Course Title: Medical Biochemistry II
RAD 2nd, Sec A
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Max Marks: 50

Note: There are FIVE questions, each carry 10 marks with grand total of 50 marks.
ATTEMPT all questions.
Avoid copy paste material, as it may deduct your marks.

Q1. Explain the process of "ATP synthesis coupled with electron flow".

Ans) CELLULAR RESPIRATION: It is the process through which the cell synthesis energy in the form of ATP for itself through different metabolic processes.

GLYCOLYSIS: In this process the glucose converts into pyruvate and NAD^+ converts into NADH.

KREB'S CYCLE: first pyruvate converts into Acetyl Coenzyme A. This Acetyl – coA enters the Kreb's cycle, and in the process it converts NAD^+ into NADH and FADH into $FADH_2$.

- The NADH and $FADH_2$ are e^- carriers which transfer the electrons in ETC and will synthesis the ATP for the body.
- The NADH and $FADH_2$ are in reduced form.

ELECTRON TRANSPORT CHAIN:

DEFINITION: The electron transport chain is a cluster of proteins that transfer electrons through a membrane within a mitochondria to form a gradient of protons that drives the creation of ATP.

OCCURRENCE:

- The process of ETC occurs in the inner membrane of mitochondria.

PROTEIN COMPLEXES:

- Where on the inner membrane there are four attach protein complexes.
- These protein complexes process the ETC.
- The coenzyme Q is present between complex 1 and 2, the molecules of cytochrome is present between 3 and 4 complex protein.
- In the cytochrome molecule there are four arranged molecules like cyt b, cyt c, cyt a, and cyt a3 arranged in a specific pattern.

- Apart from these protein complexes and enzyme ATP synthase is also present.
- ATP synthase help in the production of ATP.
- These membranes bound electron carriers passed on the electrons to the other electron carriers until they are finally given to O_2 and produce water.

COMPLEX 1:

- The NADH is in reduce form and is highly energetic so it will give its electrons to the complex 1 molecule of protein and itself convert into NAD^+ form.
- In this transferring of electrons, most of the energy is released and the free H^+ ions from the matrix is transfer to inter membrane space.
- The complex 1 molecule transfer its electron to the coenzyme Q which is present between complex 1 and 2 molecule.
- Complex 1 molecule itself get oxidized and reduce the coenzyme Q.
- It is not much energetic as NADH so no H^+ ion transfer from matrix to the inner membranal space.

COMPLEX 2:

- Now, the most energetic molecule $FADH_2$ get oxidize and reduce the complex 2 molecule by giving its electrons and convert itself into FADH form.
- The electrons from complex 2 transfer to coenzyme Q and it transfer the electrons to complex 3 and finally reach to the complex 4.
- No H^+ ions are transported to the inter membrane space in this process.

COMPLEX 3:

- The Coenzyme Q itself get oxidized by giving electrons to the complex 3 molecule and reduce it.
- This process releases energy which transfer the H^+ ion from matrix to the inter membranal space.
- The complex 3 transfer its electrons to the cytochrome and itself get oxidize.
- This redox rxn do not produce as much energy, so that the H^+ ion do not transfer to the inter membranal space.

COMPLEX 4:

- In the next step the cytochrome will lose electrons and transfer it to the complex 4 in order to reduce it.
- Again more energy will produce in this redox rxn which helps in releases of the H^+ ion from matrix to the inter membranal space.

DIFFERENCE BETWEEN NADH AND $FADH_2$ IN TRANSFER OF ELECTRONS:

- In this redox rxn the energy is releases in each transfer of electrons and the transferring of H^+ ion takes place from matrix to the inter membranal space.

- The difference is that the NADH transfer electrons to the complex 1 molecule and $FADH_2$ transfer its electrons to complex 3 molecules.

CHEMIOSMOSIS:

- The electrons finally reaches to complex 4, there are no more complexes of proteins on the inner membrane so it gives its electrons to the matrix.
- The oxygen molecules in the matrix takes the electrons and react with the H^+ ions in the matrix to form water molecule.
- The O_2 itself in the matrix do not react directly with the H^+ ion until it accepts electrons.
- The final electron acceptor in ETC is oxygen.
- In the final step, where the H^+ ion concentration is now higher in intermembranal space.
- The ATP synthase molecule helps the energize H^+ ion to allow them to reach matrix.
- The ATP synthase takes the energy from H^+ ion, and H^+ ion loses energy.
- The ATP synthase transfers its energy to ADP, and ADP reacts with inorganic phosphate to produce ATP for the body.

