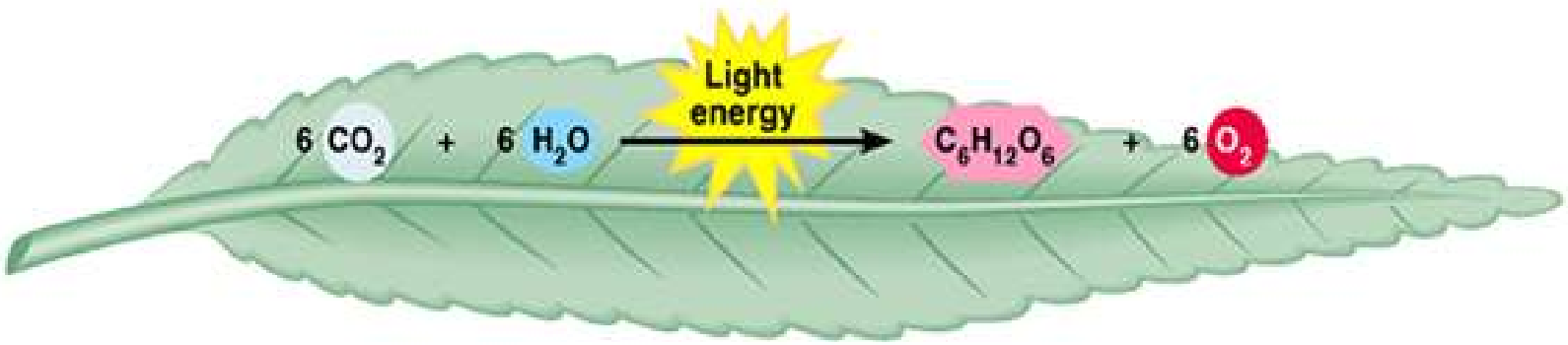
Unit 6: Cellular Energy

Learning Goal

- Explain how photosynthetic organisms use the process of photosynthesis and respiration

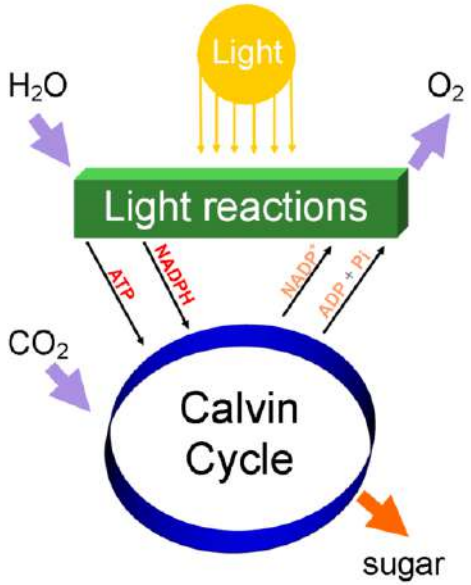
I. Photosynthesis Overview

- Plant, algae, and some bacteria use the products of photosynthesis to create complex carbohydrates
  - Examples: starch and cellulose



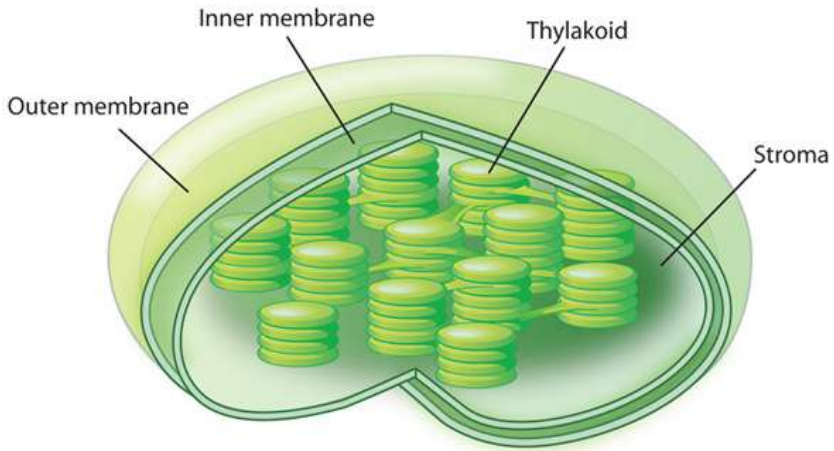
I. Photosynthesis Overview

- Happens in the Chloroplast
- There are 2 Steps
  - Light dependent
  - Light independent (AKA the Calvin Cycle)



