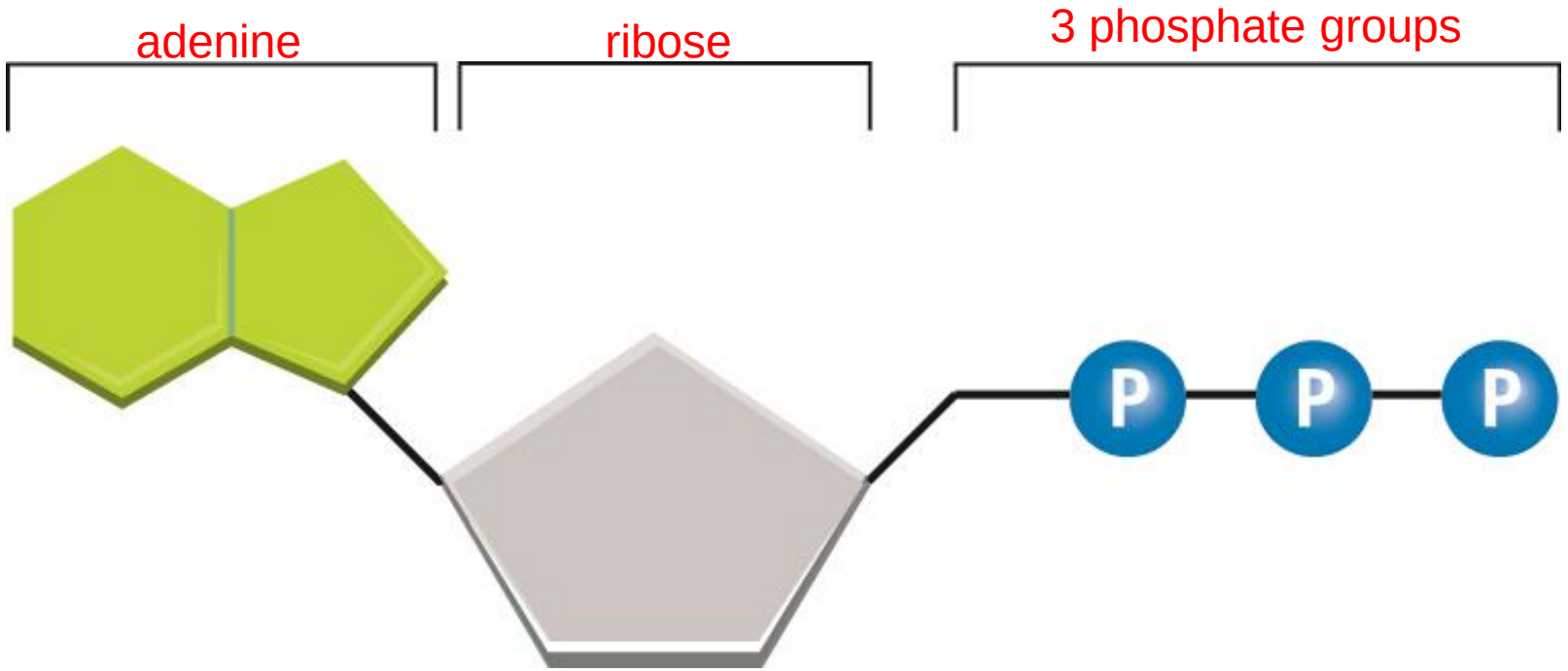
Energy and Life

Learning Objectives

- Describe why ATP is useful to cells.
- Describe what happens during the process of photosynthesis.

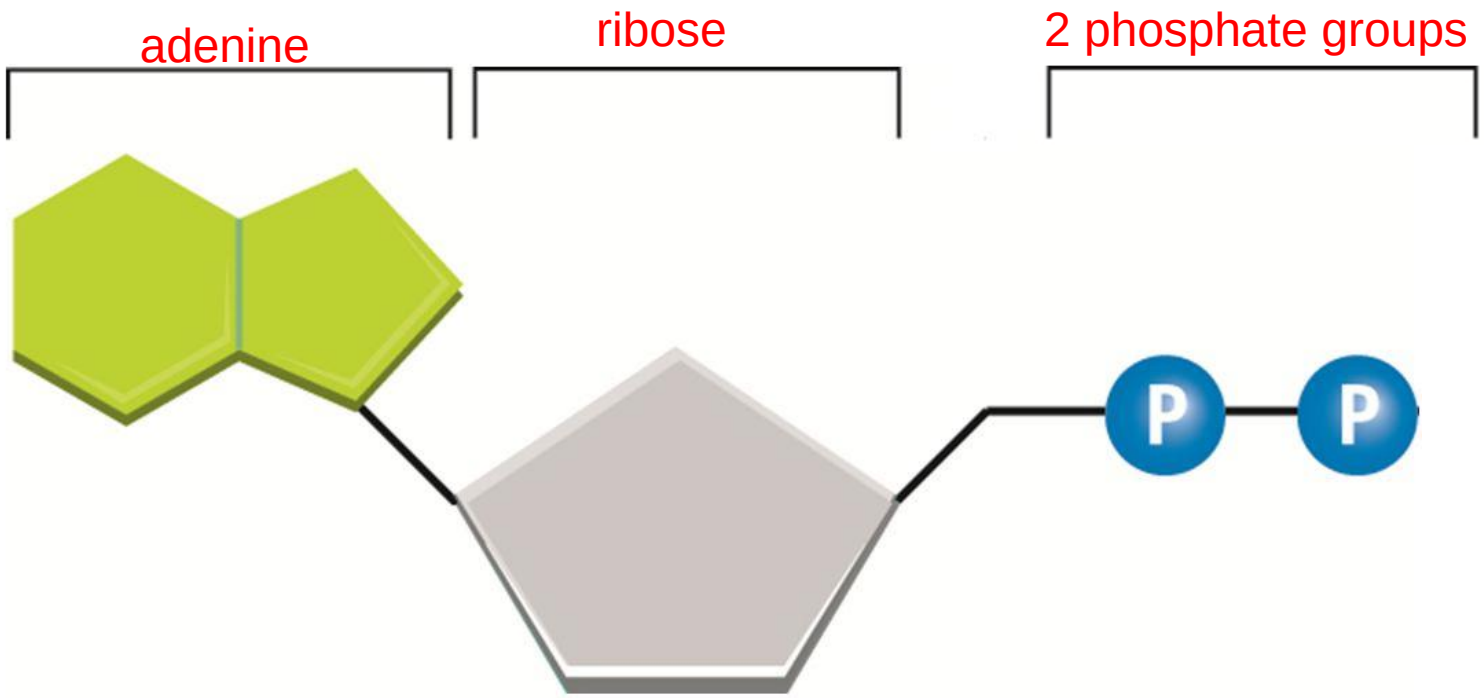
Adenosine Triphosphate (ATP)

Adenosine triphosphate (ATP) is one of the most important compounds that cells use to store and release energy.



Adenosine Diphosphate (ADP)

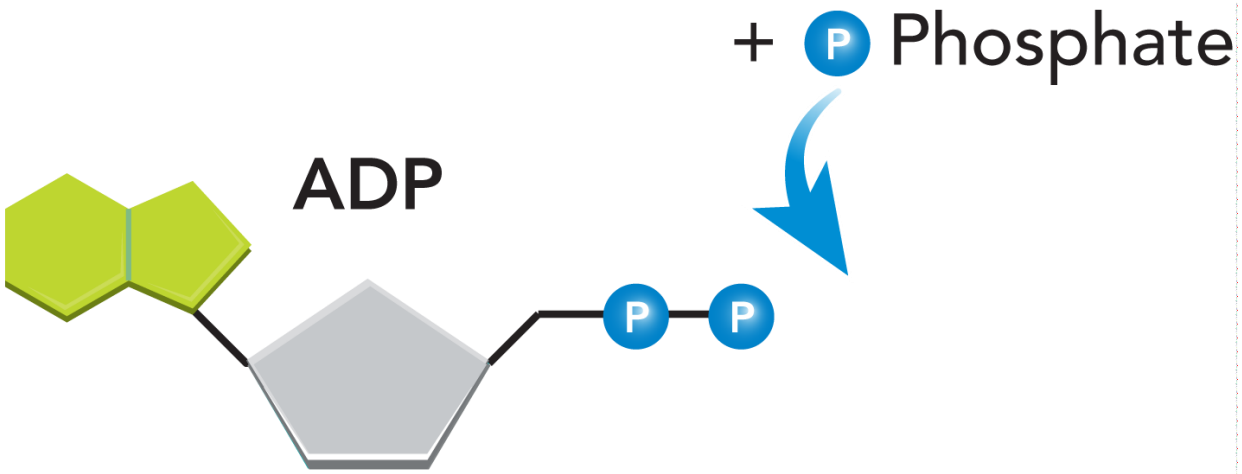
Adenosine diphosphate (ADP) has two phosphate groups instead of three.



Storing Energy

When a cell has energy available, it can store small amounts of it by adding phosphate groups to ADP molecules, producing ATP.

Partially Charged Battery

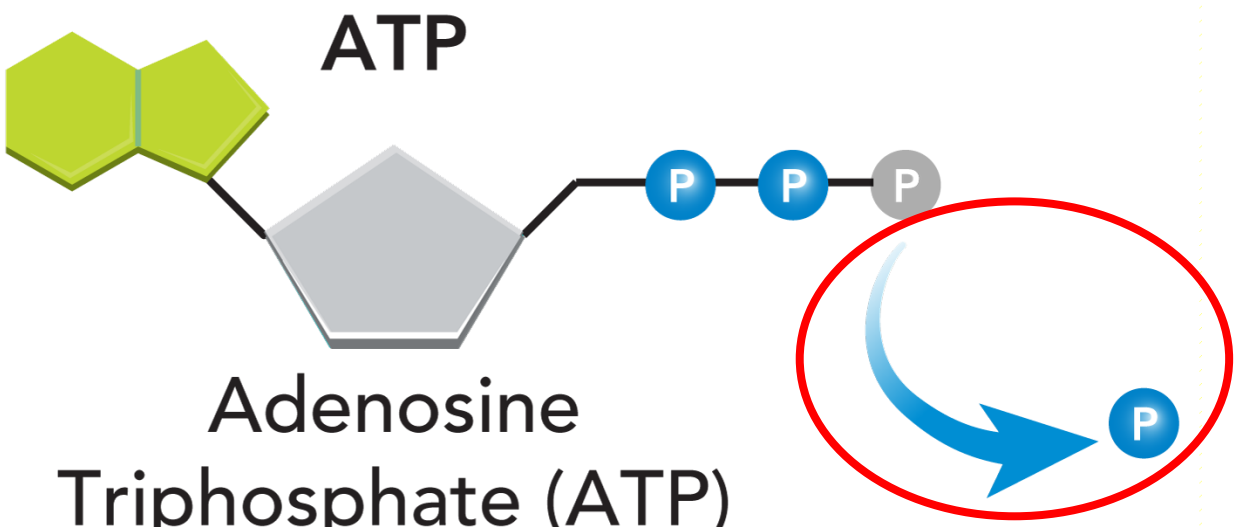


Adenosine Diphosphate (ADP)

