MYP 4
UNIT 2
LESSON 5

Photosynthesis Requirement and Product.

Objectives

- I can explain why the survival of consumers depends upon photosynthesis in producers.
- I can describe photosynthesis as an endothermic chemical process, highlighting the role of light and how leaves are adapted for this process.
- I can use simple models to explain what happens during photosynthesis, including a model of the two main stages.

Producers, photosynthesis, and consumers

Keywords

producer	an organism that makes its own food
photosynthesis	the process used by producers to make their own food via a series of chemical reactions
biomass	the mass of biological material in one or more organisms
cellular respiration	a chemical process that transfers energy for life processes, using glucose as a fuel
consumer	an organism that eats other organisms for food

Keywords

endothermic	a chemical process that requires energy transferred from its surroundings
adaptation	a feature that helps an organism to function and survive
chloroplast	subcellular structure in which photosynthesis takes place
chlorophyll	green pigment in chloroplasts, to which energy is transferred by light
stomata	pores (holes) in the surface of a leaf, through which water, oxygen and carbon dioxide can diffuse

Lesson outline

Producers, photosynthesis and consumers

- Producers and photosynthesis
- Producers and consumers
- Producers and the atmosphere

Producers and photosynthesis

Explanation

All living organisms need food to stay alive and grow. This is the common life process of nutrition.

But not all living organisms need to eat. Can you explain why?

Some organisms are **producers** that make their own food in their cells.

Examples of **producers** include …

plants that grow on land, such as grasses, trees and flowers

aquatic plants that grow in water

microorganisms such as algae

Producers and photosynthesis

Check

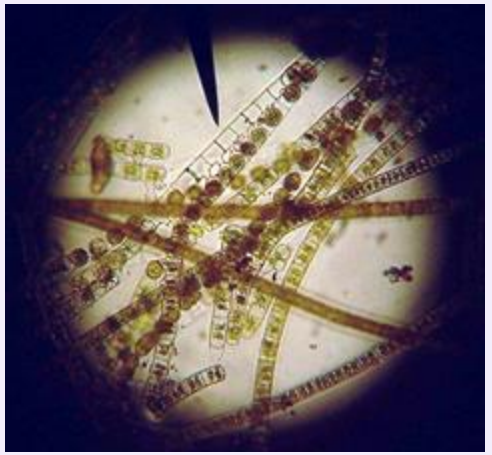
Which of these organisms are producers?

vegetable plants

a ✓

grass

b ✓



freshwater green algae

c ✓

pollinators

d

Producers and photosynthesis

Explanation

Producers make their own food using the process of **photosynthesis**.

Photosynthesis is a series of chemical reactions that happens inside cells of producers.

A **word summary** of the reactants and products is:

carbon dioxide + water ⟶ glucose + oxygen

reactants products

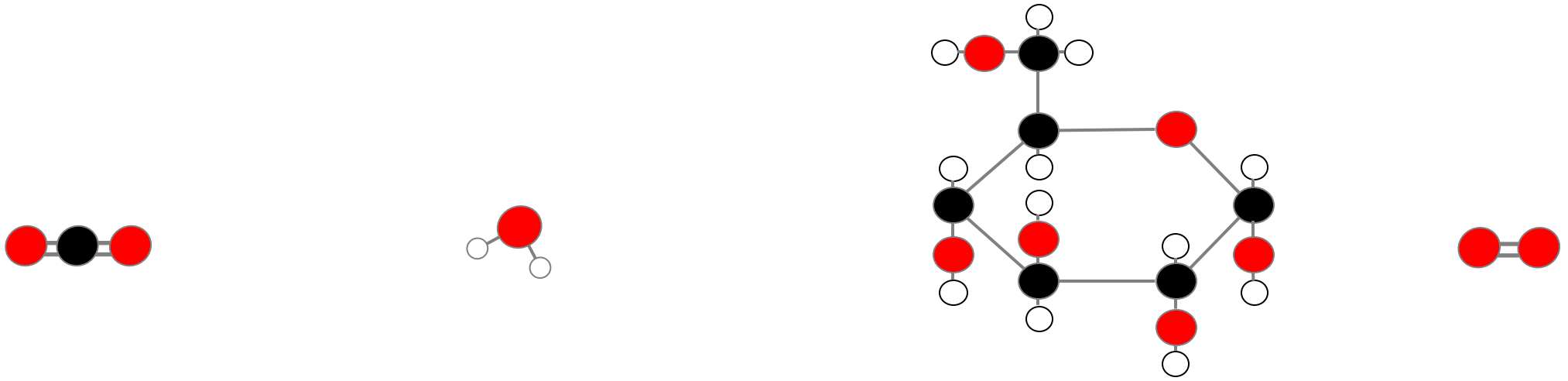
Light transfers the energy needed for the chemical reactions of photosynthesis to take place.

Producers and photosynthesis

Explanation

The reactants and products of **photosynthesis** are all made up of:

- carbon
- oxygen
- hydrogen



carbon dioxide + water → glucose + oxygen

Producers and photosynthesis

Check

Which of these are the products of photosynthesis?

a carbon dioxide

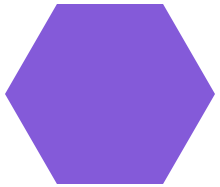
b glucose ✓

c oxygen ✓

d water

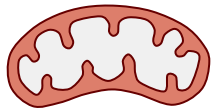
Producers and photosynthesis

Explanation

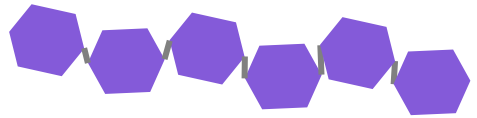


Glucose is a type of sugar, which is a simple carbohydrate.

The glucose made by **photosynthesis** is used by **producers** in various ways …



… some is used as fuel for **cellular respiration** to transfer energy for life processes.



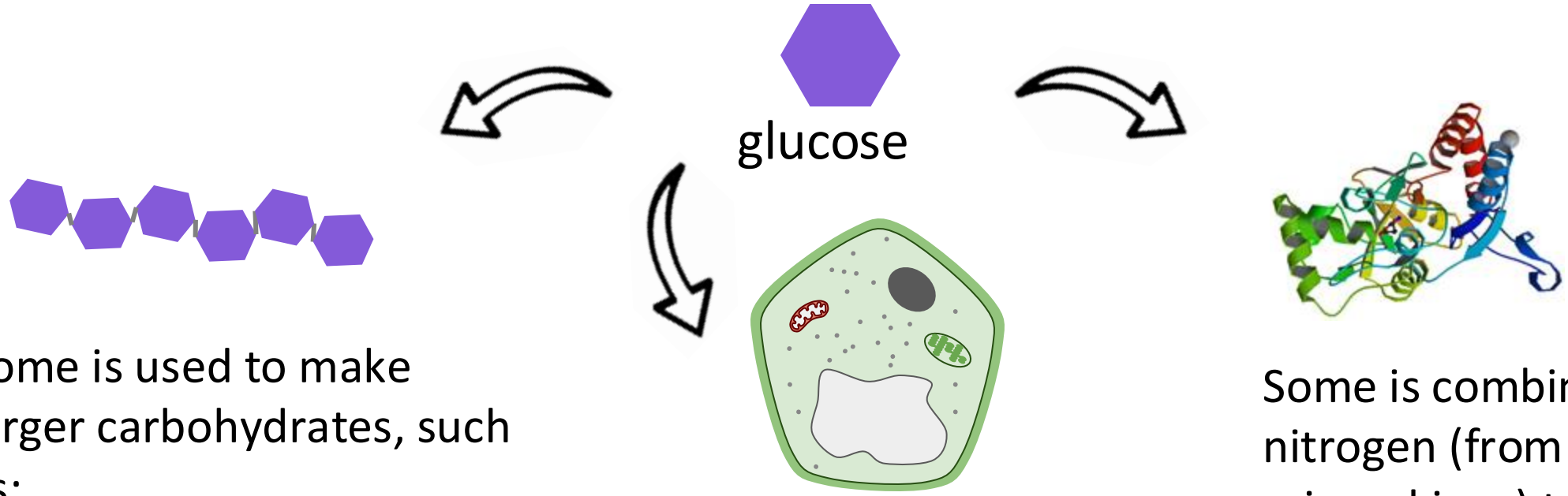
… some is used to build **biomass** for growth and repair.

Biomass is all the biological material that makes up the cells and tissues of the organism.

Producers and photosynthesis

Explanation

All the **biomass** of a producer is made from glucose:



Some is used to make larger carbohydrates, such as:

- starch, for storage
- cellulose and lignin, to build cell walls

Some is used to make lipids (fats and oils), for storage and to build cell membranes.

Some is combined with nitrogen (from nitrate mineral ions) to make amino acids and proteins (including enzymes).

Producers and photosynthesis

Explanation

In science, the word ‘food’ means something that an organism uses as both …

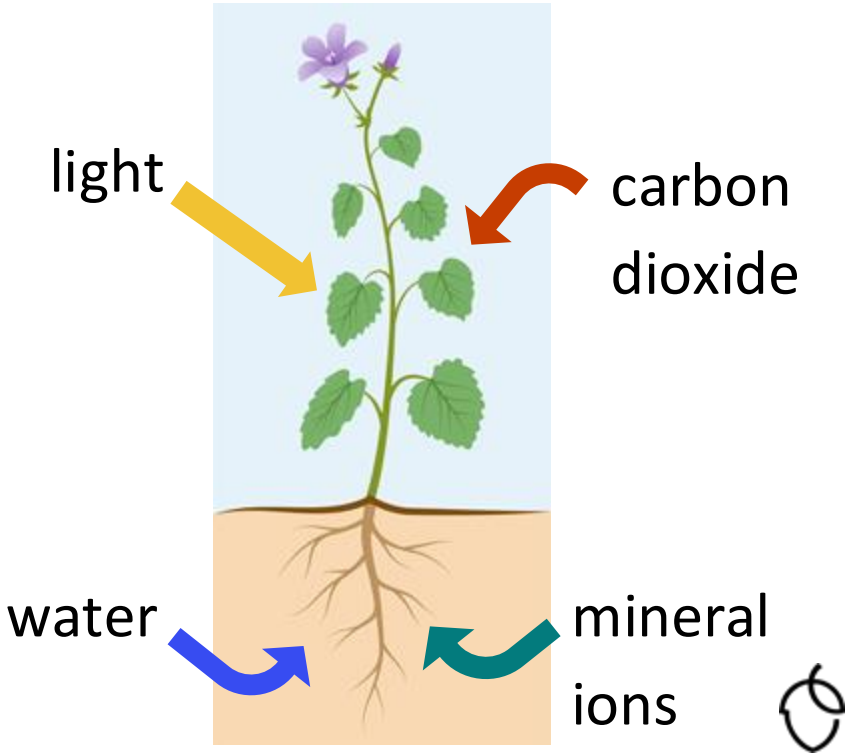
… a source of materials for growth and repair …

and

… a source of energy.

The things that **producers** take in from their surroundings are not food because each thing is only used in one of these ways, not both.

The glucose made by **photosynthesis** is used in both of these ways, and is all the food a producer needs.



Lesson outline

Producers, photosynthesis and consumers

- Producers and photosynthesis
- Producers and consumers
- Producers and the atmosphere

Producers and consumers

Explanation

Some living organisms cannot photosynthesise, so cannot make their own food.

But like all living organisms, they do need food as a source of energy and a source of materials to make **biomass** for growth and repair.

These organisms are **consumers** that get food by eating **producers** or other consumers.

All living organisms need food.

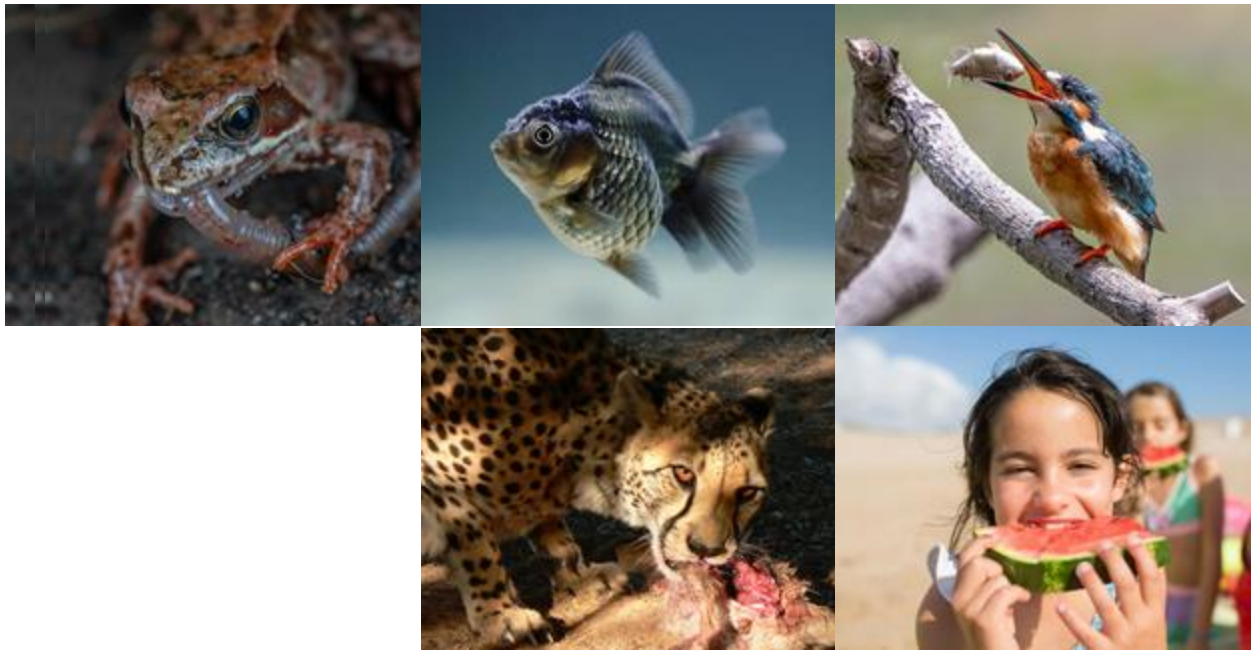
Producers and consumers

Explanation

All animals are **consumers**.

