

Please write clearly in block capitals.

Centre number

Candidate number

Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

A-level BIOLOGY

Paper 3

Monday 17 June 2019

Morning

Time allowed: 2 hours

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A**.
- Answer **one** question from **Section B**.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 78.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



J U N 1 9 7 4 0 2 3 0 1

Section A

Answer **all** questions in this section.

You are advised to spend no more than one hour and 15 minutes on this section.

0 1 . 1

Describe how ultrafiltration occurs in a glomerulus.

[3 marks]

Blood enters the glomerulus at high hydrostatic pressure because the afferent arteriole is wider than the efferent arteriole.

This forces small molecules such as water, glucose, amino acids, urea and mineral ions (e.g. Na^+) out of the blood.

They pass through the small pores (fenestrations) in the capillary endothelium and then through the basement membrane into the Bowman's capsule, while blood cells and large proteins stay in the blood.

0 1 . 2

Glucose and water are reabsorbed by the proximal convoluted tubule of a nephron.

Put a tick (✓) in the box next to the correct ways in which glucose and water are reabsorbed.

[1 mark]

Glucose by active transport and water against a water potential gradient

☐

Glucose by diffusion and water down a water potential gradient

☐

Glucose by facilitated diffusion and active transport and water against a water potential gradient

☐

Glucose by facilitated diffusion and active transport and water down a water potential gradient

☒


0	1	3
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The equation shows the relationship between urine concentration in arbitrary units (y) and mean length of the loop of Henle in mm (x).

$$y = 0.72x + 4$$

Calculate the mean length of the loop of Henle in an organism that produces urine with a concentration of 16.56 arbitrary units.

[1 mark]

$$16.56 = 0.72x + 4$$

$$0.72x = 16.56 - 4 = 12.56$$

$$x = 12.56 / 0.72 = 17.44$$

Answer = 17.4 mm

Question 1 continues on the next page

Turn over ►

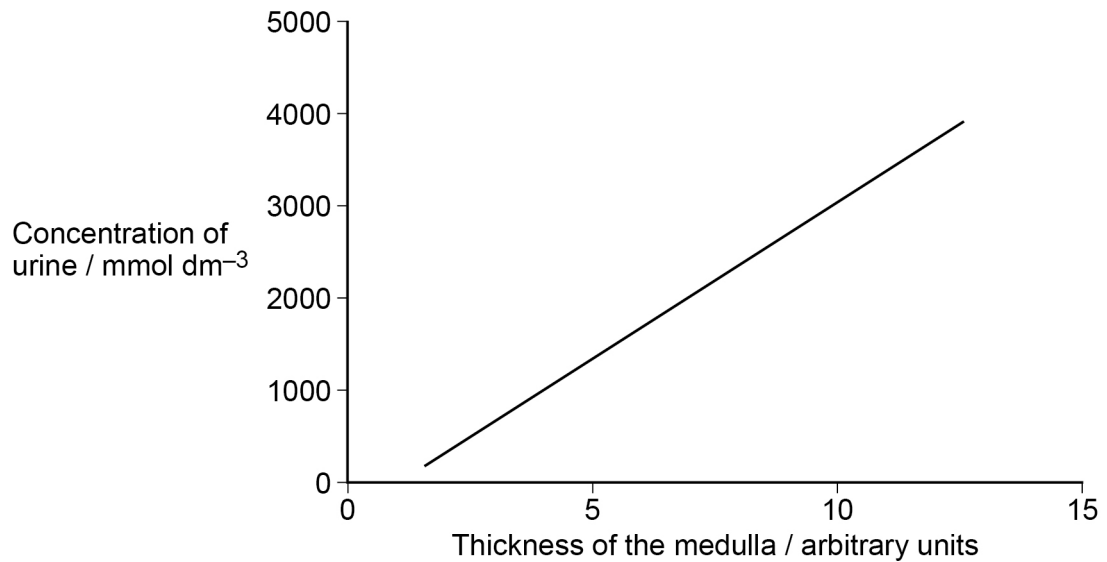


0 1 . 4

Scientists investigated the relationship between the thickness of the kidney medulla of different species of mammals and the concentration of their urine.

Figure 1 shows their results.

Figure 1



Explain the pattern shown by the results in **Figure 1**.

[3 marks]

As the thickness of the medulla increases, the concentration of the urine increases (positive correlation).

A thicker medulla means the loop of Henle is longer, so more sodium ions are actively transported out of the ascending limb into the medulla, increasing the sodium ion concentration of the medulla.

This creates and maintains a water potential gradient for longer, so more water is reabsorbed by osmosis from the loop of Henle and the collecting duct into the medulla (and then the blood), so the urine is more concentrated.



0 2 . 1

Describe the role of saprobionts in the nitrogen cycle.

[2 marks]*Saprobionts secrete enzymes that decompose (hydrolyse)**nitrogen-containing molecules such as proteins, DNA, RNA and urea in
dead organisms and waste.**This releases ammonia / ammonium ions into the soil (ammonification),
which nitrifying bacteria can then convert to nitrites and nitrates.*

0 2 . 2

One environmental issue arising from the use of fertilisers is eutrophication.
Eutrophication can cause water to become cloudy.

You are given samples of water from three different rivers.

