

Please write clearly in block capitals.

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 4 Control

Monday 2 June 2025

07:00 GMT

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

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



J U N 2 5 B L 0 4 0 1

Answer **all** questions in the spaces provided.

0 1

Insulin is important in the control of blood glucose concentration.

0 1 . 1

Insulin binds to receptors on target cells.

Describe how this causes the concentration of blood glucose to decrease.

[3 marks]

Binding of insulin causes more glucose transport (carrier / channel)

proteins to move to the plasma membrane and to become open / active.

So more glucose moves (diffuses) into the cells, lowering the blood glucose concentration.

Insulin activates enzymes in the cells that convert glucose to glycogen (glycogenesis).

It also stimulates the formation of fat (lipid) from glucose and raises the rate of respiration in cells, using more glucose.

0 1 . 2

The insulin gene is 1.425 kilobases in length. The DNA helix makes one complete turn every 10 base pairs. Each complete turn is 3.4 nm in length.

Calculate the length of the insulin gene.

Give your answer in micrometres (μm) and to 3 significant figures.

[3 marks]

1.425 kb = 1425 base pairs

Number of complete turns = $1425 \div 10 = 142.5$

Length = $142.5 \times 3.4 = 484.5 \text{ nm} = 0.4845 \mu\text{m}$

Length of insulin gene = 0.485 μm



0 1 . 3

Mutations in the insulin gene can change the amino acid sequence of insulin. This change can prevent insulin from binding to receptors.

Explain why.

[3 marks]

A change in the amino acid sequence changes the secondary and

tertiary structure (3D shape) of insulin,

as the position of hydrogen bonds, ionic bonds and disulfide bridges

between R groups changes.

So insulin is no longer complementary to the receptor and can no longer

fit / bind to the receptor.

9

Turn over for the next question

Turn over ►



0 2

The movement of ions is important in the functioning of neurones.

0 2 . 1

Sodium ions and potassium ions can only cross the membrane of a neurone through proteins.

Explain why.

[2 marks]

Sodium and potassium ions cannot move (diffuse) through the phospholipid bilayer, as they are charged / hydrophilic / water soluble and not lipid soluble, so cannot pass through the hydrophobic fatty acid tails.

0 2 . 2

Explain the role of sodium-potassium pumps and ATP in a neurone.

[3 marks]

The sodium-potassium pump uses energy from the hydrolysis of ATP to actively transport ions against their concentration gradients. Three sodium ions are pumped out of the neurone (axon) and two potassium ions are pumped into the neurone, so there is a higher concentration of sodium ions outside and a higher concentration of potassium ions inside, which maintains (and re-establishes) the resting potential.



Scientists investigate the effects of a drug called lidocaine on neurones.

The scientists:

- use different concentrations of lidocaine
- measure the neurone membrane permeability to sodium ions when stimulated.

Table 1 shows the scientists' results.

Table 1

Concentration of lidocaine / $\mu\text{mol dm}^{-3}$	Membrane permeability to sodium ions / % of control
0.2	86
0.4	72
0.6	56
0.8	45
1.0	34

0 2 . 3 Suggest why lidocaine can be used during surgery to prevent pain.

[3 marks]

Lidocaine reduces the permeability of the membrane to sodium ions, so

less / no sodium ions diffuse into the neurone when stimulated.

Not enough sodium ions enter to cause depolarisation, so the threshold value is not reached,

so fewer / no action potentials (nerve impulses) are generated and

transmitted along the pain pathways to the brain, so pain is not felt.

8

Turn over for the next question

Turn over ►



0 3

Scientists investigate the effect of training on the muscle fibres in a large muscle in the leg.

The scientists:

- select 15 healthy male ice hockey players
- take a sample of muscle tissue from each player before and after a training programme.

0 3 . 1

Suggest **two** factors the scientists consider when they select players for the investigation.

[2 marks]

1 *Age (all similar age)*

2 *Weight and height / BMI (also fitness level)*

0 3 . 2

The scientists use muscle tissue samples to record the proportion of fast and slow fibres.

Give **two** features of slow muscle fibres that would allow the scientists to identify them in a muscle tissue sample.

