Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE AS – NEW AS

B400U10-1

S16-B400U10-1

BIOLOGY – Component 1
Basic Biochemistry and Cell Organisation

P.M. THURSDAY, 26 May 2016

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**6**	
3.	**7**	
4.	**16**	
5.	**13**	
6.	**15**	
7.	**9**	
Total	**75**	

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01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 7.

The quality of written communication will affect the awarding of marks.

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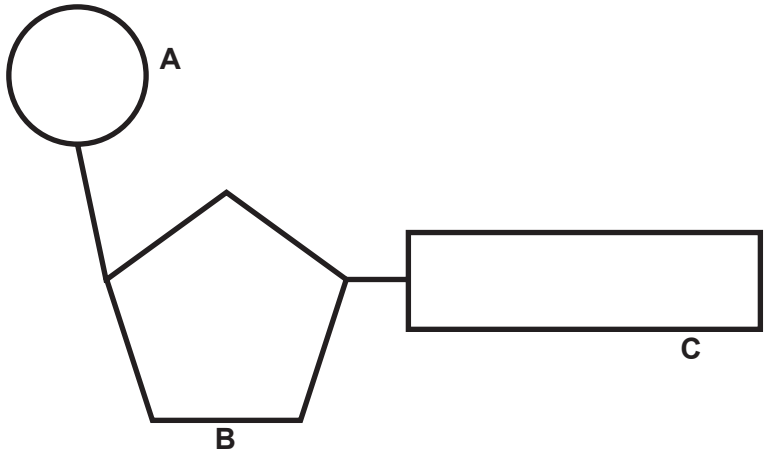
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Answer **all** *questions.*

1. Nucleotides are the building blocks of nucleic acids. They have an important role in many biochemical reactions in cell metabolism and regulation, including transport across cell membranes.

The diagram below shows a nucleotide.



(a) (i) Identify components **A**, **B** and **C**. [1]

A Phosphate

B Pentose (5C) sugar

C Nitrogenous (organic) base

(ii) With reference to components **A** and **B** shown above, describe the composition of the nucleotides of DNA, RNA and ATP. [3]

DNA A: 1 phosphate group, B: deoxyribose sugar.

RNA A: 1 phosphate group, B: ribose sugar.

ATP A: 3 phosphate groups, B: ribose sugar.

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(b) An experiment was carried out to investigate the rates of uptake of different sugars by the small intestine. One experiment used normal intestine, the second used a piece of intestine treated with cyanide. The results are shown in the table below.

	Relative rates of absorption / a.u.	
Sugar	**Normal intestine**	**Intestine treated with cyanide**
glucose	1.00	0.33
galactose	1.10	0.53
xylose	0.30	0.31
arabinose	0.29	0.29

(i) Name **two** sugars from the table which can be absorbed by active transport. [1]

glucose galactose

(ii) Using evidence from the table, explain why you chose these sugars. [2]

The rates of both glucose and galactose decrease when cyanide is added (glucose 1.00 to 0.33, galactose 1.10 to 0.53).

Cyanide stops active transport as it stops ATP production, and active transport requires energy from ATP.

Xylose and arabinose stay at the same rate because they do not need ATP (energy) to be absorbed.

(c) It was concluded that all of the sugars named in the table can be absorbed by diffusion. Under what conditions could this take place and how does evidence from the table support this conclusion? [2]

The concentration of the sugar outside (in the lumen) must be higher than inside the cells, as diffusion is the movement of molecules down a concentration gradient.

All the sugars still show some uptake when cyanide is present, so this must be by diffusion, as diffusion is a passive process and is not affected by cyanide.

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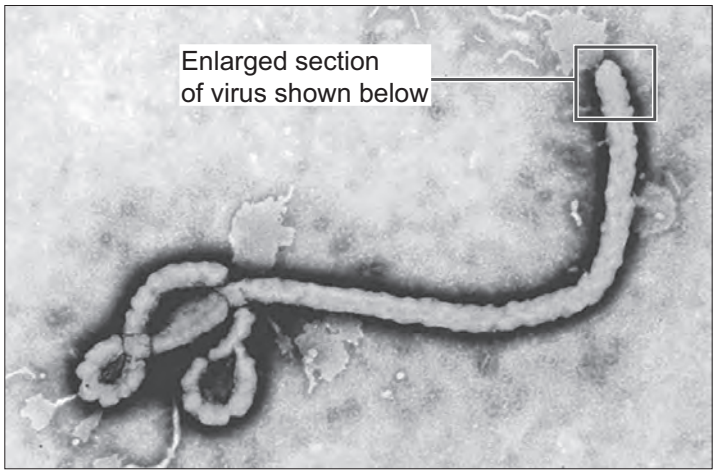
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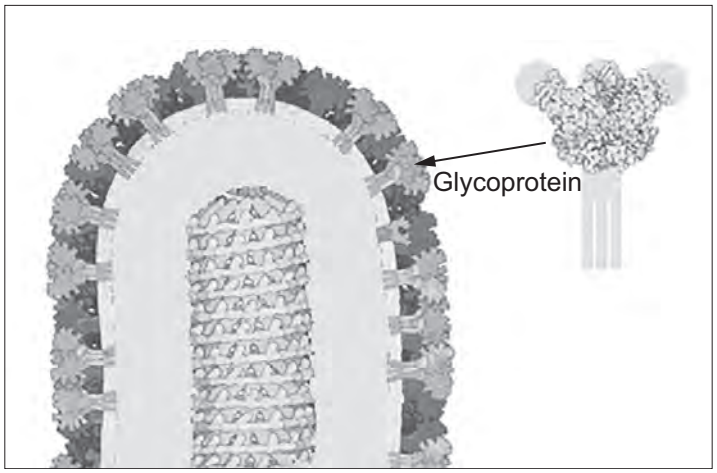
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2. Ebola virus disease is a serious illness of humans that originated in Africa, where there was an outbreak which started in 2014. The photographs and diagrams below show the Ebola virus and an enlarged section of the virus in detail.



