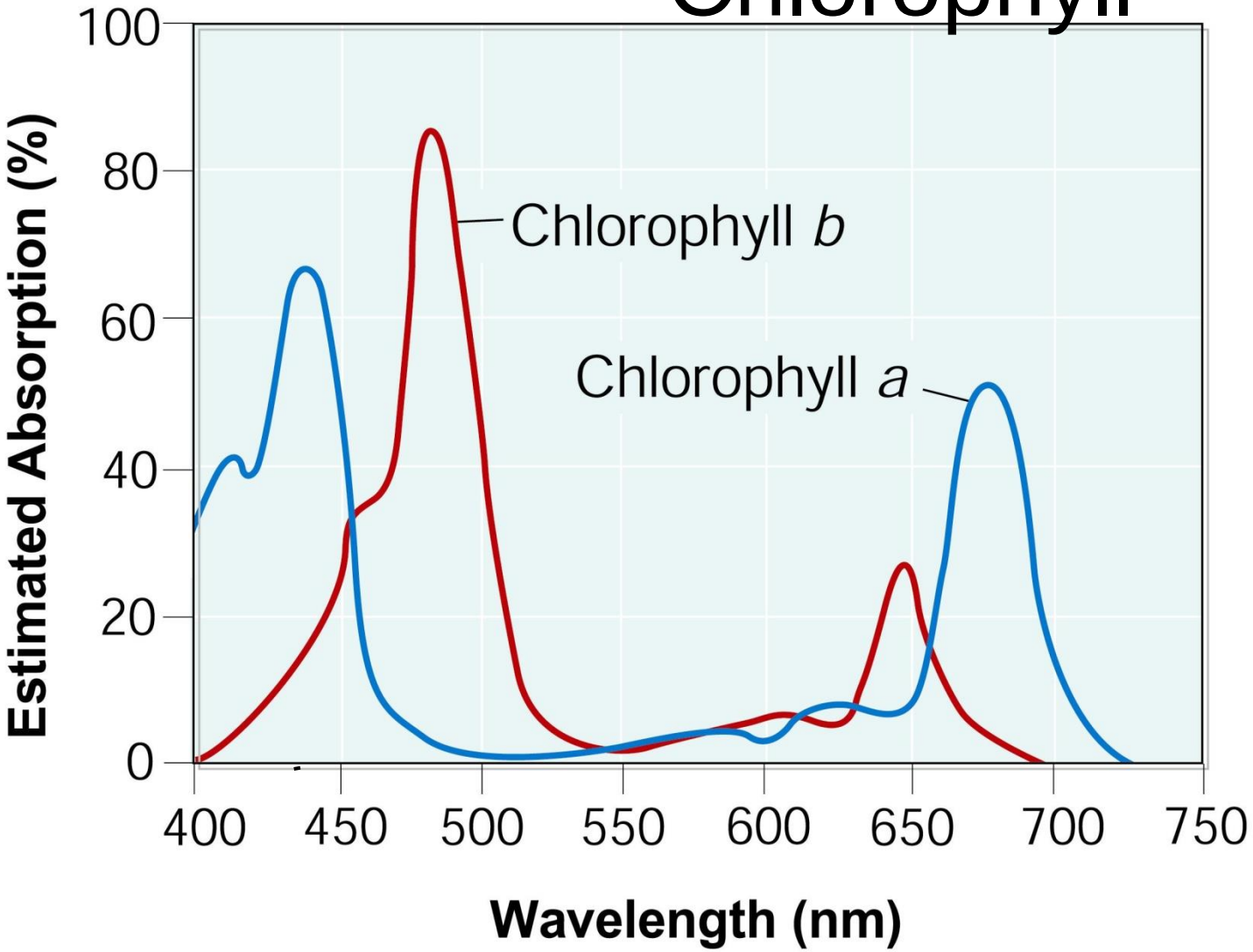
Photosynthesis

- $6CO_2 + 6H_20 \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$

- Carbon dioxide + water $\xrightarrow{\text{light}}$ sugar + oxygen
- Chlorophyll – pigment that absorbs light energy
- Absorbs red and blue light
- Reflects green and yellow light

Chlorophyll

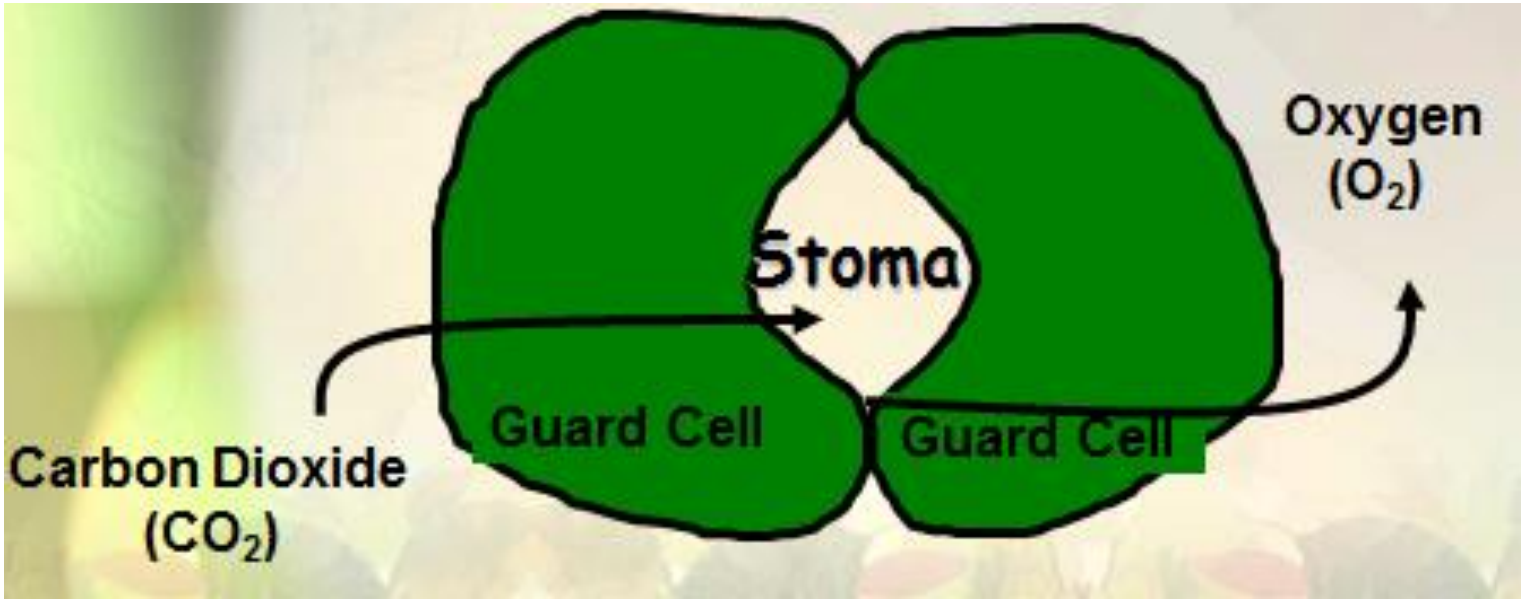


Fall Colors

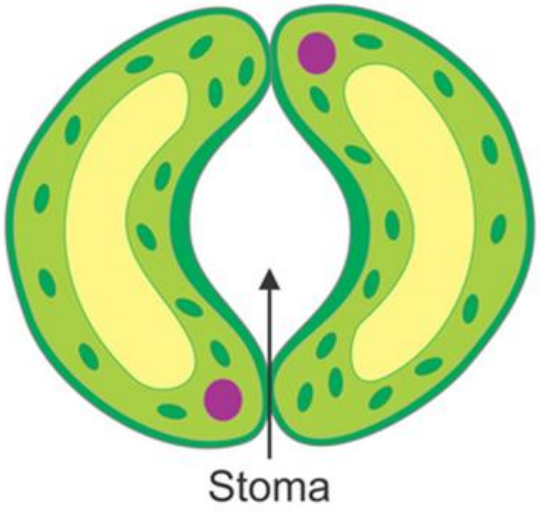
- In addition to the chlorophyll pigments, there are other pigments present
- During the fall, the green chlorophyll pigments are greatly reduced revealing the other pigments
- Carotenoids are pigments that are either red, orange, or yellow
- Carotenoids are "accessory pigments"
  - They can't do photosynthesis directly, but can pass energy along to chlorophyll

Stomata (stoma)

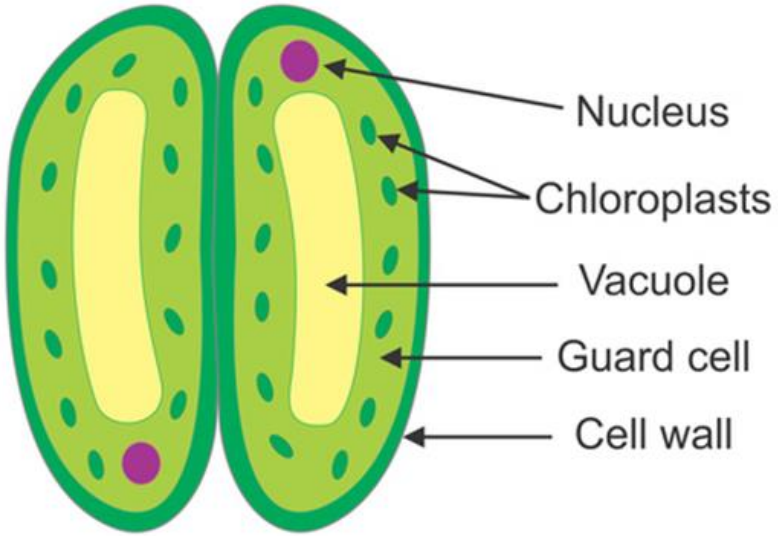
- **Pores** in a plant's cuticle through which **water vapor** and **gases (CO_2 & O_2)** are exchanged between the plant and the atmosphere.
- Found on the underside of leaves