Releasing Energy

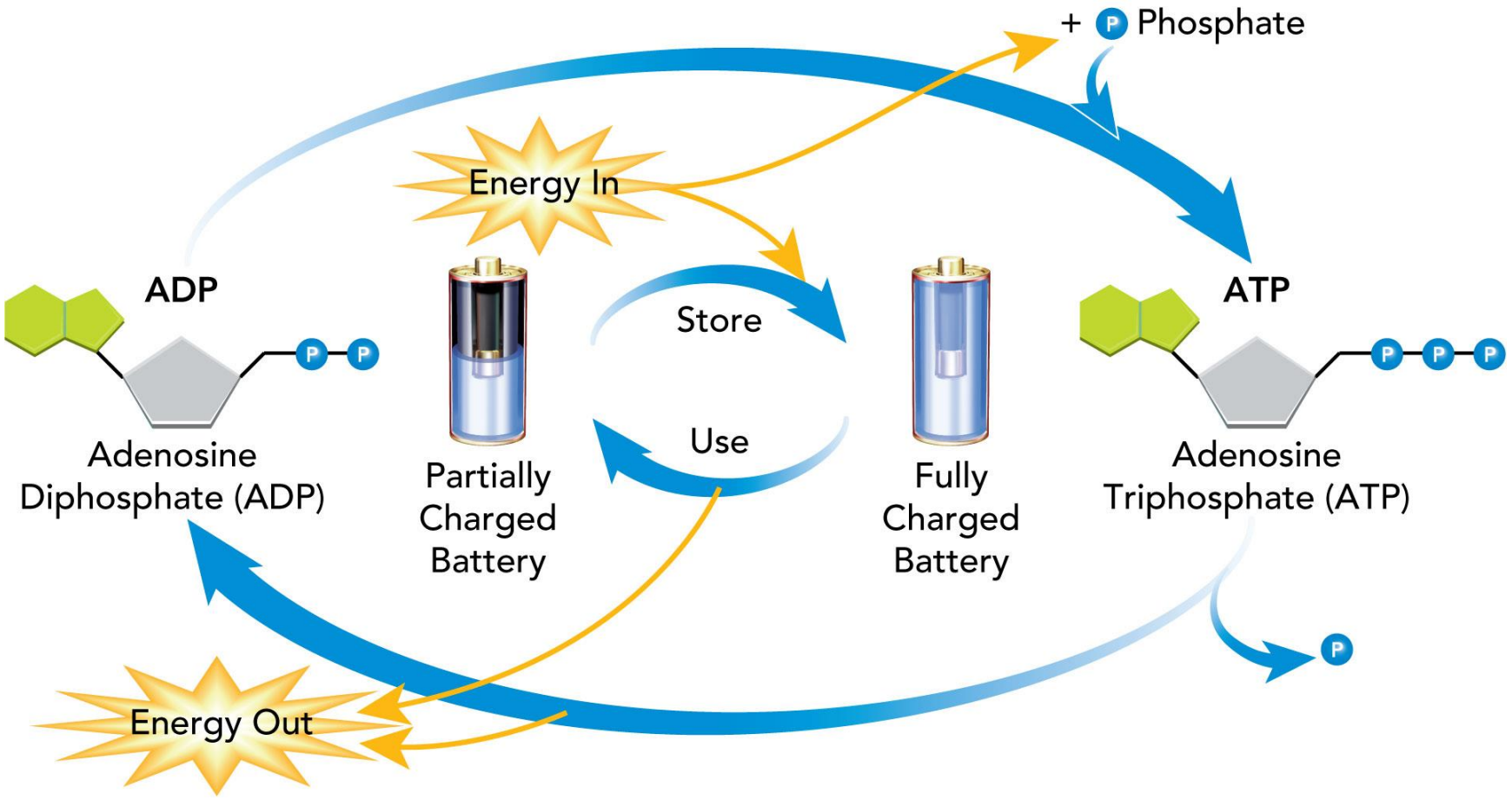
When a cell needs energy, it can release it by breaking the bond between the second and third phosphate groups in ATP.

Fully Charged Battery



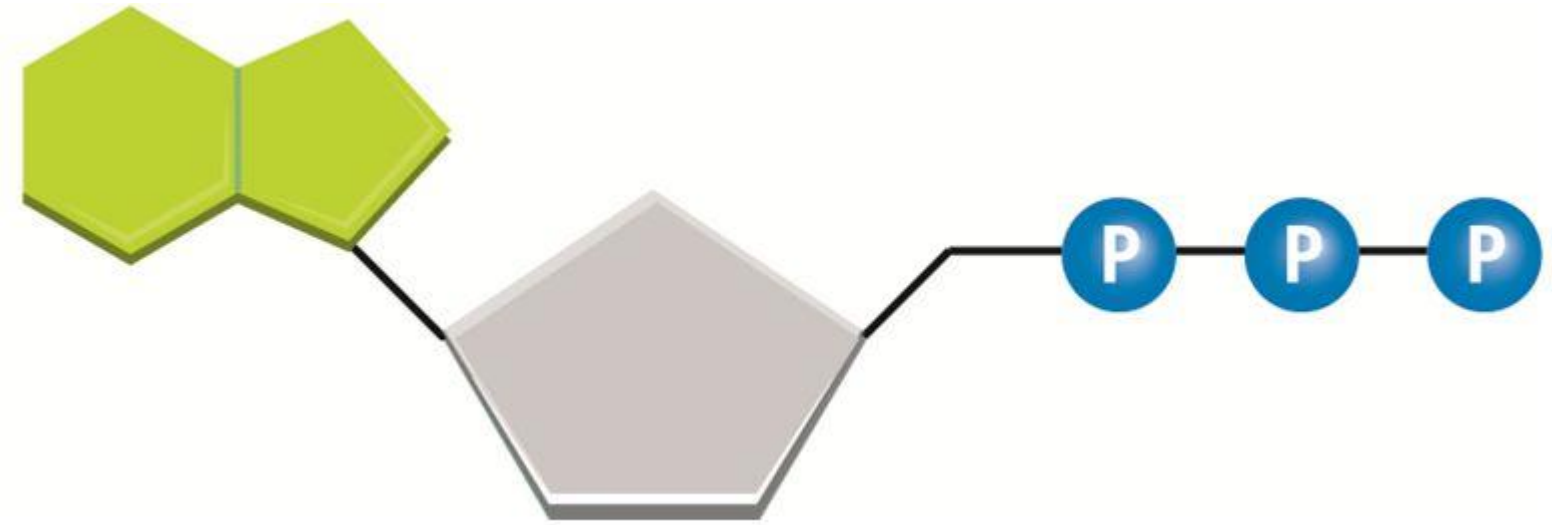
Adenosine Triphosphate (ATP)

ATP and Batteries



ATP Production

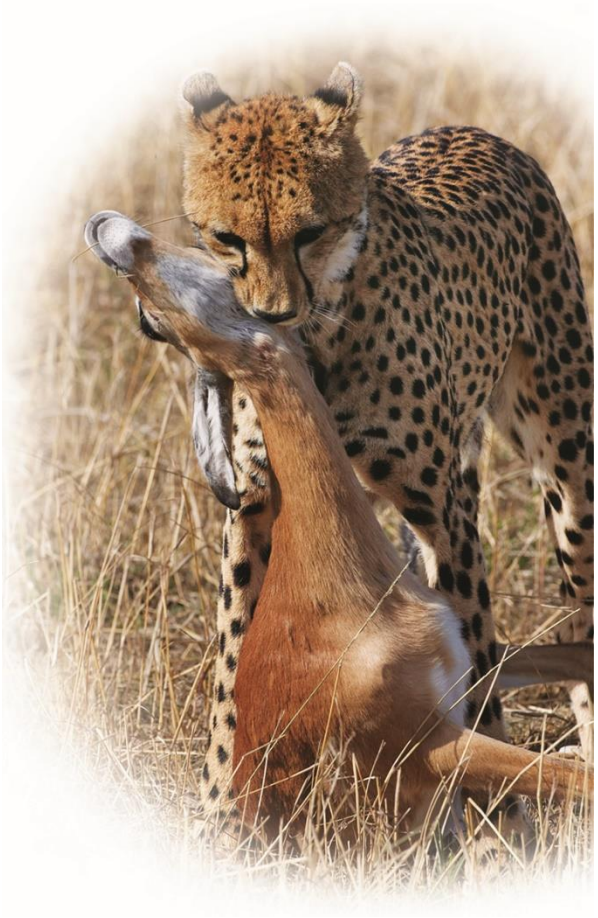
Cells must produce ATP. In photosynthesis, plants convert the energy of sunlight into chemical energy stored in the bonds of carbohydrates.



Heterotrophs and Autotrophs

Organisms that make their own food are autotrophs.

Organisms that obtain food by consuming other living things are heterotrophs.



Photosynthesis: An Overview

Learning Objectives

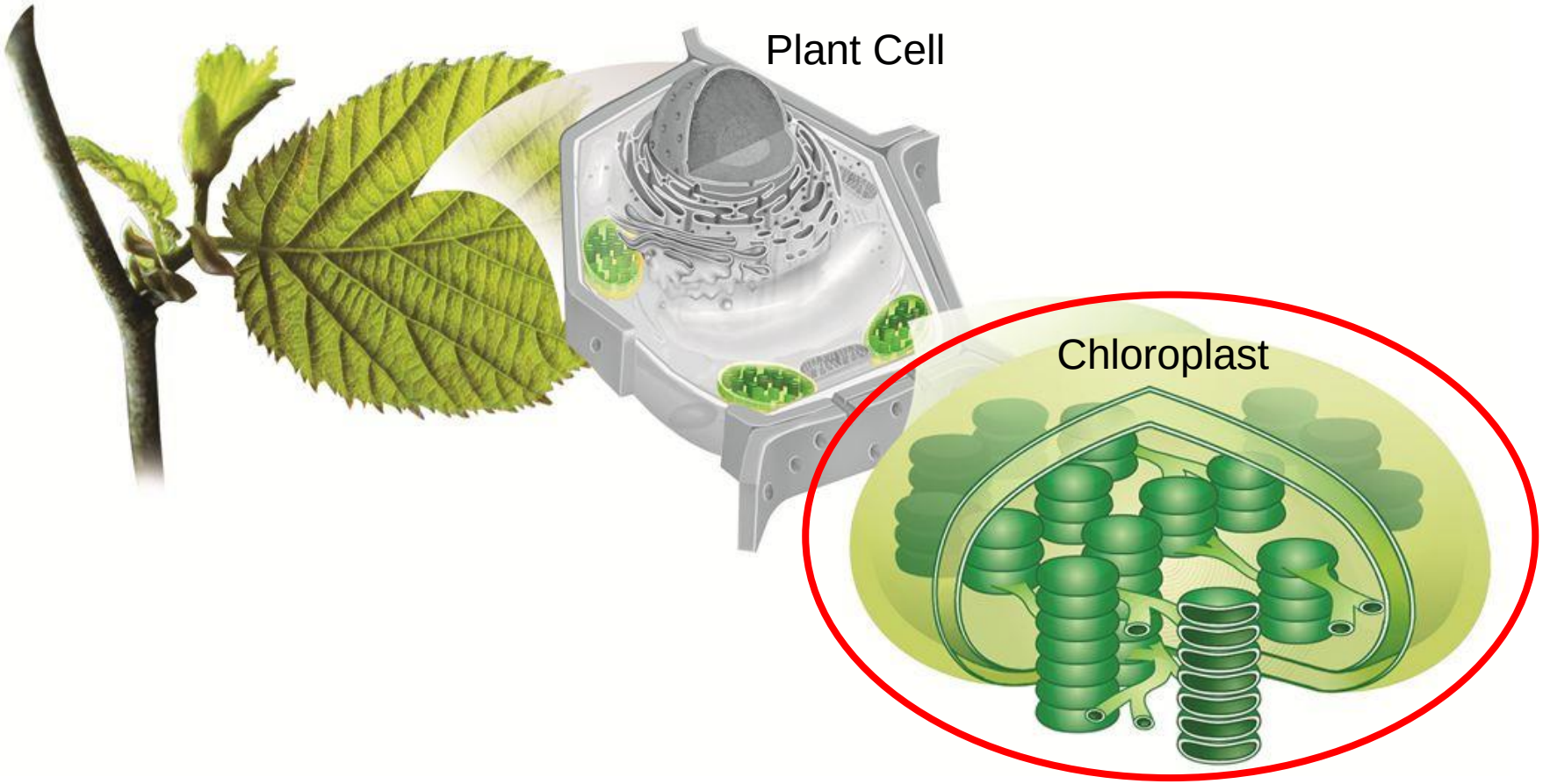
- Explain the role of pigments in the process of photosynthesis.
- Describe the role of electron carrier molecules.
- Identify the reactants and products of photosynthesis.

Chlorophyll and Chloroplasts

- Light energy from the sun must be captured for photosynthesis to occur.
- Sunlight is “white” light—actually a mixture of different wavelengths.
- Photosynthetic organisms capture energy from sunlight with pigments—principally with chlorophyll.