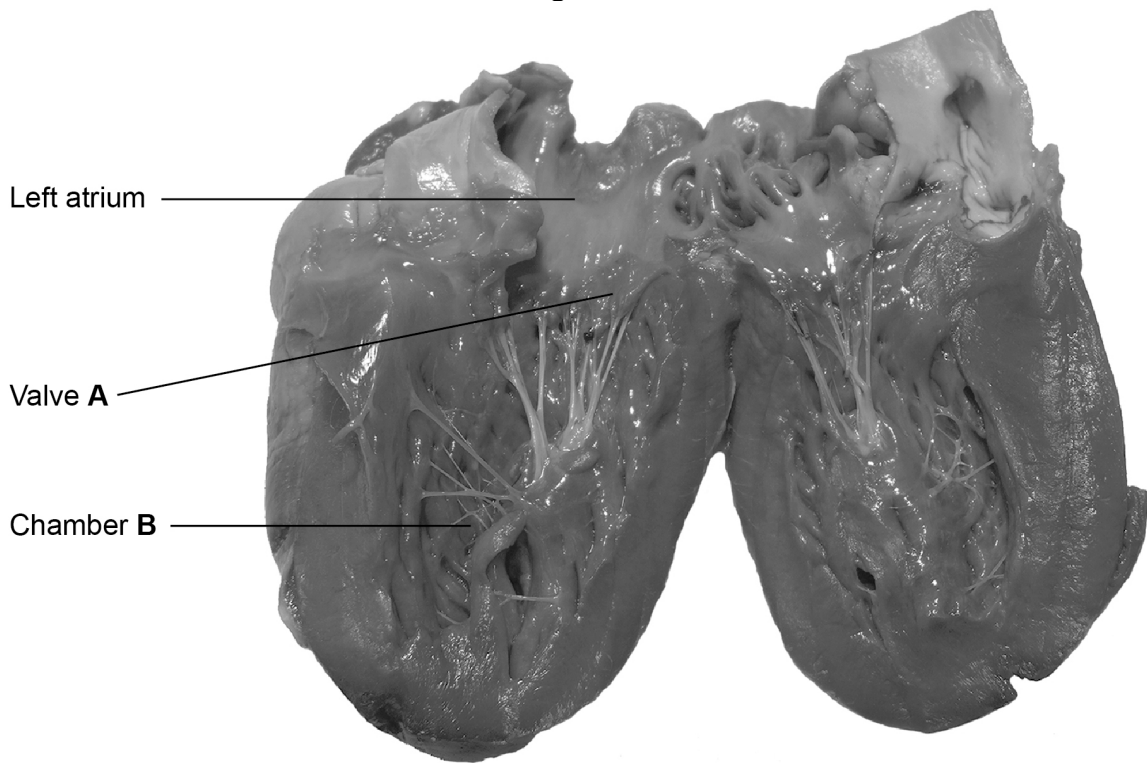
Describe how you would obtain a quantitative measurement of their cloudiness.

[3 marks]*Use a colorimeter. First zero (calibrate) it using a cuvette of distilled
water.**Put the same volume of each river sample into a cuvette, shaking each
sample first so any particles are evenly mixed.**Measure the absorbance (or % transmission) of light through each
sample, using the same wavelength / filter each time. The higher the
absorbance, the cloudier the water.**Repeat each reading three times and calculate a mean.***Turn over ►**

0 3

Figure 2 shows a photograph of a dissected heart.

Figure 2



0 3 . 1

Name valve **A** and chamber **B**.

[1 mark]

Valve **A** (Left) atrioventricular valve (bicuspid / mitral valve)

Chamber **B** Left ventricle

0 3 . 2

Give **two** safety precautions that should be followed when dissecting a heart.

[1 mark]

1 Wear gloves (or wash hands thoroughly afterwards).

2 Use a sharp scalpel and cut away from yourself on a hard surface (dissecting board), then disinfect the bench and equipment.



0	3	3
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Explain how valve **A** in **Figure 2** maintains a unidirectional flow of blood.

[2 marks]

When the pressure in the left atrium is higher than the pressure in the left ventricle (chamber B), the valve is pushed open so blood flows from the atrium into the ventricle.

When the ventricle contracts, the pressure in the ventricle becomes higher than in the atrium, so the valve is forced shut, preventing backflow into the atrium. The tendons (chordae tendineae) stop the valve turning inside out.

Question 3 continues on the next page

Turn over ►



A research scientist investigated the effect of caffeine on heart rate in human volunteers.

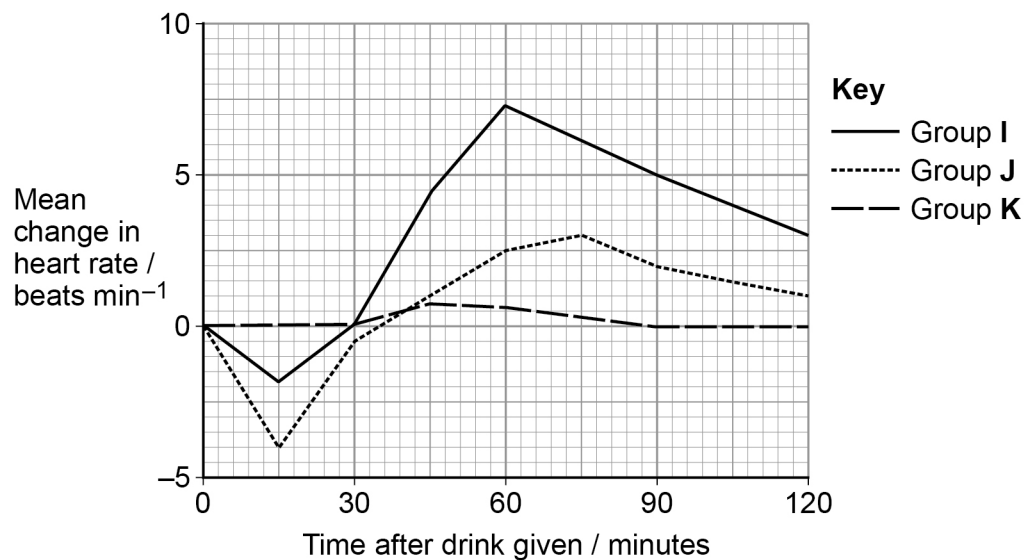
The scientist divided volunteers into three groups. Each group was given the same volume of fluid.

