Multiple Choice Questions

1. **Light absorption**
   
   **Pages: 742-743  Difficulty: 2  Ans: D**
   
   Absorption of light energy in chloroplast “light reactions” leads to:
   
   A) collapse of a proton gradient.  
   B) absorption of O\textsubscript{2} and release of CO\textsubscript{2}.  
   C) hydrolysis of ATP and reduction of NADP\textsuperscript{+}.  
   D) production of a proton concentration gradient across thylakoid membrane  
   E) release of phosphate.

2. **General features of photophosphorylation**
   
   **Pages: 743-744  Difficulty: 2  Ans: C**
   
   Which of the following statements about the light reactions in photosynthetic plants is false?
   
   A) A membrane-bound ATPase couples ATP synthesis to electron transfer-mediated proton transpport.  
   B) (Plasto)quinones, hemes and iron-sulfur cluster mediate electron transport.  
   C) O\textsubscript{2} is consumed.  
   D) The ultimate source of electrons for the process is H\textsubscript{2}O.  
   E) There are two distinct photosystems, linked together by an electron transfer chain.

3. **General features of photophosphorylation**
   
   **Pages: 743-744  Difficulty: 1  Ans: D**
   
   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\textsubscript{2}O, yielding O\textsubscript{2}.  
   E) produce secondary light emission so that plants can grow underground.

4. **General features of photophosphorylation**
   
   **Pages: 723-744  Difficulty: 2  Ans: C**
   
   Photosynthetic phosphorylation and oxidative phosphorylation appear to be generally similar processes, both consisting of ATP synthesis coupled to the transfer of electrons along an electron carrier chain. Which of the following is not true of both processes?
   
   A) Both contain cytochromes in their electron carrier chains.  
   B) Both processes are associated with membranous elements of the cell.  
   C) Both use oxygen as a terminal electron acceptor.
D) Both produce ATP by ATP synthase.
E) Protons are pumped from the inside to the outside of both mitochondria and chloroplast membranes

5. **Light absorption**
   Pages: 744-745  Difficulty: 2  Ans: A
   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.

6. **Light absorption**
   Page: 747  Difficulty: 2  Ans: B
   The experimental determination of the effectiveness of light of different colors in promoting photosynthesis is called the:
   
   A) absorption spectrum.
   B) action spectrum.
   C) difference spectrum.
   D) reflectance spectrum.
   E) refraction spectrum.

7. **Light absorption**
   Pages: 747-748  Difficulty: 2  Ans: C
   In what order do the following five steps occur in the photochemical reaction centers?

   1) Excitation of the chlorophyll $a$ molecule at the reaction center
   2) Replacement of the electron in the reaction center chlorophyll
   3) Light excitation of antenna chlorophyll molecule
   4) Passage of excited electron to electron-transfer chain
   5) Exiton transfer to neighboring chlorophyll

   A) 1-2-3-4-5
   B) 3-2-5-4-1
   C) 3-5-1-4-2
   D) 4-2-3-5-1
   E) 5-4-3-2-1

8. **The central photochemical event: light-driven electron flow**
   Pages: 752-762  Difficulty: 3  Ans: A
   Which one of the following is true about reaction centers?
A) Cyanobacteria and plants have two reaction centers arranged in tandem.
B) Cyanobacteria contain a single reaction center of the Fe-S type.
C) Plant photosystems have a single reaction center of the FeS type.
9. **The central photochemical event: light-driven electron flow**  
   Page: 753 Difficulty: 3 Ans: C  
   In the photolytic cleavage of water by the oxygen-evolving complex \[2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + 4e^- + \text{O}_2\], how many photons of light at a wavelength of 680 nm are required?  
   
   A) 1  
   B) 2  
   C) 4  
   D) 6  
   E) 8

**Short Answer Questions**

10. **Light absorption**  
   Page: 747 Difficulty: 2  
   Discuss how “accessory pigments” are able to extend the range of light absorption of the chlorophylls. Name a class of accessory pigments.

   **Ans:** Accessory pigments are able to absorb light and transfer the absorbed energy to the chlorophylls in a process known as “exciton transfer.” Carotenoids.

11. **Light absorption**  
   Page: 747 Difficulty: 2  
   What is an action spectrum, and what do peaks in an action spectrum signify? Show a typical action spectrum plot for photosynthesis.

