Diet, insulin and blood glucose

1) Why is glucose important for the body?

_____

_____

2) What are hormones?

_____

_____

3) Name two hormones which are responsible for controlling the amount of glucose in the blood.

_____ _____

4) What happens when the amount of blood glucose rises?

_____

5) What happens when the amount of blood glucose falls?

_____

6) What is Diabetes Mellitus?

_____

_____

7) List five symptoms of diabetes.

_____

_____

_____

_____

_____

8) What is the difference between type 1 and type 2 diabetes?

_____

_____

_____

9) Complete the table below

Risk factors for Type 1 diabetes	Risk factors for Type 2 diabetes

10) Explain how the following can contribute to a healthy diet for people with diabetes:

a) carbohydrate:

_____

_____

b) dietary fibre(NSP):

_____

_____

c) fat:

_____

_____

d) alcohol:

_____

_____

d) diabetic food products:

_____

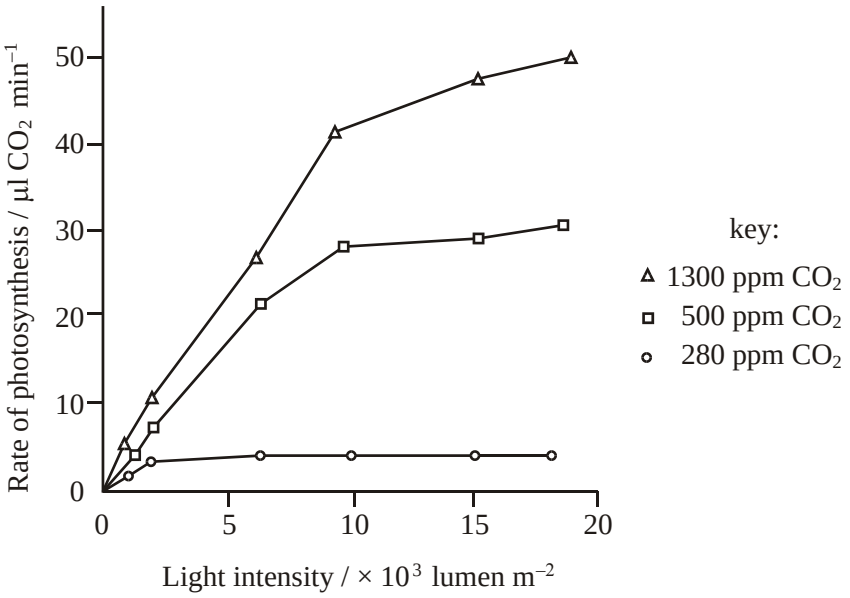
_____

11) It is important to keep a healthy weight to reduce the risk and symptoms of diabetes. The acronym BMI stands for _____ _____ _____. The formula used to calculate BMI is _____.

Topic 2 Past Exam Questions

Data Analysis Questions

1. There are many abiotic factors that affect the rate of photosynthesis in terrestrial plants. Wheat is an important cereal crop in many parts of the world. Wheat seedlings were grown at three different concentrations of carbon dioxide (in parts per million) and the rate of photosynthesis was measured at various light intensities.



[Source: Adapted from J P Kimmins, 1997 *Forest Ecology*, (2nd edition) page 161]

(a) Describe the relationship between the rate of photosynthesis and light intensity for wheat seedlings grown at a CO_2 concentration of 500 ppm.

.....

.....

.....

.....

(2)

(b) Outline the effect of CO_2 concentration on the rate of photosynthesis of the wheat seedlings.

.....

.....

.....

.....

.....

.....

(3)

(c) The normal atmospheric concentration of CO_2 is 370 ppm. Deduce the effect of doubling the CO_2 concentration to 740 ppm on the growth of wheat plants.

.....

.....

.....

.....

(2)

Leaf area and chlorophyll levels were measured in sun leaves and shade leaves of *Hedera helix* (English Ivy) and *Prunus laurocerasus* (Cherry Laurel). Sun leaves developed under maximal sunlight conditions while shade leaves developed at reduced sunlight levels in the shadow of other leaves.

Species	**Leaf Type**	**Chlorophyll/ μg ml^{-1}**	**Leaf Area/ cm^2**
Ivy	Shade	4.3	72.6
	Sun	3.8	62.9
Laurel	Shade	4.7	38.7
	Sun	4.2	25.7

[Source: D Curtis, Plant Ecology independent project, 1990]

(d) Calculate the percentage increase in the amount of chlorophyll in shade leaves of ivy compared to sun leaves of ivy

.....

.....

.....

(1)

(e) Suggest a reason for the differences in chlorophyll concentration and leaf area in sun and shade leaves in these two species.

.....

.....

.....

.....

(2)
(Total 10 marks)

2. Studies were carried out on the leaves of the wild type of the flowering mustard plant (*Arabidopsis thaliana*) to determine the pigment composition of the thylakoid membrane. The results were compared with the leaves of a mutant strain of the plant. These studies were repeated using thylakoid membranes from leaves grown in cultures deficient in either iron or magnesium.

Strain of Plant	Mineral Deficiency	Chlorophyll / $\mu g\ g^{-1}$ leaf	Carotenoids / $\mu g\ g^{-1}$ leaf
Wild Type	None	454	16
	Iron	441	71
	Magnesium	317	64
Mutant	None	387	67
	Iron	317	81
	Magnesium	172	95

[Source: Lu *et al*, (1995), *Botanical Bulletin of Academia Sinica*, **36**, pages 175–179]

(a) State the concentration of chlorophyll found in the leaves of the mutant strain of plant when deficient in iron.

.....

(1)

(b) (i) Calculate the percentage increase in carotenoids found in the wild type when magnesium is deficient.

.....

(1)

(ii) Suggest why magnesium deficiency causes the changes shown in the pigment content of the leaves.

.....

.....

.....

.....

(2)

(c) Using the data in the table, outline the effects of iron deficiency on the pigment content of the leaves.

.....

.....

.....

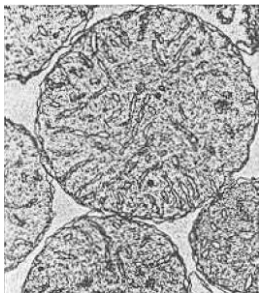
.....

(2)
(Total 6 marks)

3. The electron micrographs below show mitochondria in longitudinal section. The mitochondrion in A is from a bat pancreas cell and that in B is from a mouse liver cell.

A.

B.



[Source: Tribe and Whittaker, *Chloroplasts and Mitochondria*, (1972), **31,** pp 28–29]

(a) Annotate the micrographs to show **two** similarities in the structure of the mitochondria.

(2)

(b) The mitochondria differ in size. State **two** other differences that are visible in the mitochondria.

1. .....

2. .....

(2)

(c) Predict, with **two** reasons, which of the mitochondria would have been able to produce ATP at a greater rate.

.....

.....

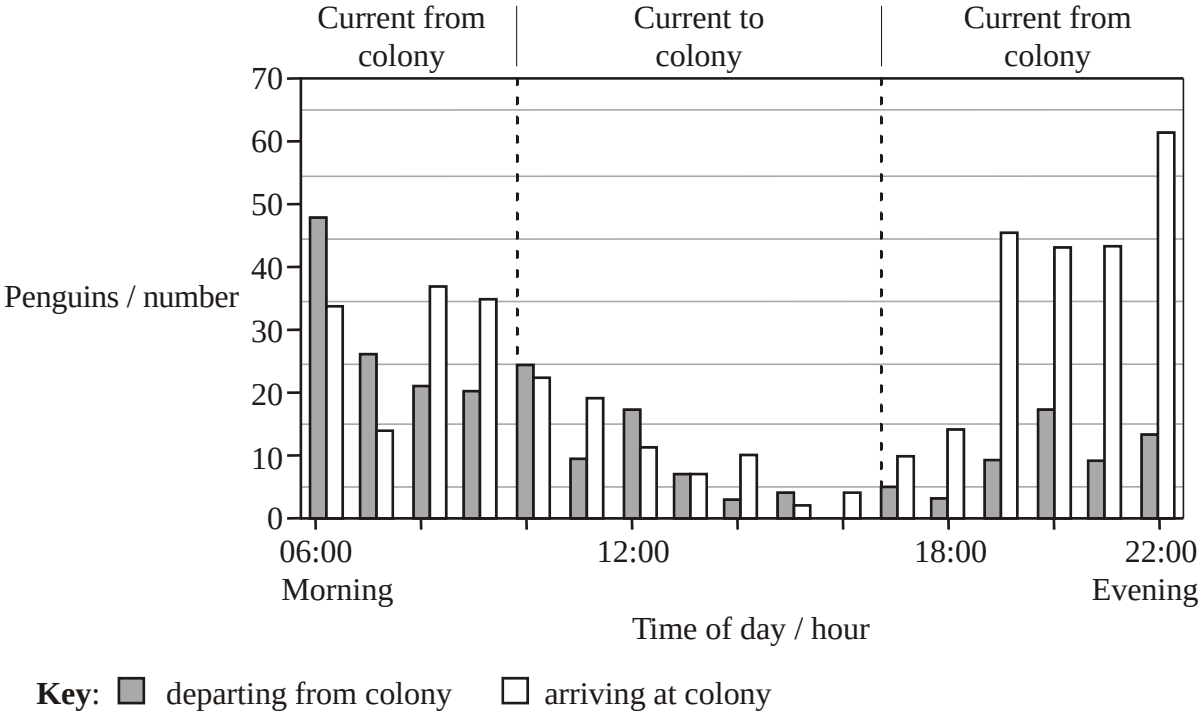
.....

.....

.....

(3)
(Total 7 marks)

4. Magellanic penguins (*Spheniscus magellanicus*) live and breed near the coast of Argentina. However, their colonies are a long way from the open sea where they hunt for fish. They cannot fly so have to swim to the feeding grounds. A study investigated how the water currents due to high and low tides affected their journey to and from their colonies. The results are shown below.



[Source: R. P. Wilson, "Magellanic Penguins Spheniscus magellanicus commuting through San Julian Bay; do current trends induce tidal tactics?", *Journal of Avian Biology* (Oct 30 2003), vol. 32, issue 1, pp. 83-89. Copyright © 2003. Reprinted with permission of Blackwell Publishing Ltd.]

(a) (i) Identify the number of penguins departing from the colony at 06:00 hours.

.....

(1)

(ii) Identify the time of day when most penguins arrive at the colony.

.....

(1)

(b) Describe the pattern of movement of penguins departing from the colony between 06:00 hours and 22:00 hours.

.....

.....

.....

.....

(2)

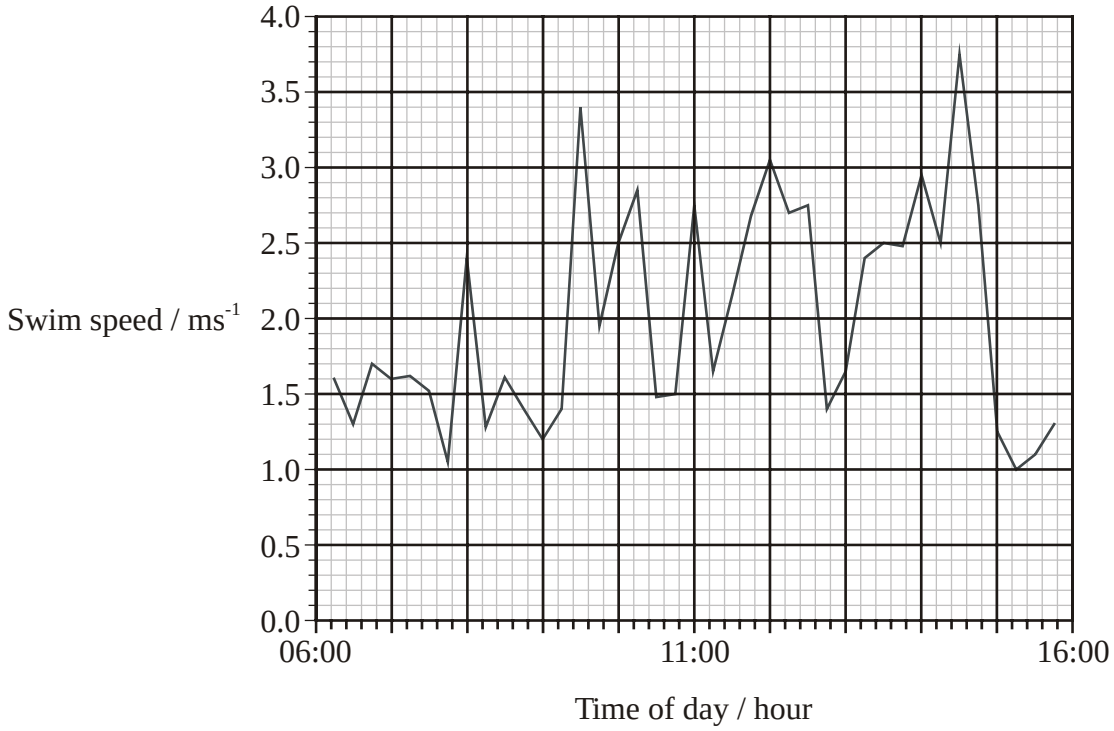
(c) Suggest why there is little movement in either direction between 14:00 hours and 16:00 hours.

.....

.....

(2)

The study also investigated the range of swim speed for one penguin when out hunting in the open sea.



[Source: R. P. Wilson, "Magellanic Penguins Spheniscus magellanicus commuting through San Julian Bay; do current trends induce tidal tactics?", *Journal of Avian Biology* (Oct 30 2003), vol. 32, issue 1, pp. 83-89. Copyright © 2003. Reprinted with permission of Blackwell Publishing Ltd.]

(d) Calculate the greatest difference in swim speed during the study.

.....

.....

(1)

(e) Suggest **two** reasons for the changes in swim speed of the penguin during the period of time of the study.

.....

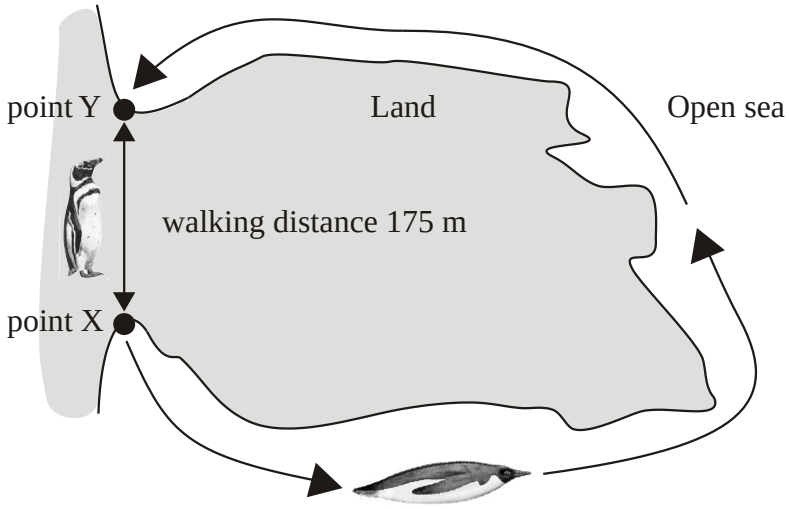
.....

.....

.....

(2)

The diagram below shows part of the coastline.



[Source: R. P. Wilson, "Magellanic Penguins Spheniscus magellanicus commuting through San Julian Bay; do current trends induce tidal tactics?", *Journal of Avian Biology* (Oct 30 2003), vol. 32, issue 1, pp. 83-89. Copyright © 2003. Reprinted with permission of Blackwell Publishing Ltd.]

(f) A penguin uses 88 joules of energy to walk one metre. Calculate the energy used to walk from point X to point Y.

.....

.....

(1)

(g) The penguin uses more energy swimming. Suggest **one** reason why most penguins actually swim rather than walk from point X to point Y.

.....

.....

(1)

(h) Explain why penguins have many mitochondria in the muscles used for swimming.

.....

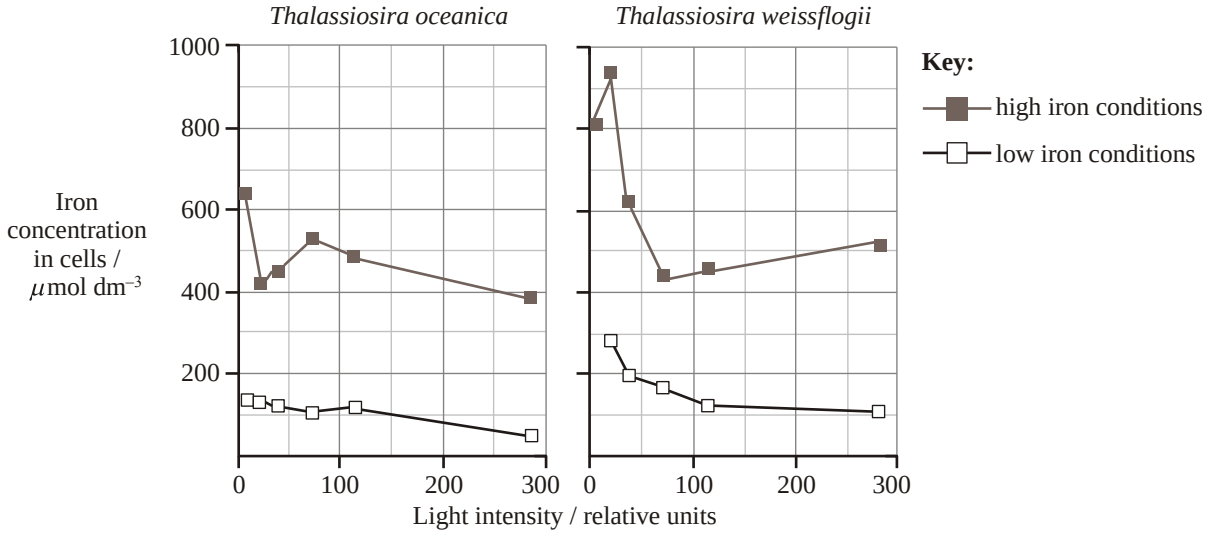
.....

.....

.....

(2)
(Total 13 marks)

5. Diatoms are unicellular algae which live as plankton in fresh water and oceans. Biochemists investigated two species of diatom, *Thalassiosira oceanica* which lives in the open ocean where the water is clear and *Thalassiosira weissflogii* which lives in coastal waters where the water is often cloudy. Iron is an important part of a number of molecules involved in photosynthesis. Iron however is often deficient in the waters of the open ocean. The scientists investigated the amount of iron present in the cells of the diatoms when they were grown at different intensities of light, in both high and low iron conditions.



[Source: Reprinted with permission from Macmillan Publishers Ltd: Robert F. Strzepek and Paul J. Harrison, "Photosynthetic architecture differs in coastal and oceanic diatoms", *Nature* (7 October 2004), vol. 431, issue 7009, p. 689, © 2004]

(a) Compare the iron concentrations in the cells of *T. oceanica* and *T. weissflogii* under high iron conditions.

.....

.....

.....

.....

(2)

(b) Suggest a reason for the response of *T. weissflogii* to low light intensities.

.....

.....

.....

.....

(2)

When the growth of these two species was compared in the two iron conditions it was found that the growth of *T. oceanica* was not affected by low iron concentrations but the growth of *T. weissflogii* was reduced by about 20%.

(c) Explain how *T. oceanica* is adapted to oceanic waters.

.....

.....

.....

.....

.....

.....

(3)

(d) Predict what would be the effect on the populations of these diatoms if atmospheric pollution reduced light intensities over the oceans.

.....

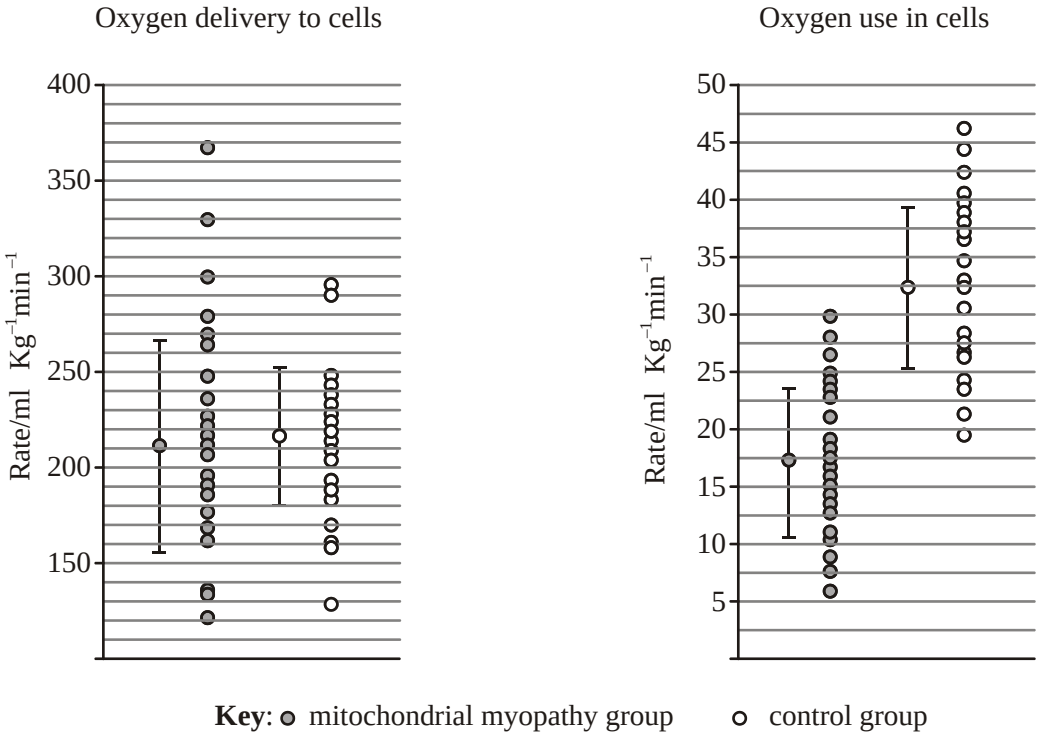
.....

.....

(1)

(Total 8 marks)

6. Mitochondrial electron transport defects (called mitochondrial myopathy) causes tiredness at low levels of exercise and varies from mild to severe. Scientists measured oxygen delivery to cells and oxygen use in cells of thirty-five patients with mitochondrial myopathy. The results were compared to a control group of thirty-two healthy individuals. The results are shown in the two charts below.



[Source: adapted from T. Taivassalo and R. G. Haller, (2006), 'Exercise and training in mitochondrial myopathies', *Medicine and Science in Sports and Exercise*, **37** (12) 2094-2101, © Lippincott Williams & Wilkins, USA]

(a) State the mean value for oxygen delivery to cells in patients suffering from mitochondrial myopathy.

.....

(1)

(b) Calculate the percentage difference of the oxygen use in cells by the control group compared to oxygen use in cells of patients with mitochondrial myopathy.

..... %

(1)

(c) Discuss why people with mitochondrial myopathy tire more easily than healthy individuals.

.....

.....

.....

.....

(3)
(Total 5 marks)

Cells & Organelles Name _____

Directions: Match the function cards and memory items by gluing them into the correct locations in the chart below.

Organelle	Function/Description	How can I remember it?
Cell Membrane		
Cell Wall		
Cytoplasm		
Mitochondria		
Lysosomes		
Vacuoles		
Golgi Bodies		
Chloroplasts		
Endoplasmic Reticulum		
Ribosomes		
Nucleus		
Nucleolus		
Chromatin		

Function Cards

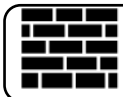
Captures energy from the sunlight and uses it to produce food in a plant cells	Receives proteins & materials from the ER, packages them, & distributes them
Controls what comes into and out of a cell; found in plant and animal cells	Produces the energy a cell needs to carry out its functions
Gel-like fluid where the organelles are found	Assesembles amino acids to create proteins
Control center of the cell; contains DNA	Stores food, water, wastes, and other materials
Found inside the nucleus and produces ribosomes	Has passageways that carry proteins and other materials from one part of the cell to another
Ridged outer layer of a plant cell	Tiny strands inside the nucleus that contain the instructions for directing the cell's functions
Uses chemicals to break down food and worn out cell parts	

Memory Items


Make me something sweet to eat


Members only can come and go.


I'm a "GOLden" packer.


I'm a brick wall.


I am the little nucleus.


I'm a transportER.


I am a "mighty" power house.

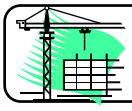

I clean things up! (Hint: Lysol)


I'll store anything, (Hint: Vacuum Bags)


I'm the control center.

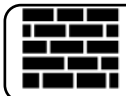
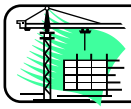

I'm a "tin" of information.


Sail through my plasma.


I make “some” nice proteins.

Cells & Organelles **ANSWER KEY**

Directions: Match the function cards and memory items by gluing them into the correct locations in the chart below.

Organelle	Function/Description	How can I remember it?
Cell Membrane	Controls what comes into and out of a cell; found in plant and animal cells	 Members only can come and go.
Cell Wall	Ridged outer layer of a plant cell	 I'm a brick wall.
Cytoplasm	Gel-like fluid where the organelles are found	 Sail through my plasma.
Mitochondria	Produces the energy a cell needs to carry out its functions	 I am a "mighty" power house.
Lysosomes	Uses chemicals to break down food and worn out cell parts	 I clean things up! (Hint: Lysol)
Vacuoles	Stores food, water, wastes, and other materials	 I'll store anything, (Hint: Vacuum Bags)
Golgi Bodies	Receives proteins & materials from the ER, packages them, & distributes them	 I'm a "GOLden" packer.
Chloroplasts	Captures energy from the sunlight and uses it to produce food in a plant cells	 Make me something sweet to eat
Endoplasmic Reticulum	Has passageways that carry proteins and other materials from one part of the cell to another	 I'm a transportER.
Ribosomes	Assesembles amino acids to create proteins	 I make “some” nice proteins.
Nucleus	Contains DNA, which controls the functions of the cell and production of proteins	 I'm the control center.
Nucleolus	Found inside the nucleus and produces ribosomes	 I’m in “control” of the number of “ribos”.
Chromatin	Tiny strands inside the nucleus that contain the instructions for directing the cell's functions	 I'm a "tin" of information.

IB Biology Study Notes

Unit 1 – Cells

1.1

- Living Organisms are composed of cells, they are the smallest unit of life, they come from pre existing cells.
- A virus is a non-cellular structure consisting of DNA or RNA surrounded by a protein coat.

Advantages of Light Microscopes	Advantages of Electron Microscopes
▪ Enables user to see larger structures within eukaryotes and distinguish individual prokaryotes. ▪ They are user-friendly: small, portable, easily-prepared slides, relatively cheap to buy and maintain. ▪ Both living and dead material may be viewed. ▪ Material is rarely distorted by preparation. ▪ Thicker materials may be viewed ▪ Allows experimenter to view image directly. ▪ Allows for specimen to be observed in natural state. ▪ Slides are simple to prepare ▪ Faster ▪ Color ▪ Can observe movement.	▪ Magnifies over 500,000x ▪ Resolving power for biological specimen around 1nm ▪ 3-D view instead of one. ▪ Interior view ▪ See organelles than cannot be observed w/ light microscope

- An organelle is a discrete structure within a cell, and has a specific function

Membrane Thickness – 1 nm

Viruses – 100 nm

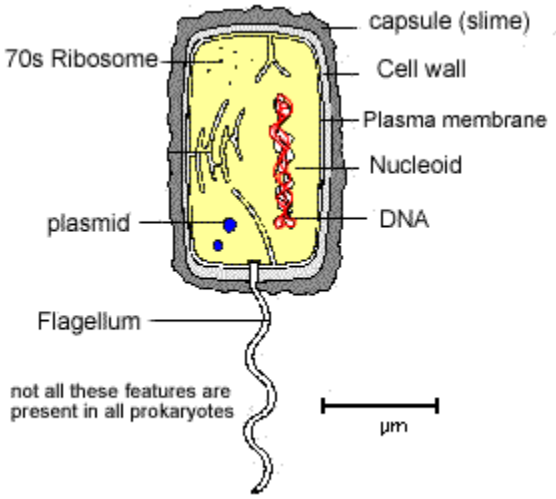
Bacteria – 1um

Organelles – up to 10 um

Most cells – up to 100 um

- Surface area to volume ratio – as the size increases the ratio decreases, thus decreases the rate of exchange.
- Unicellular organisms carry out all of the functions of life, including metabolism, response, homeostasis, growth, reproduction and nutrition.

1.2



- Prokaryote – a cell that lacks any membrane bound organelles. Prokaryotes belong to their own kingdom, bacteria.

Cell Wall – Gives cell it's shape, protects the cell and prevents the cell from absorbing too much water

Ribosomes – small granules found in all cells. Made of RNA and protein, they are important in protein synthesis. Produce protein for use inside cells

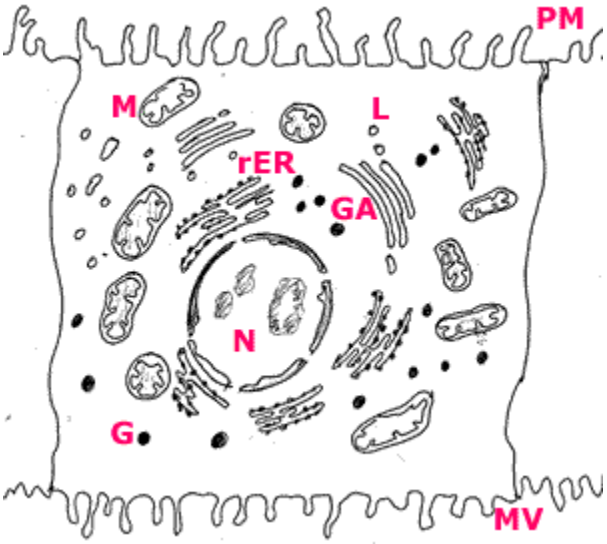
Slime/Capsule – surrounds the cell wall of bacteria, it helps to keep the cell from being digested or drying out.

Flagellum – An organelle that propels a cell

Plasma Membrane – Controls the movement of things in and out of the cell. Protects organelles inside from the outside environment. Made of phospholipids

- Prokaryotic cells divide by binary fission

1.3

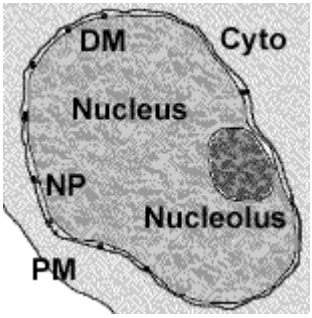


- N:Nucleus
- PM: plasma membrane
- M: mitochondria
- rER: Rough endoplasmic reticulum
- GA: Golgi apparatus
- L: Lysosome
- MV: Microvilli

see 2.3.2 form functions of the cell components.

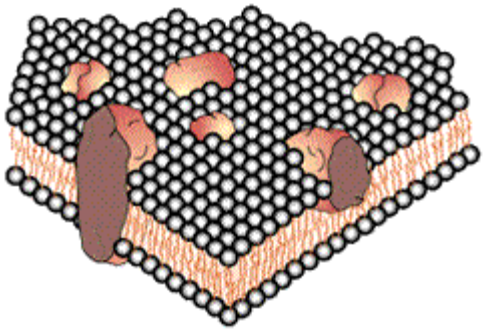
2.3.2 Annotate the diagram from 2.3.1 with the functions of each named structure.

Nucleus: This is the largest of the organelles. The nucleus contains the chromosomes which during interphase are to be found the nucleolus.



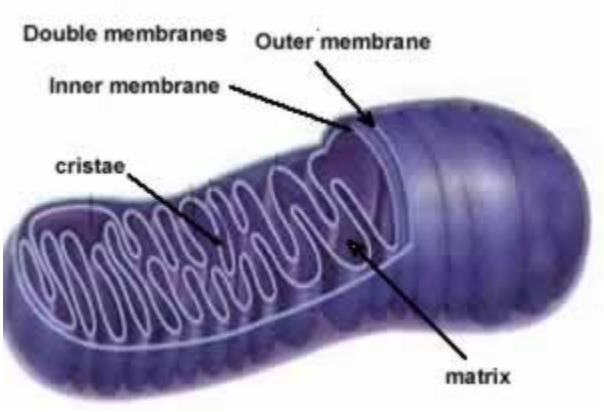
- The nucleus has a double membrane with pores(NP).
- The nucleus controls the cells functions through the expression of genes.
- Some cells are multi nucleated such as the muscle fibre

Plasma membrane: controls which substances can enter and exit a cell. It is a fluid structure that can radically change shape. see 2.4



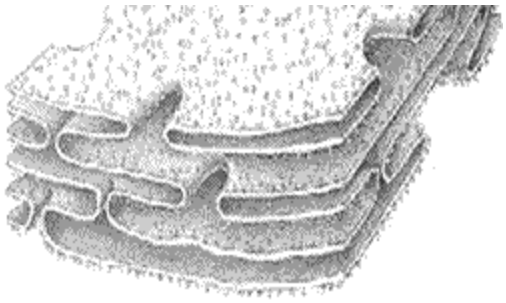
- The membrane is a double layer of water repellant molecules.
- Receptors in the outer surface detect signals to the cell and relay these to the interior.
- The membrane has pores that run through the water repellant layer called channel proteins.

Mitochondria: location of aerobic respiration and a majot synthesis of ATP region..



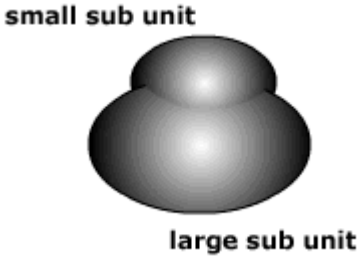
- Double membrane organelle.
- Inner membrane has folds called cristae. This is the site of oxidative phosphorylation.
- Centre of the structure is called the matrix and is the location of the Krebs cycle.
- Oxygen is consumed in the synthesis of ATP on the inner membrane
- The more active a cell the greater the number of mitochondria.

Rough endoplasmic reticulum (rER): protein synthesis and packaging into vesicles.

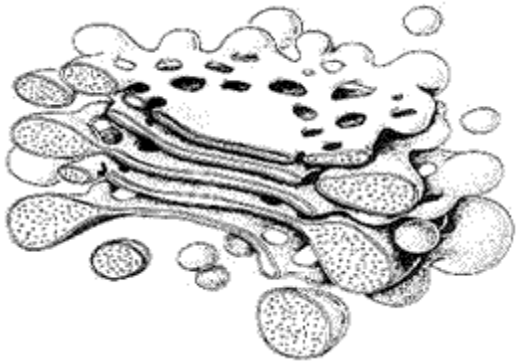


- rER form a network of tubules with a maze like structure.
- In general these run away from the nucleus
- The 'rough' on the reticulum is caused by the presence of ribosomes.
- Proteins made here are secreted out of the cell

Ribosomes: the free ribosome produces proteins for internal use within the cell.



Golgi apparatus: modification of proteins prior to secretion.



- proteins for secretion are modified
- possible addition of carbohydrate or lipid components to protein
- packaged into vesicles for secretion

Lysozyme:

- Vesicles in the above diagram that have formed on the golgi apparatus.
- Containing hydrolytic enzymes.
- Functions include the digestion of old organelles, engulfed bacteria and viruses.

top

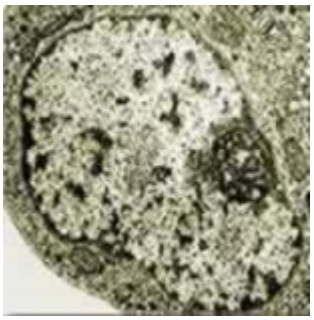
2.3.3 Identify structures from 2.3.1 in electron micrographs of liver cells.(2)

Identify: To find an answer from a given number of possibilities.

To identify structures within an electron micrograph it is necessary to know the scale at which the image has been taken. Look around the image to find the nucleus and then the

mitochondria. In a plant cell there will also be the cell wall, chloroplasts and the vacuole to identify.

Nucleus:



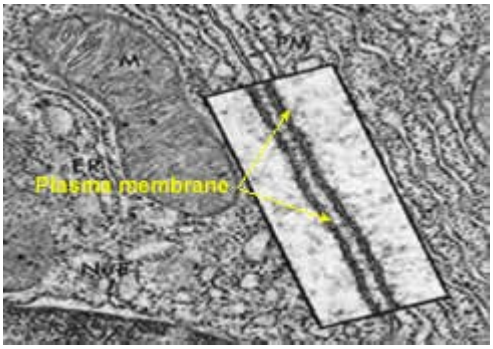
In an electron micrograph the nucleus will be the largest of the organelles.

In this image there is a dark stained region called the nucleolus which is the location of the DNA.

The membrane has pores which allow the entry of cell signal molecules, nucleotides and the exit of mRNA.

Generally the nucleus appears spherical however there are cells in which the nucleus has more unusual shape such as the multi-lobbed white blood cells.

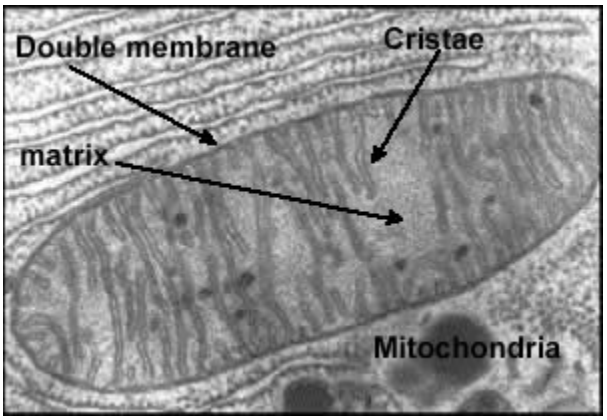
Plasma membrane:



This image shows the junction between two liver cells. The image has been manipulated for clarity to see the two adjoining plasma membranes.

Notice the mitochondria to the left and the rER to the right of the membranes.

Mitochondria:

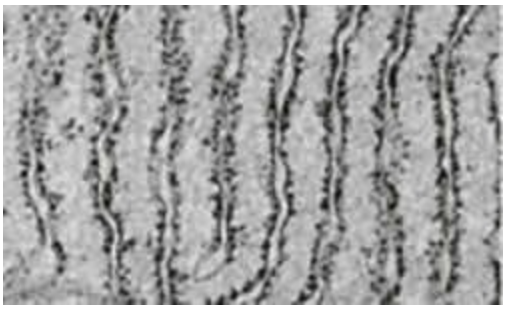


This micrograph of a mitochondria shows:

- Double outer membrane
- Folded inner membrane called the cristae.
- Matrix of the mitochondria

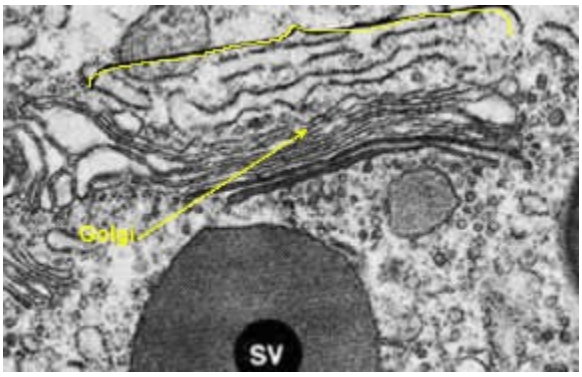
These features are common to all mitochondria. Notice the rER above the mitochondria for scale and the dark granules of glycogen below the organelle.

Endoplasmic reticulum (rER).



- The rER runs vertical in the image. Note the dark spots which are the ribosomes.
- A cell with a great deal of rER is producing proteins for secretion outside of the cell.
- The network of endoplasmic tubules allows proteins to be moved around within the cytoplasm before final packaging and secretion.

Golgi apparatus:



- The golgi apparatus in the diagram forms a stack of membrane envelopes on top of each other.
- Vesicles containing proteins fuse with the structure.
- The proteins are modified inside the apparatus usually with the addition of non-protein substances.

Lysozyme:

- simple membrane bound vesicle containing hydrolytic enzymes
- produced in the golgi apparatus.
- used to digest engulfed bacteria or viruses or old organelles

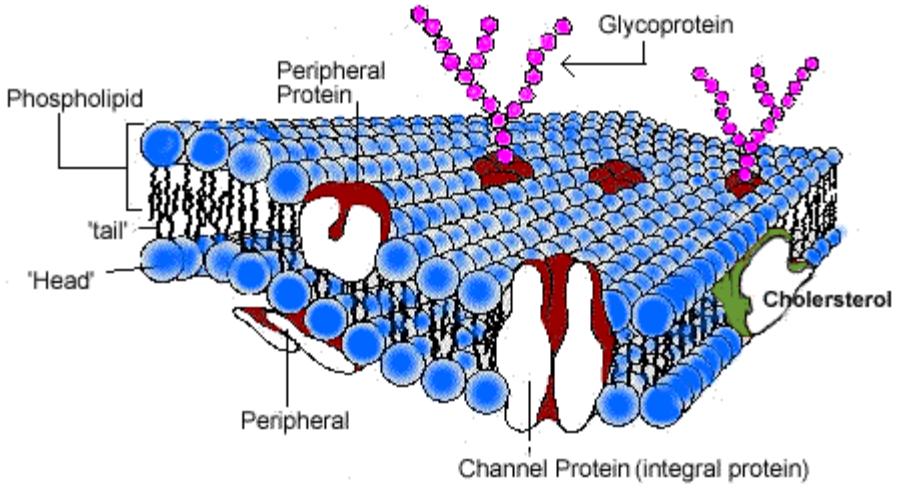
- used to digest macromolecules
- hydrolytic enzymes are retained within the vesicle membrane to prevent autodigestion of the cell.

2.3.4 Comparison of prokaryotic and eukaryotic cells (3).

Prokaryotic	Eukaryotic
Small cells (< 5um)	large cells (> 10um)
always unicellular	often multi cellular
no nucleus instead has a 'naked loop' called a nucleoid	always has nucleus with linear DNA (chromosomes) and histones
no membrane bound organelles	membrane bound organelles
ribosomes are small (70s) s = **svedberg** unit of measure of the size of organelles.	ribosomes are large (80s)
no mitochondria	mitochondria present
cell division by binary fission	cell division by mitosis or meiosis
reproduction mainly asexual however there are some non meiotic forms of gene exchange such as **conjugation**.	reproduction asexual or sexual
many metabolic pathways, fermentation, nitrogen fixation and photosynthesis.	common form of respiration involving organic molecules like sugar.

top

Feature	Animal	Plant
Cell Wall	Not present as animal cells only have a plasma membrane	Cell wall present along with an inner plasma membrane
Chloroplast	Not present	Present in plant cells that photosynthesis
Carbohydrate storage	Glycogen	Starch
Vacuole	Not usually present. Small temporary vacuoles sometimes found.	Large fluid-filled vacuoles often present. Surrounded by a membrane called the tonoplast. This control substances moving from the cytoplasm to the vacuole and visa-versa.
Shape	Able to change shape. Usually rounded	Fixed shape. Usually rather irregular.



Membrane Structure	*Function*
Phospholipid Bilayer	▪ The phospholipids are arranged in a bilayer, with their polar, hydrophilic phosphate heads facing outwards, and their non-polar, hydrophobic fatty acid tails facing each other in the middle of the bilayer. ▪ This hydrophobic layer acts as a barrier to all but the smallest molecules (oxygen & Carbon Dioxide), effectively isolating the two sides of the membrane. ▪ Phospholipids can exchange position in the horizontal plane but not the vertical.
Integral Proteins	▪ Usually span from one side of the phospholipid bilayer to the other. ▪ Proteins that span the membrane are usually involved in transporting substances across the membrane (more detail below)
Peripheral Proteins	▪ These proteins sit on one of the surfaces (peripheral proteins). They can slide around the membrane very quickly and collide with each other, but can never flip from one side to the other. ▪ Proteins on the inside surface of plasma membrane are often involved in maintaining the cell's shape, or in cell motility. ▪ They may also be enzymes, catalysing reactions in the cytoplasm.
Glycoproteins	▪ Usually involved in cell recognition which is part of the immune system. They can also acts as receptors in cell signaling such as with hormones.
Cholesterol	▪ Binds together lipid in the plasma membrane reducing its fluidity as conferring structural stability

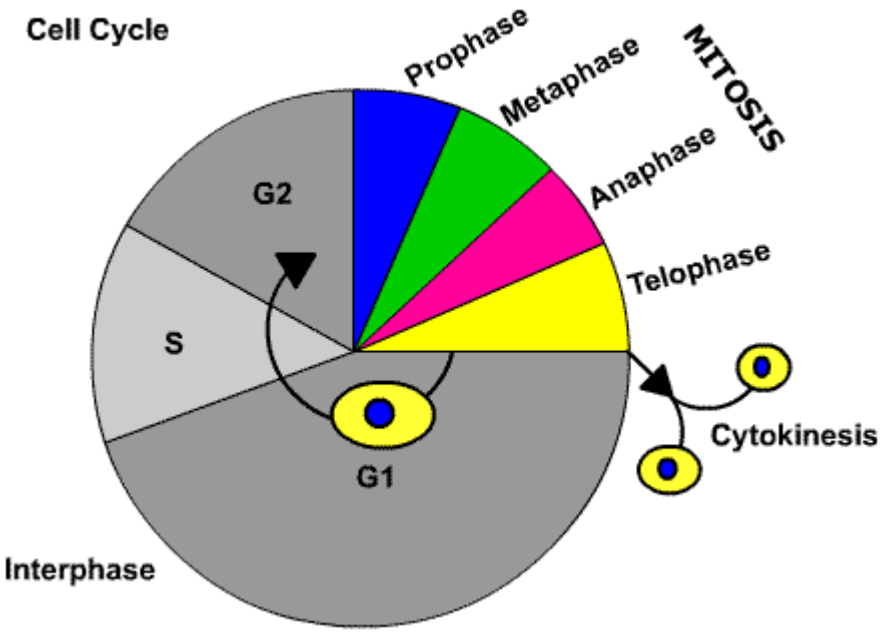
Diffusion: passive movement of particles from a region of high concentration to a region of low concentration.

