PHOTOSYNTHESIS

All organisms need energy to drive life's processes

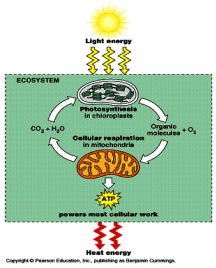
Energy

- Ability to do work
- needed for all biological processes

Fundamental biological processes for making and using energy

Photosynthesis: plants convert radiant energy to chemical energy (glucose)

Respiration: glucose molecules are broken to make ATP



Photosynthesis - plants make glucose
Respiration – animals break down glucose

TYPES OF ORGANISMS BY ENERGY PRODUCTION

Autotrophs

- produce organic mols. from inorganic substances (photosynthesis or chemosynthesis)
- make own food

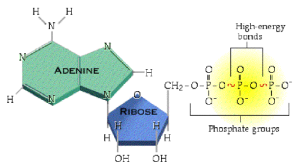
Heterotrophs

- organisms that obtain energy from other orgs. (heterotrophs or autotrophs)
- do not make own food

ENERGY PRODUCTION

ATP: adenosine triphosphate

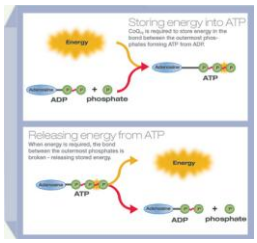
molecule that stores useable energy

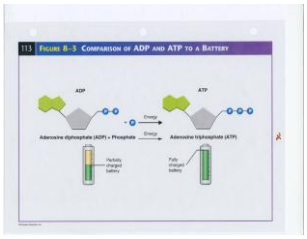


ATP/ADP CYCLE

- energy is stored in **high energy bonds** between phosphate groups
- bond must be broken to use energy

Phosphorylation: addition of phosphate group to ADP or AMP to rebuild ATP

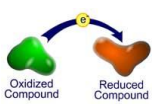




Redox reactions: involve transfer of energy

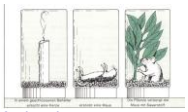
- **oxidation**: loss of electrons (H atom) loss of energy
- **reduction**: gain of electrons (H atom) gain of energy

when one substance is oxidized, another must be reduced



DISCOVERY OF PHOTOSYNTHESIS

- Jean Van Helmont (Dutch)
  - grew tree from small seedling
  - after 5 years was 75 kg (mass of soil unchanged)
  - CONCL: change came from CO_2
- Priestly (100 years later) English
  - put candle in jar – went out
  - put plant in jar, candle stayed lit
  - CONCL: PLANT GAVE OFF O_2 needed for burning

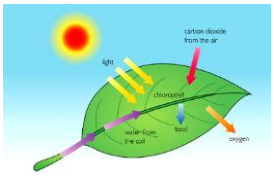


- Ingerhaousz (Dutch)
  - did same experiment but showed O_2 produced only when plant exposed to light
  - CONCL: light necessary for plant to produce O_2

PHOTOSYNTHESIS

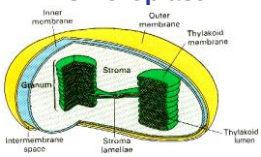
$6\ CO_2 + 6\ H_2O$ + light energy → $C_6H_{12}O_6 + 6\ O_2$

- process whereby autotrophs (plants) take in light energy and convert it to chemical energy (sugar)



Location of photosynthesis

Chloroplast



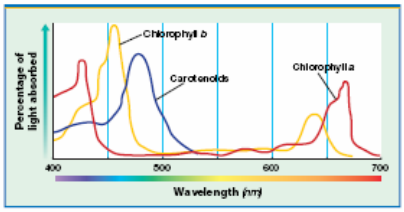
Thylakoid discs (make up photosysytems)
Harvest sunlight
Contains chlorophyll

Grana (stacks of thylakoid discs)
location of light reactions

Stroma (protein rich solution, outside grana)
location of dark reactions

Pigment: substance that absorbs light

- in photosynthesis: absorbed light energy is used to make chemical bond energy
- wavelengths not absorbed are reflected (color we see)



Photosynthetic pigments
(located in thylakoids of chloroplasts)