Stoma open

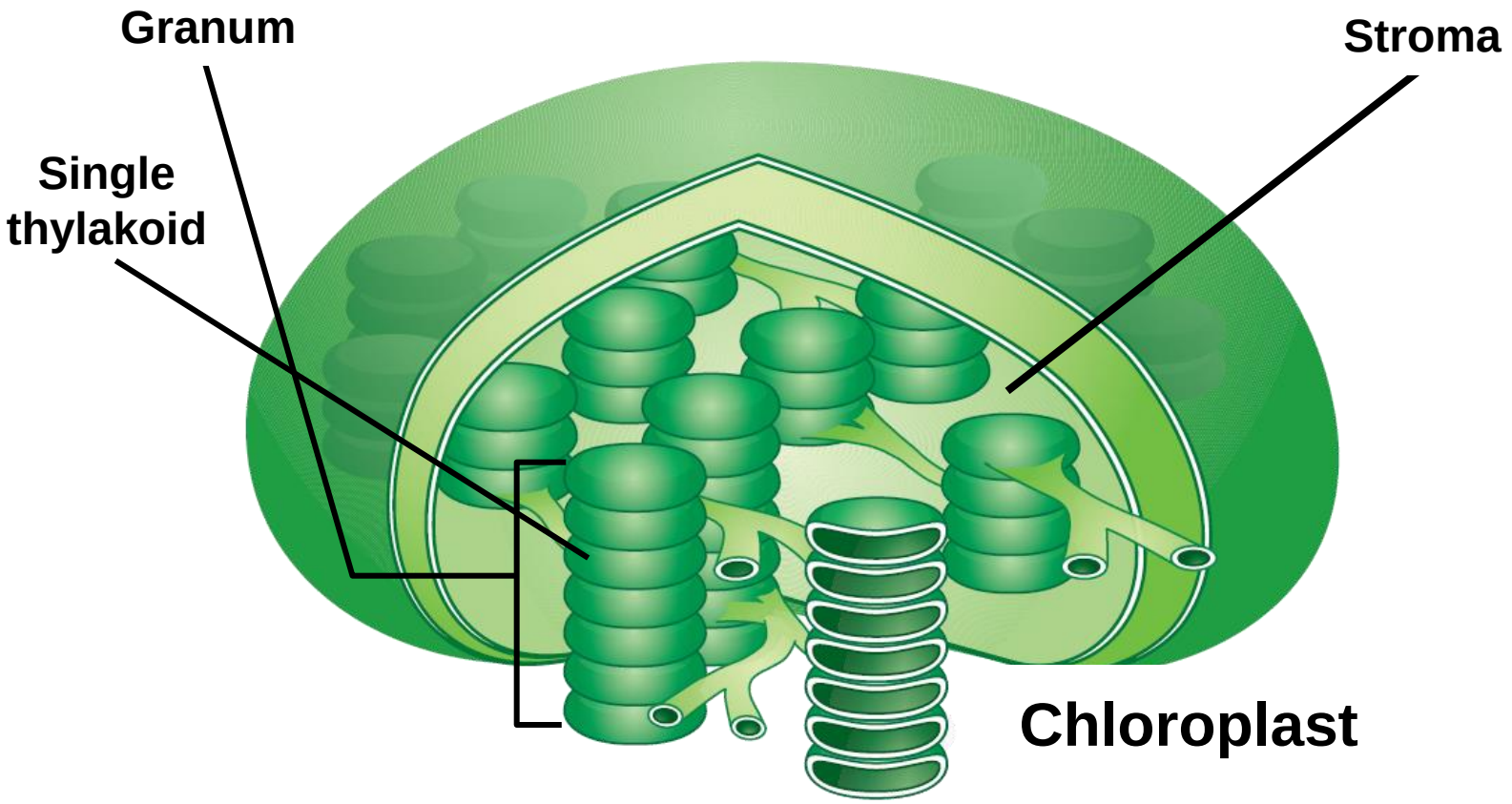


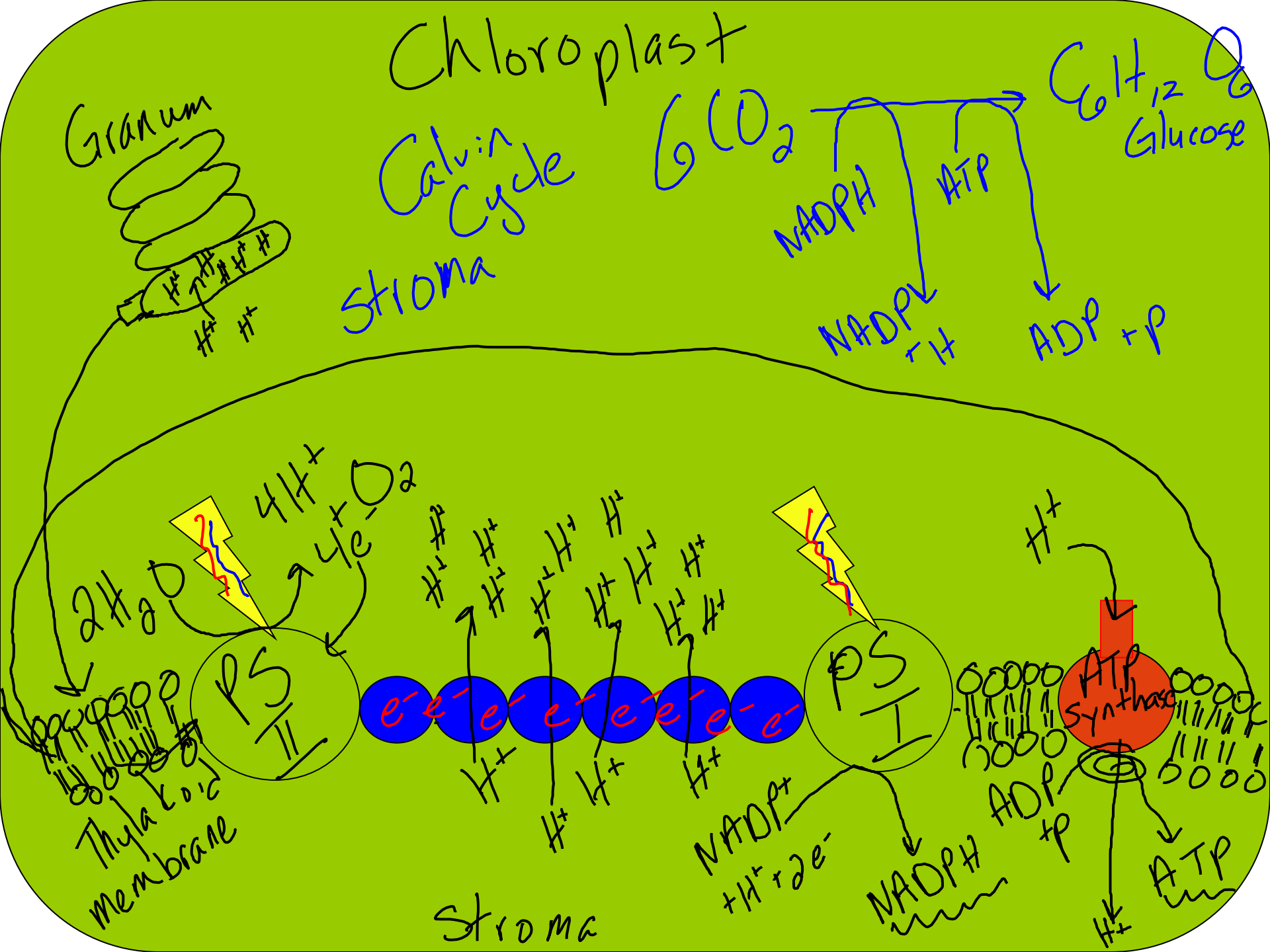
Stoma closed



Inside a Chloroplast

- **Thylakoids**—saclike photosynthetic membranes
- **Grana** – Stacks of thylakoids
- **Stroma** – space inside chloroplast



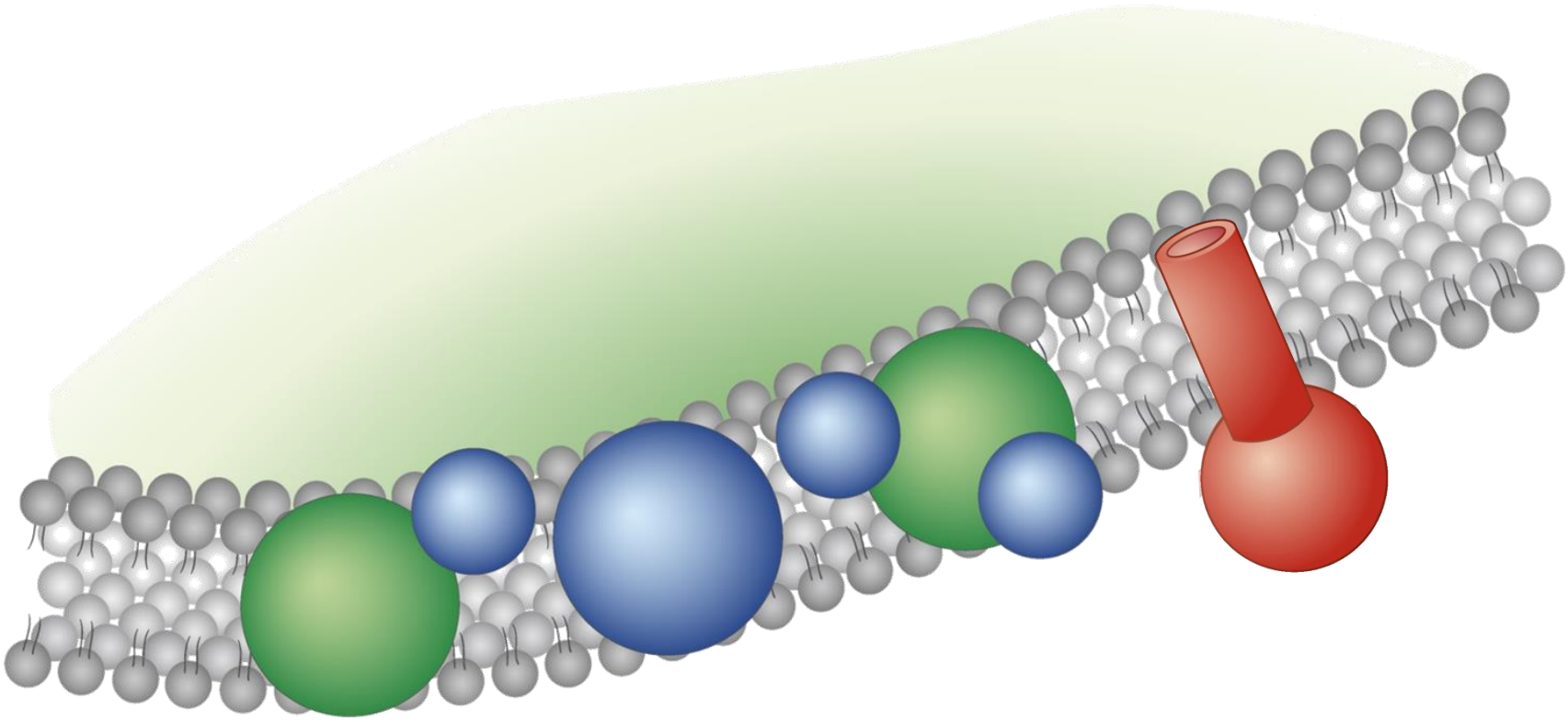

Chloroplast
Granum
Calvin Cycle
Stroma
6 CO2
C6H12O6
Glucose
NADPH
ATP
NADP+ +H
ADP +P
2H2O
4H+
4e- +O2
PS II
PS I
ATP synthase
Thylakoid membrane
Stroma
NADP+ +H+ +2e-
NADPH
ADP +P
ATP
H+

Light Reactions

take place in the Thylakoid membrane

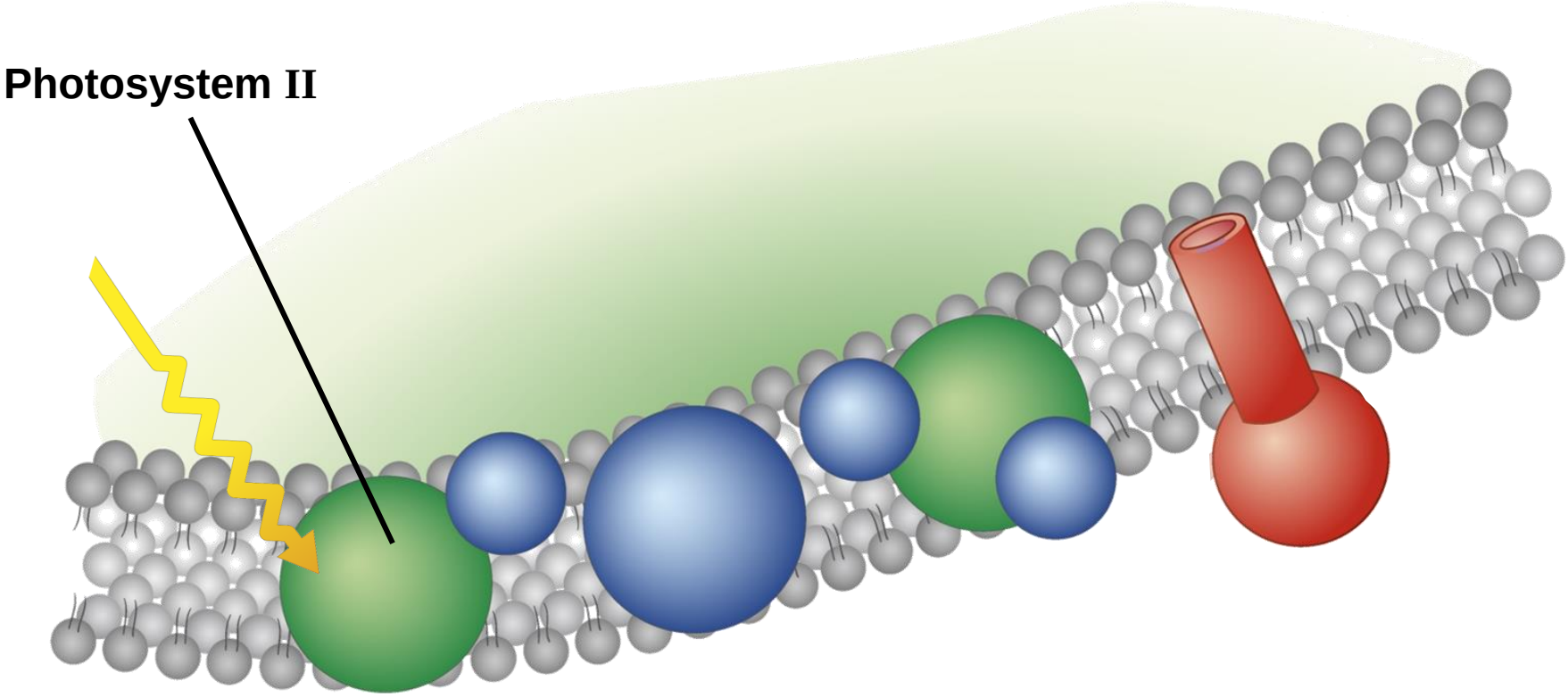
1. Chlorophyll in Photosystem II absorbs light
2. Electrons absorb the energy, become excited, and jump to a higher energy level (get energized)
3. Energized electrons are passed down the electron transport chain to photosystem I
4. Energy from electrons used to pump H^+ ions from stroma into thylakoid
5. Chlorophyll in Photosystem I absorbs light
6. Electrons get reenergized
7. $NADP^+$ picks up electrons and a H^+ ion to become NADPH
8. $2\ H_20 \rightarrow 4\ H^+ + O_2$ (replaces energized electrons in PS II)
9. O_2 is released to air, H^+ is released inside the thylakoid
10. H+ ions pass through ATP synthase (facilitated diffusion) to turn ADP into ATP

