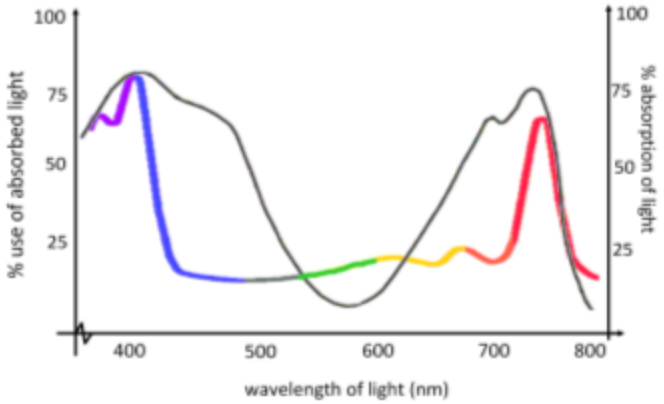


Photosynthesis (Core)

Stephen Taylor

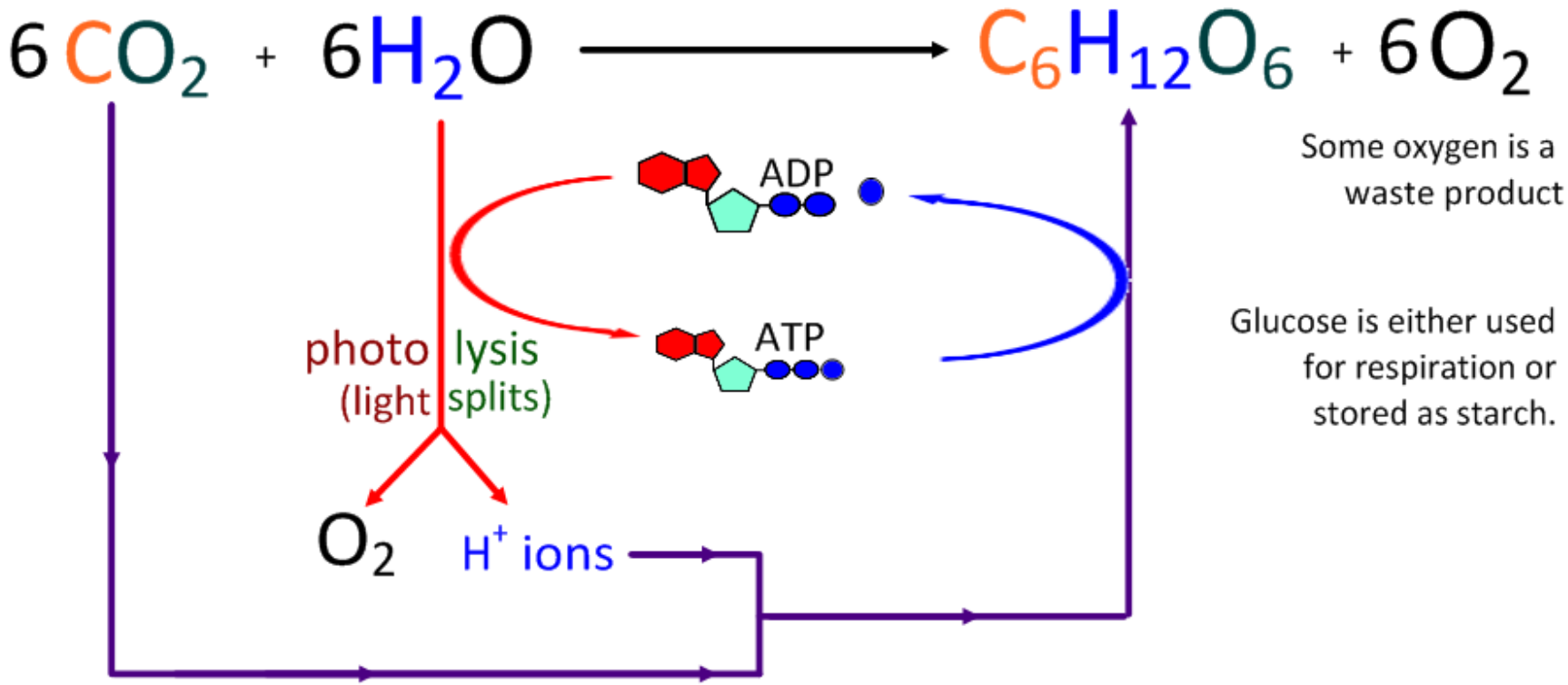
Bandung International School

Photosynthesis generates a chemical store of energy in the form of carbohydrates.

It converts light energy to chemical energy.
Photosynthetic organisms are examples of autotrophs.

Light dependent reactions use light energy to produce ATP and to split water (photolysis), making H^+ ions

Light independent reactions use ATP and H^+ ions to 'fix' CO_2, making glucose.

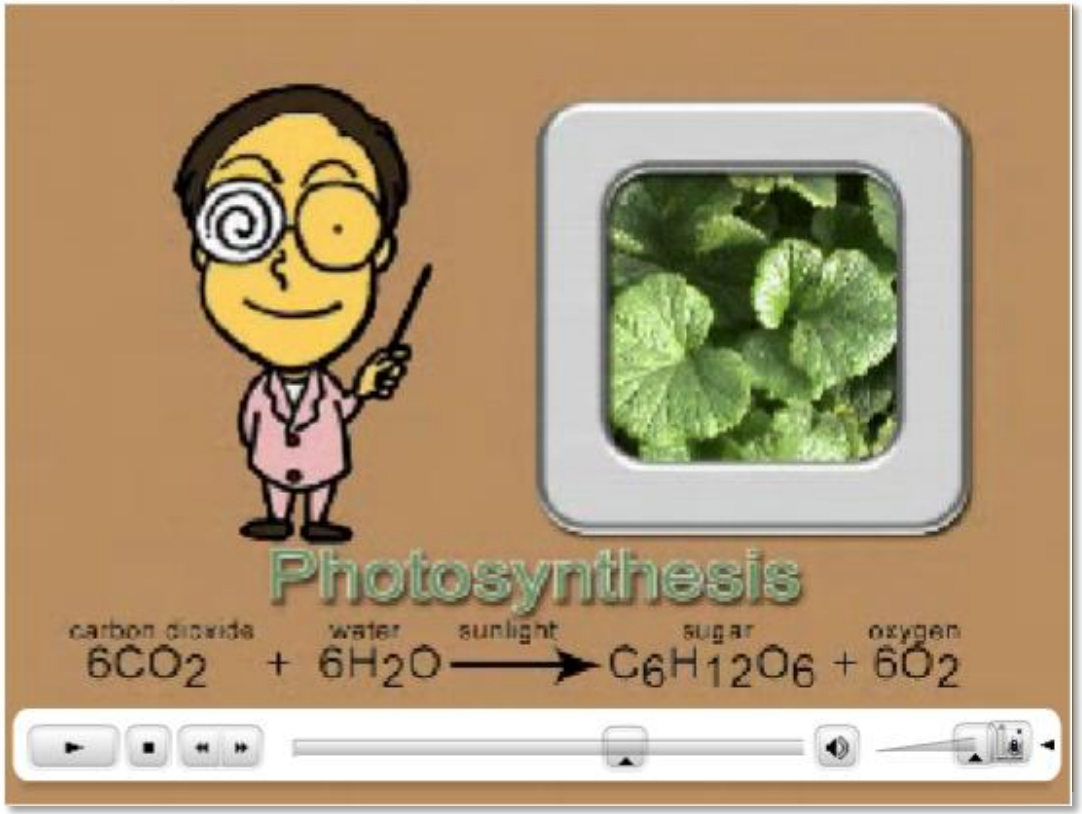


Some oxygen is a waste product

Glucose is either used for respiration or stored as starch.