- Each member of Group **I** was given a sports drink containing caffeine and sugar.
- Each member of Group **J** was given a sports drink containing caffeine and no sugar.
- Each member of Group **K** was given water.

The scientist recorded the volunteers' heart rate before the drink was given and for 120 minutes after the drink was given.

Her results can be seen in **Figure 3**.

Figure 3



0 3 . 4 Caffeine affects the autonomic nervous system.

Suggest how caffeine could account for the results of Group I in **Figure 3** at 60 minutes.

[2 marks]

Caffeine could cause more impulses (action potentials) to be sent along the sympathetic nervous system from the cardiovascular centre in the medulla.

These impulses go to the sinoatrial node (SAN), increasing the frequency of its waves of excitation, so the heart rate increases, by about 7 beats per minute at 60 minutes.

0 3 . 5 Before taking the drink, the mean heart rate of Group J was 68 beats per minute.

Fifteen minutes after taking the drink, the mean volume of blood leaving the hearts of Group J was 4700 cm³ per minute.

Calculate the mean volume of blood leaving the heart at each beat fifteen minutes after taking the drink.

[1 mark]

Heart rate at 15 min = 68 - 4 = 64 beats per minute

Volume per beat = 4700 / 64 = 73.4375

Answer = 73.4 cm³

Question 3 continues on the next page

Turn over ►



0 3 . 6

The increase seen in Group I could be due to the combination of caffeine and sugar.

Suggest **one** drink to be given to an **additional** group that should be investigated to find out if this is true.

Give a reason for your answer.

[2 marks]

Group to be given A drink containing sugar only (sugar solution with no caffeine).

Reason To see the effect of sugar on its own, so I can show whether the sugar alone is causing the increase in heart rate, or whether it is the combination of caffeine and sugar.

9



Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

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0 4

Mitochondrial DNA (mtDNA) is a small circular DNA molecule located in mitochondria. It is 16 569 nucleotides long and contains 37 genes and a control region.

Sports scientists investigated whether a mutation in the control region of mtDNA in human males was related to an ability to exercise for longer.

- The males in Group **T** had thymine at nucleotide position 16 519
- The males in Group **C** had a mutation resulting in cytosine at nucleotide position 16 519

0 4 . 1

The control regions of Group **T** and Group **C** were the same length.

Name the type of gene mutation that is most likely to have occurred at nucleotide position 16 519

[1 mark]

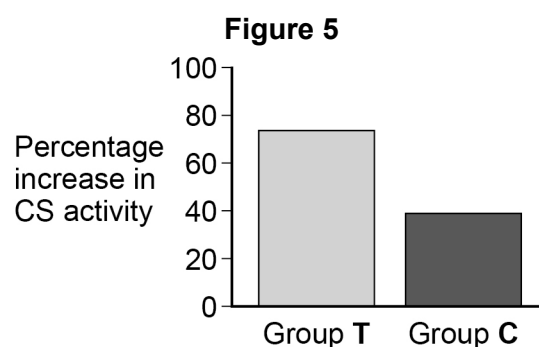
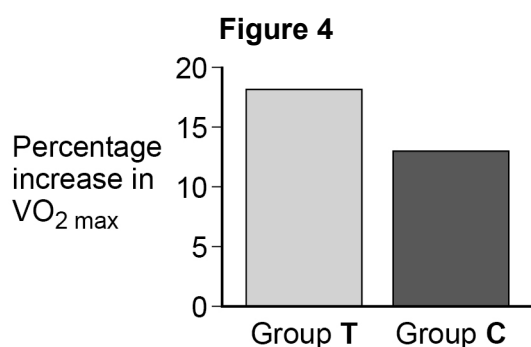
Substitution

Group **T** and Group **C** completed the same 8-week training programme. The following measurements were taken at the start of the 8-week programme, and again at the end.

1. $VO_{2\max}$ (a measure of maximal oxygen uptake).
2. Citrate synthase (CS) activity (CS is an enzyme involved in the Krebs cycle).

The scientists then calculated the percentage increase in each measurement in both groups.

Figure 4 and **Figure 5** show their results.



0 4 . 2

A student concluded from **Figure 4** and **Figure 5** that training has a positive effect on $\text{VO}_{2\text{max}}$ and CS activity.

Evaluate the student's conclusion.

[3 marks]

The figures support the conclusion because both VO_2 max and CS activity increased in both Group T and Group C after the training.

However, no statistical test (e.g. a t-test) was carried out, so we do not know if the increases are significant; they could be due to chance.

Also, the training only lasted 8 weeks, and only males were studied, so it might not be true for longer training, for other types of exercise or for females.