Light-Dependent Reactions

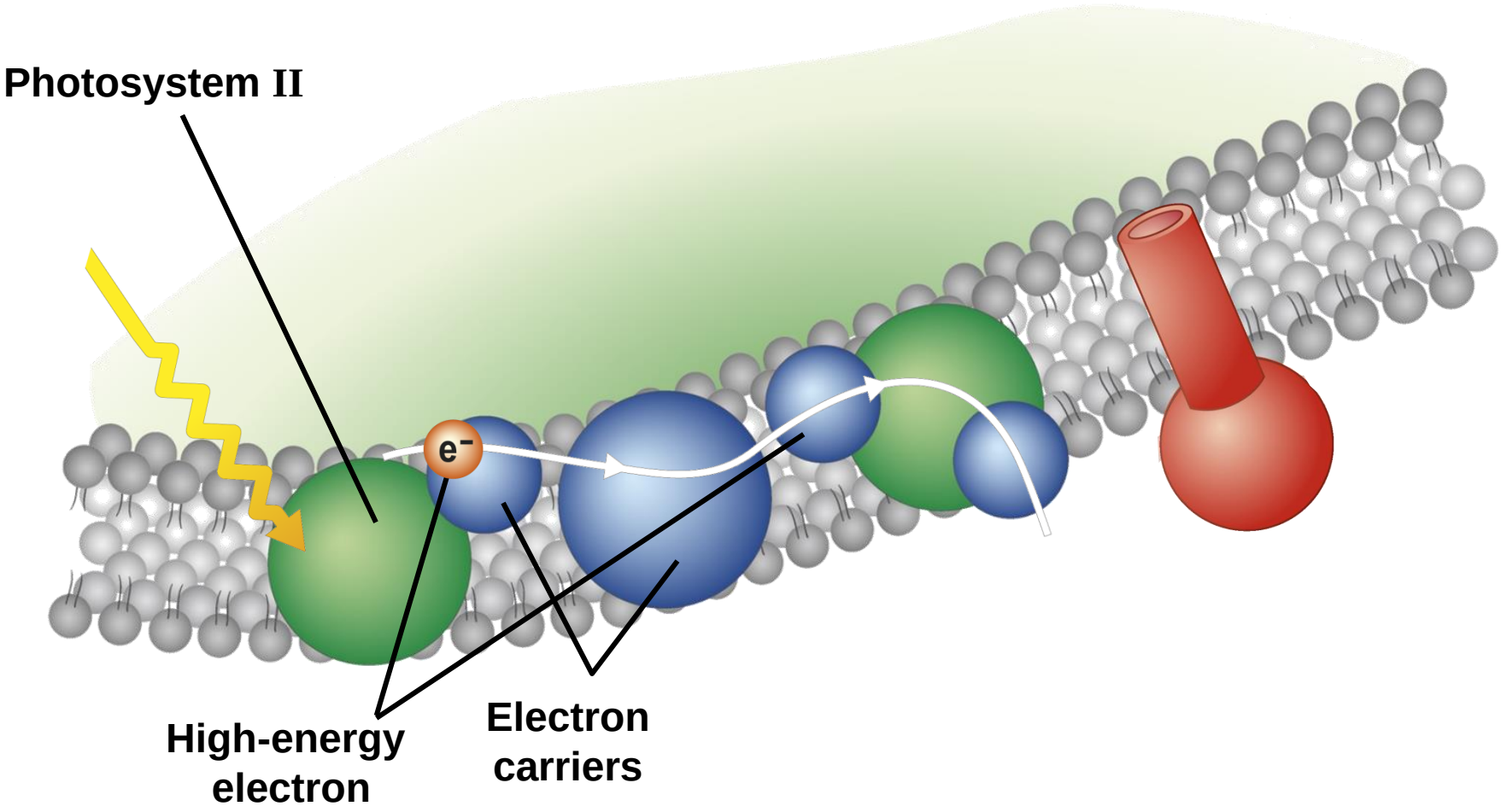


Light-Dependent Reactions

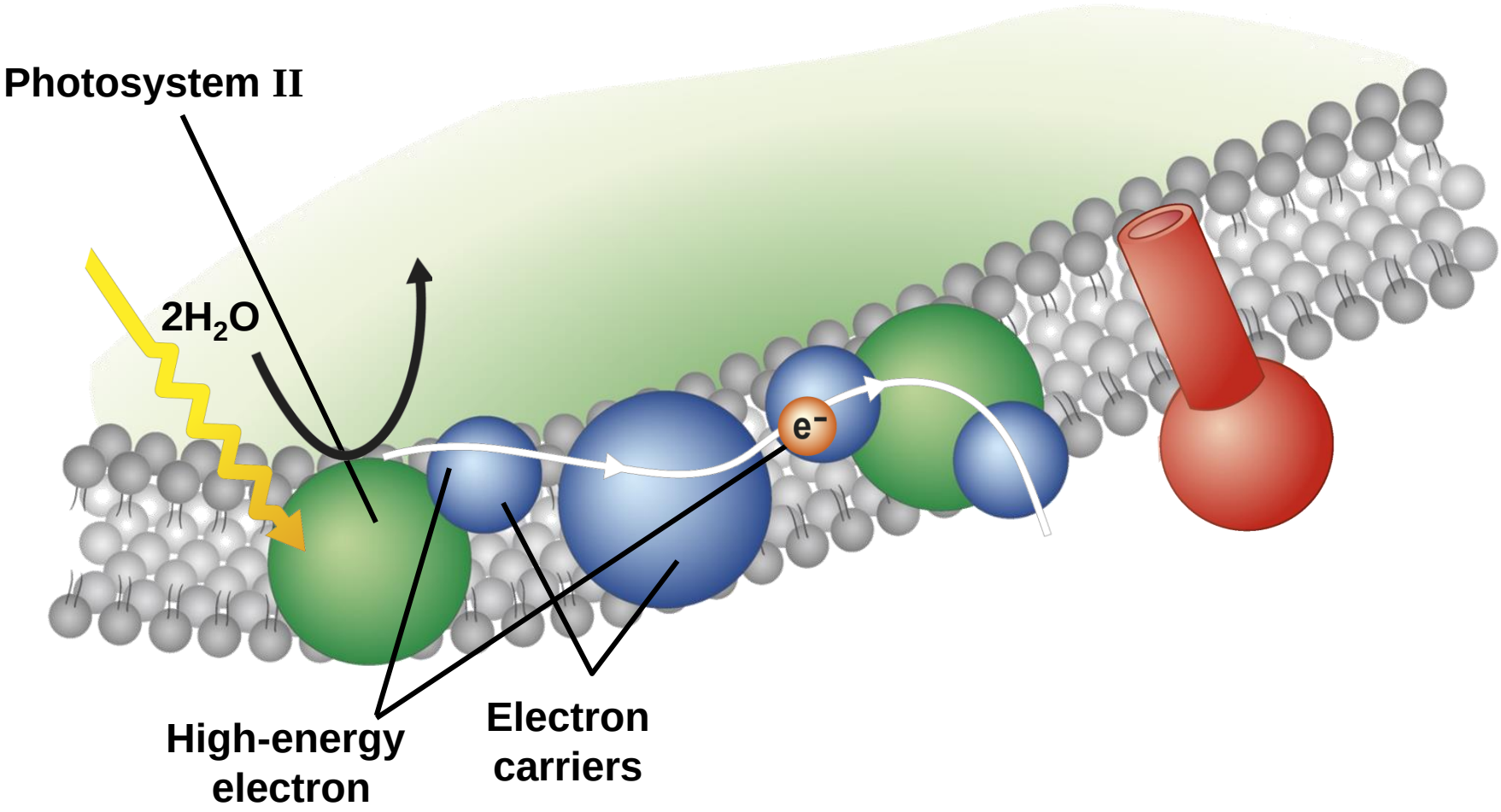
- Photosynthesis begins when pigments in photosystem II absorb light, increasing their energy level.



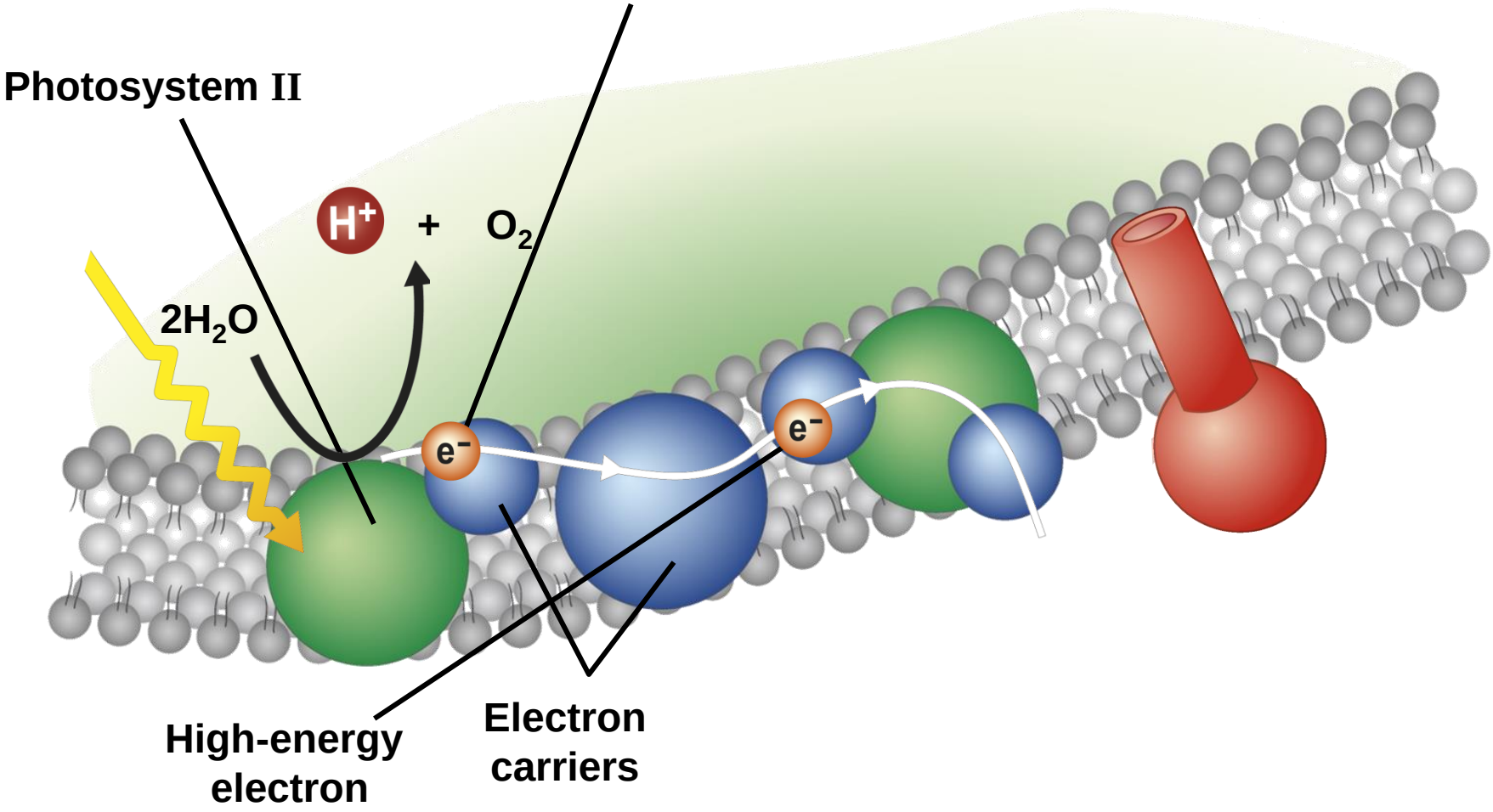
- These high-energy electrons are passed on to the electron transport chain.