   **Ans:** An action spectrum is a plot of the effectiveness of a process (such as photosynthesis) versus wavelength of incident light. Its peaks signify the presence of a chromophore that absorbs light at that wavelength. (See Fig. 19-51, p. 747.)

12. **The central photochemical event: light-driven electron flow**  
   Pages: 749-762 Difficulty: 2  
   Give general classes of electron carriers that function in mitochondrial and/or photosynthetic electron transport.

   **Ans:** Any five of the following: pyridine nucleotides (NADH, NADPH); flavin nucleotides (FADH$_2$, FMNH$_2$); quinones (ubiquinone, plastoquinone); cytochromes/hemes; Fe-S clusters/Fe-S proteins.

13. **The central photochemical event: light-driven electron flow**  
   Pages: 749-762 Difficulty: 3  
   The processes of oxidative phosphorylation coupled with electron transfer (in mitochondria) and photophosphorylation (in chloroplasts) resemble each other in certain respects. Describe ways in which the two processes are similar, and describe significant differences between the two processes.
Ans: Similarities include: both contain a chain of membrane-bound electron carriers; electron transfer leads to establishment of a proton gradient; an ATPase/ATP synthase is a coupling factor; both require a system of intact membranes to separate electrons inside and outside. Differences include: Electron donor in chloroplast is H$_2$O in mitochondria it is NADH (derived from organic molecules). Energy input is light in chloroplasts, but chemical energy (stored in electrons activated from organic molecules) in respiration.

14. The central photochemical event: light-driven electron flow
Page: 752 Difficulty: 2
Show the path of electrons from photosystem II to NADPH in the chloroplast. What is the source of the energy that moves electrons through this path? Show where oxygen is involved in this pathway.

Ans:
Detailed: H$_2$O >"water splitting complex” > P680 > Pheophytin > PQA > PQB > cyt b$_{0f}$ complex > Plastocyanin > P700 > A$_0$ > A$_1$ > Fe-S > Ferredoxin > Ferredoxin-NADP$^+$ oxidoreductase > NADP$^+$
Less detailed: PSII, cytochrome b6f, plastocyanin >PSI > NADP$^+$
The energy that drives the electron flow is derived from light. O$_2$ is generated from H$_2$O when H$_2$O donates electrons to PSII.

15. The central photochemical event: light-driven electron flow
Page: 752 Difficulty: 2
Plants carrying out photosynthesis produce O$_2$. Describe the source of this O$_2$, and explain, with chemical equations or schematic diagrams, why O$_2$ production occurs only during daylight hours.

Ans: O$_2$ is generated by the splitting and oxidation of H$_2$O, driven by the absorption of a photon by PSII (which occurs only in daylight). (See Fig. 19-56, p. 752.)

16. The central photochemical event: light-driven electron flow
Page: 752 Difficulty: 2
During photophosphorylation in plants, electrons flow through a series of carriers in the chloroplast. What is the ultimate donor of electrons, and what is the ultimate acceptor? What provides the energy to move those electrons?

Ans: The ultimate donor is H$_2$O, and the acceptor, NADP$^+$. The energy that drives this electron flow is from light.

17. The central photochemical event: light-driven electron flow
Page: 752 Difficulty: 3
Describe what happens when a photon is absorbed by photosystem II; end the description of electron flow at plastoquinone.
Absorption of a photon by PSII excites a special set of chlorophylls (P680) to P680*, which passes an electron to pheophytin, which passes the electron to plastoquinone. P680, now lacking an electron, takes one away from a “water-splitting complex” of PSII, which in turn takes one from H₂O. (See Fig. 19-56, p. 752.)

18. ATP synthesis by photophosphorylation

DCMU is an herbicide that acts by blocking photosynthetic electron flow from photosystem II (PSII) to the cytochrome b₆f complex. Predict the effect of DCMU on O₂ production and on ATP synthesis in the chloroplasts of plants sensitive to DCMU.

Ans: DCMU blocks electron flow from PSII to PSI, preventing generation of O₂ from H₂O. ATP synthesis will be inhibited, but not completely; cyclic photophosphorylation can continue in the presence of DCMU.

19. Evolution of oxygenic photosynthesis

What is the evolutionary origin of chloroplast? What theory proposes a origin for chloroplasts? What chloroplast features are in line with the theory?

Cyanobacteria(-like) organisms were permanently incorporated into a eukaryotic cell. Endosymbiosis theory. Chloroplasts contain a chromosome (DNA), ribosomes and have a double membrane that separates them from the cytoplasm of the 'host eukaryote'.