Ebola virus



Enlarged section of Ebola virus

In addition to the usual viral structure, Ebola is surrounded by a lipid-bilayer, which is derived from infected cell membranes as the virus buds from the cell.

A viral transmembrane glycoprotein, is incorporated into this membrane and allows the virus to bind to blood vessel cells.

(a) What are the **two** major biochemical components present in **all** viruses? [1]

Protein ..... Nucleic acid (DNA or RNA) .....

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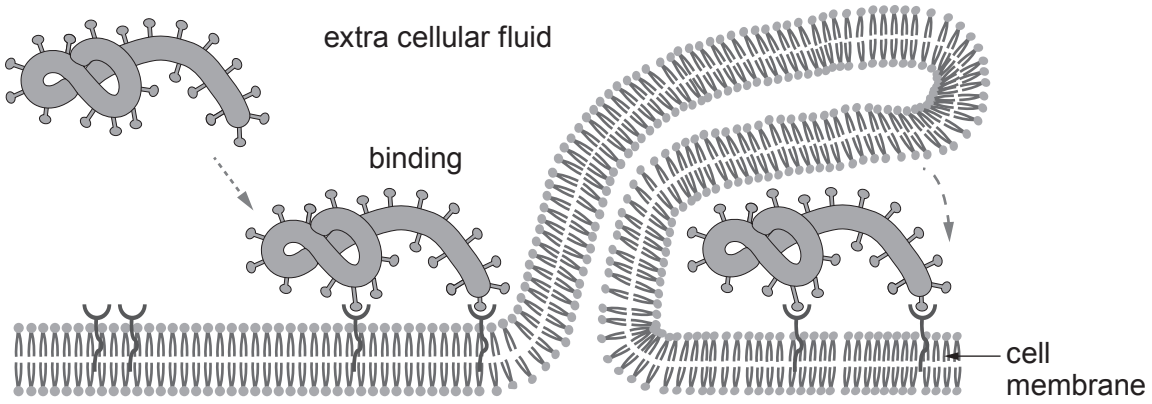
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(b) Describe the biochemical structure of a glycoprotein. [2]

A (globular) protein (polypeptide) with a carbohydrate chain (oligosaccharide) attached to it.

The initial stage of infection involves the following process.



(c) Using information from the diagrams, explain how Ebola virus particles enter a host cell. [3]

The glycoprotein on the virus binds to a receptor (glycoprotein) on the surface of the host cell membrane.

The virus is then taken in by endocytosis (phagocytosis).

The cell membrane engulfs (encloses) the virus, pinching off to form a vesicle inside the cytoplasm.

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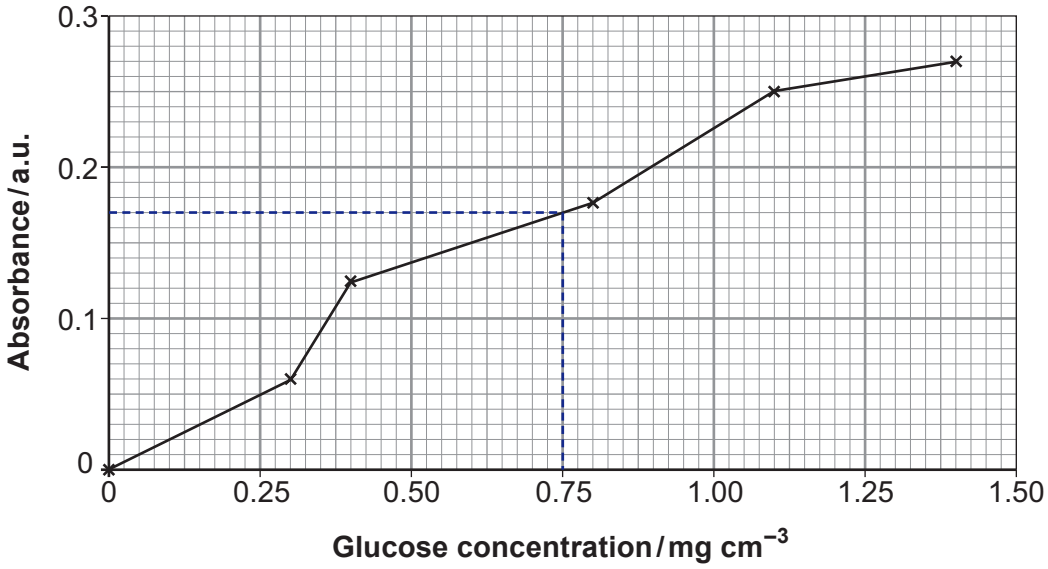
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3. *(a)* Glucose concentration in body fluids can be detected by using a number of tests. In one technique, known concentrations of glucose and reagents are prepared leading to a colour change. The absorbance is then measured using a colorimeter. The results are used to plot a standard (calibration) curve as shown below. Unknown solutions can then be compared with the standard curve to determine their concentration.



Glucose does not appear in urine until blood glucose concentrations of 0.18 mg cm^{-3} and above are reached. This occurs in untreated diabetics.

(i) When tested, a urine sample gave an absorbance of 0.17 a.u.. State and explain what diagnosis you could reach based on this reading. [2]

The person has diabetes (untreated).

An absorbance of 0.17 a.u. is a reading of 0.75 mg cm^{-3} of glucose,

which is above 0.18 mg cm^{-3} (it should be 0 for a non-diabetic).