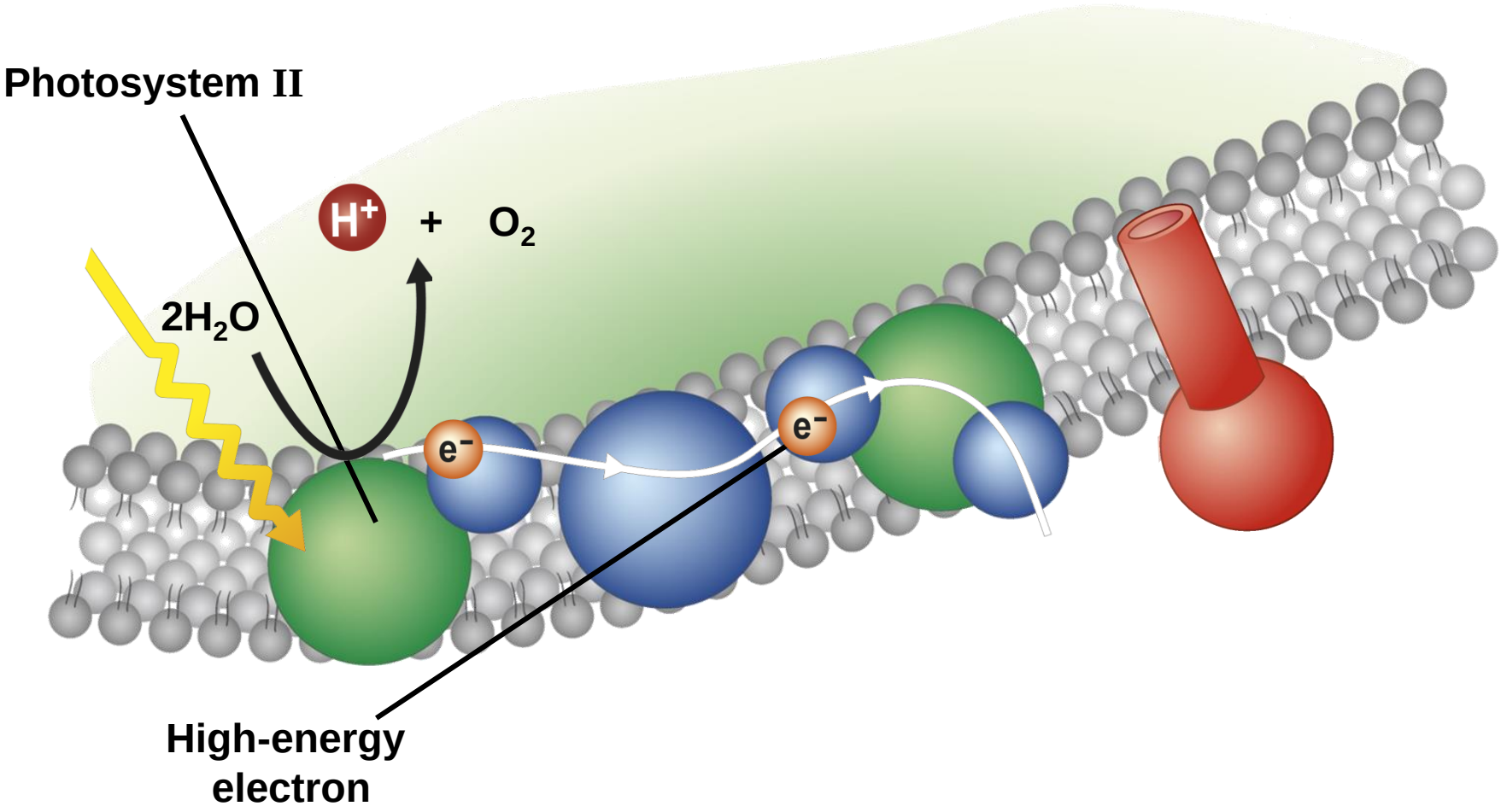
- Enzymes on the thylakoid membrane break water molecules into:



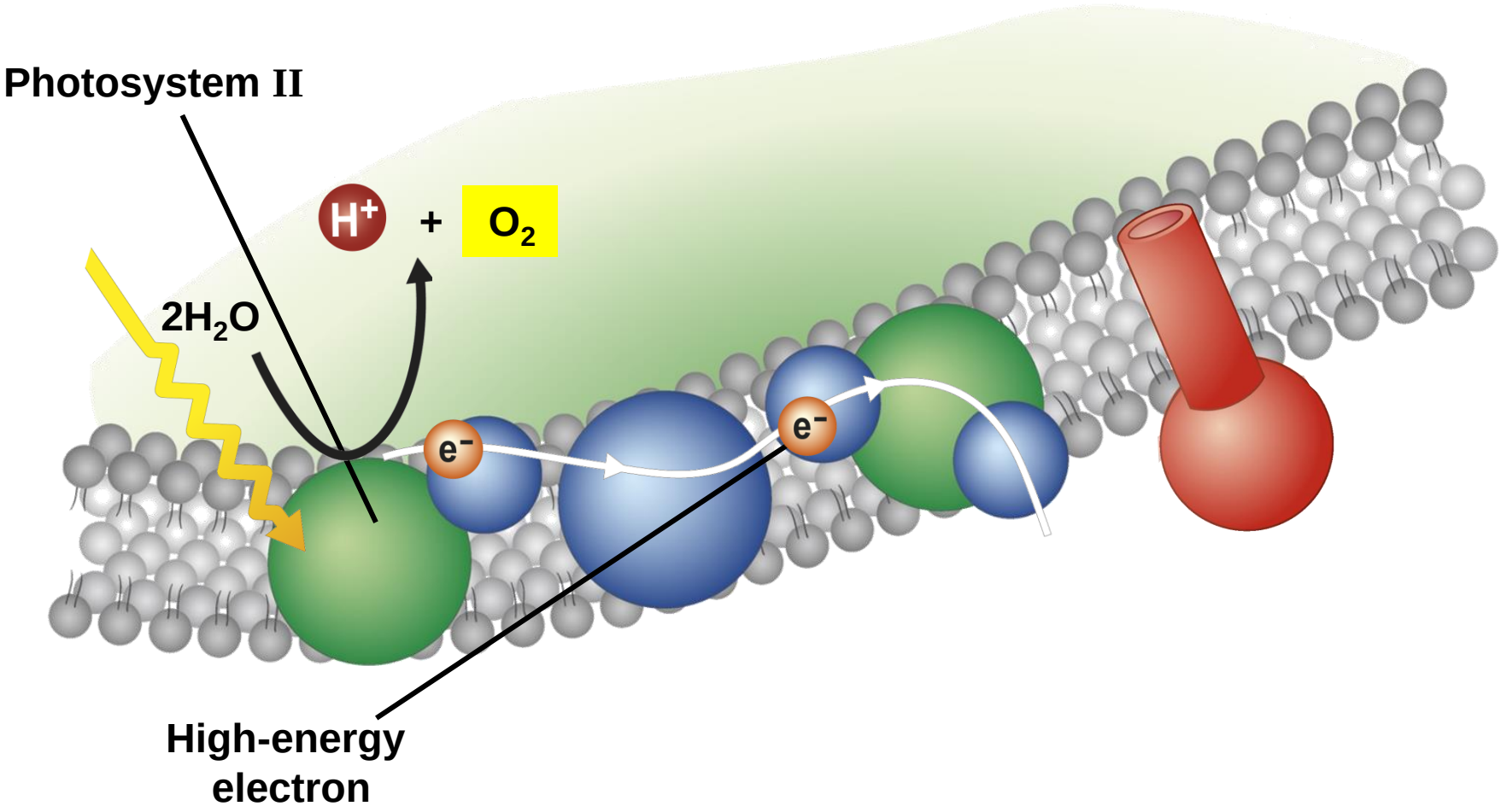
– hydrogen ions
– oxygen atoms
– energized electrons



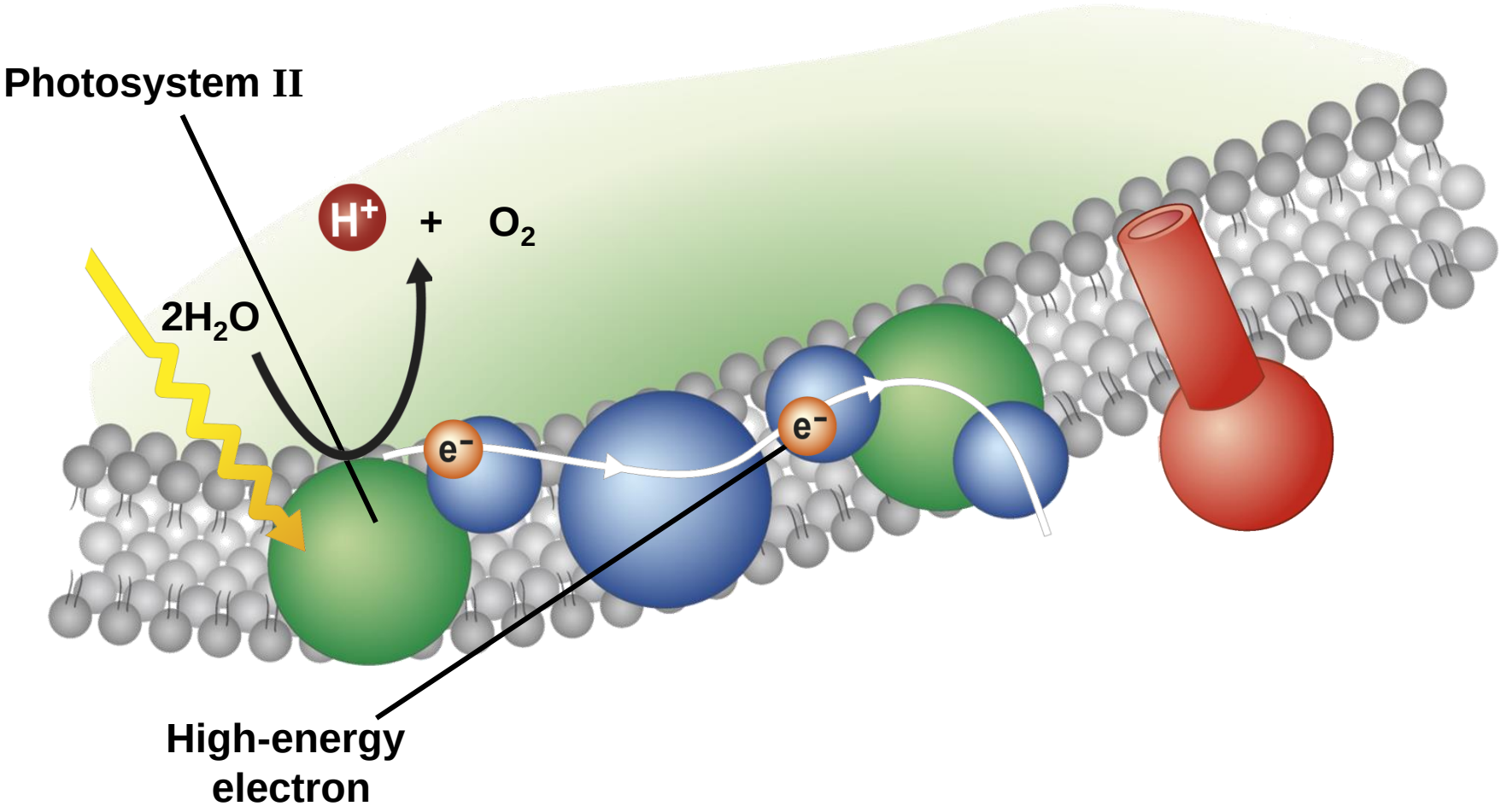
- The energized electrons from water replace the high-energy electrons that chlorophyll lost to the electron transport chain.



