Get a head start

Helping you to bridge the gap between…

Combined Science GCSE

+

Y12 A-Level Biology

This booklet reviews the specification points from the separate biology course that would be useful to know if you are considering A Level Biology. There are questions so that you can test yourself after each section. Good luck!

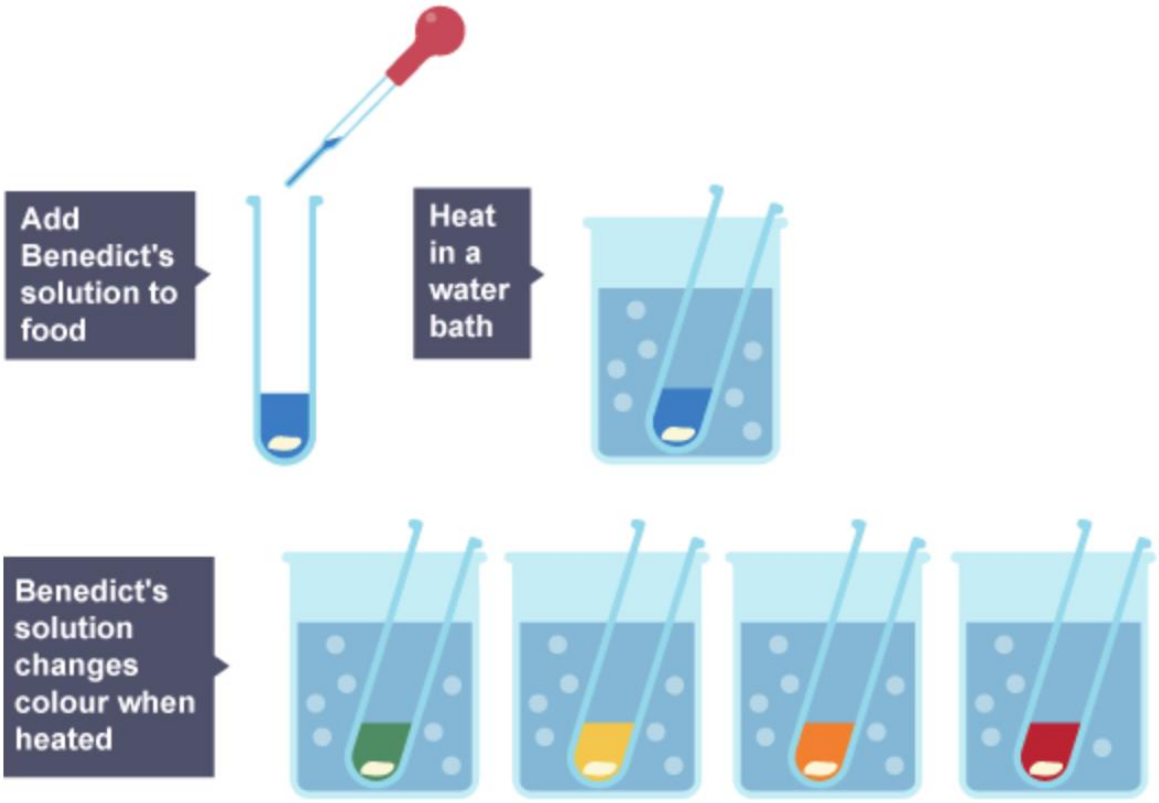
After completing each section, check your work with the answers at the back!

TOPIC 1 – Key Concepts in Biology

Investigate the use of chemical reagents to identify starch, reducing sugars, proteins and fats

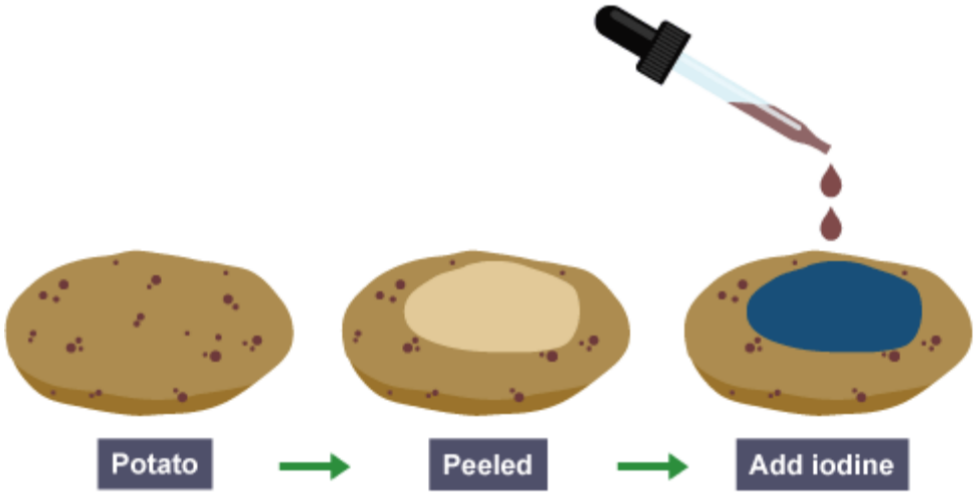
Food sample	Reagent	Method	Initial colour	Colour of positive result
Reducing sugar	Benedict's	Add Benedict's reagent to the food and boil in a water bath.	Blue	Brick red precipitate
Starch	Iodine	Add iodine reagent to the food.	Yellow-brown	Blue-black
Protein/amino acids	Biuret (a mixture of sodium hydroxide and copper sulfate).	Add Biuret reagent to the food.	Blue	Lilac/purple
Fat	Ethanol	Add ethanol to the food to dissolve the fat then add water.	Colourless	White emulsion

Testing for the presence of reducing sugars (like glucose):



Testing for the presence of starch:

