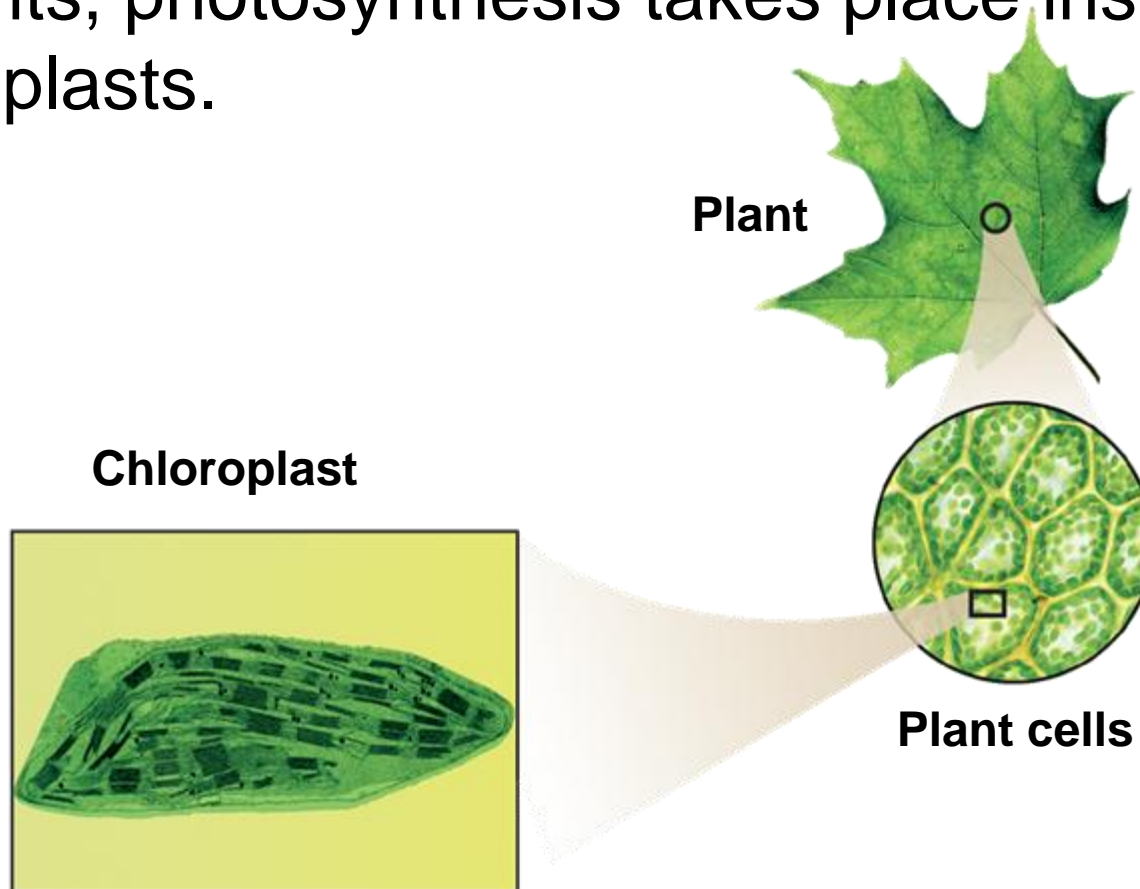


8-3 The Reactions of Photosynthesis

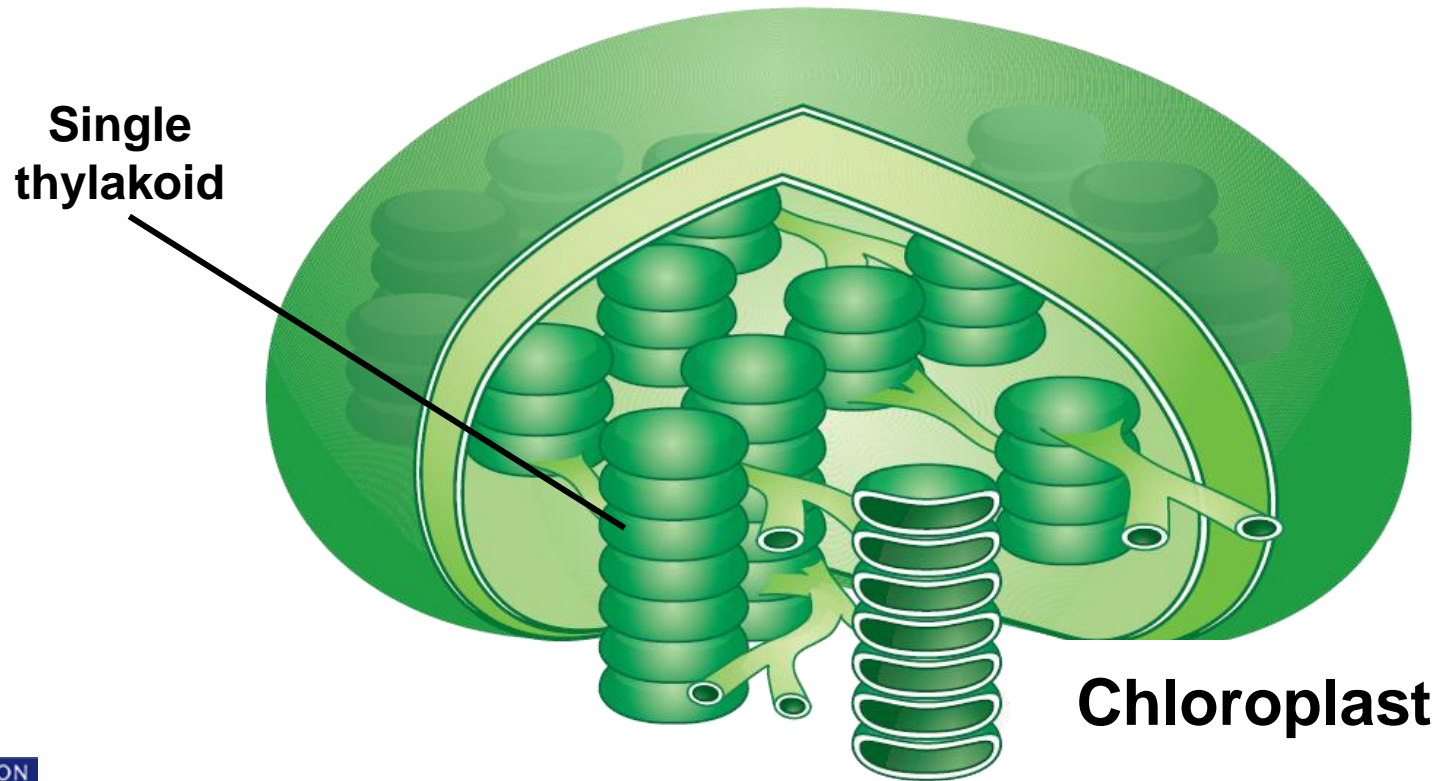


Inside a Chloroplast

In plants, photosynthesis takes place inside chloroplasts.

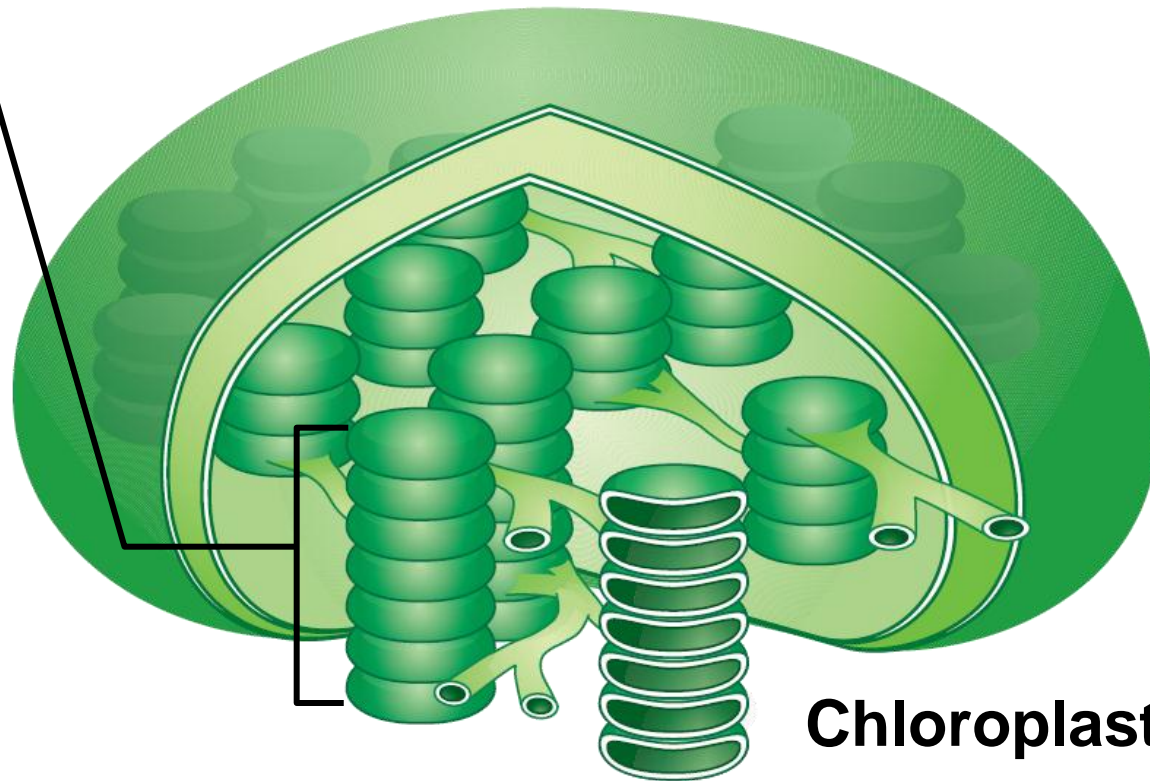


Chloroplasts contain **thylakoids**—saclike photosynthetic membranes.



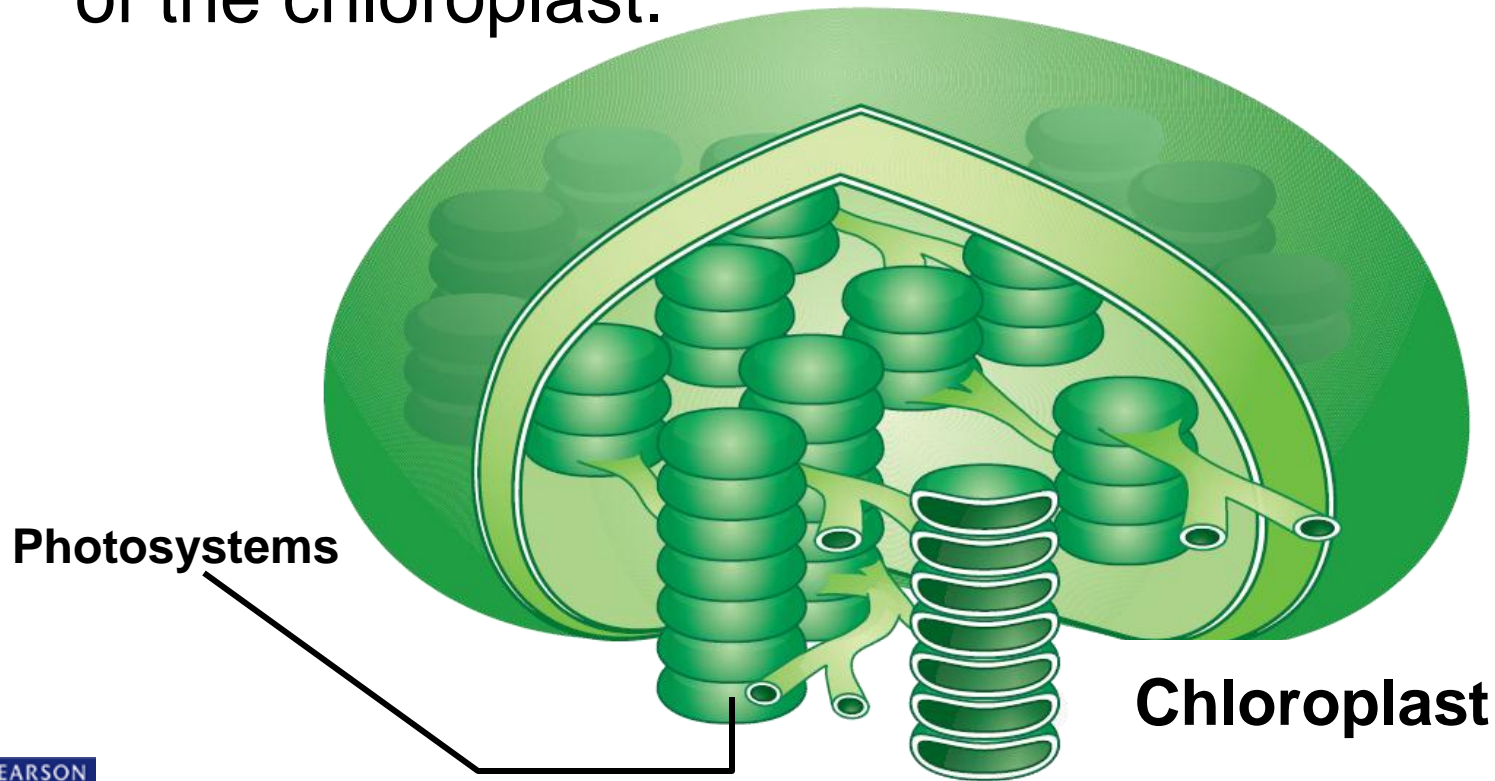
Thylakoids are arranged in stacks known as grana. A singular stack is called a granum.

Granum



Chloroplast

Proteins in the thylakoid membrane organize chlorophyll and other pigments into clusters called **photosystems**, which are the light-collecting units of the chloroplast.