This includes …

… all invertebrates, such as jellyfish, worms, arachnids and insects.



… all vertebrates, such as amphibians, fish, birds, reptiles and mammals (including humans).

Producers and consumers

Check

The photograph shows a chipmunk (a mammal) eating a sunflower (a plant).
Which of them is a consumer?

a both

b just the chipmunk ✓

c just the sunflower

d neither

Producers and consumers

Explanation

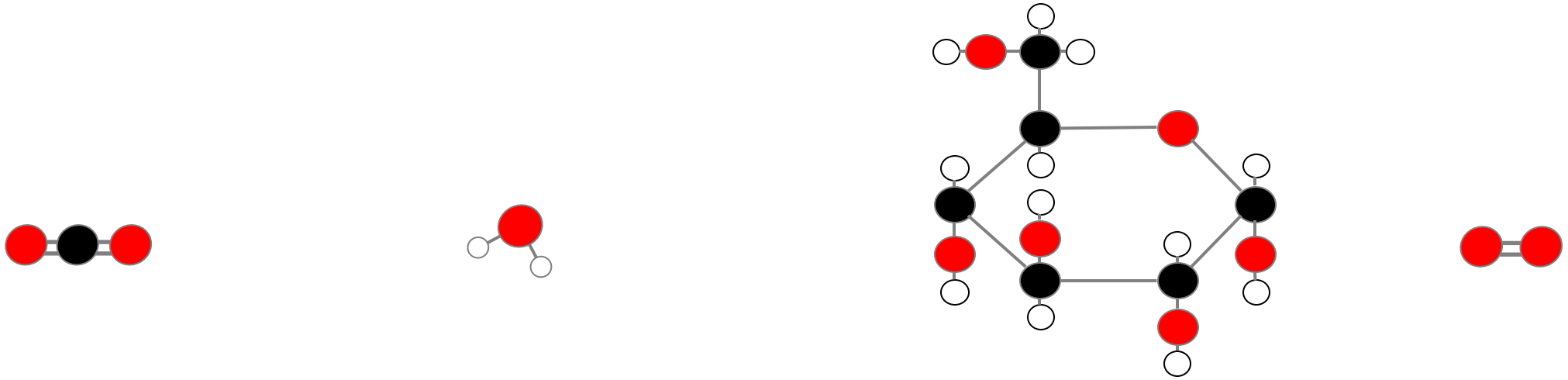
The **biomass** of all living organisms is made mostly of carbon atoms.

Producers get carbon from carbon dioxide in the atmosphere.Through **photosynthesis** they convert it into glucose, which they use to build biomass.

carbon

oxygen

hydrogen



carbon dioxide + water ⟶ glucose + oxygen

Producers and consumers

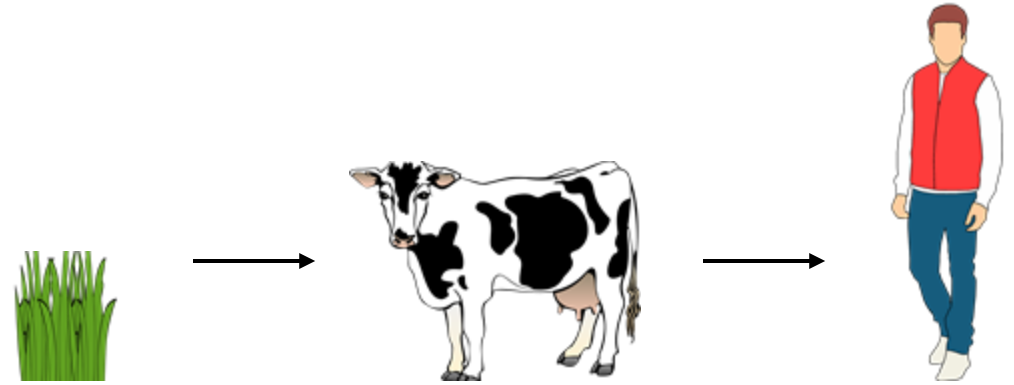
Explanation

Consumers cannot use carbon dioxide from the environment to make **biomass**.

Similarly, consumers cannot absorb nitrogen from the environment to make amino acids and proteins.

Consumers can only get carbon and nitrogen by eating the biomass of **producers** (or of other consumers that ate producers).

Every food chain starts with a producer that makes all the biomass that is transferred along the chain when organisms are eaten.



Producers and consumers

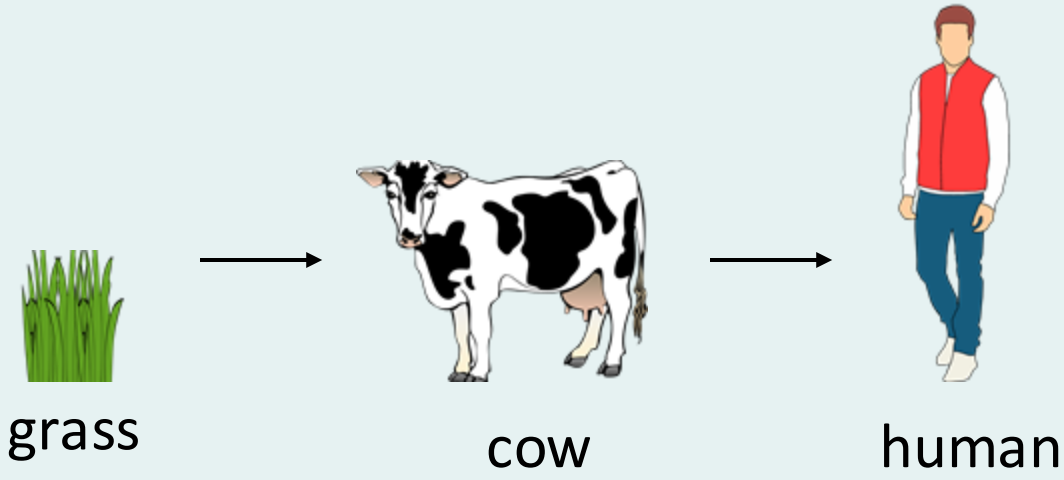
Check

Which organisms in the food chain are consumers?

a grass

b cow ✓

c human ✓



Lesson outline

Producers, photosynthesis and consumers

- Producers and photosynthesis
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- Producers and the atmosphere

Producers and the atmosphere

Explanation

Photosynthesis:

water + carbon dioxide → glucose + oxygen

During photosynthesis, **producers**:

- take in carbon dioxide from the atmosphere
- release waste oxygen into the atmosphere

Producers and the atmosphere

Explanation

Evidence from rocks and fossils suggests that **photosynthesis** first evolved approximately 3.5 billion years ago.

Scientists think that before this, Earth's atmosphere was similar to the atmosphere on Mars today where there are no **producers** - as far as we know!

gas	% of the atmosphere
carbon dioxide	95
oxygen	0.13
others	4.87

Photosynthesis in producers has changed the % of carbon dioxide and oxygen in Earth's atmosphere.

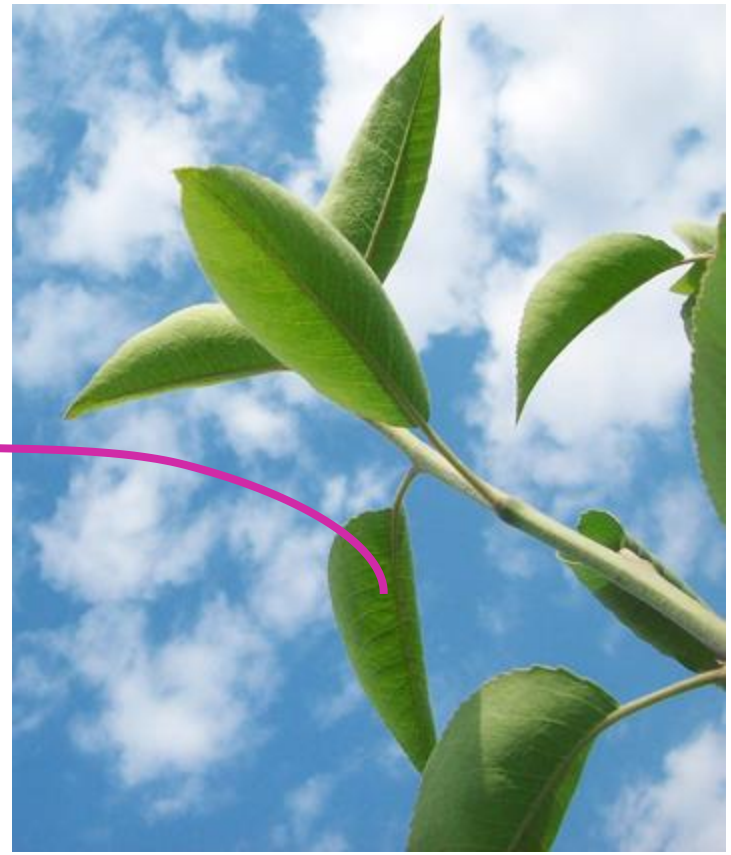
gas	% of the atmosphere
carbon dioxide	0.04
oxygen	21
others	78.96

Producers and the atmosphere

Explanation

Producers and **consumers** need oxygen from the atmosphere for aerobic **cellular respiration**.

Without **photosynthesis** in producers, there would not be enough oxygen in the atmosphere for cellular respiration.



This means there would not be enough oxygen to support life.

So consumers depend upon photosynthesis in producers for both the food and oxygen we need to stay alive.

Producers and the atmosphere

Check

Which statements are true?

a Photosynthesis adds carbon dioxide to the atmosphere.

b Photosynthesis adds oxygen to the atmosphere. ✓

c Photosynthesis removes carbon dioxide from the atmosphere. ✓

d Photosynthesis removes oxygen from the atmosphere.

Photosynthesis: an endothermic process that takes place in chloroplasts

Lesson outline

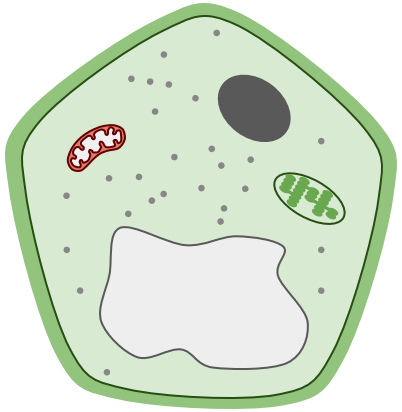
Photosynthesis: an endothermic process that takes place in chloroplasts

- An endothermic process
- Adaptations of leaves for photosynthesis

An endothermic process

Explanation

Plants and other producers make their own food inside their cells using a process called photosynthesis.



plant cell

The process uses carbon dioxide and water.

It makes glucose (a type of sugar and a simple carbohydrate), that is the producer's food. It is used to make biomass for growth and repair, and as fuel for cellular respiration to transfer energy for life processes.

The reactants and products of photosynthesis can be summarised:

carbon dioxide + water $\longrightarrow$ glucose + oxygen

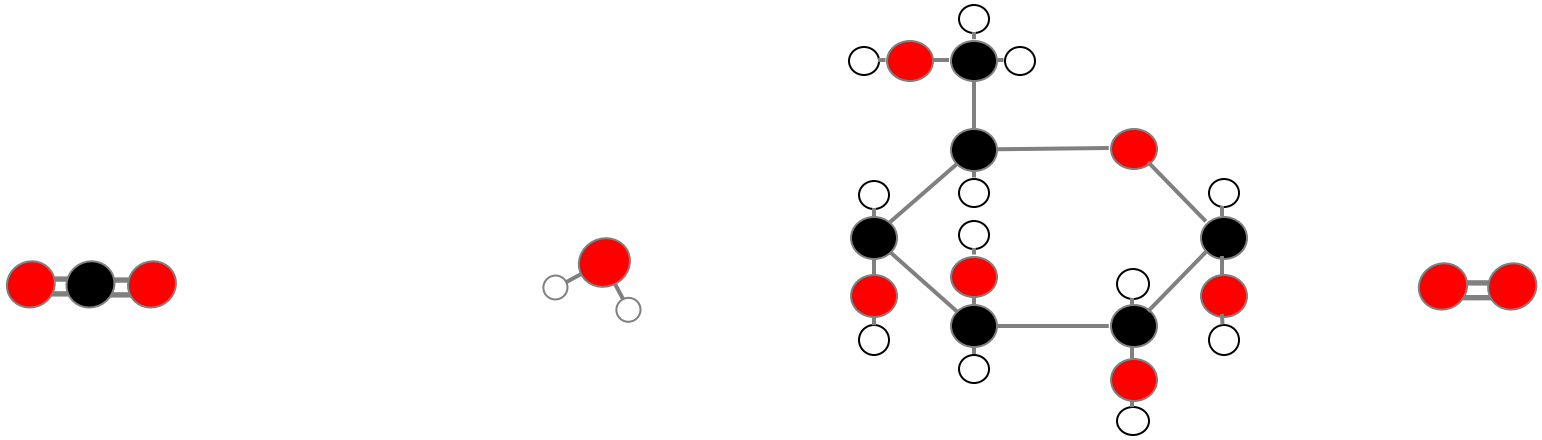
reactants products

An endothermic process

Explanation

Let’s think about the atoms and molecules in photosynthesis:

carbon oxygen hydrogen



carbon dioxide + water → glucose + oxygen

1 carbon
3 oxygen
2 hydrogen

6 carbon
8 oxygen
12 hydrogen

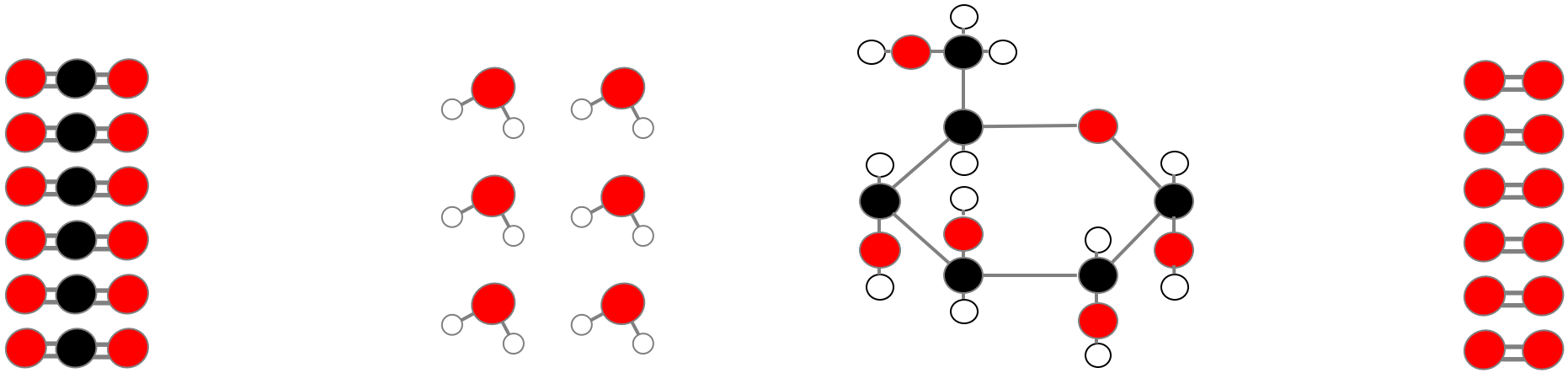
Count up the atoms …

The equation is not balanced!

An endothermic process

Explanation

If we want to make one molecule of glucose, to balance the equation we will need …



carbon dioxide + water ⟶ glucose + oxygen

We can summarise this using a balanced symbol equation:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

An endothermic process

Check

Which is the correct symbol equation for photosynthesis?

a $6CO_2 + C_6H_{12}O_6 \longrightarrow 6H_2O + 6O_2$

b $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$ ✓

c $C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2$

d $C_6H_{12}O_6 + 6H_2O \longrightarrow 6CO_2 + 6O_2$

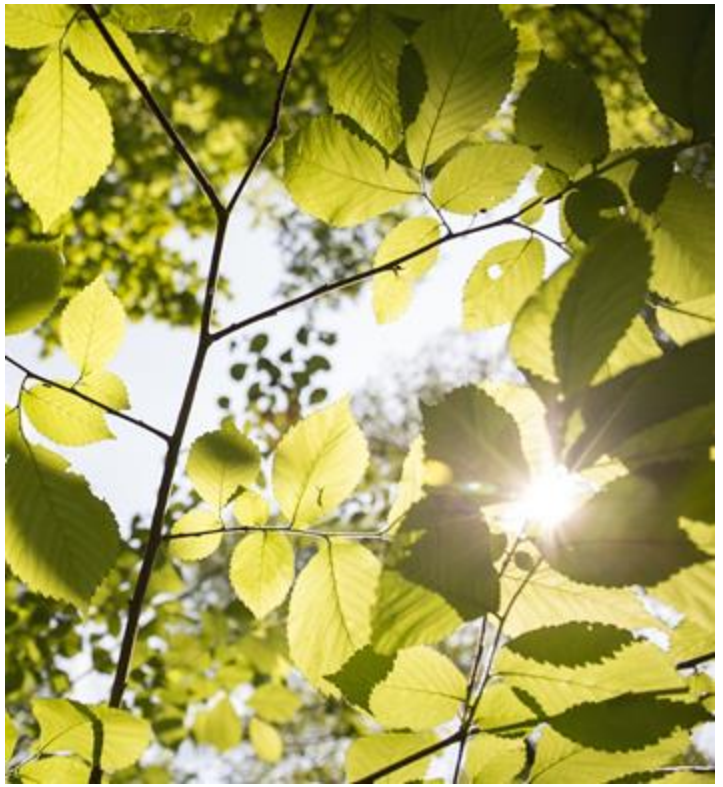
An endothermic process

Explanation

In a plant, photosynthesis happens in the leaves and other green parts of the plant that are above the ground.

This is because photosynthesis requires light.

The process cannot happen without light.



leaves of a tree in sunlight

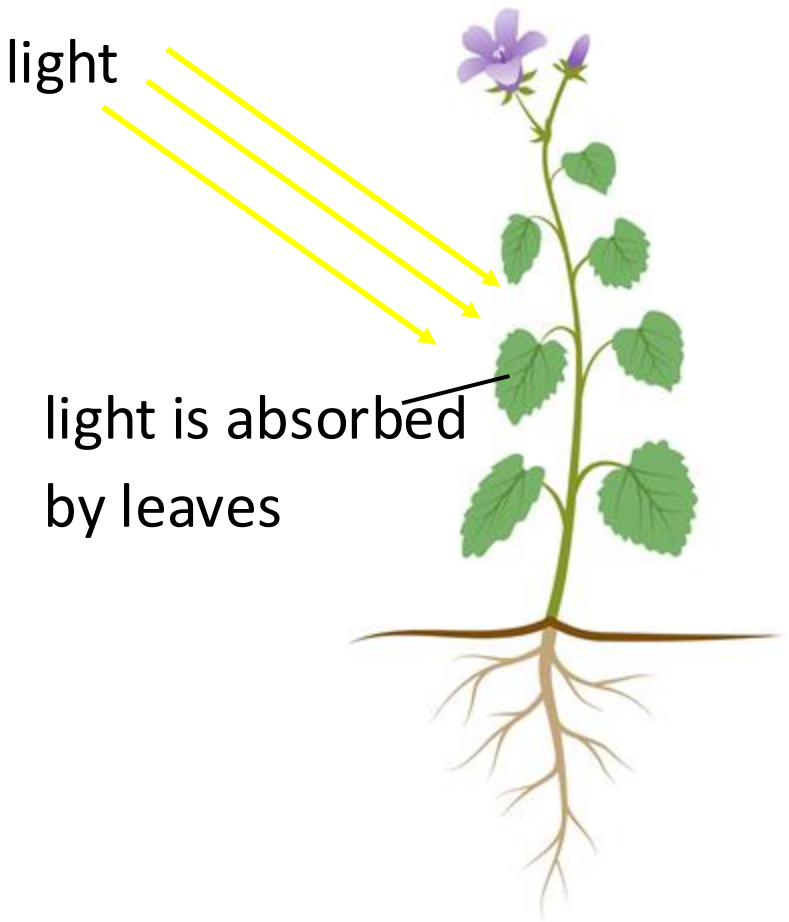
An endothermic process

Explanation

However:

- Light is not a substance.
- Light is not a chemical reactant in photosynthesis.
- Light is not turned into a product by photosynthesis.

Light transfers the energy needed for the chemical reactions of photosynthesis to take place.



An endothermic process

Check

Who is correct?

Light is a chemical reactant in photosynthesis.

Alex

a

Light is turned into glucose by photosynthesis.

Aisha

b

Light transfers the energy needed for photosynthesis.

Lucas ✓

c

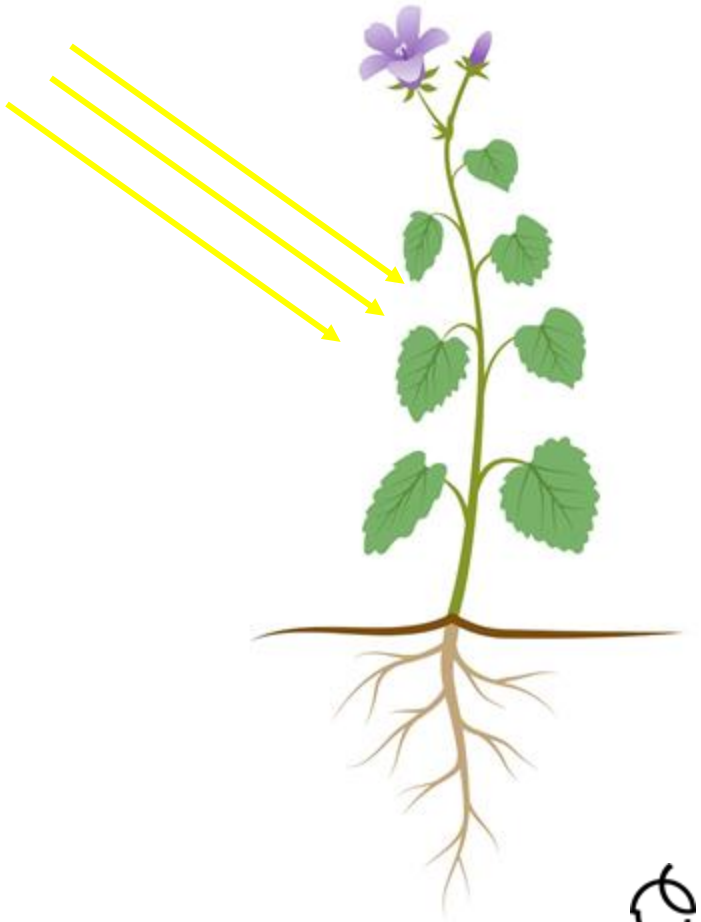
An endothermic process

Explanation

Photosynthesis requires energy from a light source such as the Sun.

A chemical process that requires energy transferred from its surroundings
is described as an **endothermic** process.

Light transfers energy for photosynthesis



An endothermic process

Check

True or false?

Photosynthesis is an exothermic process.

T **True**

F **False** ✓

Why?

Photosynthesis requires energy transferred from its surroundings. The correct word to describe this kind of process is **endothermic**.

Lesson outline

Photosynthesis: an endothermic process that takes place in chloroplasts

- An endothermic process
- Adaptations of leaves for photosynthesis

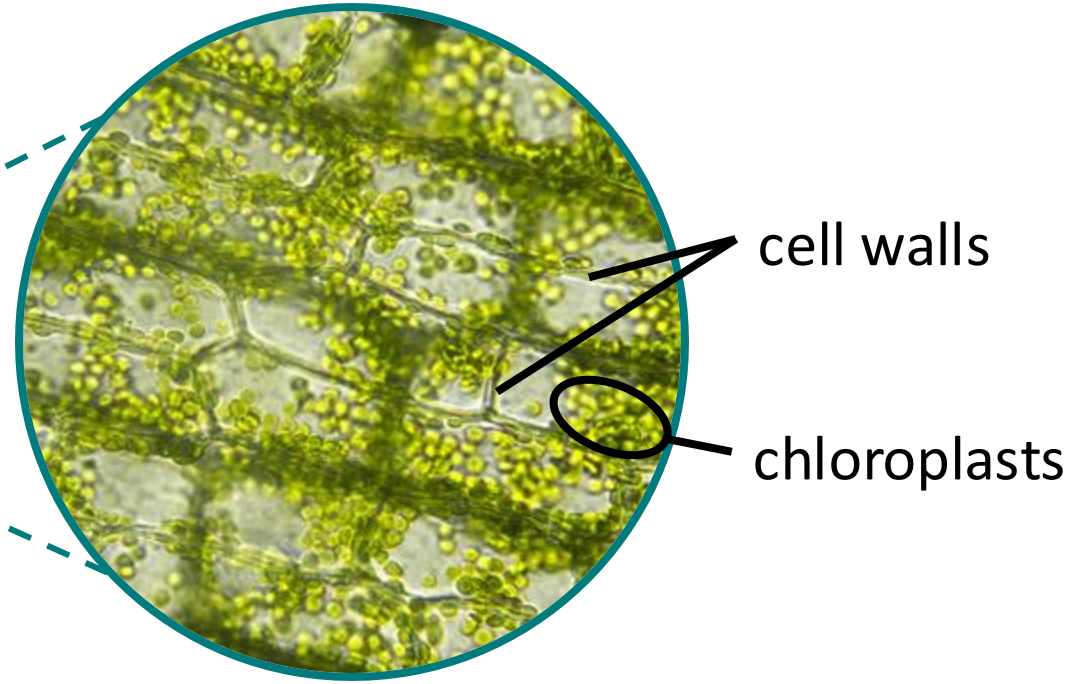
Adaptations of leaves for photosynthesis

Explanation

Leaves are made up of cells.