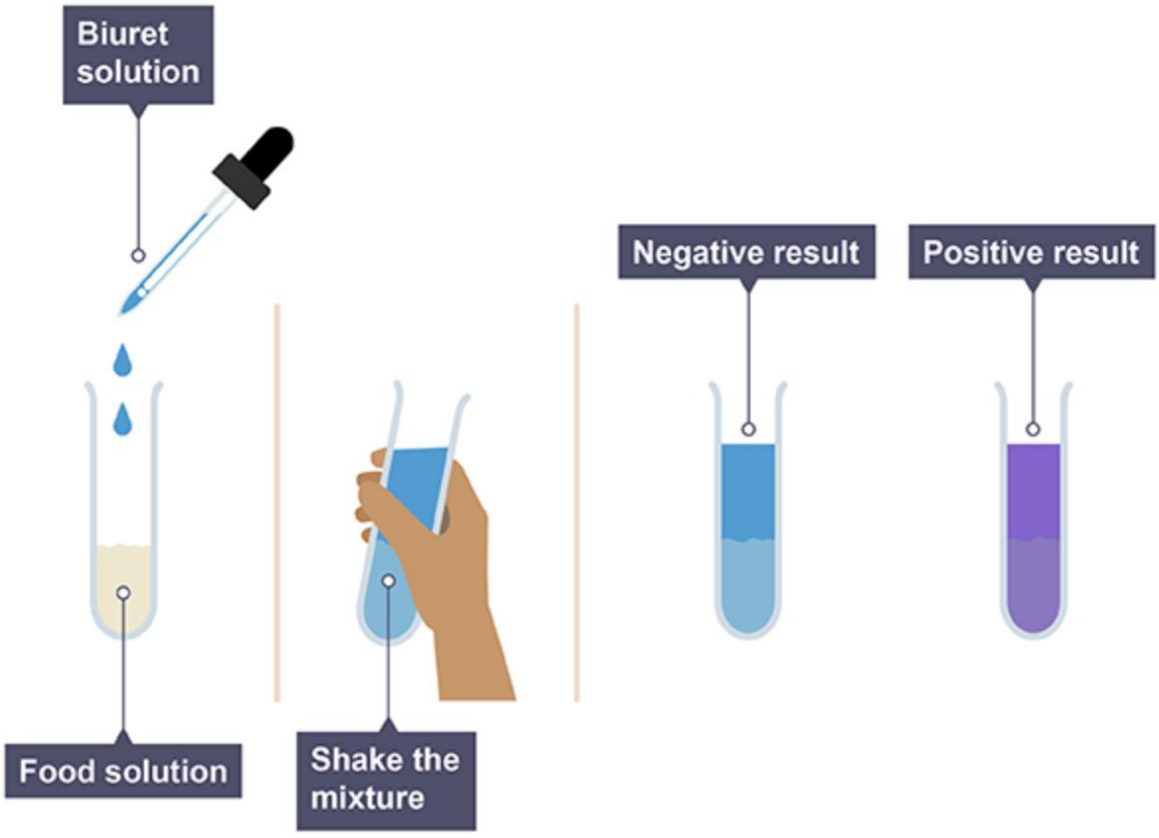
Add iodine solution to the food being tested.



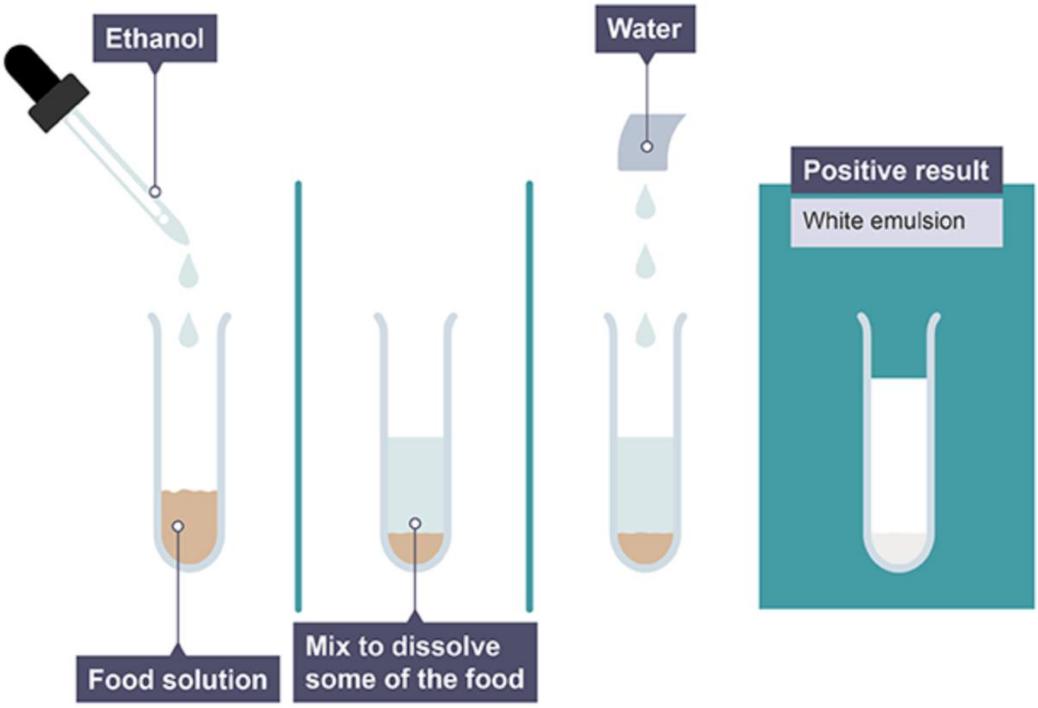
Foods containing starch will turn a blue-black colour.

The iodine test can also be used with a microscope to stain starch grains in plant cells.

Testing for the presence of protein:



Testing for the presence of fats:



How could we improve these experiments?

We should use a **control** in each experiment to ensure we know what a positive and negative result looks like. For example, a positive control for the Biuret test would be anything containing protein (e.g egg white) whereas a negative control would be a solution that does not contain protein (e.g distilled water).

For more information visit Bitesize: https://www.bbc.co.uk/bitesize/guides/z88hcj6/revision/5

Test yourself:

1 Circle the food substance that is identified by each food test.

a	Benedict's test	fat	protein	reducing sugar	starch
b	biuret test	fat	protein	reducing sugar	starch
c	iodine test	fat	protein	reducing sugar	starch
d	emulsion test	fat	protein	reducing sugar	starch

2 Complete the table to show the colour of each reagent and the colour it turns to show a positive result.

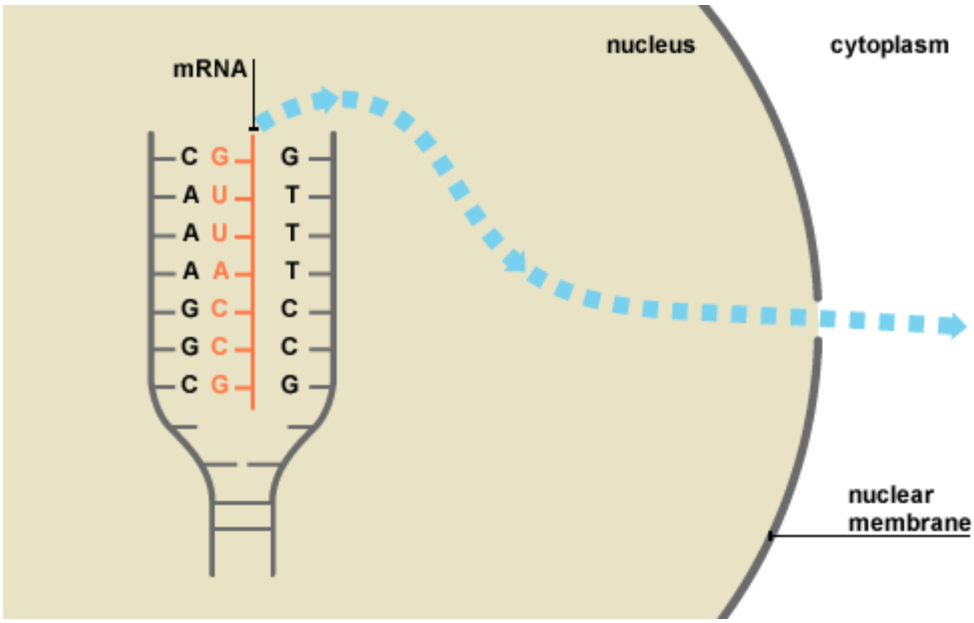
Reagent	Colour before test	Colour of positive result
Benedict's solution		
biuret test (potassium hydroxide and copper sulfate)		
iodine solution		
ethanol		