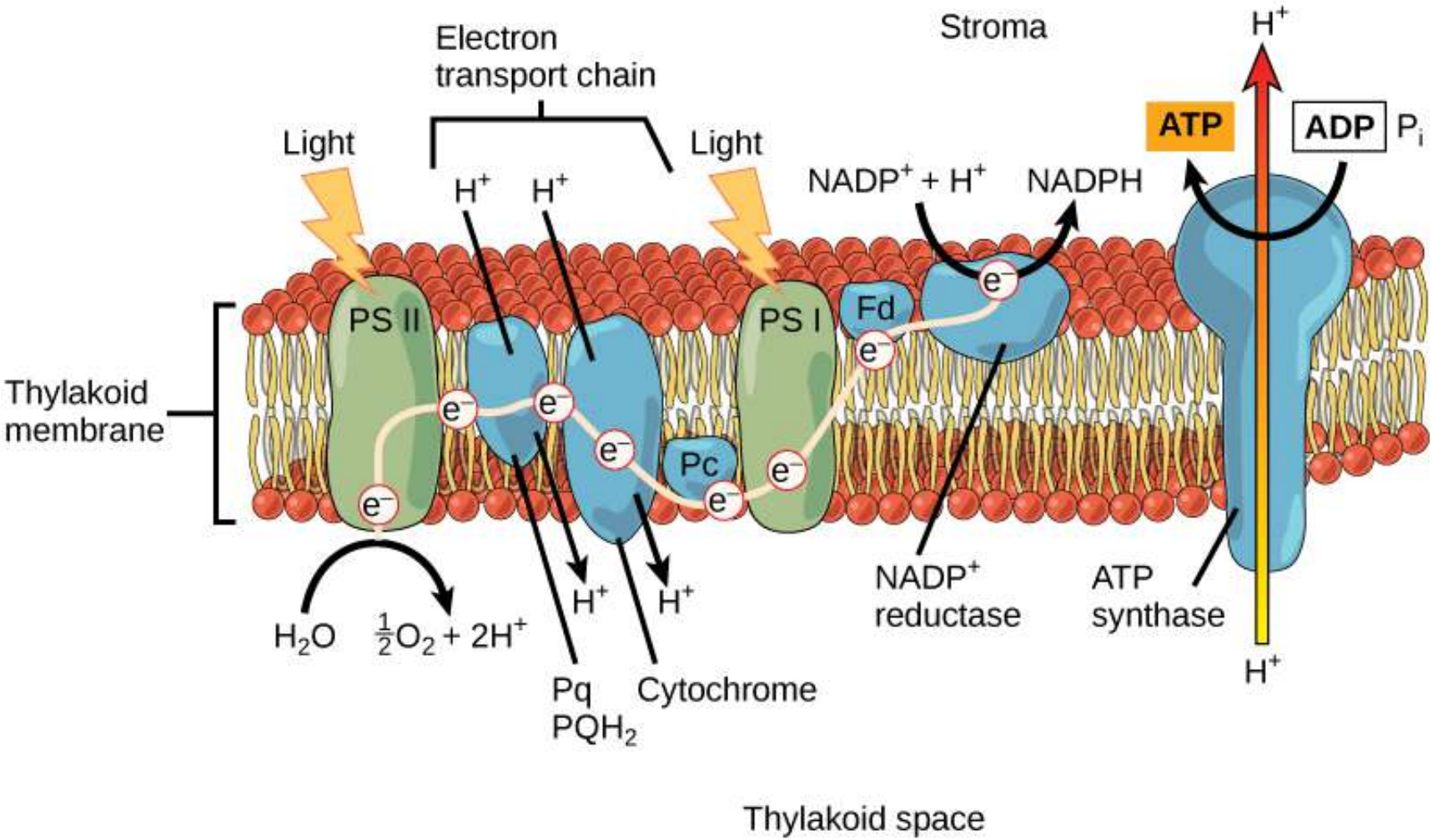
II. The Chloroplast

- The Chloroplast is made of 2 parts
  - Thylakoids
    - Home of the light dependent reactions
    - Contain the pigment chlorophyll
  - Stroma Home of the light-independent reactions



