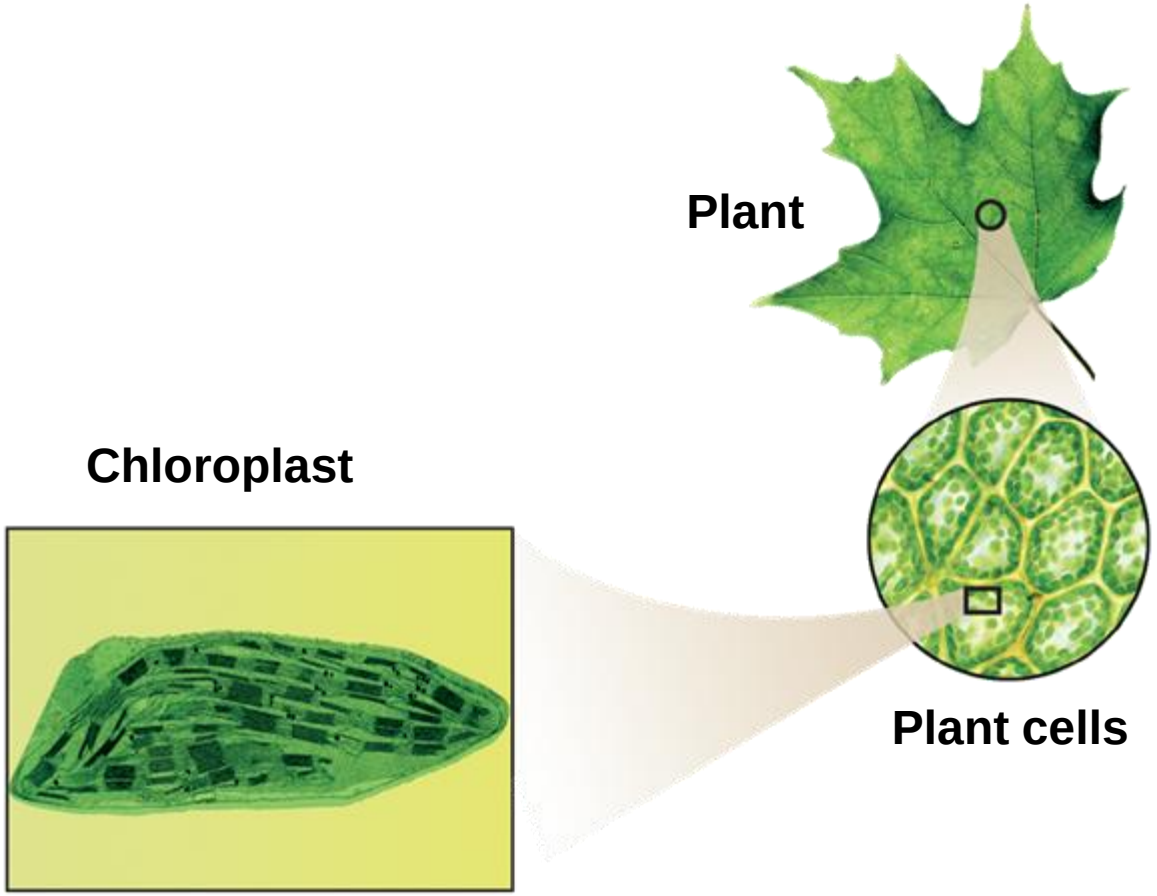
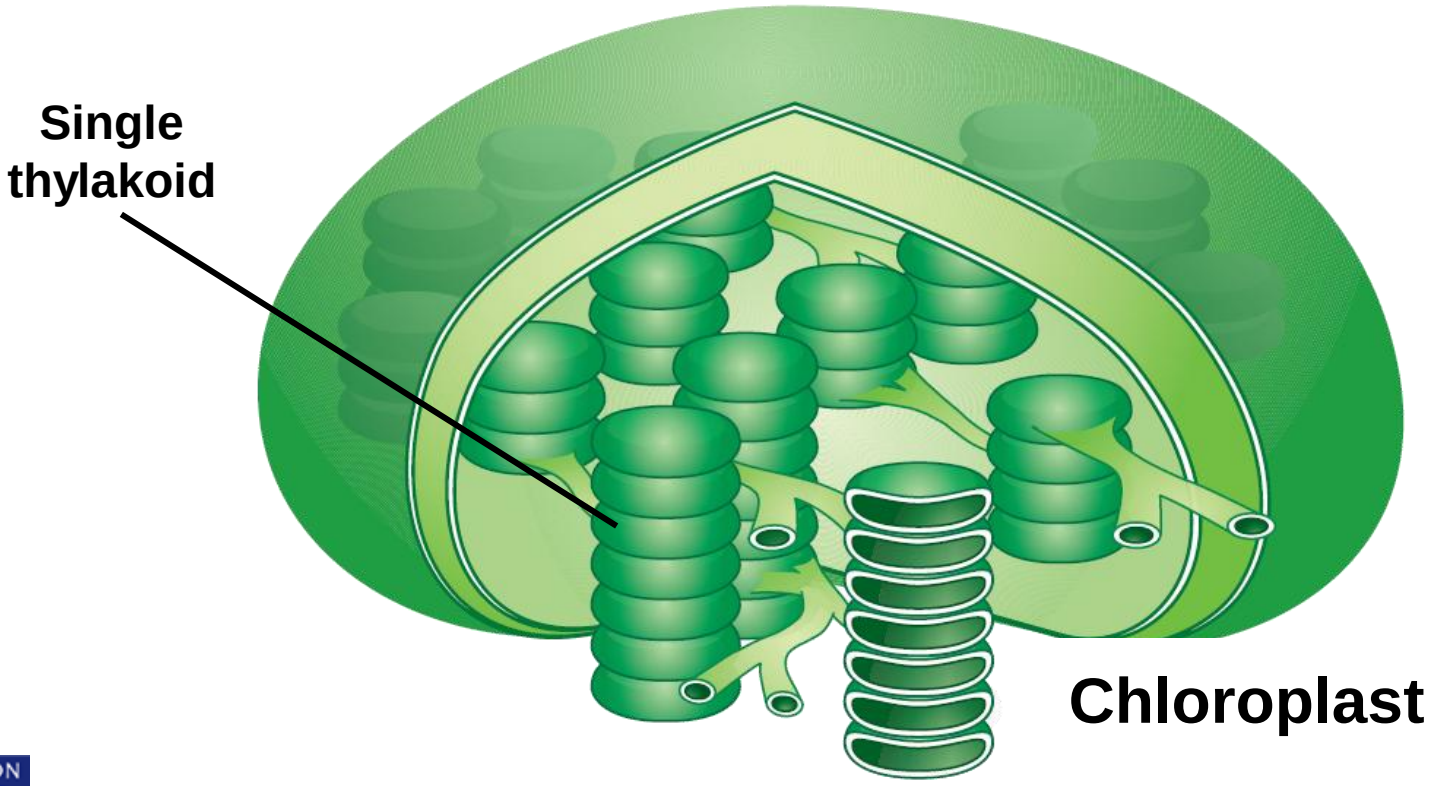
8-3 The Reactions of Photosynthesis

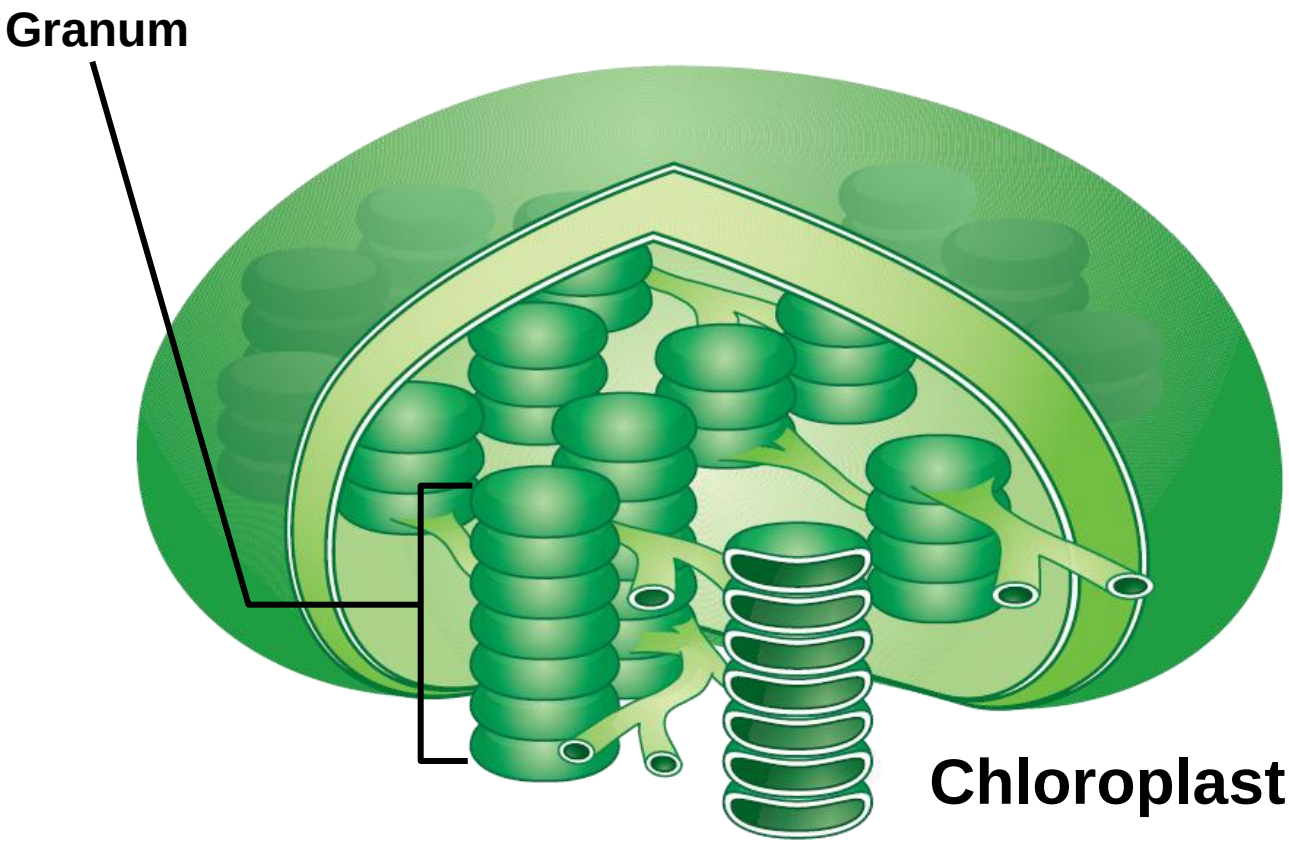
Inside a Chloroplast



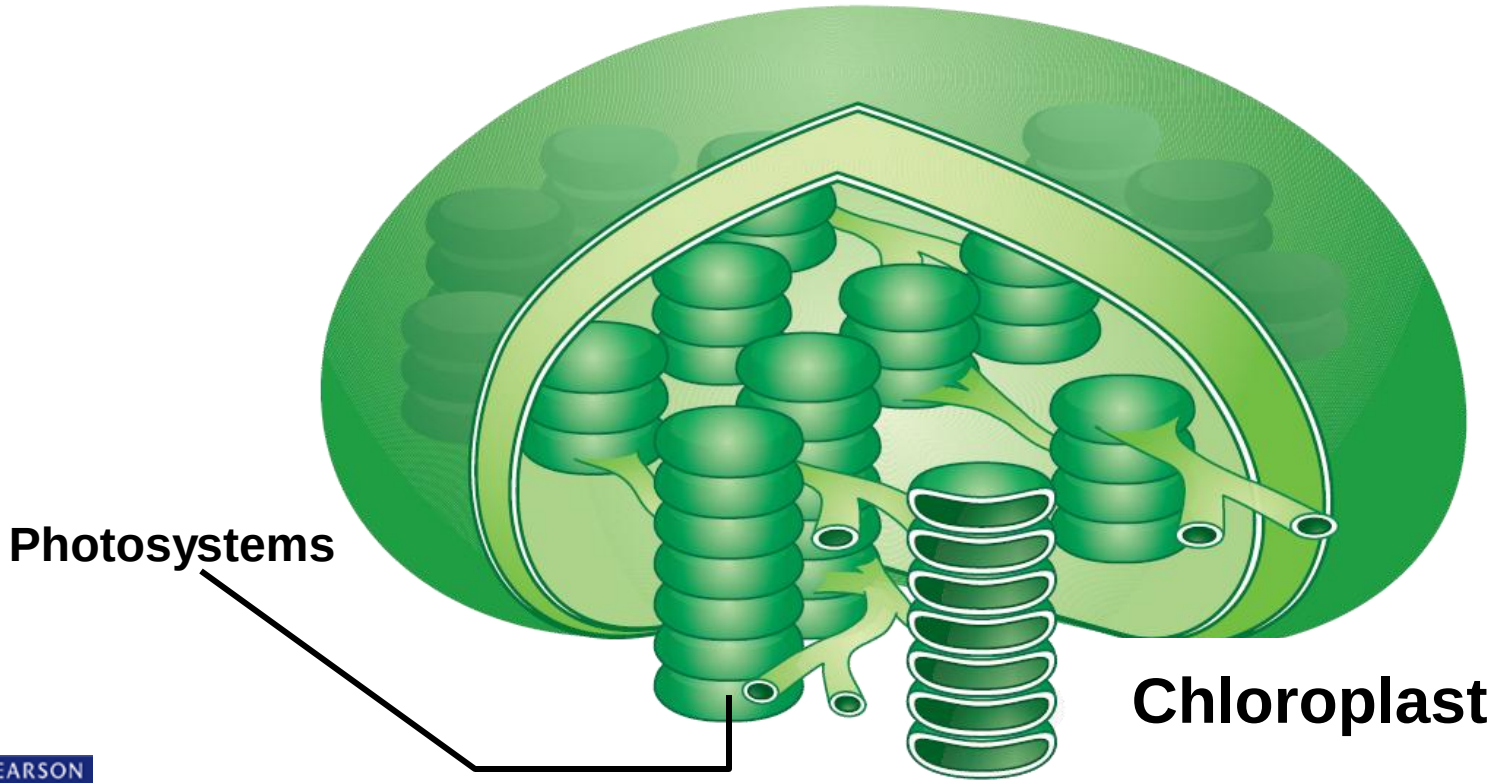
Thylakoids—saclike photosynthetic membranes.