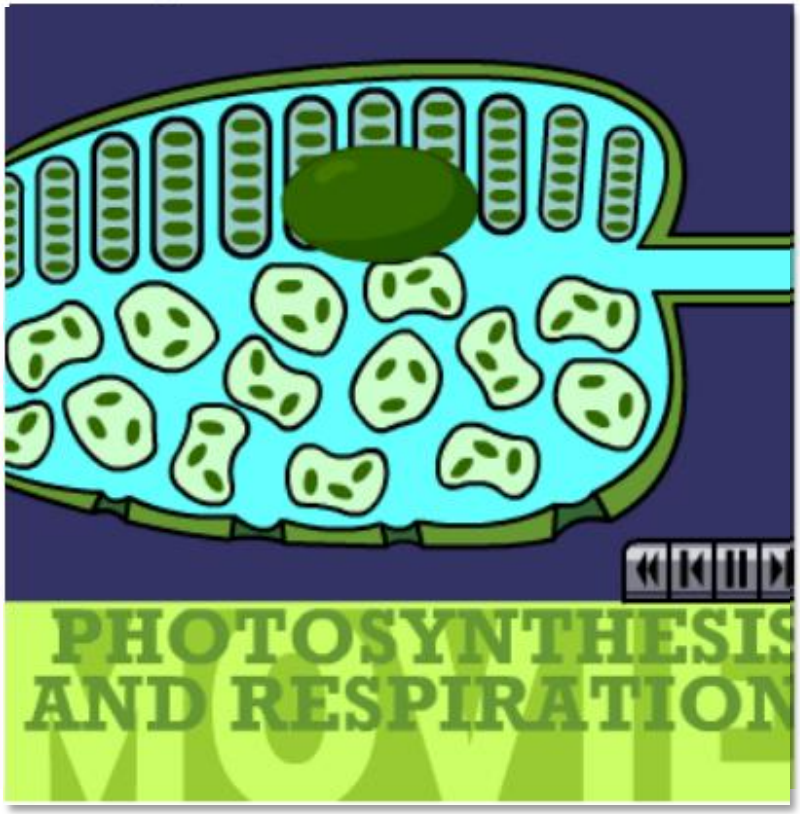
Some very basic overviews of photosynthesis:

Photosynthesis Song:



http://www.youtube.com/watch?v=C1_uez5WX1o

BrainPop:



http://tinyurl.com/2e28gvb

Starch and cellulose are polysaccharide molecules found in plants.

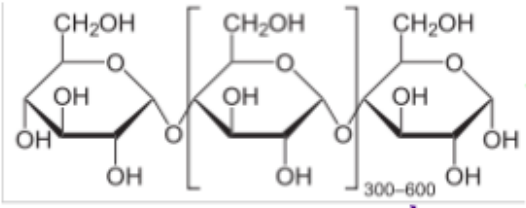
Starch is a chemical store of energy. Cellulose builds up the plant cell wall.

Revision:

What is the process through which monosaccharides are combined to make carbohydrates?

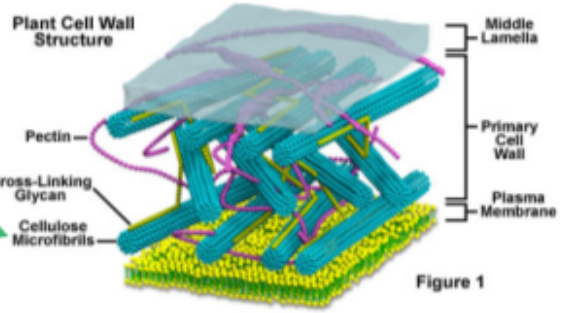
$C_6H_{12}O_6$ + $C_6H_{12}O_6$ + … ⟶ $(C_6H_{10}O_5)_n$

glucose glucose polysaccharide (repeating units)



Starch (amylose)

(repeating units)



Cell walls (cellulose)

http://en.wikipedia.org/wiki/Starch

http://micro.magnet.fsu.edu/cells/plants/images/cellwallfigure1.jpg

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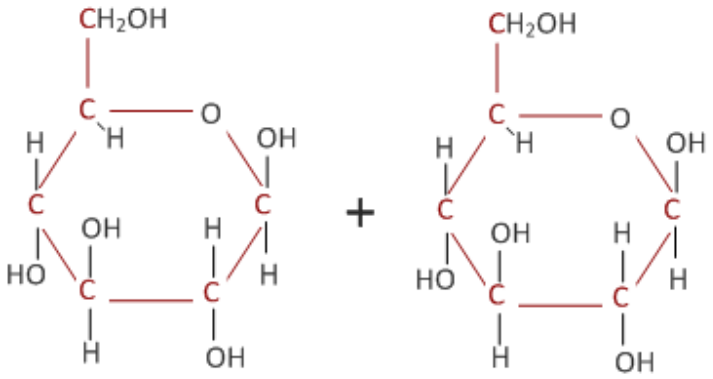
It's condensation!



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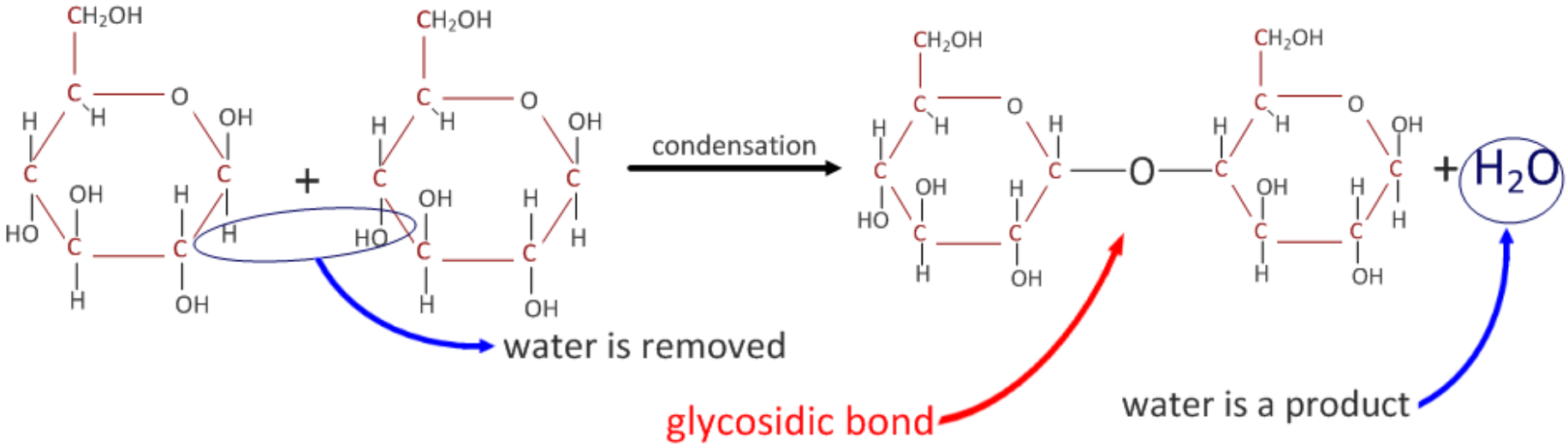
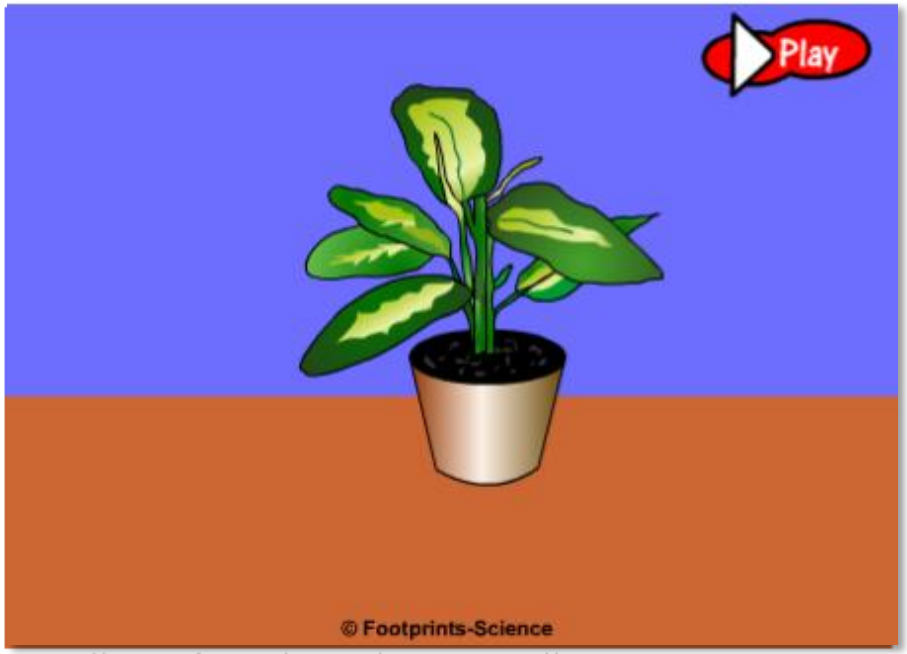


Testing a leaf for starch:



http://www.footprints-science.co.uk/Starch.htm

1. Collect some leaves from the plants in the class and follow the steps to test for starch. Make observations in your lab book.