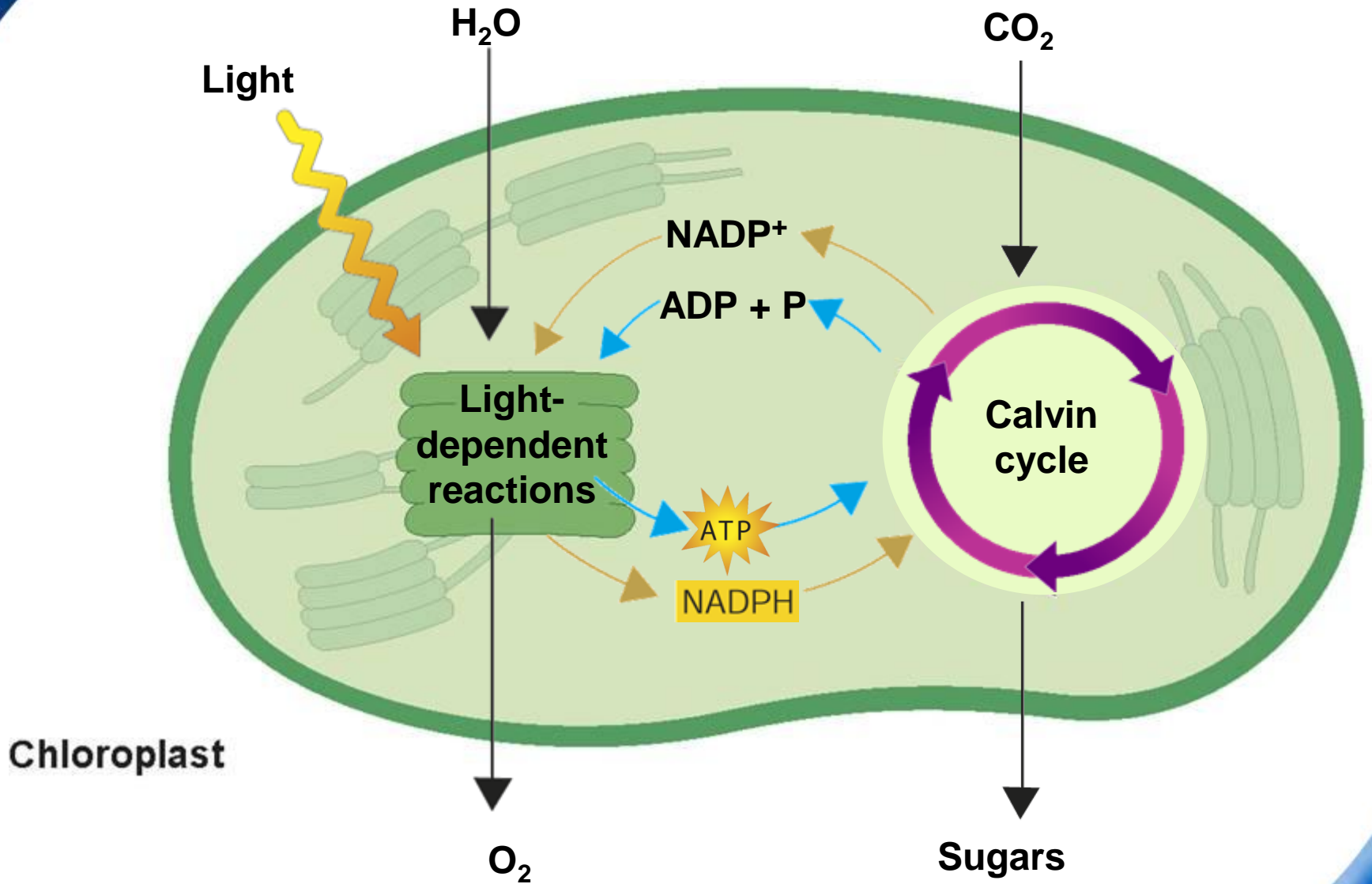


The reactions of photosystems include: the light-dependent reactions and the light-independent reactions, or Calvin cycle.

The light-dependent reactions take place within the thylakoid membranes.

The Calvin cycle takes place in the **stroma**, which is the region outside the thylakoid membranes.

8-3 The Reactions of Photosynthesis → Inside a Chloroplast



Chloroplast

Electron Carriers

When electrons in chlorophyll absorb sunlight, the electrons gain a great deal of energy.

Cells use electron carriers to transport these high-energy electrons from chlorophyll to other molecules.

One carrier molecule is **NADP⁺**.

Electron carriers, such as NADP⁺, transport electrons.

NADP⁺ accepts and holds 2 high-energy electrons along with a hydrogen ion (H⁺). This converts the NADP⁺ into NADPH.

The conversion of NADP^+ into NADPH is one way some of the energy of sunlight can be trapped in chemical form.

The NADPH carries high-energy electrons to chemical reactions elsewhere in the cell.

These high-energy electrons are used to help build a variety of molecules the cell needs, including carbohydrates like glucose.



What happens in the light-dependent reactions?

Light-Dependent Reactions

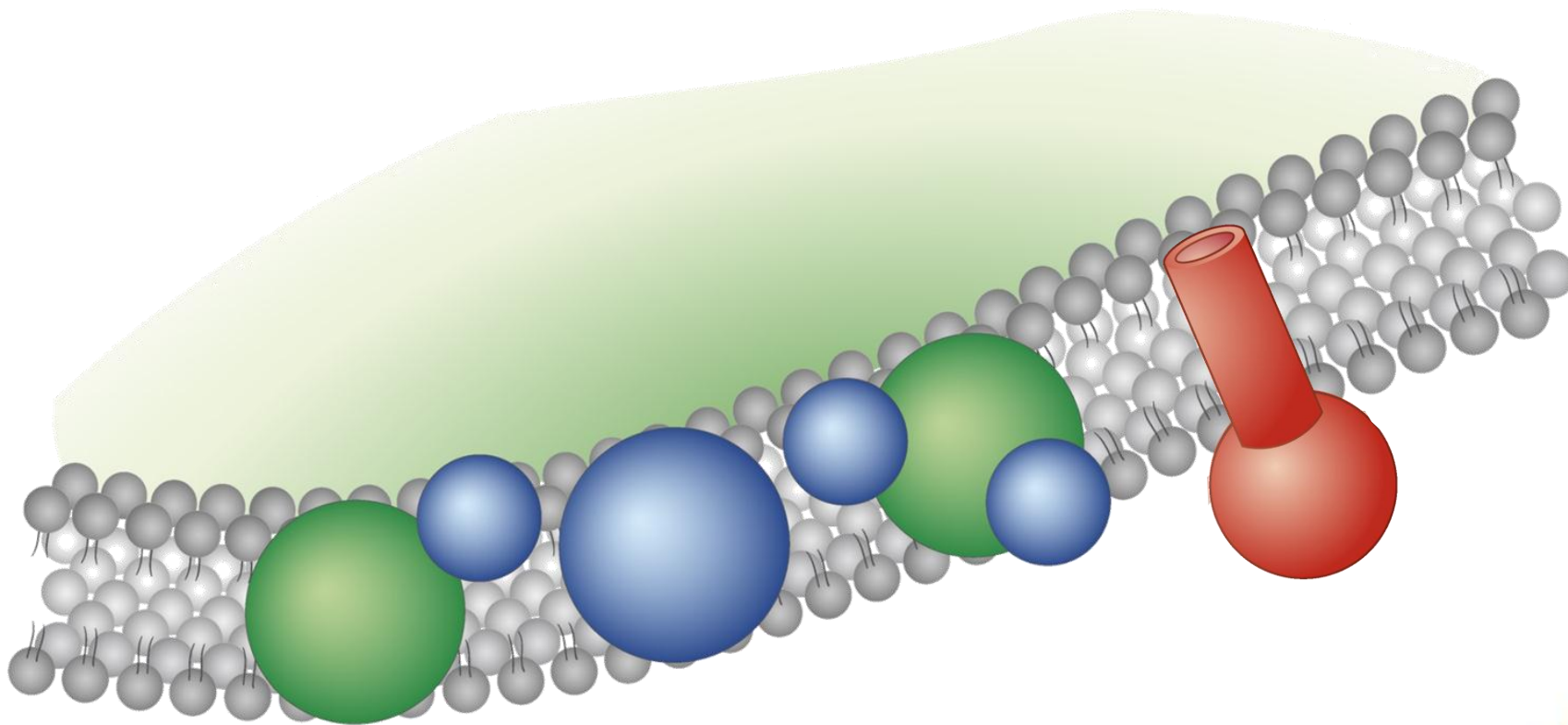
The light-dependent reactions require light.



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

8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

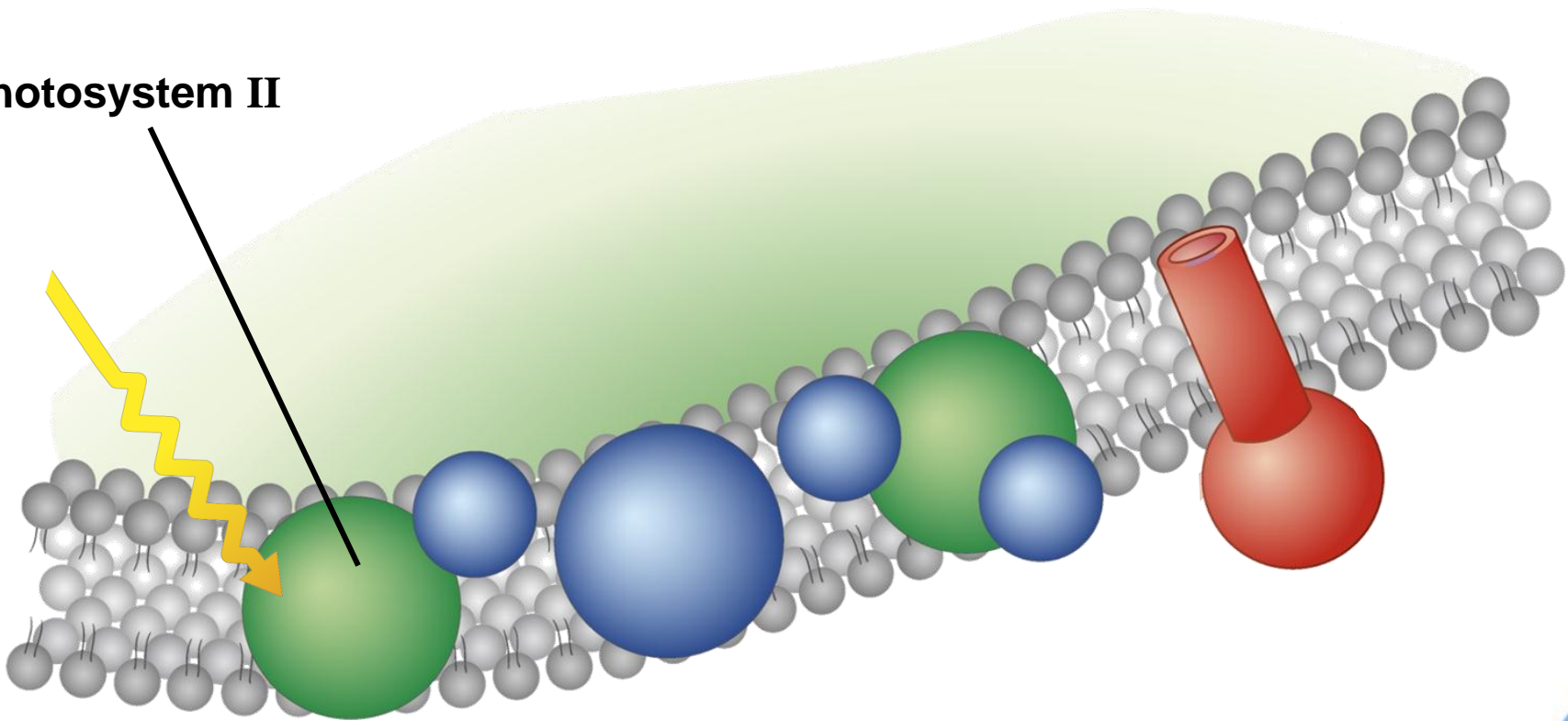
movie
click to start



8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Photosynthesis begins when pigments in photosystem II absorb light, increasing their energy level.

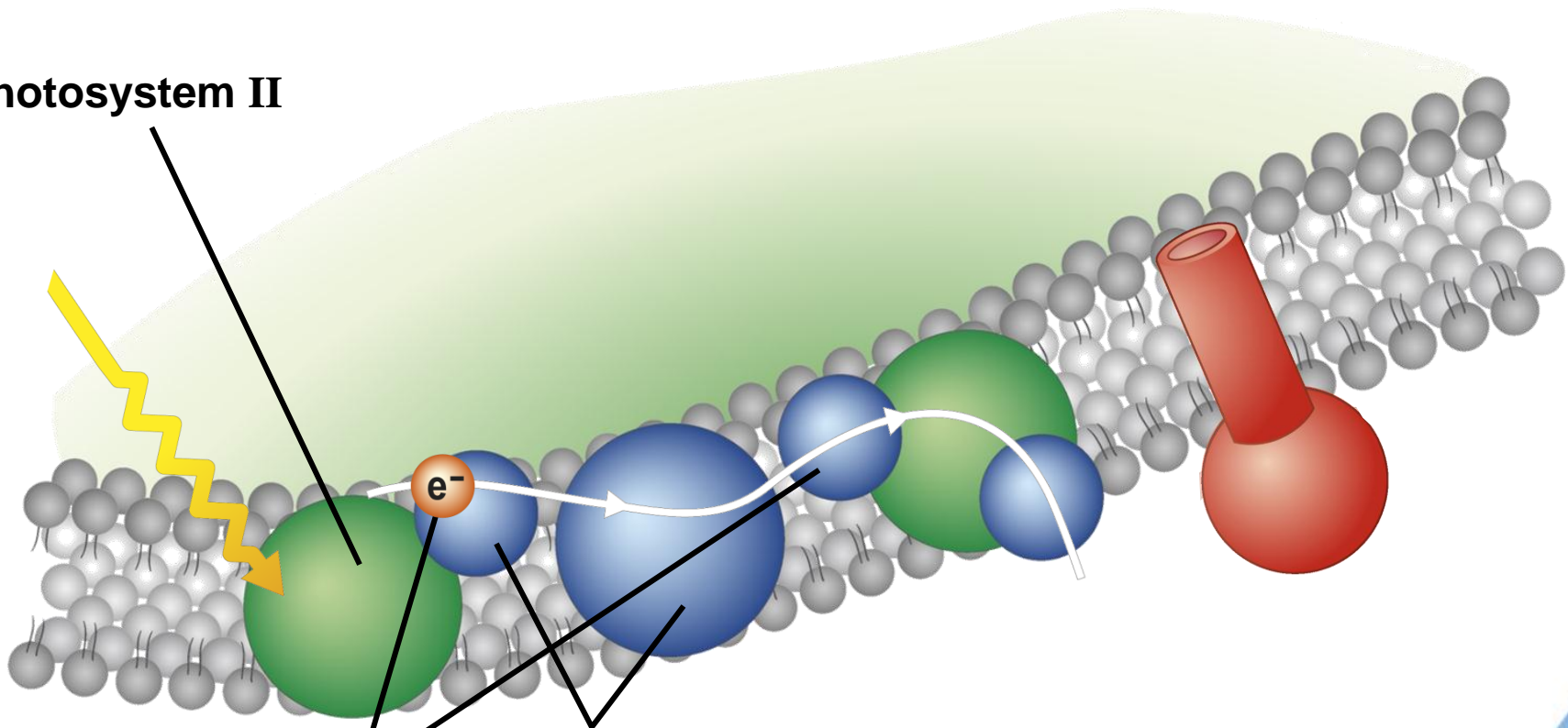
Photosystem II



8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

These high-energy electrons are passed on to the electron transport chain.

