Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE A LEVEL

A400U20-1

S24-A400U20-1

FRIDAY, 14 JUNE 2024 – MORNING

BIOLOGY – A level component 2
Continuity of Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**18**	
2.	**15**	
3.	**11**	
4.	**14**	
5.	**11**	
6.	**22**	
7.	**9**	
Total	**100**	

A400U201
01

ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

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

You may use a pencil for graphs and diagrams only.

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 additional page(s) 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.

JUN24A400U20101

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Answer **all** questions.

1. (a) The placenta is the site of exchange between maternal and foetal blood. **Image 1.1** shows a section of the human placenta.

Image 1.1



(i) During pregnancy, the placenta secretes the hormone oestrogen. State **two** effects of oestrogen on the mother's body. [2]

Oestrogen stimulates the growth of the uterus (to accommodate the growing foetus).

It stimulates the growth and development of the mammary glands, and inhibits FSH and LH.

During human placental development, maternal uterus capillaries are lost and large spaces containing blood are formed (labelled **X** on **Image 1.1**).

(ii) Suggest how this adaptation improves exchange in the placenta. [2]

Maternal blood is in direct contact with (bathes) the chorionic villi, so there are fewer membranes between maternal and foetal blood.

This gives a shorter diffusion distance, so exchange is faster.

A400U201 03

© WJEC CBAC Ltd.

stemup.co.uk

(b) Gestational age (age of the developing foetus) is measured in weeks, from the first day of the woman's last menstrual cycle to the current date. A normal pregnancy can range from 38 to 42 weeks. Pregnancy is divided into three trimesters, each lasting for approximately three months.

A study of 730 pregnant women was carried out to investigate placental thickness as a way of estimating gestational age.

Tables 1.2A, 1.2B and **1.2C** show the results of the study.

Table 1.2A First trimester

Gestational age / weeks	Number of cases	Mean placental thickness / mm	Standard deviation
7	3	9.6	±1.9
8	7	9.0	±1.0
9	17	10.9	±1.7
10	9	10.0	±1.2
11	6	11.0	±0.9
12	13	15.3	±3.1
13	9	18.0	±3.0

First trimester mean placental thickness = 12.5 mm ±3.7 mm

Table 1.2B Second trimester

Gestational age / weeks	Number of cases	Mean placental thickness / mm	Standard deviation
14	3	18.3	±1.2
15	23	18.7	±3.7
16	27	22.0	±2.9
17	15	21.2	±3.4
18	15	23.7	±2.6
19	23	23.7	±4.3
20	17	25.4	±4.3
21	24	27.2	±4.9
22	16	28.6	±4.5
23	20	27.3	±3.3
24	12	28.9	±5.1
25	17	27.4	±5.2
26	25	32.5	±4.9

Second trimester mean placental thickness = 25.2 mm ±5.6 mm

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Table 1.2C Third trimester

Gestational age /weeks	Number of cases	Mean placental thickness/mm	Standard deviation
27	24	31.4	±4.5
28	28	32.0	±4.4
29	28	33.8	±4.4
30	21	36.0	±5.4
31	31	36.8	±4.7
32	48	36.0	±5.6
33	27	37.0	±7.0
34	28	37.3	±4.0
35	37	41.1	±7.6
36	33	39.3	±7.1
37	31	46.5	±5.6
38	33	42.5	±5.8
39	31	45.1	±6.4
40	14	43.0	±5.3
41	15	43.4	±8.3

Third trimester mean placental thickness = 38.4 mm ±7.1 mm

The placental thickness data also shows the standard deviation of the sample.

(i) State what standard deviation measures. [1]

It measures the spread (variation) of the data around the mean, i.e. how varied the sample is from the mean.

(ii) Explain why standard deviation is used rather than the range. [1]

SD takes all values into account, not just the highest and lowest; the range can be distorted by outliers or anomalies.

A400U201
05

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

The dimensions of the placenta can be found using scans.

(iii) The volume of a placenta was found to be 1227 cm^3, with a diameter of 25 cm.