2. Keep some chlorophyll.

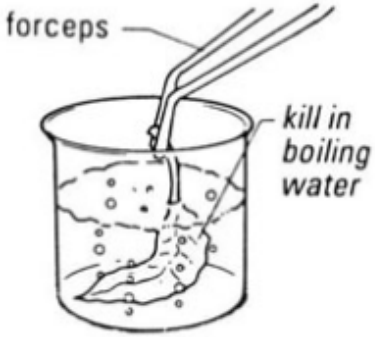
3. What happens if the leaf is not boiled, is very waxy or no alcohol is used? Explain your answers, based on your knowledge of cell structure and membranes.

4. Make masks to cover up some leaves, completely.

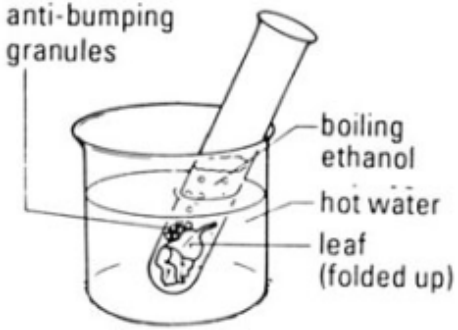
5. Place plants in the sunlight for a week.

6. Test the covered leaves for starch and make further observations.

1.

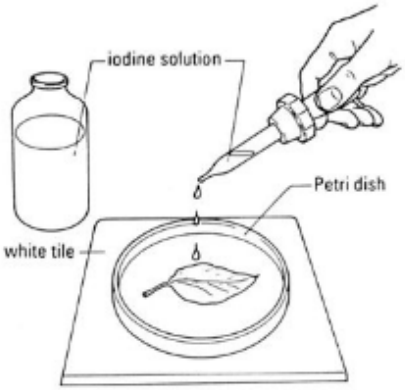


2.



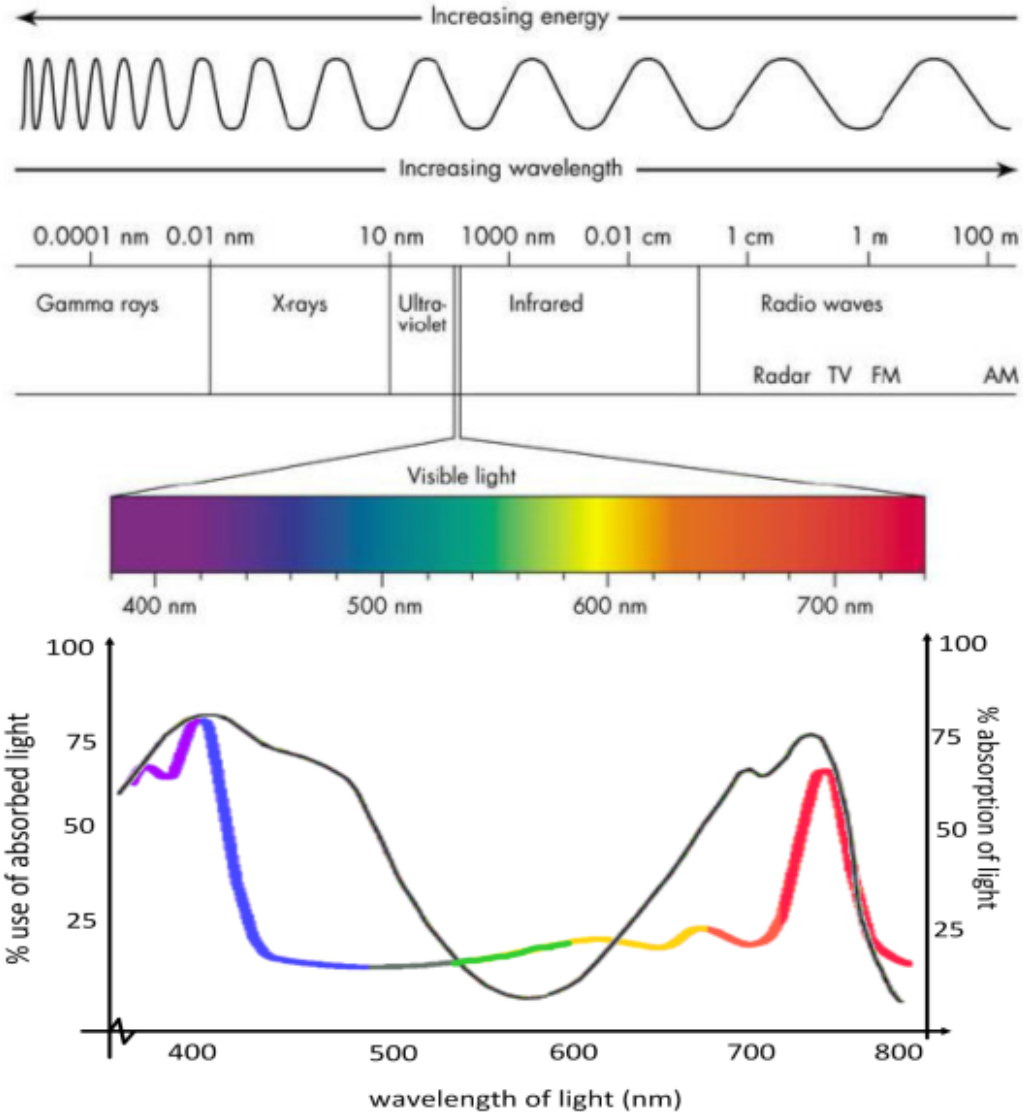
3.

4.



http://www.practicalbiology.org/areas/introductory/energy/photosynthesis/testing-leaves-for-starch-the-technique,73,EXP.html

Middle School Review: The Electromagnetic Spectrum



http://www.antonine-education.co.uk/physics_gcse/Unit_1/Topic_5/em_spectrum.jpg

All radiation has a frequency and a wavelength. Waves with a low frequency are more spaced out, so have a longer wavelength, and vice versa.

High frequency radiation has many waves per unit time, and therefore a lot of energy. UV, X-rays and gamma rays are harmful to living organisms because they encourage cell and DNA damage (hence skin cancer and tumours).

Only a small part of the electromagnetic spectrum is visible to our eyes.

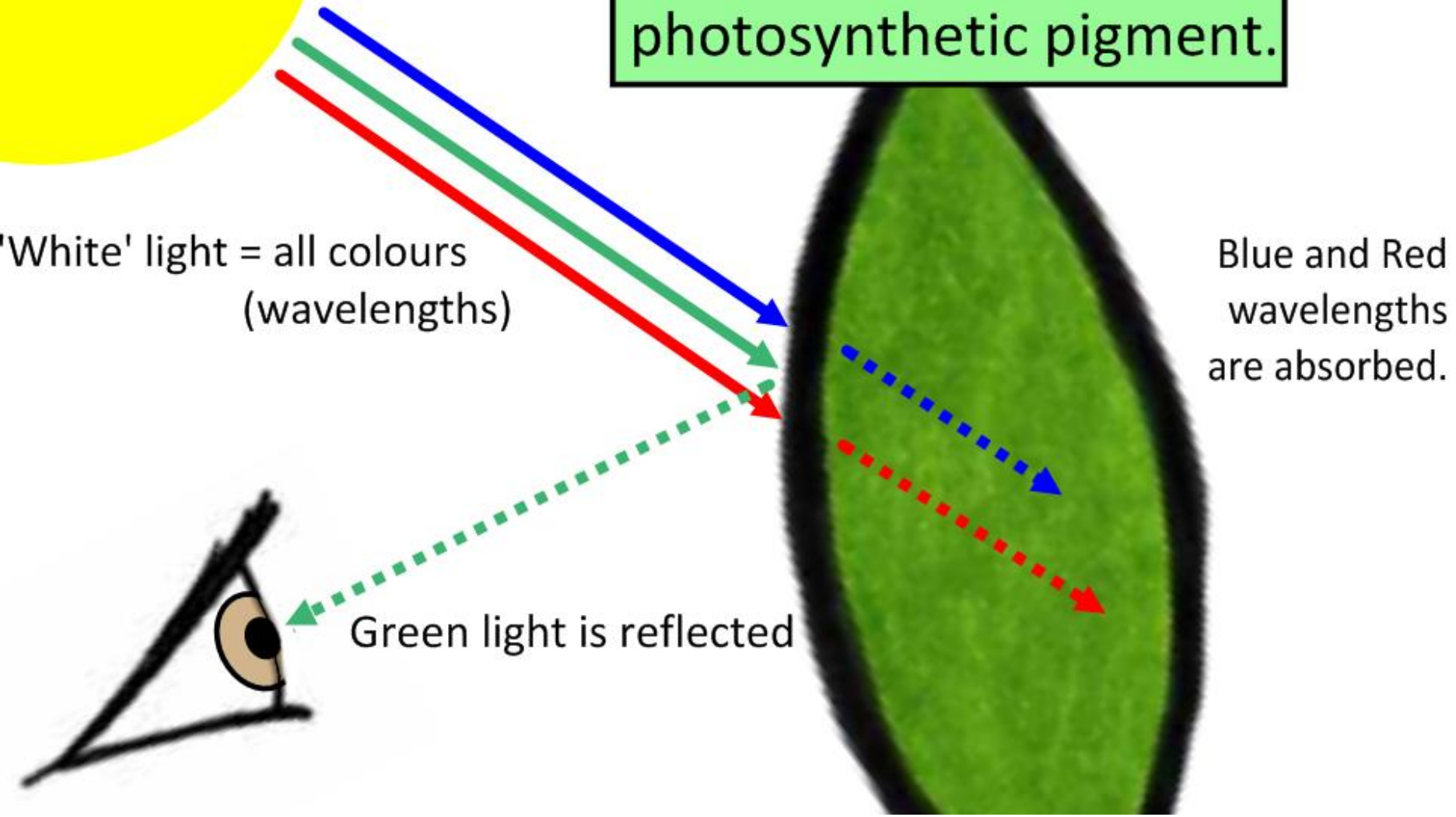
Low frequency radiation is low in energy - too low to be used in most living organisms.