TOPIC 3 - Genetics

Describe the stages of protein synthesis, including transcription and translation

Explain how the order of bases in a section of DNA decides the order of amino acids in the protein and that these the fold to produce specifically shaped proteins such as enzymes

Watch this: https://www.bbc.co.uk/bitesize/guides/zgcn97h/video



- Each group of three bases (e.g ACT, AGG, GAC) codes for an amino acid.
- The amino acids are joined together and fold to make a protein. It is the different types and order of amino acids that determine which type of protein it is. Often these proteins are enzymes, which need to have a very specific shape.
- Therefore it is the order of bases in DNA that determine which proteins are produced.

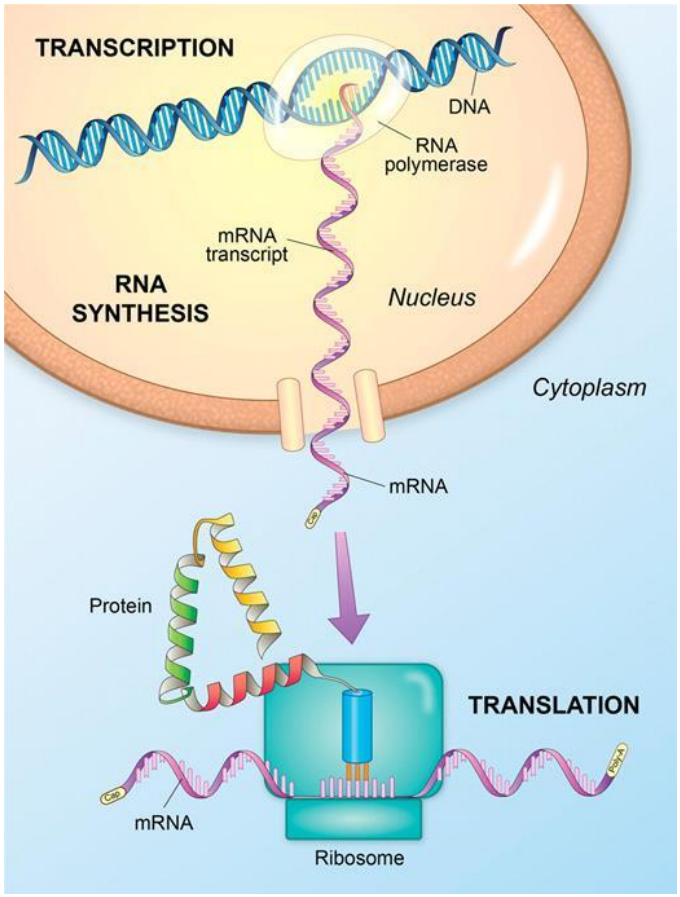
There are also non-coding parts of DNA that do not code for proteins. Some of them are responsible for switching genes on or off, i.e. controlling whether the gene is used to form a protein or not.

Read this article: https://www.bbc.co.uk/news/science-environment-41311087

Protein synthesis: the process of producing a protein from DNA

If a gene is coded to make a protein, it has been expressed.

1. **DNA contains the genetic code for making a protein, but it cannot move out of the nucleus as it is too big.**
2. **The mRNA nucleotides themselves are then joined together, creating a new strand called the mRNA strand. This is a template of the original DNA.**
3. **An enzyme called RNA polymerase binds to non-coding DNA located in front of a gene on the DNA strand.**
4. **The two strands of DNA pull apart from each other, and RNA polymerase allows mRNA nucleotides (messenger RNA: a different type of nucleotide) to match to their complementary base on the strand.**
5. **The mRNA then moves out of the nucleus to the cytoplasm and onto structures called ribosomes.**
6. **At the ribosomes, the bases on the mRNA are read in threes (triplets) to code for an amino acid (the first three bases code for one amino acid, the second three bases code for another etc).**
7. **The corresponding amino acids are brought to the ribosomes by carrier molecules called tRNAs - transport RNAs.**
8. **These amino acids connect together to form a polypeptide (amino acids linked by peptide bonds).**
9. **When the chain is complete the protein folds to form a unique 3D structure, which is the final protein.**



Test yourself:

Transcription and translation

1 Write out the following statements in the correct order. Add labels to show which parts of the process are **transcription** and which are **translation**.

2

RNA polymerase links the **RNA** nucleotides together to form a strand of **mRNA.**
A **tRNA** molecule pairs up with each **codon.**
In the cytoplasm, a **ribosome** attaches to the mRNA strand.
Inside the nucleus, RNA **polymerase** attaches to a non-coding section of DNA.
RNA polymerase adds **complementary** RNA nucleotides to the **template strand.**
The enzyme separates the two strands of DNA.
The ribosome joins together the amino acids carried by the tRNA molecules.
The strand of mRNA travels out of the nucleus through a **nuclear pore.**
The types and order of amino acids in the chain cause it to fold into a specific shape.
RNA polymerase continues to move along the DNA to reach the coding region of a gene.
This results in the formation of a **polypeptide.**

Describe how genetic variants in the coding DNA of a gene can affect phenotype by altering the sequence of amino acids and therefore the activity of the protein produced

Mutation and variation

Extensive genetic variation is contained within any species. This is clearly visible in the domestic dog species.

Variation is seen in all species of life including dogs

Variation within genes leads to different **genotypes**, and this can be seen by a different **phenotype**. Genetic variation and environmental variation can both cause these different phenotypes. All variation arises from **mutations** and most have no effect on the phenotype.

Genetic variants are small changes in the order of bases that make up a strand of DNA. They can affect the structure of proteins in different ways, depending on whether they occur in coding DNA or non-coding DNA.

Coding DNA: A genetic variant will alter the sequence of bases (e.g ACT -> AGT) and therefore will change the sequence of amino acids (e.g Glycine -> Valine). This alters the final structure of the protein produced.