OXIDATIVE PHOSPHORYLATION:

- Oxidative phosphorylation is made up of two closely connected processes, the electron transport chain and the chemiosmosis.

Q2. Write the reactions that are catalyzed by the following enzymes.

i. Acyl CoA dehydrogenase

ii. Adenosine deaminase

iii. Nucleotidase

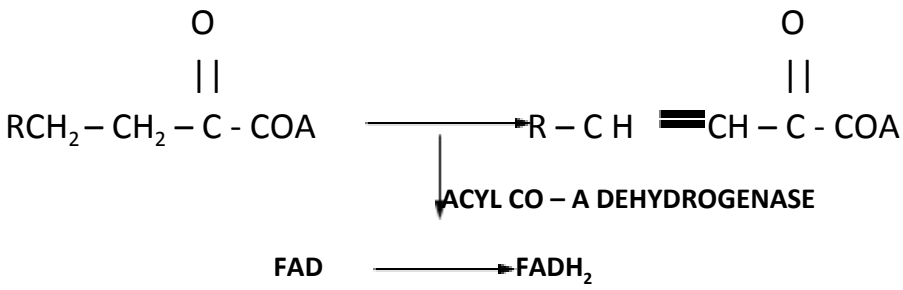
iv. Gluconolactonase

v. Enoyl-CoA hydratase

1. **ACYL CO-A DEHYDROGENASE:** It forms a double bond between the alpha and beta carbon atoms in the fatty acid chain. Produces one $FADH_2$.

REACTANT → **PRODUCT**

ACYL – COENZYME A → ENOYL - COA



2. **ADENOSINE DEAMINASE:** With the help of this enzyme NH_3 group is removed from the adenosine and formed an inosine.

REACTANT → **PRODUCT**

ADENOSINE → INOSINE

NH_3 (removed)

3. **NUCLEOTIDASE:** With the help of this enzyme adenosine mono phosphate is converted into adenosine by the removal of phosphate group.

REACTANT → **PRODUCT**

ADENOSINE MONO PHOSPATE → ADENOSINE

INORGANIC PHOSPHATE (REMOVED)

4. **GLUCONOLACTONASE:**

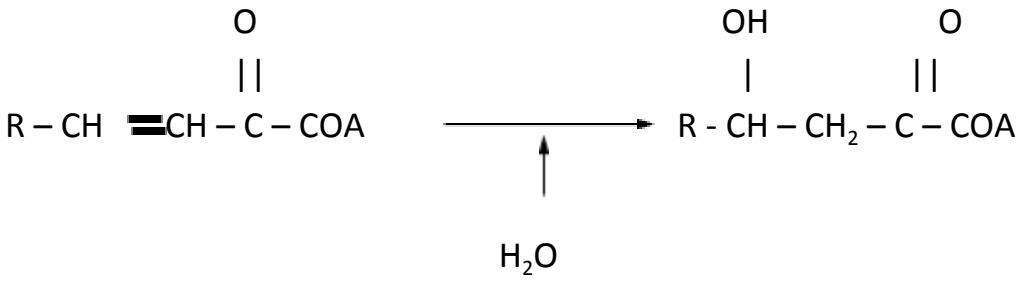
REACTANT **PRODUCT**

GLUCOSE – 6 – PHOSPHOLACTONE → 6 – PHOSPHOGLUCONATE

H_2O → H^+

5. **ENOYL COA HYDRATASE:** It incorporates a water molecule into the fatty acid chain, thereby breaking the double bond between the alpha and beta carbon atoms.

REACTANT	**PRODUCT**
Enoyl	beta-hydroxyacyl CoA



Q3. Define nucleotide, nucleoside and differentiate between DNA and RNA.

ANS:

Nucleosides:

- Composed of Purine or Pyrimidine
- linked to D-ribose in RNA or D-2- *deoxy*ribose (DNA)
- Joined by beta-N-Glycosidic linkage .