The pigments in photosynthetic organisms (chlorophyll), absorb useful wavelengths of light - those that contain energy appropriate for photolysis in the light-dependent reactions.

This gives rise to the action and absorption spectra for photosynthesis.

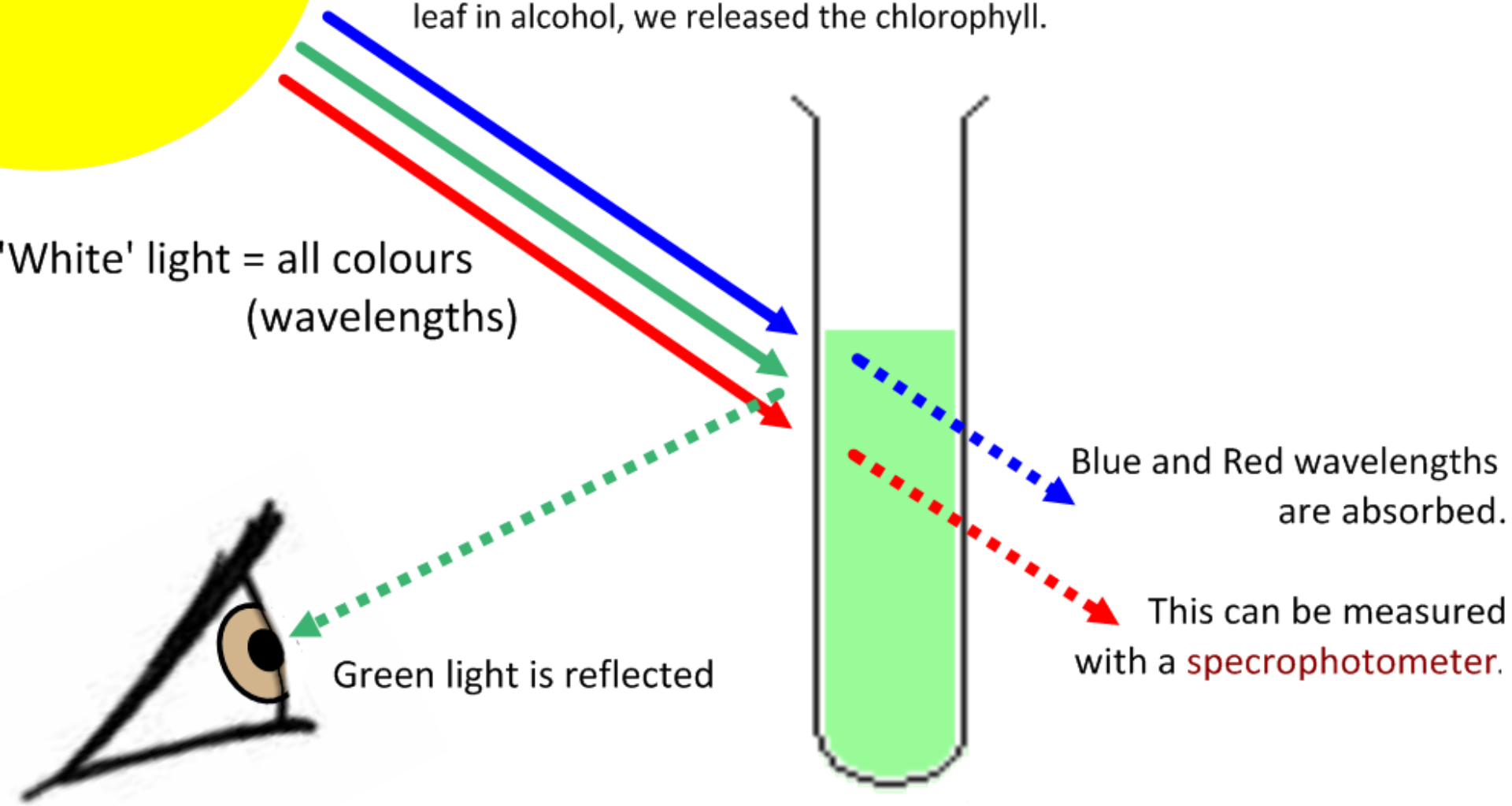
Why does a leaf look green?

Chlorophyll is the main photosynthetic pigment.



Why does a leaf look green?

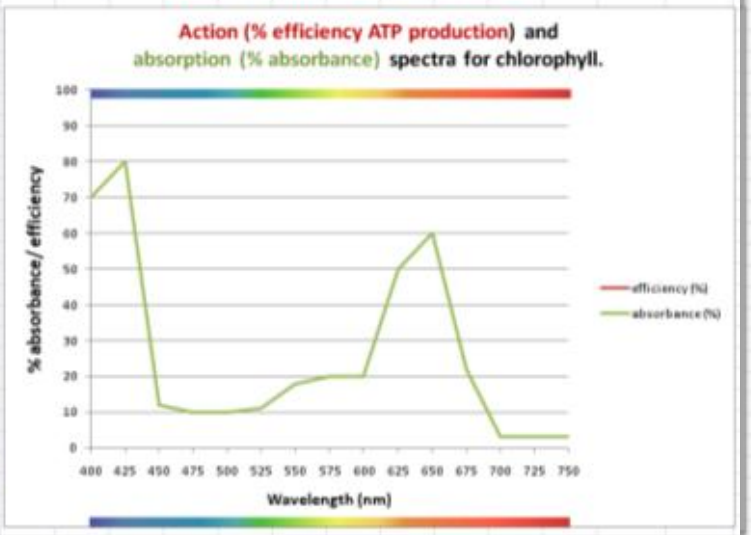
Chlorophyll is a pigment - a chemical that changes the colour of reflected light. It is stored in chloroplasts, but by heating the leaf in alcohol, we released the chlorophyll.



Build an action spectrum for photosynthesis:

What is the Action Spectrum of photosynthesis?

wavelength (nm)	efficiency (%)	absorbance (%)
400		70
425		80
450		12
475		10
500		10
525		11
550		18
575		20
600		20
625		50
650		60
675		22
700		3
725		3
750		3



The data already plotted show the absorption spectrum for chlorophyll.

Use this simulation to add the action spectrum:
http://www.mhhe.com/biosci/genbio/biolink/j_explorations/ch09expl.htm
Set light intensity to maximum (200lux)

Answer these questions:
1. What is the difference between action and absorption spectrum?
2. Why are leaves generally green?
3. Why are some leaves brown? (hint - accessory pigments)

https://www.box.net/shared/cs6jvzv8n4

Build an action spectrum for photsynthesis using this spreadsheet and simulation.

Go further: what is the effect of light intensity on the efficiency of ATP production?

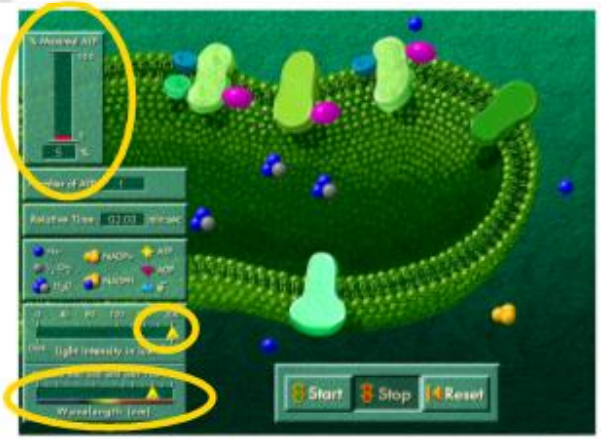
Photosynthesis Simulations.xlsx

https://www.box.net/shared/gbjqt3aihb

How efficient is ATP production?