Photosystem II



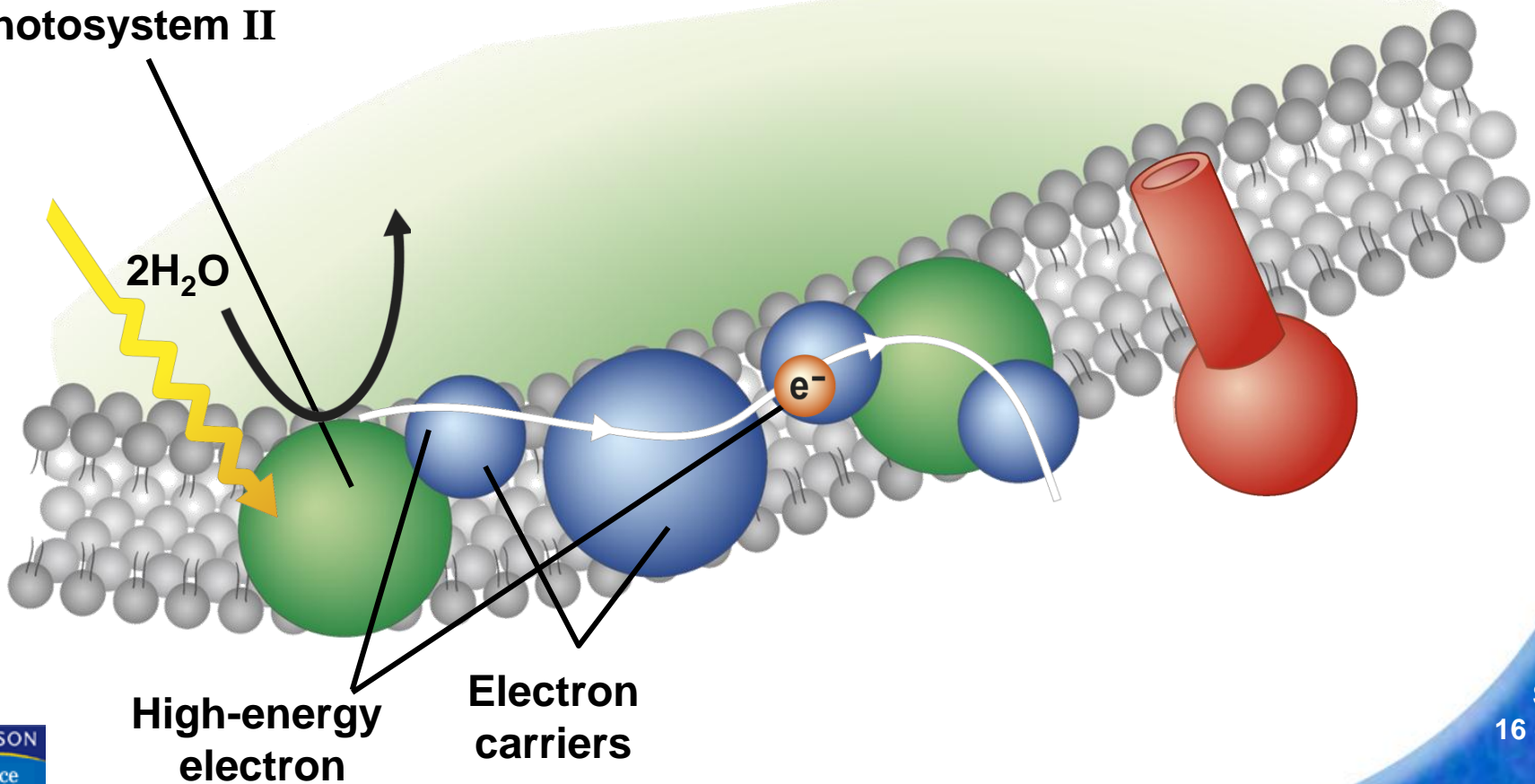
High-energy electron

Electron carriers

8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Enzymes on the thylakoid membrane break water molecules into:

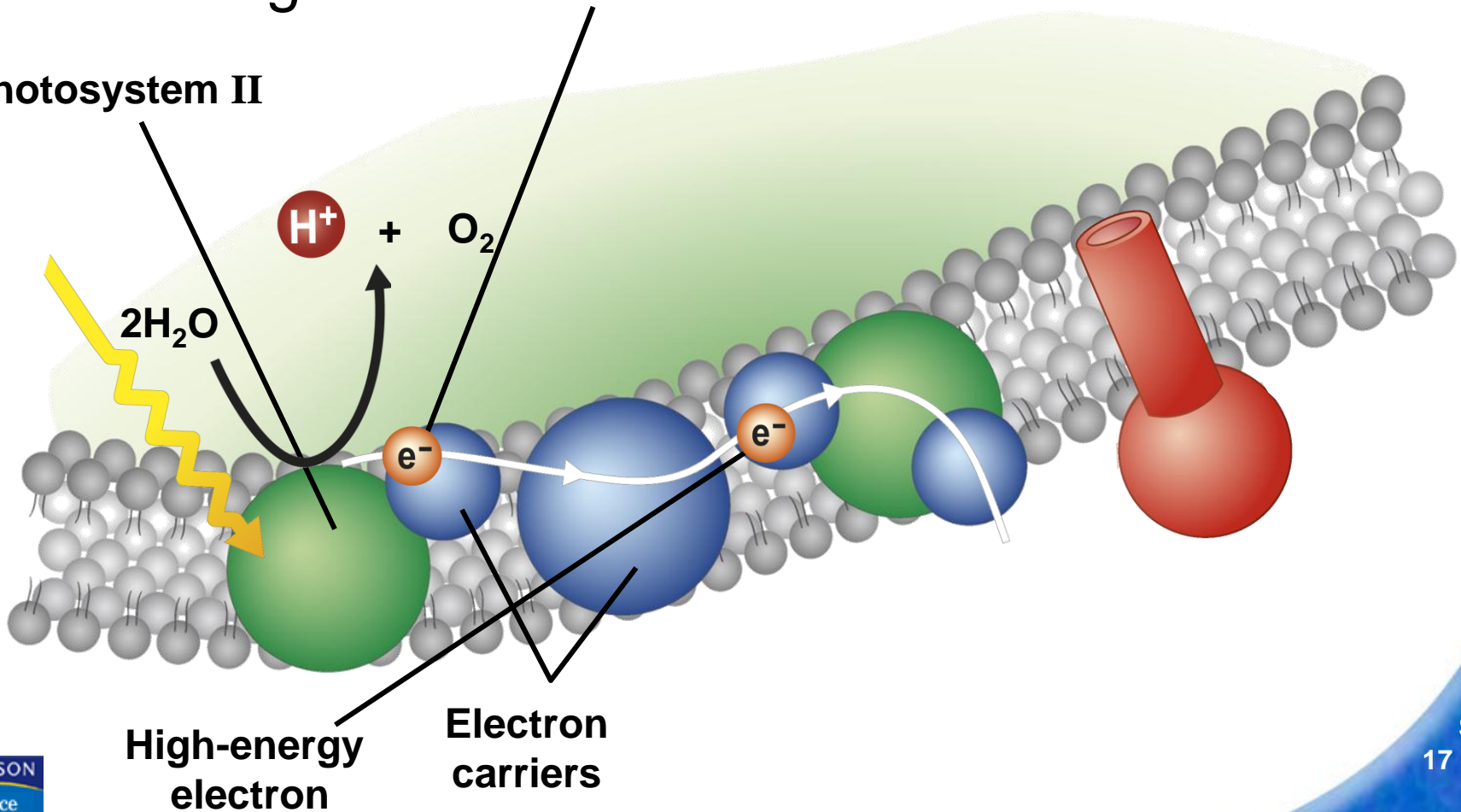
Photosystem II



8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

- hydrogen ions
- oxygen atoms
- energized electrons

Photosystem II



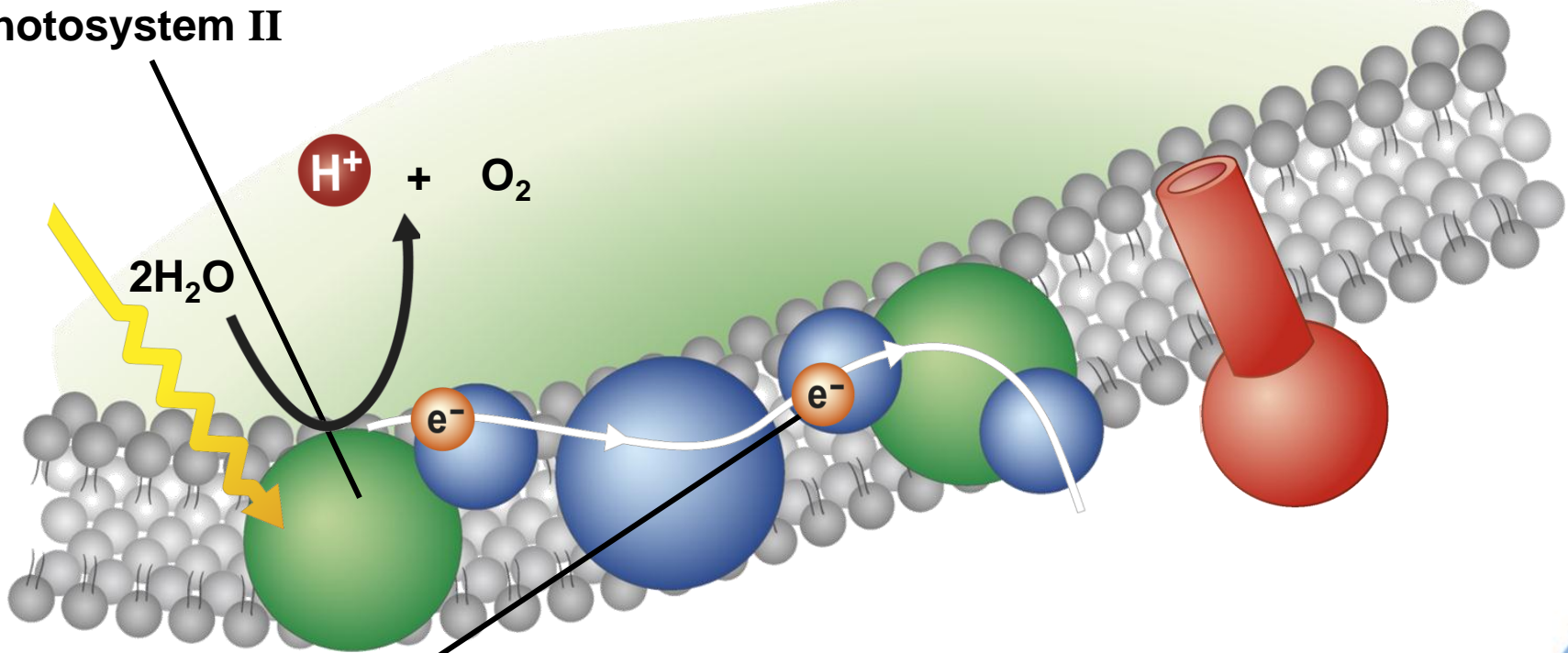
High-energy electron

Electron carriers

8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

The energized electrons from water replace the high-energy electrons that chlorophyll lost to the electron transport chain.