Thylakoids →arranged in stacks - grana.



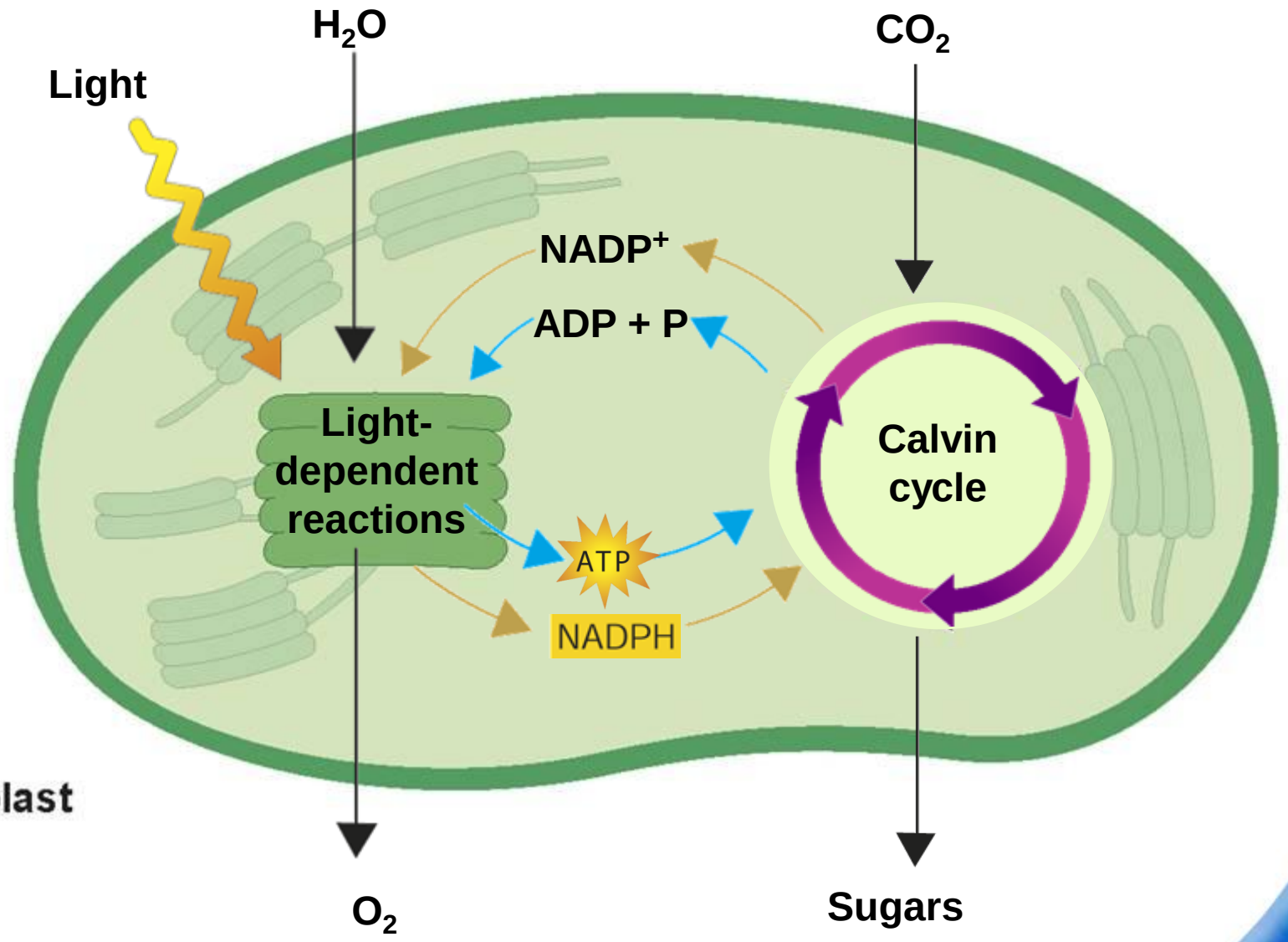
Photosystems,→light-collecting units



Light-dependent reactions →thylakoid membranes.

Calvin cycle (light independent) → **stroma**,

-outside the thylakoid membranes.



Electron Carriers

Electrons absorb sunlight, gain energy.

-used to transport high-energy electrons to other molecules.

One carrier molecule is **$NADP^+$**.

$NADP^+ \rightarrow NADPH$

$NADP^+$ accepts and holds 2 high-energy electrons along with a hydrogen ion (H^+).

-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.

-used to help build a variety of molecules including carbohydrates like glucose.

Light-Dependent Reactions

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

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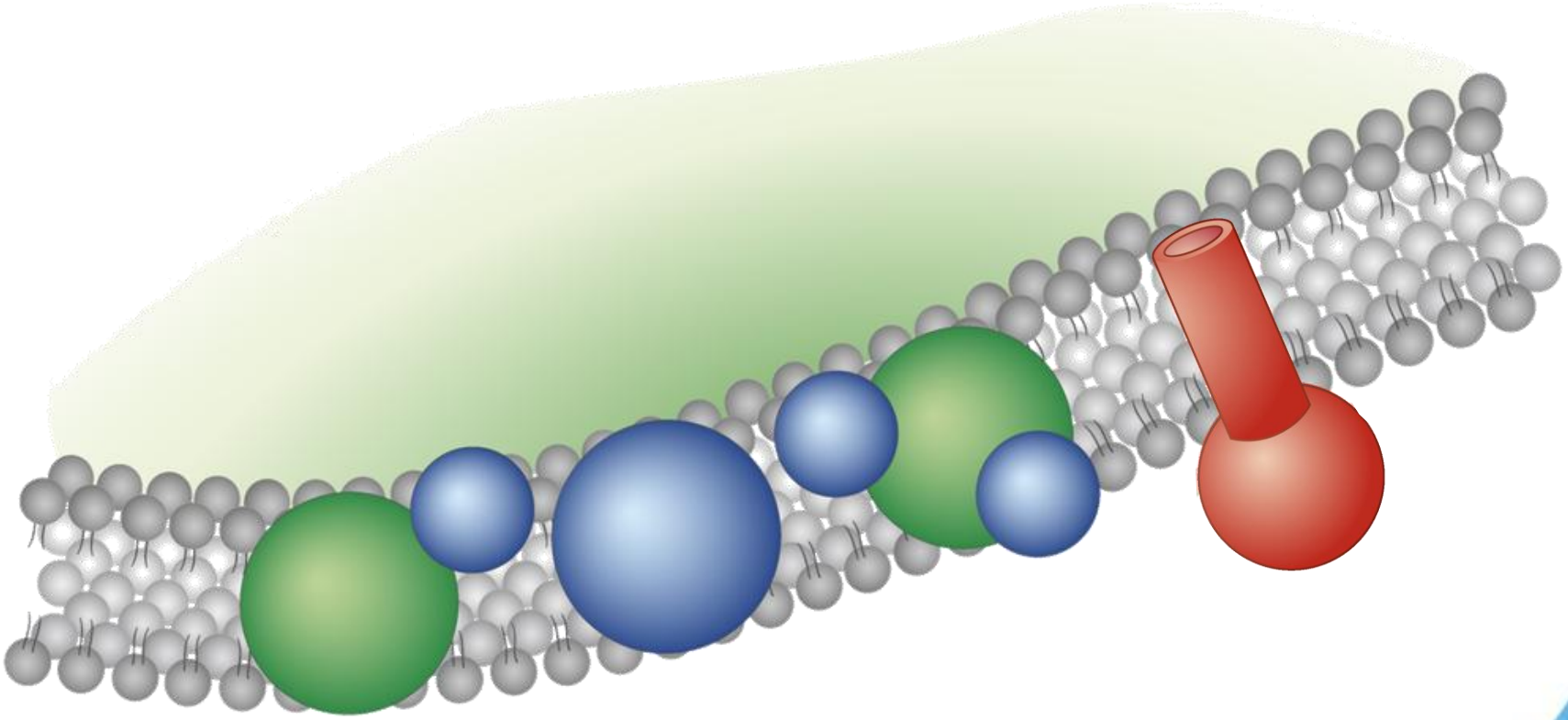
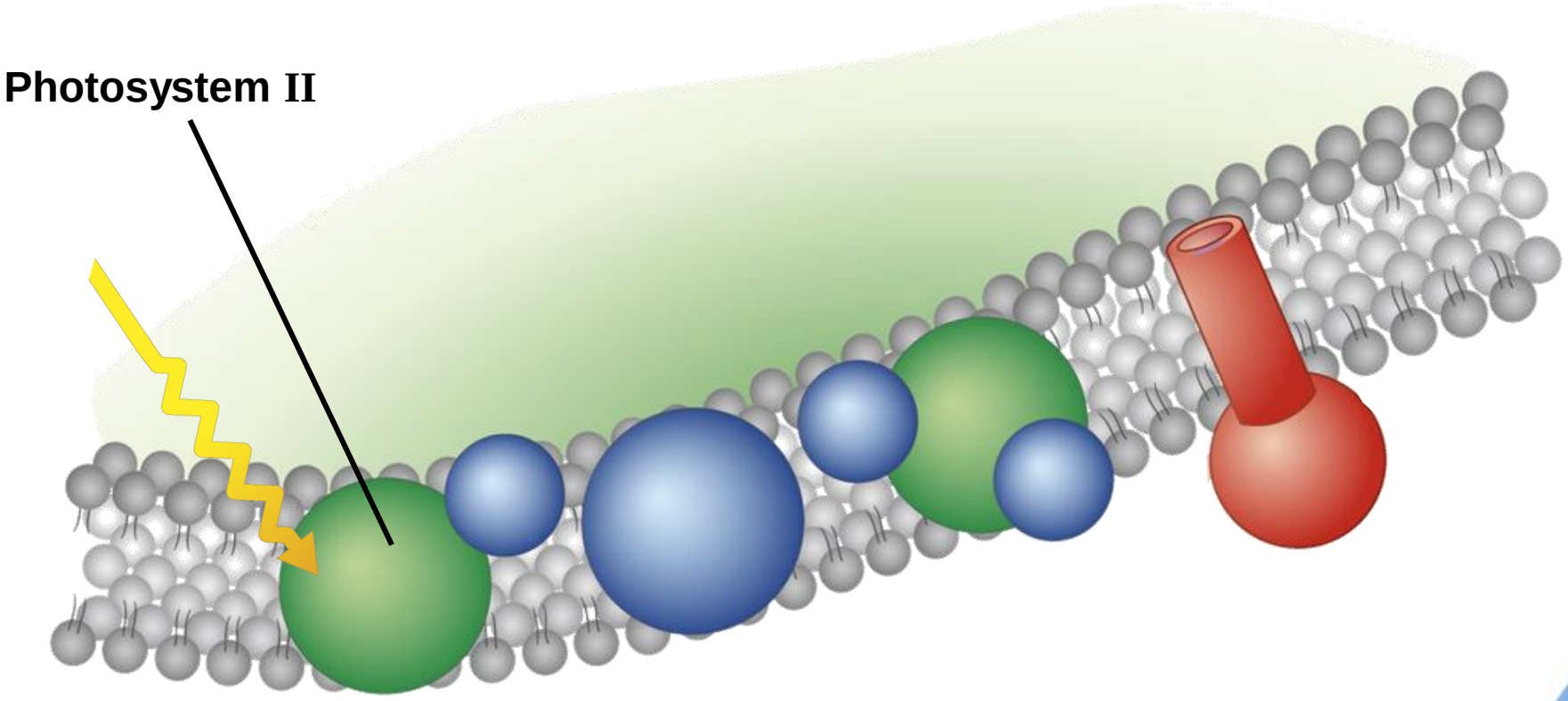
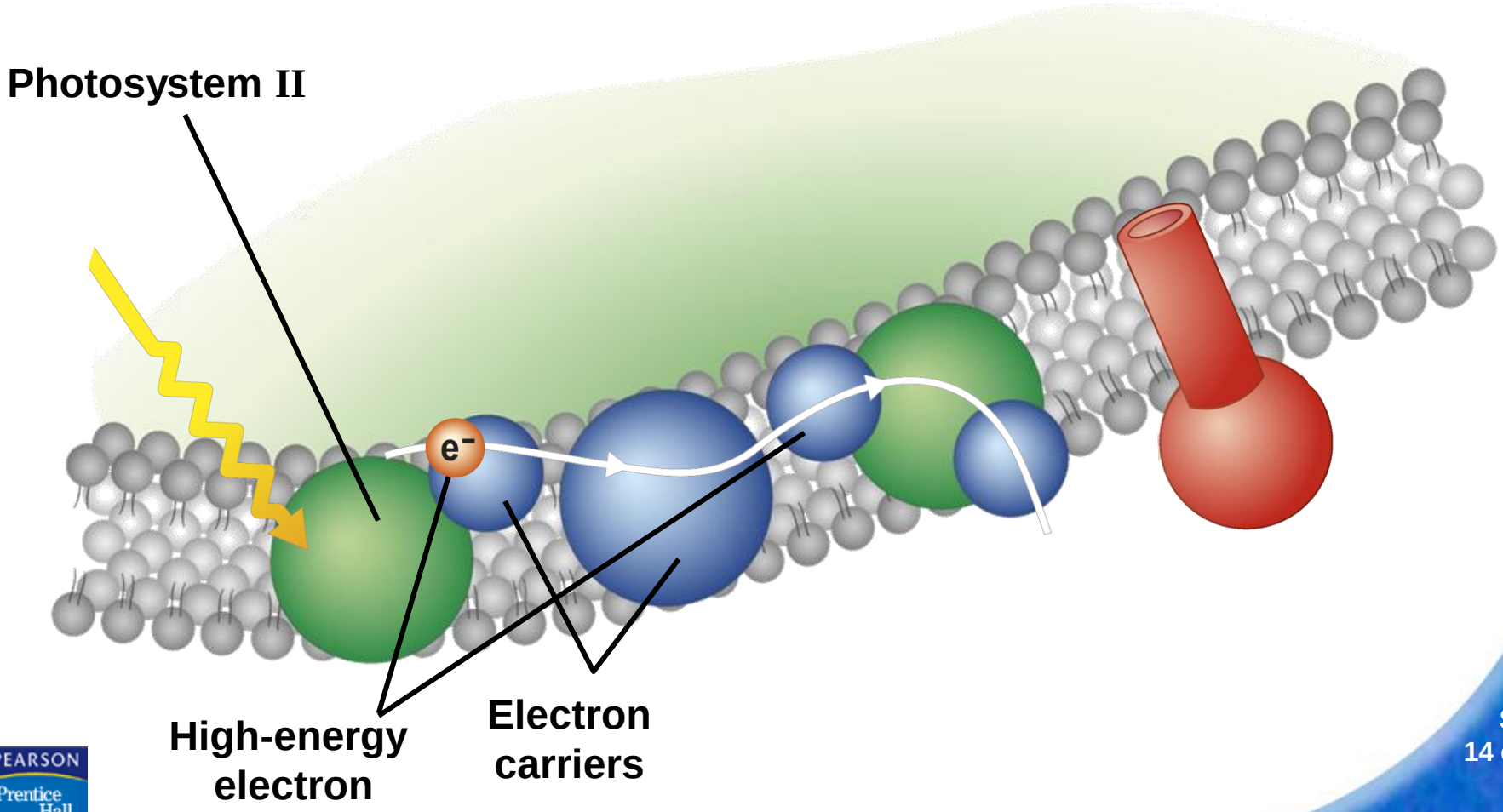


