesis is low or absent in alpha thalassemia. The synthesis of the beta-globin chain is low or absent in beta-thalassemia.
(E) F - Methemoglobin is the oxidized form of normal Hemoglobin. So ferrous (Fe2+) state of the ion is transformed into the ferric (Fe3+) state. So it decreases capacity for oxygen binding and transport.

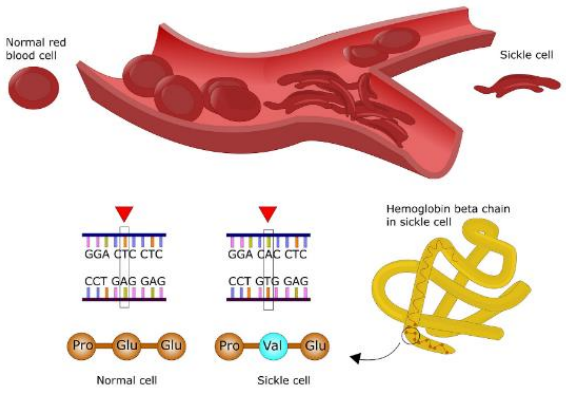


Figure 7-Sickle cell anemia
(https://stock.adobe.com/lk/78166795

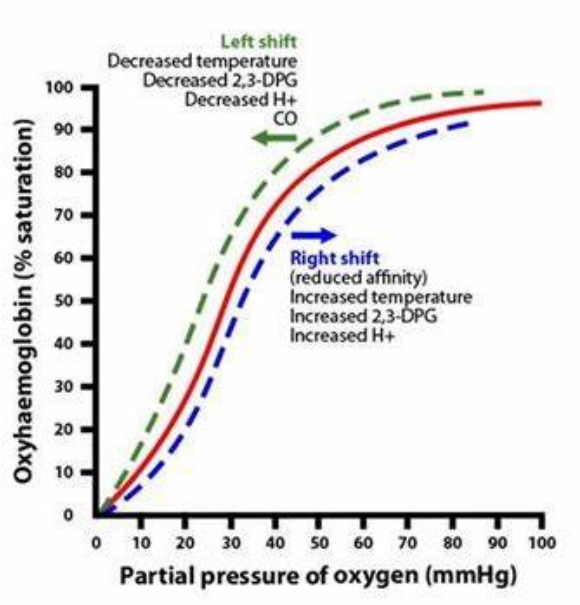


Figure 6-Oxygen-Haemoglobin dissociation curve(https://www.instagram.com/icuadvantage/p/Cg7ueX5uRXx/)

Q6. Which of the following is true regarding Hemoglobin structure?

(A) T - Hemoglobin comprises 4 heme groups. Each Heme is comprised of a porphyrin ring structure with one iron (Fe) atom chelated in the center by 4 nitrogen atoms. This is the site of reversible, oxygen attachment.

(B) F - Haemoglobin comprises four globin protein subunits. Adult hemoglobin A (HbA), is comprised of two α-chains and two β-chains.

(C) F - There are four iron atoms in each molecule of hemoglobin, which accordingly can bind four molecules of oxygen.

(D) T - Hb is a tetramer, consisting of two α-subunits (α1 and α2) and two β-subunits (β1 and β2) that are structurally similar and about the same size.

(E) T - Haemoglobin is an allosteric protein. This means that the binding of oxygen to one of the subunits is affected by its interactions with the other subunits.

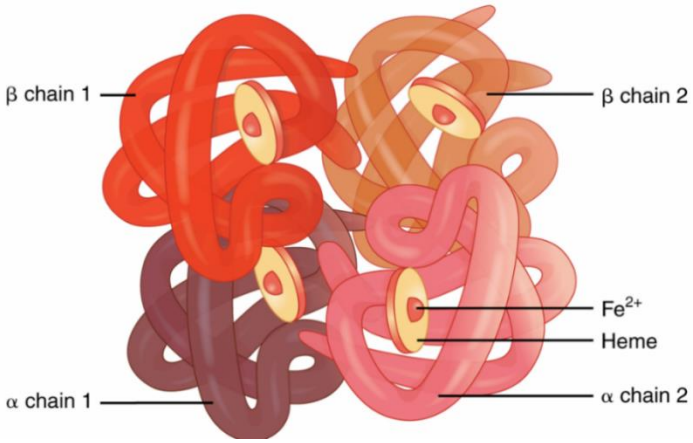


Figure 8-Structure of hemoglobin(https://studymind.co.uk/notes/transport-of-oxygen/)

Q7. A 5-month-old infant presented to the pediatric ward with difficulty in feeding and poor weight gain. On examination, the child had severe pallor, tachypneic, and hepatosplenomegaly. Which of the following investigations will be helpful in the diagnosis?

The given case scenario suggests a thalassemia major clinical picture. It is an autosomal recessive hereditary disorder of the globin gene which causes deficient production of Beta globin chains in hemoglobin. So when fetal hemoglobin converts to adult hemoglobin, symptoms appear.

(A) T - As the child has severe pallor, we have to investigate hemoglobin level to confirm it. In beta thalassemia major we get a low hemoglobin level which supports the diagnosis.

(B) T - A Blood picture of thalassemia major shows microcytic hypochromic anemia, target cells, and pencil cells.

(C) T - The mean corpuscular hemoglobin is the average mass of hemoglobin per red blood cell in a sample of blood. As thalassemia causes hypochromic anemia, MCH becomes low.

(D) T - High-performance liquid chromatography (HPLC), is a technique in analytical chemistry used to separate, identify, and quantify specific

	Beta Major	Beta Minor	Alpha HbH	Alpha Trait
Hb% M => 13.8-18.0 g/dL F => 12 - 15 g/d	2-4 g/dl	9-11g/dl	2 - 8g/dl	10-14g/dl
MCV (fl) **Normal** 80 - 100 fl	50-60	60-80	60-70	60-80
MCH(pg) normal 27-31 pg/cel	16-22	28-32	24-28	28-32
MCHC	Decrease	Normal or Slight Decrease	Decrease	Normal or Slight Decrease
RDW Normal => 11 - 15%	Increased	Normal <14%	Normal	Normal
Reticulocytosis	Moderately high	mild	mild	normal

Figure 9-Full blood count findings of thalassemia (https://www.slideshare.net/slideshow/laboratory-diagonosis-thalassemia-chirantan/9519345)

components in mixtures. HPLC is a sensitive and accurate test for identifying adult Hb, Fetal Hb, and abnormal hemoglobins. So widely used in diagnosing thalassemia.

(E) T - The mean corpuscular volume, is a measure of the average volume of a red blood corpuscle. As thalassemia causes microcytic hypochromic anemia, MCV becomes low

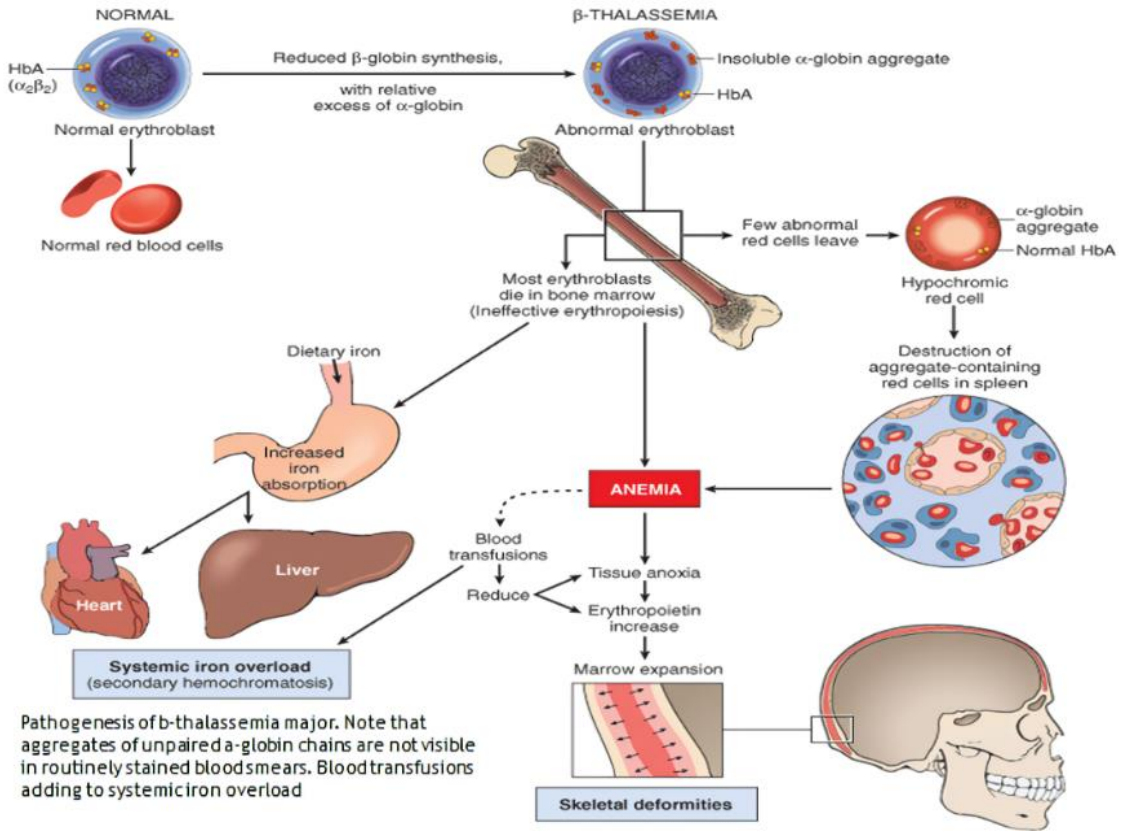


Figure 10-Pathogenesis of β-thalassemia
(https://www.pinterest.com/pin/460282024414587301/)

Q8. Which of the following causes the right shift of the normal Oxygen-Hemoglobin dissociation curve?

The oxygen-hemoglobin dissociation curve is a graphical representation of the relationship between the amount of oxygen bound to hemoglobin and the partial pressure of oxygen in the blood. The curve is sigmoidal, with a steep slope at low partial pressures of oxygen and a more gradual slope at higher partial pressures.

A rightward shift of the curve indicates that hemoglobin has a decreased affinity for oxygen, thus, oxygen actively unloads. And give a better oxygen supply for tissues.

(A) T - During exercise, where the temperature of muscle increases secondary to its utilization, shift the curve to the right and allow oxygen to be more easily unloaded from hemoglobin and delivered to tissues in need.

(B) F - lower temperatures will cause a leftward shift in the dissociation curve.

(C) T - Acidosis means high CO2 in cells. Acidosis causes a right shift in the oxyhemoglobin dissociation curve and this facilitates oxygen delivery to tissues.

(D) F - 2,3-DPG acts as a regulator of the allosteric properties of hemoglobin in the RBC. When 2,3-DPG is bound to hemoglobin, it decreases hemoglobin affinity for oxygen.

(E) F - Fetal Hb (alpha2gamma2) introduces a leftward shift of the curve, favoring O2 binding to hemoglobin at lower oxygen tension. This is favorable in the womb, to allow the growing fetus to pull O2 from the maternal circulation.

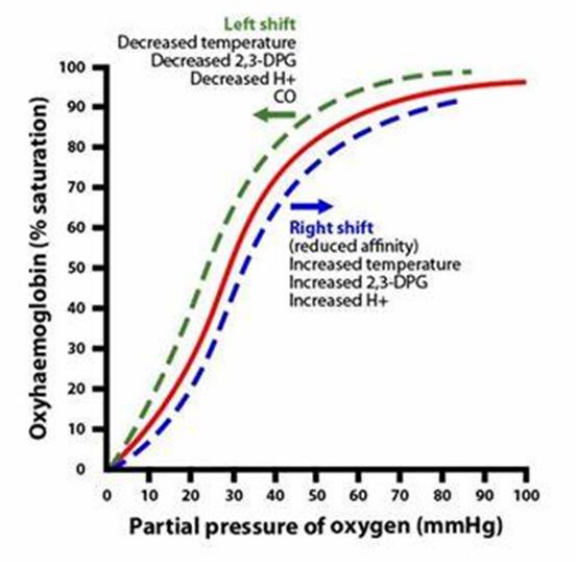


Figure 11-Oxygen-Haemoglobin dissociation curve (https://www.instagram.com/icuadvantage/p/Cg7ueX5uRXx/)

Q9. Which of the following are true regarding the structure and function of mitochondria?

(A) T - Mitochondria are surrounded by a double membrane system, consisting of inner and outer mitochondrial membrane

(B) T - The inner membrane is the principal site of ATP generation by the breakdown of carbohydrates, and fatty acids, via oxidative phosphorylation.

(C) F - It is the inner membrane which forms numerous cristae

(D) F - The matrix contains the mitochondrial genetic system and the enzymes responsible for the central reactions of oxidative metabolism.

(E) T - Mitochondria contain their own DNA which encodes tRNA, rRNA, and some mitochondrial proteins.

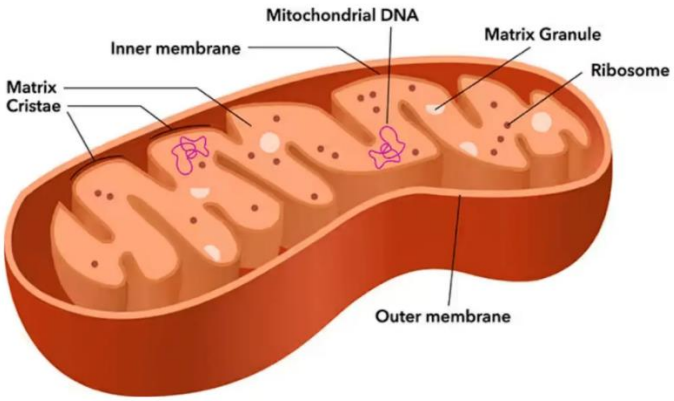


Figure 12-Structure of mitochondria (https://www.bio-techne.com/research-areas/cell-biology/cell-markers/mitochondrial-markers)

Q10. Which of the following is true regarding glycolysis?

(A) T - Glycolysis is the metabolic pathway that converts glucose into pyruvate. It is the first step in the breakdown of glucose to extract energy.

(B) T - Three rate-limiting steps regulate the glycolytic pathway.

- Phosphorylation of Glucose
- Phosphorylation of fructose-6-phosphate
- Conversion of Phosphoenolpyruvate to pyruvate

(C) F - Glycolysis occurs in the cytosol of cells

(D) T - Insulin promotes glycolysis by encouraging glucose uptake. Glucagon inhibits glycolysis and encourages gluconeogenesis

(E) T - Glycolysis is the primary source of energy in red blood cells. As mature red blood cells lack mitochondria, the Krebs cycle does not take place in red blood cells.

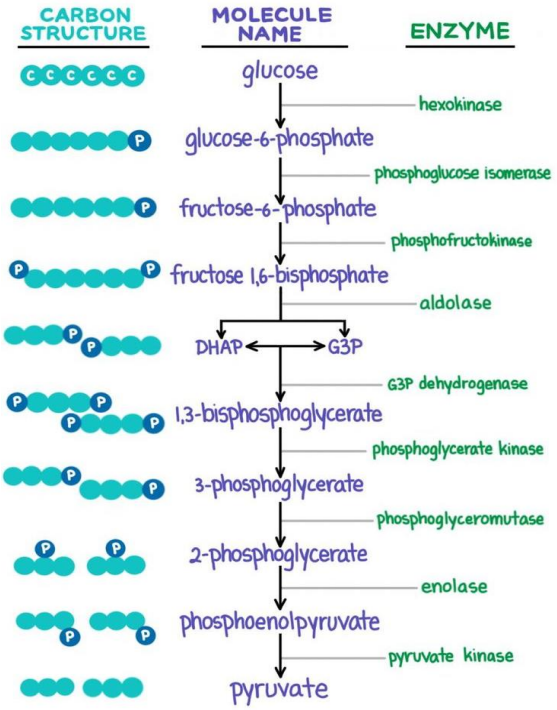


Figure 13-Glycolysis (https://ru.pinterest.com/pin/886716614129218304/)

Q11. An infant presented with poor growth and refusal of feeding was diagnosed with cystathione deficiency. Which of the following components is likely to be increased in his blood?

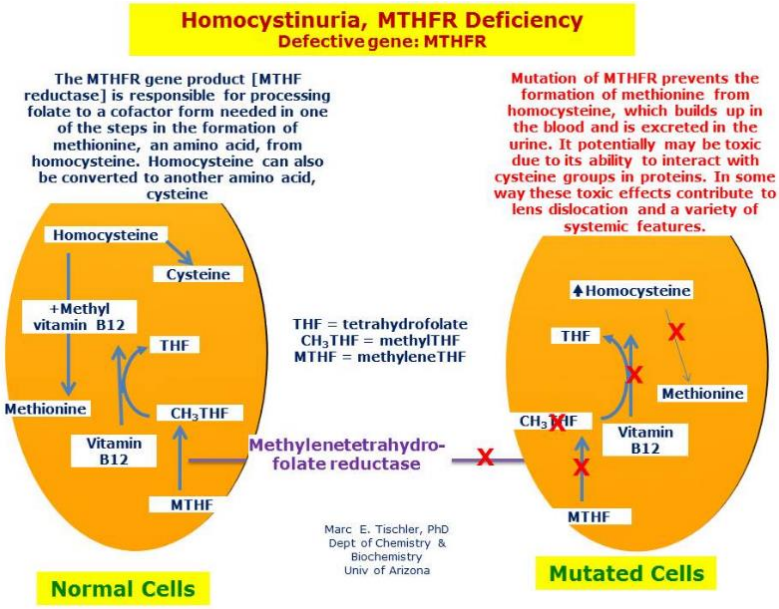
The most accurate response to the question is (C)

(A) Typically, cysteine levels would be low due to the impaired conversion from homocysteine.

(B) While methionine levels may also be affected, it is not the primary component that accumulates in this condition.

(C) This is the correct answer. Due to the enzyme deficiency, homocysteine accumulates in the blood, leading to elevated levels.

(D) Serine levels are not directly impacted by cystathionine deficiency and are unlikely to be elevated.



(E) This amino acid is unrelated to cystathionine metabolism and would not be expected to increase.

Figure 14-Homocystinuria (https://disorders.eyes.arizona.edu/disorders/homocystinuria-beta-synthase-deficiency)

This reflects the primary metabolic disturbance associated with cystathionine deficiency, as homocysteine accumulates due to the impaired conversion process. Understanding these biochemical changes is essential for diagnosing and managing the condition effectively.

Cystathionine deficiency is caused by a lack of cystathionine β-synthase, which is necessary for converting homocysteine into cystathionine. This blockage leads to an accumulation of homocysteine.

Q12. A buffer is a solution that can resist pH change upon the addition of acidic or basic components. Which of the following is the best statement regarding pH and buffers?

Best answer (E)

(A) and (B)

An amino acid can act as a buffer because it can react with added acids as well as keep the pH nearly constant. Because an amino acid has both an acidic group which is a carboxyl group and a basic group which is an amine group, hence it can act as both acid and as a base therefore amino acids can act as a buffer. The buffering capacity of amino acids was the strongest at pK.

Histidine is particularly effective as a buffer at physiological pH because it has a pKa value close to this range.

(C) Buffer capacity depends on concentration as well as the ratio of acid and its conjugate base.
(D) The main buffer in the urine is phosphate buffer system although bicarbonate also important in maintaining pH.
(E) Buffering capacity is maximum at pKa of the substance.

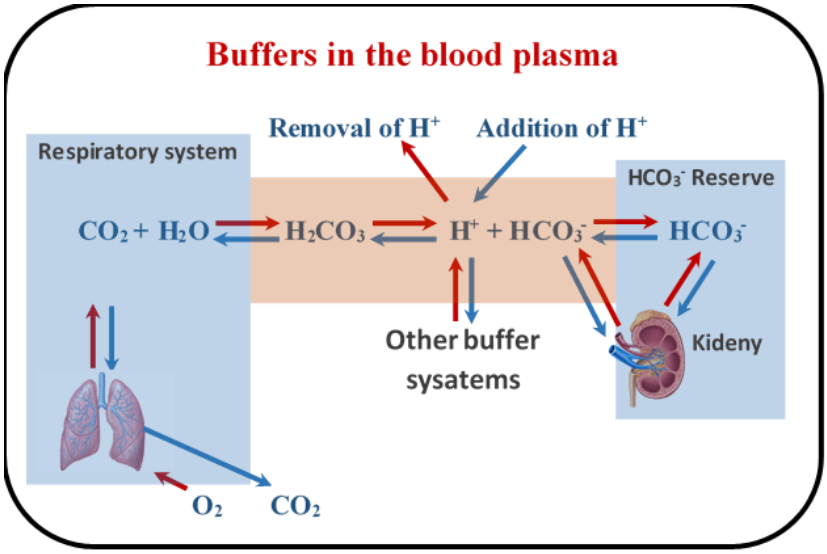


Figure 15-Buffers in blood
(https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introduction)

Q13. Albumin is a plasma protein made by the liver. Which of the following is true regarding Albumin?

(A) T - Albumin acts as a transport carrier for various biomolecules like fatty acids, trace elements, and drugs
(B) T - Albumin drags water. So contributes to maintaining oncotic pressure. Thus maintains fluid distribution between blood and tissues
(C) F - Oedema develops when the albumin level decreases in the blood and fluid filters out.
(D) T - Hypoalbuminemia can be physiological in instances like pregnancy where plasma volume increases
(E) F - Albuminuria is always pathological and seen in nephrotic syndrome and acute nephritis

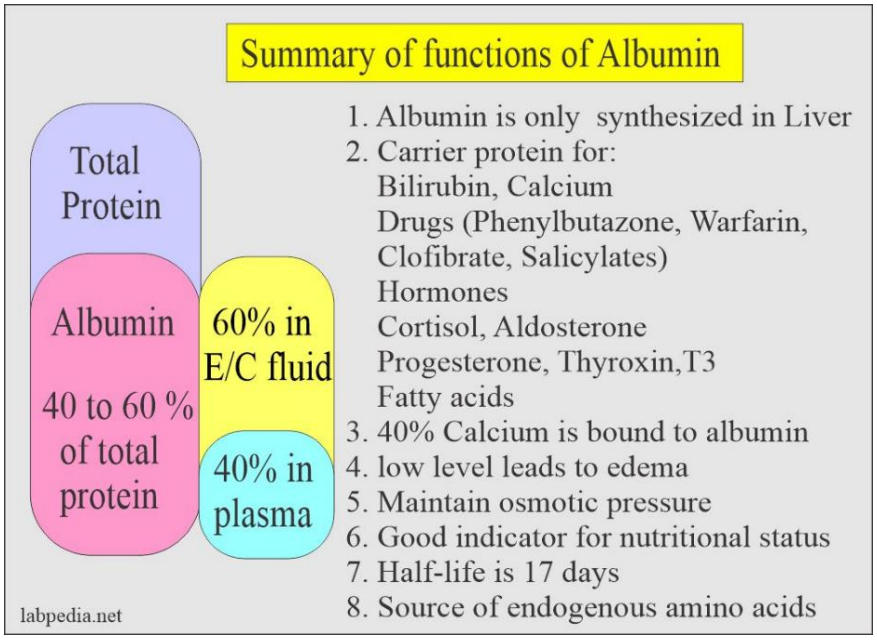


Figure 16-Functions of albumin
(https://labpedia.net/albumin-serum-albumin/)

Q14. Which of the following are true regarding lysosomes,

(A) T - Lysosymes are membrane-enclosed organelles that contain an array of enzymes capable of breaking down proteins, nucleic acids, carbohydrates, and lipids.

(B) T - Lysosomes are produced through vesicle budding that occurs on the trans face of the Golgi Apparatus. As the vesicle breaks off, another vesicle with lysosomal enzymes fuses with the vesicle that came from the Golgi Apparatus.

(C) F - Ribosomes are the important cell organelles that are involved in protein synthesis

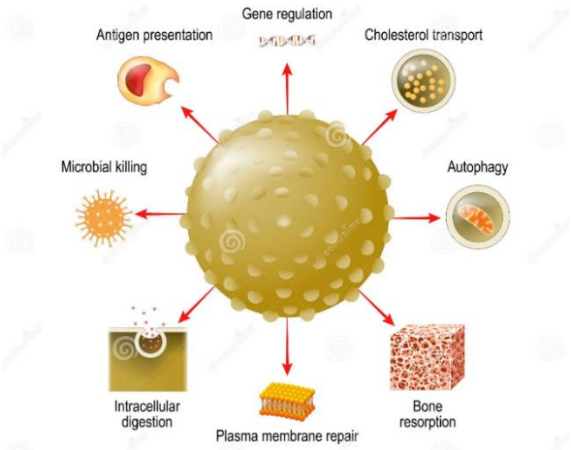


Figure 17-Functions of lysosome (https://www.pond5.com/stock-images/illustrations/item/134736008-lysosome-function-multitask-lysosome-intracellular-digestion)

(D) T - Lysozymes function as the digestive system of cells serving both to degrade material taken up from outside the cell and to digest absolute components of the cell itself

(E) T - Lysosomes are hydrolytic enzymes. They need an acidic environment for proper functioning, they are referred to as acid hydrolases.

Q15. Which of the following are true regarding eukaryotic cells?

(A) T - Eukaryotic cells are surrounded by a cell membrane, also known as the plasma membrane. The cell membrane is a semi-permeable barrier that separates the cell's internal environment from the external environment. It consists primarily of a phospholipid bilayer embedded with proteins, cholesterol, and other molecules.

(B) F - In eukaryotic cells, DNA replication takes place in the cell nucleus. The nucleus is a membrane-bound organelle that houses the cell's genetic material, including DNA.

(C) T - In the cytoplasm, ribosomes, the cellular machinery responsible for protein synthesis, bind to the mRNA molecule and initiate the process of translation. During translation, the ribosome reads the mRNA sequence in groups of three nucleotides called codons. Each codon corresponds to a specific amino acid, which is added to the growing polypeptide chain.

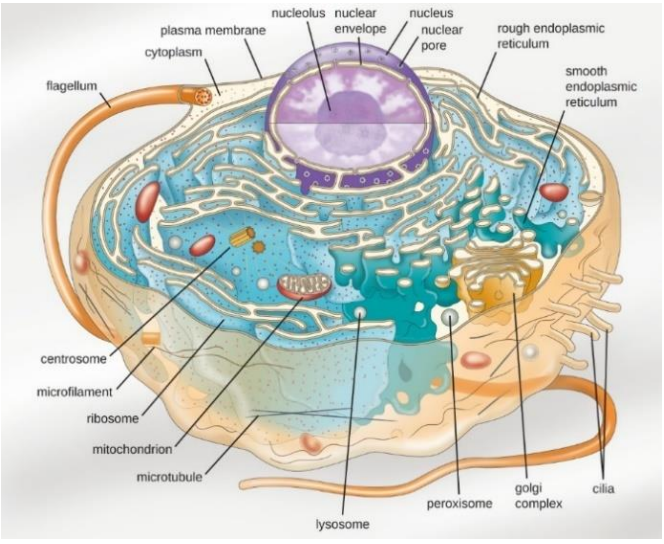


Figure 18-Structure of a eukaryotic cell (https://www.nursinghero.com/study-guides/lcc-ctc-microbiology/unique-characteristics-of-eukaryotic-cells)

(D) T - Mitochondria are found in almost all eukaryotic cells. They are membrane-bound organelles that play a crucial role in cellular respiration, the process by which cells generate energy in the form of ATP

(E) F - All eukaryotic cells have a nucleus. The nucleus is a membrane-bound organelle that contains the cell's genetic material, in the form of chromosomes composed of DNA and associated proteins.

Q16. Which of the following is a key difference between eukaryotic and prokaryotic cells?

(A) T - Eukaryotes have a nucleus and membrane-bound organelles, while prokaryotes lack a nucleus and organelles.
(B) F - Eukaryotes are typically larger and more complex, while prokaryotes are usually smaller and simpler. Eukaryotes can be unicellular or multicellular, while prokaryotes are predominantly unicellular.
(C) F - Eukaryotes have a membrane-bound nucleus that houses their genetic material, while prokaryotes do not have a nucleus.
(D) F - Eukaryotic cell walls are primarily made of cellulose in plants and chitin in fungi. Prokaryotic cell walls are primarily made of peptidoglycan, a polymer consisting of sugars and amino acids. However, not all prokaryotes have cell walls made of peptidoglycan; for example, Archaea have cell walls made of different materials.
(E) F - Prokaryotic cells undergo binary fission, a form of asexual reproduction where one cell divides into two identical daughter cells. This process is characteristic of bacteria and archaea.

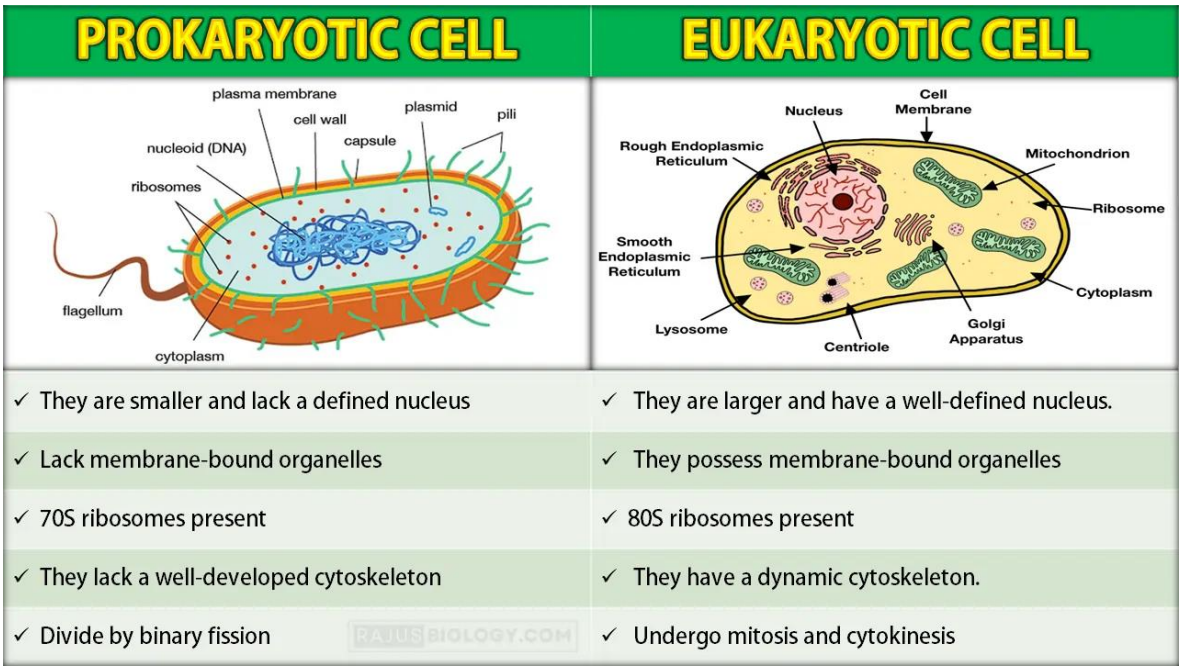


Figure 19-Differences between prokaryotic and eukaryotic cell (https://rajusbiology.com/prokaryotic-and-eukaryotic-cell/)

Q17. Which of the following statements regarding glycolysis is correct?

(A) T - Glycolysis indeed takes place in the cytoplasm of all cells and is the initial step in glucose metabolism, leading to the production of pyruvate.

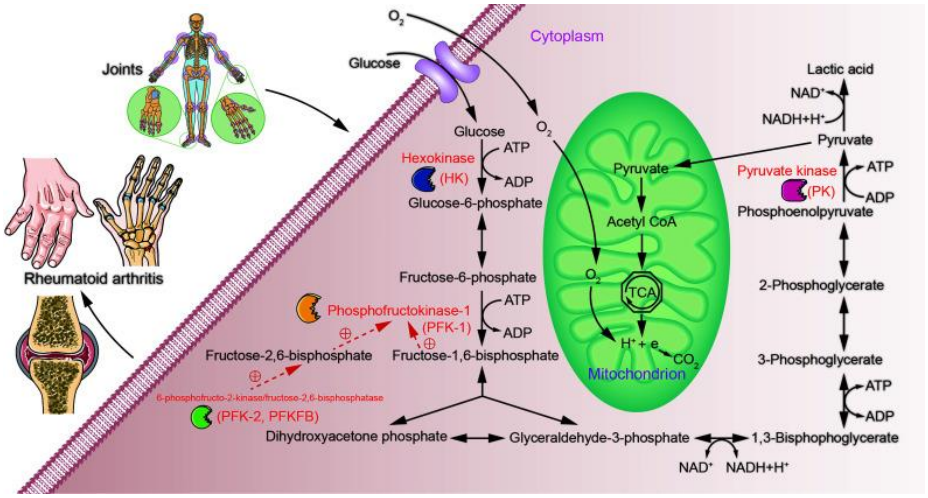


Figure 20-Glucose metabolism (https://www.researchgate.net/figure/Possible-role-of-glucose-metabolism-during-RA-Over-or-under-expression-of-glycolysis_fig1_356658012)

(B) F - Glycolysis occurs in the cytoplasm, not in the mitochondria. While glycolysis does produce ATP, its primary purpose is to convert glucose into pyruvate.

(C) F - Glycolysis is an anaerobic process, meaning it does not require oxygen. It can proceed in both aerobic and anaerobic conditions, though aerobic conditions allow for further metabolism of pyruvate in the citric acid cycle and oxidative phosphorylation.

(D) F - Glycolysis produces a net gain of 2 molecules of ATP per molecule of glucose. Initially, 2 ATP molecules are invested, but 4 ATP molecules are produced later, resulting in a net gain of 2 ATP molecules.

(E) T - The enzyme hexokinase catalyzes the conversion of glucose to glucose-6-phosphate in the first step of glycolysis, not the mitochondria. This step is irreversible and is essential for trapping glucose inside the cell and priming it for further metabolic pathways.

Q18. Which of the following are true regarding actions to be taken to avoid laboratory accidents?

(A) F - Laboratory procedures often require a high level of focus, attention to detail, and adherence to protocols. Distractions such as listening to news can divert attention away from these critical tasks.

(B) T - Opening windows can help improve ventilation within the laboratory. Adequate ventilation is crucial to remove potentially harmful fumes, gases, or vapors that may be released during experiments or from laboratory equipment.

(C) F - Many chemicals used in laboratories can be harmful to the environment if disposed of improperly. Flushing chemicals down the sink can lead to contamination of water sources, soil, and ecosystems. Proper disposal of chemicals involves segregating different types of waste, using designated waste containers, and arranging for collection by licensed waste disposal services. This ensures that chemicals are handled safely from cradle to grave, minimizing risks to human health and the environment.

(D) T - Laboratories often contain hazards such as chemicals, glassware, sharp objects, and potentially slippery surfaces. Protective shoes, such as closed-toe footwear with non-slip soles, provide physical protection against accidental spills, falling objects, or sharp items that could cause foot injuries.

(E) F - Hospital laboratories handle potentially infectious materials such as blood, urine, and tissues. Allowing patients into these areas could increase the risk of cross-contamination and transmission of infectious diseases between patients, staff, and laboratory environments.

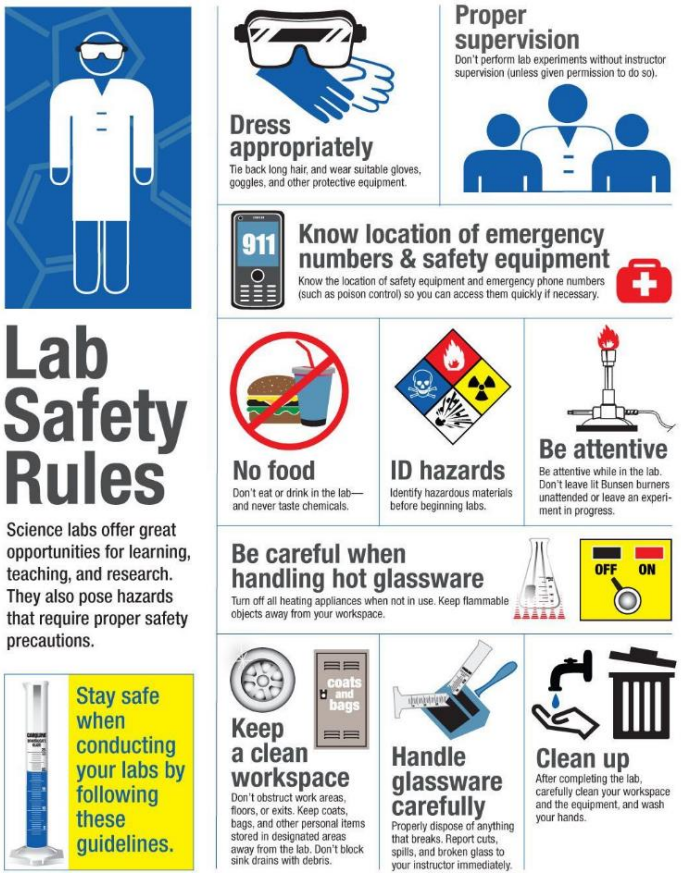


Figure 21-Laboratory safety rules (https://pharmacy.nu.edu.sa/en/234)

Q19. Which of the following statements accurately describes a key function of the electron transport chain (ETC) in cellular respiration?

