



Study Guide #2

1. Which complex of the electron transport chain contains the largest number of proteins?
 - A. I
 - B. II
 - C. III
 - D. IV
 - E. All contain the same number of proteins.

2. True or False - *Pyruvate kinase* deficiency is the most common hemolytic anemia that results from a deficiency of a glycolytic enzyme?

3. All the following are inhibitors of *pyruvate dehydrogenase complex* activity, except?
 - A. NADH
 - B. ATP
 - C. NAD⁺
 - D. Acetyl-CoA
 - E. None of the above

4. All the following are correct regarding Arsenic, except?
- A. It is part of column 15 of the periodic table of elements just below phosphorus.
 - B. Is a known carcinogen.
 - C. Interferes with phosphorus metabolism.
 - D. Inhibits substrate level phosphorylation.
 - E. All the above are correct.
5. True or False - Succinic acid is a dicarboxylic acid which is a central part of the Krebs cycle and can donate its electrons to the electron transport chain via Complex II.
6. All the following are correct with regards to nicotinamide adenine dinucleotide (NAD⁺) and nicotinamide adenine dinucleotide, hydrogen (NADH) as part of glycolysis, except?
- A. NAD⁺ is an essential cofactor in glycolysis (and other reactions) and must be regenerated.
 - B. The reduction of pyruvate to lactate by NADH + H⁺ regenerates NAD⁺.
 - C. In mammals, all cells have LDH with lactate being the end-product of electron transport chain reaction.
 - D. A & B
 - E. None of the above are correct.
7. True or False - When lactic acid is formed such as oxygen debt in muscles, this lactate is excreted into the blood then taken up the brain and used as a substrate for glycogenolysis?
8. Which of the following is incorrect with regards to electron transport chain regulation?
- A. The simplest mechanism of ETC control is through the supply of ADP.
 - B. When ADP levels go up, ATP synthesis is stimulated. This mechanism appears to be mediated through intracellular proteins, e.g., cAMP, control on complex IV.

- C. When ADP is completely converted to ATP, ETC respiration returns to baseline.
 - D. Through fuel flux into the mitochondria feedback regulatory mechanisms are activated such as the ADP/ATP ratio.
 - E. All the above are correct.
9. True or False - Gluconeogenesis is exactly like glycolysis, just in reverse?
10. True or False - Glutathione is involved in citric (acid) to cis-aconitate conversion. Deficiency of glutathione can lead to an increase in citric acid from enzyme inhibition of *aconitase*.
11. All the following are true of thiamine, except?
- A. Thiamine is a B1-vitamin found in various foods such as whole grains, legumes, fish, and some meats.
 - B. It supports multiple dehydrogenase complexes, including pyruvate, alpha-ketoglutarate, and branched chain ketoacid dehydrogenase complexes.
 - C. Thiamine must be obtained from the diet.
 - D. Gut microbes synthesize a significant amount of thiamine, about 25%.
 - E. It has a short half-life of approximately 2 to 12 hours with limited cellular storage of about 2 to 3 weeks.
12. All the following are correct of benfotiamine, except?
- A. It readily crosses the blood brain barrier.
 - B. It is not transporter dependent and is high potency.
 - C. Better GI tolerance, and useful for those with hyperglycemia.
 - D. Preferred for neurodevelopmental disorders.
 - E. All the above are correct.

13. True or False - The main regulatory enzymes of the Krebs cycle, *pyruvate dehydrogenase complex (PDC)* and *isocitrate dehydrogenase (IDH)*, are affected by the products of the Krebs cycle and electron transport chain?
14. The following are correct of Krebs cycle activity during resting and a high carbohydrate meal, except?
- A. The demand for ATP is reduced.
 - B. Increased insulin stimulates the *pyruvate dehydrogenase complex*, and the accumulation of ATP and NADH inhibit the *isocitrate dehydrogenase* enzyme.
 - C. Citrate builds up which can then be exported from the mitochondria for the synthesis of fatty acids.
 - D. None of the above are correct.
 - E. All the above are correct.
15. True or False - *Isocitrate dehydrogenase (IDH)* is also downregulated by ATP and NADH and stimulated by ADP and NAD⁺.
16. Points to consider with regards to ammonia detoxification as discussed in module #5. Which one is incorrect?
- A. *Ornithine transcarbamoylase (OTC)* deficiency is the most common urea cycle disorder.
 - B. OTC inhibition leads to an increased serum ammonia level, increased serum and urinary orotic acid levels.
 - C. The hyperammonemia depletes alpha-ketoglutarate leading to the inhibition of the tricarboxylic acid cycle (TCA) decreasing adenosine triphosphate (ATP) production.
 - D. None of the above are correct.
 - E. All the above are correct.