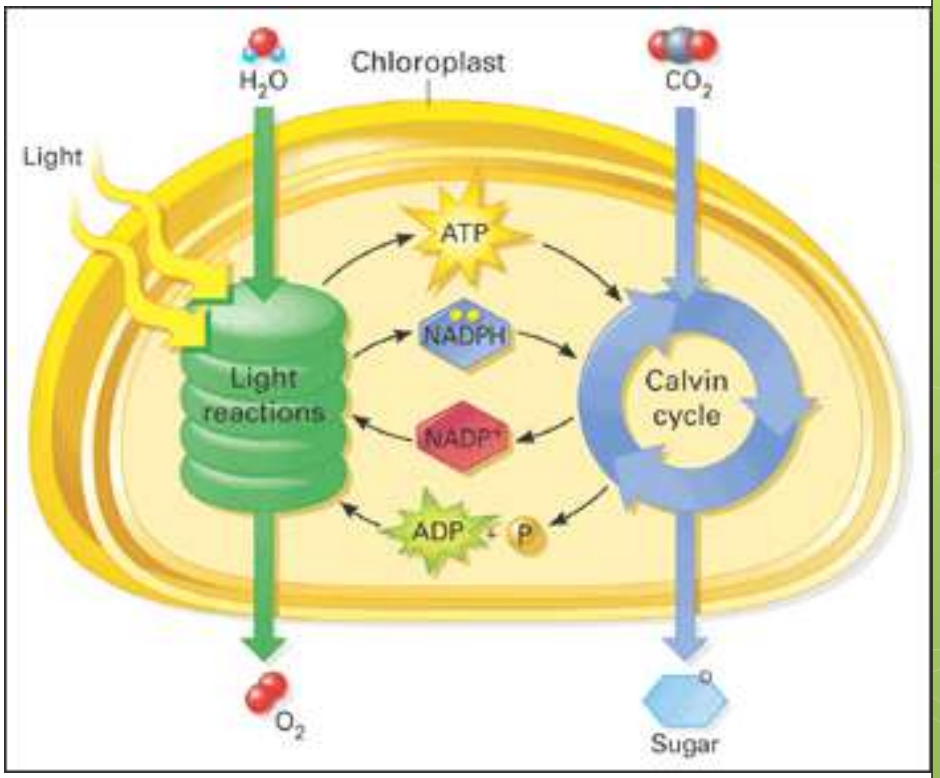
III. Light Dependent Reactions

- Light hits the chlorophyll
- Chlorophyll splits a water molecule
- Electrons are sent down an electron transport chain
- Electrons lose energy
- Electrons are reenergized when light hits more chlorophyll


Electron
transport chain
Stroma
Light
Light
H+
H+
NADP+ + H+
NADPH
ATP
ADP
Pi
PS II
PS I
Fd
Thylakoid
membrane
e−
Pc
H2O
½O2 + 2H+
Pq
PQH2
Cytochrome
NADP+
reductase
ATP
synthase
Thylakoid space

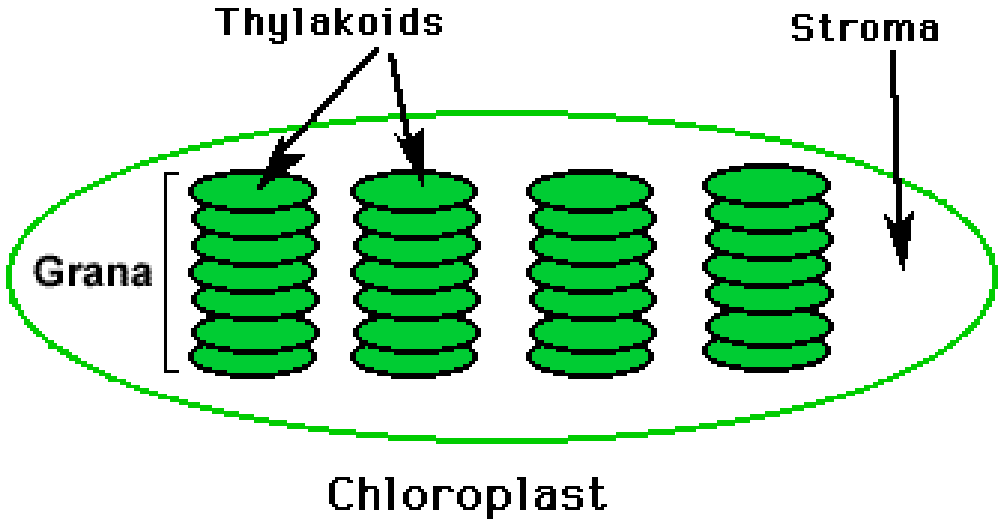
III. Light Dependent Reactions

- During the light dependent process ATP and NADH are produced to take energy from the light dependent reactions to the light-independent reactions