I. Use the following formula to find the thickness of the placenta.
Assume the placenta is the same thickness across its diameter.
Show your working. [3]

Volume = $\pi r^2 h$
Where r = radius of placenta
h = thickness of placenta
π = 3.14

$r = 25 \div 2 = 12.5$ cm

$r^2 = 12.5 \times 12.5 = 156.25$ cm^2

$h = V \div \pi r^2 = 1227 \div (3.14 \times 156.25)$

$h = 1227 \div 490.625 = 2.501$ cm

Thickness of placenta = 2.5 cm

II. Use your result from I. and **Tables 1.2A**, **1.2B** and **1.2C** to conclude the trimester of pregnancy. [1]

Trimester of pregnancy = second

(iv) It was concluded that using placental thickness is an accurate way of predicting the trimester but not the gestational age in weeks of a foetus.
Use the information in **Tables 1.2A**, **1.2B** and **1.2C** to evaluate this conclusion. [3]

Not reliable for weeks: SDs of neighbouring weeks overlap, e.g. week 9 (10.9 ±1.7) and week 10 (10.0 ±1.2).

Mean thickness is the same or decreases between some weeks, e.g. 23.7 mm at weeks 18 and 19; 46.5 at week 37 but 42.5 at 38.

Better for trimesters as their SD ranges (8.8 to 16.2, 19.6 to 30.8, 31.3 to 45.5 mm) do not overlap; fewer groups so less chance of overlap.

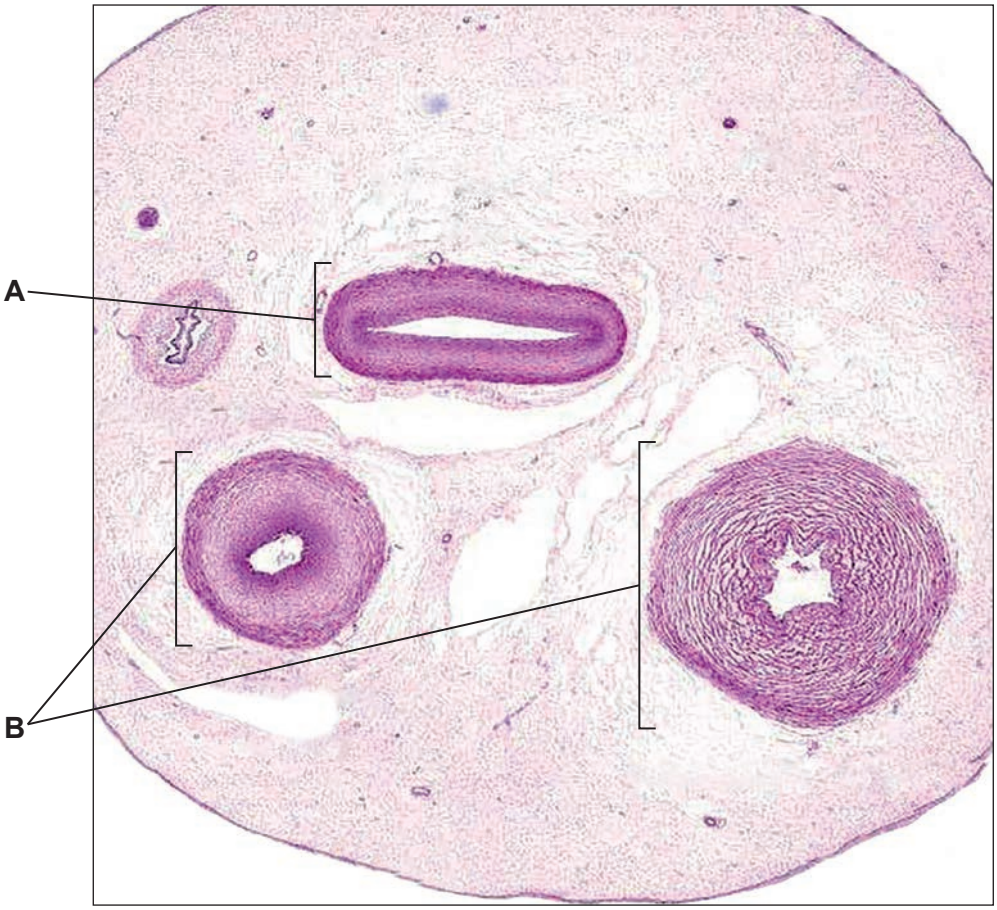
© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) **Image 1.3** shows a cross-section through the umbilical cord. Three blood vessels are labelled. The blood vessels labelled **B** are the same type of blood vessel.