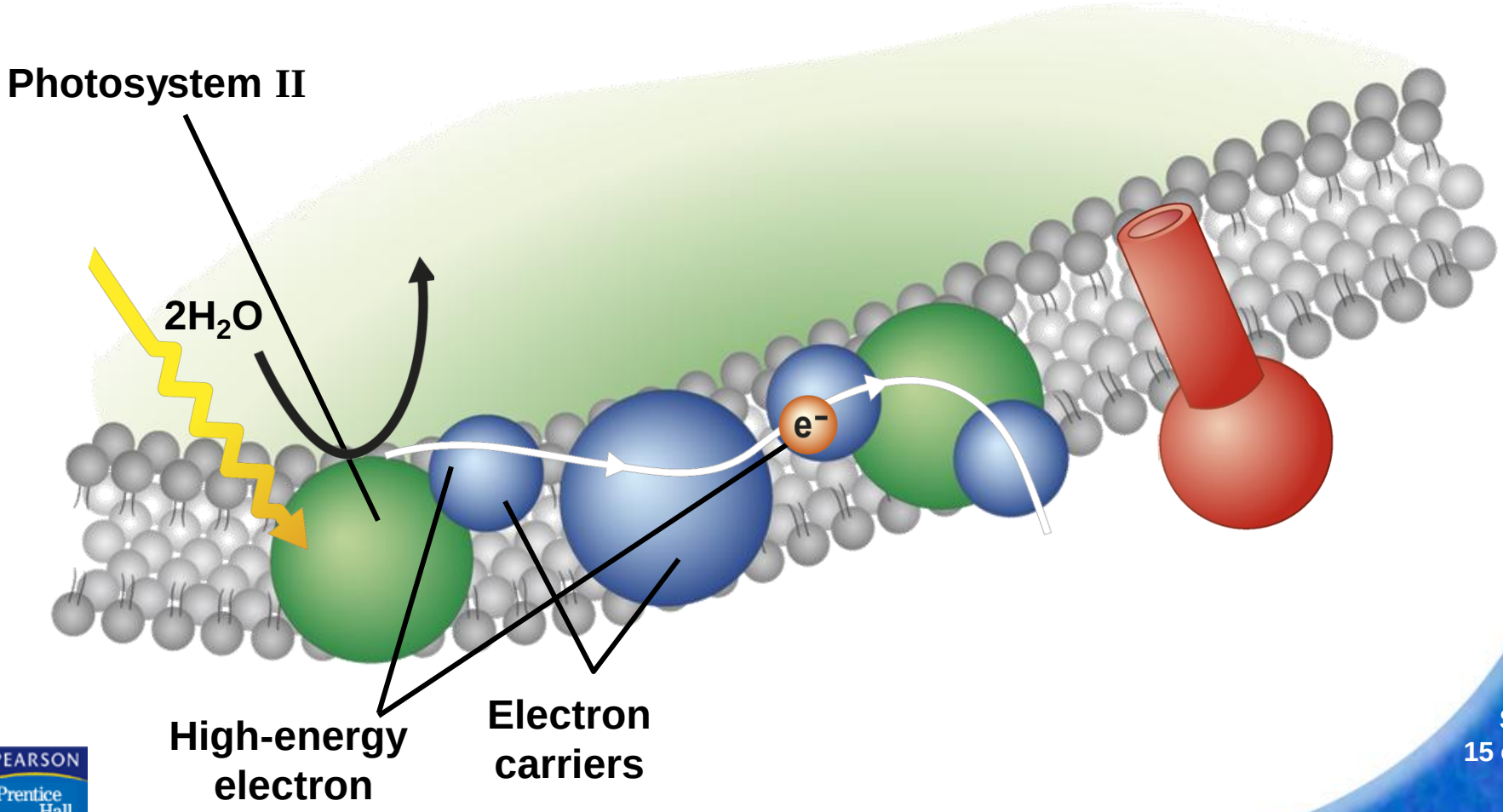
Photosynthesis begins when pigments in photosystem II absorb light, increasing their energy level.



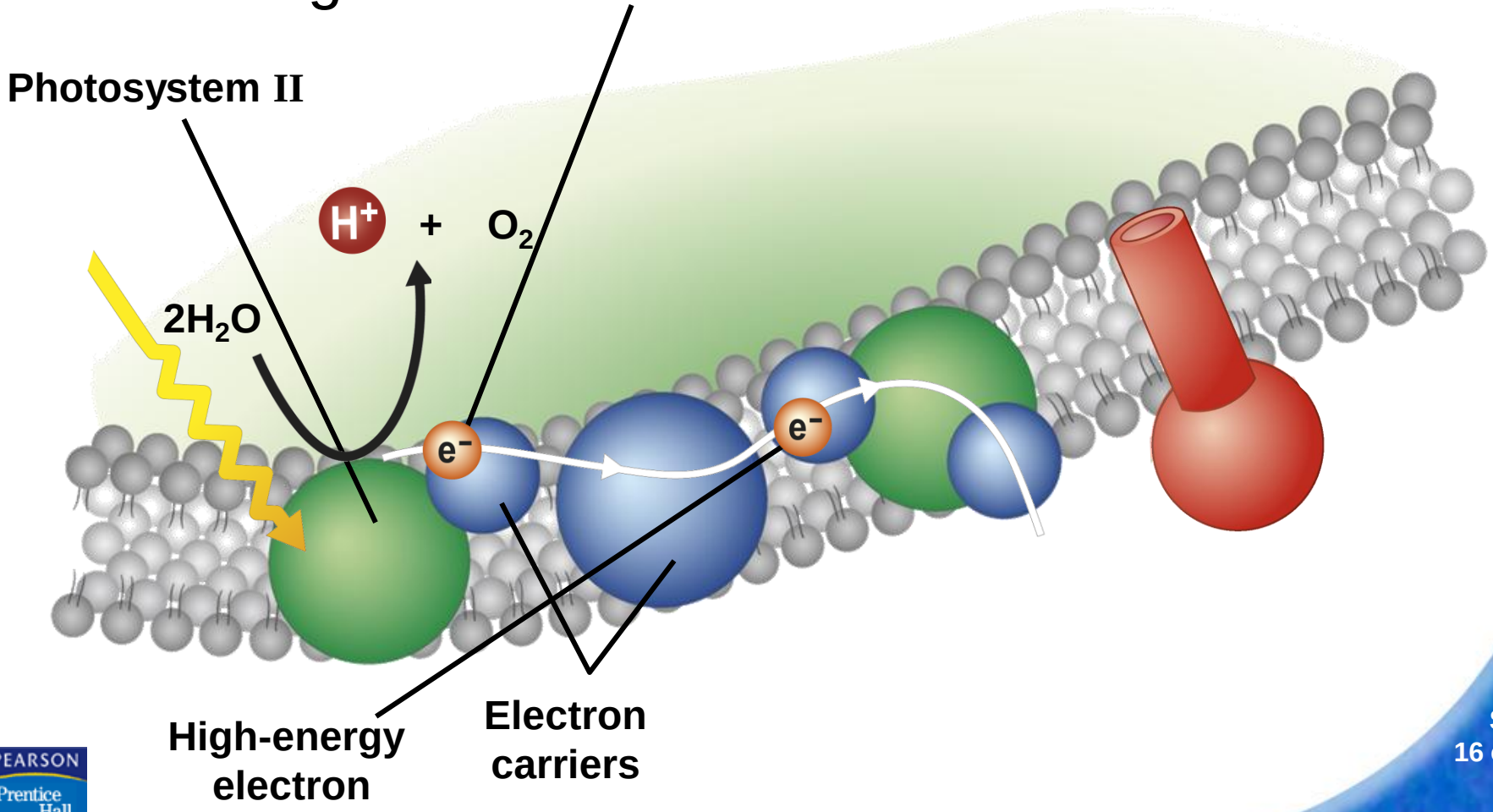
These high-energy electrons are passed on to the electron transport chain.



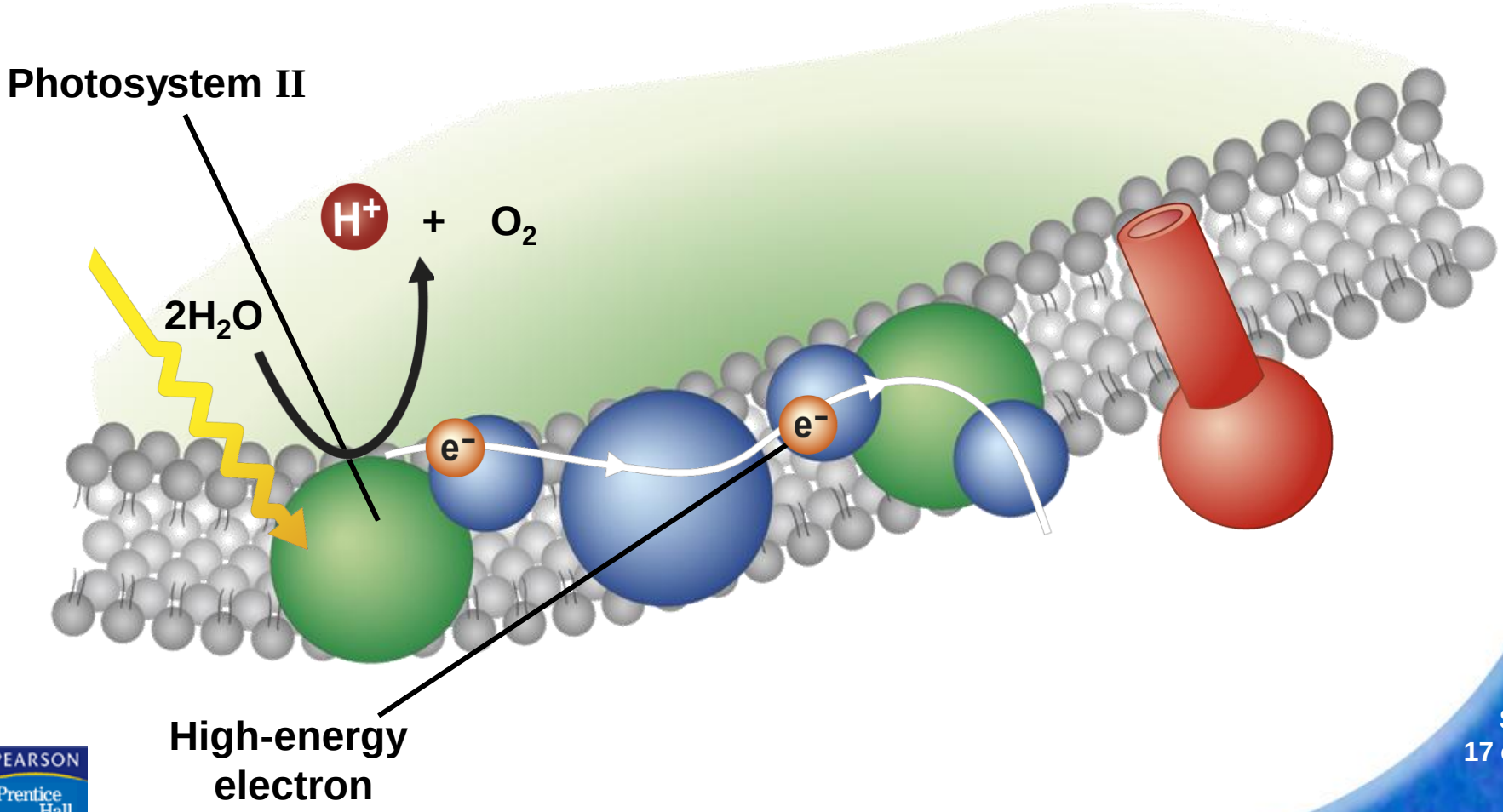
Enzymes on the thylakoid membrane break water molecules into:



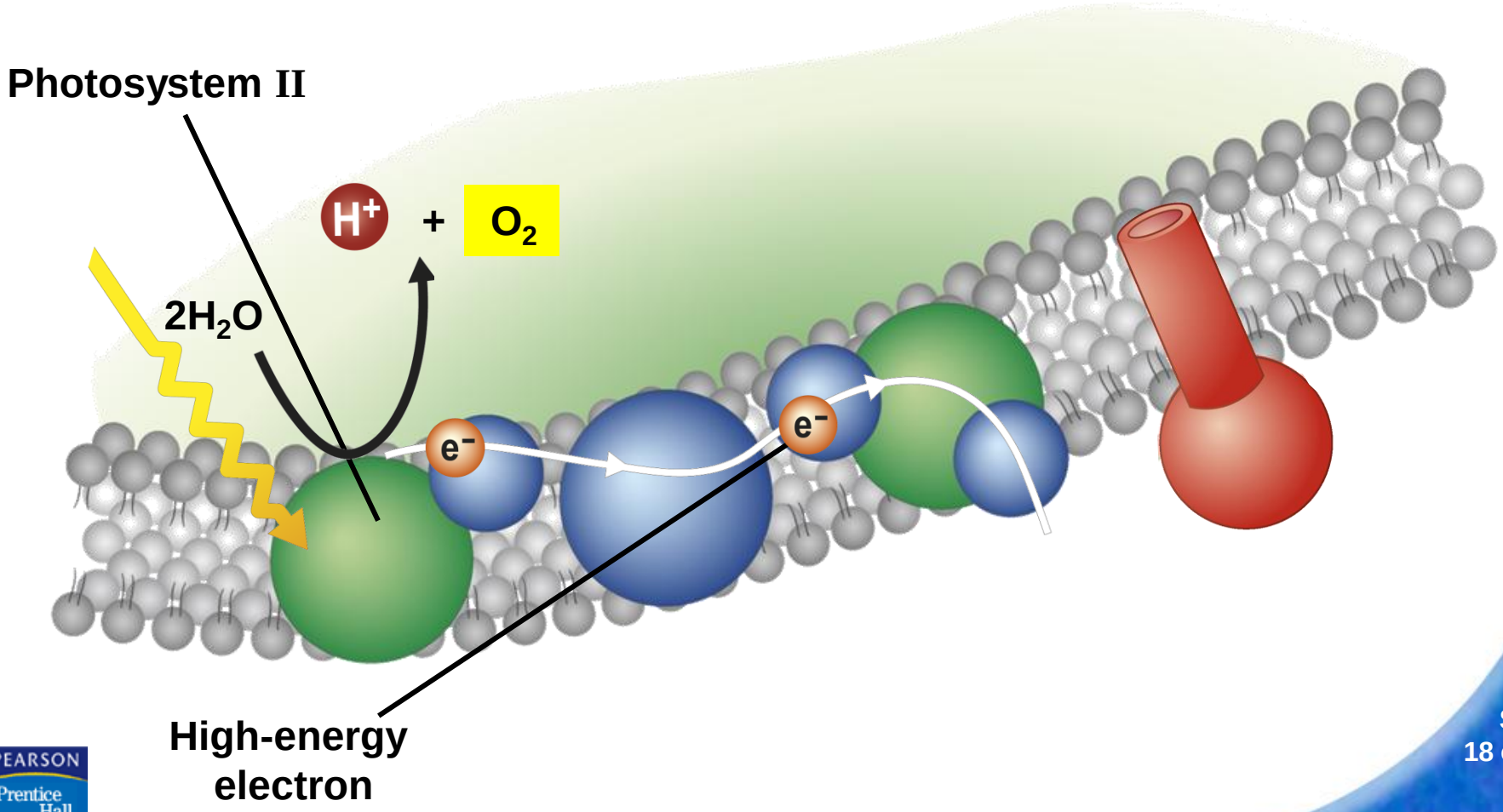
- hydrogen ions
- oxygen atoms
- energized electrons



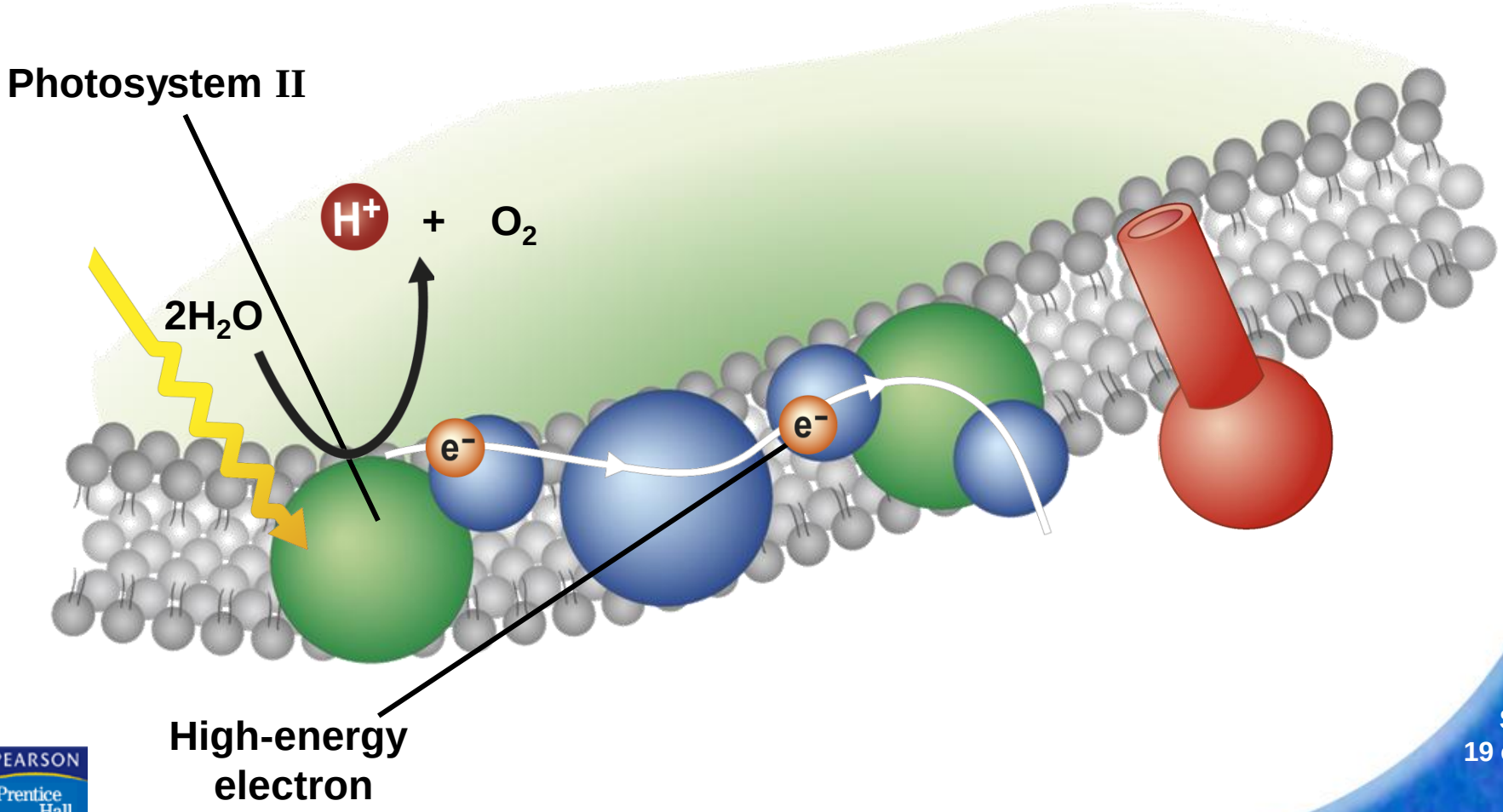
The energized electrons from water replace the high-energy electrons that chlorophyll lost to the electron transport chain.



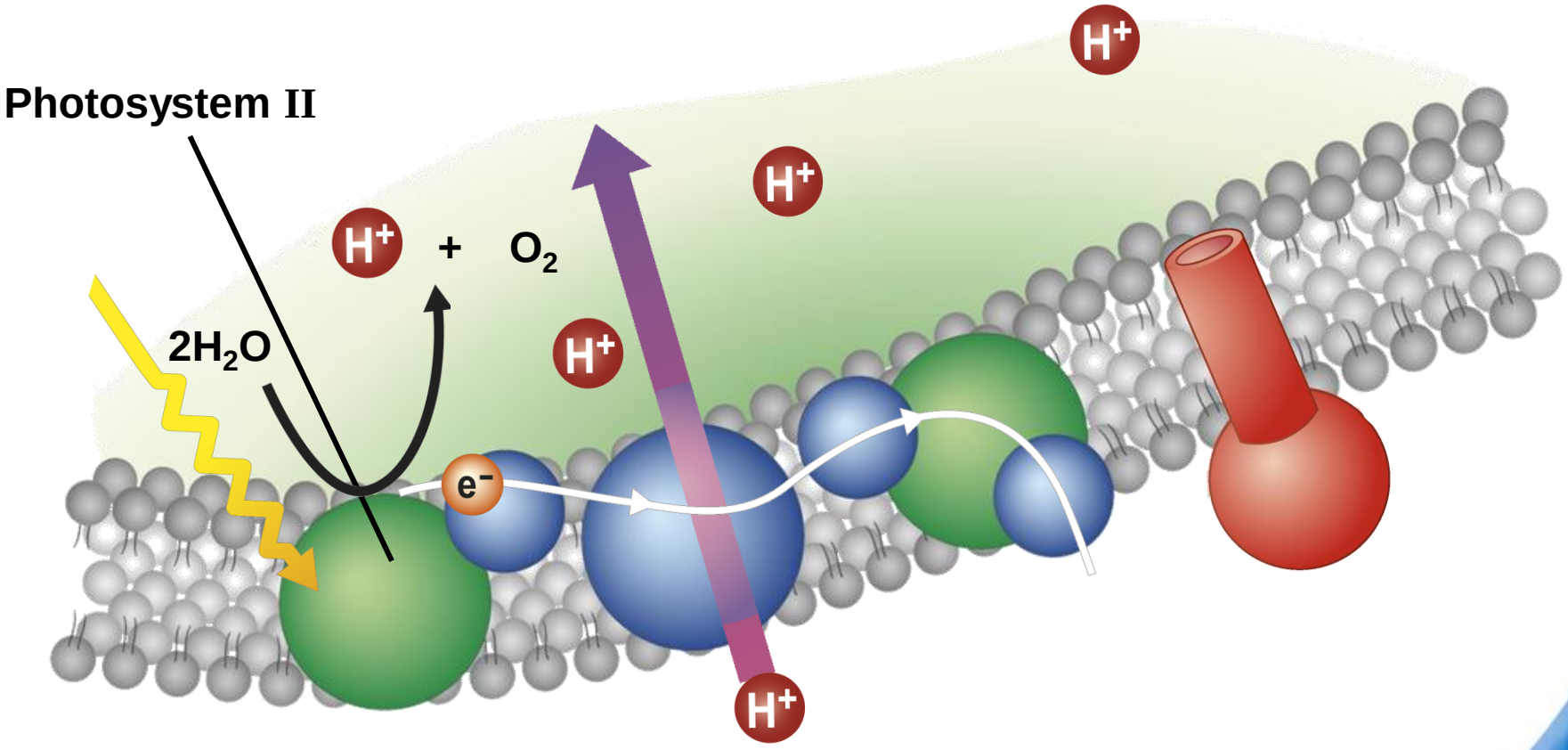
As plants remove electrons from water, oxygen is left behind and is released into the air.



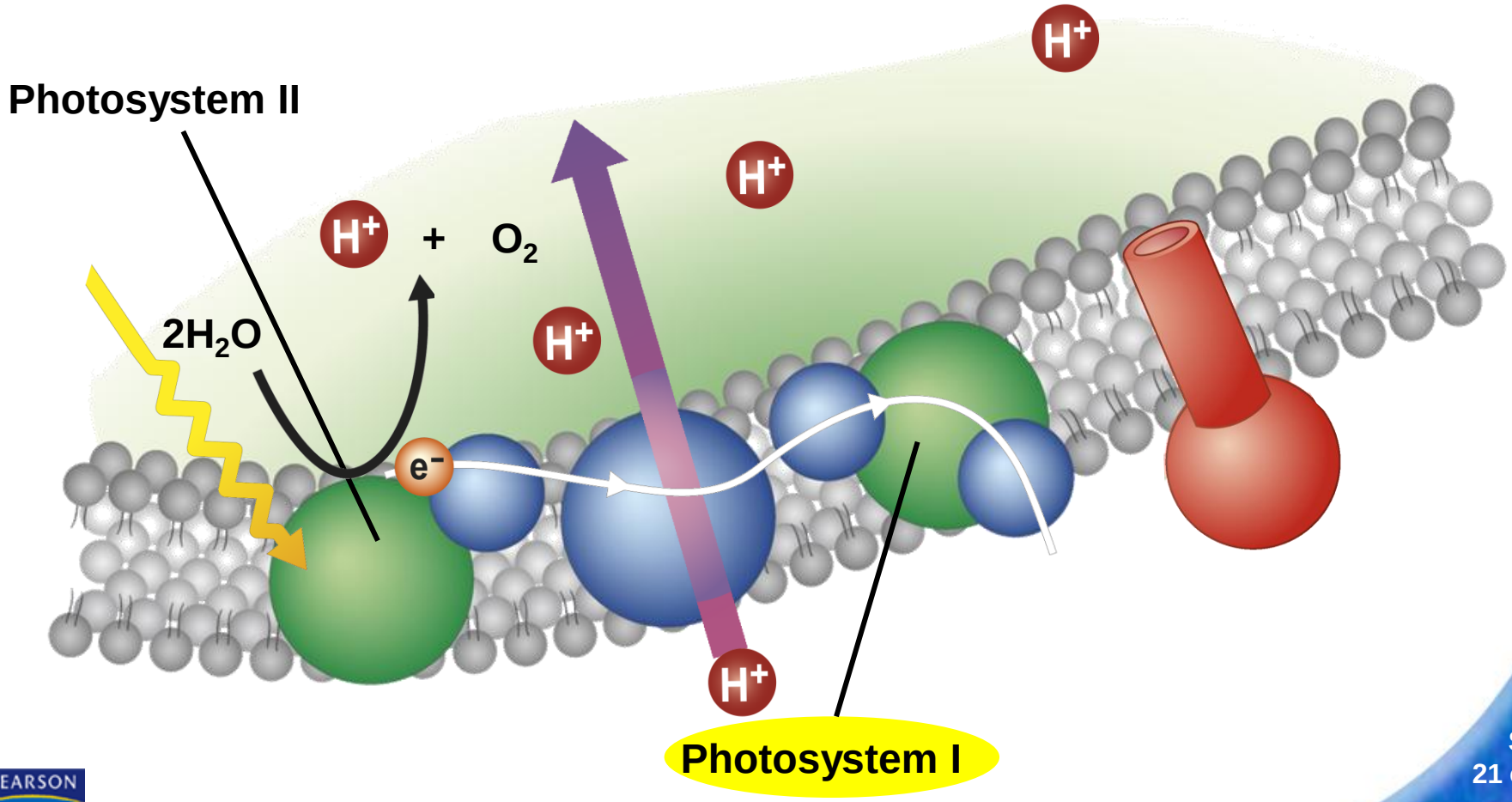
The hydrogen ions left behind when water is broken apart are released inside the thylakoid membrane.