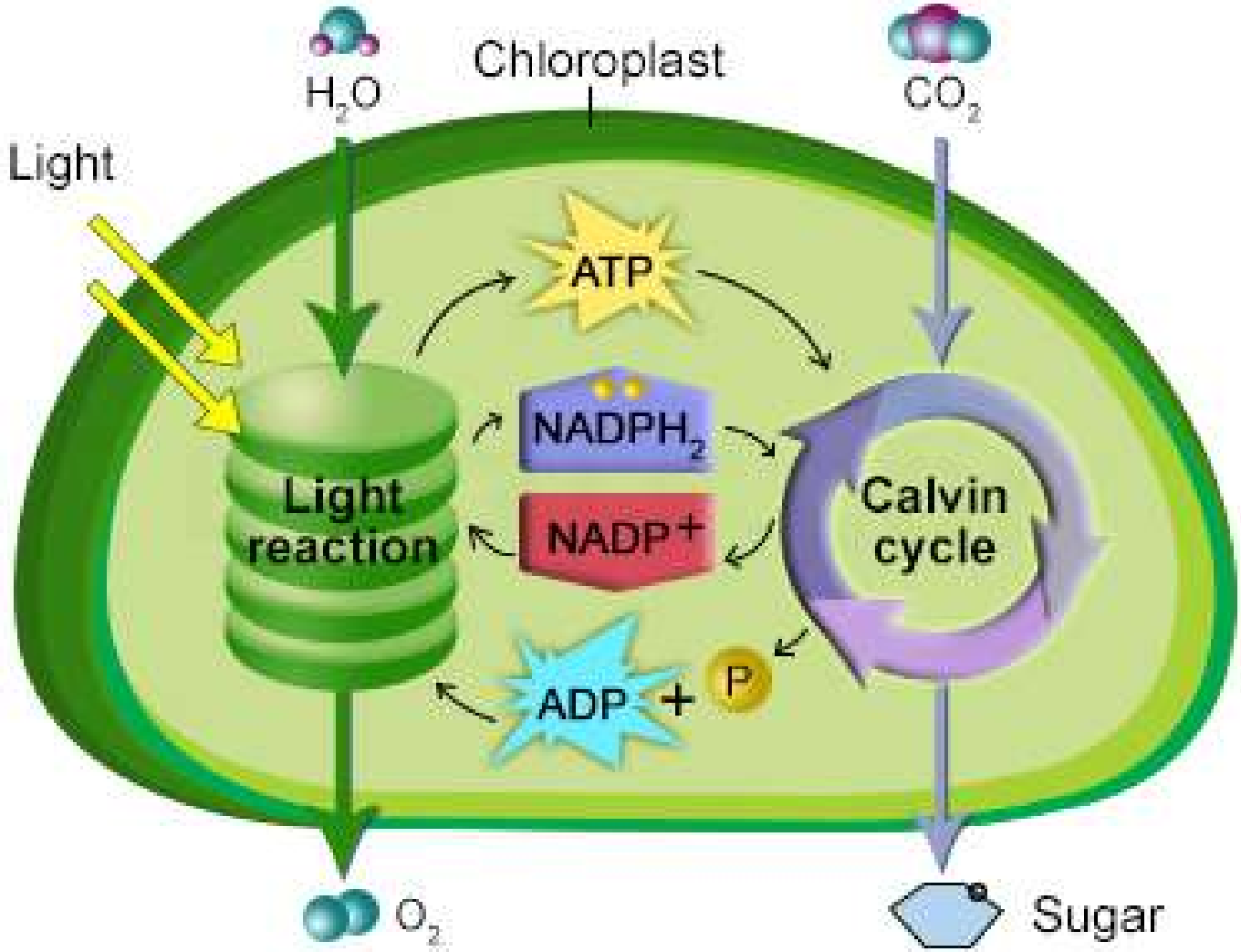
III. Light Dependent Reactions

- Products of the light-dependent reactions
  - Oxygen → released into the atmosphere
  - ATP → taken to the stroma
  - NADPH → taken to the stroma



IV. Light-Independent Reactions

- Also known as the Calvin Cycle and Carbon fixation reactions
- Happens in the stroma
- Uses ATP from the light dependent reactions for energy
- Carbon Dioxide and NADPH are used to make glucose ($C_6H_{12}O_6$)


H_2O
Chloroplast
CO_2
Light
ATP
$NADPH_2$
Light reaction
$NADP^+$
Calvin cycle
ADP
+
P
O_2
Sugar
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Learning Goal

