Directions: Please **WRITE your name and ID on this Exam** AND on the **ANSWER SHEET** by bubbling in **Your Name and Panther ID**. Please note that numerical answers without their units are wrong and that genus species names must be italicized or underlined. Please answer all questions by bubbling in on the Answer Sheet, the **BEST possible lettered answer**.

**Multiple Choice Questions:**

1. Almost all of the oxygen ($O_2$) one consumes in breathing is converted to:
   A) acetyl-CoA.   B) carbon dioxide ($CO_2$).   C) carbon monoxide and then to carbon dioxide.   D) water.   E) none of the above.

2. Antimycin A blocks electron transfer between cytochromes b and c1. If intact mitochondria were incubated with antimycin A, excess NADH, and an adequate supply of $O_2$, which of the following would be found in the oxidized state?

3. If electron transfer in tightly coupled mitochondria is blocked (with antimycin A) between cytochrome b and cytochrome c1, then:
   A) all ATP synthesis will stop.   B) ATP synthesis will continue, but the P/O ratio will drop to one.   C) electron transfer from NADH will cease, but $O_2$ uptake will continue.   D) electron transfer from succinate to $O_2$ will continue unabated.   E) energy diverted from the cytochromes will be used to make ATP, and the P/O ratio will rise.

4. 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 chemiosmotic theory.   E) All of the above are correct.

5. Upon the addition of 2,4-dinitrophenol (DNP) to a suspension of mitochondria carrying out oxidative phosphorylation linked to the oxidation of malate, all of the following occur except:
   A) oxygen consumption decreases.   B) oxygen consumption increases.   C) the P/O ratio drops from a value of approximately 2.5 to 0.   D) the proton gradient dissipates.   E) the rate of transport of electrons from NADH to $O_2$ becomes maximal.

6. Which of the following is correct concerning the mitochondrial ATP synthase?
   A) It can synthesize ATP after it is extracted from broken mitochondria.   B) It catalyzes the formation of ATP even though the reaction has a large positive $\Delta G^{\circ}$.   C) It consists of Fo and F1 subunits, which are transmembrane (integral) polypeptides.   D) It is actually an ATPase and only catalyzes the hydrolysis of ATP.   E) When it catalyzes the ATP synthesis reaction, the $\Delta G^{\circ}$ is actually close to zero.

7. The oxidation of a particular hydroxy substrate to a keto product by mitochondria has a P/O ratio of less than 2. The **initial oxidation step** is very likely directly coupled to the:

8. Electron transport Complex-1 has an internal:
   A) $NAD^+$.   B) cytochrome-a.   C) FMN.   D) lipoic acid.   E) ADP.
9. The light reactions in photosynthetic higher plants:
A) do not require chlorophyll.  B) produce ATP and consume NADH.  C) require the action of a single
reaction center.  D) result in the splitting of H$_2$O, yielding O$_2$.  E) serve to produce light so that plants can see.

10. The relative concentrations of ATP and ADP control the cellular rates of:
A) glycolysis.  B) oxidative phosphorylation.  C) pyruvate oxidation.  D) the citric acid cycle.
E) all of the above.

11. Oxidative phosphorylation and photophosphorylation share all of the following except:
A) chlorophyll.  B) involvement of cytochromes.  C) participation of quinones.
D) proton pumping across a membrane to create electrochemical potential.
E) use of iron-sulfur proteins.

12. In the photolytic cleavage of water by the oxygen-evolving complex [2H$_2$O $\rightarrow$ 4 H$^+$ + 4 e$^-$ + O$_2$], how many photons of light at a wavelength of 680 nm are required?
A) 1  B) 2  C) 4  D) 6  E) 8

13. Cyclic electron flow in chloroplasts produces:
A) ATP and O$_2$, but not NADPH.  B) ATP, but not NADPH or O$_2$.  C) NADPH and ATP and O$_2$.
D) NADPH, but not ATP or O$_2$.  E) O$_2$, but not ATP or NADPH.