The correct answer is (C)

(A) This describes gluconeogenesis, which occurs in the cytoplasm, not the ETC.

(B) Substrate-level phosphorylation occurs in glycolysis and the Krebs cycle, not primarily in the ETC. The ETC mainly generates ATP through oxidative phosphorylation.

(C) The ETC creates a proton gradient by pumping protons (H^+ ions) into the intermembrane space of the mitochondria. This gradient is crucial for ATP production via ATP synthase.

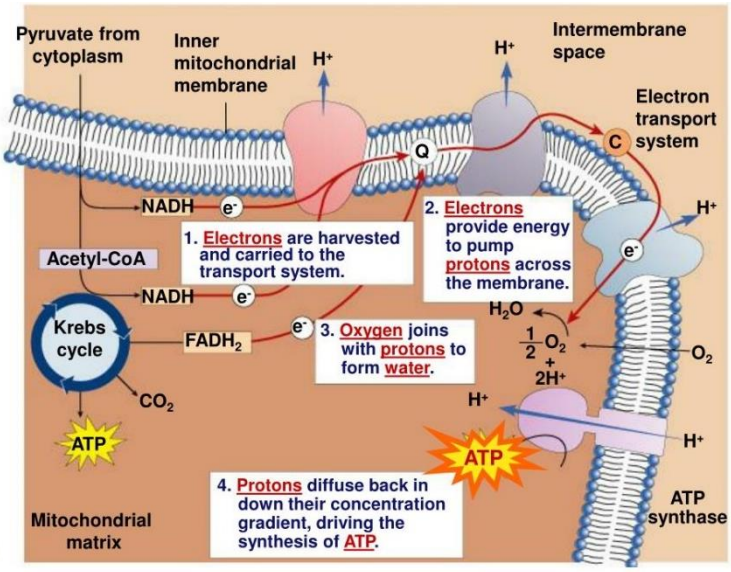


Figure 22-Overview of ATP synthesis(https://www.slideshare.net/slideshow/electron-transport-chain)

(D) This process occurs during fermentation, not in the ETC.
(E) The ETC occurs in the inner mitochondrial membrane of eukaryotic cells, not the plasma membrane.

Q20. Which of the following statements are correct regarding Hemoglobin?

(A) F - Hemoglobin primarily transports oxygen in the blood, not carbon dioxide.
(B) T - Hemoglobin is a tetramer consisting of four subunits, each containing a heme group responsible for binding oxygen.
(C) F - Hemoglobin has a much higher affinity for carbon monoxide than for oxygen, so the binding of carbon monoxide actually decreases the availability of oxygen to tissues.
(D) F - Hemoglobin exists primarily in the oxygenated (oxyhemoglobin) state in arterial blood and in the deoxygenated (deoxyhemoglobin) state in venous blood.
(E) T - Hemoglobin degrades into several components during its lifecycle.

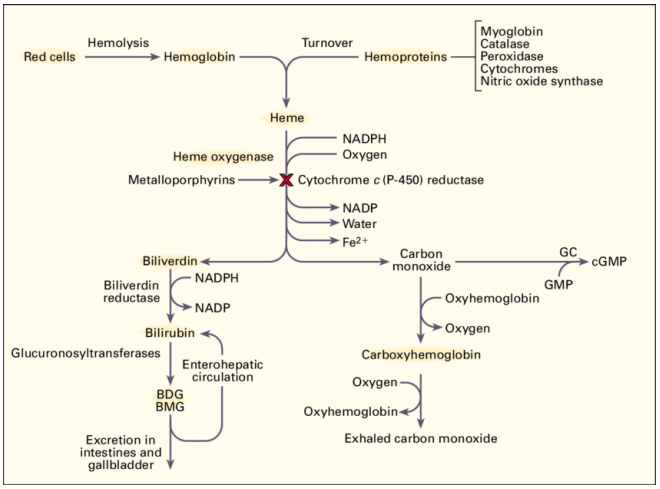


Figure 23-Degradation of hemoglobin (https://www.researchgate.net/figure/Metabolic-Pathway-of-the-Degradation-of-Heme-and-the-Formtion-of-Bilirubin-Heme

Globin Chains

Heme: The heme component of hemoglobin is where the iron atom is located. When hemoglobin is degraded, heme is separated from globin. The iron atom released from heme is either recycled or stored as ferritin or hemosiderin in the body.

Biliverdin and Bilirubin: Heme is metabolized into biliverdin, which is rapidly converted into bilirubin. Bilirubin is released into the bloodstream and eventually transported to the liver, where it undergoes further processing and is eventually excreted in bile.

Q21. Which of the following best describes methemoglobinemia?

Methemoglobinemia is a condition where hemoglobin in the blood is oxidized to form methemoglobin, which is unable to bind oxygen effectively

(A) F - Hemoglobin is converted to methemoglobin which cannot bind oxygen effectively. So Methemoglobinemia decreases the oxygen-carrying capacity of blood.
(B) F - Methemoglobinemia does not occur due to iron deficiency. Instead, it is caused by the oxidation of iron with hemoglobin from its normal ferrous state to the ferric state
(C) T - The oxidation of iron from Fe2+ to Fe3+ changes normal oxygen structure making it unable to bind oxygen effectively

(D) F - Methemoglobinemia primarily affects oxygen transport rather than influencing CO2 transport

(E) F - Impaired production of red blood cells due to genetic mutations such as thalassemia sickle cell disease can indirectly affect oxygen transport but typically do not cause methemoglobinemia.

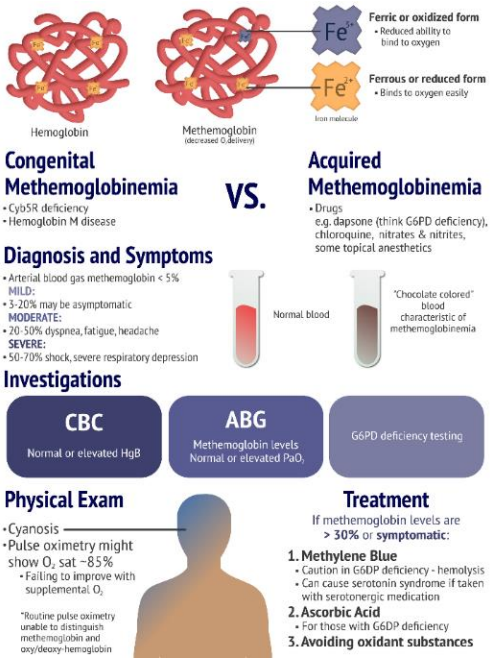


Figure 24-Methamoglobinemia (https://www.theinternatwork.com/infographics-2/2021/10/31/methamoglobinemia

Q22. Which of the following statements accurately describes the characteristics of the eukaryotic nucleus?

(A) F - While the main nuclear genome in eukaryotes is composed of linear chromosomes, certain exceptions exist. For example, some organisms, such as certain yeasts, have circular chromosomes in addition to linear ones

(B) T - The double membrane structure of the nucleus, consisting of the outer and inner nuclear membranes, is a defining feature of eukaryotic cells. It provides a protective boundary around the genetic material and regulates molecular traffic between the nucleus and the rest of the cell.

(C) T - Eukaryotic ribosomes are integral to the process of protein synthesis, translating the genetic code from mRNA into functional proteins that are essential for the structure and function of cells.

(D) F – The Nucleus of eukaryotic cells is central to gene expression, housing the processes of transcription and

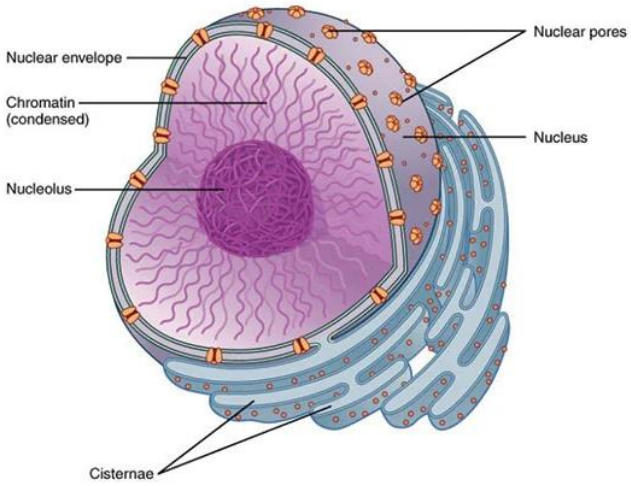


Figure 25-Structure of nucleus (https://simple.wikipedia.org/wiki/Nuclear_membrane

RNA processing that are essential for the production of functional proteins required for cellular structure and function.

(E) T - Nuclear division (mitosis and meiosis) is a fundamental process in the eukaryotic cell cycle, crucial for growth, development, and reproduction. It involves precise coordination of events within the nucleus to ensure the faithful transmission of genetic information to subsequent generations of cells.

Q23. Which of the following statements about polysaccharides is correct?

(A) F - Cellulose is actually a structural polysaccharide found in plants and some other organisms. It provides rigidity and strength to cell walls and is not used as a storage molecule in animals.

(B) T - Glycogen is a storage polysaccharide in animals, primarily stored in the liver and skeletal muscles. It serves as a readily mobilizable form of glucose, helping to maintain blood glucose levels and provide energy during times of need.

(C) F - Chitin does indeed contain glucose monomers, but they are linked by 1,4 glycosidic bonds of N-acetylglucosamine (GlcNAc) units, not regular glucose units.

(D) F - Amylopectin is a branched polymer of glucose molecules. It is a component of starch, alongside amylose. Amylopectin has α-1,4 glycosidic bonds forming linear chains of glucose units, but it also has α-1,6 glycosidic bonds that create branch points in the molecule. These branch points give amylopectin its characteristic branched structure.

(E) T - Cellulose provides rigidity and strength to plant cell walls

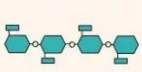
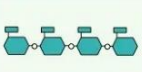
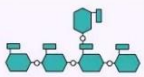
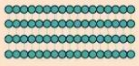
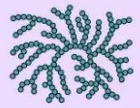
	Cellulose	Starch		Glycogen
		Amylose	Amylopectin	
Source	Plant	Plant	Plant	Animal
Subunit	β-glucose	α-glucose	α-glucose	α-glucose
Bonds	1-4	1-4	1-4 *and* 1-6	1-4 *and* 1-6
Branches	No	No	Yes (~per 20 subunits)	Yes (~per 10 subunits)
Diagram				
Shape				

Figure 26-Differences between polysaccharides
(https://coredefferences.com/defference-between-cellulose-starch-and-glycogen/)

Q24. Which of the following statements about Golgi bodies (Golgi apparatus) is correct?

(A) F - Golgi bodies (or Golgi apparatus) are not responsible for cellular respiration. Cellular respiration typically occurs in the mitochondria (in eukaryotic cells) or the cytoplasm (in prokaryotic cells).

(B) F - Golgi bodies (or Golgi apparatus) do not primarily synthesize proteins. Protein synthesis primarily occurs in the rough endoplasmic reticulum (ER), where ribosomes attached to the ER membrane synthesize proteins using instructions encoded in RNA molecules.

(C) T - Their main function is to modify, sort, and package proteins and lipids that are synthesized elsewhere in the cell, such as the endoplasmic reticulum (ER). The Golgi apparatus processes these molecules by adding molecular tags (like carbohydrates) and sorting them into vesicles that transport them to specific destinations

(D) F - They are membrane-bound organelles present in both plant and animal cells, though their structure and function can vary slightly between the two.

(E) F - Golgi bodies (Golgi apparatus) do not store genetic information. Genetic information in eukaryotic cells is primarily stored in the nucleus in the form of DNA molecules organized into chromosomes.

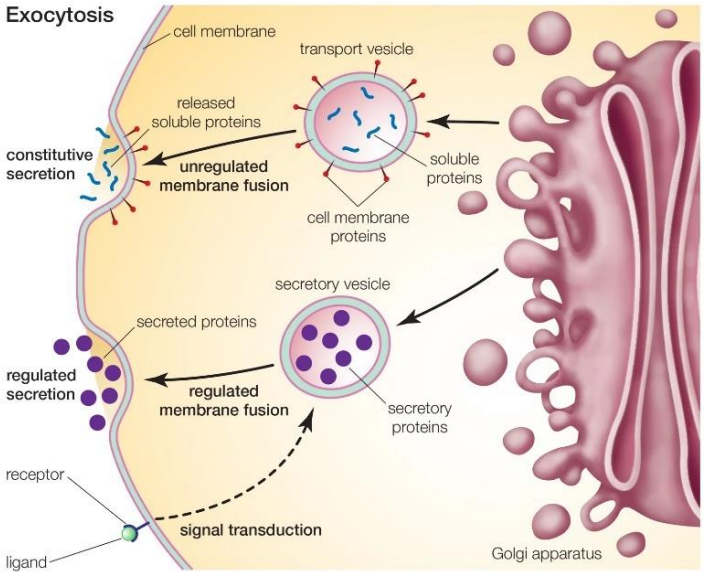


Figure 27-Functions of Golgi apparatus (https://www.slideshare.net/slideshow/3cell-transport-mechanismsppt/)

Q25. Which of the following accurately describes the role of lipoprotein lipase in lipid metabolism?

(A) F - Lipoprotein lipase (LPL) is an enzyme primarily involved in hydrolyzing triglycerides (TG) from circulating lipoproteins (such as chylomicrons and very low-density lipoproteins) into fatty acids and glycerol. This process occurs at the surface of endothelial cells lining blood vessels, particularly in adipose tissue and skeletal muscle.

(B) T - Lipoprotein lipase (LPL) indeed hydrolyzes triglycerides (TG) from circulating lipoproteins, such as chylomicrons and very low-density lipoproteins (VLDLs), releasing fatty acids and glycerol.

(C) F - Lipoprotein lipase (LPL) does not convert cholesterol into bile acids in the liver. The process of converting cholesterol into bile acids primarily occurs in the liver through a series of enzymatic reactions involving several enzymes and transporters, but not LPL.

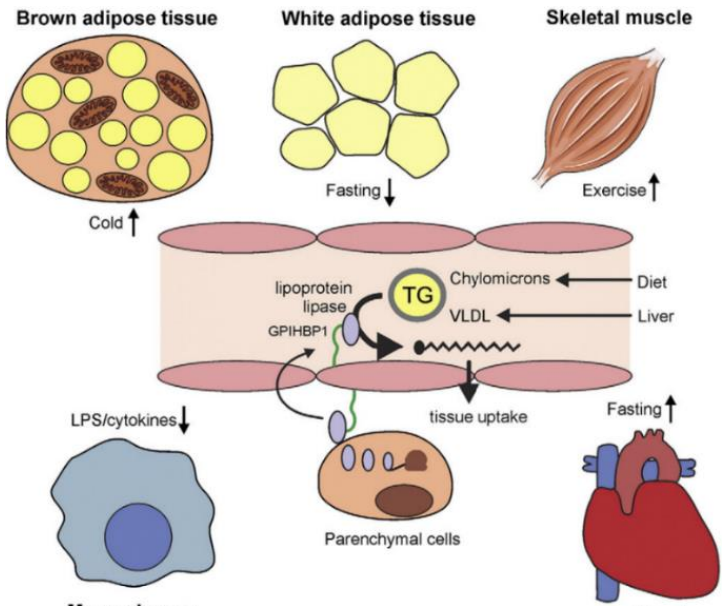


Figure 28-Functions of lipoprotein lipase (https://www.sciencedirect.com/science/article/pii/S1388198114000663)

(D) F - While LPL is crucial for lipid metabolism by facilitating the breakdown of triglycerides, it does not transport lipids across cell membranes. Instead, it acts at the surface of endothelial cells to release fatty acids from circulating lipoproteins, enabling their cellular uptake.

(E) T - The liver's multifaceted role in lipid metabolism ensures the maintenance of lipid homeostasis throughout the body, impacting energy metabolism, hormone production, and overall health.

Q26. Which of the following statements about pH and buffers is correct?

(A) F - pH of 7.0 is neutral, not acidic or basic.

(B) T - The function of buffers is to maintain a relatively stable pH by neutralizing acids or bases that are added to the solution.

(C) F - Temperature changes do not always affect the effectiveness of buffers; some buffers may work better at higher temperatures.

(D) F - Buffers play a crucial role in biological systems, maintaining stable pH levels necessary for enzymatic activity and cellular function.

(E) F - Decreasing temperature reduces its effectiveness. But not always.

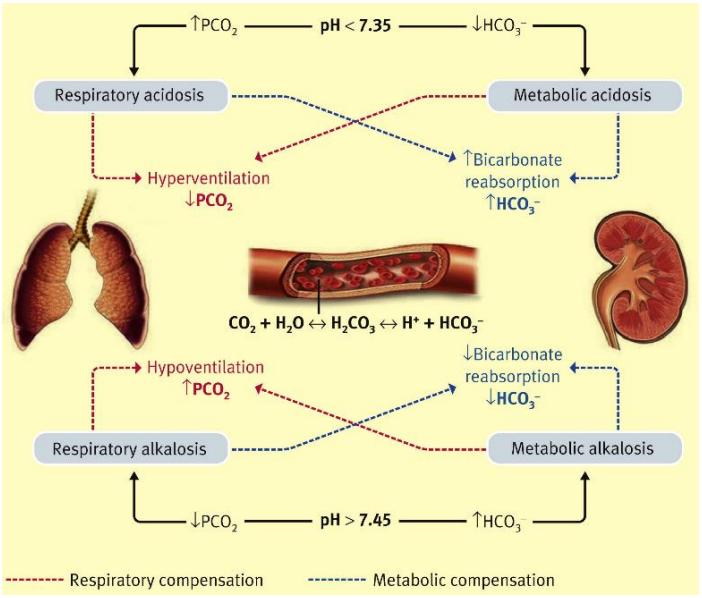


Figure 29-Buffering mechanisms (www.paediatricsandchild-healthjournal.co.uk/article/S1751-7222%2811%2900221-6/fulltext

Q27. An enzyme catalyzes the conversion of substrate S to product P. Which of the following statements are true regarding enzyme activity?

(A) T - Enzyme activity is highest when substrate concentration is lower than enzyme concentration because at lower substrate concentrations, all enzyme molecules can readily bind to substrate molecules, leading to maximum reaction rates. As substrate concentration increases and approaches enzyme concentration, the enzyme active sites become saturated, leading to no further increase in reaction rate (Vmax is reached).

(B) F - Competitive inhibitors decrease enzyme activity by reversibly binding to the enzyme's active site, thereby competing with the substrate for binding. They do not irreversibly bind and can be displaced from the active site under certain conditions, allowing the enzyme to regain its activity.

(C) F - While increasing temperature generally increases enzyme activity up to a point (the optimal temperature), further increases can lead to decreased activity due to enzyme denaturation.

(D) T - pH affects enzyme activity primarily by altering the ionization states of amino acid side chains within the enzyme molecule, thereby influencing the enzyme's ability to bind substrate and catalyze reactions effectively. This sensitivity to pH is crucial for enzymes to function optimally in their specific biological environments.

(E) F - Cofactors play crucial roles in enzyme function and activity. Enzymes often require specific cofactors to achieve their full catalytic potential.

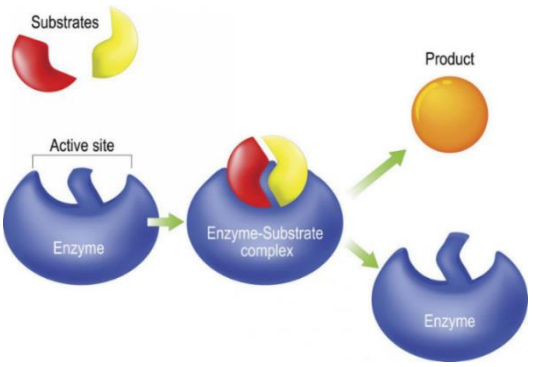


Figure 30-Lock and key hypothesis (https://www.researchgate.net/figure/Figure-2-Clarifies-the-lock-and-key-hypothesis)

Q28. Cyanide is poisonous because of its,

The answer is C

(A) Cyanide does not form a complex with hemoglobin. It interferes with cellular respiration rather than oxygen transport in the blood.

(B) Cyanide does not combine with the erythrocyte membrane. Its toxicity is not due to affecting red blood cells directly.

(C) Cyanide is highly toxic because it inhibits cytochrome c oxidase, an enzyme in the electron transport chain in mitochondria. This inhibition prevents cells from using oxygen to produce ATP, leading to cell death.

(D) Cyanide does not inhibit myoglobin. Myoglobin is involved in oxygen storage in muscles, but cyanide's toxicity is more related to mitochondrial processes rather than muscle oxygen storage.

(E) Cyanide does not block oxygen transport in the blood; instead, it prevents cells from utilizing oxygen effectively, even though oxygen is still carried in the blood.

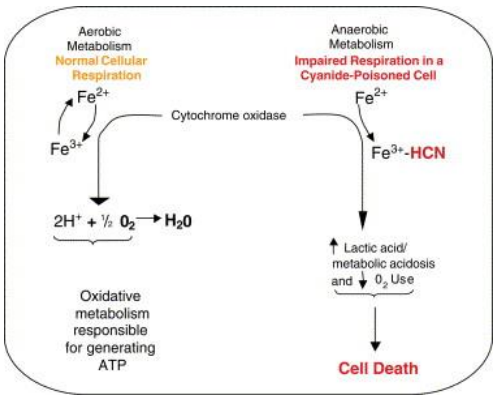


Figure 32-Mechanism of cyanide poisoning (https://www.jenonline.org/article/S0099-1767(06)00271-6/fulltext)

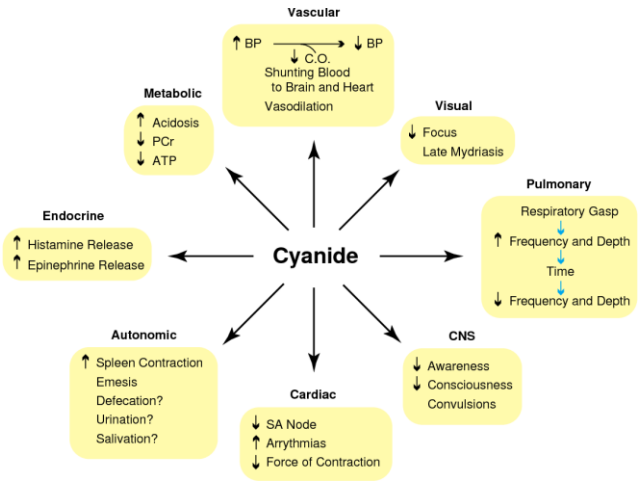


Figure 31-Pharmacodynamics in cyanide poisoning (https://slideplayer.com/slide/7229851/)

Q29. In the context of plasma proteins, which of the following statements regarding fibrinogen is correct?

(A) T - The liver produces fibrinogen and secretes it into the bloodstream, where it plays a key role in the coagulation process by forming a fibrin mesh that helps stabilize blood clots.

(B) F - Specifically, it is a blood plasma protein that gets converted into fibrin during the clotting process. The enzyme responsible for this conversion is thrombin. Thrombin catalyzes the conversion of fibrinogen into fibrin.

(C) T - Fibrinogen is classified as an acute-phase protein, which means its levels increase in response to inflammation.

(D) F - Fibrinogen can influence the immune response by aiding in the formation of a fibrin clot, which helps contain infections and facilitates tissue repair. It can also interact with other immune system components, but its main role is in blood clotting and inflammation rather than direct antigen clearance.

(E) F - The main proteins responsible for maintaining osmotic balance in the blood are albumin and other plasma proteins. Albumin, in particular, helps regulate the osmotic pressure of blood, ensuring proper fluid balance between blood vessels and tissues. While fibrinogen does contribute to blood volume and viscosity, its primary function is to participate in the coagulation process and inflammation.

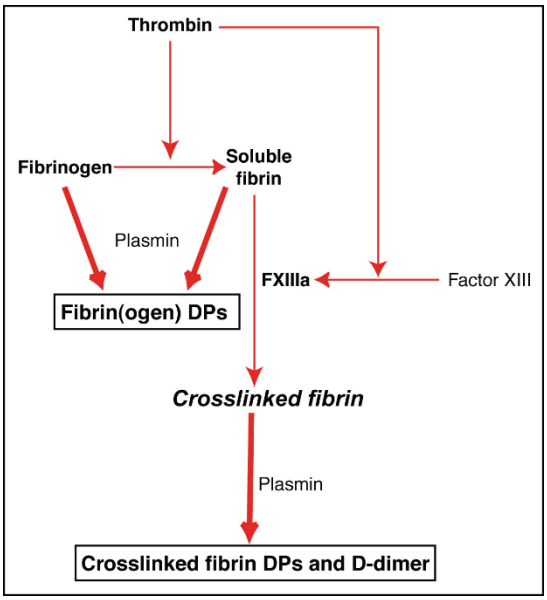


Figure 33-Action of fibrinogen (https://eclinpath.com/dd_fdps/)

Q30. In competitive inhibition,

(A) F - In competitive inhibition, the total concentration of enzyme remains unchanged; instead, the inhibitor competes with the substrate for the active site.

(B) F - Vmax remains the same in competitive inhibition because if enough substrate is present, it can outcompete the inhibitor.

(C) T - The concentration of the enzyme itself does not change; it's the availability of the active site that is affected.

(D) T - In competitive inhibition, the apparent Km (Michaelis constant) increases because more substrate is needed to reach half of Vmax due to the presence of the inhibitor.

(E) F - This statement contradicts the effect of competitive inhibition; the apparent Km actually increases.

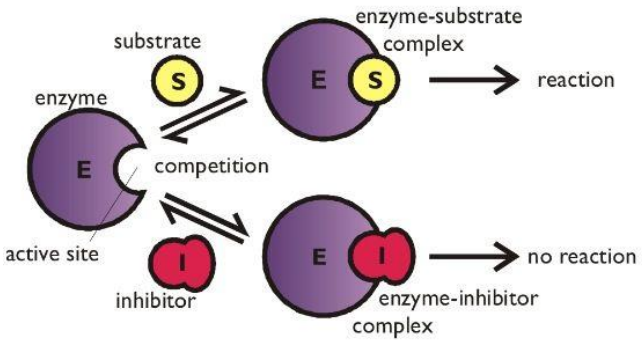


Figure 34-Competitive inhibition (https://www.pinterest.com/pin/81768549470787502/)

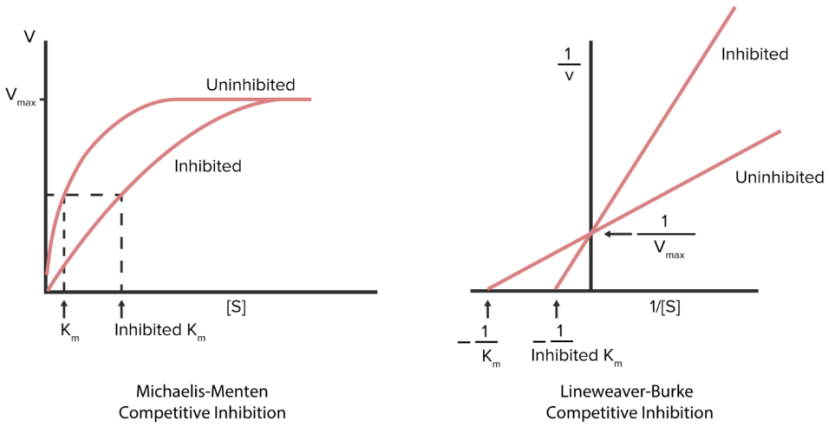


Figure 35-Competitive inhibition
(https://www.slideshare.net/slideshow/biologial-d-234pdfy7ttyytyyt7iyfgiyyyy/267146794)

Q31. Which of the following statements accurately describes the role and characteristics of ribosomal RNA (rRNA) in eukaryotic cells?

(A) F - rRNA is synthesized in the nucleolus, not the cytoplasm, and while it plays a role in translation, it does not directly regulate mRNA stability.
(B) T - rRNA is indeed transcribed in the nucleolus of eukaryotic cells.
(C) F - rRNA is not a template for DNA replication; it functions in protein synthesis and is found in ribosomes throughout the cytoplasm and on the rough endoplasmic reticulum, not just in mitochondria.
(D) F - While rRNA is synthesized in the nucleus, it does not carry amino acids; that role is fulfilled by tRNA.
(E) T - rRNA is a key structural component of ribosomes and is essential for their function in protein synthesis.

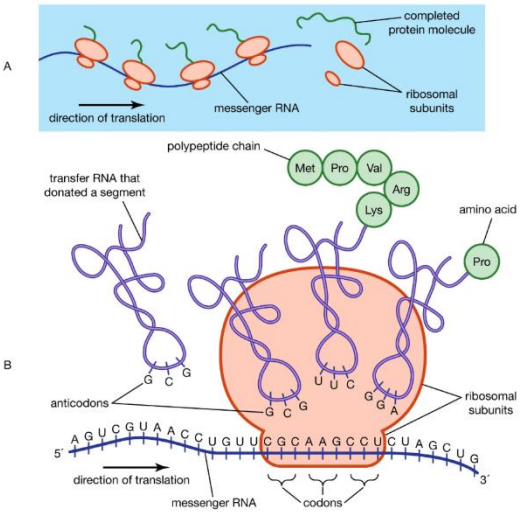


Figure 36-Function of ribosomal RNA
(https://www.britannica.com/science/protein/General-structure-and-properties-of-proteins)

Q32. A patient was brought to the hospital with an acute intoxication of wood alcohol. Inhibition of which enzyme is the most beneficial in his management.

(A) F - This enzyme is not directly involved in the metabolism of wood alcohol (methanol).
(B) T - Inhibiting alcohol dehydrogenase can prevent the conversion of methanol to toxic metabolites like formaldehyde, making it beneficial in managing methanol intoxication.
(C) F - This enzyme is not primarily related to the metabolism of alcohols and is not relevant in methanol intoxication.

(D) F - This enzyme metabolizes acetaldehyde, a product of ethanol metabolism, not methanol.
(E) F - This enzyme is involved in glycolysis and is not directly related to the management of methanol intoxication.

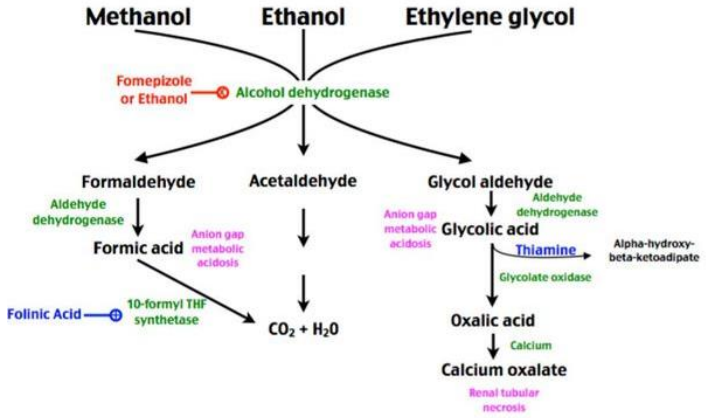


Figure 37-Alcohol metabolism
(https://www.pinterest.com/pin/533465518344704660/)

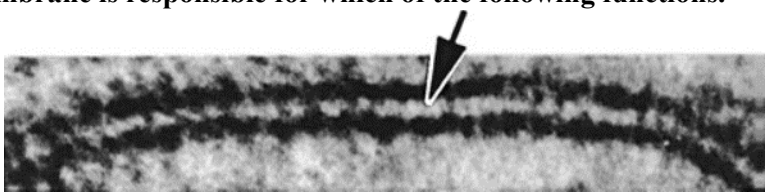
BIOCHEMISTRY TUTORIALS & ANSWERS

1. **COURSE 1 – CELL BIOCHEMISTRY**
2. **COURSE 2 – BIOMOLECULES**
3. **COURSE 3 – FUNCTIONAL ASPECTS OF PROTEIN**

COURSE 1 – CELL BIOCHEMISTRY

Cell Structure and Function

1. The region labeled with the arrow in the accompanying electron micrograph of the plasma membrane is responsible for which of the following functions.



a. Creation of a barrier to water-soluble molecules
b. Specific cellular receptors for ligands
c. Catalyzing membrane-associated activities
d. Transport of small ions
e. Connections to the cytoskeleton

The answer is A.

The hydrophobic layer of the cell (plasma) membrane is labeled with the arrow. It is responsible for the fundamental structure of the membrane and provides the barrier to water-soluble molecules in the external milieu. It also provides a two-dimensional solvent for membrane proteins. Other membrane functions are performed primarily by proteins that function as receptors, enzymes (catalysis of membrane-associated activities), and transporters (answers b, c, and d). Connection to the cytoskeleton (answer e) is performed by members of the spectrin family of proteins reinforcing the membrane on the cytosolic side.

The membrane consists of a bilayer of phospholipids with the nonpolar, hydrophobic layer in the central portion of the membrane and the hydrophilic polar regions of the phospholipids in contact with the aqueous components at the intra- or extracellular surfaces of the membrane. Proteins are generally dispersed within the lipid bilayer. The polar head groups of the lipid bilayer react with osmium to create the tri-laminar appearance observed in electron micrographs of the plasma membrane. Cell membranes range in thickness from 7 to 10 nm [1nm = 10–9 m, 1 μm = 10–6 m; the diameter of a red blood cell (erythrocyte) is 7 μm].

2. Which of the following establishes the asymmetry of the cell membrane?

a. Membrane synthesis in the endoplasmic reticulum
b. Membrane modification in the Golgi apparatus
c. Presence of carbohydrates on the cytoplasmic surface
d. The distribution of cholesterol
e. Flipping proteins between the leaflets of the lipid bilayer

The answer is A.

Asymmetry of the lipid bilayer is established during membrane synthesis in the endoplasmic reticulum (answer a) before reaching the Golgi apparatus (answer b). Carbohydrates are associated with the N terminals of transmembrane proteins that extend from the extracellular surface, not the cytoplasmic surface (answer c). Cholesterol is different from proteins and phospholipids that are asymmetrically distributed within the bilayer (answer d). Cholesterol is found on both sides of the bilayer. The small polar head group structure of cholesterol allows it to flip-flop from leaflet to leaflet and respond to changes in shape. In contrast to cholesterol, most proteins and phospholipids are capable of only rare flip-flops (answer e). For example, trans bilayer movement of phospholipid is limited mostly to the endoplasmic reticulum.

3. Which of the following is the function of the large subunit of the ribosome?

a. Bind messenger RNA (mRNA)
b. Bind transfer RNA (tRNA)
c. Catalyze peptide bond formation
d. Link adjacent ribosomes in a polyribosome
e. Initiate protein synthesis

The answer is C. (Alberts, pp 343–346. Ross and Pawlina, p 46.)

The large subunit of the ribosome catalyzes peptide bond formation by activation of peptidyl transferase. The small ribosomal subunit contains the peptidyl-tRNA-binding (P) site that binds the tRNA molecule (answer a) attached to the carboxyl end of the growing end of the polypeptide chain. The small subunit also contains the aminoacyl-tRNA-binding (A) site that holds the incoming tRNA and amino acid. The initiation factors are loaded on the small ribosomal subunit that must locate the AUG (start) codon to initiate protein synthesis. This occurs before the binding of the large subunit.

