

# Key

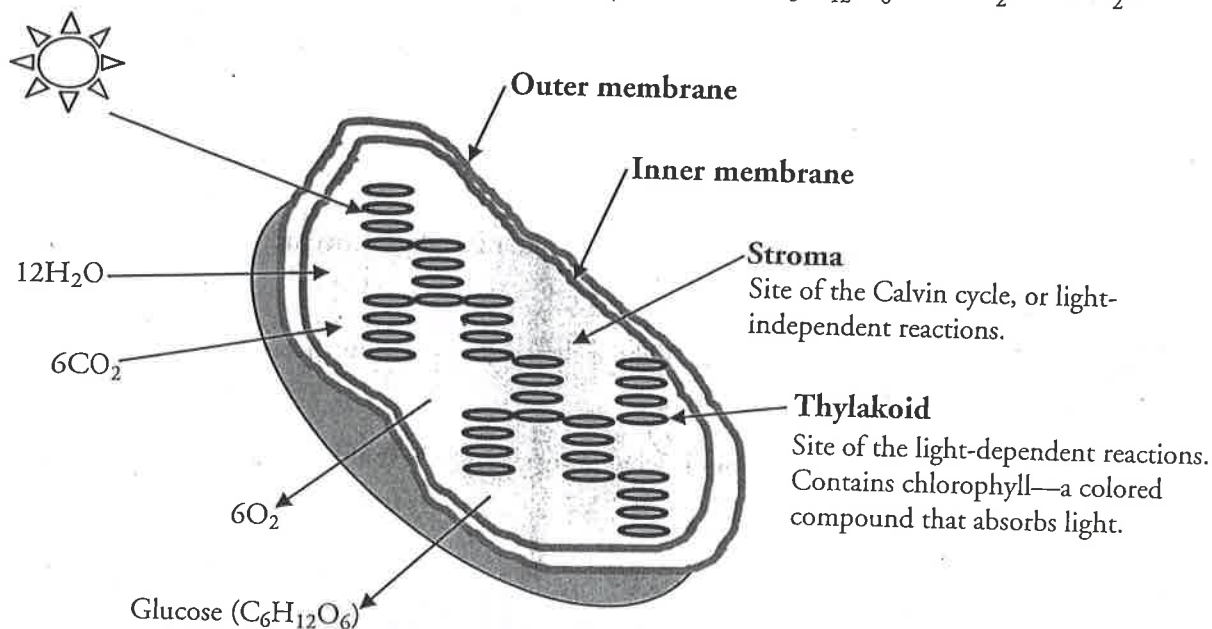
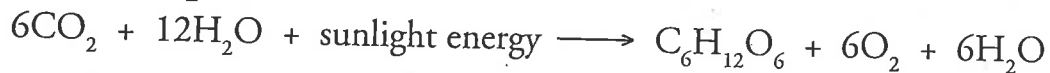
## Photosynthesis

How do light-dependent and light-independent reactions provide food for a plant?

### Why?

Plants are the original solar panels. Through photosynthesis a plant is able to convert electromagnetic (light) energy into chemical energy. This energy is used not only to keep the plant alive, but also to sustain all creatures that rely on the plant for food and shelter. Plants and photosynthetic algae are also the source of all oxygen on Earth, allowing the inhabitants of Earth to benefit from our most plentiful renewable energy resource.