The cells contain subcellular structures called **chloroplasts**, where photosynthesis takes place.

leaf of a maple tree



leaf cells observed using a light microscope

Adaptations of leaves for photosynthesis

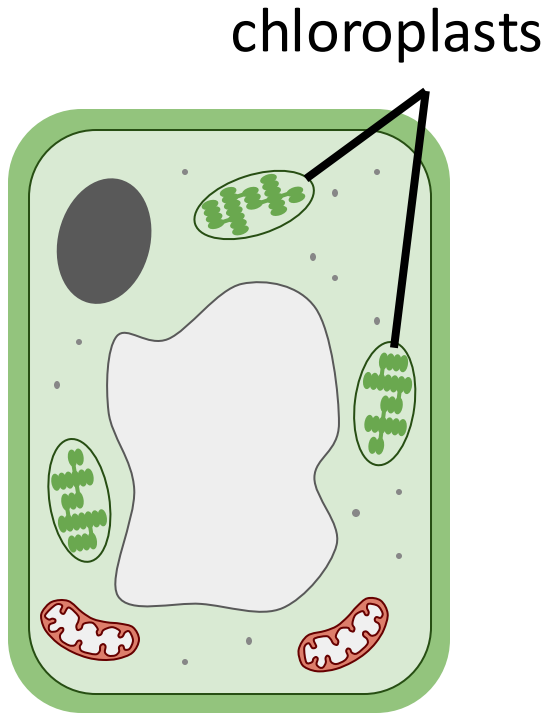
Explanation

In biology, an **adaptation** is a feature that helps an organism to function and survive.

Chloroplasts are an adaptation of plant cells that enables plants to make their own food by photosynthesis.

Chloroplasts contain a green pigment called **chlorophyll**, which provides a chemical store of energy for photosynthesis.

Light transfers energy to chlorophyll, which enables photosynthesis to occur.



simple model of a plant cell

Adaptations of leaves for photosynthesis

Check

Use words from the box to complete the sentences.

carbon dioxide	chlorophyll	chloroplasts	light	oxygen	water

Cells in green parts of a plant contain subcellular structures called _____ chloroplasts.

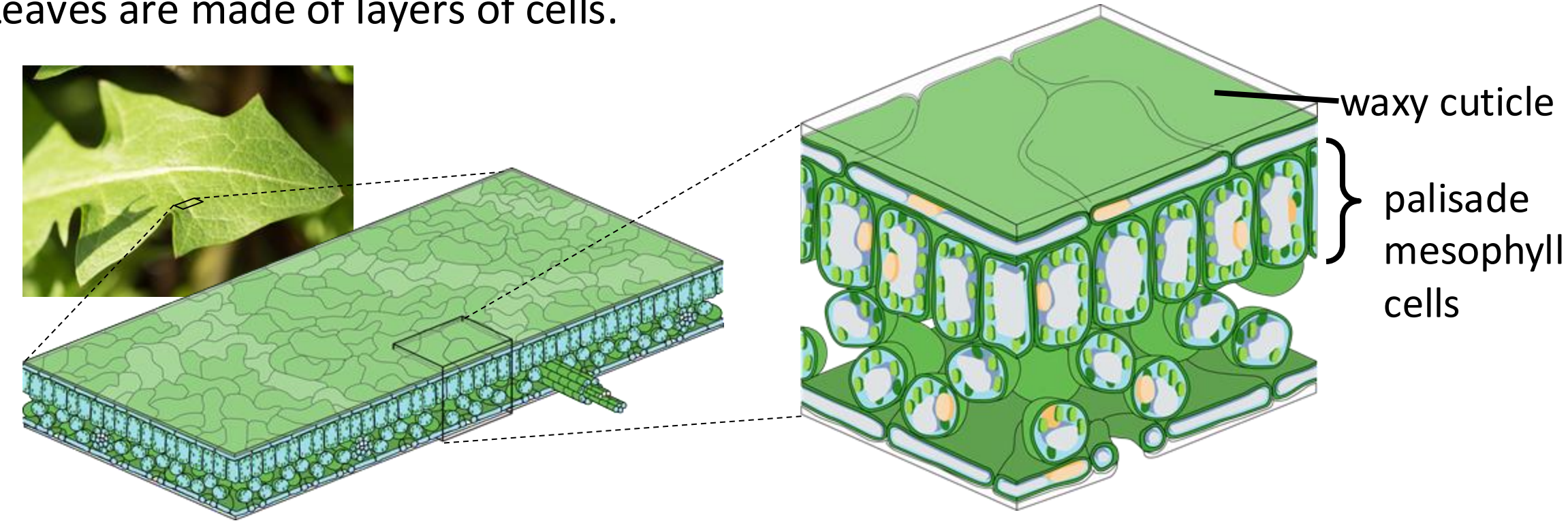
These structures contain a green pigment called _____ chlorophyll.

Light _____ sfers energy to this pigment for photosynthesis.

Adaptations of leaves for photosynthesis

Explanation

Leaves are made of layers of cells.

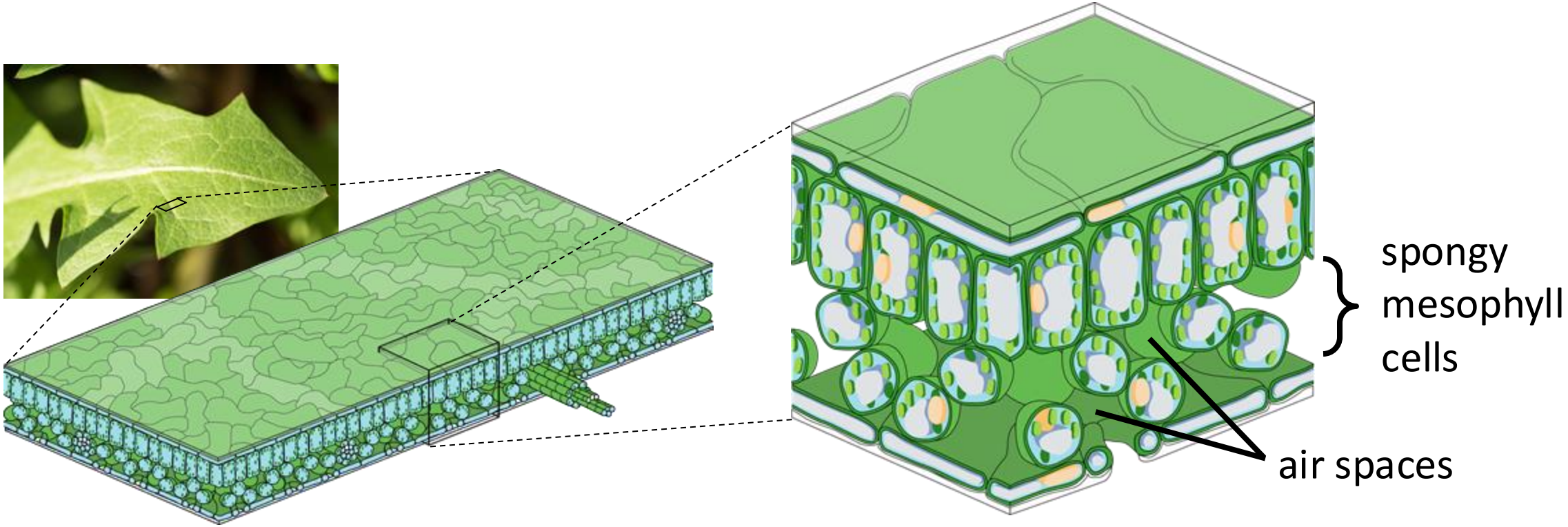


Palisade mesophyll cells contain large numbers of **chloroplasts**. They form the primary tissue where photosynthesis takes place.

This is an **adaptation** to maximise the amount of photosynthesis.

Adaptations of leaves for photosynthesis

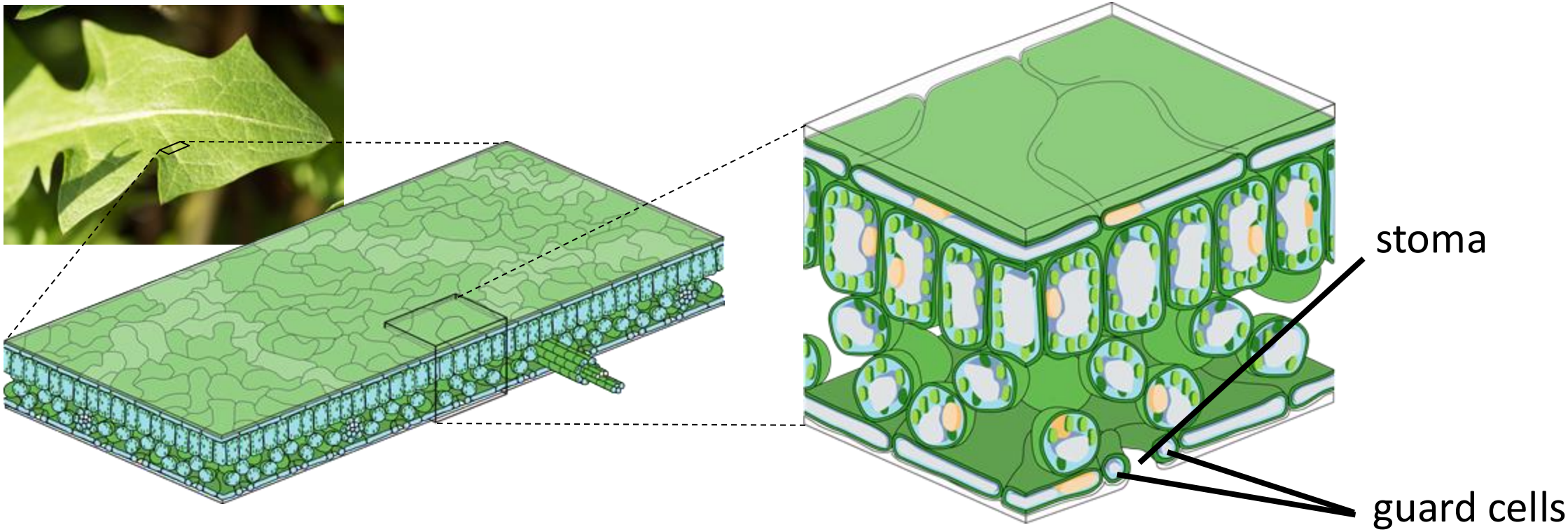
Explanation



Spongy mesophyll cells form a tissue with lots of air spaces in it, like a sponge. This **adaptation** provides a large surface area for gases to diffuse into and out of cells during photosynthesis.

Adaptations of leaves for photosynthesis

Explanation



Leaves have pores (holes) called **stomata** (singular: stoma) in their surface.

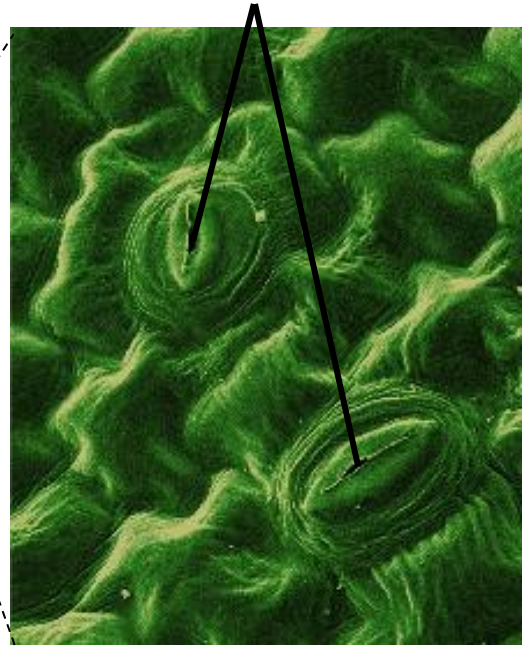
Stomata allow gases to diffuse in and out of the air spaces in the spongy mesophyll tissue.

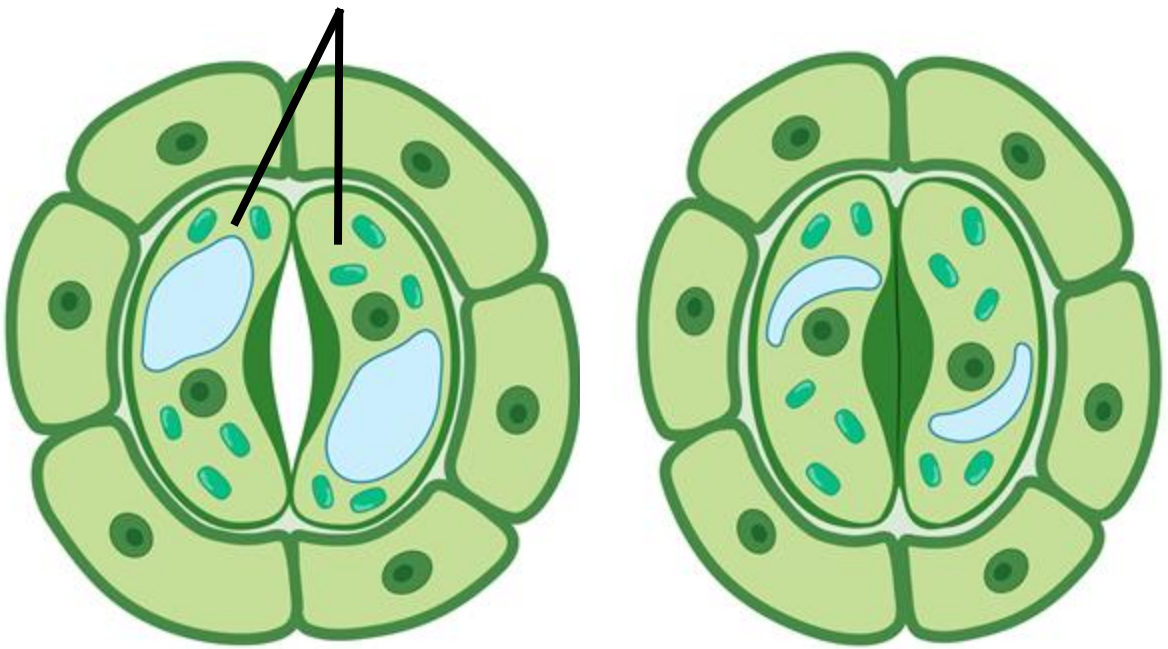
Each stoma is surrounded by a pair of guard cells.