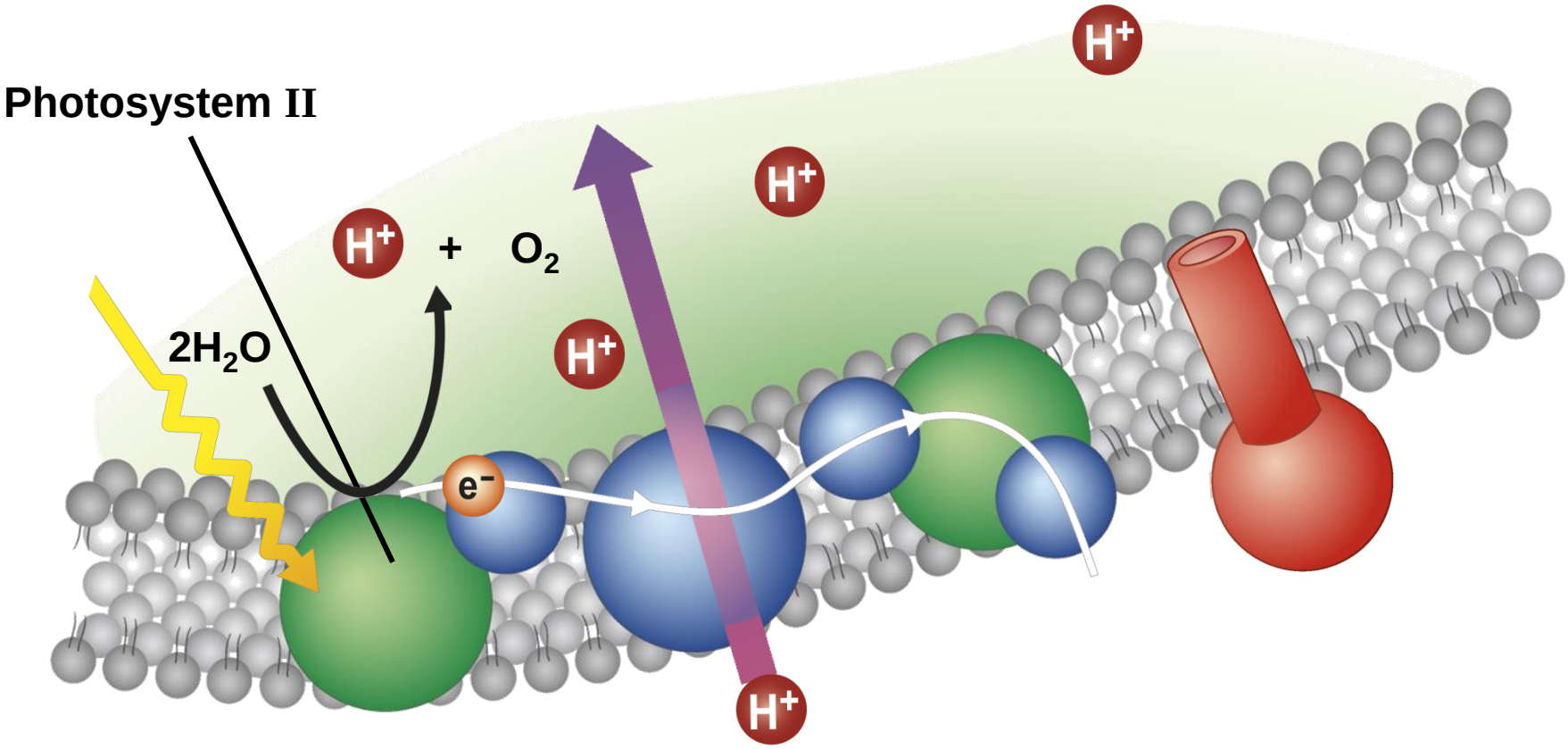
- As plants remove electrons from water, oxygen is left behind and is released into the air.



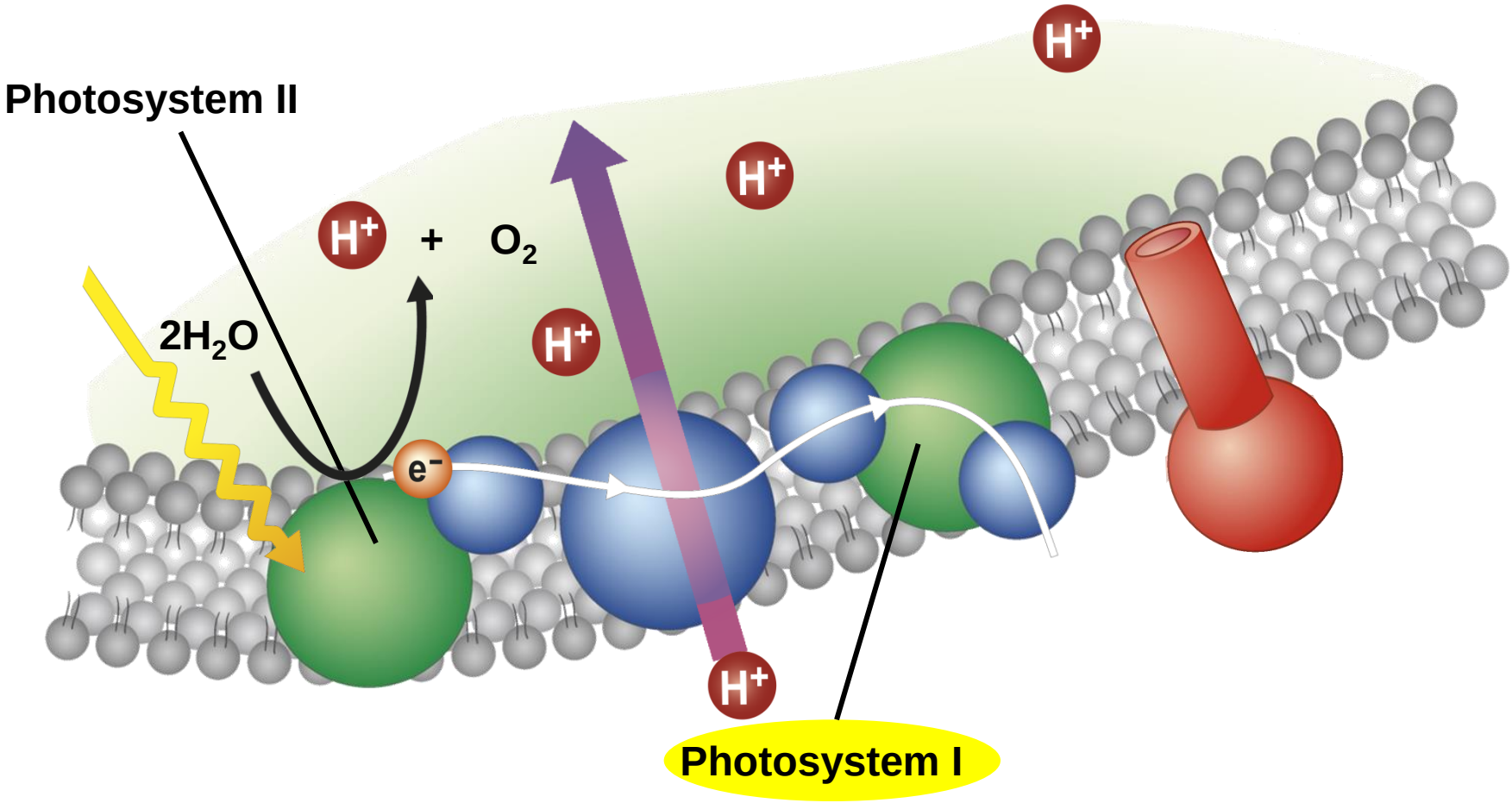
- The hydrogen ions left behind when water is broken apart are released inside the thylakoid membrane.



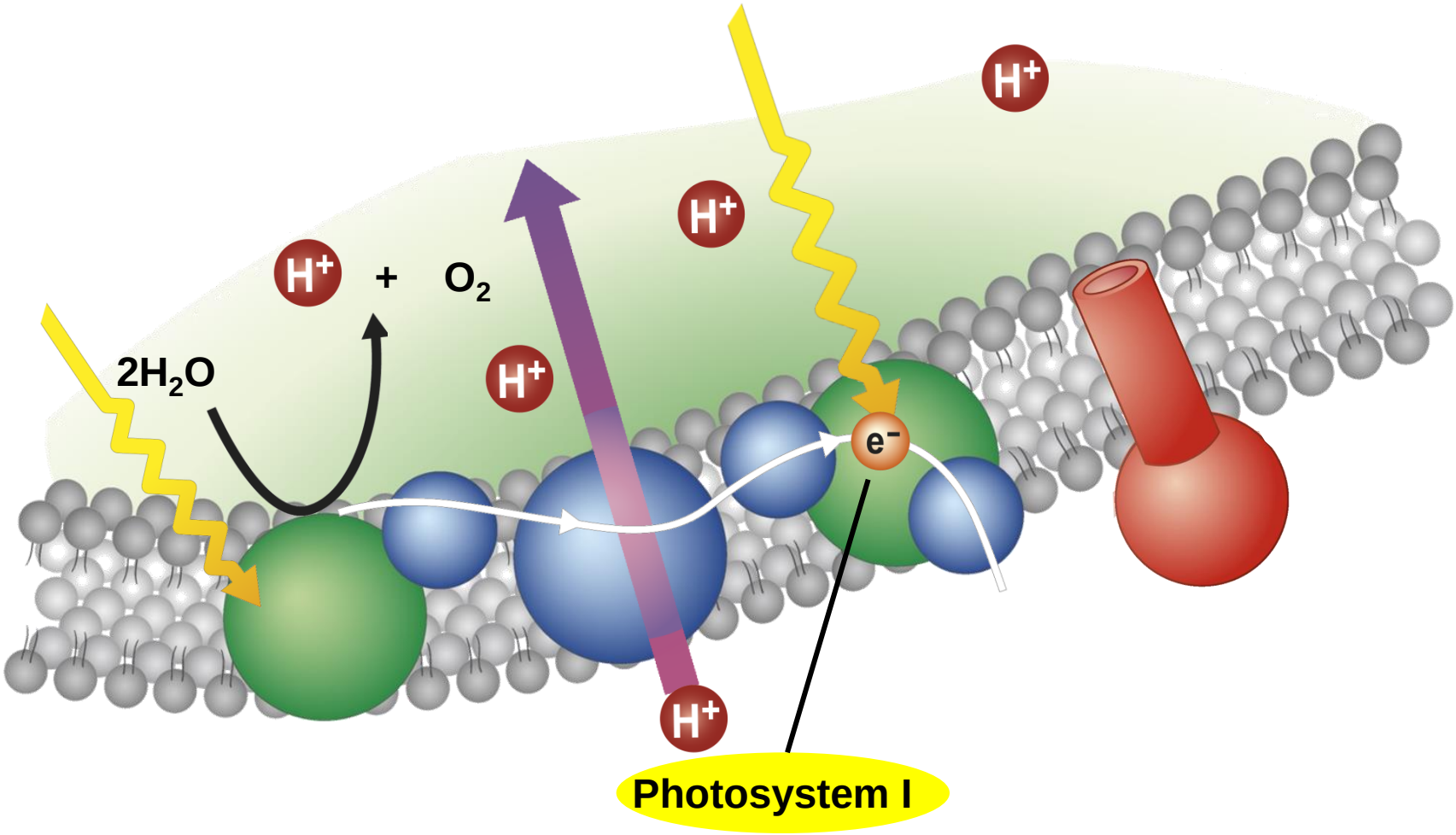
- Energy from the electrons is used to transport H^+ ions from the stroma into the inner thylakoid space.