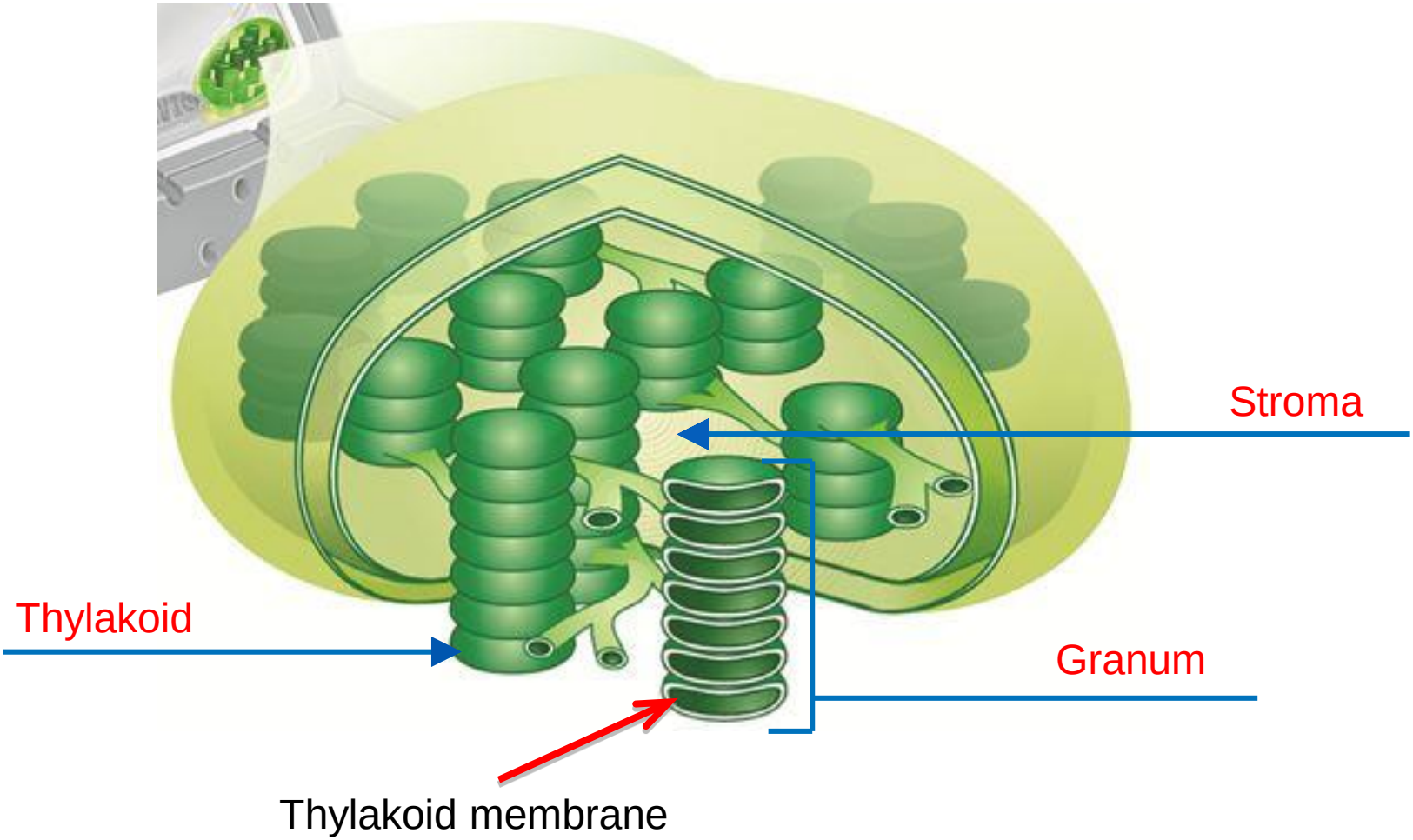
Chloroplasts

Photosynthesis takes place inside organelles called chloroplasts.



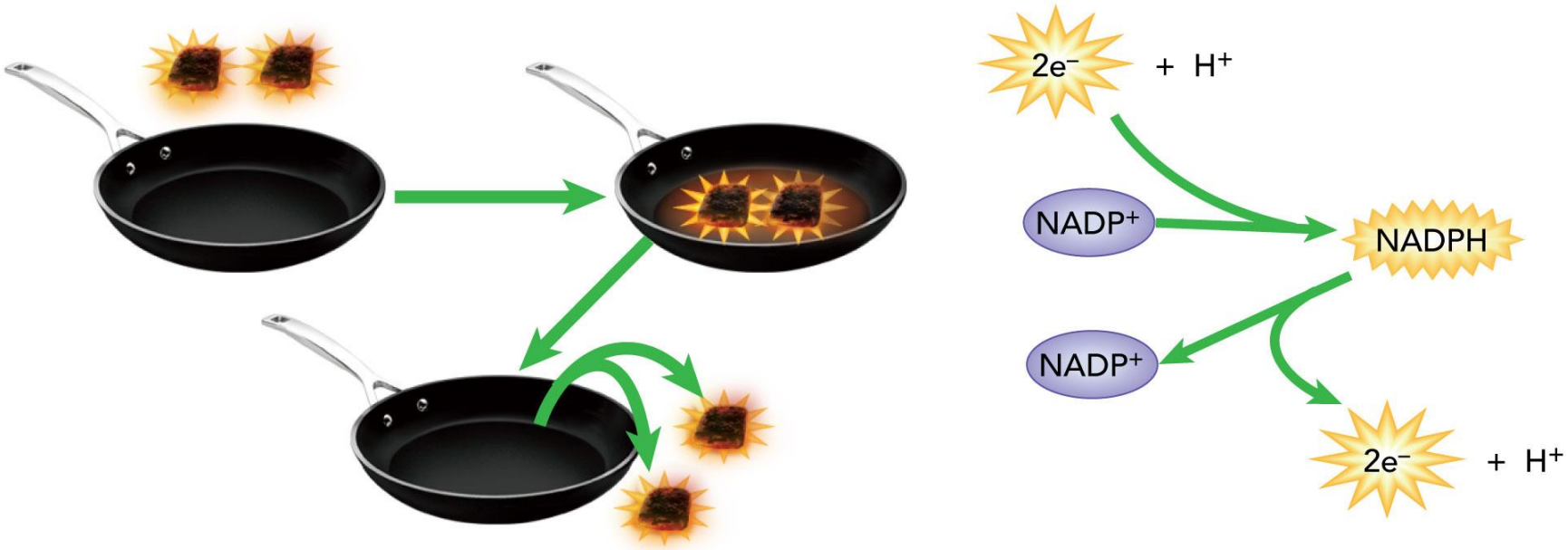
Chloroplast Structure

In plants, photosynthesis takes place inside chloroplasts.



Electron Carriers

The high-energy electrons produced by chlorophyll are highly reactive and require a special “carrier.”



Electron Carrier

- An electron carrier is a compound that can accept a pair of high-energy electrons and transfer them, along with most of their energy, to another molecule.
- NADPH can carry the high-energy electrons that were produced by light absorption in chlorophyll to chemical reactions elsewhere in the cell.

An Overview of Photosynthesis

Photosynthesis uses the energy of sunlight to convert water and carbon dioxide (low-energy reactants) into high-energy sugars and oxygen (products).

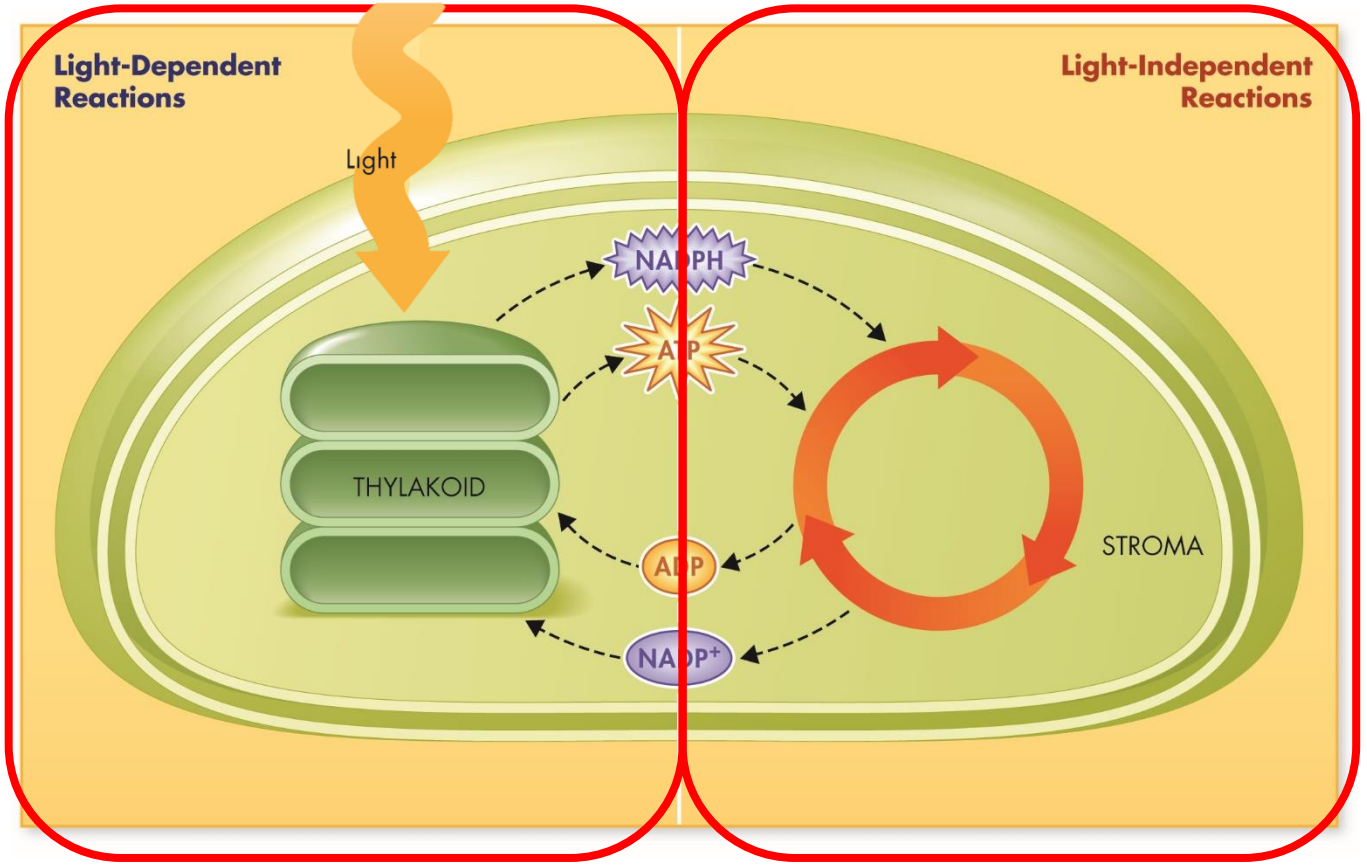
$$\text{Carbon dioxide} + \text{Water} \xrightarrow{\text{light}} \text{Sugars} + \text{Oxygen}$$

$$\underline{\quad 6CO_2 \quad} + \underline{\quad 6H_2O \quad} \xrightarrow{\text{light}} \underline{\quad C_6H_{12}O_6 \quad} + \underline{\quad 6O_2 \quad}$$