Adaptations of leaves for photosynthesis

Explanation

the underside of a leaf





Guard cells change shape to open and close the stoma (pore).

In the light, each guard cell fills with water and becomes turgid, opening the pore. When it's dark, the guard cells become flaccid and close the pore.

monikozi/Shutterstock

Adaptations of leaves for photosynthesis

Explanation

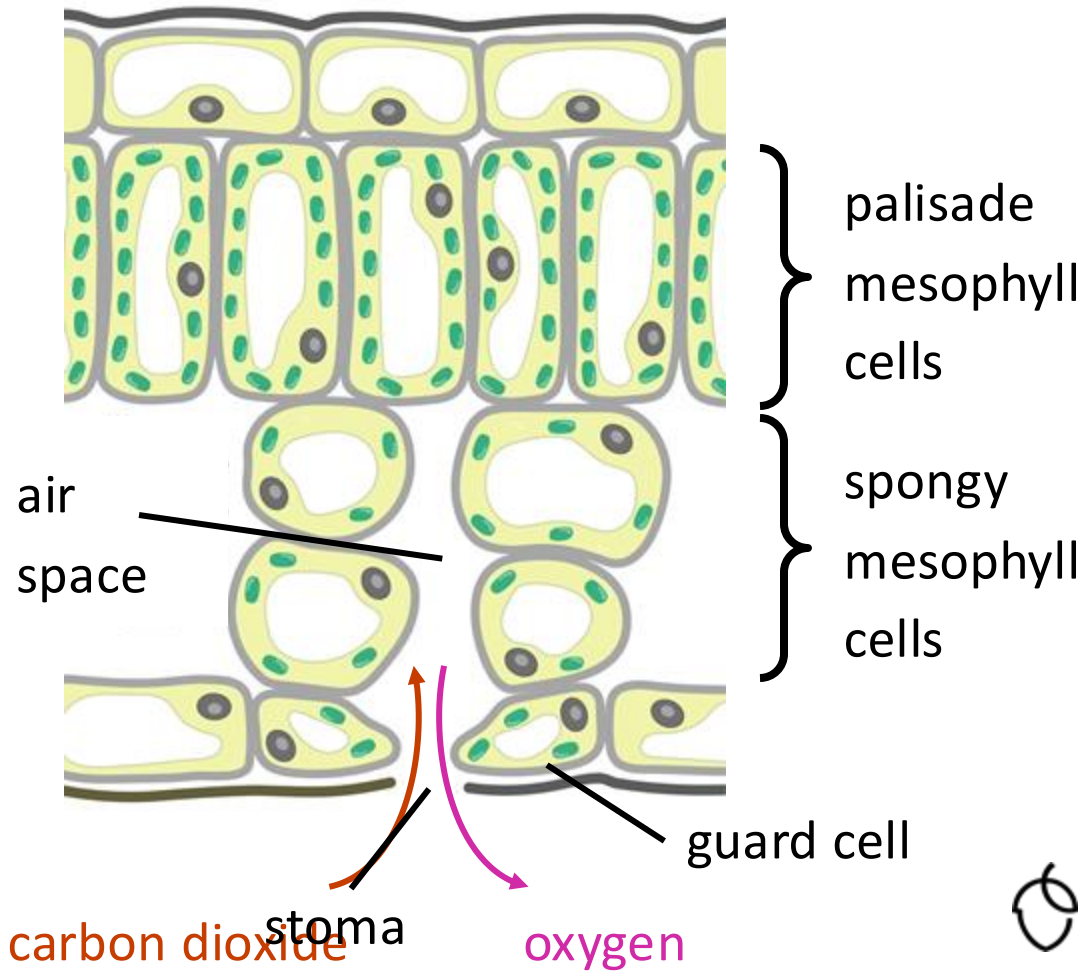
Photosynthesis:

water + carbon dioxide → glucose + oxygen

Guard cells open the stoma when it's light. This allows:

- molecules of carbon dioxide gas to diffuse into the air space inside the leaf and into mesophyll cells for photosynthesis
- molecules of waste oxygen gas to diffuse out

Stomata are an **adaptation** to maximise gas exchange for photosynthesis.

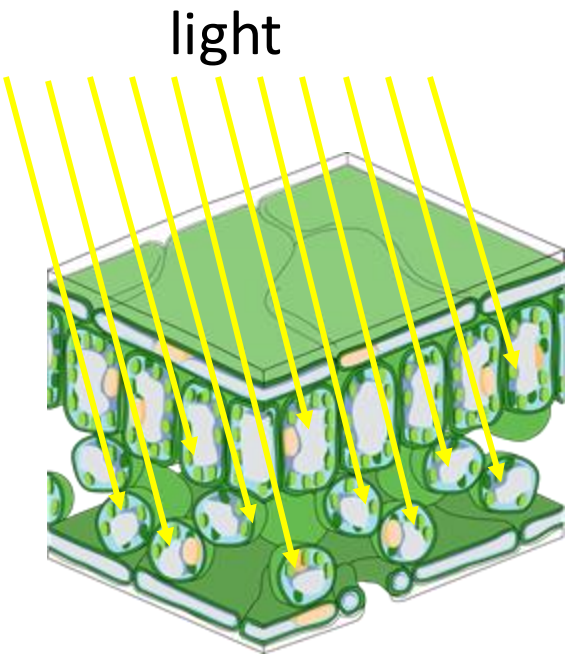


Adaptations of leaves for photosynthesis

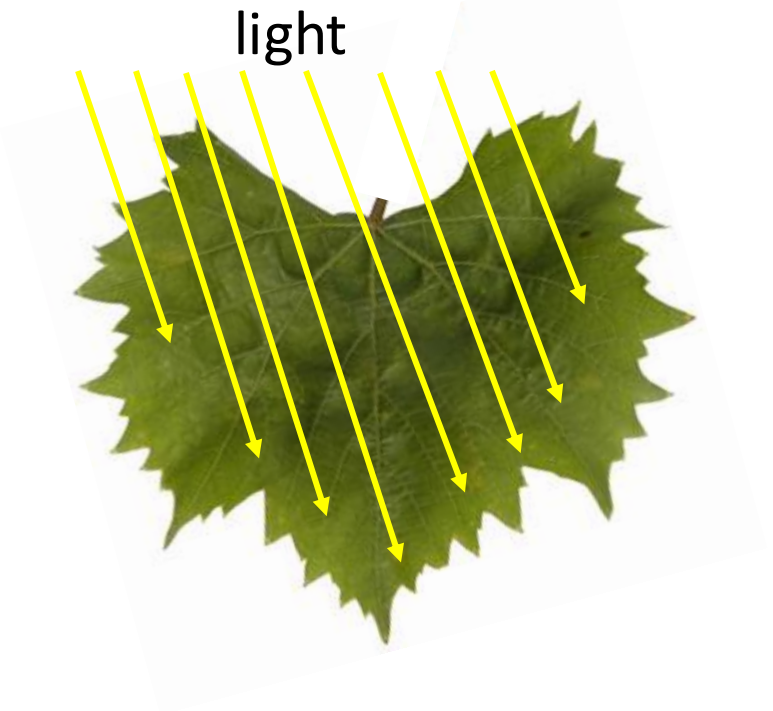
Explanation

Further **adaptations** of leaves for photosynthesis:

They are thin to allow light to pass through to reach all the cells containing chloroplasts.



They have a large surface area to absorb as much light as possible for photosynthesis.



Adaptations of leaves for photosynthesis

Check

Use words from the box to complete the sentences.

carbon dioxide	chloroplasts	light	oxygen	stomata

Palisade mesophyll cells contain large numbers of structures called _____ chloroplasts thesis.

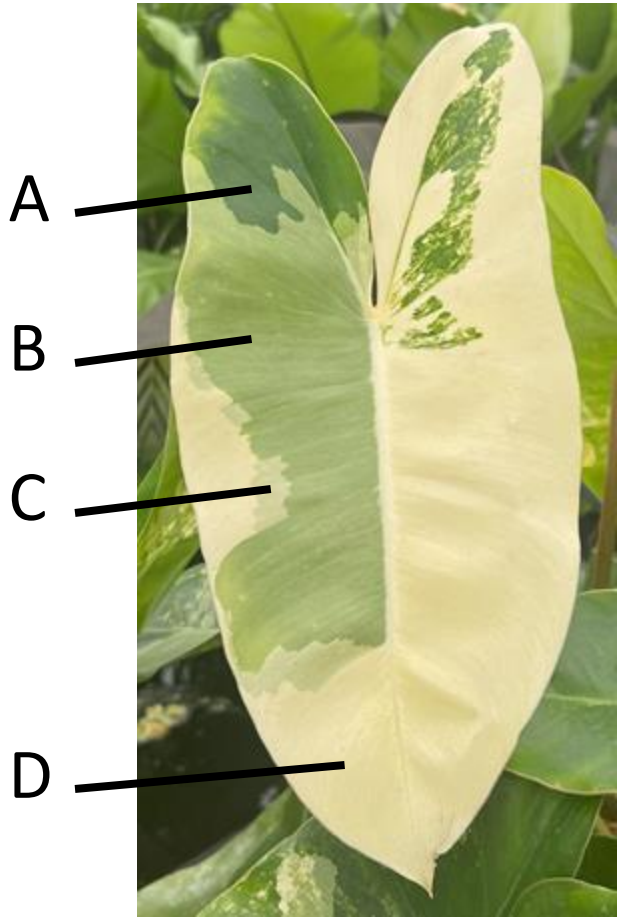
Guard cells change shape to open _____ stomata _____ for carbon dioxide nd release waste _____ . oxygen.

Leaves are thin and have a large surface area to absorb as much _____ as light er energy for photosynthesis.

The photograph shows a variegated leaf.

1. In which part of the leaf will the most photosynthesis occur? Explain your answer.

2. Explain how carbon dioxide moves into the leaf for photosynthesis and how waste oxygen made by photosynthesis moves out.



Task B Adaptations of leaves for photosynthesis

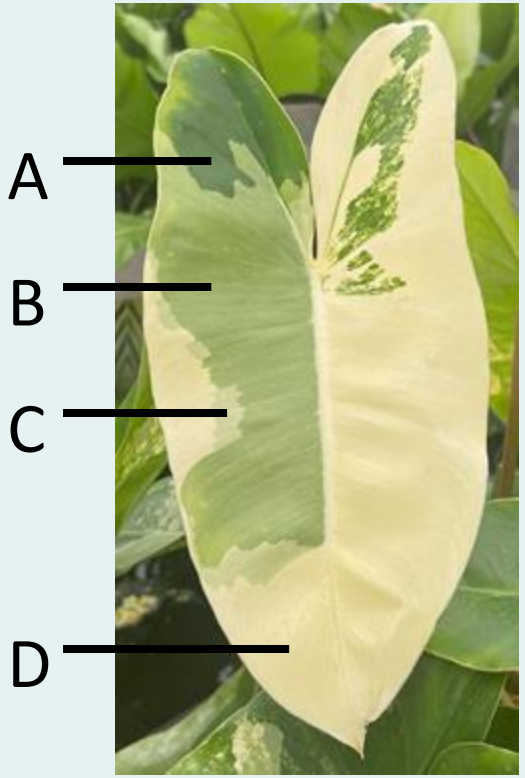
Feedback

1. In which part of the leaf will the most photosynthesis occur? Explain your answer.

   In part A. This part is darkest green, so contains the most chloroplasts. These contain chlorophyll, to which energy is transferred from light for photosynthesis.

2. Explain how carbon dioxide moves into the leaf for photosynthesis and how waste oxygen made by photosynthesis moves out.

   There are pores in the leaf surface called stomata. Guard cells change shape to open stomata to allow carbon dioxide and oxygen to diffuse in and out.



Models of photosynthesis

Lesson outline

- Simple models of photosynthesis
- A two-stage model of photosynthesis

Simple models of photosynthesis

Explanation

A **model** is a simpler representation of a complex thing or idea.

It’s common to see models in everyday life.

a model of a person, used to display clothes in a shop

Models are also commonly used in science.

