Bio Factsheet

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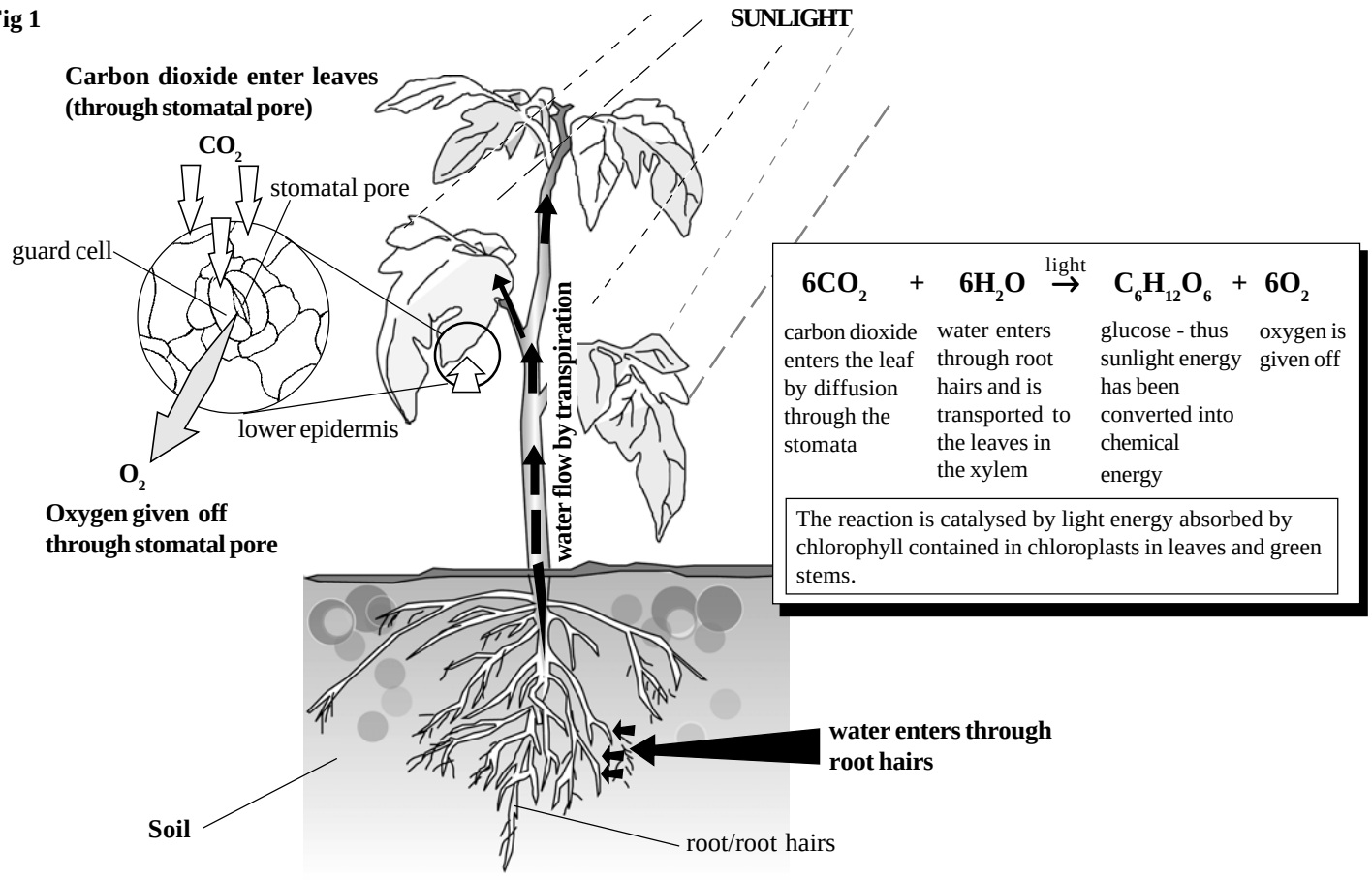
The Light Dependent Stage of Photosynthesis

This Factsheet focusses on te first stage of photosynthesis: the light dependent stage. It updates Factsheet 2 (The essential guide to photosynthesis) 1994 and reviews the exam questions which have appeared since September 2000 (all speccification)