Osmosis is the passive movement of water molecules from regions of lower solute concentration to a region of higher solute concentration

2.5.1 Outline the stages in the cell cycle, including interphase (G1, S, G 2), mitosis and cytokinesis (2).

outline means to give a brief summary

The cell cycle describes the major phases of activity in the division of a cell. The length of the cell cycle depends on the particular function of the cell. For example bacterial cells can divide every 30 minutes under suitable conditions, skin cells divide about every 12 hours on average, liver cells every 2 years, and muscle cells never divide at all after maturing**.**



- The total length of a cell cycle varies depending on the specialised function of a cell.
- Interphase (grey) is the longest phase which itself occurs in three stages.
- G1 The cell performs its normal differentiated function. Protein synthesis/ mitochondria replication/ chloroplast replication.
- S DNA replication. At this point the mass of DNA in the cell has doubled.
- G2 Preparation for cell division
- Phases of mitosis (see 2.5.4)
- Cytokinesis: division of the cytoplasm to form two daughter cells.

An appreciation of mitosis only comes when you have studied the structure of nucleic acids, DNA replication and some gene expression. At that point you will understand better the significance of the S phase= DNA replication.

2.5.2 State that tumours (cancers) are the result of uncontrolled cell division and that these can occur in any organ or tissue(1)

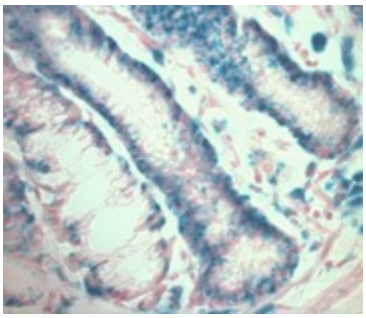
calculation. State means to give a specific name, value or other brief answer without explanation or

'Tumours are not foreign invaders. They arise from the same material used by the body to construct its own tissues. Tumours use the same components -human cells- to form the jumbled masses that disrupt biological order and function and, if left unchecked, to bring the whole complex, life sustaining edifice that is the human body crashing down'.

R. Weinberg, R. (1998) *One Renegade Cell.* London:Phoenix, Science Masters Series.

'Cancer is, in essence a genetic disease'

Volgestein and Kinzler



- Tumours (cancers) are a cell mass formed as a result of uncontrolled cell division.
- They can occur in any tissue.
- Stomach cancer

Not on the syllabus and just for interest

Cells are normally in state of repressed mitosis. The default condition is for the cell to progress into mitosis and cytokinesis. In a tumour something happens (mutation to the proto-oncogene) to release the repression of cell division. There appear to be atleast two groups of genes which are important in the formation of tumours:

a) Oncogenes, which if accidentally or inappropriately activated increase the risk of tumour formation.

b) Tumour Suppressor genes (TSG) which as the name suggests normally are actively suppressing tumours. If these are switched off by a mutation then the suppression is lost.

Evolution of Cancer:

1. Multi step carcinogenisis: Cancers do not arise as invasive malignant metastatic (spreading) tumours. Rather they follow a series of steps that begins with a contained benign growth. A cell will eventually arise within the benign mass which is more aggressive in its growth rate and with a tendency to invade surrounding tissue. These cells have a selective advantage and will become the dominant cell type within the tumour. The cancer has now progresses to an aggressive invasive form. In the next stage a further mutation to a cell makes this cell not only aggressive and invasive but with a tendency to break up and spread to other tissues (metastasis). This latter tumour stage is the malignant tumour

2. Oncogene activation: There are within a cell many proteins that are either cell signals or control proteins within the cell cycle. The proteins are coded for by genes that are referred to as proto-oncogenes. When transformed by mutagenic agents(chemicals, radiation) they are transformed (mutated) into oncogenes. It is these oncogenes that when expressed will cause a loss of control of division within that cell. There is then the production of a protein that signals the cell internally to increase the rate of cell division. Since this gives these cells a selective advantage they become more common at the expense of non-mutated cells. These types of genes that create transform cell function were discovered as early as 1910.

3. Tumour Suppressor deactivation. An alternative or additional feature is the idea of tumour suppression which holds cell division in check. The tumour suppressor could simply be a protein that inhibits the cell cycle. Alternatively there are proteins that repair DNA which also suppress tumour suppression by maintaining the integrity of DNA. Therefore the suppression is removed and the cell progresses into uncontrolled cell division.

This might suggestion from this description therefore is that the development of a cancer will require atleast two mutations; one of the proto-oncogene; two of the tumour suppressor.

Cancer exerts its deleterious effect on the body by: destroying the surrounding adjacent tissues: e.g. compressing nerves, eroding blood vessels, or causing perforation of organs: replacing normal functioning cells in distant sites: e.g. replacing blood forming cells in the bone marrow, replacing bones leading to increased calcium levels in the blood, or in the heart muscles so that the heart**fails.**

2.5.3 State that interphase is an active period in the life of a cell when many metabolic reactions occur, including protein synthesis, DNA replication and an increase in the number of mitochondria and/or chloroplasts (1).

State means to give a specific name, value or other brief answer without explanation or calculation.

- The cell specialises to a particular function in a process called differentiation.
- Through gene expression and protein synthesis there is a specialisation of cell structure and function.

- During this interphase the cell carries out this specialist function.

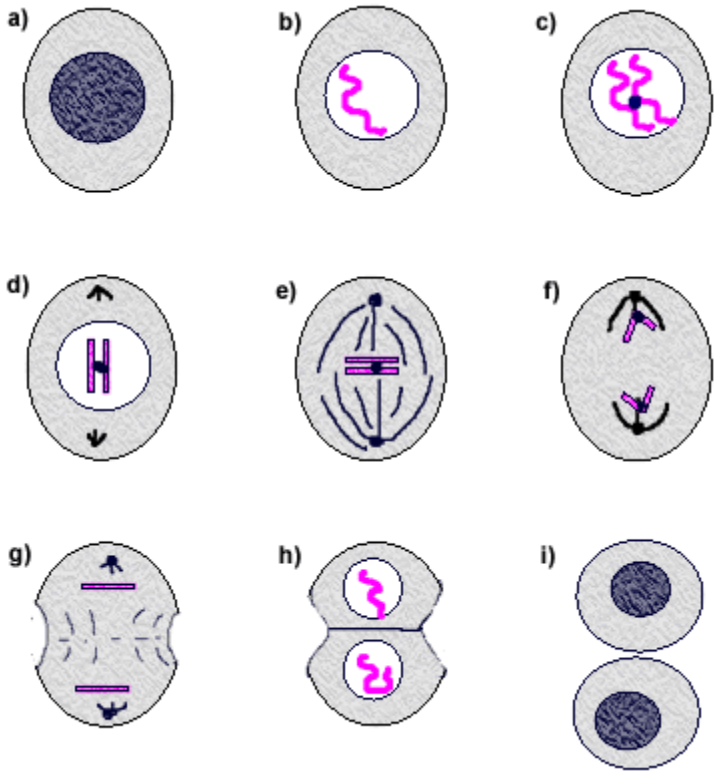
- The length of the interphase varies from one type of cell to another.
- G1 follows cytokinesis. The cell is involved in the synthesis of various proteins which allow the cell to specialise.
- S-phase involves the replication of DNA molecules which takes place prior to the phases of mitosis.
- G2 preparation for the phases of mitosis which involves the replication of mitochondria and in the case of plants, the chloroplast.

2.5.4 Describe the events that occur in the four phases of mitosis (prophase, metaphase, anaphase and telophase (2).

Describe means to give a detailed account.

Super coiling: Eukaryotic DNA is combined with histone proteins and non-histone proteins to form chromatin. The method of folding of chromatin is specific to each chromosome leaving genes in predictable positions and a distinctive overall chromosome shape. The human cell has a DNA length of about 1.8 m this has to be packed into a nucleus which has only a 5 um diameter. This packaging process requires up to a X 15,000 reduction. This super coiling makes the structure so dense that it can be see with a light microscope during the phases of mitosis.

In this sequence only one chromosome is illustrated so that we can more clearly follow the process. In a human a complete diagram would have 46 chromosomes each replicating and condensing and separating.



a)The cell membrane is intact during this the interphase. The chromosomes cannot be seen during G1,S and G2.

b) G1,Within the nucleus, genes on the chromosome are being expressed to carry out normal cell function (interphase). Remember you cannot see chromosomes at this stage. The diagram has a 'see's through' the nuclear membrane so you can see inside. In reality it would look just like cell a).

c) S-phase in which DNA replication occurs and the

chromosomes are copied. The copies called **sister chromatids** are held together by a protein to form the centromere. It is still not possible to see this happen with an intact cell.

d) Early **Prophase** in which the sister chromatids have condensed by super coiling. Note the formation of the spindle microtubules and their attachment to centrioles. The nuclear membrane will now break down to reveal sister chromatids. The internal arrangements of chromosomes can now be seen with a light microscope.

e) **Metaphase** the chromosomes arranged on the equator of the cell each attached to a spindle microtubule at the centromere

f) **Anaphase:** The spindle microtubules contract and pull apart the sister chromatids one to each pole of the cell. The centromere splits allowing the sister chromatids to be separate.

g) **Telophase:** at each pole there are separate groups of the replicated chromosomes the spindles is degenerating

h) **Cytokinesis:** the cell membrane begins to separate, dividing the cell into two new cells. The nuclear membrane is reforming around each cell.

i) Two daughter cells are formed. They are genetically identical to each other and in effect the basis of a clone. (see 2.5.6)

Notice that cell a) begins with one chromosome and that by step h) there are two cells each with a copy of that chromosome.

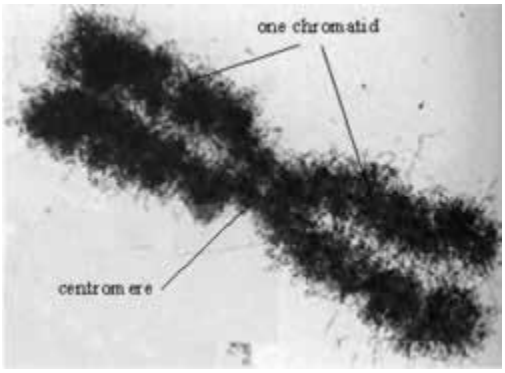
As suggested by cell theory, all cells have come from other cells.

2.5.5 Explain how mitosis produces two genetically identical nuclei (3).

Explain means to give a detailed account of causes, reasons or mechanisms.

- The process of cell division produces genetically identical daughter cells.
- Conservation of chromosome number. The chromosome number in each of the daughter cells is the same as that of the original parental cell
- During the S-phase, each chromosome is copied exactly. The two copies of each chromosome are held together by a protein structure called a centromere.
- Therefore just prior to the beginning of the phases of mitosis there is actually double the number of chromosomes present in a cell.

- Each chromosome in this state is represented by a pair of sister chromatids. These give the now classic cross image of the DNA (see image below)



This pair of sister chromatids image was taken during one of the phases of mitosis.

The two sister chromatids are held together at the centromere

The arms of the chromatids are visible because of a condensation of the molecule called super coiling. This condenses the molecule some x 15,000 times of its original length The pairs of sister chromatids is a non-random organisation. The position of genes is predicable within the structure seen here. Also there is a unique shape to each of the chromosomes.

Mitosis makes sure that each cell obtains a copy of each of the chromosomes in the parental cell.

However, it is the process of DNA replication during the S-phase that actually copies each DNA molecules to make mitosis possible.

State that growth, embryonic development, tissue repair and asexual reproduction involve mitosis(1).

State means to give a specific name, value or other brief answer without explanation or calculation.

- Growth: multicellular organisms increase their size through growth. This growth involves increasing the number of cells through mitosis. These cells will differentiate and specialise their function.
- Embryonic development is when the fertilised egg cell (zygote) divides to form the multicellular organism. Each cell in the organisms is identical (genetically) to all the other cells. However, each cell will express only a few of its genes to determine its overall specialisms, a process called differentiation. In this way a stem cell may becomes a muscle, or it may become a nerve cell or any one of the many different kinds of cells found in a complex multicellular organism. The best book about this process for the interested reader is
- Tissue Repair: As tissues are damaged they can recover through replacing damaged or dead cells. This is easily observed in a skin wound. More complex organ regeneration can occur in some species of amphibian.

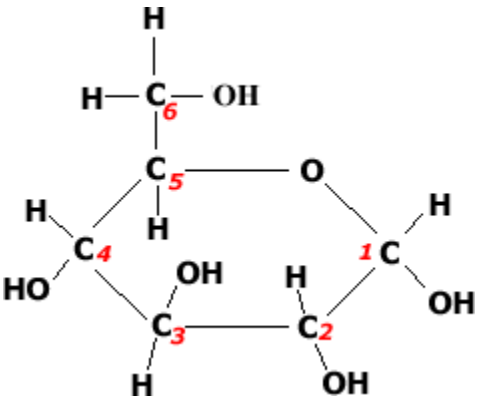
- Asexual Reproduction: This the production of offspring from a single parent using mitosis. The offspring are therefore genetically identical to each other and to their "parent"- in other words they are clones. Asexual reproduction is very common in nature, and in addition we humans have developed some new, artificial methods. Bacteria DO NOT asexually reproduce by mitosis but rather by a process called Binary Fission.

3.2.2 Identify amino acids, glucose, ribose and fatty acids from diagrams showing their structure(2).

Identify means to find an answer from a given number of possibilities.

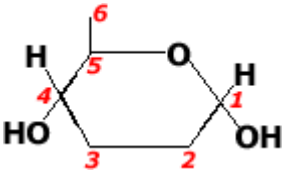
The following are examples of the most common organic molecules in living things:

Monosaccharide sugars. These are the monomers from which larger polymer molecules are constructed. Molecules like glucose and fructose are metabolically active molecules usually stored in an inactive, insoluble polysaccharide form.



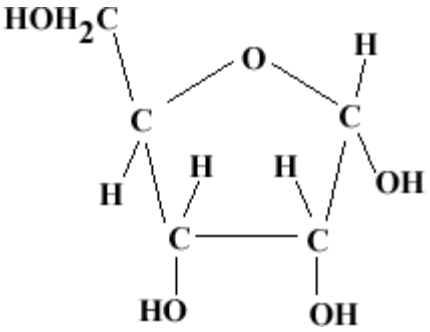
- Glucose: $C_6H_{12}O_6$ this is a hexose sugar (six carbons) most commonly found in this ring structure.
- Glucose will be known to most students as a product of photosynthesis or the substrate molecule for respiration.
- Glucose is also found in a polymer as starch, glycogen or cellulose.
- All bonds are covalent.
- Glucose is a reducing sugar and will give positive (Brick red) precipitate in a Benedicts test.
- Glucose is metabolically active compound

Glucose is soluble and has osmotic effects when in solution



This is an alternative diagram of glucose where the carbons are assumed to be at each of the corners or ends of the lines (bonds). In this image the carbons are numbered so you can compare to the diagram above. Normally such numbers would be omitted form a diagram. These shorthand diagrams allow

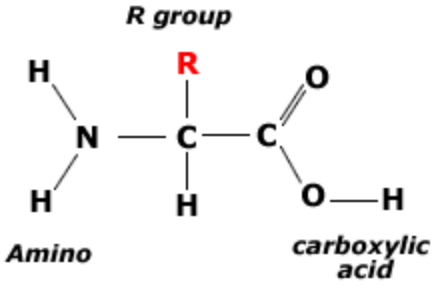
organic molecules to be drawn faster. There are examples further down the page of this type of diagram.



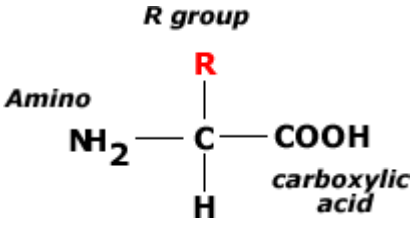
- Ribose: Pentose (5 carbon sugar).
- Ribose is part of one the important organic molecules in photosynthesis, ribulose bisphosphate. (RUBP)
- A modified version of ribose, deoxyribose is perhaps best known for its role in Deoxyribonucleic acid or DNA where it forms part of the sugar phosphate backbone. The chemical properties of deoxyribose are very different from the properties of ribulose
- Both Ribose and Glucose will attract water molecules (hydrogen bonding) to form solutions.

top

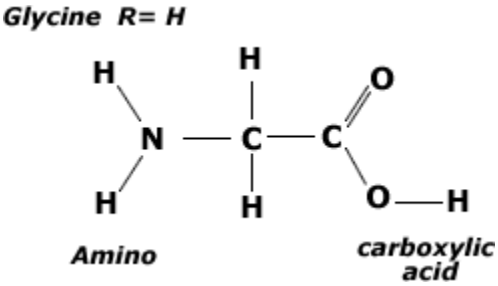
Amino Acids: There are 20 common amino acids found in the protein structures of living things. Amino acids are monomers which combine to form the larger polypeptides. In turn polypeptides combine to form proteins. Proteins molecules are the basis of enzymes and many cellular and extra cellular components.



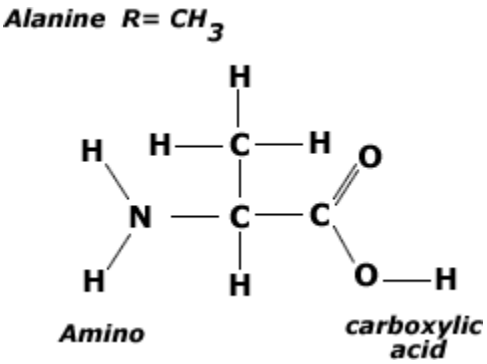
- This model shows the structure of the general amino acid. If you build one in a molecular kit you will appreciate better the 3D structure.
- Each of the common amino acids has the same structure as the one shown except that the R group is different.
- Amino acids are soluble



- This is an alternative way to draw the general amino acid structure.
- This diagram illustrates the 'amino' group which is $-NH_2$
- There is also the acidic group -COOH which ionizes in solution to form an $-COO^-$ and H^+ groups
- This acid group is known as a carboxylic acid group .



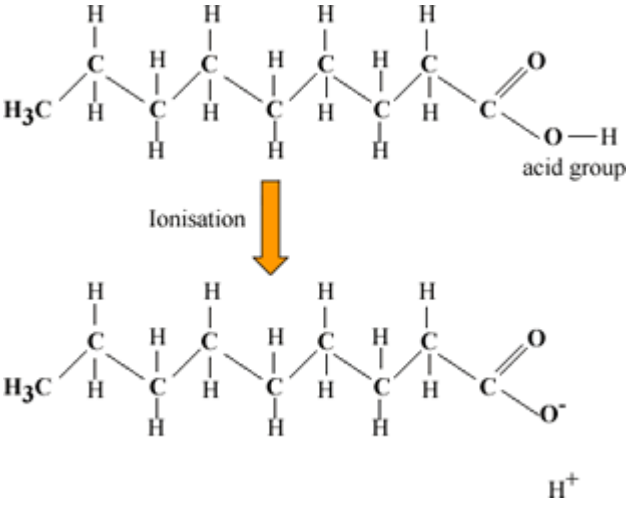
- This is an illustration of the smallest of the amino acids, Glycine.
- Notice that Glycine has an amino group, carboxylic acid group and a R group = H
- A common source of glycine is sugar cane.



- This image shows a common amino acids, Alanine
- Note the similarity in structure with glycine but this time the R group is $-CH_3$
- Students are not required to know the structure of all 20 common amino acids

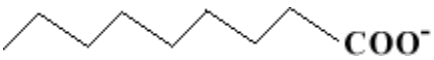
top

Fatty Acids: These molecules are the basis of triglycerides and many other types of lipid. These molecules are also the basis of the phospholipid molecules that form the bilayer of the cell membrane.

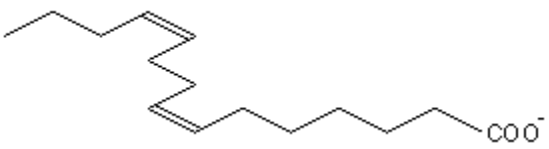


- The image shows a basic saturated (no double bonds) fatty acid.
- There is a methyl group (-CH_3) at one end of the chain.
- Chain is the formed from a series of covalently bonded carbons saturated with hydrogens.
- The chain is non-polar and hydrophobic
- The carbonyl group is polar

making this ends of the molecule hydrophilic.



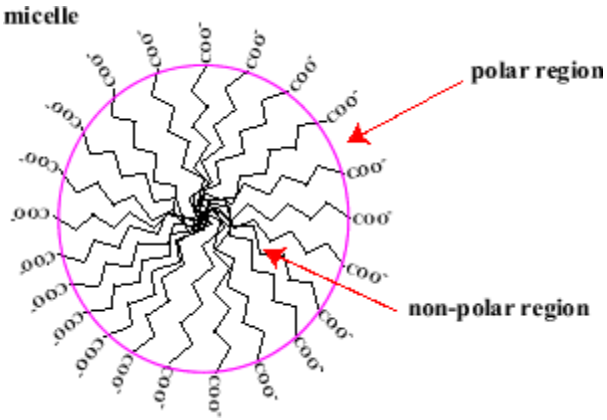
- The complex diagram of the fatty acid can be abbreviated to this simpler diagram.



- This image show the unsaturated double bond which is characteristic of animal fats.

- If there are many double bonds the fatty acid is known as polyunsaturated.

Micelle

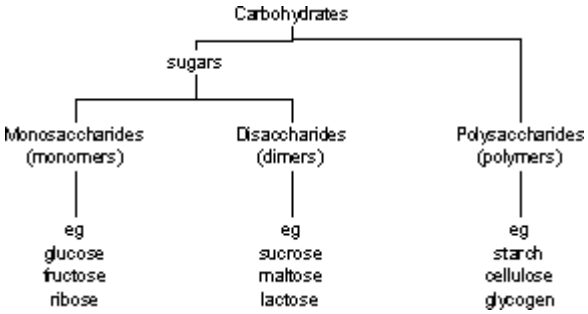


top

- In water fatty acid molecules arrange themselves into spheres called micelles.
- The polar carbonyl groups on the outside in contact with water molecules.
- The non-polar tail sections are in the centre away from water.
- This is an important aspect of fat digestion and membrane structure.

3.2.3 List three examples each of monosaccharides, disaccharides and polysaccharides(1)

List means to Give a sequence of names or other brief answers with no explanation.



Carbohydrates	Examples
Monosaccharides	Glucose, Fructose and Galactose
Disaccharides	Maltose, Lactose and Sucrose
Polysaccharides	Starch, Glycogen and Cellulose

top

3.2.4 State one function of glucose, lactose and glycogen in animals, and of fructose, sucrose and cellulose in plants(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

Carbohydrates (A-animal, P-plant)	Example	Function
Monosaccharides (A)	Glucose	Respiratory substrate
Disaccharides (A)	Lactose	Milk sugar
Polysaccahride (A)	Glycogen	Insoluble storage polymer of glucose
Monosaccharides(P)	Fructose	Fruit sugar (first discovered in fruit)
Disaccharide (P)	Sucrose	Soluble, metabolically inactive, transported in phloem sap
Polysaccharide	Cellulose	Insoluble, structural fibres of plant cell wall

3.2.6 State three functions of lipids(1).

State means to give a specific name, value or other brief answer without explanation or calculation.

Functions	Detail
Energy Storage	• Fats in animals (triglycerides) • Oils in plants
Thermal insulation	• A layer of fat beneath the skin called subcutaneous, insulates against heat loss. This type of fat is not triglyceride
Buoyancy	• Lipid are less dense than water and therefore it helps animals to float.

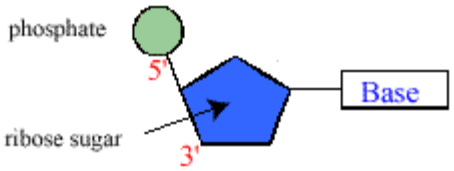
3.2.7 Compare the use of carbohydrates and lipids in energy storage(3).

Compare means to give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout.

Carbohydrates	Lipids
Carbohydrates are more easily digested than lipids so the energy stored by them can be released more rapidly	Lipids contain more energy per gram than carbohydrates. Therefore lipid is a lighter store than carbohydrates for the same amount of energy.
Carbohydrates are soluble in water and therefore easily move to and from the store.	Lipids are insoluble in water and therefore do not cause problems with osmosis in the cell.
	Generally speaking lipids require more oxygen per molecule metabolised and therefore can only be utilised at lower levels of energy demand.

3.3.1 Outline DNA nucleotide structure in terms of sugar (deoxyribose), base and phosphate(2)

Outline means to give a brief account or summary. .



- Sugar is deoxyribose which differs from ribose in having one less oxygen on carbon 2.

- Phosphate is the PO_4^{-3} group.
- Bases are nitrogen based ring structures of which there are 4 different kinds.

top

3.3.2 State the names of the four bases in DNA (1).

State means to give a specific name, value or other brief answer without explanation or calculation.

Base name	Nucleoside (s+b)	Abbreviation
Cytosine	Cytidine	C
Thymine	Thymidine	T
Adenine	Adenosine	A
Guanine	Guanosine	G

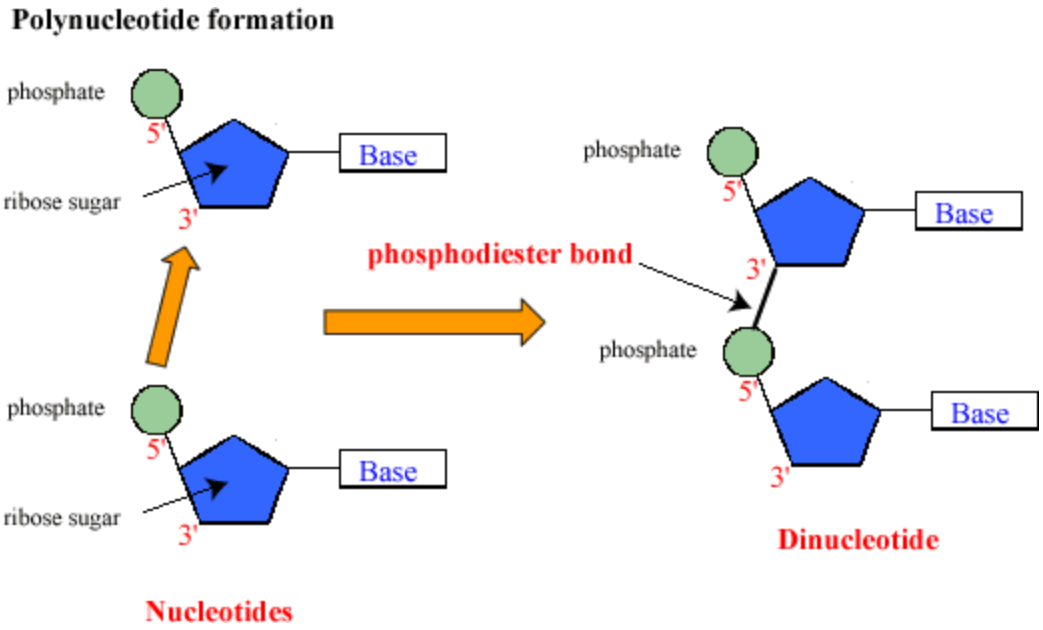
- Nucleosides are the combination of sugar and base only and are not required for the syllabus. You will however see the terms used in the literature.

- These are the four bases which are universally found in living things.
- In 1950 Edwin Chargaff determined that within an organism there was same approx the same amount of A as T and the same amount of G=C.
- Chargaff surveyed a wide variety of organsims and found in the ratio of A:T, G:C consistently across the range of his specimens
- These ratios became known as Chargaff's ratio's and would later prove to be a significant clue to the structure of DNA.

top

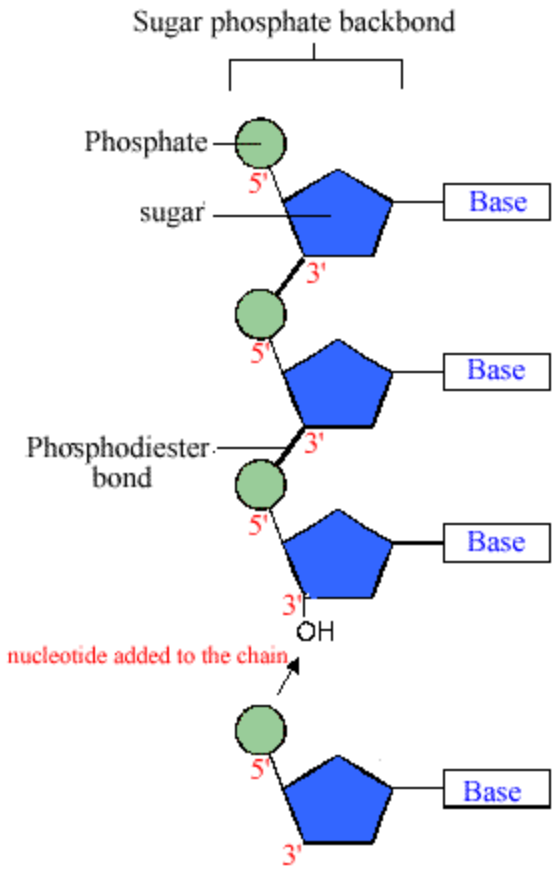
3.3.3 Outline how DNA nucleotides are linked together by covalent bonds into a single strand (2).

Outline means to give a brief summary.



- DNA is composed of two polynucleotides chains.
- Nucleotides are covalently bonded between the phosphate of one nucleotide to the C3 of the second nucleotide.
- The phosphate group creates a bridge connecting C5 on one pentose with the C3 on the next pentose.
- The bond is a phosphodiester bond which indicates that there are two covalent bonds formed between the -OH and the acidic phosphate group.

top



Polynucleotide

The image is of one polynucleotide chain.

Note:

- The sugar phosphate backbone which provides the stable backbone of one of the helices.
- Covalent bonds that link the nucleotides along the backbone of the molecule.
- The bases projecting into the centre.

- At one end there is pentose with 5' (said "five prime") carbon which is free from bonding.
- At the other end there is a 3' carbon free from bonding to other nucleotides.
- Additional nucleotides are joined to the 3' end of the existing polynucleotide chain.

top

3.3.4 Explain how a DNA double helix is formed using complementary base pairing and hydrogen bonds (3).

History:

complementary means matching, is different from complimentary, which means being nice. You may recall that in 1950 Edwin Chargaff working in Columbia University USA had determined that the mass of the bases(in a DNA speciment) formed ratios of A:T and G:C. This held true when taking samples from individuals within a population or when comparing species across large classification divides. In the cell of any organism the mass of Adenine seems to be about the same as the mass of Thymine. The mass of Cytosine seems to be about the same as the mass of Guanine.

Three years later the significance of *Chargaff's Rule* was realize by Watson and Crick at the Cavendish Laboratory in Cambridge, England. Watson an American geneticist and Crick an English physicist began model building DNA based on a collection of results from other researchers, including Chargaff. The model building technique uses the principles of chemistry such as molecular structure and bond angles as then developed by Linus Pauling. Together with the data from X-ray crystallography studies (the combined work of Wilkins and Franklin) they began to build DNA and part of that process involved the pairing of the bases in the centre of the helix.

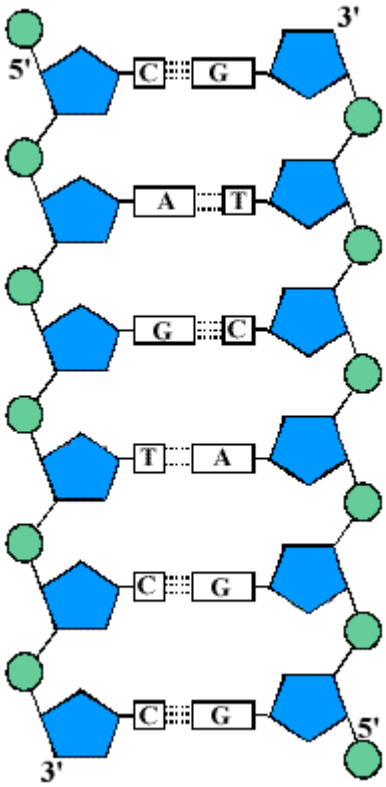
Explain means to give a detailed account of causes, reasons or mechanisms.

The molecular distance from Adenine combined with Thymine is the same as the molecular distance between Guanine combined with cytosine. This gave a uniform distance that could fill the centre of the helix.

The complementary bases are formed (A-T, G-C) when hydrogen bonded occur between the two bases in a pair.

Refer to the diagram and notes in the next section..

3.3.5 Draw and label a simple diagram of the molecular structure of DNA(1) .



Draw means to be able to represent by means of pencil lines.

This image of DNA shows the arrangement of the two polynucleotide chains but not the helical shape which can be seen in the space filled model below.

This is image shows:

- Two polynucleotide chains.
- Two anti-parallel chains. (definition).

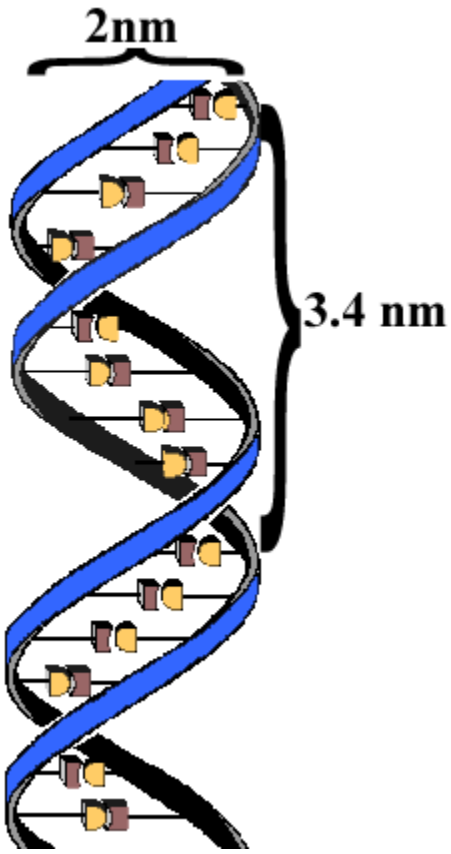
a)The number followed by the prime (') determined the carbon in deoxyribose free from bonding to another nucleotide.

b) Note that the two chains are in opposite directions 3' to 5' is parallel to 5' to 3' chain.

- The anti-parallel chains have a uniform distance (2nm) between the outside of the two sugar phosphate backbones
- Complementary base pairs: Inside the double helix bases form one strand hydrogen bond to bases on the opposite strand but always in the following way:

a) Adenine hydrogen binds to Thymine

b) Cytosine hydrogen bonds to Guanine



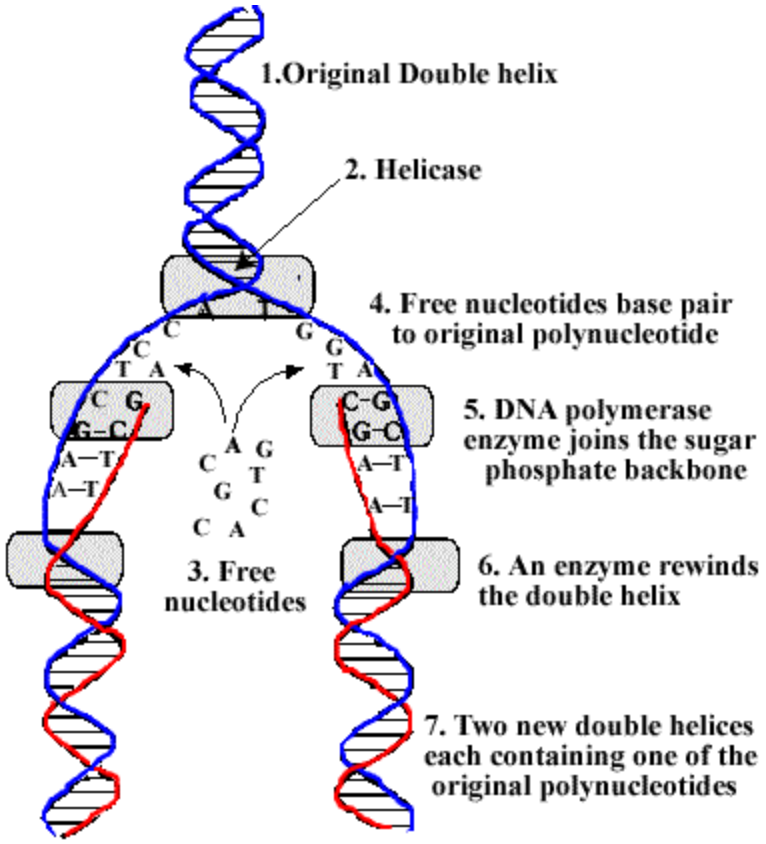
The three-dimensional structure of DNA was discovered in 1953 by Watson and Crick in Cambridge, using the experimental data of Wilkins and Franklin in London, for which work they won a Nobel prize. Ms Franklin however died before the award and the Nobel Prize is never awarded posthumously.

The main features of the structure are:

- DNA is double-stranded, so there are two polynucleotide stands alongside each other.
- The strands are antiparallel, i.e. they run in opposite directions thus 5' to 3' is parallel to 3' to 5'.
- The two strands are wound round each other to form a double helix (not a spiral, despite what some textbooks say).
- The two strands are joined together by hydrogen bonds between the bases.
- The bases therefore form base pairs, which are like rungs of a ladder.
- The base pairs are specific. A only binds to T (and T with A), and C only binds to G (and G with C).
- These are called complementary base pairs (or sometimes Watson-Crick base pairs). (A-T and G-C)
- This means that whatever the sequence of bases along one strand, the sequence of bases on the other stand must be complementary to it.

3.4.1 Explain DNA replication in terms of unwinding the double helix and separation of the strands by helicase, followed by formation of the new complementary strands by DNA polymerase.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.



1. The original double helix molecule.

2. Helicase enzyme breaks the hydrogen bonds between complementary base pairs. This unzips the double helix at a position called the replication fork.

3. There is an abundant supply of nucleotides in the nucleus for the formation of the new polynucleotides.

4. Nucleotides base pair to the bases in the original strands.

5. DNA polymerase joins together the nucleotides together with strong covalent phosphodiester bonds To form a new complementary polynucleotide strand.

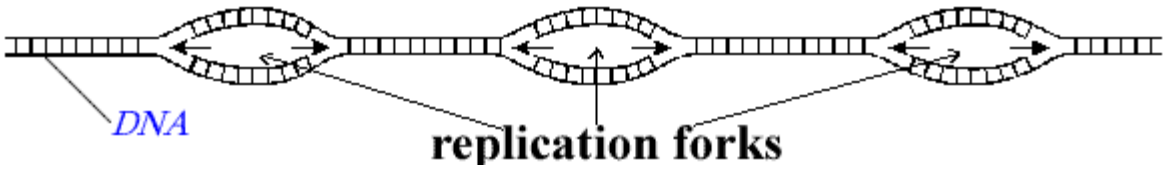
6. The double strand reforms a double helix under the influence of an enzyme.

7 Two copies of the DNA molecule form behind the replication fork. These are the new daughter chromosomes.

top

Speed of replication:

- DNA replication can take a few hours and this limits the speed of cell division.
- Bacteria can replicate quickly because of the relatively small amount of DNA.
- Eukaryotic organism's accelerate DNA replication by having thousands of replication forks along the length of the DNA molecule.



top

3.4.2 Explain the significance of complementary base pairing in the conservation of the base sequence of DNA.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.

- The significance of the mechanism outlined above is that the DNA molecule is copied precisely from one cell generation to the next.
- In a unicellular organism this means that the total genome is successfully copied into each new generation.
- In the multi-cellular organism all cells contain an exact copy of the total genome (even though not fully expressed).
- Genes (base sequences) are faithfully passed from one generation to the next.
- The genes (base sequences) which the reader possess have been passed from generation to generation until they arrived in you now. With minor and rare modification the base sequences copied by DNA replication and successfully passed on through sexual reproduction. Your base sequences have been copied for thousands of years.

3.5.1Compare the structure of RNA and DNA.(3).

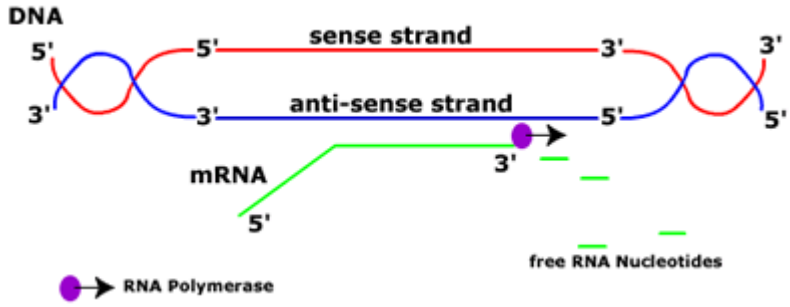
Compare means to give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout.

DNA	RNA
Deoxyribonucleic acid	Ribonucleic acid
Deoxyribose sugar C2 no oxygen	Ribose sugar C2 carries one -OH group and one -H
Two polynucleotide chains	One polynucleotide chain
Bases are ATGC	Bases are AUGC the base Uracil replaces thymine

3.5.2 Outline DNA transcription in terms of the formation of an RNA strand complementary to the DNA strand by RNA polymerase.(2).

Outline means to give a brief account or summary.

This model illustrate the process of transcription that takes place in the nucleus. The DNA base sequence of the gene is copied into messenger RNA (mRNA)



- The DNA helix is opened at the position of the gene.
- The helix is unwound by RNA polymerase

- RNA nucleotides are found in the nucleus space.
- One of the polynucleotide chains act as a template for mRNA
- Free nucleotides base pair with DNA nucleotides
- The phosphodiester bonds on the mRNA chain are formed by RNA polymerase

- mRNA is a single polynucleotide chain but the base thymine is replaced by Uracil.
- After the mRNA is complete the molecule detach's from the DNA and leaves the nucleus for the cytoplasm ribosomes.
- The DNA helix reforms.

3.5.3 Describe the genetic code in terms of codons composed of triplets of bases. (2)

Describe means to give a detailed account.

'You can treat the genetic code like a dictionary in which sixty-four words in one language (the sixty-four possible triplets of a four-letter alphabet) are mapped onto twenty-one words in another language (twenty amino acids plus a punctuation mark). The odds of arriving at the same 64:21 mapping are less than one in a million million million million million. Yet the genetic code is in fact literally identical in all animals, plants and bacteria that have ever been looked at. All living things are certainly descended from a single ancestor'

R.Dawkins, (1995),*River out of Eden*.

Well actually the code is nearly Universal. Interestingly the DNA in the mitochondria and chloroplast is slightly different in both prokaryotic and eukaryotic organisms. There are also some Protists in which UAA and UAG code for glutamine rather than acting as stop codons. The significance of these differences is as yet unclear

The genetic code:

- A polynucleotide is a sequence of bases
- Bases are either A T G or C

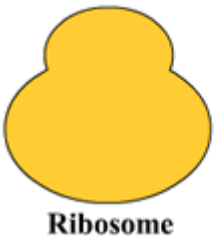
- There are 4 bases which operate in sets of 3 (a triplet).= 4^3possible triplets of DNA =64 triplets
- There are 20 common amino acids
- Therefore 64 triplets are mapped to 20 amino acids
- However there is a 'punctuation' triplets.
- Therefore the mapping of the code is 64: 21

3.5.4 Explain the process of translation, leading to polypeptide formation.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.