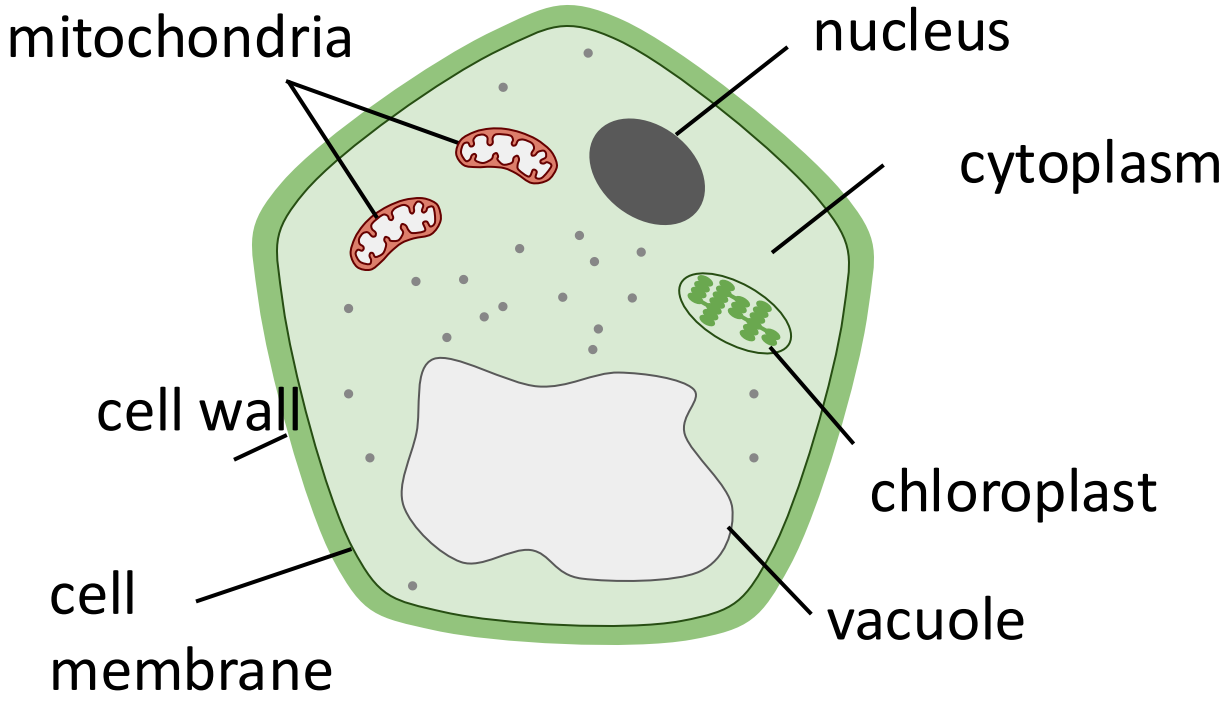
models of the human heart, used to explain its structure

Simple models of photosynthesis

Explanation

Models are used in science to explain things that can be difficult to see or understand. For example:

A plant cell can be modelled in 2D …



… and in 3D.

Kostikova Natalia/Shutterstock

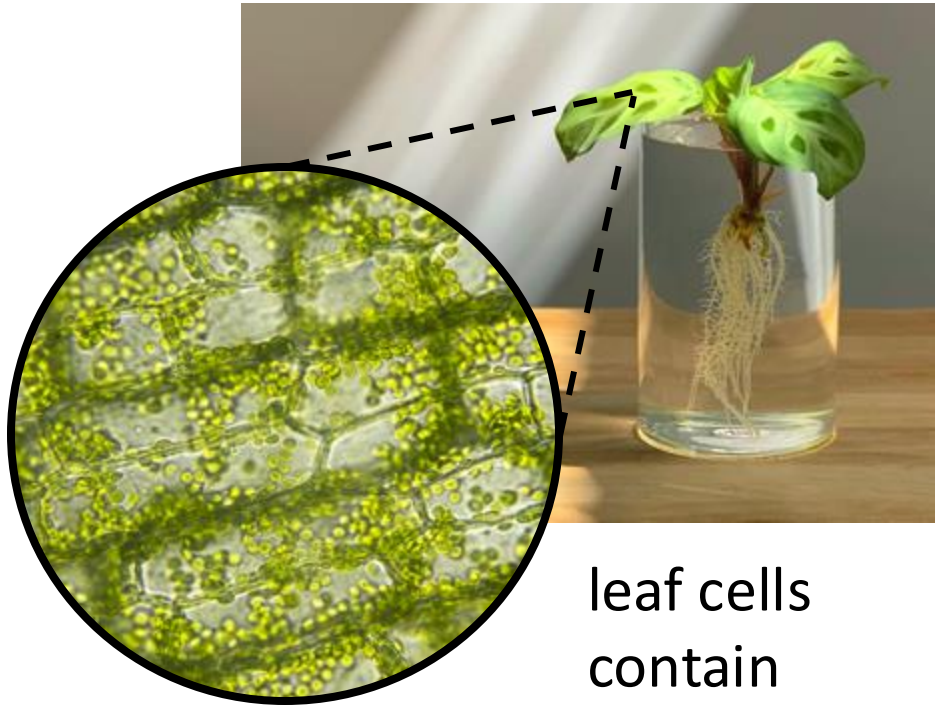
Simple models of photosynthesis

Explanation

Photosynthesis is a very important process.

The growth and survival of producers and consumers depends on the food and oxygen made by photosynthesis.

Photosynthesis happens on a tiny scale - molecules reacting together inside **chloroplasts** inside cells - far beyond our ability to observe the process happening.



leaf cells contain chloroplasts

But it's very useful for us to know what happens during photosynthesis.

Simple models of photosynthesis

Explanation

Photosynthesis is not just one reaction. It's a series of reactions catalysed by enzymes.

But it's useful to summarise the reactants and products of photosynthesis using a word equation:

This is a very simple **model** of the process.

We can add another detail to this model: the idea that light transfers the energy needed for photosynthesis to take place.

Simple models of photosynthesis

Explanation

water + carbon dioxide ⟶ glucose + oxygen

Even a very simple **model** can be used to …

- … explain aspects of what happens.

  For example: from this model we can see that the reactants of **photosynthesis** are water and carbon dioxide, and the products are glucose and oxygen.

- … make a **prediction**.

  For example: from this model we can predict that if more water and carbon dioxide are available, photosynthesis could make more glucose and oxygen.

Simple models of photosynthesis

Explanation

We can use diagrams as **models** of the atoms and molecules in **photosynthesis**:

carbon
oxygen
hydrogen

water carbon dioxide glucose oxygen

We can use a balanced symbol equation as a model of how they react:

$$6H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$$

This model shows how many atoms and molecules are involved in making one molecule of glucose by photosynthesis.

Simple models of photosynthesis

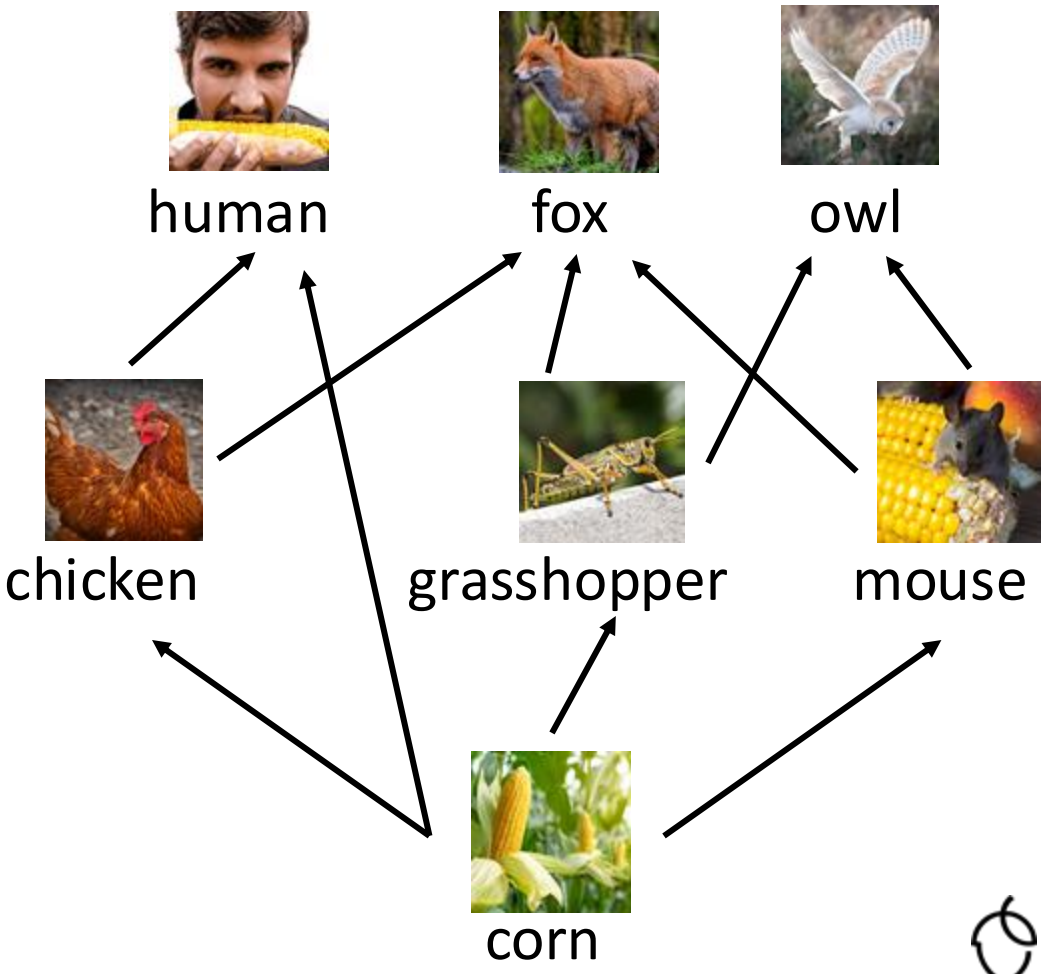
Explanation

Because **photosynthesis** happens on a tiny scale, we can't see the substances, atoms and molecules involved.

The simple **models** we have explored help us to understand the roles of these substances in photosynthesis.

Photosynthesis is also important on much larger scales. For example, it affects the populations of producers and consumers that depend on the food it makes.

We can use models, such as food web diagrams, to help us understand these relationships.

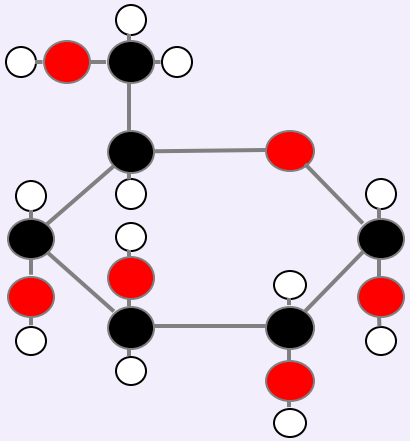


Corn: Photoongraphy/Shutterstock

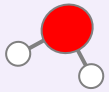
Simple models of photosynthesis

Check

Which diagram is a simple model of a molecule of glucose?



a



b

c

Simple models of photosynthesis

Check

Which symbol equation is a model of photosynthesis?

a $C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2$

b $6CO_2 + C_6H_{12}O_6 \longrightarrow 6H_2O + 6O_2$

c $C_6H_{12}O_6 + 6H_2O \longrightarrow 6CO_2 + 6O_2$

d $6H_2O + 6CO_2 \longrightarrow C_6H_{12}O_6 + 6O_2$ ✓

Lesson outline

- Simple models of photosynthesis
- A two-stage model of photosynthesis

A two-stage model of photosynthesis

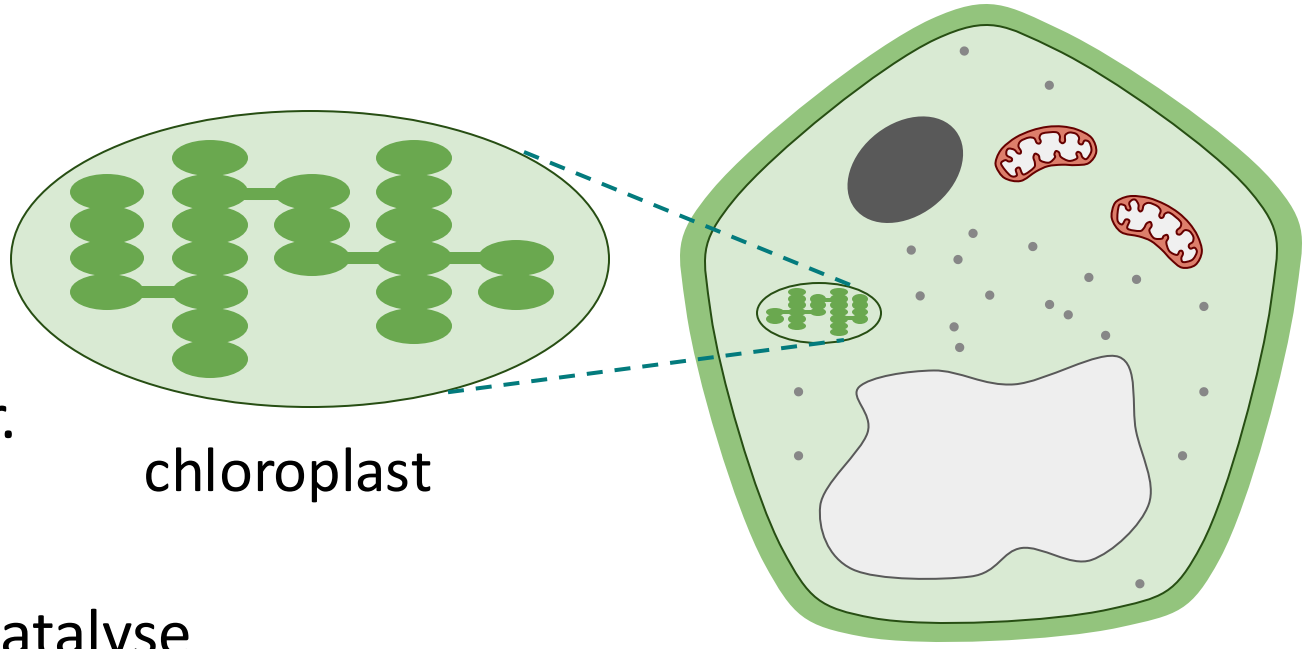
Explanation

A more detailed **model** of photosynthesis summarises two main stages in the process.

Both stages take place in **chloroplasts** in plant cells.

Inside chloroplasts there are many layers of membranes containing **chlorophyll**.

