1) How many electrons do iron-sulfur cluster transfer?
   A) Depends on the number of Fe involves  
   B) Always 1  
   C) Always 2  
   D) Depends on the electron carrier  
   E) Depends on the geometry of the cluster

2) Complexes I and II each transfer electrons to ______.
   A) Membranes  
   B) Cytosol  
   C) Intermembrane space  
   D) Zn$^{2+}$  
   E) CoQ

3) Bacteria carry out electron transport in the _____ membrane.
   A) Matrix  
   B) Outer  
   C) Plasma  
   D) Cristae  
   E) Nitrocellulose

4) Iron-sulfur proteins where one Fe atom is coordinated by two His residues are named:
   A) Poison iron-sulfur proteins  
   B) Rieske iron-sulfur proteins  
   C) Warburg iron-sulfur proteins  
   D) Homo iron-sulfur proteins  
   E) Cytochrome C iron-sulfur proteins

5) Which complex is unable to pump protons across the mitochondrial membrane?
   A) Complex I  
   B) Complex II  
   C) Complex III  
   D) Complex IV  
   E) All the complexes are able to pump protons.

6) In the electron transport chain, cytochromes contain
   A) FMN.  
   B) heme.  
   C) lymph.  
   D) iron-sulfur clusters.  
   E) CoQ.
7) Germinating plant seeds can convert acetyl-CoA (from fatty acids stored as oils) into carbohydrates, whereas animals cannot convert fatty acids into glucose. This difference is due to the fact that:
   A) animals have glycogen and don’t need to make glucose from fatty acids.
   B) plants use the **glyoxylate cycle to convert two acetyl CoA to succinate**.
   C) plant seeds use photosynthesis to make sugar.
   D) animals use the citric acid cycle exclusively for energy production, whereas plants do not require much energy and just use glycolysis.
   E) C and D

8) In the Glyoxylate cycle, similar to the TCA cycle Acetyl-CoA is condensed with oxaloacetate. Which of the following answers correctly describes the sequence of intermediates:
   A) Citrate, Isocitrate, malate, oxaloacetate
   B) Citrate, Glyoxylate, Succinate, oxaloacetate
   C) Isocitrate, citrate, malate, oxaloacetate
   D) Glyoxylate, citrate, isocitrate, malate, oxaloacetate
   E) **Citrate, isocitrate, glyoxylate, malate, oxaloacetate**

9) Which of the following enzymes is unique to the Glyoxylate cycle?
   A) malate dehydrogenase
   B) **malate synthase**
   C) aconitase
   D) citrate synthase
   E) glyoxylate lyase

10) Which property of Coenzyme Q makes it an ideal electron transporter between the three membrane-bound respiratory chain complexes I, II and III?
   A) its optical spectra
   B) its charge
   C) **its hydrophobicity**
   D) its hydrophilicity
   E) its metal center

11) Oxidative phosphorylation is regulated by.
   A) the availability of reduced cofactors from catabolic pathways.
   B) the availability of the dNTPs.
   C) the availability of ADP and P<sub>i</sub>.
   D) the availability of DNP
   E) **A and C**
12) During oxidative phosphorylation, the proton motive force that is generated by electron transport is used to:
   A) create a pore in the inner mitochondrial membrane.
   B) generate the substrates (ADP and P_i) for the ATP synthase.
   C) induce a conformational change in the ATP synthase.
   D) oxidize NADH to NAD^+.
   E) reduce O_2 to H_2O.

13) Compound X is an inhibitor of mitochondrial ATP synthesis. It was observed that when compound X was added to cells, the NAD^+/NADH ratio decreased. Would you expect X to be an:
   A) uncoupling agent
   B) inhibitor of respiratory electron transfer
   C) a Boyer compound
   D) inhibitor of F_1 F_0 ATP synthase
   E) B or D

14) The electron transport chain is sometimes called
   A) the citric acid cycle.
   B) β-oxidation.
   C) transamination.
   D) the respiratory chain.
   E) fermentation

15) Cyanide ion and carbon monoxide inhibit
   A) cytochrome c oxidase.
   B) ATP production.
   C) antibiotic activity.
   D) CoQ formation.
   E) CoA formation.

16) Which of the following statements about the chemiosmotic theory is correct?
   A) Electron transfer in mitochondria is accompanied by an asymmetric release of protons on one side of the inner mitochondrial membrane.
   B) It predicts that oxidative phosphorylation can occur even in the absence of an intact inner mitochondrial membrane.
   C) The effect of uncoupling reagents is a consequence of their ability to carry electrons through membranes.
   D) The membrane ATP synthase has no significant role in the theory.
   E) All of the above are correct.
17) Uncoupling of mitochondrial oxidative phosphorylation:
   A) allows continued mitochondrial ATP formation, but halts O₂ consumption.
   B) halts all mitochondrial metabolism.
   C) halts mitochondrial ATP formation, but allows continued O₂ consumption.
   D) slows down the citric acid cycle.
   E) slows the conversion of glucose to pyruvate by glycolysis.

18) The overall reaction of complex IV can be summarized in the equation below. Provide the missing coefficients n,m,x,y,z:
   \[ n \text{ cyt c} \text{(red)} + m \text{ H}^+ + \text{ O}_2 \rightarrow x \text{ cyt c} \text{(ox)} + y \text{ H}^+_\text{p} + z \text{ H}_2\text{O} \]
   A) 4,8,4,4,2
   B) 4,4,4,8,1
   C) 2,4,4,2,2
   D) 2,2,2,2,1
   E) 8,4,8,4,2

19) When the F1 domains are removed from SMPs what happens to the electron transport and the proton gradient?
   A) electron transports ends and proton gradient is maintained
   B) electron transport continues and proton gradient is maintained
   C) electron transport continues and proton gradient ceases
   D) electron transport ends and proton gradient ceases
   E) electron transport end and protein gradient is elevated

20) The binding change mechanism of energy coupling was proposed by Paul Boyer. He shared the Nobel prize for this model that accounts for the existence of 3 catalytic sites in F1. What are the three conformations of the binding sites?
   A) tight, loose, open
   B) right, left, middle
   C) red, blue, yellow
   D) strong, weak, no binding
   E) high, medium, low