Photosystem II

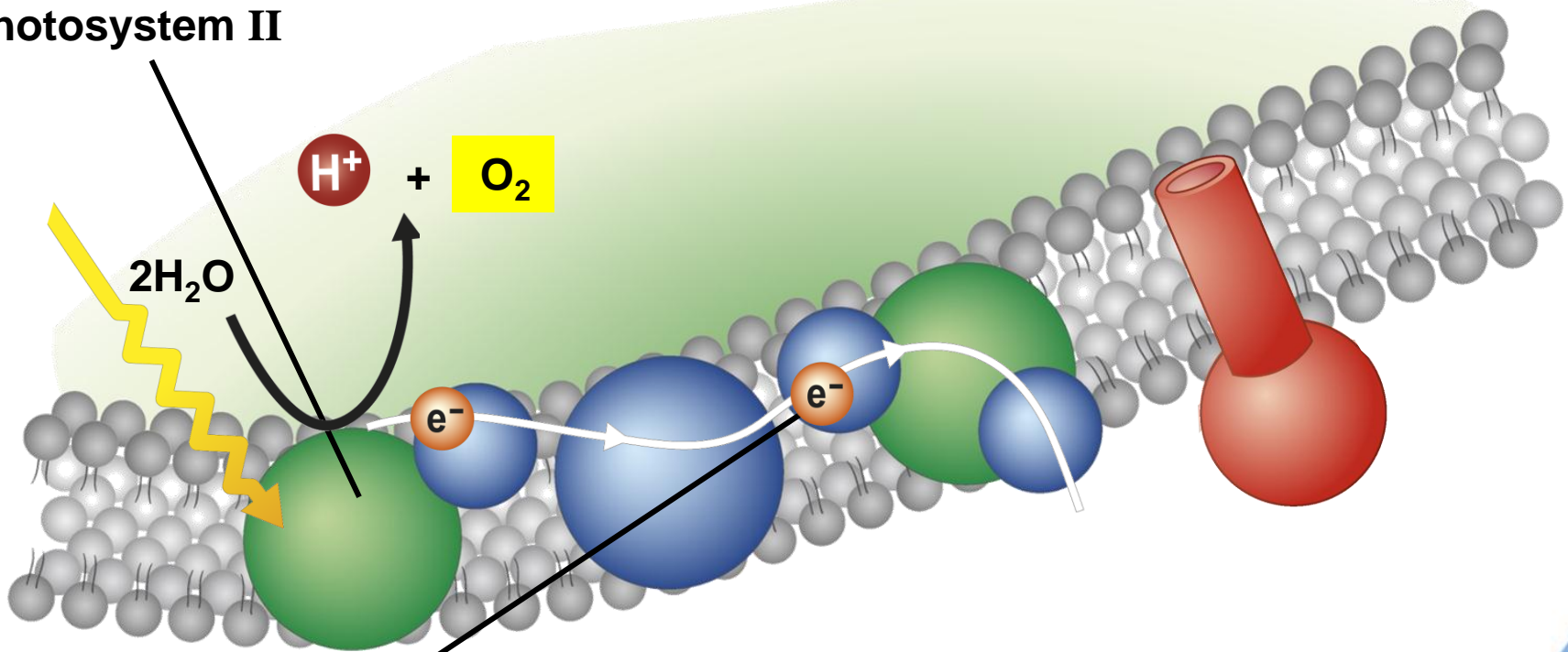


High-energy
electron

8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

As plants remove electrons from water, oxygen is left behind and is released into the air.

Photosystem II

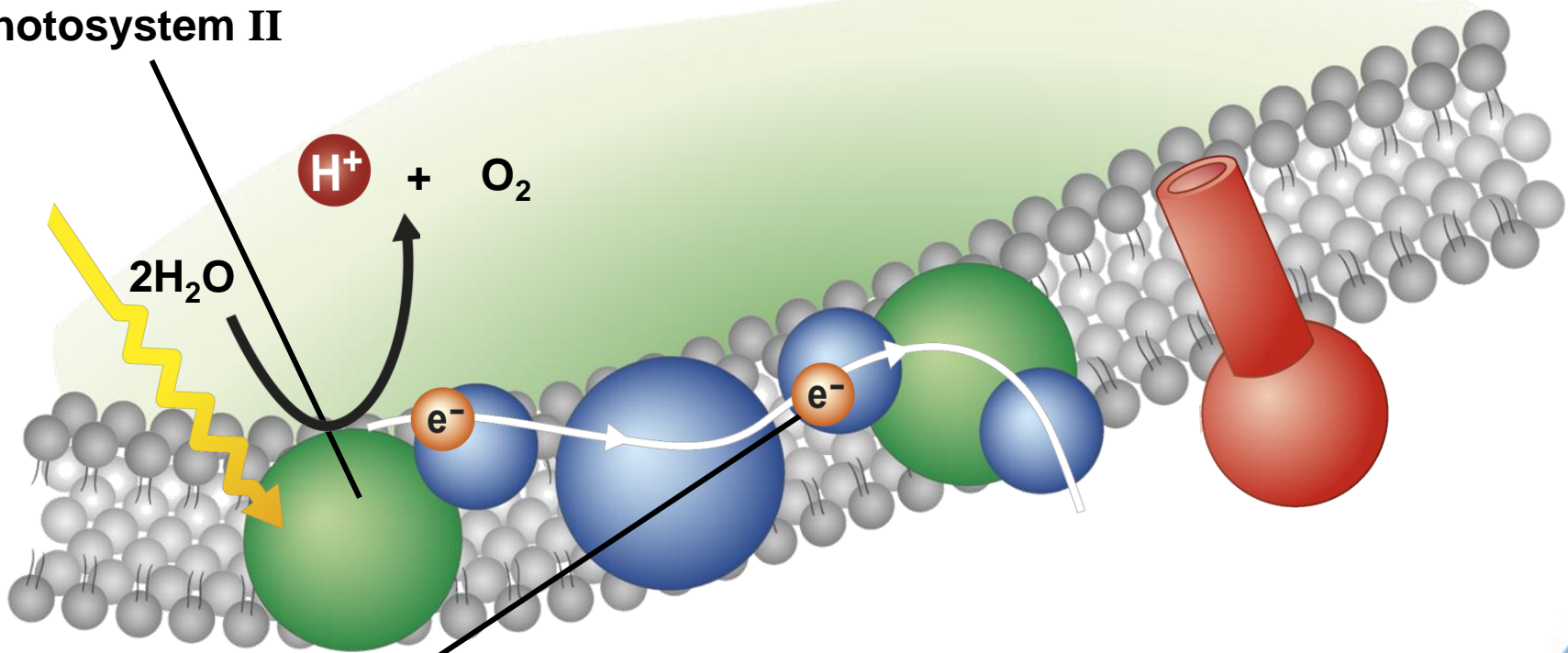


High-energy electron

8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

The hydrogen ions left behind when water is broken apart are released inside the thylakoid membrane.

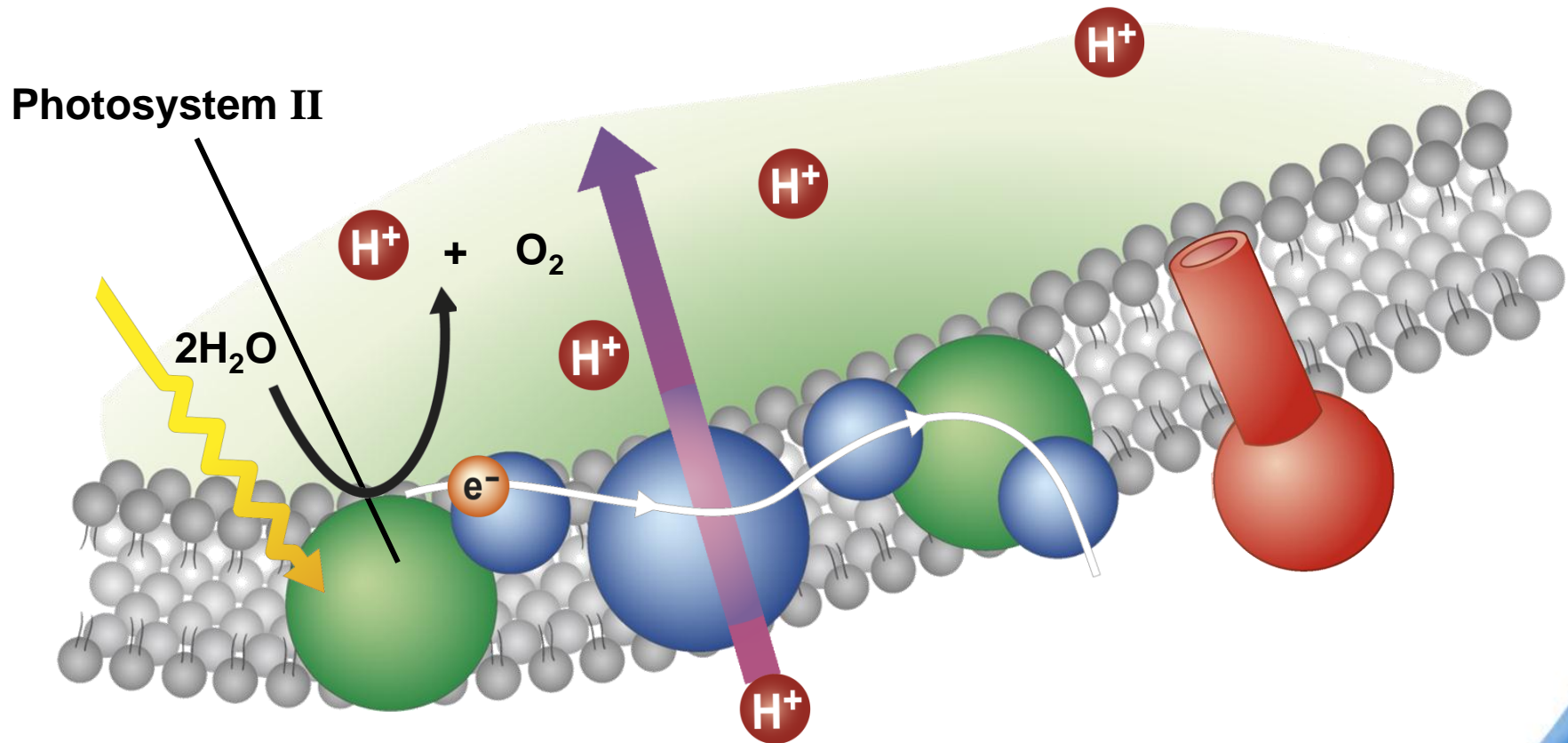
Photosystem II



High-energy
electron

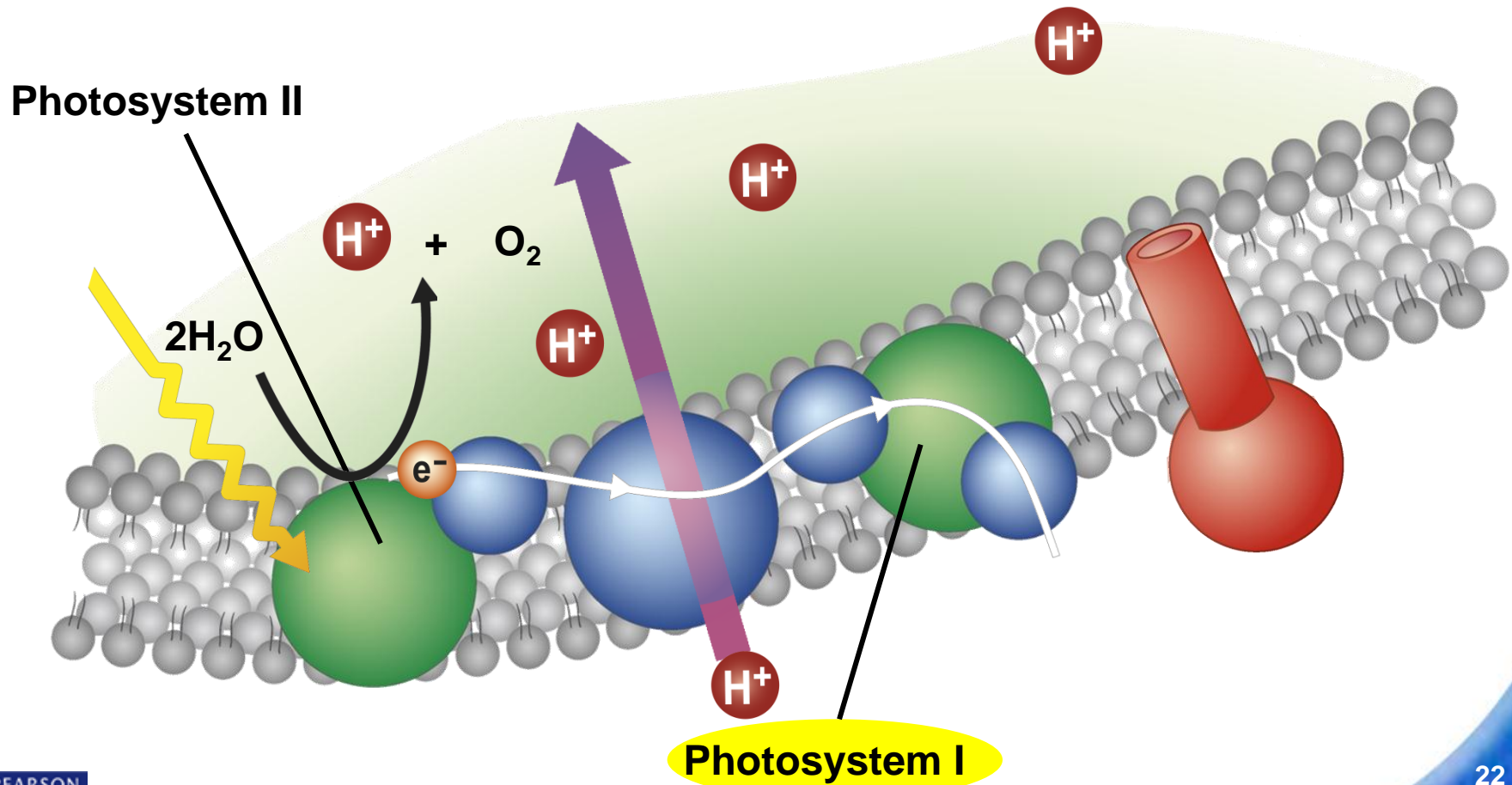
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Energy from the electrons is used to transport H^+ ions from the stroma into the inner thylakoid space.