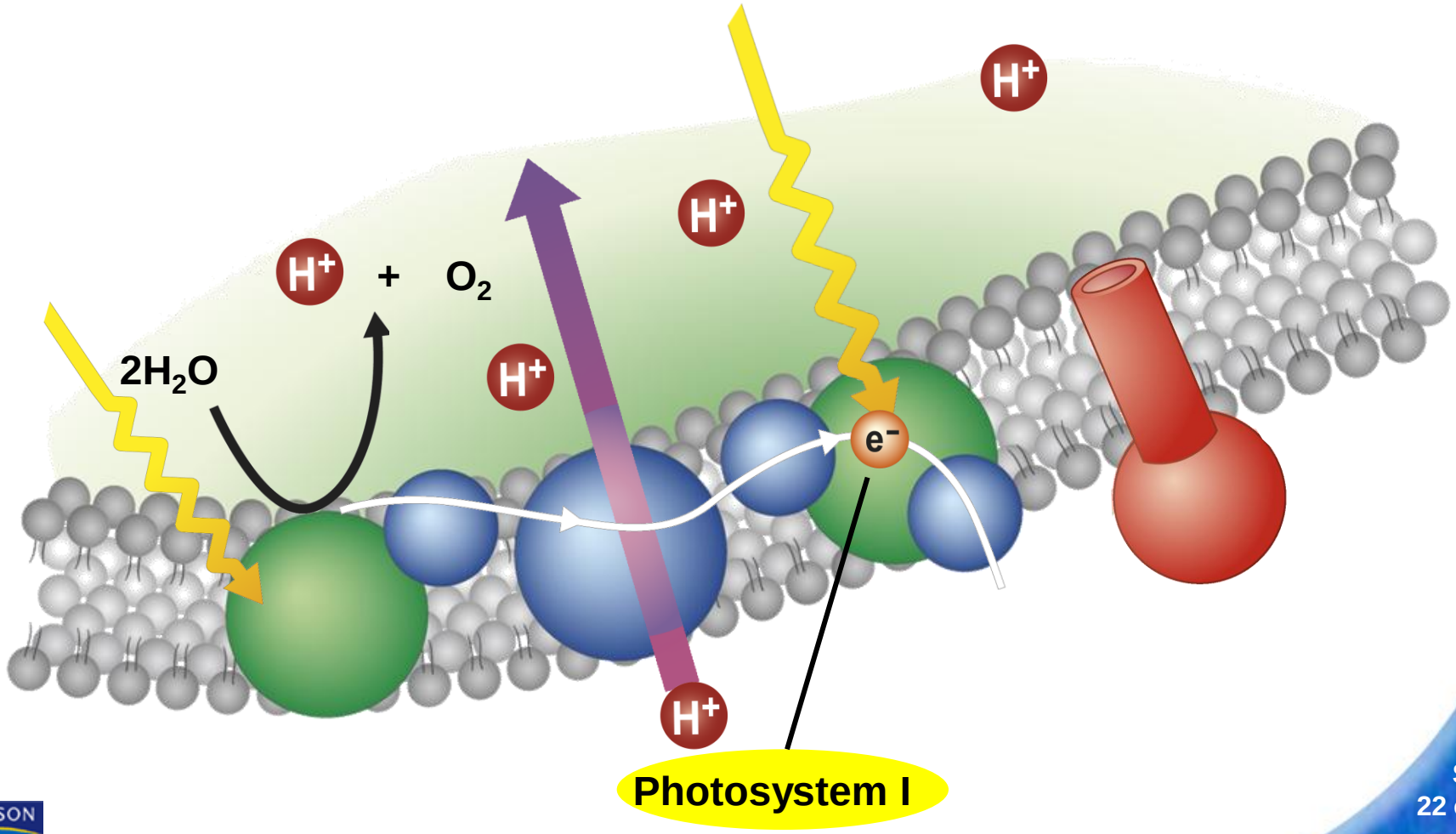
Energy from the electrons is used to transport H^+ ions from the stroma into the inner thylakoid space.



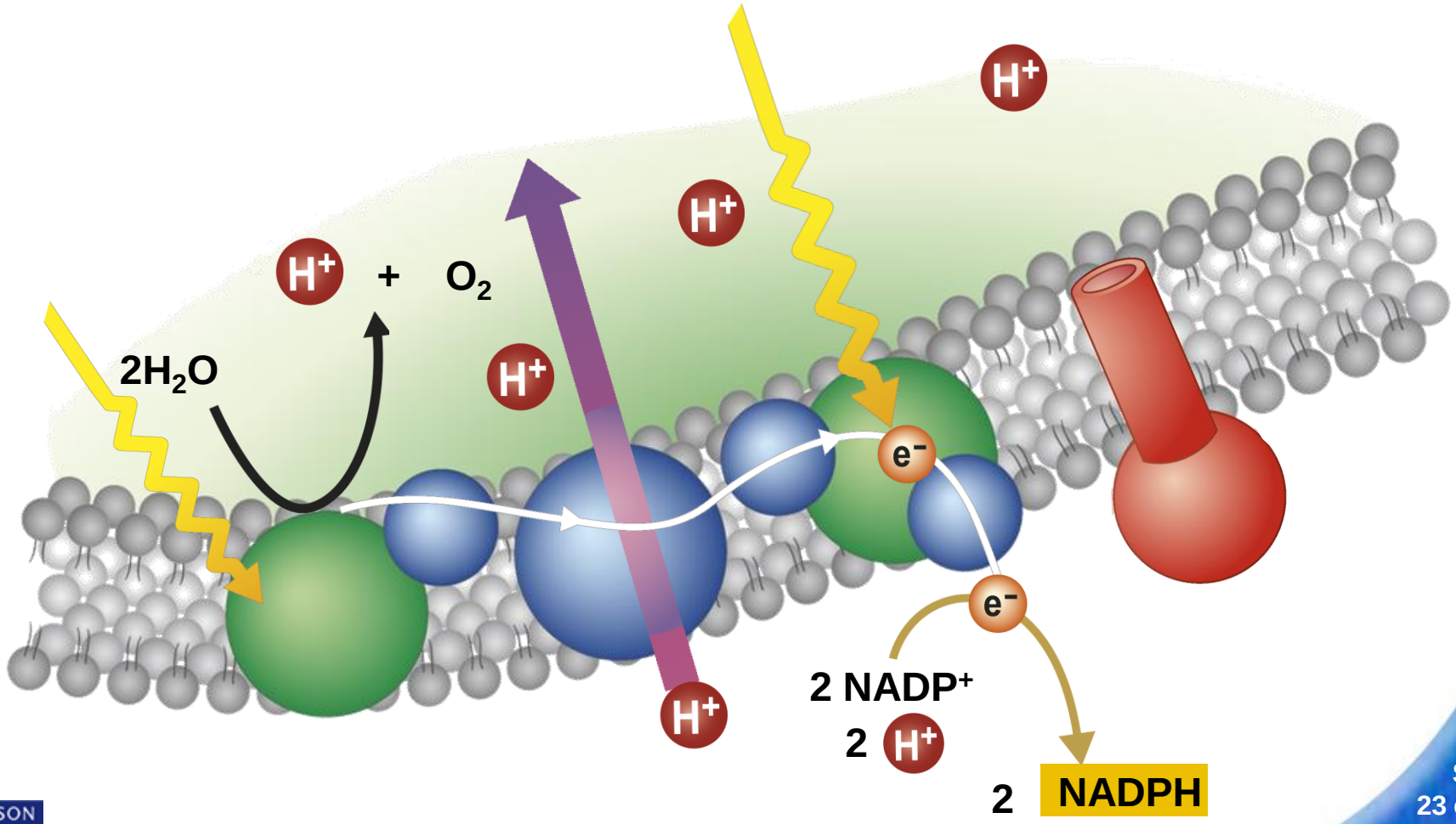
High-energy electrons move through the electron transport chain from photosystem II to photosystem I.



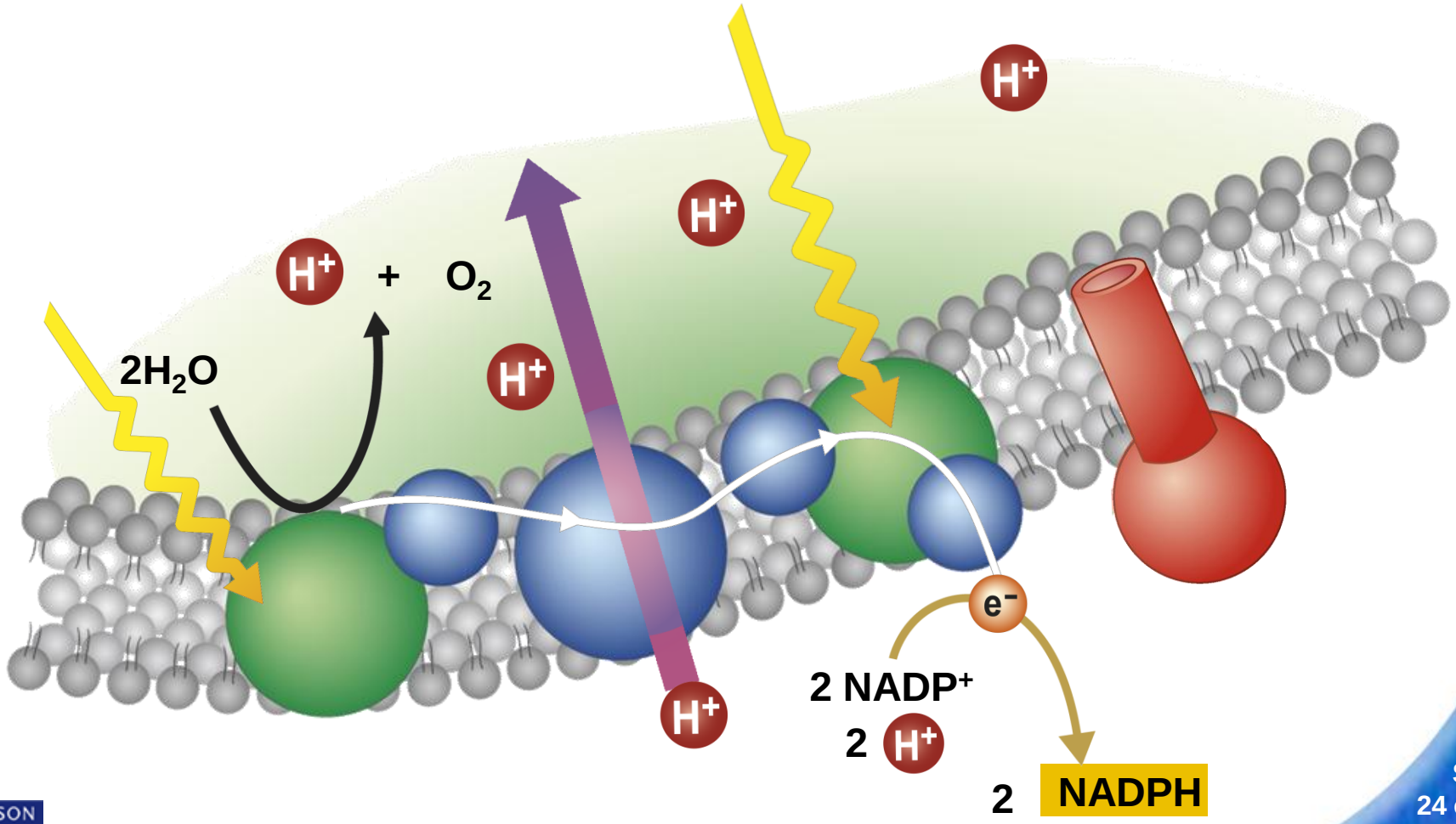
Pigments in photosystem I use energy from light to re-energize the electrons.