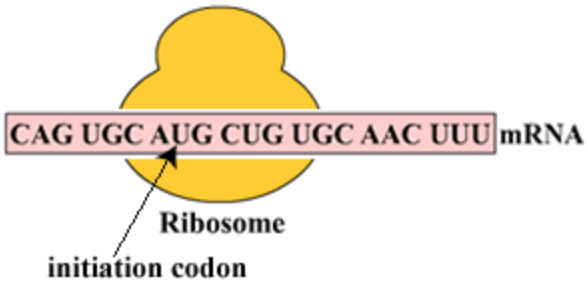
- mRNA is translated into an amino acid sequence (mapping above)

1. Location: Cytoplasm/ Ribosomes



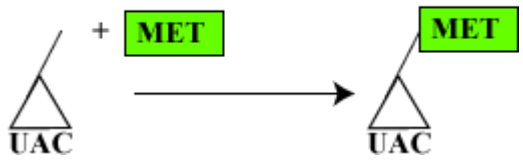
- The location of translation is the ribosomes in the cytoplasm.
- Ribosomes are also composed of RNA (rRNA) which acts as a catalyst for the translation of the mRNA.
- Free ribosomes form polypeptides (proteins) for internal cell use.
- Ribosomes on the endoplasmic reticulum synthesis proteins for secretion.

2. Location: Cytoplasm/ Ribosomes



- mRNA from the nucleus locates onto the ribosome.
- The start codon (initiation codon) AUG occupies one of two rib some site.
- In this image the second site is occupied by CUG codon.
- The ribosome moves along the mRNA
- One mRNA can have many ribosomes (polysome) which accelerates protein synthesis.

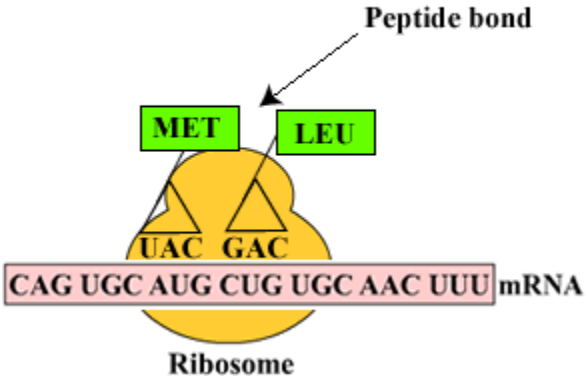
3. Activation



Activation is a process in which Transfer RNA (tRNA) molecules attach to specific amino acids.

- The tRNA molecule an anti-codon, three bases that are complementary to the codons on mRNA.
- In heterotrophs the amino acids for activation come form consumed protein in the diet.

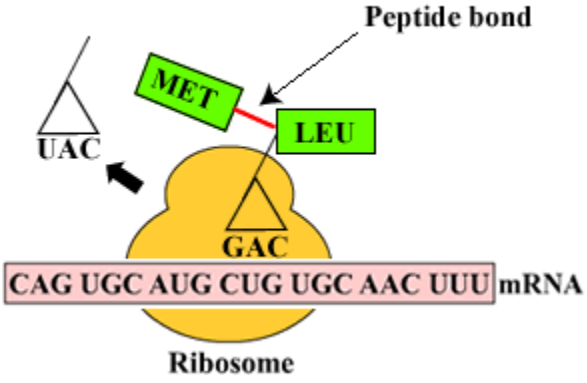
4. Codon-anticodon binding



antiparallel

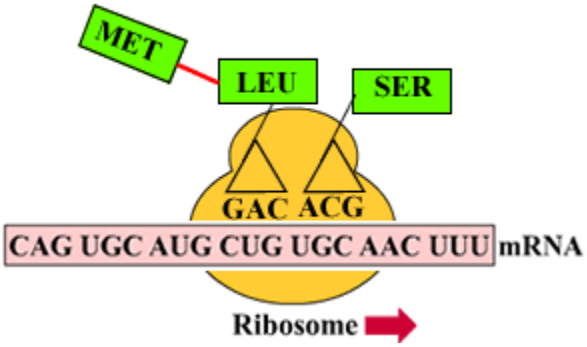
- The first codon (AUG) bonds to the tRNA anti-codon UAC.
- This tRNA carried the amino acid Methionine.
- The second tRNA (GAC) binds to the second site with mRNA codon CUG
- The second tRNA carried the amino acid Leucine.
- Note that codon-anticodon binding is

5. Peptide bond formation



- The link between the tRNA and the amino acid Methionine is broken.
- The bond energy is transferred to form a peptide bond between methionine and Leucine.
- The first tRNA is released form the ribosome first site.
- This tRNA molecule moves away to pick up more methionine.

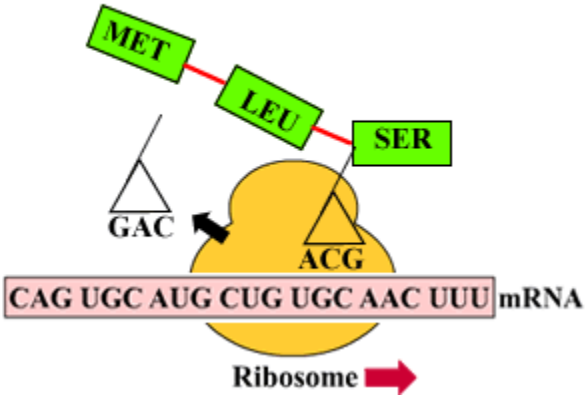
6. Ribosome movement



ribosome.

- The ribosome move one mRNA codon to the right (in this image).
- mRNA now occupied site one on the ribosome
- The mRNA codon is UGC which has the complementary tRNA of ACG and is charged with Serine.
- This occupied site site on the

7. Polypeptide formation



- The bond between tRNA and Leucine is broken.
- The bond energy is transferred to form a peptide bond between Leucine and Serine.
- The tRNA for leucine is released form site one.
- Then ribosome shift to the right and the process repeats itself until the stop codon is encountered.
- As the amino acid chain is built the polypeptide self assembles into the correct shape. It essentially folds up due to intra-molecular forces such as hydrogen bonds.

3.5.5 Discuss the relationship between one gene and one polypeptide.(3)

Discuss means to Give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.

Theory: One gene is transcribed and translated to produce one polypeptide.

Some proteins are composed of a number of polypeptides and in this theory each polypeptide has its own gene.

e.g. haemoglobin is composed of 4 polypeptides (2 of each type) and there is a gene for each type of polypeptide.

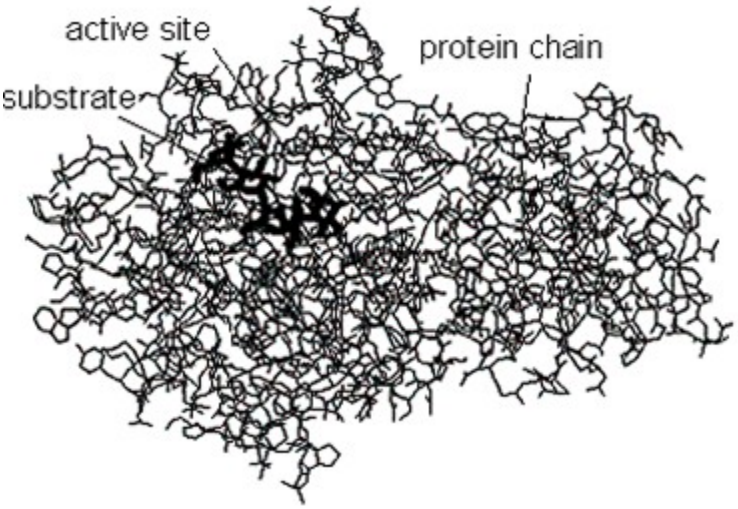
This theory, like so many in biology has exceptions. e.g.

1) Some genes code for types of RNA which do not produce polypeptides.

2) Some genes control the expression of other genes.

3.6.1 Define enzyme and active site.(1)

Define means to give the precise meaning of a word, phrase or physical quantity.

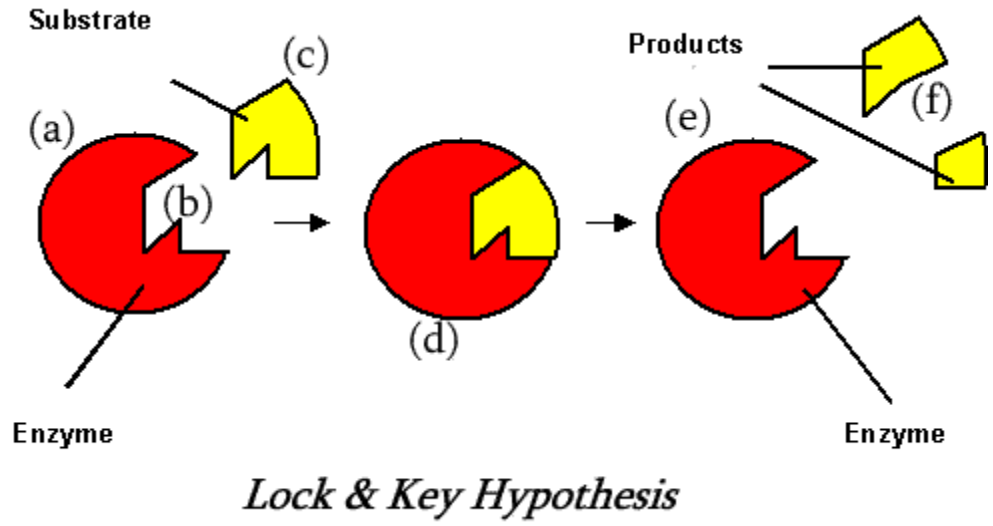


- globular proteins
- catalysts which speed up biological reactions
- unchanged by the reaction
- specific to their substrate
- **active site is the position on the enzyme occupied by the substrate**
- affected by temperature and pH

top

3.6.2 Explain enzyme–substrate specificity. (3)

Explain means to give a detailed account of causes, reasons or mechanisms.



Lock & Key Hypothesis

a) Large globular protein enzyme

b) Active Site where the substrate combines to the enzyme

c)Substrate which fits the active site

d) Activated complex. The substrate is weakened to allow the reaction.

e)Unchanged enzyme/ re-used at low concentrations

f) Product of the reaction

other keypoints from the hypothesis:

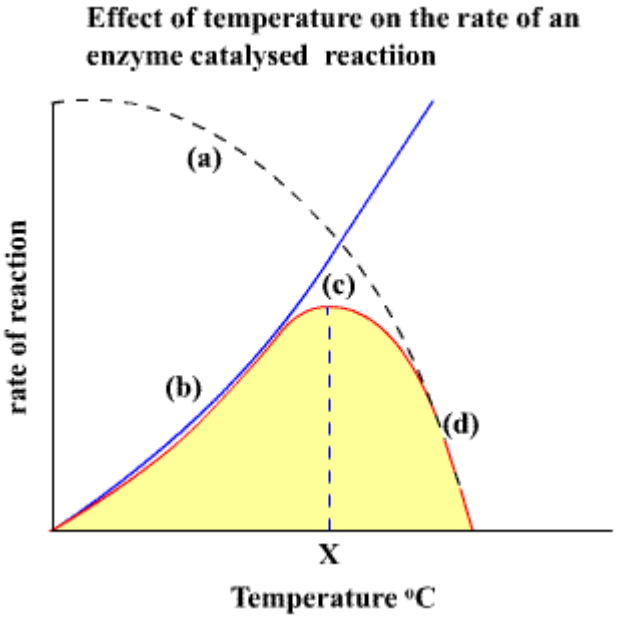
- The active site is often composed of open loops of polar amino acids on the exterior of the enzyme molecule.
- **Enzyme specificity** is due to the complementary shape of the active site and the substrate.
- Enzymes work at low concentrations because they are unaffected by the reaction and can return for more substrate.

top

3.6.3 Explain the effects of temperature, pH and substrate concentration on enzyme activity.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.

Effect of temperature on the rate of an enzyme catalysed reaction:

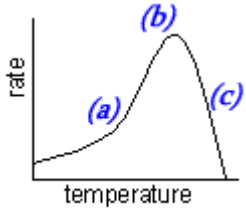


(a) As the temperature increases enzyme stability decreases. The kinetic energy of the enzyme atoms increases causing vibrations in the enzyme molecule that lead to the hydrogen bonds to breaking, shape changes in the active site.

(b) As the temperature increases the kinetic energy of the substrate and enzyme molecules also increases. Therefore more collisions of the substrate with the active site and the formation of activated complex's and product. The rate of reaction is increasing.

(c) The optimal temperature (X) is the highest rate of reaction. Compromise between decreasing enzyme stability and kinetic energy of the reactants.

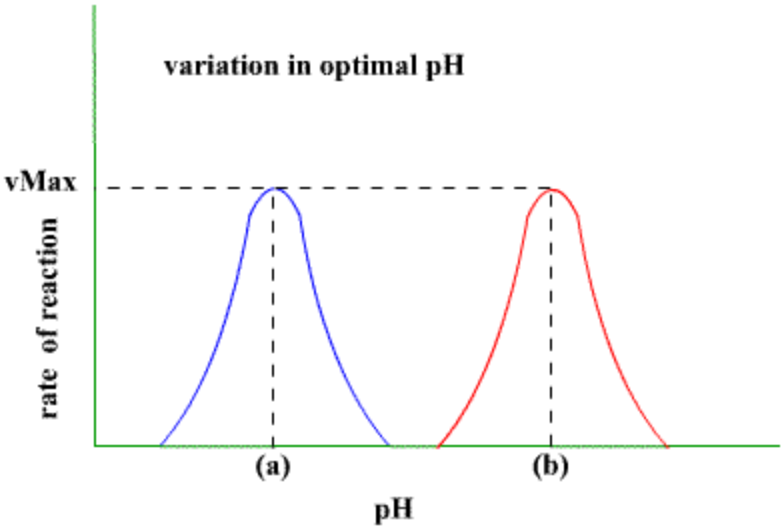
(d) Higher temperature increases the kinetic energy of the enzyme atoms so much that they break bonds, change shape of the active site.



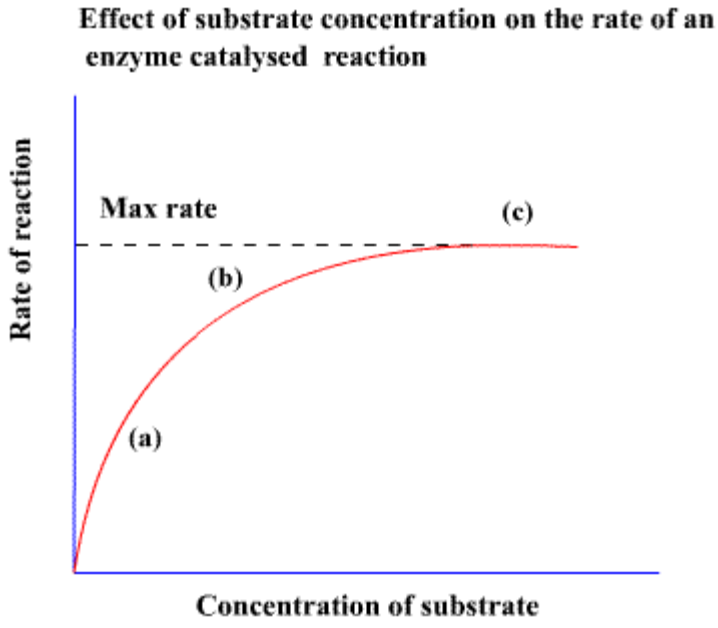
The main diagram is often simplified to this diagram which still shows the three key stages in the reaction.

top

The effect of pH on the rate of an enzyme catalysed reaction:



- pH also affects the rate of reaction of an enzyme catalysed reaction.
- At the optimal pH (a) or (b) the maximum rate of reaction is achieved.
- Above or below the optimal pH the rate decreases.
- The change in rate is because bonds are made and broken which change the shape of the active site and therefore decrease the rate of reaction.
- The two enzyme shown in the image illustrate the fact that different enzymes can have very different optimal pH.
- e.g. Blue curve = pepsin (a)= pH3, Red curve =salivary amylase (b)= pH 7.2



Effect of substrate concentration on the rate of an enzyme catalysed reaction:

(a) As the substate concentration is increased the rate of reaction increases.

There are more collisions between the substrate and the enzyme such that more activated complex's are formed and therefore product per unit time.

(b) Further increases in substrate also increase the rate but proportionately less than previously.

The number of occupied active site is increasing and there is competition for the active site.

(c) The rate is constant.

The enzyme active site is fully saturated with substrate such that adding more substrate does not increase the rate of reaction. The enzymes molecules are fully occupied converting substrate to product and any substrate must await a free active site before conversion to product.

top

3.6.4 Define denaturation.(1)

Define means to give the precise meaning of a word, phrase or physical quantity.

Denaturation is a structural change in a protein that results in the loss (usually permanent) of its biological properties.

Temperature:(see section 3.6.3)

- Temperature rises cause the average kinetic energy of the enzyme atoms to increase.
- This vibration breaks the weakest bonds first, which in the enzyme are the hydrogen bonds.
- The breaking of bonds, changes the shape of the enzyme.
- Change the shape of the enzyme changes the shape of the active site.
- Change the shape of the active site prevents substrate from entering.
- The rate of reaction reduces or stops.

pH: (see section 3.6.3)

- At pH lower than the optimal pH the concentration of H^+ in the solution will be higher than normal.
- The hydrogens will tend to be attracted to electronegative regions of the enzyme protein.

- Bonds are formed or changed as a consequence of the additional H^+ which changes the shape of the enzyme molecule.
- Changes in shape, change the active site shape.
- Changes in active site shape reduces the ability of the substrate to bind with the active site.
- This reduces the rate of reaction that changes substrate to product.
- The rate of reaction reduces.
- For pH values above the optimum breaks bonds in the same way and have the same reductions in the rate of reaction

top

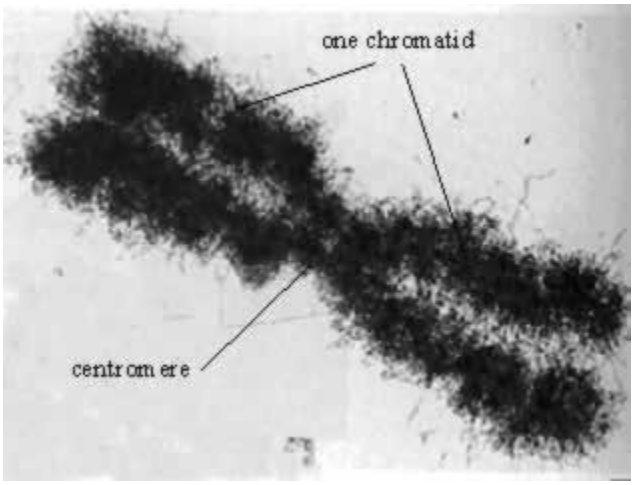
3.6.5 Explain the use of lactase in the production of lactose-free milk.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.

- Lactose is a disaccharide (glucose + Galactose) milk sugar
- Around **90%** of all humans show some kind of lactose intolerance.
- People who are lactose intolerant can drink milk if it is lactose free.
- Lact**ase** is an enzyme extracted from yeast that can digest the milk sugar to glucose and galactose.

4.1.1 State that eukaryote chromosomes are made of DNA and proteins.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.



- The chromosome is composed of two main molecules.

a) DNA

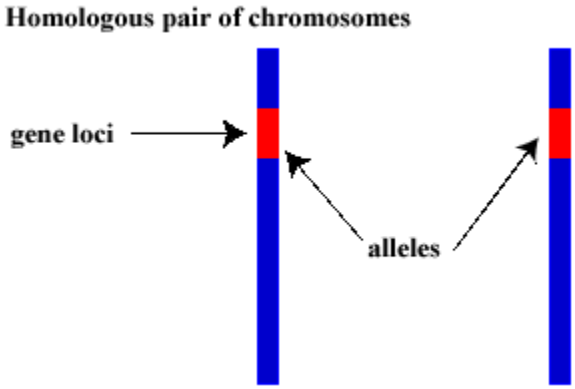
b) Proteins called histones.

- This image was taken shortly after DNA a replication but before the prophase. It is composed of two daughter chromatids joined at the centromere.
- The chromosome is super coiled by a factor around x16,000. The DNA molecule is about 1.8m long but is located in the nucleus which is only 10um in diameter!

top

4.1.2 Define gene, allele and genome. (1)

Define means to give the precise meaning of a word, phrase or physical quantity.

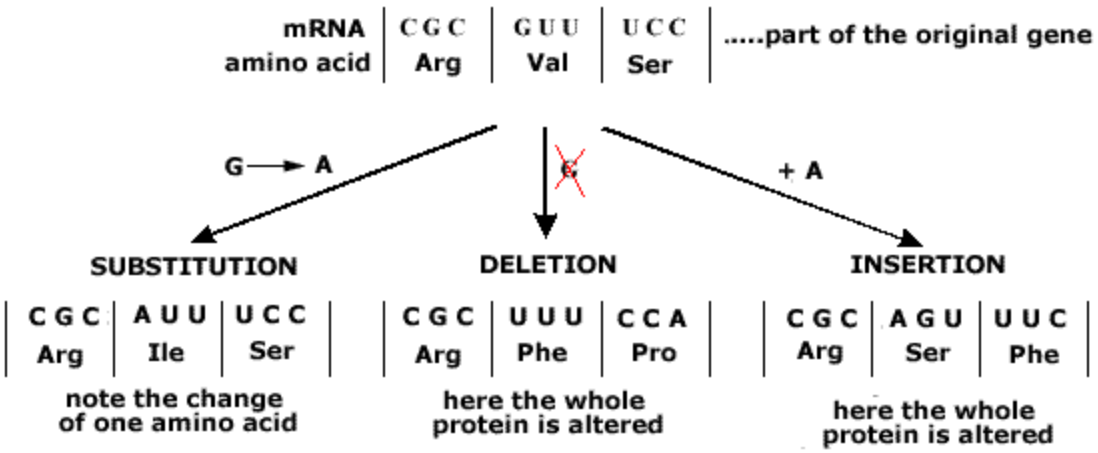


- Gene:a heritable factor that controls a specific characteristic.
- Allele: one specific form of a gene, differing form other alleles by one or a few bases only and occupying the same gene locus as other alleles of that gene.
- Genome: the whole genetic information of the organism.

4.1.3 Define gene mutation. (1)

Define means to give the precise meaning of a word, phrase or physical quantity.

- Gene mutation is a change in the base sequence of an allele.
- The changed base sequence may produce a different amino acid sequence in the protein translated.
- The changed base sequence may not change the protein because of the degenerate nature of the genetic code.
- The expression of the mutated gene may or may not be beneficial to the organism.
- Substances that cause mutation are called mutagens and include chemicals and radiation.



Mutation was coined by Hugo de Vries a dutch researcher who at the time was testing the work of mendel. His research at the begriming of the 20th Century even suggested that sudden changes in gene might explain an evolutionary 'jumping' mechanisms rather than the gradual mechanisms suggested by Darwinism. Subsequently it has been shown that the plant that de Vries was working on has unusual genetic behaviour.

Mutations are not rare, even as you read these pages you are accumulating thousands of mutations and if you are male the mutation rate is even higher. Most mutations will not improve condition but just occasionally against all the odds this is the case. Mutation of course creates the raw material for the process of evolution. Cellular machinery acts against mutation with the presence of all sort of enzymes that correct the frequent errors. Nevertheless look around you and take in the diversity of life, at any level you care to consider the cause of this variation is mutation.

The production of mutation is in its self a series of random mistakes. Mutagens are the cause of mutations, radiation is a well know examples but there is also chemical-mutagenesis as discovered by Charlotte Albach. As mentioned the mutation is random and not directional, an animal exposed to a cold environment is just as likely to produce mutations which have advantages in warm climates as it is to a cold climate but it is even more likely to produce a mutation that has nothing to do with climate.

That said the rate of mutation is balance between the environmental mutagen attaching the genome and the corrective mechanisms such as the polymerase enzymes or corrective DNA enzymes. But why does mutation occur at all? Or for that matter why is the rate not very very high? The answer is not clear but perhaps the rate of mutation is a consequence of evolution itself. No mutation would result in an inflexible genome incapable of responding (as a gene pool) to the environmental changes of time. Too much mutation would render the organsims largely non functional and compromise its survival. The 'allowed' rate provides sufficient variation to respond to environmental change whilst not compromising the integrity of the organisms physiology. An interesting discover which in directly support this view is the discovery that some bacteria

- A mutation story

top

4.1.4 Explain the consequence of a base substitution mutation in relation to the processes of transcription and translation, using the example of sickle-cell anemia.(3)

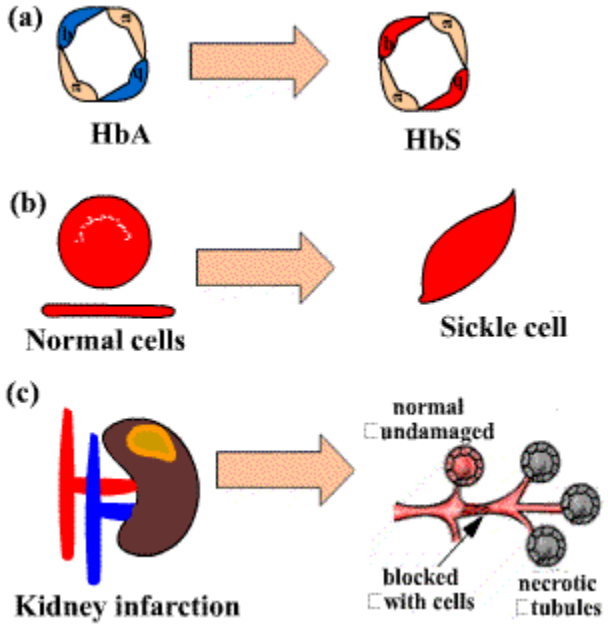
Explain means to give a detailed account of causes, reasons or mechanisms.

Sickle cell anaemia is a genetic disease.

Frequency ia about 1 in 655 African Americans

The disease is inherited not contracted by infectious routes.

Sickle cell anaemia at the tissue level:



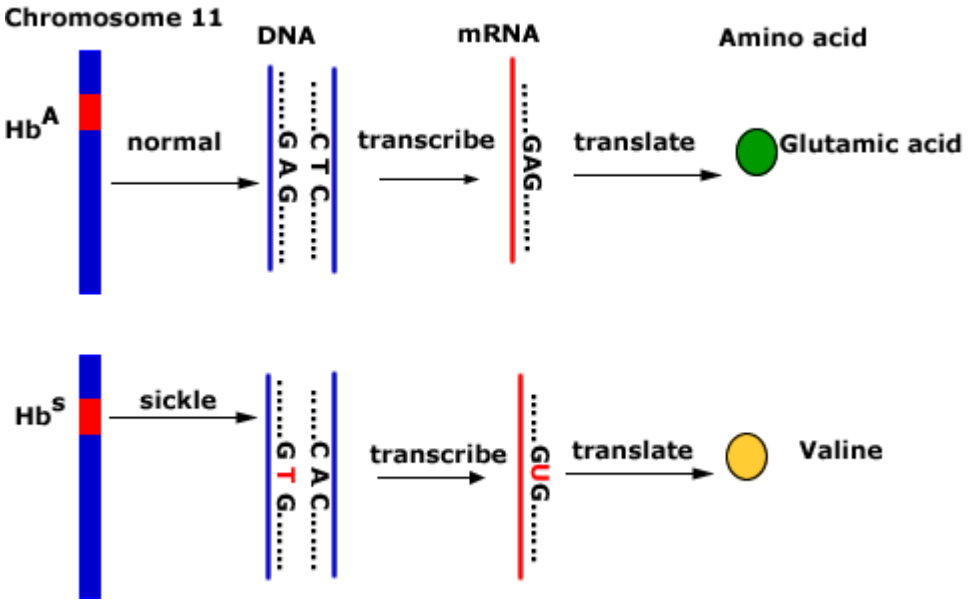
(a) Normal haemoglobin has two of four proteins changed in the mutation.

(b) The normal biconcave disc shape of the red blood cell is changed to a 'sickle' shape.

(c) In addition to not carrying oxygen correctly (anaemia) the cells also causes local clots (infarctions) such as is shown in the kidney tubules. This leads to necrosis (death) of the tubules, kidney damage, kidney failure and possible to death.

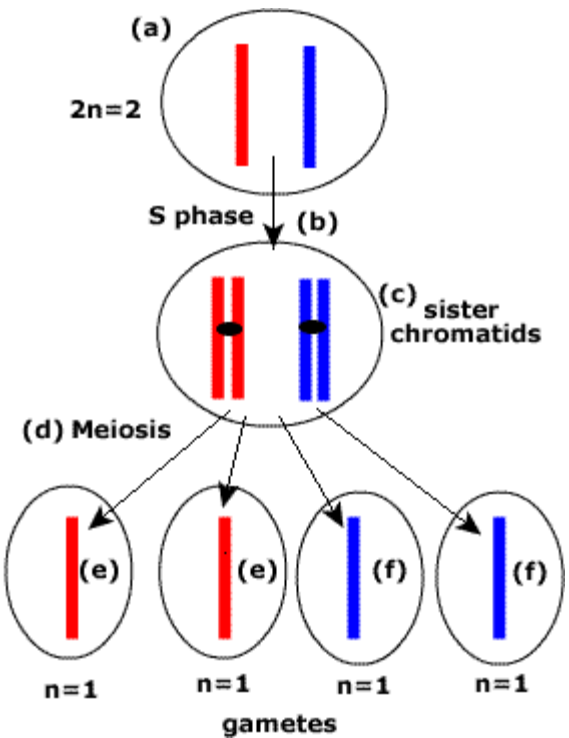
top

Genetics of Sickle Cell.



The gene locus for the normal beta chain of haemoglobin is on chromosome 11.

- The normal allele carried the triplet GAG at the sixth amino acid position for the beta chain (146 amino acids).
- This transcribed and translates into the negatively charged Glutamic acid.
- The mutation changes a single base (T replaces A) and this transcribes and translates into the amino acid Valine.
- Valine has a neutral charge and the result is a change in the shape of the beta chain with long needle like structures forming.
- This gene is noted for many mutations and it is estimated that some 5% of humans carry one or other variants.



.2.1 State that meiosis is a reduction division of a diploid nucleus to form haploid nuclei.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

Meiosis is a reduction division of a diploid nucleus(2n) to form a haploid nucleus (n).

For clarity the nuclear membrane has been omitted from the diagram.

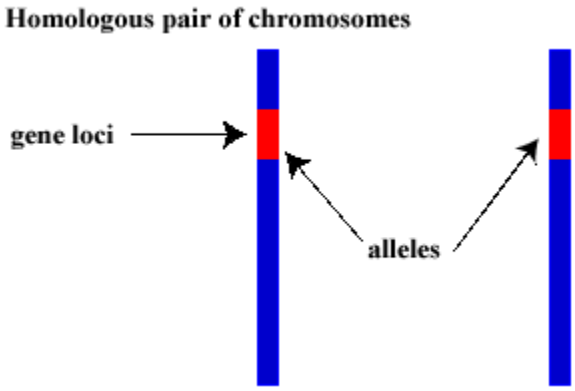
- (a) The cell is in G1 of the interphase and has a total of 2 chromosomes, 2n=2.
- (b) The S phase of the interphase is DNA replication.
- (c) In G2 of the interphase the cell has two daughter chromatids per chromosome, the cell mass of DNA has doubled.
- (d) Meiosis occurs in a series of phases similar to mitosis ut with significant differences.
- (e) The diploid cell has divided to form haploid gamete cells (n=1).
- (f) The homologous pair of chromosomes has been separated (red from blue).

One diploid cell which undergoes meiosis produces four haploid gametic cells.

top

4.2.2 Define homologous chromosomes. (1)

Define means to give the precise meaning of a word, phrase or physical quantity.



- Homologous chromosomes form pairs within the nucleus and during cell division.
- The name suggest that both members of the pair share certain structural characteristics.
- They are the same length of chromosomes.
- They have the same shape of chromosomes.
- They carry the same genes in the same gene loci.
- The forms of the gene found on the homologous pairs are the alleles of the gene that an individual may posses. Note that for every gene there are normally two alleles in the individual.

top

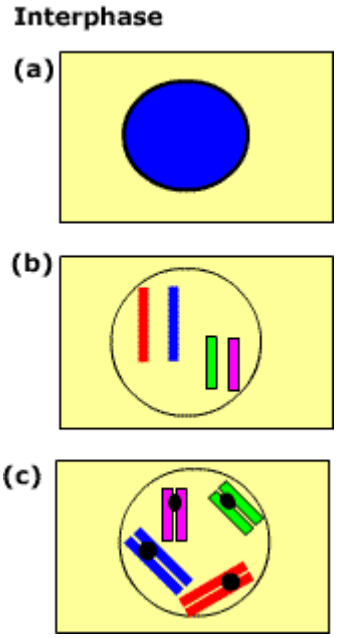
4.2.3 Outline the process of meiosis, including pairing of homologous chromosomes and crossing over, followed by two divisions, which results in four haploid cells. (2)

Outline means to give a brief account or summary.

Meiosis is a form of cell division that produces gametes. It takes place in the reproductive organs and shows variation in how long the process occurs. Although meiosis can produce millions of gametes in a short period of time in comparison to mitosis in the body it is relatively rare.

The stages of meiosis are shown below but begins with some diagrams about Interphase as a reminder. In the diagrams homologous pairs are shown in different colours ((red with blue), (purple with green)). The organism shown is an animal cell with a diploid number (2n)= 4. Therefore we expect to see four gametes each with a haploid number (n) =2.

Meiosis I: This is the first of two sets of divisions. In meiosis one the prophase, metaphase, anaphase and telophase will divide the cell into two and separate the homologous pairs. This is perhaps the most significant step in terms of genetics.



Interphase:

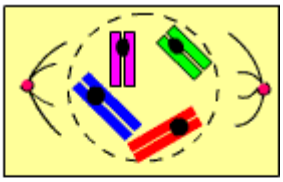
(a) The nuclear membrane is intact and the chromosomes inside cannot be seen. At this stage the chromosomes are not greatly coiled or condensed which allows genes to be expressed. Each DNA molecule is about 1.8m long but still wound sufficiently such that it can be contained inside a 10um nucleus.

(b) In the G1 stage of the Interphase each chromosome is a single DNA molecule (+histones). Here we can see (although in-reality you cannot since the nucleus is intact) that there are four chromosomes and the diploid number of the cell is 2n=4. Red and blue are a homologous pair as are green and purple.

(c) In S1 of the interphase the DNA molecules replicate. Each copy (sister chromatids) are held together at the centromere (black dot). The cell is now preparing for the meiotic division in which:
Chromosome number will be halved and the Homologous chromosomes will be separated

Prophase I

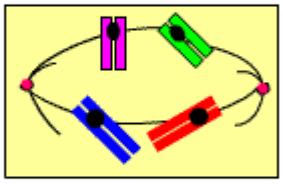
(d)



(d):Early prophase, the nuclear membrane is breaking down.

The spindle of microtubules is forming from opposite ends of the cell.

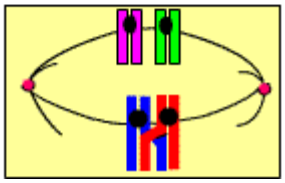
(e)



Centrioles organise the spindle construction at the poles of the cell.

(e) The pairs of sister chromatids attach to the spindle microtubules at the centromere.

(f)



The DNA is condensing by super coiling, this will reach it peak in the metaphase.

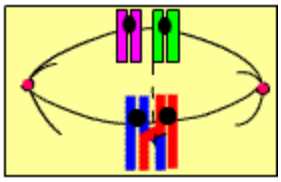
(f) The pairs of chromatids will move up and down the between the poles but gradually move towards the equatorial plate (centre) of the cell.

The nucleus has now disappeared and the chromosomes are dense enough to be seen with a light microscope. Note that the red and blue homologous pair are 'crossing over' , see metaphase for details.

Prophase is the longest of the meiotic phases of cell division. In humans the process of meiosis in the testes can take up to a month form the diploid cell to the mature sperms cell. In human females the process begins as a foetus whilst still in the uterus but does not complete until the instance of fertilisation many years later.

Metaphase I

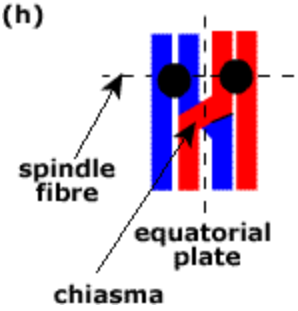
(g)



(g) The metaphase is marked by **all** pairs of sister chromatids aligned on the equator.

The chromosomes are at their most condensed and therefore most visible at the metaphase.

(h)



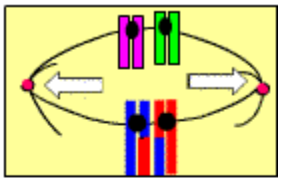
(h) Cross-over. Notice that the chromosome of one homologous chromosome is exchanging with the chromosome of the parallel non-sister chromosome.

Cross-over is the exchange of genetic material between non-sister chromatids during Prophase I but is most readily seen during the metaphase.

The point at which the chromosomes exchange genetic information is called the **chiasma.** This may occur many times along a chromosome and not just once as shown in the diagram.

Anaphase I

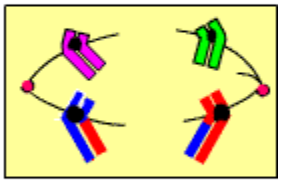
(i)



(i) Early anaphase with the homologous pairs are aligned together on the equatorial plate of the cell

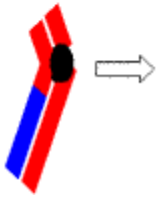
The spindle microtubules contract and pull the homologous pairs (alleles) apart.

(j)



The homologous pairs separate one to either pole. This is the case with all homologous pairs.

(k)



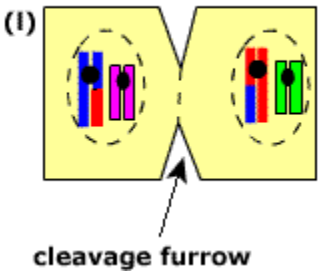
(j) Late anaphase the pairs of chromatids are moving to the poles.

Notice that there has been an exchange of genetic material on the 'arm' of the red and blue homologous pair.

New combinations of genes are not found on the same chromosome.

(K) Illustrates how to identify anaphase by the 'arrow' shape make by the pair of sister chromatids points towards the poles.

Telophase I



(l) chromosomes are now in two sets at opposite ends of the cell.

Each set contains one from each of the homologous pairs.

In some species a nuclear membrane may form, in others there is a progression straight into Prophase II.

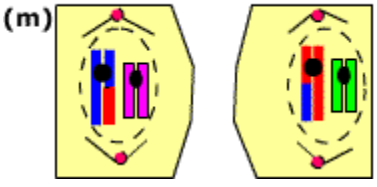
The cell membrane 'pinches' towards the centre in a 'cleavage furrow' the membrane will fuse at a central point and the cell will have divided in half.

This marks the end of meiosis one (reduction division) in which the homologous pairs have been separated.

top

Meiosis II: involves the separation of the sister chromatids and looks very like mitosis.

Prophase II



(m) The nuclear membrane breaks down if present.

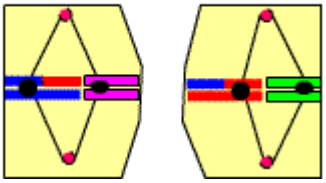
Spindles reform (shown here in the vertical plane only to distinguish from the diagrams above).

Centrioles begin the organisation of the spindle microtubules.

Pairs of sister chromatids will attach one to each spindle microtubule set.

Metaphase II

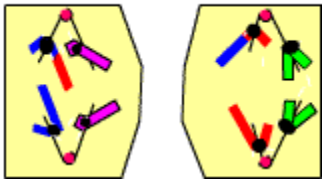
(n)



(n) All Pairs of sister chromatids aligned on the equatorial plate of the cell.

Anaphase II

(o)

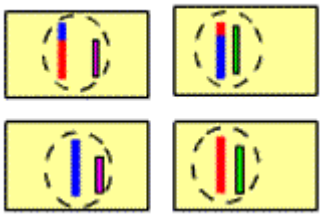


(o) The spindle fibres contract and the pairs of sister chromatids separate.

Each pole receives one of the chromosomes (one chromatid).

Telophase II

(p)



(p) Nuclear membranes form around each of the **tetrad** of haploid game cells.

Notice that each cell contains two chromosomes n=2 (haploid).

Notice that the homologous pairs are separated (no red with blue, no purple with green)

There are some unusual chromosomes with exchanged genetic material due to cross-over.

top

Non-syllabus information:

Fertilisation = n + n = 2n

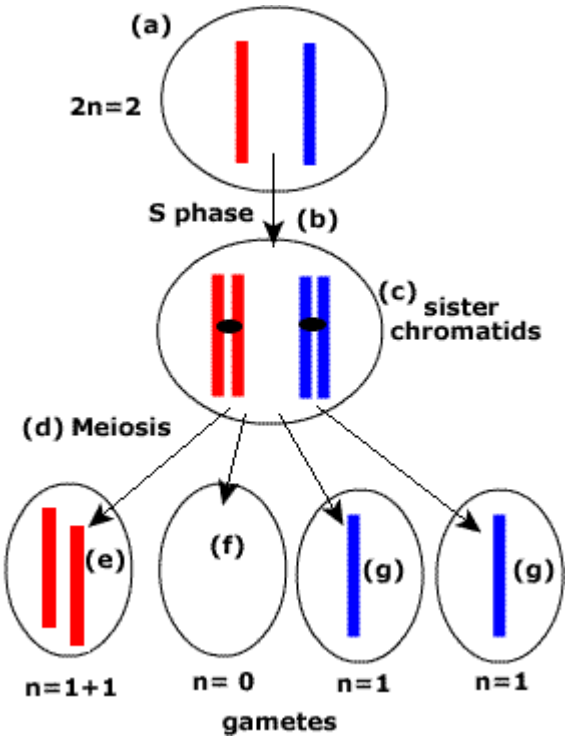
Two cells (from meiosis) one the female (egg) the other the male sperm (n) will join together their sets of chromosomes to form a new complete diploid set, this is called fertilisation.

The diploid offspring are genetically unique and show differences to other individuals both their parents, siblings and others in the population. The members of a population show differences (variation) for a given characteristic. This is the basis of one of the remarkable contributions of Charles Darwin to biology, *population thinking* , which is to say that a population shows variation. Of course Darwin new little of the details of meiosis.

4.2.4 Explain that non-disjunction can lead to changes in chromosome number, illustrated by reference to Down syndrome (trisomy 21). Objective level (3)

Explain means to give a detailed account of causes, reasons or mechanisms.

Non-disjunction is an error in meiosis produce cells with unusual combinations of chromosomes.



(a) This is the diploid parental cell (2n=2)

(b) S-phase involves DNA replication during the interphase.

(c) Pairs of sister chromatids are formed during the interphase

(d) meiosis should separate; i) Homologous pairs ii) sister chromatids, so that each cell contains one chromosome (in this example).

(e) Has an extra red chromosome so that sister chromatids have failed to separate during meiosis II. This games has one extra chromosomes

(f) This gamete has one less chromosome that it should have (none in this case).

(g) These gametes are normal

Non-disjunction can also occur during meiosis I in which case all the tetrad are affected.

top

Example: **Downs Syndrome**

Trisomy 21: An individual with Down's syndrome has three copies of chromosome 21.

During meiosis the sister chromatids have not been separated (non-disjunction) so that the gamete has had 24 chromosomes (23 + i extra chromosome number 21).

At fertilisation when the chromosomes form new homologous pairs the 21stpair actually is a triplet.

The image to the left shows a set of human chromosomes in their homologous pairs.

Chromosome 21 shows trisomy.

