



Plant Nutrition

IGCSE BIOLOGY



Syllabus Requirement:

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Core

- Define photosynthesis
- State word and symbol equations for photosynthesis
- Describe the intake of raw materials, the trapping and storing of energy, the formation of food substances and their subsequent storage
- Identify the cellular and tissue structure of a dicotyledonous leaf
- Demonstrate the significance of these features in terms of functions
- Describe the importance of nitrate ions for protein synthesis and magnesium ions for chlorophyll synthesis
- Describe the uses and the dangers of overuse of nitrogen fertilizers

Supplement

- demonstrate the significance of these features in terms of functions
- describe the importance of nitrate ions for protein synthesis and magnesium ions for chlorophyll synthesis
- describe the uses and the dangers of overuse of nitrogen fertilizers explain the effects of nitrate ion and magnesium ion deficiency on plant growth
- Use hydrogencarbonate indicator solution to investigate the effect of gas exchange of an aquatic plant kept in the light and in the dark
- Describe the use of carbon dioxide enrichment, optimum light and optimum temperatures in glasshouses in temperate and tropical countries
- Outline the subsequent use and storage of the carbohydrates made in photosynthesis
- Design and investigate how the limiting factors can affect the rate of photosynthesis in the water plant

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Adapted from Cambridge IGCSE Biology 0610. Syllabus for examination in 2016, 2017 and 2018.
Biology at Glance IGCSE and GCSE review, Revision Guide Oxford

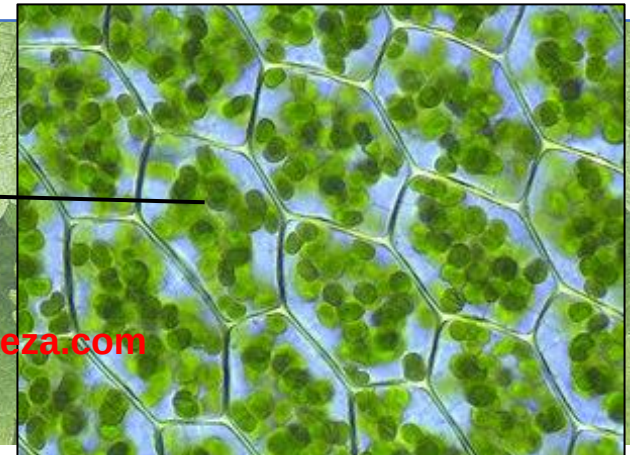
Photosynthesis

Definition: process by which plants manufacture carbohydrates(*organic*) from raw materials using energy from light (**Light** energy to **Chemical** energy)

CHLOROPHYLL:

- *The green pigment that makes plant look green*
- *Inside chloroplast*
- *Absorbs sunlight energy and converts it to chemical energy available for the formation of carbohydrates*

chloroplast



Photosynthesis

Photosynthesis

Word equation



Carbon
dioxide

+ Water

Light



Glucose + Oxygen

Chlorophyll

Symbol equation



$6\text{CO}_2 + 6\text{H}_2\text{O}$

Light

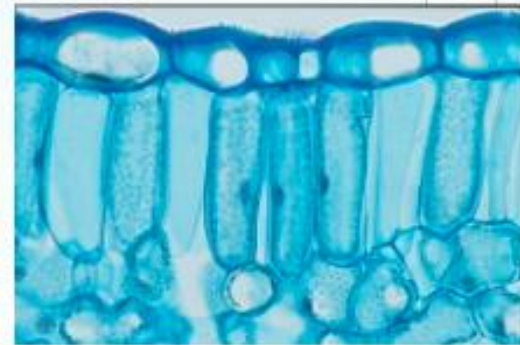
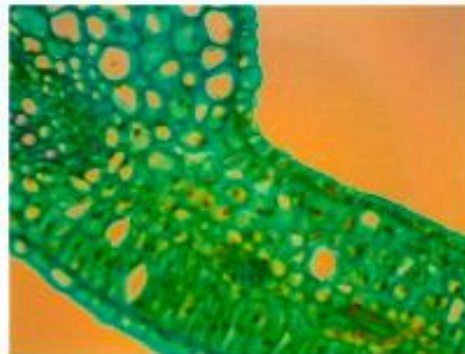
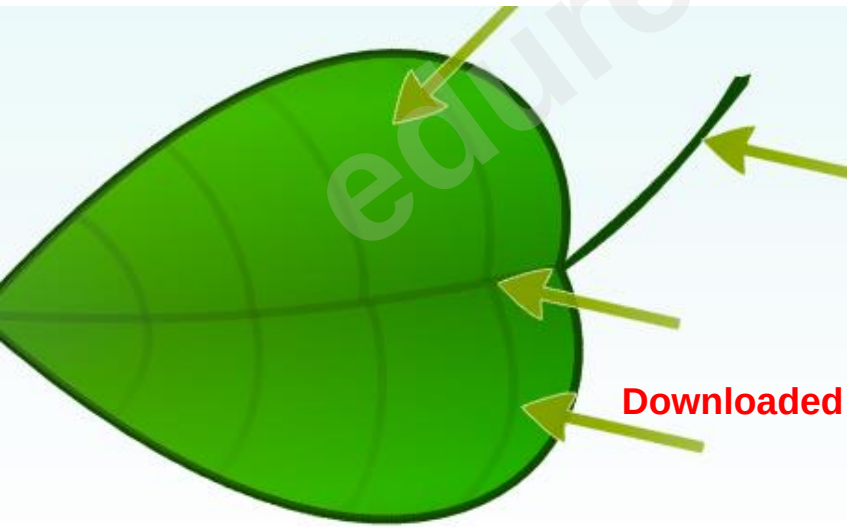