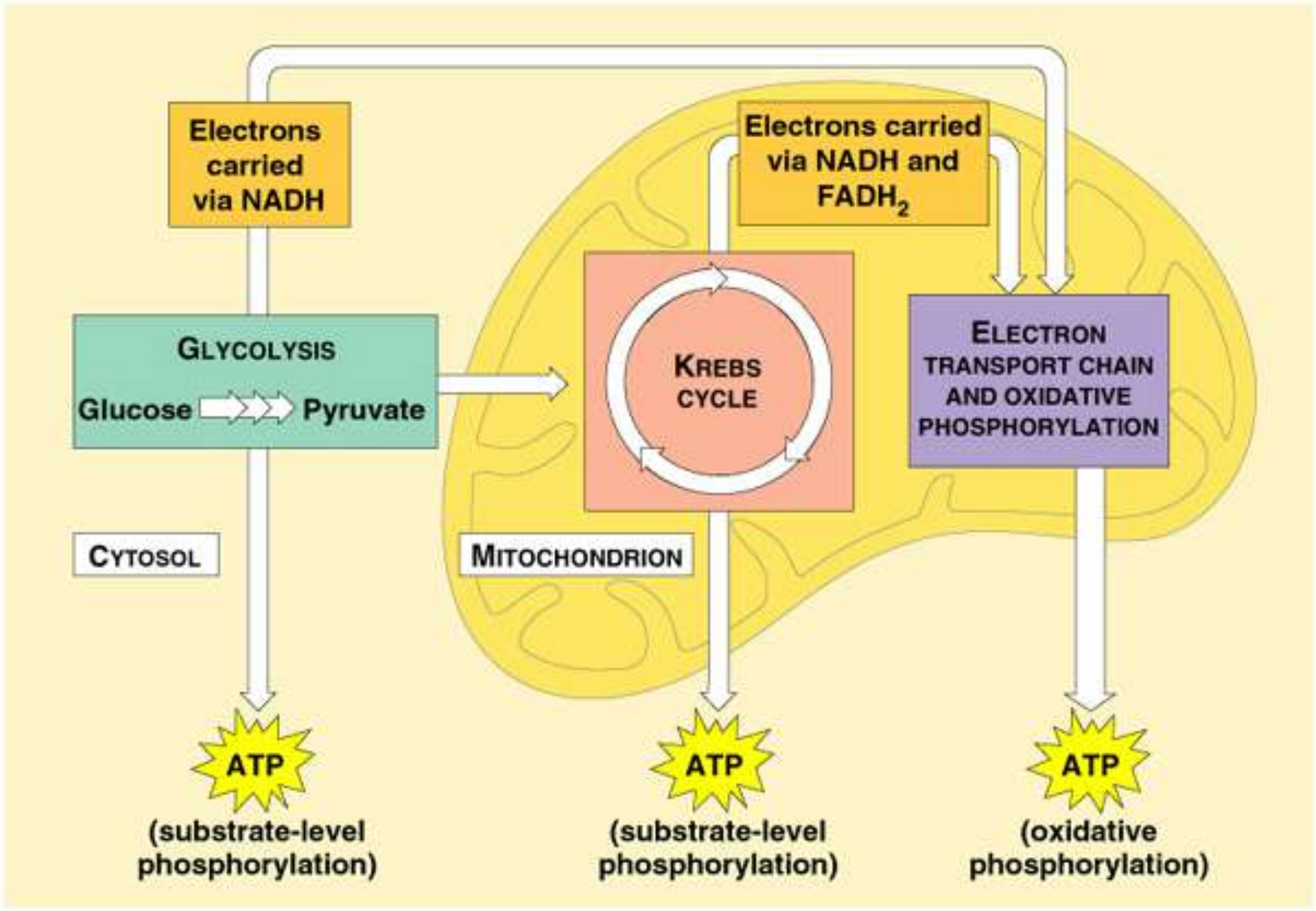
- Identify the cellular sites and follow through the major pathways of anaerobic respiration and account for how aerobic respiration produces more ATP per monosaccharide

V. Cellular Respiration Overview

- **Cellular respiration is the process of breaking down food molecules to release energy**
- Two types of respiration
  - **Aerobic respiration – occurs in the presence of oxygen**
  - **Anaerobic respiration – occurs without oxygen**