There was also no control group that did no training, so the increase might not be caused by the training.

0 4 . 3

The mitochondrial DNA (mtDNA) control region is an area of mtDNA that is non-coding. This region stimulates the synthesis of both mtDNA and mitochondrial messenger RNA.

Use this information to suggest **two** reasons why the mutation at nucleotide position 16 519 could lead to the differences seen in **Figure 5**.

[2 marks]

1 *The mutation in the control region could cause less replication of mtDNA, so fewer mitochondria are produced in Group C.*

2 *It could cause less transcription of mitochondrial genes such as CS, so less mRNA is translated and less CS enzyme is made.*

Question 4 continues on the next page

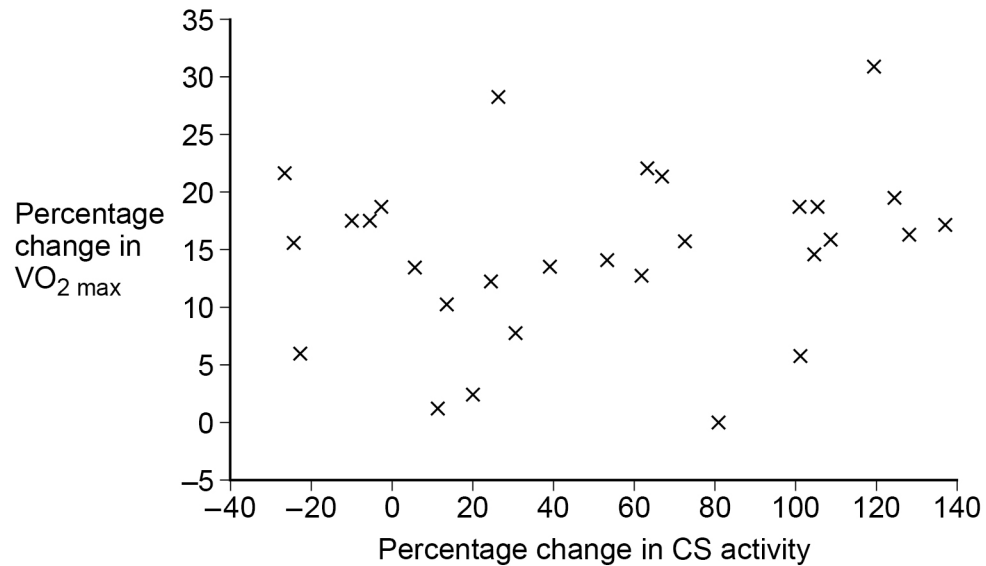
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The sports scientists investigated whether there was a correlation between the percentage change in $VO_{2\max}$ and percentage change in CS activity in Group T.

Figure 6 shows their results.

Figure 6



0 4 . 4

'Having thymine at nucleotide position 16 519 in Group T causes an increase in ability to exercise for longer.'

Evaluate this conclusion.

Use **all** the data in this question.

[3 marks]

For: Group T had a larger increase in CS activity (about 74% compared with 39%), so more Krebs cycle activity, and in VO_2 max (about 18% compared with 13%), so more oxygen for aerobic respiration and less lactate.

Against: Figure 6 shows no correlation between the percentage change in VO_2 max and the percentage change in CS activity in Group T.

Other differences in the control region of Group T, not thymine, may cause the increase.

VO_2 max and CS activity are not the only measures of ability to exercise for longer, which was not actually measured.

[Extra space]

9

Turn over for the next question

Turn over ►



0 5

The crown-of-thorns starfish (COTS) is one of the main causes of the decline of the world's coral reefs.

Marine biologists used a choice chamber to investigate the effects of flashing and constant light on the behaviour of COTS.

Table 1 shows their results as they presented them. The P values show results from a statistical test.

Table 1

Behaviour of COTS	Type of light used in choice chamber	
	Flashing	Constant
COTS moving towards the stimulus	22	12
COTS moving away from the stimulus	28	38
P value	0.69	0.02

0 5 . 1

State a null hypothesis the marine biologists tested in this investigation.

[1 mark]

The type of light (flashing or constant) has no effect on the movement (behaviour) of COTS.

0 5 . 2

The natural habitat of COTS is coral reefs of tropical oceans.

Suggest **two** factors that should be kept constant in the choice chambers so that COTS display normal behaviour.

[1 mark]

- 1 *Temperature of the water*
- 2 *Salinity (salt concentration) of the water*



0 5 . 3

A journalist studying **Table 1** suggested that **either** type of light could be used to cause COTS to move away from coral reefs.

Evaluate the journalist's suggestion.

[3 marks]

Partly agree: more COTS moved away from both types of light than towards it, so it suggests negative phototaxis to either type of light.

For constant light, the movement away is significant, as $P = 0.02$, which is less than 0.05, so it is not due to chance.

But for flashing light, $P = 0.69$, which is greater than 0.05, so the movement away is not significant and could be due to chance. So only constant light can be relied on, and the journalist is wrong about either type.

0 5 . 4

One of the reasons COTS can destroy coral reefs in a short time is because COTS move quickly, allowing them to move from one reef to another.

Table 2 shows the maximum speeds recorded of COTS in constant light.

Table 2

Response to light	Maximum speed / mm min^{-1}
COTS moving towards constant light	259
COTS moving away from constant light	564

Calculate the shortest time one COTS would take to move up a coral reef from 66 m under water to 18 m under water in hours of daylight.

Give your answer to the nearest hour.