$\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

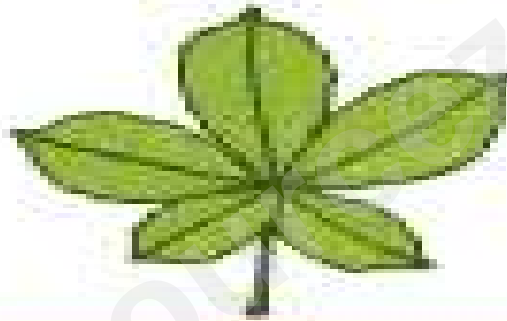
Chlorophyll

LEAVES

- Attached to the stem by a STALK or PETIOLE.
- The leaf stalk continues into the leaf as a MIDRIB.
- From the midrib branches a network of veins which deliver water and salts and carry away the food made in the leaves.
- The LEAF BLADE or LAMINA is broad to receive sunlight.



How are leaves adapted for photosynthesis?



Does photosynthesis take place
in all parts of a leaf?
Click on the leaf to take a look inside.

Transverse section of leaf

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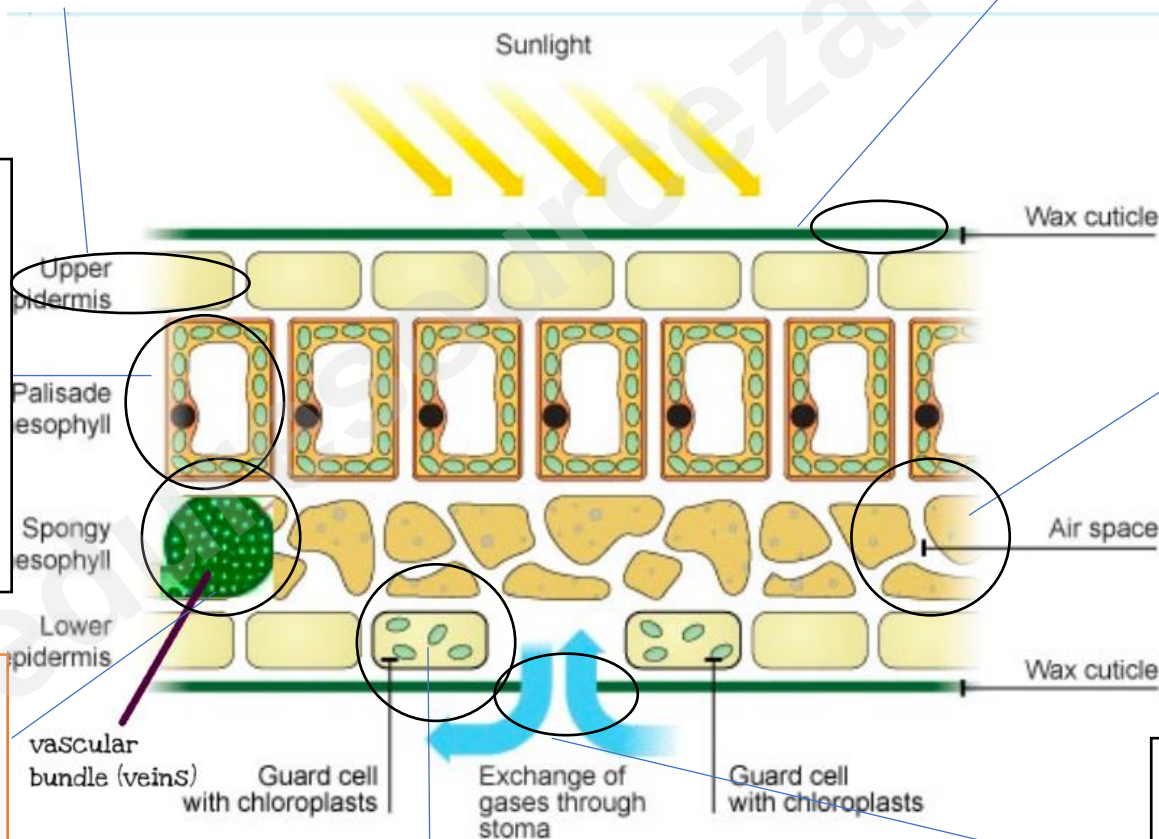
Thin layer of cells without chloroplasts that provides the protection to cells below (transparent)

Waxy layer secreted by the cells in epidermis. Prevents water evaporation (transparent)

Layer of elongated cells full of chloroplasts for photosynthesis. They are close to the top of the leaf so they receive a lot of light

Some photosynthesis can happen here as well. Have air spaces between them to allow CO_2 to diffuse to palisade cells from stomata

Water is provided by xylem tissue. Sucrose made in photosynthesis is transported away in phloem tissue.