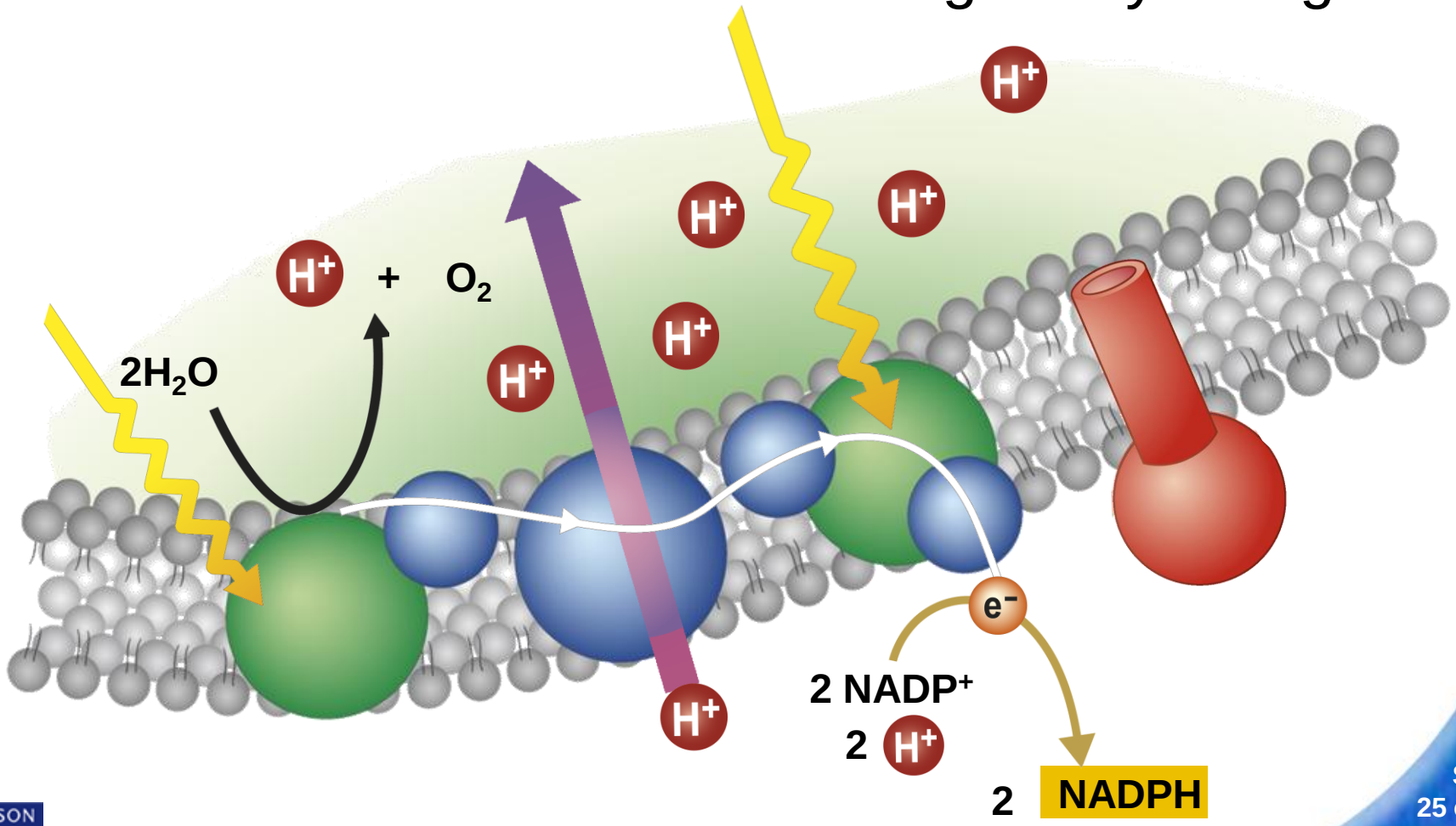
NADP+ then picks up these high-energy electrons, along with H+ ions, and becomes NADPH.



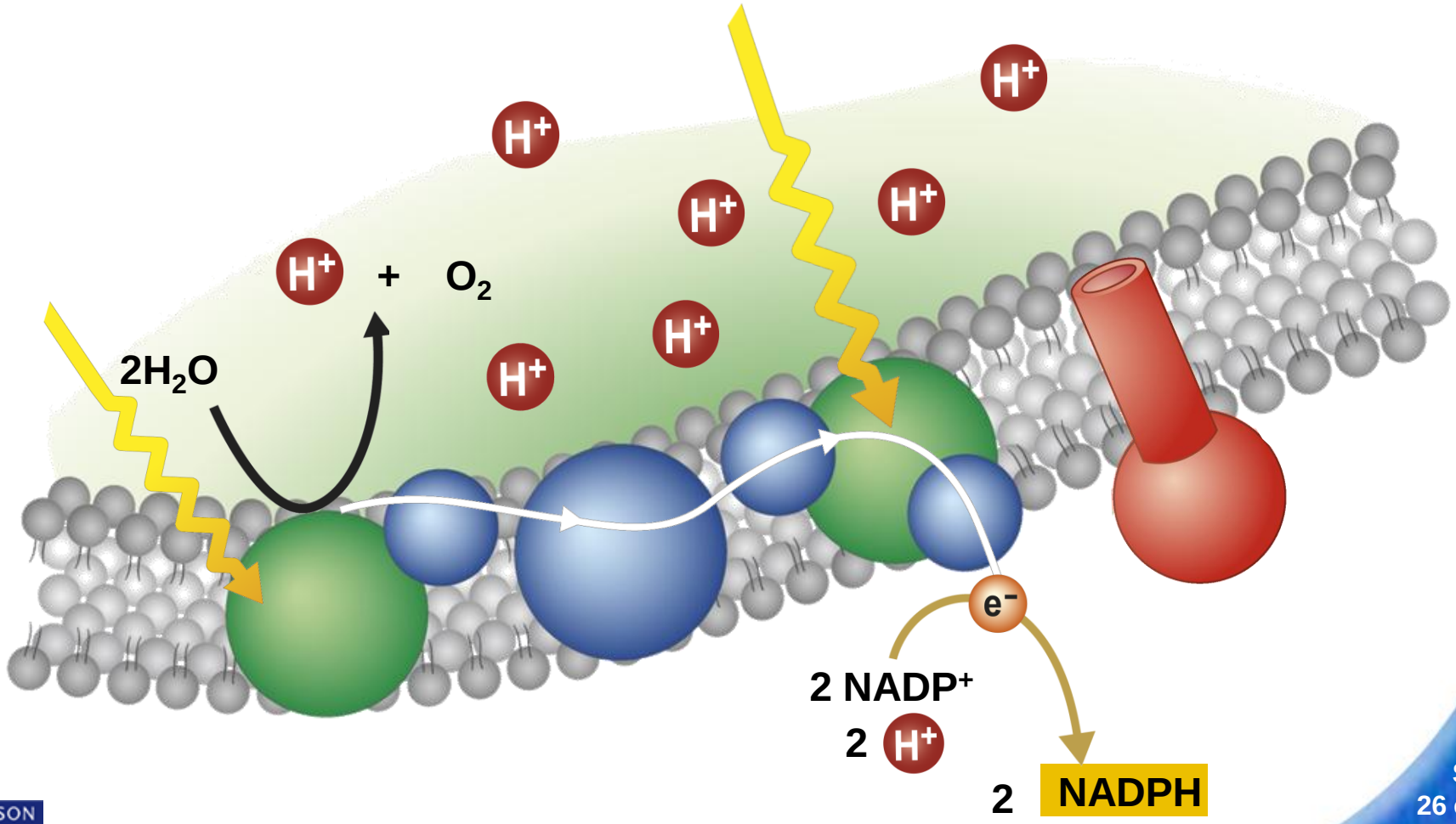
As electrons are passed from chlorophyll to $NADP^+$, more H^+ ions are pumped across the membrane.



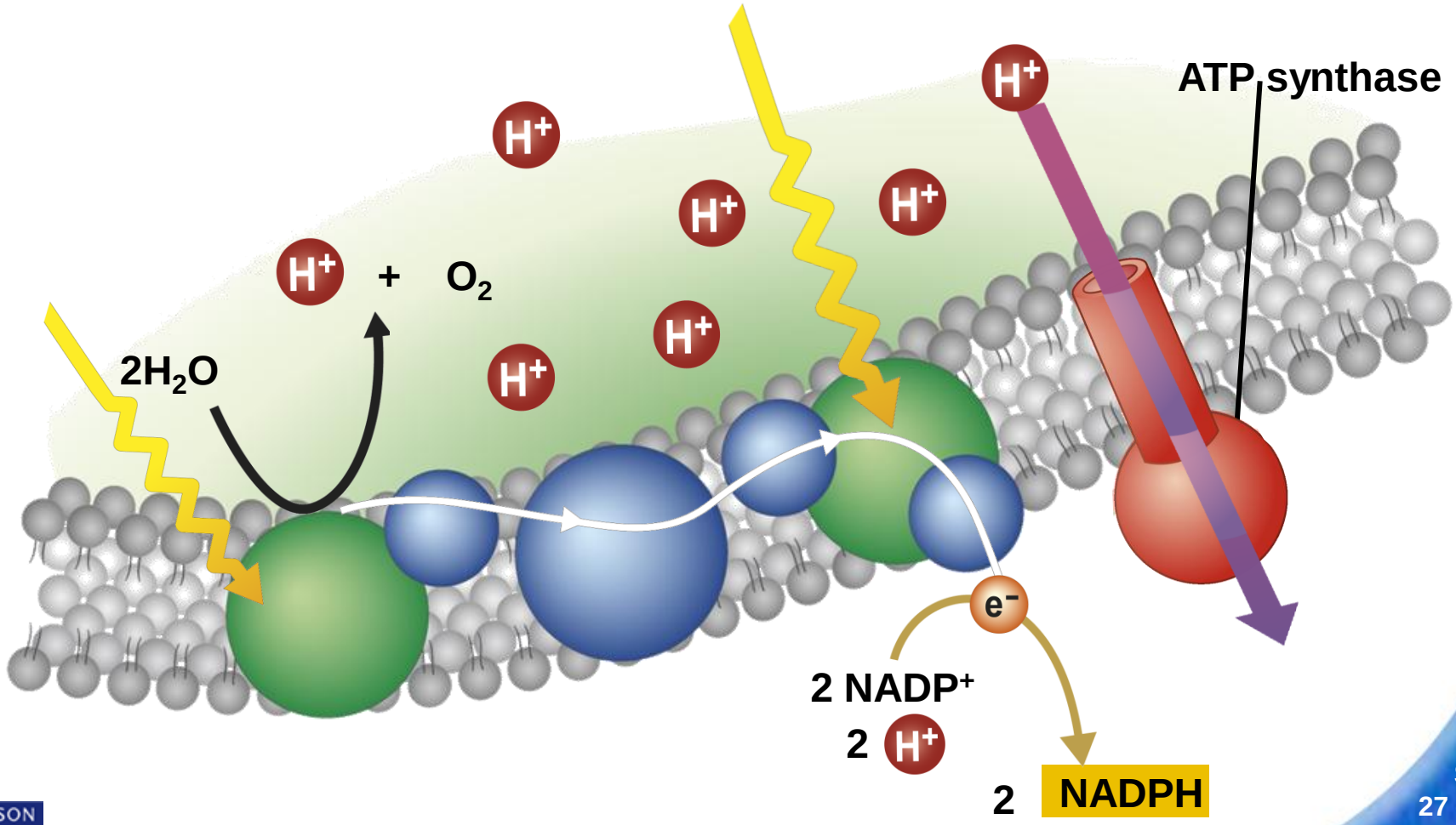
Soon, the inside of the membrane fills up with positively charged hydrogen ions, which makes the outside of the membrane negatively charged.



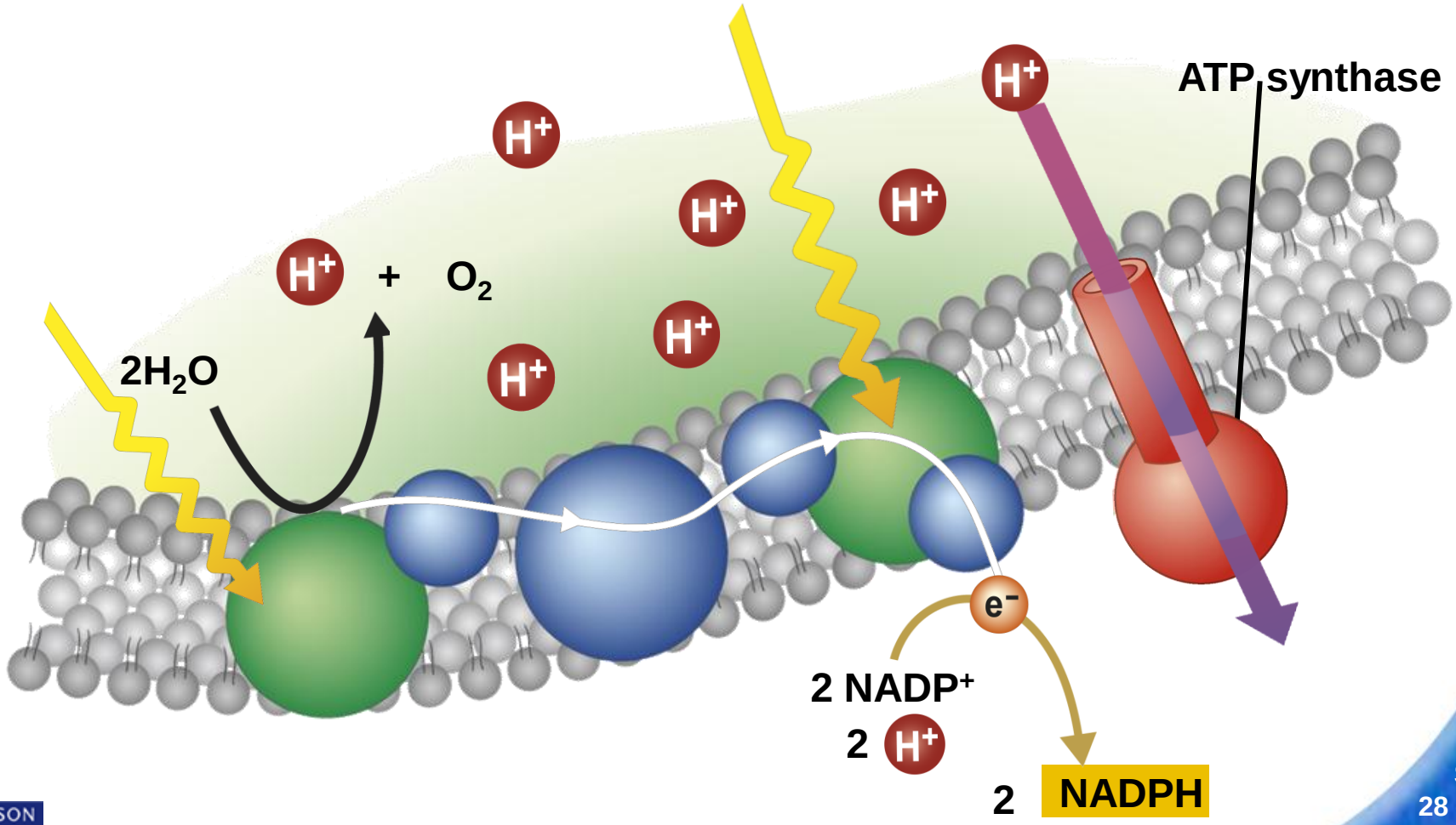
The difference in charges across the membrane provides the energy to make ATP.