Photosynthesis and Light

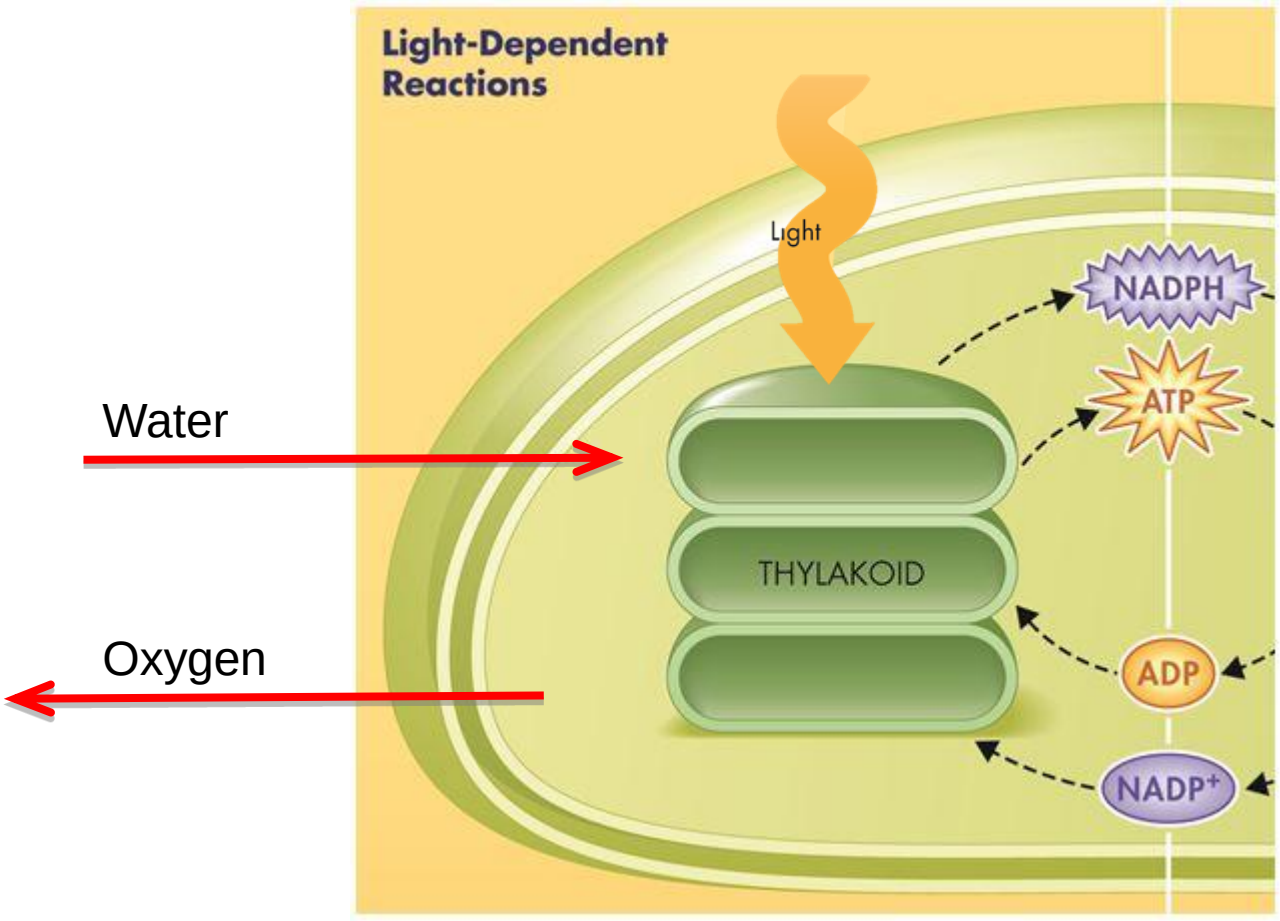
Photosynthesis involves two sets of reactions:

- Light-dependent reactions
- Light-independent reactions



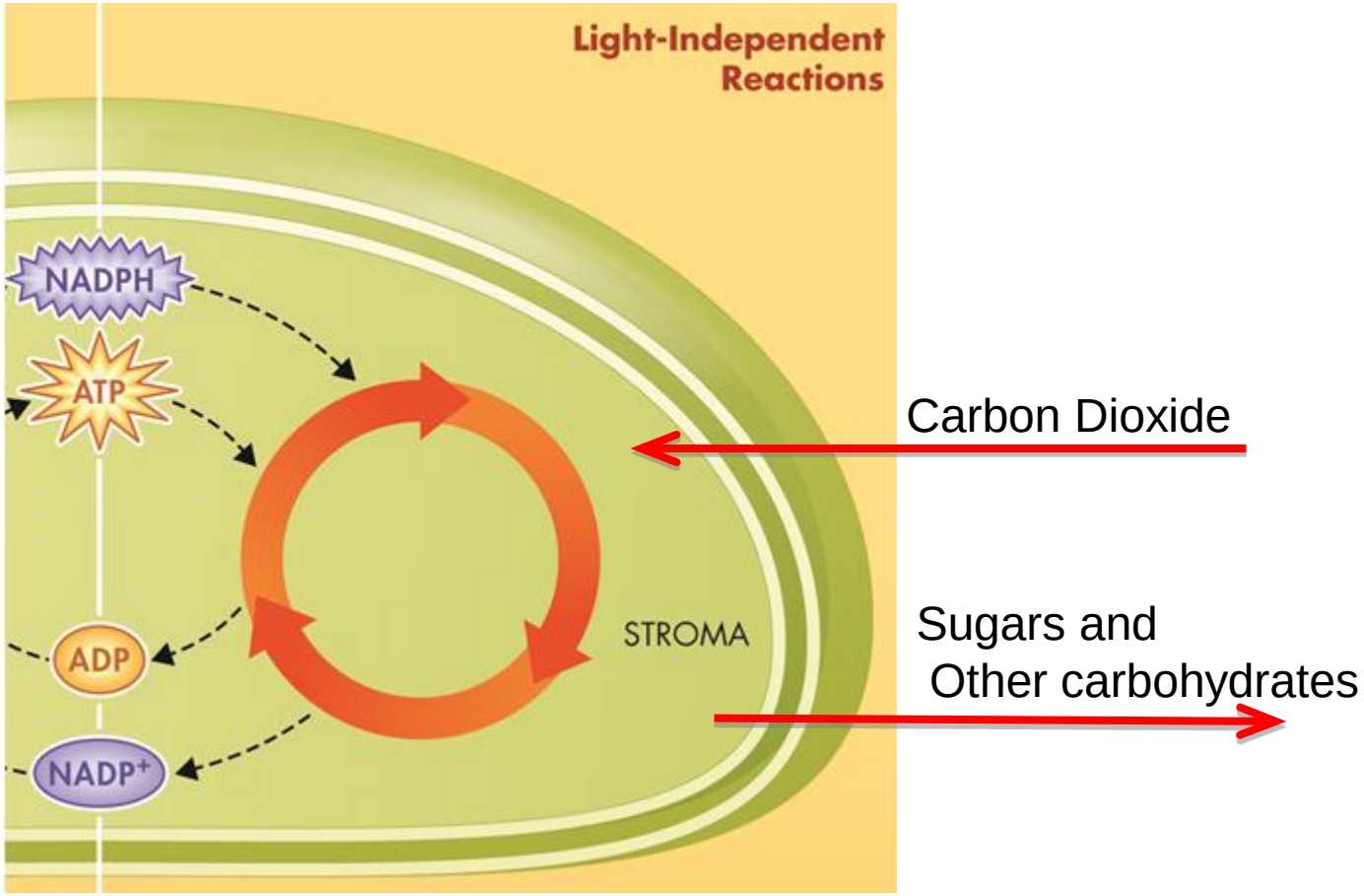
Light-Dependent Reactions

Light-dependent reactions require the direct involvement of light and light-absorbing pigments.



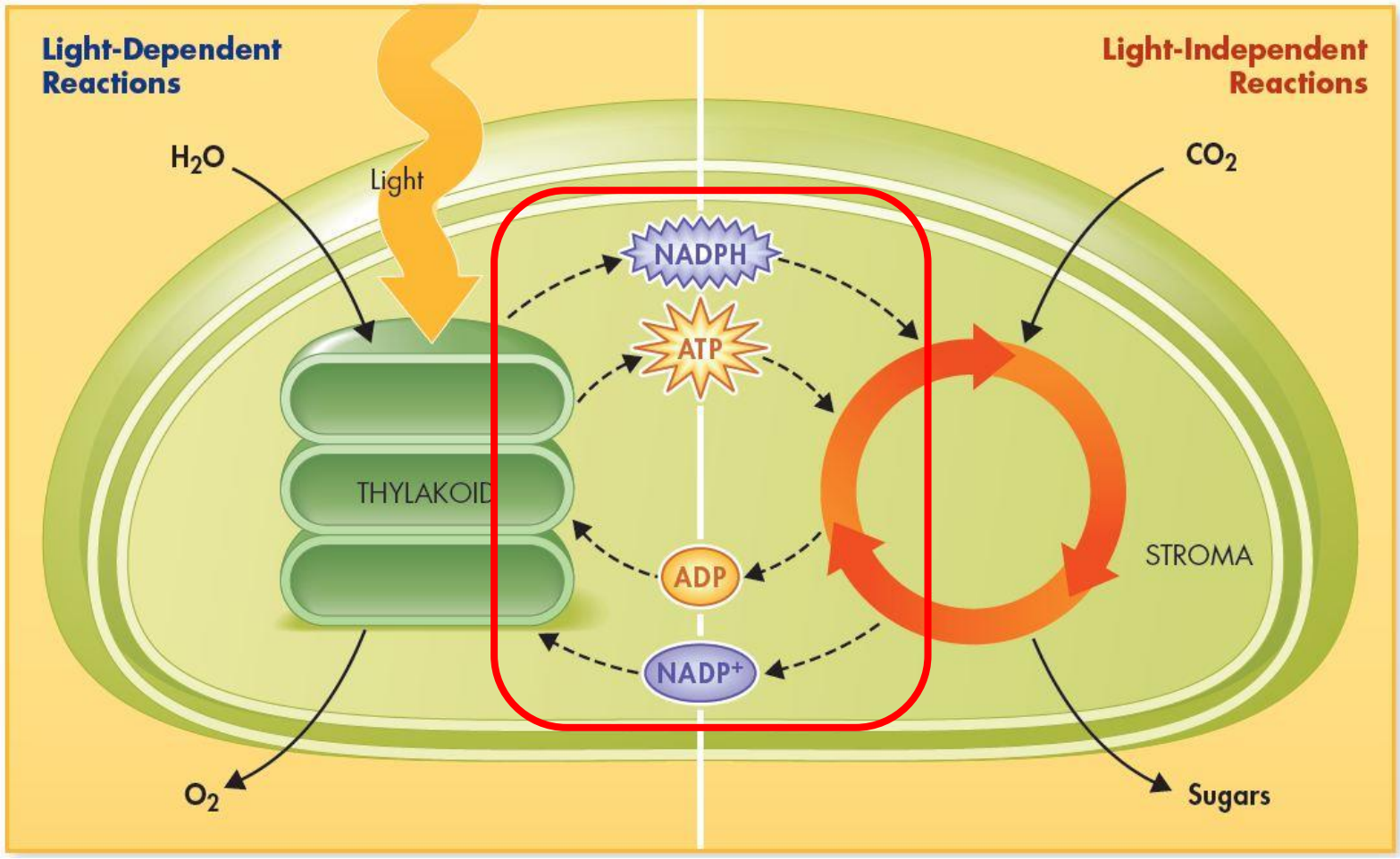
Light-Independent Reactions

Light-independent reactions use ATP and NADPH molecules produced in the light-dependent reactions to produce high-energy sugars from carbon dioxide



Interdependence of Reactions

Light-dependent and light-independent reactions have an interdependent relationship.