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Guard cells can change shape to open or close the stomata

CO_2 enters and O_2 + $\text{H}_2\text{O}_{(g)}$ leave by diffusion through stomata

TEST YOURSELF

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TEST YOURSELF



How are leaves adapted to their functions?

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Maximum light absorption

- Broad and flat surface
- Position and arrangement
- Large surface area

To expose as much of the leaf to sun

So sunlight penetrates

Thin and transparent epidermal cells

*Many **chloroplasts** in the palisade cells and arranged broadside on*



Efficient gas exchange

- Large surface area of leaf
- Leaves are very thin
- Air spaces in spongy mesophyll

To obtain water

- Branching network of veins provides a good water supply to the photosynthetic cells

To expose chlorophyll to sunlight

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What happens to the glucose?

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Respiration to provide energy to drive the metabolic reactions needed to keep the plant alive

Conversion to other molecules such as oils and proteins. This may require mineral salts (e.g. nitrates)

Glucose

Conversion to sucrose to transport to other parts of the plants via phloem (translocated)

Conversion to cellulose for the construction of plant cells walls.

Conversion to starch for storage. Starch is insoluble so does not affect water potential of plant cells.

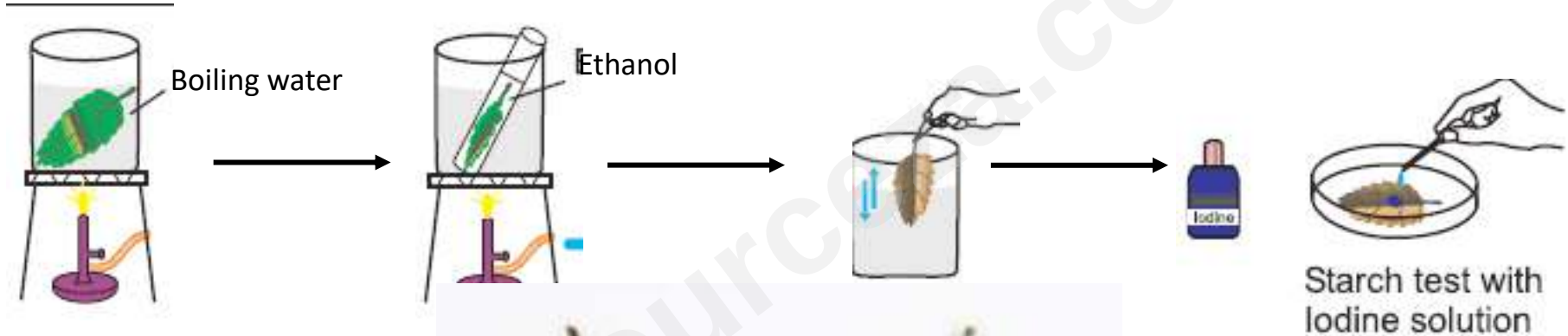
NOTE: *glucose is not a good storage molecule because it is reactive and soluble water.*

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Starch Test

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To determine whether a leaf has been photosynthesizing you can test it for starch.



1. Place the leaf in the boiling water. This destroys the waxy cuticle and breaks open the cell membrane

2. Put the leaf in the ethanol to dissolve the chlorophyll from the leaf



No starch

Has starch

4. Add iodine solution and look for the blue black color.

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How do growing conditions affect starch production?

Plant A
normal
conditions



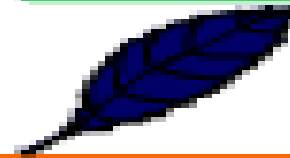
Plant B
leaf
covered by
black paper
strip



Plant C
airtight +
soda lime



Plant D
airtight +
hydrogen-
carbonate



Plant E
variegated
plant
in normal
conditions



Well done! A perfect match!
What do the results tell you about
the conditions needed for photosynthesis?



Investigating what is needed for photosynthesis

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Test for chlorophyll

- *variegated leaves (green and white)*
- *The parts that were green go blue black*

Light

- *Partly cover a leaf with black paper and stand the plant in light place for day*
- *The parts that were uncovered go blue black*

Carbon dioxide

- *Use substance that absorbs CO_2 (soda lime) to remove CO_2 from air.*
- *Place one container with soda lime, identical container with no soda lime.*
- *Only leaf that had CO_2 goes blue black*