<u>Non-Coding DNA:</u> A genetic variant in the coding DNA can affect phenotype differently. The enzyme RNA polymerase (see Section 3.8B) binds to non-coding DNA, and a change in the order of bases in this non-coding DNA can affect the amount of RNA polymerase that can bind to it. If less RNA polymerase is able to bind, less mRNA can be formed and the structure of the final protein is affected.

A change in the type/sequence of amino acids will affect the way it folds and therefore the structure.

Most mutations do not alter the protein or only do so slightly.

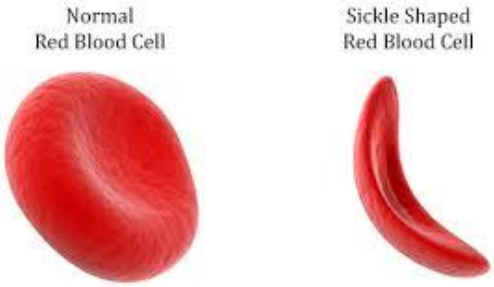
Some can have a serious effect and can change the shape

- **The substrate will not fit into the active site so it cannot act as a protein.**
- **A structural protein may lose its shape.**

Watch the following link:

Sickle cell disease

Sickle Cell Anaemia



Answer these questions.

1 H What is a mutation?

_____

_____

2 H How can mutations alter the functions of proteins?

_____

_____

3 H How can mutations alter the amount of protein that is produced?

_____

_____

TOPIC 4 – Natural selection and genetic modification

Describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection and explain the impact of these ideas on modern biology

Watch this vlog style film:

Darwin and Wallace

Charles Darwin

- Scientist and naturalist
- Put forward the theory of evolution
- This was supported by experimentation and his knowledge of geology and fossils that he discovered on a round the world expedition
- Published 'On the Origin of Species' in 1859

Theory of Evolution:

- Variation exists within species as a result of mutations in DNA
- Organisms with characteristics most suited to the environment are more likely to survive to reproductive age and breed successfully – called **survival of the fittest**.
- The beneficial characteristics are then passed on to the next generation
- Over many generations the frequency of alleles for this advantageous characteristic increase within the population

There was lots of controversy surrounding his ideas for many reasons:

1. It contradicted the idea that God was the creator of all species on Earth.
2. There was not enough evidence at the time as few studies had been done on how organisms change over time.
3. The mechanism of inheritance and variation were not known at the time.

Alfred Russel Wallace developed the theory of speciation, and therefore evolution by natural selection.

- On his travels, he had the idea that the individuals who did not have characteristics to help them survive a change in the environment would die out.
- He published joint studies with Darwin.
- The publication of **'On the Origin of Species'** meant Darwin received the credit for the theory.
- He continued to work across the world to collect evidence – one of his most important works was on warning colouration in animals
- Much more evidence over time has resulted in our current understanding.

The process of speciation:

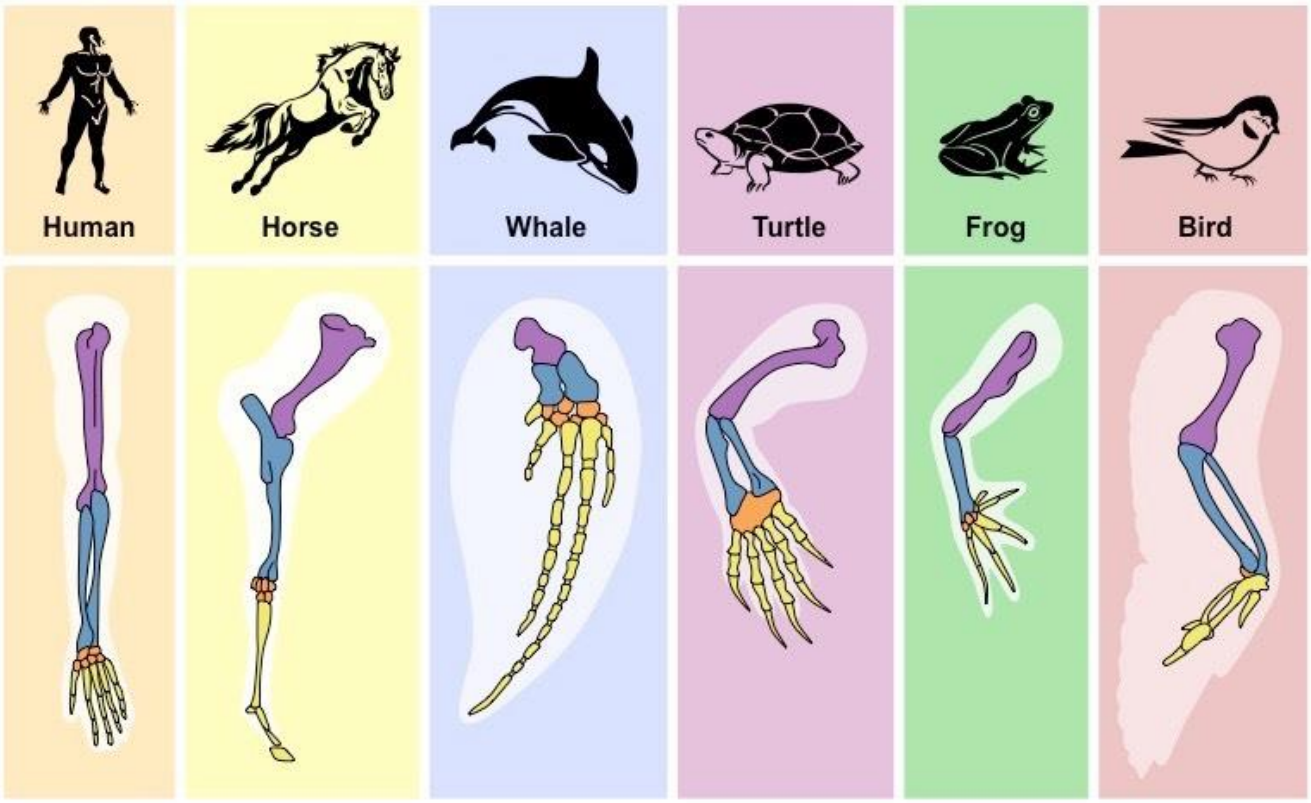
1. **Variation** exists within a population as a result of **genetic mutations.**
2. Alleles which provide a survival advantage are selected for through natural selection.
3. Populations of a species can become **isolated**, for example through physical barriers such as a rock fall preventing them from breeding together.
4. Different alleles may be advantageous in the new environment, leading to them being selected for.
5. Over time the **selection of different alleles** will **increase the genetic variation** between the two populations.
6. When they are **no longer able to breed together to produce fertile offspring,** a new species has formed.