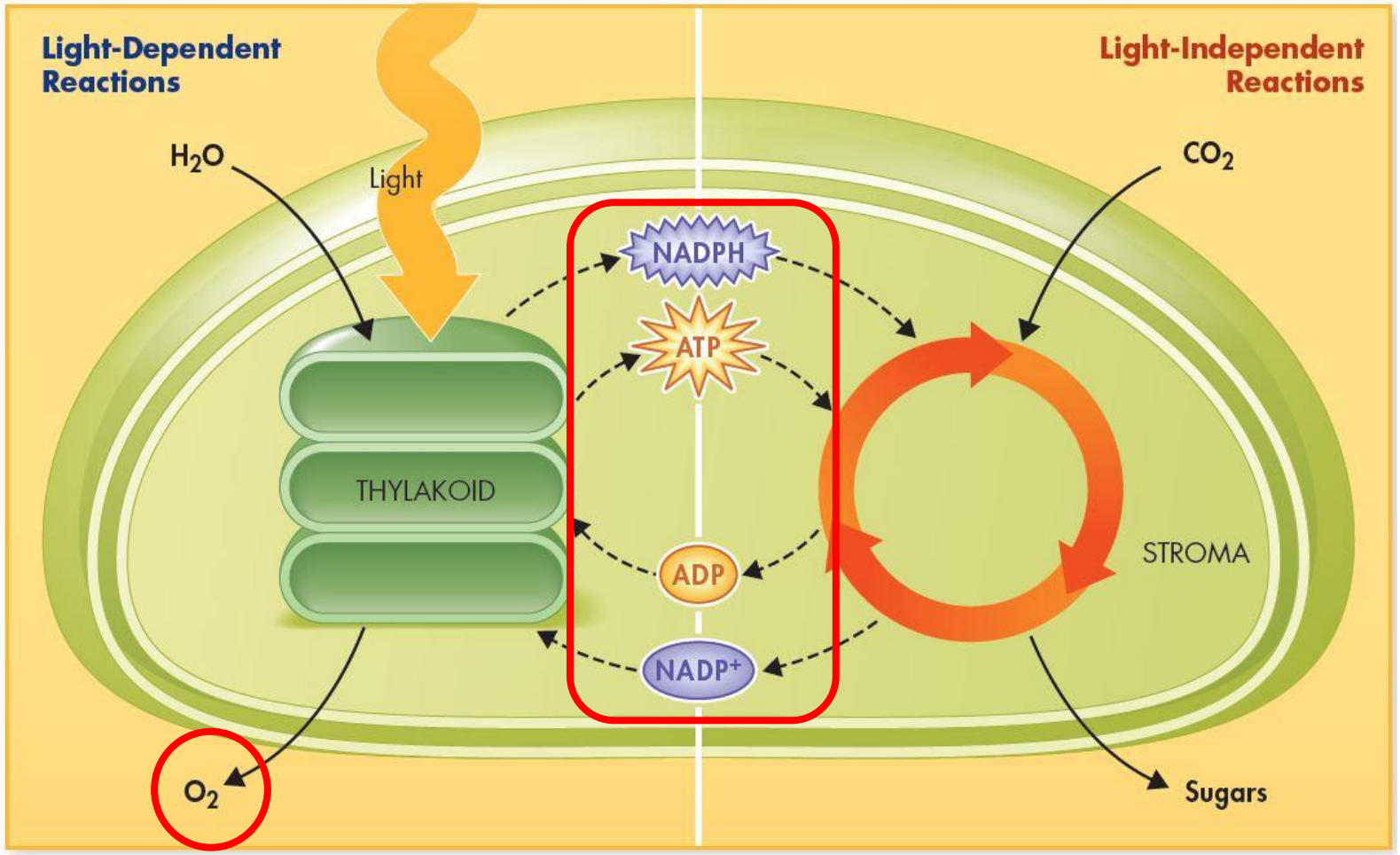
The Process of Photosynthesis

Learning Objectives

- Explain what happens during the light-dependent reactions.
- Explain what happens during the light-independent reactions.
- Identify the factors that affect photosynthesis.

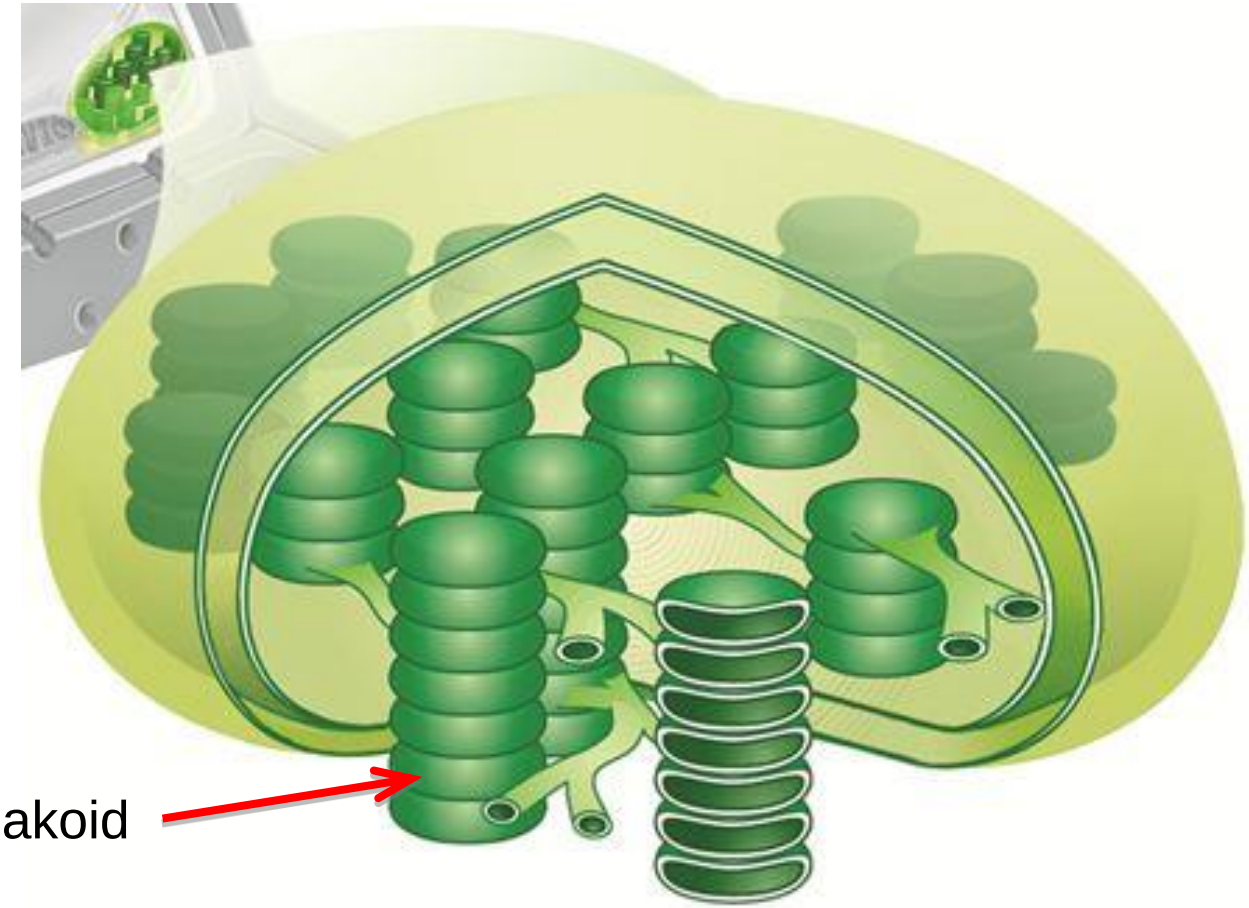
Two Sets of Reactions

Photosynthesis involves two primary sets of reactions: light-dependent reactions and light-independent reactions.



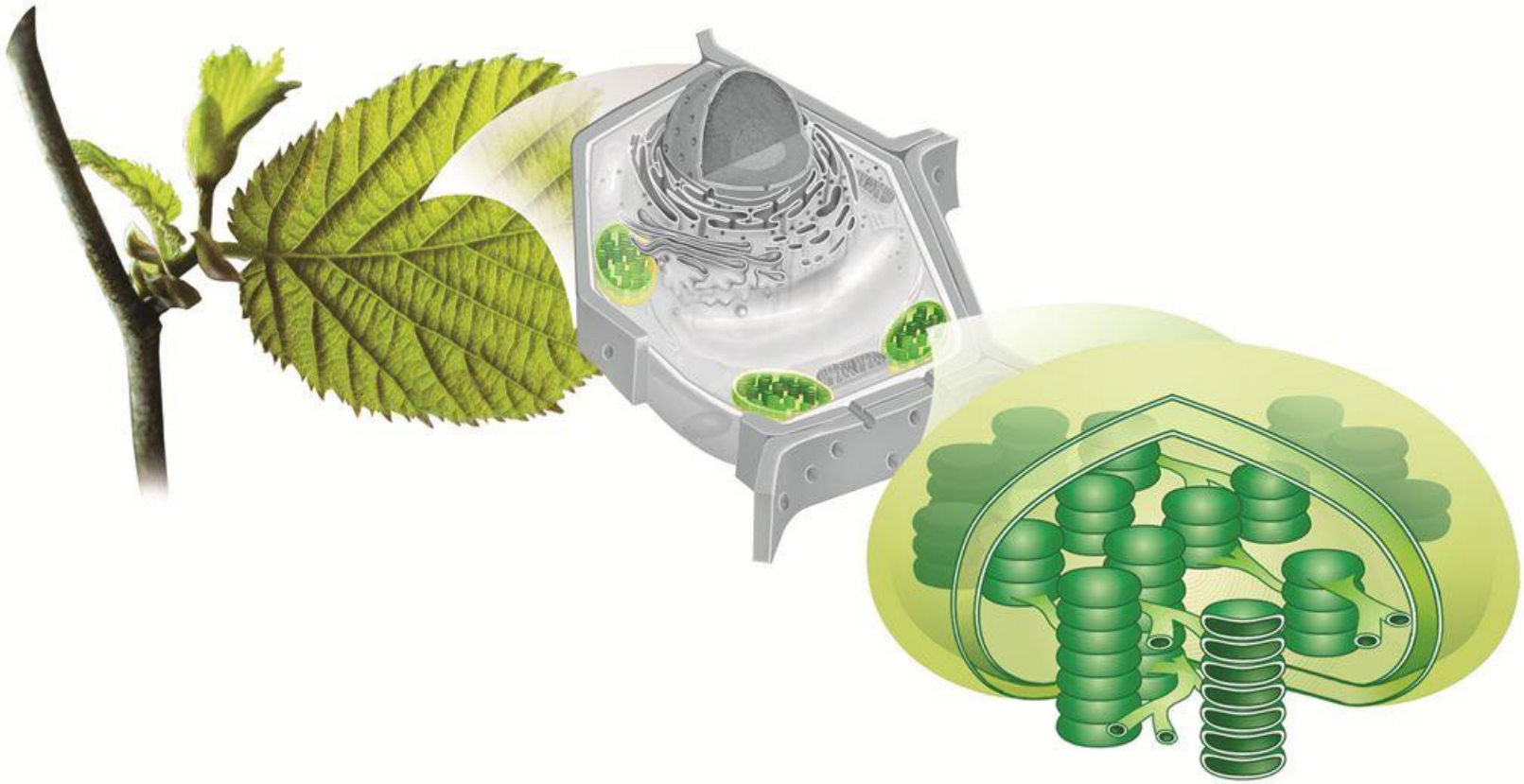
Light-Dependent Reactions

Light-dependent reactions use energy from sunlight to produce ATP, NADPH, and oxygen.



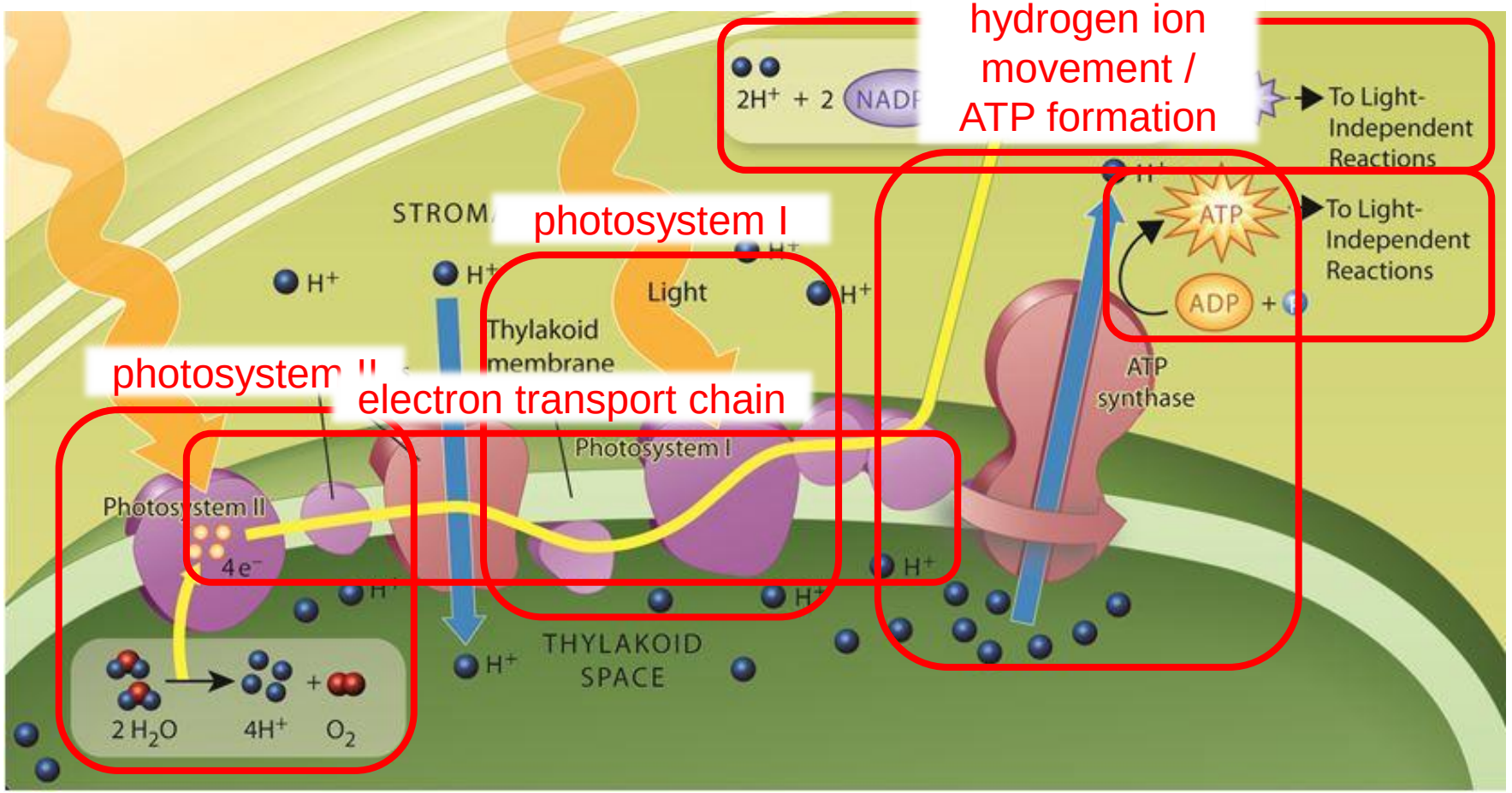
Thylakoid

Thylakoids contain clusters of chlorophyll and proteins known as photosystems.