Set to maximum light intensity

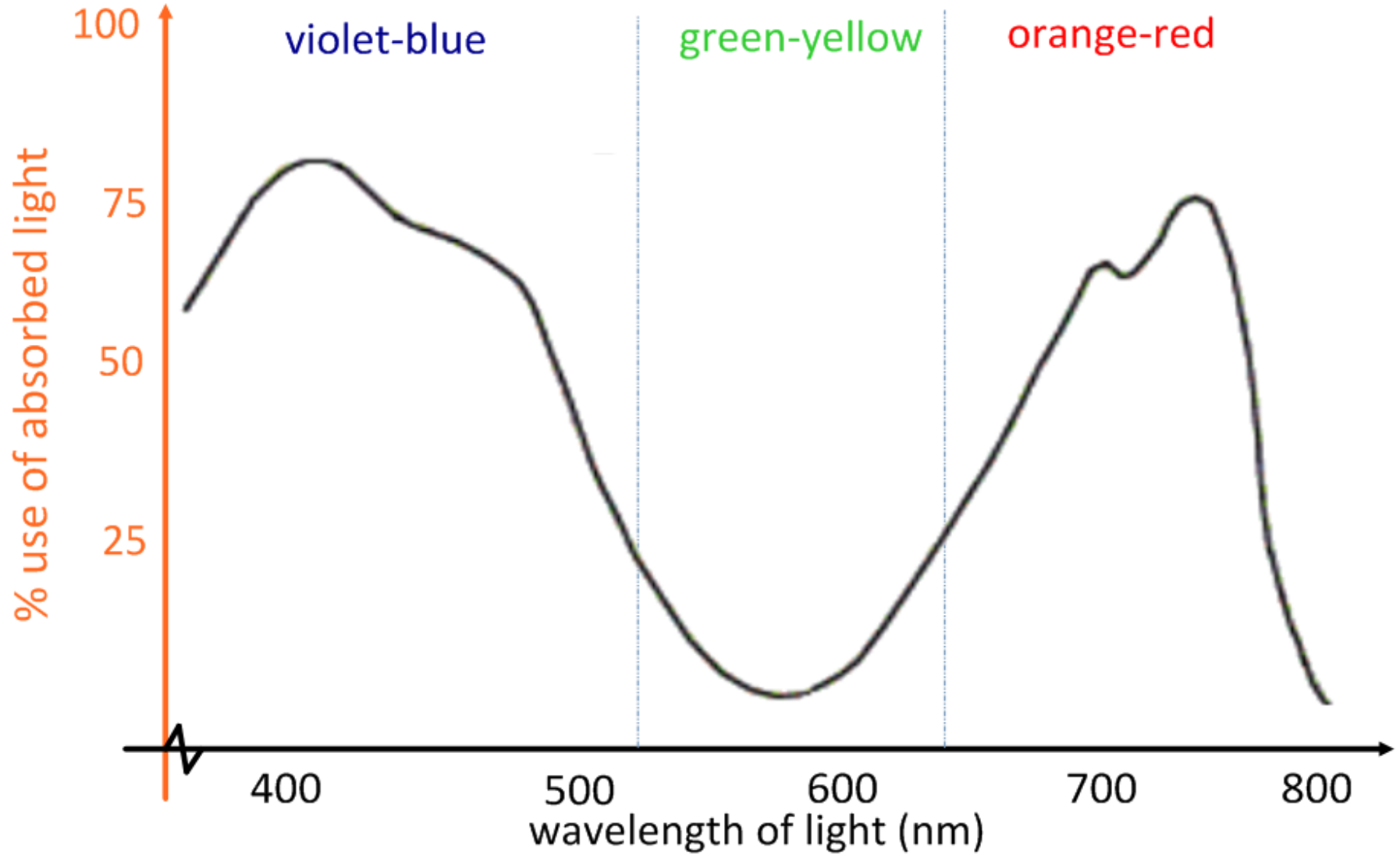
Use a wide range of wavelengths (15 increments)



http://www.mhhe.com/biosci/genbio/biolink/j_explorations/ch09expl.htm

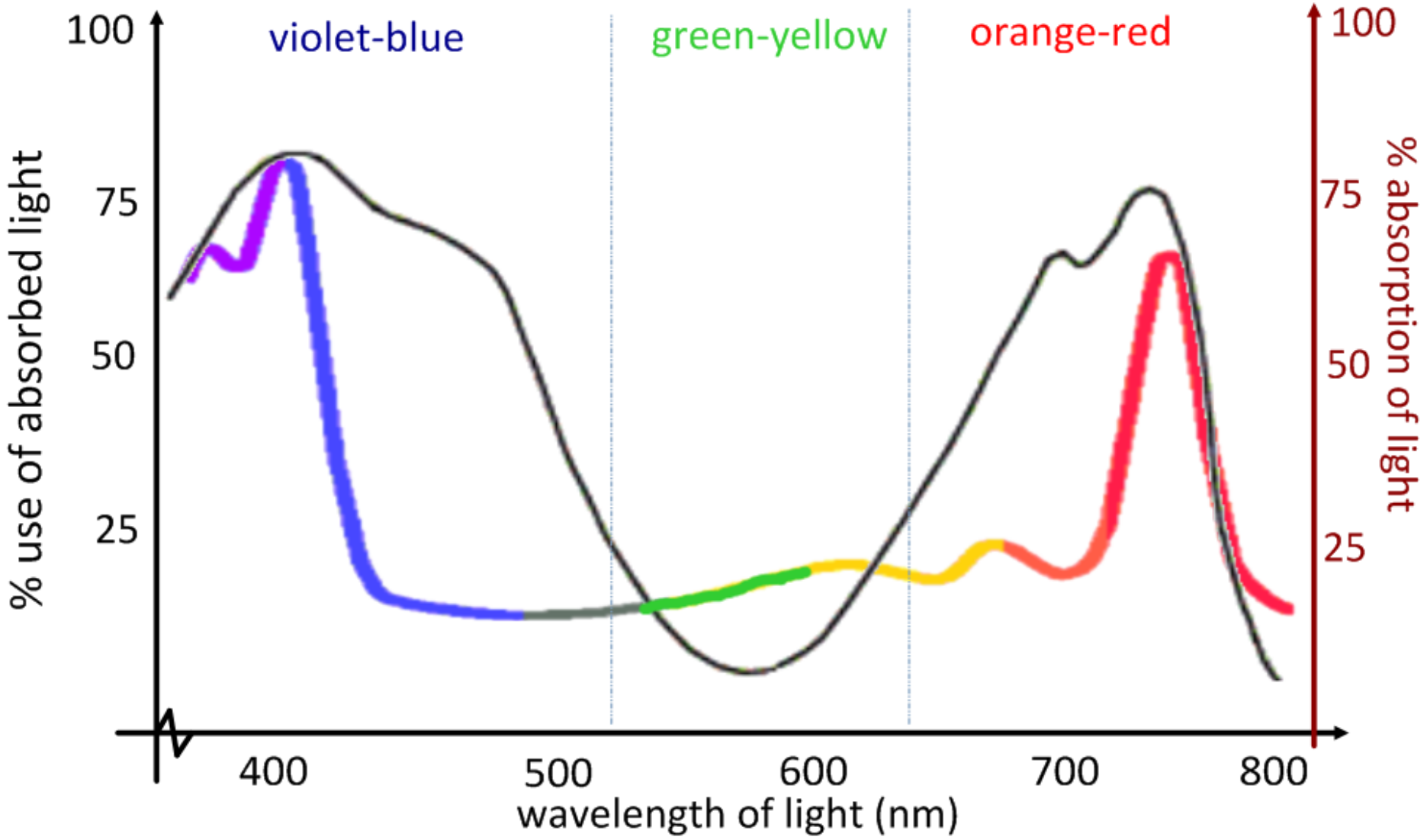
Action Spectrum

This is the range of wavelengths of light which can be used in the light-dependent reactions.