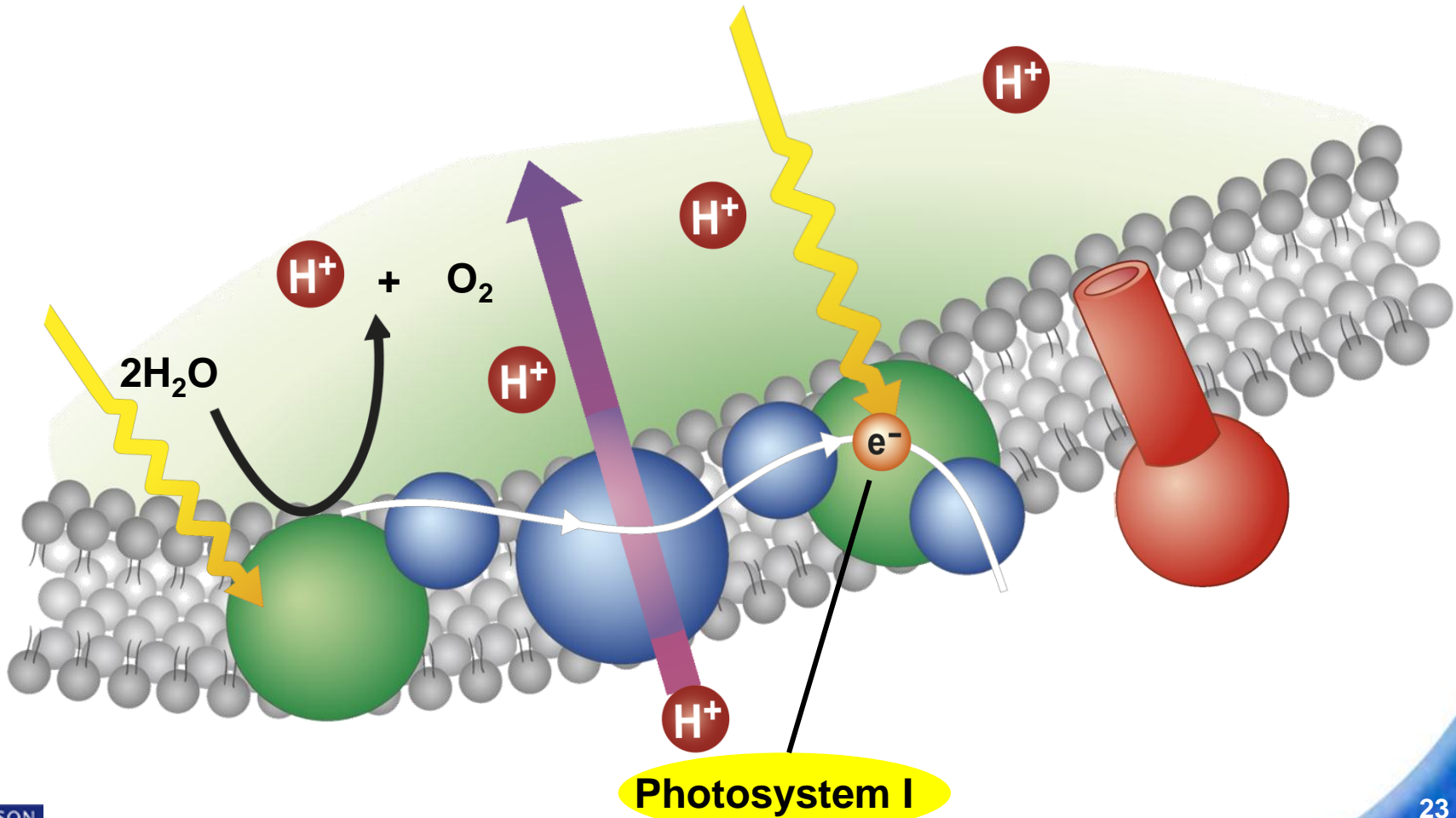
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

High-energy electrons move through the electron transport chain from photosystem II to photosystem I.



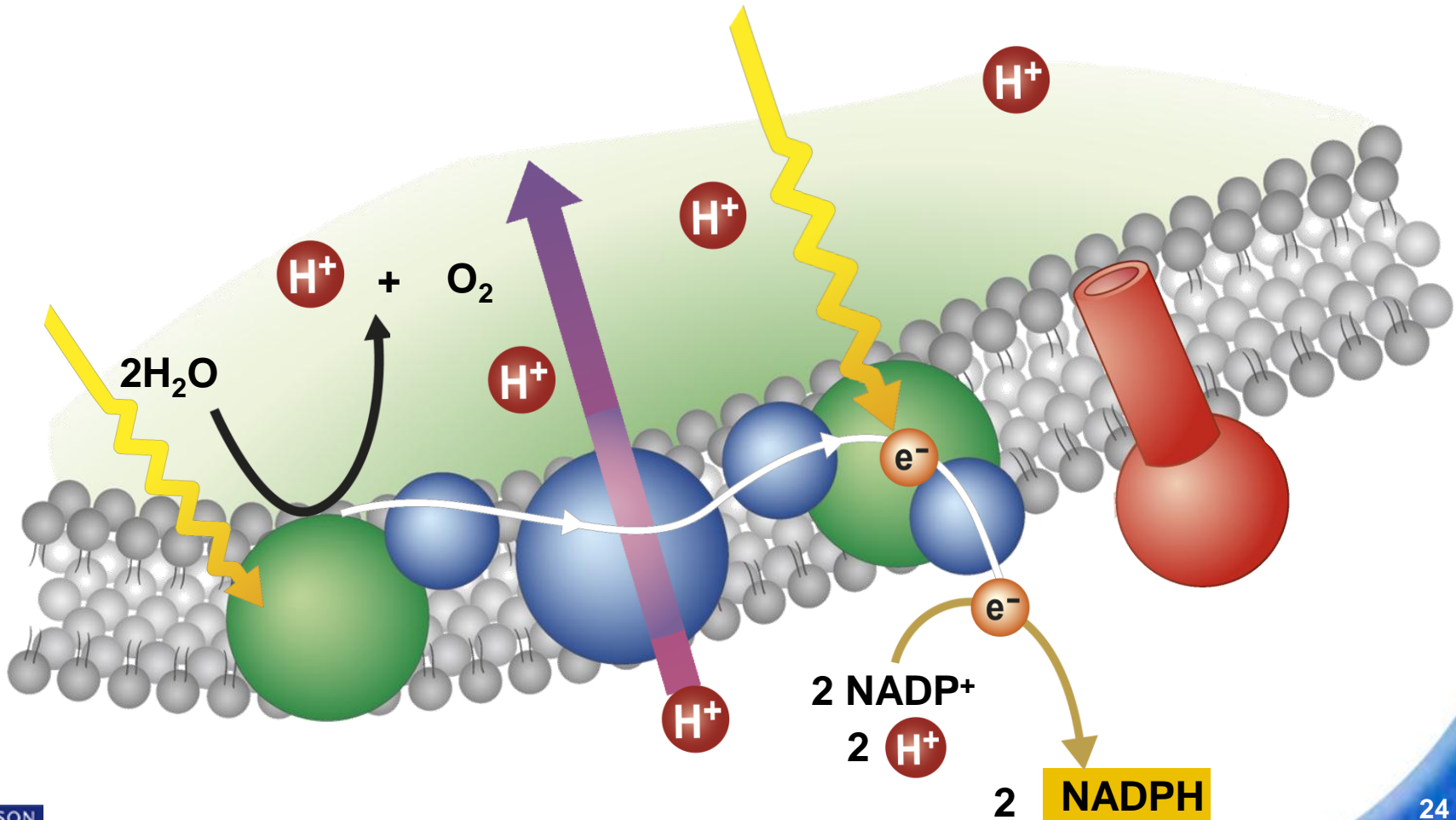
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Pigments in photosystem I use energy from light to re-energize the electrons.



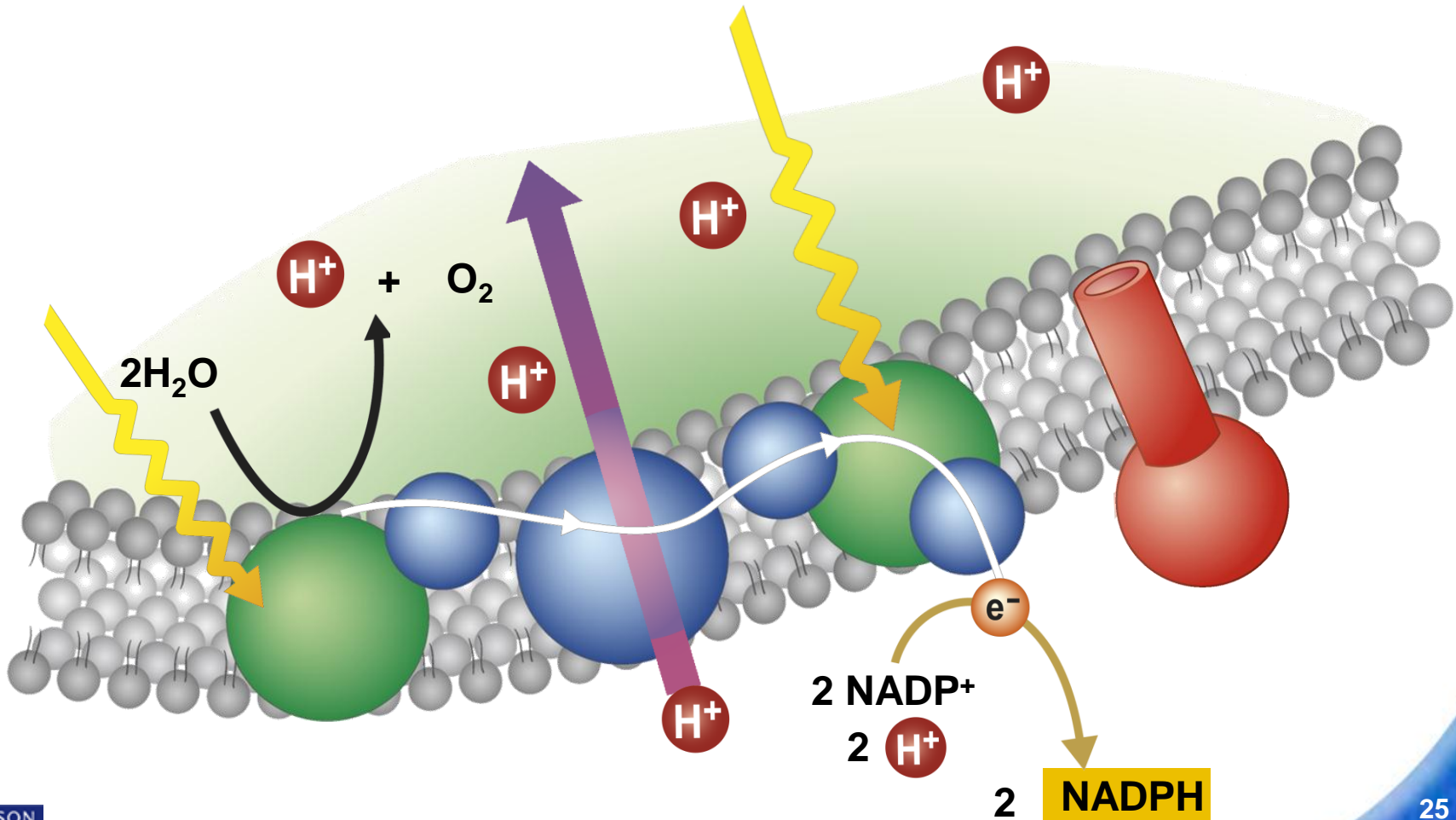
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

NADP⁺ then picks up these high-energy electrons, along with H⁺ ions, and becomes NADPH.



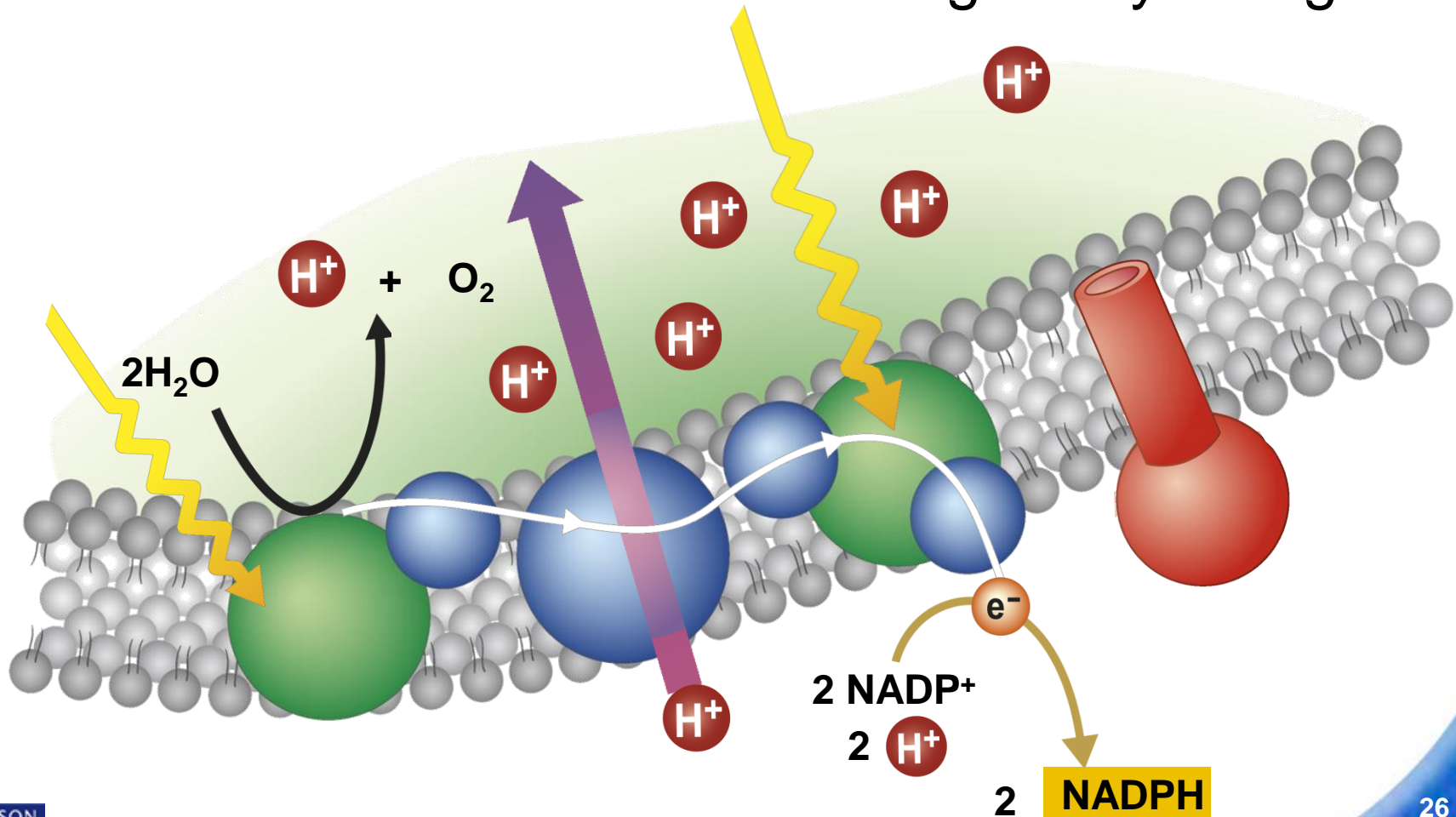
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

As electrons are passed from chlorophyll to NADP⁺, more H⁺ ions are pumped across the membrane.