Click this link to listen to David Attenborough discuss the work of Alfred Wallace

Describe how the anatomy of the pentadactyl limb provides scientists with evidence for evolution

A pentadactyl limb is a limb with five digits. This can be seen in a number of organisms, implying that they all come from a **common ancestor** - and that each 'branched off' at some stage of evolution. This could have been **due to different selection pressures** within different environments.

The human hand has **five digits** (four fingers and a thumb), but bats, cats, horses and birds also have this pattern within their limbs. However, that does not mean that we evolved **directly** from these animals but humans are distantly related to them via a **common ancestor.**



Test yourself:

2 Draw lines to join up the boxes to complete the sentences.

Before Darwin explained his theory, most people believed…	… they evolved from earlier species.
Darwin suggested that different species exist because…	… he could not explain how characteristics were passed on.
Many scientists accepted Darwin's theory because…	… that God had created all the different species and fossils.
Some scientists did not accept Darwin's theory because…	… characteristics are passed on by genes.
Today we know that …	… it explained many observations about fossils and living organisms.

TOPIC 5 – Health, disease and the development of medicines

Describe how some plants defend themselves against attack from pests and pathogens by physical barriers, including the leaf cuticle and cell wall, and by producing chemicals, some of which can be used to treat human diseases or relieve symptoms

Plant defences video link

Plants have several methods of guarding their cells and tissues against pathogens that cause disease. Some of these methods involve having **physical** barriers against disease, whereas others use **chemicals** to defend against attack from pests and pathogens

Physical barriers

- A thick **cellulose cell wall**, which is impermeable to many pathogens
- A thick **waxy cuticle** on the surface of the leaf, which acts as a barrier to most pathogens
- Some plants are also covered in a **layer of bark** (e.g trees) which prevents pathogens from reaching the **cells and tissues inside**.
- Leaves can often close their **stomata** (pores) to stop pathogens entering the plant.

Chemical barriers

- Cells of some plants can produce antimicrobial chemicals, proteins and enzymes
- Some plants can release compounds that attract larger insects than the pests, which feed on the pests and stop them eating the plant.
- Often, we can extract antimicrobial compounds from these plants for use in drugs such as antibiotics.

Visit this website for more information:

Plant defences

Test yourself:

1 Below is a list of examples of how plants defend themselves against attack by pathogens and **pests**.

leaf **cuticle** _____ poison inside cells _____ insect repellent _____ cell wall _____

a Write P next to any example of a **physical barrier** to a pest or pathogen.

b Write C next to any example of a **chemical defence** against a pest or pathogen.

c Select one physical barrier from the list and explain how it helps to protect the plant.

_____

d Select one chemical defence and explain how it helps to protect the plant.

_____

_____

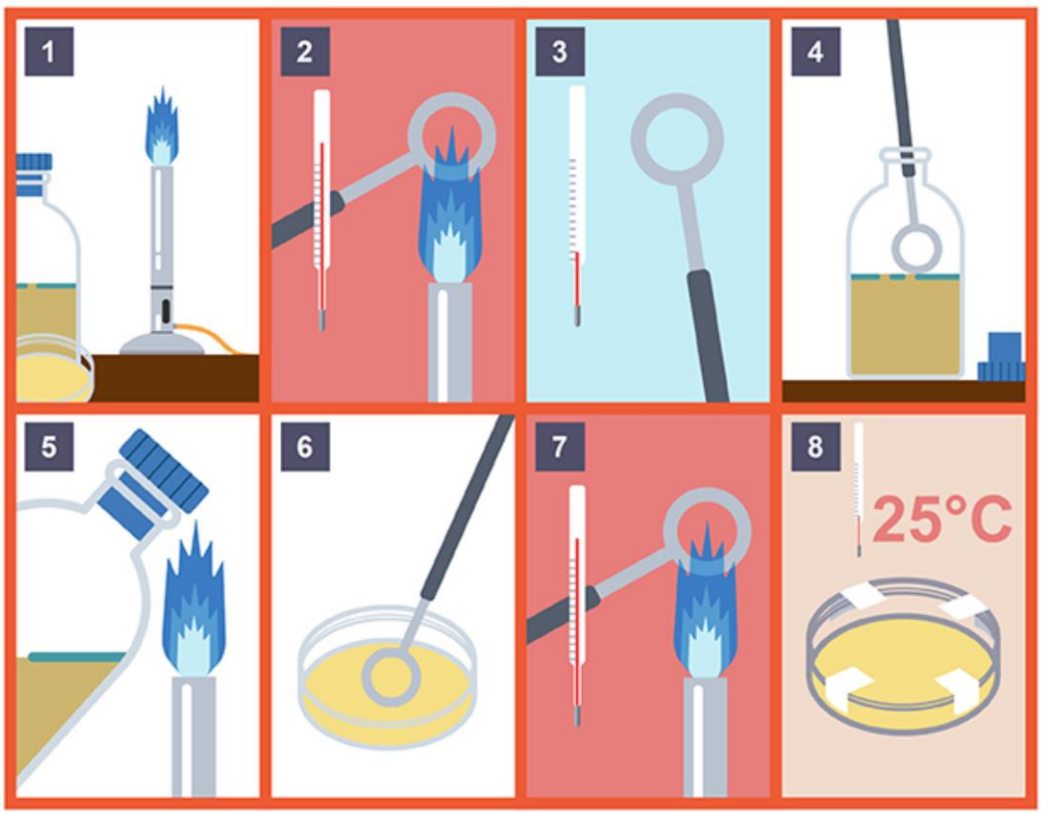
Explain the aseptic techniques used in culturing microorganisms in the laboratory, including the use of an autoclave to prepare sterile growth medium and petri dishes, the use of sterile inoculating loops to transfer microorganisms and the need to keep petri dishes and culture vials covered

Microorganisms are very small, so in order for scientists to study them they need to grow many of them in the lab using nutrients (culturing them).

The culture medium contains **carbohydrates** for energy, **minerals**, **proteins** and **vitamins**.

There are two ways to grow microorganisms in the lab:

1. In **nutrient broth solution**- involves making a suspension of bacteria to be grown and mixing with sterile nutrient broth (the **culture medium**), stoppering the flask with cotton wool to prevent air from contaminating it and shaking regularly to provide oxygen for the growing bacteria.
2. On an **agar gel plate**- the agar acts as the culture medium, and bacteria grown on it form colonies on the surface.
   Making the plate:
   - Hot sterilised agar jelly is poured into a sterilised **Petri dish**, which is left to cool and set
   - Sterilised wire loops called **inoculating loops** are dipped in a solution of the microorganism and spread over the agar evenly
   - A lid is taped on and the plate is **incubated** for a few days so the microorganisms can grow (stored upside down)



Aseptic techniques

The reasons why we follow certain steps in this procedure need to be understood.