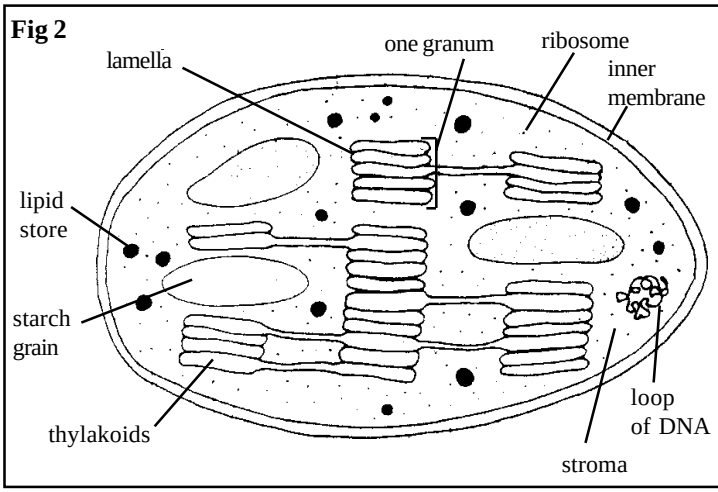
Fig 1 summarises what you learned at GCSE.

Fig 1



Photosynthesis occurs in the chloroplast and you've got to know your basic chloroplast structure (Fig 2).

Fig 2

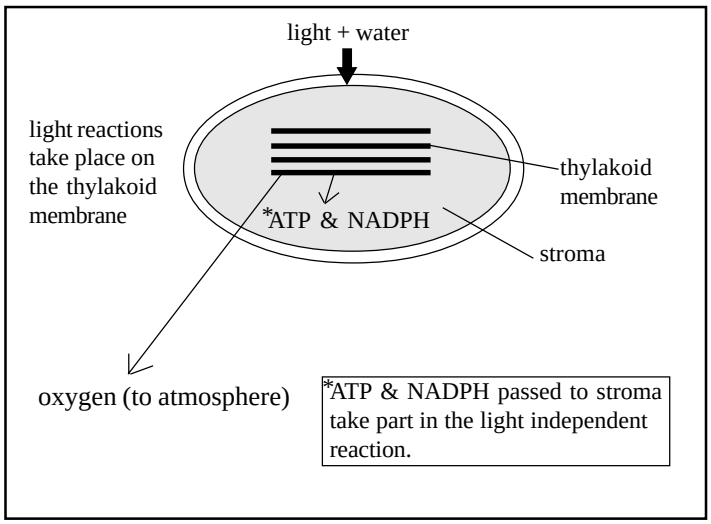


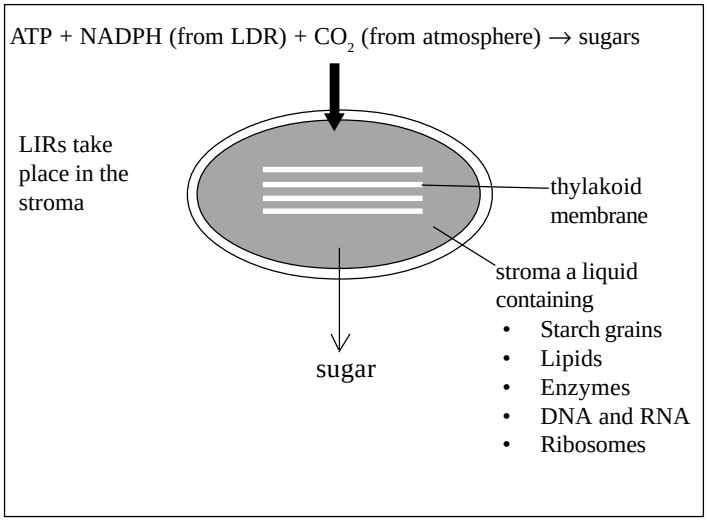
Structures	Functions
Ribosomes in stroma	Synthesising enzymes – Ribulose bisphosphate carboxylase, for example.
Starch grain	The soluble sugars made in photosynthesis cannot be stored. They can only be stored if they are converted into an insoluble form.
Grana	Creates large surface area for chlorophyll so lots of light can be absorbed.
Thylakoid membranes	Compartmentalization - allowing different enzyme – driven reactions to occur within the chloroplasts at the same time.
DNA	Codes for some of the chloroplast proteins.