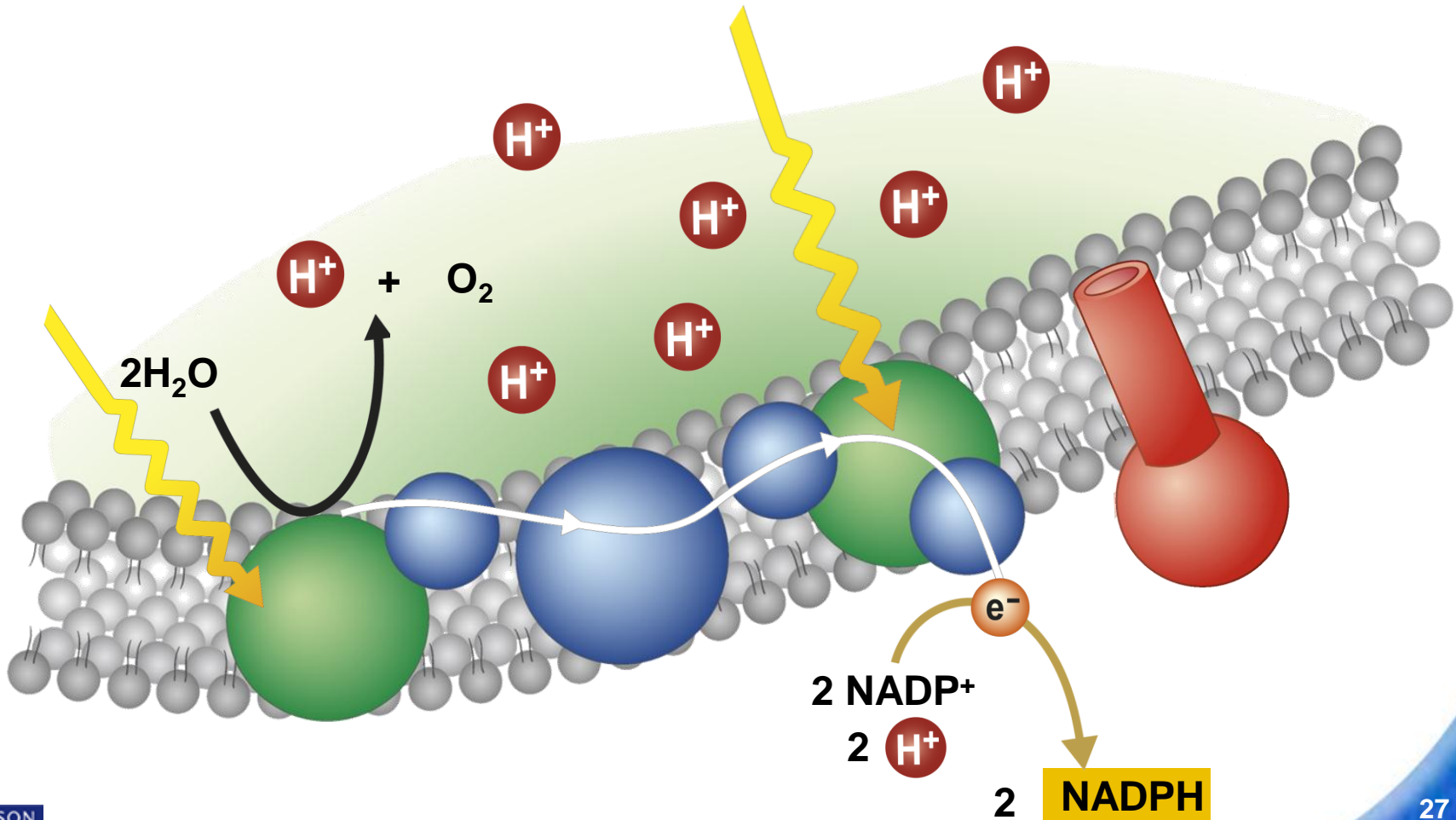
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Soon, the inside of the membrane fills up with positively charged hydrogen ions, which makes the outside of the membrane negatively charged.



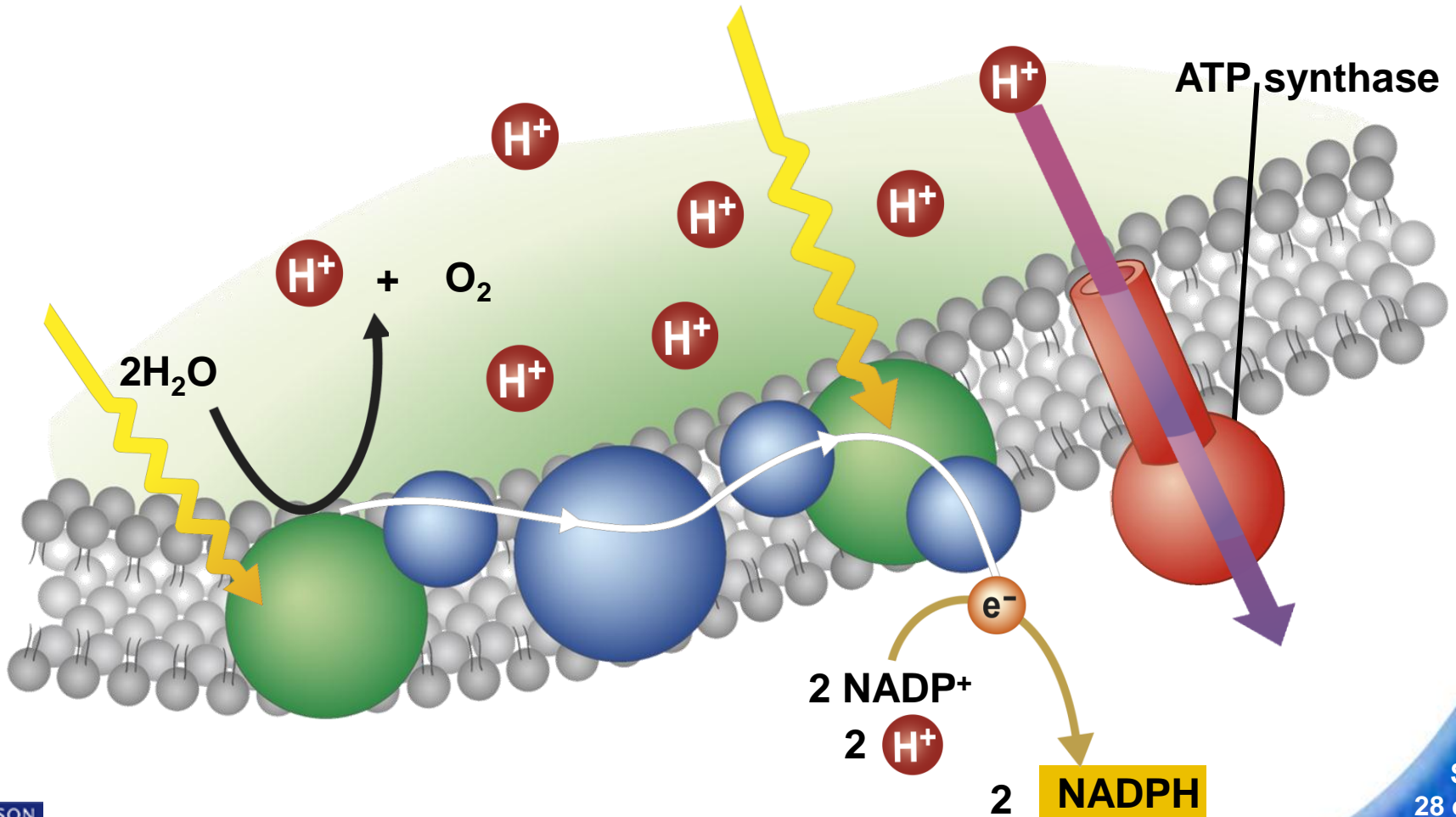
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

The difference in charges across the membrane provides the energy to make ATP.



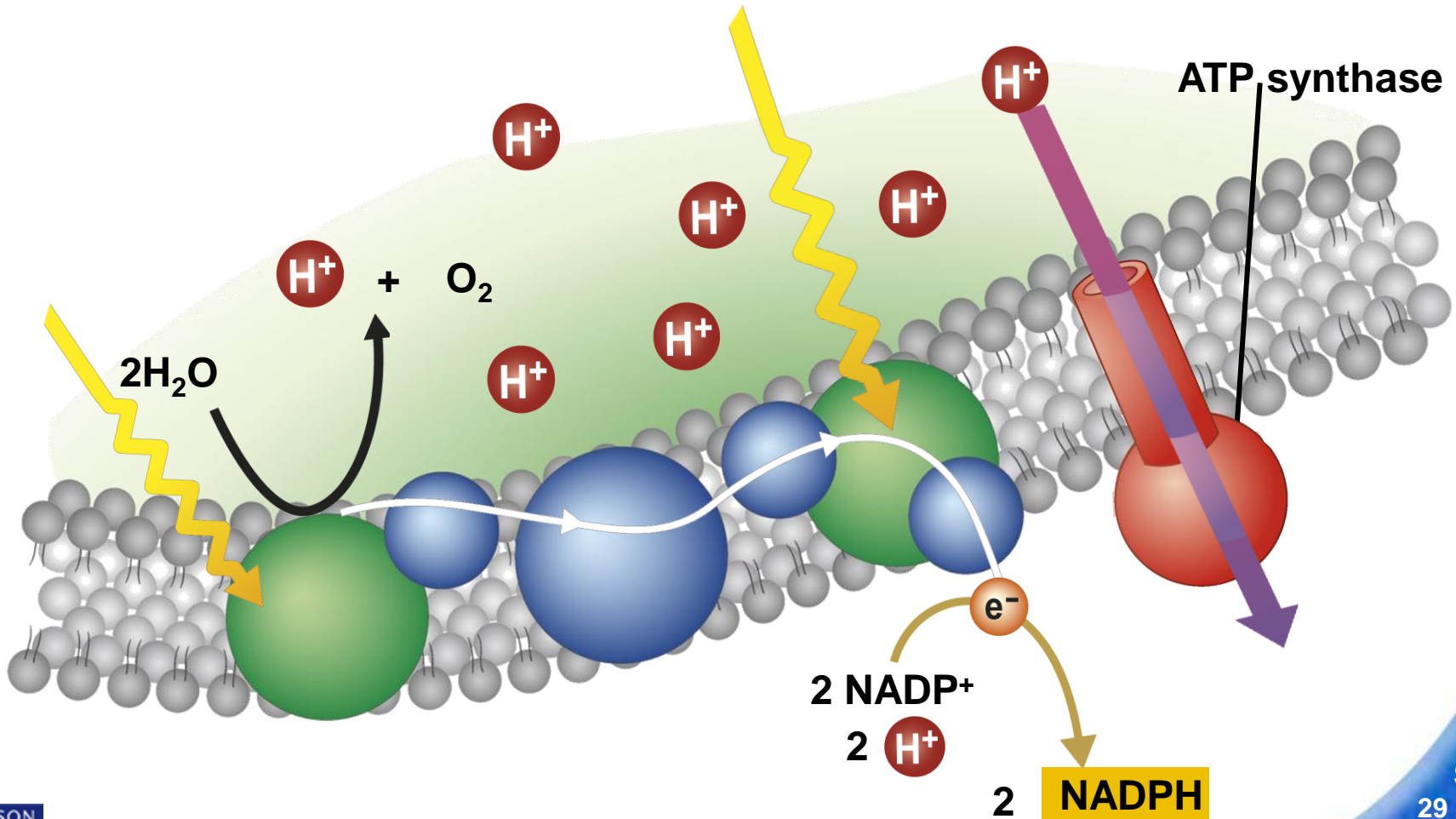
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

H⁺ ions cannot cross the membrane directly.