In addition, the initiator tRNA containing methionine provides the amino acid necessary to start protein synthesis. The initiator tRNA is also located on the small subunit. It resides at the P site (the normal peptidyl site) even though it is an aminoacyl-tRNA. This occurs before binding to the mRNA (answer b). Therefore, the initiation phase of protein synthesis is regulated by the small subunit of the ribosome (answer d). Ribosomes are composed of both protein and RNA (predominantly rRNA, but also mRNA and tRNA). Single ribosomes are involved in the synthesis of cytosolic proteins. Polyribosomes, linked by mRNA (answer e), synthesize proteins that are translocated into the cisternal space of the rough endoplasmic reticulum (RER) and destined for export or specific organelles.

4. The stability and arrangement of actin filaments as well as their properties and functions depend on which of the following?

a. The structure of the actin filaments
b. Microtubules
c. Intermediate filament proteins
d. Actin-binding proteins
e. Motor molecules, such as kinesin

The answer is D.

The stability, arrangement, and functions of actin filaments depend on the actin-binding proteins. The fundamental structure of the actin molecule is the same no matter what the function or arrangement in

a cell. Actin-binding proteins have a variety of functions: (1) tropomyosin strengthens actin filaments, (2) fibrin and villin are actin-bundling proteins, (3) filamin and gelsolin regulate transformation from the sol to the gel state, (4) members of the myosin II family are responsible for sliding filaments, (5) myosin I (mini myosin) is responsible for movement of vesicles on filaments, and (6) spectrin cross-links the sides of actin filaments to the plasma membrane.

5. Which of the following mechanisms is used to establish the mitochondrial electrochemical gradient?

a. The action of ATP synthase
b. Transfer of electrons from NADH to O2 in the intermembrane space
c. Pumping of protons into the mitochondrial matrix by respiratory chain activity
d. Proton-translocating activity in the inner membrane
e. Transport of ATP out of the matrix compartment by a specific transporter

The answer is D.

The mitochondrial electrochemical gradient is established by a proton pump. The pump is located in the inner membrane, associated with the respiratory chain and ATP synthase. The impermeability of the inner membrane to protons causes an osmotic and electrochemical gradient to develop. Mitochondria produce energy that the cell uses in transport and other energy-dependent processes. Cellular energy is stored as ATP, which is synthesized by the phosphorylation of ADP by ATP synthase (answer a). Mitochondria use the electron-transport (respiratory) chain that transfers energy from NADH to O2 (answer b). As electrons released by oxidation of substrate in the matrix flow down the respiratory chain, hydrogen ions are pumped into the intermembrane space (answer c). Protons in the matrix drive ATP synthase in a mechanism similar to that of a waterwheel. ATP synthase, therefore, couples oxidative transport through the electron-transport (respiratory) chain with energy storage (ATP). ATP is not transported out of the matrix compartment by a specific transporter (answer e).

6. Endocytosis of low-density lipoprotein (LDL) differs from phagocytosis of damaged cells in which of the following?

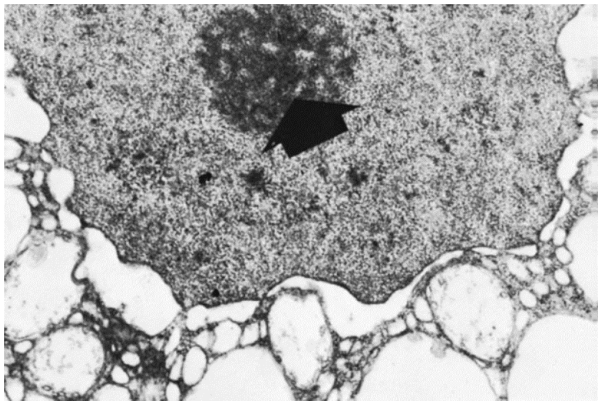
a. Use of membrane-enclosed vesicles in the uptake process
b. Coupling with the lysosomal system
c. Dependence on acidification
d. Use of clathrin-coated pits
e. Use of hydrolases

The answer is D.

Receptor-mediated endocytosis of ligand-receptor complexes is a selective process that requires invagination of the cell membrane to form clathrin-coated pits and vesicles. Clathrin is not involved in phagocytosis. Phagocytosis of damaged cells occurs by evagination to engulf the IgG-coated surface of the target. Both processes use acidification of compartments and hydrolases to uncouple receptors and ligands (receptor-mediated endocytosis) or destroy engulfed material (phagocytosis). Both processes use membrane-enclosed vesicles and are associated with lysosomal activity (answers a, b, c, and e). Low-density lipoprotein (LDL) is the form in which most cholesterol is transported in the blood; cellular

uptake of LDL is the classic example of receptor-mediated endocytosis. The receptors are bound to clathrin-coated pits, but the ligand is only directly bound to its cell surface receptor. The LDL-LDL receptor (ligand-receptor) complexes are incorporated into the cell in coated vesicles. The acidic environment of the endosome results in the cleavage of the ligand from its receptor (i.e., LDL from its receptor). The LDL receptors are recycled to the membrane for additional exposure to LDL, and the LDL in the endosome is transferred to lysosomes, where it is broken down to cholesterol. Other ligands differ in subtle ways from LDL in their endocytic pathways.

7. A newborn boy is born with first arch congenital malformations classified as Treacher-Collins syndrome, which is an autosomal dominant inherited disorder. The Treacher Collins-Franceschetti syndrome 1 (TCOF) gene encodes the protein treacle. Treacle is localized to the structure labeled with the arrows in the accompanying transmission electron micrograph. Treacle is most likely involved in which of the following?



a. Assembly of ribosomal subunits into mature ribosomes
b. Translation of cytosolic proteins
c. Transcription of nuclear proteins
d. Transcription of ribosomal proteins
e. Organelle degradation

The answer is D.

The TCOF1 gene encodes treacle. Expression of treacle is critical during early embryonic development in structures that form bones and other facial structures. Treacle is active in the nucleolus, the structure labeled in the transmission electron micrograph. The nucleolus is the site of ribosomal protein transcription and treacle regulates ribosomal DNA transcription and therefore ribosomal RNA (rRNA) synthesis. The nucleolus is a highly organized, heterogeneous structure within the nucleus, with distinct regions visible by electron microscopy: (1) fibrillar centers, which represent the nucleolar organizer regions where DNA is not being actively transcribed; (2) dense fibrillar components (pars fibrosa) where RNA molecules are being transcribed; and (3) a granular component (pars granulosa) where ribosomal subunits undergo maturation. The nucleolar organizer contains clusters of rRNA genes (DNA). The size and number of nucleoli differ with the metabolic activity of cells. Ribosomal synthesis occurs in the nucleolus, but the complete assembly and maturation of ribosomes requires transport to the cytoplasm (answer a). Ribosomal proteins as well as all proteins that function in the nucleus are synthesized in the cytosol and transported into the nucleus (answer b). Nuclear proteins are also translated on ribosomes in the cytoplasm (answer c) and targeted to the nucleus (traveling through the

nuclear pores) by specific nuclear localization signals (NLSs). Cytosolic proteins are synthesized on isolated ribosomes compared with most protein synthesis that occurs on polyribosomes. Nuclear proteins are transcribed on euchromatin (answer c). Lysosomes carry out the degradation of organelles (answer e).

8. Which of the following molecules forms the coating of vesicles involved in the transport of secretory vesicles from the trans-Golgi network (TGN) to targets?

a. Clathrin
b. Spectrin
c. Ankyrin
d. Actin
e. Vimentin
f. COP I
g. COP II

The answer is A.

Clathrin is an important protein that forms the coating of secretory vesicles transported from the TGN to targets and coated pits and vesicles involved in endocytosis. It is involved in the retrieval of membranes following exocytosis. Spectrin heterodimers (answer b) form tetramers that interact with actin and provide flexibility and support for the membrane. The protein ankyrin (answer c) "anchors" the band 3 protein to the spectrin-membrane skeleton indirectly binding band 3 protein to the cytoskeleton (spectrin tetramers) of the red blood cell (RBC). The band 3 protein is known to be an anion transport protein of the RBC. Actin (answer d) is the protein found in thin filaments in the RBC cytoplasm. Intermediate filaments are important cytoskeletal elements with specificity that depend on the origin of the cells in question. Vimentin (answer e) is specific for cells derived from mesenchyme, e.g., fibroblasts and chondrocytes. COP-I (COat Protein-I) coats vesicles involved in retrograde transport from Golgi→RER (answer f). COP-II is the coat protein for vesicles transported in an anterograde direction from the RER→Golgi (answer g).

Defects in Cellular Organelles and Cell Membranes that Lead to Diseases

1. **Defects in cellular organelles and cell membranes can lead to a variety of diseases due to the disruption of essential cellular processes. Cellular organelles such as the mitochondria, endoplasmic reticulum (ER), lysosomes, and Golgi apparatus play vital roles in energy production, protein folding, waste degradation, and lipid transport. Similarly, the cell membrane regulates the entry and exit of substances, maintains cell integrity, and facilitates cell signaling.**

1.1 How do defects in cell membranes affect cellular function and homeostasis? (10 marks)

Defects in cell membranes can severely impact cellular function and homeostasis. They disrupt selective permeability, leading to ion imbalances and nutrient deficiencies, which hinder energy production and protein synthesis. Cell signaling is compromised due to impaired receptor function and breakdowns in cell-to-cell communication, affecting tissue and organ function. Structural integrity is also compromised, making cells more prone to rupture and weakening interactions with the cytoskeleton, which impacts cell shape and movement.

Homeostasis is altered as defects cause osmotic imbalances, leading to cells swelling or shrinking, and disrupting pH regulation, affecting enzyme activity. Additionally, defective membranes increase susceptibility to pathogens and toxins by compromising the barrier function and impairing interactions with immune cells. Energy production is disrupted when mitochondrial membranes are affected, leading to ATP production issues and energy deficits. Finally, these defects can trigger inappropriate apoptotic signaling, leading to unnecessary cell death, and cause necrosis, resulting in uncontrolled cell death and inflammation.

Overall, membrane defects can lead to significant health issues and diseases by impairing vital cellular processes and disrupting homeostasis.

1.1.2 What are the implications of mutations in the gene encoding LDL receptors, and how do these mutations contribute to the development of familial hypercholesterolemia? (20 marks)

Mutations in the gene encoding low-density lipoprotein (LDL) receptors have significant implications for cholesterol metabolism, primarily leading to familial hypercholesterolemia (FH). These mutations reduce the number or functionality of LDL receptors, which are crucial for removing LDL cholesterol from the bloodstream. As a result, blood LDL levels increase, raising the risk of cholesterol deposition in arteries and subsequent atherosclerosis. FH, an autosomal dominant disorder, arises from these genetic mutations, causing significantly elevated LDL cholesterol levels. Heterozygous individuals (one mutated gene copy) have LDL levels two to three times higher than normal, while homozygous individuals (both gene copies mutated) experience even higher levels. The mutations can lead to reduced receptor expression, defective receptor processing, impaired LDL binding, or faulty internalization, each contributing to the elevated LDL levels and increased cardiovascular risk seen in FH.

Clinically, FH manifests as extremely high LDL cholesterol from an early age, with signs like xanthomas and a high risk of premature cardiovascular disease. Management focuses on aggressively lowering LDL levels through lifestyle changes, medications such as statins, ezetimibe, and PCSK9 inhibitors, and in severe cases, advanced therapies like LDL apheresis or liver transplantation.

1.1.3 What is the genetic basis of achondroplasia, and how do mutations in the FGFR3 gene lead to the characteristic features of this condition? (20 marks)

Achondroplasia is a genetic disorder caused by mutations in the FGFR3 gene, which encodes the fibroblast growth factor receptor 3. This receptor plays a crucial role in regulating bone growth by inhibiting the proliferation of chondrocytes, the cells responsible for cartilage formation. In achondroplasia, a specific point mutation in the FGFR3 gene leads to a gain-of-function alteration, resulting in an overly active receptor. This hyperactivity excessively inhibits chondrocyte proliferation and cartilage formation, impairing normal bone growth and leading to the characteristic features of the condition, such as short stature, disproportionately short limbs, and other skeletal abnormalities. Achondroplasia is inherited in an autosomal dominant pattern, meaning a single copy of the mutated gene can cause the disorder.

1.2.1 How do mutations in the CFTR gene lead to the pathophysiology of cystic fibrosis, and what are the current therapeutic approaches to manage this condition? (15 marks)

Mutations in the CFTR (cystic fibrosis transmembrane conductance regulator) gene cause cystic fibrosis by disrupting the function of the CFTR protein, which regulates the movement of chloride ions across cell membranes. This disruption leads to thick, sticky mucus buildup in various organs, particularly the lungs and digestive system, causing respiratory infections, lung damage, and digestive issues. The thick mucus also obstructs pancreatic enzyme release, impairing digestion and nutrient absorption. Current therapeutic approaches to manage cystic fibrosis include airway clearance techniques, inhaled medications to thin mucus, antibiotics to treat infections, pancreatic enzyme supplements, and CFTR modulators like ivacaftor, lumacaftor, and tezacaftor, which help improve the function of the defective CFTR protein. Emerging gene therapies and precision medicine are also being explored to target the underlying genetic causes of the disease.

1.2.2 What are the molecular mechanisms and clinical consequences of defects in copper transporters, such as those observed in Wilson's disease and Menkes disease? (15 marks)

Defects in copper transporters lead to distinct molecular mechanisms and clinical consequences in Wilson's disease and Menke's disease. Wilson's disease is caused by mutations in the ATP7B gene, impairing copper transport into the bile for excretion, leading to copper accumulation in the liver, brain, and other tissues. This results in liver disease, neurological symptoms, and psychiatric issues. Conversely, Menkes disease arises from mutations in the ATP7A gene, which disrupts copper absorption and distribution throughout the body, causing severe copper deficiency. This leads to developmental delays, connective tissue disorders, neurological degeneration, and characteristic kinky hair.

Both conditions highlight the critical role of copper homeostasis, with Wilson's disease managed through copper chelation therapy and zinc supplementation to reduce copper levels, and Menkes disease requiring early copper injections to mitigate copper deficiency effects.

1.2.3 What is the underlying cause of Inclusion-Cell (I-Cell) Disease, and how do defects in the trafficking of lysosomal enzymes lead to the characteristic features and clinical manifestations of this condition? (20 marks)

Inclusion-Cell (I-Cell) Disease, also known as mucolipidosis II, is caused by mutations in the GNPTAB gene, which encodes the enzyme N-acetylglucosamine-1-phosphotransferase. This enzyme is crucial for tagging lysosomal enzymes with mannose-6-phosphate, a marker that directs them to the lysosomes.

Without this tag, lysosomal enzymes are misdirected and secreted outside the cell instead of being delivered to lysosomes. Consequently, lysosomes lack the necessary enzymes to break down complex molecules, leading to the accumulation of undegraded substrates, forming inclusion bodies within cells. This disruption in cellular waste processing results in the characteristic features of I-Cell Disease, including severe developmental delays, growth impairment, coarse facial features, skeletal abnormalities, and organomegaly. The clinical manifestations are primarily due to the dysfunctional lysosomal degradation and the resultant cellular and tissue damage.

Transport across the membranes

1. What are the two main components of cell membranes?

a. Proteins and cellulose
b. Cellulose and lipids
c. Phospholipids and proteins
d. Glycoproteins and cellulose

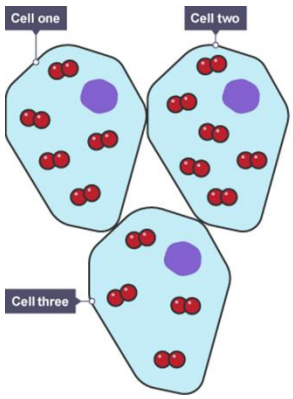
The answer is C

2. A glucose molecule diffuses out of a cell through the selectively permeable cell membrane. What is this an example of?

a. Active transport
b. Osmosis
c. Passive transport
d. Diffusion

The answer is B

3. The diagram shows three animal cells. Pairs of red circles represent oxygen molecules.

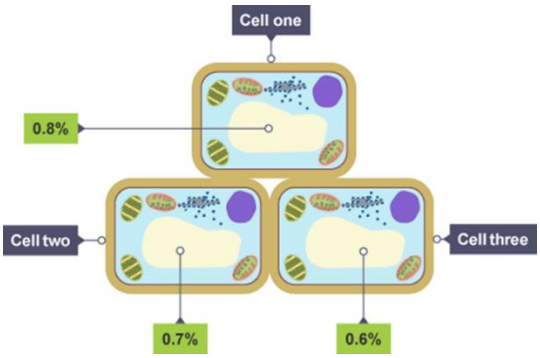


Which two cells have the highest oxygen concentration gradient?

a. One and two
b. Two and three
c. One and three
d. None of the above

The answer is B

4. The diagram shows three plant cells and the solute concentrations of their cell solutions.



Between which cells will the movement of water by osmosis occur?

a. From three to one
b. From one to two
c. From one to three
d. None of the above

The answer is C

5. What may happen to red blood cells placed in distilled (pure) water?

a. They may burst
b. They may become turgid
c. They may shrink
d. None of the above

The answer is A

6. Which of the following processes requires energy to occur?

a. Osmosis
b. Passive transport
c. Active transport
d. Diffusion

The answer is C

7. Where are peripheral proteins attached?

a. The surface of the cell membrane
b. The rough endoplasmic reticulum
c. The Golgi apparatus
d. The interior of the cell membrane

The answer is A

8. Proteins are not embedded in the cell membrane.

a. True
b. False

The answer is B

9. What structure do Integral/ transmembrane proteins include?

a. Pumps
b. Cell membrane
c. Protein channels and carrier proteins
d. Vesicles

The answer is B

10. What organic compound is often attached to integral proteins?

a. Carbohydrates
b. Proteins
c. Lipids
d. RNA

The answer is A

11. What is the best definition of equilibrium?

a. Slightly higher concentration outside the cell compared to the inside of the cell.
b. Equal amounts of a cell in different parts of an organism.
c. Equal concentrations of a substance inside and outside of the cell.
d. Slightly lower concentration inside the cell compared to the outside of the cell.

The answer is C

12. What is one of the most important ways in which cells maintain homeostasis?

a. Keeping the amount of cytoplasm at a certain level
b. Keeping all the organelles of the cell healthy
c. Controlling what the organelles in the cell do
d. Controlling what moves across the cell membrane

The answer is D

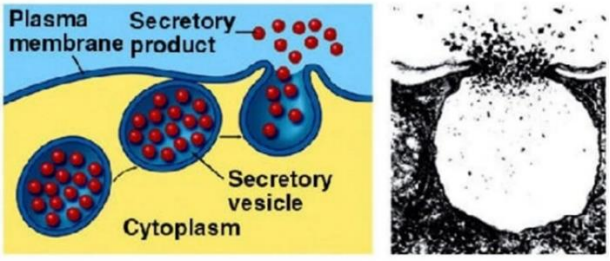
13. What are the three types of passive transport?

a. Simple diffusion, facilitated diffusion, and pumps

b. Exocytosis, endocytosis, pump
c. Exocytosis, endocytosis, osmosis
d. Simple diffusion, facilitated diffusion, and osmosis

The answer is D

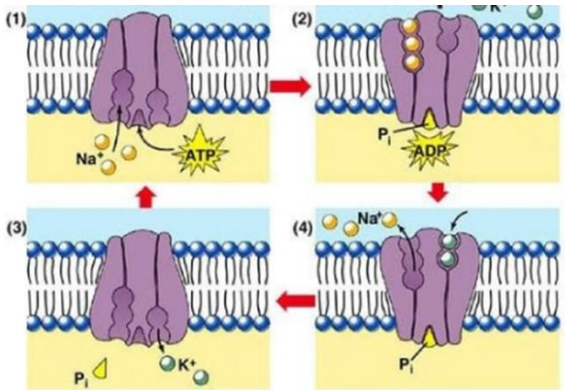
14. The pictures below depict what mode of active transport is used.



a. Endocytosis
b. Exocytosis
c. Pumps
d. The pictures represent a mode of passive transport

The answer is B

15.



What does this illustration represent?

a. Vesicle moving
b. A sodium-Glucose cotransport
c. A sodium-potassium pump
d. None of the above

The answer is C

pH and buffers

1. 20 cm^3 of 0.10 mol dm^{-3} hydrochloric acid is added to 10 cm^3 of 0.10 mol dm^{-3} sodium hydroxide. What is the pH of the resulting mixture?

(A) 1.00

(B) 1.18

(C) 1.30

(D) 1.48

Answer - For HCl:

Number of moles of HCl = concentration × volume = 0.10 mol dm−3 × 20 cm3 = 2 mmol

Number of moles of HCl=concentration × volume=0.10mol dm−3 × 20cm3 = 2mmol

For NaOH:

Number of moles of NaOH = concentration × volume = 0.10 mol dm−3 × 10 cm3 = 1 mmol

Since NaOH is the limiting reactant, it will be fully consumed in the reaction.

Now, let's calculate the moles of HCl left after the reaction:

Moles of HCl left = initial moles − moles reacted with NaOH

Moles of HCl left = 2 mmol – 1 mmol = 1 mmol

So, after the reaction, we have 1 mmol of HCl left in 20 cm^3 of solution. To find the concentration of HCl in the resulting solution,

Concentration of HCl = moles of HCl /volume = 1 mmol / (20 cm3 × 10−3) mol dm−3

Concentration of HCl = 0.05 mol dm−3

Now, we know the concentration of HCl in the resulting mixture. We also know that during the neutralization reaction, HCl reacts with NaOH to form water and sodium chloride:

$$HCl + NaOH \rightarrow NaCl + H2O$$

Since HCl is a strong acid and NaOH is a strong base, the resulting solution will contain sodium chloride (a salt) and water.

To find the pH of the solution, we can use the concentration of the excess HCl to calculate the concentration of H^+ ions in the solution and then find the pH.

The concentration of H^+ ions from the excess HCl is the same as the concentration of the HCl, which is 0.05 mol dm^{-3}.

pH = − log ([H+])

$$pH = -\log(0.05)$$

$$pH = -\log(0.05)$$

$$pH \approx -\log(5 \times 10^{-2})$$

$$pH \approx -\log(5) + 2$$

$$pH \approx 2 - 0.6990$$

$$pH \approx 1.30$$

So, the pH of the resulting mixture is approximately 1.30.

2. Phosphoric acid is a tribasic acid. What is the mass of $Ca(OH)_2$ that completely neutralizes 100 cm^3 of 0.100 mol dm^{-3} phosphoric acid?

(A) 0.49 g

(B) 0.74 g

(C) 1.11 g

(D) 2.22 g

Answer - In the given equation:

$$H_3AsO_4 + H_2O \rightleftharpoons H_2AsO_4^- + H_3O^+$$

We can identify the following species:

H_3AsO_4: Arsenic acid (H_3AsO_4)

- H_2O: Water
- $H_2AsO_4^-$: Dihydrogen arsenate ion ($H_2AsO_4^-$)
- H_3O^+: Hydronium ion

Now, to identify the conjugate acid-base pairs, we need to understand the concept of conjugate acids and bases:

- Conjugate Acid: An acid is a species that donates a proton (H^+ ion). Its conjugate acid is formed when it accepts a proton.
- Conjugate Base: A base is a species that accepts a proton. Its conjugate base is formed when it donates a proton.

In the given equation, we can see the following proton transfer reactions:

i. H_3AsO_4 donates a proton to H_2O to form $H_2AsO_4^-$ and H_3O^+
ii. Here, H_3AsO_4 donates a proton (acts as an acid), and H_2O accepts a proton (acts as a base), forming $H_2AsO_4^-$ (conjugate base of H_3AsO_4) and H_3O^+ (conjugate acid of H_2O).

Therefore, the conjugate acid-base pair is an option (A) H_3AsO_4 and H_2O

3. The equation shows the dissociation of the acid H3AsO4 in water.

$H_3AsO_4 + H_2O \rightleftharpoons H_2AsO_4^- + H_3O^+$ Which pair is a conjugate acid-base pair?

(A) H3AsO4 and H2O

(B) H2AsO4− and H3O+

(C) H3AsO4 and H3O+

(D) H3O+ and H2O

Answer - The balanced chemical equation for the neutralization reaction between phosphoric acid and calcium hydroxide (Ca(OH)2) is:

$$2\ H3PO4 + 3\ Ca(OH)2 \rightarrow Ca3(PO4)2 + 6\ H2O2$$

From the equation, we can see that two moles of phosphoric acid react with three moles of calcium hydroxide. So, the stoichiometry of the reaction is 2:3 for phosphoric acid to calcium hydroxide.

Given:

- Volume of phosphoric acid solution = 100 cm^3
- Concentration of phosphoric acid solution = 0.100 mol dm^{-3}

We can start by calculating the number of moles of phosphoric acid present:

$$\text{Number of moles of } H3PO4 = \text{concentration} \times \text{volume}$$

$$\text{Number of moles of } H3PO4 = 0.100 \text{ mol dm}{-3} \times 100/1000 \text{ dm3}$$

$$\text{Number of moles of } H3PO4 = 0.010 \text{ mol}$$

Since the stoichiometry of the reaction is 2:3 (phosphoric acid to calcium hydroxide), we need three times the moles of calcium hydroxide compared to the moles of phosphoric acid.

$$\text{Number of moles of } Ca(OH)2 = 3 \times \text{Number of moles of } H3PO4$$

$$\text{Number of moles of } Ca(OH)2 = 3 \times 0.010 \text{ mol}$$

$$\text{Number of moles of } Ca(OH)2 = 0.030 \text{ mol}$$

Now, we need to calculate the molar mass of Ca(OH)2:

$$\text{Molar mass of } Ca(OH)2 = 74.16 \text{ g/mol}$$

Finally, we can calculate the mass of Ca(OH)2 needed:

$$\text{Mass of } Ca(OH)2 = \text{Number of moles} \times \text{Molar mass}$$

$$\text{Mass of } Ca(OH)2 = 0.030 \text{ mol} \times 74.16 \text{ g/mol}$$

$$\text{Mass of } Ca(OH)2 = 2.2248 \text{ g}$$

Therefore, approximately 2.22 grams of calcium hydroxide (Ca(OH)2) are needed to completely neutralize 100 cm^3 of 0.100 mol dm^{-3} phosphoric acid.

4. A buffer solution is prepared by mixing 200 cm^3 of 2.00 mol dm^{-3} propanoic acid, CH_3CH_2COOH, with 600 cm^3 of 1.00 mol dm^{-3} sodium propanoate, CH_3CH_2COONa.
Ka for $CH_3CH_2COOH = 1.32 \times 10^{-5}$ mol dm^{-3}
What is the pH of the buffer solution?

(A) 4.58

(B) 4.70

(C) 5.06

(D) 5.18

Answer - To find the pH of the buffer solution, we'll use the Henderson-Hasselbalch equation:

$$pH = pKa + \log([A^-]/[HA])$$

where:

- pH is the negative logarithm of the hydrogen ion concentration
- pKa is the negative logarithm of the acid dissociation constant (Ka) of the weak acid
- $[A^-]$ is the concentration of the conjugate base (sodium propanoate)
- [HA] is the concentration of the weak acid (propanoic acid)

Given:

- Volume of propanoic acid solution (HA) = 200 cm^3
- Concentration of propanoic acid solution (HA) = 2.00 mol dm^{-3}
- Volume of sodium propanoate solution (A^-) = 600 cm^3
- Concentration of sodium propanoate solution (A^-) = 1.00 mol dm^{-3}
- Ka for propanoic acid (CH3CH2COOH) = 1.32×10^{-5} mol dm^{-3}

First, let's calculate the concentrations of $[A^-]$ and [HA]:

$$[HA]=\text{concentration of propanoic acid}=2.00\ \text{mol dm}-3$$

$$[A-]=\text{concentration of sodium propanoate}=1.00\ \text{mol dm}-3$$

Now, we can calculate the pH using the Henderson-Hasselbalch equation:

$$pH=pKa+\log([A-]/[HA])$$

$$pH=-\log(Ka)+\log([A-]/[HA])$$

$$pH=-\log(1.32\times10-5)+\log(1.00/2.00)$$

$$pH=-(-4.88)+\log(0.5)$$

$$pH=4.88+(-0.30)$$

$$pH=4.58$$

Therefore, the pH of the buffer solution is approximately 4.58.

5. 25.0 cm^3 of 6.0 mol dm^{-3} HA is mixed with 45.0 cm^3 of 3.0 mol dm^{-3} HB. What is the $H^+(aq)$ concentration, in mol dm^{-3}, in the resulting solution?

(A) 1.9

(B) 2.1

(C) 4.1

(D) 4.5

Answer - To find the hydrogen ion concentration ([H+]) in the resulting solution, we need to first determine the total number of moles of hydrogen ions in the solution. We can do this by considering the dissociation of the acids HA and HB.

Given:

- Volume of solution containing HAHA = 25.0 cm^3
- Concentration of HAHA = 6.0 mol dm^{-3}
- Volume of solution containing HBHB = 45.0 cm^3
- Concentration of HBHB = 3.0 mol dm^{-3}

The dissociation equations for HA and HB are:

$$HA \rightleftharpoons H+ + A-$$

$$HB \rightleftharpoons H+ + B-$$

Since we're mixing solutions of HA and HB, the total concentration of H+ ions in the resulting solution will be the sum of the concentrations from both acids.

First, let's calculate the number of moles of H+ ions contributed by HA:

$$\text{Moles of H+ ions from HA} = \text{concentration of HA} \times \text{volume of HA}$$

$$\text{Moles of H+ ions from HA} = 6.0 \text{ mol dm}-3 \times 25.0/1000 \text{ dm3}$$

$$\text{Moles of H+ ions from HA} = 6.0 \times 25.0 \times 10-3 \text{ mol}$$

Next, let's calculate the number of moles of H+ ions contributed by HB:

$$\text{Moles of H+ ions from HB} = \text{concentration of HB} \times \text{volume of HB}$$

$$\text{Moles of H+ ions from HB} = 3.0 \text{ mol dm}-3 \times 45.0/1000 \text{ dm3}$$

$$\text{Moles of H+ ions from HB} = 3.0 \times 45.0 \times 10-3 \text{ mol}$$

Now, we can calculate the total moles of H+ ions in the resulting solution:

$$\text{Total moles of H+} = \text{Moles of H+ ions from HA} + \text{Moles of H+ ions from HB}$$

$$\text{Total moles of H+} = 6.0 \times 25.0 \times 10-3 + 3.0 \times 45.0 \times 10-3 \text{ mol}$$

Finally, we can calculate the concentration of H+ ions in the resulting solution by dividing the total moles of H+ ions by the total volume of the solution:

$$[H+]=\text{Total moles of } H+/\text{ Total volume of solution}$$

Let's perform these calculations:

$$[H+]=(6.0\times25.0\times10-3)+(3.0\times45.0\times10-3)/(25.0+45.0)\times10-3$$

$$[H+]=(0.15+0.135)/70\times10-3$$

$$[H+]=0.28570$$

$$[H+]=0.00407 \text{ mol dm}-3$$

Therefore, the [H+] concentration in the resulting solution is 0.00407 mol dm−3.

6. A 0.040 mol dm^{-3} solution of a weak monobasic acid is 1.0% dissociated.

What is the value of Ka for the acid?

(A) 2.0 × 10^{-7} mol dm^{-3}

(B) 4.0 × 10^{-6} mol dm^{-3}

(C) 4.0 × 10^{-4} mol dm^{-3}

(D) 4.0 × 10^{-2} mol dm^{-3}

Answer - To solve this problem, we can use the definition of percent dissociation and the equilibrium expression for a weak monobasic acid to find the value of Ka.

Given:

- Concentration of the weak monobasic acid (HA) = 0.040 mol dm^{-3}
- Percent dissociation (%α) = 1.0%

The percent dissociation (%α%α) is defined as the ratio of the concentration of dissociated acid ([A−]) to the initial concentration of the acid ([HA]0), multiplied by 100:

$$\%\alpha = [A-]/[HA]0\times100\%$$

For a weak monobasic acid (HA dissociating into H+ and A−), the equilibrium expression for the dissociation reaction is:

$$Ka = [H+][A-]/[HA]$$

Given that the acid is weak, we can assume that the change in concentration of HA due to dissociation ($[HA]-[HA]0$) is approximately equal to the concentration of A−.

Since %α is given as 1.0%, we can rewrite it as 0.01. So, we have:

$$0.01=([A]/0.040)\times100$$

$$[A-]=0.040\times0.01$$

$$[A-]=0.0004 \text{ mol dm}-3$$

Now, we can use the fact that the concentration of HA decreases by the same amount as the concentration of A− increases, so:

$$[HA]=[HA]0-[A-]$$

$$[HA]=0.040-0.0004$$

$$[HA]=0.0396 \text{ mol dm}-3$$

Now that we have the concentrations of HA and A−, we can use the equilibrium expression for Ka to find its value:

$$Ka = [H+][A-]/[HA]$$

Given that [H+] is equal to [A−] due to the weak acid being monobasic:

$$Ka=[A-]2/[HA]$$

$$Ka=(0.0004)2/0.0396$$

$$Ka=0.00000016/0.0396$$

$$Ka \approx 4.04\times10-6 \text{ mol dm}-3$$

Therefore, the value of Ka for the weak monobasic acid is approximately 4.04×10−6 mol dm−3.

7. Which statement is correct for a neutral solution at any temperature?

(A) Kw = 1.00×10^{-14} mol2 dm^{-6}

(B) The solution contains only H_2O

(C) $[H^+] = [OH^-]$

(D) pH = 7

Answer - The correct statement for a neutral solution at any temperature is:

(C) [H+] = [OH−]

In a neutral solution, the concentration of hydrogen ions ([H+]) is equal to the concentration of hydroxide ions ([OH−]). This condition defines neutrality in aqueous solutions.

Option (A) is incorrect because Kw (the ion product of water) is equal to 1.00×10−14 mol^2 dm^{-6} only at 25°C. The value of Kw changes with temperature according to the auto-ionization of water.

Option (B) is incorrect because while a neutral solution primarily consists of water molecules, it may also contain small amounts of H+ and OH− ions.

Option (D) is incorrect because the pH of a neutral solution is not always 7; it is 7 only at 25°C. At different temperatures, the pH of a neutral solution may vary due to changes in the auto-ionization of water.

8. A buffer solution is based on methanoic acid, HCOOH (Ka = 1.70 × 10^{-4} mol dm^{-3}), and methanoate ions, $HCOO^-$. In the buffer solution, the HCOOH concentration is half the $HCOO^-$ concentration. What is the pH of the buffer solution?

(A) 2.47

(B) 3.07

(C) 3.47

(D) 4.07

Answer - To solve this problem, we'll use the Henderson-Hasselbalch equation for a buffer solution:

$$pH = pKa + \log([A^-]/[HA])$$

Given:

- Ka for methanoic acid (HCOOH) = 1.70×10−4 mol dm^{-3}
- Concentration of methanoic acid (HCOOH) = [HA]
- Concentration of methanoate ions ($HCOO^-$) = $[A^-]$
- [HA]=2$[A^-]$(as given in the problem)

First, let's determine the concentration of HCOOH and $HCOO^-$ in the buffer solution:

Given [HA] = 2$[A^-]$, we can let $[A^-]=x$, then [HA] = $2x$

Since the total concentration of the buffer solution is the sum of [HA] and $[A^-]$, we have:

$$[HA]+[A^-] = 3x$$

$3x$= total buffer concentration

Now, we know that:

$$Ka = [H^+][A^-]/[HA]$$

Given that $[A^-]$= x and [HA]=2x, we can substitute these values into the equation for Ka:

$$Ka=[H^+][x]/[2x]$$

$$Ka=([H^+]x)/2x$$

$$Ka=[H^+]/2$$

Now, we can rearrange this equation to solve for $[H^+]$:

$$[H^+]=2Ka$$

$$[H^+]= 2\times1.70\times10^{-4}$$

$$[H^+]=3.40\times10^{-4} \text{ mol } dm^{-3}$$

Now, we can use the definition of pH to find the pH of the buffer solution:

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

$$pH=-\log(3.40\times10^{-4})$$

$$pH \approx -\log(3.40)$$

$$pH \approx -(-3.47)$$

$$pH \approx 3.47$$

Therefore, the pH of the buffer solution is approximately 3.47.

9. A solution of propanoic acid, CH3CH2COOH, has a pH of 2.89 at 25 °C. What is [H+] in this solution?

(A) 1.7×10^{-6} mol dm^{-3}

(B) 4.6×10^{-4} mol dm^{-3}

(C) 1.3×10^{-3} mol dm^{-3}

(D) 0.46 mol dm^{-3}

Answer - To find the concentration of H+ ions (H+]) in the solution, we'll first convert the given pH to the hydrogen ion concentration.