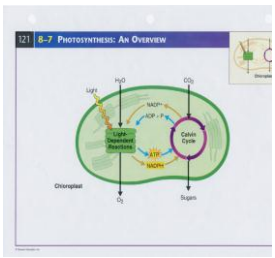
- **chlorophyll a**
  - primary photosynthetic pigment
  - directly involved in converting light → chemical energy
  - hides other pigments
- **chlorophyll b**
  - accessory pigment
  - absorbs light and transfers energy to chlorophyll a
- **carotenoids** (orange, brown), **xanthophylls** (yellow)
  - accessory pigments
  - converts energy to chloro. a
  - seen in autumn when chloro. breaks down

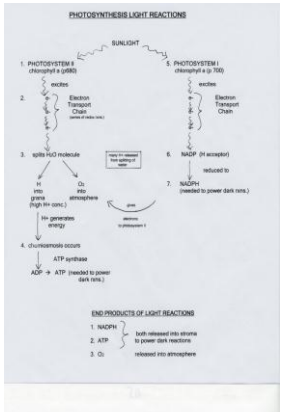
Overview of Stages of Photosynthesis

Light Reactions: (needs light)
- occurs in thylakoid discs

4 basic processes
- light absorption
- electron transport
- O2 production
- ATP and NADPH production

Calvin Cycle (Dark Reactions):
- occurs after light reactions (can occur in light or dark)
- occurs in stroma
- carbon fixation to glucose molecule





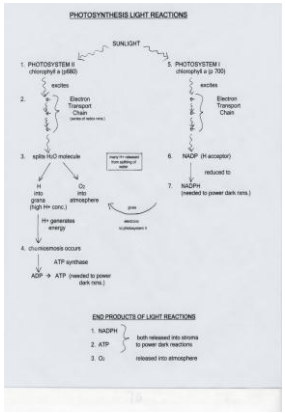
STEPS OF LIGHT REACTIONS

1. **photosystem II** absorbs light and excites electrons of chlorophyll a molecules

2. excited electrons leave chlorophyll a molecule go into **electron transport chain** (makes ATP)

   - **water is split and O2 is released into atmosphere**

Purpose of Photosystem II
generate ATP
supply electrons to photosystem I

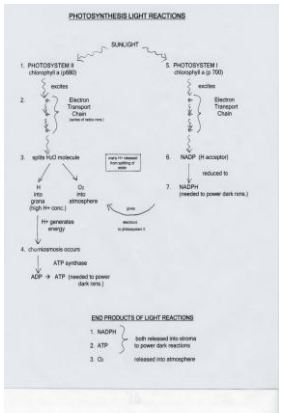


3. at end of electron transport chain electrons are passed to **photosystem I**

   - electrons go thru separate electron transport chain in photosystem I

4. **NADP+** accepts electrons and becomes **NADPH**

Purpose of photosystem I
make NADPH



End products of light reactions

1. **ATP AND NADPH:** needed to power Calvin Cycle

2. **O2:** by product (from split water) released into atmosphere

CALVIN CYCLE (DARK REACTIONS)

- light independent: can occur in light or darkness, always after light rxns
- occurs in stroma
- purpose: Carbon attachment to glucose molecule (from CO2 in atmosphere)

Steps of Calvin Cycle

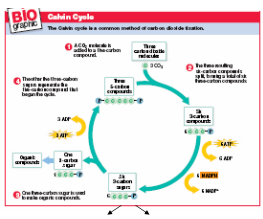
1. CO2 enters plant from **atmosphere** and binds with a 5 C sugar
   ** THIS IS CO_2 FIXATION TO GLUCOSE**
   - forms unstable 6 C sugar
   C + (C-C-C-C-C) → (C-C-C-C-C-C)

2. Two 3 C molecules formed from unstable 6 C sugar
   C-C-C C-C-C

3. One carbon from attaches to glucose molecule,
   other Carbons start cycle over again (cyclical)

End product of Calvin Cycle
Glucose

6 turns of cycle needed to make 1 molecule of glucose



Factors Affecting Rate of Photosynthesis

1. **light intensity**
   - high intensity = high rate
   - saturation point: levels off after certain intensity because pigments can only absorb so much light

2. **CO2 levels**
   - same mechanism as light

3. **temperature**
   - higher temp = higher rate
   - if temp goes too high, enzymes denature, rate slows down