• In purine :-

Linkage is at position 9 of purine base and C1 of deoxysugar or sugar.

e.g: adenine-9-riboside

• In Pyramidines :-

Lineage at position 1 of pyrimidine and C1 of ribose or deoxyribose

e.g: uracil - 1 - riboside

Nucleotides:

- Nucleoside + Phosphoric Acid is Nucleotide
- Bond between them is Phosphoric Acid diester bond
- In ribose, phosphate esterification only takes place at positions 2',3',5'.
- In deoxynucleoside, takes place at 3' and 5' due to the -OH groups present in these area only.

important examples of Nucleotides are:

1. ATP (imp source of energy)
2. ADP (primary phosphoric acid acceptor in oxidative phosphorylation)
3. Amp (activates several imp enzymes for e.g activates Phospho fructokinase used in Glycolytic Pathway)
4. GTP (required for protein synthesis)
5. Cyclic AMP (acts as 2nd messenger in cells and also inhibits biosynthesis of

Cholesterol)

Differentiate between DNA and RNA

DNA (Deoxyribonucleic acid)	**RNA**(Ribonucleic acid)
DEFINITION	
It is a long polymer. It has a deoxyribose and phosphate backbone having four distinct bases: thymine, adenine, cytosine, and guanine.	Is a polymer with a ribose and phosphate backbone with four varying bases: uracil, cytosine, adenine, and guanine.
● Has Thymine	● Has uracil
● deoxyribose sugar	● ribose sugar
● Double stranded	● Single stranded
LOCATION	
It is located in the nucleus of a cell and in the mitochondria.	It is found in the cytoplasm, nucleus, and in the ribosome.
FUNCTIONS	
● DNA can form RNA during transcription ● DNA is functional is the transmission of genetic information. ● It forms as a media for long-term storage	● RNA can form DNA only under special experimental conditions using Reverse transcriptase ● RNA is functional is the transmission of the genetic code that is necessary for the protein creation from the nucleus to the ribosome.
● One strand i.e 3'-5' carries genetic information	● mRNA transcribed carries genetic information

• Purine and pyrimidine Contents almost equal	• not equal
• Alkali Hydrolysis doesn't gives 2'-3' Cyclic diesters	• Alkali Hydrolysis gives 2'-3' cyclic diesters
PROPAGATION	
• DNA replicates on its own, it is self-replicating.	• RNA does not replicate on its own. It is synthesized from DNA when required.

Q4. Why Dickens and Horecker's Pathway is called HMP pathway. Enlist the enzymes used in PPP Pathway.

ANS:

HMP PATHWAY:

HMP pathway also known as **Hexose Monophosphate Pathway**

OR

PPP (**Pentose Phosphate Pathway**)

OR

Dickens and **Horecker** after the name of scientist.

Its called HMP shunt because this pathway or shunt begins at the level of glucose-6-phosphate during glycolysis and leads to the formation of nucleotides and NADPH .

Glucose 6 phosphate as a compound starts this pathway.

HMP pathway is further divided into two phases.

1) oxidative phase.

2) non oxidative phase.

Non oxidative phase:

Non oxidative phase is started from the molecule known as Ribulose-5-phosphate. It takes place in all tissues.

Occurrence :