Image 1.3



(i) Identify the type of blood vessels labelled **A** and **B**. [1]

A (umbilical) vein

B (umbilical) artery

(ii) Using the letters **A** or **B**, complete **Table 1.4** by identifying which blood vessel has the higher concentration of the following molecules. [1]

Table 1.4

Molecules	Blood vessel **A** or **B**
oxygen and glucose	A
urea	B

A400U201 07

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(d) During and after birth, the mother's posterior pituitary gland releases the hormones oxytocin and prolactin.

State the effects of:

(i) oxytocin during birth; [1]

Oxytocin stimulates contraction of the uterus wall (myometrium).

(ii) prolactin after birth. [1]

Prolactin stimulates the production of milk (by the mammary glands).

(e) After the baby is born, the placenta and the umbilical cord can be used as a source of stem cells. These may be used for replacing damaged tissues and organs when the baby grows older.
It is better to take the baby's stem cells from the umbilical cord rather than the placenta.
Suggest the reason for this. [1]

The umbilical cord only contains cells from the baby, whereas the placenta contains both the mother's and the baby's cells.

18

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

2. The Human Genome Project set out to sequence the 3 billion base pairs that make up human DNA and to identify all the genes in the human chromosomes. The project was set up in 1990 and involved scientists working in 18 different countries.

DNA samples were collected from a group of volunteers. The samples had their identification removed.

(a) (i) Suggest why it was important to the **volunteers** that the DNA samples had their identification removed. [2]

The samples cannot be matched to the individuals, so the volunteers would not find out if they had problem genes.

They will not be discriminated against, e.g. refused life insurance or job opportunities.

(ii) Suggest **two** ways in which the Human Genome Project may lead to improved treatments for genetic medical conditions. [2]

It locates problem genes (alleles) that cause genetic conditions, allowing greater use of gene therapy.

Treatment can be tailored to an individual or a specific condition (genomic medicine).

(b) DNA base sequencing has also been completed for other organisms to determine evolutionary relatedness. The base sequences coding for some of their proteins have been completed, including haemoglobin.

Haemoglobin is a globular protein with a quaternary structure that transports oxygen around the body of many animals.

(i) Explain the meaning of quaternary structure. [1]

The protein contains more than one polypeptide chain bonded together.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Beta-globin (β-globin) is one of the sub-units found in the haemoglobin molecule. It is coded for by the β-globin gene.

A comparison of the following sequences was made between human, rabbit, mouse and chimpanzee:

- DNA base sequence of the exons of the β-globin gene
- DNA base sequence of the introns of the β-globin gene
- Amino acid sequence of the β-globin sub-unit.

The results are shown in **Table 2**.

Table 2

β-globin sequences being compared	Sequence similarity / %		
	Bases of exons	Bases of introns	Amino acids
human / chimpanzee	100.0	98.4	100.0
human / rabbit	89.3	67.0	90.4
human / mouse	82.1	61.0	80.1

(ii) I. With the human and chimpanzee comparison, the amino acid sequence is identical but the base sequence of the intron is different.

Mutations in the base sequences of the introns do not affect the amino acid sequence. Explain why. [1]

Introns are non-coding regions; they are removed (spliced out) of pre-mRNA, so only exons code.

II. The base sequence of the exons can be different but still code for the same amino acid sequence. Explain why. [1]

The DNA code is degenerate: the same amino acid may be coded for by more than one triplet (codon).

A400U201
11

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) ATP is the universal energy currency. Cytochrome c is a protein involved in the electron transport chain in ATP production. Cytochrome c consists of 104 amino acids.

(i) Calculate the minimum number of nucleotides needed to code for cytochrome c. [1]

104 × 3 = 312

Minimum number of nucleotides = 312

(ii) Cytochrome c is more useful than haemoglobin for studying how closely related different organisms are. Suggest **one** reason for this. [1]

All organisms respire and use ATP so all have cytochrome c, but not all organisms have haemoglobin.

(d) Double-stranded DNA can be taken from different species. The molecules are heated to make the DNA single-stranded.

(i) Explain how heating results in single-stranded DNA. [1]

Heat provides energy to break the hydrogen bonds between complementary bases.

Single-stranded DNA from one species is then mixed with single-stranded DNA from another species. These are allowed to bond together and form hybrid DNA molecules. The temperatures at which the hybrid DNA can be separated again into single strands (separation temperature) can give an indication of evolutionary relatedness.

(ii) Biologists formed hybrid DNA from a human and a chimpanzee and from a human and an orangutan.
Suggest why hybrid human / chimpanzee DNA separated at higher temperatures than hybrid human / orangutan DNA. [3]

Humans are more closely related to chimpanzees than to orangutans, sharing a more recent common ancestor.

