

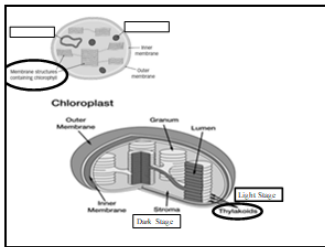
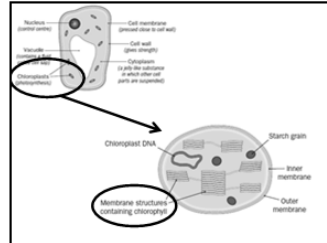
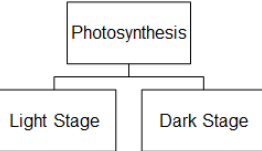
## Photosynthesis

Plants making their own food

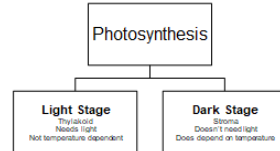
### Role of Photosynthesis

- Plants use it to make food
- Animals get their food from plants
- It produces oxygen which is needed in respiration to release energy
- It is responsible for forming fossil fuels
- It removes carbon dioxide from the air
- This is an **anabolic reaction**, it requires energy to make complex molecules from simpler molecules

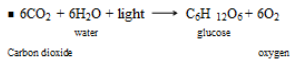
### 2 stages of Photosynthesis



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### Balanced Equation for Photosynthesis



### Photosynthesis requires:

- Carbon dioxide (CO<sub>2</sub>):**
  - comes from air through stomata
  - By product of respiration
- Water:**
  - From soil, through roots using osmosis
  - By product of respiration
- Light:**
  - From sun
- Chlorophyll:** present in chloroplast of cells.

### Photosynthesis produces

Glucose (monosaccharide):

- Burn it in respiration to release energy
- In good conditions: polysaccharides are formed
  - (1) Starch (storage)
  - (2) Cellulose (Plant cell wall)
- Oxygen:**
  - Released out of the stomata
  - Used in respiration

### Photosynthesis converts

light energy  
↓  
chemical energy

### Stages in Photosynthesis

- Light is absorbed
- Water is split
- Products are produced (4 protons, 4 electrons and oxygen)
- Light energises electrons
- Glucose is formed

### 1. Light is Absorbed

- The light (form of energy) that reaches a plant is trapped by chlorophyll
- Chlorophyll is found in the chloroplasts of plant cells
- Therefore photosynthesis occurs in chloroplasts
- The trapped light provides the energy the plants need to make glucose

### Photosynthesis

- CO<sub>2</sub> (from the atmosphere) and protons (hydrogen ions) from the proton pool produced in the Light Stage join together to make a carbohydrate C<sub>6</sub>(H<sub>2</sub>O)<sub>5</sub>.
- High energy from the Light Stage produce energy required to make this carbohydrate.

### Sources of light for plants

- Sunlight is the natural source of light for plants but they can use artificial light for photosynthesis
- Artificial light is often used in greenhouses stimulate growth
- Increasing light can increase growth up to a certain saturation point where no more light can be absorbed and photosynthesis will level off

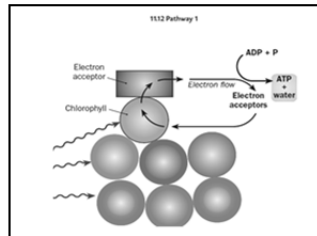
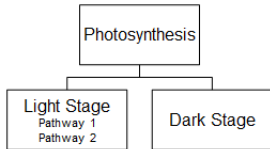
### Sources of carbon dioxide for plants

- Plants have 2 sources of carbon dioxide one is external the other is internal
- Plants get most of their carbon dioxide from the atmosphere this is external
- Plants get carbon dioxide internally from their own cellular respiration
- Sometimes artificial sources of carbon dioxide are used to stimulate growth eg. burning gas in a green house

### Sources of water for plants

- Water is absorbed from the soil by the roots of plants
- This water passes up the stem and is used for photosynthesis

### 2 stages of Photosynthesis



### 2. Water is Split

- Some of the trapped light energy is used to split water into oxygen gas (O<sub>2</sub>) protons (H<sup>+</sup>) and electrons (e<sup>-</sup>)
- Summarised as  

$$2\text{H}_2\text{O} \longrightarrow 4\text{H}^+ \text{ and } 4\text{e}^- \text{ and } \text{O}_2$$

### 3. What happens to these Products?

- The electrons are passed to chlorophyll
- The protons are stored in a proton pool for later use (source of Hydrogen)
- The oxygen may:
  - pass out of the leaf into the atmosphere
  - may be used for plant aerobic respiration

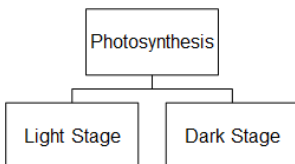
### 4. Light Energises Electrons

- The electrons that were passed to the chlorophyll become energised by some of the trapped light energy -- this changes them into high energy electrons

### 5. Glucose is formed

- The high energy electrons along with protons from the proton pool are combined with carbon dioxide to form glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)

### 2 stages of Photosynthesis



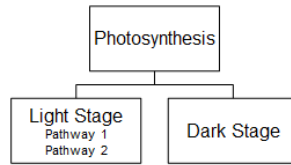
### Photosynthesis

- The first stage is called the **Light Stage**, as it requires light. Also called the **Light Dependent Stage**. Takes place in the chlorophyll.
- The second stage is called the **Dark Stage** or the '**light independent stage**.' It does not require light but does require the products produced in the Light Stage (high energy electrons, protons). Dark Stage takes place in the chloroplast.