Given:

- pH of the solution = 2.89

The pH is defined as the negative logarithm (base 10) of the hydrogen ion concentration:

$$pH = -\log([H+])$$

To find [H+], we rearrange the equation:

$$[H+] = 10^{-pH}$$

Now, let's plug in the given pH value and solve for [H+]:

$$[H+] = 10^{-2.89}$$

$$[H+] = 1.26 \times 10^{-3} \text{ mol } dm^{-3}$$

Therefore, the concentration of H+ ions in the solution is 1.26×10^{-3}mol $dm^{-3} \sim 1.3 \times 10^{-3}$mol dm^{-3}.

Bioenergetics

1. **Bioenergetics is the study of the transformation of energy in living organisms. It explores how cells convert nutrients into energy through metabolic processes, primarily focusing on the production and utilization of adenosine triphosphate (ATP), the primary energy currency of the cell. This field bridges biology and chemistry, providing insights into cellular respiration, photosynthesis, and overall energy management within biological systems.**

1.1) Explain briefly "What is Bioenergetics"?

1.2) Explain the below-mentioned terms

I. Energy
II. Kinetic energy
III. Potential energy
IV. Free-Energy Change

1.3) Describe the characteristics of an exergonic reaction.

1.3.1) How do these reactions contribute to cellular metabolism, and provide examples of a key exergonic reaction in cellular respiration?

1.4) Explain the nature of endergonic reactions and how they are integrated into cellular processes.

1.4.1) What role does ATP play in facilitating these reactions? Provide an example of an endergonic reaction in the context of cellular metabolism.

1.5) What are high-energy compounds, and why are they critical in biological systems?

1.5.1) Discuss the role of ATP as a high-energy compound, and describe how its structure contributes to its high-energy characteristics.

1.5.2) Provide an example of how ATP is used in a cellular process.

1.6) Define super high-energy compounds and explain how they differ from regular high-energy compounds like ATP.

1.6.1) Provide an example of a super high energy compound, and describe its role and significance in biological systems.

2. **The Creatine Phosphate (CrP) shuttle is a mechanism in muscle cells that facilitates the rapid transfer of high-energy phosphate from mitochondria to myofibrils. This system uses creatine phosphate as a mobile carrier to transport energy in the form of phosphate groups. During periods of high energy demand, creatine kinase catalyzes the transfer of a phosphate group from creatine phosphate to ADP, quickly regenerating ATP and ensuring a steady supply of energy for muscle contraction.**

2.1) Explain the role of creatine phosphate (CrP) in cellular energy metabolism.

2.1.1) How does the creatine phosphate shuttle contribute to muscle function during high-intensity exercise?

2.1.2) Discuss the enzyme involved in this process and its mechanism of action.

2.2) Describe the biosynthesis of creatine in the human body.

2.2.1) What are the key organs involved, and which enzymes play a crucial role in this process?

2.2.2) Outline the main biochemical steps and the importance of creatine in muscle physiology.

2.3) Discuss the significance of creatine phosphate (CrP) in cardiomyocytes.

2.3.1) How does the CrP shuttle system support the energy demands of the heart muscle?

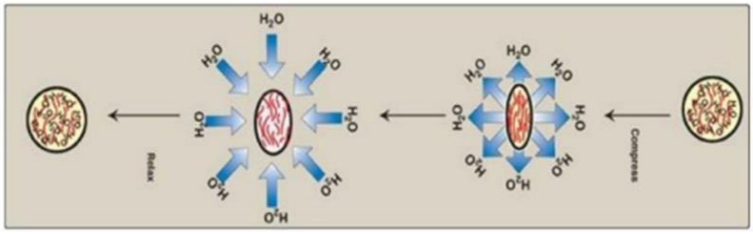
2.3.2) Highlight the role of creatine kinase and the implications of CrP dynamics in cardiac function and health.

COURSE 2 - BIOMOLECULES

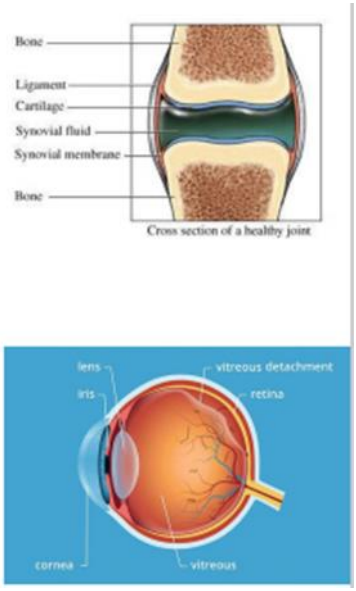
Carbohydrates

Q1.) Discuss how the ability of GAGs to recover their shape after deformation is essential for their biological functions

- Glycosaminoglycans (GAGs) play a vital role in the extracellular matrix (ECM) by providing structural support and maintaining tissue integrity



- The resilience properties of GAGs, such as their ability to recover their shape after deformation, are essential for their biological functions



- When a solution of GAGs is compressed, water is squeezed out, causing the GAGs to occupy a smaller volume
- Upon release of compression, the repulsion of their negative charges enables GAGs to spring back to their original hydrated state
- This resilience property is particularly crucial in synovial fluid and vitreous humor
- In synovial fluid, the ability of GAGs to rebound and maintain their shape ensures proper lubrication and cushioning of joints, facilitating smooth movement and reducing friction
- Similarly, in the vitreous humor of the eye, GAGs contribute to the maintenance of ocular structure and transparency by withstanding deformation and retaining their shape
- The resilience properties of GAGs in the ECM are essential for supporting various biological functions, emphasizing their significance in maintaining tissue health and functionality

Q2.) Explain how glycoproteins with carbohydrate portions facing the extracellular space play a role in cell-membrane

- Vesicles containing glycoproteins move towards the cell membrane and fuse with it, facilitating the incorporation of glycoproteins into the membrane
- The glycoproteins are oriented in a specific manner during this process, with their carbohydrate portions facing the extracellular space
- Once incorporated into the cell membrane, glycoproteins can undergo various modifications and serve as receptors or transporters, influencing cellular processes
- This orientation is crucial for cell-membrane interactions, as glycoproteins with exposed carbohydrates can serve as recognition sites for various cell-cell interactions, signaling processes, cell adhesion, communication with neighboring cells or external molecules and extracellular matrix regulation

➢ Cellular Communication: Cells often communicate with each other through interactions between glycoproteins

➢ Immune Response: Glycoproteins on the surface of cells can be recognized by immune cells

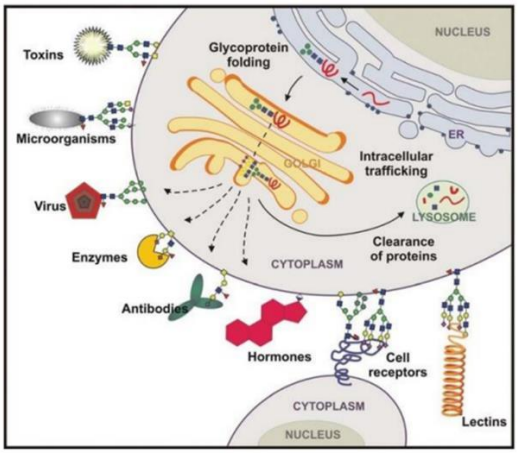
➢ Receptor Activation: Many receptors on the cell surface are glycoproteins. Binding of a specific molecule (ligand) to the carbohydrate can trigger a cascade of intracellular signals

➢ Hormone Response: Hormones can bind to glycoprotein receptors, initiating a signaling pathway that leads to cellular responses

- Cell Adhesion (Cadherins and Integrins): These are examples of glycoproteins that facilitate cell-cell adhesion and cell-ECM adhesion, respectively
- Tissue Formation: Cell adhesion is vital for the formation and maintenance of tissues, allowing cells to stay in place and communicate effectively

➢ Membrane Stability: The carbohydrate of glycoproteins can interact with other cell membrane components, stabilizing the membrane

➢ Barrier Function: Glycoproteins can form a protective glycocalyx layer on the cell surface, which acts as a barrier against pathogens and mechanical damage



- Some glycoproteins are released outside the cell, contributing to intercellular signaling, immune responses, or extracellular matrix maintenance

➢ Matrix Interactions: Glycoproteins in the ECM can interact with other ECM components, such as collagen, elastin, and proteoglycans, helping to maintain the matrix structure

➢ Cell Anchorage: Cells are anchored to the ECM through interactions between glycoproteins and ECM molecules

Q3.) Describe the mechanisms involved in the degradation of glycoproteins within lysosomes. How do deficiencies in specific lysosomal enzymes lead to glycoprotein storage diseases?

- Glycoproteins are internalized by cells through endocytosis or phagocytosis and delivered to lysosomes, where they are degraded by a series of specific hydrolytic enzymes
- The degradation of glycoproteins in lysosomes is a complex process involving specific lysosomal enzymes
- Initial cleavage of glycoproteins occurs through the action of endoglycosidases, leading to the formation of oligosaccharides
- Sequential degradation then takes place, where oligosaccharides are further broken down sequentially from the non-reducing end
- The degradation process involves the removal of terminal sialic acids, followed by galactose, N-acetylglucosamine, and mannose residues, among others
- Deficiencies in specific lysosomal enzymes result in the incomplete degradation of glycoproteins, leading to their accumulation within lysosomes
- These conditions are collectively known as glycoprotein storage diseases or oligosaccharidosis
- Alpha-Mannosidosis: Caused by a deficiency in alpha-mannosidase, leading to the accumulation of mannose-rich oligosaccharides
- Fucosidosis: Caused by a deficiency in alpha-L-fucosidase, resulting in the accumulation of fucose-containing oligosaccharides
- Sialidosis: Caused by a deficiency in neuraminidase, leading to the accumulation of sialylated oligosaccharides
- As a consequence, after cell death, these partially degraded glycoprotein structures are excreted in the urine, indicating cellular dysfunction
- Symptoms of glycoprotein storage diseases vary widely but often include developmental delay, skeletal abnormalities, organomegaly, and neurological decline
- These conditions are progressive and can lead to severe disability and reduced life expectancy

Nucleic acids

Multiple-choice questions (MCQs) with Answers

Select the single best answer

1. What are the components of a nucleotide in nucleic acids?

a) A pentose sugar, a nitrogenous base, a phosphate group

b) A hexose sugar, a nitrogenous base, a phosphate group

c) A pentose sugar, an amino acid, a phosphate group

d) A hexose sugar, an amino acid, a phosphate group

e) A pentose sugar, a lipid, a phosphate group

The answer is A

2. Which nitrogenous base is found only in RNA?

a) Thymine

b) Cytosine

c) Guanine

d) Uracil

e) Adenine

The answer is D

3. In DNA, which nitrogenous base does adenine pair with?

a) Guanine

b) Cytosine

c) Thymine

d) Uracil

e) None of the above

The answer is C

4. Which of the following describes the major and minor grooves in the DNA double helix?

a) They are sites where RNA polymerase binds during transcription.

b) They facilitate binding with specific regulatory proteins.

c) They are sites where DNA replication starts.

d) They indicate the polarity of the DNA strands.

e) They are the points where DNA strands are linked by covalent bonds.

The answer is B

5. Which type of RNA has peptidyl transferase activity?

a) mRNA

b) tRNA

c) rRNA

d) siRNA

e) miRNA

The answer is C

6. What is the main function of tRNA?

a) Carries genetic information from DNA to the ribosome

b) Serves as a template for protein synthesis

c) Carries specific amino acids to the ribosome during protein synthesis

d) Forms the core structural and enzymatic components of ribosomes

e) Regulates gene expression by silencing mRNA

The answer is C

7. Which level of DNA packaging involves the nucleosome structure?

a) Level I

b) Level II

c) Level III

d) Level IV

e) Level V

The answer is B

8. Which molecule serves as the primary information-carrying molecule in many viruses?

a) DNA

b) RNA

c) Protein

d) Lipid

e) Carbohydrate

The answer is B

9. What kind of chemical bond connects two nucleotides in a nucleic acid?

a) Hydrogen bond

b) Ionic bond

c) Phosphodiester bond

d) Peptide bond

e) Glycosidic bond

The answer is C

10. Which synthetic nucleotide analog is used as a chemotherapeutic agent by inhibiting transcription?

a) Doxycycline

b) Dactinomycin

c) Chloramphenicol

d) Tetracycline

e) Ampicillin

The answer is B

True or False Questions with Answers

1. Nucleotides and Their Components:

A. A nucleotide consists of a sugar, a nitrogenous base, and one or more phosphate groups.

B. In RNA, the sugar is deoxyribose.

C. The nitrogenous base adenine pairs with cytosine in DNA.

D. Guanine is a pyrimidine base.

E. ATP is an example of a nucleotide with three phosphate groups.

Answer – TFFFT

2. Characteristics of DNA:

A. DNA is double-stranded and forms a double helix structure.

B. The two strands of DNA run parallel to each other.

C. The DNA double helix has major and minor grooves.

D. The amount of adenine in DNA equals the amount of cytosine.

E. DNA can only exist in the B-form helix under physiological conditions.

Answer - TFTFF

3. RNA Types and Functions:

A. mRNA carries the genetic code from DNA to the ribosome for protein synthesis.

B. tRNA molecules have an anticodon region that matches mRNA codons.

C. rRNA catalyzes peptide bond formation during translation.

D. miRNA molecules are involved in protein synthesis as ribosomal components.

E. siRNA typically forms imperfect RNA-RNA duplexes.

Answer - TTTFF

4. DNA Packaging and Chromatin Structure:

A. Chromatin is composed of DNA, histones, and non-histone proteins.

B. Histones are acidic proteins that bind to DNA.

C. Nucleosomes consist of DNA wrapped around a histone octamer.

D. The "beads-on-a-string" structure is formed by nucleosomes linked by RNA.

E. The chromatin fiber is formed by the coiling of nucleosomes.

Answer - TFTFT

5. Biomedical Applications of Nucleic Acids:

A. PCR is a technique used to amplify specific DNA sequences.

B. mRNA vaccines work by introducing viral DNA into human cells.

C. Gene therapy can involve altering the genetic material within a person's cells.

D. DNA fingerprinting is used to determine paternity.

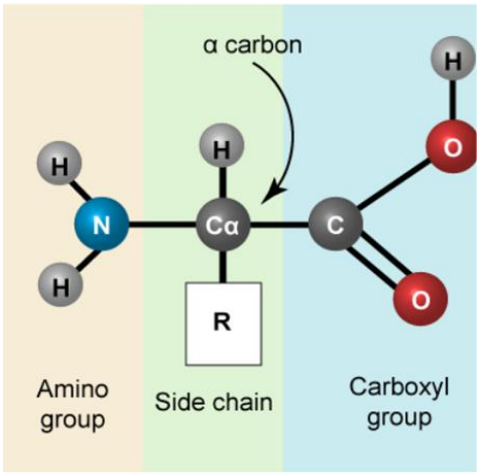
E. Southern blotting is used to detect RNA sequences.

Answer – TFTTF

Proteins

Q1.)

01. Briefly explain the Amino Acid Structure, along with a diagram illustrating its components

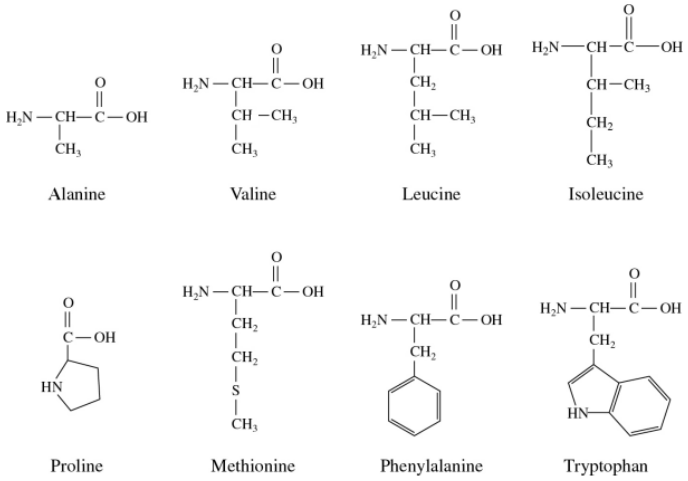


- Amino acids are the building blocks of proteins
- They have a basic structure that consists of a central carbon atom, also known as the alpha carbon, bonded to an amino group (NH2), a carboxyl group (COOH), and a hydrogen atom
- The alpha carbon is also attached to a side chain that is denoted by R, which can vary in size, shape, and charge
- The side chain is what distinguishes different amino acids and gives them their unique properties

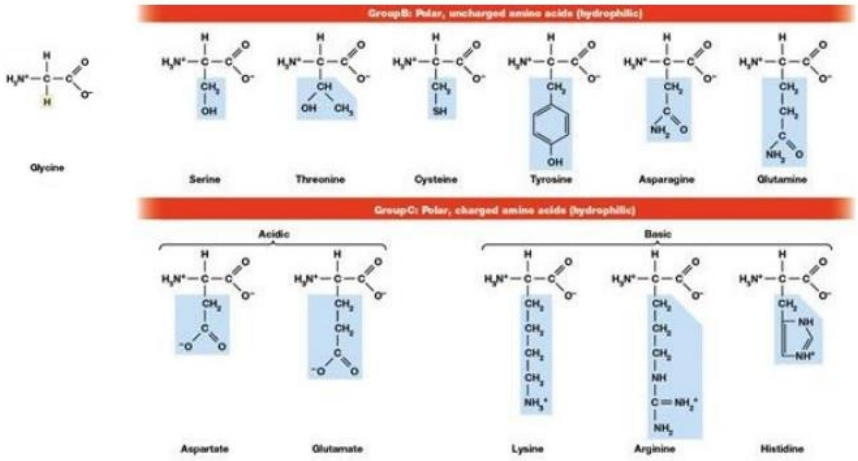
02. Classify the 20 amino acids found in proteins into hydrophobic and hydrophilic categories

Hydrophobic Amino Acids	Hydrophilic Amino Acids
Alanine	Glycine
Valine	Serine
Leucine	Threonine
Isoleucine	Tyrosine
Methionine	Cysteine
Phenyl Alanine	Asparagine
Proline	Glutamine
Tryptophan	Aspartic acid
	Glutamic acid
	Lysine
	Arginine
	Histidine

Hydrophobic amino acids



Hydrophilic amino acids



03. Explain the concept of essential amino acids, and list them down

- Essential amino acids are those that cannot be synthesized by the human body and must be obtained through the diet; they are essential for body functions, including building proteins, hormones, and neurotransmitters, and play vital roles in processes such as protein synthesis, enzyme production, and maintaining muscle and immune system health
- Essential amino acids are

➢ Isoleucine

➢ Leucine

➢ Lysine

➢ Methionine

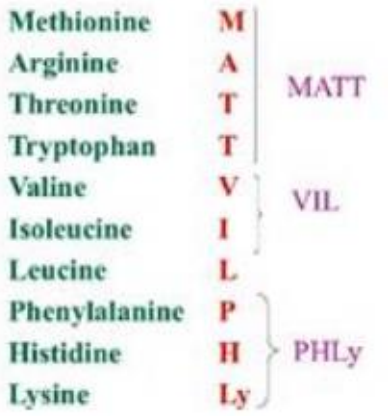
➢ Phenylalanine

➢ Threonine

➢ Tryptophan

➢ Valine

➢ Histidine, Arginine



- Arginine is considered a conditionally essential amino acid
- While the body can typically produce arginine on its own, there are times when the demand for arginine exceeds the body's ability to produce it, such as during periods of rapid growth, illness, or stress
- In such cases, arginine must be obtained from the diet



04. Identify the essential amino acid that is specific to infants but not to adults and explain why this difference exists.

- Histidine
- Histidine is an essential amino acid for infants but not for adults
- In adults, their body naturally develops the ability to produce histidine from other amino acids this reduces the requirement to obtain from a diet
- But infants, have immature metabolic pathways to produce Histidine in their body
- Meanwhile infants show rapid growth and development increases the requirement for histidine than adults
- This creates Histidine as an essential amino acid in infants and needs to be consumed through diet

5. Elaborate on the term "ampholytes" as it pertains to amino acids

- Amino acids are ampholytes because it has both positive and negative groups
- Amino acids can act as both protein acceptor (COO-) and proton donor (NH3+)

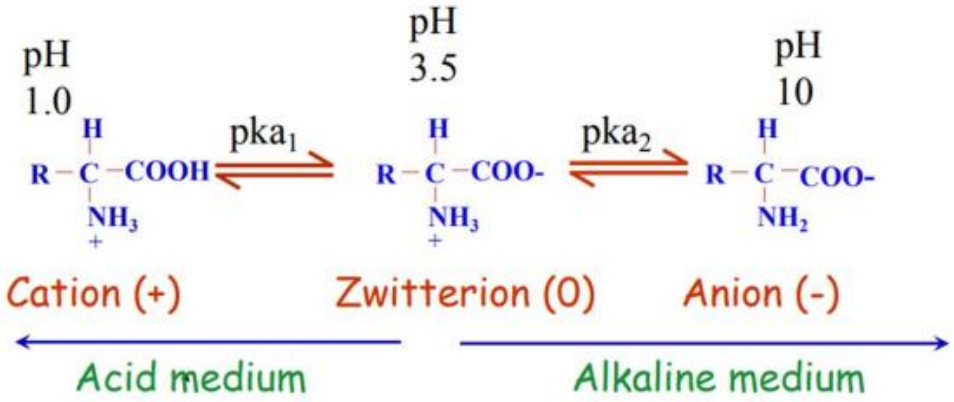
➢ The carboxyl group (COOH) in amino acids can donate a proton (act as an acid)

➢ The amine group (NH_2) can accept a proton (act as a base)

- When the amino acid is dissolved in H2O, it exists in several ionic forms depending on the pH of the solution

6. Clarify the term "Zwitterions" in terms of amino acids

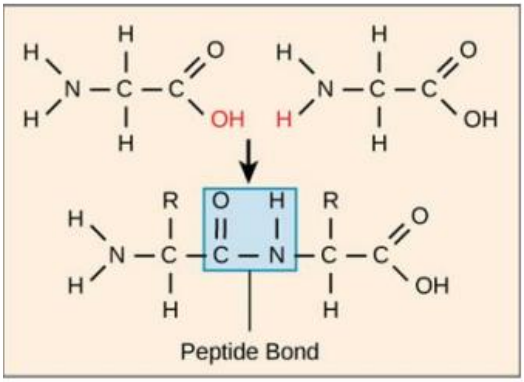
- A Zwitterion is a compound with no overall electrical charge but contains separate parts that are positively and negatively charged
- Amino acids exist as Zwitterion at Isoelectric pH
- This Zwitterion exits both acidic and basic property



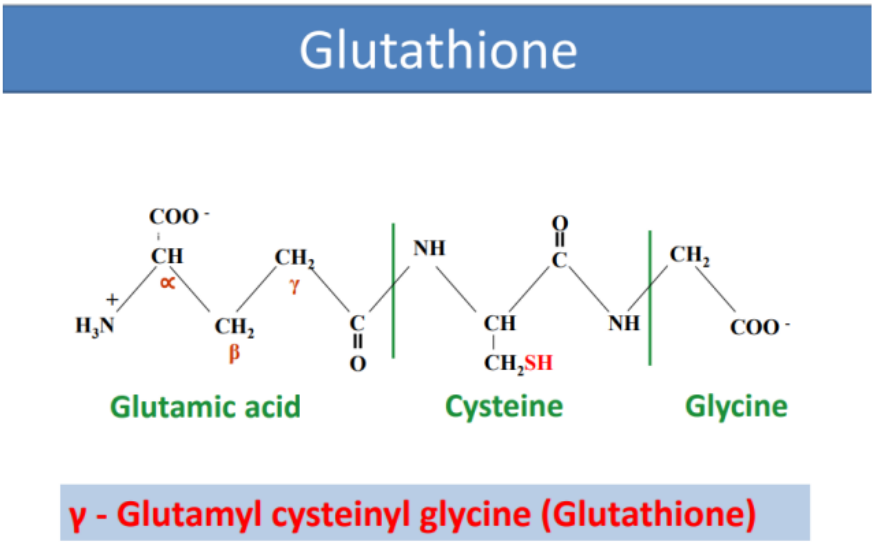
Q2.)

1. Illustrate, with a diagram, the process of peptide bond formation between amino acids

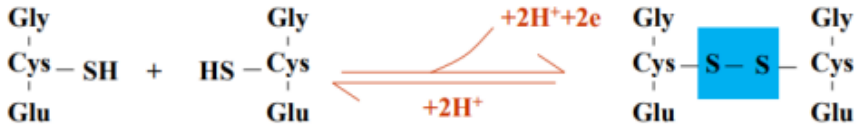
- A peptide bond covalently attaches amino acids through a dehydration reaction
- One amino acid's carboxyl group and another amino acid's amino group combine, releasing a water molecule
- The resulting bond is the peptide bond

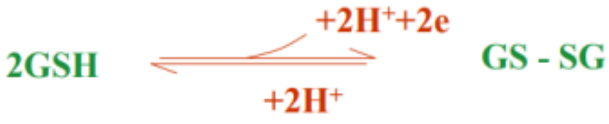


02. List out the biological importance of Glutathione



- Glutathione is an antioxidant that plays a key role in regulating cellular oxido-reduction reactions and destroys free radicals in the cell
- Can undergo reversible oxidation to the disulfide form





Free radical scavenging
Reduction of Met-Hb
Act as a coenzyme for some reactions

- Reduction of Met-Hb and Act as a coenzyme for some reactions (Glutathione as a Cofactor)

➢ Glutathione, in its reduced form (GSH), acts as a cofactor for another enzyme called methemoglobin reductase

➢ This enzyme catalyzes the reduction of MetHb to functional hemoglobin (Hb)

➢ The reduced form of glutathione (GSH) serves as a source of electrons in this reaction, which ultimately leads to the conversion of MetHb back to Hb

$$\mathrm{MetHb} + 2\,\mathrm{GSH} + \mathrm{NADPH} + \mathrm{H}^{+} \rightarrow \mathrm{Hb} + \mathrm{GSSG} + \mathrm{NADP}^{+}$$

- Helps in DNA synthesis and Repair
- Regenerating vitamins C and E
- Supporting immune function
- Helping certain enzyme's function
- Forming sperm cell
- Detoxification - Transporting mercury out of the brain

03. Explain why insulin cannot be consumed orally

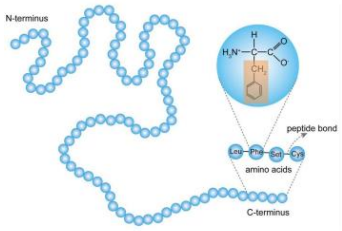
- Insulin is not given orally because the proteolytic enzymes in digestive juices in the stomach and intestine will break down the insulin and inactivate before it enters the bloodstream
- Insulin is a poly-peptide protein, which can be broken down by enzymes in the digestive system
- By the time it reaches the small intestine, where it is absorbed, it is only a single peptide and can no longer function as insulin
- So, it is not given orally. It can be given either IM or IV injections

Q3)

1. Explain how the structure of the protein is maintained in relation to primary, secondary, and tertiary structures

Primary Structure

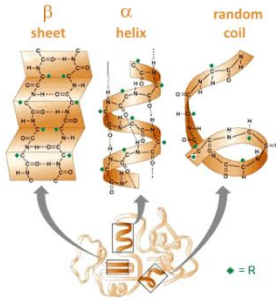
- The simplest level of protein structure, is simply the Linear sequence of amino acids in a polypeptide chain
- Amino acid residues are held together by covalent peptide bonds
- The sequence of nucleotides in a protein-coding region of DNA specifies the amino acid sequence of a polypeptide



Secondary structure

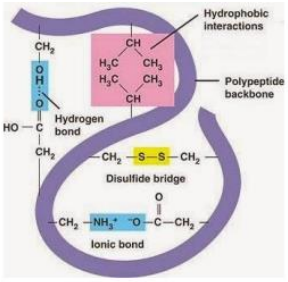
- Linear sequence of amino acids folds upon itself
- The secondary structure is the way a polypeptide folds in a repeating arrangement to form αhelices or β-pleated sheets or random coils
- This folding is a result of hydrogen bonding between the amine and carboxyl groups of nonadjacent amino acids

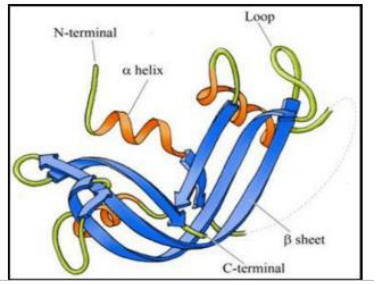
- Secondary structure provides the polypeptide chain with a level of mechanical stability (due to the presence of hydrogen bonds



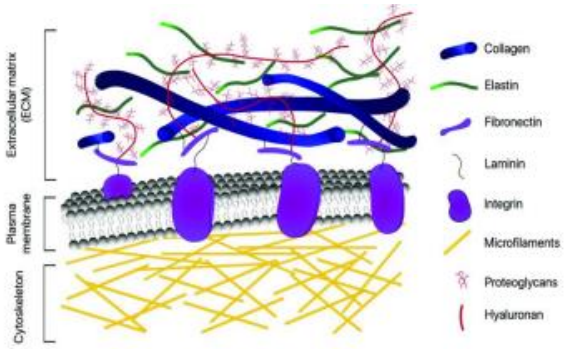
Tertiary structure

- The way the polypeptide chain coils and turns to form a complex molecular shape/ 3D shape
- It is caused by interactions between R groups; including H bonds, disulfide bridges, ionic bonds, and hydrophobic interactions
- Tertiary structure may be important for the function of the protein (e.g. specificity of active site in enzymes)
- They are mainly in globular or fibrous structure





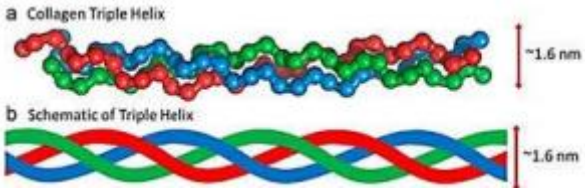
02. Describe the structure of Collagen in terms of Protein

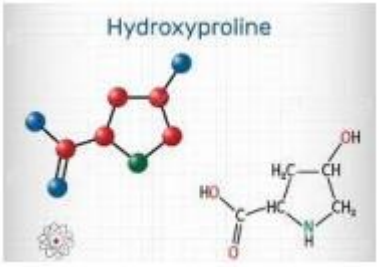


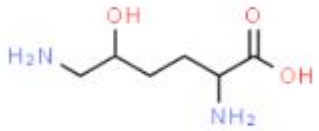
- Extracellular protein of connective tissue
- It is a glycoprotein
- Embedded in the matrix of proteoglycans
- 1/3 of all body protein is composed of collagen
- It is the most abundant structural protein in the body
- Present in all organs and tissues – especially high in supporting structures such as the organic matrix of bones and tendons
- It has a Triple helix chain – Each coiled as a left-handed helix. Here Three helical polypeptides twist tightly and form a right-handed triple-stranded superhelix
- Each chain consists of about 1000 amino acid residues
- Three amino acids per turn
- Repeating structure can be represented by (Gly – X – Y) where X and Y are amino acids other than glycine

➢ X- Proline/ Hydroxy proline

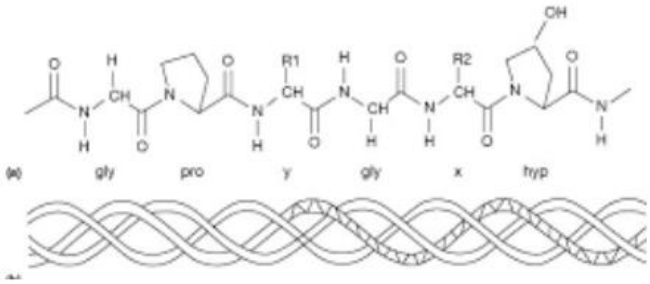
➢ Y- Lysine/Hydroxylysine







- Gly- X- Y- Gly- X- Y -Gly-X- Y
- Glycine is the predominant (33%)
- Proline and hydroxyproline (X) together constitute about 20-35%
- Lysine and hydroxylysine (Y) are also present in appreciable amounts



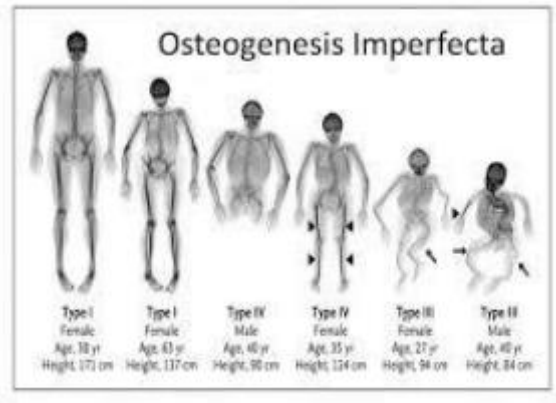
3. Briefly explain the following inheritance disorders in relation to collagen assembly

i. Osteogenesis imperfecta

ii. Ehlers-Danlos syndrome

iii. Alport Syndrome

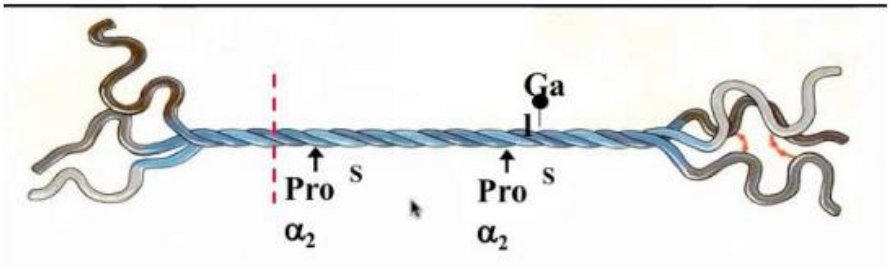
Osteogenesis imperfecta



- It is an autosomal dominant disease
- Also known as brittle bone syndrome
- Is also a heterogeneous group of inherited disorders distinguished by bones that easily bend and fracture (extremely fragile bones)
- There are 8 types
- Caused by a defect in the Type 1 collagen gene (an important building block in gene formation)
- Susceptible to fractures
- Usually patients with Osteogenesis Imperfecta are below-average height

Osteogenesis Imperfecta	Defect	Consequences
Type I	Pro α_2^S	Abnormal fibrils due to shortened procollagen



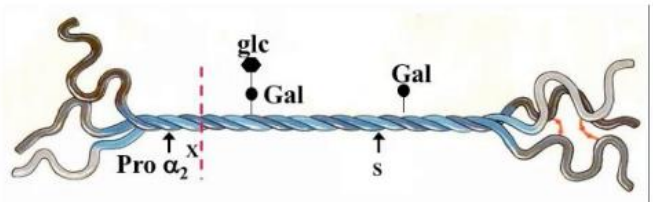


Ehlers-Danlos Syndrome

- Results from a deficiency of collagen-processing enzymes (for example, lysyl hydroxylase or procollagen peptidase), or from mutations in the amino acid sequences of collagen types I, III, or V
- Unusually large range of joint movement (Hypermobility)
- Also shows hyper-extensibility of the skin and abnormal tissue fragility

Defect	Disease	Consequences
Lysyl Hydroxylase	Ehlers – Danlos syndrome type VI	Exhibit marked joint hyper mobility Tendency to occur rupture
Procollagen N - proteinase	Ehlers – Danlos syndrome type VII Autosomal recessive	Resistance to procollagen N-proteinase and persistence of pN collagen







Alport syndrome

- Alport syndrome is a genetic condition in which the kidneys don't produce normal type IV collagen proteins (Major collagen found in renal glomeruli)
- Characterized by Kidney disease, hearing loss, and eye abnormalities
- This leads to progressive loss in kidney function
- Sign shows hematuria and end-stage renal disease

04. Briefly explain the factors that affect the functions of proteins

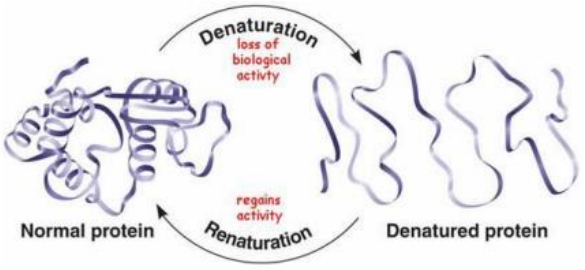
➢ Heat

➢ pH

➢ Heavy metals

➢ Vibrational energy

- The above factors cause the loss of secondary structures leading to loss in biological activity and functions of protein