So human and chimpanzee DNA have more similar base sequences, with more complementary bases.

So more hydrogen bonds form between the strands, which need more heat energy to be broken.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(iii) Hybrid DNA molecules were formed from single strands of DNA from several individuals of the **same** species. There were differences in the separation temperatures of the different hybrid DNA molecules, even though they were from the same species.
Explain a reason for this. [1]

Individuals of the same species have different alleles (base sequences), e.g. due to mutations.

(e) When DNA is extracted from plant cells the enzyme cellulase may need to be added.
Explain why cellulase is not needed when extracting DNA from human cells. [1]

Human (animal) cells do not have a cell wall, so there is no cellulose to break down.

15

A400U201
13

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

3. Glucose-6-phosphate dehydrogenase (G6PD) is an enzyme found in all cells of the body. It is involved in converting glucose to pentose sugars. During this reaction a co-enzyme is produced that protects the cell membrane from oxidative damage.

This co-enzyme is also produced in oxidative phosphorylation.

(a) (i) Red blood cells do not contain mitochondria. Use all the information given to conclude why red blood cells are at greater risk of membrane damage than other body cells. [2]

Mitochondria are the site of oxidative phosphorylation, which produces the protective co-enzyme.

Therefore red blood cells have fewer co-enzymes (only from the G6PD reaction) so are less protected from oxidative damage.

(ii) State the name of **two** nucleotides that contain pentose sugar. [1]

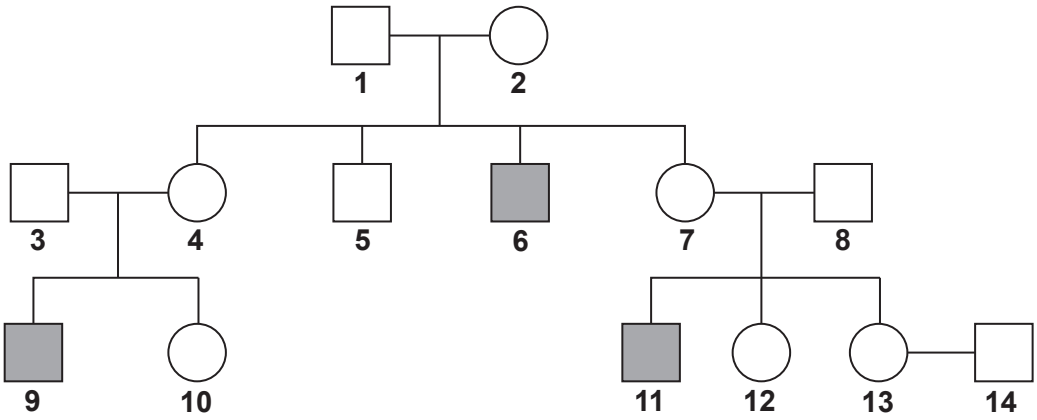
DNA

ATP

(b) G6PD deficiency is a hereditary condition in which red blood cells break down when the body is exposed to certain foods, drugs, infections or stress. The gene coding for G6PD is found on the X chromosome.

Image 3 shows the inheritance of G6PD deficiency in one family.

Image 3



© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(i) State **two** factors that affect an organism's phenotype. [2]

Genes (genotype / alleles)

Environment (epigenetics)

(ii) G6PD deficiency is caused by a recessive allele.
Explain this statement. Use a suitable example from **Image 3** to support your answer. [2]

Parents without the deficiency (a carrier mother) can have sons with the deficiency, so the allele is only expressed when no dominant allele is present.

Example: 3 and 4 are unaffected but produce son 9 with the deficiency.

The following symbols represent the chromosomes and alleles carried by individuals in **Image 3**.

$\mathbf{X^G}$ = an X chromosome carrying the unaffected allele
$\mathbf{X^g}$ = an X chromosome carrying the allele for G6PD deficiency
Y = a Y chromosome

(iii) Using these symbols, state **all** the possible genotypes for the following individuals in **Image 3**. [3]

4 X^GX^g

5 X^GY

6 X^gY

10 X^GX^G or X^GX^g

(iv) A genetic screening test shows that individual **13** is a carrier of the allele for the G6PD deficiency.