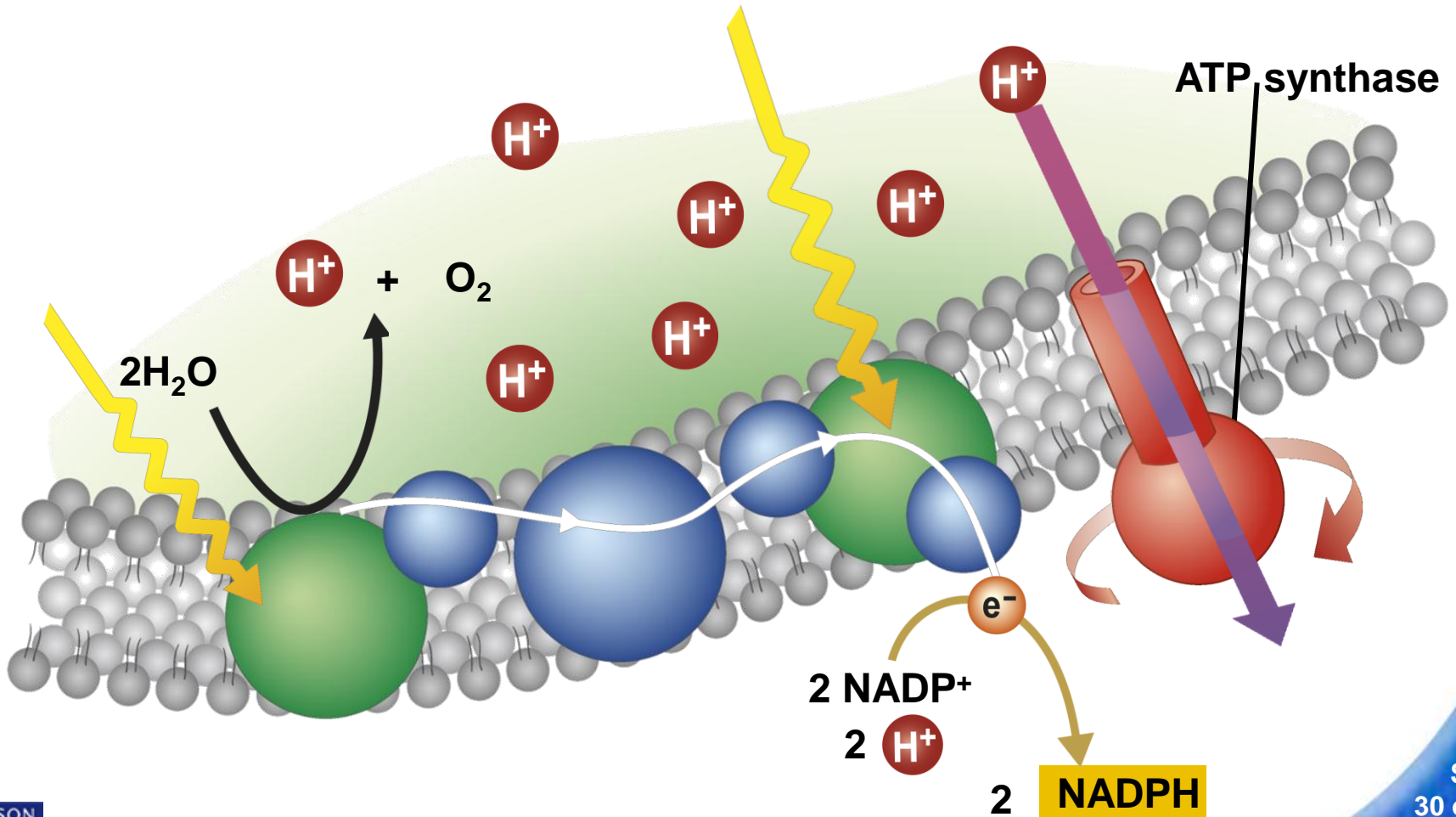
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

The cell membrane contains a protein called **ATP synthase** that allows H^+ ions to pass through it.



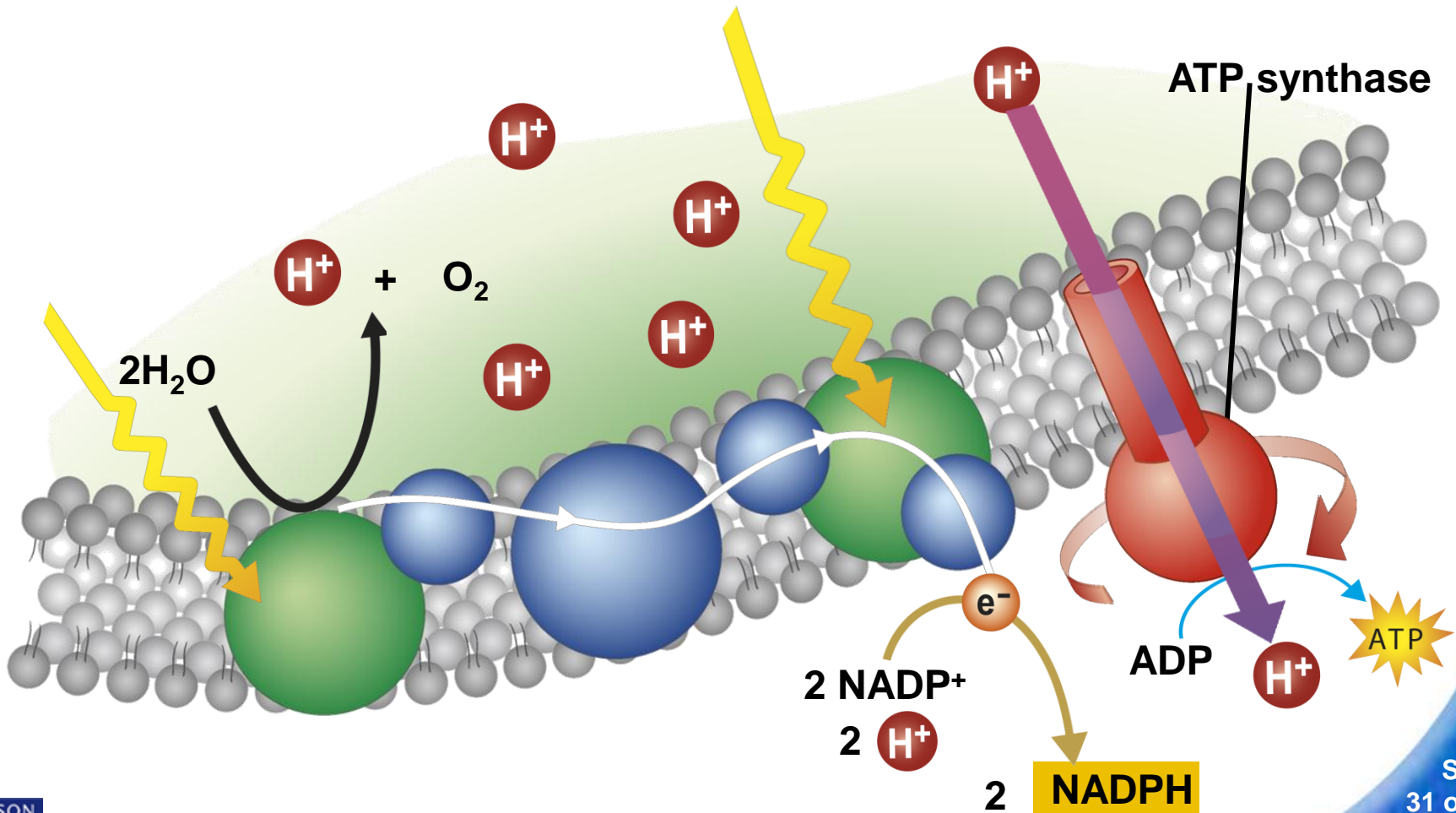
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

As H^+ ions pass through ATP synthase, the protein rotates.



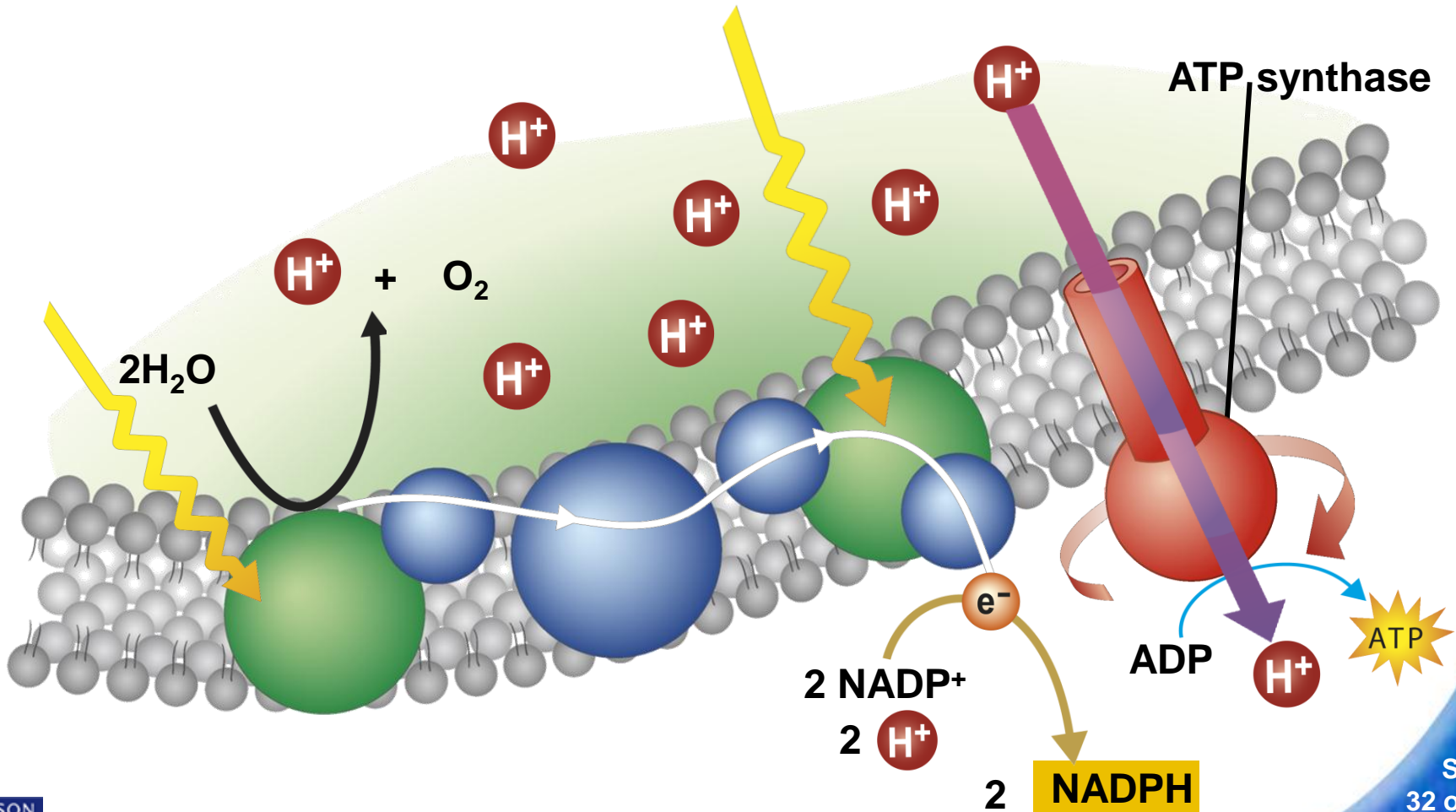
8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

As it rotates, ATP synthase binds ADP and a phosphate group together to produce ATP.



8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

Because of this system, light-dependent electron transport produces not only high-energy electrons but ATP as well.



8-3 The Reactions of Photosynthesis → Light-Dependent Reactions

The light-dependent reactions use water, ADP, and NADP⁺.

The light-dependent reactions produce oxygen, ATP, and NADPH.

These compounds provide the energy to build energy-containing sugars from low-energy compounds.



What is the Calvin cycle?

The Calvin Cycle

ATP and NADPH formed by the light-dependent reactions contain an abundance of chemical energy, but they are not stable enough to store that energy for more than a few minutes.

During the **Calvin cycle** plants use the energy that ATP and NADPH contain to build high-energy compounds that can be stored for a long time.

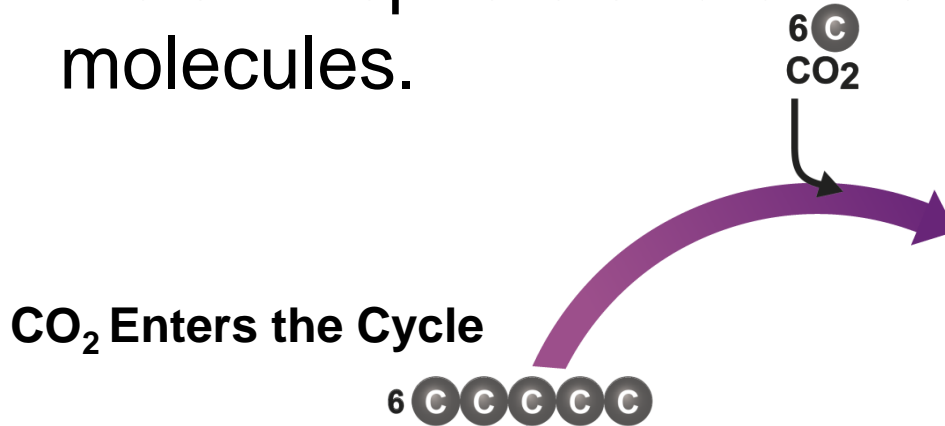


The Calvin cycle uses ATP and NADPH from the light-dependent reactions to produce high-energy sugars.

Because the Calvin cycle does not require light, these reactions are also called the light-independent reactions.

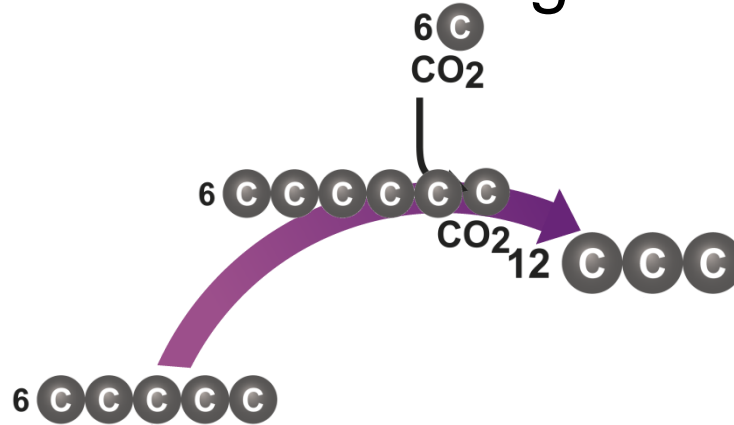
8-3 The Reactions of Photosynthesis → The Calvin Cycle

Six carbon dioxide molecules enter the cycle from the atmosphere and combine with six 5-carbon molecules.