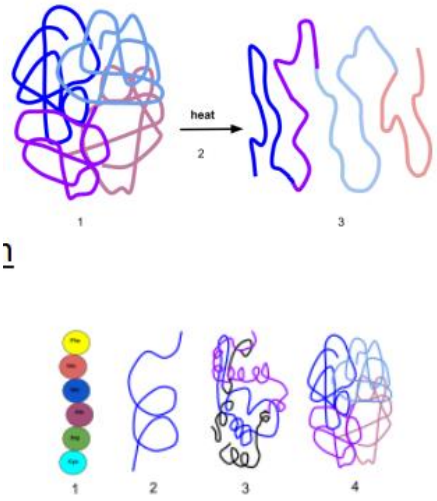


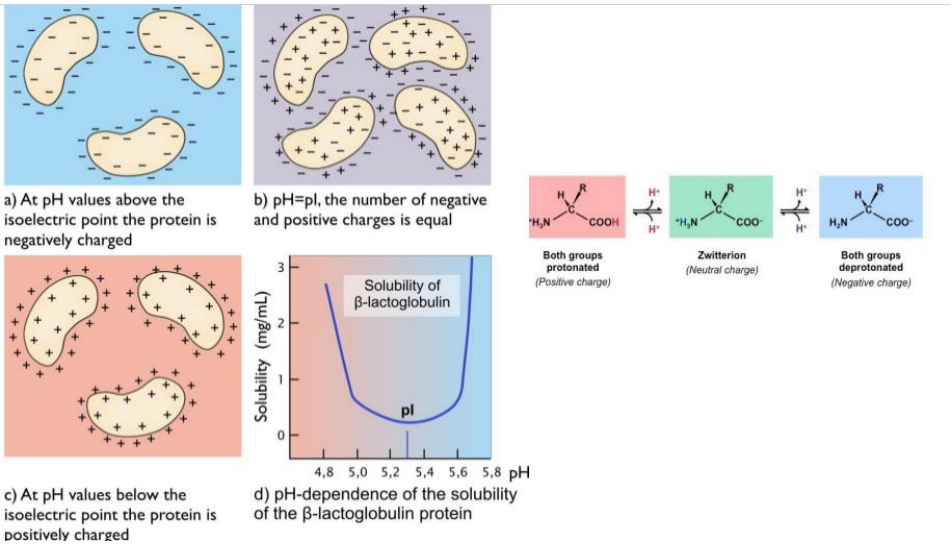
Heat

- Protein structures are highly sensitive to temperature
- Week bonds like hydrogen bonds would be disturbed
- Leads to the unfolding of the polypeptide chain
- High temperatures affect the secondary, tertiary, and quaternary structures of polypeptide chains
- Leads to loss of functions of proteins

pH

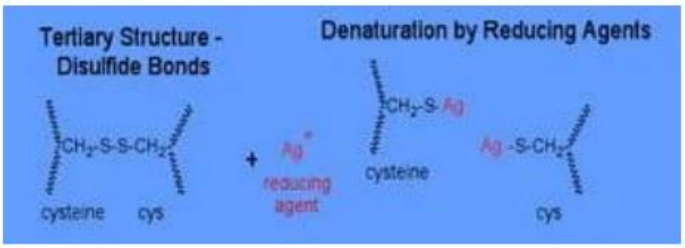
- In isoelectric pH where a protein has no net charge (equal positive and negative charges)
- At this point, the protein is least soluble and thus unstable
- Below pI (Acidic Conditions): Protein carries a net positive charge (acts like a cation)
- Above pI (Basic Conditions): Protein carries a net negative charge (acts like an anion)
- Both above and below pI, proteins are more soluble
- Altering pH affects amino acid chemistry and can cause proteins to unfold

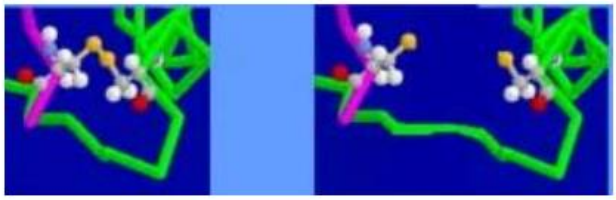




Heavy metals

- Heavy metals can disrupt protein activity and function
- Form complexes with functional side chain groups of proteins/ forms bind to free thiols in proteins
- It also Oxidize amino acid side chains in proteins
- Interfere with protein folding, reducing stability and activity





05. Briefly explain the following with reference to myoglobin

(i) Primary structure

(ii) Secondary structure

(iii) Tertiary structure

- Myoglobin, a protein found in muscle tissues, plays a crucial role in oxygen storage

Primary Structure

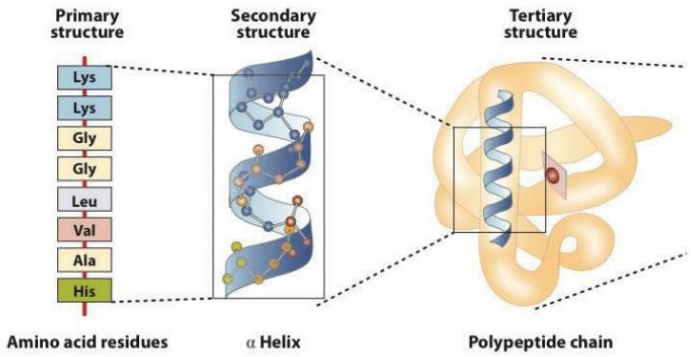
- The primary structure of a protein refers to the linear sequence of amino acids in its polypeptide chain
- Myoglobin consists of a single polypeptide chain with about 150 amino acids
- The specific order of these amino acids is determined by the gene encoding myoglobin
- Even a single amino acid change can impact the protein's overall structure and function

Secondary Structure

- Secondary structure describes local folding patterns within a protein
- Myoglobin contains eight α-helices (coiled structures) stabilized by hydrogen bonds between nearby amino acids
- These helices create a compact globular shape, crucial for oxygen binding and release

Tertiary Structure

- Tertiary structure refers to the 3D arrangement of the entire polypeptide chain
- In myoglobin, the α-helices fold upon themselves, forming a compact, globular structure
- The heme group (containing iron) binds to myoglobin, allowing it to capture and release oxygen
- Hydrophobic interactions, disulfide bonds, and other forces contribute to the stable tertiary conformation



Q4)

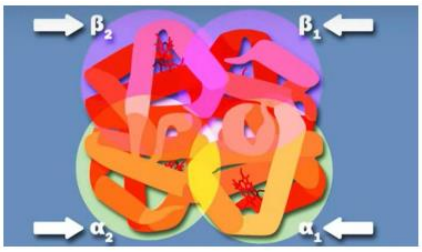
01. Briefly explain the structural adaptations of Hemoglobin for its function

- Hemoglobin, an iron-containing protein found in red blood cells (RBCs), plays a crucial role in oxygen transport
- Quaternary Structure:

➢ Hemoglobin has a tetrameric structure composed of four subunits

➢ Each subunit contains a heme group, which binds to oxygen

➢ The quaternary structure allows efficient binding and release of oxygen

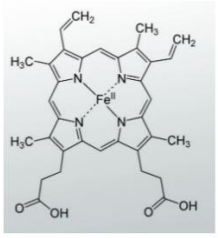


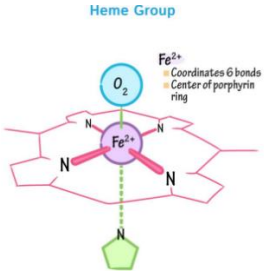
- Heme Prosthetic Groups:

➢ The heme groups within each subunit contain iron ions

➢ These iron ions bind to oxygen, forming oxyhemoglobin

➢ This reversible binding ensures efficient oxygen transport



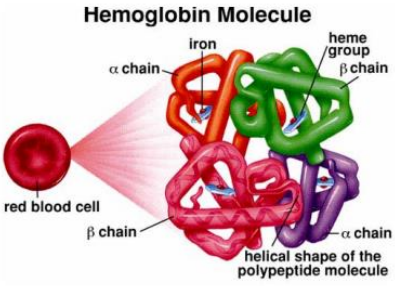


- Globin Subunits:

➢ Hemoglobin consists of two alpha (α) and two beta (β) globin subunits

➢ Different globin subunits contribute to the affinity of hemoglobin for oxygen binding

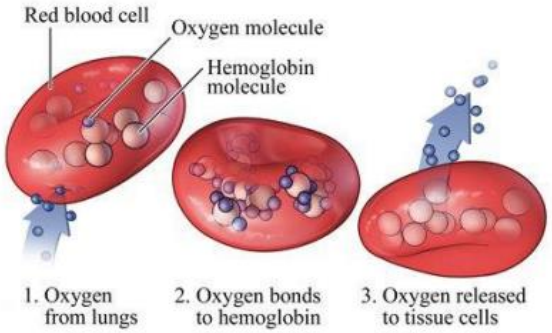




- No Nucleus in RBCs:

➢ Red blood cells lack a nucleus, providing more space for hemoglobin

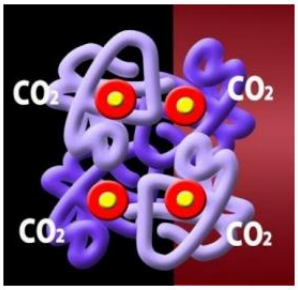
➢ This absence allows RBCs to pack more hemoglobin molecules, enhancing oxygen-carrying capacity



- Affinity for Carbon Dioxide:

➢ Hemoglobin also transports carbon dioxide

➢ It binds to CO_2, forming carbaminohemoglobin, which facilitates CO_2 removal from tissues



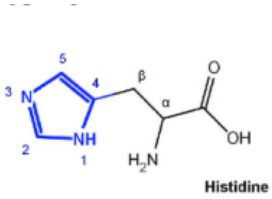
02. The buffering action of proteins in plasma is primarily due to the presence of histidine in their structure. Briefly explain this statement

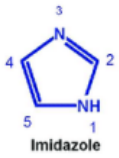
- Histidine's imidazole group, with a pKa of about 7, is crucial for the buffering action of proteins, especially at physiological pH
- This allows proteins to help stabilize pH in biological systems by acting as both proton donors and acceptors
- Proteins as Buffers:

➢ Due to the charged nature, proteins function as buffers

➢ Proteins can function as buffers because they are generally weak acids

➢ The buffering capacity of proteins helps maintain pH stability in biological systems



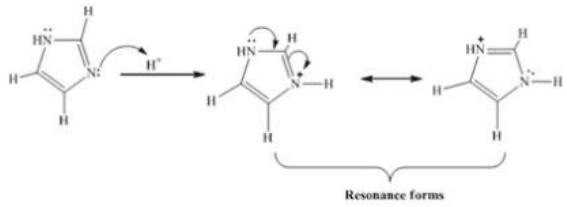


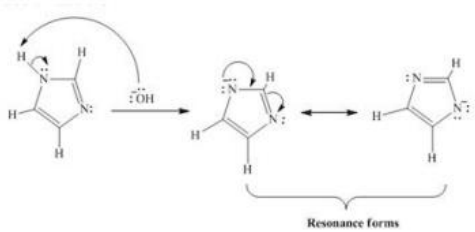
- Role of Histidine:

➢ Histidine residues in proteins play a crucial role in their buffering action

➢ The imidazole group in histidine can act as both a proton donor and acceptor

➢ This dual capability makes histidine effective in stabilizing pH





- Physiological pH:

➢ At physiological pH (around 7.4), histidine is a major buffering component

➢ The imidazole group of histidine has a pKa of about 7, close to the physiological pH

- Buffering Action at pKa:

➢ Buffering action is maximal at the pKa of the buffering group

➢ Since the pKa of the imidazole group is around 7, it is most effective at buffering near this pH

- Importance in Hemoglobin

➢ Haemoglobin which contains 38 histidine residues per monomer

➢ Histidine residues in hemoglobin contribute significantly to its buffering capacity, helping maintain blood pH

➢ Haemoglobin owes its buffering action to the imidazole group-60% buffering of the carbonic acid produced

- Plasma proteins contribute 15% of the total buffering capacity of Blood

Lipids

True or False Questions with Answers

1. **Which statements about phospholipids are true?**
   a. Phospholipids are a type of simple lipid.
   b. Phospholipids have both hydrophilic and hydrophobic parts.
   c. Phospholipids form the main structure of cell membranes.
   d. Phospholipids are insoluble in water.
   e. Phospholipids contain glycerol.

Answer: b, c, e

2. **Which statements about fatty acids are accurate?**
   a. Fatty acids are always saturated.
   b. Fatty acids have a carboxyl group at one end.
   c. Fatty acids are a type of derived lipid.
   d. Fatty acids can be classified by chain length.
   e. Fatty acids are always found in free form in the body.

Answer: b, c, d

3. **Which of the following statements would you include in a presentation about the health effects of dietary fats?**
   a. Omega-3 fatty acids do not have a beneficial effect on heart health.
   b. Saturated fats should be consumed in moderation.
   c. Monounsaturated fats can help reduce the risk of heart disease.
   d. Omega-3 fatty acids are important for brain health.
   e. All fats have the same impact on health.

Answer: b, c, d

4. **Which of the following statements regarding short-chain fatty acids (SCFAs) are true?**
   a. SCFAs are typically found in dairy products.
   b. SCFAs have fewer than six carbon atoms.
   c. SCFAs are beneficial for gut health.
   d. SCFAs are harmful to the intestinal lining.
   e. SCFAs are used by colon cells as an energy source.

Answer: b, c, e

5. **A patient is looking to improve their lipid profile. Which dietary advice would be effective?**
   a. Increase intake of trans fats to lower LDL cholesterol.
   b. Replace saturated fats with monounsaturated fats.
   c. Avoid all dietary fats to reduce cholesterol.
   d. Include more omega-3 fatty acids in the diet.
   e. Consume high amounts of dietary cholesterol.

Answer: b, d

6. **Which of the following statements about medium-chain fatty acids (MCFAs) are correct?**
   a. MCFAs are absorbed directly into the bloodstream.
   b. MCFAs have 6-12 carbon atoms.
   c. MCFAs are an alternative fuel for the brain during fasting.

d. MCFAs are rapidly metabolized for energy.
e. MCFAs are primarily found in Dietary fiber.

Answer: a, b, c, d

7. **Which of the following statements about long-chain fatty acids (LCFAs) are accurate?**
   a. LCFAs are typically found in animal fats and oils.
   b. LCFAs have more than 10 carbon atoms.
   c. LCFAs are absorbed directly into the bloodstream.
   d. LCFAs are stored in adipose tissue.
   e. LCFAs are metabolized slower than MCFAs.

Answer: a, d, e

8. **Which statements about saturated fatty acids are true?**
   a. Saturated fatty acids have no double bonds.
   b. Saturated fatty acids are liquid at room temperature.
   c. Saturated fatty acids are typically found in animal products.
   d. Saturated fatty acids have one or more double bonds.
   e. Saturated fatty acids can contribute to cardiovascular disease.

Answer: a, c, e

9. **A dietitian is educating a cardiac patient about fat intake. Which of the following recommendations are beneficial?**
   a. Increase intake of trans fats to improve blood lipid profile.
   b. Choose monounsaturated fats such as those in avocados and nuts.
   c. Avoid all sources of dietary fat.
   d. Replace saturated fats with polyunsaturated fats.
   e. Consume large quantities of fatty red meat.

Answer: b, d

10. **Which of the following statements regarding monounsaturated fatty acids (MUFAs) are correct?**
    a. MUFAs have one double bond in their structure.
    b. MUFAs are found in high amounts in olive oil.
    c. MUFAs are typically solid at room temperature.
    d. MUFAs are considered unhealthy fats.
    e. MUFAs can help reduce bad cholesterol levels.

Answer: a, b, e

11. **A pregnant woman is seeking advice on omega-3 fatty acids. Which of the following suggestions would be appropriate?**
    a. Increase intake of fatty fish like salmon.
    b. Avoid all fish due to mercury concerns.
    c. Include flaxseeds and walnuts in the diet.
    d. Rely solely on omega-3 supplements without dietary changes.
    e. Consume fish oil supplements without consulting a healthcare provider.

Answer: a, c

12. Which statements about polyunsaturated fatty acids (PUFAs) are accurate?

a. PUFAs have multiple double bonds.
b. PUFAs are found in high amounts in fish oils.
c. PUFAs are typically solid at room temperature.
d. PUFAs include omega-3 and omega-6 fatty acids.
e. PUFAs are not essential for human health.

Answer: a, b, d

13. Which of the following statements about essential fatty acids are true?

a. Essential fatty acids can be synthesized by the body.
b. Essential fatty acids must be obtained from the diet.
c. Linoleic acid (LA) is an essential fatty acid.
d. Alpha-linolenic acid (ALA) is not an essential fatty acid.
e. Essential fatty acids are important for cardiovascular health.

Answer: b, c, e

14. Which statements regarding linoleic acid (LA) are correct?

a. LA is an omega-3 fatty acid.
b. LA is showing anti-inflammatory properties.
c. LA is an omega-6 fatty acid.
d. LA can be synthesized by the human body.
e. LA is essential for human health.

Answer: b, c, e

15. Which of the following statements about omega-3 fatty acids are true?

a. Omega-3 fatty acids are important for cardiovascular health.
b. Omega-3 fatty acids are not found in plant sources.
c. Omega-3 fatty acids include EPA and DHA.
d. Omega-3 fatty acids are found in high amounts in fish oil.
e. Omega-3 fatty acids cannot be converted into other forms in the body.

Answer: a, c, d

16. Which of the following statements about alpha-linolenic acid (ALA) are accurate?

a. ALA is an omega-6 fatty acid.
b. ALA exhibits thrombotic properties.
c. ALA is essential for cognitive function.
d. ALA can be converted into EPA and DHA in the body.
e. ALA is not found in plant sources.

Answer: b, c, d

17. Which statements about triglycerides are correct?

a. Triglycerides are the main form of stored fat in the body.
b. Triglycerides are composed of three fatty acids and one glycerol molecule.
c. Triglycerides are a type of phospholipid.
d. Triglycerides are classified as compound lipids.
e. Triglycerides provide insulation and protection for organs.

Answer: a, b, e

18. Which of the following statements about the hydrogenation of fats are true?

a. Hydrogenation converts unsaturated fats to saturated fats.
b. Hydrogenation increases the melting point of fats.
c. Hydrogenation converts vegetable oils to solid fats.
d. Hydrogenation decreases the shelf life of fats.
e. Hydrogenation requires a catalyst to increase the rate of reaction.

Answer: a, b, c, e

COURSE 3 – FUNCTIONAL ASPECTS OF PROTEIN

Hemoglobin

1.

a. A newborn baby has a Hb of 18g/dl while its Hb will become normal in 5 to 6 months.

Explain the biochemical basis behind that.

- The high hemoglobin (Hb) level of 18g/dl in a newborn baby is a physiological adaptation to life in the womb.
- Developing fetus relies on fetal hemoglobin (HbF).
- HbF has a higher affinity for oxygen than adult hemoglobin (HbA).
- This allows the fetus to extract oxygen efficiently from the mother's blood through the placenta.
- After birth, the baby's body gradually replaces HbF with adult hemoglobin (HbA).
- This transition occurs over several months.
- HbF levels decline, and HbA levels increase as the baby grows.
- Initially, the baby needs a higher hemoglobin concentration to meet its oxygen demands.
- HbF provides this high oxygen affinity.
- As the baby adapts to breathing air and its oxygen requirements change, the need for high HbF decreases.
- Around 5 to 6 months of age, the baby's hemoglobin levels start to stabilize.
- At this point, the baby's body requires less hemoglobin to function normally.
- Therefore, the hemoglobin concentration decreases to a more typical range.

b. A baby with methemoglobinemia presented to the ward with severe respiratory distress and a SpO2 of 70%. His partial pressure of O2 remains 100mmHg. Explain the biochemical basis behind the above phenomena.

- Normal Blood has only less than 1% of Methemoglobin.
- Methemoglobinemia occurs when the iron atom in hemoglobin is oxidized to the ferric (Fe^{3+}) state, forming methemoglobin.
- Unlike normal hemoglobin (which binds oxygen), methemoglobin has a markedly decreased capacity for oxygen binding and transport.
- As a result, symptoms of methemoglobinemia stem from inadequate oxygen transport.
- It is manifested as cyanosis (Bluish Discoloration of the skin resulting from poor circulation).
- Methemoglobin shifts the Hb-02 dissociation curve to the right, requiring a higher PaO_2 for the same SpO2.

2. An 8-month-old infant presented to the pediatric ward with respiratory distress, difficulty in feeding

significant pale and hepatosplenomegaly and found to have beta thalassemia major.

a. Describe his HPLC report.

- The HPLC (High-Performance Liquid Chromatography) report for an infant with beta-thalassemia major would typically show a significant elevation in the levels of hemoglobin F (HbF) and a decrease in the levels of hemoglobin A (HbA).
- Additionally, there may be an increase in the levels of hemoglobin A2 (HbA2), which is a minor fraction of hemoglobin.
- The specific values may vary depending on the severity of the beta-thalassemia and other factors, but the general pattern reflects the imbalance in hemoglobin production characteristic of beta-thalassemia major.

b. Explain the biochemical basis behind his physical findings.

- Beta-thalassemia major is a genetic disorder characterized by reduced or absent synthesis of beta-globin chains, leading to ineffective erythropoiesis and hemolysis.
- The absence or reduced production of beta-globin chains results in an imbalance in the synthesis of globin chains, leading to an excess of alpha-globin chains.
- This excess of alpha-globin chains forms unstable tetramers known as hemoglobin H (HbH) and precipitates within red blood cells, leading to hemolysis.
- The ineffective erythropoiesis and hemolysis result in severe anemia, which manifests as pallor and can lead to tissue hypoxia, causing respiratory distress.
- The bone marrow attempts to compensate for the anemia by increasing erythropoiesis, resulting in hepatosplenomegaly due to extramedullary hematopoiesis in these organs.
- However, this compensatory mechanism is inadequate to maintain normal hemoglobin levels, leading to ongoing anemia and its associated symptoms.

BIOCHEMISTRY
SMALL GROUP DISCUSSION (SGD)
QUESTIONS & ANSWERS

1. **COURSE 1 – CELL BIOCHEMISTRY**
2. **COURSE 2 – BIOMOLECULES**
3. **COURSE 3 – FUNCTIONAL ASPECTS OF PROTEIN**

COURSE 1 – CELL BIOCHEMISTRY

Bioenergetics

Objectives

- These structured essay questions and sub-questions aim to guide a detailed exploration of the Electron Transport Chain and the effects of its inhibitors on cellular respiration and energy production.

1. The Electron Transport Chain (ETC).

1.1. Define what is the "Electron Transport Chain". (10 Marks)

A "specialized set of electron carriers"

The Electron Transport Chain (ETC) is a series of protein complexes and other molecules embedded in the inner mitochondrial membrane that facilitate the transfer of electrons from electron donors (NADH and FADH2) to electron acceptors (primarily oxygen).

1.2. What are the main components of the Electron Transport Chain, and where is it located within the cell? (30 Marks)

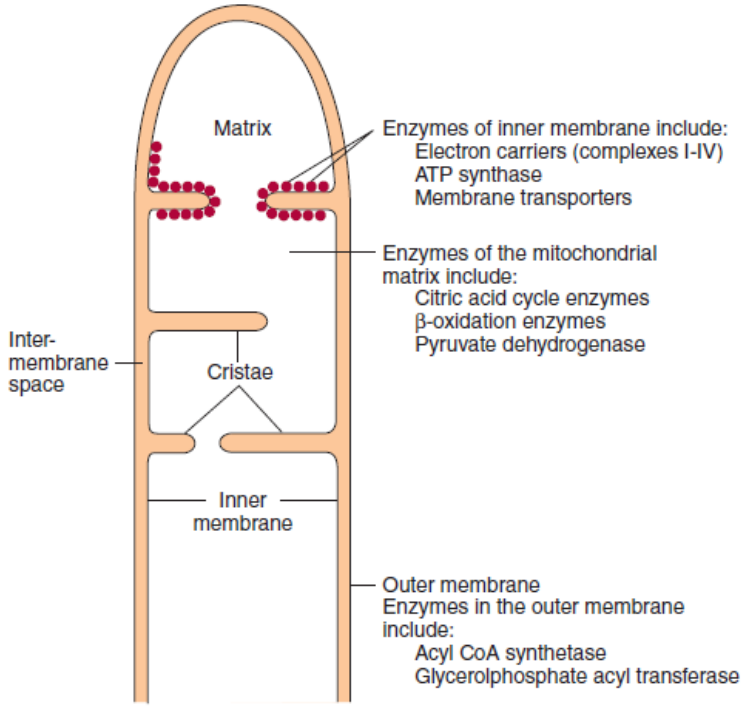


FIGURE 13–1 Structure of the mitochondrial membranes. Note that the inner membrane contains many folds or cristae.

- The Electron Transport Chain (ETC) is located in the inner mitochondrial membrane of eukaryotic cells.
- Its main components include four multi-protein complexes
- NADH-Q oxidoreductase (Complex I)
- Succinate-Q reductase (Complex II)
- Q-cytochrome c oxidoreductase (Complex III)
- Cytochrome c; and cytochrome c oxidase (Complex IV)

work together to facilitate electron transfer from NADH and FADH2 to oxygen, the final electron acceptor.

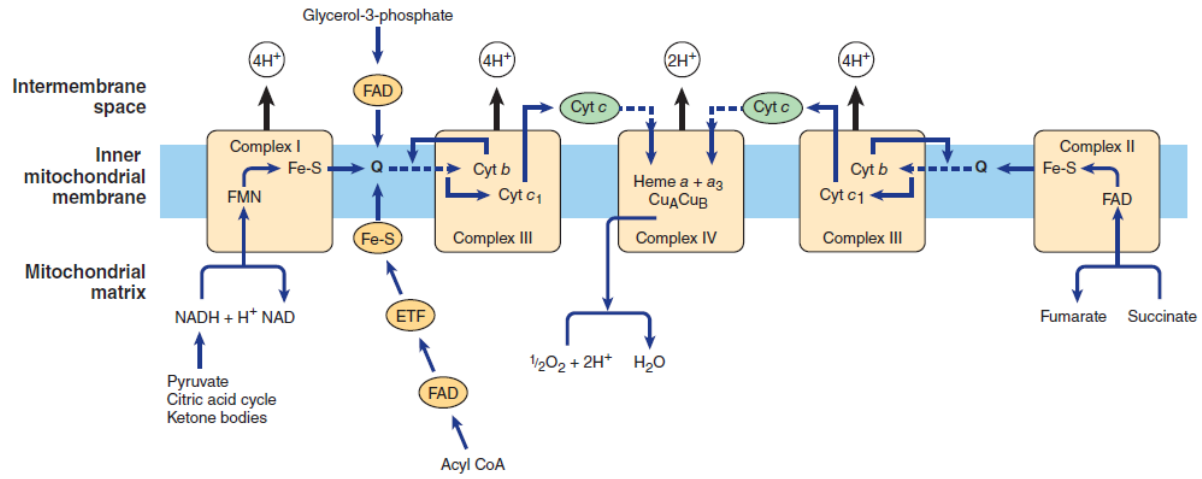


FIGURE 13–5 **Flow of electrons through the respiratory chain complexes, showing the entry points for reducing equivalents from important substrates.** Q and cyt *c* are mobile components of the system as indicated by the dotted arrows. The flow through Complex III (the Q cycle) is shown in more detail in Figure 13–6. (cyt, cytochrome; ETF, electron transferring flavoprotein; Fe-S, iron-sulfur protein; Q, coenzyme Q or ubiquinone.)

1.3. Explain the role of electron carriers (NADH and FADH2) in the ETC. (10 Marks)

- NADH and FADH2, produced in the citric acid cycle, donate electrons to the ETC.
- NADH transfers electrons to Complex I, while FADH2 transfers electrons to Complex II.
- These electron transfers drive the movement of electrons through the chain and the pumping of protons across the mitochondrial membrane.

1.4. How is the proton gradient established across the mitochondrial membrane, and why is it important for ATP synthesis? (20 Marks)

- As electrons move through Complexes I, III, and IV, protons (H+) are pumped from the mitochondrial matrix into the intermembrane space, creating an electrochemical gradient (proton motive force).
- This gradient is essential for ATP synthesis because it provides the energy required for the phosphorylation of ADP to ATP.

1.5. Describe the process of chemiosmosis and its significance in the production of ATP.

(30 Marks)

- Chemiosmosis is the process by which the proton gradient generated by the ETC drives ATP synthesis.
- Protons flow back into the mitochondrial matrix through ATP synthase, a protein complex that uses the energy from this flow to convert ADP and inorganic phosphate (Pi) into ATP.
- This mechanism is central to the production of ATP in cellular respiration.

2. The role of oxidative phosphorylation in energy production.

2.1. What is oxidative phosphorylation, and how does it differ from substrate-level phosphorylation?
(20 Marks)

- Oxidative phosphorylation is the process of ATP production linked to the transfer of electrons through the ETC and the resulting proton gradient, whereas substrate-level phosphorylation occurs directly in metabolic pathways like glycolysis and the citric acid cycle, independent of the ETC.

2.2. Describe the role of ATP synthase in the ETC. (20 Marks)

- ATP synthase is an enzyme complex located in the inner mitochondrial membrane. It synthesizes ATP by utilizing the proton motive force created by the ETC.
- Protons flowing back into the mitochondrial matrix through ATP synthase cause it to rotate, catalyzing the conversion of ADP and Pi into ATP.

2.3. How does the coupling of the electron transport chain and ATP synthesis occur?
(30 Marks)

- The ETC and ATP synthesis are coupled processes through the proton gradient.
- The energy released from electron transfer through the ETC is used to pump protons, creating a gradient.
- This gradient then powers ATP synthase to produce ATP, demonstrating the interdependence of the two processes.

2.4. Discuss the impact of oxygen availability on the efficiency of the electron transport chain and ATP production. (30 Marks)

- Oxygen is the final electron acceptor in the ETC.
- Without oxygen, electrons cannot be passed through the chain, halting proton pumping and ATP production.
- This lack of oxygen (hypoxia or anoxia) leads to reduced ATP production, affecting cell function and survival.

3. The mechanisms by which inhibitors of the Electron Transport Chain disrupt cellular respiration.

3.1. Identify and describe three major classes of ETC inhibitors and their specific targets within the chain.
(30 Marks)

- Complex I inhibitors: Rotenone and amytal inhibit electron transfer from NADH to ubiquinone.
- Complex III inhibitors: Antimycin A inhibits electron transfer within the cytochrome bc1 complex.
- Complex IV inhibitors: Cyanide, carbon monoxide, and azide inhibit cytochrome c oxidase, blocking electron transfer to oxygen.

3.2. Explain how these inhibitors affect the flow of electrons and the establishment of the proton gradient. (20 Marks)

- ETC inhibitors block specific sites in the chain, preventing electron flow and halting proton pumping. This disruption stops the establishment of the proton gradient, leading to reduced ATP synthesis as the proton motive force is essential for ATP synthase activity.

3.3. What are the physiological consequences of ETC inhibition on cellular metabolism?
(30 Marks)

- Inhibition of the ETC leads to decreased ATP production, causing energy deficits in cells.
- This can result in cellular dysfunction and death, manifesting as various physiological issues, including muscle weakness, neurological deficits, and, in severe cases, organ failure.

3.4. Provide examples of natural or synthetic substances that act as ETC inhibitors and their applications in research or medicine. (20 Marks)

- Rotenone: A natural pesticide used in research to study Parkinson's disease models.
- Antimycin A: Used to study mitochondrial function and apoptosis.
- Cyanide and carbon monoxide: Studied for their toxicological effects and mechanisms of poisoning.

4. The effects of specific inhibitors on the Electron Transport Chain and the implications for ATP production.

4.1. Describe the action of cyanide and carbon monoxide as ETC inhibitors and their specific points of action within the chain. (20 Marks)

- Cyanide and carbon monoxide inhibit Complex IV (cytochrome c oxidase).
- Cyanide binds to the iron within the heme group, preventing electron transfer to oxygen.
- Carbon monoxide binds to the same site, blocking oxygen binding and electron transfer.

4.2. How do these inhibitors interfere with oxygen utilization and ATP synthesis?
(20 Marks)

- By inhibiting cytochrome c oxidase, these substances prevent the reduction of oxygen to water, stopping the electron flow and proton pumping. This halts ATP synthesis, leading to severe energy deficits and potential cell death.

4.3. Discuss the clinical manifestations and treatment strategies for poisoning by ETC inhibitors like cyanide and carbon monoxide. (30 Marks)

- Cyanide poisoning: Symptoms include headache, dizziness, shortness of breath, and loss of consciousness. Treatment involves administering antidotes like hydroxocobalamin, which binds cyanide, or sodium thiosulfate, which enhances cyanide detoxification.
- Carbon monoxide poisoning: Symptoms include headache, dizziness, confusion, and potentially death. Treatment includes administering 100% oxygen or hyperbaric oxygen therapy to displace CO from hemoglobin and cytochrome c oxidase.

5. Evaluate the use of ETC inhibitors in scientific research to study mitochondrial function and disease mechanisms. (30 Marks)

- ETC inhibitors like cyanide and carbon monoxide are used to study mitochondrial dysfunction and the role of oxidative phosphorylation in various diseases.
- They help in understanding the pathophysiology of conditions like ischemia-reperfusion injury and neurodegenerative diseases.

Cell Structure and Function

1. Why do mitochondria need a special translocator to import proteins across the outer membrane, when the membrane already has large pores formed by porins?

2. Which statements are true? Explain why or why not.

2.1 Like the lumen of the ER, the interior of the nucleus is topologically equivalent to the outside of the cell.

2.2 ER-bound and free ribosomes, which are structurally and functionally identical, differ only in the proteins they happen to be making at a particular time.

2.3 To avoid the inevitable collisions that would occur if two-way traffic through a single pore were allowed, nuclear pore complexes are specialized so that some mediate import while others mediate export.

2.4 Peroxisomes are found in only a few specialized types of eukaryotic cell

Transport across the membranes

1. Which statements are true? Explain why or why not.

- **Transport by transporters can be either active or passive, whereas transport by channels is always passive.**

The statement is true.

- Transport by Transporters: Can be either active (requiring energy) or passive (not requiring energy). Active transport can move molecules against their concentration gradient, while passive transport moves molecules down their concentration gradient.
- Transport by Channels: Always passive. Channels provide a pathway for ions or water to move down their concentration or electrochemical gradients, facilitating rapid and efficient transport without the use of cellular energy.

- **Transporters saturate at high concentrations of the transported molecule when all their binding sites are occupied; channels, on the other hand, do not bind the ions they transport and thus the flux of ions through a channel does not saturate.**

The statement is true.

Transporters bind to the molecules they transport and can become saturated at high concentrations when all their binding sites are occupied, limiting the transport rate (Vmax). Channels, on the other hand, do not bind the ions they transport; instead, ions flow through channels based on concentration gradients, allowing continuous flux without saturation. Transporters follow Michaelis-Menten kinetics, while channels do not.

- **The membrane potential arises from movements of charge that leave ion concentrations practically unaffected, causing only a very slight discrepancy in the number of positive and negative ions on the two sides of the membrane.**

The statement is true.

The membrane potential indeed arises from the movements of ions (charges) across the cell membrane, creating an electrical gradient. This process involves only a very slight discrepancy in the number of positive and negative ions on either side of the membrane, leaving the overall ion concentrations practically unaffected. This small imbalance is enough to generate a measurable voltage difference across the membrane.

2. Discuss the following problems.

- **Order Ca2+, CO2, ethanol, glucose, RNA, and H2O according to their ability to diffuse through a lipid bilayer, beginning with the one that crosses the bilayer most readily. Explain your order.**

CO2 ➡ Ethanol➡ H2O ➡ Glucose ➡Ca2+ ➡RNA

CO2 is a small, nonpolar gas molecule, allowing it to easily diffuse through the lipid bilayer without any assistance. Ethanol is a small polar molecule with some hydrophobic characteristics due to its ethyl group, enabling it to diffuse through the lipid bilayer more readily than larger polar molecules. Water is a small polar molecule that can pass through the lipid bilayer relatively easily, though not as freely as CO2. It often uses specialized channels called aquaporins to increase its permeability. Glucose is a larger polar molecule that cannot easily diffuse through the lipid bilayer. It typically requires transporters (e.g., GLUT transporters) to cross the membrane. Ca2+ is a small ion but has a strong positive charge, making it highly impermeable to the lipid bilayer. It requires specific ion channels or transporters to cross the membrane. RNA molecules are large, polar, and charged (due to the phosphate backbone), making them highly impermeable to the lipid bilayer. RNA typically needs active transport mechanisms (e.g., nuclear pores, ribonucleoproteins) to move across membranes.