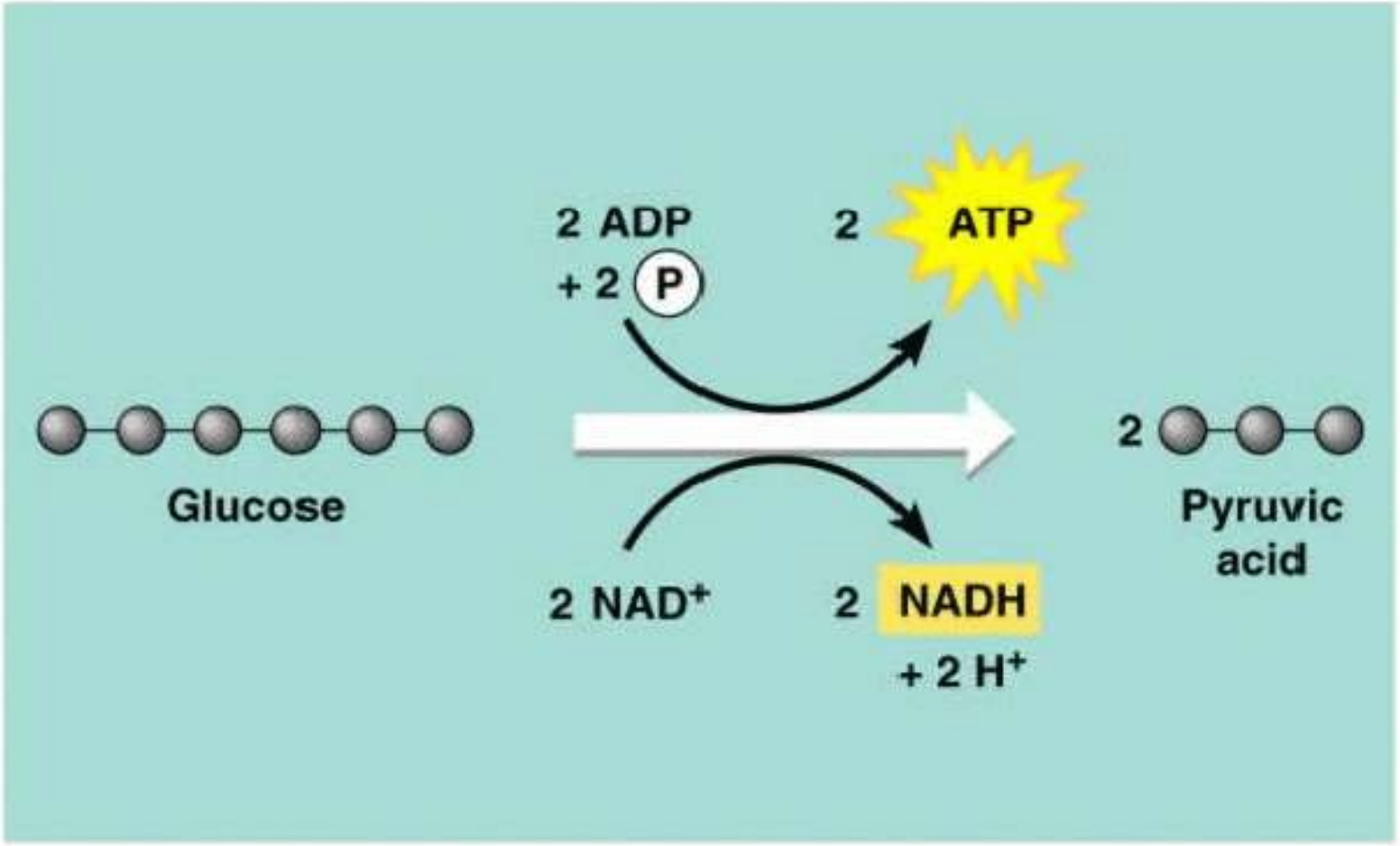
VI. Aerobic Respiration

- Has 3 steps
  - Glycolysis
  - Krebs Cycle
  - Electron Transport Chain (ETC)
- All reactions occur with the help of enzymes