17. True or False - Fluoride forms a complex with phosphate and magnesium in *the enolase* enzyme blocking access of 2-phosphoglycerate as part of glycolysis?
18. This cytochrome of the electron transport chain is directly involved in mitochondria and cellular apoptosis?
- A. Complex II
 - B. Iron-sulfur cluster
 - C. Cytochrome c
 - D. Ubiquinone
 - E. None of the above
19. True or False - via glycolysis we establish 2 net ATP (4 total produced). This leaves 34 more ATP to be accounted for via the Krebs cycle (Kc) and electron transport chain (ETC).
20. Which of the following is not correct with regards to the Pentose Phosphate Pathway (PPP)?
- A. NADPH is a major product of the PPP in all cells.
 - B. The redox stage of PPP yields both nicotinamide adenine-dinucleotide phosphate, hydrogen (NADPH) and pentose phosphates.
 - C. The interconversion stage of excess PPP products allows for pentose phosphates to be recycled back into the glycolytic pathway.
 - D. The PPP is a cytosolic primary pathway for pentose phosphate formation and the synthesis of nucleotides of DNA and RNA.
 - E. All the above are correct.
21. *Pyruvate carboxylase* (PC) is a mitochondrial protein which contains a vitamin B12 group and requires the presence of mercury (Hg^{2+}) or arsenic (As^{2+}) to be functional?

22. True or False - Biologically, approximately 40% of food energy is conserved as adenosine triphosphate (ATP). The remaining 60% (approx.) of food energy is liberated as heat.
23. In the electron transport chain all the following are within the IMM, except?
- A. 4 large protein complexes: I, II, III, IV
 - B. 2 independent components: ubiquinone, cytochrome c.
 - C. 1 *ATP synthase*
 - D. Only A is correct.
 - E. All the above are correct.
24. The following are correct regarding ubiquinone, except?
- A. Ubiquinone is ubiquitous in virtually all living systems.
 - B. It is a lipid-soluble compound found in the IMM.
 - C. It diffuses within the IMM, and accepts electrons from the 4 flavoproteins, and transfers them to complex III.
 - D. The primary form of CoQ₁₀ (Q) contains a side chain of 10 isoprene units.
 - E. All the above are correct.
25. True or False - The NADH that is produced in the cytosol during carbohydrate metabolism can easily pass across the IMM into the matrix?
26. As discussed in module #6, all the following are correct with regards to the iron-sulfur complexes.
- A. Iron is important in heme proteins such as hemoglobin, myoglobin, cytochromes, and catalase.
 - B. Iron as a ferredoxin acts as biological capacitor accepting or discharging electrons changing iron between Fe²⁺ (ferrous) and Fe³⁺ (ferric).

- C. Iron in the electron transport chain is usually involved in one electron transfers.
 - D. The iron-sulfur clusters undergo distortion and relaxation during redox reactions.
 - E. All the above are correct.
27. True or False – The *Citrate synthase* enzyme of the Krebs cycle is encoded by mitochondria DNA to help maintain efficiency of the cycle under increased metabolic demand?
28. All the following are correct regarding Cytochrome c, except?
- A. Cytochrome c (cyt c) is a small heme protein loosely bound to outer surface of the IMM.
 - B. It shuttles e^- from complex III to complex IV. Each cyt c carries one e^- so the reduction of O_2 to $2H_2O$ via complex IV requires 4 cyt c molecules.
 - C. The reduction of Fe^{3+} to Fe^{2+} by cytochrome c_1 leads to a change in the three-dimensional Fe-S cluster and charge distribution.
 - D. Increases oxidative stress and cell injury allows for cyt c to be released from the IMM into the IMS triggering apoptosis.
29. True or False – thyroid hormone (T3) appears to play a role in body heat production by interacting with mitochondrial uncoupling proteins?
30. True or False – A kinase is an enzyme that catalyzes the transfer of phosphate groups from high-energy, phosphate-donating molecules, e.g., ATP to specific substrates?