MOLECULAR CELL PHYSIOLOGY - Photosynthesis

I. Photosynthesis - The process which occurs in the chloroplasts of green plants in which simple sugars are formed from carbon dioxide and water in the presence of light and chlorophyll

- **A. Two major parts of photosynthesis**
  - **1. Light reactions: conversion of light energy into ATP and NADPH**
  - **2. Dark reactions: use of energy (ATP & NADPH) to form carbohydrates**
- **B. Purpose of photosynthesis**
  - **1. Main biosynthetic pathway by which carbon and energy enter the web of life**

II. Where it occurs

- **A. Chloroplast**
  - **1. Light reactions - granum (several thylakoids) and thylakoid membranes**
  - **2. Dark reactions - stroma**

III. Light reactions (also light-dependent reactions)

- **A. Light-trapping molecule**
  - **1. Chlorophyll (antenna chlorophyll pick up light)**
    - **a) Transmits green and absorbs red and blue, etc.**
    - **b) Right wavelength of energy excites an electron of chlorophyll**
    - **c) Inductive resonance carries excitation energy from molecule to molecule**
    - **d) Energy (P700 or P680) is transferred to an acceptor molecule**
- **B. Two options for electron excitation energy**
  - **1. Cyclic (short) pathway)**
  - **2. Non-cyclic (long pathway)**
- **C. Cyclic photophosphorylation**
  - **1. (Photosystem I) LIGHT - P700 - P700* (Chl a/b redox) - [ETS: Fe-S protein-Ferredoxin-Plastoquinone] - P700 + ATP**
- **D. Non-cyclic photophosphorylation (Photosystem II and then I)**
  - **1. (Photosystem II) LIGHT - (OEC) - P680 - P680* (Pheophytin a) - [ETS: Plastoquinone-Plastocyanin + ATP - (Photosystem I) W/LIGHT - P700 - P700* (Chl a/b redox) - [ETS: Fe-S protein-Ferredoxin] - NADPH (NADPH from 2 e^- and 1 H^+)**
  - **2. Electrons replaced by water (O_2 is released and H^+ goes into thylakoid)**
  - **3. Split of water referred to as photolysis**
  - **4. ATP comes from proton gradient (H^+ stored in thylakoid leaves to makes ATP)**
- **E. Use of products from photosynthesis**
  - **1. ATP - energy**
  - **2. NADPH - reducing equivalents for organic synthesis**

IV. Dark reactions (also light-independent reactions)

- **A. Major purpose - use energy from light reactions to fix CO_2 into organic molecules**
- **B. Reagents of dark reactions**
  - **1. ATP and NADPH**
  - **2. CO_2**
  - **3. Ribulose bisphosphate**
  - **4. Enzymes (especially RUBISCO - Ribulose bisphosphate carboxylase / oxygenase)**
- **C. Why fix CO_2?**
  - **1. Store and use chemical energy in the form of organic compounds**
- **D. Steps of CO_2 fixation:**
  - **1. CO_2 and H_2O (1 carbon) are added to ribulose bisphosphate (5 carbons) to form two molecules of 3-phosphoglyceric acid (3-PGA) (total of 6 carbons)**
  - **2. Catalysis of this reaction by RUBISCO**
  - **3. 3-PGA is reduced to 3-PGAL with the help of NADPH and ATP**
  - **4. 3-PGAL is converted to either fructose diphosphate or, eventually ribulose bisphosphate**
  - **5. Fructose diphosphate goes to other aspects of metabolism and ribulose bisphosphate goes back to the original cycle of CO_2 fixation**

MOLECULAR CELL PHYSIOLOGY - Photosynthesis (continued)

E. Overall reaction of photosynthesis

$12H_2O + 6CO_2$ ==== light ====> $6O_2 + C_6H_{12}O_6 + 6H_2O$

F. Other types of CO_2 fixation - under hot conditions (to prevent O_2 competition)

1. C4 plants - fix CO_2 by combining it with PEP to form OAA (PEP carboxylase)

2. OAA (Malate after reduction) from mesophyll releases CO_2 to bundle sheath where RUBISCO carries on its usual process)

3. Recyclization occurs when Malate is converted to pyruvate and, subsequently PEP for another round of CO_2 fixation

G. Now what happens?

1. We have carbohydrate - a principle form of organic energy

a) Respiration will harvest energy and convert it to the universal currency - ATP