Determine the probability that a child of individuals **13** and **14** will be a male with G6PD deficiency. [1]

$X^GX^g \times X^GY$

Probability = 0.25 (1 in 4)

11

A400U201
15

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

4. **Images 4.1A** and **4.1B** show two forms of the same species of Mexican tetra fish (*Astyanax mexicanus*).

Image 4.1A



surface form

Image 4.1B



cave form

The surface form is found in streams open to the sky.
The cave form is blind and found in streams inside caves.

Scientists collected fish of both forms.

(a) A **surface form** fish was bred with a **cave form** fish and offspring were produced. Describe the next steps that would need to be taken to show the two forms were from the same species. Explain your answer. [2]

Breed the offspring together (with each other).

If young are produced, the offspring are fertile, which shows the two forms are the same species (they can produce fertile offspring).

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) The energetic cost of tissues can be measured as the oxygen demand per gram of tissue per hour (mg O_2 g^{-1} $hour^{-1}$).

The scientists investigated the energetic cost of vision in Mexican tetra fish. Eight fish of each form were studied. The oxygen demand for the whole body and for the eyes was calculated.

The results for the **surface form** are shown in **Table 4.2**.

Table 4.2

	Oxygen demand per g of fish / mg O_2 g^{-1} $hour^{-1}$								
	Fish 1	Fish 2	Fish 3	Fish 4	Fish 5	Fish 6	Fish 7	Fish 8	Mean
whole body	0.844	0.852	0.861	0.841	0.839	0.848	0.850	0.840	0.847
eyes	0.102	0.095	0.104	0.083	0.084	0.101	0.103	0.098	0.096

(i) Calculate the mean whole body oxygen demand per g of fish.

Write your answer in the space in Table 4.2. [2]

(0.844 + 0.852 + 0.861 + 0.841 + 0.839 + 0.848 + 0.850 + 0.840) ÷ 8

= 6.775 ÷ 8 = 0.846875 = 0.847

(ii) Explain why the units for oxygen demand are given per gram of fish. [1]

The fish may be different sizes (masses), so this allows a fair comparison.

The oxygen demand shows that the eyes in the surface form use approximately 11% of the total energy of the whole body.

The percentage of oxygen demand for the eyes of the **cave form** was zero.

(iii) Suggest the advantage of the difference in energetic cost for eyes for the **cave form**. [2]

Less energy is needed for the eyes, so the fish does not need to eat as much food in the cave.

More energy (ATP) is available to be used for growth and reproduction.

A400U201
17

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

It has been suggested that the two forms of fish will eventually become separate species due to allopatric speciation.

(iv) Explain what is meant by allopatric speciation. [2]

Populations live in different areas, i.e. geographical isolation by a physical barrier.

This prevents interbreeding (gene flow), so the populations evolve separately into new species.

It had been suggested that the **cave form** may have developed due to a small population undergoing genetic drift.

(v) Explain why genetic drift has a bigger impact on small populations. [2]

Changes in allele frequency (or loss of an allele) are due to chance.

In a small gene pool a small random change causes a large change in allele frequency, so alleles are more easily lost.

(c) A group of scientists recently studied the genomes of the two forms of fish.

The scientists found the two forms of fish had very similar genomes but there were much higher levels of methylation in the **cave form** when compared with the **surface form**.

Methylation is the addition of methyl groups to bases.

Suggest what these findings may show about the effect of the levels of methylation present in the DNA of the **cave form**. Explain your answer. [3]

The increased methylation switches genes off, so the genes are not expressed: transcription of the genes needed to produce eyes is prevented.

This leads to the non-production of eyes (blindness) in the cave form.

It is an epigenetic factor, which explains why the genomes are very similar but the phenotypes differ.

14

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

5. Black wattle (*Acacia mearnsii*) is a plant that lives in dry environments that are subjected to forest fires. Black wattle seeds have elaiosomes. These are structures containing lipids and proteins. The seeds are shown in **Image 5**.

Image 5



(a) It has been found that there are more saturated fatty acids than unsaturated fatty acids in the elaiosomes.

(i) State **one** difference between saturated and unsaturated fatty acids. [1]

Saturated fatty acids have no C=C double bonds (maximum H), unsaturated have C=C double bonds (less H).

(ii) Describe a chemical test to show the presence of protein in the elaiosome. [1]

Add Biuret reagent (no heating): it turns from blue to purple (violet) if protein is present.

(b) The elaiosome attracts ants. The seeds are taken into the ants' underground nest and the elaiosomes are fed to the ants' larvae while the seeds are discarded.