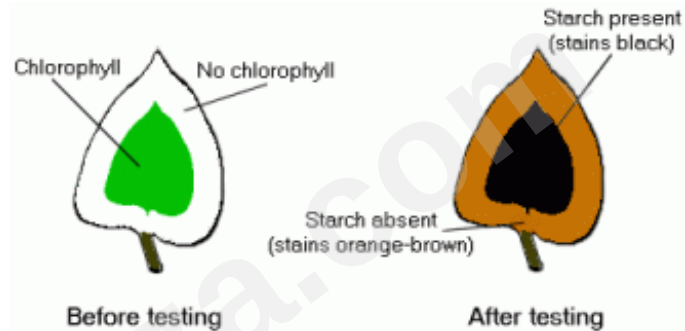
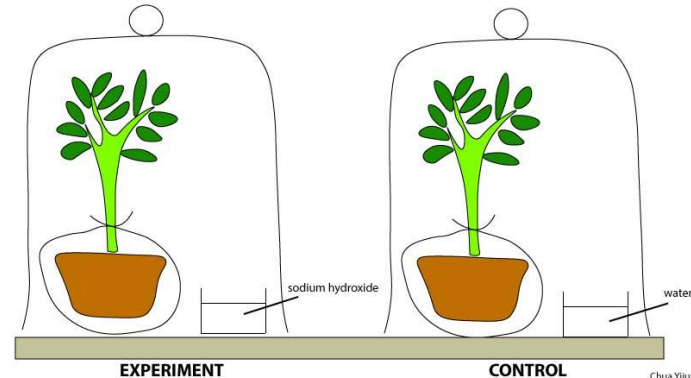
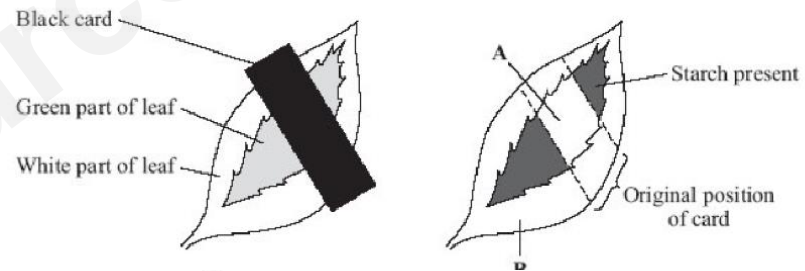


Diagram 1

Diagram 2



In each experiment, **control** is used. For example, in the black paper experiment, we can compare results for the parts of the leaf that had light with parts that did not have light!

Investigating the rate of photosynthesis (aquatic plants)

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Measuring the **rate** of photosynthesis

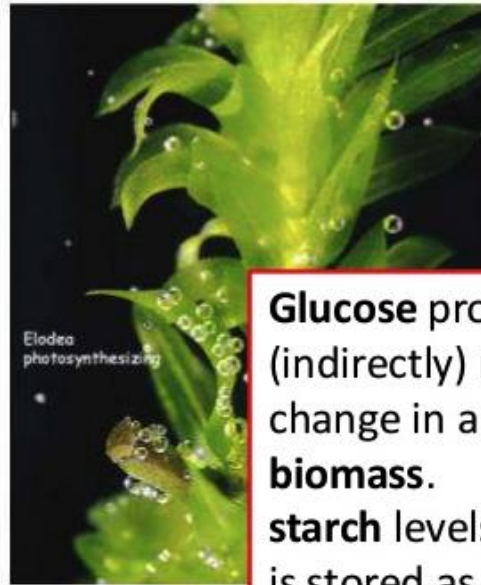
$$\text{rate} = \frac{\text{change}}{\text{time}} \quad \begin{matrix} \text{(measured)} \\ \text{(controlled)} \end{matrix}$$

Glucose production can be (indirectly) measured by a change in a plant's **dry biomass**.
starch levels in a plant (glucose is stored as starch) can be identified by staining with **iodine solution**, this can be quantitated using a **colorimeter**.

on:
collect with a gas syringe

Change in biomass:
indirect measurement

in surrounding pH.



Elodea photosynthesizing

<http://fig.cox.miami.edu/>



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

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What equipment is used to test the rate of photosynthesis?

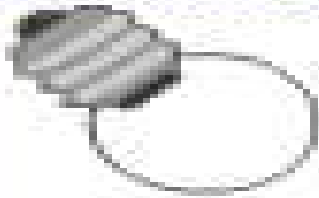
Assemble the apparatus to investigate how light intensity affects the rate of photosynthesis.



Set up for experiment



How does light intensity affect the rate of photosynthesis?



Use the slider to change the light intensity and see how this affects the amount of oxygen produced by the plant.



How do temperature and light affect photosynthesis?

Class 1051 carried out experiments to investigate how the amount of light and temperature affect the rate of photosynthesis.

Click on the apparatus to see the results.



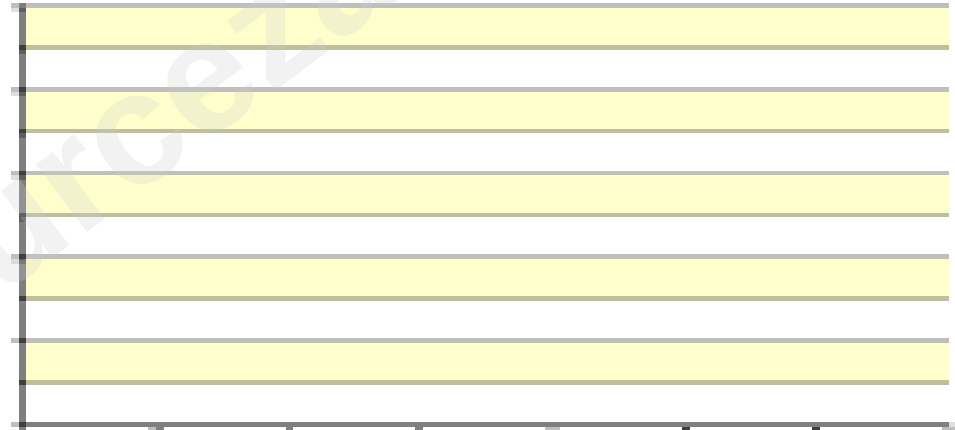


How does light intensity affect the rate of photosynthesis?