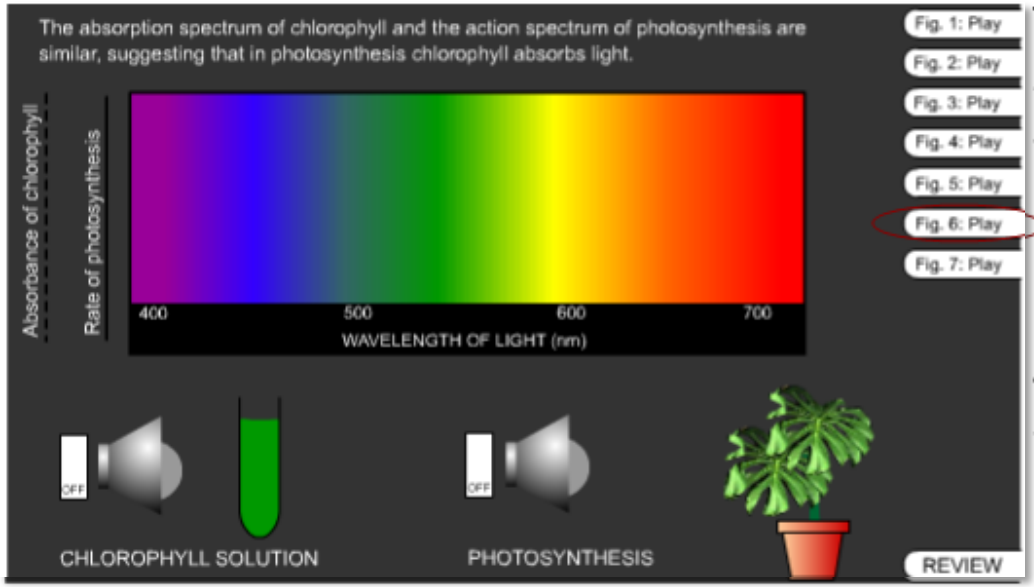


Absorption Spectrum

This is the range of wavelengths of light are absorbed by chlorophyll, the photosynthetic pigment.



More about action and absorption spectra:



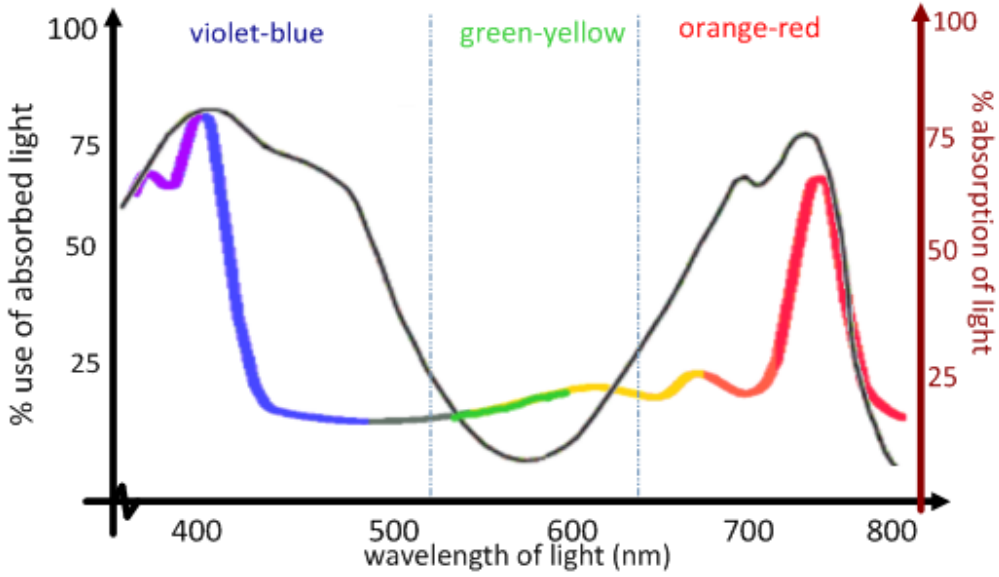
http://www.abdn.ac.uk/~clt011/flash/samples/photosyn.swf

The action spectrum of photosynthesis and absorption spectrum of chlorophyll overlap each other - this tells us that chlorophyll is the most important of the photosynthetic pigments (there are others).

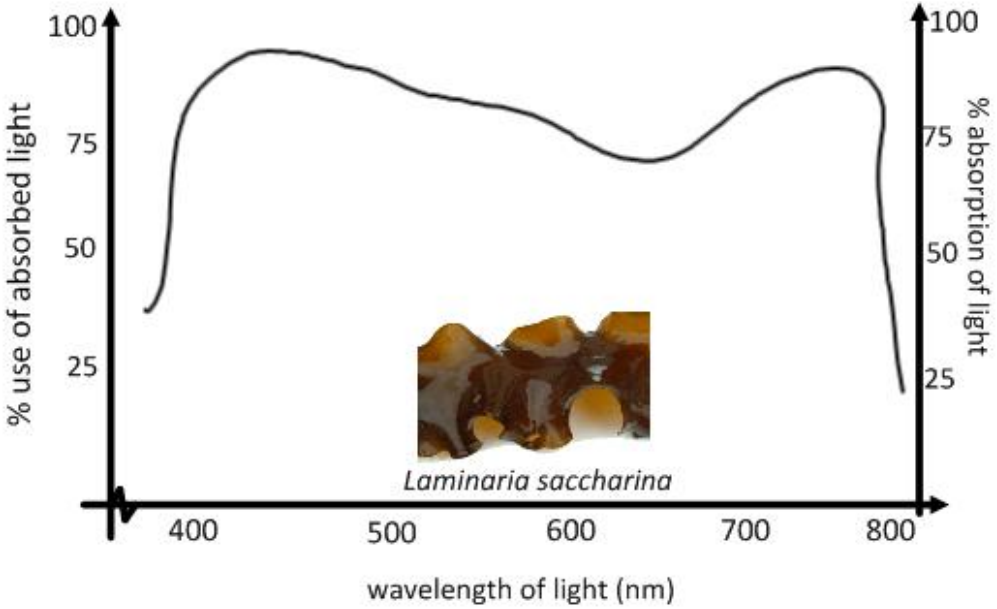
Artificial light sources could be used (as long as they are within the spectrum), though light intensity is much stronger from the Sun.

Light at the blue end of the spectrum is contains more energy than light at the red end (though red light is more efficiently absorbed than blue).

UV radiation is higher-energy still, but cannot be used. In fact, it causes cell damage and mutations.



Do all plants have the same action/ absorption spectrum?



If the answer were *yes*, Canada would be stuck for an emblem!

Accessory pigments allow some plants to take advantage of the green wavelengths of light - an competive advantage or an advantage in low-light conditions, such as underwater.

Why do leaves turn brown in the autumn?

Some leaves have accessory pigments which cannot normally be seen when chlorophyll is active. When temperatures cool down, chlorophyll breaks down before the accessory pigments, leaving them to show through.

Animation source unknown

Measuring the rate of photosynthesis

http://fig.cox.miami.edu/~cmallery/150/phts/c2x20elodea.jpg

$$\text{rate} = \frac{\text{change}}{\text{time}}$$

(measured)
(controlled)

Oxygen production:

count bubbles/ collect with a gas syringe

http://www.atm.helsinki.fi/SMEAR/index.php?action=3

CO_2 uptake:

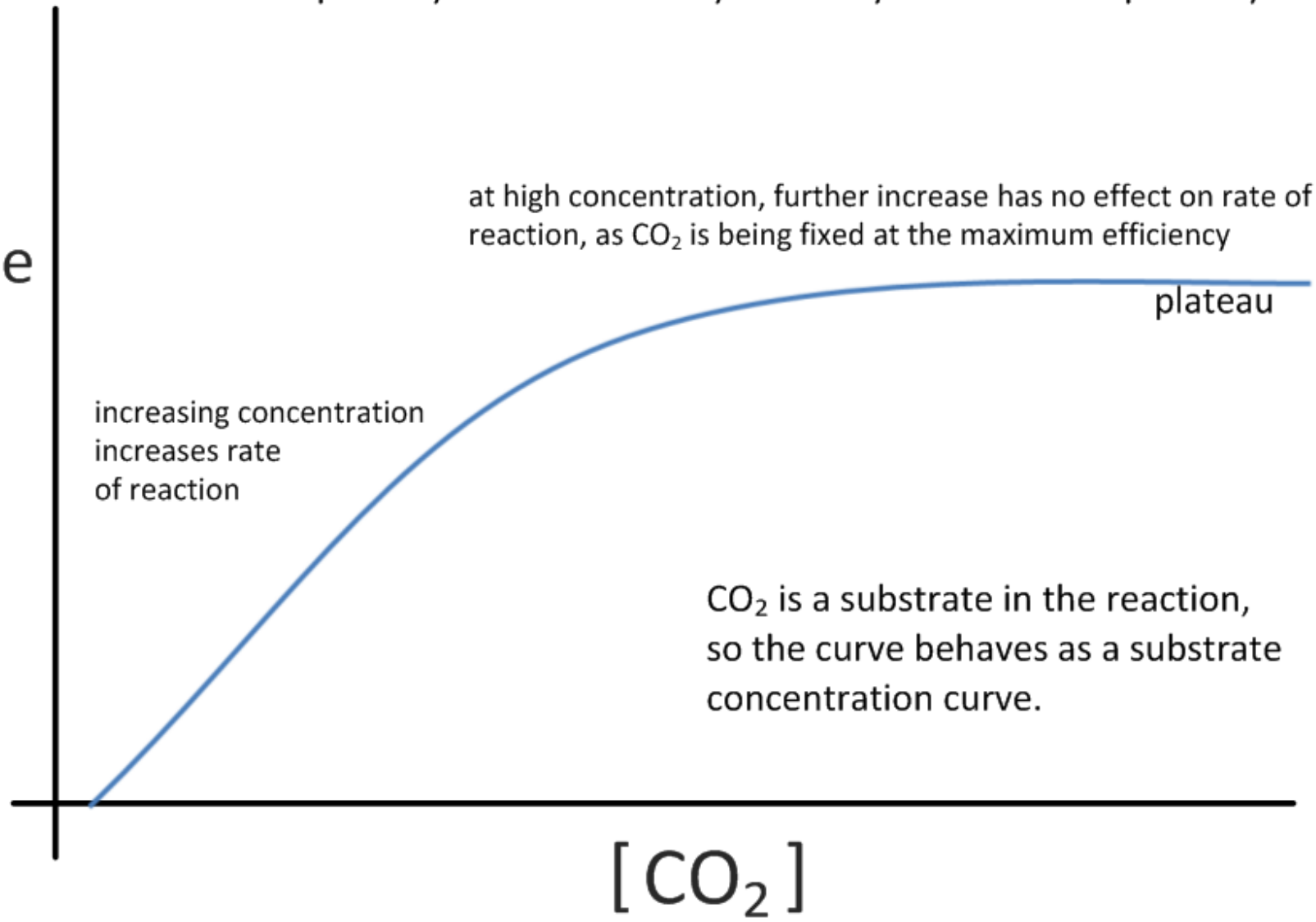
tricky, can be indirectly measured as an increase in surrounding pH.