Explain how the presence of the elaiosome is an advantage to the black wattle plant. [2]

It results in seed dispersal, which reduces competition with the parent plant. The seed is taken underground so it escapes fire and is not eaten by other animals.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) When a forest fire occurs, the heat stimulates the black wattle seeds to germinate. The heat results in the rapid expansion of the seed coat, causing it to crack.

(i) Explain **one** way that the cracking of the seed coat allows the seed to begin to germinate. [2]

It allows water to enter the seed (imbibition).

This allows aqueous reactions to take place and mobilisation of enzymes, which break down food stores.

(ii) Suggest **two** advantages to plants that grow from seeds after a forest fire. [2]

More light is available as there is less competition for light (taller plants burnt).

The ash provides nutrients (minerals).

(d) When areas of forest are burned, nitrogen oxides are released into the air in the smoke. These dissolve in rainwater to produce nitrites.

After a forest fire, lakes and rivers close to the fire experience a sudden growth in the production of microscopic algae.

Use the information to explain the sudden growth of microscopic algae. [3]

The nitrites enter the water of the lakes and rivers in rainwater (run-off).

The nitrites are converted to nitrates (by nitrifying bacteria).

The algae use the nitrates to make proteins and DNA (nitrogenous compounds), resulting in increased cell division and reproductive rate.

11

© WJEC CBAC Ltd.

stemup.co.uk

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

© WJEC CBAC Ltd.

stemup.co.uk

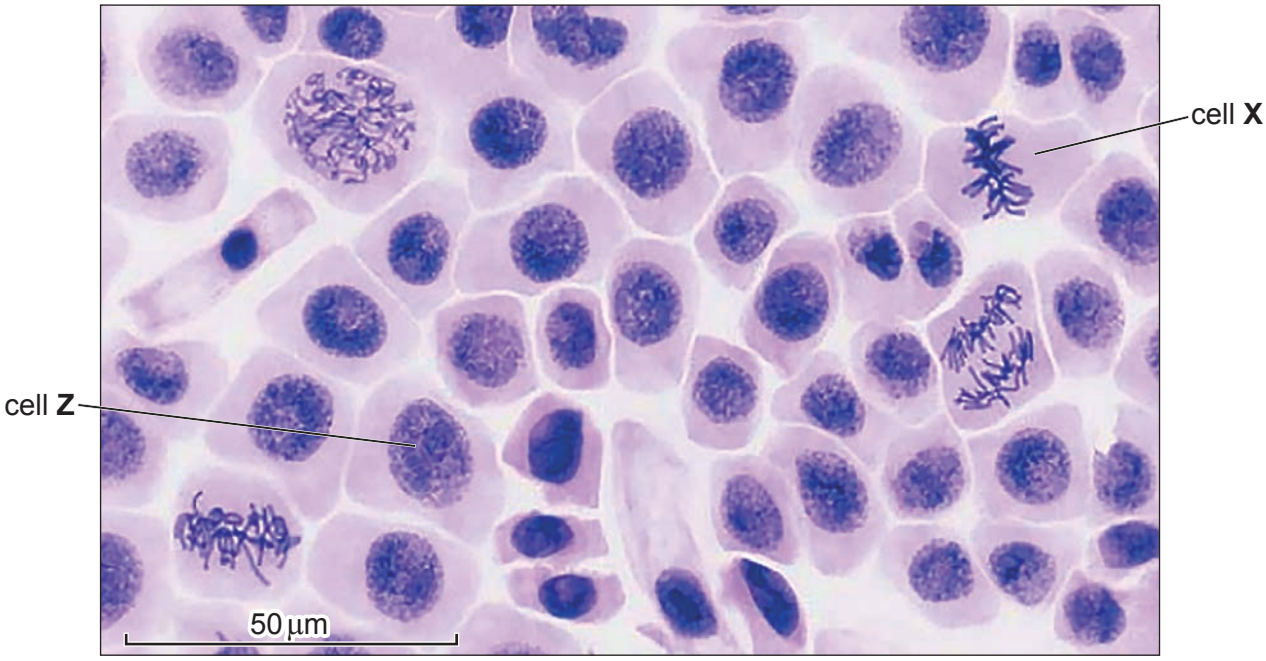
Examiner only

6. Mast cell tumours (MCTs) are a type of cancer found in the skin of dogs.

(a) A sample of the tumour can be removed and stained to allow the DNA in the cells to be seen using a light microscope.