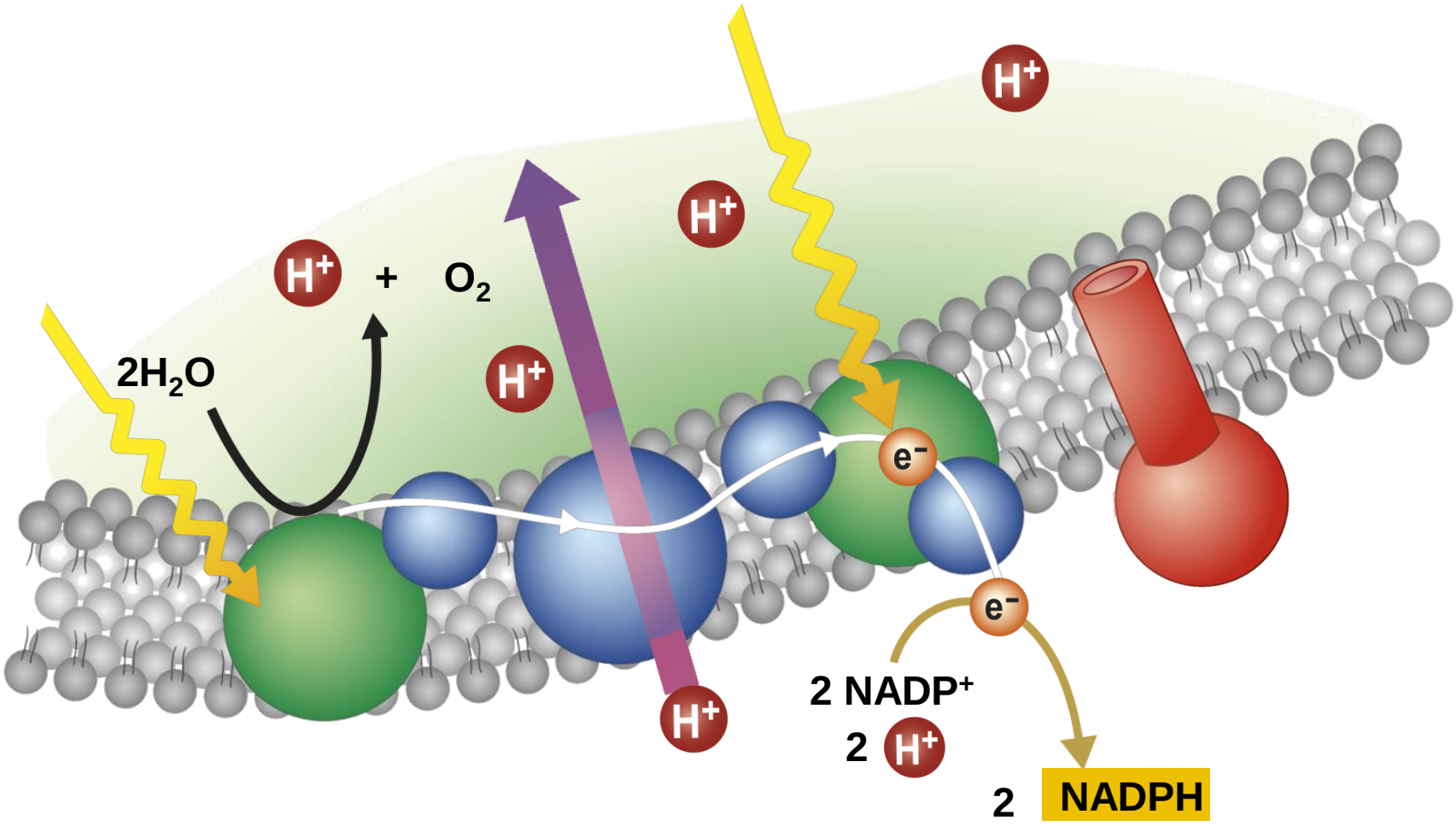
- High-energy electrons move through the electron transport chain from photosystem II to photosystem I.



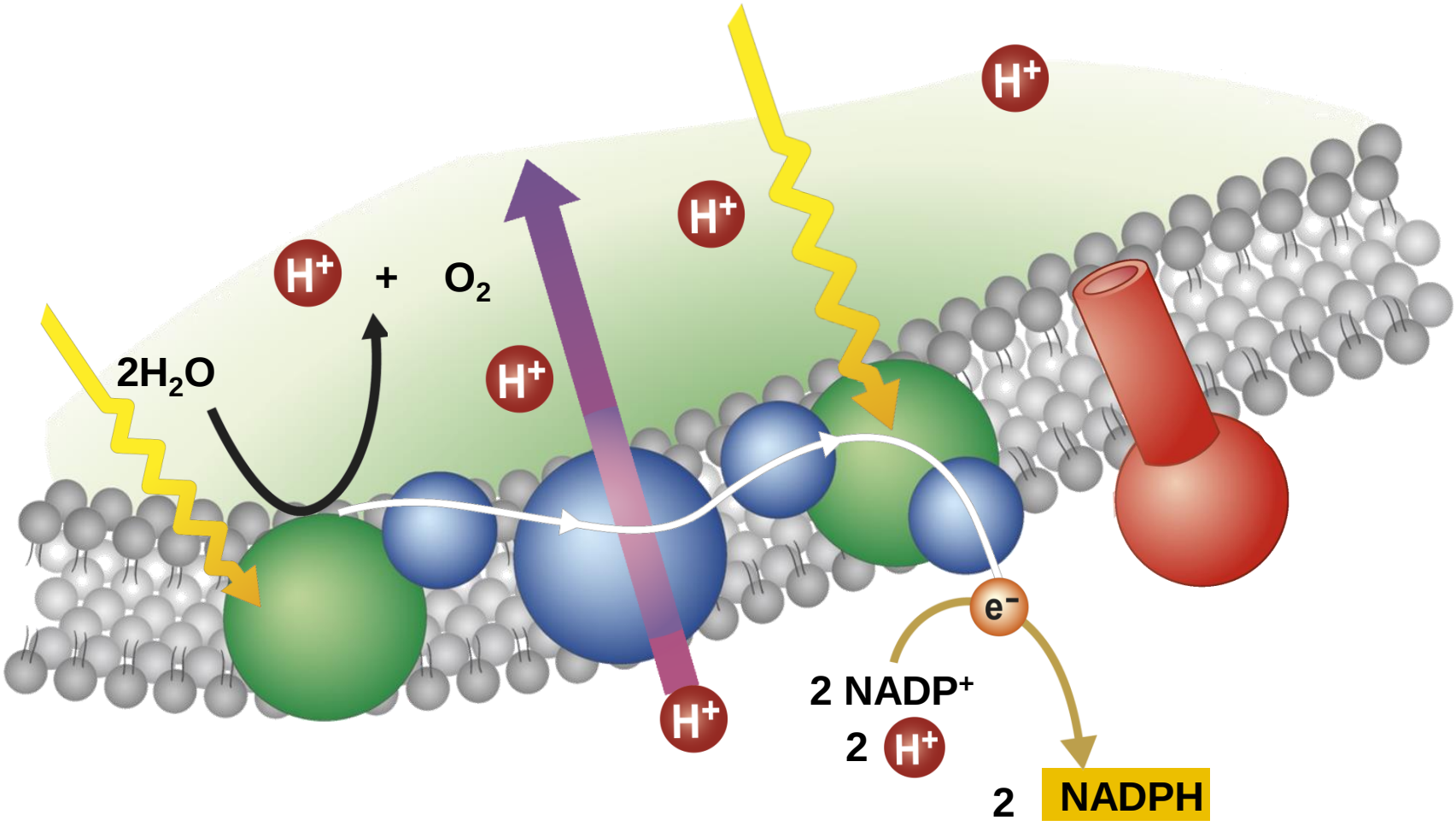
- Pigments in photosystem I use energy from light to re-energize the electrons.



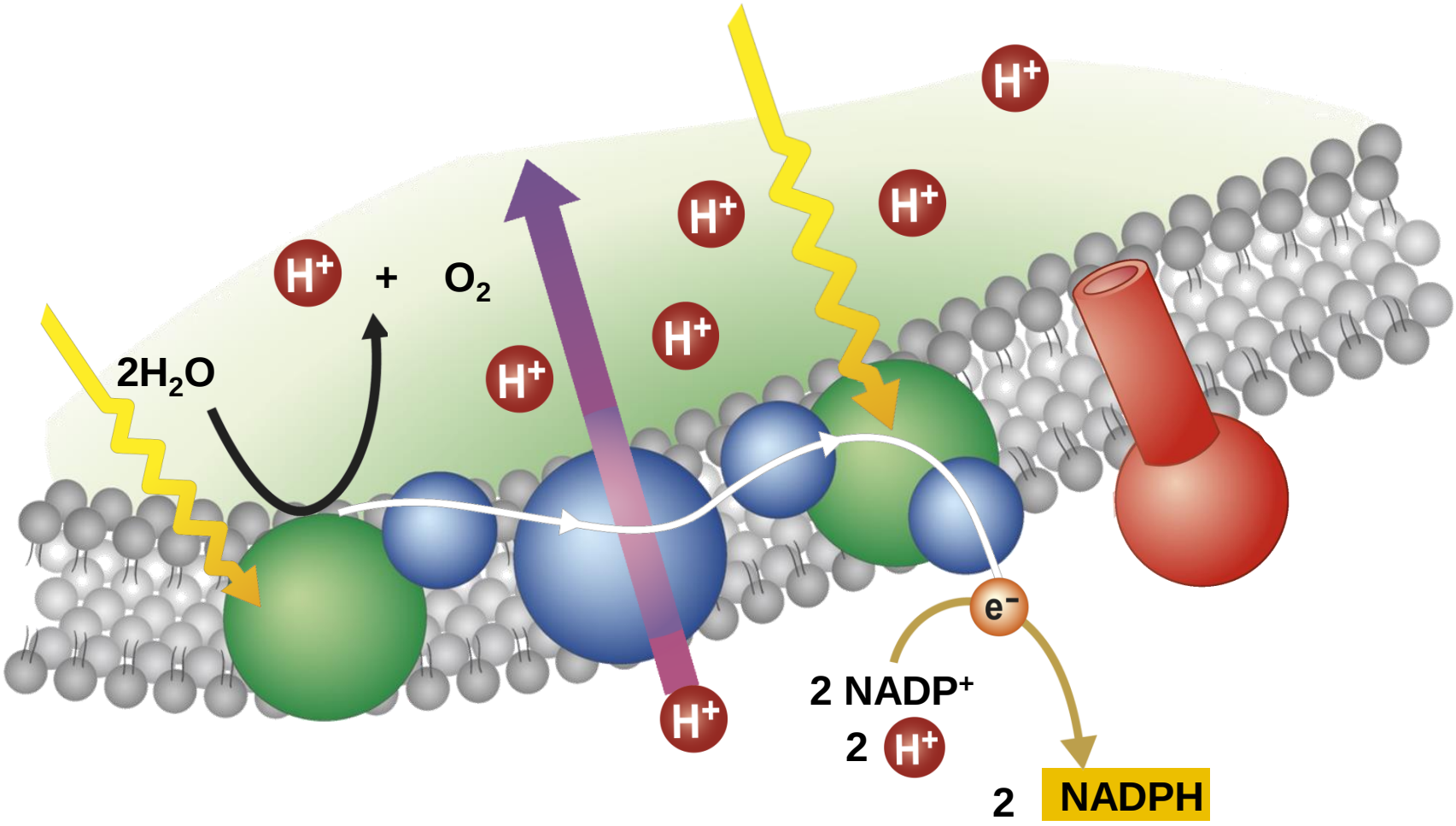
- $NADP^+$ then picks up these high-energy electrons, along with H^+ ions, and becomes NADPH.



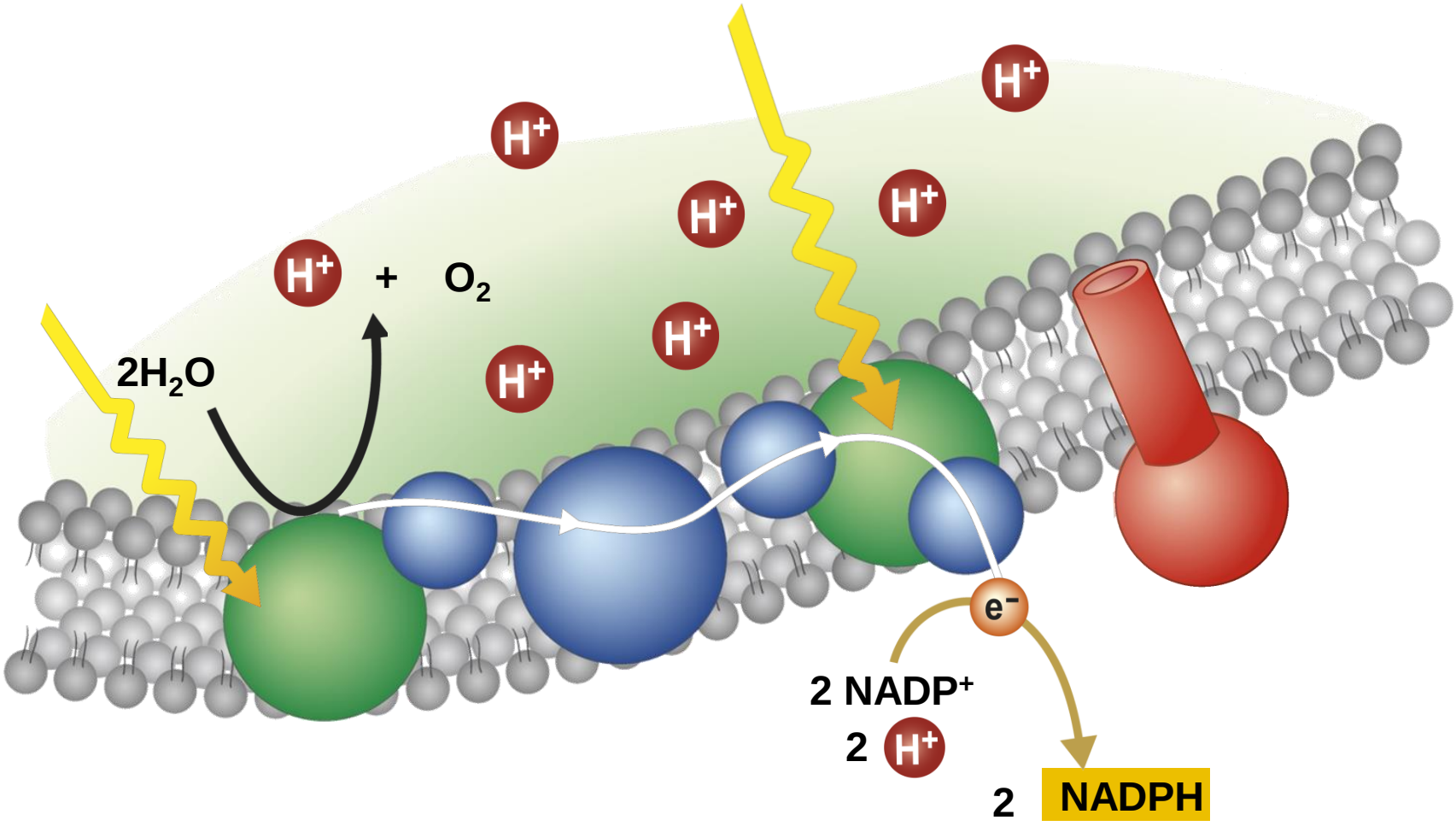
- As electrons are passed from chlorophyll to $NADP^+$, more H^+ ions are pumped across the membrane.