Change in biomass:

indirect measurement

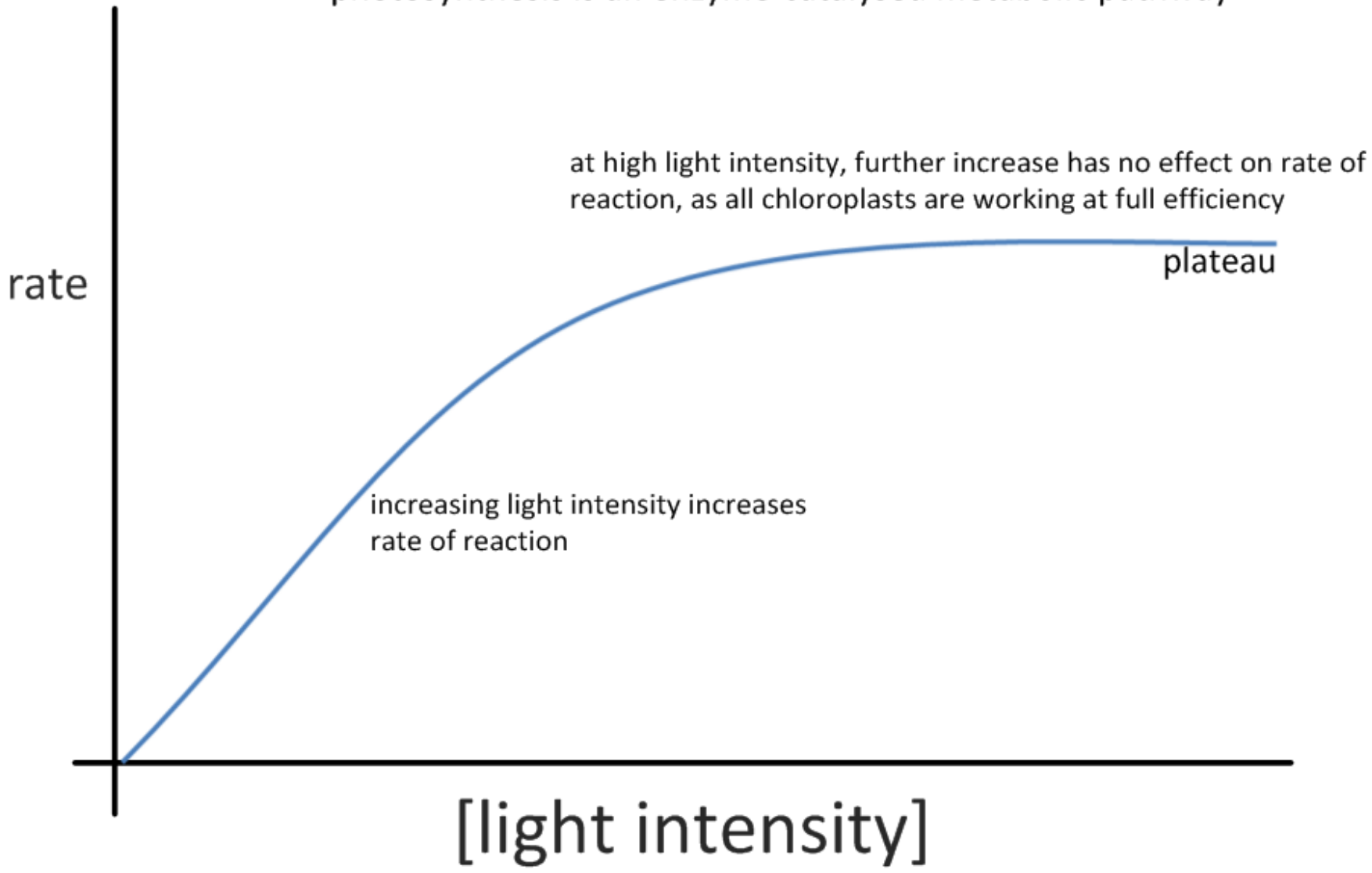
Factors affecting rate of photosynthesis: CO_2 concentration

photosynthesis is an enzyme-catalysed metabolic pathway



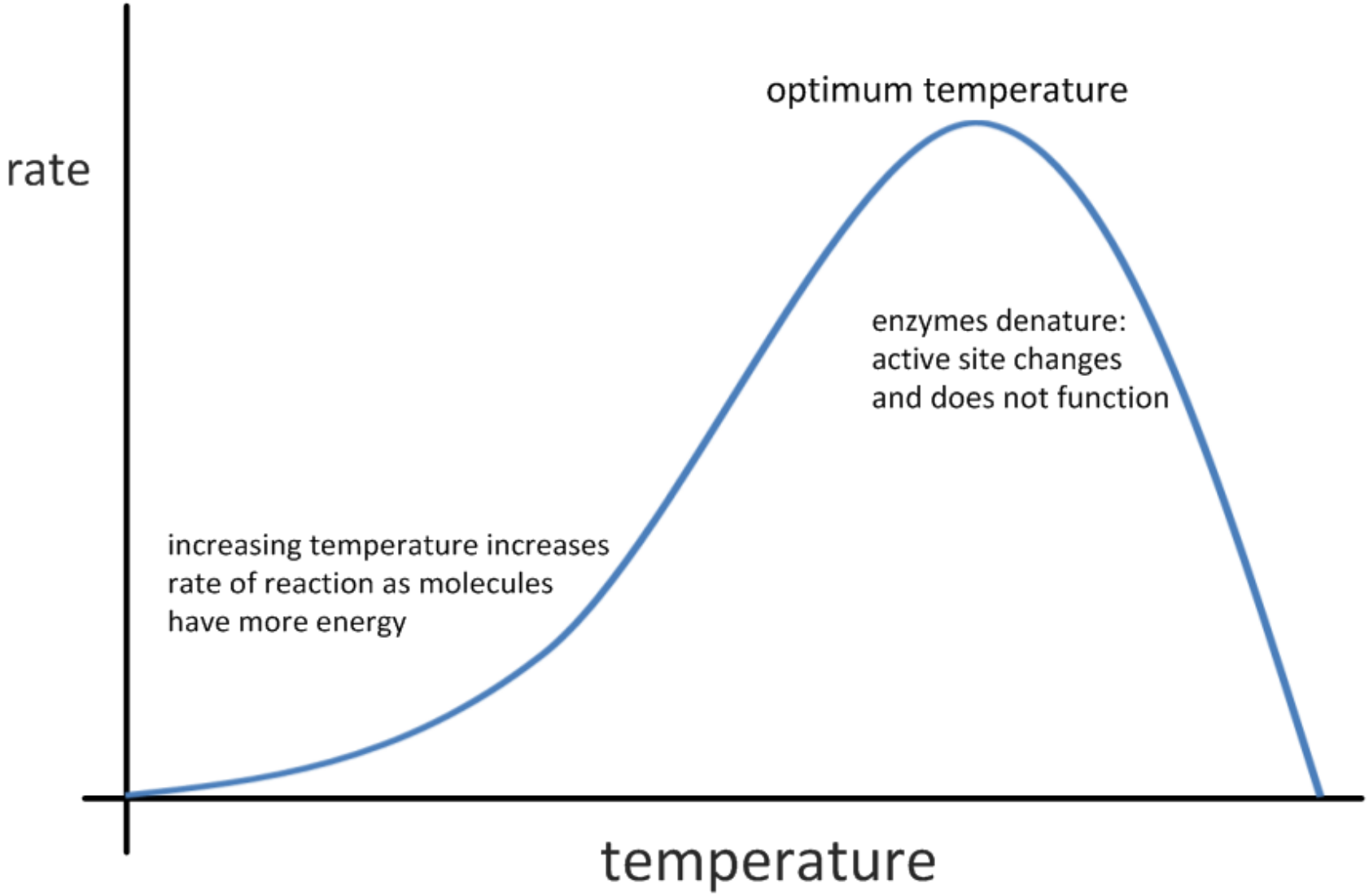
Factors affecting rate of photosynthesis: light intensity