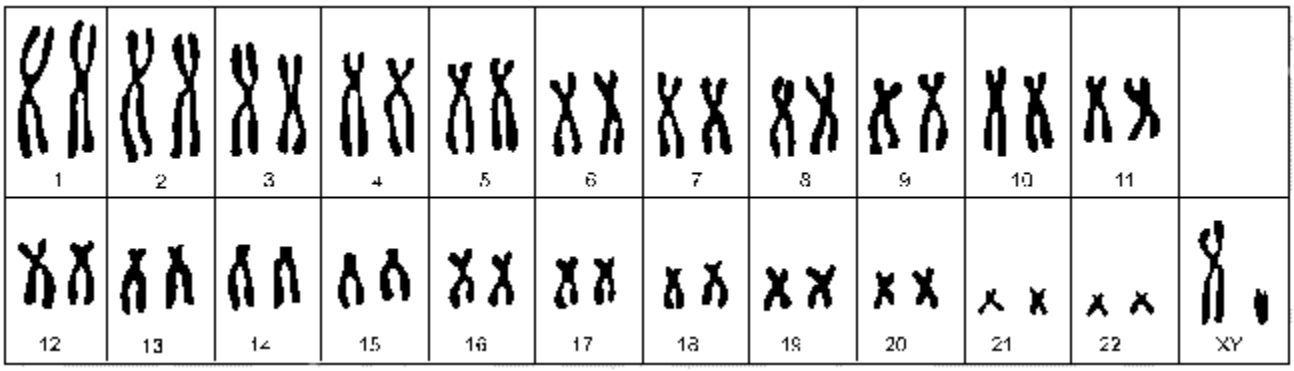
Down's is called a syndrome because it shows wide variation in the symptoms and signs of the condition. Individuals can experience learning and social problems along with additional physiological abnormalities. That said, I have personally met an individual with Down's syndrome so mild that they had passed many public examinations. As always we must be ever so careful to jump top conclusions about assigning labels to individuals.

top

4.2.5 State that, in karyotyping, chromosomes are arranged in pairs according to their size and structure.(1).

State measn to give a specific name, value or other brief answer without explanation or calculation.

- Pictures can be taken of the human chromosomes during the metaphase.
- They can then be arranged into pairs on the basis of size and structure.



- The chromosomes appear as pairs of sister chromatids.
- There are 23 pairs (46 chromosomes) therefore this is human
- In this case the 23rdpair in this case are one long pair of chromatids (X-chromosome) and one very short (Y chromosome).
- This is a male human.
- There is no visible chromosomal abnormality.

4.3.1 Define genotype, phenotype, dominant allele, recessive allele, codominant alleles, locus, homozygous, heterozygous, carrier and test cross.(1)

Define means to give the precise meaning of a word, phrase or physical quantity.

Genotype	the alleles possessed by an organism
Phenotype	the characteristics of an organism
Dominant allele	an allele that has the same effect on the phenotype whether it is present in the homozygous or the heterozygous state
Recessive allele	an allele that only has an effect on the phenotype when present in the homozygous state.
Codominant allele	pairs of alleles that both affect the phenotype when present in the heterozygous state.
Locus	the particular position on homologous chromosomes of a gene.
Homozygous	having two identical alleles
Heterozygous	having two different alleles
Carrier	an individual that has a recessive allele of a gene that does not have an effect on their phenotype
Test Cross	testing a suspected heterozygote by crossing it with a known homozygous recessive

top

4.3.2 Determine the genotypes and phenotypes of the offspring of a monohybrid cross using a Punnett grid.(3)

Determine means to find the only possible answer.

It is possible using genetic crosses to determine the genotype and phenotype of the offspring. The method used is called the Punnett square which is a simple grid which allows the genotypes and phenotypes to be determined methodically.

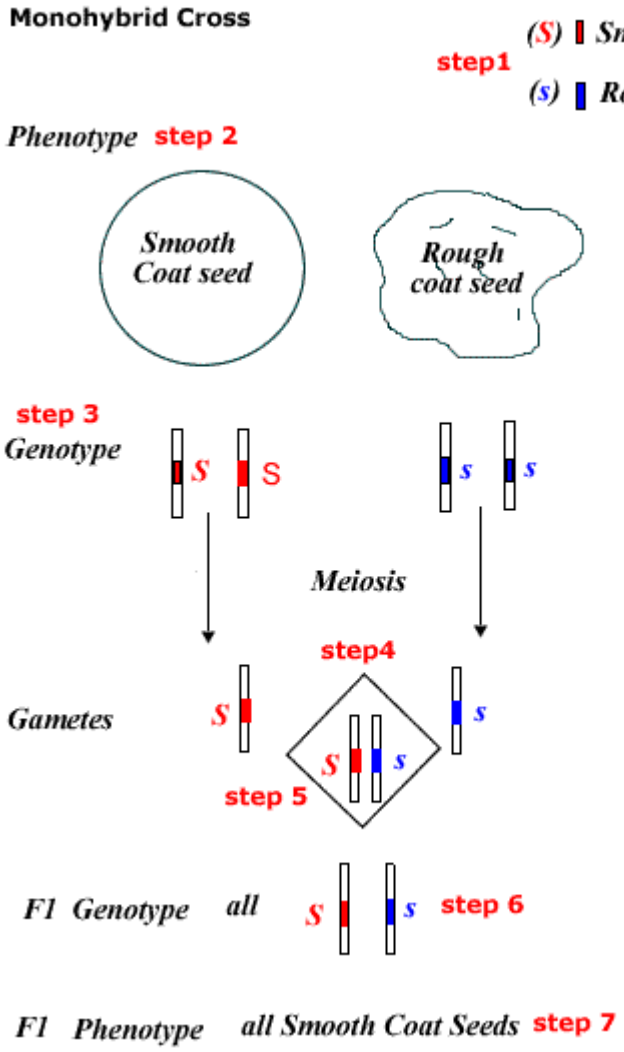
When you begin genetic crosses it is worth writing out in full the calculation and only later start to abbreviate your calculations. This may seem very time consuming but it will prepare you properly for the questions asked in the examination.

In the following example a very long hand form is used that includes images of chromosomes and alleles to help us track what it taking place. I strongly advise that students always think about what is taking place in the stages of meiosis and fertilisation.

Monohybrid genetic crosses: genetics involving one gene.

- Example: Pea plants and the texture of their seed coats.
- The characteristic of seed coat texture is controlled by by one gene with two alleles.
- The seed coat can be either smooth or rough.

- Smooth coat is dominant to rough coat.
- One parent is homozygous dominant and the other is homozygous recessive.



Step 1: Write an allele key using the upper case letter for the dominant allele and the lower case latter for the recessive. (here S and s). It is actually better to use easily distinguished letter such as L and l, Q and q and so on.

Step 2: Write out the parental phenotype cross.

Step 3: Write down the genotypes of the parents(diploid).

In this case they are both homozygous

Step 4: Write down the genotype of the gametes (haploid).

In this case since both alleles are the same in appearance they can only produce on genotype of gamete for this gene.

Step 5 : In the Punnett square write down the possible fertilisations.

Remember these are just probabilities (chance fertilisations).

Step 6: Write out the genotypes and ratio of the offspring.

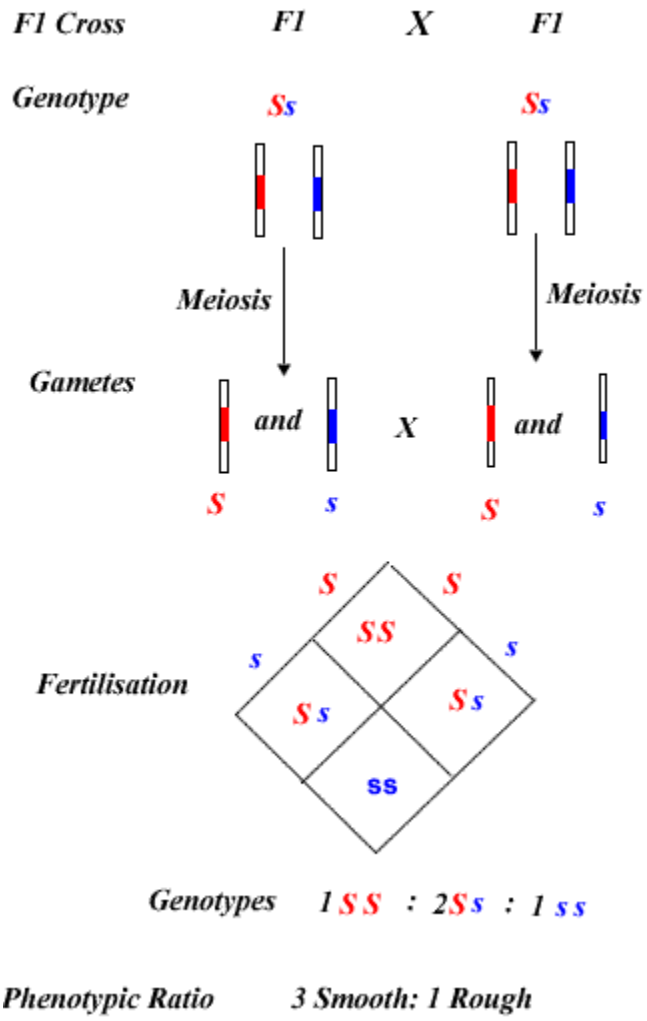
Step 7. Write out the phenotypic ratio.

The drawings help to visualize where the alleles are going. However the aim is just to use the allele code letters.

F= filial (first generation of the homozygous parent cross.) Note that they are all heterozygous.

F1 Cross = F1 (heterozygote) x F1 (heterozygote)

Phenotype = Smooth coat seed x Smooth coated seed:



Step 1: use the same allele key as above.

Step 2: Smooth Coat X Smooth coat

Step 3: Ss X Ss

Meiosis will separate the homologous pairs (Ss).

Step 4: Gamete genotypes are S and s for both parents.

Step 5: Enter possible fertilisations into the Punnett grid. Note this time each parent will produce two types of gamete. The chance of producing on or other type of gamete is p= 0.5 (50%) or 1 in 2.

Step 6. Write out the gamete genotype and ratio.

1 SS : 2Ss: 1ss

Step 7: Write out the phenotypic ratio:

3 Smooth coats: 1 Rough Coat

Remember that homozygous dominant cannot be distinguished from the heterozygote so they all appear the same.

top

Points to remember:

- All parental alleles must segregate in meiosis to form gametes.
- There is an equal probability of each allele carried occurring in the gamete.
- Fertilisation is a random process with each gamete(allele) from one parent having an equal chance of fertilizing any of other gamete (alleles) of the other parent.
- The genotypes of any particular offspring genotype or phenotype are only probabilities.
- One fertilisation of two gametes does not affect he probability of the other possible fertilisations.

In the previous example **F1 x F1 the ratio produced is 3:1**

- The probability of the offspring developing to produce smooth coated seeds is 3 in 4 or 75%
- The larger the population of offspring the closer the phenotypic ratio will be to 3:1
- The smaller the population the more likely a larger deviation from the 3:1 ratio.

top

4.3.3 State that some genes have more than two alleles (multiple alleles).(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

- Some genes have more than two alleles.
- An individual can only possess two alleles.
- The population may contain many alleles for a given gene.
- Multiple alleles increases the number of different phenotypes.
- Multiple alleles can be dominant, recessive or co-dominant to each other.
- Example: Rabbit coat colour(C) has four alleles which have the dominance hierarchy: $C > c^{ch} > c^{h} > c$

This produces 5 phenotypes, Dark(C_) , Chinchilla($c^{ch}c^{ch}$), light grey ($c^{ch}c^{h}$,$c^{ch}c$), Point restricted (c^{h} c^{h}, $c^{h}c$) and albino (cc)

top

4.3.4 Describe ABO blood groups as an example of codominance and multiple alleles. (2)

Describe means to a detailed account

Phenotype	Genotype
O	ii
A	I^AI^A or I^A i
B	$I^B I^B$ or I^B i
AB	I^AI^B

The ABO blood group system is an example of both a multiple allele and codominance condition.

There are three alleles the base letter = I stands for immunoglobulin

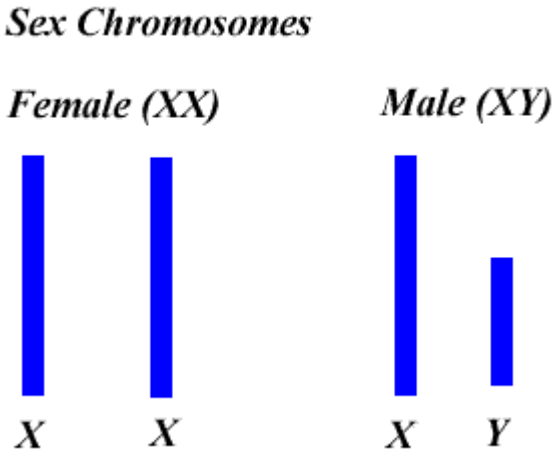
I^A and I^B are codominant to each other. Both these alleles are dominant to i

The Allele hierarchy is $I^A = I^B > i$

top

4.3.5 Explain how the sex chromosomes control gender by referring to the inheritance of X and Y chromosomes in humans.(3)

Explain means to give a detailed account of causes, reasons or mechanisms.



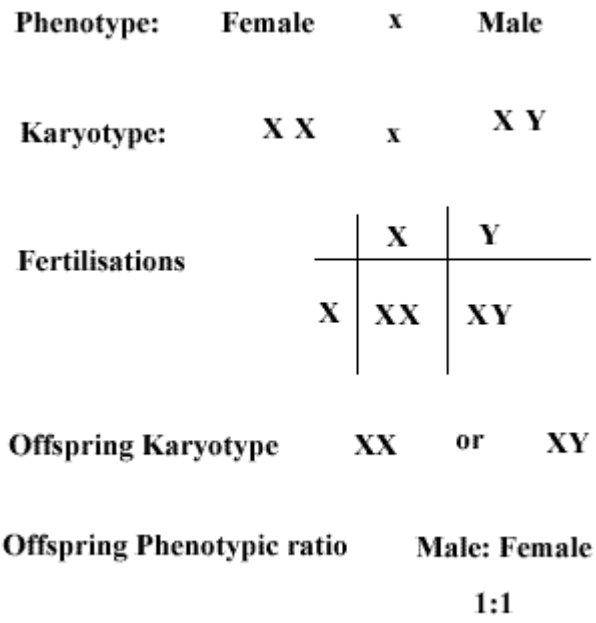
Gender in humans is controlled by the 23rd pair of chromosomes.

XX is female and XY is male.

The female possess two X chromosomes one inherited from the father the other from the mother. They are both the longer chromosomes

The male possess one X chromosome inherited from the mother and the much shorter Y chromosome inherited form the father.

The image to the left represents the difference in the XX and XY combination. The y chromosome length is greatly exaggerated in this image.



- This image represent a theoretical cross between a human male and female
- The female can provide only one type of chromosome (X)
- The male however provides sperm cells either with and X or with a Y.
- Theoretically this means that in any fertilisation there is a P=0.5 (50% , 1 in 2) chance of having either a boy or a girl.
- This is the basis of many genetic crosses and the one adopted here.

- However studies of families shows that some families tend to have more boys than girl and some families have more girls than boys. The inheritance of this tendency is explored in the excellent book about the Y-chromosome:

  Sykes, B. *(2003). Adams Curse. New York:* Norton Paperback

- The genetic basis of gender is associated with the SRY gene (Sex determining region of the Y chromosome) that was identified as the previously hypothesised *trf gene*. This gene is normally found at the very tip of the y-chromosome but has also been

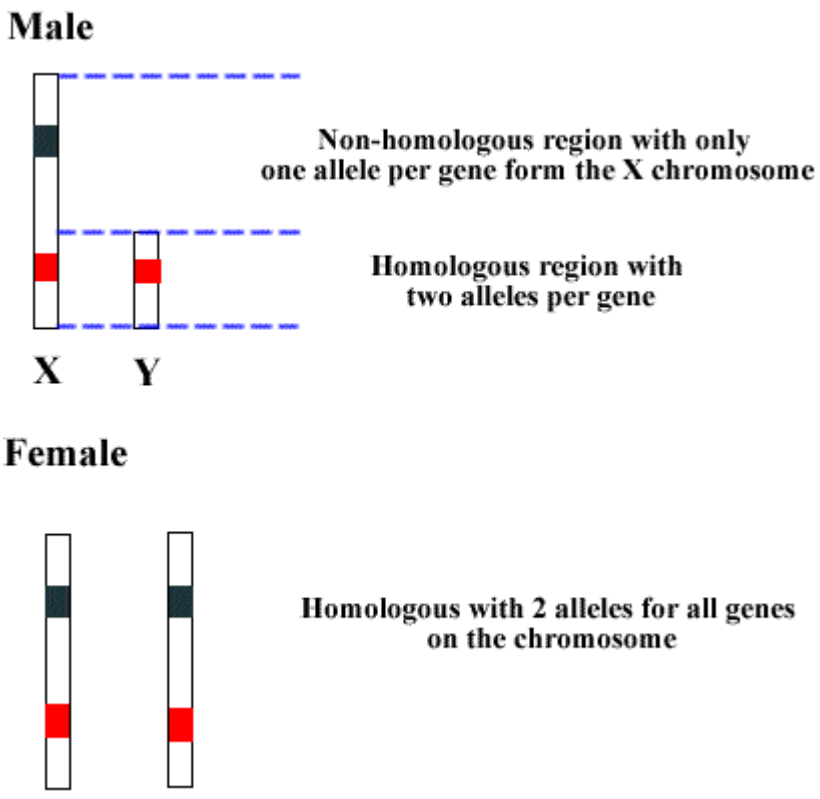
found on the X-chromosome due to translocation errors. In such a case it is possible to be male and yet have XX chromosomes.

- New Scientist 1
- New Scientist 2
- Sexual differentiation (wiki)
- SRY Gene (wiki)

top

4.3.6 State that some genes are present on the X chromosome and absent from the shorter Y chromosome in humans.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.



Male:

- Some genes are present on the X-chromosome but missing on the shorter Y-chromosome.
- The image of the male 23rd pair of homologous chromosomes represent the size difference in the two chromosomes.
- In the non-homologous region of the X-chromosome a male will only have one allele for any gene in this region.
- Genes in the homologous region have two alleles per gene and function just as other genes already described.

Female:

- The complete length of the X-chromosome has a homologous pair on the other X-chromosome.
- Genes on the x-chromosome of female therefore have two alleles just like another gene on the other chromosomes.

top

4.3.7 Define sex linkage.(1)

Define means to give a precise meaning of a word, phrase or physical quantity.

Genes on the non-homologous region of the X - chromosome are said to be sex linked.

Females have two such chromosomes (therefore two alleles) and males only one.

Phenotypes associated with recessive alleles are more common in males than in females.

Gene A= height plant

Alleles A= Tall a= small

Female	Male
$X^A X^A$	$X^A Y$
$X^A X^a$	$X^a Y$
$X^a X^a$	
33.3 % recesive	50% Recessive

Assuming that this plant species is dioecious

- The recessive allele (a) is found on the non-homologous region of the X-chromosome.
- Males only get one allele for this gene.
- Males have a 50% chance of being recessive.
- Female have a lower risk (33.3 %) since they always receive 2 alleles.
- 'Recessive' males can pass on this condition(X-chromosome) to the 'daughter'.
- Cannot pass these conditions to the 'sons' as they pass the y-chromosome with no alleles.

top

4.3.8 Describe the inheritance of colour blindness and hemophilia as examples of sex linkage.(2)

Describe means to give a deatiled account

Red Green Colour blindness

Allele Key X^B ***Normal colour vision***
X^b ***Red Green Colour blind***

Female	***Male***
$X^B X^B$	$X^B Y$
$X^B X^b$	$X^b Y$
$X^b X^b$	
0.33 chance of being colour blind	***0.5 chance of being colour blind***

- Red Green colourblindness is a sex linked condition.
- The gene loci is on the non-homologous region of the X-chromosomes.
- Red Green colour blindness is more common in males than in females.
- Males always inherit the colourblind allele form their mothers.
- Males cannot pass on colourblindness to their sons since the Y-allele does not have any of the colourblindness alleles.

Inheritance of colourblindness:

Calculation: Calculate the phenotypic ratio of a cross between a female carrier for red green colour blindness and a normal vision male.

Answer.

Haemophilia

Haemophilia

Allele Key X^H ***Normal***

X^h ***Haemophiliac***

Female Genotypes	*Male Genotypes*
$X^H X^H$	$X^H Y$
$X^H X^h$	$X^h Y$
* $X^h X^h$	

- Haemophilia is a recessive, sex-linked genetic disorder.
- Persons suffering from haemophilia are unable to produce clotting factor.
- The haemophiliac allele (X^h)is recessive to the normal allele (X^H).
- The gene is located on the non-homologous region of the x-chromosome.
- Haemophilia is more common in men than women.
- Males inherit the allele from their mother and develop the disease.
- Since (until recently) the prognosis for survival was poor and haemophiliac males did not survive to pass on the allele to their daughters (its on the X-chromosome). Therefore female haemophilia where rare.

top

Phenotype: Normal(carrier) Female x Normal Male

Genotype: $X^H X^h$ $X^H Y$

Fertilisation	X^H	Y
X^H	$X^H X^H$	$X^H Y$
X^h	$X^H X^h$	$X^h Y$

Ofspring Genotype $X^H X^H$ $X^H X^h$ $X^H Y$ $X^h Y$

Offspring Phenotypic Ratio: **1 Normal Female: 1 Carrier Female: 1 Normal Male: 1 Haemophiliac male**

- Haemophilia can occur in the children where the mother is a carrier and a normal male.
- The mother is heterozygous for the allele ($X^H X^h$) .
- The father carries the normal allele on the x-chromosome and none on the Y chromosomes ($X^H Y$).

- We can see that from such a cross the probability of being a haemophiliac male is P=0.25 (25% or 1 in 4).
- Today with treatment haemophiliac males can survive until sexual maturity but they cannot have daughters who are normal for this condition, why?
- Historically the haemophiliac allele has played a significant role in history and not least amongst the royal families of europe.

top

4.3.9 State that a human female can be homozygous or heterozygous with respect to sex-linked genes.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

Condition	Homozygous	Heterozygous
Haemophilia	X^hX^h , X^HX^H	$X^H X^h$
Red Green colourblind	X^bX^b , X^BX^B	$X^B X^b$

- Females can be homozygous or heterozygous for the sex-linked alleles

top

4.3.10 Explain that female carriers are heterozygous for X-linked recessive alleles. (3)

Explain means to give a detailed account of causes, reasons or mechanisms.

- Carrier are individuals that are heterozygous for the allele.
- The have both the dominant and the recessive (disease) allele.
- Females have two long x chromosomes (two alleles) but males have only one such chromosome (one allele).

- Heterozygous famales can carry the disease causing allele but are normal as they also have the dominant allele.
- To carry a disease causing allele in the heterozygote and be normal is called a ' Carrier'.

top

4.3.11 Predict the genotypic and phenotypic ratios of offspring of monohybrid crosses involving any of the above patterns of inheritance.(3)

Predict means to give an expected result.

1.The ability to taste the chemical PTC is determined by a single gene in humans with the ability to taste given by the dominant allele T and inability to taste by the recessive allele t. Suppose two heterozygous tasters (Tt) have a large family.

a. Predict the proportion of their children who will be tasters and non-tasters.
b. Use a Punnett square to illustrate how you make these predictions.is the likelihood that their first child will be a taster?
c. What is the likelihood that their fourth child will be a taster?
d. what is the likelihood that the first three children of this couple will be non tasters.

answer

2.In certain trees, smooth bark is dominant over wrinkled.

a. Cross two trees that are heterozygous for smooth bark.
b. If there are 100 offspring produced, how many will have wrinkled bark.

answer

3. A rooster with grey feathers is mated with a hen of the same phenotype. Among their offspring 15 chicks are grey, 6 are black and 8 are white.

a. What is the simplest explanation for the inheritance of these colours in chickens?
b. What offspring would you expect from the mating of a grey rooster and a black hen?

answer

4.In Mountain Boomers, the genes for length of tail exhibit co-dominance.

a. Use a Punnett Square to predict the result of a cross between a homozygous Long-tailed and a homozygous Short-tailed Mountain Boomer.
b. Suggest what the the offspring might look like?

answer

5. In roses, red petal is dominant over white petal. Use the allele key R for the red allele and r for the white allele.

a. Cross two heterozygous red roses,
b. Describe the phenotype of the offspring.

answer

6. In dogs, wire hair is due to a dominant gene (W) and smooth hair is due to its recessive allele (w).

a. If a homozygous wire-haired dog is mated with a smooth-haired dog, what type of offspring could be produced?
b. What type of offspring could be produced in the F2?
c. Two wire-haired dogs are mated. Among the offspring of their first litter is a smooth-haired pup. If these two wire-haired dogs mate again, what are the chances that they will produce another smooth-haired pup? What are the chances that the pup will be wire-haired?
d. A wire-haired male is mated with a smooth-haired female. The mother of the wire-haired male was smooth-haired. What are the phenotypes and genotypes of the pups they could produce?

answer

7.In snapdragons, red flower colour is incompletely dominant over white flower colour; the heterozygous plants have pink flowers.

a.If a red-flowered plant is crossed with a white-flowered plant, what are the genotypes and phenotypes of the plants of the F1 generation?
b. What genotypes and phenotypes can be produced in the F2 generation?
c. What kinds of offspring can be produced if a red-flowered plant is crossed with a pink-flowered plant?
d.What kinds of offspring can be produced if a pink-flowered plant is crossed with a white-flowered plant?

answer

8. In cattle, roan coat colour (mixed red and white hairs) occurs in the heterozygous (Rr) offspring of red (RR) and white (rr) homozygotes. When two roan cattle are crossed, the phenotypes of the progeny are found to be in the ratio of 1 red : 2 roan : 1 white. Which of the following crosses could produce he highest percentage of roan cattle?

(a) red x white; (b) roan x roan; (c) white x roan; (d) red x roan; (e) all of the above crosses would give the same percentage of roan.

answer

9.Roan colour in cattle is the result of the absence of dominance between red and white colour genes. How would one produce a herd of pure-breeding roan-coloured cattle?

answer

10.In some cats, black colour is due to a sex-linked (X-linked) recessive gene (b); the dominant allele (B) produces orange colour The heterozygote (Bb) is calico.

a. What kinds of offspring would be expected from the cross of an orange male and a black female?

answer

11. Haemophilia is a sex-linked trait where X^H gives normal blood clotting and is dominant to the haemophilia allele X^h.

a. Give the genotypes of 1) a woman with normal blood clotting whose father had haemophilia and 2) a normal man whose father had haemophilia.
b. What is the probability that a mating between these two individuals will produce a child, regardless of sex, that has haemophilia?
c. If this couple has a daughter, what is the probability that the daughter will be a carrier of the haemophilia trait? What is the probability a daughter would have haemophilia?
d. If this couple has a son, what is the probability he will have haemophilia?

answer

12. If a woman who is red-green colour blind mates with a man with normal vision, what phenotypes would one expect their children to have?

answer

13. Cystic fibrosis is found on the autosomal chromosomes. It is a recessive disorder in which the allele key is dominant $C^F$and C^f for the recessive allele.

a. A child is diagnosed with cystic fibrosis show with a diagram the likely genotype of their parents?
b. What is the probability of the next child from this couple being not having the disease?

answer

More monohybrid questions.

Even more monohybrid questions

More sex linkage questions.

Sex linkage (Arizona) set 1

Sex linkage (Arizona) set 2

TOKBIT 4.3.11

Quote:

'Statisticians are convinced that Mendel's results are too close to exact ratios to be genuine'.

'....whether it is right to discard results that do not fit a theory as Louis Pasteur is known to have done,....'

- To what extent are statements like these made with the benefit of hind site or with the benefit of historical perspective?
- Is it correct to judge the work of another person by the value system and methodologies of a historically later date?

External Links

Mendel Web homepage

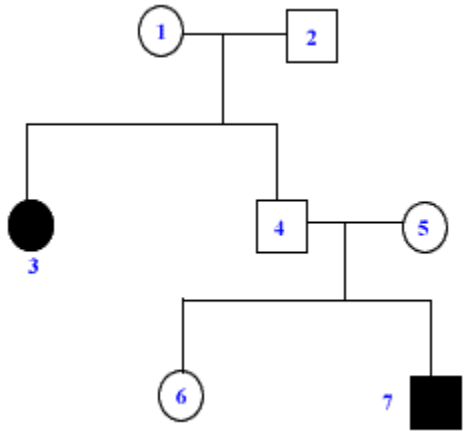
Comment:

It is most important when considering the above statements that we do not lapse into an all too easily adopted cynical evaluation of the work of people like Mendel, Pasteur, Darwin and more recently Watson and Crick. Historical revision of events of course is valuable but only if it has us reflects on our own conduct. I would suggest it is more important to realize that scientific work today which seems entirely valid (by today's standards) may well fail the the quality assurance standards of future generations. The work of the scientist mentioned and so many more besides stands as pivotal moments in scientific history. Students of the IB diploma might like to reflect on how their own work will be evaluated when they participate in the group 4 projects!

4.3.12 Deduce the genotypes and phenotypes of individuals in pedigree charts.(3)

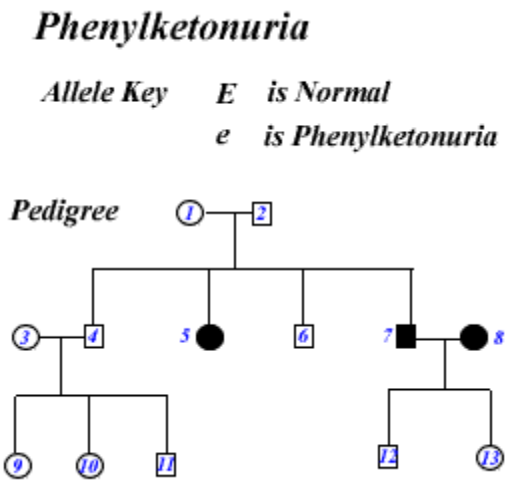
Deduce means to give reach a conclusion from the information given.

Often geneticists will carry out planned experiments in which breeding pairs are selected and the offspring phenotypes counted. However this is not acceptable or possible when working with humans. Instead geneticists have to collect information form about individuals and relatives within a family and construct diagrams of inheritance(family trees) called pedigrees.



- The chart show the typical symbol found in a pedigree chart.

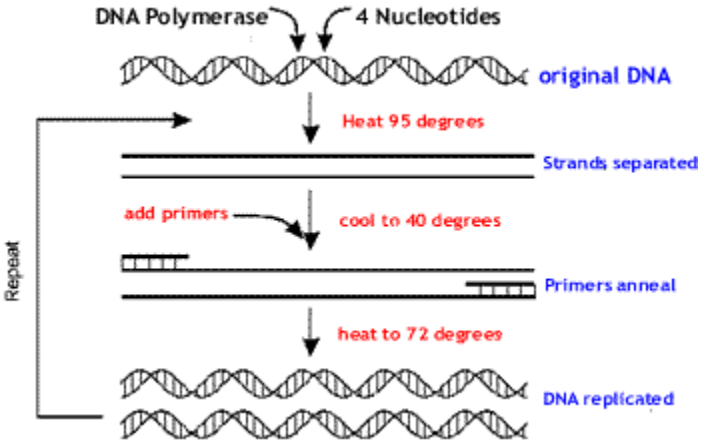
- Circles are female(1),(3),(5), (6).
- Squares are male (2), (4), (7).
- Black means that the individual is affected by the condition,(3).
- White indicates that the individual is unaffected by the condition.
- Mating: Female 1 and male 2 (Horizontal line)
- Children: Female (3) and male (4) are the children of (1) and (2).
- Individuals (6) and (7) are the paternal grandchildren of (1) and (2).



- Phenylketonuria (PKU) is a metabolic disorder and a recessive genetic condition.
- The pedigree shows the inheritance through a particular family.
- Which individuals can we be sure about their genotype?
- Since it was not possible to identify the condition of 12 and 13 suggest their genotype and phenotype and how the diagram may need modifying?

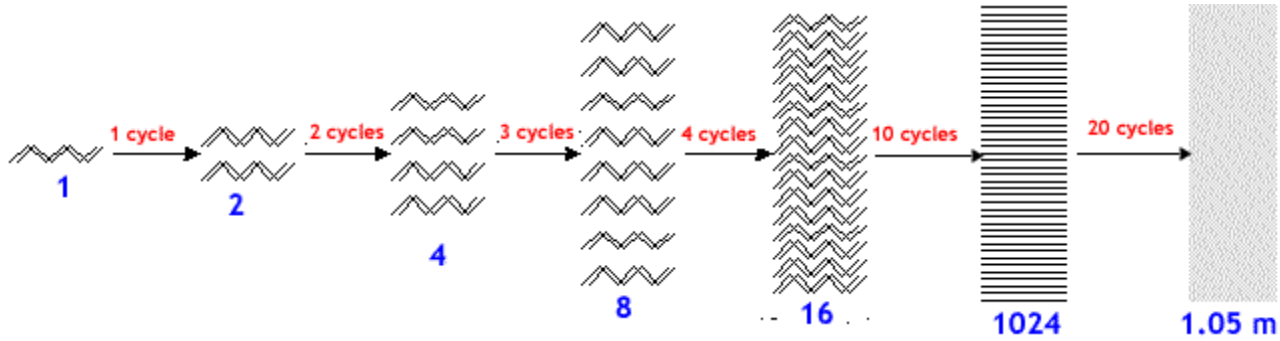
4.4.1 Outline the use of polymerase chain reaction (PCR) to copy and amplify minute quantities of DNA. (2)

Outline means to give a brief account or summary



- PCR is the cloning of DNA (amplification).
- Copies are made and the amount of DNA can be rapidly increased. Useful if the source of DNA is small.
- Temperature is used instead of enzymes like helicases (95°C).

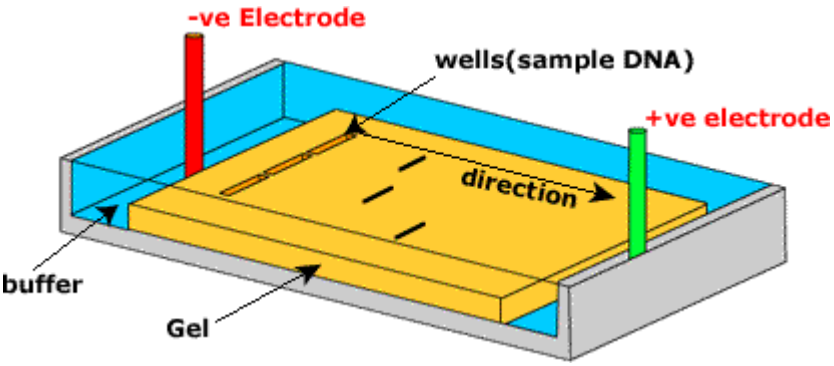
- DNA polymerase is thermostable to protect it against the reaction temperatures.
- This is an automated process and can produce sufficient DNA in 20 cycles.



top

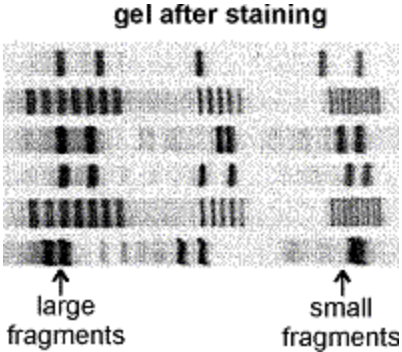
4.4.2 State that, in gel electrophoresis, fragments of DNA move in an electric field and are separated according to their size.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.



- Sample of fragmented DNA is placed in one of the wells on the gel.
- An electrical current is passed across the gel.
- Fragment separation is based on charge and size.
- Large fragments move slowly.
- Negative fragments are moved to the right.

Gel after staining:



This diagram shows the separation of 6 separate mixtures of DNA.

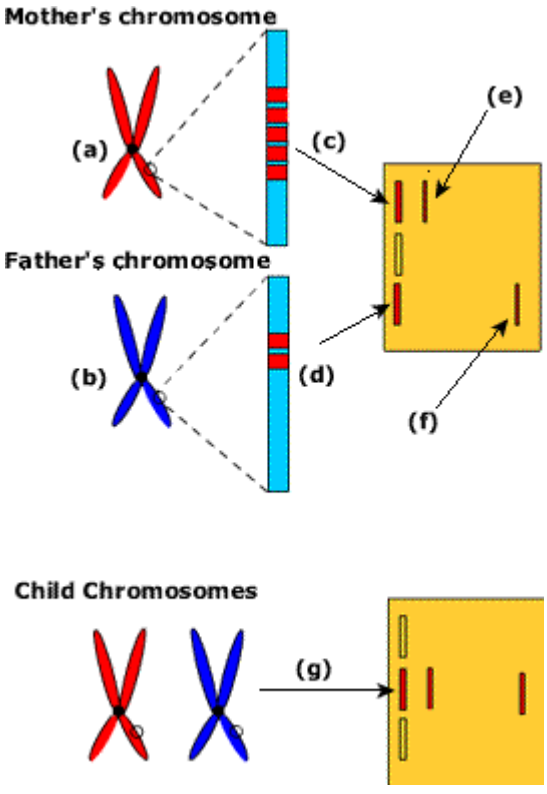
- The dark bands to the left are those with a large molecular mass or a positive charge
- (a) contains 5 fragments of DNA. Each bands corresponds to a group of DNA molecules of the same size and charge.
- (b) and (c) have the same bands. They are identical

top

4.4.3 State that gel electrophoresis of DNA is used in DNA profiling.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

- Gel electrophoresis is used in DNA profiling.
- **Satellite (Tandem repeating) DNA** are highly repetitive sequences of DNA from the non coding region of DNA.
- Different individuals have a unique length to their satellite regions.
- These can be used to differentiate between one individual and another.
- There are different types of 'DNA fingerprinting' for different circumstance



(a) The mothers chromosome provides a DNA STR cutting the chromosome with particular restriction enzymes.

(b)The fathers chromosome provides the same fragment using the same restriction enzymes.

(c) The mother DNA fragment placed in the well of the gel.

(d) The mother DNA fragment placed in the well of the gel.

(e) Mothers fragment produces 5 STR and moves a short distance along the electrophoresis gel.

(f) fathers fragment produces 2 STR and moves a longer distance along the electrophoresis gel.

(g) The child is heterozygous for the fragment having on homologous chromosome form the father and one form the mother.

Both 5 STR and 2 STR are shown in the electrophoresis.

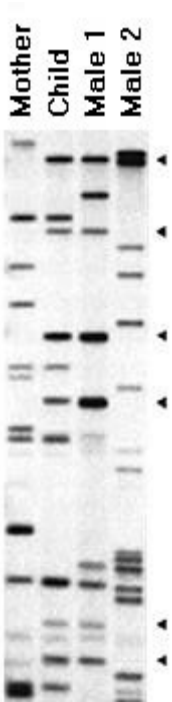
The technique can be used in:

- Forensic crime investigations
- Parentage Issues
- Animal breeding pedigrees
- Disease detection

top

4.4.4 Describe the application of DNA profiling to determine paternity and also in forensic investigations.(2).

Describe means to give a detailed account.



Paternity Investigation:

-

  Trying to determine who are the biological parents of a child.

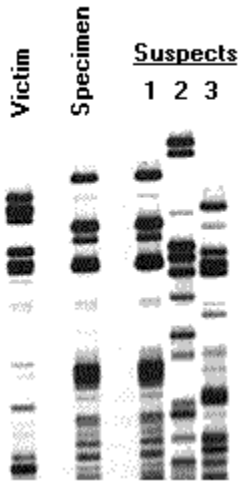
- The DNA fragments in the child comes from the mother and father.

- A band present in the child must come either from the mother or from the father
- Comparing male 1 with the child then male 2 with the child.

Interpretation:

- The bands on the child's fragments are either found on the mother or the male1.
- **Male 1** therefore is this father of this child.
- None of the Male 2 bands appear in the child

Forensic Investigation:



- A specimen of DNA is taken from the victim or the crime scene.
- DNA samples are taken from the 3 suspects.
- The bands are compared to associate the suspects but to eliminate the victims DNA from the specimens

Interpretation:

- Note that the bands on the specimen are matched by the bands on the Suspect 1.
- This means that Suspect 1 was present at the crime scene.
- The law will still require to prove a crime was committed and then that Suspect 1 committed the crime

top

4.4.5 Analyse DNA profiles to draw conclusions about paternity or forensic investigations.(3)

Analyse means to interpret data to reach conclusions.

In the above example the description has been extended to an interpretation.

4.4.6 Outline three outcomes of the sequencing of the complete human genome. (2)

Outline means to give a brief account or summmary.

Begun formally in 1990 the international projects aims where:

- identify all the approximate 30,000 genes in human DNA.
- determine the sequences of the 3 billion chemical base pairs that make up human DNA.
- store this information in database.
- improve tools for data analysis.
- transfer related technologies to the private sector.
- address the ethical, legal, and social issues (ELSI) that may arise from the project.
- To help achieve these goals, researchers also are studying the genetic makeup of several nonhuman organisms. These include the common human gut bacterium Escherichia coli, the fruit fly, and the laboratory mouse.

External Links:

- Sanger Institute
- US GOV

top

4.4.7 State that, when genes are transferred between species, the amino acid sequence of polypeptides translated from them is unchanged because the genetic code is universal.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

- The genetic code is universal
- All known organisms use the same genetic code.
- Therefore in principle if we transfer a gene from one species to another it should still be transcribed and translated into the same protein.

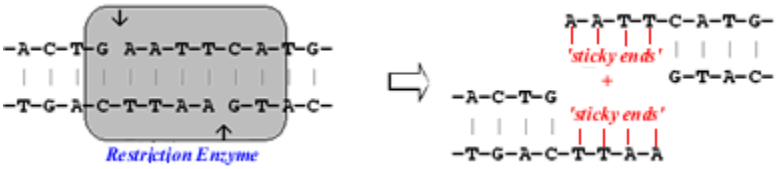
As with all of biology its the 'exceptions that prove the rule' and so it is with the 'Universal genetic code. There are in fact some prokaryotes which have one or two different code specifications. However they do not adopt a radically different system. Once more this demonstrates the emergent properties of complex biological systems.

top

4.4.8 Outline a basic technique used for gene transfer involving plasmids, a host cell (bacterium, yeast or other cell), restriction enzymes (endonucleases) and DNA ligase. (2)

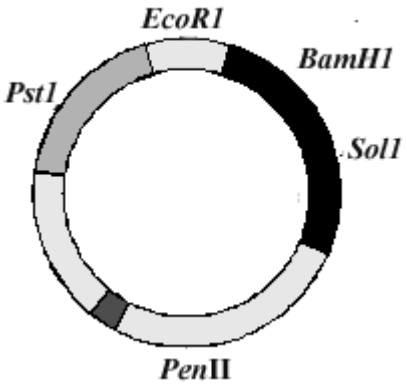
Outline means to give a brief account of summary.

Stage 1: obtaining the gene for transfer:



- Restriction enzymes are used to cut out the useful gene that is to be transferred.
- Note the 'sticky ends' of unattached hydrogen bonds.

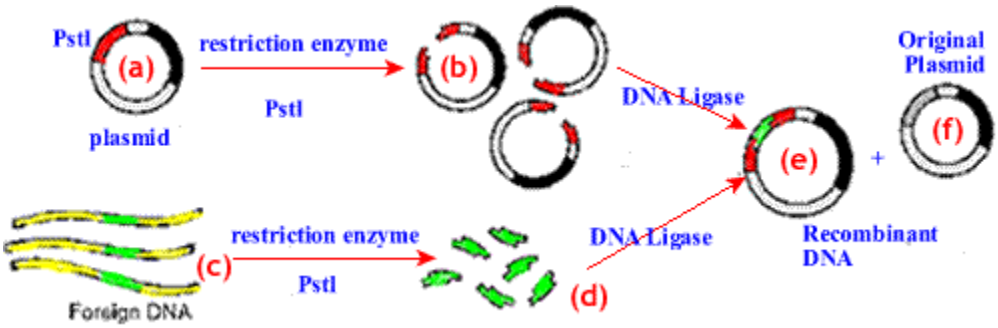
Stage 2. Preparing a vector for the transferred gene:



the diagram.

- Plasmids are small circular DNA molecules found in bacteria.
- These can be cut with the same restriction enzyme as above.
- This leaves the same complementary 'sticky ends' in the plasmid
- The plasmid can be cut at particular sites. These are called restriction sites and some are named in

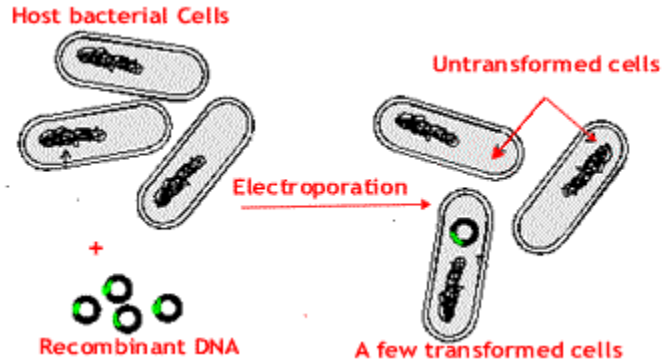
Stage3. Recombinant DNA



- **(a)** plasmid that will be the vector
- **(b)** plasmid cut at restriction site PstI
- **(c)** Source DNA cut with same restriction enzyme as plasmid to **(d)**
- **(e)** Recombinant DNA
- **(f)** unaffected plasmid

Expression vectors: usually if a eukaryotic gene is inserted into the genome of a prokaryote it make very little of the desired gene product. Therefore additional factors are included in the vector plasmid 'package' which includes types of RNA. The final plasmid as outlined above containing these additional factors is called an' Expression vector'.