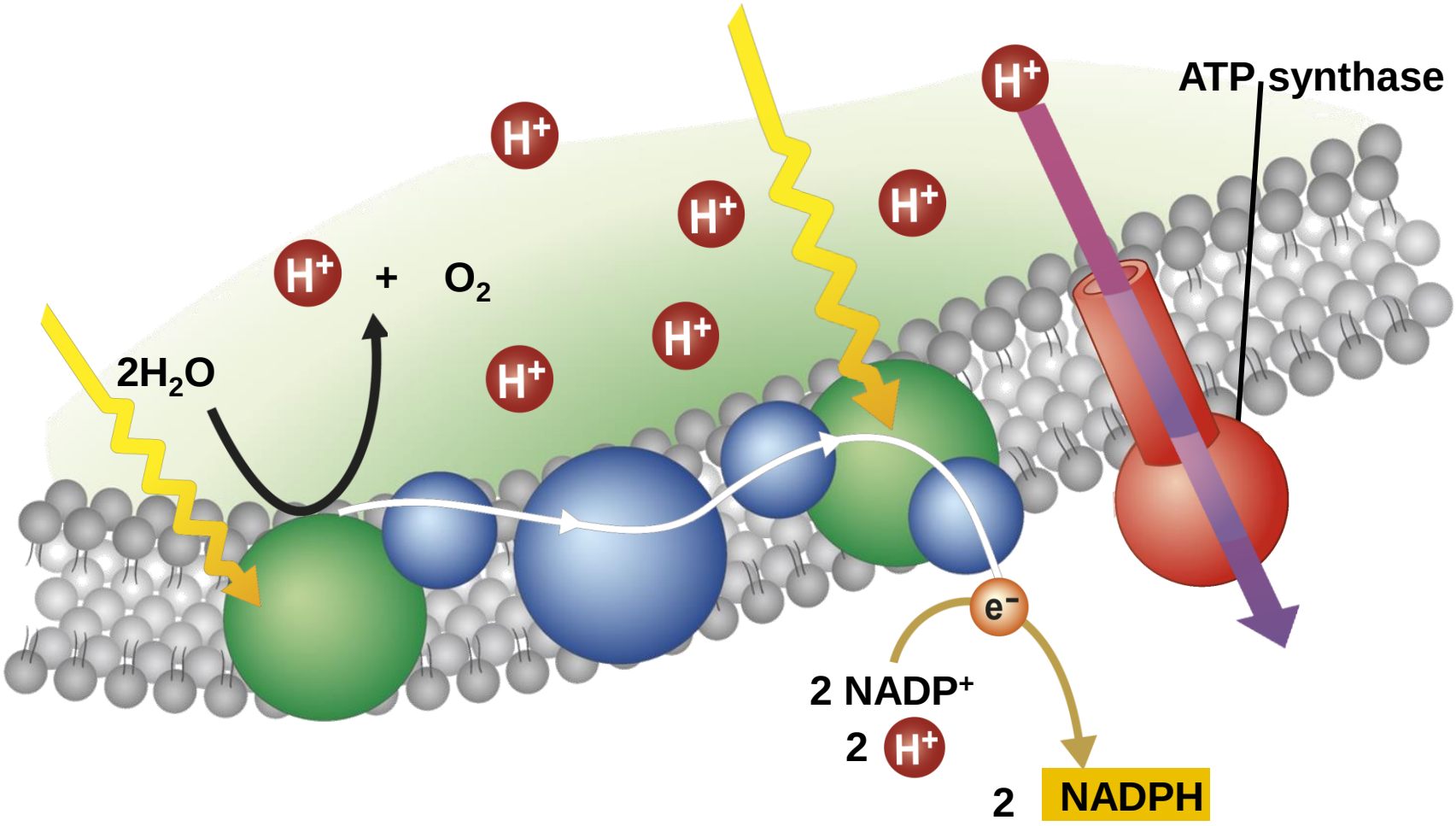
- Soon, the inside of the membrane fills up with positively charged hydrogen ions, which makes the outside of the membrane negatively charged.



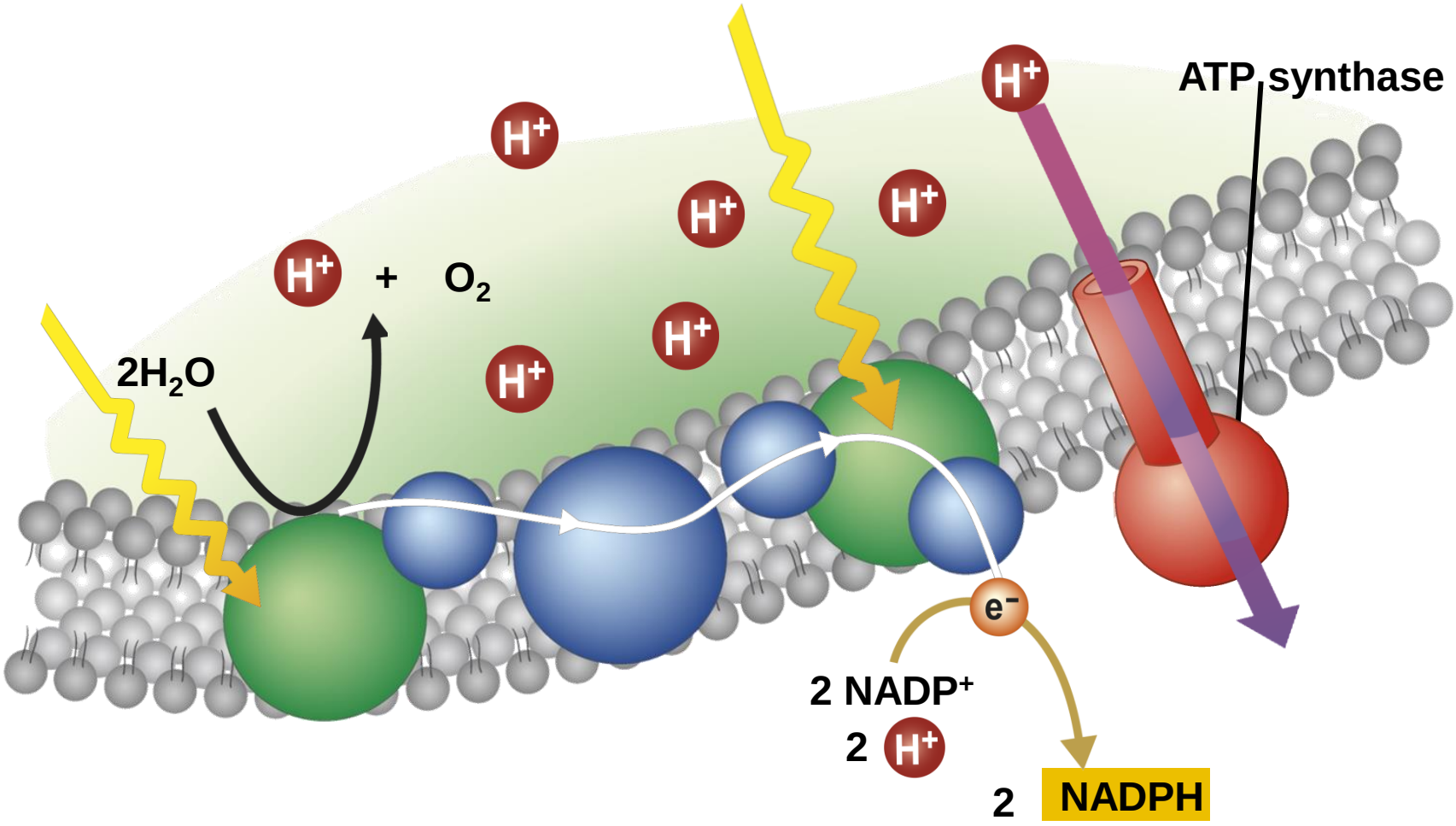
- The difference in charges across the membrane provides the energy to make ATP



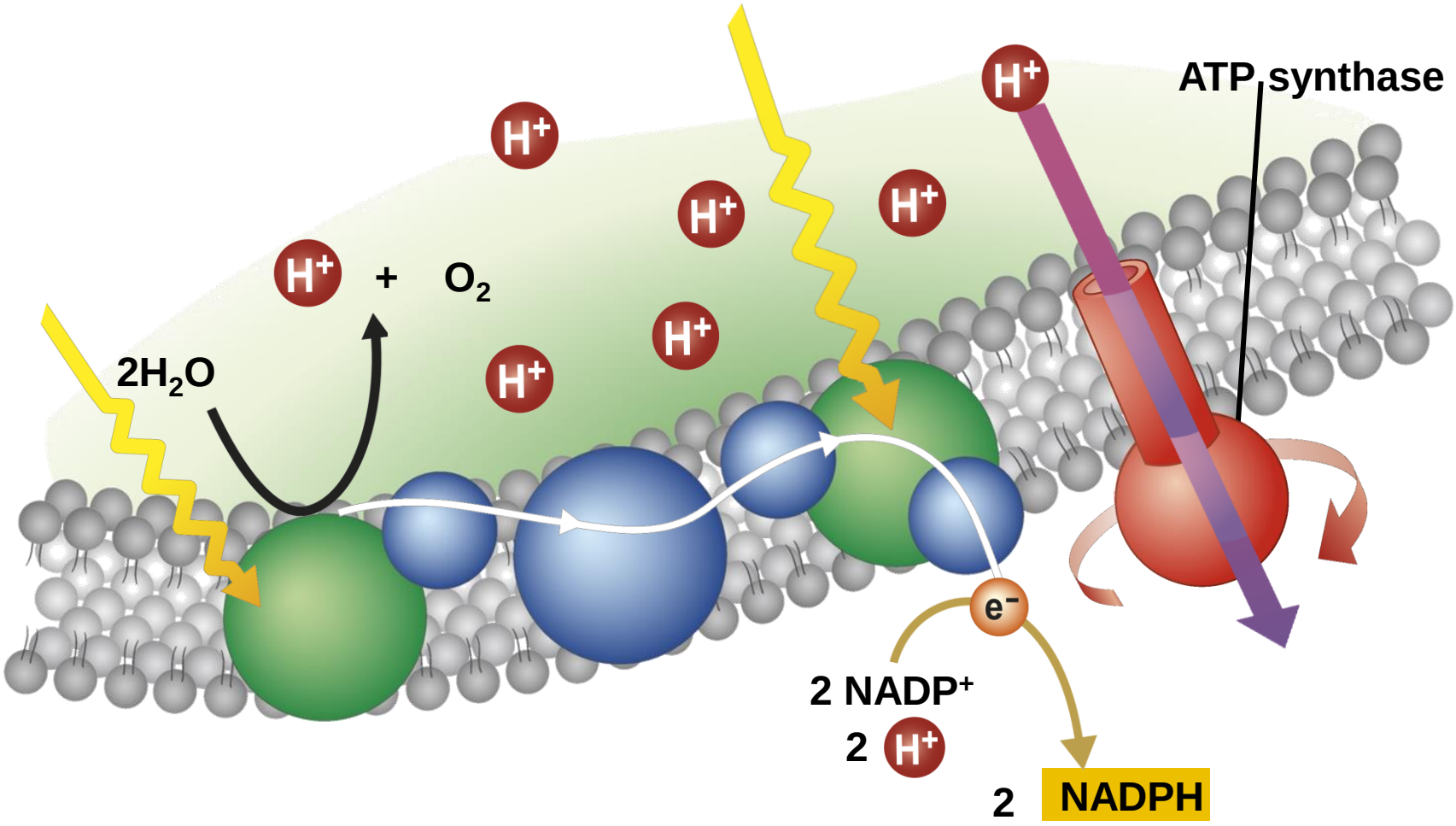
•H^+ ions cannot cross the membrane directly.