[2 marks]

$$\text{Distance} = 66 - 18 = 48 \text{ m} = 48\,000 \text{ mm}$$

$$\text{Moving up towards daylight: } 259 \text{ mm min}^{-1}$$

$$\text{Time} = 48\,000 / 259 = 185.3 \text{ min} = 3.09 \text{ hours}$$

Answer = 3 hours

7

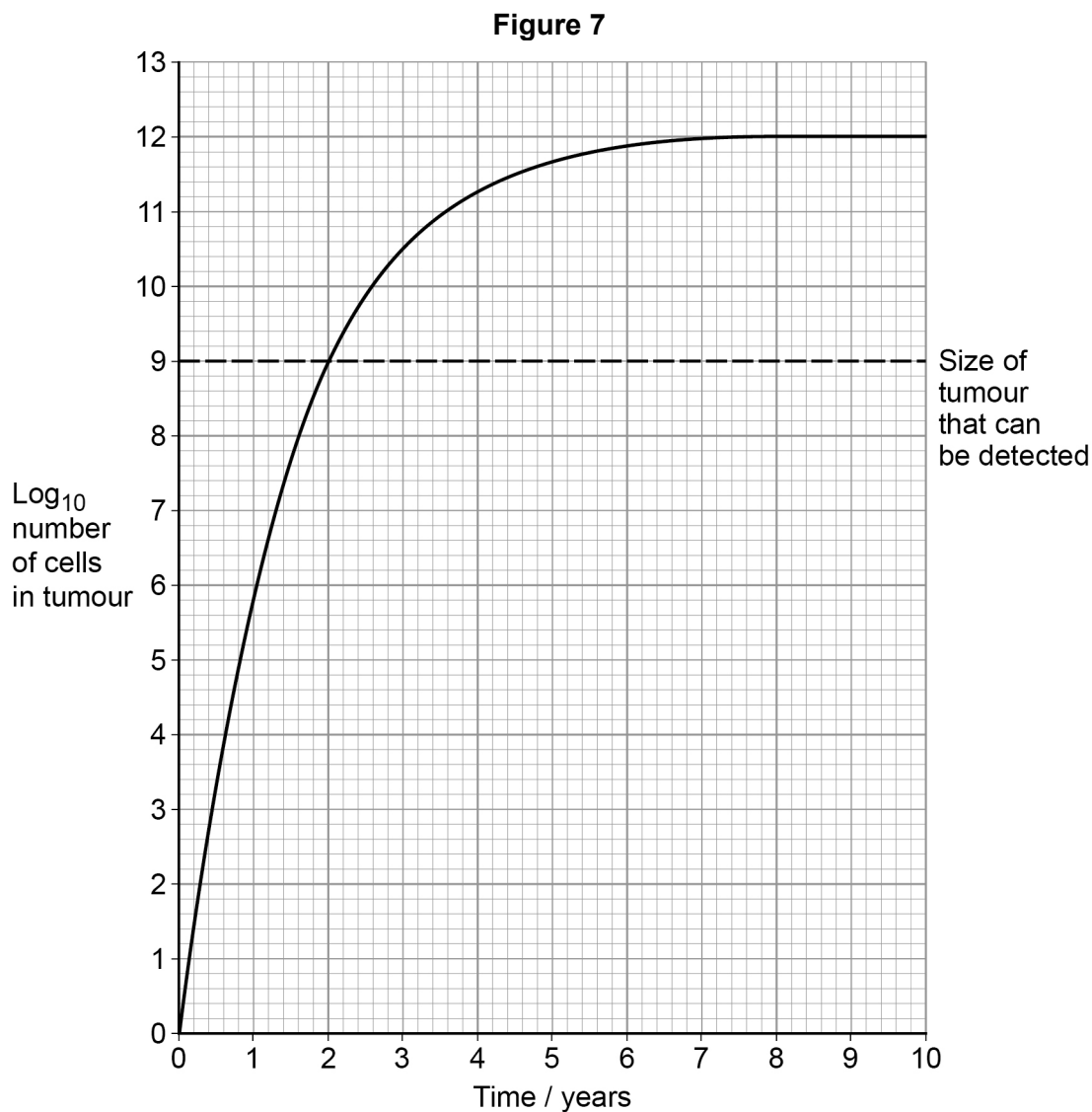
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0 6

Uncontrolled cell division can cause tumours to form.

Figure 7 shows the growth pattern followed by a type of tumour.



0 6 . 1

Use **Figure 7** to calculate the percentage of maximum growth this type of tumour reaches before it can be detected.

You will need to use the 10^x button on your calculator.

[1 mark]

Detected at $\log 9 = 10^9$ cells; maximum $\log 12 = 10^{12}$ cells

$$(10^9 / 10^{12}) \times 100 = 0.1$$

Answer = 0.1 %



0 6 . 2

Figure 7 can also be used to calculate the age of this type of tumour.

At diagnosis, a patient had a tumour of 3.98×10^{11} cells.
Calculate the age of the tumour.

You will need to use the $\log_{10}$ button on your calculator.

[1 mark]

$$\log_{10} (3.98 \times 10^{11}) = 11.6$$

Reading 11.6 on Figure 7 gives a time of 4.8 years

Answer = 4.8 years

Question 6 continues on the next page

Turn over ►



Trexall is a drug that can be used to slow the development of various forms of cancer.

Trexall slows cell division by interacting with an enzyme called dihydrofolate reductase (DR).