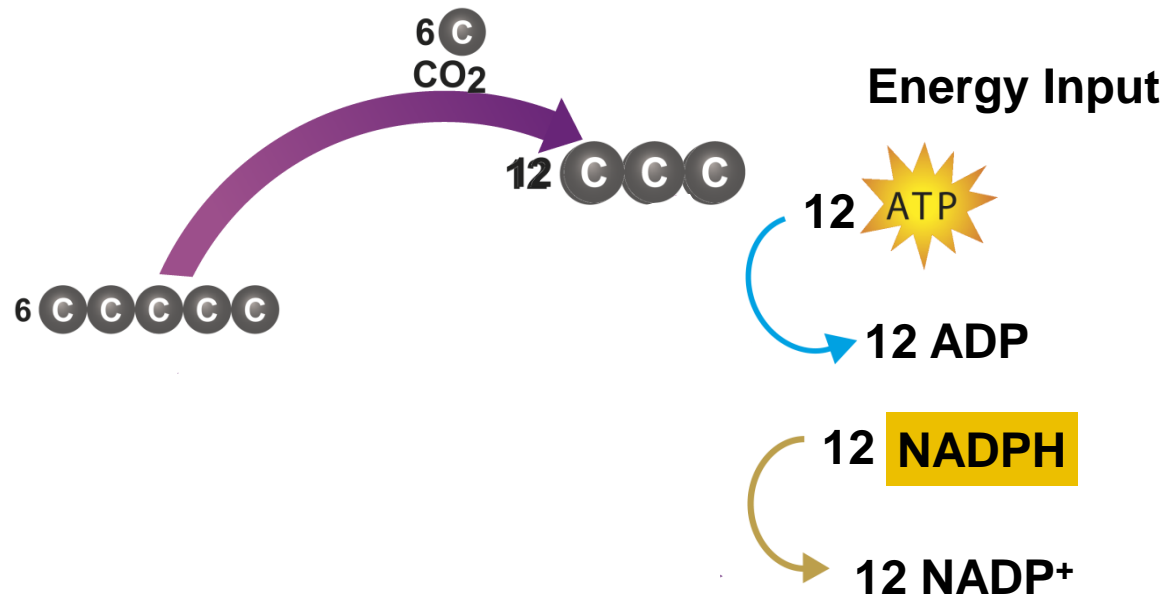
8-3 The Reactions of Photosynthesis → The Calvin Cycle

The result is twelve 3-carbon molecules, which are then converted into higher-energy forms.



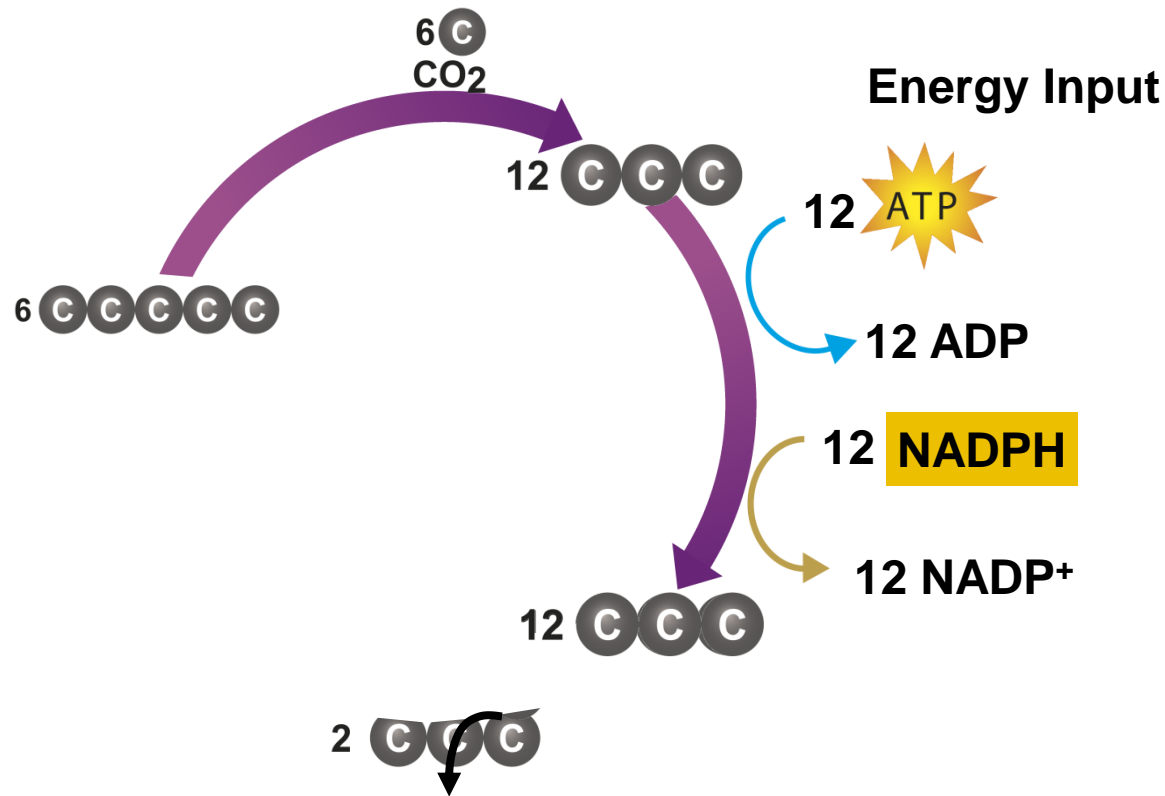
8-3 The Reactions of Photosynthesis → The Calvin Cycle

The energy for this conversion comes from ATP and high-energy electrons from NADPH.



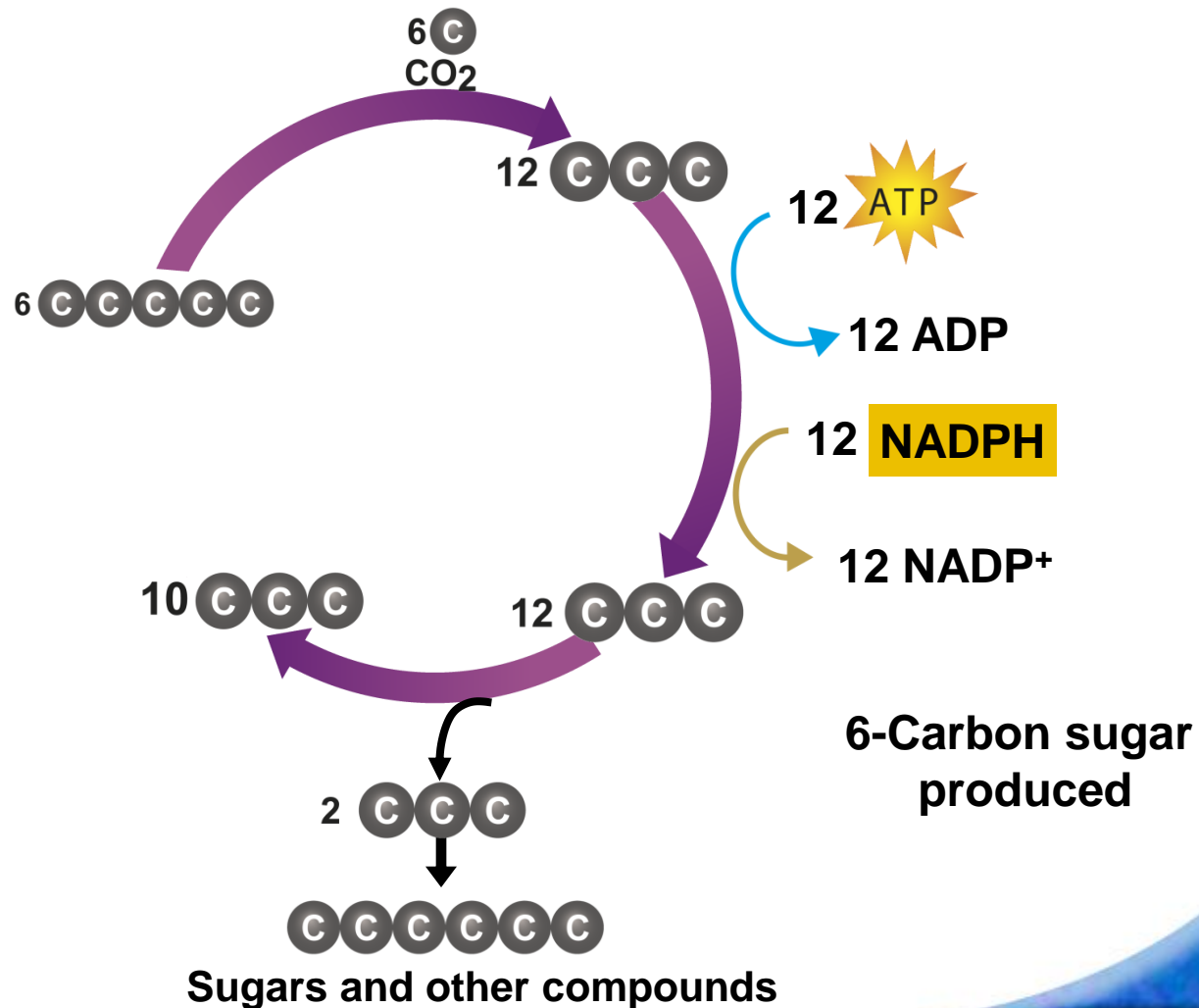
8-3 The Reactions of Photosynthesis → The Calvin Cycle

Two of twelve 3-carbon molecules are removed from the cycle.



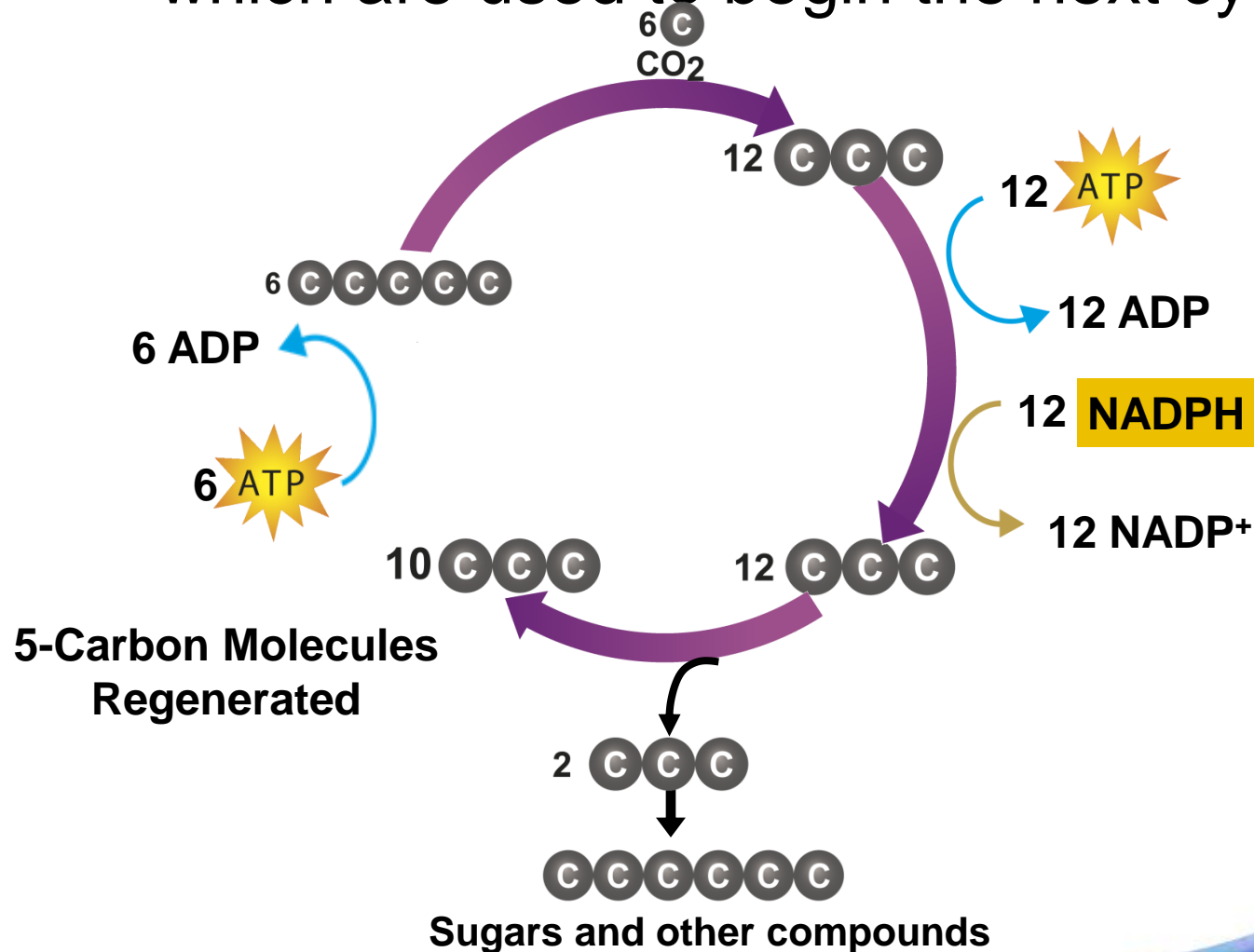
8-3 The Reactions of Photosynthesis → The Calvin Cycle

The molecules are used to produce sugars, lipids, amino acids and other compounds.



8-3 The Reactions of Photosynthesis → The Calvin Cycle

The 10 remaining 3-carbon molecules are converted back into six 5-carbon molecules, which are used to begin the next cycle.



The two sets of photosynthetic reactions work together.

- The light-dependent reactions trap sunlight energy in chemical form.
- The light-independent reactions use that chemical energy to produce stable, high-energy sugars from carbon dioxide and water.

Factors Affecting Photosynthesis

Many factors affect the rate of photosynthesis, including:

- Water
- Temperature
- Intensity of light

8-3 Section QUIZ

Continue to:

Section QUIZ

- or -

Click to Launch:



8-3 Section QUIZ

- 1 In plants, photosynthesis takes place inside the
- a. thylakoids.
 - A b. chloroplasts.**
 - c. photosystems.
 - d. chlorophyll.

8-3 Section QUIZ

2 Energy to make ATP in the chloroplast comes most directly from

A a. hydrogen ions flowing through an enzyme in the thylakoid membrane.

b. transfer of a phosphate from ADP.

c. electrons moving through the electron transport chain.

d. electrons transferred directly from NADPH.

8-3 Section QUIZ

3 NADPH is produced in light-dependent reactions and carries energy in the form of

a. ATP.

A b. high-energy electrons.

c. low-energy electrons.

d. ADP.

8-3 Section QUIZ

4 What is another name for the Calvin cycle?

a. light-dependent reactions

A b. light-independent reactions

c. electron transport chain

d. photosynthesis

8-3 Section QUIZ

5 Which of the following factors does NOT directly affect photosynthesis?

A

a. wind

b. water supply

c. temperature

d. light intensity

END OF SECTION