Step	Why?
Petri dishes and culture media must be sterilised before use, often done by an **autoclave** (an oven) or UV light.	If this step does not take place, they are likely to be contaminated with other microorganisms. These could be harmless but will compete with the desired bacteria for nutrients and space, or they could be harmful (for example through a mutation taking place), potentially producing a new pathogen.
Inoculating loops must be sterilised by passing them through a flame.	This kills unwanted microorganisms, which is needed for reasons above.
The lid of the Petri dish should be sealed (but not completely) with tape.	Sealing stops airborne microorganisms from contaminating the culture, but it should not be sealed all the way around as this would result in harmful anaerobic bacteria growing (due to no oxygen entering).
The Petri dish should be stored upside down.	This is to prevent condensation from the lid landing on the agar surface and disrupting growth.
The culture should be incubated at 25 degrees.	If it were incubated at a higher temperature, nearer 37 degrees (human body temperature), it would be more likely that bacteria that could be harmful to humans would be able to grow as this is their optimum temperature. At lower temperatures, colonies of such bacteria would not be able to grow.

Investigate the effects of antiseptics, antibiotics or plant extracts on microbial cultures. Calculate cross-sectional areas of bacterial cultures and clear agar jelly using πr^2

The effectiveness of an antiseptic or antibiotic

The effectiveness of the chosen antibiotic or antiseptic can be measured numerically by using the formula πr^2. Using the diagram below.

Method

1. For π use 3.14. This value may vary slightly in a specific question.
2. Measure the diameter of the zone of inhibition and divide it by 2 to find the radius.
3. Use the equation: πr^2

Example

In the diagram below, the diameter of the clear zone around antibiotic sample B is 10 mm.

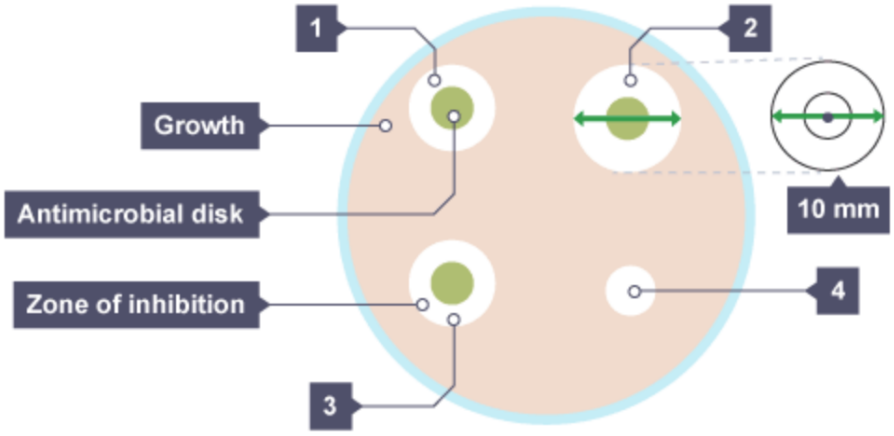
The radius of the clear zone is 5 mm ($radius = \frac{diameter}{2}$)

The area of the clear zone = πr^2

= 3.14 × 5 × 5

= 3.14 × 25

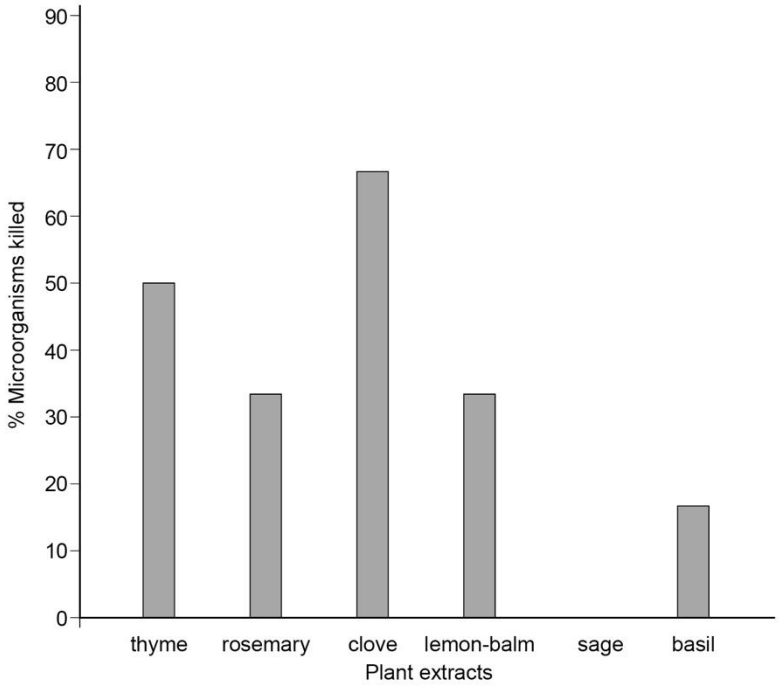
= 78.5 mm^2



1 Antibiotic Sample A
2 Antibiotic Sample B
3 Antibiotic Sample C
4 Control disk (no antibiotic)

Test yourself:

1 The chart shows the result of an investigation into the effect of extracts from several plants on the growth of bacteria in a liquid growth medium (agar broth).



a Name the plant extract that had no effect on bacterial growth.

_____

b If the experiment had been done with paper discs containing plant extracts placed on a bacterial lawn plate, state which extract would have made the largest clear zone around the disc at the end of the experiment. Give a reason for your answer.

_____

_____

_____

c **Aseptic techniques** were used to prepare materials for this experiment. Suggest the technique used to prepare the liquid growth medium. _____

_____

_____

d Explain why preparation using aseptic techniques was important in this experiment.