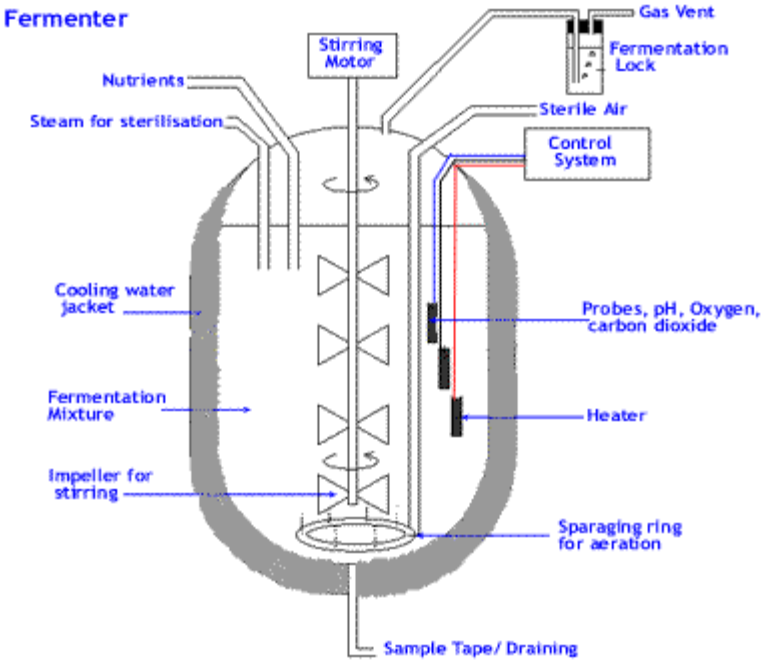
Stage4. Isolation of transformed cells



- Recombinant DNA is introduced into the host cells
- Many cells remain untransformed

- Some cells are transformed to contain the recombinant DNA.
- These transformed cells must be separated from untransformed

Stage 5. Product manufacture.



- The transformed bacterial cells are isolated.
- They are introduced into a Fermenter to be cloned.
- The bacterial population grows by asexual reproduction.
- The Recombinant DNA is copied along with the rest of the bacterial genome.

- In a fermenter the conditions for growth and reproduction are controlled.
- Once the bacteria express the transformed gene the product is produced.
- The next (long) step is to isolate and purify the product. This is called downstream processing.

top

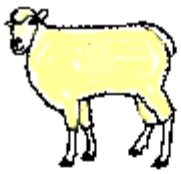
4.4.9 State two examples of the current uses of genetically modified crops or animals.(1)

State means to give a specific name, value or other brief answer without explanation or calculation.

- Genetically modified organism (GMO) is an organism containing a transplanted gene.
- The organism will express the gene and synthesis the protein.

Factor IX : A human clotting factor is produces by genetically modified sheep. The protein (factor IX) is expressed in milk from which it must be isolated before use by haemophiliacs.

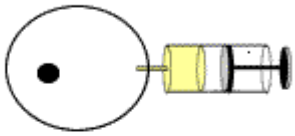
(a)



A ewe is treated with fertility drugs to create super-ovulation.

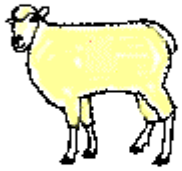
Eggs are inseminated.

(b)



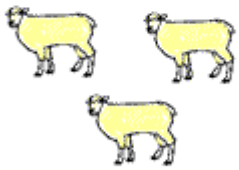
Each fertilised egg has the transgene injected.

(c)



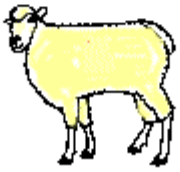
A surrogate ewe has the egg implanted for gestation.

(d)



Lambs are born which are transgenic, GMO for this factor IX gene.

(e)



Each Lamb when mature can produce milk.

(f)

Milk--> Protein

The factor IX protein is in the milk and so must be isolated and purified before use in human.

top

Tomato salt tolerance:

Plants find it hard to grow in salty conditions since this hypertonic soil water results in desiccation, wilting and death of the plant.

Tomato plants have now been genetically modified to carry the gene for salt tolerance.

The origin of the gene was a weed called *Arabidopsis thaliana.*

The transgenic tomato plant can tolerate plants.

This now provides the opportunity for a crop to be grown in an otherwise sterile soil.

Links:

Rice with retinol:

Retinol deficiency:

Retinol (Vitamin A1) is essential for the development of an effective immune system, normal vision and growth. Where a child lacks Retinol they have stunted growth and in extreme cases blindness. A serious complication arises from the combined of malnutrition, disease and retinol deficiency. The coincidence of these three conditions together is seen in some third word nations. In Zambia more than 54% of the population of children have retinol deficient diets. Even if children have sufficient food (calories) the problem is that is not a balanced diet. These children experience retarded growth for their age group and vision problems are common. Vision problems usually begin with a loss of night vision and then ultimately complete blindness. As might be expected these communities find it very difficult to support children with these multiple problems. To make matters worse diseases such as malaria and measles (known killer diseases) disable or kill large numbers of children as they have ineffective immune systems, another consequence of retinol deficiency.

- Rice does not contain retinol or beta-carotene (used by the body to make retinol).
- Rice does contain a molecule that is normally used to make beta-carotene.
- The gene and enzymes to manufacture are missing from rice.
- Genetically modified rice contains the gene for the manufacture of beta-carotene.
- Source of the gene is either *Erwinia* bacterium or the common daffodil.
- The transgenic rice is usually yellow in colour because of the accumulation of beta-carotene.
- This transgenic rice is then crossed with local strains of rice.

Herbicides: Roundup

- Weeds growing amongst a crop use up soil nutrients that would otherwise be used by the crop plant.
- This competition of resources reduces the productivity of the crop plant and therefore the efficiency of farming.
- Herbicides can be used prior to crop planting to kills weeds.
- The herbicide cannot be used after crops have been sown as they will also kill the crop.
- The major herbicide in use is called 'Glyphosate', anyone who has gardened will know this as 'Roundup' which is the market name for the product.
- However, Cotton, Corn and Soybeans have been genetically modified to contain an enzyme that breaks down glyphosate.
- This makes these crops resistant to the herbicide.
- Herbicide can then be use after the crop has grown to prevent the reoccurrence of weed competition.

top

4.4.10 Discuss the potential benefits and possible harmful effects of one example of genetic modification.(3)

Discuss means to give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.

The advantages and disadvantages of GMO is a controversial topic with wide political, environmental, health and social effects. The following issues can be applied specifically to the above examples of GMO.

The benefits of GMO include:

- Increased yields particularly in regions of food shortage.
- Yields of crops with specific dietary requirement such as vitamins and minerals.
- Crops that do not spoil so easily during storage.
- GM animals produce similar effect including higher meat yields.

The disadvantages or concerns about GMO usually can be found:

- The foods (animal and plant) are considered un-natural and unsafe for human consumption.
- There is a risk of the escape of 'genes' into the environment where they may be passed to other organisms with unknown effects.

top

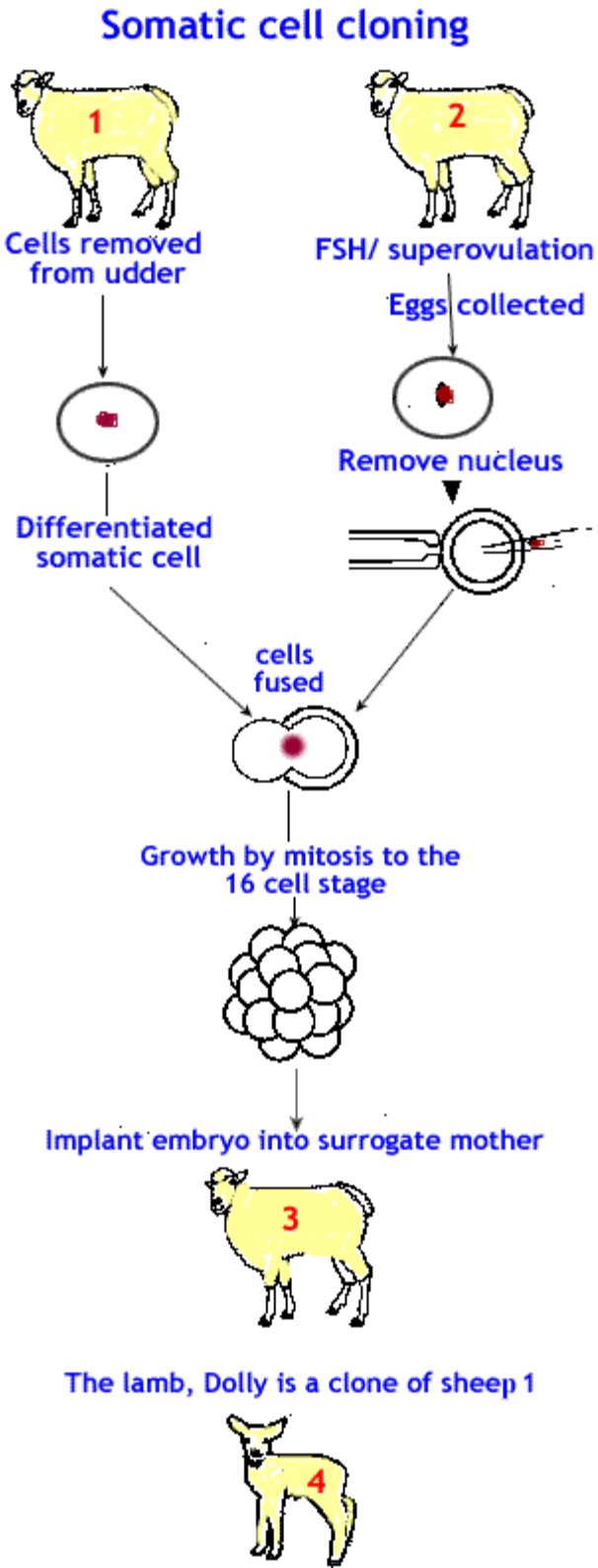
4.4.11 Define clone.(1)

define means to give the precise meaning of a word, phrase or physical quantity.

Syllabus statement: ' Clone: a group of genetically identical organisms or a group of cells derived from a single parent'.

4.4.12 Outline a technique for cloning using differentiated animal cells.(2)

Outline means to give a brief account or sumarry.



- Somatic cells are differentiated that is specialised to a particular function. In the case of Dolly (1996) the cell was taken from the udder of the original sheep (**1**) that was to be cloned.
- Sheep (**2**) provides the egg cell after being stimulated to superovulated by the use of the hormone FSH.
- The nucleus is removed from the egg cell. This removes the genetic information of sheep (**2**).
- The cells are fused combining the nucleus of sheep (**1**) with the egg cell from sheep(**2**). The egg cell retains its ability to replicate chromosomes and divide by mitosis.

- The cell is grown 'in-vitro' until it reaches the16 cell stage this will then be implanted into a surrogate mother sheep.

- Sheep (**3**) is the surrogate mother sheep and is not related to any of the other sheep. There is a normal gestation period before the 'Clone lamb' is born.

- Lamb (**4**) is dolly the clone of sheep (**1**). They are genetically identical. However they will experience a different set of environmental conditions.It should be noted that this technique was tried many times before it was successful.

4.4.13 Discuss the ethical issues of therapeutic cloning in humans.(3)

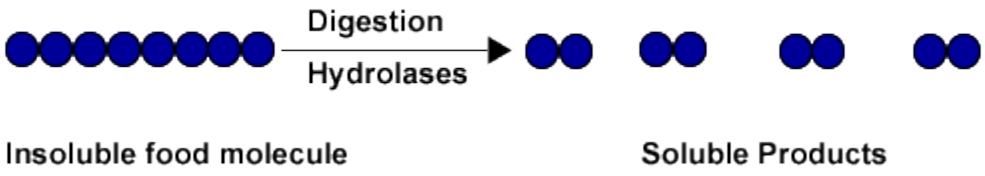
Discuss means to give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.

The discussion is about the creation of an embryo to supply stem cells for medical use.

- Research what is meant by therapeutic cloning.
- Decide what the ethical issues are in therapeutic cloning.
- What is an embryo?
- Where would they be obtained from? Alternatives?
- Try to make yourself aware of the stance of interest groups on the issues.

6.1.1 Explain why digestion of large food molecules is essential.(3)

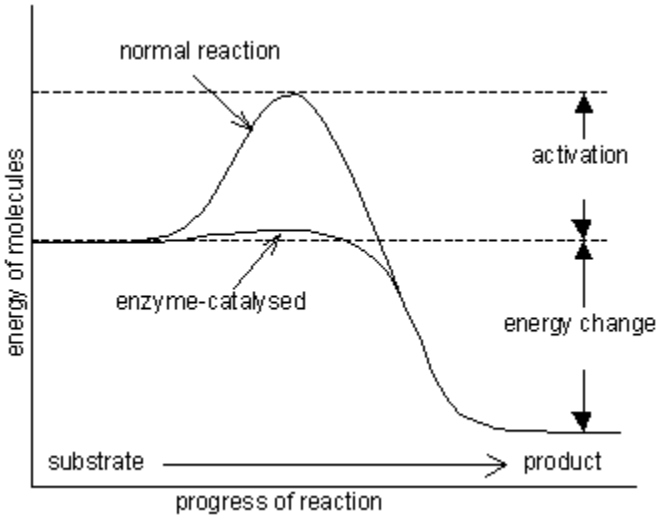
- Most food molecules are large polymers and insoluble
- They must first be digested to smaller soluble molecules before they can be absorbed into the blood



top

6.1.2 Explain the need for enzymes in digestion.(3)

- Enzymes are biological catalysts that increase the rate of reaction
- Digestive enzymes are secreted into the lumen of the gut
- Digestive enzyme increase the rate of reaction of the hydrolysis of insoluble food molecules to soluble end products
- Digestive enzymes increase the rate of reaction at body temperature

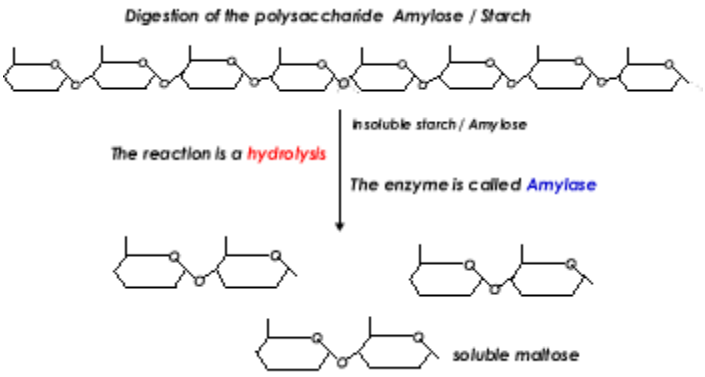


- This image illustrates the reduction in activation energy that is achieved by the use of an enzyme
- Notice that the normal reaction requires a higher activation energy which would correspond to a high body temperature. This is usually not possible in living organisms.
- The enzyme-catalysed reaction has a lower activation energy. This lower activation energy would correspond to body temperature but is only possible in the presence of an enzyme

top

6.1.3 State the source, substrate, products and optimum pH conditions for one amylase, one protease and one lipase.(1)

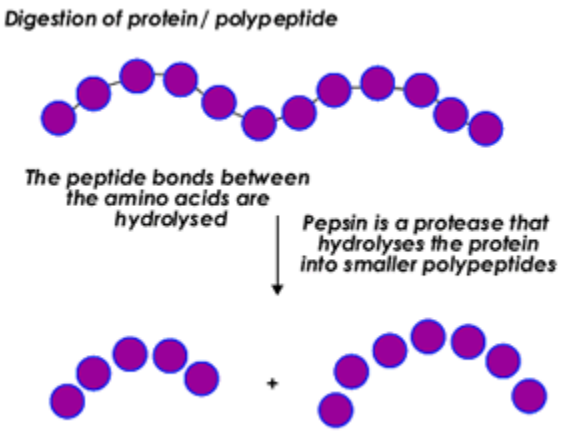
Example 1 Pancreatic amylase:



Conditions:

- Source the Pancreas
- Optimal pH 7.5-7.8
- Substrate is starch (amylose)
- End product is the disaccharide maltose
- Action: hydrolysis of 1-4 glycosidic bonds

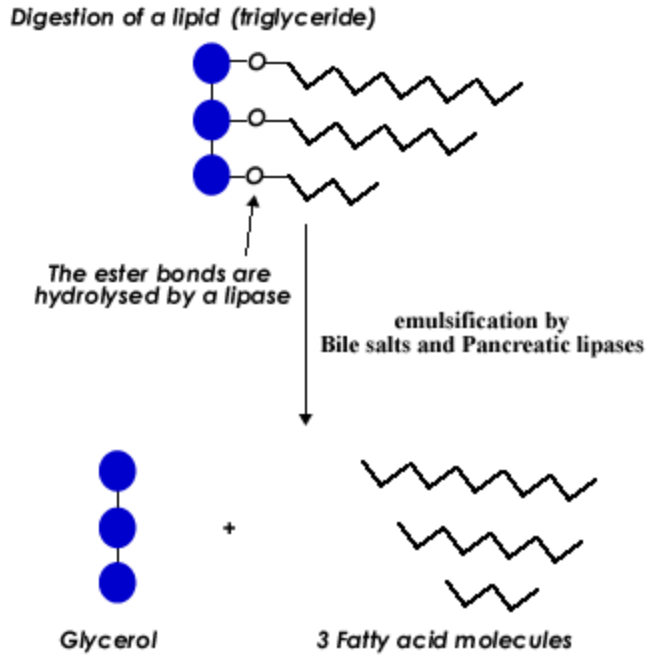
Example 2: Pepsin is a protease produced in the stomach



Conditions:

- Source is the stomach
- Optimal pH is 2
- Substrate is a polypeptide chains of amino acids
- End product is small polypeptides
- Action is the hydrolysis of peptide bonds within the polypeptide chain (endopeptidase).

Example 3: Pancreatic lipases:



- Source is the pancreas

- The optimal pH is 7.2
- The substrate is a triglyceride lipid
- The product is glycerol and fatty acid chains

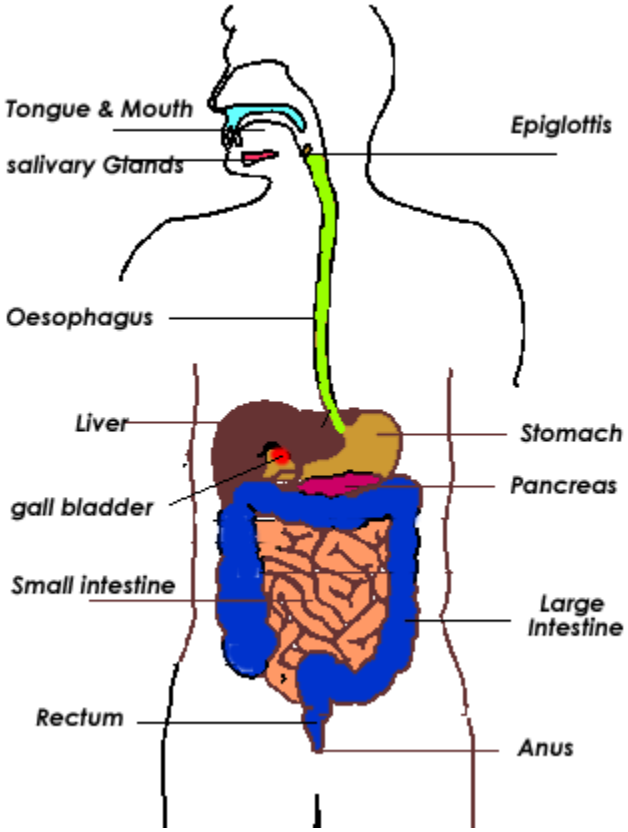
- The action of pancreatic amylases also requires the presence of bile salts that emulsify the lipid. This emulsification has two effects:

1. Increases the surface area of the lipid for the digestion of fat
2. Exposes the glycerol 'head' structure to the enzyme

- Action: hydrolysis of ester bonds between the glycerol molecules and the fatty acid chains.

top

6.1.4 Draw and label a diagram of the digestive system.(1)

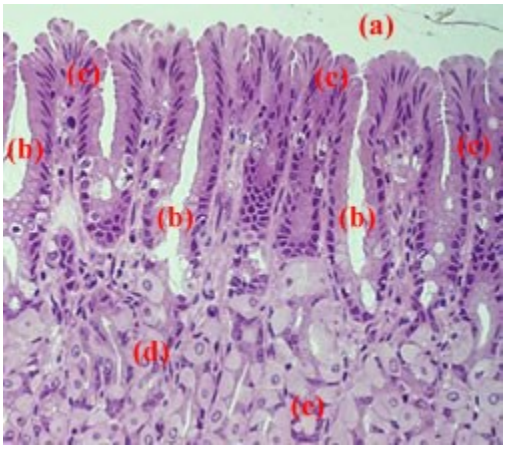


top

6.1.5 Outline the function of the stomach, small intestine and large intestine.(2)

1. Stomach:

The stomach stores the food from a meal and begins protein digestion.



(a) Lumen of the stomach which stores the food from a meal

(b) Gastric pits from which mucus , enzymes and acid are secreted

(c) Mucus secreting cells. Mucus protects the surface of the stomach from auto-digestion

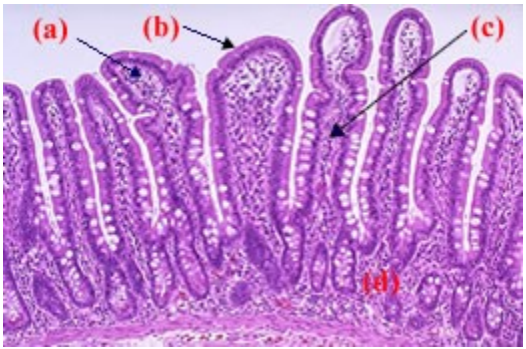
(d) Parietal cells that produce HCL which kills microorganism that enter the digestive system (food & tracheal mucus). This also converts inactive pepsinogen to active pepsin

(e) Chief cells: produces pepsinogen a protease enzyme

2. small Intestine

In the small intestine digestion is completed.

The products of digestion are absorbed into the blood stream.



(a) Villus which increase the surface area for absorption of the products of digestion

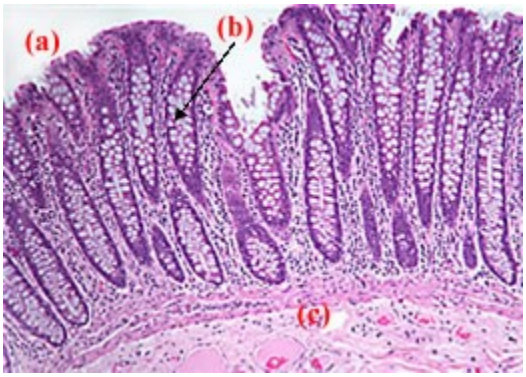
(b) Microvilli border of the epithelial cell increases the surface are for absorption.

(c) Lacteals are connect to the lymphatic system for the transport of lipids.

(d) In the wall of the small intestine are the blood vessels to transport absorbed products to the general circulation, There are also the muscle to maintain peristalsis

3. Large Intestine or colon:

The colon is responsible for the reabsorption of water from the gut.

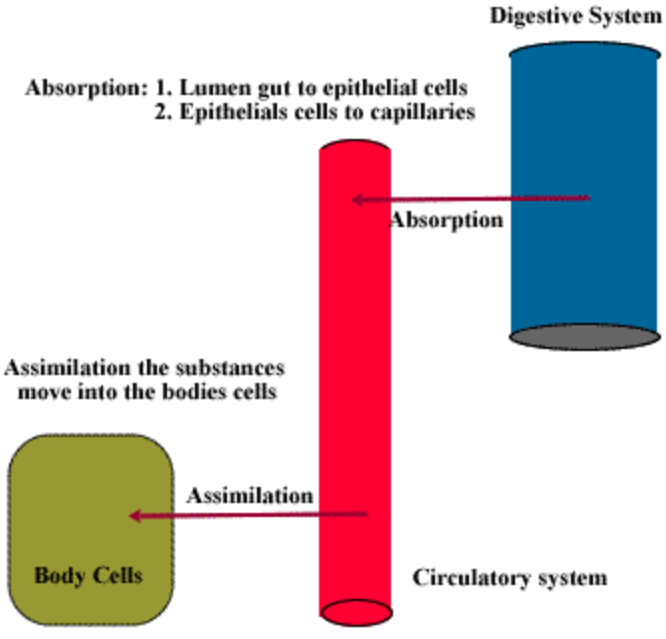


(a) The lumen of the colon

(b) The mucus producing goblet cells

(b) Muscular walls to maintain peristalsis

top



6.1.6 Distinguish between absorption and assimilation.(2)

Insoluble food molecules are digested to soluble products in the lumen of the gut.

Absorption:

1. The soluble products are first taken up by various mechanisms into the epithelial cells that line the gut.
2. These epithelial cells then load the various absorbed molecules into the blood stream.

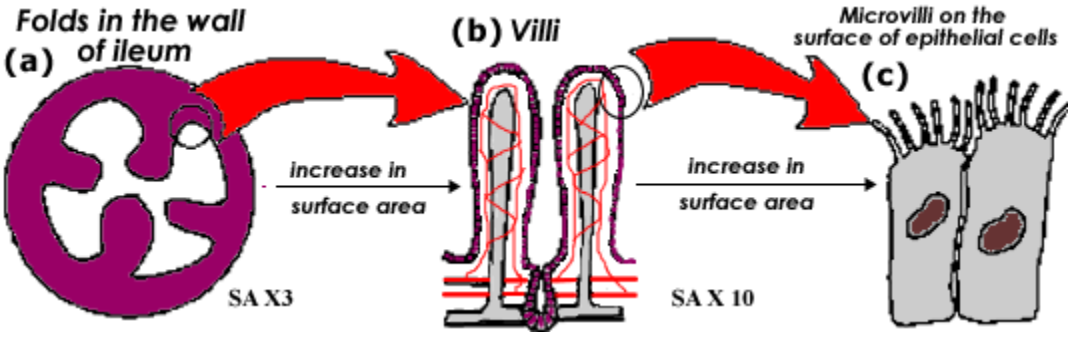
Assimilation:

1. The soluble products of digestion are then transported to the various tissues by the circulatory system.
2. The cells of the tissues then absorb the molecules for use within this tissues

top

6.1.7Explain how the structure of the villus is related to its role in absorption and transport of the products of digestion.(3)

The structure of the villus increases the surface are for the absorption of digested food molecules.

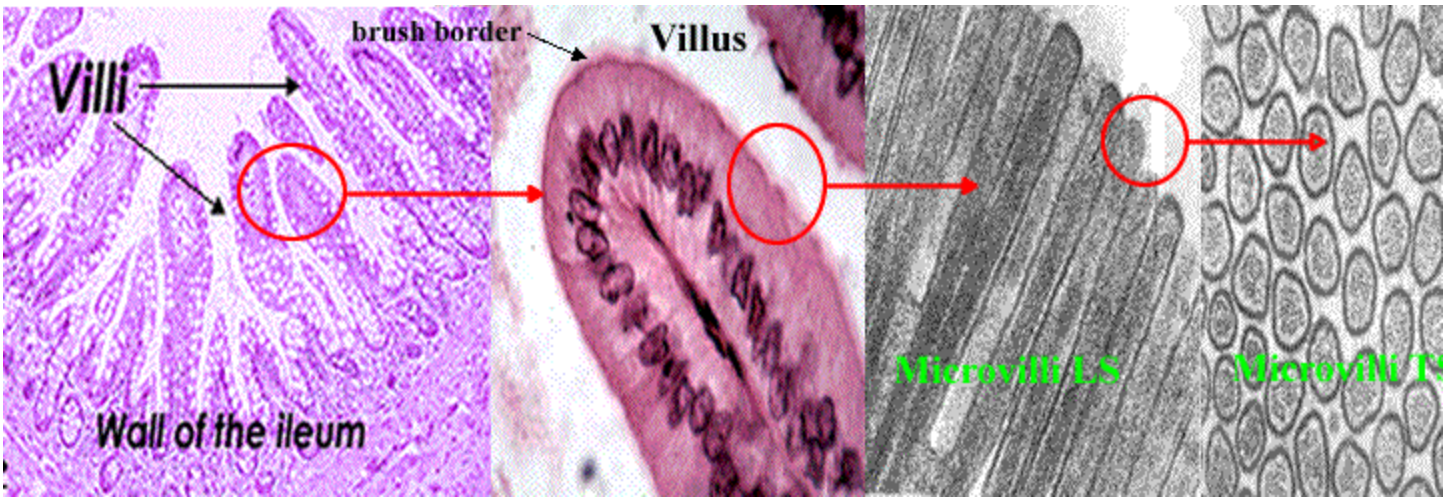


(a) folds increase SA:VOL ration by X 3

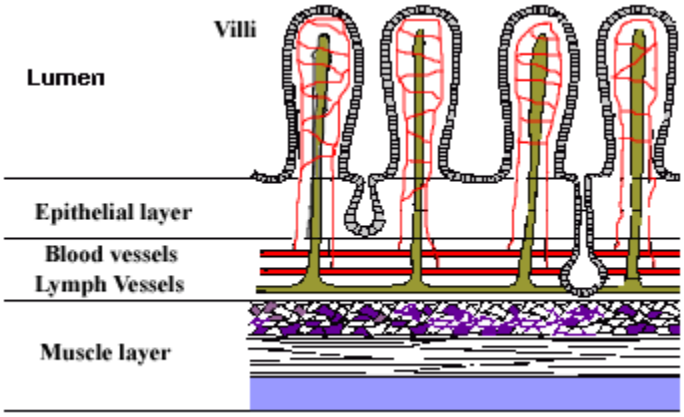
(b) Villi project into the lumen of the gut increasing the surface area by X 10

(c) Microvilli are outward folds of the plasma membrane increasing the surface area another X10

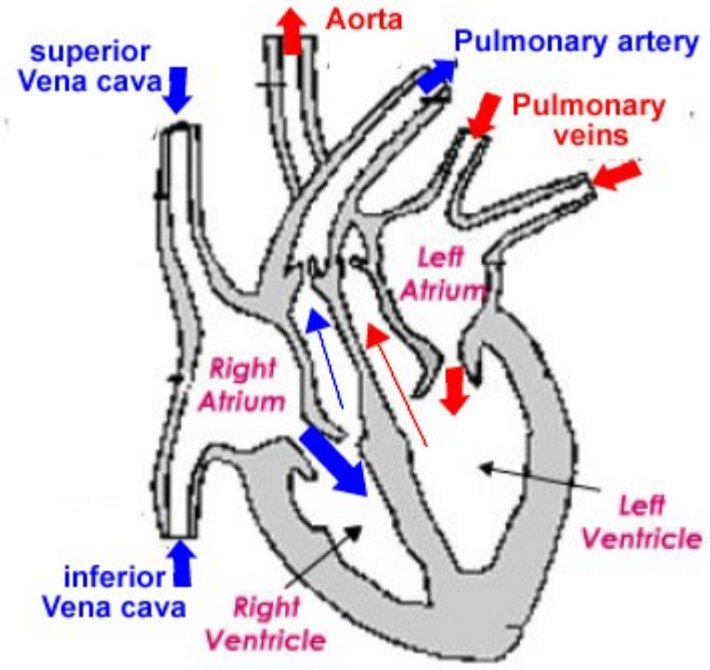
This sequence of light microscope and electron micrograph images show the same sequence as the diagram above.



Histological adaptations within the villus.

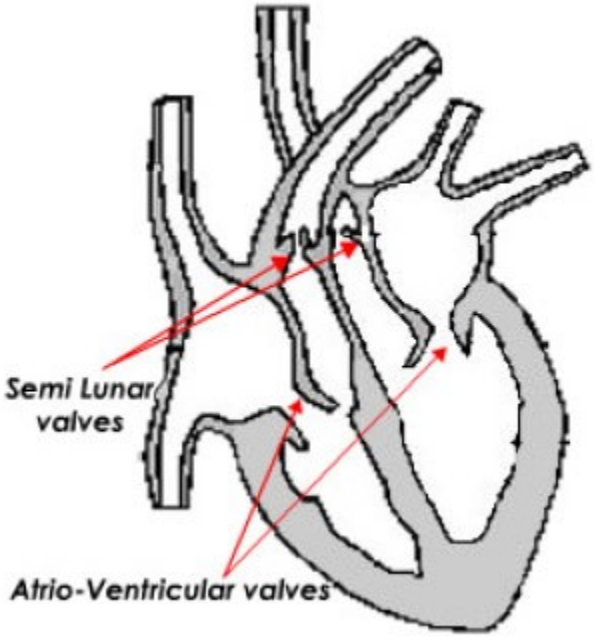


- Blood supply in the villus which absorb the end products of digestion from the epithelial cells
- The lacteals (green) that receive the lipoproteins before transporting them to the circulatory system.
- Muscular walls that maintain the movement of chyme by peristalsis.



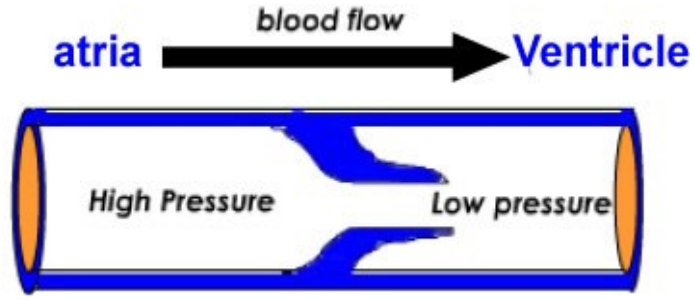
6.2.1 Draw and label a diagram of the heart showing the four chambers, associated blood vessels, valves and the route of blood through the heart.(1)

- Each atrium fills with blood from the veins.
- Ventricles are filled with blood from their respective atria.
- Blood exits the ventricles (and heart) in arteries.
- The red arrows suggest oxygenated blood
- Blue arrows represent deoxygenated blood.
- Blood enters the heart under lower pressure in veins, it exists the heart in arteries under high pressure.



Heart Valves

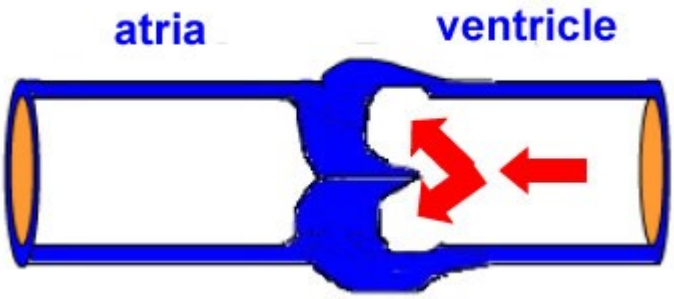
- Vales maintain a one way flow of blood.
- Atrio-ventricular vales open to let blood flow from atria to the ventricles.
- The atrio-ventricular valves close to prevent a back flow of blood into the atria.
- Semi-lunar valves open to allow high pressure blood to pulse into the arteries.
- Semi-lunar valves close to prevent black flow of blood into the ventricles form arteries.
- The left atrio-ventricular valve is also know as the bicuspid valve.
- The right atrio-ventricular valve is also known as the tricuspid valve.



Pressure of blood to the left is greater than pressure to the right

Valve flaps (cusps) pushed open.

Blood flows to the right.

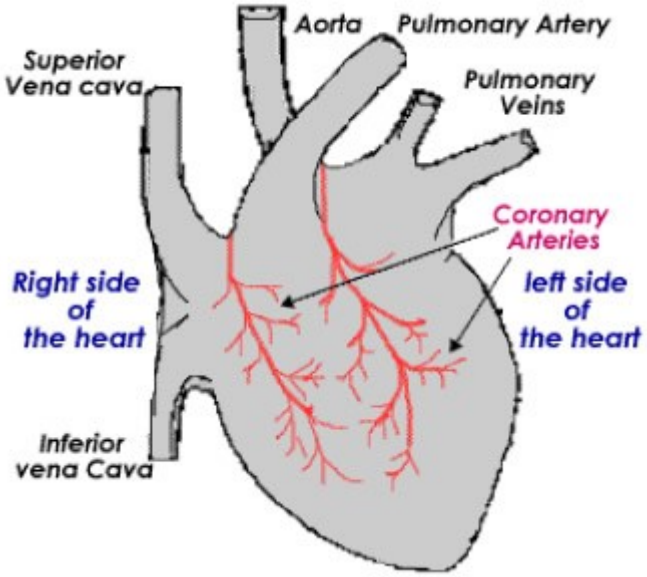


The pressure on the right is greater than the pressure on the left.

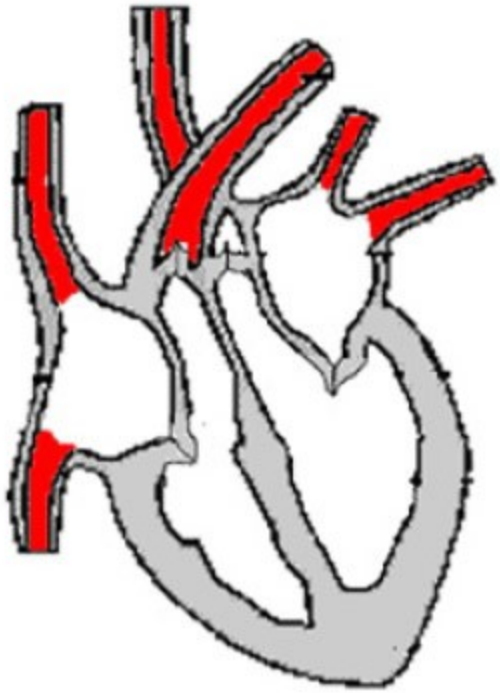
Cusps pushed closed.

Back flow stops

6.2.2 State that the coronary arteries supply heart muscle with oxygen and nutrients.(1)



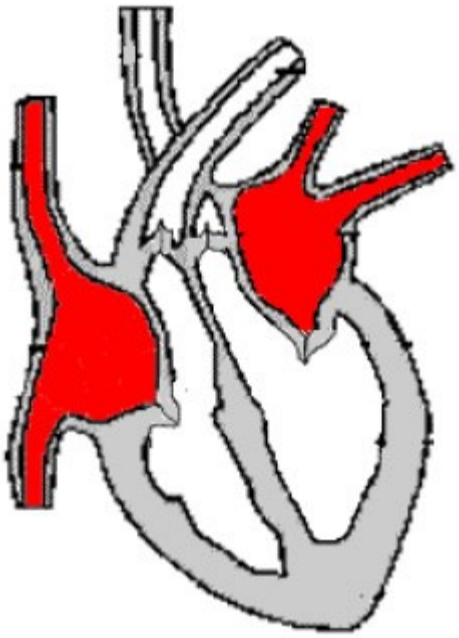
- The heart has its own blood vessels.
- Blood passing through the chambers of the heart does not provide nutrient or oxygen to the heart muscle cells.
- Coronary arteries are branches of the aorta which provide the heart muscle with a supply of oxygen and nutrient.
- The coronary arteries branch and spread through the heart muscle supplying the individual muscles cells.



6.2.3 Explain the action of the heart in terms of collecting blood, pumping blood, and opening and closing of valves.(3)

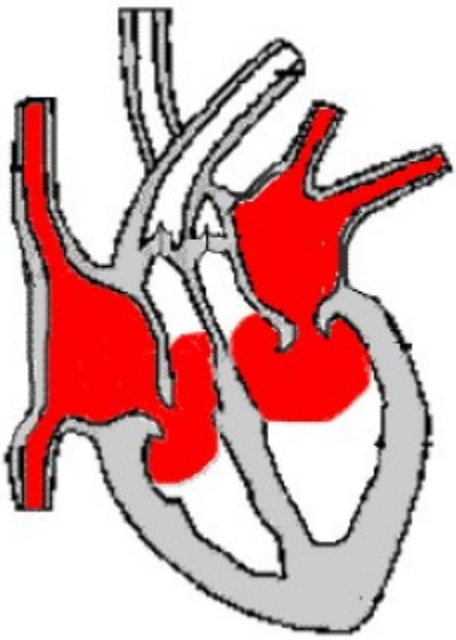
Diastole

- The heart muscle is relaxed this is called **diastole**.
- There is no pressure in the heart chambers.
- Blood tries to flow back into the heart but closes the semi-lunar valves.



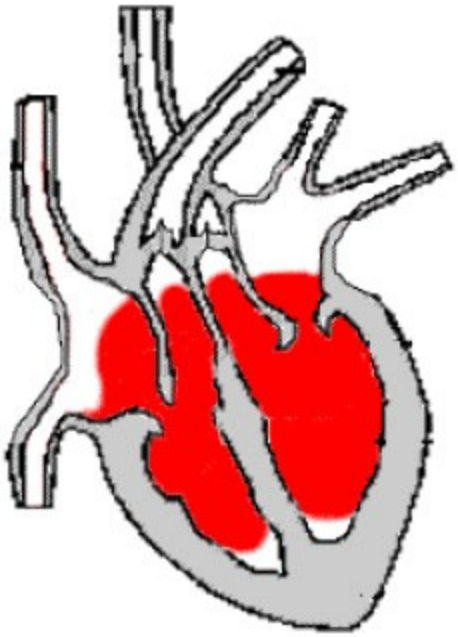
Diastole

- Both atria fill with blood returning to the heart in the veins.
- The right atria fills with blood returning in the vena cava from the body tissues (deoxygenated).
- The atrio-ventricular valves are still closed and the atria fill up.
- When the pressure in the atria is greater than the pressure in the ventricles the atrio-ventricular valves will open.



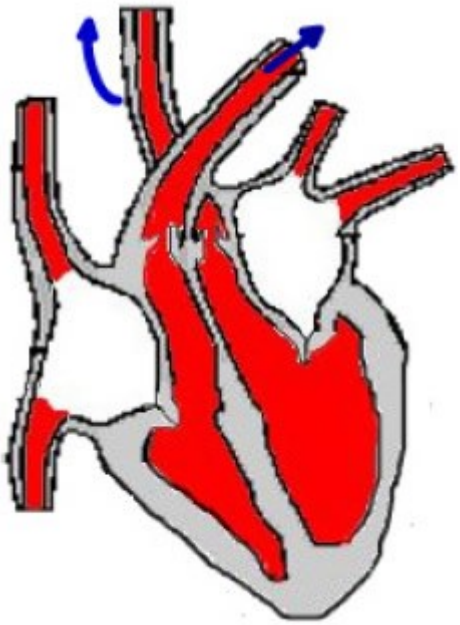
Late Diastole

- In this diagram the heart is still relaxed (diastole).
- The pressure of blood returning to the heart and filling the atria is now high enough to open the atrio-ventricular valves.
- The pressure in the atria is greater than the pressure in the ventricles.
- Atrio-ventricular valves open
- Ventricles begin to fill with blood.



Atrial systole

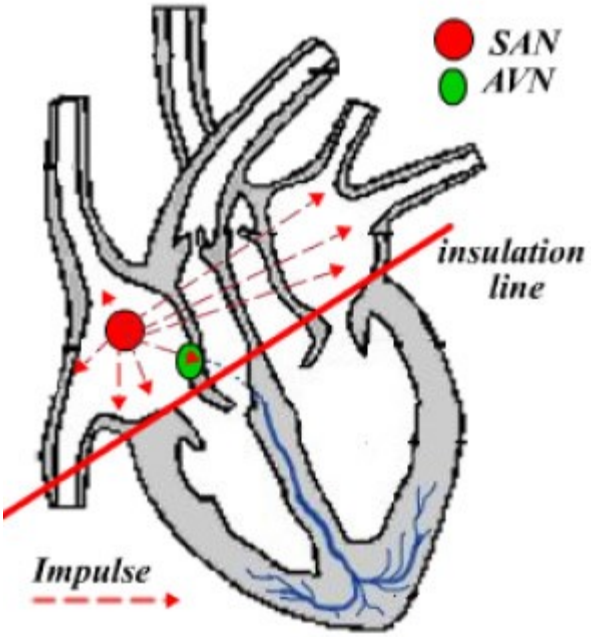
- Both atria contract together (see control of heart rate)
- The muscles of the atria contract.
- volume of the atria reduces.
- Pressure of blood increases
- Blood flow into the ventricle, filling this chamber and causing the ventricle wall to stretch.



