Indraprastha Institute of Information Technology Delhi (IIITD)
Department of Computational Biotechnology

BIO211 – Cell Biology and Biochemistry

Quiz-2 (November 14, 2022)

Duration: 45 mins **Total marks: 30**

1. State whether the following statements are correct or incorrect? Justify your answer in each case.

a) The electron-transport chain generates an electrical potential across the membrane because it moves electrons from the intermembrane space into the matrix.

Incorrect. The potential is due to protons (H^+) that are pumped across the membrane from the matrix to the intermembrane space. Electrons remain bound to electron carriers in the inner mitochondrial membrane.

b) Complete oxidation of glucose to CO_2 and H_2O in aerobic organisms involves glycolysis, citric acid cycle and oxidative phosphorylation.

Correct. Glucose is broken down to pyruvate molecules during glycolysis. ATP and NADH are also generated during this process. This pyruvate is converted to acetyl-CoA, which then enters citric acid cycle forming CO_2 and activated carriers. High energy electrons from these activated carriers then pass through the electron transport chain facilitating the synthesis of ATP molecules.

c) Many steps in the oxidation of sugar molecules involve reaction with oxygen gas.

Incorrect. Molecular oxygen (O_2) is used only in the very last step of the reaction as the final acceptor of the electrons passing through ETC.

d) The complete oxidation of sugar molecules can be represented by the general reaction: $C_6H_{12}O_6$ (glucose) + $6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy. However, some cells that grow in the absence of oxygen can also produce CO_2.

Correct. Anaerobically growing cells use glycolysis to oxidize sugars to pyruvate. Animal cells convert pyruvate to lactate, and no CO_2 is produced; yeast cells, however, convert pyruvate to ethanol and CO_2. (2 marks each)

2. Fill in the blanks:

a) Ubiquinone and Cytochrome c are the two diffusible electron carriers in electron-transport chain.

b) A single molecule of glucose generates two molecules of acetyl CoA, which enter the citric acid cycle.

c) Energy generated by each NADH molecule in electron-transport chain can generate about 2.5 molecules of ATP, whereas each molecule of $FADH_2$ can generate 1.5 ATP molecules.

d) Acetyl CoA is formed from pyruvate by oxidative decarboxylation reaction. (Dehydration/Reduction/Oxidative decarboxylation/Dephosphorylation)

e) NADPH and NADH are highly similar molecules. Among these, NADPH mainly operates with enzymes that catalyze anabolic reactions, whereas NADH is an important intermediate in catabolic reactions. (1 mark each)

3. Match the following:

A. Isomerase	i. Phosphofructokinase
B. Mutase	ii. Shifting of chemical group within a molecule
C. Fermentation in muscles	iii. Fructose-1,6-bisphosphatase
D. Succinyl-CoA	iv. Lactate

E. Glycolysis — v. Rearrangement of bonds within a molecule
F. Gluconeogenesis — vi. Chlorophyll

a) A-ii, B-v, C-vi, D-iv, E-iii, F-i
b) A-v, B-ii, C-iv, D-vi, E-i, F-iii (3 marks)
c) A-ii, B-v, C-iv, D-vi, E-iii, F-i
d) A-v, B-ii, C-vi, D-iv, E-iii, F-i

4. Name three activated carriers that carry energy in the form of hydrogen and high-energy electrons. How many of these activated carriers are generated as a result of oxidation of 1 molecule of glucose?

NADH, NADPH, $FADH_2$
From 1 molecule of glucose: 10 NADH, 2 $FADH_2$, 0 NADPH (3+2 marks)

5. A drug called dinitrophenol when added to mitochondria makes its inner membrane permeable to protons (H^+). How will this affect the establishment of electrochemical proton gradient and the overall process of ATP generation?

Dinitrophenol collapses the electrochemical proton gradient completely. H^+ ions that are pumped to one side of the membrane flow back freely due to the permeability of the membrane, and therefore no energy to drive ATP synthesis can be stored across the membrane. (3 marks)

6. During movement, muscle cells require large amounts of ATP to fuel their contractile apparatus. These cells contain high levels of creatine phosphate, which consists of a phosphate bond that has a standard free-energy change or $\Delta G°$ of -10.3 kcal/mole for its hydrolysis. Why is this a useful compound to store energy? (*Hint: $\Delta G°$ of ATP hydrolysis is -7.3 kcal/mol*) (3 marks)

The amount of free energy stored in the phosphate bond in creatine phosphate is larger than that of the anhydride bonds in ATP. Hydrolysis of creatine phosphate can therefore be directly coupled to the production of ATP.

creatine phosphate + ADP → creatine + ATP

The $\Delta G°$ for this reaction will be −3 kcal/mole, indicating that it will proceed rapidly to the right.