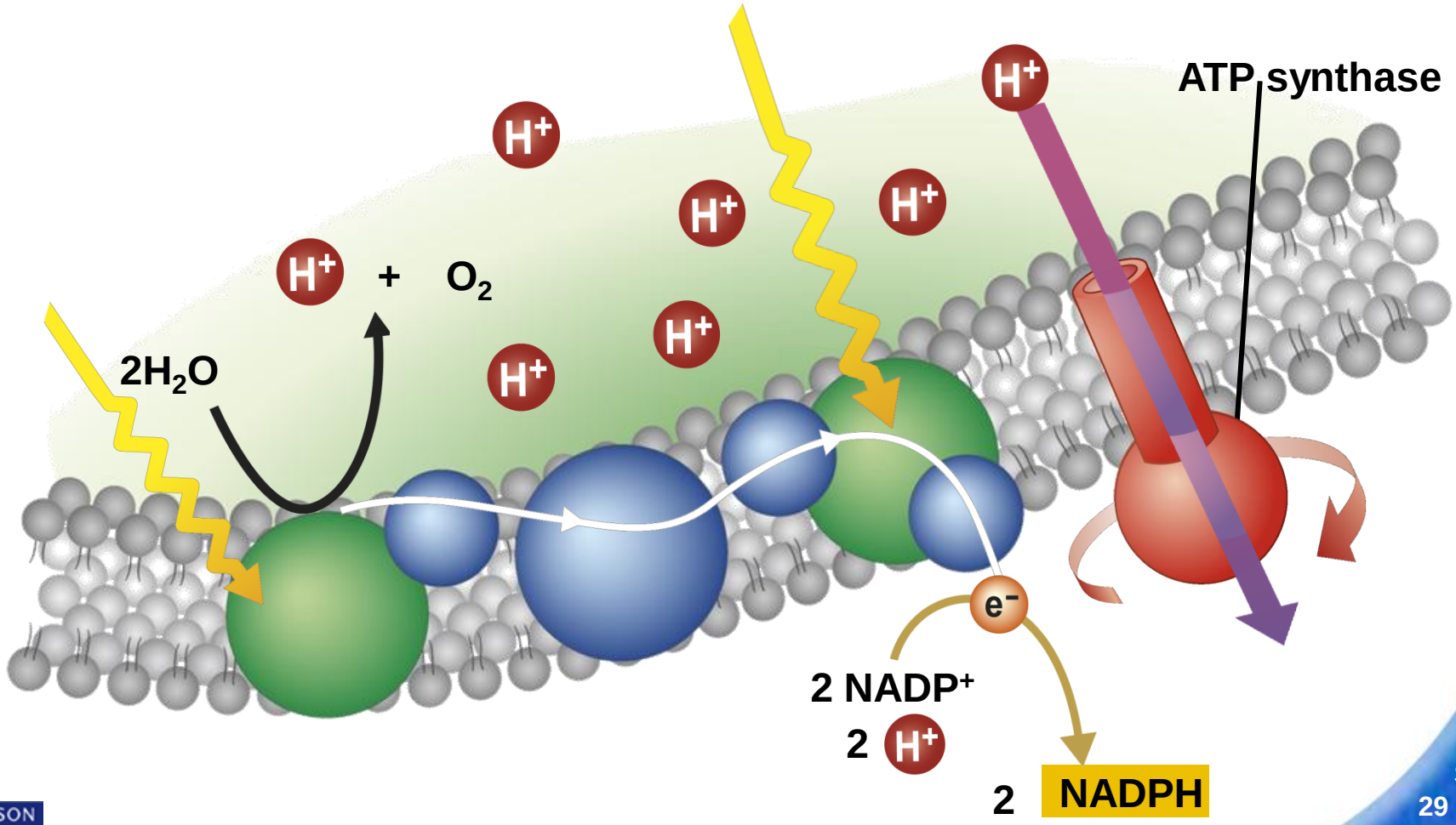
H^+ ions cannot cross the membrane directly.



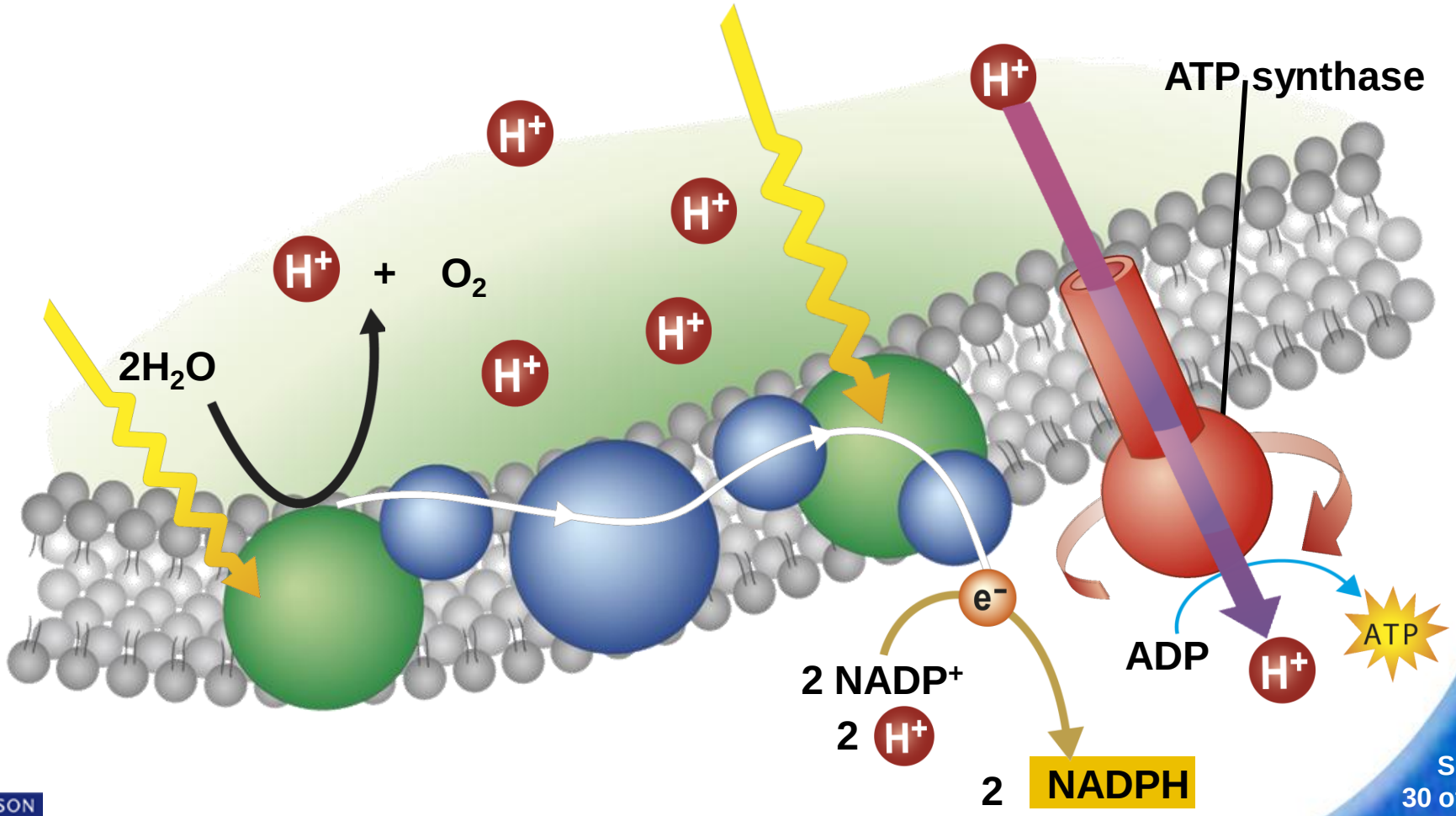
The cell membrane contains a protein called **ATP synthase** that allows H^+ ions to pass through it.



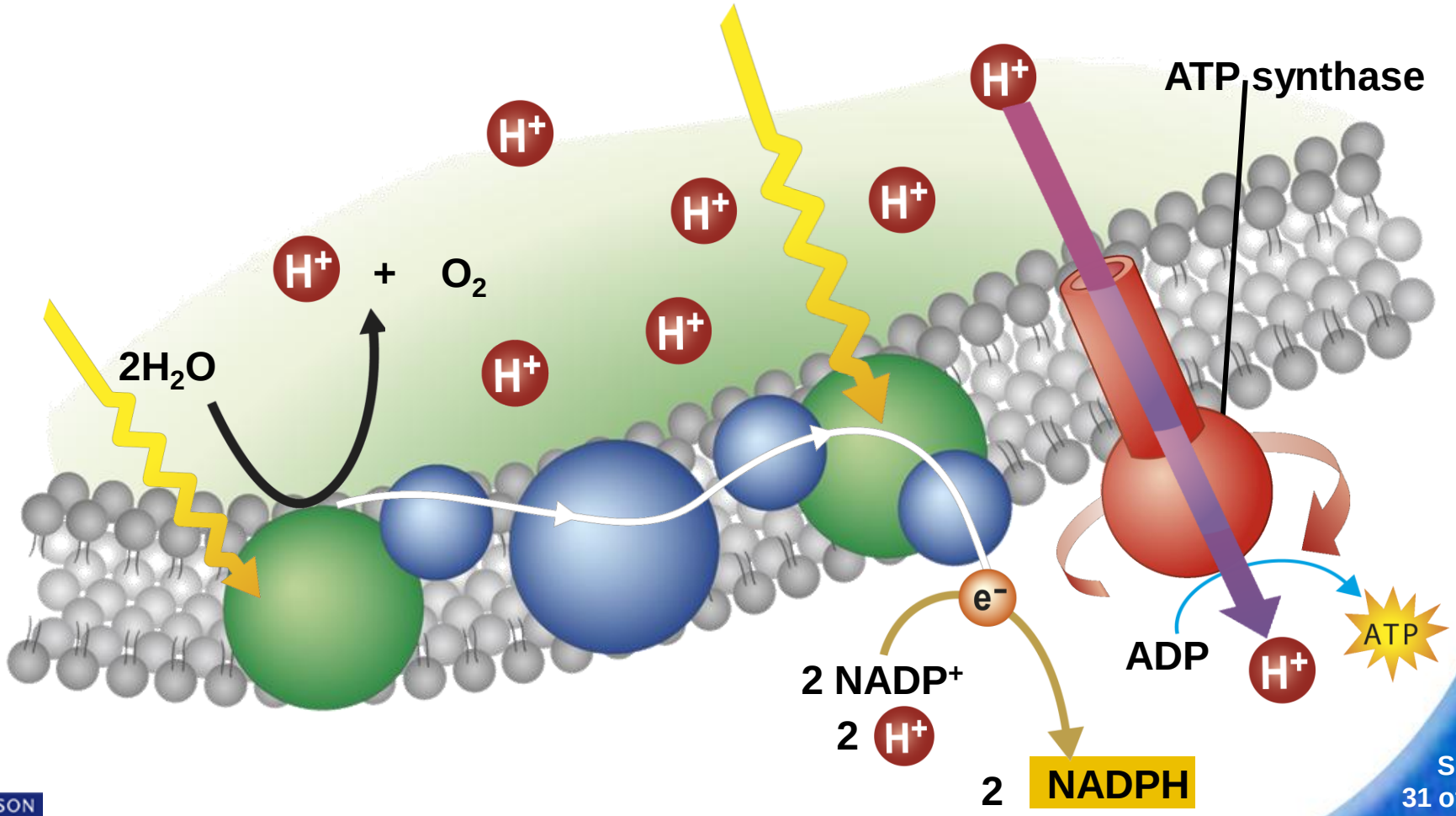
As H^+ ions pass through ATP synthase, the protein rotates.



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



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



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.

The Calvin Cycle

ATP and NADPH contain an abundance of chemical energy,

-not stable enough to store that energy for more than a few minutes.

Calvin cycle →uses the energy to build high-energy compounds →long term storage.

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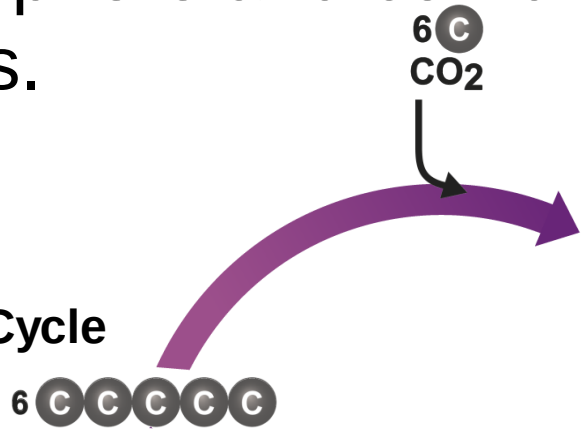
The Calvin cycle uses ATP and NADPH from the light-dependent reactions to produce high-energy sugars.