Exam Hint: *In the exam you won't be asked to draw the chloroplast but could be asked to label or describe the functions of the parts.*

Photosynthesis can be broken down into two stages:

1. **The Light-Dependent Reaction (LDR) which only occurs in the light.**
2. **The Light- Independent reaction (LIR), which as the name implies, doesn't need light. So it can, in theory, occur day and night.**

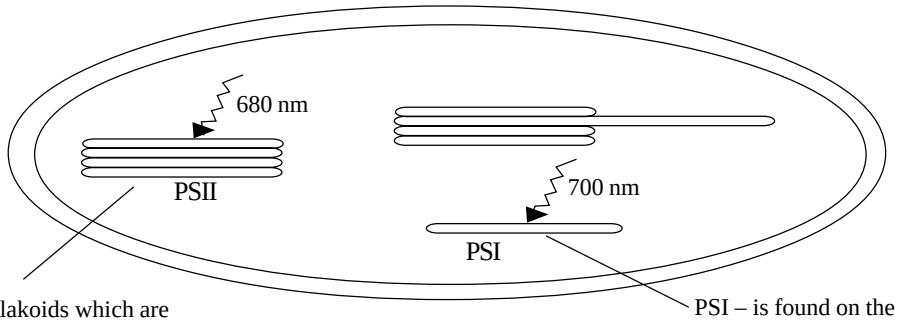




Photosystems

On the thylakoid membranes chlorophyll molecules are arranged into clusters called photoystems I and II (PSI and PSII) (Fig3a)

Fig 3a

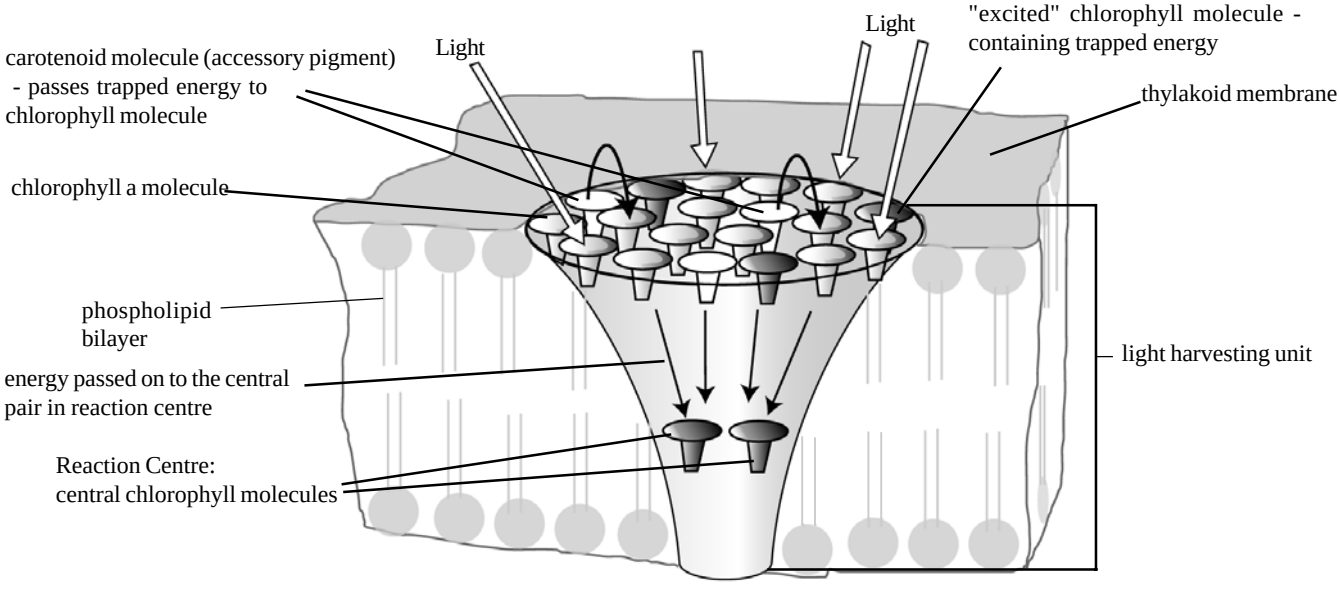


PSII – is found on the thylakoids which are stacked into grana. PSII absorbs light of wavelength 680 nm most effectively.