photosynthesis is an enzyme-catalysed metabolic pathway



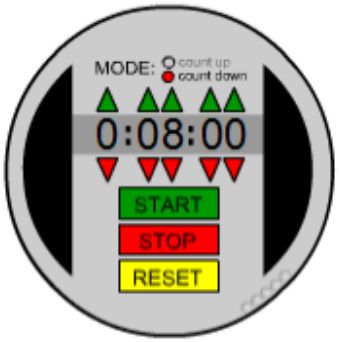
Factors affecting rate of photosynthesis: temperature

photosynthesis is an enzyme-catalysed metabolic pathway



Outline the effects of light intensity, temperature and carbon dioxide concentration on the rate of photosynthesis of a green plant.

(6 marks)



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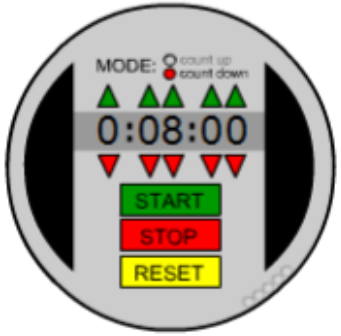


light intensity:
rate of photosynthesis increases as light intensity increases;
photosynthetic rate reaches plateau at high light levels;

temperature:
rate of photosynthesis increases with increase in temperature;
up to optimal level / maximum;
high temperatures reduce the rate of photosynthesis;

CO_2 concentration:
photosynthetic rate rises as CO_2 concentration rises;
up to a maximum where a plateau is reached;

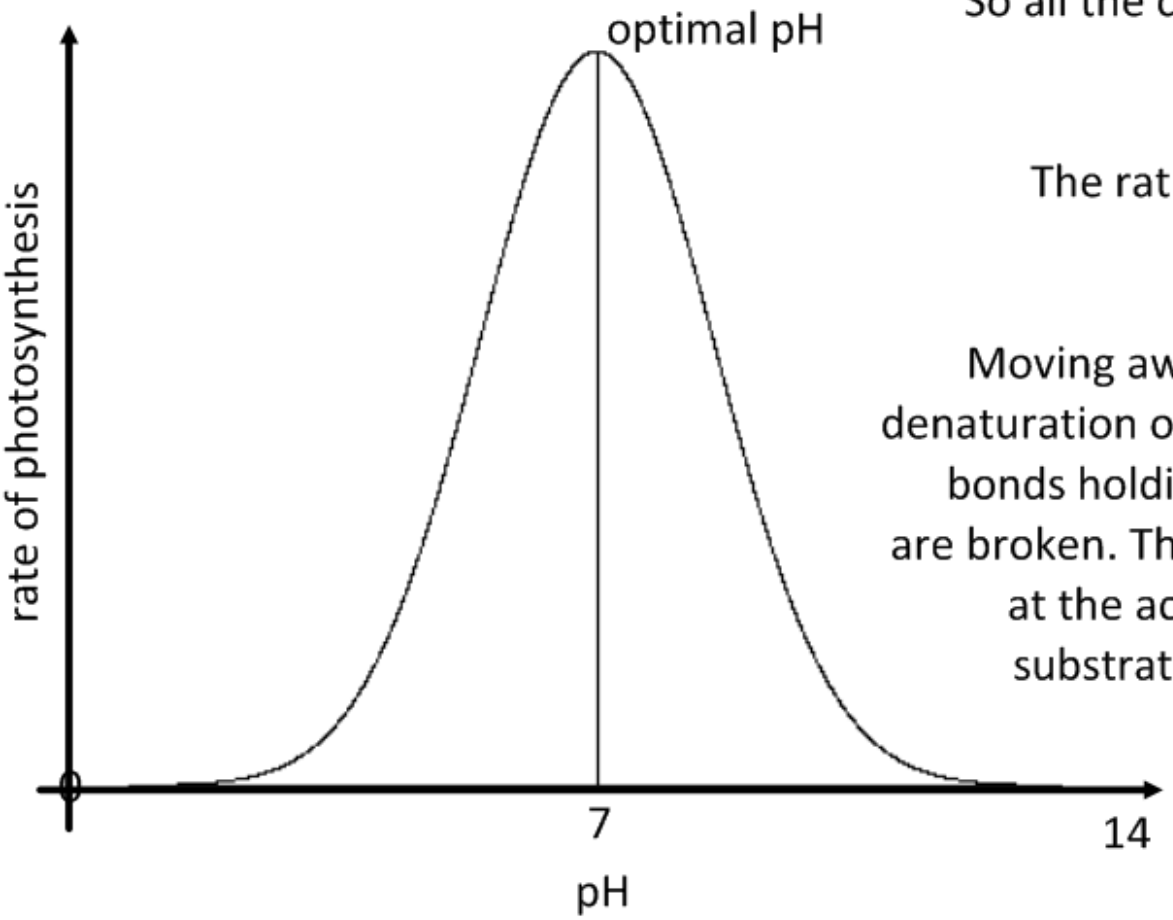
Some of the above points may be achieved by means of annotated diagrams or graphs.

From QuestionBank CDRom

Think: How would pH affect the rate of photosynthesis of a green plant?

Think: How would pH affect the rate of photosynthesis of a green plant?

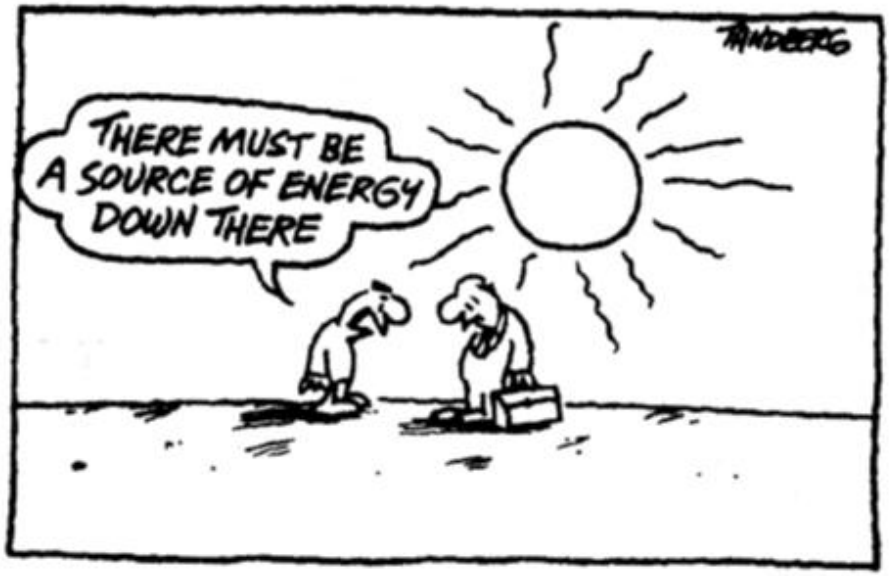
Photosynthesis is an enzyme-controlled metabolic pathway



So all the conditions that apply to enzyme reactions also apply here.

The rate of photosynthesis is at a peak at the optimal pH for the plant.

Moving away from the optimal pH causes denaturation of the enzymes, as the hydrogen bonds holding secondary protein structure are broken. There is a conformational change at the active site, so it no longer fits the substrates. The reactions cannot occur.



For more IB Biology resources:
http://sciencevideos.wordpress.com

Cartoon from:
http://www.thebreakthrough.org/blog/2007/08/in_love_with_the_sun.shtml