[2 marks]

1 *Higher number (density) of mitochondria*

2 *Dense network of blood capillaries (appear dark red, with more myoglobin)*



Question 3 continues on the next page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



0 7

Succinate dehydrogenase (SDH) is an enzyme that catalyses one of the reactions in aerobic respiration.

The scientists use the samples of muscle tissue to find the:

- mean percentage of fast and slow fibres
- mean SDH activity
- mean number of capillaries in contact with muscle fibre per cross-sectional area of muscle fibre (CSA).

Table 2 shows the scientists' results for before and after the training programme.

SE represents standard error.

Table 2

Type of muscle fibre	Mean percentage of fast and slow fibres $\pm$ SE	
	Before	After
Slow	55.90 $\pm$ 4.40	61.24 $\pm$ 4.90
Fast	43.20 $\pm$ 4.65	38.76 $\pm$ 4.50

Type of muscle fibre	Mean SDH activity / arbitrary units $\pm$ SE	
	Before	After
Slow	0.12 $\pm$ 0.02	0.17 $\pm$ 0.01
Fast	0.08 $\pm$ 0.01	0.08 $\pm$ 0.01

Type of muscle fibre	Mean CSA / arbitrary units $\pm$ SE	
	Before	After
Slow	1.05 $\pm$ 0.20	1.40 $\pm$ 0.10
Fast	0.85 $\pm$ 0.15	1.00 $\pm$ 0.15



0 3 . 3

Describe what the results in **Table 2** show about the effect of training.**[4 marks]**

There is no significant difference in the mean percentage of slow and fast fibres before and after training, as the $\pm$ SE ranges overlap (e.g. slow 55.90 ± 4.40 and 61.24 ± 4.90).

Mean SDH activity shows a significant increase for slow fibres (0.12 ± 0.02 to 0.17 ± 0.01), but no significant difference / no change for fast fibres (0.08 both).

Mean CSA shows a significant increase for slow fibres (1.05 ± 0.20 to 1.40 ± 0.10), but no significant difference for fast fibres.

The SE ranges (error bars) do not overlap for the slow fibre SDH, so the difference is significant, but they overlap for fast fibres, so there is no significant difference.

0 3 . 4

After the training programme, the players can exercise for a longer amount of time.

Explain why.

Use information from **Table 2**.**[3 marks]**

Slow fibres are adapted for endurance (long periods of activity), and the proportion of slow fibres increases slightly.

SDH activity increases in slow fibres, so a higher rate of aerobic respiration (Krebs cycle) and more ATP production for muscle contraction.

The increase in CSA increases the supply of oxygen to the muscle fibres, so more aerobic respiration, delaying the onset of anaerobic respiration and lactate build-up, so muscle fatigue is delayed.



0 4

A student investigates the effects of indoleacetic acid (IAA) on the growth of seedlings.

The student:

- cuts 20 mm lengths of shoot tips from 50 seedlings of the same age
- puts 10 shoot tips into each of 5 Petri dishes
- adds a different concentration of IAA solution to each Petri dish
- measures the length of each shoot tip after 48 hours
- calculates the mean increase in shoot tip length at each of the IAA concentrations.

Table 3 shows the student's results.

Table 3

IAA concentration / mg dm^{-3}	Mean increase in shoot tip length / mm
0.00	1.4
0.01	1.6
0.10	2.3
1.00	5.4
10.00	6.9

0 4 . 1

Give the reason why the student uses an IAA concentration of 0.00 mg dm^{-3}

[1 mark]

To act as a control experiment, to compare with the other groups / to show the growth of shoot tips without added IAA.



0 4 . 2

Describe how the student would present the data shown in **Table 3** as a graph.**[3 marks]**

IAA concentration (mg dm^{-3}) on the x-axis and mean increase in shoot tip length (mm) on the y-axis.

Use a logarithmic scale for the x-axis (IAA concentration), as the concentrations increase by a factor of ten.

Plot the mean values as points and draw a line (curve) of best fit, as a line graph because the data are continuous.

0 4 . 3

Describe the results shown in **Table 3**.**[2 marks]**

As the IAA concentration increases, the mean increase in shoot tip length increases (positive correlation).