Image 6.1 shows a sample of an MCT taken from the skin of a dog.

Image 6.1



(i) Name the phase of mitosis shown by cell **X**. [1]

metaphase

(ii) Cell **Z** is in interphase.
State **three** events that must occur during interphase before mitosis can take place. [3]

Replication of DNA.

Organelles (e.g. mitochondria, ribosomes) are produced.

Protein (enzyme) synthesis, e.g. of spindle proteins.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(b) A group of vets gathered data from 160 dogs with MCTs.

The MCTs were classified as one of three different grades, which have different effects on the survival of dogs. These are shown in **Table 6.2**.

Table 6.2

MCT grade	Effect of MCT
I	long term survival and most were cured with surgical removal
II	may survive a long time but the tumour could potentially start growing faster and spread throughout the body
III	median survival time of 6 months as they are faster-growing tumours

It has been proposed that MCTs could be classified according to the number of cells in different stages of mitosis. This is done by examining samples of tumour tissues under a light microscope.

(i) Describe and explain what should have been done when counting cells to make sure that the data obtained for each sample was reliable and accurate. [4]

Reliable:

Count many cells in many fields of view (a large sample size) for each sample, so that a mean can be calculated and anomalies have less effect.

Accurate:

Use a method for dealing with cells at the edge of the field of view, e.g. only count half cells on two sides, to standardise the count. Use well stained, thin samples at high magnification to ensure correct identification of stages.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

Table 6.3 shows the data for a tissue sample from a grade I MCT.

Table 6.3

Stage of cell cycle	Number of cells in stage
interphase	497
prophase	12
metaphase	6
anaphase	3
telophase	4

The mitotic index (MI) is a measure of the growth activity of a tissue. The mitotic index of a sample can be calculated using the formula:

$$\text{Mitotic Index} = \frac{\text{number of cells in mitosis} \times 100}{\text{total number of cells}}$$

(ii) Calculate the mitotic index of the tumour sample in **Table 6.3** to **two decimal places**. Show your working. [2]

(12 + 6 + 3 + 4) × 100 ÷ (497 + 25) = 25 × 100 ÷ 522

MI = 4.79

(iii) Using the information given, explain why a tissue sample from a grade III MCT would have a higher mitotic index. [1]

Grade III tumours grow faster, so more cells are in mitosis and fewer in interphase.

(iv) Apart from the grade of MCT, suggest **three** other factors that could have led to a variety of survival times for the dogs studied. [3]

breed

age

diet / different treatments

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(c) (i) To predict the increase in the number of cancer cells over time, the following equation can be used:

$$N_t = N_c e^{rt}$$

Where:

N_t = number of cancer cells after a given time

N_c = number of cancer cells at the start

e = 2.72 (base of natural log)

r = growth rate

t = time period in hours over which r applies

A group of 150 cancer cells were grown on nutrient gel in a Petri dish.

Use the equation above to calculate the predicted number of cancer cells that would be present after 24 hours if the growth rate is 0.05 (5%). [2]

$N_t = 150 \times 2.72^{(0.05 \times 24)}$

$rt = 0.05 \times 24 = 1.2$

$2.72^{1.2} = 3.323$

$N_t = 150 \times 3.323 = 498.4$

Predicted number of cancer cells = 498

(ii) If the 150 cancer cells were part of a mast cell tumour in a dog rather than on nutrient gel the actual number of cancer cells after 24 hours may be less than predicted in (c)(i).

Suggest **one** explanation for this. [1]

There is less access to nutrients in the dog, and some cells may be killed by the dog's immune system.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

(d) It has been suggested that the rate of mitosis in a tumour could be estimated by measuring the uptake of radioactive thymine. A sample of the tumour is added to a nutrient solution containing radioactive thymine. After three days the tumour is removed and the level of radioactivity of the tumour is measured.

(i) Use the information given and **Table 6.2** to explain why grade II tumours would have a higher level of radioactivity than grade I tumours after being removed from the nutrient solution. [2]

Grade II tumours could grow faster, so the fastest dividing cells take up the greatest amounts of thymine, as cells dividing most synthesise more DNA (DNA replication before mitosis).

(ii) Explain why **radioactive thymine** would be used to measure the rate of mitosis and **not radioactive guanine**. [2]

Thymine is only present in DNA, not in RNA, so it only measures DNA replication.