DR is involved in making nucleotides; the substrate for DR is folic acid.

Figure 8 shows the chemical structure of Trexall.

Figure 9 shows the chemical structure of folic acid.

Figure 8

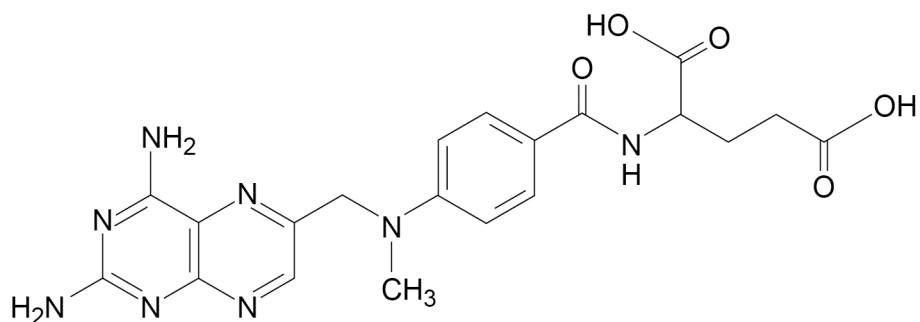
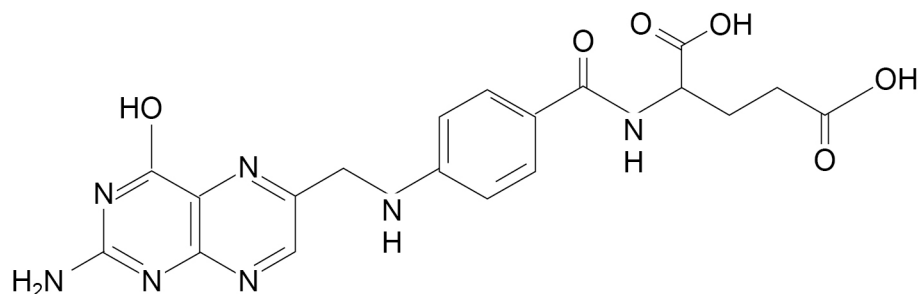


Figure 9



0	6	.	3
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Use the information provided to suggest how Trexall slows cell division.

[3 marks]

Trexall has a similar structure to folic acid, so it acts as a competitive inhibitor: it is complementary to and binds to the active site of dihydrofolate reductase.

This means less folic acid can bind to the active site, so fewer enzyme-substrate complexes are formed.

So fewer nucleotides are made, so there are not enough nucleotides for DNA replication (semi-conservative replication in interphase), so the cell cycle and mitosis are slowed.

Question 6 continues on the next page

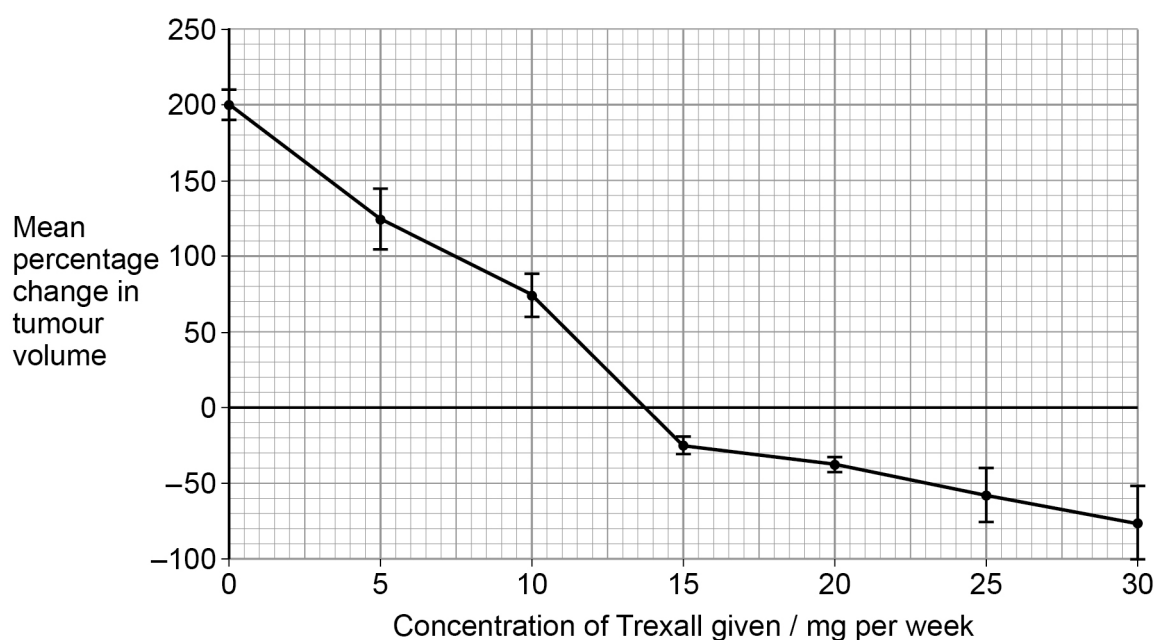
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Doctors investigated how the concentration of Trexall given to patients affected the growth of lung tumours. The doctors measured the volume of tumours at the beginning of the study and after 8 months.

Figure 10 shows the results of this investigation. The bars represent ± 2 standard deviations. A value of ± 2 standard deviations from the mean includes over 95% of the data.

Figure 10



0 6 . 4 The scientists measured the percentage change in tumour volume.