Slow increase up to 0.10 mg dm^{-3} (1.4 to 2.3 mm), then a faster increase in shoot length (to 6.9 mm at 10.00 mg dm^{-3}).

0 4 . 4

Explain how the pattern in the results would be different if the student uses root tips instead of shoot tips.

[2 marks]

As the concentration of IAA increases, the growth of the root tips would decrease (negative correlation),

because IAA inhibits cell elongation (growth) in roots.

Turn over ►

Another student investigates the effect of red light and of blue light on the growth of seedlings.

This is the method the student uses.

1. Cover 10 seedlings with a cardboard box with a hole cut into one side.
2. Shine red light through the hole in the cardboard box.
3. Measure the angle of curvature of the seedlings each day for 7 days (as shown in **Figure 1**).
4. Repeat steps 1–3 for seedlings exposed to blue light.

Figure 1

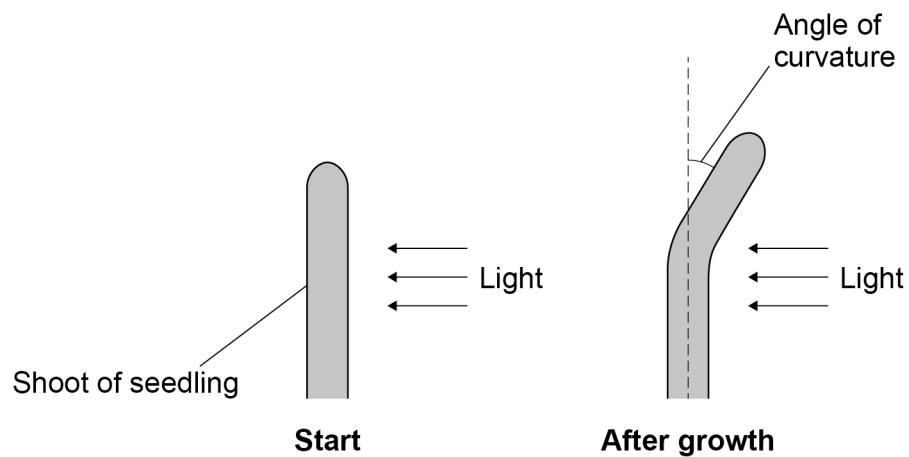
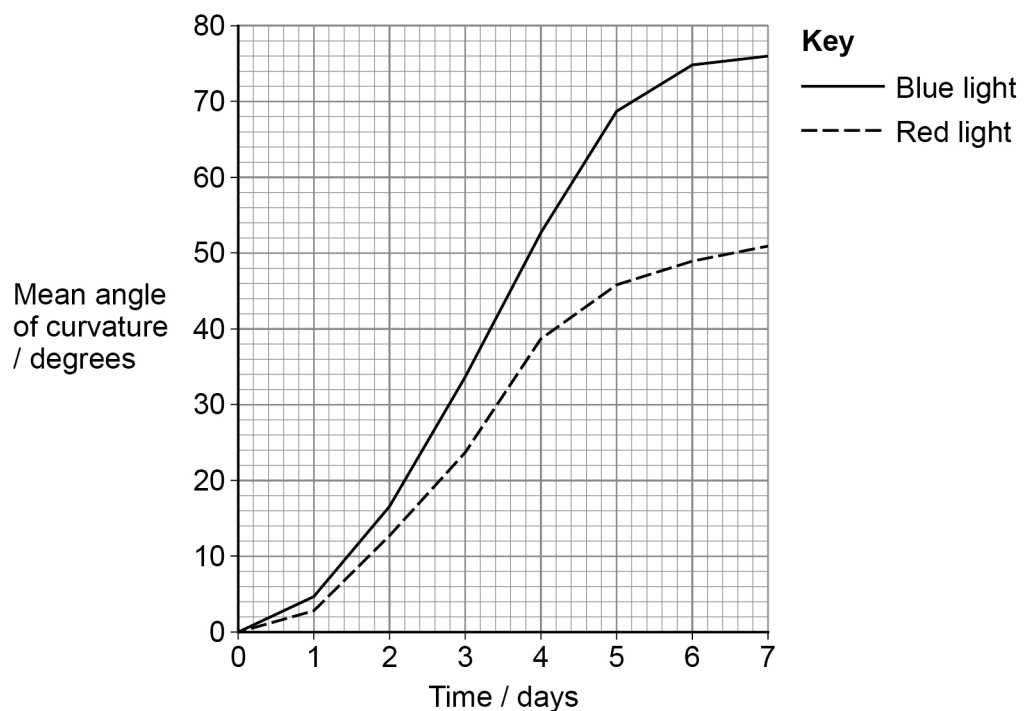


Figure 2

Figure 2 shows the student's results.



