CHAPTER 14
ENERGY GENERATION IN MITOCHONDRIA AND CHLOROPLASTS

Mitochondria and Oxidative Phosphorylation

14-1 The link between bond-forming reactions and membrane transport processes in the mitochondria is called _____.

(a) chemiosmotic coupling
(b) proton pumping
(c) electron transfer
(d) ATP synthesis

14-2 Describe how a standard flashlight battery can convert energy into useful work and explain how this is similar to the energy conversions in the mitochondria.

14-3 Modern eucaryotes depend on mitochondria to generate most of the cell's ATP. How many molecules of ATP can a single molecule of glucose generate?

(a) 30
(b) 2
(c) 20
(d) 36

14-4 The citric acid cycle generates NADH and $FADH_2$, which are then used in the process of oxidative phosphorylation to make ATP. If the citric acid cycle (which does not use oxygen) and oxidative phosphorylation are separate processes, as they are, then why is it that the citric acid cycle stops almost immediately when O_2 is removed?

14-5 Indicate whether the following statements are true or false. If a statement is false, explain why it is false.

A. The number and location of mitochondria within a cell can change, depending on the both the cell type and the amount of energy required.
B. The inner mitochondrial membrane contains porins, which allow pyruvate to enter for use in the citric acid cycle.
C. The inner mitochondrial membrane is actually a series of discrete flattened membrane-enclosed compartments called cristae, similar to what is seen in the Golgi apparatus.
D. The intermembrane space of the mitochondria is chemically equivalent to the cytosol with respect to pH and the small molecules present.

14-6 In which of the four compartments of a mitochondrion are each of the following located?

A. porin

B. the mitochondrial genome
C. citric acid cycle enzymes
D. proteins of the electron-transport chain
E. ATP synthase
F. membrane transport protein for pyruvate

14-7 NADH contains a high-energy bond that, when cleaved, donates a pair of electrons to the electron-transport chain. What are the immediate products of this bond cleavage?

(a) $NAD^+ + OH^-$
(b) $NAD^+ + H^-$
(c) $NAD^- + H^+$
(d) NAD + H

14-8 For each of the following sentences, fill in the blanks with the best word or phrase selected from the list below. Not all words or phrases will be used; each word or phrase should be used only once.

Mitochondria can use both _____ and _____ directly as fuel. _____ produced in the citric acid cycle donates electrons to the electron-transport chain. The citric acid cycle oxidizes _____ and produces _____ as a waste product. _____ acts as the final electron acceptor in the electron-transport chain. The synthesis of ATP in mitochondria is also known as _____.

acetyl groups	NADH
carbon dioxide	$NADP^+$
chemiosmosis	NADPH
fatty acids	oxidative phosphorylation
glucose	oxygen
NAD^+	pyruvate

14-9 Electron transport is coupled to ATP synthesis in mitochondria, in chloroplasts, and in the thermophilic bacterium *Methanococcus*. Which of the following is likely to affect the coupling of electron transport to ATP synthesis in *all* of these systems?

(a) a potent inhibitor of cytochrome oxidase
(b) the removal of oxygen
(c) the absence of light
(d) an ADP analogue that inhibits ATP synthase

14-10 Stage 1 of oxidative phosphorylation requires the movement of electrons along the electron-transport chain coupled to the pumping of protons into the intermembrane space. What is the final result of these electron transfers?

(a) OH^- is oxidized to O_2.
(b) Pyruvate is oxidized to CO_2.
(c) O_2 is reduced to H_2O.

(d) H^- is converted to H_2.

14-11 Which component of the electron-transport chain is required to combine the pair of electrons with molecular oxygen?

(a) cytochrome *c*
(b) cytochrome *b*-c_1 complex
(c) ubiquinone
(d) cytochrome *c* oxidase

14-12 For each of the following sentences, fill in the blanks with the best word or phrase selected from the list below. Not all words or phrases will be used; each word or phrase should be used only once.

NADH donates electrons to the _____ of the three respiratory enzyme complexes in the mitochondrial electron-transport chain. _____ is a small protein that acts as a mobile electron carrier in the respiratory chain. _____ transfers electrons to oxygen. Electron transfer in the chain occurs in a series of _____ reactions. The first mobile electron carrier in the respiratory chain is _____.

cytochrome *c*
cytochrome oxidase
first
NADH dehydrogenase
oxidation
oxidation–reduction
phosphorylation
plastoquinone
reduction
second
the cytochrome *b*-c_1 complex
third
ubiquinone

14-13 In oxidative phosphorylation, ATP production is coupled to the events in the electron-transport chain. What is accomplished in the final electron transfer event in the electron-transport chain?

(a) OH^- is oxidized to O_2.
(b) Pyruvate is oxidized to CO_2.
(c) O_2 is reduced to H_2O.
(d) NAD^+ is reduced to NADH.

14-14 Which of the following statements is *true*?

(a) Because the electrons in NADH are at a higher energy than the electrons in reduced ubiquinone, the NADH dehydrogenase complex can pump more protons than can the cytochrome *b*-c_1 complex.
(b) The pH in the mitochondrial matrix is higher than the pH in the intermembrane space.
(c) The proton concentration gradient and the membrane potential across the inner mitochondrial membrane tend to work against each other in driving protons from the intermembrane space into the matrix.