Course Title: Medical Biochemistry II
RAD 2nd, Sec A
Student Name:
Student ID:

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".

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

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

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

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

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Subject. Biochemistry

Section. A

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Question 2.

Answer. A

submitted by andro(147), 2 months ago

Fatty Acid degradation

-Occurs in mitochondria or peroxisomes

First step - uptake of the fatty acids by the cell and addition of CoA to them

Second step - Uptake of the Fatty Acyl CoA molecule into the mitochondria by the Carnitine Shuttle *(which involves removal and then addition of the CoA molecule again to the fatty acid once inside the mitochondria)

Once in the mitochondria the fatty acid may undergo , Beta-oxidation (a process in which a fatty acid is oxidized/cleaved at the Beta carbon to

Acetyl CoA in several cycles)

An Acyl CoA dehydrogenase catalyzes the initial step .

Look out for Hypoketotic Hypoglycemia in defects of fatty acid degradation

The 2 main subtypes to be aware of are -a problem with the carnitine shuttle (systemic carnitine deficiency) - or with an Acyl CoA dehydrogenase (eg MCAD deficiency)

notyasupreme It's actually funny because the question stem makes it seemlike it's an MCAD deficiency (presence of dicarboxylic acid) and all the symptoms, but then treat it with MCAD. Whatever, I got it right but it just felt like a weird question to me. +1 a month ago

nbmeanswersownersucks yeah I was confused too but I also think the negative serum carnitine is supposed to help r/o MCAD deficiency since that usually has elevated serum carnitine. + a month ago

baja_blast If Carnitine was an option here, how could we differentiate this from primary carnitine deficiency? Would it have been possible? +4 a month ago

melanoma the presence of dicarboxylic aciduria is more related to mcad/lcad deficiency. the patient receives medium chain tryglicerides

because he has the enzyme to metabolize it. +1 23 days ago

melanoma but no for the long chain + 23 days ago

Answer 2 B.

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Adenosine deaminase is an enzyme involved in purine metabolism. It is needed for the breakdown of adenosine from food and for the turnover of nucleic acids in tissues. Its primary function in humans is the development and maintenance of the immune system.

Answer 2 C.

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A nucleotidase is a hydrolytic enzyme that catalyzes the hydrolysis of a nucleotide into a nucleoside and a phosphate. A nucleotide + H_2O = a nucleoside + phosphate For example, it converts adenosine monophosphate to adenosine, and guanosine monophosphate to guanosine.

Answer 2 D.

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In enzymology, a gluconolactonase is an enzyme that catalyzes the chemical

reaction D-glucono-1,5-lactone + H_2O D-gluconate Thus, the two substrates of this enzyme are D-glucono-1,5-lactone and H_2O, whereas its product is D-gluconate.

Answer 2. D.

Enoyl-CoA hydratase or crotonase is an enzyme that hydrates the double bond between the second and third carbons on 2-trans/cis-enoyl-CoA: ECH is essential to metabolizing fatty acids in beta oxidation to produce both acetyl CoA and energy in the form of ATP

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Question. 1.

Answer.

Synthesis Coupled to Respiratory Electron Flow

We now turn to the most fundamental question about mitochondrial oxidative phosphorylation: how does the flow of electrons through the respiratory chain channel energy into the synthesis of ATP? We have seen that electron transfer through the respiratory chain releases more than enough free energy to form ATP. Mitochondrial oxidative phosphorylation therefore poses no thermodynamic problem. However, one cannot deduce from thermodynamic

considerations the chemical mechanism by which energy released in one exergonic reaction (the oxidation of NADH by O2) is channeled into a second, endergonic, reaction (the condensation of ADP and Pi). To describe the process of oxidative phosphorylation completely, we need to identify the physical and chemical changes that result from electron flow and cause ADP phosphorylation - the mechanism that couples oxidation with phosphorylation.