### Model 1 – Chloroplast

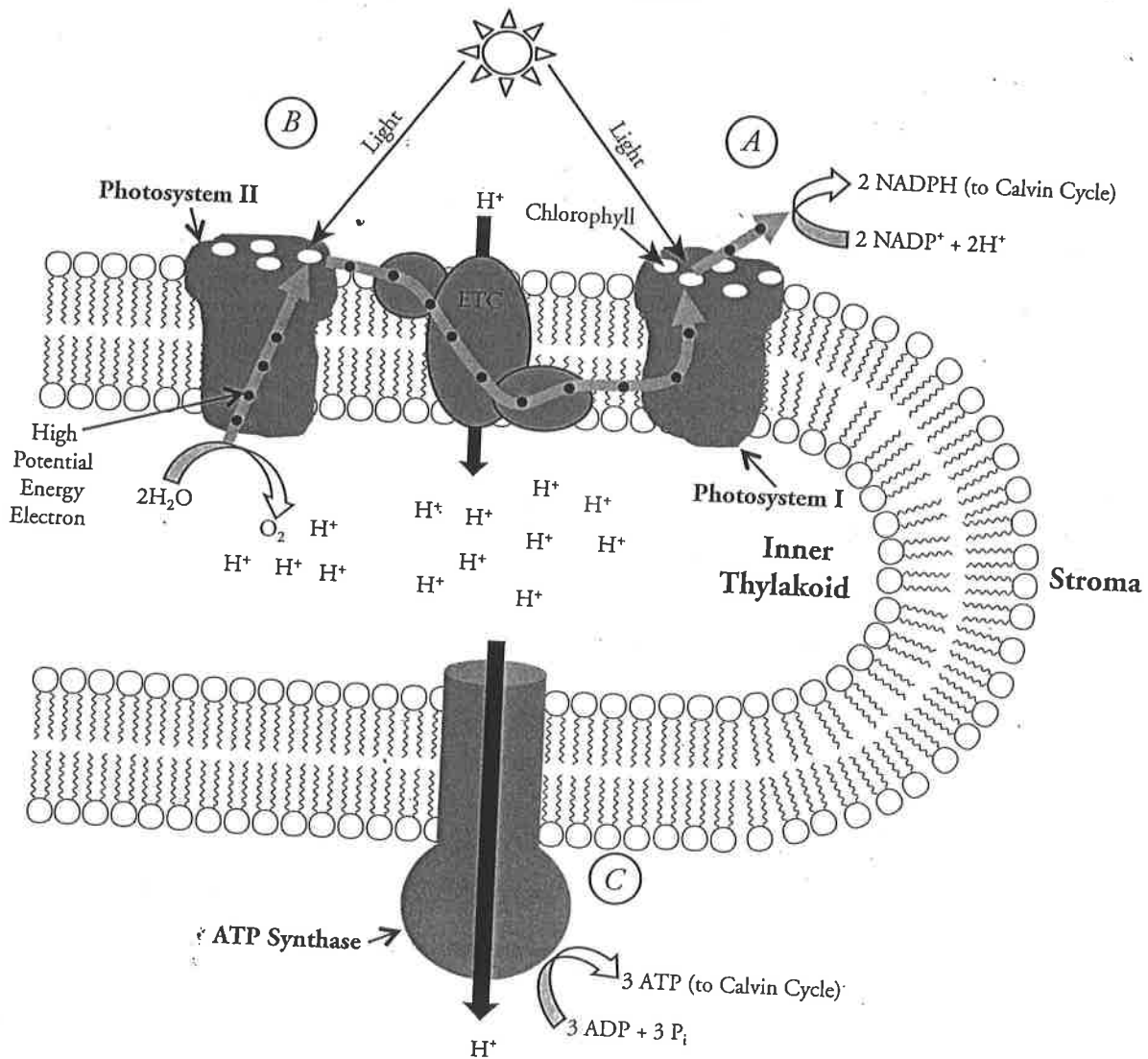


1. Consider the organelle illustrated in Model 1.
  - a. What is the name of this organelle?  
*A chloroplast.*
  - b. Is this organelle more likely to be found in animal cells or plant cells?  
*Chloroplasts are found in plant cells.*
2. The structures inside the organelle in Model 1 are called thylakoids. What compound necessary for photosynthesis is contained in the thylakoids?  
*Chlorophyll.*

3. Consider the chemical reaction in Model 1. This represents photosynthesis.
- What substances are the reactants in photosynthesis? Include the name and chemical formula of each substance in your answer.  
*Carbon dioxide ( $\text{CO}_2$ ) and water ( $\text{H}_2\text{O}$ ).*
  - Where in the organelle are these molecules stored before they are used in photosynthesis?  
*The stroma.*
  - Is photosynthesis an endergonic or exergonic reaction? Support your answer with evidence from Model 1.  
*Endergonic—the reaction has sunlight on the left side, meaning it must be absorbed.*
  - What is the energy source for photosynthesis?  
*Sunlight.*
4. Photosynthesis occurs in two parts—the **light-dependent reactions** and the **light-independent reactions**.
- What is another name for the light-independent reactions?  
*The Calvin cycle.*
  - In what part of the chloroplast do the light-dependent reactions occur?  
*Thylakoid.*
  - In what part of the chloroplast do the light-independent reactions occur?  
*In the stroma.*
5. Considering your answers to Question 4, what compound is best able to absorb the light energy from the Sun and convert it into chemical energy?  
*Chlorophyll.*
6. What substances are produced during photosynthesis? Include the name and chemical formula of each substance in your answer.  
*Glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) and oxygen ( $\text{O}_2$ ).*
7. Why is it necessary to have six  $\text{CO}_2$  entering the chloroplast?  
*The photosynthesis reaction must be balanced. Six carbons are needed to make glucose, so six  $\text{CO}_2$  molecules are needed.*