Suggest why they recorded both percentage change **and** tumour volume.

[2 marks]

Percentage change To allow comparison between patients, as the tumours may have been different sizes (volumes) at the start of the investigation.

Tumour volume Tumours differ in shape, length and width, so volume is the best indication of the number of cells in the tumour.



0 6 . 5

A lung cancer patient received 15 mg of Trexall per week. After treatment, the diameter of his lung tumour was 35.8 mm

Assuming the tumour was spherical, use the mean percentage change in tumour volume shown in **Figure 10** to calculate the volume of the patient's tumour **before treatment** with Trexall.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

[2 marks]

$$r = 35.8 / 2 = 17.9 \text{ mm}$$

$$\text{Volume after} = \frac{4}{3} \times 3.14 \times 17.9^3 = 24\,011.95 \text{ mm}^3$$

At 15 mg the mean change is -25%, so after = 75% of before

$$\text{Before} = 24\,011.95 / 0.75 = 32\,015.9$$

Answer = 32 016 mm³

0 6 . 6

To reduce the size of tumours, would it be better to use 30 mg of Trexall per week, or 20 mg of Trexall per week?

Explain your answer.

[2 marks]

30 mg is better: the standard deviation bars for 20 mg and 30 mg do not overlap, so 30 mg gives a significantly greater reduction in tumour volume (about -78% compared with -38%).

Also, with 30 mg some tumours were reduced by 100%, so they would have been eradicated.

However, there is a lot more variation in effectiveness with 30 mg, and a higher dose may cost more and cause more side effects.

Question 6 continues on the next page

Turn over ►



Trexall can also be used to slow the development of rheumatoid arthritis (a pain-causing joint disease).

Scientists investigated the effectiveness of Trexall as a pain relief treatment in 12 rheumatoid arthritis patients. All of the patients were female. They randomly divided the patients into two groups:

- Group **R** received Trexall tablets for 35 days
- Group **S** was a control group.

They asked both groups to rate their pain on a scale of 0–10 (0 being no pain and 10 being the worst pain possible) at the start and then every 7 days for 35 days. They calculated mean scores for each group.

Their results can be seen in **Table 3**.

Table 3

Number of days of treatment	Mean score for severity of pain (scale 0–10)	
	Group R	Group S
0	9.7	9.8
7	8.2	9.1
14	8.4	8.6
21	7.6	7.2
28	6.3	7.5
35	5.1	7.8

0 6 7

Apart from age and general health, give **two** important factors when choosing patients for this investigation.

[1 mark]

1 Severity (stage) of their arthritis

2 Other medication they are currently taking



0 6 8

A student analysed **Table 3** and concluded that Trexall was effective in reducing pain in arthritis patients.

Evaluate the student's conclusion.

[3 marks]

For: the pain score decreased more in Group R (by 4.6, from 9.7 to 5.1) than in the control Group S (by 2.0, from 9.8 to 7.8), so Trexall appears to reduce pain.

Against: the pain score of the control group also decreased, and at 21 days Group S was actually lower than Group R.

The sample size was small (only 12 people, about 6 per group) and all were female, so the effect in males could be different.

No statistical test was done, so we do not know if the difference is significant, and pain is a subjective measurement, so patients may not rate it accurately.

15

Turn over for Section B

Turn over ►



Section BAnswer **one** question.

You are advised to spend no more than 45 minutes on this section.

0 7Write an essay on **one** of the topics below.**EITHER****0 7 . 1**The importance of DNA as an information-carrying molecule **and** its use in gene technologies.**[25 marks]****OR****0 7 . 2**

The importance of bonds and bonding in organisms.

[25 marks]*07.2 The importance of bonds and bonding in organisms*

Bonds hold atoms together in the molecules that make up organisms, and weaker bonds between and within molecules give those molecules their shapes and properties. Strong covalent bonds give stability, while weak hydrogen and ionic bonds can be broken and reformed easily, which allows molecules to change shape, separate and interact. Life depends on both.

Biological polymers are built from monomers joined by covalent bonds formed in condensation reactions, which release a molecule of water, and broken by hydrolysis reactions, which use water. In carbohydrates, two alpha-glucose molecules are joined by a 1,4-glycosidic bond to form maltose, and many alpha-glucose molecules form starch and glycogen. Glycogen has many 1,6-glycosidic bonds, so it is highly branched, with many ends that enzymes can hydrolyse quickly to release glucose for respiration, which is important in animals with high metabolic rates. In cellulose, beta-glucose monomers are joined with alternate molecules



inverted, so the long straight chains lie parallel and form many hydrogen bonds between them. Although each hydrogen bond is weak, there are so many that they form strong microfibrils, giving the cell wall the strength to resist the turgor pressure of the cell. In triglycerides, three fatty acids are joined to glycerol by ester bonds. The many carbon to hydrogen bonds in the fatty acids store a lot of energy, so lipids are an excellent energy store.