Light transfers energy to chlorophyll, which enables photosynthesis to occur.



chloroplast

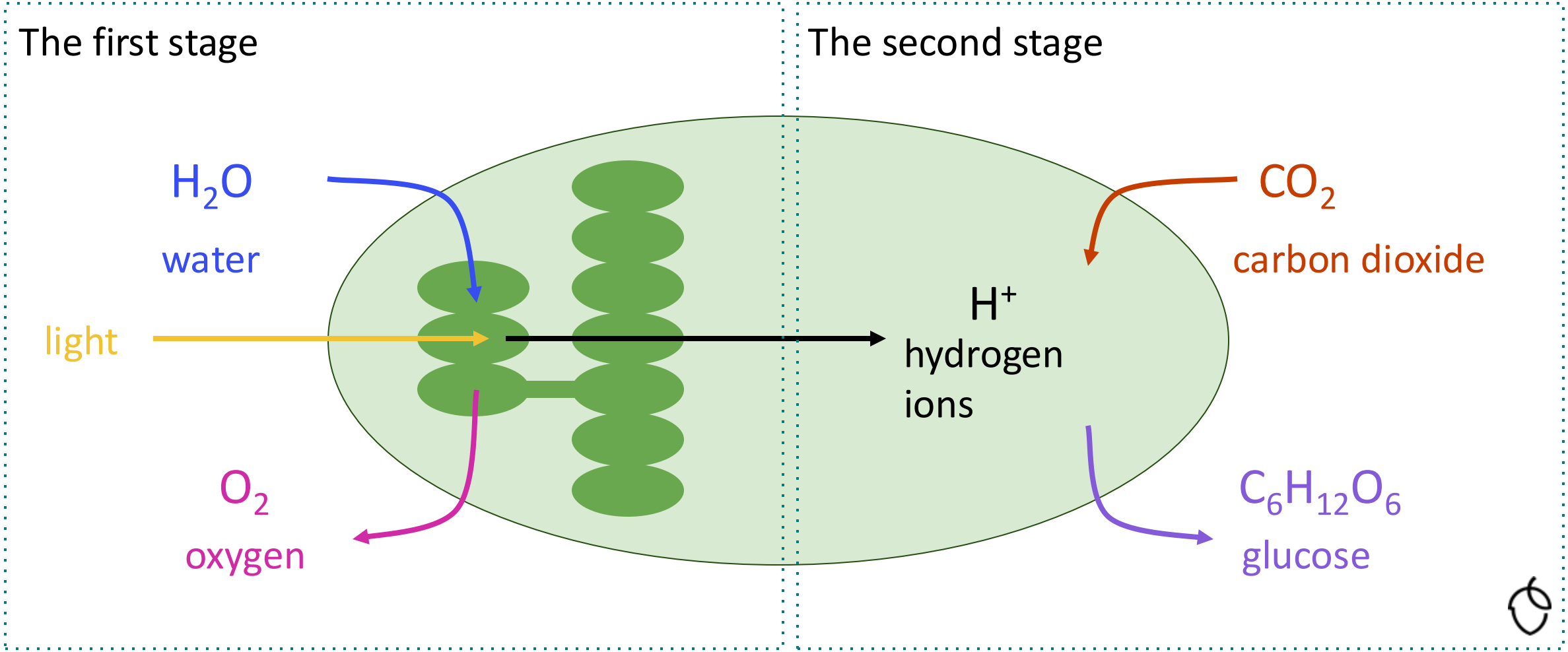
a plant cell

Chloroplasts also contain enzymes to catalyse the reactions of photosynthesis.

A two-stage model of photosynthesis

Explanation

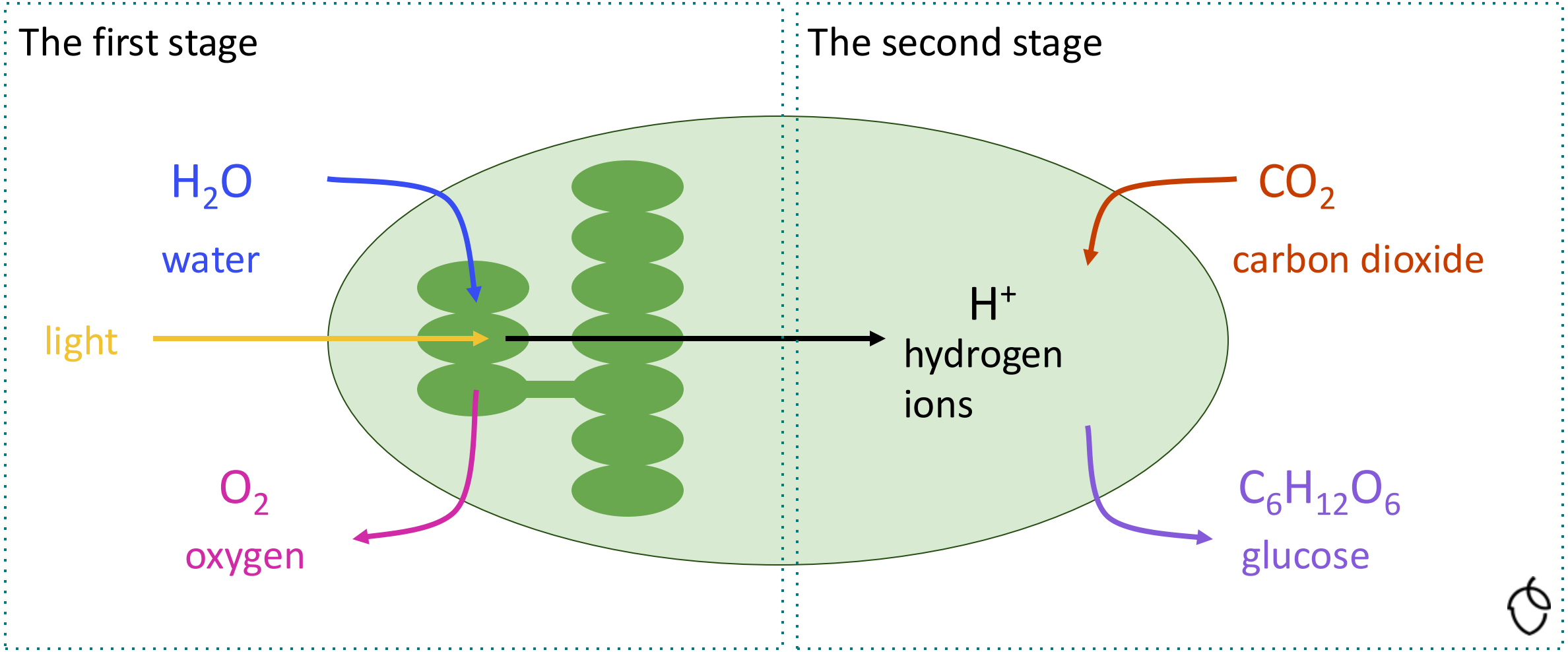
The two main stages of **photosynthesis**:



A two-stage model of photosynthesis

Explanation

Let's run through that again!

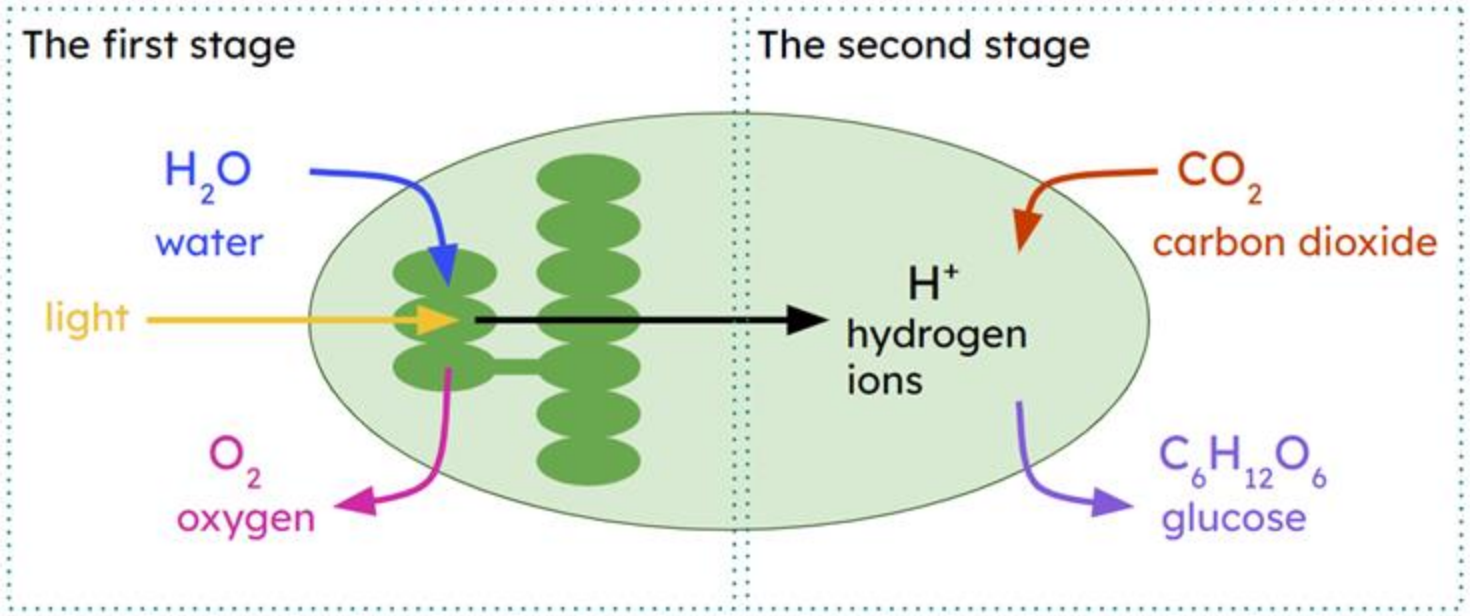


A two-stage model of photosynthesis

Explanation

The two-stage model of **photosynthesis** helps us to understand that:

- Light is only needed for the first stage, which scientists call the light-dependent stage.



- The reactions of the first stage take place in the chloroplast membranes (where chlorophyll is located).
- The reactions of the second stage take place elsewhere in the chloroplast (where enzymes catalyse these reactions).

A two-stage model of photosynthesis

Check

Which stage of photosynthesis requires energy from light?

a Both stages

b Only the first stage ✓

c Only the second stage

d Neither stage

The requirements and products of photosynthesis: practical

Lesson outline

The requirements and products of photosynthesis:

practical

- Testing leaves for starch
- Predict, explain, observe, explain

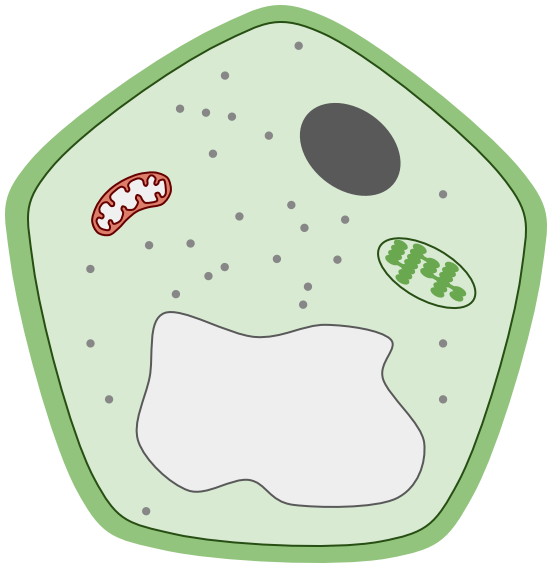
Testing leaves for starch

Explanation

Plants make their own food inside their cells using a process called **photosynthesis**.

The process uses carbon dioxide and water.

It makes **glucose** (a type of sugar and a simple carbohydrate), that is the plant's food.



plant cell

The reactants and products of photosynthesis can be summarised:

carbon dioxide + water ⟶ glucose + oxygen

reactants products

Testing leaves for starch

Explanation

In a plant, **photosynthesis** happens in the cells of the leaves and other green parts of the plant that are above the ground.

This is because photosynthesis requires energy from a light source such as the Sun.

Leaves are green because they contain chlorophyll.

Light transfers energy to chlorophyll to enable the chemical reactions of photosynthesis to take place.

leaves of a tree in sunlight

Testing leaves for starch

Explanation

Photosynthesis:

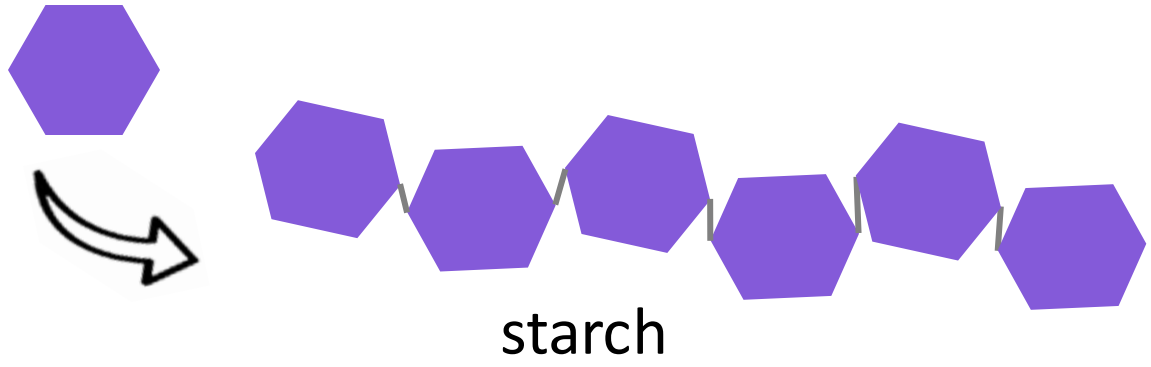
carbon dioxide + water ⟶ glucose + oxygen

Glucose is a type of sugar, which is a simple carbohydrate.