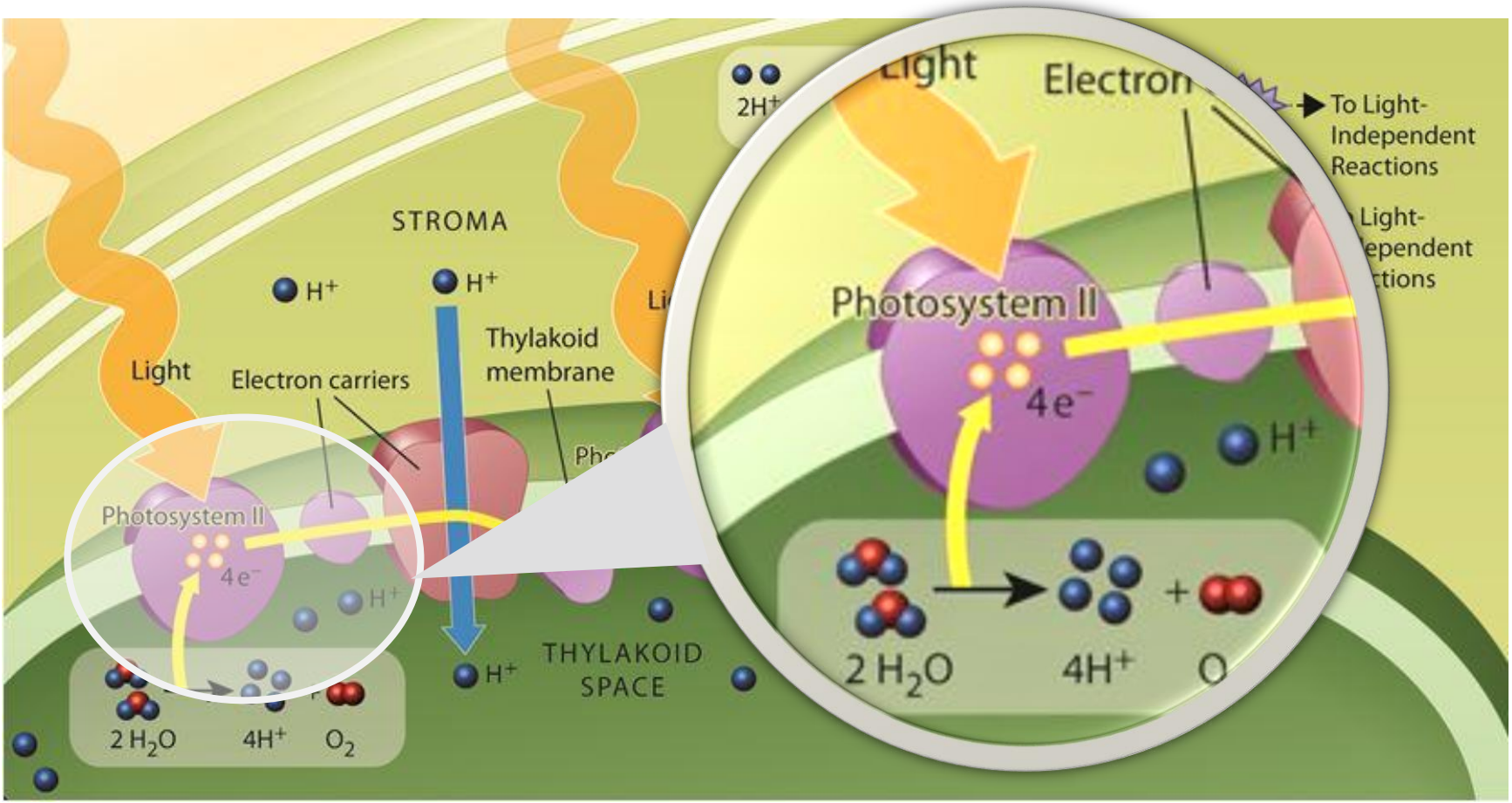
Light-Dependent Reactions

- Use energy from sunlight to produce oxygen
- Convert ADP and $NADP^+$ into energy carriers ATP and NADPH



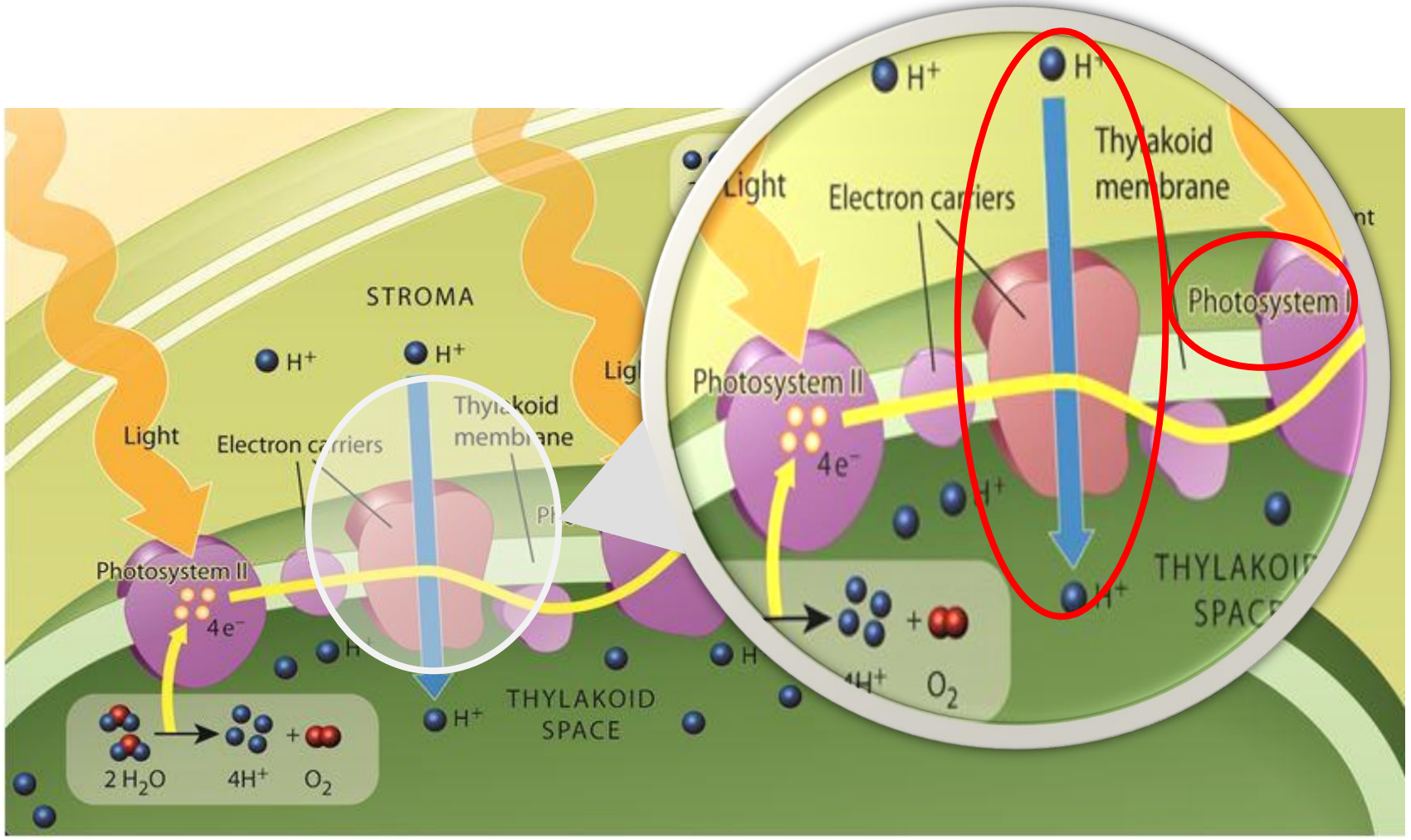
Photosystem II

- Absorbs light energy and produces high-energy electrons
- Splits water molecules, releasing H^+ ions and oxygen



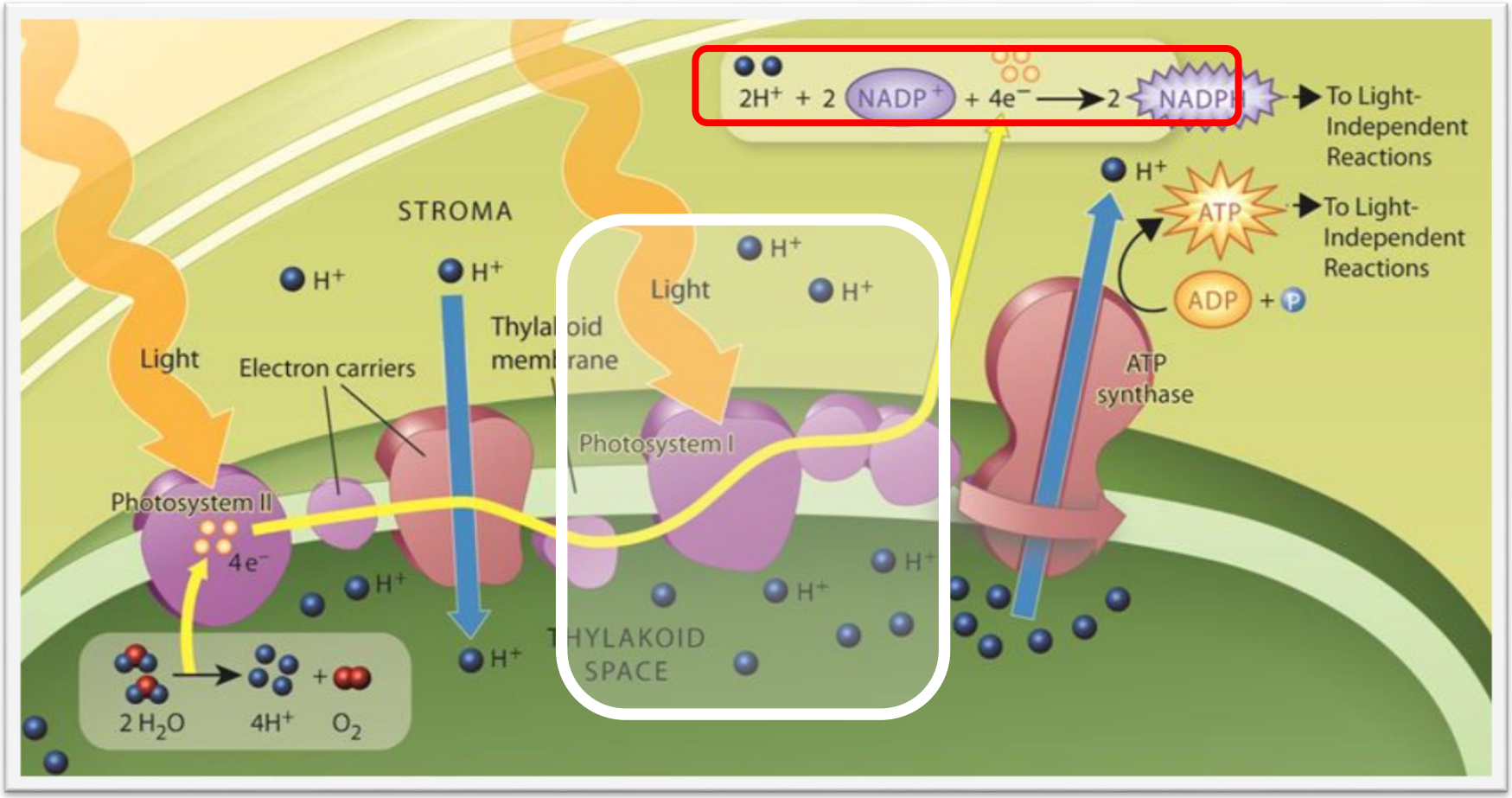
Electron Transport Chain

A series of electron carrier proteins shuttle high-energy electrons during ATP-generating reactions.