PSI – is found on the single thylakoids. PSI absorbs light of wavelength 700 nm most effectively.

Both PSI and PSII consist of **primary pigments** (forms of chlorophyll a molecules) and **accessory pigments** (other forms of chlorophyll a, along with chlorophyll b and caratenoids) (Fig 3 b). The role of the accsesory pigments is to capture light energy and pass it to a chlorophyll a - the primary pigment.

Fig 3 b. Photosystem unit

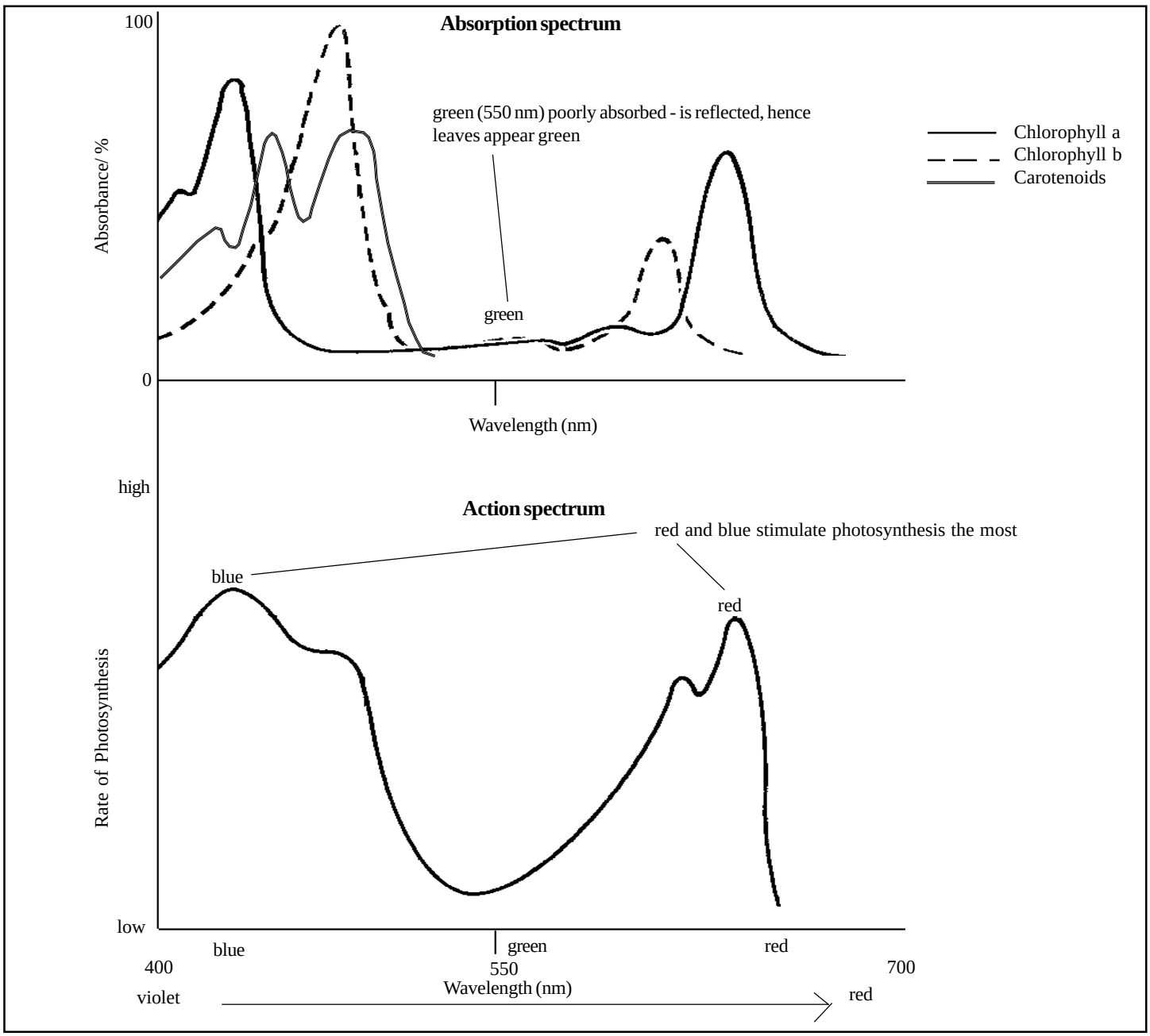


Chlorophyll a and b and the caratenoids absorb different parts of the visible spectrum
You need to know about two important graphs :