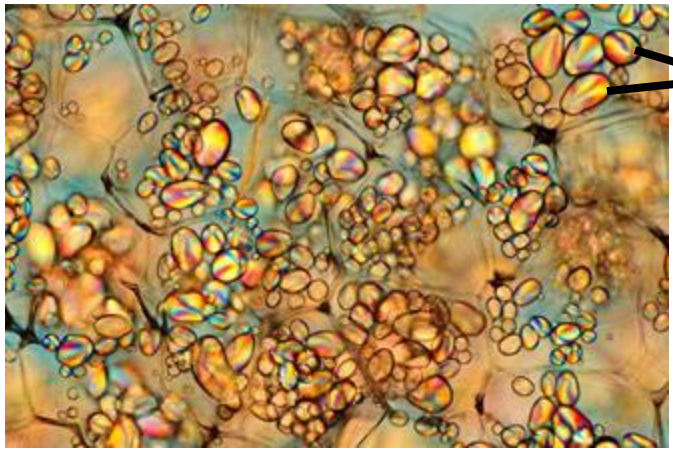
Some of the glucose molecules are used to make larger carbohydrates, such as **starch**.

Starch is stored in cells as starch grains.

Starch is a source of glucose for growth and cellular respiration.



starch



starch grains in potato cells, observed with a microscope

Testing leaves for starch

Explanation

It is possible to test leaves for the presence of starch.

This test uses the reagent **iodine solution**.

Iodine is usually orange / brown.

Iodine turns blue / black when starch is present.

Testing leaves for starch

Check

What colour does iodine solution turn in the presence of starch?

a Brown / orange

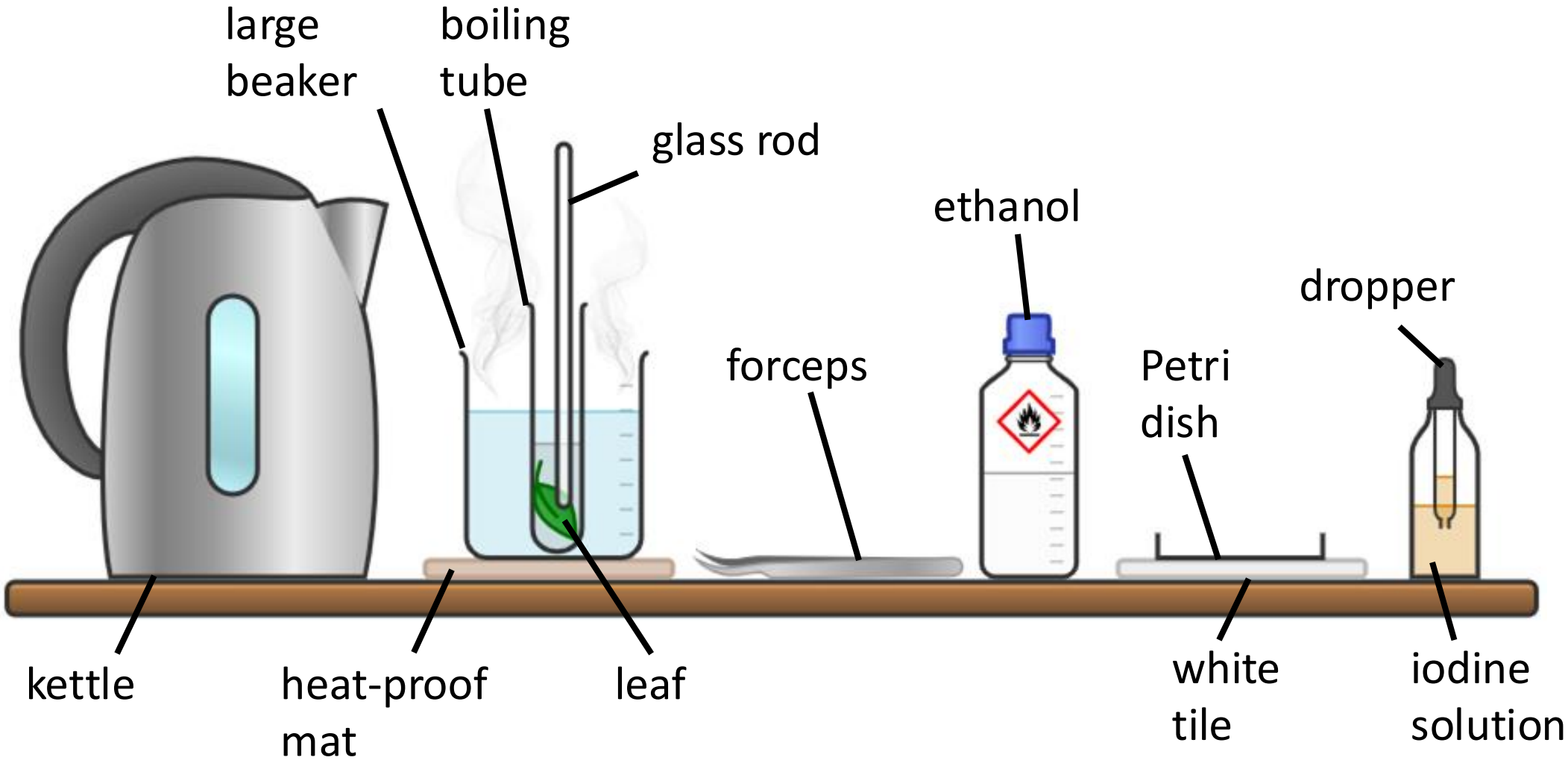
b Blue / black ✓

c No change

Testing leaves for starch

Explanation

To test a leaf for starch, you will need:

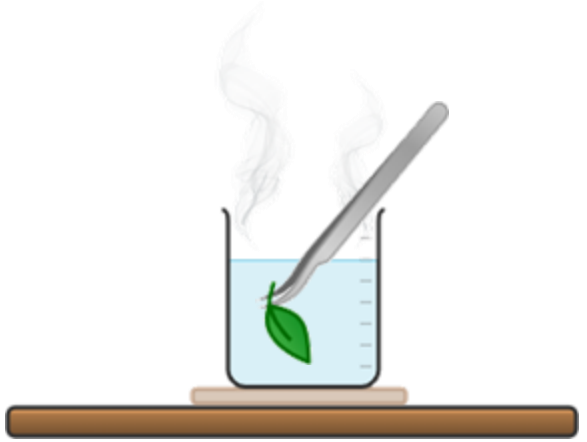


Testing leaves for starch

Explanation

Method for testing a leaf for **starch**:

Safety advice: Wear safety goggles.



1. Collect a leaf to test.
2. Fill a large beaker with hot water (at approximately 90°C) from a kettle.
3. Use the forceps to hold the leaf in the hot water for approximately 1 minute.
4. Use the forceps to remove the leaf from the hot water and place it in the boiling tube. Use the glass rod to carefully push the leaf to the bottom of the tube.

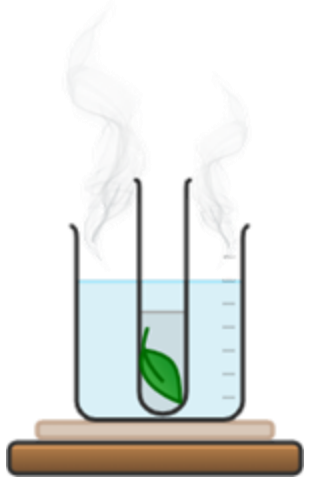
Testing leaves for starch

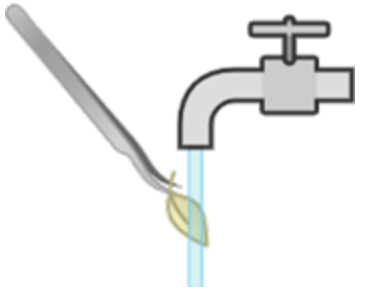
Explanation

5. Add ethanol to the tube to cover the leaf.

Safety advice: Ethanol is flammable. Do not use it in the same room as a naked flame.

6. Stand the boiling tube in the beaker of hot water for approximately 5 minutes (or until the ethanol has removed the chlorophyll from the leaf).





7. Use the forceps to remove the leaf from the ethanol, and rinse in cold tap water.

8. Place the leaf in a Petri dish on a white tile.

9. Use the dropper to add **iodine solution** to cover the leaf.

Testing leaves for starch

Check

Put the steps in the correct order to test a leaf for starch.

a	Add ethanol to cover the leaf in a boiling tube.	2
b	Add iodine solution to cover the leaf.	4
c	Hold the leaf in hot water for approximately 1 minute.	1
d	Stand the boiling tube in a beaker of hot water for approximately 5 minutes.	3

Lesson outline

The requirements and products of photosynthesis: practical

- Testing leaves for starch
- Predict, explain, observe, explain

Predict, explain, observe, explain

Explanation

This plant has been kept in the dark for 2 days.

During this time:

- No **photosynthesis** will have taken place because there was no light to provide the energy required.
- No new **starch** will have been made, as no **glucose** was made by photosynthesis.
- The plant used up its stores of starch to provide glucose for cellular respiration.

a geranium plant in a pot

The plant has been destarched.

Predict, explain, observe, explain

Explanation

We can predict the outcome of testing a leaf from this plant for the presence of **starch**.

A scientific **prediction** is a testable statement about a possible outcome, which can be tested in an experiment.

Prediction: A leaf from a plant kept in the dark for 2 days will not contain starch.

It's good practice to explain our prediction.

Explanation: No photosynthesis has taken place, so no new starch has been made. Stores of starch have been used up to provide glucose for cellular respiration.

a geranium plant kept in the dark for 2 days

Predict, explain, observe, explain

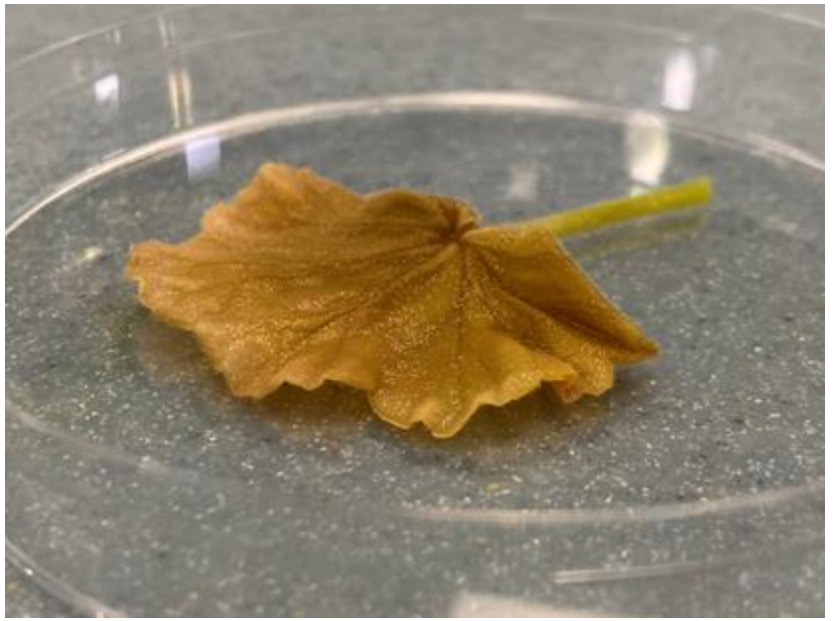
Explanation

We can test our prediction using the method for testing a leaf for **starch** using **iodine solution** and observing the outcome.

Observation: When tested with iodine solution, the leaf appeared orange / brown.

This observation supports our prediction that the leaf would not contain starch.

Explanation: Iodine solution remains orange / brown when there is no starch present.



the result of the test with iodine solution

Predict, explain, observe, explain

Check

Who makes a testable scientific prediction?

Prediction:
The leaves will not contain any starch.

Jacob ✓

a

Observation:
The iodine stayed an orange / brown colour.

Sam

b

Explanation:
No photosynthesis has taken place.

Sophia

c

Predict, explain, observe, explain

Explanation

Three plants are kept in the dark for 2 days to destarch them.

Then, they are kept in the light for 2 days in different conditions:

Destarched plant 1

Foil strips on the leaves, to block out the light.

Destarched plant 2

In a jar with soda lime, to remove carbon dioxide.

Destarched plant 3

In a jar with marble chips in acid, to provide carbon dioxide.

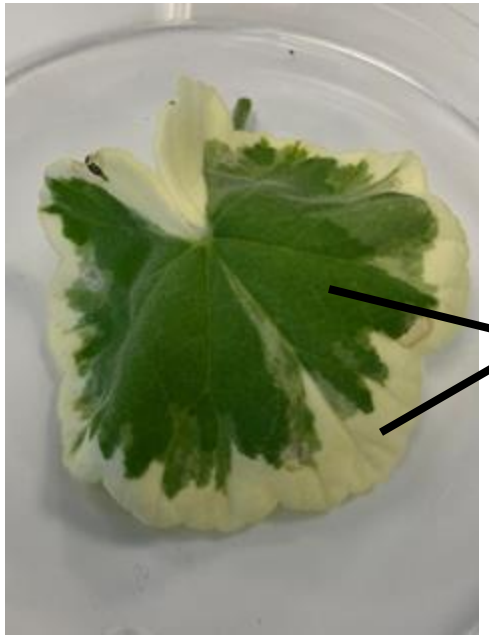
Predict, explain, observe, explain

Explanation

We are going to test leaves from each of the three plants for **starch** using **iodine solution**.

Leaf from plant 1
(foil strip)

Leaf from plant 2
(from jar with soda lime)



Leaf from plant 3
(from jar with marble in acid)

In a variegated leaf, some parts have more chlorophyll than others.

Predict, explain, observe, explain

Check

What is the purpose of the soda lime?

a To block out the light.

b To provide carbon dioxide.

c To remove carbon dioxide. ✓

END