We begin our discussion by considering the stoichiometry of oxidation and phosphorylation in isolated mitochondria and the evidence for obligatory coupling of the two processes. The chemiosmotic interpretation of oxidative phosphorylation is then presented, with the major lines of evidence that support it. The enzyme ATP synthase, which is directly responsible for ATP synthesis, is the equivalent of an F-type ATP-dependent proton pump working in reverse; the flow of protons down their electrochemical gradient through this "pump" drives the condensation of Pi and ADP. We describe also the membrane transport systems that move substrates, products, and reducing equivalents between the cytosol and the mitochondrial matrix. Having looked in detail at the coupling of ATP synthesis to electron flow, we will see that in the mitochondria of some tissues the two processes are deliberately

"uncoupled" to produce heat.

We conclude with a summary of the overall regulation of ATPproducing processes in the cell, and a look at two further interesting aspects of mitochondria: the mitochondrial genome (and the effects of mutations therein) and the likely evolutionary origins of these organelles.

Phosphorylation of ADP Is Coupled to Electron Transfer

When isolated mitochondria are suspended in a buffer containing ADP, Pi, and an oxidizable substrate such as succinate, three easily measured processes occur: (1) the substrate is oxidized (succinate yields fumarate), (2) O2 is consumed (respiration occurs), and (3) ATP is synthesized. Careful experimental measurements of the stoichiometry of electron transfer to O2 and the associated synthesis of ATP show that with NADH as electron donor, mitochondria synthesize nearly 3.0 ATP per pair of electrons passed to O2, and with succinate nearly 2.0 ATP per electron pair. Oxygen consumption and ATP synthesis are dependent upon substrate oxidation, as can be seen in the experiments diagrammed in Figure 18-13.

Figure 18-13 Electron transfer to O2 is tightly coupled to ATP synthesis in

mitochondria, as is demonstrated in these experiments. Mitochondria are suspended in a buffered medium, and an O2 electrode is used to monitor O2 consumption. At intervals, samples are removed and assayed for the presence of ATP. (a) The addition of ADP and Pi alone results in little or no increase in either respiration (O2 consumption; black) or ATP synthesis (red). When succinate is added, respiration begins immediately and ATP is synthesized. The addition of cyanide (CN^-), which blocks electron transfer between cytochrome oxidase and O2, inhibits both respiration and ATP synthesis. (b) Mitochondria provided with succinate respire and synthesize ATP only when ADP and Pi are added. Subsequent addition of venturicidin or oligomycin, inhibitors of ATP synthase, blocks both ATP synthesis and respiration. Dinitrophenol (DNP) allows respiration to continue without ATP synthesis; DNP acts as an uncoupler.

Because the energy of substrate oxidation drives ATP synthesis in mitochondria, it is not surprising that inhibitors of the passage of electrons to O2 (e.g., cyanide ion, carbon monoxide, and antimycin A) block ATP synthesis (Fig. 18-13a). It is perhaps not so obvious that the converse is true: inhibition of ATP synthesis blocks electron transfer in intact mitochondria. This obligatory coupling can be demonstrated in isolated mitochondria by

providing O2 and oxidizable substrates, but not ADP (Fig. 18-13b). Under these conditions, no ATP synthesis can occur, and electron transfer to O2 is also strikingly reduced. Coupling of oxidation and phosphorylation can also be demonstrated using oligomycin or venturicidin, toxic antibiotics that bind to the ATP synthase in mitochondria. These compounds are potent inhibitors of both ATP synthesis and the transfer of electrons through the chain of carriers to O2 Because oligomycin is known not to interact directly with the electron carriers but only with ATP synthase, it follows that electron transfer and ATP synthesis are obligatorily coupled; neither reaction occurs without the other.

There are, however, certain conditions and reagents that uncouple oxidation from phosphorylation. When intact mitochondria are disrupted by treatment with detergent or physical shear, the resulting memfbrane fragments are still capable of catalyzing electron transfer from succinate or NADH to O2, but no ATP synthesis is coupled to this respiration. Certain chemical compounds also cause uncoupling without disrupting mitochondrial structure. The chemical uncouplers include 2,4-dinitrophenol (DNP) and a group of compounds related to carbonylcyanide phenylhydrazone . All of these uncouplers are weak acids with hydrophobic properties. Ionophores (p. 560)

also uncouple oxidative phosphorylation. These agents bind to inorganic ions and surround them with hydrophobic moieties; the ionophore-metal ion complexes pass easily through membranes. We shall see later how the chemiosmotic theory accounts for the action of uncouplers.