The availability of light can act as a limiting factor for photosynthesis.

Click "play" to find out more.

rate of photosynthesis



light intensity





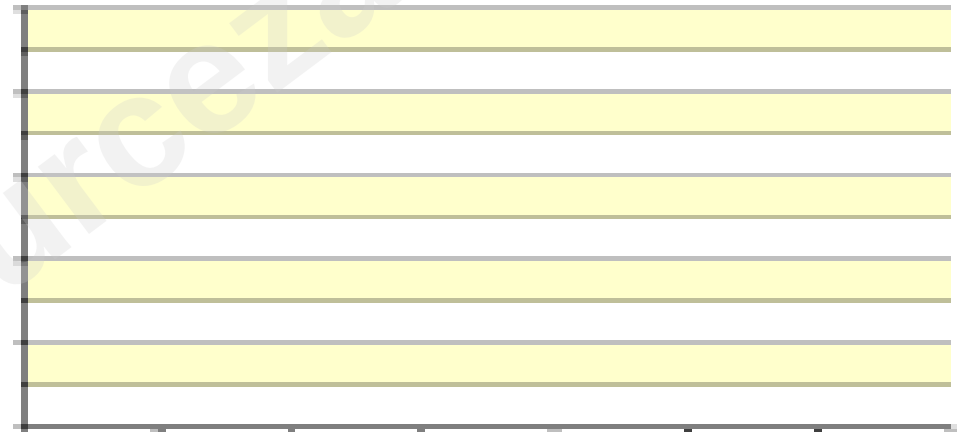
How does carbon dioxide affect the rate of photosynthesis?

Carbon dioxide is a raw material for photosynthesis.

How will changing the level of carbon dioxide affect the rate of photosynthesis?

Click "play" to find out.

rate of photosynthesis



carbon dioxide levels



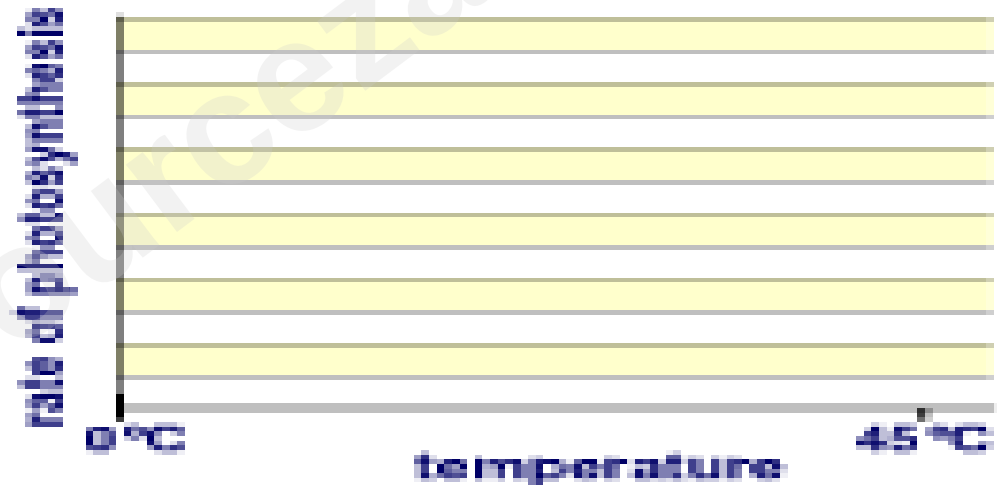


How does temperature affect the rate of photosynthesis?

Photosynthesis is controlled by temperature-sensitive enzymes.

This means that temperature changes have a big impact on the rate.

Click "play" to find out more.