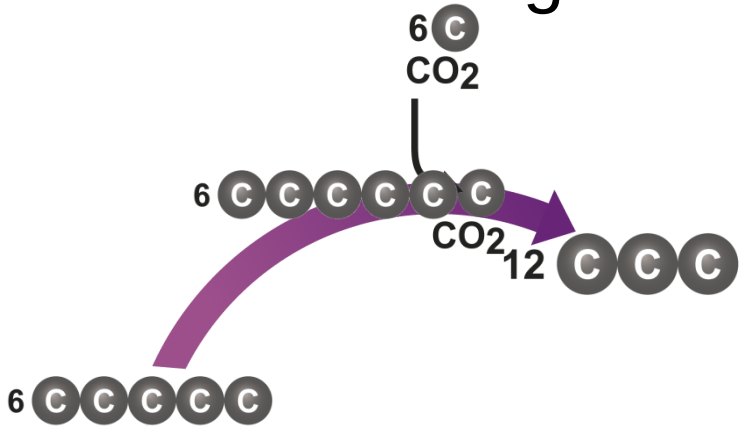
-also called the light-independent reactions.

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

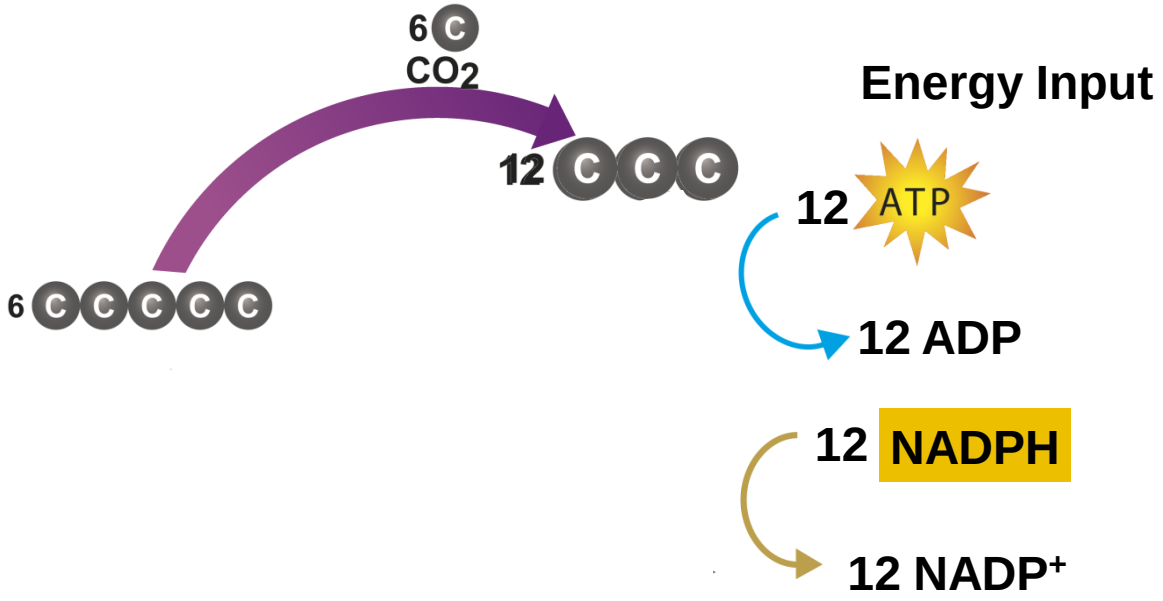


CO_2 Enters the Cycle

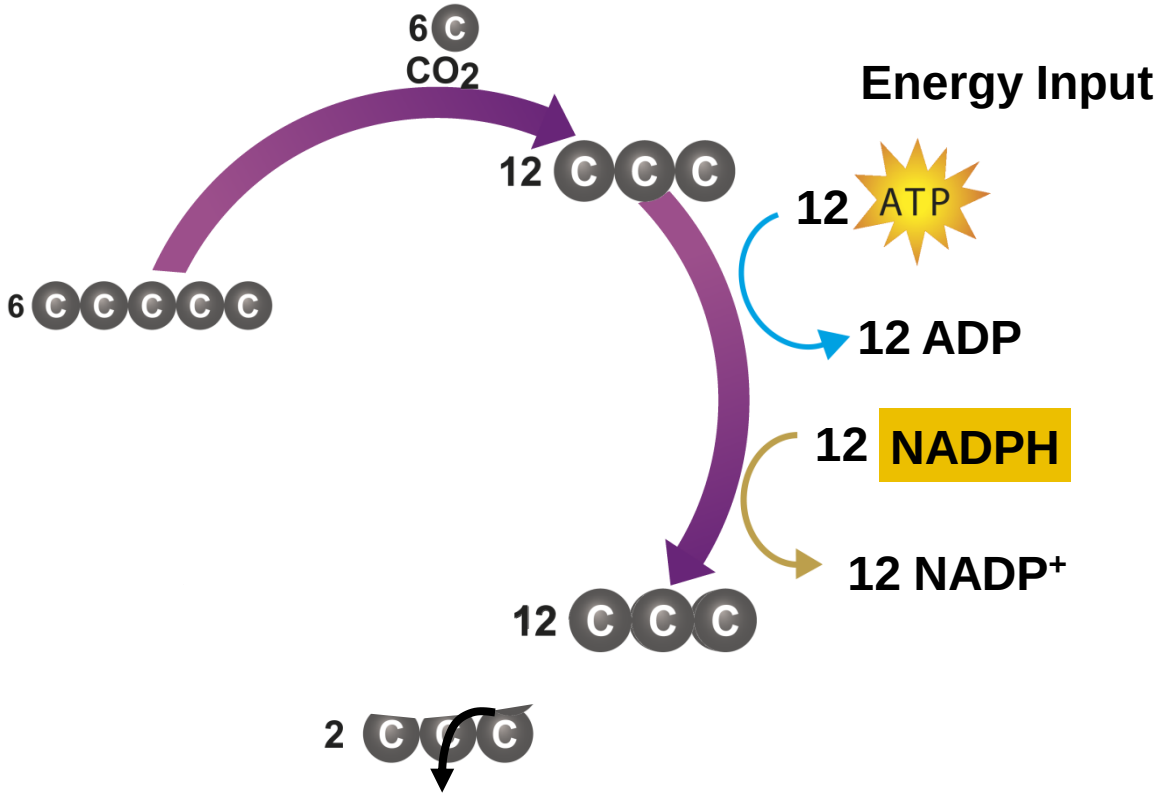
The result is twelve 3-carbon molecules, which are then converted into higher-energy forms.



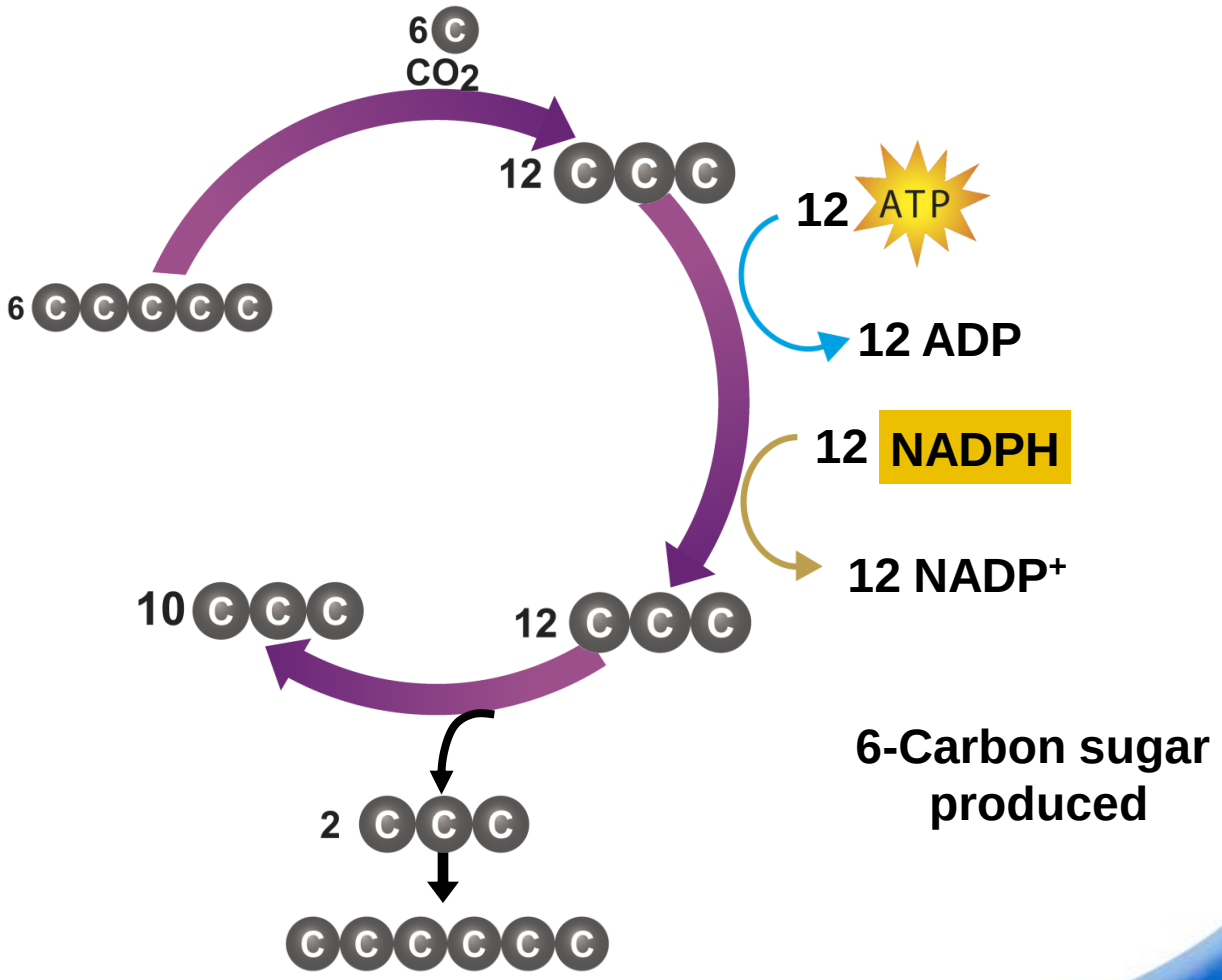
The energy for this conversion comes from ATP and high-energy electrons from NADPH.



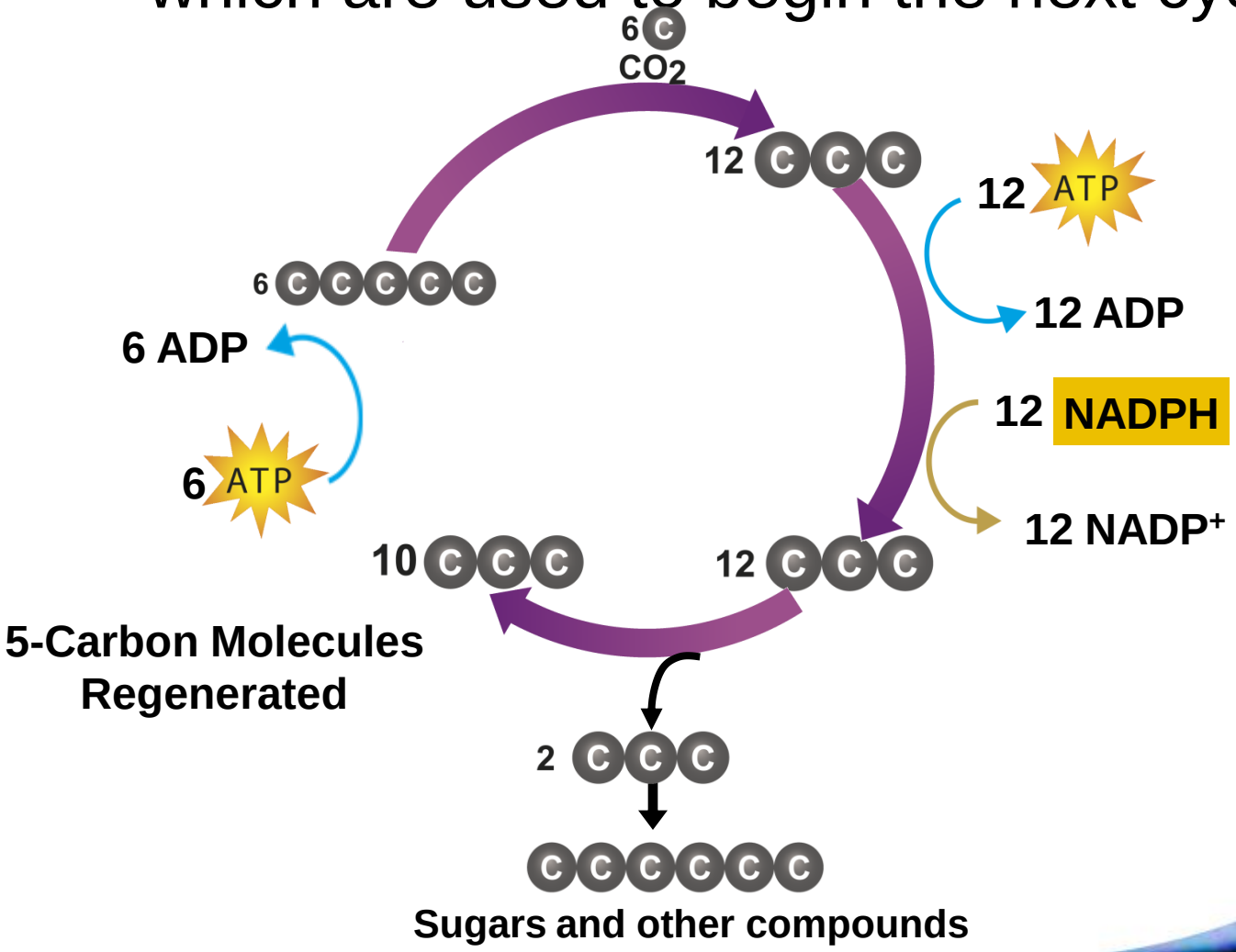
Two of twelve 3-carbon molecules are removed from the cycle.



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



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

END OF SECTION