(ii) Why is it not possible to use the standard curve for glucose determination in a **whole blood** sample? [1]

Blood is red (coloured), so light cannot pass through and a colorimeter

reading could not be obtained.

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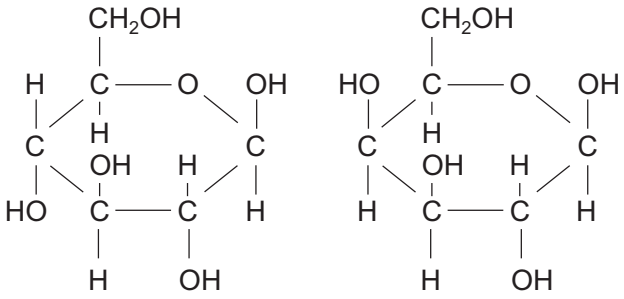
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(b) Modern medicine uses immobilised enzymes, in devices called biosensors, to detect blood glucose levels. This involves the use of glucose oxidase as the enzyme and glucose as the substrate. Give **two** advantages of using immobilised enzymes for blood glucose monitoring. [2]

Enzymes are specific, so only glucose will give a result.

They detect very low concentrations of glucose, and the reading is more accurate, as the immobilised enzyme is more stable.

(c) The following structures show two monosaccharides.



Glucose **Galactose**

(i) Describe the difference between these two molecules. [1]

On carbon 4, glucose has the H above the ring and the OH below, while in galactose it is the reverse (OH above, H below).

(ii) What would be the products of a condensation reaction between these two molecules? [1]

Lactose and water.

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7

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4. An experiment was carried out to determine the change in mass of potato tissue immersed in different sucrose solutions. Skinless potato cylinders were prepared in order to carry out this experiment.

(a) Calculate the total surface area, to one decimal place, of one of the cylinders which had a length of 45 mm and a diameter of 8 mm. [3]

Surface area of a cylinder is
$2 \pi r^2 + 2 \pi r h$
r = radius
h = length
$\pi = 3.14$

$r = 8 \div 2 = 4$ mm, $h = 45$ mm

$SA = (2 \times 3.14 \times 4^2) + (2 \times 3.14 \times 4 \times 45)$

$= 100.48 + 1130.4$

$= 1230.88$

Surface area = 1230.9 mm^2

Sucrose solutions were prepared at different concentrations. The skinless potato cylinders of equal length from the same potato were weighed and each immersed in one of the solutions. After two hours they were blotted dry and reweighed. The percentage change in mass was calculated.

The results are shown below.

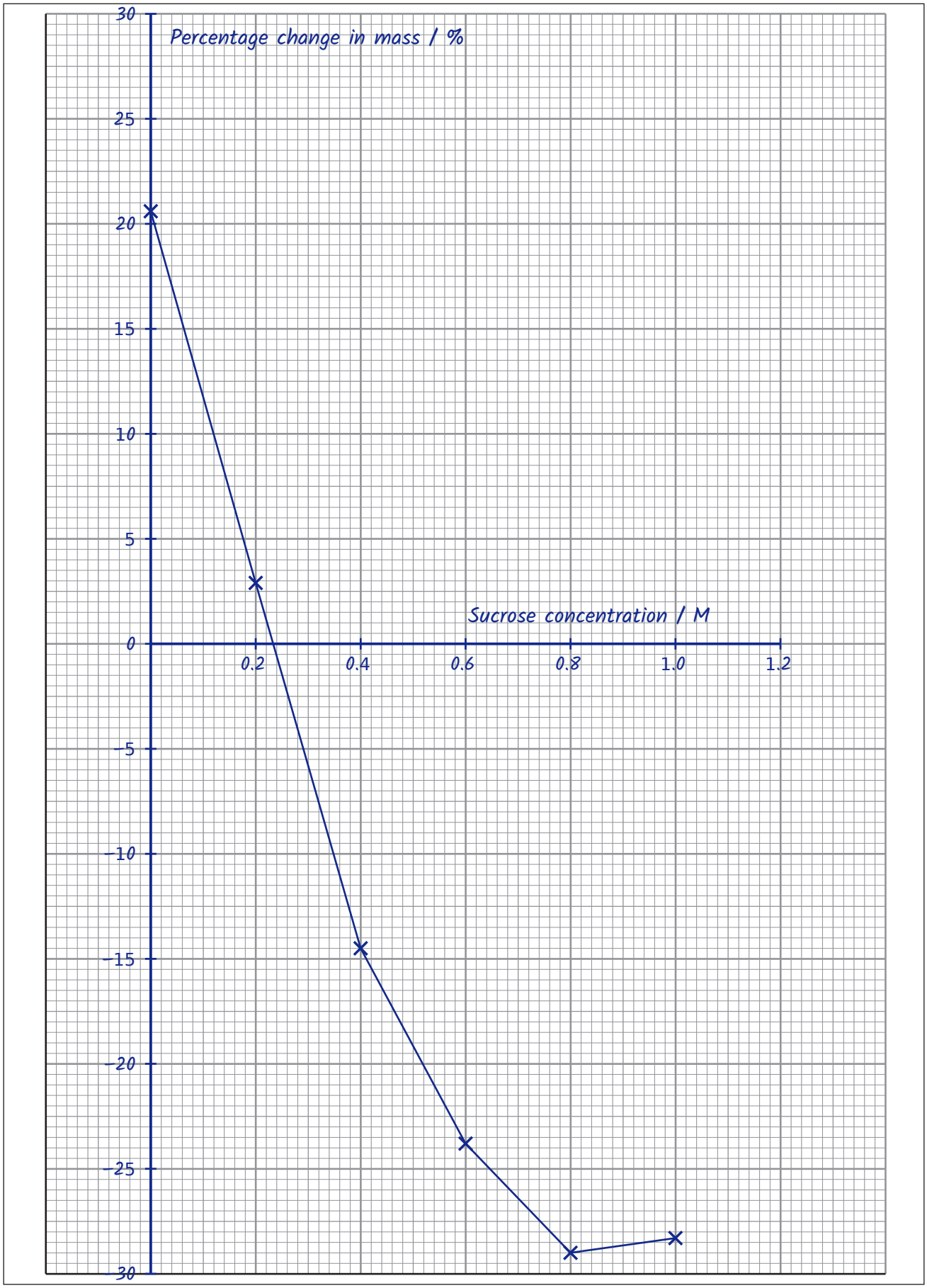
Sucrose Concentration /M	Initial Mass /g	Final Mass /g	Change in Mass /g	Percentage Change in Mass /%
0.0	3.4	4.1	0.7	20.6
0.2	3.4	3.5	0.1	2.9
0.4	6.2	5.3	–0.9	–14.5
0.6	6.3	4.8	–1.5	–23.8
0.8	6.2	4.4	–1.8	–29.0
1.0	6.0	4.3	–1.7	–28.3