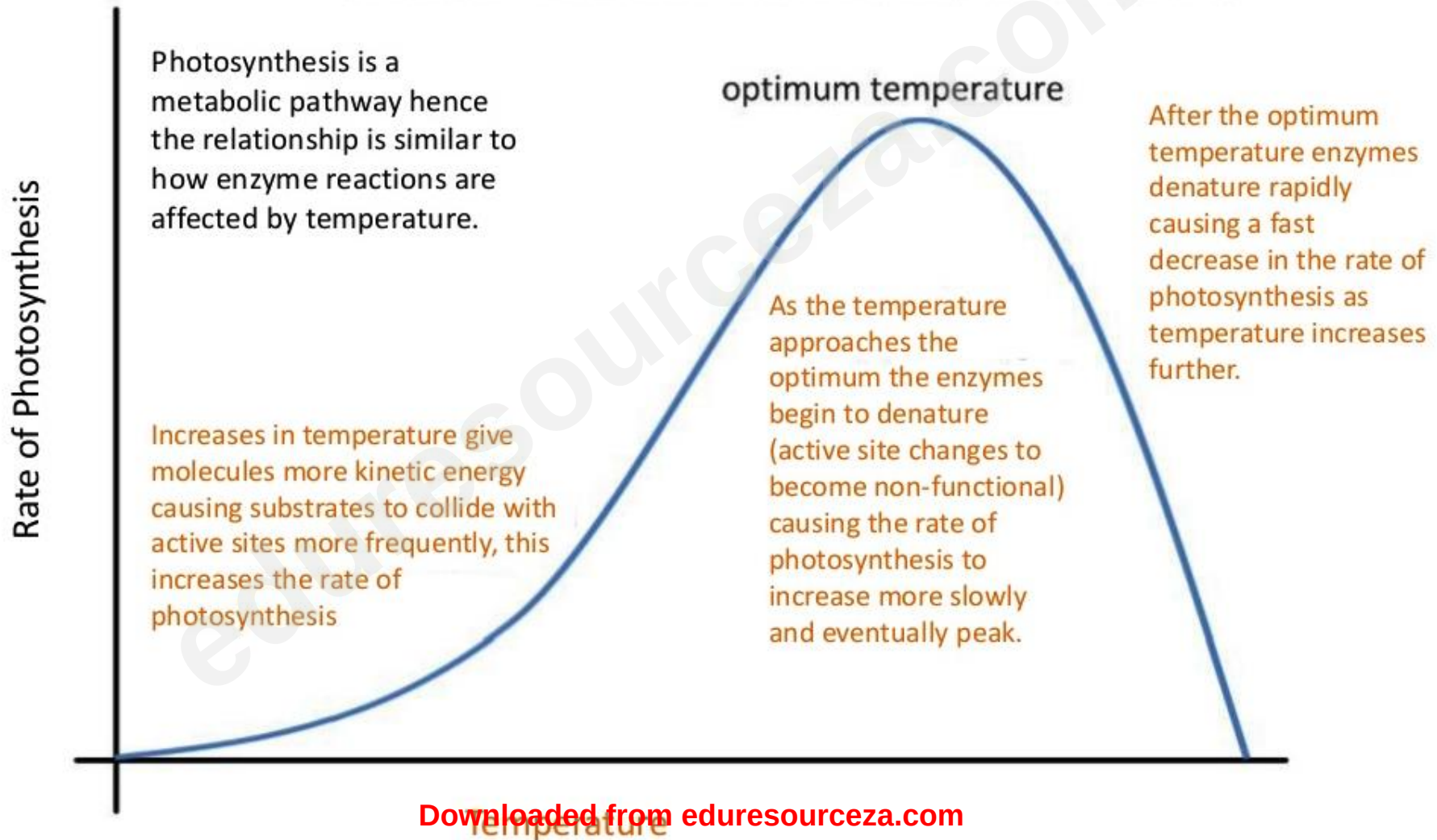
Limiting Factors

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something present in the environment in such short supply that it restricts life processes

Factors affecting rate of photosynthesis: **temperature**

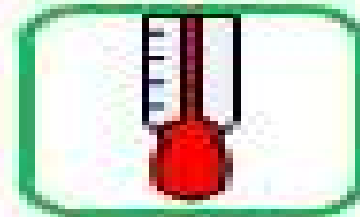
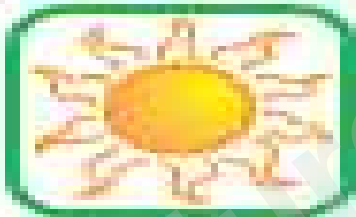
photosynthesis is an enzyme-catalysed metabolic pathway



How do limiting factors control the rate of photosynthesis?

The rate of photosynthesis is controlled by light, carbon dioxide and temperature.

Click on the icons below to see graphs showing how each factor affects the rate of photosynthesis. Label each graph to show the limiting factors.



Greenhouse (Application)

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Allows conditions to be controlled.

Maximize the rate of photosynthesis

Faster photosynthesis = growth increase (Yield increase)

Temperate country

- Low light intensity + temperature

Tropical country

- Low CO₂



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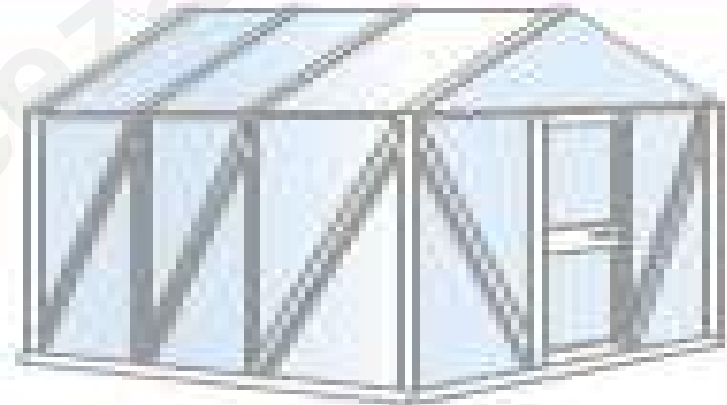
What conditions are needed for optimum plant growth?

You work at a plant nursery,
in charge of the greenhouses
where roses are grown.

You control the amount of
carbon dioxide, light and heat
that the plants receive.

Under what conditions
will the roses grow best?

Click on the door to enter
the greenhouse.