Ventricular Systole

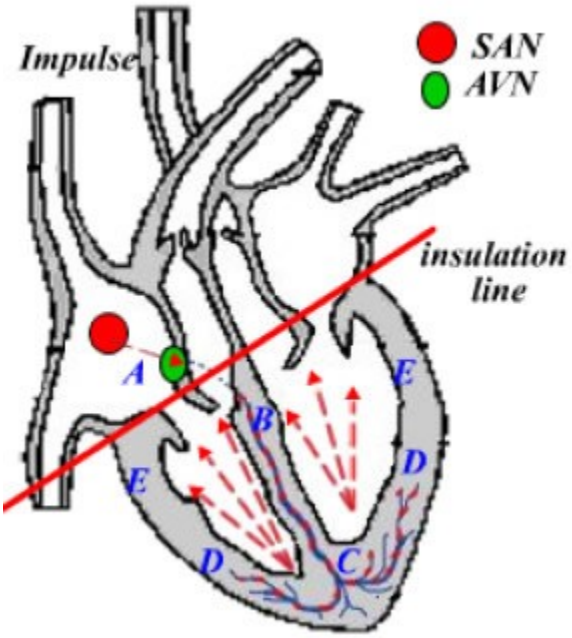
- The ventricle contracts (systole)
- The pressure increases in the ventricle
- The atrio-ventricular valve closes
- The pressure rises further
- Pressure in the ventricle is greater than the artery, semi-lunar valve opens
- Blood pulses into the arteries

6.2.4 Outline the control of the heartbeat in terms of myogenic muscle contraction, the role of the pacemaker, nerves, the medulla of the brain and epinephrine (adrenaline).(2)



- Myogenic muscle contraction describes the way the heart generates its own impulse to contract. It does not require external nerve input.

- In the wall of the right atrium there are a group of specialised cells(SAN).
- Cells of the Sino-Atrial Node generate an impulse that can spread across the muscle cell of both atria (red pathway).
- The impulse causes a contraction of both atria together.
- The impulse cannot spread to the muscle cells of the ventricles.
- The impulse is picked up by a sensory ending called the atrio-ventricular node (AVN).



The atria have already contracted sending blood down into the ventricles.

The ventricles are stretched and full of blood.

(A) The impulse to contract (generated in the SAN) is picked up by the AVN .

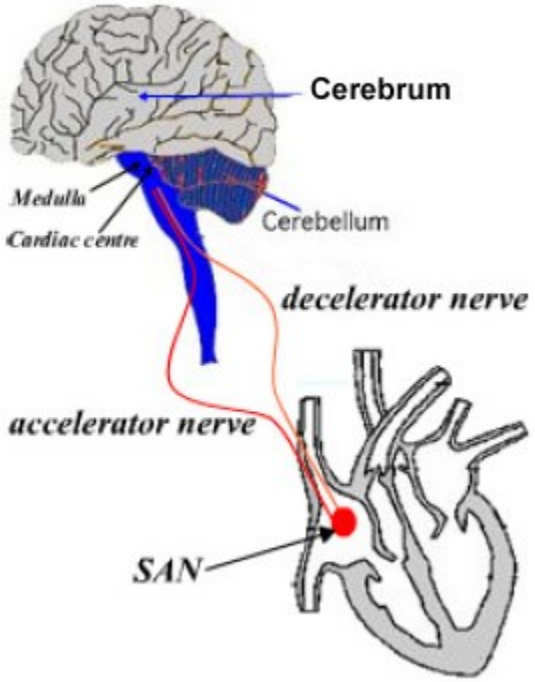
(B) The impulse to 'contract' travels down the septum of the heart, insulated from ventricle muscle fibres

(C) The impulse emerges first at the apex of the heart. This causes this region to contract first.

(D) The impulse now emerges higher up causing this region to contract.

(E). This region contract last.

The effect is to spread the contraction from the apex upwards, pushing blood towards the semi-lunar valves.

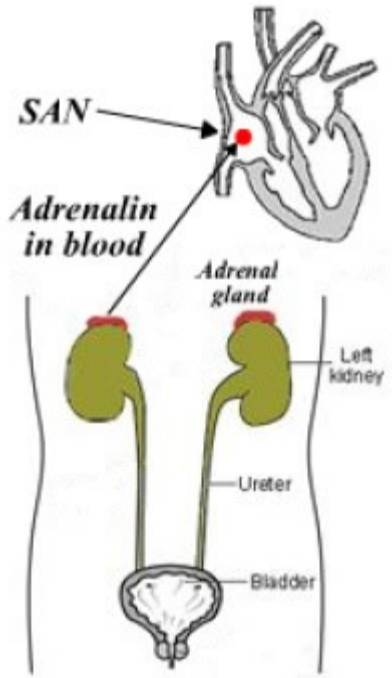


Modification of myogenic contraction

The basic myogenic contraction can be accelerated or slowed by nerve input form the brain stem or medulla.

There are two nerves:

- Decelerator nerve (parasympathetic) which decreases the rate of depolarisation at the SAN. Note that the synapse releases acetyl choline.
- Accelerator nerve (sympathetic) which accelerates the rate of depolarisation at the SAN. Synapse releases nor-adrenaline.

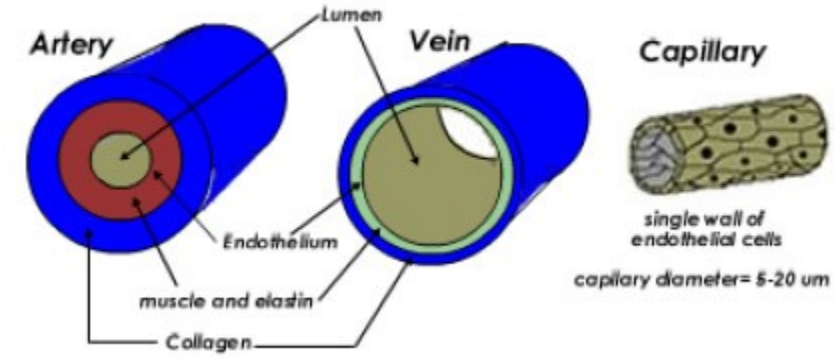


Epinephrine (adrenaline) and heart rate

- The hormone epinephrine is produced in the adrenal glands (an endocrine gland).

- The hormone travels through the blood to its target tissue, the sino-atrial node(SAN).
- Epinephrine increases the rate of depolarisation of the SAN.
- This accelerates heart rate.
- This reaction is associated with the 'fight or flight response'.

6.2.5 Explain the relationship between the structure and function of arteries, capillaries and veins.(3).



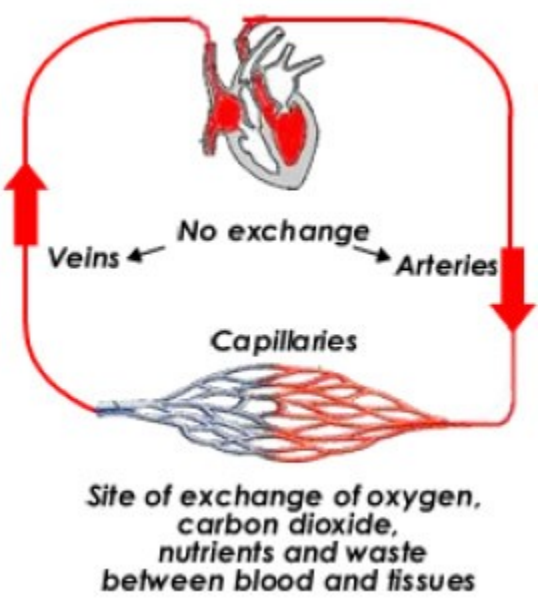
a) Arteries have muscular walls and outer layer of collagen for support.

The collagen resists the expansion due to the high pressure of blood.

The muscle layer contracts on the pulse of blood maintaining pressure all the way to the tissues.

b) Veins have carry blood under low pressure the lumen is wide to reduce the resistance to blood flow.

c) Capillaries have only a single layer of endothelium through which exchange can occur in the tissues.

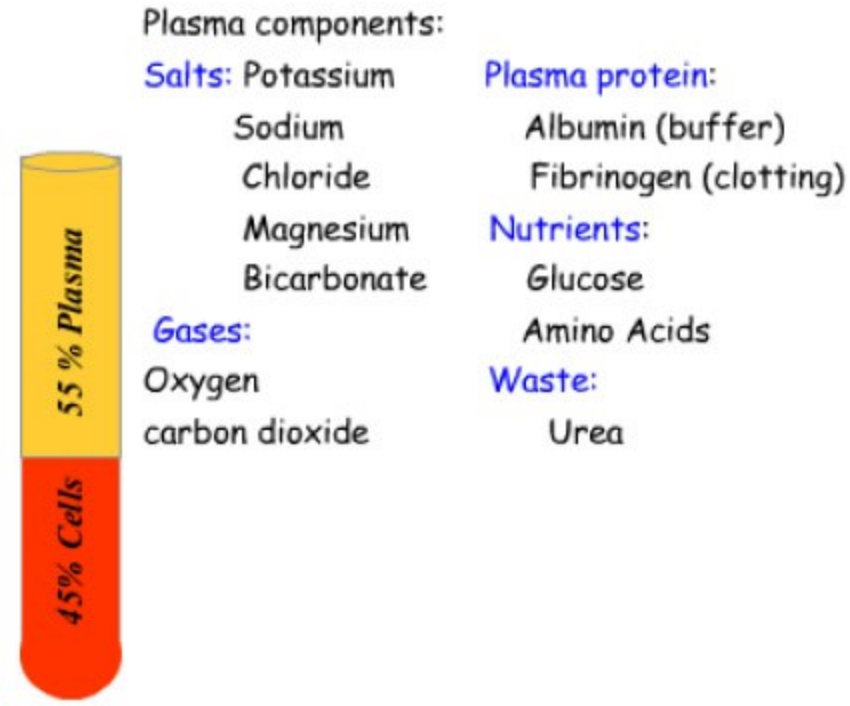


General functions of arteries and veins.

Arteries carry blood away form the heart under high pressure.

Veins return blood to the heart under lower pressure.

Capillaries are the site of exchange of blood with tissue fluid and cells.

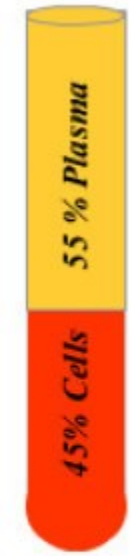


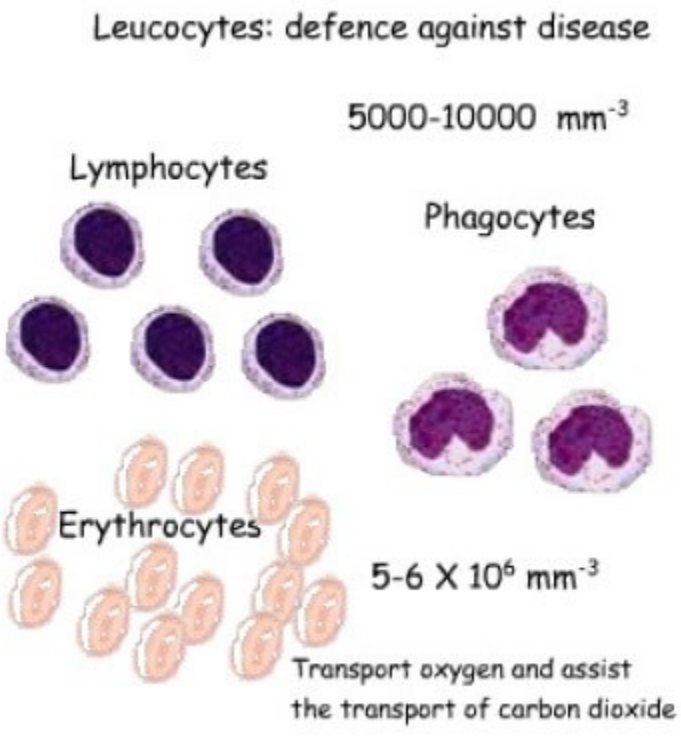
6.2.6 State that blood is composed of plasma, erythrocytes, leucocytes (phagocytes and lymphocytes) and platelets.(1)

Plasma is largely water and makes up about 55% of the total blood volume.

This is the main transporting part of blood and takes advantage of the solvent properties of water.

The items listed to the left are shown for discussion only.





Erythrocytes are the red blood cells.

Leucocytes are the white blood cells

Relative numbers are shown for illustration purposes only.

6.2.7 State that the following are transported by the blood: nutrients, oxygen, carbon dioxide, hormones, antibodies, urea and heat.(1)

The items listed above take advantage of the properties of water (as a solvent):

- Nutrients
- Carbon dioxide
- Hormones
- Antibodies
- Urea

or its thermal properties:

- heat

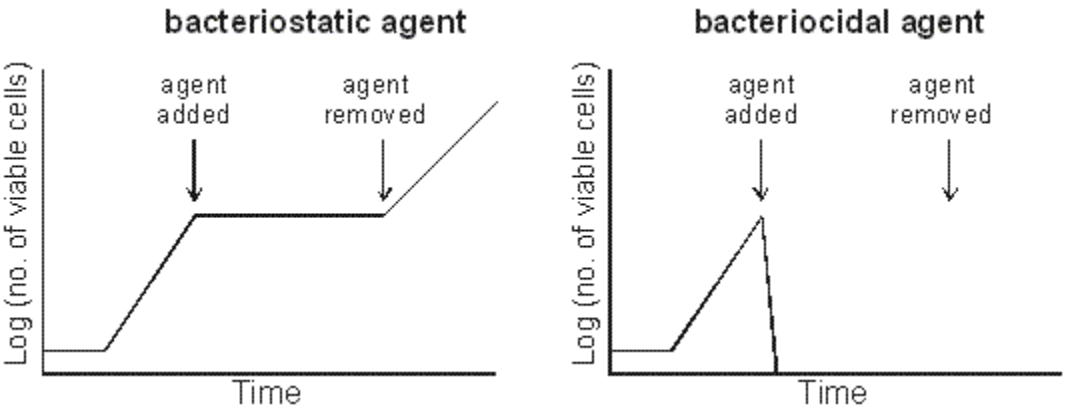
Oxygen and carbon dioxide rely in the RBC for their transport:

6.3.1Define pathogen. (1)

- A pathogen is an organism that can cause disease.
- Pathogens include bacteria, viruses, protista, fungi and other parasitic multicellular organisms.

top

6.3.2 Explain why antibiotics are effective against bacteria but not against viruses.(3)



Antibiotics block specific metabolic pathways found in bacteria, but not in eukaryotic cells.

These graphs show how the two kinds of drug (see below) affect bacterial growth curves.

- Bacteri**cidal** or fungi**cida**l antibiotics kill microbes.
- Others are antibiotics are **static** (bacterio**static**, fungi**static**, etc.), which means they stop further growth, but don't kill existing cells.
- Both are useful medically, because if the growth of an infective pathogen is stopped, the body's immune system will be able to kill it.
- Antibiotics can be selectively toxic by targeting such features as the bacterial cell wall, 70S ribosomes, and enzymes that are specific to bacteria. In this way the human eukaryotic cells are unaffected.

Viruses reproduce using the host cell metabolic pathways that are not affected by antibiotics.

- Viruses do not have metabolic pathways like bacteria and therefore antibiotics do not work on viruses.

- Viruses can only be treated by their specific anti-microbial agent and antibiotics should never be prescribed for viral infections (such as flu).

6.3.3 Outline the role of skin and mucous membranes in defence against pathogens.(2)

Skin :

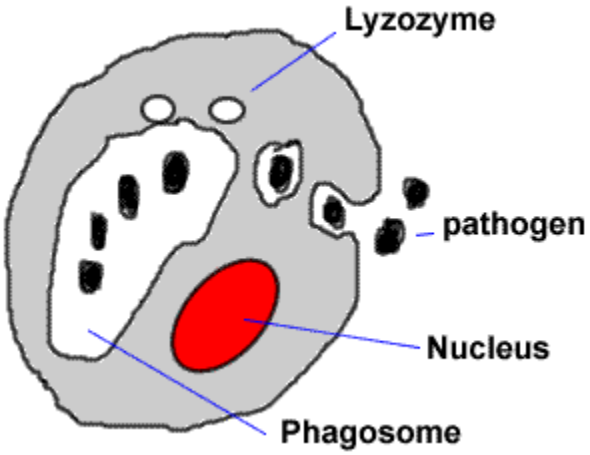
- The skin is a tough outer layer called the epidermis, which is 20-30 cells thick whose cells are toughened by the protein keratin. Beneath this is the layer called the dermis (20-40 times thicker) making up the main skin layer and contains sensory receptor cells, blood capillaries and hairs. Deeper down the skin divides to produce new cells which replace those lost from the surface.

- The lining of the lung is another way that pathogen can enter the body. The trachea, bronchi and bronchioles are protected from infection by mucus to which various particles when inhaled. Other cells have cilia, hair like extensions of the cell membrane move the mucus upward to the epiglottis. Here the mixture of mucus and micro-organisms are swallowed down into the acid of the stomach.

top

6.3.4 Outline how phagocytic leucocytes ingest pathogens in the blood and in body tissues.(2)

The second line of defence is the non-specific immune system, a host of quick, non-specific methods of killing microbes that have passed the first line of defence and entered the body.



- Phagocytes are large, irregularly-shaped leukocytes that destroy bacteria, viruses, and dust particles.

- The phagocytes show amoeboid movement, constantly changing shape, as they engulf microbes. The engulf vesicles join together to form phagozomes.

- The phagosome then fuses with lysosomes which contain containing lysozymes. These enzymes killing and digesting the microbes.
- The process is called phagosytosis

top

6.3.5 Distinguish between antigens and antibodies.(2)

Antigen is often used to describe something that has infected the body. However it is more accurate to describe them as follows:

- An antigen is a large molecule (protein, glycoprotein, lipoprotein or polysaccharide) on the outer surface of a cell.
- All living cells have these antigens as part of their cell membrane or cell wall.
- The capsid proteins of viruses and even individual protein molecules can also be classed as antigens.
- Their purpose is for cell communication, and cells from different individuals have different antigens, while all the cells of the same individual have the same antigens.
- Antigens are genetically controlled, so close relative have more similar antigens than unrelated individuals.
- Blood groups are an example of antigens on red blood cells, but all cells have them.

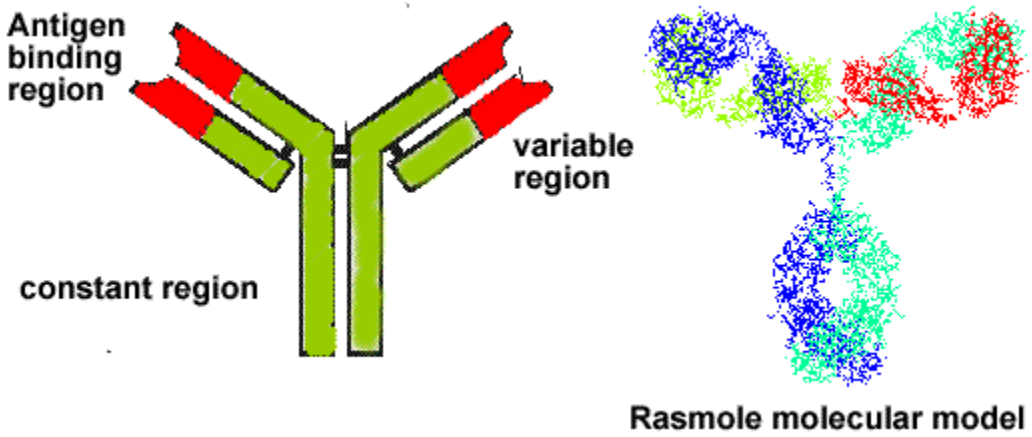
The link with infection is that when a pathogen or toxin enters the body it this that the immune system reacts against.

Antibodies are proteins secreted from lymphocytes that destroy pathogen and antigen infections

- B-cells make antibodies.
- An antibody (also called an immunoglobulin) is a protein molecule that can bind specifically to an antigen.
- Antibodies all have a similar structure composed of 4 polypeptide chains (2 heavy chains and 2 light chains) joined together by strong disulphide bonds to form a Y-shaped structure.
- The stem of the Y is called the constant region because in all immunoglobulin's it has the same amino acid sequence, and therefore same structure.

- The ends of the arms of the Y are called the variable regions of the molecule because different immunoglobulin molecules have different amino acid structure and therefore different structures.

- These variable regions are where the antigens bind to form a highly specific antigen-antibody complex, much like an enzyme-substrate complex.



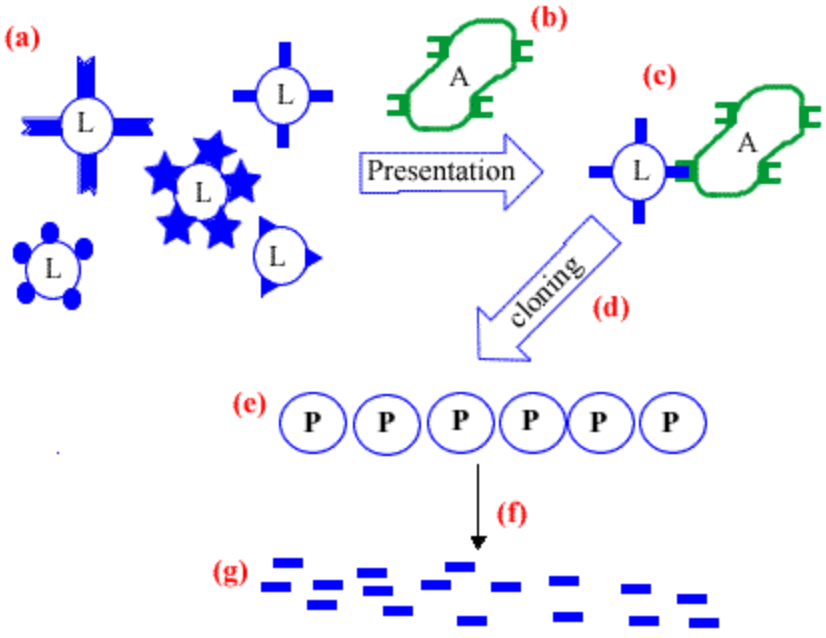
Rasmole molecular model

- Each B-cell has around 10^5 membrane-bound antibody molecules on its surface and can also secrete soluble antibodies into its surroundings.

- Every human has around 10^8 different types of B cell, each making antibodies with slightly different variable regions.

- Between them, these antibodies can therefore bind specifically to 10^8 different antigens, so there will be an antibody to match almost every conceivable antigen that might enter the body.

top



6.3.6 Explain antibody production. (3)

(a) There are many different lymphocytes.

(b) The antigen infects and is presented to the lymphocytes

(c) The lymphocyte with a surface epitope complementary to the antigen is selected.

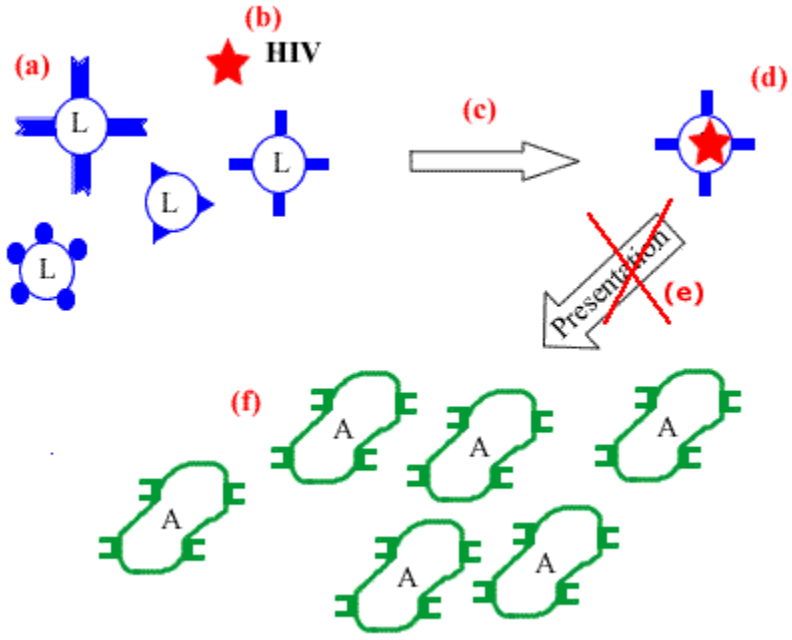
(d) The Lymphocyte clones to produce many plasma cells. This occurs in the lymph nodes.

(e) The clone of plasma cells

(f) The gene for the antibody is expressed and secreted into the plasma and tissue fluid.

(g) The antibody circulated in body fluids destroying the infectious antigen

top



6.3.7 Outline the effects of HIV on the immune system.(2)

HIV is a virus that selectively infects Lymphocytes

(a) Different lymphocytes

(b) HIV virus

(c) Infection as the virus attaches then enters the host lymphocyte.

(d) The infected lymphocyte is 'disabled' by the virus

(e) When an antigen infection is presented the lymphocyte cannot produce antibodies.

(f) The antigen is not challenged by the immune system and is able to freely proliferate

The consequence is that the infected individual will have no immune and develop that disease.

Therefore an individual who is HIV +ve (infected) will eventually develop a disease which will go unchecked. The consequence is that that disease will severely damage the infected person and will eventually bring about their death.

top

6.3.8 Discuss the cause, transmission and social implications of AIDS.(3)

AIDS: **Acquired Immuno deficiency syndrome**.

- ***Acquired*** relates the infectious nature of AIDS through the transmission of the HIV virus.
- ***Immuno deficient*** relates to the way diseases cannot be resisted.
- ***Syndrome*** relates to the variation in the way the disease manifest itself. People who develop AIDS can be a affected by quite different set of diseases.

Cause: is the HIV retro-virus that selectively infects cells of the immune system effectively disabling primary and secondary response to infection.

Transmission: Through contact with the body fluids of an infected person. In particular the fluids are blood and semen, vaginal mucus. There is a very low risk (almost zero) associated with salivary mucus.

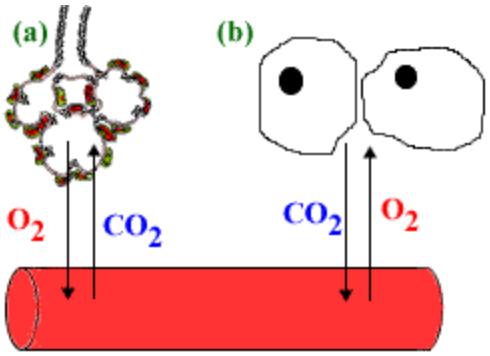
6.4.1 Distinguish between ventilation, gas exchange and cell respiration.(2)

1. Ventilation:

- The flow of air in and out of the alveoli is called ventilation and has two stages: inspiration (or inhalation) and expiration (or exhalation).

- Lungs are not muscular and cannot ventilate themselves, but instead the whole thorax moves and changes size, due to the action of two sets of muscles: the intercostal muscles and the diaphragm.

2. Gas Exchange:



This is the diffusion of gases (oxygen and carbon dioxide)

There are two sites for gas exchange

- (a)Alveoli: Oxygen diffuses into the blood from the alveoli and carbon dioxide diffuses from the blood into the alveoli

- (b)Tissues: Oxygen diffuses from blood into the cells and carbon dioxide diffuses from cells to the blood

3. Cell Respiration

- Aerobic respiration uses oxygen in the mitochondria and produces carbon dioxide

- Anaerobic respiration does not use oxygen but still produces carbon dioxide

top

6.4.2 Explain the need for a ventilation system.(3)

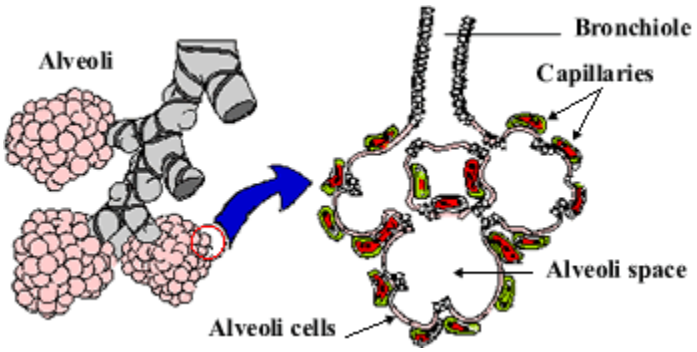
- A ventilation system is needed to maintain concentration gradients in the alveoli

- The steep concentration gradient across the respiratory surface is maintained in two ways: by blood flow on one side and by air flow on the other side. The ventilation system replaces diffuses oxygen (keeping the concentration high) and removes carbon dioxide (keeping the concentration low).

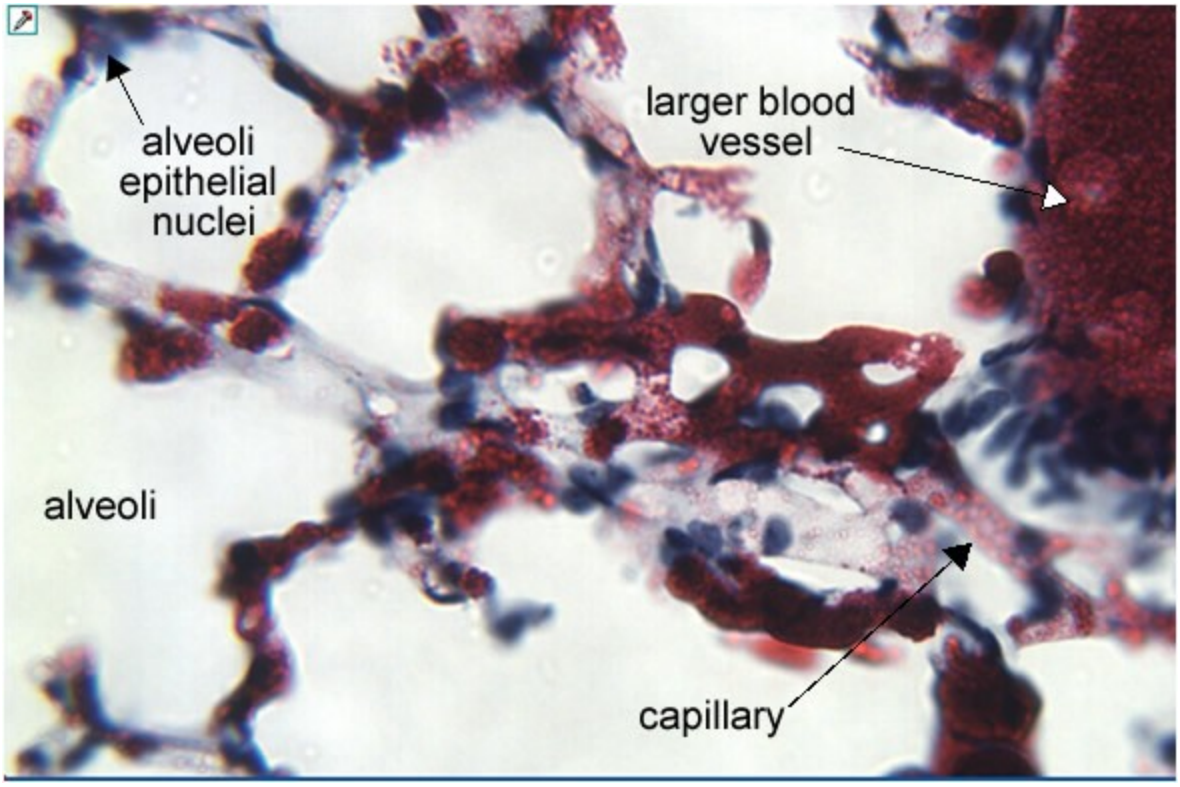
- This means oxygen can always diffuse down its concentration gradient from the air to the blood, while at the same time carbon dioxide can diffuse down its concentration gradient from the blood to the air.

top

6.4.3 Describe the features of alveoli that adapt them to gas exchange.(2)

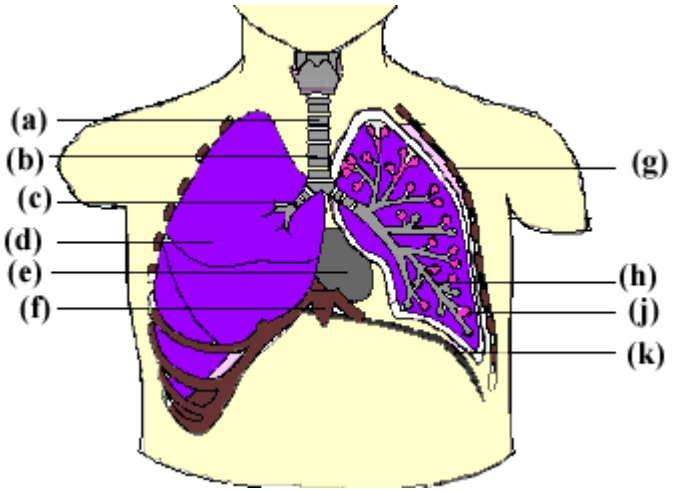


- Large surface area due to the combined spherical shape (600 million alveoli = 80 m^2)
- Flattened epithelial cells of alveoli and close association with capillaries
- Short diffusion distance from alveoli to blood (0.5-1.0 um)
- Dense capillary network
- Moist surface for the solution of gases



top

6.4.4 Draw and label a diagram of the ventilation system, including trachea, lungs, bronchi, bronchioles and alveoli.(1).



(a) Trachea

(b) Cartilage ring support

(c) Bronchi (plural) Bronchus (single)

(d) Lung

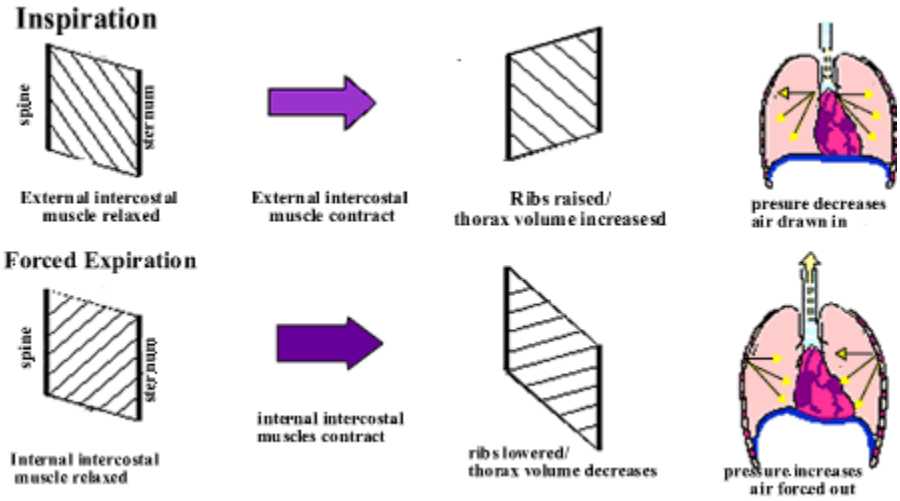
(e) Heart

(f) Sternum

(g) Rib cage

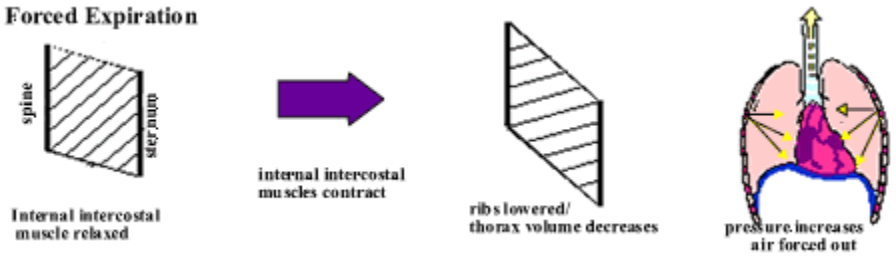
(h) Bronchioles (j) Alveoli (k) Diaphragm

6.4.5 Explain the mechanism of ventilation of the lungs in terms of volume and pressure changes caused by the internal and external intercostal muscles, the diaphragm and abdominal muscles.(3)



The diaphragm contracts and flattens downwards.

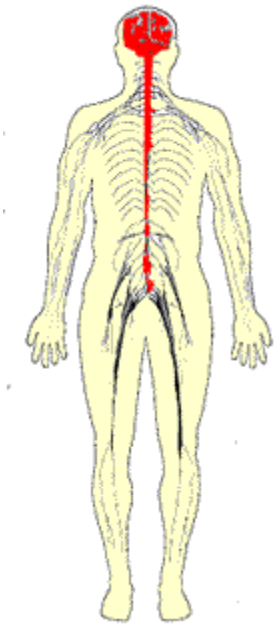
- The external intercostal muscles contract, pulling the ribs up and out
- this increases the volume of the thorax this increases the lung and alveoli volume
- this decreases the pressure of air in the alveoli below atmospheric (Boyle's law)air flows in to equalise the pressure

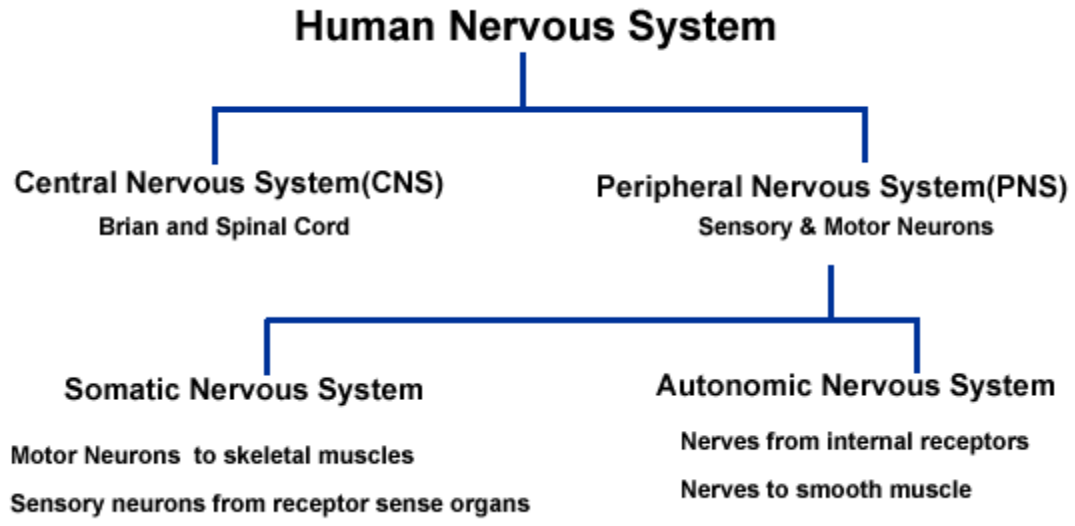


- The diaphragm relaxes and curves upwards
- the external intercostal muscles relax, allowing the ribs to fall
- this decreases the volume of the thorax
- this decreases the lung and alveoli volume
- this increases the pressure of air in the alveoli above atmospheric (Boyle's law)air flows out to equalise the pressure.

- The abdominal muscles contract, pushing the diaphragm upwards
- The internal intercostal muscles contract, pulling the ribs downward
- This gives a larger and faster expiration, used in exercise

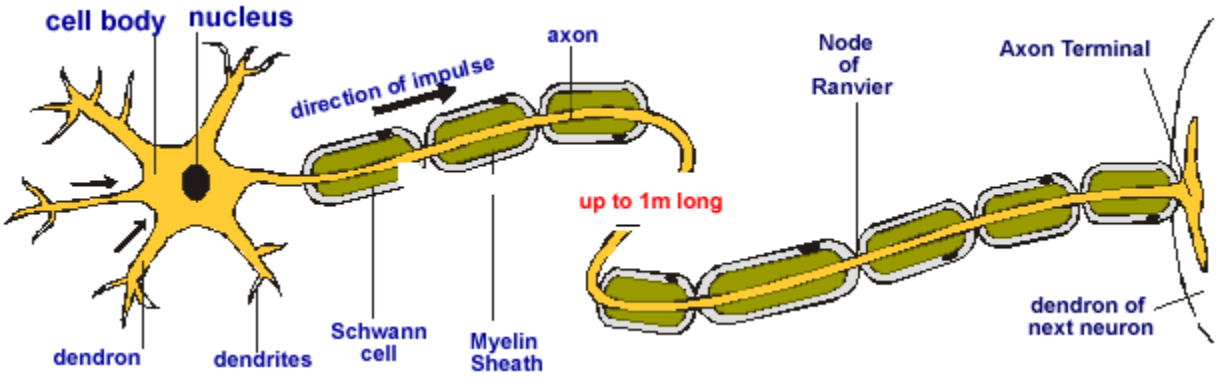
6.5.1 State that the nervous system consists of the central nervous system (CNS) and peripheral nerves, and is composed of cells called neurons that can carry rapid electrical impulses.(1)





top

6.5.2 Draw and label a diagram of the structure of a motor neuron.(1)



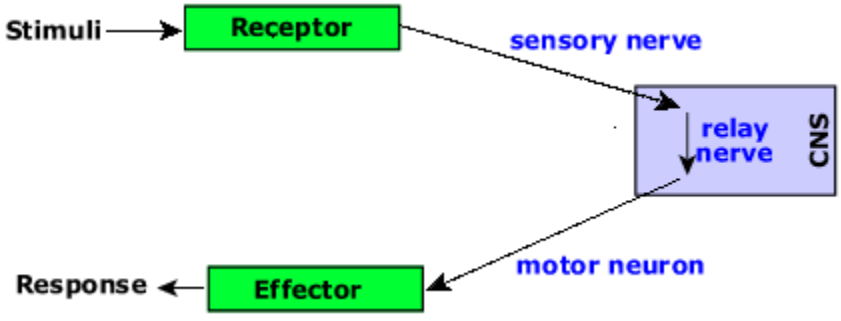
Electron micrograph cross section

- A neuron has a cell body with extensions leading off it.
- Numerous dendrons and dendrites provide a large surface area for connecting with other neurons, and carry nerve impulses towards the cell body.
- A single long axon carries the nerve impulse away from the cell body.
- The axon is only 10μm in diameter but can be up to 4m in length in a large animal (a piece of spaghetti the same shape would be 400m long)!
- Most neurons have many companion cells called Schwann cells, which wrap their cell membrane around the axon many times in a spiral to form a thick insulating lipid layer called the myelin sheath.
- Nerve impulse can be passed from the axon of one neuron to the dendron of another at a synapse. A nerve is a discrete bundle of several thousand neuron axons.

Humans have three types of neuron:

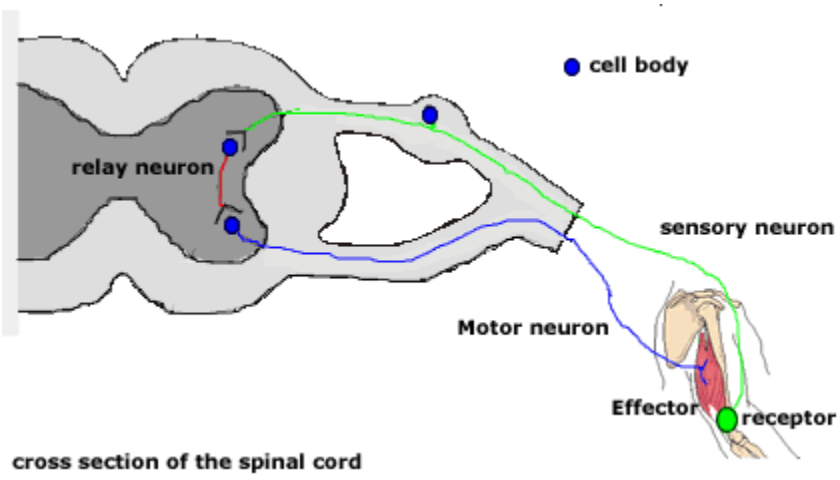
- Sensory neurons have long axons and transmit nerve impulses from sensory receptors all over the body to the central nervous system.
- Motor neurons also have long axons and transmit nerve impulses from the central nervous system to effectors (muscles and glands) all over the body.
- Interneurones (also called connector neurons or relay neurons) are usually much smaller cells, with many interconnections.

6.5.3 State that nerve impulses are conducted from receptors to the CNS by sensory neurons, within the CNS by relay neurons, and from the CNS to effectors by motor neurons.(1)



- There are various receptor around the body such as skin and the eye.
- Stimuli (think of them as energy forms) are detected by the receptors and turned into an nerve impulse (chemical energy).
- Nerve impulses from sensory nerves are conducted to the central nervous system along sensory neurons.
- The impulse is sent to the relay neurons that move it around inside the central nervous system (brain and spine).

- Motor neurons take the relayed nerve impulse to the effectors (often muscles) which then produce the response.