(b) Use the data above to **draw a graph** on the page opposite showing how percentage change in mass of potato is affected by the change in sucrose concentration. [3]

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(c) Using the conversion table below, determine the water potential of the potato tissue in this experiment. Explain how you reached this conclusion. [3]

Sucrose concentration /M	Water potential /kPa
0.05	–130
0.10	–260
0.15	–410
0.20	–540
0.25	–680
0.30	–860
0.35	–970
0.40	–1120
0.45	–1280
0.50	–1450
0.55	–1620
0.60	–1800
0.65	–1980
0.70	–2180

The line crosses the x axis at 0.23 M, which converts to about –630 kPa.

Where the line intercepts the x axis there is no change in mass (no net water movement).

Here ψ of the external solution = ψ of the tissue (isotonic).

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(d) Explain what has caused the percentage difference in the mass of the tissue in the following concentrations of sucrose solution in terms of water potential. [4]

0.0 M The external ψ (of the solution) is higher than the ψ of the cells, so water moves into the tissue by osmosis, so the tissue gains mass.

0.8 M The external ψ is lower than the ψ of the cells, so water moves out of the tissue by osmosis, so the mass decreases.

(e) The experiment was repeated using the same range of sucrose concentrations and sweet potato but there was no decrease in mass at any sucrose concentration.

(i) Explain why there was no decrease in mass at any of the sucrose concentrations. [1]

Sweet potato has a very high sugar concentration, so a very low water potential, lower than even the 1.0 M solution.

(ii) Describe how you would modify the method to determine the ψ_{tissue} of sweet potato. [2]

Increase the sucrose concentration (use a wider range of more concentrated solutions, above 1.0 M).

Continue until a point is reached where water flows out of the potato and it loses mass, then find where the line crosses zero.

16

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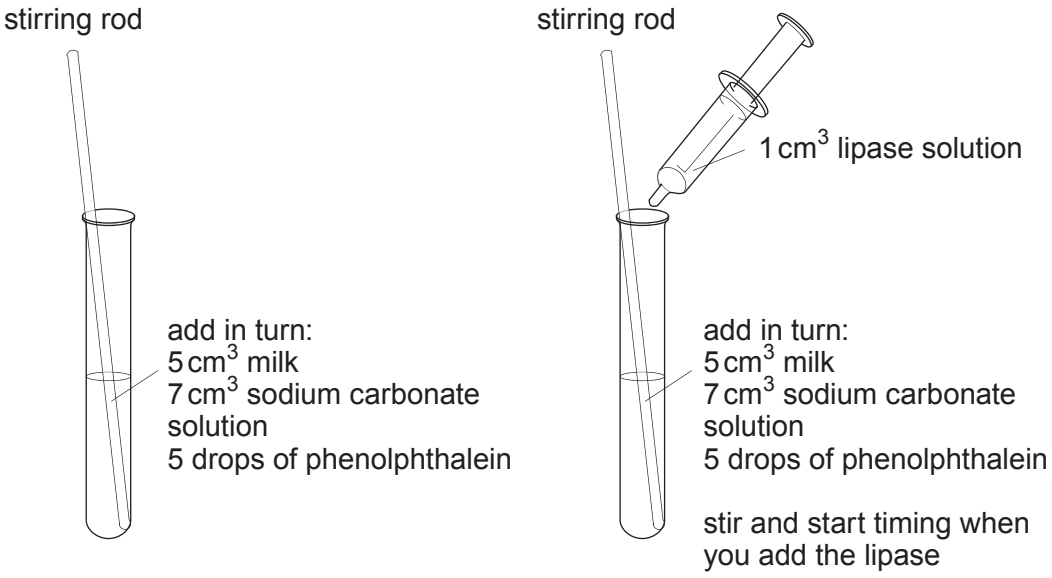
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5. An experiment was set up as shown below with the addition of alkaline sodium carbonate causing the milk to turn pink. Phenolphthalein is a pH indicator which is pink in alkaline conditions and colourless when in acid conditions. The experiment was timed to see how long it took for the indicator to turn from pink to colourless.



B400U101
13

(a) Explain what caused the indicator to lose the pink colour and become colourless. [3]

Lipase hydrolyses (breaks down) the lipids (triglycerides) in the milk.

This produces fatty acids (and glycerol).

The fatty acids make the milk more acidic (lower the pH), so the phenolphthalein becomes colourless.

(b) Why would this experiment not be suitable for assessing the effect of different pH values on lipase? [1]

The result depends on the pH change in the test tube, so the pH cannot be changed: at acid pH it starts colourless, and a buffer would prevent the colour change.

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Weight loss in obese patients can be achieved by a reduction in their intake of lipids or by reducing their ability to digest and / or absorb lipids.