- **How is it possible for some molecules to be at equilibrium across a biological membrane and yet not be at the same concentration on both sides?**

Molecules can be at equilibrium across a biological membrane without being at the same concentration on both sides because equilibrium is determined by the electrochemical gradient, which includes both the concentration gradient and the electrical potential difference across the membrane. This means that the balance of forces from these gradients can result in unequal concentrations while still maintaining a state of no net movement of the molecules.

Defects in Cellular Organelles and Cell Membranes that Lead to Diseases

True or False

1. **Familial hypercholesterolemia (FH) is a genetic disorder of lipoprotein metabolism,**
   a) FH is an autosomal recessive inherited disorder of lipoprotein metabolism characterized by very high plasma concentrations of low-density lipoprotein cholesterol (LDL), tendon xanthomas, and an increased risk of premature coronary heart disease (CHD).
   b) LDL receptors on the surface of hepatocytes are necessary for the binding and subsequent uptake of LDL molecules in the blood. This mutation leads to a decrease in the LDL receptor number.
   c) If this mutation is heterozygous, some LDL receptors will be present on the hepatocytes, then LDL is usually around 300 mg/dL.
   d) In homozygous mutations, it will result in the complete absence of LDL receptors on hepatocytes, increasing the LDL cholesterol levels to 1000 mg/dL.
   e) Patients with FH have an increased risk of premature cardiovascular disease.

2. **Defects in cellular organelles and cell membranes can lead to a variety of diseases due to the disruption of essential cellular processes.**
   a) Defects in ion channel proteins in the cell membrane can lead to diseases such as cystic fibrosis and epilepsy.
   b) Lipid rafts in the cell membrane play a crucial role in signaling pathways and membrane protein localization.
   c) Mutations in aquaporin channels, which regulate water flow across the cell membrane, have no impact on cellular hydration status.
   d) Aberrant cholesterol levels in the cell membrane can alter membrane fluidity and permeability, impacting cellular function.
   e) Disruption of the Na+/K+ ATPase pump in the cell membrane can result in altered cellular ion homeostasis and contribute to hypertension.

3. **Achondroplasia is a genetic disorder,**
   a) It is the most common form of short-limb dwarfism. It is caused by a mutation in the FGFR3 gene.
   b) The condition follows an autosomal recessive pattern of inheritance.
   c) The FGFR3 gene mutation that causes achondroplasia is located on the X chromosome.
   d) Individuals with achondroplasia often have characteristic facial features, including a prominent forehead and midface hypoplasia.
   e) Achondroplasia can be diagnosed prenatally through genetic testing and ultrasound.

4. **Cystic fibrosis, a genetic disorder that affects the lungs, pancreas, and other organs,**
   a) Cystic fibrosis (CF) is caused by mutations in the CFTR gene. CF is an autosomal dominant disorder.
   b) Cystic fibrosis is caused by defects in the cystic fibrosis transmembrane conductance regulator (CFTR) protein.
   c) Mutations in the CFTR gene lead to abnormal ion transport across epithelial cell membranes.
   d) The CFTR protein is primarily involved in glucose transport across cell membranes.
   e) CFTR modulators, such as ivacaftor and lumacaftor, target specific mutations to improve CFTR function.

5. **Defects in copper transporters lead to distinct molecular mechanisms and clinical consequences in Wilson's disease and Menkes disease.**
   a) Wilson's disease is caused by mutations in the ATP7A gene. ATP7A encodes a copper-transporting ATPase, which is essential for copper homeostasis.
   b) Menke disease is caused by mutations in the ATP7B gene. ATP7B encodes a copper-transporting ATPase, which is crucial for copper distribution in the body.
   c) Wilson's disease is caused by a deficiency in iron transport proteins. ATP7B mutations lead to increased copper excretion in the bile.
   d) Penicillamine and trientine are chelating agents used to treat Wilson's disease by promoting copper excretion.
   e) Menkes disease follows an X-linked recessive pattern of inheritance.

Single best choice

1. **What is Inclusion-Cell (I-Cell) Disease?**
   a) A genetic disorder characterized by the absence of lysosomal enzymes
   b) An autoimmune disorder affecting the nervous system
   c) A viral infection causing respiratory issues
   d) A type of disease affecting the liver
   e) A metabolic disorder affecting carbohydrate metabolism

2. **Which gene is mutated in I-Cell Disease?**
   a) GLA
   b) GNPTAB
   c) HEXA
   d) SMPD1
   e) IDUA

3. **Which of the following best describes the inheritance pattern of Achondroplasia?**
   a) Autosomal recessive
   b) Autosomal dominant
   c) X-linked recessive
   d) X-linked dominant
   e) Mitochondrial inheritance

4. **Which gene is mutated in Cystic Fibrosis?**
   a) CFTR gene
   b) BRCA1 gene
   c) G6PD gene
   d) HBB gene
   e) TSC1 gene

5. **A deficiency in which enzyme activity is characteristic of Menkes disease?**
   a) Cytochrome c oxidase
   b) Lysyl oxidase
   c) Glucose-6-phosphate dehydrogenase
   d) Superoxide dismutase
   e) Hexokinase

pH and Buffers

1. pH and Its Biological Importance

1.1. Define pH. **(10 marks)**

pH is a measure of the hydrogen ion activity in a solution, indicating its acidity or alkalinity. It is defined as the negative logarithm (base 10) of the hydrogen ion concentration: pH = -log[H^+]. The pH scale ranges from 0 to 14, with 7 being neutral. Values below 7 indicate acidity, and values above 7 indicate alkalinity.

1.2. Describe three (03) major systems/factors influencing pH levels in the human body.

(15 marks)

Several factors influence pH levels in the human body, including the presence of acids and bases, and the function of buffer systems. Major buffer systems include the bicarbonate buffer system, phosphate buffer system, and protein buffer system.

- Acids and Bases: Acids donate hydrogen ions (H^+), lowering pH, while bases accept hydrogen ions, increasing pH.

- Respiration: The respiratory system regulates blood pH by controlling CO_2 levels. CO_2 reacts with water to form carbonic acid, which dissociates into hydrogen ions and bicarbonate.

- Renal Function: The kidneys help maintain pH by excreting hydrogen ions and reabsorbing bicarbonate from urine.

1.3. State the role of pH in Physiological Processes. **(10 Marks)**

- Enzyme Activity and Protein Function: Enzymes and proteins have optimal pH ranges where they function best. Deviations from this range can lead to denaturation or reduced activity.

- Metabolic Processes: Cellular metabolism produces acids, such as lactic acid during anaerobic respiration. Proper pH balance ensures these acids are neutralized or excreted.

- Blood pH Regulation: Blood pH is tightly regulated between 7.35 and 7.45. Acidosis (pH < 7.35) and alkalosis (pH > 7.45) can disrupt cellular functions. The bicarbonate buffer system, respiratory regulation, and renal excretion work together to maintain this balance.

- Gastric pH: The stomach maintains a highly acidic environment (pH 1.5-3.5) for digestion. This acidity activates digestive enzymes like pepsin and helps kill pathogens.

1.4. List 03 (03) laboratory methods for measuring pH in urine samples and their significance in Medicine. **(15 Marks)**

Methods	Significance
pH Indicator Strips pH indicator strips, also known as pH paper, are dipped into a urine sample. The strip changes color based on the pH of the urine. The resulting color is then compared to a color chart to determine the pH value.	• Quick and Convenient: pH indicator strips provide a rapid, simple, and cost-effective way to measure urine pH, making them useful for routine screening in clinical settings. • Initial Diagnosis of Metabolic and Renal Disorders: Changes in urine pH can indicate metabolic conditions such as renal tubular acidosis or dietary influences, prompting further investigation.
Digital pH Meter A digital pH meter uses an electrode to measure the hydrogen ion concentration in the urine sample. The electrode is immersed in the urine, and the meter provides a digital readout of the pH value.	• High Precision: Digital pH meters provide more accurate and precise pH measurements compared to indicator strips, which is crucial for detailed diagnostic purposes. • Diagnosis and Monitoring of Renal Disorders: Accurate urine pH measurement is essential for diagnosing and managing conditions like renal tubular acidosis, where the kidneys' ability to acidify urine is impaired. • Research and Clinical Studies: Digital pH meters are valuable in research settings for studying the effects of different treatments or conditions on urine pH, providing reliable data for clinical studies.
Automated Urinalysis Analyzers Automated urinalysis analyzers are sophisticated machines that perform a comprehensive analysis of urine samples, including pH measurement. These devices use ion-selective electrodes or colorimetric sensors to determine pH.	• Comprehensive Urine Analysis: Automated analyzers provide a complete urine profile, including pH, specific gravity, and the presence of proteins, glucose, ketones, and other substances, which helps in diagnosing a wide range of conditions. • High Throughput: These analyzers are capable of processing multiple samples quickly, making them ideal for busy clinical laboratories and large-scale screening programs. • Integration with Electronic Medical Records (EMR): Automated analyzers can be integrated with EMR systems, ensuring accurate and efficient recording of results, which enhances patient care and follow-up.

2. Buffer Systems in the Human Body

2.1. Define a Buffer and Explain Its General Mechanism of Action. **(10 Marks)**

A buffer is a solution that resists changes in pH when small amounts of acid or base are added. It consists of a weak acid and its conjugate base or a weak base and its conjugate acid. Buffers work by neutralizing added acids or bases. For instance, in an acid buffer, the weak acid donates hydrogen ions to neutralize added bases, while the conjugate base absorbs hydrogen ions to neutralize added acids.

2.2. List three (03) major buffer systems in the human body. **(15 marks)**

- Bicarbonate Buffer System:

  - Components: Carbonic acid (H_2CO_3) and bicarbonate (HCO_3^-).

- Phosphate Buffer System:

  - Components: Dihydrogen phosphate ($H_2PO_4^-$) and hydrogen phosphate (HPO_4^{2-}).

- Protein Buffer System:

- Proteins (e.g., hemoglobin) act as buffers.

2.3. Explain the interaction between buffer systems of the human body. (10 marks)

Buffer systems work synergistically to maintain pH balance. The bicarbonate system primarily buffers extracellular fluid, while the phosphate system is more active intracellularly. Protein buffers function both inside cells and in blood plasma. When one buffer system is overwhelmed, others can compensate. For example, during acidosis, the bicarbonate system works alongside respiratory compensation to regulate pH.

2.4. Briefly Discuss the Response to Metabolic and Respiratory Disturbances in the following conditions. (15 Marks)

2.4.1. Metabolic Acidosis

• Caused by increased acid production (e.g. lactic acidosis) or bicarbonate loss (e.g. diarrhea).

• The body compensates by increasing respiration to expel CO_2 (respiratory compensation) and by the kidneys excreting hydrogen ions and reabsorbing bicarbonate.

2.4.2. Metabolic alkalosis

• Caused by excessive bicarbonate (e.g., ingestion of antacids) or acid loss (e.g., vomiting).

• The body compensates by decreasing respiration to retain CO_2 and by the kidneys excreting bicarbonate.

2.4.3. Respiratory Acidosis

• Caused by impaired CO_2 excretion (e.g., COPD).

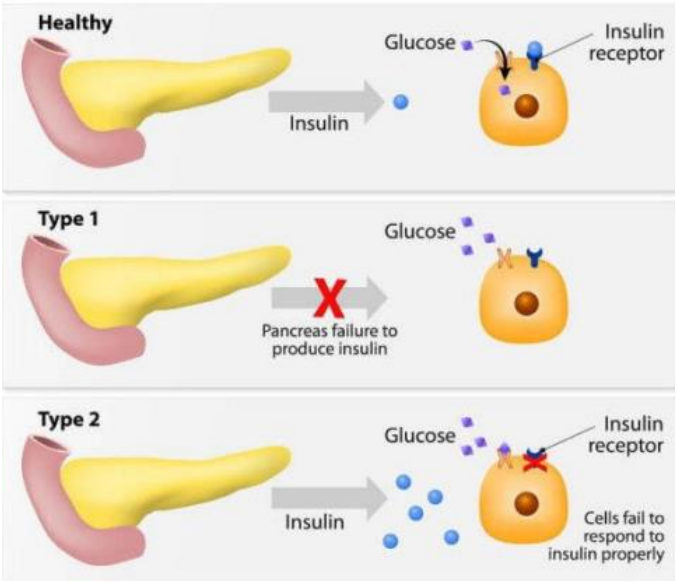
• The kidneys compensate by excreting hydrogen ions and reabsorbing bicarbonate

COURSE 2 – BIOMOLECULES

Carbohydrates

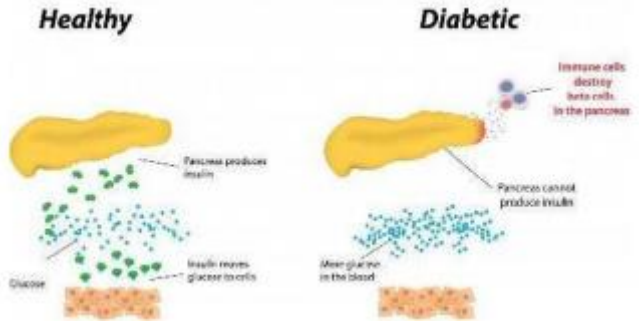
Q1.) What is Diabetes Mellitus? Describe the three primary types of Diabetes Mellitus and explain the underlying mechanisms that lead to each type.

- Diabetes Mellitus is a Chronic disease caused by inherited and/or acquired deficiency in the production of insulin by the pancreas, or by the ineffectiveness of the insulin produced
- Diabetes Mellitus is a group of metabolic disorders characterized by high blood sugar levels over a prolonged period
- The three primary types of Diabetes Mellitus are **Type 1, Type 2, and Gestational Diabetes**



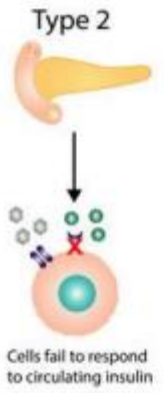
Type 1 diabetes

- Type 1 Diabetes is an autoimmune condition where the immune system mistakenly attacks and destroys insulin-producing beta cells in the pancreas
- This condition occurs when the pancreas fails to produce insulin leading to elevated blood sugar levels
- People with Type 1 Diabetes require insulin therapy to survive



Type 2 diabetes

- Results from the body's inability to respond properly to the action of insulin produced by the pancreas
- Type 2 Diabetes is the most common form of diabetes and is often associated with lifestyle factors such as poor diet, lack of physical activity, and obesity





Gestational diabetes

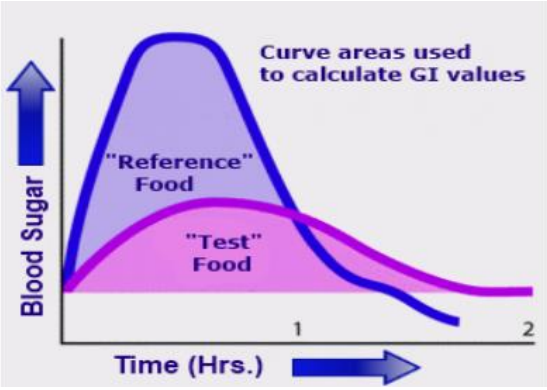
- Pregnant women who have never had diabetes before but who have high blood glucose levels during pregnancy
- Gestational Diabetes occurs during pregnancy when the body is unable to produce enough insulin to meet the extra demands and hormones produced by the placenta may interfere with insulin leading to Gestational diabetes
- It can lead to high blood sugar levels, which may pose risks to both the mother and the baby
- Gestational Diabetes usually resolves after giving birth, but women who have had it are at a higher risk of developing Type 2 Diabetes later in life



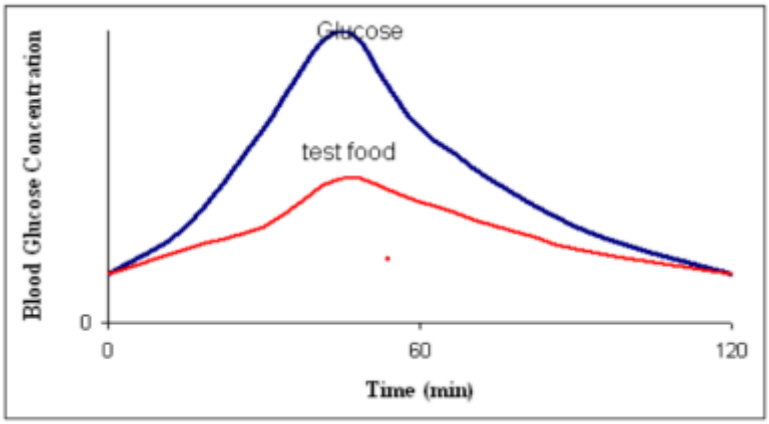
Q2.) What is the Glycemic Index (GI) and describe the way to measure GI in food?

Glycemic Index

- A ranking of carbohydrate-containing foods, based on the food's effect on blood sugar compared with a standard reference food's effect (typically pure glucose or white bread)



- The incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject
- The blood glucose concentrations are measured at regular intervals for 2 hours after consuming a test food containing 50 g



GI Testing Procedure

- **Test Food:** A portion of the test food that contains exactly 50 grams of available carbohydrates is consumed by a group of individuals

Example – If you are testing a food like an apple: Determine how much of the apple you need to consume to get 50 grams of available carbohydrates. (For example, if an apple contains 20 grams of carbohydrates per 100 grams, you would need 250 grams of apple to get 50 grams of carbohydrates.)

- **Reference Food:** On a different day, the same individuals consume a portion of the reference food (either pure glucose or white bread) that also contains exactly 50 grams of available carbohydrates

- **Blood Glucose Measurement:** Blood glucose levels are measured at regular intervals over a two-hour period after consumption of both the test food and the reference food
- **Comparison:** The blood glucose response curve for the test food is compared to the response curve for the reference food. The GI value is calculated as the percentage of the area under the blood glucose response curve for the test food relative to the reference food
- Foods with a **high GI** are rapidly digested and absorbed, causing a quick spike in blood sugar levels, while foods with a **low GI** are digested and absorbed more slowly, resulting in a gradual and more sustained increase in blood sugar levels
- Carbohydrates with a **high GI (GI > 70)** include white bread, white rice, most baked goods (cakes, cookies), sugary drinks, Potato, and Some fruits (Jack fruit, Mango)
- Carbohydrates with a **low GI (GI <55)** include whole grains, legumes, nonstarchy vegetables, nuts, seeds, dairy products, and some fruits (apple, berries, citrus fruit)

Q3.) Explain how the Glycemic Index (GI) relates to carbohydrates in clinical practice.

Clinical Application

- In clinical practice, the GI is used as a tool to help manage blood sugar levels, particularly for individuals with diabetes or those at risk of developing diabetes
- **Food Choices**: Understanding the GI of carbohydrates can help individuals make a healthier food choice
- **Diabetes Management**: For individuals with diabetes, choosing foods with a lower GI can help manage blood glucose levels more effectively throughout the day. These foods prevent rapid spikes in blood sugar after meals, reducing the need for excessive insulin secretion and promoting better glycemic control
- **Weight Management:** Low GI foods tend to provide longer-lasting energy and promote satiety, which may help in controlling appetite and managing weight
- **Physical Performance:** The GI can also be useful for athletes or individuals looking to optimize their performance. Consuming carbohydrates with a moderate to high GI before or during exercise can provide a quick source of energy
- **Overall Health:** Incorporating a variety of low to moderate GI foods in the diet supports overall health by providing sustained energy, improving insulin sensitivity, and reducing the risk of obesity and chronic diseases such as type 2 diabetes and cardiovascular disease

Q4.) Explain the concept of Glycemic Load (GL) in relation to dietary management. How does Glycemic Load differ from Glycemic Index (GI), and why is it clinically significant in conditions like diabetes?

Glycemic Load

- Glycemic Load (GL) is a crucial tool in understanding how carbohydrates in foods affect blood glucose levels, integrating both the quality (Glycemic Index, GI) and quantity of carbohydrates consumed
- Unlike **GI**, which measures how quickly a food raises blood glucose compared to glucose itself, **GL** factors in the actual amount of carbohydrates per serving

Calculating Glycemic Load:

- GL = (GI × grams of carbohydrates per serving) / 100
- A glycemic load value of 10 or less is considered low, 11–19 is considered medium, and 20 or more is considered high
- Understanding glycemic Load empowers individuals with diabetes, to make dietary choices that promote stable blood sugar levels and overall metabolic health
- By considering both the quality and quantity of carbohydrates with Glycemic Load, individuals can make more informed choices about portion sizes and food combinations to help manage blood sugar levels

Eg- Take **watermelon**, which has a high GI due to its natural sugars.

However, the actual carbohydrate content per serving is relatively low. This results in a **low GL** despite its high GI, indicating that while watermelon can cause a quick rise in blood glucose levels, the total impact is tempered by the serving size

➢ **Example GL Calculation for Watermelon**

- **GI of Watermelon:** 72 (High GI)
- **Carbohydrates in a typical serving (about 120 grams of watermelon):** 6 grams

$$GL = 72 \times 6100 = 4.32$$

So, a typical serving of watermelon (120 grams) has a Glycemic Load of approximately 4

Q5.) What are soluble fibers, and what are the health benefits associated with their consumption? Include clinical insights and mechanisms of action in your explanation

- Soluble fibers are dietary fibers that dissolve in water to form a gel-like substance during digestion
- It slows down the digestion process
- Unlike insoluble fibers, which pass through the digestive system largely intact, soluble fiber undergoes partial fermentation in the colon, leading to a range of beneficial physiological effects
- Beta glucans, Pectin, and gums are the predominant soluble dietary fibers
- These are mainly found in foods like grains like (oats, and barley), seeds (flax seeds), nuts, Lentils, Chickpeas, fruits (apples, banana, berries, citrus fruits), and vegetables like (broccoli, and carrots)

Control Blood Glucose level

- Slows the digestion
- Formed viscus gel slows the absorption of sugar in the blood
- This aids blood glucose control and reduces insulin spikes

Lowers the Blood cholesterol level

- Lowers the fat absorption
- Soluble fibers bind with bile acids in the intestine, which are then excreted. This prompts the liver to use cholesterol to produce more bile acids, thus lowering the levels of LDL cholesterol in the blood

Improve the growth of Beneficial microorganisms

- Act as a subtract for gut microbiota
- Soluble fiber undergoes fermentation and products such as SCFAs, act as an energy source for gut microbiota

Gut health

- During fermentation in the colon, soluble fibers are broken down by beneficial gut bacteria, producing short-chain fatty acids (SCFAs) like butyrate, which have anti-inflammatory properties, reduced risk of inflammatory disease serve as an energy source for colonic cells

Reduce the risk of CVD

- Lowering LDL cholesterol is crucial in reducing the risk of cardiovascular diseases, such as heart attack and stroke
- Regular consumption of soluble fibers has been shown to contribute to a significant reduction in serum cholesterol levels

Weight management

- Increase feelings of fullness (satiety) by slowing gastric emptying and promoting the release of satiety hormones which reduce the calorie intake

Q6.) What are insoluble fibers, and what are the health benefits associated with their consumption?

- Insoluble fiber that does not dissolve in water
- They remain largely intact as they pass through the digestive system, adding bulk to the stool and aiding in its passage
- Common sources of insoluble fiber include whole grains (such as wheat bran, brown rice, and whole-wheat products), nuts, and the skins and seeds of many fruits and vegetables, including potatoes, tomatoes, and carrots

Promotes Regular Bowel Movements

- Insoluble fibers increase stool bulk and promote the movement of material through the digestive tract
- This property helps prevent constipation and associated conditions like hemorrhoids and diverticulitis

Reduces Risk of Colorectal Cancer

- By speeding up the passage of food and waste through the digestive system, insoluble fibers reduce the time that the intestinal lining is exposed to potential carcinogens
- Studies have shown that a diet high in insoluble fiber is linked to a lower risk of colorectal cancer
- This protective effect underscores the importance of dietary fiber in cancer prevention strategies

Helps in weight management

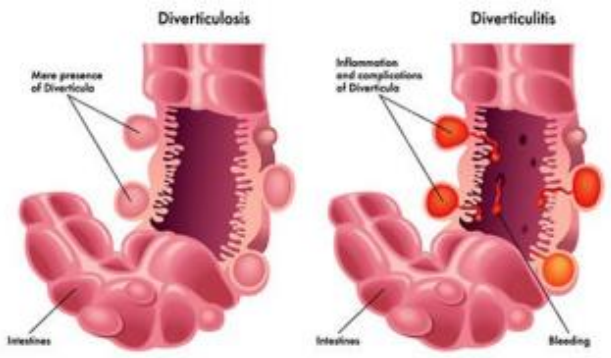
- Insoluble fibers increase dietary bulk without contributing extra calories
- Enhanced satiety can aid in weight management and prevent overeating, which is crucial for individuals aiming to maintain or reach a healthy weight

Enhance digestive health

- Insoluble fiber provides a substrate for fermentation, promoting the growth of beneficial bacteria in the gut and maintaining an optimal pH in the intestines
- A healthy gut microbiome supports various aspects of health, including improved immune function and reduced inflammation

Q7.) Differentiate between diverticulosis and diverticulitis, and recommend appropriate dietary fiber intake for each condition

- **Diverticulosis** refers to the presence of small pouches (diverticula) that form in the wall of the colon, typically in the lower part of the large intestine. These pouches develop when weak spots in the colon's muscular wall protrude outward. Diverticulosis itself usually does not cause symptoms unless complications arise



- **Diverticulitis**, on the other hand, occurs when one or more diverticula become inflamed or infected. This condition can lead to symptoms such as abdominal pain (usually on the left side), fever, nausea, vomiting, and changes in bowel habits. In severe cases, diverticulitis can cause complications like abscesses, perforation of the colon, or even peritonitis (inflammation of the abdominal lining)

Diverticulosis

- **High-fiber diet** is recommended
- Fiber helps to soften stool and reduce pressure in the colon, potentially preventing diverticula from becoming symptomatic or progressing to diverticulitis
- Adequate fiber intake promotes regular bowel movements and reduces the risk of constipation, which can exacerbate diverticulosis symptoms
- **Recommended Intake:** Aim for 25-35 grams of dietary fiber per day from sources like whole grains, fruits, vegetables, nuts, and seeds

Diverticulitis

- Initially, a **low-fiber diet** may be recommended during acute episodes to rest the colon and allow inflammation to subside
- High-fiber diet for someone experiencing an acute episode of diverticulitis can lead to several negative outcomes
- The added bulk and pressure from the fiber can irritate the already inflamed diverticula, potentially worsening the inflammation
- Low-fiber diet is recommended to allow the colon to rest and heal

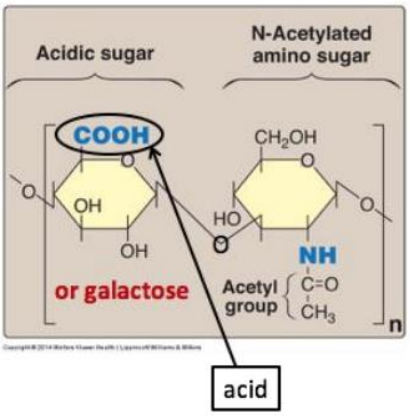
Eg - White bread, refined cereals, white rice, and certain cooked vegetables without skins or seeds

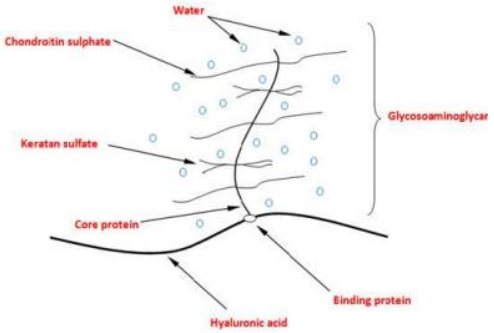
- Once the acute episode of diverticulitis has resolved and the individual is symptom-free, transitioning to a high-fiber diet is beneficial to help prevent future episodes

Q8.) Differentiate between Glycosaminoglycans (GAGs) and Proteoglycans.

Glycosaminoglycans (GAGs)

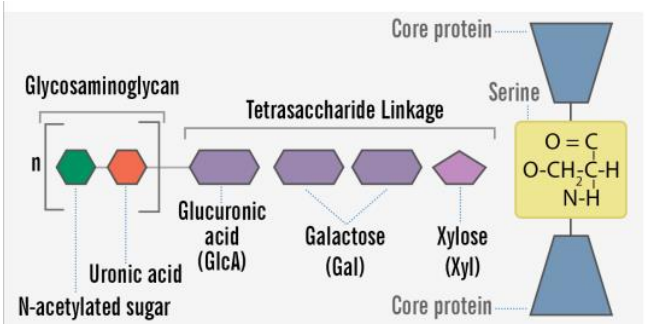
- Glycosaminoglycans are linear polysaccharides composed of repeating disaccharide units
- They are highly negatively charged due to the presence of sulfate or carboxyl groups
- GAGs are major components of extracellular matrices and play essential roles in maintaining tissue hydration, lubrication, resilience to tissues, and elasticity
- Examples include hyaluronic acid, chondroitin sulfate, dermatan sulfate, heparan sulfate, heparan, and keratan sulfate

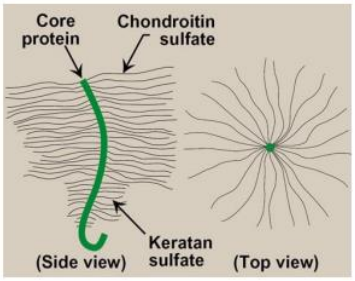




Proteoglycans

- Proteoglycans are macromolecules composed of a core protein covalently linked to one or more glycosaminoglycan (GAG) chains
- The linkage between the GAG chain and the protein core typically involves a tetrasaccharide bridge attached to a serine residue on the protein
- These molecules are crucial for the organization of extracellular matrix components and cell signaling
- Example includes aggrecan in cartilage





Lipids

Phospholipids and cholesterol

Question 1: Structure and Function of Phospholipids

1.1. Describe the general structure of a phospholipid molecule. Include the different components and their chemical nature.

The general structure of a phospholipid molecule includes

- Backbone- Glycerol or Sphingosine
- Fatty Acid Tails: Hydrophobic and nonpolar, attached to the first and second carbons of glycerol via ester bonds.
- Phosphate Group: Hydrophilic and polar, attached to the third carbon of glycerol.
- Additional Group: Often a small charged or polar group (e.g., choline, serine) attached to the phosphate group, forming a head group.

1.2. Explain how the amphipathic nature of phospholipids contributes to their role in biological membranes.

- The amphipathic nature of phospholipids means they have both hydrophilic (water-attracting) and hydrophobic (water-repelling) parts.
- In aqueous environments, they spontaneously form bilayers with hydrophobic tails facing inward and hydrophilic heads facing outward.
- This arrangement creates a semi-permeable membrane, crucial for cell compartmentalization and function.

1.3. Discuss the various functions of phospholipids in cell membranes beyond forming the bilayer structure.

Functions of phospholipids in cell membranes include:

- Barrier Formation: Creating a semi-permeable barrier to control substance movement.
- Membrane Fluidity: Maintaining membrane flexibility.
- Signal Transduction: Serving as precursors for signaling molecules.
- Membrane Protein Function: Providing a matrix for protein anchoring and function.
- Nervous transmission: Choline
- Surface active agent: Dipalmitoyl lecithin is a very effective and a major constituent of the surfactant
- Phosphatidylserine also plays a role in apoptosis
- Lipid Transport: Formation of lipoproteins for lipid transport

1.4. Illustrate how the composition of phospholipids in the cell membrane can affect membrane fluidity and function.

The composition of phospholipids affects membrane fluidity. Saturated fatty acids (no double bonds) make the membrane more rigid, while unsaturated fatty acids (with double bonds) increase fluidity. Cholesterol interspersed within the bilayer can also modulate fluidity by preventing fatty acid chains from packing tightly together.

Question 2: Biosynthesis and Regulation of Cholesterol

2.1. Outline the biosynthetic pathway of cholesterol, starting from acetyl-CoA.

Cholesterol is synthesized by

- Liver
- Intestine
- Adrenal cortex
- Reproductive tissues

Synthesis requires enzymes in the cytosol, membranes of the endoplasmic reticulum, and peroxisome

- Acetyl-CoA: Two molecules of acetyl-CoA condense to form acetoacetyl-CoA.
- HMG-CoA Synthesis: Acetoacetyl-CoA and another acetyl-CoA form HMG-CoA.
- Mevalonate Formation: HMG-CoA is reduced to mevalonate by HMG-CoA reductase. Rate limiting step
- Isoprenoid Units: Mevalonate undergoes phosphorylation and decarboxylation to form isoprenoid units.
- Squalene Formation: Isoprenoid units condense to form squalene.
- Cholesterol Formation: Squalene undergoes cyclization and further modifications to form cholesterol.

2.2. Explain the role of the enzyme HMG-CoA reductase in cholesterol synthesis and how its activity is regulated.

HMG-CoA reductase is the key regulatory enzyme in cholesterol synthesis. Its activity is regulated by

i. Sterol-dependent regulation of the gene expression. SREBP (sterol regulatory element-binding proteins) regulate the transcription of the HMG-CoA reductase gene.
ii. Sterol-accelerated enzyme degradation. Cholesterol and its derivatives can enhance enzyme degradation.
iii. Sterol-dependent phosphorylation/ dephosphorylation. AMP-activated protein kinase (AMPK) phosphorylates and inhibits the enzyme during low-energy states.
iv. Hormonal regulation. An increase in insulin favors dephosphorylation (activation) of the reductase. Whereas an increase in glucagon and epinephrine has the opposite effect.
v. Drug inhibition. Statin drugs are structural analogs of HMG CoA reductase.

2.3. Discuss the physiological importance of cholesterol in the human body.

Cholesterol is essential for:

- Membrane Structure: Providing membrane stability and fluidity.
- Precursor for Steroid Hormones: Including cortisol, aldosterone, and sex hormones.
- Bile Acid Formation: Necessary for fat digestion and absorption.
- Vitamin D Synthesis: Involved in the synthesis of vitamin D in the skin.

2.4. Describe the feedback mechanisms that regulate cholesterol levels in the body and their clinical significance.

- SREBP Regulation: Low cholesterol levels activate SREBP, increasing HMG-CoA reductase transcription.
- LDL Receptors: High intracellular cholesterol decreases LDL receptor synthesis, reducing cholesterol uptake from the blood.
- Statin Drugs: Inhibit HMG-CoA reductase, lowering cholesterol synthesis and increasing LDL receptor activity.

Question 3: Clinical Implications of Phospholipid and Cholesterol Metabolism

3.1. Discuss the role of phospholipids and cholesterol in the development of atherosclerosis.

Phospholipids and cholesterol contribute to atherosclerosis by:

- Lipoprotein Oxidation: Oxidized LDL particles (rich in cholesterol and phospholipids) are taken up by macrophages, forming foam cells and fatty streaks in arterial walls.
- Inflammation: Phospholipid derivatives can activate inflammatory pathways, promoting plaque formation.

3.2. Describe the mechanism by which statins lower cholesterol levels and their impact on cardiovascular health.

Statins lower cholesterol by:

- Inhibiting HMG-CoA Reductase: Reducing cholesterol synthesis in the liver.
- Increasing LDL Receptors: Enhancing clearance of LDL from the blood.
- Cardiovascular Impact: Reducing LDL levels, decreasing plaque formation, and lowering the risk of cardiovascular events.

3.3. Explain the significance of lipoproteins in the transport of phospholipids and cholesterol in the blood.

Lipoproteins transport lipids in the blood

- Chylomicrons: Transport dietary lipids from the intestine.
- VLDL: Transports triglycerides from the liver.
- LDL: Delivers cholesterol to tissues.
- HDL: Collects excess cholesterol from tissues and returns it to the liver.

3.4. Evaluate the potential therapeutic approaches to managing disorders related to phospholipid and cholesterol metabolism.