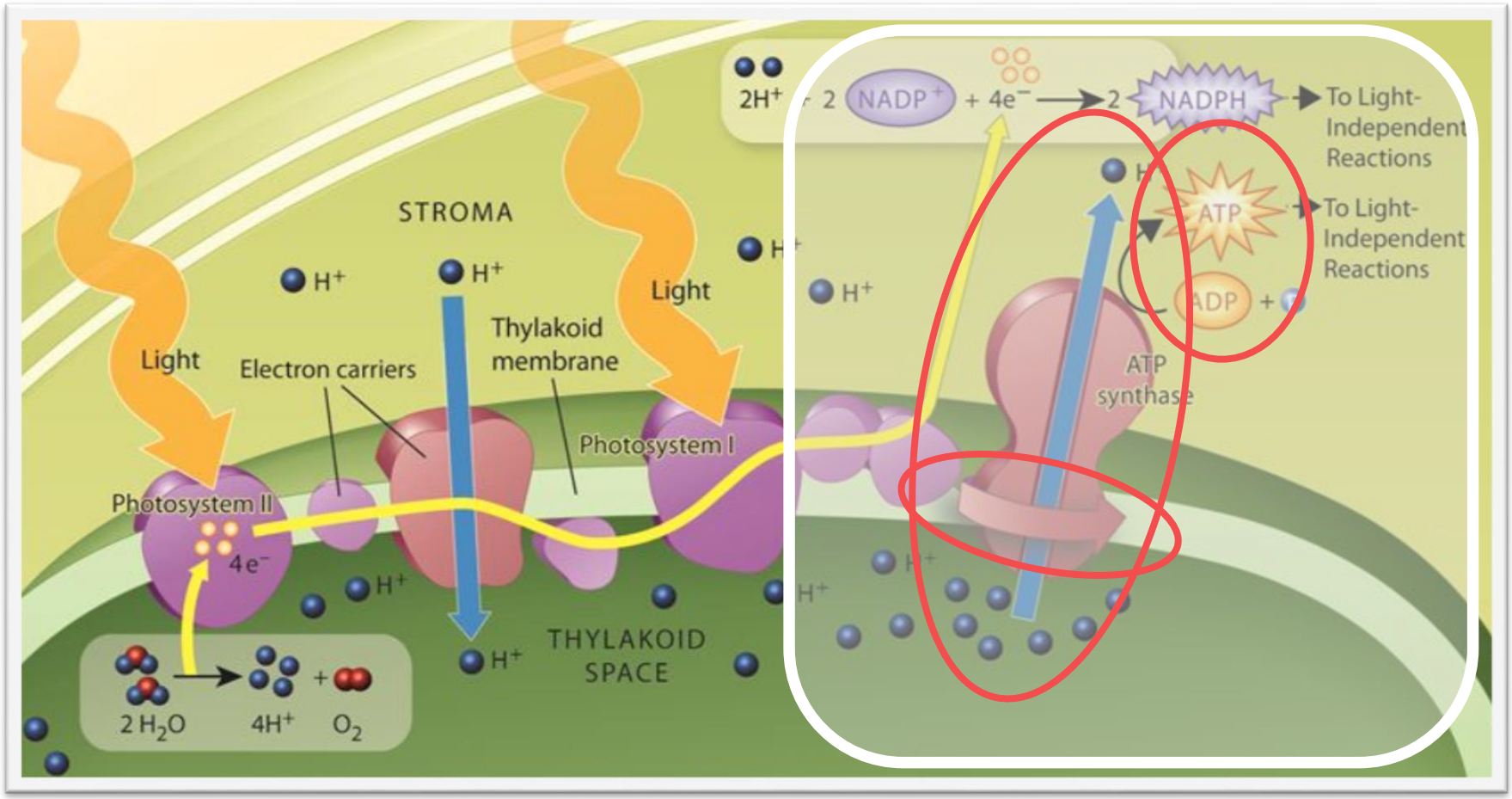
Photosystem I

- Electrons are reenergized
- Second electron transport chain transfers electrons to $NADP^+$, producing NADPH



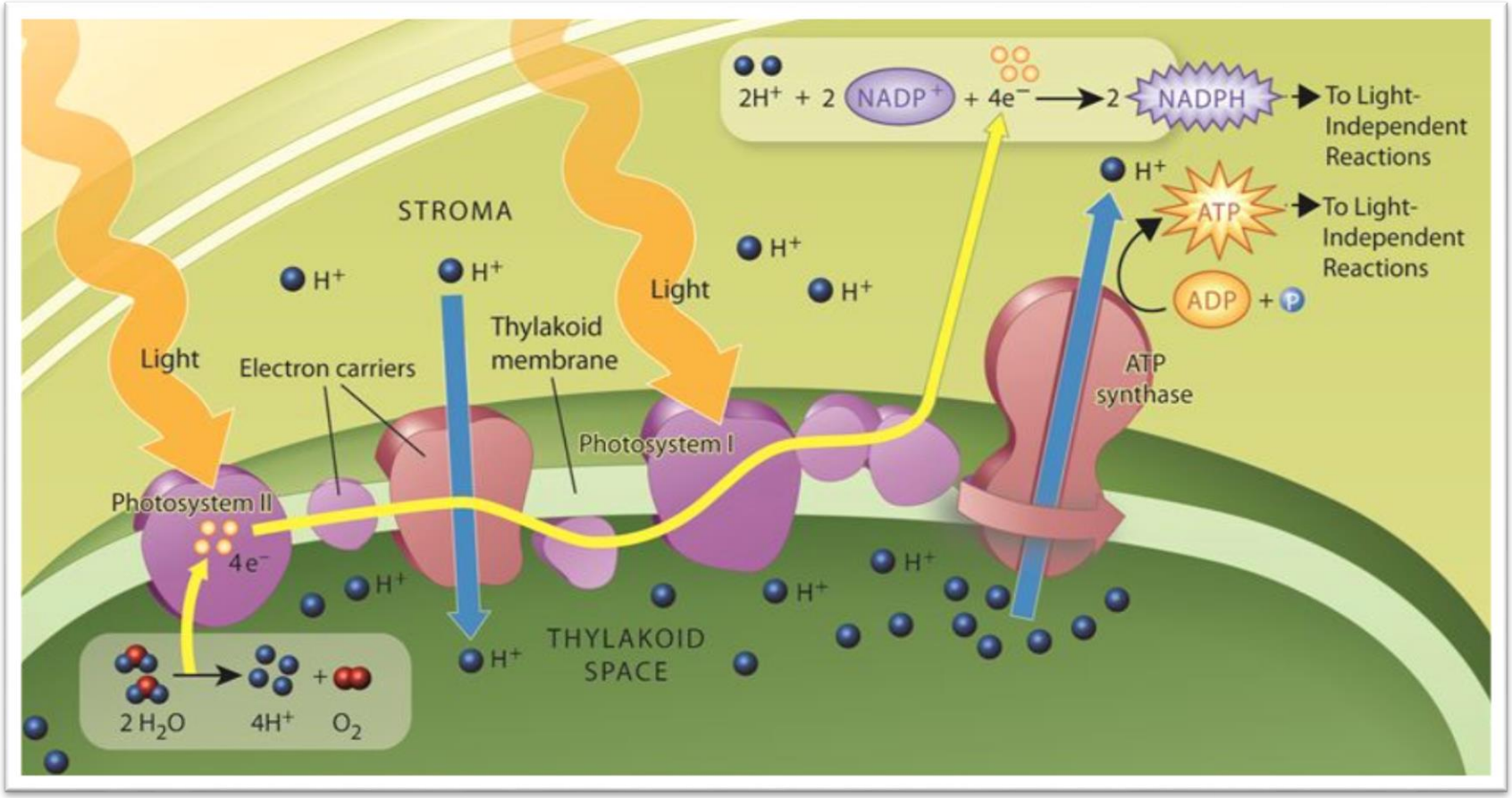
Hydrogen Ion Movement/ATP Formation

The difference in both charge and H^+ ion concentration across the membrane provides the energy to make ATP.



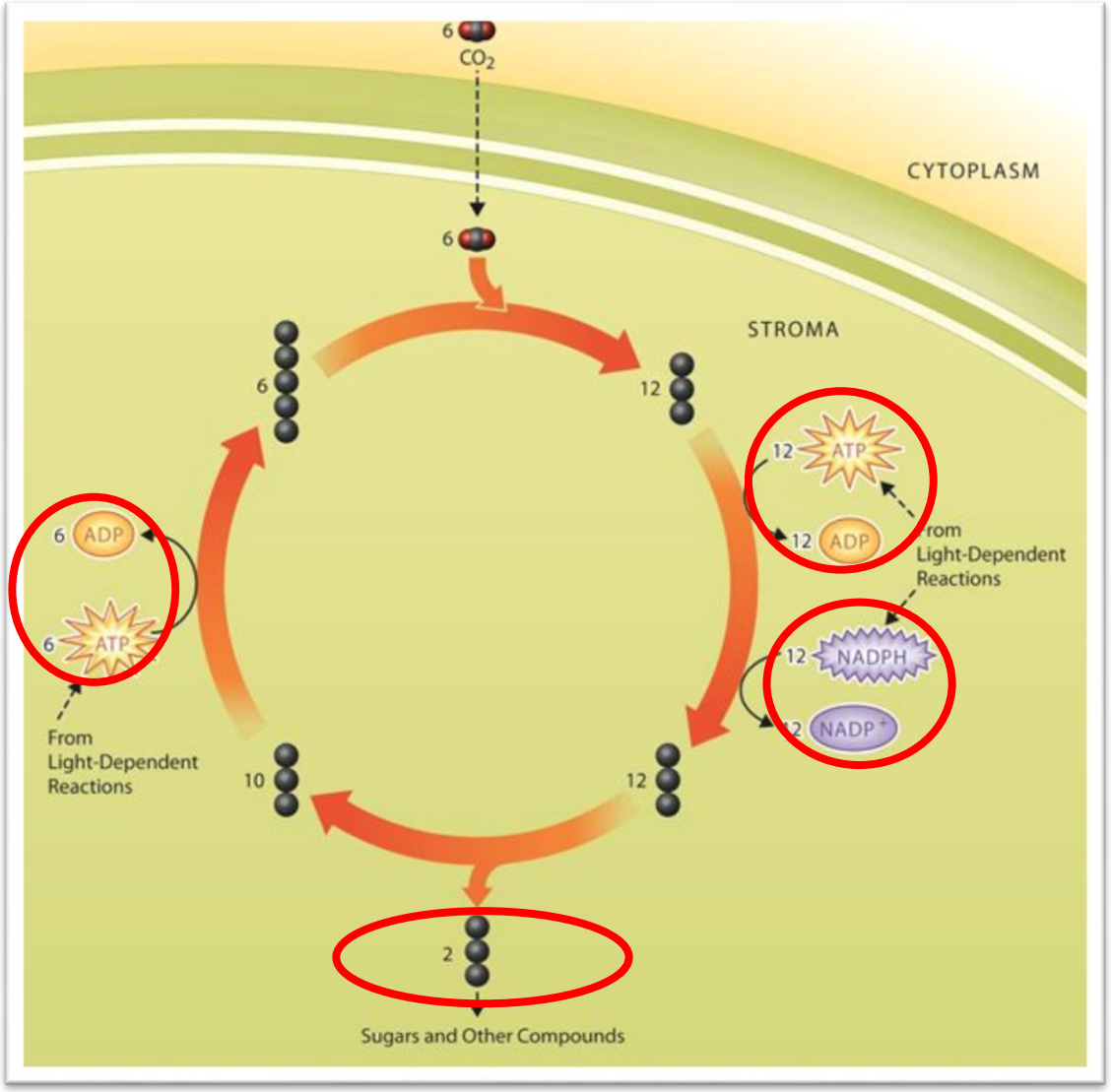
Light-Dependent Reactions Summary

The light-dependent reactions produce oxygen gas and convert ADP and $NADP^+$ into the energy carriers ATP and NADPH.