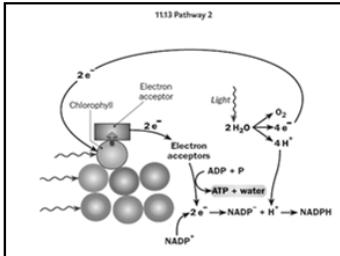
### LS: Pathway 1 (Cyclic Electron Transport)

1. Chlorophyll absorbs light energy (from Sun)
2. Electrons within chlorophyll molecule become energised
3. Energised electrons are then passed onto acceptor molecule.
4. Electrons are passed along the Electron Transport Chain (series of reactions, electrons release their energy)
5. As electrons release their energy, they combine with ADP + P (already in cell) to make ATP
6. Low energy electrons return to the chlorophyll

### 2 stages of Photosynthesis



1113 Pathway 2



### LS: Pathway 2

#### (Non-cyclic Electron Transport)

1. Chlorophyll absorbs light energy (from Sun)
2. Electrons within chlorophyll molecule become energised
3. Energised electrons are then passed onto acceptor molecule.
4. Only 2 electrons released, combines with H<sup>+</sup> and NADP<sup>+</sup> to form NADPH.

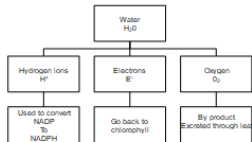
### Electron Pathway 2 (HL)

- 2 high energy electrons at a time are passed from chlorophyll to the electron acceptor and then along another series of electron acceptors
- In this case the electrons do not return to the original chlorophyll

### Electron Pathway 2 (HL)

- 5) The splitting of water using light energy is called **Photolysis**
- The chlorophyll molecule is now short of electrons and gains more from the splitting of water

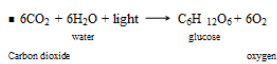
### Photolysis (HL) The splitting of water



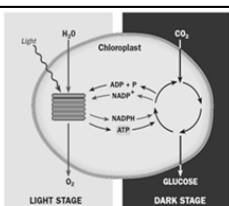
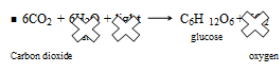
### End Products of the Light Stage (HL)

- There are 3 end products of the light stage
1. ATP this will provide energy for the dark stage
  2. NADPH this will provide protons + energised electrons for the dark stage
  3. Oxygen is made when water is split, released out of stomata

### Balanced Equation for Photosynthesis



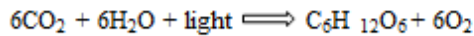
### What has been used in LS?



### Dark Stage / Calvin Cycle (HL)

- This may also be called the **light independent stage** as it can occur in the light but does not need to use it
- It takes place in the stroma of the chloroplast
- It is controlled by enzymes and therefore can be affected by temperature

### Dark Stage (HL)

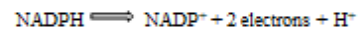


Stages required to form glucose:

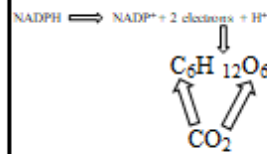
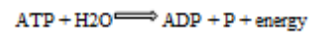
- Carbon dioxide from the air enters the chloroplast where they combine with protons + electrons to form glucose
- This needs energy and protons + electrons

### Dark Stage (HL)

- NAPDH supply: the electrons and protons ( $\text{H}^+$  ions).



- The energy is supplied by ATP

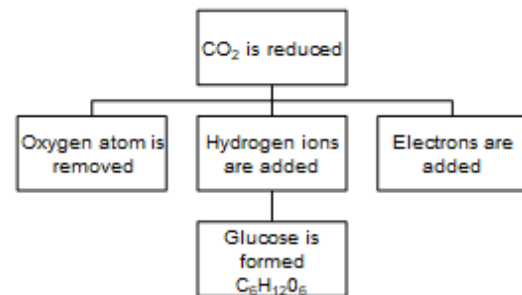


Anabolic reaction: electrons and energy are required for formation of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ).

### Dark Stage (HL)

- Remember the addition of electrons to anything is known as reduction
- Carbon Dioxide is reduced to glucose

### Dark Stage (HL)



### Main events in photosynthesis (HL)

- Light energy is absorbed by chlorophyll
- Water is split
- The electrons are passed to chlorophyll
- The protons are stored in the chloroplasts
- The oxygen is released
- Sunlight transfers energy to electrons
- The high energy electrons, stored protons (the hydrogen ions) and carbon dioxide are used to make glucose

### Homework

#### Exam papers

#### Higher Level

- 2012 Q 12b
- 2011 Q14 a
- 2010 Q 8, 14 a