Section 9.3
The Process of Photosynthesis
I Can...

- **LS 1.8** I can develop a model to explain the flow of matter and energy in photosynthesis (energy transfer from light energy into stored chemical energy).

- **LS 1.8** I can predict and communicate uses for the products of photosynthesis.
Vocabulary

- **Photosystem** - clusters of chlorophyll and proteins in the thylakoid membrane
- **Electron transport chain** - series of electron carriers that move high-energy electrons in the thylakoid membrane
- **ATP synthase** - enzyme that binds ADP and a phosphate group to make ATP
- **Calvin cycle (light-independent reactions)** - ATP and NADPH from the light-dependent reactions are used to synthesize high-energy sugars
Key Questions

1. What happens during the light-dependent reactions?
2. What happens during the light-independent reactions?
3. What factors affect photosynthesis?
The Light-Dependent Reactions

• Use energy from sunlight to produce oxygen and convert ADP and NADP$^+$ into the energy carriers ATP and NADPH.
• Occur in the thylakoids
Steps:

1. Light energy absorbed by photosystem II produces high-energy electrons. Water molecules are split to replace those electrons, releasing H\(^+\) ions and oxygen.

2. High-energy electrons move down the electron transport chain (ETC) to photosystem I. Energy from these electrons is used to pump H\(^+\) ions across the thylakoid membrane into the thylakoid space.
Steps:

3. Electrons are regenerated in photosystem I from sunlight. A second ETC then transfers these electrons to NADP$^+$ to produce NADPH.

4. As the thylakoid membrane fills up with H$^+$ ions, the inside of the thylakoid membrane becomes positively charged relative to the outside of the membrane. H$^+$ ions pass back across the membrane through ATP synthase, causing it to rotate. The energy produced is used to convert ADP to ATP.
The Light-Independent Reactions

• Also known as Calvin cycle
• Occurs in the stroma
• ATP and NADPH from the light-dependent reactions are used to synthesize high-energy sugars
Steps:

1. Six carbon dioxide molecules from the atmosphere are combined with six 5-carbon molecules (already in the plant). This produces twelve 3-carbon compounds.

2. Energy from ATP and high-energy electrons from NADPH are used to convert the 3-carbon molecules to higher-energy forms. Two of these 3-carbon molecules are removed from the cycle to produce sugars and other compounds.

3. The remaining 3-carbon molecules are converted back into the 5-carbon molecules that are used to start the cycle again.
Factors Affecting Photosynthesis

• *Temperature*- enzymes function best between 0 and 35 degrees Celsius

• *Light intensity*- after light intensity reaches a certain level, the plant reaches its maximum rate of photosynthesis

• *Water availability*- shortage of water can slow or even stop photosynthesis
Photosynthesis Under Extreme Conditions

• In order to conserve water, most plants under bright and hot conditions close the small openings in their leaves.
• This keeps the plants from drying out, but does not allow carbon dioxide in.
• This causes photosynthesis to slow down or stop.
• Some plants have successfully adapted to bright, hot conditions:
  • C4 and CAM plants.
C4 Photosynthesis

• Specialized chemical pathway that allows them to capture even very low levels of carbon dioxide
• Enables photosynthesis to keep working under intense light and high temperatures
• Requires extra ATP
• Ex. Crop plants…corn, sugar cane, and sorghum
CAM Plants

• Admit carbon dioxide into their leaves only at night
• Carbon dioxide is combined with existing molecules to “trap” the carbon dioxide in the leaves
• During the day, the leaves are tightly sealed to prevent water loss, but use the carbon dioxide that was trapped inside
• Ex. Pineapple, many desert cacti, and ice plants
Section 9.3 Exit Ticket

1. What are the roles of the electron transport chains in photosynthesis?
2. How do plants make sugars and store extra unused energy?
3. What are the various environmental factors that affect the rate of photosynthesis?
The End 😊