Guanine is present in DNA and RNA, so it would also be taken up during transcription.

(e) Suggest **one** reason why the mitotic index method of estimating the rate of mitosis would be preferred by vets rather than the radioactive thymine method. [1]

It gives faster results and is an easier, cheaper method that is safer for vets (no radioactivity).

22

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

7. Bioluminescence is the natural ability to produce light through a chemical reaction. This property is possessed by certain marine animals, such as jellyfish. *Aequorea victoria* is a jellyfish that produces a protein called green fluorescent protein (GFP) that confers the ability to glow. These are shown in **Image 7.1A**.

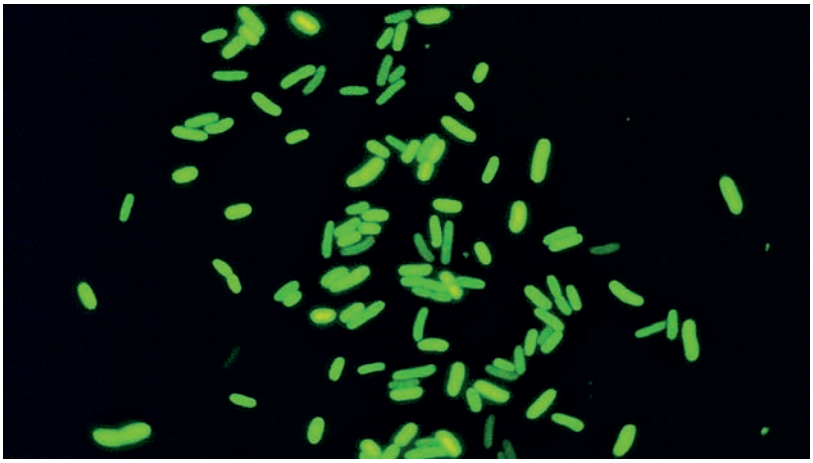
The gene for GFP was taken from the jellyfish and introduced into different organisms leading to the development of genetically engineered glow-in-the-dark organisms such as bacteria. These are shown in **Image 7.1B**.

Image 7.1A



Jellyfish

Image 7.1B



Bacteria

Bacteria can be genetically modified to contain functioning human genes. Previously, genetic modification of bacteria has relied on the introduction of antibiotic resistance marker genes. These identify genetically modified cells that contain a functioning human gene. The use of the GFP gene has been trialled as an alternative marker gene in human gene therapy.

Describe how scientists can use mRNA from the jellyfish to synthesise a DNA molecule coding for GFP.

Explain how this method overcomes the problems of removing the GFP gene directly from the jellyfish chromosomes.

Suggest how the GFP marker could be used in gene therapy and why it is more useful than the antibiotic resistance marker. [9 QER]

To make DNA coding for GFP, mRNA is taken from a jellyfish cell that produces GFP, so it contains lots of GFP mRNA. The enzyme reverse transcriptase is added with free DNA nucleotides; it uses the mRNA as a template to produce a complementary single-stranded DNA (cDNA) strand.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

The mRNA is then removed and DNA polymerase is used to produce double-stranded DNA, the GFP gene.

This overcomes the problems of taking the gene directly from the chromosomes. There is no need to locate the GFP gene among all the DNA on the jellyfish chromosomes. Restriction endonucleases are not used, so there is no risk that they cut within the GFP gene, which would leave it in non-functional fragments. The cDNA is made from mature mRNA, so it has no introns: this removes the problem of introns, because bacteria cannot carry out post-transcriptional processing (splicing) to produce functioning mRNA.

In gene therapy the GFP marker gene can be combined with the desired functioning human gene in the vector. Cells (or bacteria) that contain the functioning gene, i.e. the recombinant DNA, then glow green under UV light, so they can be identified. These cells are allowed to replicate and cells without the gene, which do not glow, are discarded.

GFP is more useful than an antibiotic resistance marker because it stops the problem of antibiotic resistance genes being passed on to other organisms such as pathogenic bacteria, and antibiotic resistance genes cannot be used in human cells. Identification is also faster, as glowing cells are seen directly without growing them on antibiotic plates and killing non-transformed cells.

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

© WJEC CBAC Ltd.

stemup.co.uk

Examiner only

END OF PAPER

9

© WJEC CBAC Ltd.

stemup.co.uk

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

© WJEC CBAC Ltd.

stemup.co.uk