One drug used to treat obesity acts as a competitive inhibitor of lipase. It prevents approximately 30% of the lipid being absorbed, thereby reducing energy (calorie) intake. The extra lipid in the large intestine can lead to unpleasant side effects such as diarrhoea and deficiency diseases. Treatment of patients requires them to take vitamin tablets since absorption of fat-soluble vitamins and other fat-soluble nutrients is inhibited by the use of the drug.
After drug treatment was stopped, a significant number of subjects regained up to 35% of the weight they had lost.

(c) Describe and explain the action of this drug on pancreatic lipase. [3]

The drug is a similar shape to the substrate (lipid), so it is complementary to the active site of lipase.

It binds to (occupies) the active site, so the lipid cannot enter it, forming an enzyme-inhibitor complex.

So fewer enzyme-substrate complexes form and fewer lipid molecules are hydrolysed by the lipase.

(d) (i) Describe how this drug would lead to weight loss. [2]

Lipids are not broken down (digested), so they cannot be absorbed and pass out of the body.

This reduces energy (calorie) uptake, so the body uses its stored fat for respiration.

(ii) With reference to the action of this drug, explain why people tended to regain the weight when they stopped taking it. [1]

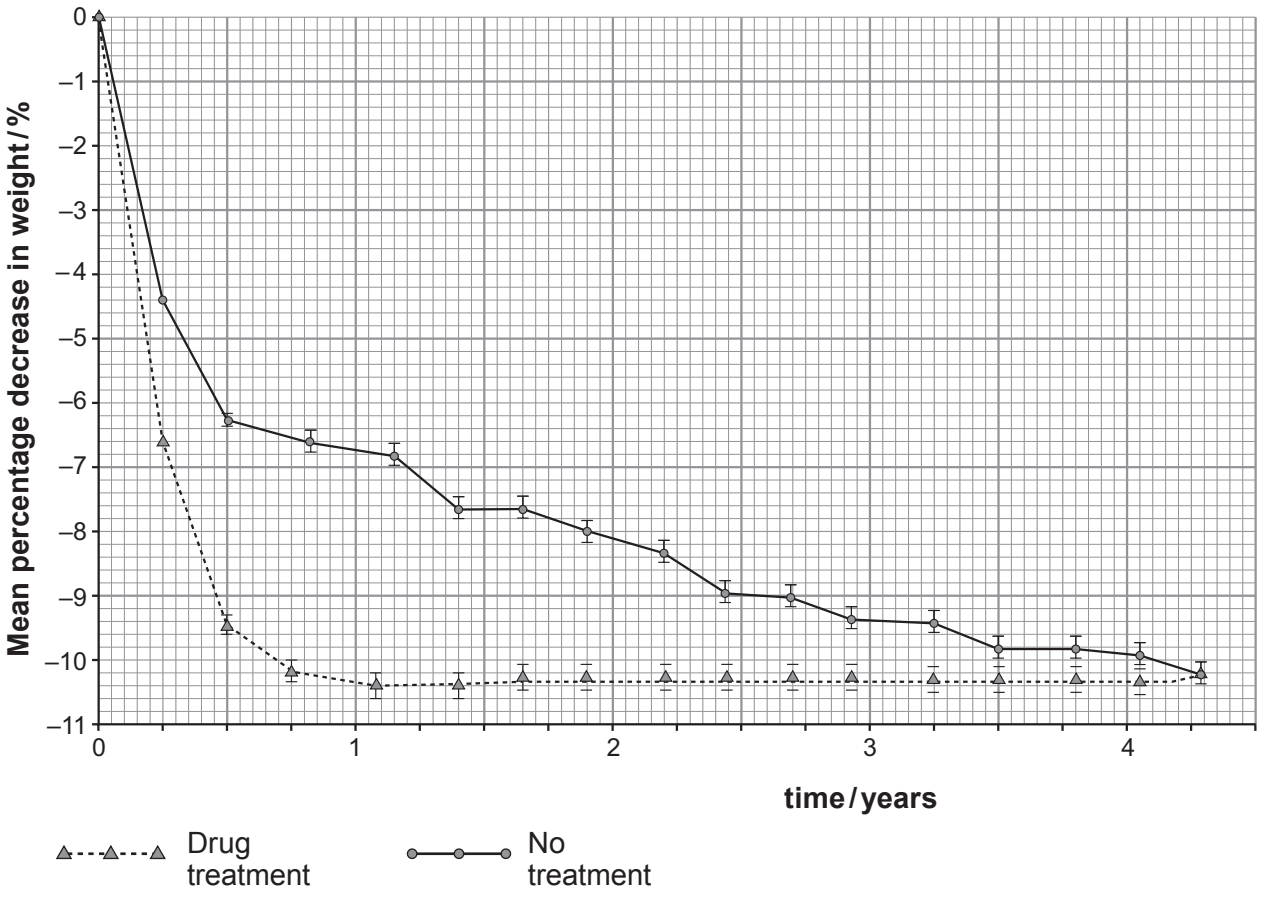
They continue to eat the same fatty diet, but now lipase is not inhibited, so the lipids are digested (hydrolysed) and absorbed.

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During clinical trials of this drug the following results were obtained. Both groups were on weight loss diets but only one group was treated with the drug.



(iii) Using all the information given in *(c)* and *(d)*, state the advantages and disadvantages of using this drug as part of a weight loss programme. [3]

Advantage: more rapid (greater) weight loss in the first year in the drug treated group, about 10% compared with 7%.

Disadvantage: no further weight loss after 1 year with the drug, and after 4 years there is no benefit as both groups lost about 10%.

Long term treatment could affect health due to diarrhoea and deficiency diseases, and the weight may be regained when the drug is stopped.