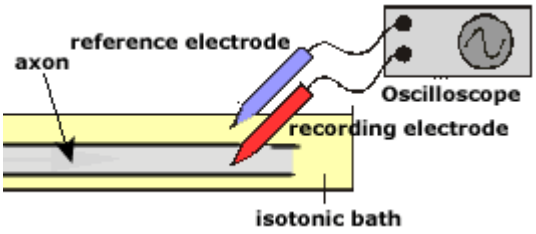


cross section of the spinal cord

- This is a cross section through the vertebrate spinal column.
- The receptor is deep in the biceps muscle.
- Sensory neuron conducts nerve impulses from the receptor to the central nervous system.
- The relay nerve conduct the impulse through the spinal cord and in a reflex back to the motor neuron.
- The motor neuron connects to the effector which in this case is the biceps muscle.

top

6.5.4 Define resting potential and action potential (depolarization and repolarization).(1).



- To record the electrical activity of a nerve it is placed in an isotonic fluid bath.
- A reference electrode is placed in the surrounding fluid.
- A recording electrode is inserted into the cytoplasm of the axon.
- The electrical disturbances are measured and displayed on the oscilloscope.

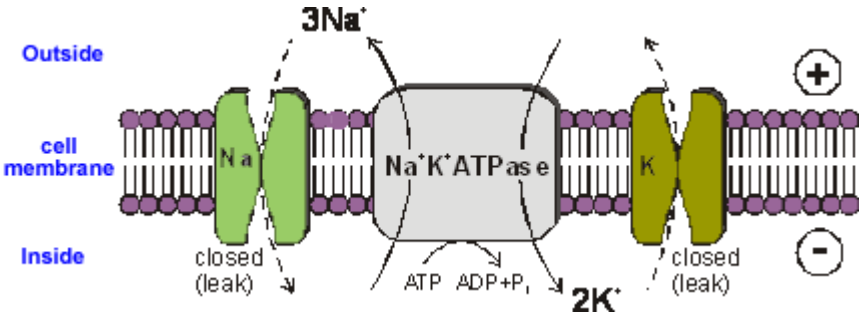
Membrane potentials:

- **Resting potential** is the negative charge registered when the nerve is at rest and not conducting a nerve impulse.
- **Action potential** is the positive electrochemical charge generated at the nerve impulse. Normally this is seen as the 'marker' of the nerve impulse position.
- **Depolarisation** is a change from the negative resting potential to the positive action potential.
- **Re-polarisation** is the change in the electrical potential from the positive action potential back to the negative resting potential.

top

6.5.5 Explain how a nerve impulse passes along a non-myelinated neuron.(3).

To understand the Resting Potential and Action Potential first consider an ion pump found in the plasma membrane

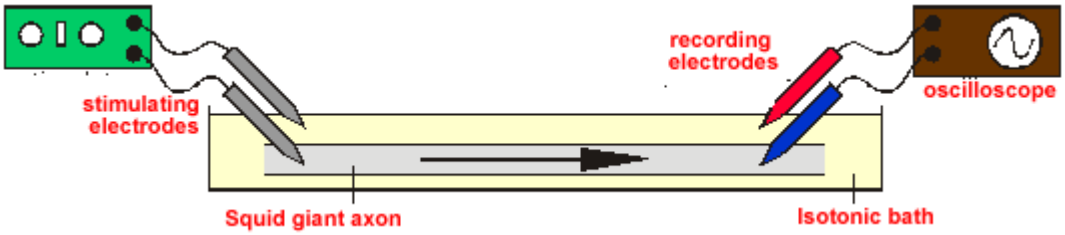


Sodium-Potassium ATPase

- This uses the energy from ATP splitting to simultaneously pump 3 sodium ions out of the cell and 2 potassium ions in.
- If this was to continue unchecked there would be no sodium or potassium ions left to pump, but there are also sodium and potassium ion channels in the membrane.
- These channels are normally closed, but even when closed, they "leak", allowing sodium ions to leak in and potassium ions to leak out, down their respective concentration gradients.
- The combination of the Na +K +ATPase pump and the leak channels cause a stable imbalance of Na + and K + ions across the membrane.
- This imbalance causes a potential difference across all animal cell membranes, called the ***membrane potential***.
- The membrane potential is always negative inside the cell, and varies in size from –20 to –200 mV in different cells and species.
- The Na $^{+}K^{+}$ ATPase is thought to have evolved as an osmoregulator to keep the internal water potential high and so stop water entering animal cells and bursting them. Plant cells don't need this as they have strong cells walls to prevent bursting.

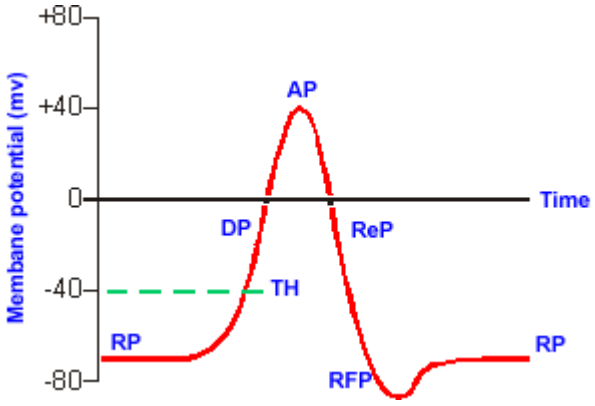
Resting Potential & Action Potential

- In nerve and muscle cells the membranes are electrically excitable, which means that they can change their membrane potential, and this is the basis of the nerve impulse.
- The sodium and potassium channels in these cells are ***voltage-gated***, which means that they can open and close depending on the voltage across the membrane.
- Early experiments on nerves focused on the non-myelinated ***Squid Giant Axon*** .
- An electrodes is placed inside the cell and one outside the cell (reference).
- The electrodes are attached to an oscilloscope
- The nerve cell is stimulated to generate a nerve impulse and the voltage change recorded on the oscilloscope.



- The normal membrane potential of these nerve cells is –70mV (inside the axon), and since this potential can change in nerve cells it is called the **resting potential.**

- When a stimulating pulse was applied a brief reversal of the membrane potential, lasting about a millisecond, was recorded. This brief reversal is called the **action potential:**



RP: **Resting Potential**

DP: Depolarisation

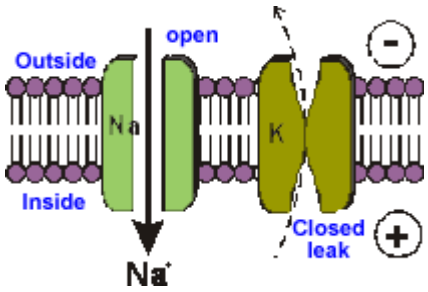
AP: Action Potential

ReP: Re-polarisation

RFP: Refractory Period

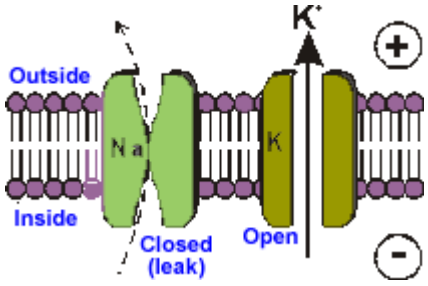
TH: Threshold

The Action Potential has two stages depolarisation (**DP**) and Re-polarisation(**ReP**)



Depolarisation .(**DP**)

- The stimulating electrodes cause the membrane potential to change a little.
- The voltage-gated ion channels can detect this change, and when the potential reaches –30mV**(TH)** the sodium channels open for 0.5ms
- The causes sodium ions to rush in, making the inside of the cell more positive.
- This phase is referred to as a depolarisation since the normal voltage polarity (negative inside) is reversed (becomes positive inside).



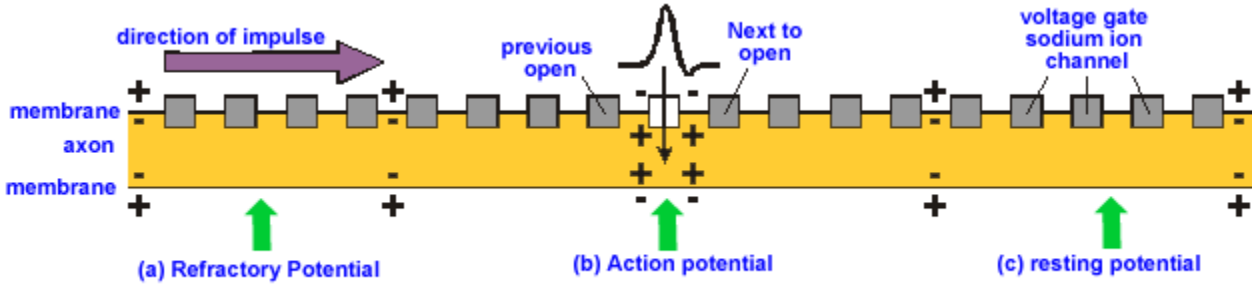
Re-polarisation (**ReP**).

- The membrane potential reaches 0V.
- The potassium channels open for 0.5ms, causing potassium ions to rush out.
- This makes the inside more negative again.
- Since this restores the original polarity, it is called re-polarisation

How the nerve impulse travels along the axon:

- Once an action potential has started it is moved (propagated) along an axon automatically.

- The local reversal of the membrane potential is detected by the surrounding voltage-gated ion channels, which open when the potential



Section a) Refractory potential:

The axon is in a refractory (**ReP**)period which means that diffusion backwards of Na^+ from the action potential is not able to depolarise the membrane channels. This means the impulse travels in one direction

Section b) Action Potential:

The voltage gates have been opened and there is a high concentration of Na^+ in the axon. This diffuses to the next set of voltage gates depolarising from resting potential.

Section c: Resting potential:

The Na^+will diffuse to this position. If the voltage reaches threshold (**TH**) then the channel will open Na^+will flood in and a new action potential site will be established.

Threshold (TH):

- The ion channels are either open or closed; there is no half-way position. This means that the action potential always reaches +40mV as it moves along an axon, and it is never attenuated (reduced) by long axons. In other word the action potential is all-or-nothing.

Re factory Period (ReP):

- After an ion channel has opened, it needs a "rest period" before it can open again.
- This is called the refractory period, and lasts about 2 ms.
- This means that, although the action potential affects all other ion channels nearby, the upstream ion channels cannot open again since they are in their refractory period, so only the downstream channels open, causing the action potential to move one-way along the axon.
- The delay caused by refractory period also prevents the summation of Action potentials (one impulse cannot catch up another impulse)

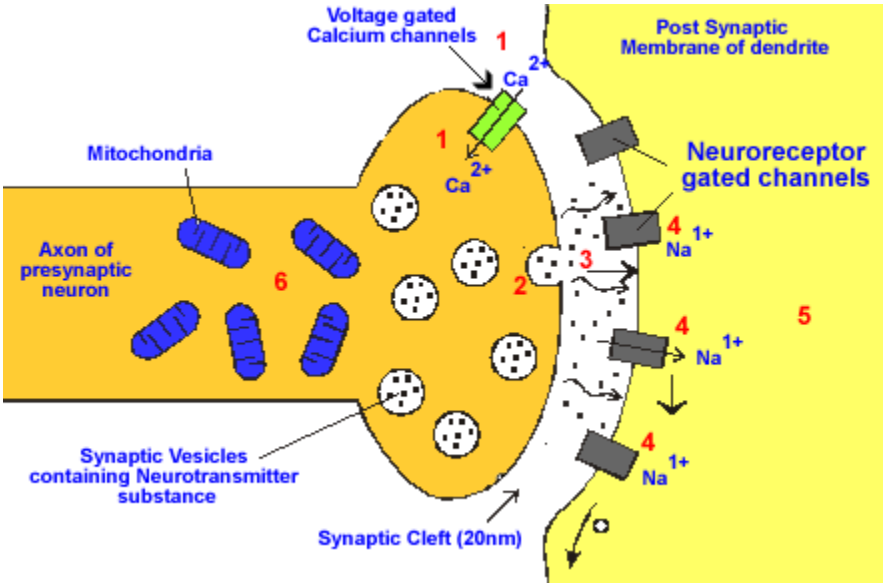
Human Nerve propagation:

It should be noted that the description given above of nerve conduction is for a squid giant axon. This is a typical arrangement in the invertebrates. To increase the rate of nerve conduction the axon diameter is increased. However, vertebrates have a different method of accelerating their nerve conduction but this is not part of the IB syllabus for this particular unit. You can however read about this method of nerve conduction called saltatory conduction.

top

6.5.6 Explain the principles of synaptic transmission.(3)

- The junction between two neurons is called a synapse.
- An action potential cannot cross the synaptic cleft between neurons, and instead the nerve impulse is carried by chemicals called neurotransmitters.
- These chemicals are made by the cell that is sending the impulse (the pre-synaptic neuron) and stored in synaptic vesicles at the end of the axon.
- The cell that is receiving the nerve impulse (the post-synaptic neuron) has chemical-gated ion channels in its membrane, called neuroreceptors.
- These have specific binding sites for the neurotransmitters



1. At the end of the pre-synaptic neuron there are voltage-gated calcium channels. When an action potential reaches the synapse these channels open, causing calcium ions to flow into the cell.

2. These calcium ions cause the synaptic vesicles to fuse with the cell membrane, releasing their contents (the neurotransmitter chemicals) by exocytosis.

3. The neurotransmitters diffuse across the synaptic cleft.

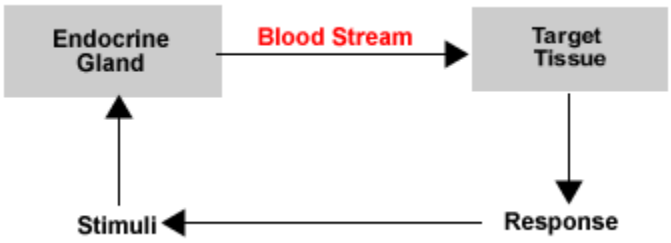
4. The neurotransmitter binds to the neuroreceptors in the post-synaptic membrane, causing the channels to open. In the example shown these are sodium channels, so sodium ions flow in.

5. This causes a depolarisation of the post-synaptic cell membrane, which may initiate an action potential.

6. The neurotransmitter is broken down by a specific enzyme in the synaptic cleft; for example the enzyme acetylcholinesterase breaks down the neurotransmitter acetylcholine. The breakdown products are absorbed by the pre-synaptic neuron by endocytosis and used to re-synthesis more neurotransmitter, using energy from the mitochondria. This stops the synapse being permanently on.

top

6.5.7 State that the endocrine system consists of glands that release hormones that are transported in the blood.(1)



- The gland secretes these hormones into the blood stream
- The hormone travels in blood to the target tissue (effector) that brings about a response.
- The response modifies the internal environment and this becomes feedback stimuli

top

6.5.8 State that homeostasis involves maintaining the internal environment between limits, including blood pH, carbon dioxide concentration, blood glucose concentration, body temperature and water balance.(1)

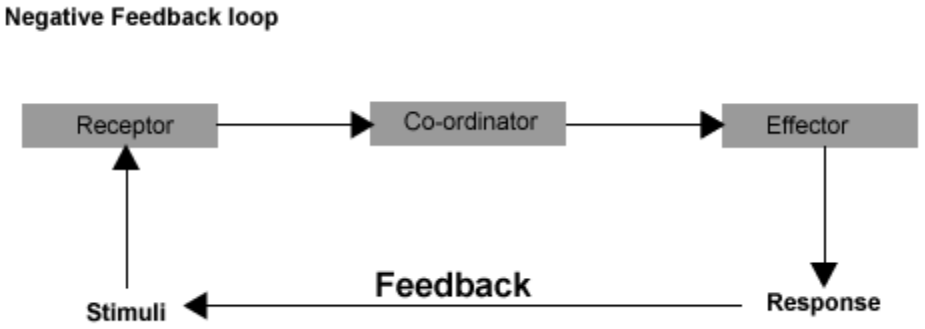
Homeostasis involves maintaining the internal environment (tissue fluid, blood) between limits.

Examples:

- Blood pH
- Blood carbon dioxide levels
- blood glucose concentration
- body temperature
- water balance

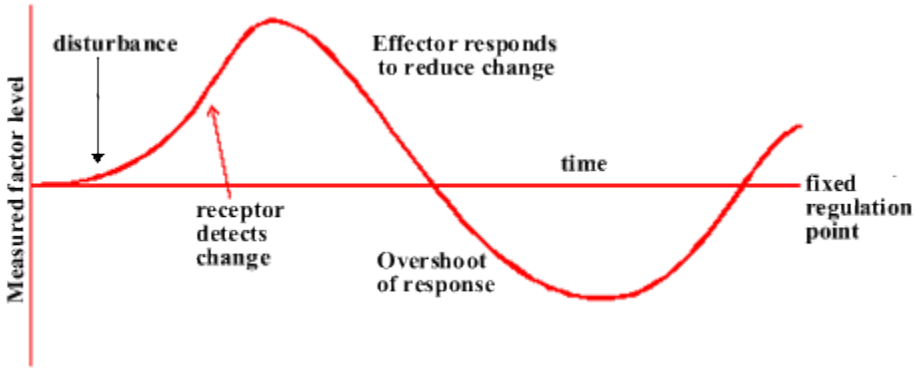
top

6.5.9 Explain that homeostasis involves monitoring levels of variables and correcting changes in levels by negative feedback mechanisms.(3)



- This model represents the main features of a negative feedback model .
- Specialised receptors detect changes within the internal conditions
- This information is relayed to a central coordinator that determines the level of response
- The coordinator in turn relays such a decision to the effector that is specialised to produce the response behaviour

- Notice that this response will modify the internal environment and that these new conditions will in turn become the new stimuli.
- The cycle will continue until conditions are reduced back to within narrow acceptable limits (fixed regulation point).
- Notice that system works responding to conditions which are lower than and higher than the fixed regulation point.
- Very efficient systems allow very little in the way of undershoot and overshoot.

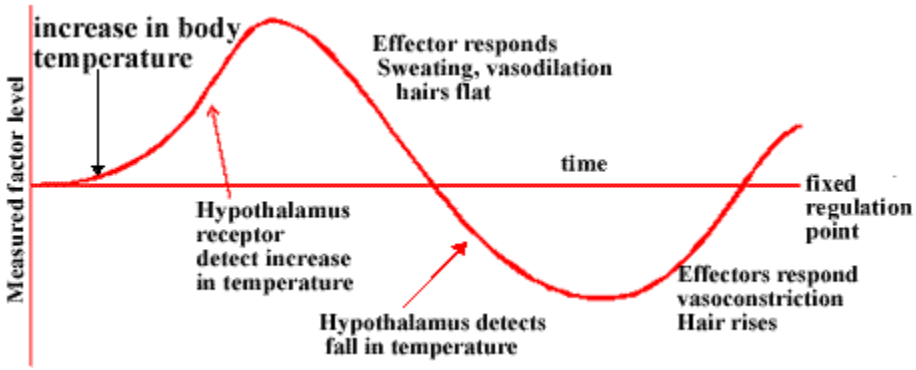


This model is an alternative representation of the negative feedback cycle but this time emphasising the deviation from a fixed regulation point.

top

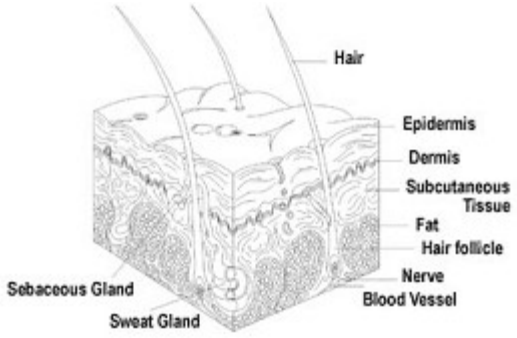
6.5.10 Explain the control of body temperature, including the transfer of heat in blood, and the roles of the hypothalamus, sweat glands, skin arterioles and shivering.(3).

The control of body temperature includes the transfer of heat in blood, the role of sweat glands and skin arterioles, and shivering.



Model of temperature control:

- The sensors are found in the hypothalamus.
- Effectors are found in the skin and in muscles.
- The fixed point for regulation is around 37.8 degrees centigrade.



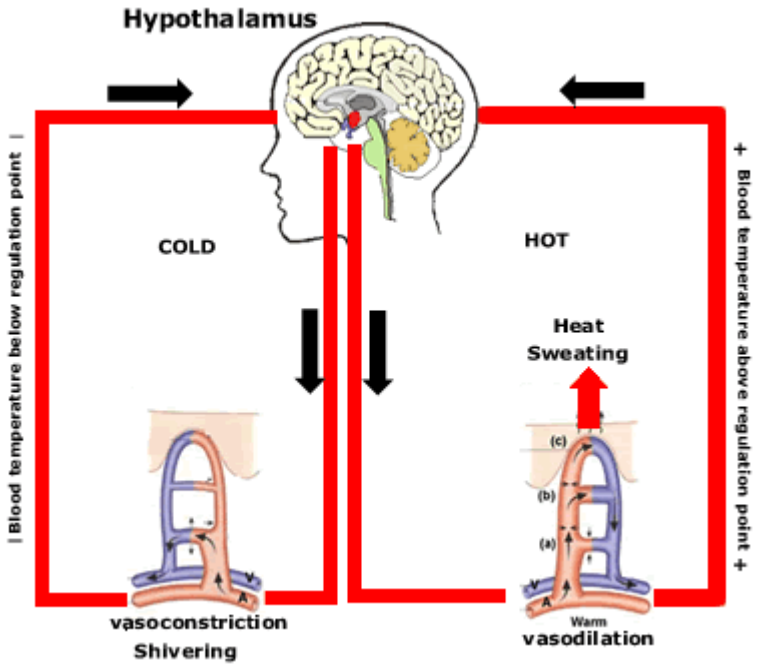
Note the particular features of skin which are involved in temperature regulation:

- Hairs with the erector Pilli muscle
- Sweat glands
- Blood arterioles
- The skin is an effector in the control of body temperature.
- It is particularly important to prevent cooling or overheating of the core (essential organs and brain)

The hypothalamus as the co-ordinator of temperature regulation:

Vasoconstriction: is a cold adaptation narrowing of arterioles that reduces blood flow to the surface of the skin is coupled with a dilation of the horizontal shunt vessels. This prevents heat loss from blood near the skin surface and retains heat in the body core for essential organs.

Vasodilation: is an adaptation to warm conditions in which arterioles dilate sending more blood closer to the skin surface from where heat can be radiated to the surrounding environment. The horizontal shunt vessels are constricted sending most blood closer to the skin surface. Additionally sweat (mainly water) is released onto the surface of the skin where it enters the vapour phase when warmed by the heat carried by blood. Therefore the vapour of sweat carried away heat energy from blood.



Cold: when cold the following events occur to reduce heat loss and raise temperature.

Lower than regulation temperature blood reaches the hypothalamus.

The hypothalamus signals the vasoconstriction (narrowing) of arterioles

Muscle effectors are produces the rapid contraction relaxation of muscles known as shivering which produces more body heat.

Hot:

- Sweat is secreted onto the surface of skin when body temperature is high
- Sweat is largely composed of water which has a high specific heat capacity (absorbs a heat easily)
- Body heat is transferred from skin and blood to the sweat
- The sweat evaporates transferring heat away and in doing so cools the body

Hair and temperature control:

- In warm weather the erector-pilli muscle are relaxed and the hairs lie flat.
- This prevents a build up of a 'boundary layer' of warm air.
- Air movement will further accelerate the loss of heat.
- In cold weather the erector-pilli muscle contracts and the hair moves vertical. This traps a 'boundary layer' of warm air that reduces the temperature gradient and in turn reduces heat loss.
- Other longer term adaptations take place when exposed to continuously high or low temperatures. These effects are often linked to the metabolic rate of the organism and are atleast in part influenced by the endocrine system.
- Whilst a significant mechanism for the control of heat loss in many mammals the relatively hairless body of humans derives very little benefit from this mechanism.

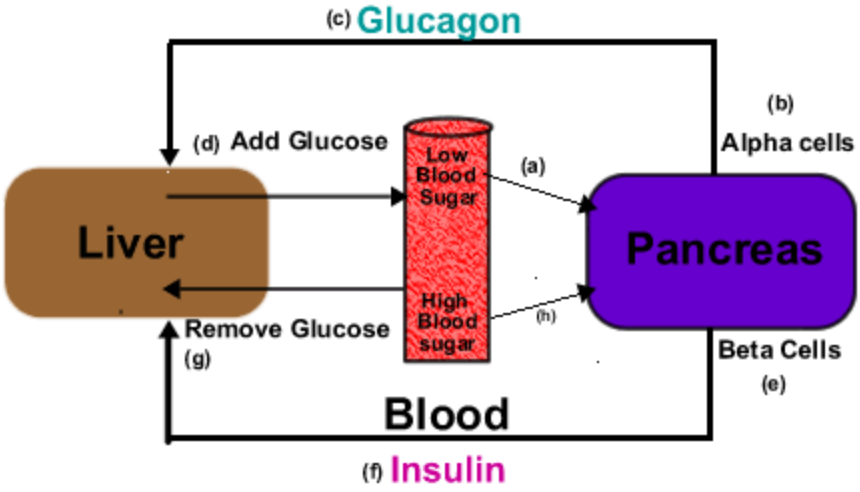
top

6.5.11 Explain the control of blood glucose concentration, including the roles of glucagon, insulin and α and β cells in the pancreatic islets.(3)

Blood sugar concentration is regulated for a number of reason amongst which:

Osmosis. content of a tissue is determined by the concentration of the surrounding tissues.

Respiration: Some tissues are entirely dependent on blood sugar as a respiratory substrate being unable to either store glucose of metabolise fat.



Model:

a) Low glucose concentration is detected by the pancreas.

b) Alpha cells in the pancreatic islets secret glucagon.

c)Glucagon flows through the blood to receptors on liver cells.

d)Liver responds by adding glucose to blood stream.

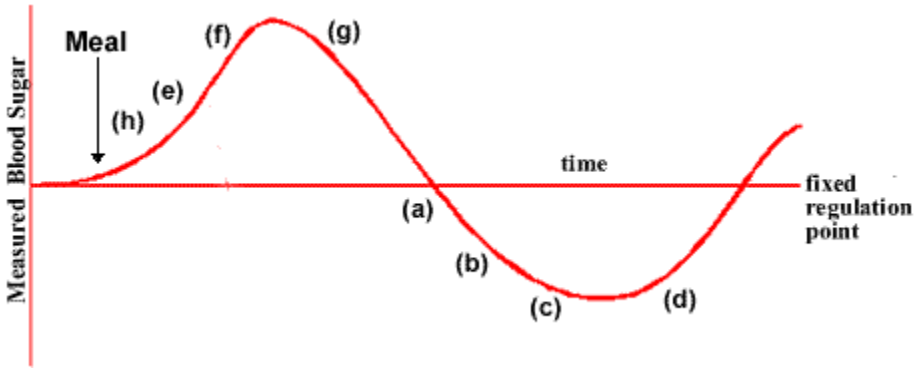
h) High blood glucose levels stimulate the beta pancreatic cells

a) Beta pancreatic cells secrete insulin.

f)Insulin flows through the blood to the receptors on liver cells.

g)Insulin stimulates the liver to remove blood glucose and store this as glycogen (insoluble)

Blood sugar regulation alternative diagram (labels correspond to both diagrams)



Note from the second diagram that the glucose levels remain within a set of narrow limits. The regulation point for blood glucose is around 5 mmol dm^{-3}.

The response and change in blood glucose levels becomes the new stimuli for receptors

This is a typical feedback control.

Additional features of blood sugar regulation:

- Insulin stimulates the 'glucose-transporter molecules' in the cell membrane of liver cells to take up glucose.
- Insulin is responsible for the conversion of glucose to glycogen but also to fat.
- Insulin stimulates the incorporation of 'glucose-transporter molecules into the cell membrane of the muscle cells. Then the glucose is taken up and stored as glycogen as in the liver. Muscles will store around 900g of glycogen in comparison to the average 100 g in the liver.

- Adipose (fat cells) are also stimulated to take up the glucose and begin its conversion to fat.
- Almost all cells are influenced in this way by insulin, except that is for the cells of the nervous system which require a constant blood glucose level.
- After the absorption of glucose most cells will switch their metabolism to the beta oxidation of fat and preserve their glycogen stores. This cannot be done by the cells of the nervous system which of course is another reason to maintain blood sugar levels.

Ask around your class for people who whilst not diabetics experience mild hyperglycaemia or have experienced this as on the odd occasion. They will describe that if they do not eat regularly that they experience muscle weakness, lethargy, mild visual disturbance. The interesting features are those that affect their nervous system and have some remarkable resemblance to mild migraine symptoms.

top

6.5.12 Distinguish between type I and type II diabetes. (2)

Type I diabetes (early or juvenile onset):

- Auto-immune disease in which the beta-cells pancreatic are destroyed.
- Unable to produce insulin.
- Responds well to regular injection of insulin probably manufactured as the genetically engineered *humulin.*

Type II diabetes (Adult onset):

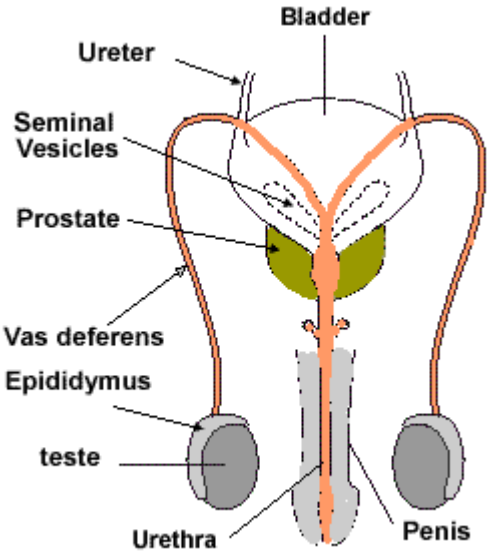
- Reduced sensitivity of the liver cells to insulin.
- Reduced number of receptors on the liver cell membrane.

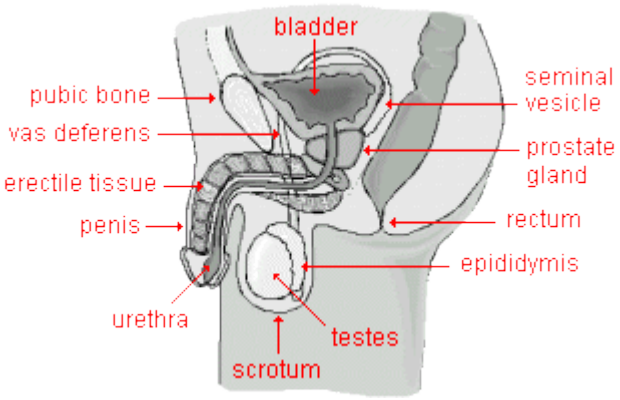
In both types of diabetes there is:

- a build of glucose in the blood stream and it will then subsequently appear in urine. (test with a *Clinistic*)
- High concentrations of blood glucose (hyperglycaemia) results in the movement of water from cells by osmosis.
- This extra fluid in the blood results in larger quantities of urine production.
- A lack of glucose in cells means that fats then proteins have to be metabolised in respiration.
- Particularly the breakdown of protein for energy creates organ damage.

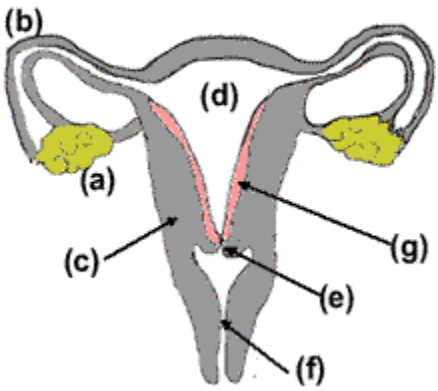
6.6.1 Draw and label diagrams of the adult male and female reproductive systems.(1)

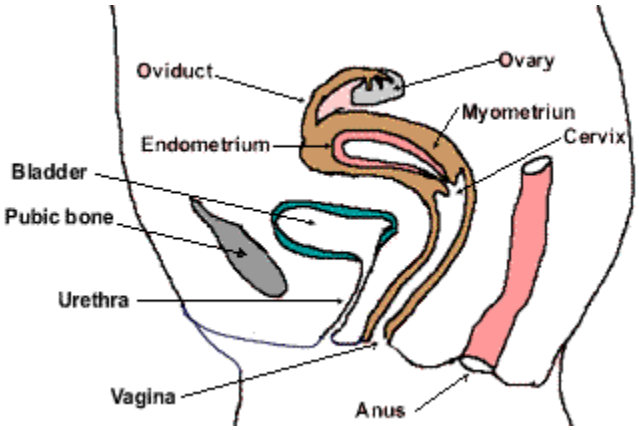
Male reproductive system:





Female reproductive system:





top

6.6.2 Outline the role of hormones in the menstrual cycle, including FSH (follicle stimulating hormone), LH (luteinizing hormone), estrogen and progesterone.(2).

- Sexual maturity in women is marked by the beginning of the menstrual cycles. These cycles coordinate the development and release of an egg with the conditions required in the uterus to support a pregnancy.
- The cycle is controlled by hormones from both the brain (FSH and LH) and the ovary(oestrogen and progesterone).
- The natural cycle repeats until there is either a pregnancy or the woman reaches menopause and the end of the reproductive phase of her life.
- FSH and LH are two hormone that are active at significant phases of human development including primary and secondary sexual characteristics. They are both significant hormones in the primary sex determination. Following puberty human become fertile and in females this is manifest as the menstrual cycle.

Anterior Pituitary Hormones:

Follicle Stimulating hormone (FSH)

- Stimulates the development of a primary follicles (oocytes).
- Increases the number of follicular cells which in turn produce oestrogens.
- Produces follicular fluids.
- Develops the oocyte in the follicle.

Luteinising Hormone (LH):

- surges in mid cycle (12 days) to bring about ovulation.
- high LH is associated with a resumption of meiosis in the oocyte. Meiosis has been arrested in Prophase I since the embryonic stage. Only at the point of fertilisation does meiosis complete.
- stimulates the development of the corpus luteum.

Ovarian Hormones

Oestrogen:

- Stimulates the development of the endometrium (lining of the uterus) and it associated blood supply.
- During the first half of the cycle there is positive feedback through increased sensitivity of the follicle cells to FSH (Up-regulation of receptors on the follicular cell plasma membrane).
- During the second half of the cycle (high oestrogen) there is negative feedback on FSH and LH.

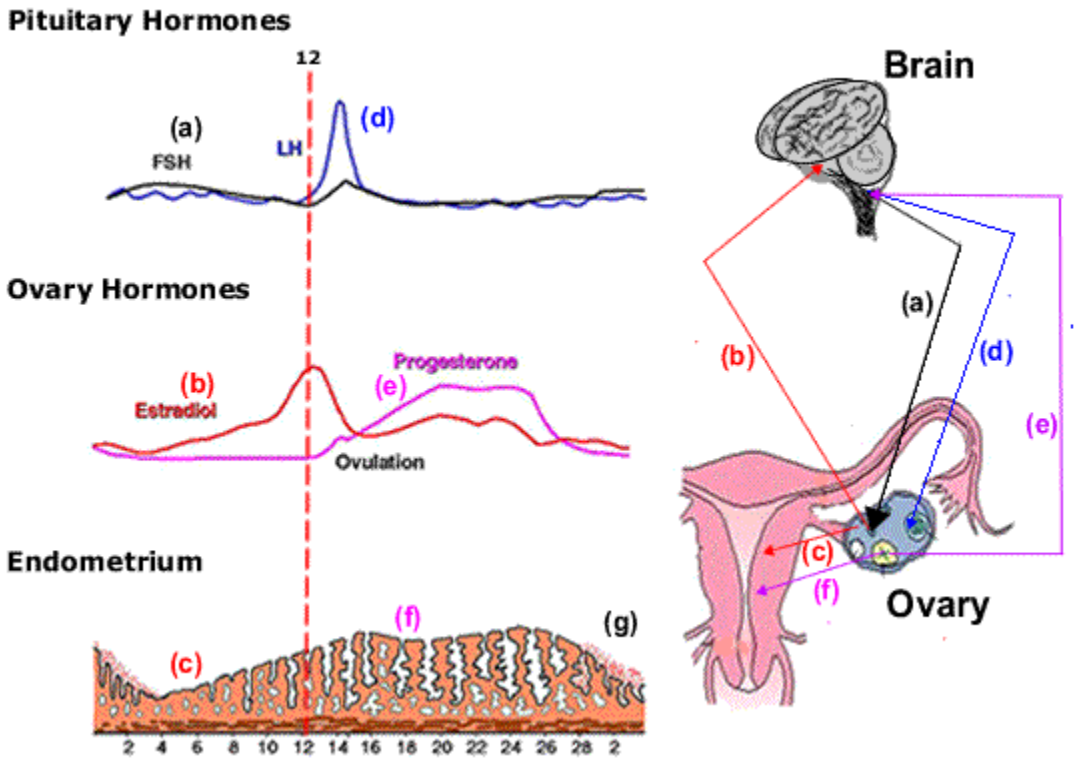
Progesterone:

- maintains the lining of the endometrium
- negative feedback on FSH and LH

top

6.6.3 Annotate a graph showing hormone levels in the menstrual cycle, illustrating the relationship between changes in hormone levels and ovulation, menstruation and thickening of the endometrium.(2)

a)



Follicle Stimulating Hormone (FSH) is secreted by the pituitary gland of the brain and stimulates the development of a primary follicle.

(b) Primary follicle cells secrete oestrogen which in turn increase the secretion of FSH in a positive feedback.

(c) The oestrogen thickens the lining of the uterus in preparation for a fertilised egg.

(d) The peak of oestrogen secretion at day 12 causes the pituitary to release a surge of LH. This loosens the now mature egg which is released in ovulation

- LH reduces the secretion of Oestrogen

- LH stimulates the empty follicle to develop into the corpus luteum

e) Progesterone and oestrogen together stop any more LH and FSH being secreted from the pituitary. (negative feedback)

- This prevents further follicle development or ovulation.

(f) Progesterone maintains the lining of the thickened endometrium in preparation for the implantation of a fertilised egg.

(g) If implantation does not take place then the Corpus luteum degenerates and fails.

The progesterone production stops.

- The endometrium breaks down and the 'menstrual period' begins
- The inhibition of FSH and LH by ovarian hormones has been removed and so they begin their secretions again of FSH.
- A new cycle has begun.

top

.

6.6.4 List three roles of testosterone in males.(1)

1. Week 7 of embryonic development, testosterone initiates the development of male genitalia.

2. Around mid teens, testosterone initiates the development of secondary sexual characteristics

- increase in muscle mass
- increase in the length of the long bones (height)
- increase in the length of the vocal cords (voice deepens)
- spermatogenesis

- growth of the penis and testis

3. Post puberty testosterone maintains the production of sperm cells and the male sex drive.

top

6.6.5 Outline the process of in vitro fertilization (IVF).(2)

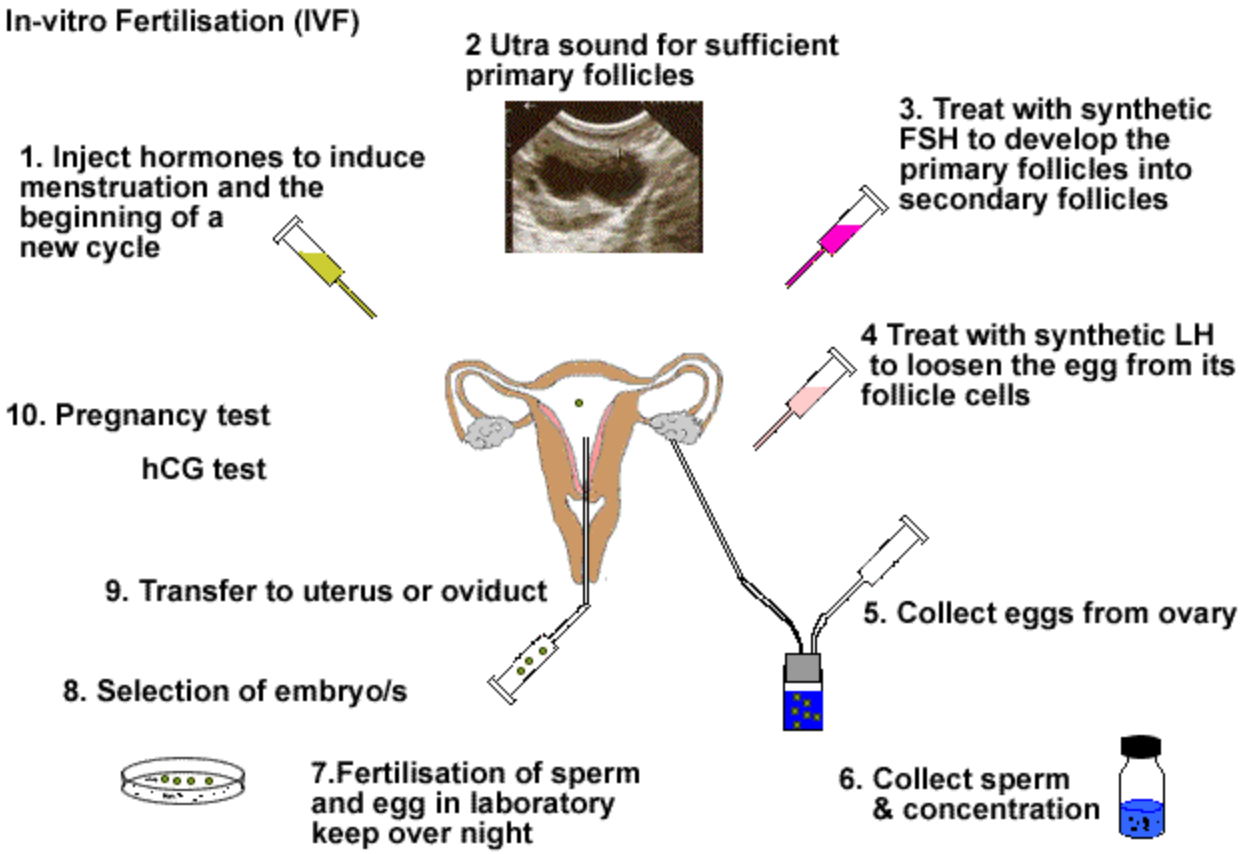
One of the common reasons that a couple cannot produce a pregnancy is the low sperm count of the male. This can be rectified by concentrating the male sperm before being placed into the uterus of the female using a catheter.

Other reasons for infertility include stenosis (blockage) of the cervix which again can be overcome by simple procedures and the mechanical introduction of sperm through this passage (as above).

In more complex cases of infertility it is necessary to fertilize the egg cell outside of the body before introducing the embryos into the uterus for implantation.

One of the assisted reproductive technologies is called 'In Vitro fertilisation' or IVF. First performed by Sir Robert Winston in 1978 Oldham England. Louise Brown was the first of millions of '*test tube babies*'.

The first stage of the technique maybe preceded by the taking of inhibitors of FSH and LH but this stage maybe missed through monitoring using ultrasound.



top

6.6.6 Discuss the ethical issues associated with IVF.(3)

Advantages of IVF: there are as many reasons for this treatment as there are people seeking this treatment. As examples

- over comes infertility
- allow families for people who must be sterilised e.g.. radiography/chemo therapy cancer patients

Disadvantages of IVF:

- what happens to unwanted embryo's
- what happens to orphaned embryo's
- should infertility be by-passed

BIOLOGY WORKSHEET – UNIT 2 MYP 5

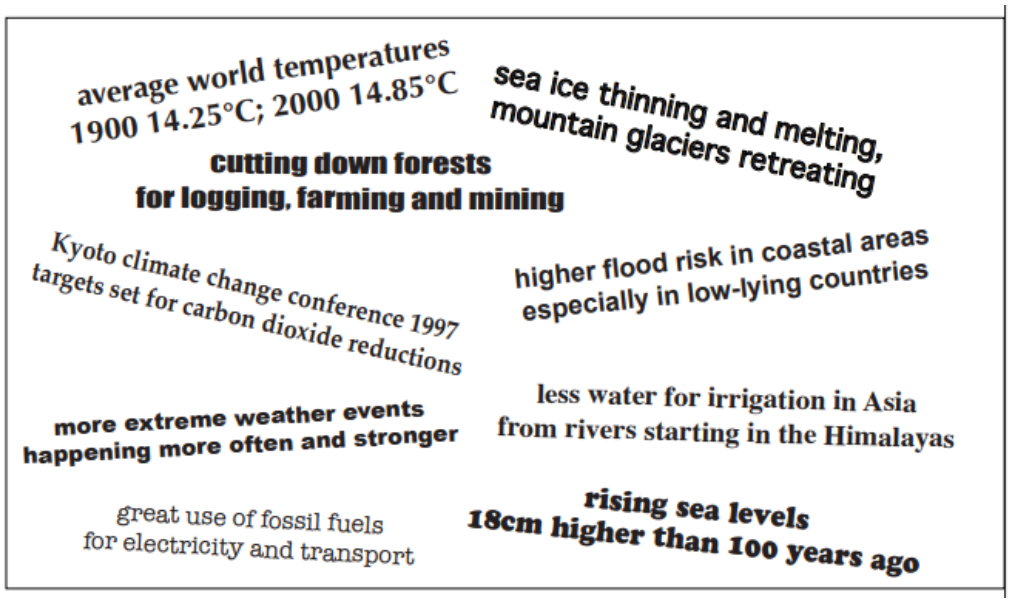
ECOSYSTEM

MYP4

CRITERION A

1. Define the terms: Population, Species, Ecosystem [1 mark each]
2. Outline: climate change, Eutrophication [3 marks each]
3. Look at the box below which contains statements about global climate change.

global climate change

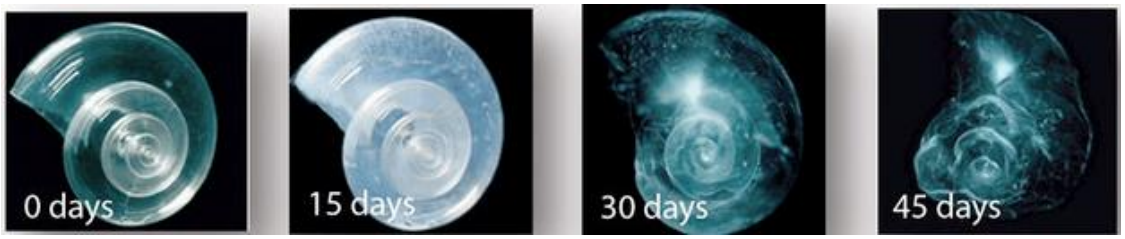


Choose two statements which give physical evidence suggesting the existence of global warming, and another two statements which are effects of global warming on people. Justify your answer. [4 marks]

CRITERION B and C

1. The pteropod is a tiny sea creature about the size of a small pea. Pteropods are a major food source for many animals including North Pacific juvenile salmon. The photos below

show what happens to a pteropod's shell when placed in sea water with pH and carbonate levels projected for the year 2100.