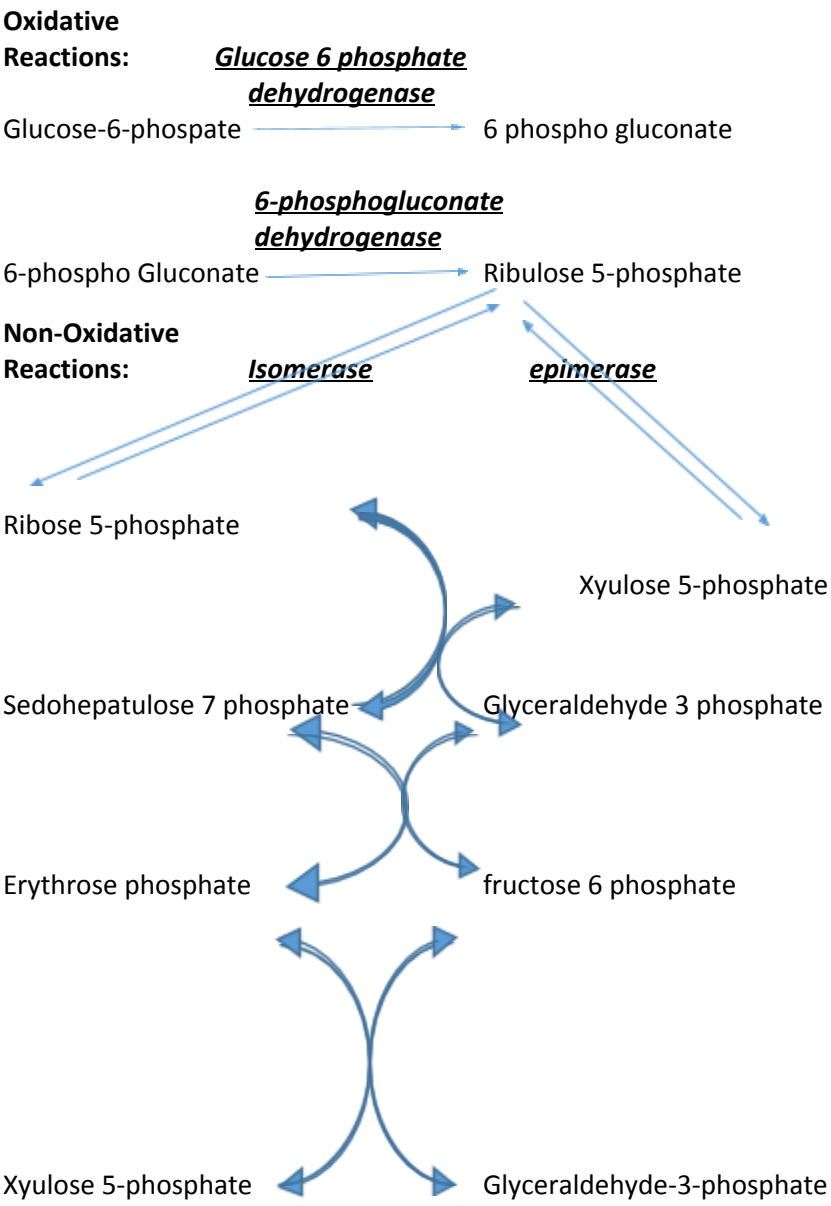
1) oxidative phase: it occurs in liver cells , adipose tissues, testes, ovaries and in mammary glands.

2) non oxidative phase: As the end product in it is ribose suger which is the main component of the hereditary material. It mostly occurs in the utilization of DNA and RNA

PHASES OF HMP PATHWAY

- There are two distinct phases in the pathway.
- The first is the oxidative phase which is irreversible.
- The second is the non-oxidative phase, which is reversible.
- In the first phase NADPH is generated.
- While in the second phase synthesis of pentose sugar occur.

Reactions of enzymes of HMP shunt



Enlist the enzymes used in PPP Pathway:

Oxidative Phase:

1) Hexokinase and glucokinase

2) Glucose- 6-phosphate dehydrogenase

3) Gluconolactonase

4) 6-phosphogluconate dehydrogenase

Non oxidative phase:

1) phosphopentose isomerase

2) Ribulose 5- phosphate Epimerase

3) Phosphate Epimerase+Tpp (coenzyme)

4) Transaldolase reaction

5) Transketolase reaction + TTP (coenzyme)

Q5. What is the function of carnitine shuttle system? Write down the stages and steps involved in Beta oxidation of Lipids.

ANS:

CARNITINE SHUTTLE SYSTEM:

Carnitine is an important nutrient that is present in diet (particularly in meat and dairy products) and is synthesized from amino acids. One is to transport long-chain fatty acids into the mitochondrion. The second function of carnitine is to regulate the intramitochondrial ratio of acyl coenzyme A to free coenzyme A.

Functions of carnitine shuttle:

>Heart conditions

>Kidney disease and dialysis

>Effect in male infertility

>As a weight loss supplement

>As an antidote in valproic acid poisoning

>To improve symptoms in moderate asthmatics

>To improve fatigue resulting from ifosfamide cancer chemotherapy

>To treat symptoms of hyperthyroidism

Write down the stages and steps involved in Beta oxidation of Lipids.