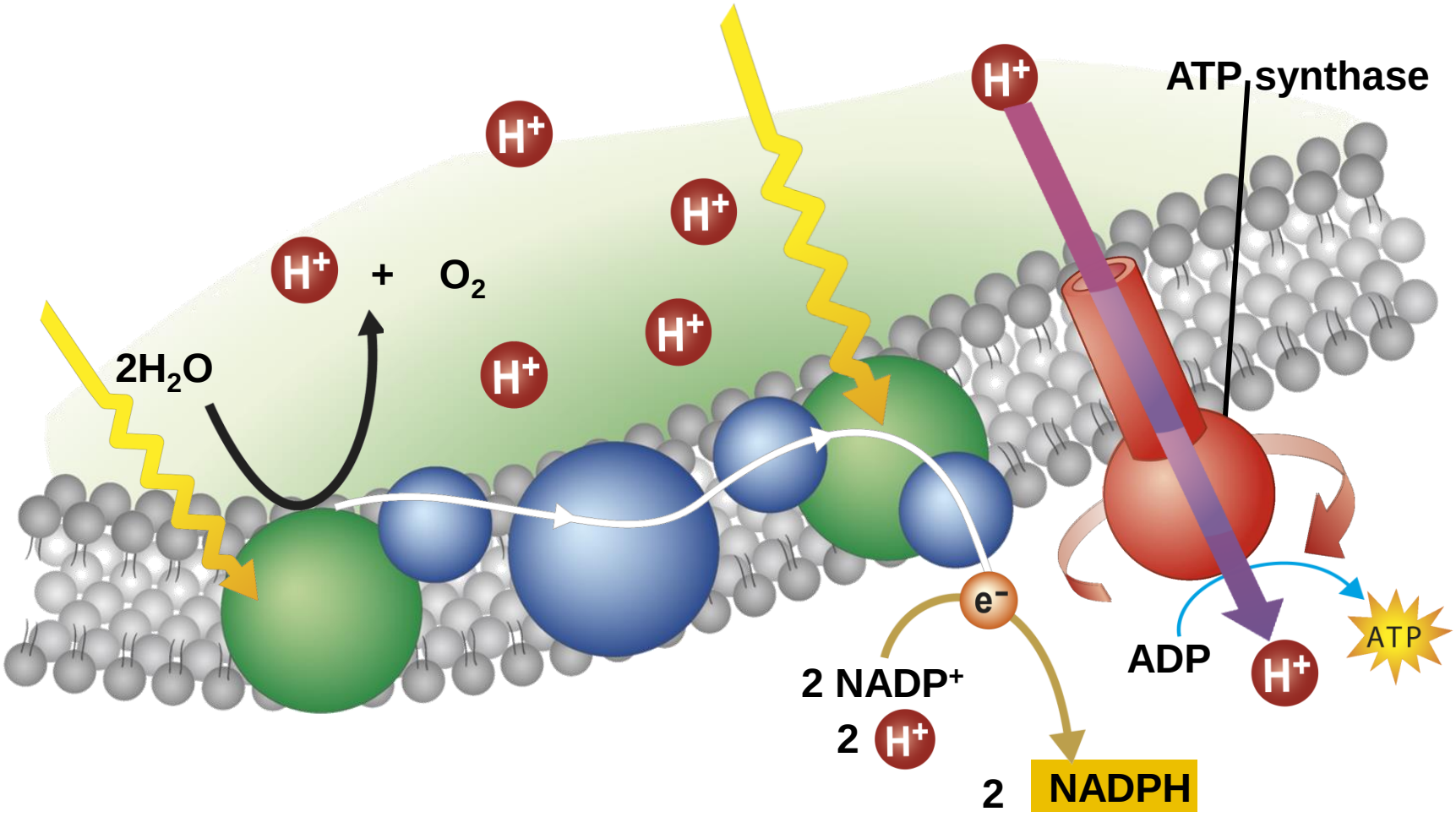
•The cell membrane contains a protein called **ATP synthase** that allows H^+ ions to pass through it



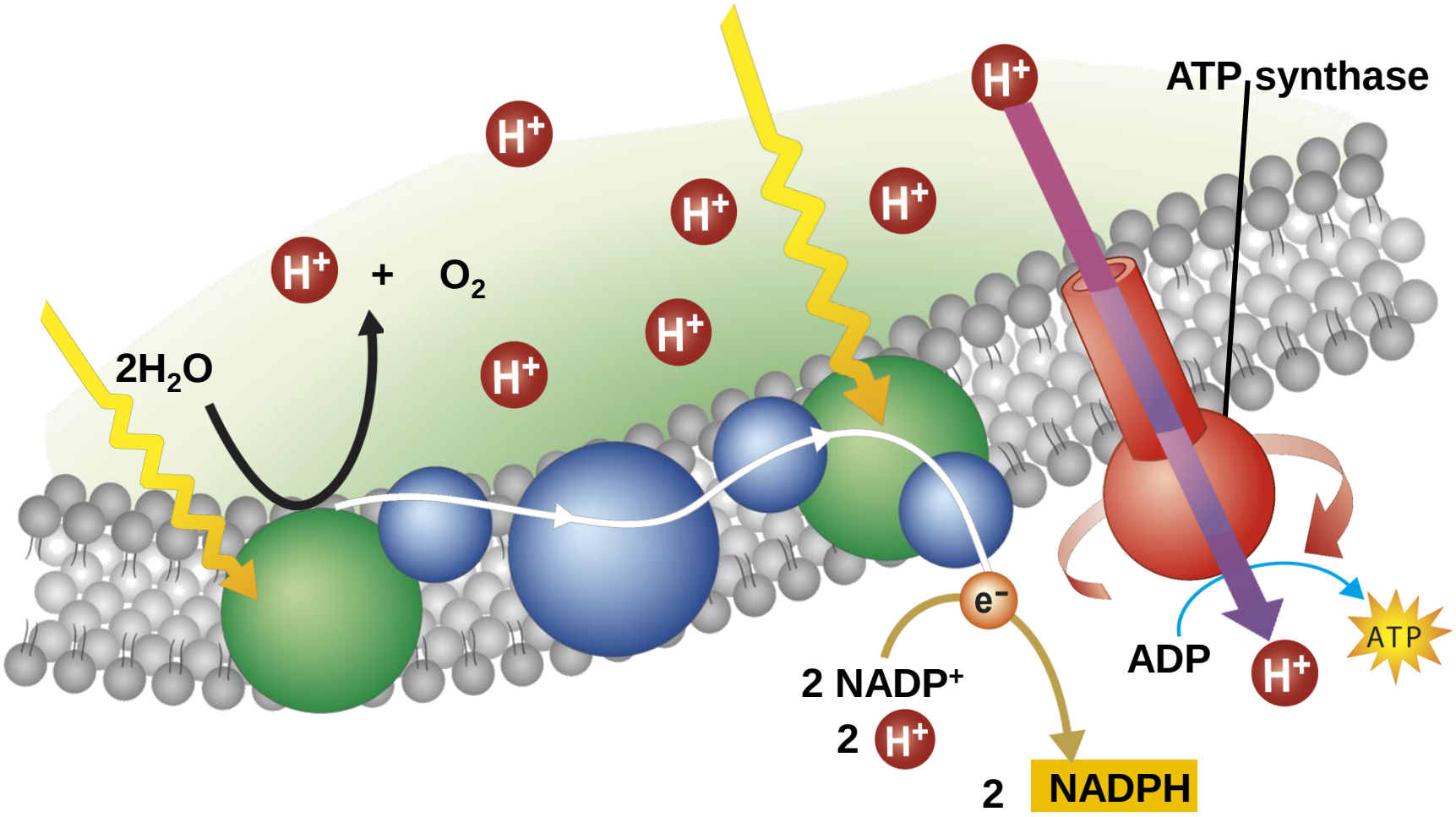
•As H^+ ions pass through ATP synthase, the protein rotates.



•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.



Products of light reaction

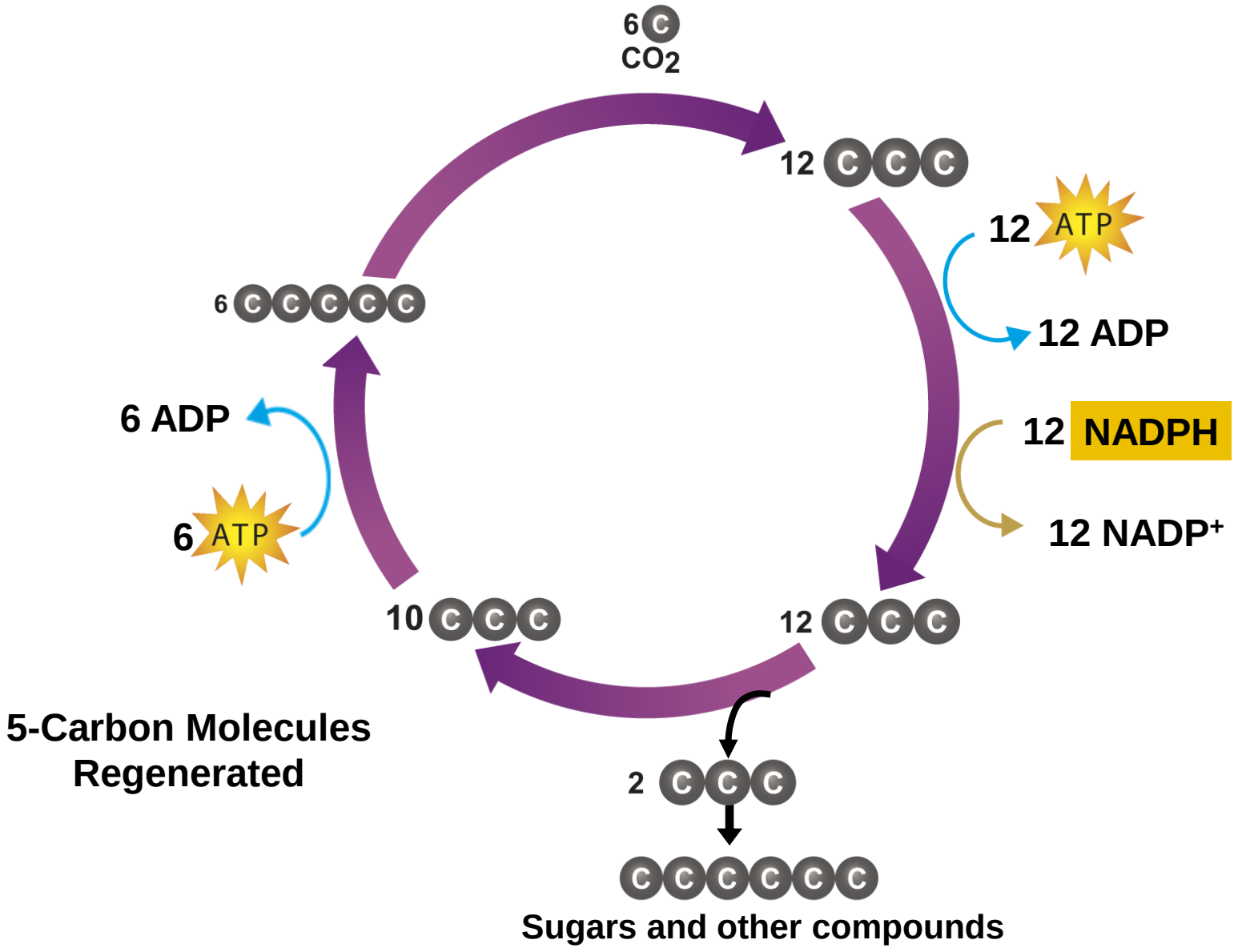
- O_2 – released to atmosphere
- ATP and NADPH – can only store energy for a few minutes

Calvin Cycle

- Occurs in the stroma
- Does not require light

1. Plant takes in CO_2 from atmosphere
2. Energy from NADPH and ATP is used to make one glucose ($C_6H_{12}O_6$) molecule from 6 CO_2 molecules
3. High energy sugar can make . . .
    1. Starch – stores energy for a long time
    2. Cellulose – cell walls

The Calvin Cycle



Chloroplast

Granum

Thylakoid membrane