0 4 . 5 Describe the results shown in **Figure 2**.

[2 marks]

As time increases, the angle of curvature increases for both groups of seedlings, they all bend towards the light (positive phototropism).

The response is greater for blue light (76° after 7 days compared with 51° for red light).

0 4 . 6 Explain what causes the response of the seedlings to light.

[2 marks]

IAA moves away from the illuminated side to the shaded side of the shoot, so there is a greater IAA concentration on the shaded side.

Cells on the shaded side have greater cell elongation, so the shoot bends / grows towards the light.

12

Turn over for the next question

Turn over ►



0	5
---	---

The retina of the eye contains two types of light-detecting cells, rods and cones.

Rods provide **high** sensitivity, but **low** visual acuity.

Cones provide **low** sensitivity, but **high** visual acuity and colour vision.

0	5
---	---

1

Define **sensitivity** and **acuity** in terms of vision.

[2 marks]

Sensitivity *The ability to detect very low levels of light (amount of light needed to generate an action potential).*

Acuity *The ability to distinguish (resolve) two objects close together as separate.*



The proportion and distribution of rods and cones in the retina is different in different species, leading to differences in vision.

Compared to humans, cats have:

- better night vision
- better peripheral vision (ability to detect movement at the edges of their vision)
- more limited colour vision.

0 5 . 2

Suggest reasons for the differences in vision between humans and cats.

Use your knowledge of the structure of the human retina.

[4 marks]

Better night vision *Cats have more rods than humans, and their rods have a more sensitive light-absorbing pigment (rhodopsin).*

Cats have more rods connected to one bipolar cell (more retinal convergence), so the threshold is reached in dim light.

Better peripheral vision *Cats have more rods / cones at the edges (periphery) of the retina than humans.*

More limited colour vision *Cats have fewer cones than humans and do not have three types of cone.*