Beta oxidation:

Beta-oxidation is the catabolic process by which fatty acid molecules are broken down in the cytosol in prokaryotes and in the mitochondria in eukaryotes to produce acetyl-CoA, which enters the citric acid cycle, and NADH and FADH2, which are co-enzymes used in the electron transport chain. Beta carbon of fatty acid undergoes oxidation to a carbonyl group that is why it is given such name. Beta-oxidation is primarily expedited by the mitochondrial trifunctional protein, an enzyme complex associated with the inner mitochondrial membrane, although very long chain fatty acids are oxidized in peroxisomes.

The overall reaction for one cycle of beta oxidation is:

Cn-acyl-CoA + FAD + NAD+ H2O + CoA

→ Cn-2-acyl-CoA + FADH2 + NADH + H+ + acetyl-CoA

Beta Oxidation Steps

Beta oxidation takes place in four steps: dehydrogenation, hydration, oxidation and thiolysis. Each step is catalyzed by a distinct enzyme.

Briefly, each cycle of this process begins with an acyl-CoA chain and ends with one acetyl-CoA, one FADH2, one NADH and water, and the acyl-CoA chain develops two carbons shorter. The total energy yield per cycle is 17 ATP molecules . This cycle is frequent until two acetyl-CoA molecules are formed as opposed to one acyl-CoA and one acetyl-CoA.

The four steps of beta oxidation are described below:

Beta Oxidation Step 1

Dehydrogenation In the first step, acyl-CoA is oxidized by the enzyme acyl CoA dehydrogenase. A double bond is created between the second and third carbons (C2 and C3) of the acyl-CoA chain entering the beta oxidation cycle; the end product of this reaction is trans-Δ2-enoyl-CoA (trans-delta 2-enoyl CoA). This step uses FAD and manufactures FADH2, which will enter the citric acid cycle and form ATP to be used as energy. The carbon count starts on the right side and the rightmost carbon acting below the oxygen atom is C1, then C2 on the left forming a double bond with C3, and so on.

Beta Oxidation Step 2

Hydration In the second step, the double bond between C2 and C3 of trans-Δ2-enoyl-CoA is hydrated, establishing the end product L-beta-hydroxy acyl CoA, which has a hydroxyl group (OH) in C2, in place of the double bond. This reaction is catalyzed by another enzyme: enoyl CoA hydratase. This step involves water.

Beta Oxidation Step 3

Oxidation In the third step, the hydroxyl group in C2 of L-beta-hydroxy acyl CoA is oxidized by NAD+ in a reaction that is catalyzed by 3-hydroxyacyl-CoA dehydrogenase. The finale products are beta-ketoacyl CoA and NADH + H. NADH will record the citric acid cycle and produce ATP that will be used as energy.

Beta Oxidation Step 4

Thiolysis Finally, in the fourth step, beta-ketoacyl CoA is severed by a thiol group (SH) of another CoA molecule (CoA-SH). The enzyme that catalyzes this reaction is beta-ketothiolase. The cleavage takes place between C2 and C3; therefore, the end products are an acetyl-CoA molecule with the original two first carbons (C1 and C2), and an acyl-CoA chain two carbons shorter than the original acyl-CoA chain that inserted the beta oxidation cycle.

End of Beta Oxidation

In the case of even-numbered acyl-CoA chains, beta oxidation ends after a four-carbon acyl-CoA chain is broken down into two acetyl-CoA units, each one containing two carbon atoms. Acetyl-CoA molecules enter the citric acid cycle to yield ATP.

Energy Yield and End Products

Each beta oxidation cycle yields 1 FADH2, 1 NADH and 1 acetyl-CoA, which in terms of energy is corresponding to 17 ATP molecules:

- 1 FADH2 (x 2 ATP) = 2 ATP
- 1 NADH (x 3 ATP) = 3 ATP
- 1 acetyl-CoA (x 12 ATP) = 12 ATP
- Total = 2 + 3 + 12 = 17 ATP

However, the theoretical ATP yield is higher than the real ATP yield. In reality, the equivalent of about 12 to 16 ATPs is produced in each beta oxidation cycle.

THE END