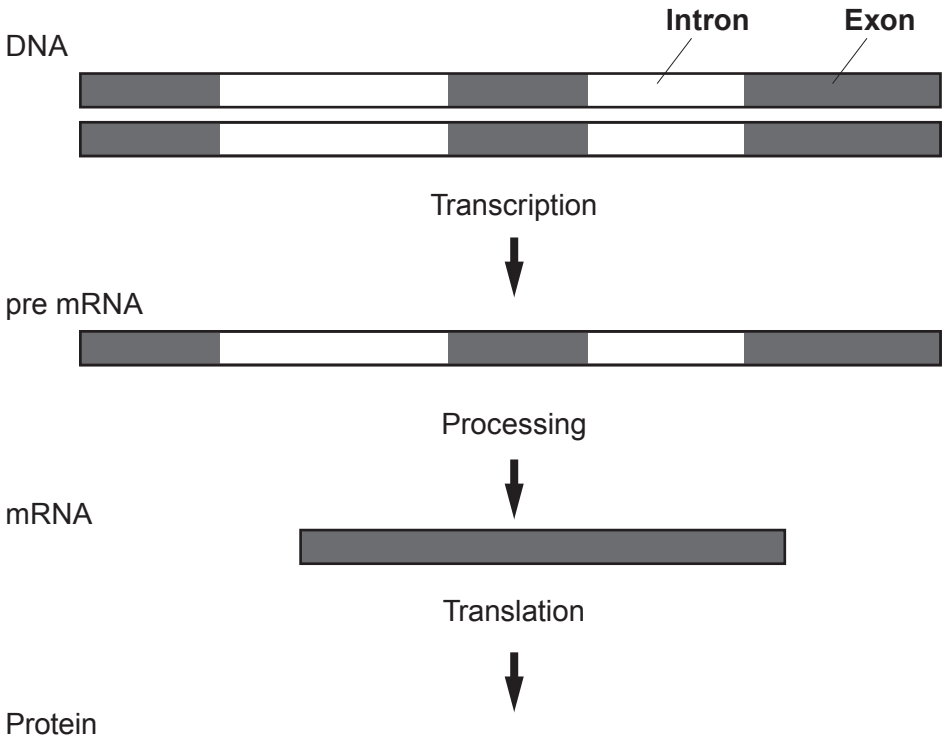
There is the additional cost of the drug and they have to take vitamin tablets.

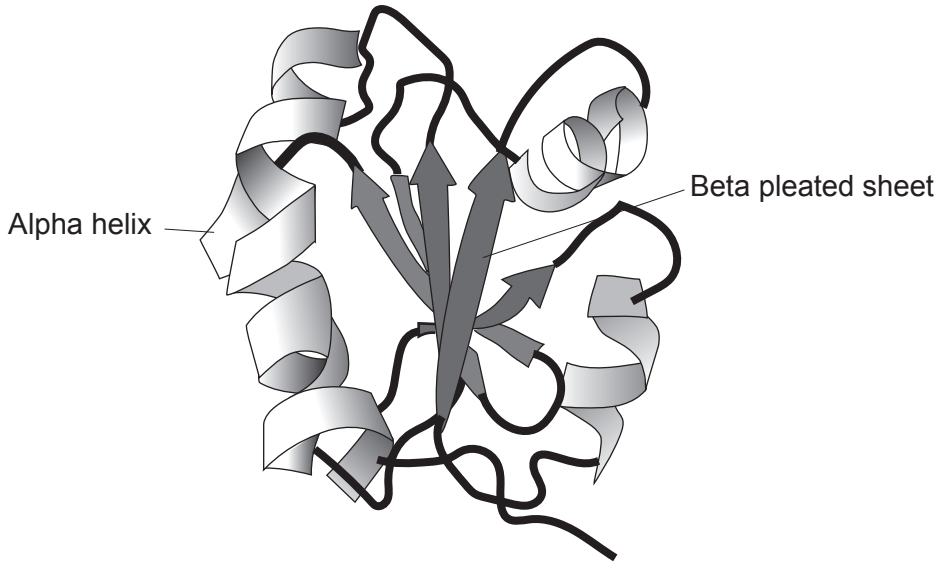
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6. In most eukaryotic genes, coding regions (exons) are interrupted by non-coding regions (introns). During transcription, the entire gene is copied into a pre-mRNA molecule, which includes exons and introns. During the process of RNA splicing, introns are removed and exons joined to form a continuous coding sequence. This "mature" mRNA is ready for translation.





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(a) Explain the process of transcription including the roles of the enzymes involved. [3]

RNA polymerase unwinds and unzips the DNA by breaking the hydrogen bonds between the bases.

Free complementary RNA nucleotides base pair with the DNA template strand (A with U, C with G).

RNA polymerase joins the RNA nucleotides together, forming phosphodiester bonds, to make the pre-mRNA.

(b) (i) Explain why it is important that the RNA which is finally translated, consists only of exons. [2]

Introns do not code for the amino acid sequence (primary structure) of the protein; only exons code for the amino acid sequence.

If introns were included, a different protein (structure) would be produced, which would not function.

(ii) Explain how a change in the sequence of bases in the DNA of the gene (a mutation) would affect the protein produced if it was in

I. an intron; [1]

No effect, as the intron is removed and is not translated.

II. an exon. [1]

It may change the amino acid sequence (primary structure), giving a different amino acid in the polypeptide chain.

