Ch 9: Cellular Pathways that Harvest Chemical Energy

1. Show, using a diagram, what happens in a redox reaction. Explain briefly.

2. Redox-reactions between metabolites in living cells are often coupled using mobile electron carriers. Name the two most important mobile electron carriers (A and B) in energy metabolism. A is water soluble and is found in the cytoplasm, while B is lipid-soluble and is found in the cell membrane in bacteria, and the mitochondrial inner membrane of eukaryotes.
   A: 
   B: 

3. Suggest reactions that do not involve oxidation or reduction, but where energy is released.

4. What is the term “substrate-level phosphorylation” used to describe, and where/when is this process particularly important?

5. How does a muscle cell benefit from producing lactic acid, and when does this occur?

6. Explain which of the following statements about the citric acid cycle are correct:
   - occurs in mitochondria
   - does not produce ATP
   - has no connection with the respiratory chain
   - is the same as fermentation

7. In a simplified representation, glycolysis is often represented by an arrow, the citric acid cycle by a circle and the most important substrates and products are given. Add the most important substrates and products to this drawing:

   glucose
8. Several enzymes in glycolysis and the citric acid cycle are allosterically regulated.
   - How does allosteric regulation function?
   - Why is it advantageous for the cell, that enzymes in these pathways are activated by AMP and ADP or are inhibited by ATP?
   - Why is it advantageous for the cell, that enzymes in the citric acid cycle are activated by NAD$^+$ or are inhibited by NADH?

9. Which of the following possibilities give the greatest energy yield to an animal cell, if it has sufficient NAD$^+$ and ADP, but neither NADH or ATP (explain your answer):
   1) The addition of $x$ mol ATP
   2) The addition of $x$ mol NADH

10. Label the missing molecules on the following diagram of the respiratory chain:
11. How do cells attain redox balance (ratio between oxidation and reduction) during respiration and fermentation, respectively?

12. Explain the difference in ATP production per glucose by:
   a) substrate-level phosphorylation
   b) respiration.

13. Commitment step
   a) What is "the commitment step"?
   b) Why is the commitment step usually the step in a pathway that is subject to regulation?
   c) Which reaction is the commitment step for glycolysis?
   d) Which enzyme catalyses this reaction, and how is it regulated?

**Example exam questions**

1. Which of the following statements about the respiratory chain are correct?
   - occurs in mitochondria
   - uses O₂ as oxidising agent
   - regenerates oxidising agents for glycolysis and the citric acid cycle
   - occurs at the same time as fermentation

2. Sketch the position of ATP synthase in the mitochondrial membrane and briefly describe the function of the enzyme.

3. Where in a eukaryotic cell do the following occur?
   a) citric acid cycle?
   b) glycolysis?
   c) elektron transport chain?
4. The following reactions may occur, after a polysaccharide has been broken down to monosaccharides like glucose:

   Reaction 1: phosphoenolpyruvate → pyruvate
   Reaction 2: pyruvate → lactate

Explain briefly the significance of each of these reactions for the energy metabolism of the cell.

   Reaction 1:
   Reaction 2:

5. Reaction: RCH₂OH + NAD⁺ ↔ RCHO + NADH, H⁺

   a. State which is the reduced and oxidized form of each molecule in this reaction.

   b. What does the abbreviation "NAD⁺" stand for?

6. Glucose can be converted by our metabolism to CO₂ and H₂O. Is the overall reaction an oxidation or reduction? Explain your answer.