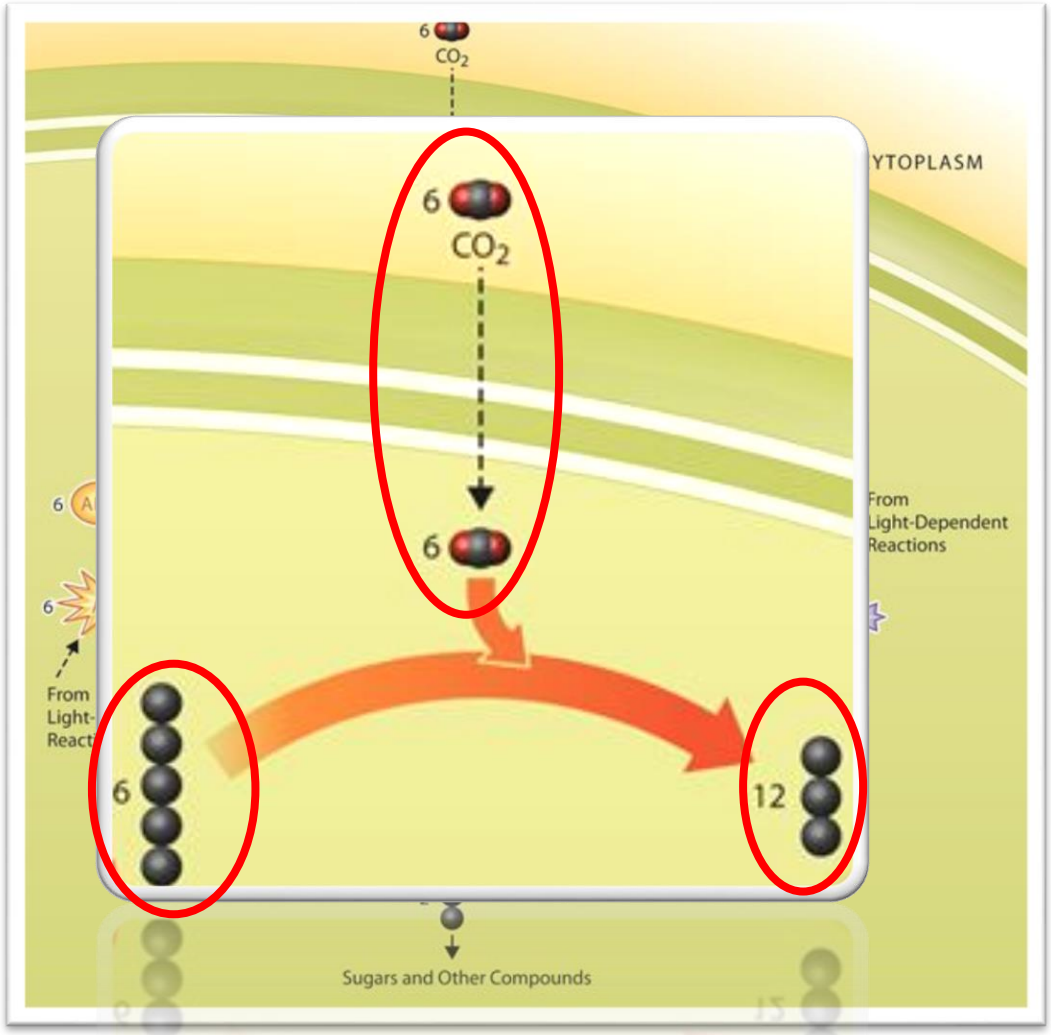
Light-Independent Reactions

ATP and NADPH are used to synthesize high-energy sugars.



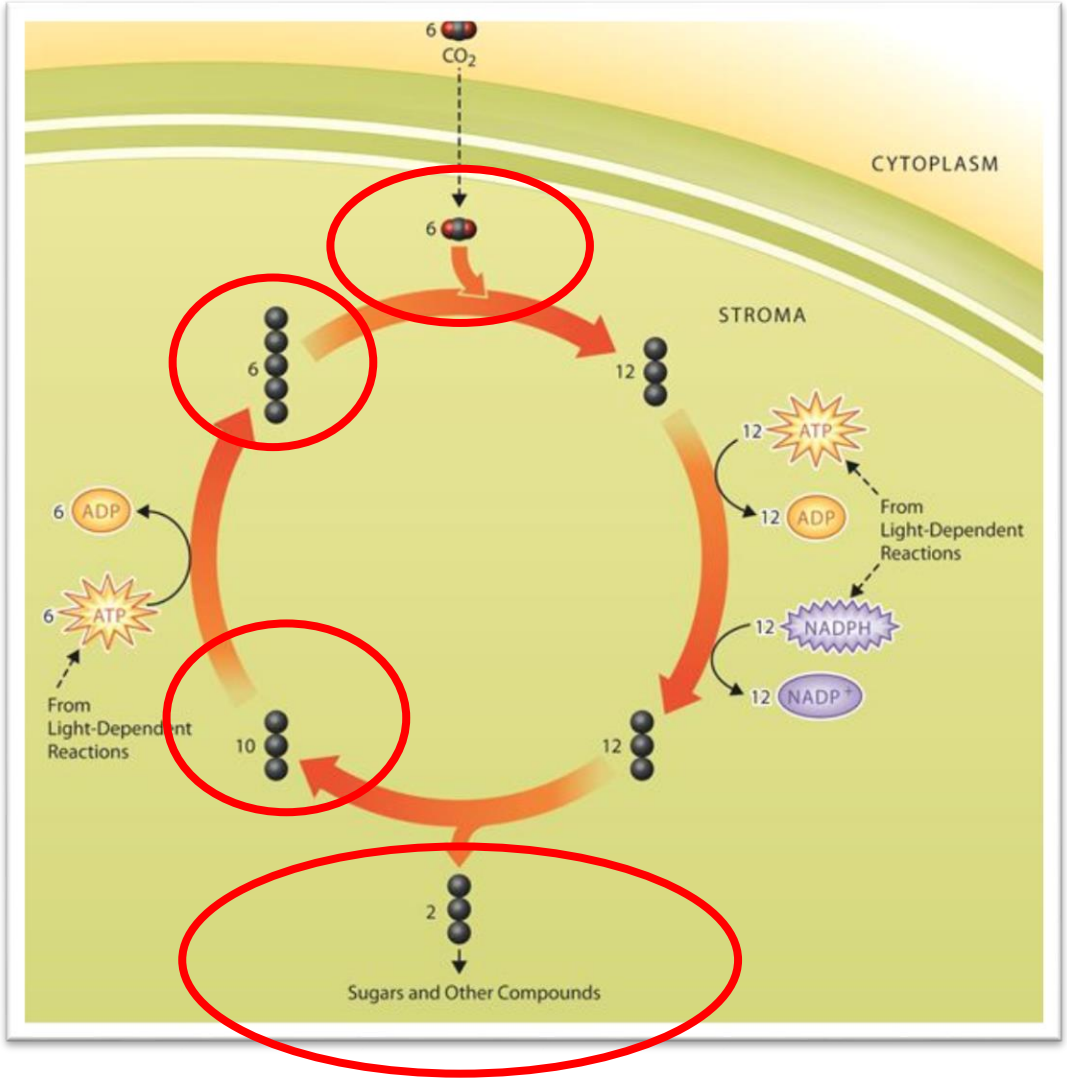
Carbon Dioxide Enters the Cycle

- Six carbon dioxide molecules from atmosphere combine with six 5-carbon molecules
- Produces 12 3-carbon compounds.

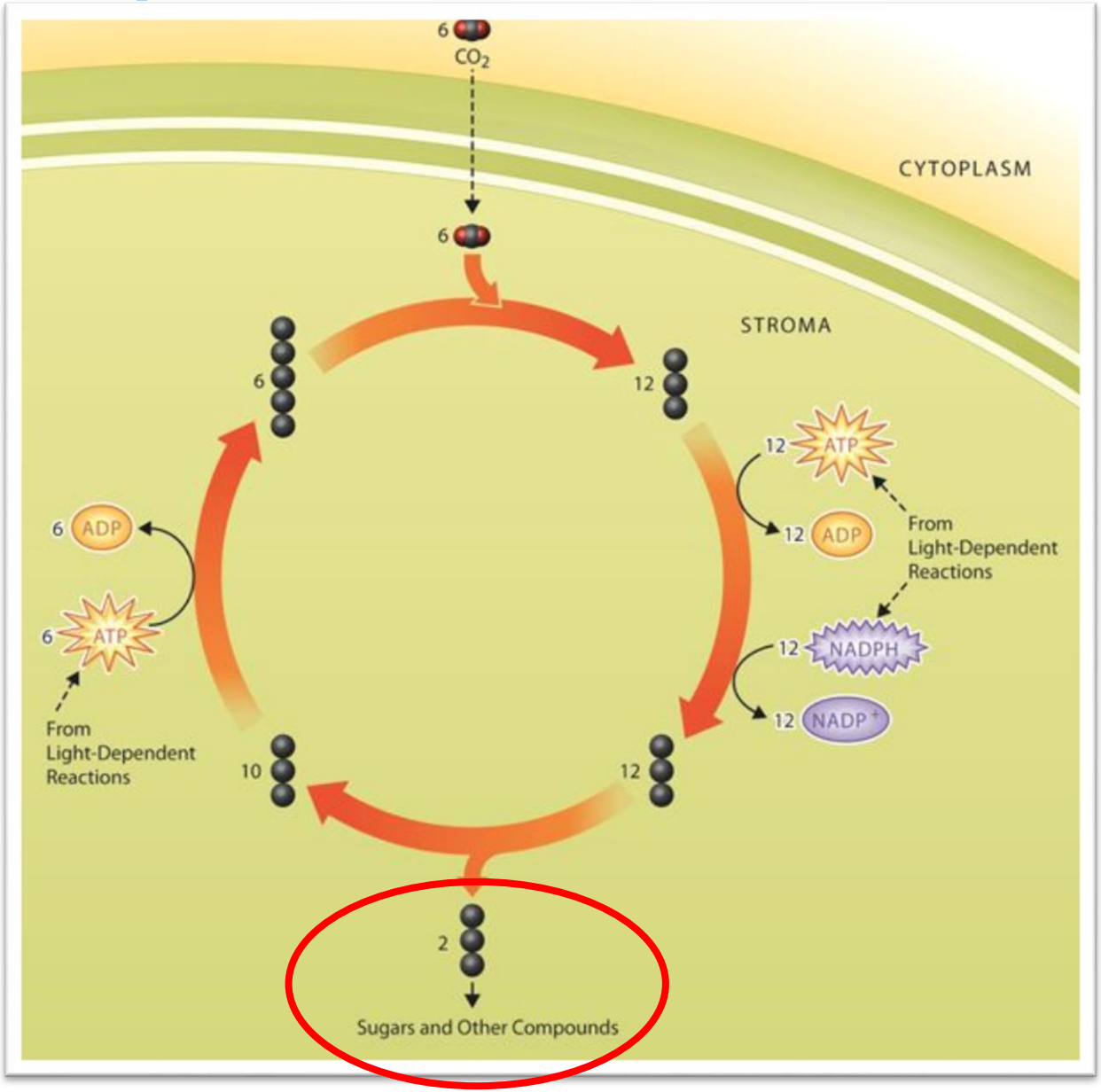


Sugar Production

Energy from ATP and high-energy electrons from NADPH are used to convert the 3-carbon molecules to higher-energy forms.



Light-Independent Reactions Summary



Factors Affecting Photosynthesis

Important factors that affect photosynthesis include temperature, light intensity, and availability of water.

Some plants have adapted to extremely bright, hot conditions: C4 plants and CAM plants.