Therapeutic approaches include:

- Statins: Lowering cholesterol synthesis.
- Lifestyle Changes: Diet and exercise to manage lipid levels.

Question 4: Phospholipids and Cholesterol in Cell Signaling

4.1. Describe the role of phospholipids in cell signaling, with specific reference to phosphatidylinositol and its derivatives.

Phospholipids in cell signaling:

- Phosphatidylinositol (PI): Can be phosphorylated to PIP2 and further to PIP3.
- PIP2: Cleaved by phospholipase C to generate IP3 and DAG, key signaling molecules.
- PIP3: Activates AKT pathway, involved in cell growth and survival.

4.2. Explain how cholesterol affects the function of membrane proteins involved in cell signaling.

Cholesterol impacts membrane proteins by:

- Modulating Membrane Fluidity: Affecting the conformation and function of membrane proteins.
- Lipid Rafts: Cholesterol-rich microdomains that concentrate signaling molecules, facilitating efficient signal transduction.

4.3. Discuss the role of lipid rafts in organizing cell signaling components within the plasma membrane.

- Lipid rafts are on the outer leaflet of the lipid bilayer
- Enriched with cholesterol, sphingolipids, and signaling proteins
- Involved in signal transduction and in response to external stimuli

4.4. Illustrate the impact of dysregulated phospholipid and cholesterol metabolism on signal transduction pathways and related diseases.

Dysregulated lipid metabolism impacts signaling pathways:

- Hypercholesterolemia: Alters membrane properties, affecting receptor function and signal transduction.
- Phospholipid Metabolism Disorders: Affect second messenger production, impacting cellular responses.
- Related Diseases: These include metabolic syndrome, cardiovascular diseases, and certain cancers due to disrupted signaling pathways.

Nucleic acid

1. **Describe the structural differences between DNA and RNA. Include a discussion on their respective roles in the cell.**

DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) differ in several key aspects:

Sugar Component: DNA contains deoxyribose, while RNA contains ribose. The absence of one oxygen atom in the deoxyribose sugar of DNA makes it more stable compared to RNA.

Nitrogenous Bases: DNA has the bases adenine, thymine, cytosine, and guanine. In contrast, RNA has adenine, uracil, cytosine, and guanine. The replacement of thymine with uracil in RNA is a significant difference.

Structure: DNA is typically double-stranded, forming a double helix, whereas RNA is usually single-stranded.

Function: DNA serves as the genetic material in most organisms, storing and transmitting genetic information. It is responsible for guiding the synthesis of RNA and proteins. RNA, on the other hand, plays various roles in the cell. Messenger RNA (mRNA) carries genetic information from DNA to the ribosome, where it is translated into proteins. Transfer RNA (tRNA) brings amino acids to the ribosome during protein synthesis, and ribosomal RNA (rRNA) forms the core structural and enzymatic components of ribosomes. Other RNA molecules, such as microRNA (miRNA) and small interfering RNA (siRNA), are involved in gene regulation.

2. **Explain the concept of complementary base pairing in DNA. How does this principle underlie the structure and function of DNA?**

Complementary base pairing in DNA refers to the specific pairing between nitrogenous bases on opposite strands of the DNA double helix. Adenine (A) pairs with thymine (T) through two hydrogen bonds, while guanine (G) pairs with cytosine (C) through three hydrogen bonds. This pairing is consistent and specific, ensuring accurate replication and transcription processes.

The principle of complementary base pairing is fundamental to the structure and function of DNA:

Structural Stability: The specific pairing of bases contributes to the uniform width of the DNA double helix, maintaining its structural integrity.

Replication: During DNA replication, each strand serves as a template for the synthesis of a new complementary strand. The accurate pairing of bases ensures that the genetic information is faithfully copied.

Transcription: During transcription, the complementary base pairing allows RNA polymerase to synthesize an RNA strand from the DNA template accurately, ensuring the correct transfer of genetic information from DNA to RNA.

3. **Discuss the various levels of DNA packaging in eukaryotic cells, from the double helix to the formation of chromosomes.**

DNA packaging in eukaryotic cells occurs in several hierarchical levels:

Double Helix: The DNA molecule itself is a double-stranded helix.

Nucleosomes: DNA wraps around histone proteins, forming nucleosomes. Each nucleosome consists of 146 base pairs of DNA wrapped around a histone octamer, composed of two copies each of histones H2A, H2B, H3, and H4.

30 nm Fiber: Nucleosomes further coil and fold to form a 30 nm chromatin fiber, also known as solenoid or zigzag structure. This level of packaging compacts the DNA about 40-fold.

Chromatin Loops: The 30 nm fiber forms loops, anchored by a scaffold of non-histone proteins. These loops are attached to the nuclear matrix, further organizing the chromatin within the nucleus.

Heterochromatin and Euchromatin: The loops can further compact into heterochromatin (highly condensed and transcriptionally inactive) or remain as euchromatin (less condensed and transcriptionally active).

Chromosome Formation: During cell division, the chromatin further condenses to form visible chromosomes, allowing the accurate segregation of genetic material.

4. Describe the structure and function of nucleosomes. How do they contribute to DNA packaging?

Nucleosomes are the fundamental units of DNA packaging in eukaryotic cells. Each nucleosome consists of a segment of DNA wrapped around a histone octamer, which includes two copies each of histones H2A, H2B, H3, and H4. The DNA wraps around the histone core approximately 1.65 times, covering about 146 base pairs.

The function of nucleosomes includes:

DNA Compaction: Nucleosomes compact the DNA, reducing its length by about sevenfold. This compaction is crucial for fitting the large eukaryotic genomes into the limited space of the cell nucleus.

Regulation of Gene Expression: The positioning and modification of nucleosomes can regulate access to the underlying DNA. Certain chemical modifications to the histone proteins can either relax or condense the chromatin structure, thus influencing gene expression by controlling the accessibility of transcription factors to DNA.

Protection of DNA: By winding DNA around histones, nucleosomes protect DNA from damage and degradation, contributing to genomic stability.

5. Explain the importance of nucleotides beyond their role in forming nucleic acids. Provide examples of their functions in cellular processes.

Nucleotides play several vital roles beyond forming DNA and RNA:

Energy Currency: Adenosine triphosphate (ATP) is the primary energy currency in cells, providing the energy required for various biochemical reactions.

Signal Transduction: Cyclic nucleotides like cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate (cGMP) act as second messengers in signal transduction pathways, relaying signals from extracellular molecules to intracellular targets.

Coenzymes: Nucleotides are components of essential coenzymes, such as NAD+ (nicotinamide adenine dinucleotide) and FAD (flavin adenine dinucleotide), which are involved in redox reactions in cellular metabolism.

Allosteric Regulation: Some nucleotides, such as ATP and GTP, can act as allosteric regulators, influencing the activity of enzymes and other proteins.

6. Discuss the role of RNA in protein synthesis, including the different types of RNA involved.

RNA plays a critical role in the process of protein synthesis, which involves several types of RNA:

Messenger RNA (mRNA): mRNA serves as the template for protein synthesis. It carries the genetic information from the DNA in the nucleus to the ribosome, where it is translated into a specific protein.

Transfer RNA (tRNA): tRNA molecules transport specific amino acids to the ribosome during protein synthesis. Each tRNA has an anticodon region that pairs with the complementary codon on the mRNA, ensuring the correct amino acid is added to the growing polypeptide chain.

Ribosomal RNA (rRNA): rRNA is a major component of ribosomes, the cellular machinery that assembles proteins. It plays both structural and catalytic roles, facilitating the alignment of mRNA and tRNAs and catalyzing the formation of peptide bonds between amino acids.

Other RNAs: Other types of RNA, such as microRNA (miRNA) and small interfering RNA (siRNA), regulate gene expression post-transcriptionally by degrading mRNA or inhibiting its translation.

7. Describe the process of DNA denaturation and renaturation. What factors influence the melting temperature (Tm) of DNA?

DNA denaturation refers to the separation of the two strands of the DNA double helix, typically caused by heat or chemical agents, breaking the hydrogen bonds between the complementary bases. Renaturation, also known as reannealing, is the process by which the separated strands reassociate to form a double helix when the conditions are normalized.

Factors influencing the melting temperature (Tm) of DNA include:

GC Content: DNA sequences with higher guanine-cytosine (GC) content have a higher Tm because GC pairs form three hydrogen bonds, compared to the two hydrogen bonds in adenine-thymine (AT) pairs, making GC pairs more stable.

Length of the DNA: Longer DNA molecules have a higher Tm because more hydrogen bonds need to be disrupted to denature the DNA.

Ionic Strength: The presence of positive ions, such as Na+ or Mg2+, stabilizes the negatively charged DNA backbone, increasing the Tm.

pH and Chemical Agents: Extreme pH or the presence of denaturing agents, like formamide or urea, can lower the Tm by destabilizing hydrogen bonds.

8. Outline the major differences between purine and pyrimidine bases. Provide examples of each and their significance in nucleic acids.

Purines and pyrimidines are two types of nitrogenous bases found in nucleic acids, differing in their structures:

Purines: These have a double-ring structure consisting of a six-membered and a five-membered nitrogen-containing ring fused together. Examples include adenine (A) and guanine (G). Purines are larger molecules and pair with pyrimidines in DNA and RNA.

Pyrimidines: These have a single six-membered nitrogen-containing ring. Examples include cytosine (C), thymine (T), and uracil (U). Thymine is found in DNA, while uracil replaces thymine in RNA.

Significance in Nucleic Acids:

Base Pairing: The specific pairing between purines and pyrimidines (A with T or U, G with C) ensures the proper encoding and replication of genetic information. This complementary base pairing is essential for the double helix structure of DNA and the fidelity of transcription and translation.

Structural Stability: The unique structures of purines and pyrimidines, along with their hydrogen-bonding properties, contribute to the stability and uniformity of nucleic acid structures.

9. Explain how synthetic nucleotide analogs can be used as chemotherapeutic agents. Include a discussion on their mechanism of action.

Synthetic nucleotide analogs are molecules that resemble natural nucleotides but contain alterations that disrupt nucleic acid synthesis and function. They are used as chemotherapeutic agents to treat cancers and viral infections.

Mechanism of Action:

Incorporation into Nucleic Acids: These analogs can be incorporated into DNA or RNA during replication or transcription. Once incorporated, they can cause chain termination, as they may lack the necessary functional groups for further nucleotide addition.

Inhibition of Enzymes: Some analogs inhibit enzymes involved in nucleic acid metabolism, such as DNA polymerase or reverse transcriptase. For example, azidothymidine (AZT) inhibits reverse transcriptase, an enzyme critical for the replication of HIV.

Inducing Mutations: Incorporation of these analogs can lead to mutations, disrupting normal cellular processes and leading to cell death.

Examples:

5-Fluorouracil (5-FU): A pyrimidine analogue that inhibits thymidylate synthase, disrupting DNA synthesis and leading to cell death.

Cytarabine (Ara-C): A cytosine analogue that inhibits DNA polymerase, used in the treatment of certain leukemias.

10. Discuss the biomedical importance of DNA, focusing on its role in genetics, diagnostics, and therapy. Provide specific examples.

Genetics:

DNA is the fundamental molecule carrying genetic information in all living organisms. It determines hereditary traits and is the blueprint for all cellular functions. Understanding DNA sequences and variations helps in studying genetic diseases, inheritance patterns, and evolutionary biology.

Diagnostics:

DNA-based diagnostics play a critical role in identifying genetic disorders, infectious diseases, and cancer. Techniques such as polymerase chain reaction (PCR) and next-generation sequencing (NGS) allow for the detection and analysis of specific DNA sequences.

Example: PCR is used to detect viral infections, such as HIV and COVID-19, by amplifying viral DNA or RNA sequences.

Therapy: Advances in DNA technology have led to innovative therapies, including gene therapy and personalized medicine.

Gene Therapy: This involves the introduction, removal, or alteration of genetic material within a patient's cells to treat diseases. For example, gene therapy can be used to replace defective genes with functional ones in conditions like cystic fibrosis.

Personalized Medicine: DNA sequencing allows for the customization of treatment based on an individual's genetic profile. This approach is particularly useful in oncology, where specific genetic mutations can guide the selection of targeted therapies.

COURSE 3 – FUNCTIONAL ASPECTS OF PROTEIN

Hemoglobin

1. **A 45-year-old diabetic lady had a fluctuating level of plasma glucose.**

   a) What is the best investigation would you order?
   HbA1c assay.

   b) What is the biochemical basis for your answer?

   - The biochemical basis for choosing HbA1c lies in its ability to provide an average of blood glucose levels over the past 2 to 3 months.
   - HbA1c, or glycated hemoglobin, forms when hemoglobin in red blood cells reacts with glucose in the bloodstream.
   - The amount of HbA1c present reflects the average blood glucose concentration over the lifespan of red blood cells, which is typically around 120 days.
   - Fluctuations in plasma glucose levels over time can affect the percentage of HbA1c.
   - Higher average glucose levels result in more glycation of hemoglobin and consequently a higher HbA1c level.
   - Therefore, measuring HbA1c provides valuable information about long-term glycemic control, complementing other measures like fasting plasma glucose and continuous glucose monitoring, which provide information about short-term variations.
   - In the case of a diabetic patient with fluctuating plasma glucose levels, an HbA1c assay would help assess overall glycemic control and guide adjustments to treatment plans to achieve better long-term management of diabetes and reduce the risk of complications.

2. **A pregnant mother's placental circulation carries an umbilical blood saturation of 35% while most of the hemoglobin is not saturated while the fetus has the same saturation with most of the hemoglobin saturated. Explain the reason.**

The difference in oxygen saturation between maternal and fetal blood can be attributed to several factors

- Oxygen diffuses from areas of higher concentration (maternal blood) to areas of lower concentration (fetal blood).
- Therefore, even if maternal blood has a lower oxygen saturation, oxygen will still transfer to the fetal blood, leading to higher oxygen saturation in the fetal circulation.
- Fetal hemoglobin (HbF), which is the predominant type of hemoglobin in the fetus, has a higher affinity for oxygen compared to adult hemoglobin (HbA) present in the maternal blood.
- This higher affinity allows fetal hemoglobin to bind oxygen more readily, leading to a higher saturation level despite lower oxygen concentrations in the placental circulation

BIOCHEMISTRY MOCK PAPERS & ANSWERS

MOCK MCQ

MULTIPLE CHOICE QUESTIONS

Time: 1 hour
This paper consists of 10 True or False type questions and 10 Single Best Answer type questions.

True or False Questions

1. **Eukaryotes differ from prokaryotes because they possess,**
   (A) Protein associated with DNA
   (B) 70S ribosome
   (C) Flagella for locomotion
   (D) Cyclin-dependent kinase
   (E) Lysosome

2. **Which of the following are true/ false regarding plasma membrane?**
   (A) It is present in both eukaryotes and prokaryotes
   (B) Its main function is to generate Metabolic energy in the cell
   (C) Phospholipid bilayer is permeable to most water-soluble molecules
   (D) Its main components are lipids and nucleic acids
   (E) The passage of ions and most biological molecules is mediated by proteins

3. **Regarding the structure and function of Mitochondria?**
   (A) It can be found in eukaryotic cells
   (B) It synthesizes ATP
   (C) Matrix contains plasmids
   (D) Engage in fat oxidation
   (E) Pyruvate is reduced to lactate in the matrix

4. **Which of the following are true/ false regarding transport across the membranes?**
   (A) Transport by transporters can be either active or passive
   (B) Transport by channels is always passive
   (C) Transporters saturate at high concentrations of the transported molecule
   (D) Channels saturate at high concentrations of transported molecule
   (E) Equilibrium across a biological membrane is determined by the concentrations.

5. **Regarding complex carbohydrates,**
   (A) Starch is composed of branched amylose and unbranched amylopectin
   (B) Amylose of starch has only alpha 1-4 linkage
   (C) Glycogen has both alpha 1-4 and alpha 1-6 linkages
   (D) Cellulose cannot be digested by humans due to its beta 1-6 linkages
   (E) Good for diabetic patients compared to simple carbohydrates

6. **Regarding enzyme activity,**
   (A) Enzyme activity is highest when substrate concentration is lower than the enzyme concentration
   (B) Competitive inhibitors decrease enzyme activity by binding irreversibly to the enzyme-substrate
   (C) Increasing temperature always increases enzyme activity
   (D) pH affects enzyme activity primarily by altering the ionization states of amino acid side chains
   (E) Enzyme activity is independent of cofactors and co-enzymes

7. **Which of the following statements are true/false regarding the structure of the Hemoglobin molecule?**
   (A) It has 4 porphyrin rings
   (B) One molecule composed of four types of globin chains
   (C) There is one ferrous ion at the center
   (D) It is tetrameric in its quaternary structure
   (E) Has allosteric proteins

8. **The right shift of the normal Oxygen-Hemoglobin dissociation curve is caused by,**
   (A) Exercises
   (B) Decreased temperature
   (C) Acidosis
   (D) 2,3 – BPG
   (E) Fetal Hemoglobin

9. **Regarding DNA replication,**
   (A) Topo isomerases are used to add deoxyribonucleic acids
   (B) Okazaki fragments are present in leading strands
   (C) DNA helicases unwind DNA
   (D) Proofreading is done by DNA polymerase 111
   (E) DNA primers are required to initiate DNA synthesis

10. **Which of the following are true regarding actions to be taken to avoid Laboratory accidents?**
    (A) Listing to news on TV while laboratory procedures undergo
    (B) Opening laboratory windows
    (C) Removing leftover chemicals via the sink
    (D) Wearing protective shoes
    (E) Letting patients into the hospital laboratory

Single Best Answer Questions

11. Which of the following statements about Golgi Bodies is correct?
(A) They are responsible for cellular respiration
(B) They primarily synthesize proteins
(C) They modify, sort, and package proteins and lipids for secretion or delivery to other
(D) They are found only in plant cells
(E) They store genetic information

12. Which of the following is false regarding the eukaryotic nucleus?
(A) It contains DNA only in the form of linear chromosomes
(B) It is surrounded by a double membrane
(C) It has an association with ribosomes involved in protein synthesis
(D) It is involved in regulation of gene expression
(E) It undergoes division during the cell cycle

13. Selective permeability of cell membranes is achieved, in part, by active transport systems. Active transport differs from passive transport in that it,
(A) Requires energy but no transport carrier
(B) Depends primarily on diffusion and osmosis
(C) Requires a carrier but no energy
(D) Requires energy, usually in the form of phosphates anhydride bonds
(E) Is necessarily associated with pinocytosis

14. Which of the following statements accurately describes the Electron Transport Chain (ETC) in cellular respiration?
(A) It synthesizes glucose from pyruvate in the presence of oxygen
(B) It produces ATP directly through substrate-level phosphorylation
(C) It generates a proton gradient across the mitochondrial membrane
(D) It converts lactic acid into pyruvate to replenish ATP stores
(E) It occurs in the plasma membrane of Eukaryotes

15. Which of the following best describes pH and buffers?
(A) Amino acids function as buffers around physiological pH
(B) Buffers act best around pH 7
(C) Buffering capacity of a buffer depends upon the concentration of the buffer
(D) Buffering capacity depends on the pK of the buffer acid or base
(E) pH of 7.0 indicates an acidic solution

16. The thin filaments of striated muscles are composed of,
(A) Actin
(B) Myosin
(C) Actomyosin
(D) Troponin
(E) Tropomyosin

17. Which of the following best describes methemoglobinemia?

(A) Increased production of Oxygen-carrying hemoglobin in red blood cells
(B) Decreased oxygen affinity of hemoglobin due to iron deficiency
(C) Oxidative conversion of hemoglobin to a non-function form
(D) Accumulation of carbon dioxide in red blood cells
(E) Impaired production of red blood cells due to genetic numbers

18. Cyanide is poisonous because of its,

(A) Formation of a complex with Hemoglobin
(B) Combination with the erythrocyte membrane
(C) Inhibition of cytochrome oxidase
(D) Inhibition of myoglobin
(E) Blockage of oxygen transport in blood

19. A patient was brought to the hospital with an acute intoxication of wood alcohol. Inhibition of which enzyme is the most beneficial in his management.

(A) Lactate dehydrogenase.
(B) Alcohol dehydrogenase.
(C) Acetyl CoA synthase.
(D) Acetaldehyde dehydrogenase.
(E) Glyceraldehyde-3-phosphate dehydrogenase.

20. Best statement about the regulation of metabolic pathways,

(A) Activity is dependent on the availability of substrates
(B) Feedback inhibition of the end product is the most important short-term control point
(C) All pathways are directly under hormonal regulation
(D) Key regulatory enzymes of pathways are reciprocally regulated
(E) Long-term regulation is achieved by induction and repression of gene coding for enzymes

MOCK MCQ ANSWERS

True or False Questions

1) TFFTT
2) TFFFT
3) TTFTF
4) TTTFF
5) FTTFT
6) TFFTF
7) TFFTT
8) TFTFF
9) FFTTT
10) FTFTF

Single Best Answer Questions

11) C
12) A
13) D
14) C
15) D
16) A
17) C
18) C
19) B
20) B

1. Eukaryotes differ from prokaryotes because they possess,

A. True - In eukaryotes, they have histones, whereas in prokaryotes, they are various types of nucleoid-associated proteins.
B. False - Prokaryotes have 70S ribosomes, but eukaryotes have 80S ribosomes. This is one of the ways in which ribosomes differ between these two groups.
C. False - Both eukaryotes and prokaryotes can have flagella for locomotion. However, their structures and mechanisms are different.
D. True - Cyclin-dependent kinases (CDKs) are involved in regulating the cell cycle and are specific to eukaryotic cells. Prokaryotes do not have cyclin-dependent kinases as they do not have a cell cycle in the same sense as eukaryotes.
E. True - Lysosomes are membrane-bound organelles that contain digestive enzymes, and they are present in eukaryotic cells but not in prokaryotic cells

2. Which of the following are true/ false regarding plasma membrane?

A. True - Because all prokaryotes and eukaryotes have a cell membrane.
B. False - Because Mitochondria generate metabolic energy in the cell.
C. False - The basic structure of the cell membrane is the phospholipid bilayer and it is impermeable to most water-soluble molecules.
D. False - The main components in the cell membrane are lipids and proteins.
E. True - The passage of ions and most biological molecules across the plasma membrane is mediated by proteins.

3. Regarding the structure and function of Mitochondria?

A. True - Because mitochondria are present in eukaryotic cells, where they play a crucial role in energy production.
B. True - Mitochondria are key to ATP synthesis through oxidative phosphorylation.
C. True - Because mitochondria are involved in fatty acid oxidation in the matrix, contributing to energy production from fats.
D. False - Because the mitochondrial matrix does not contain plasmids.
E. False - Because pyruvate is converted to lactate in the cytoplasm, not in the mitochondrial matrix.

4. Which of the following are true/ false regarding transport across the membranes?

Transport by Transporters: Can be either active (requiring energy) or passive (not requiring energy). Active transport can move molecules against their concentration gradient, while passive transport moves molecules down their concentration gradient.

- Transport by Channels: Always passive. Channels provide a pathway for ions or water to move down their concentration or electrochemical gradients, facilitating rapid and efficient transport without the use of cellular energy.
- Transporters bind to the molecules they transport and can become saturated at high concentrations when all their binding sites are occupied, limiting the transport rate (Vmax). Channels, on the other hand, do not bind the ions they transport; instead, ions flow through channels based on concentration gradients, allowing continuous flux without saturation. Transporters follow Michaelis-Menten kinetics, while channels do not.

5. Regarding complex carbohydrates,

A. True - Starch consists of unbranched amylose and branched amylopectin.
B. True - Amylose has only alpha 1-4 linkages.
C. True - Glycogen has both alpha 1-4 and alpha 1-6 linkages.
D. False - Cellulose has beta 1-4 linkages, not beta 1-6.
E. Generally correct - Complex carbohydrates are preferable for maintaining stable blood sugar levels in diabetic patients.

6. Regarding enzyme activity,

A. True - Enzyme activity is highest when substrate concentration is lower than enzyme concentration because at lower substrate concentrations, all enzyme molecules can readily bind to substrate molecules, leading to maximum reaction rates. As substrate concentration increases and approaches enzyme concentration, the enzyme active sites become saturated, leading to no further increase in reaction rate (Vmax is reached).
B. False - Competitive inhibitors decrease enzyme activity by reversibly binding to the enzyme's active site, thereby competing with the substrate for binding. They do not irreversibly bind and can be displaced from the active site under certain conditions, allowing the enzyme to regain its activity.
C. False - While increasing temperature generally increases enzyme activity up to a point (the optimal temperature), further increases can lead to decreased activity due to enzyme denaturation.
D. True - pH affects enzyme activity primarily by altering the ionization states of amino acid side chains within the enzyme molecule, thereby influencing the enzyme's ability to bind substrate and catalyze reactions effectively. This sensitivity to pH is crucial for enzymes to function optimally in their specific biological environments.
E. False - Cofactors play crucial roles in enzyme function and activity. Enzymes often require specific cofactors to achieve their full catalytic potential.

7. Which of the following statements are true/false regarding the structure of the Hemoglobin molecule?

A. True - Hemoglobin comprises 4 heme groups. Each Heme is comprised of a porphyrin ring structure with one iron (Fe) atom chelated in the center by 4 nitrogen atoms. This is the site of reversible, oxygen attachment.
B. False - Haemoglobin comprises four globin protein subunits. Adult hemoglobin A (HbA), is comprised of two α-chains and two β-chains.
C. False - There are four iron atoms in each molecule of hemoglobin, which accordingly can bind four molecules of oxygen.
D. True - Hb is a tetramer, consisting of two α-subunits (α1 and α2) and two β-subunits (β1 and β2) that are structurally similar and about the same size.
E. True - Haemoglobin is an allosteric protein. This means that the binding of oxygen to one of the subunits is affected by its interactions with the other subunits.

8. The right shift of the normal Oxygen-Hemoglobin dissociation curve is caused by,

The oxygen-hemoglobin dissociation curve is a graphical representation of the relationship between the amount of oxygen bound to hemoglobin and the partial pressure of oxygen in the blood. The curve is sigmoidal, with a steep slope at low partial pressures of oxygen and a more gradual slope at higher partial pressures. A rightward shift of the curve indicates that hemoglobin has a decreased affinity for oxygen, thus, oxygen actively unloads. And give a better oxygen supply for tissues.

A. True - During exercise, where the temperature of muscle increases secondary to its utilization, shift the curve to the right and allow oxygen to be more easily unloaded from hemoglobin and delivered to tissues in need.
B. False - Lower temperatures will cause a leftward shift in the dissociation curve.
C. True - Acidosis means high CO2 in cells. Acidosis causes a right shift in the oxyhemoglobin dissociation curve and this facilitates oxygen delivery to tissues.
D. False - 2,3-DPG acts as a regulator of the allosteric properties of hemoglobin in the RBC. When 2,3-DPG is bound to hemoglobin, it decreases hemoglobin affinity for oxygen.
E. False - Fetal Hb (alpha2gamma2) introduces a leftward shift of the curve, favoring O2 binding to hemoglobin at lower oxygen tension. This is favorable in the womb, to allow the growing fetus to pull O2 from the maternal circulation.

9. Regarding DNA replication,

A. True - Topoisomerases relieve supercoiling but do not add nucleotides.
B. False - Okazaki fragments are found on the lagging strand, not the leading strand.
C. True - DNA helicases are responsible for unwinding the DNA.
D. True - DNA polymerase III does have proofreading activity in prokaryotes, but proofreading in eukaryotes is primarily performed by other polymerases.
E. True - DNA primers are essential to initiate DNA synthesis.

10. Which of the following are true regarding actions to be taken to avoid Laboratory accidents?

A. False - Laboratory procedures often require a high level of focus, attention to detail, and adherence to protocols. Distractions such as listening to news can divert attention away from these critical tasks.
B. True - Opening windows can help improve ventilation within the laboratory. Adequate ventilation is crucial to remove potentially harmful fumes, gases, or vapors that may be released during experiments or from laboratory equipment.
C. False - Many chemicals used in laboratories can be harmful to the environment if disposed of improperly. Flushing chemicals down the sink can lead to contamination of water sources, soil, and ecosystems. Proper disposal of chemicals involves segregating different types of waste, using designated waste containers, and arranging for collection by licensed waste disposal services. This ensures that chemicals are handled safely from cradle to grave, minimizing risks to human health and the environment.
D. True - Laboratories often contain hazards such as chemicals, glassware, sharp objects, and potentially slippery surfaces. Protective shoes, such as closed-toe footwear with non-slip soles, provide physical protection against accidental spills, falling objects, or sharp items that could cause foot injuries.
E. False - Hospital laboratories handle potentially infectious materials such as blood, urine, and tissues. Allowing patients into these areas could increase the risk of cross-contamination and transmission of infectious diseases between patients, staff, and laboratory environments.

Single Best Answer Questions

11. Which of the following statements about Golgi Bodies is correct?

The answer is C

A. Golgi bodies (or Golgi apparatus) are not responsible for cellular respiration. Cellular respiration typically occurs in the mitochondria (in eukaryotic cells) or the cytoplasm (in prokaryotic cells).
B. Golgi bodies (or Golgi apparatus) do not primarily synthesize proteins. Protein synthesis primarily occurs in the rough endoplasmic reticulum (ER), where ribosomes attached to the ER membrane synthesize proteins using instructions encoded in RNA molecules.
C. Their main function is to modify, sort, and package proteins and lipids that are synthesized elsewhere in the cell, such as the endoplasmic reticulum (ER). The Golgi apparatus processes these molecules by adding molecular tags (like carbohydrates) and sorting them into vesicles that transport them to specific destinations.
D. They are membrane-bound organelles present in both plant and animal cells, though their structure and function can vary slightly between the two.
E. Golgi bodies (Golgi apparatus) do not store genetic information. Genetic information in eukaryotic cells is primarily stored in the nucleus in the form of DNA molecules organized into chromosomes.

12. Which of the following is false regarding the eukaryotic nucleus?

The answer is A

A. While the main nuclear genome in eukaryotes is composed of linear chromosomes, certain exceptions exist. For example, some organisms, such as certain yeasts, have circular chromosomes in addition to linear ones.
B. The double membrane structure of the nucleus, consisting of the outer and inner nuclear membranes, is a defining feature of eukaryotic cells. It provides a protective boundary around the genetic material and regulates molecular traffic between the nucleus and the rest of the cell.
C. Eukaryotic ribosomes are integral to the process of protein synthesis, translating the genetic code from mRNA into functional proteins that are essential for the structure and function of cells.
D. The nucleus of eukaryotic cells is central to gene expression, housing the processes of transcription and RNA processing that are essential for the production of functional proteins required for cellular structure and function.
E. Nuclear division (mitosis and meiosis) is a fundamental process in the eukaryotic cell cycle, crucial for growth, development, and reproduction. It involves precise coordination of events within the nucleus to ensure the faithful transmission of genetic information to subsequent generations of cells.

13. Selective permeability of cell membranes is achieved, in part, by active transport systems. Active transport differs from passive transport in that it,

The answer is D

Active transport is the passage of material against a concentration gradient and requires the expenditure of energy often the hydrolysis of ATP

14. Which of the following statements accurately describes the Electron Transport Chain (ETC) in cellular respiration?

The answer is C

The ETC generates a proton gradient across the mitochondrial membrane. Explanation: Option A is incorrect because glucose synthesis occurs in the reverse of glycolysis, not in the ETC. Option B is incorrect because ATP production in the ETC occurs through oxidative phosphorylation, not substrate-level phosphorylation. Option D is incorrect because the conversion of lactic acid to pyruvate happens during anaerobic respiration or in the liver, not in the ETC.

15. Which of the following best describes pH and buffers?

The answer is D

A) and B) An amino acid can act as a buffer because it can react with added acids as well as to keep the pH nearly constant. Because an amino acid has both an acidic group which is a carboxyl group and a basic group which is an amine group, hence it can act as both acid and as a base therefore amino acids can act as a buffer. The buffering capacity of amino acids was the strongest at pK. Histidine is particularly effective as a buffer at physiological pH because it has a pKa value close to this range. C)Buffer capacity depends on concentration as well as the ratio of acid and its conjugate base. D) Buffering capacity is maximum at pKa of the substance.

16. The thin filaments of striated muscles are composed of,

The answer is A

The thin filaments of striated muscles are composed of, Actin

17. Which of the following best describes methemoglobinemia?

The answer is C

Methemoglobinemia is a condition where hemoglobin in the blood is oxidized to form methemoglobin, which is unable to bind oxygen effectively.

A. Hemoglobin is converted to methemoglobin which cannot bind oxygen effectively. So Methemoglobinemia decreases the oxygen-carrying capacity of blood.
B. Methemoglobinemia does not occur due to iron deficiency. Instead, it is caused by the oxidation of iron with hemoglobin from its normal ferrous state to the ferric state.
C. The oxidation of iron from Fe^{2+} to Fe^{3+} changes normal oxygen structure making it unable to bind oxygen effectively.
D. Methemoglobinemia primarily affects oxygen transport rather than influencing CO_2 transport.
E. Impaired production of red blood cells due to genetic mutations such as thalassemia sickle cell disease can indirectly affect oxygen transport but typically do not cause methemoglobinemia.

18. Cyanide is poisonous because of its,

The answer is C

A. Cyanide poisoning primarily affects cellular respiration by inhibiting cytochrome c oxidase, an enzyme crucial for the electron transport chain in mitochondria. This inhibition disrupts aerobic metabolism, leading to cellular hypoxia and metabolic acidosis, which can be fatal if not treated promptly.
B. While cyanide can diffuse across cell membranes due to its small size and lipophilic nature, its main toxic effects occur inside cells, particularly in tissues with high metabolic rates such as the brain and heart. Therefore, the interaction of cyanide with erythrocyte membranes is not a major aspect of its toxic mechanism.
C. While cyanide can diffuse across cell membranes due to its small size and lipophilic nature, its main toxic effects occur inside cells, particularly in tissues with high metabolic rates such as the brain and heart. Therefore, the interaction of cyanide with erythrocyte membranes is not a major aspect of its toxic mechanism.
D. Myoglobin is involved in oxygen transport within muscle cells and no interaction with this.
E. In the bloodstream, oxygen is mainly transported by hemoglobin in red blood cells. Cyanide can indeed bind to hemoglobin, but it does so less avidly compared to its interaction with enzymes like cytochrome c oxidase. The affinity of hemoglobin for oxygen is much higher than for cyanide, meaning any cyanide that does bind to hemoglobin forms a relatively weak complex and does not significantly impair the ability of hemoglobin to carry oxygen.

19. A patient was brought to the hospital with an acute intoxication of wood alcohol. Inhibition of which enzyme is the most beneficial in his management.

The answer is B.

Alcohol Dehydrogenase

Reasoning: Inhibiting alcohol dehydrogenase is crucial for managing methanol poisoning because it prevents the conversion of methanol to its harmful metabolites.

20. Best statement about the regulation of metabolic pathways,

The answer is B

A. While substrate availability does influence metabolic activity, it is not the only factor involved in the regulation of metabolic pathways. Metabolic pathways are also regulated by other mechanisms such as enzyme activity, allosteric regulation, and feedback inhibition.
B. Feedback inhibition, where the end product of a metabolic pathway inhibits an earlier step in the pathway, is a critical mechanism for short-term regulation. It helps to maintain homeostasis and prevent the overproduction of metabolic intermediates.
C. While many metabolic pathways are regulated by hormones (e.g., insulin, glucagon), not all pathways are directly regulated by hormonal signals. Some pathways are regulated through other mechanisms such as allosteric control or feedback inhibition.
D. In many cases, key regulatory enzymes in opposing pathways (e.g., glycolysis and gluconeogenesis) are reciprocally regulated to ensure that one pathway is active while the other is inactive, helping to maintain metabolic balance.

E. Long-term regulation of metabolic pathways involves changes in gene expression, where the synthesis of enzymes is increased or decreased through induction and repression. This type of regulation allows for sustained changes in metabolic activity.

MOCK OSPE

Instructions

- This OSPE test consists of 10 questions. This test will be done as an online test using a PowerPoint presentation.
- Answer all 10 questions.
- 05 minutes will be given for each question.
- At the end of 05 minutes, the next question will be appeared automatically.
- Please write the answers on A4 papers (or any other suitable material)

Q1. You are provided with 03 sample collection vacutainer tubes.