Respiration and Photosynthesis

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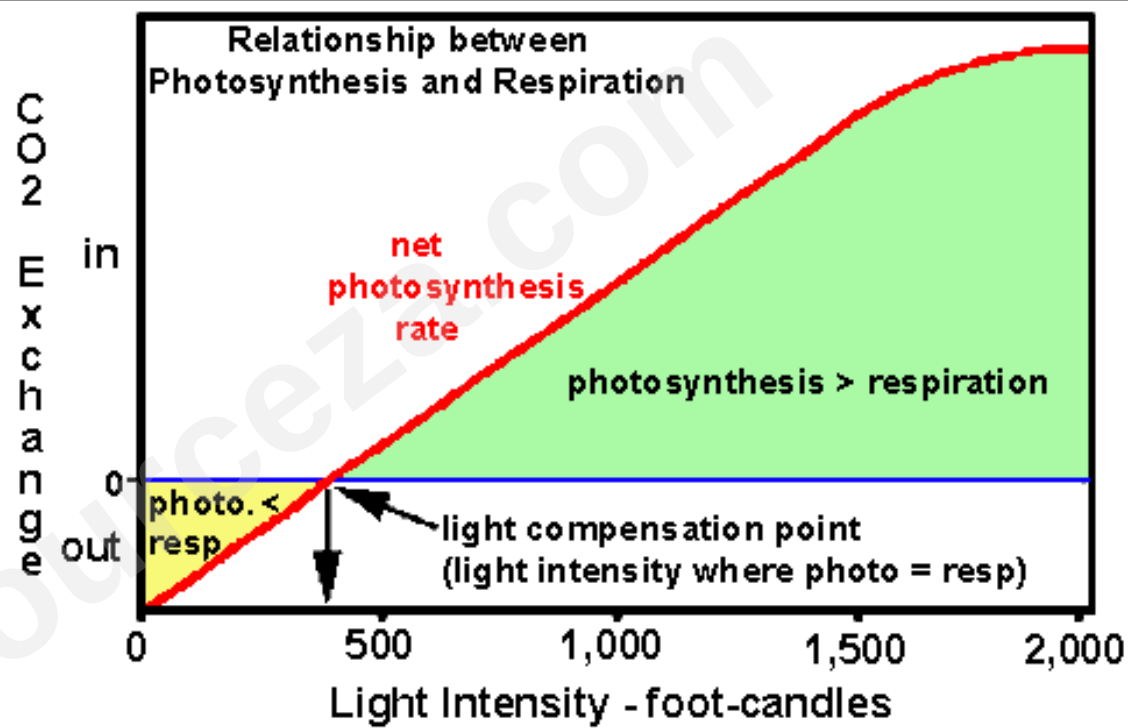
Daylight

photosynthesis $\uparrow$ respiration (rate)

- CO_2 produced by respiration is used in photosynthesis + CO_2 from air
- Some of O_2 released by photosynthesis is used up in respiration, but not all. (rest is given out)

Night (Darkness)

Only respiration takes place



Hydrogencarbonate indicator (gas exchange in aquatic plants)

Increasing CO₂ in indicator

Atmospheric CO₂ level

Decreasing CO₂ in indicator

It is red in equilibrium with atmospheric air.

orange/yellow = $\uparrow$ CO₂ level

Voilet/purple = $\downarrow$ CO₂ level

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Plants need Minerals too!

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Mineral	Source	Importance
Magnesium	Absorbed as Mg^{2+} from the soil solution	Manufacture of chloroplast Absence makes leaves turn yellow and eventually stops photosynthesis
Nitrogen	Absorbed as Nitrate or ammonium(NH_4^+) from the soil solution	Manufacture of proteins, nucleic acids and plant hormones. Absence causes poor growth, especially for leaves.



Magnesium (yellowing of leaves)



Nitrogen (poor growth)

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Fertilisers

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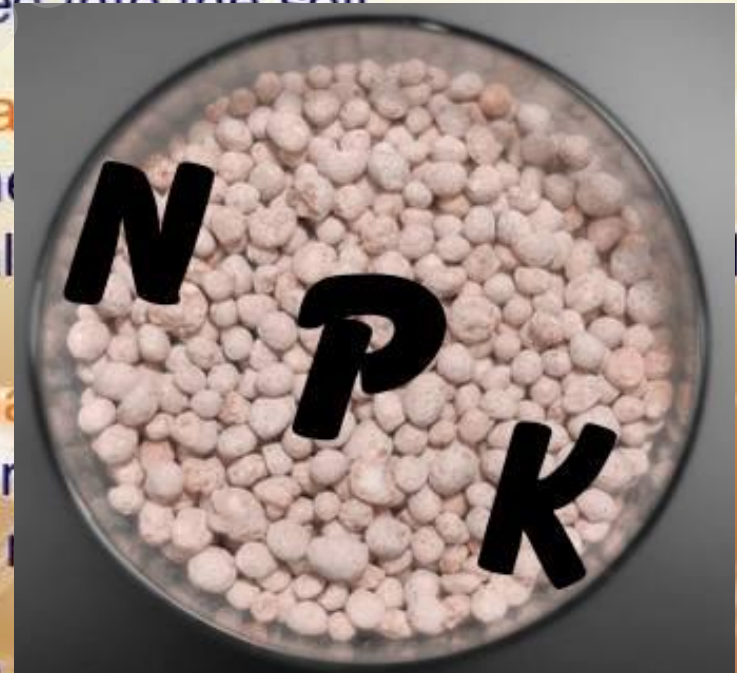
- What are the sources of minerals in the soil?