14. Non-cyclic electron flow in chloroplast produces:
A) ATP and O$_2$, but not NADPH.  B) ATP, but not NADPH or O$_2$.  C) NADPH and ATP and O$_2$.
D) NADPH, but not ATP or O$_2$.  E) O$_2$, but not ATP or NADPH.

15. What is the first product of carbon dioxide assimilation Stage 2?
A) 3-phosphoglycerate.  B) glyceraldehyde 3-phosphate.  C) ribulose 1,5-bisphosphate
D) hexoses.  E) Fructose-6-phosphate.

16. Cellulose contains the glycosidic linkage:
A) $\alpha$ 1-4.  B) $\alpha$ 1-2.  C) $\alpha$ 1-3.  D) $\beta$ 1-4.  E) $\beta$ 1-6.

17. The process of photosynthetic carbon reduction is also called:
E) Light - Dark Cycle.

18. Starch and sucrose are similar in that each is:
A) synthesized in leaf cells.  B) composed entirely of glucose.  C) synthesized in the cytoplasm.
D) hydrolysed by amylases.  E) hydrolysed by peptidases.

19. ATP synthesized in the chloroplast gets into the cytoplasm as:

20. Photorespiration occurs in plants when:
A) ATP is needed.  B) rubisco uses O$_2$ instead of CO$_2$.  C) the Calvin cycles is turned off.
D) there is no sunlight.  E) fatty acids are used as the electron donor.

21. Plants can synthesize glucose from fatty acids because:
A) gluconeogenesis occurs in the mitochondria.  B) acetyl-SCoA can be converted to pyruvate.
C) fatty acid oxidation occurs in glyoxysomes.  D) glycerol is oxidized to a gluconeogenic intermediate.

22. In plants, which of the following occurs in the dark:
E) cyclic photophosphorylation.

23. Which molecule is the substrate for starch synthesis in plants:

24. CO₂ fixed by mesophyll cells gets transported to bundle-sheath cells by movement of:

25. Which of the following is true about the difference between oxidative phosphorylation and photophosphorylation?
   A) Photophosphorylation occurs only in photosynthetic organisms and oxidative phosphorylation occurs only in non-photosynthetic organisms.
   B) In oxidative phosphorylation, NADH donates electrons; in photophosphorylation NADPH donates electrons.
   C) Photophosphorylation occurs only in the light; oxidative phosphorylation occurs only in darkness.
   D) In oxidative phosphorylation, O₂ is reduced to H₂O; in photophosphorylation H₂O is oxidized to O₂.

26. Mitochondria eliminate harmful superoxide radical, O₂⁻ that is generated at low frequency during oxidative phosphorylation by:
   A) glutathione reductase reducing O₂⁻ to water.  B) superoxide dismutase converting O₂⁻ to H₂O₂.
   C) glutathione peroxidase converting O₂⁻ to O₂.  D) transport O₂⁻ out of the mitochondria.
   E) none of the above.

27. Thermogenin keeps newborn babies warm by:
   A) making oxidative phosphorylation more efficient.  B) transferring electrons from ubiquinone to O₂.
   C) uncouples electron transport from ATP synthesis.  D) stimulates genes to make brown fat.

28. Light dependent reactions of photosynthesis takes place in the:

29) Cyanide, CN⁻, inhibits:
   A) Complex-IV.  B) ATP synthase.  C) Complex I.  D) Complex II.  E) Complex III.

30. Light control (activation) of Rubisco is based on Mg²⁺ and increased:

Written Answer Questions
1. Under a certain situation, mitochondria accumulate an excessive amount of reduced cytochrome-b (E°' = 0.077v). How much energy would be needed to oxidize cytochrome-b by transferring the electrons to NAD⁺ (E°' = -.32v)? (Hint, the Faraday constant is 96.5 kJ · v⁻¹ · mole⁻¹) (8 points).
2. Diagram, showing all atoms, the Malic Enzyme reaction found in bundle sheath cells. (5 points)

3. Diagram one Rubisco reaction. (7 points)