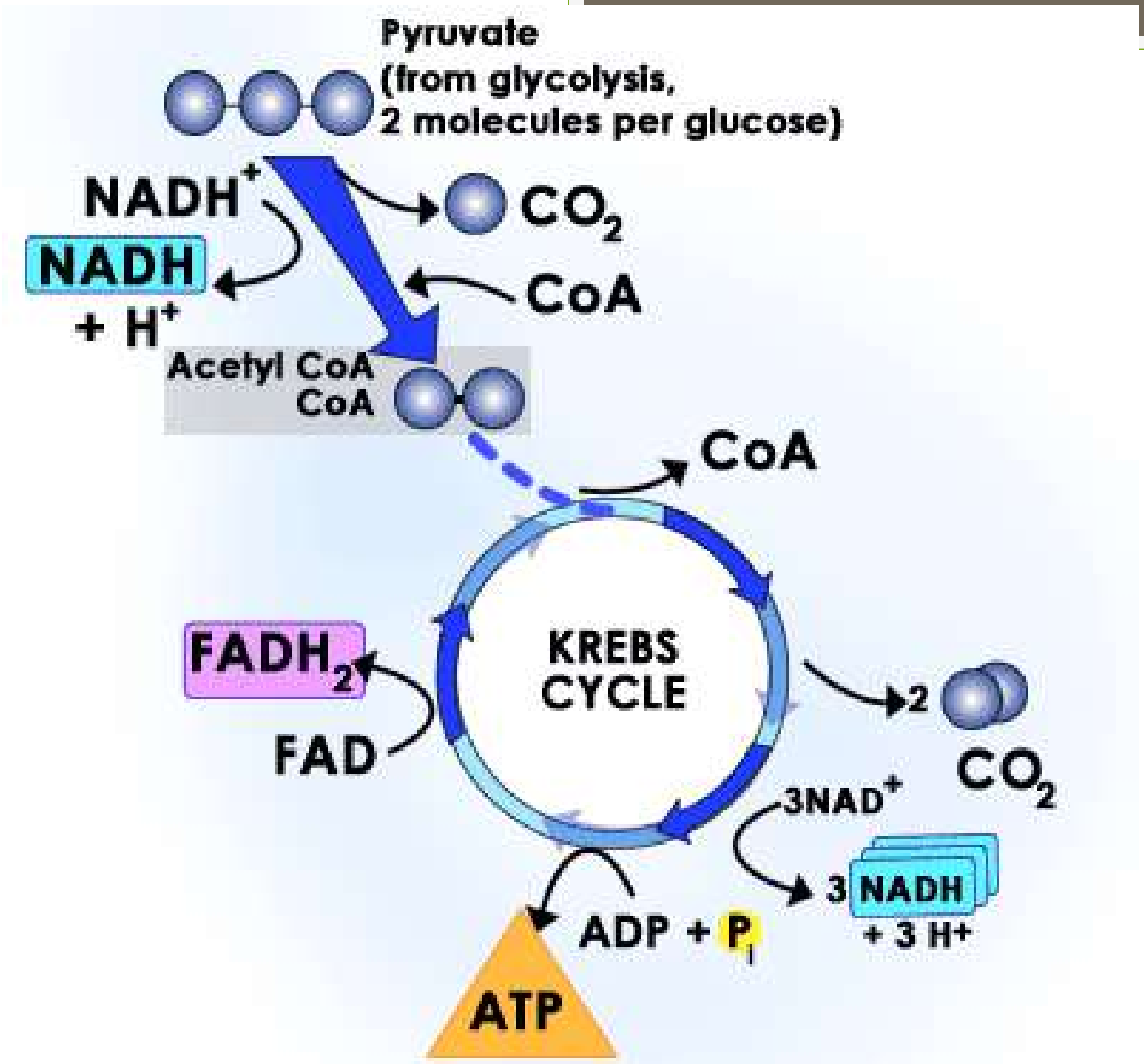
VI. Aerobic Respiration

- Glycolysis
  - **Occurs in the cytoplasm**
  - **Can occur with or without oxygen**
  - Breaks one molecule of glucose in half
  - **Produces ATP**
  - **Converts NAD+ into NADH**
    - NADH will be used later to make more ATP