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Question 5.

Answer.

The carnitine shuttle is responsible for transferring long-chain fatty acids across the barrier of the inner mitochondrial membrane to gain access to the enzymes of beta-oxidation.

Beta oxidation takes place in four steps: dehydrogenation, hydration, oxidation and thyolisis. 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 becomes two carbons shorter.

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Question 4.

Answer.

The pentose phosphate pathway (also called the phosphogluconate pathway and the hexose monophosphate shunt) is a metabolic pathway parallel to glycolysis. It generates NADPH and pentoses (5-carbon sugars) as well as ribose 5-phosphate, a precursor for the synthesis of Nucleotides. While the pentose phosphate pathway does involve oxidation of glucose, its primary role is anabolic rather than catabolic. The pathway is especially important in red blood cells (erythrocytes).

There are two distinct phases in the pathway. The first is the oxidative phase, in which NADPH is generated, and the second is the non-oxidative synthesis of 5-carbon sugars. For most organisms, the pentose phosphate pathway takes place in the cytosol; in plants, most steps take place in plastids.[1]

Similar to glycolysis, the pentose phosphate pathway appears to have a very ancient evolutionary origin. The reactions of this pathway are mostly enzyme-catalyzed in modern cells, however, they also occur non-enzymatically under conditions that replicate those of the Archean ocean, and are catalyzed by metal ions, particularly ferrous ions (Fe(II)).[2] This suggests that the origins of the pathway could date back to the prebiotic world.

The conversion of 6-phosphogluconolactone to 6-phosphogluconate is

by 6-phosphogluconolactonase (PGLS).

Glucose-6-Phosphate Dehydrogenase: G6PDH. ...

6-Phosphogluconolactonase: PGLS. ...

Hexose-6-Phosphate Dehydrogenase: H6PDH. ...

6-Phosphogluconate Dehydrogenase. ...

Non-Oxidative Reactions of the PPP.

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Question 3

Answer.

Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) are perhaps the most important molecules in cell biology, responsible for the storage and reading of genetic information that underpins all life. They are both linear polymers, consisting of sugars, phosphates and bases, but there are some key differences which separate the two1. These distinctions enable the two molecules to work together and fulfil their essential roles. Here, we look at 5 key differences between DNA and RNA. Before we delve into the differences,

we take a look at these two nucleic acids side-by-side.

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A Comparison of the Helix and Base Structure of RNA and DNA

DNA vs. RNA – A Comparison Chart

Comparison

DNA

RNA

Full Name

Deoxyribonucleic Acid

Ribonucleic Acid

Function

DNA replicates and stores genetic information. It is a blueprint for all genetic information contained within an organism

RNA converts the genetic information contained within DNA to a format used to build proteins, and then moves it to ribosomal protein factories.

Structure

DNA consists of two strands, arranged in a double helix. These strands are made up of subunits called nucleotides. Each nucleotide contains a phosphate, a 5-carbon sugar molecule and a nitrogenous base.

RNA only has one strand, but like DNA, is made up of nucleotides. RNA strands are shorter than DNA strands. RNA sometimes forms a secondary double helix structure, but only intermittently.

Length

DNA is a much longer polymer than RNA. A chromosome, for example, is a single, long DNA molecule, which would be several centimetres in length when unravelled.

RNA molecules are variable in length, but much shorter than long DNA polymers. A large RNA molecule might only be a few thousand base pairs long.

Sugar

The sugar in DNA is deoxyribose, which contains one less hydroxyl group than RNA’s ribose.

RNA contains ribose sugar molecules, without the hydroxyl modifications of deoxyribose.

Bases

The bases in DNA are Adenine (‘A’), Thymine (‘T’), Guanine (‘G’) and Cytosine (‘C’).

RNA shares Adenine (‘A’), Guanine (‘G’) and Cytosine (‘C’) with DNA, but contains Uracil (‘U’) rather than Thymine.

Base Pairs

Adenine and Thymine pair (A-T)

Cytosine and Guanine pair (C-G)

Adenine and Uracil pair (A-U)

Cytosine and Guanine pair (C-G)

Location

DNA is found in the nucleus, with a small amount of DNA also present in mitochondria.