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(c) (i) The following figures show the mRNA transcribed from two short lengths of DNA. Using the information following, **complete the correct sequence of amino acids** for each mRNA molecule. [1]

Normal

T	A	C	A	A	A	G	T	C	A	C	C	A	C	T	**template strand**
A	U	G	U	U	U	C	A	G	U	G	G	U	G	A	**mRNA**

Amino acid sequence Met - Phe - Gln - Trp - (stop)

Mutation

T	A	C	A	A	G	G	T	C	A	C	C	A	C	T	**template strand**
A	U	G	U	U	C	C	A	G	U	G	G	U	G	A	**mRNA**

Amino acid sequence Met - Phe - Gln - Trp - (stop)

Codons Found in Messenger RNA

First Base	*Second Base* U	C	A	G	*Third Base*
U	Phe	Ser	Tyr	Cys	**U**
	Phe	Ser	Tyr	Cys	**C**
	Leu	Ser	Stop	Stop	**A**
	Leu	Ser	Stop	Trp	**G**
C	Leu	Pro	Hls	Arg	**U**
	Leu	Pro	Hls	Arg	**C**
	Leu	Pro	Gln	Arg	**A**
	Leu	Pro	Gln	Arg	**G**
A	Ile	Thr	Asn	Ser	**U**
	Ile	Thr	Asn	Ser	**C**
	Ile	Thr	Lys	Arg	**A**
	Met	Thr	Lys	Arg	**G**
G	Val	Ala	Asp	Gly	**U**
	Val	Ala	Asp	Gly	**C**
	Val	Ala	Glu	Gly	**A**
	Val	Ala	Glu	Gly	**G**

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(ii) Explain why the change of bases shown is described as a silent mutation. [1]

UUC still codes for the same amino acid (Phe), so there is no change in the protein structure.

Chargaff carried out work examining the ratios of different bases in samples of DNA from different sources. A sample of his results is shown below.

Percentage composition

Source of DNA	Adenine	Thymine	Guanine	Cytosine
Yeast	31.3	32.9	18.7	17.1
Herring sperm	27.8	27.5	22.1	22.6
Human sperm	30.7	31.2	19.3	18.8

(d) (i) Calculate the exact ratio to two decimal places of adenine to thymine and guanine to cytosine for human sperm. [2]

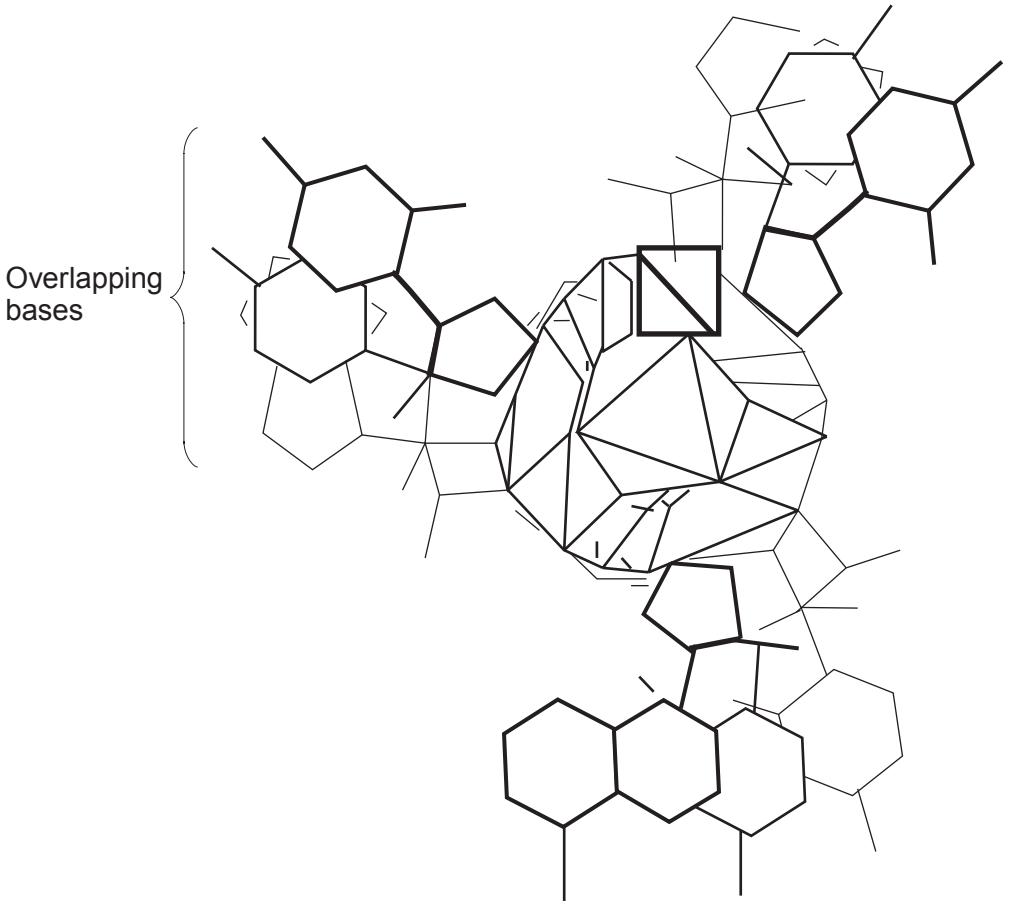
adenine to thymine ratio = 30.7 ÷ 31.2 = 0.98 : 1

guanine to cytosine ratio = 19.3 ÷ 18.8 = 1.03 : 1

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In 1952 Linus Pauling and his co-worker were researching DNA structure and suggested the following structure.