2 ADP
+ 2 P
2 ATP
Glucose
2
Pyruvic acid
2 NAD+
2 NADH
+ 2 H+

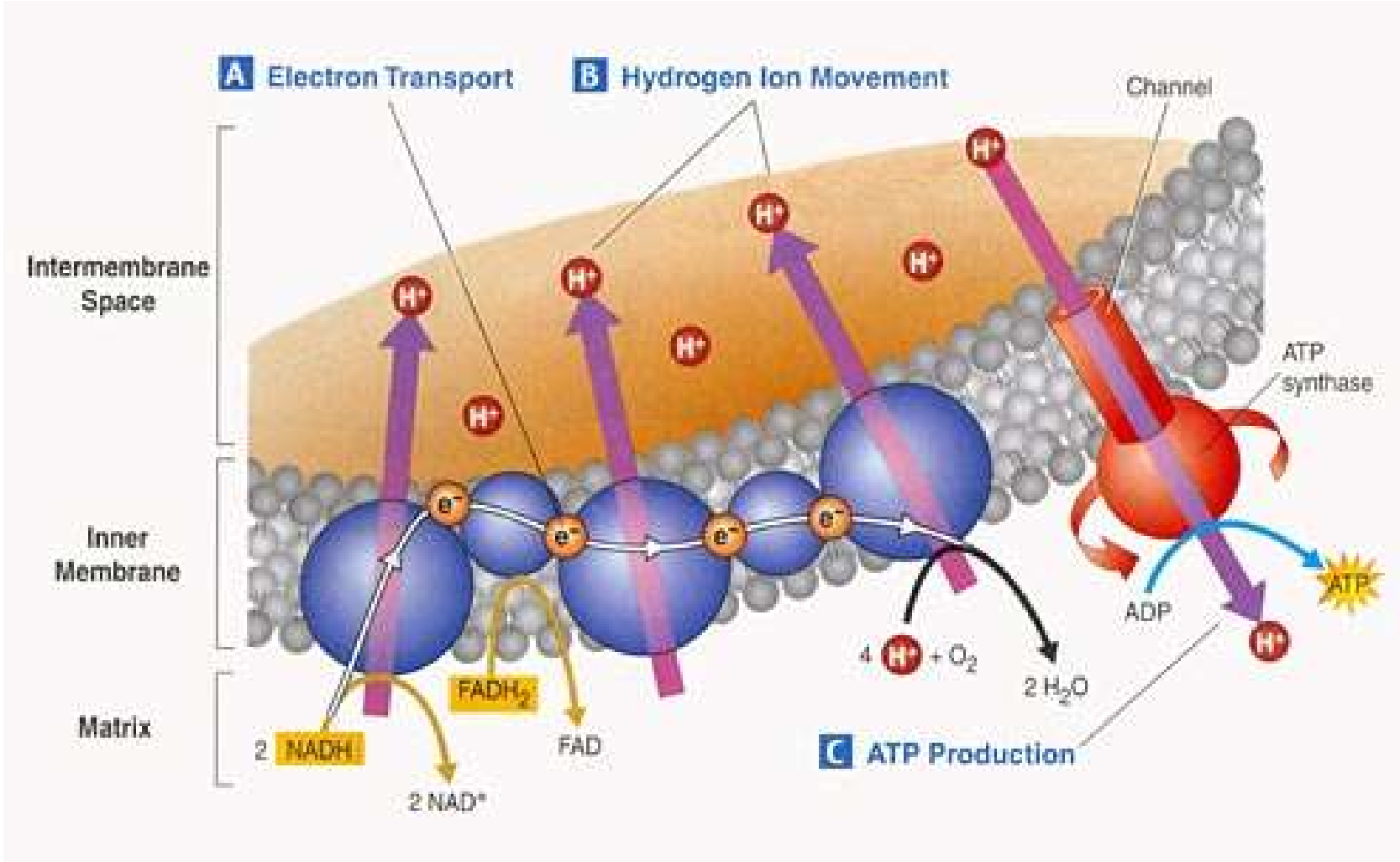
VI. Aerobic Respiration

- Citric Acid Cycle
  - AKA Krebs Cycle
  - Happens in the mitochondria
  - The 3 carbon sugars along with OXYGEN enter the mitochondria and are converted into citric acid
  - ATP, GTP, and NADH are produced


Pyruvate
(from glycolysis,
2 molecules per glucose)
NADH+
NADH
+ H+
CO2
CoA
Acetyl CoA
CoA
CoA
KREBS
CYCLE
FADH2
FAD
2
CO2
3NAD+
3 NADH
+ 3 H+
ADP + P
ATP

VI. Aerobic Respiration

- ETC
  - NADH is converted into NAD+
  - The H+ released from NADH are used to convert ADP into ATP
  - In the end, 1 glucose molecule produced 36 ATP and 6 water molecules


A Electron Transport
B Hydrogen Ion Movement
Channel
Intermembrane Space
Inner Membrane
Matrix
ATP synthase
ADP
ATP
2 NADH
2 NAD+
FADH2
FAD
4 H+ + O2
2 H2O
C ATP Production

VII. Anaerobic Respiration

- Occurs without oxygen
- Also known as fermentation
- Happens in the cytoplasm after glycolysis if oxygen is NOT present

VII. Anaerobic Respiration

- 2 types
  - 1) alcoholic fermentation
    - Yeast and some bacteria
    - Yeast produces ethanol
    - CO_2 is produces causing small holes in bread dough
    - Alcoholic fermentation is also used to produce wine, beer, liquor

VII. Anaerobic Respiration

- 2) Lactic Acid
  - Occurs in animal cells
  - Usually happens when organisms engage in strenuous exercise
  - The organisms is using its oxygen supply faster than the blood can transport oxygen
  - Cells start to produce lactic acid to get energy
  - Causes muscle soreness

VIII. Comparing Aerobic and Anaerobic Respiration

	Aerobic	Anaerobic
Glycolysis	Yes	Yes
Cytoplasm	Yes	Yes
Mitochondria	No	No
ATP Production	36	2

Leaning Goal

- Compare and contrast photosynthesis and cellular respiration

IX. Comparing Cellular Respiration and Photosynthesis

	Photosynthesis	Cellular Respiration
Function	Store energy	Release energy
Location	Chloroplast	Mitochondria
Reactants	CO_2 & H_2O	$C_6H_{12}O_6$ & O_2
Products	$C_6H_{12}O_6$ & O_2	CO_2 & H_2O
Equation	CO_2 & H_2O → $C_6H_{12}O_6$ & O_2	$C_6H_{12}O_6$ & O_2 → CO_2 & H_2O
Plants	Yes	Yes
Animals	Yes	Yes