RNA forms in the nucleolus, and then moves to specialised regions of the cytoplasm depending on the type of RNA formed.

Reactivity Due to its deoxyribose sugar, which contains one less oxygen-containing hydroxyl group, DNA is a more stable molecule than RNA, which is

useful for a molecule which has the task of keeping genetic information safe.

RNA, containing a ribose sugar, is more reactive than DNA and is not stable in alkaline conditions. RNA's larger helical grooves mean it is more easily subject to attack by enzymes.

Ultraviolet (UV) Sensitivity DNA is vulnerable to damage by ultraviolet light.

RNA is more resistant to damage from UV light than DNA.

What are the key differences between DNA and RNA?

Function

DNA encodes all genetic information, and is the blueprint from which all biological life is created. And that's only in the short-term. In the long-term, DNA is a storage device, a biological flash drive that allows the blueprint of life to be passed between generations2. RNA functions as the reader that decodes this flash drive. This reading process is multi-step and there are specialized RNAs for each of these steps. Below, we look in more detail at the three most important types of RNA.

What are the three types of RNA?

Messenger RNA (mRNA) copies portions of genetic code, a process called transcription, and transports these copies to ribosomes, which are the

cellular factories that facilitate the production of proteins from this code.

Transfer RNA (tRNA) is responsible for bringing amino acids, basic protein building blocks, to these protein factories, in response to the coded instructions introduced by the mRNA. This protein-building process is called translation.

Finally, Ribosomal RNA (rRNA) is a component of the ribosome factory itself without which protein production would not occur3.

Sugar

Both DNA and RNA are built with a sugar backbone, but whereas the sugar in DNA is called deoxyribose (left in image), the sugar in RNA is called simply ribose (right in image). The ‘deoxy’ prefix denotes that, whilst RNA has two hydroxyl (-OH) groups attached to its carbon backbone, DNA has only one, and has a lone hydrogen atom attached instead. RNA’s extra hydroxyl group proves useful in the process of converting genetic code into mRNAs that can be made into proteins, whilst the deoxyribose sugar gives DNA more stability4.

bodyText

The Chemical Structures of Deoxyribose (left) and Ribose (right)

Sugars

Bases

The nitrogen bases in DNA are the basic units of genetic code, and their correct ordering and pairing is essential to biological function. The four bases that make up this code are adenine (A), thymine (T), guanine (G) and cytosine (C). Bases pair off together in a double helix structure, these pairs being A and T, and C and G. RNA doesn't contain thymine bases, replacing them with uracil bases (U), which pair to adenine1.

Structure

Whilst the ubiquity of Francis Crick and James Watson's (or should that be Rosalind Franklin's?) DNA double helix means that the two-stranded structure of DNA structure is common knowledge, RNA's single stranded format is not as well known. RNA can form into double-stranded structures, such as during translation, when mRNA and tRNA molecules pair. DNA polymers are also much longer than RNA polymers; the 2.3m long human genome consists of 46 chromosomes, each of which is a single, long DNA molecule. RNA molecules, by comparison, are much shorter4.

Location

Eukaryotic cells, including all animal and plant cells, house the great majority of their DNA in the nucleus, where it exists in a tightly compressed form, called a chromosome5. This squeezed format means the DNA can be easily stored and transferred. In addition to nuclear DNA, some DNA is present in energy-producing mitochondria, small organelles found free-floating in the cytoplasm, the area of the cell outside the nucleus.

The three types of RNA are found in different locations. mRNA is made in the nucleus, with each mRNA fragment copied from its relative piece of DNA, before leaving the nucleus and entering the cytoplasm. The fragments are then shuttled around the cell as needed, moved along by the cell's internal transport system, the cytoskeleton. tRNA, like mRNA, is a free-roaming molecule that moves around the cytoplasm. If it receives the correct signal from the ribosome, it will then hunt down amino acid subunits in the cytoplasm and bring them to the ribosome to be built into proteins5. rRNA, as previously mentioned, is found as part of ribosomes. Ribosomes are formed in an area of the nucleus called the nucleolus, before being exported to the cytoplasm, where some ribosomes float freely. Other cytoplasmic ribosomes

bound to the endoplasmic reticulum, a membranous structure that helps process proteins and export them from the cell6.