1. The absorption spectrum is a graph that shows which wavelengths of light are absorbed by a pigment. The absorption spectrum below shows the wavelengths absorbed by chlorophyll a, chlorophyll b and the caratenoids. Red (650nm) and blue(460nm) are absorbed strongly. Green (550nm) is poorly absorbed most of it is in fact reflected – which is why leaves appear green.

2. The action spectrum is a graph which shows the wavelengths of light that are actually **used** in photosynthesis.

Fig 4. Absorption/action spectrum



As you might expect, the absorption and action spectrums look similar ie the wavelengths that are **absorbed** most strongly are the ones that **stimulate photosynthesis** the most.

Typical Exam Questions

1. *What is the advantage of having more than one type of pigment?*
   Answer : *because each type absorbs a different part of the visible spectrum. So, having several pigments means that more light can be absorbed. The job of the accessory pigments is to absorb light energy and pass it to the primary pigment molecules.*
2. *Define absorbtion spectrum/action spectrum*

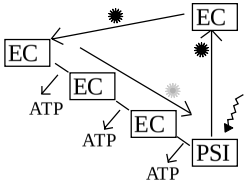
Fig 5. Overleaf describes what happens in the light dependent stage. Start at 1 and follow the numbers round.

Route B: electrons are cycled back through the electron carriers to generate ATP. This process is called **cyclic photophosphorylation(CCP)**

It`s called CPP because:

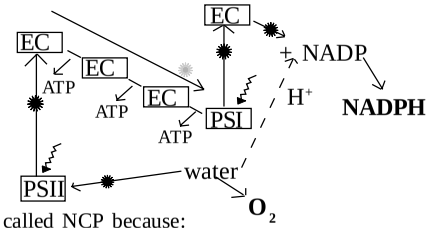
1. electrons "cycle" : PSI → ECs → PSI → ECs.....
2. "photo" - light is the energy source
3. "phosphorylation" - energy released from the electrons is used to phosphorylate (add a P) to ADP

*Photosystems involved **PSI** Products: **ATP***



What happens to the electrons emitted from PSI? They can go in two directions: Route A or B

Route A : electrons are used as part of a reaction to make **NADPH**. This is part of **non-cyclic photophosphorylation (NCP).**



It's called NCP because:

1. "non cyclic" - electrons don't cycle (they don't end up where they started.
   PSII → ECs →PSI → NADP
2. "photo" - light is the energy source
3. "phosphorylation" - energy released from the electrons is used to phosphorylate (add a P) to ADP

*Photosystems involved **PSI & PSII***
*Products: **ATP, reduced NADP (NADPH), oxygen***

electron at higher energy level

electron energy level 4

electron at lower energy level

Route B ***Route A***

Electron Carrier (EC)

3 electrons passed to an electron carrier

Electron Carrier (EC)

4 The electrons released from PSII pass through a series of electron carriers. ***The electrons lose energy as they pass between ECs - this energy is used to make ATP***

2e⁻

ADP + iP

ATP

2e⁻

Electron Carrier (EC)

2e⁻

ADP + iP

ATP

Electron Carrier (EC)

2e⁻

ADP + iP

ATP

2e⁻

6 PSI absorbs light. Electrons again become excited & emitted. They pass to an electron carrier at an even higher energy level

2e⁻

light energy

PSI

5 electrons pass into PSI

2 "excited" electrons released & boosted to **higher** energy level

1 light energy absorbed by chlorophyll molecules

PSII

2e⁻

7 loss of electrons from PSII makes it unstable. PSII stimulates (splitting / photolysis of water) $H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$
The electrons then pass to PSII making it stable again. The H^+ are used (along with electrons from PSI) to reduce NADP

electrons combine with H^+ released from photolysis of H_2O and are used to reduced NADP

+ NADP → NADPH (used in Light independent reaction)

$2H^+$

$H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

given off through stomatal pores