Rocks: The minerals in rocks are slowly dissolved by slightly acidic rainwater. These minerals are washed into the soil.

Natural
and the
animal

Artificial
contain
of the

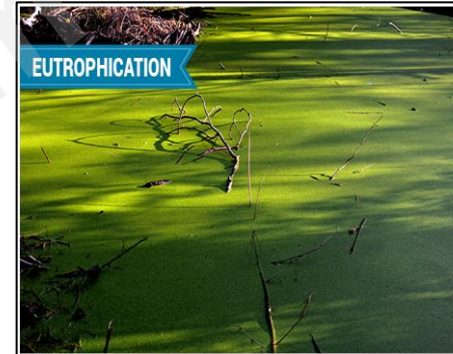
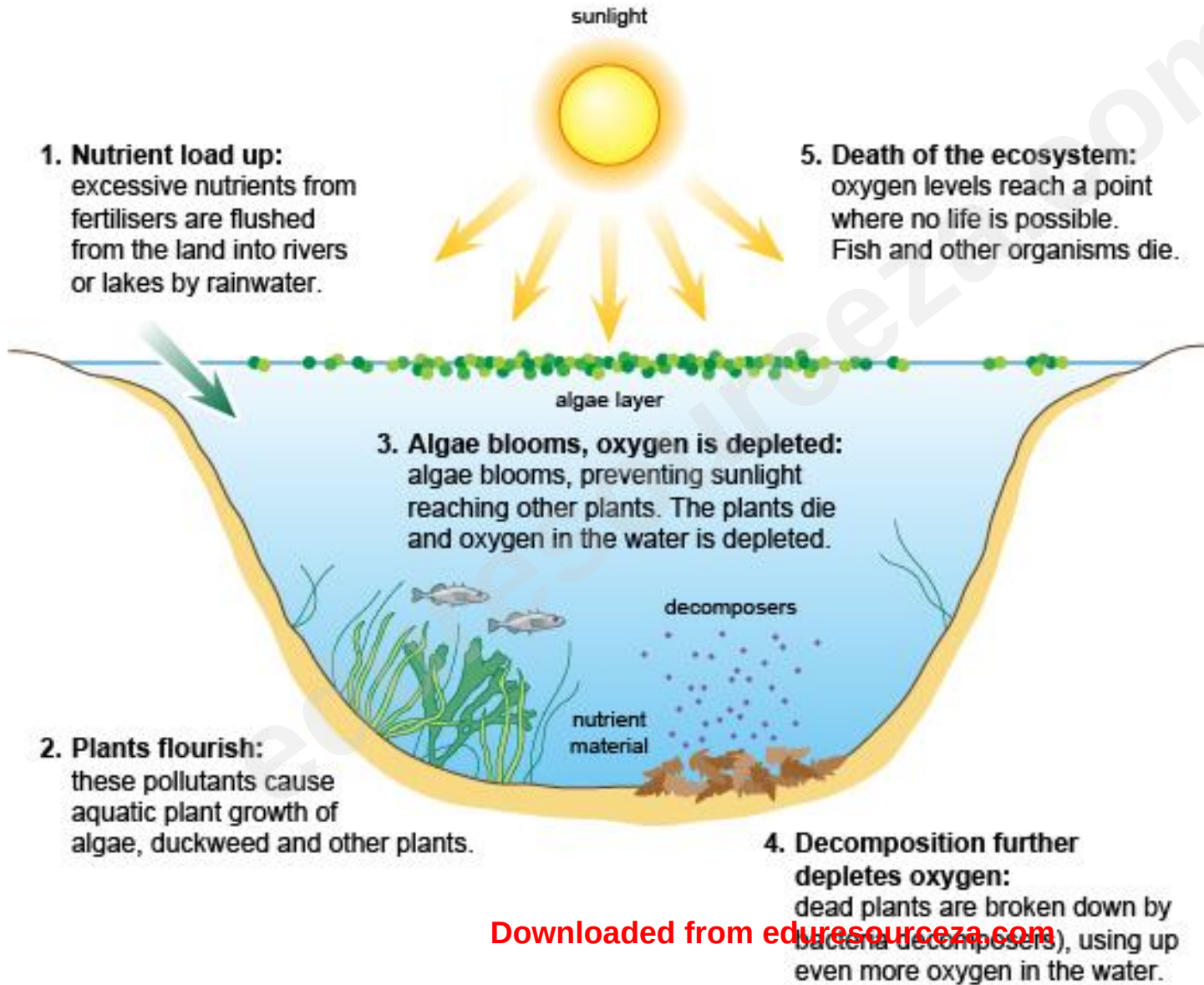


Why do farmers add fertilizers to their soil?

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Too much?? (Eutrophication)

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**PLANTS CAN
SURVIVE WITHOUT HUMANS**



**BUT HUMANS CANNOT
SURVIVE WITHOUT PLANTS**

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