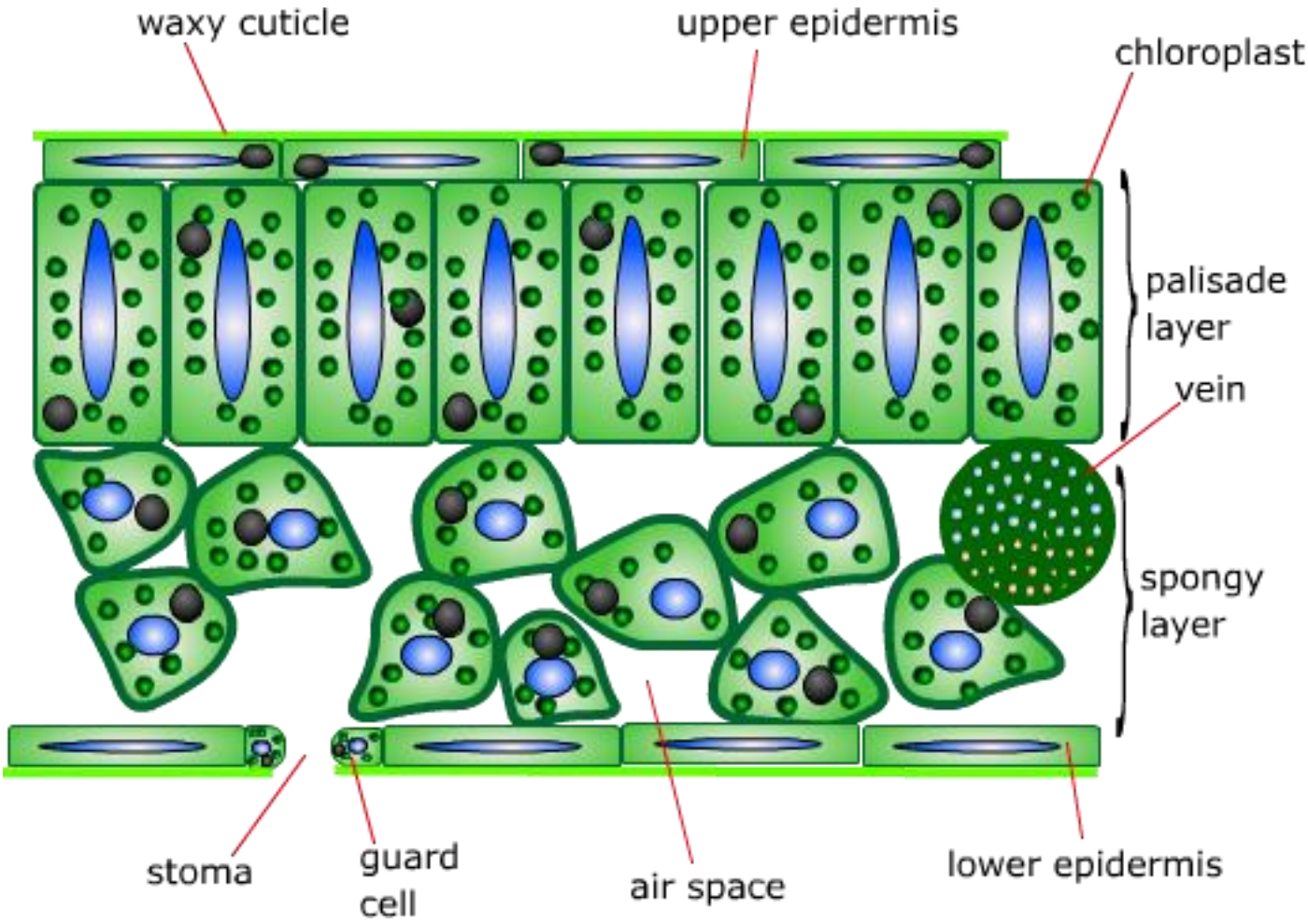
TOPIC 6 – Plant structures and their functions

Explain how the structure of a leaf is adapted for photosynthesis and gas exchange

Structure of leaves video clip

Leaves have several adaptations to allow them to perform specific functions:

Stomata: See above. They are able to close to minimise water loss and open to increase evaporation and transpiration. Stomata also allow gas exchange to occur when they are open.
Chlorophyll: Chlorophyll is green, which is the most efficient colour for absorbing light. This means that the most light possible is absorbed.
Thinness: Leaves are very thin, meaning that carbon dioxide only has a short distance to travel to enter the leaf (and work in photosynthesis) and oxygen only has a short distance to diffuse out.
Large surface area: Having a large surface area means that the leaf can absorb more light at once, maximising the rate of photosynthesis



Test yourself:

1 The drawing shows a section through a leaf from a tree with broad, flat leaves.

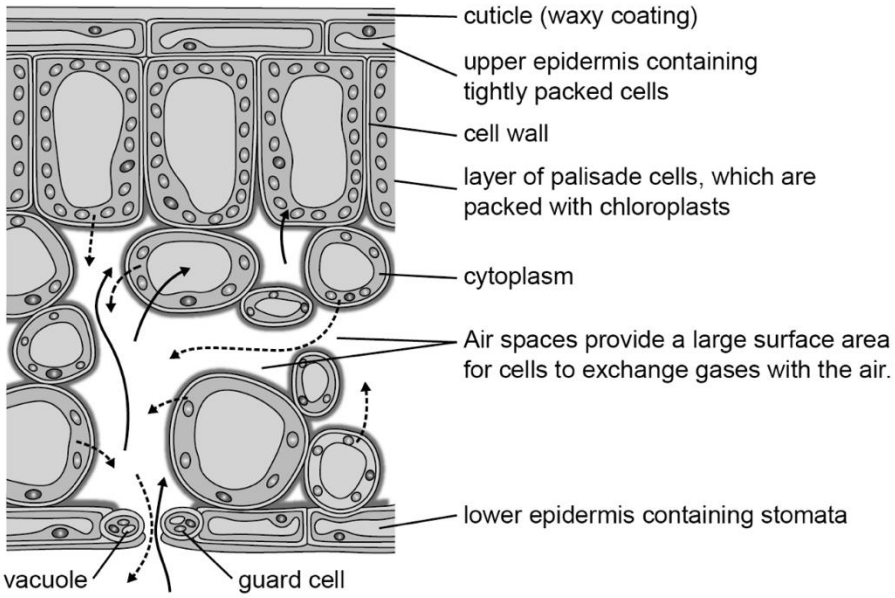
a The arrows show gas exchange. Give the names of three gases that are exchanged.

_____

_____

_____

_____



b Why do desert plants often have thick **cuticles**?

_____

c Complete the table below to explain how the adaptations of a flat, broad leaf help photosynthesis.

Adaptation	**How it helps photosynthesis**
Palisade cells are packed with chloroplasts.	_____ _____
Stomata open during the day.	_____ _____
The leaf is very thin.	_____ _____
Spongy cells create air spaces inside the leaf.	_____ _____

Explain how plants are adapted to survive in extreme environments including the effect of leaf size and shape, the cuticle and stomata

Many plants are adapted to survive in extreme environments. To do so, they need to have specific adaptations which maximise their ability to take in sunlight and carbon dioxide:

Leaf shape and size - many desert plants do not have leaves, or have very small leaves. This reduces the amount of water lost as a result of transpiration.

Presence of a waxy cuticle - many leaves have a waxy **cuticle** on top, preventing evaporation of water in environments where water is scarce.

Stomata - stomata are **small pores on the surface of a leaf**. They can be **closed** to prevent **evaporation** of water in extreme environments, and **opened** when carbon dioxide is needed for photosynthesis. This is useful, as it means that the plant can **adapt** when water is scarce.