A **B**

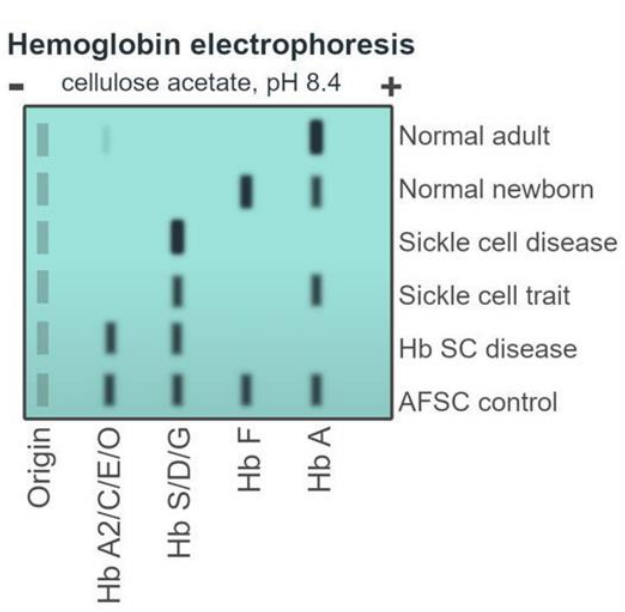


C

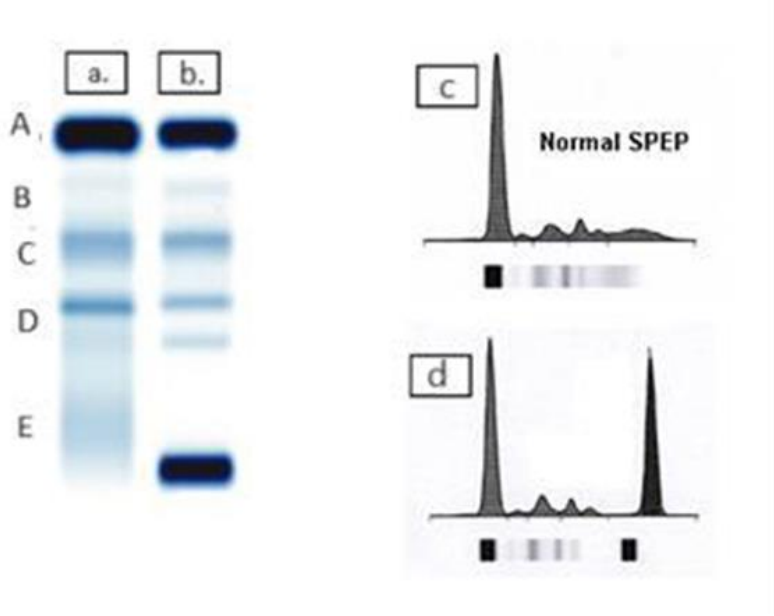
1. Which tube is used for the sample collection for Hb assay (02 marks)
2. Explain the reason (04 marks)
3. List two methods of assessment Hb in human samples (04 marks)

Q2. Observe the hemoglobin electrophoresis pattern given in the image given below and explain the differences that you observe in the electrophoresis patterns of sickle cell disease and sickle cell trait

(10 marks)



Q3. You are given an electrophoresis gel showing separated plasma proteins.



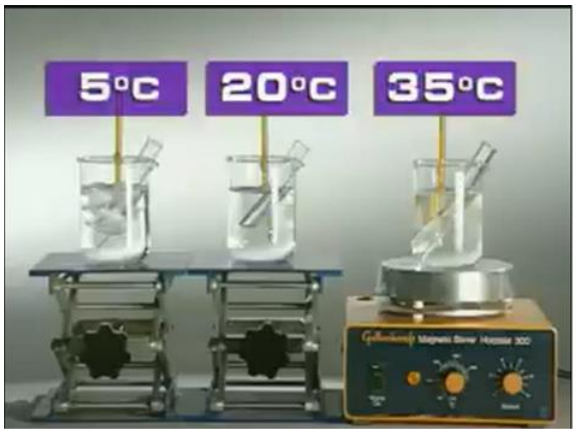
3.1. Identify the bands corresponding from A to E

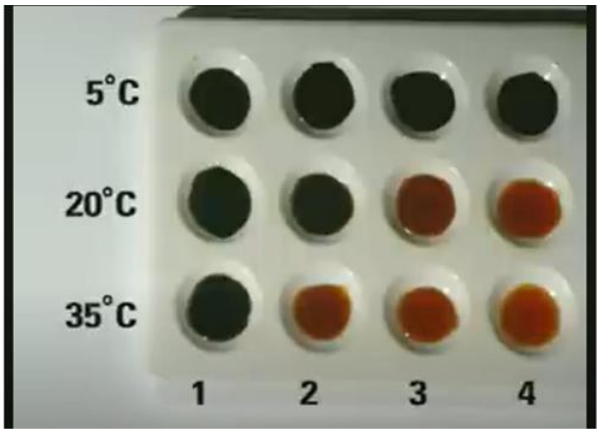
3.2. Explain any abnormalities in the pattern and possible conditions associated.

(a. Control Sample, b. Patient sample, C. Control sample, d. patient sample) (10 Marks)

Q4. 03 test tubes of starch solutions were kept in water baths of 03 separate temperatures and each tube was mixed with 02 ml of salivary amylase solution. The mixtures were tested with iodine solutions at 1-minute intervals. Interpret the results.

(10 marks)





Q5.

5.1. What color change is observed when a fructose sample is treated with Benedict's reagent?

(02 marks)

5.2 Can Benedict's test be used as a quantitative test? If so, explain how it can be used to quantify the concentration of sugars. (08 marks)

Q6.

6.1. The acrolein test is a specific test for fats. Which compound is detected during the acrolein test, and how does it relate to the presence of fats?

(06 marks)

6.2. What observations are made when performing the acrolein test on coconut oil?

(04 marks)

Q7.

7.1. List three (03) conditions that can cause protein denaturation. (03 marks)

7.2. Which bonds are typically broken during the denaturation of proteins? (04 marks)

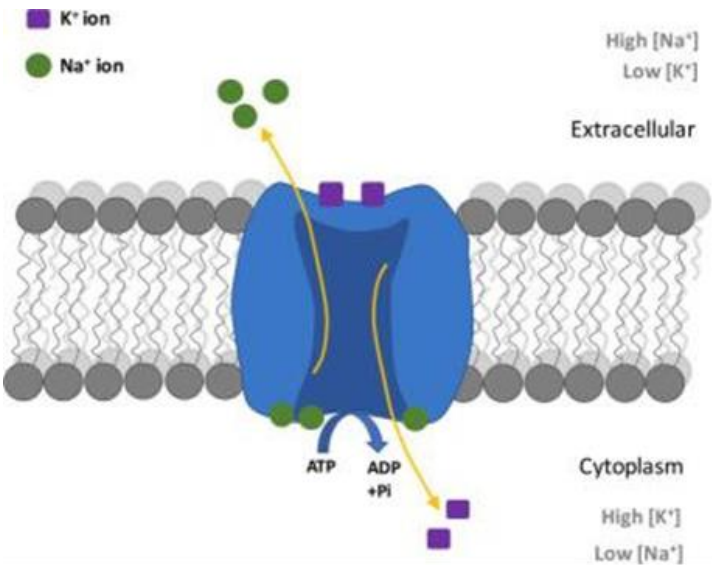
7.3. What color change would you expect when treating tryptophan and phenylalanine with the Xanthoproteic test? (04 marks)

Q8.



What is the primary advantage of using a phase contrast microscope?

Q9.



Describe the mechanism of action of the sodium-potassium pump (Na^+/K^+ ATPase) in maintaining cellular homeostasis.

Q10.



10.1. Based on your knowledge of pH, what would you expect the urine pH to be in a patient with metabolic alkalosis? Explain your reasoning. (05 marks)

10.2. If the pH of the urine is measured to be 8.5, what implications could this have for the patient's condition?

(05 marks)

BIOCHEMISTRY CONTINUOUS ASSESSMENT - 01

MCQ Paper

UVA WELLASSA UNIVERSITY
FACULTY OF MEDICINE
MBBS Degree Programme

Continuous Assessment 01
August 2024
2022/2023 (01st) Batch
BIOCHEMISTRY
Multiple Choice Question (MCQ) Paper

Time: 10.00 a.m. – 11.00 a.m. (01 Hour) **Date: 29.08.2024**

Index (MED) Number: .....

Instructions to candidates:
Answer all questions
Mark the answers clearly on the answer sheet.
The final answers should be in ink or HB pencil.

Question numbers 01 to 10 are True or False type questions. Mark your answer for each of the 5 responses (A to E).

1. Which of the following is/are True/False regarding nuclear pore complexes (NPCs)?

A. Composed of 5 different types of pore proteins.
B. Composed of proteins called nucleoporins.
C. They are simple structures.
D. They contain aqueous passages.
E. Through them, small molecules diffuse rapidly.

2. Which of the following is/are True/False regarding transport across plasma membranes?

A. During facilitated diffusion, the rate reaches its maximum, when transporters become saturated.
B. In facilitated diffusion solutes cross the membrane passively.
C. Movement of uncharged small molecules occurs along a concentration gradient.
D. To ensure the transport of glucose and sodium, the ratio of the carbohydrate (CHO) to sodium (Na) in oral rehydration solutions should be 4:1.
E. Transport of charged molecules is dependent on concentration gradient.

3. Which of the following is/are True/False regarding accurate methods of measuring the pH of urine samples?

A. pH Indicators
B. pH meter
C. pH papers
D. Titration method
E. Urine dipsticks

4. Which of the following is/are True/False regarding the cell membrane functions?

A. Dysfunction of the membranes is caused by hypercholesterolemia.
B. Endocytosis is the process by which large molecules enter the cell.
C. Homeostasis of the extracellular fluid is affected by increased Cl- in the cell.
D. Transport of copper is impaired in Wilson's disease.
E. Transport of hydrophobic molecules is done via voltage-gated ion channels.

5. Which of the following enzymes is/are involved in DNA replication?

A. Helicase
B. Ligase
C. Primase
D. Reverse transcriptase
E. Topoisomerase

6. Which of the following is/are True/False regarding Okazaki fragments?

A. Sealed by DNA ligase.
B. Synthesis is facilitated by RNA.
C. Synthesized by DNA polymerase
D. Synthesized in 3’ 5’ direction.
E. Synthesized in the leading strand.

7. Which of the following is/are True/False regarding simple sugars?

A. Lactose intolerance occurs due to lactase deficiency.
B. Monosaccharides are reducing sugars.
C. Sucrose is a non-reducing sugar.
D. Sucrose is made up of glucose and galactose.
E. They are optically active due to chiral centers.

8. Which of the following is/are True/False regarding structural proteins?

A. Fibronectin is a dimeric protein connected by disulfide linkages.
B. Hydroxylysine is present in elastin.
C. Laminin is an extracellular adhesive glycoprotein.
D. Myoglobin contains a hydrophilic haem pocket.
E. Myosin is found in the thick filaments of the muscle.

9. Which of the following is/are True/False regarding insulin?

A. Insulin produced by DNA technology and the human pancreas are differentiated by electrophoresis.
B. It has intra-chain disulfide linkage.
C. It is a heat-stable molecule.
D. It is administered orally.
E. It is synthesized as an inactive precursor.

10. Which of the following is/are True/False regarding buffers?

A. Bicarbonate buffer system is the primary buffer system in the blood.
B. pH of a buffer changes significantly when a small amount of water is added.
C. pH of a buffer solution is calculated by the Henderson-Hasselbalch equation.
D. They are effective in maintaining pH around their pKa value.
E. They consist of a weak acid and its conjugate base.

Questions number 11 to 20 are Single Best Response (SBR) type. Select the best response to each question.

11. A 72-year-old male with a long-standing history of heart failure is on digoxin (cardiac glycoside). The role of digoxin is to manage his symptoms by improving his heart's function at the cellular level.

Which of the following best describes the mechanism by which digoxin helps improve the cardiac function in this patient?

A. It inhibits the Na+/K+ pump.
B. It increases intracellular calcium levels.
C. It blocks the sodium-potassium ATPase.
D. It enhances the heart's pumping efficiency.
E. It reduces the function of the sodium-calcium exchanger.

12. The phospholipid bilayer is essential to maintain the cellular vitality.

What is the most important function of phospholipids to maintain the vitality of the cell?

A. Acting as the primary source of energy.
B. Formation of the structural framework of cell membranes.
C. Storage of calcium in muscle cells.
D. Facilitation of the storage of dietary fats.
E. Regulation of the synthesis of steroid hormones.

13. Cellular organelle defects lead to abnormalities in the structures within a cell, which can lead to various health issues.

Which of the following statements most accurately describes the impact of cellular organelle defects?

A. Defects of mitochondria affect the synthesis of cellular proteins.
B. Defects in the rough endoplasmic reticulum affect anabolic reactions.
C. Lysosomal defects lead to the accumulation of cellular particles.

D. Defects in the nucleus primarily affect cellular energy metabolism.
E. Defects of the Golgi apparatus lead to impaired protein transport.

14. A researcher is studying the process of DNA transcription in a laboratory setting. The goal is to understand how genetic information is copied from DNA to RNA as a precursor to protein synthesis.

Which of the following best describes the process of DNA transcription?

A. The synthesis of a new strand of nucleotide from a nucleotide template strand.
B. The synthesis of mRNA from a DNA template strand.
C. The synthesis of a complementary RNA strand from a DNA template strand.
D. It is the process that initiates protein synthesis in the nucleus.
E. Synthesis of RNA using DNA polymerase.

15. A 25-year-old athlete is undergoing a nutritional assessment to optimize his performance during intense exercise. The nutritionist is explaining the role of glycogen as a form of carbohydrate storage in the body.

Which of the following statements accurately describes glycogen in the context of energy storage?

A. The main long-term storage form of energy.
B. The β-1,4 glycosidic bond is important in rapid release of energy.
C. The α-1,6 glycosidic bond is important in rapid release of energy.
D. Amylopectin is a recommended dietary carbohydrate source for the above athlete.
E. Glycogen stored in the liver is used exclusively in rapid energy expenditure.

16. Glycosaminoglycans (GAGs) play a major role in joint health and the extracellular matrix.

Which of the following statements accurately describes glycosaminoglycans in this context?

A. The predominant components of the extracellular matrix.
B. The negative charge is associated with their function.
C. The resilience feature is significant in the function of synovial fluid.
D. Are linked to the core proteins using N-glycosidic linkage.
E. The degradation is facilitated by rough endoplasmic reticulum.

17. Spontaneity and favorability of biochemical reactions can be determined by the Gibbs free energy change (ΔG).

Which of the following statements most accurately describes a reaction when ΔG is positive?

A. Reaction absorbs free energy.
B. Reaction is not thermodynamically favored.
C. Reaction is endergonic.
D. Reaction is not spontaneous.
E. It is a single reaction.

18. A 25-year-old male athlete was brought to the emergency department after collapsing during a marathon. His blood gas analysis revealed a pH of 7.28, elevated levels of carbon dioxide, and a reduced partial pressure of oxygen. The attending physician suspected that the physiological response in his tissues was influenced by the Bohr effect.

Which of the following statements best explains the role of the Bohr effect in this patient's oxygen transport by hemoglobin?

A. Bohr effect causes hemoglobin to release more oxygen in tissues with high pH.
B. Bohr effect increases the oxygen-binding affinity of hemoglobin in tissues where carbon dioxide concentration is elevated.
C. Bohr effect results in hemoglobin releasing oxygen more readily in tissues with elevated carbon dioxide.
D. Bohr effect causes a high affinity of hemoglobin to oxygen in acidic environments.
E. Bohr effect is primarily responsible for the transport of carbon dioxide from tissues to the lungs by hemoglobin.

19. The function of the enzymes can be better understood if the characteristics of its active site are examined.

Which of the following characteristics most accurately facilitates the function of the active site?

A. It is a pocket formed by the specific folding of secondary structures of a polypeptide.
B. The specificity of the active site.
C. Being located on the surface of the enzyme.
D. Non-flexibility.
E. Lining of the active site by the side chains of amino acids.

20. A 15-year-old child was admitted to the emergency unit with blunt trauma including swellings due to a fall from a tree. The clinician diagnosed the cause of the swelling as acute inflammation.

Which statement most correctly describes the role of acute phase proteins in inflammation?

A. They attack pathogens in the bloodstream.
B. They regulate the immune system during chronic inflammation.
C. Their levels increase or decrease in response to inflammation.
D. They provide mechanical support to tissues during injury.
E. They act as transport proteins.

MCQ paper answers

1. FTFTT
2. TTTFF
3. FTFFT
4. TTTTF
5. TTTFT
6. TTTFF
7. TTTFT
8. TFTFT
9. FTFFT
10. TFTTT
11. B
12. B
13. C
14. B
15. C
16. B
17. C
18. C
19. E
20. C

Structured Essay Paper

UVA WELLASSA UNIVERSITY
FACULTY OF MEDICINE

Continuous Assessment Test 01
2024 August
2022/2023 (01st) Batch
BIOCHEMISTRY
STRUCTURED ESSAY PAPER

11.00 a.m. – 12.00 a.m. (01 hr.) 29.08.2024

Instructions to candidates:

- This paper consists of two (02) Structure Essay Questions
- Answer all questions
- Write the answers on answer sheets provided
- Write your index number in the space provided on each answer sheet
- Start each question on a new page

Q.1

1.1

a. Briefly explain the structure of peroxisomes. (10marks)
b. List three (03) functions of peroxisomes. (15marks)
c. List the main five (05) components of the ETC and mention the function of each (25 marks)
d. Briefly explain the role of brown adipose tissue (BAT) in thermogenesis. (20 marks)

1.2.

a. List three (03) health benefits of short-chain fatty acids. (15 marks)
b. List five (05) functions of cholesterol in humans. (15 marks)

(Total 100 Marks)

Q2.

1.1 List the main five (05)classes of plasma proteins and state a function for each. (25 Marks)

1.2 Define what is a nucleoside, nucleotide and nucleosome. (15 marks)

1.3 Compare the structure and function of HbA with that of HbF. (30 Marks)

1.4 Catalytic efficiency of regulatory enzymes of metabolic pathways is controlled by 2 main mechanisms. Briefly explain the two (02) mechanisms with glycogen phosphorylase (muscle) as an example. (30 Marks)

(Total 100 Marks)

SEQ Paper Answers

Q.1

1.1

a. Briefly explain the structure of peroxisomes.

Peroxisomes are surrounded by only a single membrane (2 marks)

- They do not contain DNA or ribosomes (2 marks).
- Thus, because peroxisomes lack a genome, all of their proteins are encoded in the nucleus (2 marks).
- Peroxisomes acquire most of these proteins by selective import from the cytosol, although some of them enter the peroxisome membrane via the ER (4 marks).
- Contain enzymes

(10 marks)

b. List three (03) functions of peroxisomes.

- Detoxification
- Peroxisomes are involved in biosynthesis of lipids and the amino acid, lysine. (5 marks).
- In the liver, peroxisomes are also involved in the synthesis of bile acids, which are derived from cholesterol (5 marks).
- In addition, peroxisomes contain enzymes required for the synthesis of plasmalogens- a family of phospholipids. (5 marks).

(15 marks)

c. List the main five (05) components of the ETC and mention the function of each.

- Complex I (NADH: Ubiquinone Oxidoreductase)/NADH dehydrogenase (03) -
  Transfers electrons from NADH to ubiquinone (coenzyme Q). Pumps protons from the mitochondrial matrix to the intermembrane space. (02)
- Complex II (Succinate: Ubiquinone Oxidoreductase)/Succinate dehydrogenase (03) -
  Transfers electrons from succinate (via FADH2) to ubiquinone. Does not pump protons but contributes to the pool of reduced ubiquinone. (02)
- Ubiquinone (Coenzyme Q)/Cytochrome reductase (03) -
  A lipid-soluble electron carrier that transports electrons from Complexes I and II to Complex III. Complex III (Cytochrome bc1 Complex). Transfers electrons from ubiquinone to cytochrome c(reduce cytochrome c). Pumps protons from the mitochondrial matrix to the intermembrane space. (02)
- Cytochrome c -
  A small, soluble protein that transfers electrons from Complex III to Complex IV. (02)
- Complex IV (Cytochrome c Oxidase) (03) -
  Transfers electrons from cytochrome c to oxygen, the final electron acceptor. Pumps protons from the mitochondrial matrix to the intermembrane space. Reduces oxygen to form water. (02)
- ATP Synthase (Complex V) (03) -

Utilizes the proton gradient created by the other complexes to synthesize ATP from ADP and inorganic phosphate (Pi). Protons flow back into the mitochondrial matrix through ATP synthase, driving ATP production.

(25 marks)

d. Briefly explain the role of brown adipose tissue (BAT) in thermogenesis.

The ETC in mitochondria typically creates a proton gradient across the inner mitochondrial membrane by transporting electrons from NADH and FADH2 through complexes I to IV. This proton gradient is used by ATP synthase (Complex V) to produce ATP from ADP and inorganic phosphate. In BAT, UCP1 uncouples this process (04) by providing an alternative pathway (04) for protons to flow back into the matrix (04), bypassing ATP synthase. (04)This uncoupling reduces ATP production but increases heat generation. (04)

(20 marks)

1.2.

a. List three (03) health benefits of short-chain fatty acids.

Short-chain fatty acids (SCFAs) are primarily produced by the fermentation of dietary fibers by gut microbiota in the cecum and colon

Answer (Any three of these benefits can be listed for the answer)

- Help reduce serum cholesterol levels
- Reducing the risk of metabolic syndrome and type 2 diabetes
- Possess anti-cancer properties
- Butyrate, in particular, is a primary energy source for colonocytes (cells lining the colon)
- Promotes healthy gut integrity

(15 marks)

b. List five (05) functions of cholesterol in humans.

- Membrane Fluidity: Regulation of membrane fluidity and stability, Role in lipid rafts for cell signaling
- Steroid Hormone Synthesis: Precursor to corticosteroids, androgens, estrogens, and progestogens
- Bile Acid Synthesis: Essential for digestion and absorption of dietary fats
- Vitamin D Synthesis: Precursor to vitamin D synthesis upon UV exposure
- Cell Signaling and Transport: Role in intracellular transport, cell signaling, and nerve conduction

(15 marks)
(Total 100 Marks)

Q2.

2.1 List the main five (05) classes of plasma proteins and state a function for each.

- Albumin: Maintains osmotic pressure, helping to regulate blood volume and tissue fluid balance
- Globulin: Involved in immune response, particularly in the transport of antibodies
- Fibrinogen: Plays a crucial role in blood clotting
- Lipoproteins: Transport lipids
- Complement proteins: part of the immune system, Help to destroy pathogens

Or

- Albumin: Monitoring oncotic pressure, Transport including; fatty acids, hormones, vitamins, and drugs, buffering action
- α 1 globulin: Inhibiting proteases, transport hormones
- α 2 globulin: Transporting metals, involved in inflammatory response
- β globulin: transporting iron and lipids, involved in immune response
- γ globulin: Long-term protective immunity

(25 Marks)

2.2 define what is a nucleoside, nucleotide, and nucleosome.

- Nucleoside - Purine or pyrimidine base covalently attached to a sugar molecule. (Base + Sugar). Eg; Adenosine, Guanosine
- Nucleotide- Nucleoside (Base+Sugar) is covalently joined to a phosphate group. (Base + Sugar + Phosphate). Eg; AMP, GMP
- Nucleosome- A complex of DNA and histone proteins. Eight core histone proteins aggregate to form the histone core (octamer complex) of the nucleosome. DNA wrapped two times around the octamer core/octamer complex. Nucleosomes are linked together by "Linker" DNA. Produces the "Beads–on–a–string" appearances seen in electron microscopy

(15 Marks)

2.3. Compare the structure and function of HbA with that of HbF.

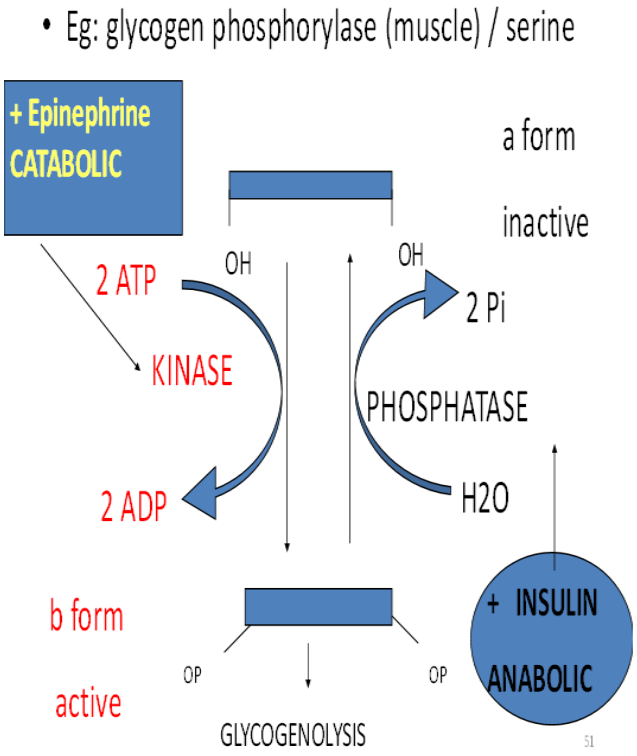
HbA	**HbF**
Composed of 2 α and 2 β globin chains	Composed of 2 α and 2 γ globin chains
Predominant form of hemoglobin after birth	Predominant form of hemoglobin during fetal development
Has a lower affinity for oxygen compared to HbF	Has a higher affinity for oxygen, allowing the fetus to effectively extract oxygen from maternal blood

2.5×12 **(30 Marks)**

2.4. Catalytic efficiency of regulatory enzymes of metabolic pathways is controlled by 2 main mechanisms. Briefly explain the two (02) mechanisms with glycogen phosphorylase (muscle) as an example.

- Allosteric control (3 m)
- Binding the modifier site by positive or negative modifiers. (4 m)
- Glycogen phosphorylase (muscle)-

    - + AMP
    - - ATP & G6P (G. phosphorylase - T state) (3 m x 2)
    - Covalent modification (3 m)
    - Under hormonal regulation – cascade activation (3 m)
    - Enzyme activation and inhibition by phosphorylation and dephosphorylation by enzymes activated via cascade. (4 m)



7 m for the above diagram **(30 Marks)**

(Total 100 Marks)

OSPE QUESTIONS AND ANSWERS

Q.1

You are provided with three (03) solutions:

1.1 Measure the pH of each solution (A, B, and C) using the pH papers provided and identify the following solutions.

I. Acetic acid solution:…… (02 Marks)
II. Distilled water:…… (02 Marks)
III. 1M NaOH solution:……. (02 Marks)

1.2 Write two (02) examples of biological buffer systems.

(04 Marks)

(Total 10 Marks)

Q.2

A 50-year-old patient presented to the clinic with symptoms of fatigue and frequent urination. A urinalysis was performed, and the urine sample gave positive results for both Benedict's and Seliwanoff's tests.

2.1 Determine the type of sugar present in the urine sample. (05 Marks)

2.2 Based on the sugar identified in part 2.1., describe the color observation when the sugar solution is treated with Seliwanoff's test.

(05 Marks)

Answer:- Fructose, Answer Red color (Cherry red color)

(Total 10 Marks)

Q.3

You are provided with 03 solutions labeled A, B & C which have been tested with iodine solution.

3.1 Identify the sample that contains a solution of starch. (05 Marks)

3.2 Explain the reason for the answer 3.1. (05 Marks)

Answer:- Starch, Answer:The colour change is due to the absorption of iodine molecules by the helical structure of amylose

(Total 10 Marks)

Q.4

A 55-year-old male patient presented with symptoms of coronary artery disease and was undergoing dietary assessment. To evaluate the impact of different fatty acids on health, you are provided with samples of Palmitic acid (a saturated fat) and Oleic acid (an unsaturated fat).

You decided to test these fatty acids with bromine water.

4.1. Describe the expected results of this test. (05 Marks)

4.2. The above patient had been consuming partially hydrogenated fats as part of his diet, which might have contributed to his current health issues.

Concerning the patient's health, describe the drawback of consuming partially hydrogenated fats.

(05 Marks)

Answer:-

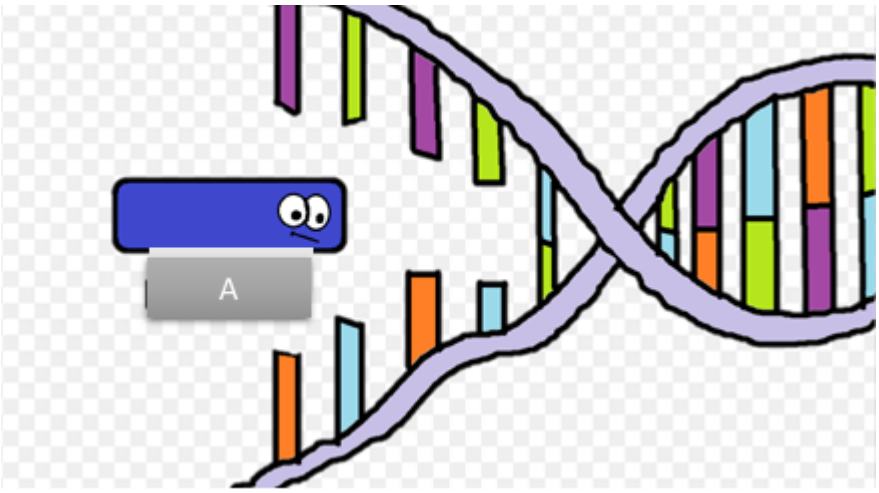
4.1 Bromine water added to Palmitic acid remains orange-yellow, while the Orange-yellow color of Bromine water treated with Oleic acid vanishes/decolorized

4.2 Partial hydrogenation of fats leads to the formation of trans fatty acids (the natural cis fatty acids are converted to trans fats), formed trans fats are associated with an increased risk of cardiovascular diseases, such as coronary artery disease, which may contribute to the patient's current health issues.

(Total 10 Marks)

Q.5

This enzyme "A" unwinds the double helix



5.1 Name the enzyme (04 marks)

5.2 Name the biological process that is initiated by this enzyme (03 marks)

5.3 Name another protein that facilitates this process (03 marks)

Answer:- Helicase, DNA replication, SSB protein

(Total 10 Marks)

Q.6

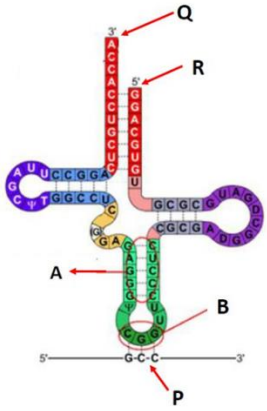
The following tests were performed (Ninhydrin test, Biuret test, Xanthoproteic test & Sulphosalicylic Acid test) with the solutions A, B, C & D.

6.1. Identify the solutions A, B, C, and D (10 marks)

Test / Experiment	Solution A	Solution B	Solution C	Solution D
Ninhydrin Test	+	++	-	+++
Biuret Test	+	+	-	-
Sulphosalicylic acid	+	-	-	-
Xanthoproteic test	+	+	-	-
Identify the solutions	.....	.....	.....	.....

(Total 10 Marks)

Q.7



7.1 Identify this molecule. (02 marks)

7.2 Name A and B (04 marks)

7.3 identify the binding site of the relevant amino acid. (02 marks)

7.4 Identify the function of this molecule in protein synthesis. (02 marks)

Answer:- 1. t_RNA molecule

2. A – Intramolecular base paring B – Anticodon

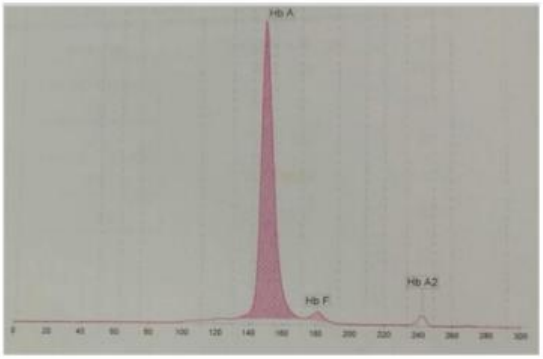
3. Q

4. The translation process

(Total 10 Marks)

Q.8

A 7-year-old child had anemia with a hemoglobin level of 9.5g/dl. His hemoglobin electrophoresis is shown below with the HPLC report.



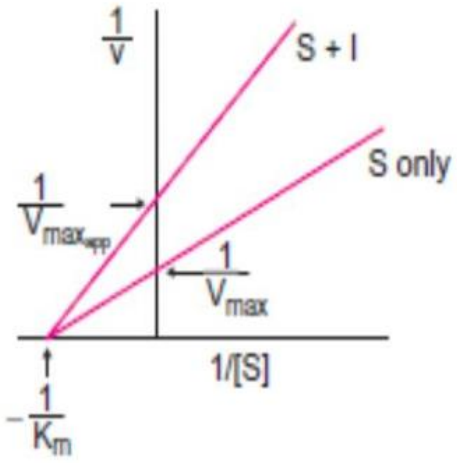
Haemoglobin	Value	Reference Value
Hb A	93.7%	>95%
Hb F	2.3%	<0.5%
HbA2	4%	2.2-3.2

8.1. Identify the diagnosis.

(Total 10 Marks)

Q.9

Lineweaver-Burke plot for an enzymatic reaction and the change following the addition of an inhibitor is shown below.



9.1. Identify the type of inhibition. (05 marks)

9.2. Give an example for such inhibition. (05 marks)

Answer:- Noncompetitive (Alanine/CN/etc)

(Total 10 Marks)

Q.10

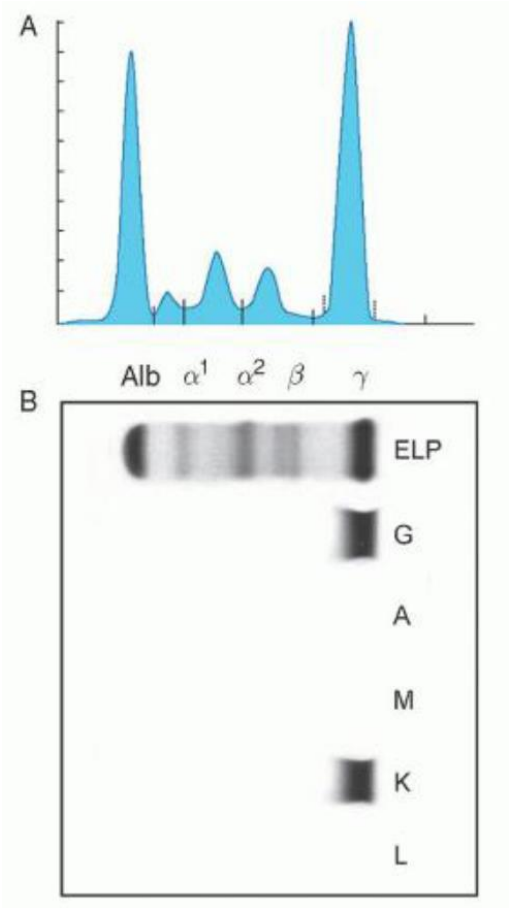
10.1 **A 65-year-old patient presented with recurrent infections. His CRP (C reactive Protein) was 60**

What are the common causes of elevated CRP levels? (02 Marks)

10.2 **His laboratory tests revealed an elevated level of IgG.**

List two key functions of IgG in the immune response (02 Marks)

10.3 His history revealed that he had been having bone Pain, fatigue, easy bruising, and unexplained weight loss over the last 3 months. Serum electrophoresis was done and the results are shown below



Identify the probable diagnosis. (01 Mark)

Name the abnormality you detected. (02 Marks)

10.4 **During the treatment process prophylactic Influenza vaccination was prescribed. Just after the vaccination patient developed difficulty in breathing and fainted.**

Identify the clinical condition you suspect. (01 Mark)

What is the Immunoglobulin involved in this condition? (02 Marks)

Answers:- Infections (bacterial, viral), inflammatory diseases (rheumatoid arthritis, systemic lupus erythematosus), and tissue injury or trauma. IgG can neutralize toxins and viruses by binding to them and preventing their interaction with host cells. IgG can opsonize pathogens, marking them for phagocytosis by immune cells. Multiple myeloma, abnormal M-spike appears on the electrophoresis graph, Anaphylaxis, IgE

(Total 10 Marks)