## Model 2 – The Light-Dependent Reactions



8. In Model 2, what shape or symbol represents a single electron?  
*Small black dot.*
9. In the light-dependent reactions electrons are released from molecules in two ways.
  - a. Find two places in Model 2 where electrons are released from chlorophyll by a photon of light coming from the Sun.  
*On the stroma side of photosystem I and photosystem II.*
  - b. Find one place in Model 2 where electrons are released from water molecules.  
*On the inner thylakoid side of photosystem II.*
  - c. When the electrons are released from water molecules, what other products are formed?  
*Oxygen ( $\text{O}_2$ ) and hydrogen ions ( $\text{H}^+$ ).*

## Read This!

The light-dependent reactions of photosynthesis include three major processes:

- A. Excited electrons leave chlorophyll and reduce  $\text{NADP}^+$  into NADPH.
- B. Excited electrons moving through the electron transport chain provide the free energy needed to pump hydrogen ions into the inner thylakoid.
- C. Hydrogen ions flowing out of the thylakoid via a protein channel provide the free energy needed to convert ADP to ATP.

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10. In Model 2, label the diagram with "A," "B," and "C" to indicate where the three steps in the *Read This!* box are occurring.

*See Model 2.*

11. The light-dependent reactions include an electron transport chain system that works in a very similar fashion to the electron transport chain in respiration. Briefly describe how this system works and what job it performs in the light-dependent reactions. (Your answer should include a discussion about concentration gradient.)

*The electron transport chain uses the energy from excited electrons to move hydrogen ions ( $\text{H}^+$ ) across the thylakoid membrane in a direction that is against the concentration gradient. This produces a high concentration of  $\text{H}^+$  inside the thylakoid membrane.*

12. Refer to Model 2.

- a. Name the embedded protein complex found in the thylakoid membrane that uses excited electrons to reduce  $\text{NADP}^+$  into NADPH?

*Photosystem I.*

- b. Name the embedded protein complex found in the thylakoid membrane that provides excited electrons to the electron transport chain?

*Photosystem II.*

- c. Name the embedded protein complex found in the thylakoid membrane that converts ADP to ATP using free energy from a flow of hydrogen ions.

*ATP synthase.*

13. Once a chlorophyll molecule has released electrons it is no longer useful until those electrons are replaced.

a. According to Model 2, what is the source of replacement electrons for those released from photosystem I?

*Electrons that have completed the electron transport chain.*

b. According to Model 2, what is the source of replacement electrons for those released from photosystem II?

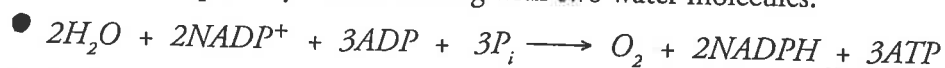
*Electrons from the splitting of water.*

14. Is carbon dioxide involved in the light-dependent reaction?

*No, carbon dioxide is not involved.*

15. Refer to Model 2.

a. Write a chemical reaction that summarizes all of the chemical reactions in the light-dependent reactions of photosynthesis starting with two water molecules.



b. In the photosynthesis reaction in Model 1, twelve water molecules are shown as reactants, but six water molecules are shown as products. Are any of the twelve water molecules products of the light-dependent reactions?

*No, water molecules are not products in the light-dependent reactions of photosynthesis.*

c. Calculate the total number of oxygen, NADPH, and ATP molecules that are produced when twelve water molecules complete the light-dependent reactions.



16. Where do the ATP and NADPH produced during the light-dependent reactions go when the process is complete?

*To the Calvin cycle (light-independent cycle).*