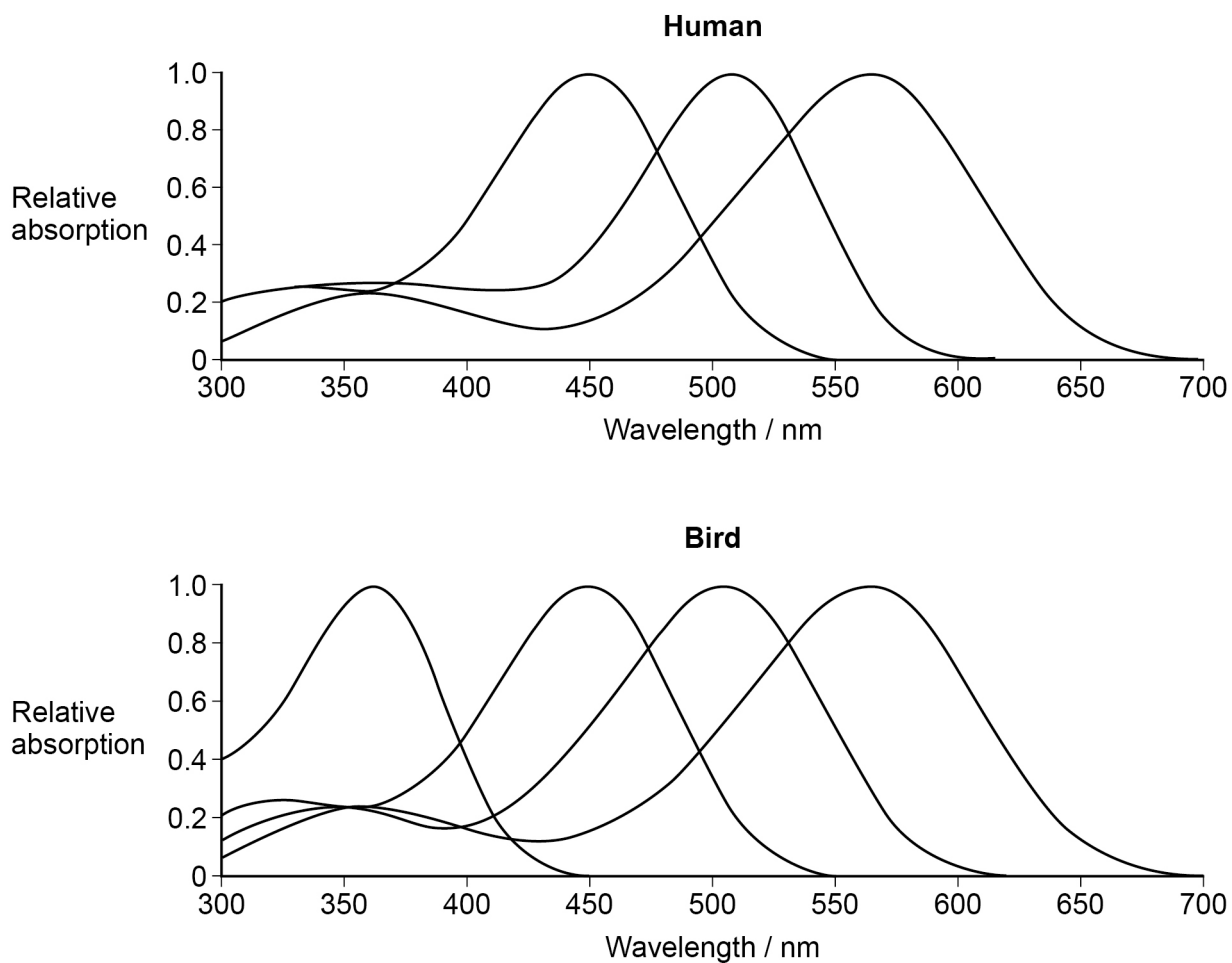
Question 5 continues on the next page

Turn over ►



Figure 3 shows the light absorption of cone cells in the retina of a human and of a bird.

Figure 3



0 5 . 3

Compare light absorption in the cones of birds and of humans.

Use information from **Figure 3**.

[3 marks]

Both birds and humans have three peaks of absorption at approximately similar wavelengths (about 450, 505 and 565 nm).

Birds have four peaks of absorption, whereas humans have three peaks.

Birds have an extra peak of absorption at approximately 360 nm (ultraviolet), which humans do not have.

Both humans and birds have no absorption above 700 nm.

0 5 . 4

Suggest why it is useful for a bird to be able to detect a wide range of wavelengths of light.

[1 mark]

It allows the bird to detect predators and additional food sources (e.g. fruits or flowers reflecting UV light).

10

Turn over for the next question

Turn over ►



There are no questions printed on this page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



0 6

Recombinant DNA technology involves the transfer of fragments of DNA from one organism to another organism.

0 6 . 1

State why DNA from one species can be successfully expressed in a different species.

[1 mark]

The genetic code is universal, and transcription and translation mechanisms are the same in all species.

Question 6 continues on the next page

Turn over ►

Golden rice is a genetically-modified variety of rice.