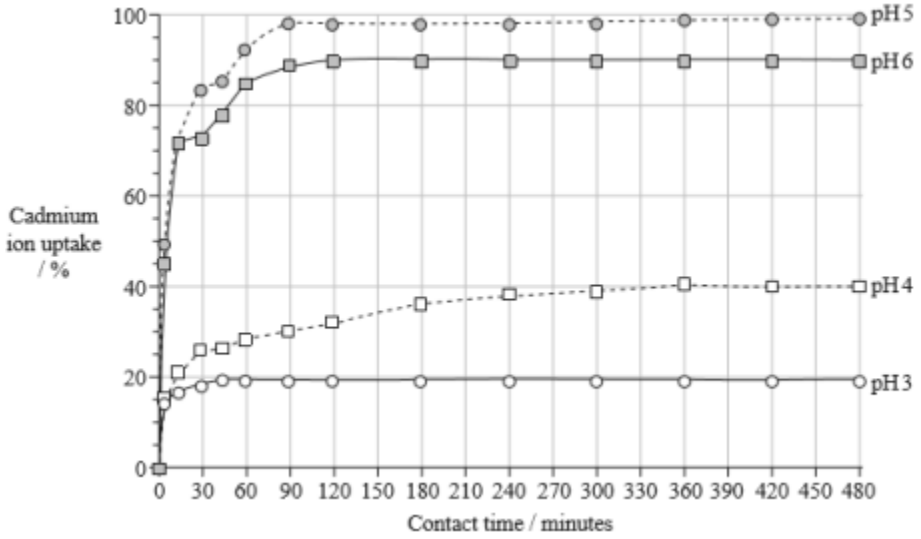


Design an experiment to demonstrate that acidification of oceans are a threat to shelled animals like pteropods/snails etc.

2. Removal of toxic heavy metals from industrial waste water is essential in order to control environmental pollution.

Industrial wastewater near Yanbu City, Saudi Arabia was found to contain 19 species of microorganisms that could tolerate heavy metals. The accumulation of cadmium ions in the most common of these microorganisms, Aspergillus fumigatus, was investigated.

The graph below shows the effect of pH on the ability of A. fumigatus to absorb cadmium ions from an aqueous Solution.



A. Identify the IV, DV and 2 CVs for this experiment.
B. Suggest a limitation and provide an improvement.
C. Suggest an extension.

3. Using the data given in the graph above answer the following.

A. Describe the cadmium ion uptake by A. fumigatus at pH 6.

B. Calculate the difference in cadmium ion uptake between pH 4 and pH 5 at 60 minutes.

C. Discuss the use of A. fumigatus for the removal of cadmium ions in polluted waters.

D. The investigation found that both living and dead A. fumigatus cells were able to absorb cadmium ions. Suggest an advantage of using dead A. fumigatus cells.

CRITERION D

1 (i). Outline the causes and consequences of greenhouse gases.

(ii). Discuss possible solutions to minimize their presence in the atmosphere.

2. Two possible solutions for Overpopulation of humans are:

   A. **Improved access to reproductive healthcare:**

   By making contraceptives readily available and affordable, individuals can better control their fertility and decide when and how many children to have, leading to a decrease in birth rates.

   B. Empowering women through education:

   Educated women tend to have fewer children as they are more likely to participate in the workforce, have greater economic independence, and make informed decisions regarding family planning.

   - Discuss an advantage and a disadvantage of the 2 methods.
   - Economic impacts of the 2 solutions.
   - A concluding appraisal.

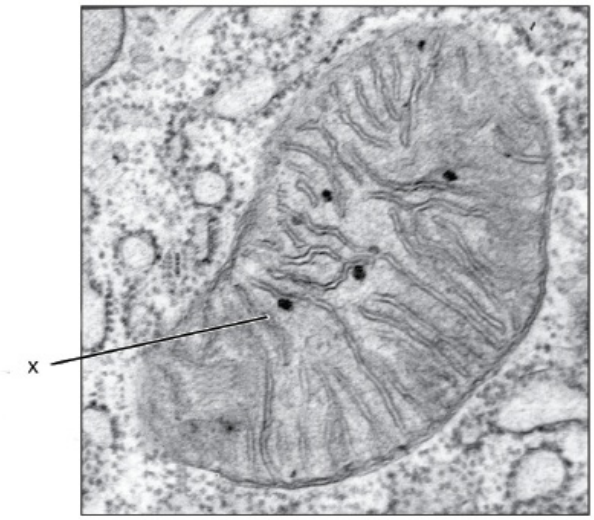
T1-1 *[247 marks]*

1. What structures are part of an *Escherichia coli* cell? *[1 mark]*
A. Ribosomes, nucleoid and Golgi apparatus
B. Ribosomes, mitochondria and pili
C. Cell wall, plasma membrane and nuclear membrane
D. Pili, flagella and cytoplasm

2. A botanist measures a leaf and finds it is 24 cm long and 8 cm wide. His drawing of the leaf is 4 cm wide. Which was the magnification and length of his drawing, assuming that the proportions of the drawing were correct? *[1 mark]*

	Scale	Length / cm
A.	×2	48
B.	×2	12
C.	×0.5	48
D.	×0.5	12

3. What is the structure labeled X in the electron micrograph of a rat liver cell? *[1 mark]*



> [Source: "0315 Mitochondrion new" by OpenStax College - Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.. Licensed under CC BY 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:0315_Mitochondrion_new.jpg#/media/File:0315_Mitochondrion_new.jpg]

A. Ribosome
B. Lysosome
C. Mitochondrion
D. Nucleus

4. Which events occur during both mitosis and meiosis? *[1 mark]*
A. Production of haploid cells from diploid cells
B. Crossing over
C. Separation of the chromatids from each chromosome
D. Production of genetically different cells

5. Which functions of life are carried out by all unicellular organisms? *[1 mark]*

A. Response, homeostasis, growth and photosynthesis
B. Metabolism, ventilation, reproduction and nutrition
C. Response, homeostasis, metabolism and growth
D. Reproduction, ventilation, response and nutrition

6. Which sequence shows increasing relative size? *[1 mark]*

	Smallest → Largest		
A.	membrane thickness	virus	bacterium
B.	molecule	virus	membrane thickness
C.	bacterium	virus	eukaryotic cell
D.	bacterium	organelle	virus

7. What is a function of the plant cell wall? *[1 mark]*

A. Formation of vesicles for transport of large molecules
B. Prevention of excessive water uptake
C. Communication with other cells by means of glycoproteins
D. Active transport of ions

8. Why do multicellular organisms have emergent properties? *[1 mark]*

A. They have more genes than unicellular organisms.
B. Properties of unicellular organisms are enhanced by having many cells.
C. All of their genes are expressed whereas unicellular organisms express only some.
D. They show properties that can only result from the interaction of many cells.

9. What distinguishes prokaryotic cells from eukaryotic cells? *[1 mark]*

	Prokaryotic cells	Eukaryotic cells
A.	no plasma membrane	plasma membrane
B.	80S ribosomes	70S ribosomes
C.	Golgi apparatus	mitochondria
D.	no internal membrane compartments	internal membrane compartments

10. What is osmosis? *[1 mark]*

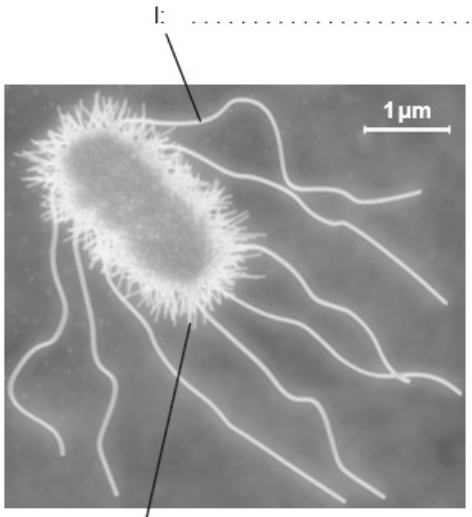
A. The movement of water through a membrane from a low to a high solute concentration
B. The movement of solutes through a membrane from a high to a low water concentration
C. The movement of water through a membrane from a high to a low solute concentration
D. The movement of solutes through a membrane from a low to a high water concentration

11a. Outline the cell theory *[2 marks]*

. . . . . .

. . . . . .

. . . . . .



11b. Annotate the electron micrograph of the *Escherichia coli* cell with the function of the structures labelled I and II. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

11c. Calculate the magnification of the electron micrograph. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

12a. Describe the genetic code and its relationship to polypeptides and proteins. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

12b. Outline the role of proteins in active and passive transport of molecules through membranes. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

12c. Many cell functions, like synthesis of macromolecules and transport, require energy in the form of ATP. Explain how ATP is generated in animal cells. *[8 marks]*

. . . . . .

. . . . . .

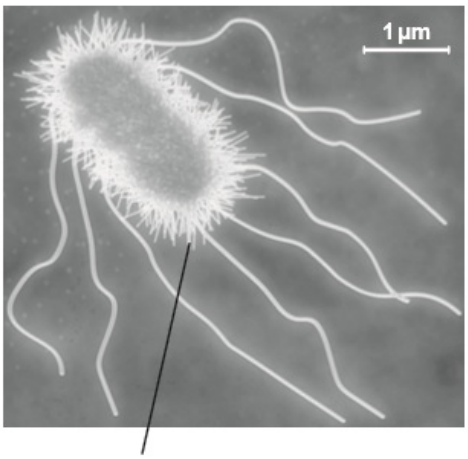
. . . . . .

13a. Outline the cell theory. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .



. . . . . .

13b. Annotate the electron micrograph of the *Escherichia coli* cell with the function of the indicated structure. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

13c. Calculate the magnification of the electron micrograph. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

13d. Explain the role of the following enzymes in DNA replication. *[1 mark]*
Helicase

. . . . . .

. . . . . .

. . . . . .

13e. Explain the role of the following enzymes in DNA replication. *[1 mark]*
DNA ligase

. . . . . .

. . . . . .

. . . . . .

14a. Explain how minerals move into plants. *[8 marks]*

. . . . . .

. . . . . .

. . . . . .

14b. Outline the conditions needed for the germination of a typical seed. *[3 marks]*

. . . . . .

. . . . . .

. . . . . .

14c. Following germination of seeds, plants undergo a rapid increase in the number of cells. Describe stages in the cell cycle that result in this increase of cells. *[7 marks]*

. . . . . .

. . . . . .

. . . . . .

15a. Draw a labelled diagram of a prokaryotic cell. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

15b. Bacteria are prokaryotes that sometimes act as pathogens. Describe how the body can defend itself against pathogens. *[7 marks]*

. . . . . .

. . . . . .

. . . . . .

15c. Explain the evolution of antibiotic resistance in bacteria. *[6 marks]*

. . . . . .

. . . . . .

. . . . . .

16a. Draw a labelled diagram showing the structure of three water molecules and how they interact. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

16b. Aquatic and other environments are being affected by a global rise in temperature. Outline the consequences of this on arctic ecosystems *[6 marks]*

. . . . . .

. . . . . .

. . . . . .

16c. Cell membranes separate aqueous environments in cells. Explain how the properties of phospholipids help to maintain the structure of cell membranes. *[8 marks]*

. . . . . .

. . . . . .

. . . . . .

17. Discuss the endosymbiotic theory for the origin of eukaryotes. *[4 marks]*

. . . . . .

. . . . . .

. . . . . .

18. What happens to the cell surface area to volume ratio as a cell grows? *[1 mark]*

A. It decreases, so production of waste material is reduced.
B. It increases, so mineral ion absorption is increased.
C. It increases, so osmosis is reduced.
D. It decreases, so rate of gas exchange is too low.

. . . . . .

. . . . . .

. . . . . .

19. What is a function of the plant cell wall? *[1 mark]*

A. Formation of vesicles for transport of large molecules
B. Prevention of excessive water uptake
C. Communication with other cells by means of glycoproteins
D. Active transport of ions

. . . . . .

. . . . . .

. . . . . .

20. What distinguishes prokaryotic cells from eukaryotic cells? *[1 mark]*

	Prokaryotic cells	Eukaryotic cells
A.	no plasma membrane	plasma membrane
B.	80S ribosomes	70S ribosomes
C.	Golgi apparatus	mitochondria
D.	no internal membrane compartments	internal membrane compartments

. . . . . .

. . . . . .

. . . . . .

21. What is an example of binary fission? *[1 mark]*

A. Cell division in prokaryotes
B. Production of haploid gametes
C. Separation of chromatids in prokaryotic cells
D. Replication of prokaryotic DNA occurring simultaneously in two directions

. . . . . .

. . . . . .

. . . . . .

22. Where are proteins synthesized by free ribosomes used? *[1 mark]*

A. Outside the cell after secretion
B. Within the nucleus
C. Within the lysosomes
D. Within the cytoplasm

. . . . . .

. . . . . .

. . . . . .

23a. Draw a labelled diagram to show the structure of the plasma membrane. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

23b. The light-dependent reactions in photosynthesis take place on the thylakoid membranes. Explain the light-dependent reactions. *[8 marks]*

. . . . . .

. . . . . .

. . . . . .

23c. Outline two factors that affect the rate of photosynthesis. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

24a. Outline the endosymbiotic theory. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

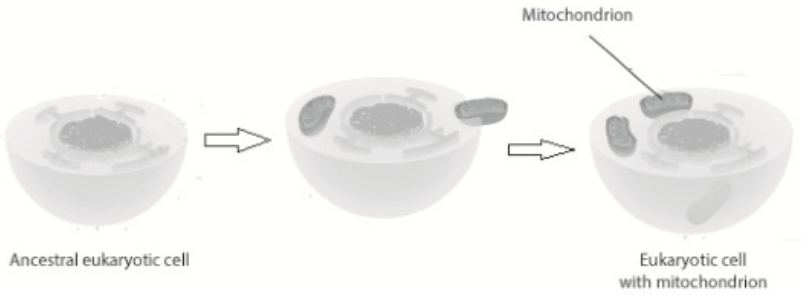
24b. Define *gene pool*. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

25. The diagram shows some of the later stages in the origin of eukaryotic cells according to the endosymbiotic theory. *[3 marks]*



[Source: "Serial endosymbiosis" by Kelvinsong - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Serial_endosymbiosis.svg#/media/File:Serial_endosymbiosis.svg]

Discuss the endosymbiotic theory including the evidence for the process shown in the diagram.

. . . . . .

. . . . . .

. . . . . .

26. Which functions of life are carried out by **all** unicellular organisms? *[1 mark]*

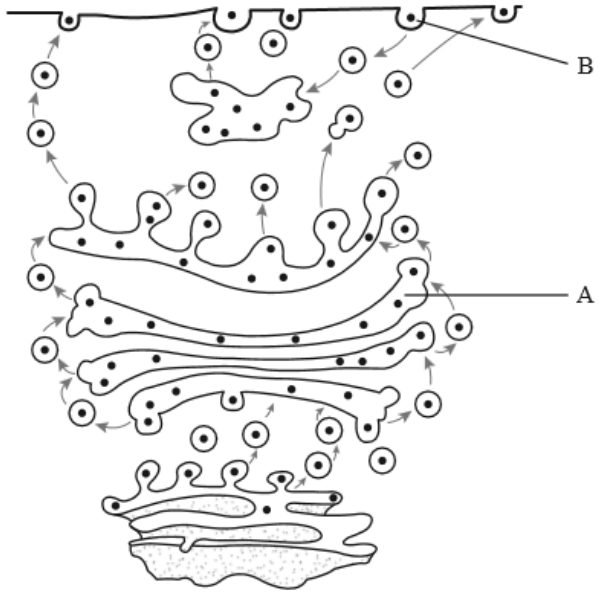
A.	photosynthesis	nutrition	homeostasis
B.	nutrition	reproduction	response
C.	metabolism	photosynthesis	growth
D.	growth	reproduction	photosynthesis

. . . . . .

. . . . . .

. . . . . .

The diagram shows how vesicles are used to transport materials in a cell.



27a. State the name of organelle A. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

27b. State the process occurring at B. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

27c. Describe how the structure of the membrane allows the formation of vesicles. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

28a. Draw a labelled diagram of a prokaryotic cell. *[4 marks]*

. . . . . .

. . . . . .

. . . . . .

28b. Outline transcription in prokaryotes. *[6 marks]*

. . . . . .

. . . . . .

. . . . . .

28c. Some prokaryotes cause infectious disease in humans. Explain the principles of vaccination. *[8 marks]*

. . . . . .

. . . . . .

. . . . . .

29a. Describe **four** different types of transport of substances across a membrane. *[4 marks]*

. . . . . .

. . . . . .

. . . . . .

29b. Hormones such as FSH (follicle stimulating hormone) and LH (luteinizing hormone) affect the development of certain cells by binding to receptors in the plasma membranes. Outline the role of FSH and LH in the menstrual cycle. *[6 marks]*

. . . . . .

. . . . . .

. . . . . .

29c. In the placenta, many substances are transported across membranes. Explain the structure and role of the placenta. *[8 marks]*

. . . . . .

. . . . . .

. . . . . .

30. Which functions of life are carried out by **all** unicellular organisms? *[1 mark]*

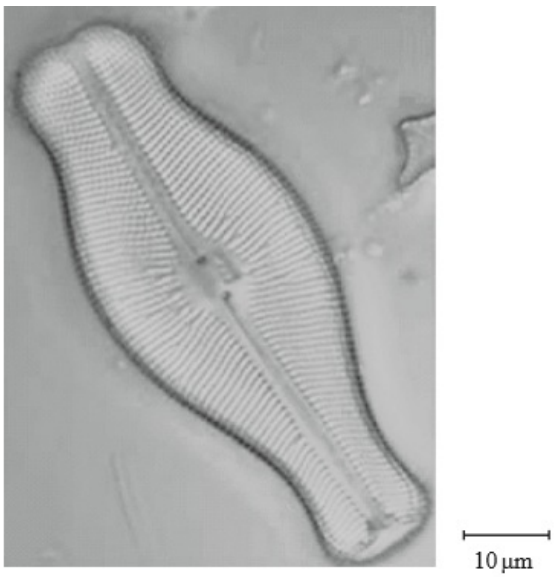
A.	photosynthesis	nutrition	homeostasis
B.	nutrition	reproduction	response
C.	metabolism	photosynthesis	growth
D.	growth	reproduction	photosynthesis

. . . . . .

. . . . . .

. . . . . .

31. The diatom *Didymosphenia geminata* is a species of single-celled alga that lives in warm, shallow water. In the light microscope image below, the scale bar is equal to 10 micrometres (10 µm). What is the actual length of the cell? *[1 mark]*



[Source: United States Environmental Protection Agency
http://www.epa.gov/region8/water/didymosphenia/White%20Paper%20Jan%202007.pdf
EPA white paper]

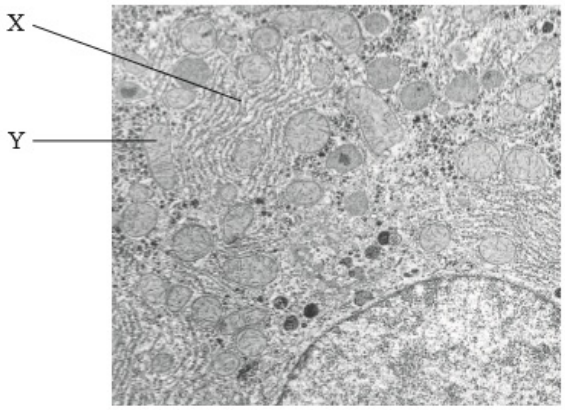
A. 0.007 mm
B. 0.07 mm
C. 0.7 mm
D. 7.0 mm

. . . . . .

. . . . . .

. . . . . .

32. In the electron micrograph of a rat liver cell below, what are the structures labelled X and Y? *[1 mark]*



[Source: ©Principia Cybernetica. Used with permission.]

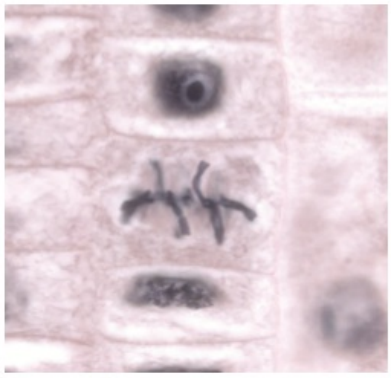
	X	Y
A.	rough endoplasmic reticulum	mitochondrion
B.	smooth endoplasmic reticulum	nucleus
C.	Golgi apparatus	vesicle
D.	chromosome	vacuole

. . . . . .

. . . . . .

. . . . . .

33. Which phase of mitosis is shown in the photomicrograph? *[1 mark]*



[Source: http://commons.wikimedia.org/wiki/File:Allium-Mitose03-DM100x_BL28.jpg]

A. Anaphase
B. Metaphase
C. Prophase
D. Telophase

. . . . . .

. . . . . .

. . . . . .

34. What are stem cells? *[1 mark]*

A. Specialized cells that can be used therapeutically
B. Surplus cells taken from an embryo
C. Cells that retain their ability to divide and differentiate
D. Cells in the xylem and phloem tissues that support a plant

. . . . . .

. . . . . .

. . . . . .

35. What causes cells to differentiate? *[1 mark]*

A. Sufficient nutrition
B. Full expression of all genes
C. Specialized functions at different stages of embryo development
D. Expression of some genes with suppression of other genes

. . . . . .

. . . . . .

. . . . . .

36. What features of a cell favour efficient removal of waste products? *[1 mark]*

	Surface area	Volume
A.	high	high
B.	high	low
C.	low	high
D.	low	low

. . . . . .

. . . . . .

. . . . . .

37. What actions occur during interphase? *[1 mark]*

A. DNA replication and RNA synthesis
B. Spindle formation and DNA replication
C. Chromosome alignment at the metaphase plate
D. Growth and separation of sister chromatids

. . . . . .

. . . . . .

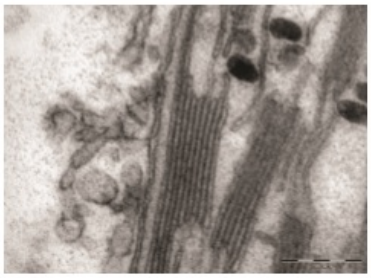
. . . . . .

38. In the electron photomicrographs which organelle is involved in vesicle formation? *[1 mark]*

A.

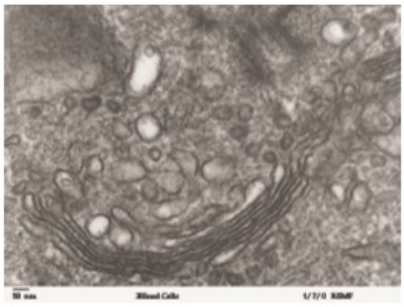
http://en.wikipedia.org/wiki/File:Mitochondria,_mammalian_lung_-_TEM.jpg

B.



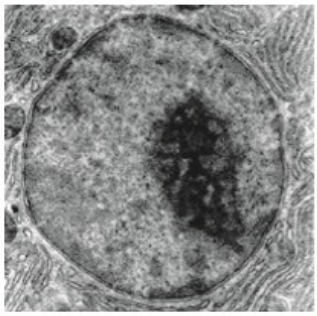
http://en.wikipedia.org/wiki/File:Chloroplast_in_leaf_of_Anemone_sp_TEM_85000x.png

C.



http://en.wikipedia.org/wiki/File:Human_leukocyte,_showing_golgi_-_TEM.jpg

D.



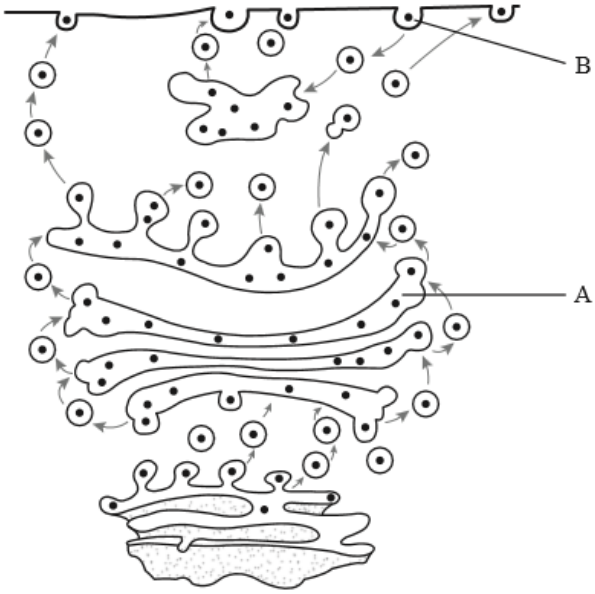
http://en.wikipedia.org/wiki/File:Micrograph_of_a_cell_nucleus.png

. . . . . .

. . . . . .

. . . . . .

The diagram shows how vesicles are used to transport materials in a cell.



39a. State the name of organelle A. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

39b. State the process occurring at B. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

39c. Describe how the structure of the membrane allows the formation of vesicles. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

39d. Explain active transport across membranes. *[3 marks]*

. . . . . .

. . . . . .

. . . . . .

40a. State **three** processes occurring in a cell during interphase of the cell cycle but not in mitosis. *[3 marks]*

1. .....
2. .....
3. .....

. . . . . .

. . . . . .

. . . . . .

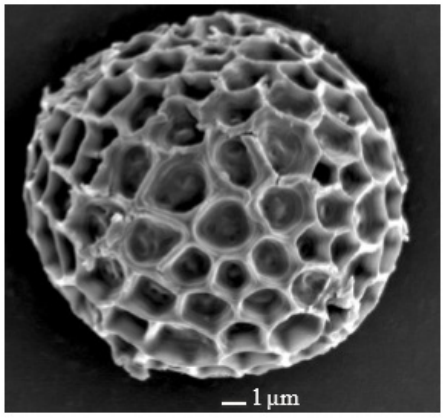
40b. Explain how sexual reproduction can allow evolution to occur. *[3 marks]*

. . . . . .

. . . . . .

. . . . . .

41a. The electron micrograph is of a spore of a fungus (Tilletia controversa) which affects wheat. *[2 marks]*



[www.padil.gov.au/pbt/index.php?q=node/15&pbtID=163]

Determine the magnification of the spore in the electron micrograph. The scale bar represents 1 µm. Show your working.

. . . . . .

. . . . . .

. . . . . .

41b. Explain the importance of surface area to volume ratio as a limit to cell size. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

42a. State the functions of the following organelles of a eukaryotic animal cell: lysosome, Golgi apparatus, free ribosomes, plasma membrane, rough endoplasmic reticulum. *[5 marks]*

. . . . . .

. . . . . .

. . . . . .

42b. Distinguish between anaerobic and aerobic cell respiration in eukaryotes. *[4 marks]*

. . . . . .

. . . . . .

. . . . . .

42c. Explain the mechanism of ventilation in the lungs in order to promote gas exchange for cell respiration. *[9 marks]*

. . . . . .

. . . . . .

. . . . . .

43. What happens to the surface area to volume ratio as a cell grows? *[1 mark]*

A. It decreases.
B. It increases.
C. It doubles.
D. It does not change.

. . . . . .

. . . . . .

. . . . . .

44. What are characteristics of eukaryotic cells? *[1 mark]*

	Nucleus	Mitochondria	Ribosomes
A.	present	present	80S
B.	present	absent	70S
C.	absent	present	80S
D.	absent	absent	70S

. . . . . .

. . . . . .

. . . . . .

45. Which movement occurs by osmosis? *[1 mark]*

A. Oxygen from alveoli into the blood
B. Water from a leaf into the atmosphere
C. Water from soil to root
D. Nitrate ions from soil to root

. . . . . .

. . . . . .

. . . . . .

46. Which structure is found in *E. coli*, but **not** in a eukaryotic cell? *[1 mark]*

A. Cell wall
B. Endoplasmic reticulum
C. Cytoplasm
D. Pili

. . . . . .

. . . . . .

. . . . . .

47. Which process contributes to growth of a multicellular body? *[1 mark]*

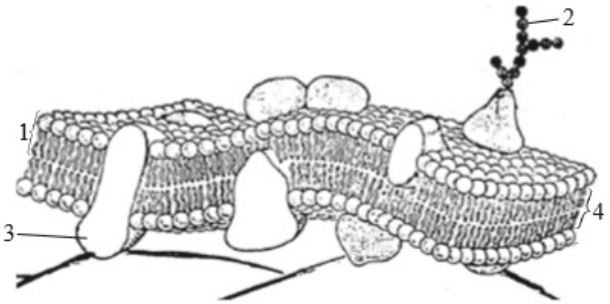
A. Exocytosis
B. Meiosis
C. Mitosis
D. Osmosis

. . . . . .

. . . . . .

. . . . . .

48. What are the parts of the cell membrane indicated in the diagram? *[1 mark]*



	1	2	3	4
A.	phospholipid	glycoprotein	integral protein	hydrophobic layer
B.	hydrophilic layer	carbohydrate	cholesterol	phospholipid
C.	phospholipid	peripheral protein	glycoprotein	cholesterol
D.	hydrophobic layer	carbohydrate	integral protein	phospholipid

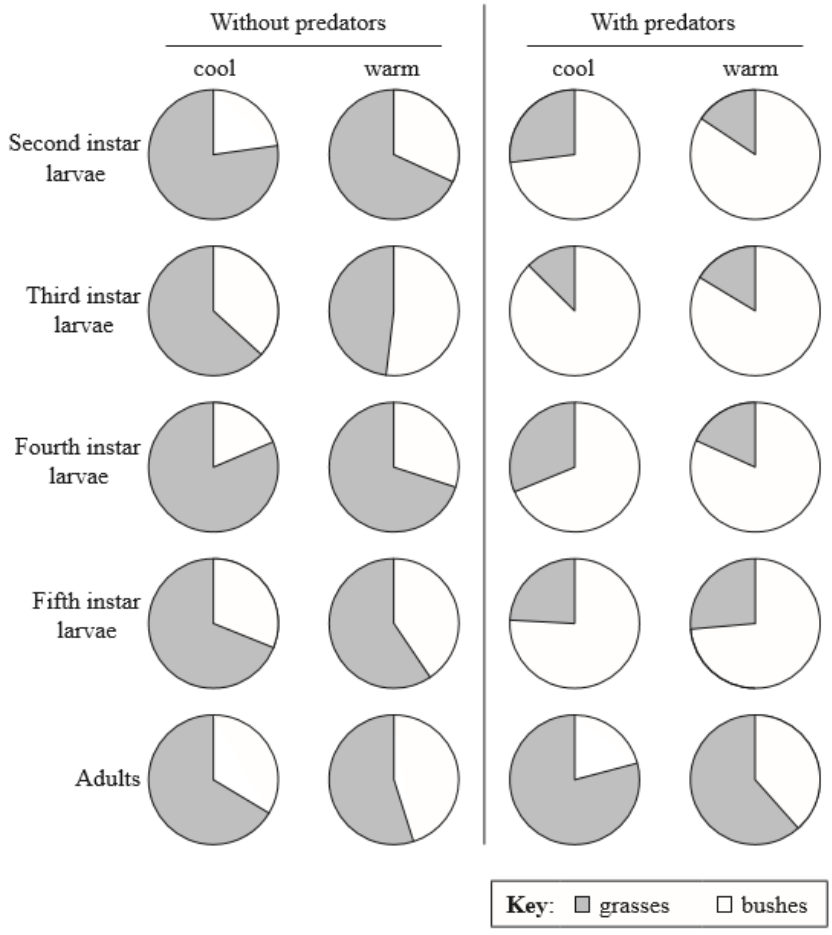
. . . . . .

. . . . . .

. . . . . .

A grassland food web was studied to understand how climate warming affects the interaction of different animal and plant species. Grasshoppers (*Melanoplus femurrubrum*) feed on grasses growing amongst taller bushes. Spiders (*Pisaurina mira*) feed on the grasshoppers. For 75 days, the feeding behaviour of the grasshoppers was observed with and without predators, in temperatures that were cool or warm. During the study period, the grasshoppers progressed through stages of larval development (instars) to adulthood.

Proportion of time spent on feeding



[Source: B. T. Barton (2010) *Ecology*, 91(10), pages 2811–2818. Used by permission of the Ecological Society of America.]

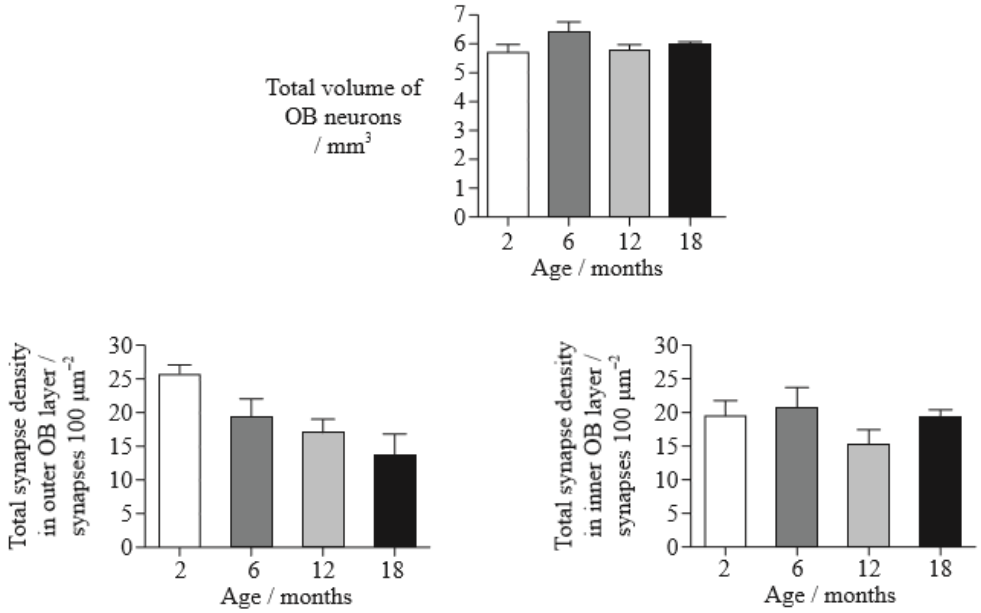
49a. Identify the primary food for all grasshoppers without predators. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

The hypothesis that aging involves loss of brain cells was investigated in mice. The olfactory bulb (OB) of the brain was studied because its layered arrangement of neurons resembles large regions of the human brain. Sensory input about smell is sent to the OB by axons of receptor cells that line the upper nasal cavity. These axons synapse with relay neurons in the OB where interpretation of smell perception begins. The bar charts show the total volume of neurons in the OB and the density of synapses (number of synapses per unit area) in two regions of a mouse's OB.



[Source: Marion Richard et al., "Age-induced disruption of selective olfactory bulb synaptic circuits", *PNAS* 107 (35), 15,613–15,618. Copyright 2010, National Academy of Sciences, USA.]

49b. State when the total volume of OB neurons is the greatest. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

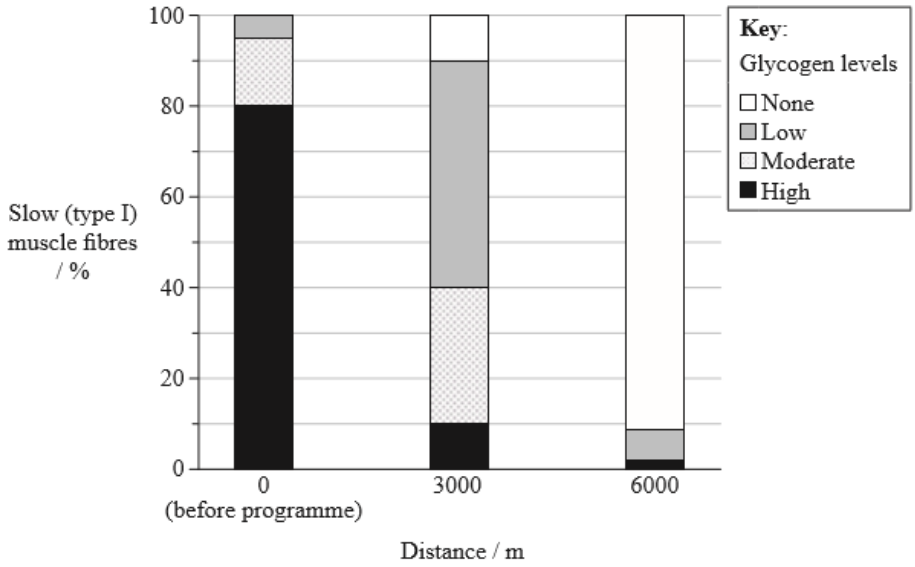
An investigation was conducted among competitive swimmers to determine the effects of two different training programmes.

3000 m programme: 6×500 m front crawl swims with 1-minute rests between each swim

6000 m programme: 60×100 m front crawl swims with 20-second rests between each swim

Swimmers were encouraged to maintain an even pace throughout the programmes. The pace was slightly slower in the 3000 m programme than in the 6000 m programme.

Tissue samples were taken from the shoulder muscle of each swimmer, before and after each session. Glycogen levels were analysed in slow (type I) muscle fibres.



[Source: adapted from D H Costill, *et al.*, (1988), *Journal of Swimming Research*, **4**(1), pages 13–18. Used with the author's permission.]

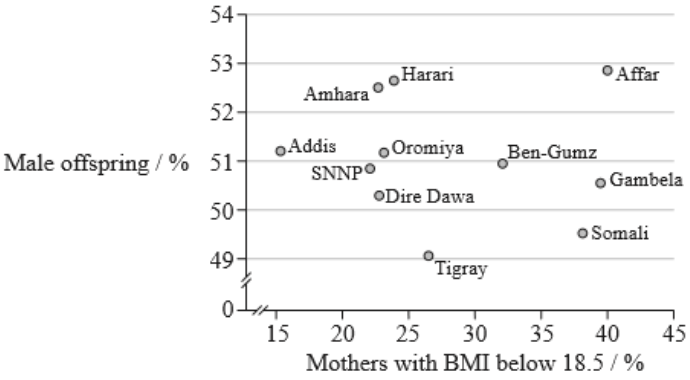
49c. Calculate the percentage of slow (type I) muscle fibres that contain low levels of glycogen after the 3000m programme. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

Malnutrition affects the body mass index (BMI) of mothers. The height and mass of over 7000 mothers in Ethiopia and the sex of their most recently born child was recorded. The graph shows the percentage of mothers with a BMI below 18.5 and the percentage of their most recent births that were males in 11 regions across Ethiopia.



[Source: Aryeh D. Stein, Paul G. Barnett, Daniel W. Sellen, Maternal undernutrition and the sex ratio at birth in Ethiopia: evidence from a national sample, *Proc. R. Soc. Lond. B* (Suppl.), 271, 2004, pages S37–S39, by permission of the Royal Society.]

49d. State the regions with the highest and lowest percentage of male offspring. *[1 mark]*

Region with highest percentage: .....

Region with lowest percentage: .....

. . . . . .

. . . . . .

. . . . . .

49e. Compare the total synapse density of neurons in the outer and inner OB layers. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49f. State the effect of the 3000 m programme on glycogen levels in slow (type I) muscle fibres. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

49g. Comment on the variation in BMI of mothers in Ethiopia. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49h. Deduce, using the data, how the feeding behaviour of instar larvae changes if without predators, conditions change from cool to warm. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

49i. Deduce, using the data, how the feeding behaviour of instar larvae changes if in warm conditions, predators are introduced. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

49j. Compare adult feeding to instar larval feeding. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49k. Evaluate, using the data in the bar charts, the hypothesis that aging involves loss of brain cells. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49l. Discuss whether the data supports the hypothesis that malnutrition affects the sex ratio of offspring. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49m. Compare the effects of the 3000 m programme with the 6000 m programme on muscle glycogen levels. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49n. Suggest reasons for the differences between the 3000 m programme and the 6000m programme in their effects on muscle glycogen levels. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49o. Suggest why adult feeding differs from instar larval feeding when predators are present. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

49p. Suggest the implications of the data for humans. *[2 marks]*

. . . . . .

. . . . . .

. . . . . .

49q. Suggest **one** limitation of the data. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

49r. Suggest **one** limitation of the data. *[1 mark]*

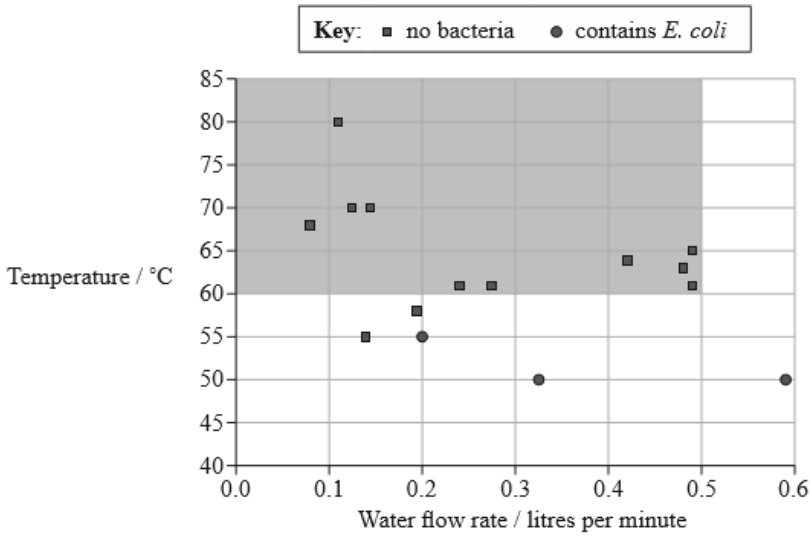
. . . . . .

. . . . . .

. . . . . .

49s. In 2003, the Integrated Approach to Community Development (IACD) organization introduced the chulli water purifier to homes in Bangladesh that had not previously had access to safe drinking water. It was designed to be made cheaply from local materials. The purifier uses sand filtration to remove organic particles and heat treatment to eliminate microbes from water. *[2 marks]*

Water samples from 15 different locations containing high levels of the bacterium E. coli were passed through the purifier at different flow rates and temperatures to test its effect on contaminated water. The shaded area of the graph below represents the recommended temperature and flow rate for using the purifier.



[Source: S. K. Gupta et al. (2008) *American Journal of Tropical Medicine and Hygiene*, 78, pages 979–984]

Evaluate the chulli purifier as a method of controlling microbial growth.

. . . . . .

. . . . . .

. . . . . .

49t. Suggest **one** factor that could cause malnutrition in mothers. *[1 mark]*

. . . . . .

. . . . . .

. . . . . .

MYP 4
REVISION TASK SHEET
DIGESTION, ENZYMES

1. You had pizza- wheat base for lunch yesterday with double cheese, jalapenos, tomatoes and onion as topping. Outline the journey of Pizza in your alimentary canal describing the various stages of digestion of each Component of food in the pizza.
   You can write a Paragraph or Poem or a Story.