Pauling stated that:

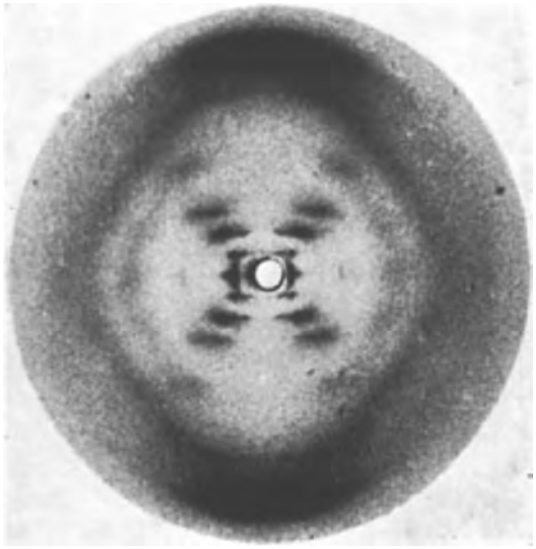
> *"it is unlikely that the sugar groups constitute the core of the molecule as no satisfactory way of packing them has been found. We conclude that the core of the molecule is probably formed of the phosphate groups arranged in a three chained helix. The purine and pyrimidine groups are on the periphery of the molecule."*

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At this time, Rosalind Franklin was carrying out X-Ray crystallography on pure DNA samples.



X-ray diffraction image of the double helix structure of the DNA molecule, taken in 1952 by Raymond Gosling, commonly referred to as "Photo 51", during work by Rosalind Franklin on the structure of DNA.

In 1952 **Franklin** concluded that:

> *"The results suggest a helical structure of DNA, containing probably 2, 3, or 4 nucleic acid chains and having the phosphate groups near the outside."*

(ii) Evaluate how closely the suggestions by **Pauling** and **Franklin**, shown in the boxes above and opposite, **match the current understanding** of the arrangement of nucleotides in DNA. [4]

Pauling

3 strands is incorrect (should be 2), so no 1:1 base pairing. Correct that sugars are not in the core, but phosphates are put inside not outside, and bases on the periphery not the centre.

Franklin

Closer to modern knowledge than Pauling; correct that DNA is a helical structure and that the phosphates are on the outside, but did not determine that it contains 2 chains.

15

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7. In multicellular animals cell division is essential for the survival of an individual and its species.

The diagrams below show two types of cell division in the fruit fly *Drosophila*. Discuss the significance of each type of cell division and explain why the cells produced by the process shown in diagram **B** could lead to the formation of a tumour whilst those produced by diagram **A** do not. [9]

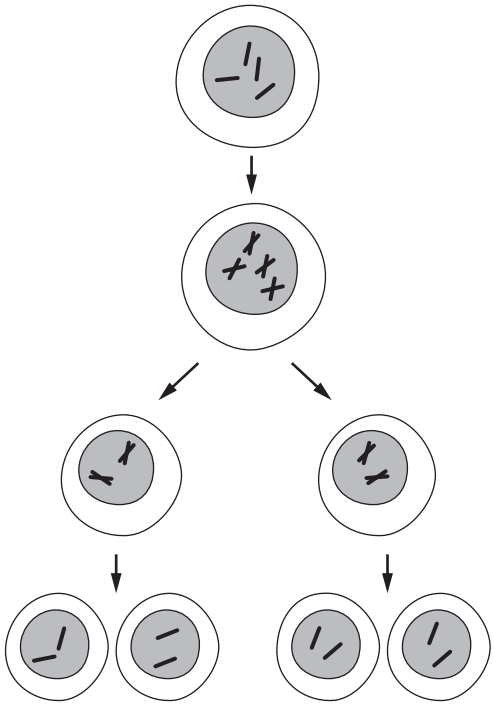


Diagram **A**

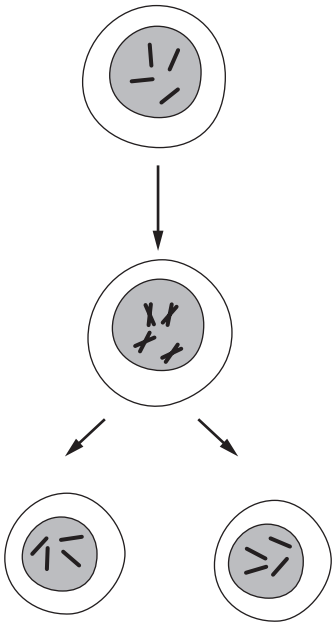


Diagram **B**

Diagram A is meiosis and diagram B is mitosis.

Mitosis produces two daughter cells that are genetically identical to the parent cell and to each other, and it maintains the chromosome number (diploid cells stay diploid). This is significant for the individual because it allows growth of the organism, and repair and healing of tissues following damage and disease. It also allows repeated cell renewal by continuous cell division, for example in the skin, the gut lining and the bone marrow, where red and white blood cells are produced. Cells are replaced with identical cells, so they can carry out the same function.

Meiosis produces four haploid daughter cells that are genetically different (non-identical) from each other and from the parent cell. It is significant for the species because it is used for gamete production. As the gametes are haploid, the

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diploid number is regained at fertilisation, so the chromosome number stays constant from generation to generation.

Meiosis is a source of genetic variation: crossing over between homologous chromosomes in prophase I, and the independent (random) assortment of chromosomes in metaphase I, give new combinations of alleles. Combined with random fertilisation in sexual reproduction, this variation is the raw material for evolution by natural selection (survival of the fittest). It is an advantage in the event of environmental change or disease, as some individuals are likely to have characteristics that allow them to survive and reproduce, so the species survives.

Tumour formation: the cells produced by mitosis (diagram B) can go on dividing again. If there is a genetic change (a mutation) in a gene that controls the cell cycle in B, mitosis can continue in an unrestricted (uncontrolled) way. This produces a solid mass of cells, a tumour, which prevents the normal cells from functioning. A tumour may be benign, staying in one place, or malignant (cancer), spreading to other parts of the body.

The cells produced by meiosis (diagram A) are gametes, which are haploid and do not divide further by mitosis unless fertilisation takes place, so cell division stops after meiosis and a tumour cannot form from them.

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