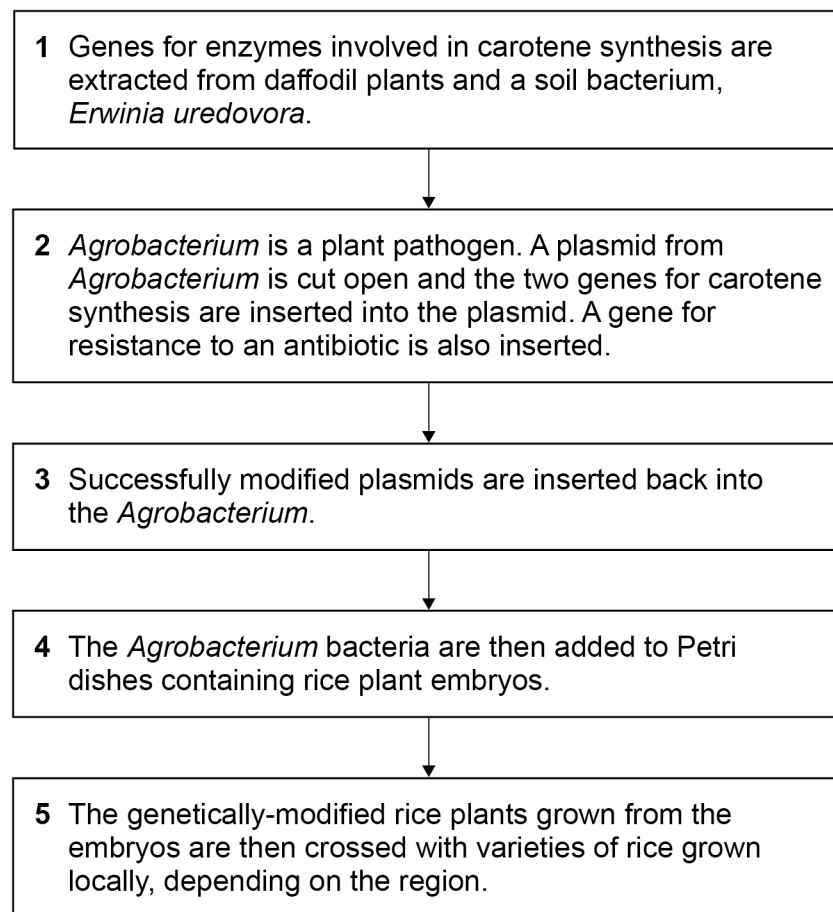
It produces carotene, a chemical required by the body to produce vitamin A.

Vitamin A is involved in many functions in the body.

Vitamin A deficiency is common in some countries, with up to 500 000 children affected annually.

Figure 4 shows the steps involved in creating golden rice.

Figure 4



0 6 . 2

Explain how the genes for carotene synthesis are inserted into the plasmid in step 2.

[3 marks]

The plasmid and the carotene genes are cut using the same restriction enzyme (restriction endonuclease), producing complementary sticky ends, so the sticky ends of the genes pair with the sticky ends of the plasmid. DNA ligase then joins the genes into the plasmid by forming phosphodiester bonds.

0 6 . 3

Give the reason why a gene for resistance to an antibiotic is inserted in step 2.

[1 mark]

It allows identification of the bacteria which have successfully taken up the modified plasmid with the genes for carotene synthesis (only these survive on antibiotic).

0 6 . 4

Suggest why it is necessary to cross the genetically-modified rice plants with varieties of rice that are grown locally (step 5).

[1 mark]

So that the rice plants are adapted to the local conditions in which they will be growing.

Question 6 continues on the next page**Turn over ►**

Producing genetically-modified crops like golden rice is expensive.

The costs and benefits of golden rice must be calculated to decide how effective the product is compared to alternative treatments for vitamin A deficiency.

Scientists estimated the costs and benefits of growing golden rice in Bangladesh for 15 years.

Table 4 shows the scientists' estimates (all figures are in millions of US dollars).

Table 4

Cost or benefit	US Dollars (millions)
Total Research & Development costs	11.6
Health benefits	5767.4
Productivity benefits	2927.4
Total benefits	8694.8
Net benefit	8683.2
Benefit : cost ratio	748.6

0 6 . 5

Describe how each of the following figures have been calculated.

[2 marks]

Net benefits Total benefits – total R&D costs (8694.8 – 11.6 = 8683.2)

Benefit : cost ratio Net benefit ÷ total R&D costs (8683.2 ÷ 11.6 = 748.6)



The scientists' estimates are based on the predicted length of time the golden rice can be grown and harvested in the farmers' fields.

0 6 . 6

Suggest a reason why the golden rice can only be grown for a limited length of time in the farmers' fields.

[1 mark]

*Crossing with native varieties of rice reduces the carotene content / crop
pests specific to golden rice accumulate over time.*

0 6 . 7

Suggest a **different** approach to vitamin A deficiency that countries could use.

[1 mark]

*Give dietary supplements of carotene / vitamin A (or encourage people to
eat foods naturally high in vitamin A).*

10

Turn over for the next question

Turn over ►



07

Most cells in the body contain copies of every gene, but **not** every gene is expressed in every cell.