Bonding is vital to the structure and function of proteins. Amino acids are joined by peptide bonds to form the primary structure. The secondary structure, the alpha helix and beta pleated sheet, is held by hydrogen bonds between the NH and C=O groups. The tertiary structure is held by hydrogen bonds, ionic bonds and disulfide bridges between the R groups, which fold the polypeptide into a precise 3D shape. In enzymes, this gives a specific active site that is complementary to the substrate, so an enzyme-substrate complex forms. If the temperature is too high, the increased kinetic energy breaks the hydrogen and ionic bonds, and extremes of pH alter the charges on R groups, so the active site changes shape and the enzyme is denatured. A mutation that changes one amino acid can change where these bonds form, altering the tertiary structure, which is why a substitution can make a protein non-functional. Haemoglobin has a quaternary structure of four polypeptides, each with a haem group, and when one oxygen binds it changes the shape of the molecule so the other sites bind oxygen more easily (cooperative binding). The binding of oxygen to haem is reversible, so oxygen is loaded in the lungs and unloaded in respiring tissues, with the Bohr effect increasing unloading where carbon dioxide concentration

Turn over ►



is high.

Hydrogen bonds are central to DNA as an information-carrying molecule. Nucleotides are joined by phosphodiester bonds into a sugar-phosphate backbone, and the two strands are held together by hydrogen bonds between complementary base pairs: adenine with thymine (two hydrogen bonds) and cytosine with guanine (three). The strong covalent backbone protects the base sequence, while the weak hydrogen bonds allow the strands to be separated by DNA helicase during replication and transcription. In semi-conservative replication, free nucleotides pair with the exposed bases by hydrogen bonding and DNA polymerase forms the phosphodiester bonds, so the base sequence is copied accurately before mitosis. In protein synthesis, mRNA codons pair with tRNA anticodons by hydrogen bonds on the ribosome, so amino acids are added in the correct order. In recombinant DNA technology, restriction endonucleases hydrolyse phosphodiester bonds at specific recognition sequences, leaving sticky ends which pair by hydrogen bonding with complementary sticky ends on a plasmid, and DNA ligase then forms phosphodiester bonds to seal the gene into the vector.

Hydrogen bonding between water molecules gives water properties that are important to organisms. Water is a polar molecule, so hydrogen bonds form between the slightly negative oxygen of one molecule and the slightly positive hydrogen of another. This gives water a high specific heat capacity, so a lot of energy is needed to raise its temperature, buffering organisms and aquatic habitats against temperature changes. Water also has a high latent heat of vaporisation, so sweating gives effective cooling. Cohesion between water molecules is essential in the



cohesion-tension theory: as water evaporates from the leaves during transpiration, it pulls a continuous column of water molecules up the xylem, so plants can transport water and mineral ions to their leaves without using energy. Water is also a good solvent because its polarity allows it to form bonds with ions and polar molecules, so metabolic reactions can take place in solution.

Energy in cells is transferred by making and breaking bonds. ATP is hydrolysed to ADP and inorganic phosphate by ATP hydrolase, releasing energy that is used for active transport, muscle contraction and the synthesis of polymers. The phosphate released can be used to phosphorylate other compounds, making them more reactive, as in glycolysis when glucose is phosphorylated. ATP is resynthesised by ATP synthase in a condensation reaction during respiration and photosynthesis, using energy from the flow of protons through the enzyme in chemiosmosis. In skeletal muscle, myosin heads form cross-bridges with binding sites on actin once calcium ions have moved tropomyosin out of the way. The heads then pivot in the power stroke, and ATP binding causes the cross-bridge to detach, so the myosin can bind again further along. This repeated forming and breaking of bonds makes the sarcomere shorten, allowing movement.

Weak, specific bonds also allow cells to recognise and communicate with each other. Antigens on the surface of pathogens have a specific shape, and antibodies, made of four polypeptide chains held together by disulfide bridges, have variable regions with binding sites complementary to one antigen. The antigen-antibody complex forms by weak bonds, and because each antibody has two binding sites, pathogens are agglutinated so phagocytes can engulf them. Similarly, hormones such as insulin bind

Turn over ►

to specific receptors on liver cells, causing glucose transport proteins to be inserted into the membrane and activating enzymes that convert glucose to glycogen, while glucagon binding leads to cyclic AMP being formed as a second messenger. At synapses, acetylcholine binds to receptors on the postsynaptic membrane, opening sodium ion channels, and acetylcholinesterase then hydrolyses it so the stimulus does not continue. Oestrogen diffuses into cells and binds to a receptor, allowing a transcription factor to bind to the promoter of a gene and stimulate transcription, showing how binding can control gene expression.

Bonds in membranes also matter. Phospholipids have a hydrophilic phosphate head and hydrophobic fatty acid tails, so in water they form a bilayer with the tails facing inwards. This means lipid-soluble substances can diffuse through, but ions and polar molecules need channel and carrier proteins, so the cell can control what enters and leaves.

Beyond the specification, the importance of bonding is clear in the role of chaperone proteins such as heat shock proteins. These proteins bind to newly made polypeptides and help them fold correctly, preventing incorrect hydrogen and hydrophobic interactions forming between R groups. When proteins misfold, as in prion diseases such as Creutzfeldt-Jakob disease, a change from alpha helices to beta pleated sheets lets the abnormal proteins stick together by hydrogen bonding into insoluble aggregates that damage neurones. This shows that the correct pattern of weak bonds is essential for protein function.

In conclusion, covalent bonds such as glycosidic, peptide, ester and phosphodiester bonds give biological molecules their stability, while weaker hydrogen bonds, ionic bonds and other interactions give them



their specific shapes and allow them to be broken and reformed. From the replication of DNA to transport in the xylem, enzyme action, energy transfer by ATP and communication between cells, bonds and bonding underpin almost every process in living organisms.

Turn over ►



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[illegible]

[illegible]

[illegible]

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END OF QUESTIONS

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