Planet Earth Clip - David Attenborough

Cacti are well adapted for survival in the desert. They have:

- **Stems** that can store water.
- **Widespread or very deep root systems** that can collect water from a large area or from very deep underground.
- **Spines** which are modified leaves. These minimise the surface area and so reduce water loss. The spines also protect the cacti from animals that might eat them.
- **Very thick, waxy cuticle** to reduce water loss by **evaporation**.
- **Reduced number of stomata** to reduce water loss by **transpiration**.

Desert plants

A cactus is adapted to life in a hot climate

Test yourself:

1 Draw lines to match each adaptation of a certain cactus plant with the reason for that adaptation.

Adaptation	**Reason for adaptation**
no leaves	It cuts down the evaporation of water directly from cells on the surface of the stem.
stomata only open at night	Water vapour is trapped, and the rate of diffusion of water out of the plant is reduced.
stem stores water	Water loss is reduced, because the plant has less surface area.
thick **cuticle**	Less water loss occurs during the heat of the day.
stomata are hidden in dips in the stem	It provides a raw material for photosynthesis when there is no rain.

TOPIC 8 – Exchange and transport in animals

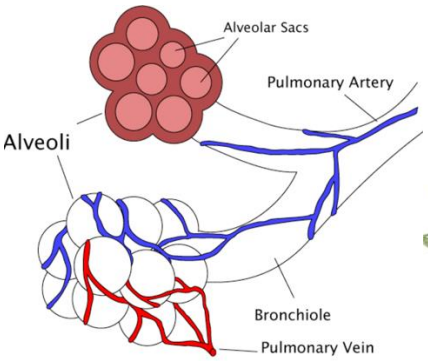
Describe the factors affecting the rate of diffusion, including surface area, concentration gradient and diffusion distance

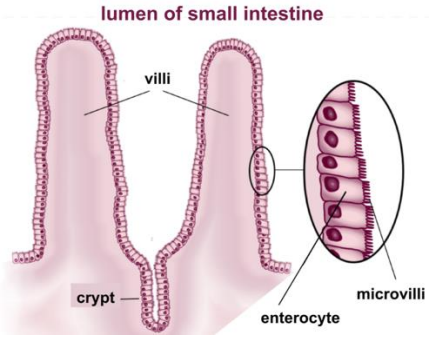
Watch this YouTube clip

The rate of diffusion depends on three factors:

1. **distance** - if the diffusion distance is small, diffusion happens faster because the particles do not have as far to travel
2. **concentration difference** (concentration gradient) - diffusion is faster if there is a big difference in the concentration between the area the substance travels from and the area that it is moving to
3. **surface area** - the larger the surface area the higher the number of particles that will be able to move in a given time so the faster the rate

Alveoli in the lungs, fish gills and the villi in the small intestine are adapted so that they have short diffusion distance, big concentration difference and large surface area. This means that they are adapted to have a rapid rate of diffusion. This is important for the survival of animals because they need to obtain as much oxygen, sugar and amino acids to meet the needs of metabolism and they need to expel waste substances such as urea as quickly as possible.





Alveoli **Fish gills** **Villi of small intestine**

Calculate the rate of diffusion using Fick's law:

Fick's Law

Fick's Law describes the relationship between the rate of diffusion and the three factors that affect diffusion. It states that 'the rate of diffusion is proportional to both the surface area and concentration difference and is inversely proportional to the thickness of the membrane'.

Fick's law can be written as:

$$Rate\ of\ diffusion \propto \frac{surface\ area \times concentration\ difference}{thickness\ of\ membrane}$$

$\propto$ means 'is proportional to'.

The rate of diffusion will double if:

1. surface area or concentration difference is doubled or
2. thickness of the exchange membrane is halved.

All of the exchange surfaces consist of cell membranes which are very thin. This explains why diffusion is very fast across membranes.

Question

The cell membrane has a thickness of 10 nm.

Describe what happens to the rate of diffusion of oxygen into the cell if the thickness changes to 20 nm.

4 In the sentences below, underline the correct word in each *pair*.

a When surface area increases, the rate of diffusion *increases* | *decreases.*

b When the thickness of the membrane increases, the rate of diffusion *increases* | *decreases.*

c When the concentration difference decreases, the rate of diffusion *increases* | *decreases.*

Answers

Topic 1

1 **a** reducing sugar
b protein
c starch
d fat/lipid

2

Reagent	Colour before test	Colour of positive result
Benedict's solution	bright blue	red precipitate
biuret solution	pale blue	purple
iodine solution	yellow/orange	blue/black
ethanol	clear	cloudy emulsion

Topic 3

- The order of the stages is as follows:
- Inside the nucleus, RNA polymerase attaches to a non-coding section of DNA.
- The enzyme separates the two strands of DNA.
- RNA polymerase continues to move along the DNA to reach the coding region of a gene.
- RNA polymerase adds complementary RNA nucleotides to the template strand.
- RNA polymerase links the RNA nucleotides together to form a strand of mRNA.
- The strand of mRNA travels out of the nucleus through a nuclear pore.
- In the cytoplasm, a ribosome attaches to the mRNA strand.
- A tRNA molecule pairs up with each codon.
- The ribosome joins together the amino acids carried by the tRNA molecules.
- This results in the formation of a polypeptide.
- The types and order of amino acids in the chain cause it to fold into a specific shape.

Topic 5

1 **a** P leaf cuticle, cell wall

b C poison, insect repellent

c (Both examples) makes it more difficult for a pathogen to get inside cells and cause damage.

d Either: Poison kills the pest that eats part of the plant, so that it doesn't cause more damage.
or: Insect repellent means the pest moves away from the plant and so cannot cause damage.

3 **a** sage

b Clove, because it killed most bacteria and, in an experiment using paper discs, this would cause the largest clear zone

c heating in an autoclave

d It kills any microorganisms that might affect the results of the experiment, or stops them getting into sterile equipment.

Topic 6

1 **a** oxygen, carbon dioxide, water vapour

b to cut down water loss through evaporation of water from cells near the leaf surface

c Palisade cells are packed with chloroplasts – to trap a lot of the energy transferred by light.

Stomata open during the day – to allow carbon dioxide to enter when there is light for photosynthesis.

The leaf is very thin – so that carbon dioxide does not have far to diffuse before reaching a cell that needs it.

Spongy cells create air spaces inside the leaf – so that cells have a lot of surface area exposed to air containing carbon dioxide and/or it allows the easy diffusion of gases/carbon dioxide inside the leaf.

1 No leaves – water loss is reduced, because the plant has less surface area.

Stomata only open at night – less water loss occurs during the heat of the day.

Stem stores water – it provides a raw material for photosynthesis when there is no rain.

Thick cuticle – cuts down the evaporation of water from cells on the plant's stem.

Stomata are hidden in dips in the stem – water vapour is trapped and the rate of diffusion of water out of the plant is reduced.

Topic 8

The rate of diffusion will halve.

4 **a** increases

b decreases

c decreases