Gene expression is controlled by many factors, including epigenetics.

During methylation of DNA, methyl groups attach to cytosine bases and prevent gene expression.

07.1

Describe how methylation of DNA prevents gene expression.

[2 marks]

Methylation prevents the binding of transcription factors and RNA polymerase to the promoter (it causes the DNA / chromatin to bind together tightly),
so it prevents transcription of the gene, and no mRNA is formed.

The cell cycle is regulated by specific genes. Epigenetic changes to DNA are associated with many types of cancer.

07.2

Explain how too much methylation could lead to cancer.

[2 marks]

Too much methylation prevents (silences) the transcription / expression of tumour suppressor genes,
so the cell cycle is not regulated, leading to uncontrolled cell division (and less apoptosis), forming a tumour.



An understanding of the epigenetic control of genes has allowed scientists to develop epigenetic therapies for the treatment of cancers.

The enzymes responsible for DNA methylation are called DNA methyltransferases (DNMT).

A DNMTi is a chemical which inhibits DNMT enzymes by binding to the enzyme permanently.

0 7 . 3

Suggest how a DNMTi works to treat certain types of cancer.

[3 marks]

The DNMTi binds permanently to the DNMT enzyme, altering the shape of its active site (or blocking it), so DNA cannot bind.

This reduces the amount of DNA methylation, e.g. of the tumour suppressor genes.

So tumour suppressor genes can be transcribed and expressed again, slowing cell division / causing apoptosis of cancer cells.

Question 7 continues on the next page

Turn over ►



DAC and Aza-TdC are two chemicals which act as a DNMTi.

The scientists investigated the anti-cancer activity of the two DNMTi chemicals.

The scientists:

- inject a cell suspension of human cancer cells into mice
- put the mice into one of three treatment groups when tumours reach 150 mg
- inject the mice in each group as follows:
 - group 1 (16 mice) with saline
 - group 2 (18 mice) with DAC
 - group 3 (18 mice) with Aza-TdC
- inject the mice daily for 60 days
- measure the tumours every day (length $\times$ width $\times$ depth) and calculate the tumour mass from these measurements
- calculate tumour growth delay to decide how effective the treatments were.

07.4

Why do the scientists wait until the tumours in each of the mice reach 150 mg before starting treatment?

[1 mark]

So that the results of the different treatments can be compared (all start with the same tumour mass, large enough to measure a change).

07.5

Why is it necessary to calculate the mass of the tumours from measurements of length, width and depth?

[1 mark]

It is not possible to weigh the tumour directly without removing it from the mouse.



Tumour growth delay is calculated using the formula:

$$\frac{(T-C) \times 100}{C}$$

where T and C are the median times for the tumour to reach a certain mass in mg for the treatment group (T) and the control group (C).

0 7 . 6 Calculate the tumour growth delay for the two treatments using the following data.

C = 28 days

Treatment 1 (DAC): T = 39 days

Treatment 2 (Aza-TdC): T = 52 days

[1 mark]

Treatment 1 (DAC):

$$(39 - 28) \times 100 \div 28 = 1100 \div 28$$

Tumour growth delay = 39.3 %

Treatment 2 (Aza-TdC):

$$(52 - 28) \times 100 \div 28 = 2400 \div 28$$

Tumour growth delay = 85.7 %

Question 7 continues on the next page

Turn over ►



07.7

Evaluate the use of these two chemicals for treating cancer in humans.

[5 marks]

Both chemicals increased the tumour growth delay (slowed tumour growth); Aza-TdC is more effective as it has a greater tumour growth delay (85.7% compared with 39.3%).

However, the investigation was carried out in mice, so the chemicals may not have the same effect in humans.

The group sizes were small (16 to 18 mice), so not representative; and only one type of cancer was used, so they may not work on all cancers.

It was only studied for 60 days, so the long-term (side) effects are unknown; they only slow tumour growth, so may not be an effective treatment.

No statistical test was done, so it is unknown if the difference in tumour growth delay is significant.

15

END OF QUESTIONS

There are no questions printed on this page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**





Do not write
outside the
box

[illegible]

