



National
Qualifications
2024

X807/76/12

Biology
Paper 1 — Multiple choice

WEDNESDAY, 15 MAY

9:00 AM – 9:40 AM

Total marks — 25

Attempt ALL questions.

You may use a calculator.

Instructions for the completion of Paper 1 are given on *page 02* of your answer booklet X807/76/02.

Record your answers on the answer grid on *page 03* of your answer booklet.

Space for rough work is provided at the end of this booklet.

Before leaving the examination room you must give your answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



Total marks — 25 marks
Attempt ALL questions

1. In a DNA molecule, phosphate groups are found at
- A 3' ends and are joined to bases
 - B 3' ends and are joined to deoxyribose sugar
 - C 5' ends and are joined to bases
 - D 5' ends and are joined to deoxyribose sugar.
2. The DNA in prokaryotes is organised as
- A linear chromosomes and plasmids in the cytoplasm
 - B circular chromosomes and plasmids in the cytoplasm
 - C linear chromosomes in the nucleus and plasmids in the cytoplasm
 - D circular chromosomes in the nucleus and plasmids in the cytoplasm.
3. During PCR, repeated cycles of heating and cooling are used to amplify a region of DNA. Which row in the table identifies the events taking place at 72 °C and 55 °C?

	72 °C	55 °C
A	DNA strands separate	primers bind to target sequences
B	primers bind to target sequences	DNA polymerase replicates the region of DNA
C	DNA polymerase replicates the region of DNA	DNA strands separate
D	DNA polymerase replicates the region of DNA	primers bind to target sequences

4. Which statement about introns is correct?
- A They are coding and retained in the mature transcript.
 - B They are coding and removed from the primary transcript.
 - C They are non-coding and retained in the mature transcript.
 - D They are non-coding and removed from the primary transcript.

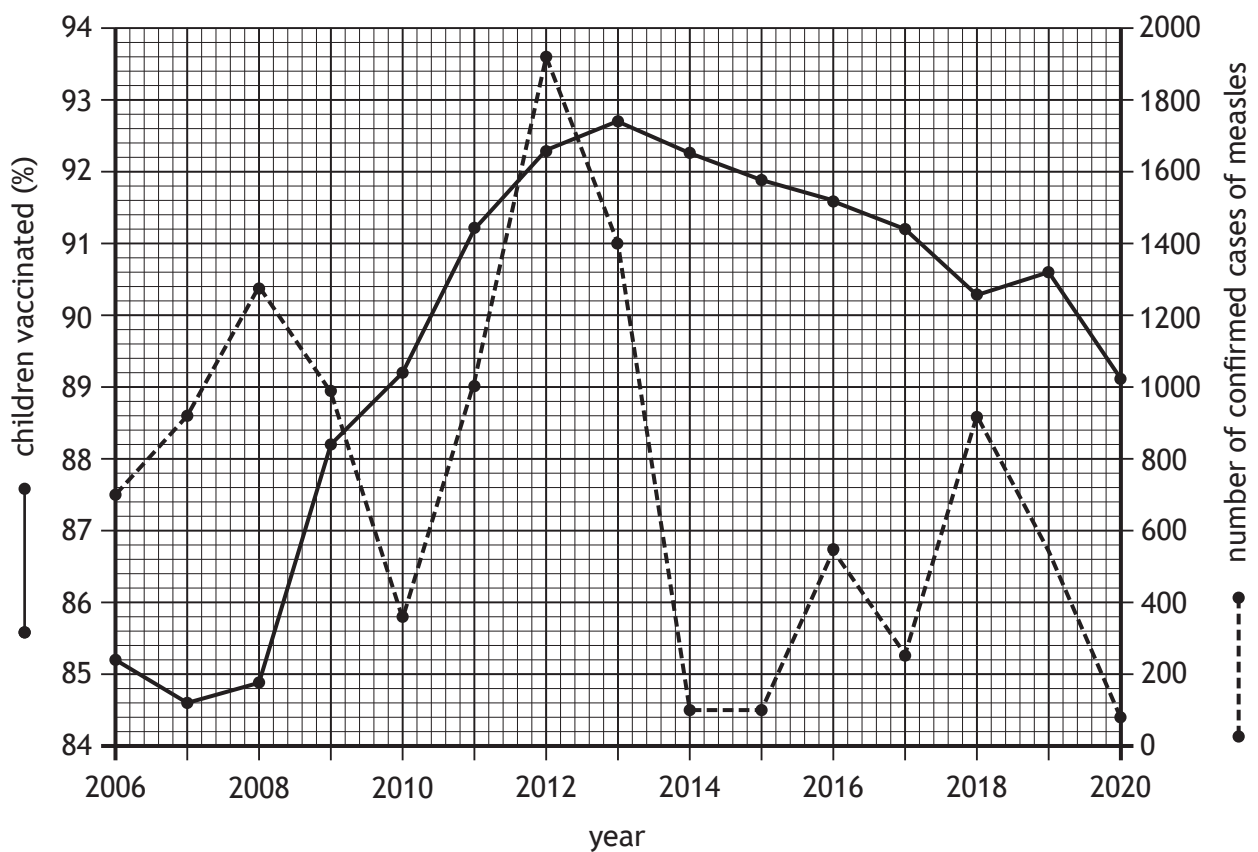
5. The list describes features of stem cells.

1. Involved in growth and repair.
2. All their genes can be switched on.
3. Can divide or differentiate.

Which of these features apply to tissue stem cells?

- A 1 only
- B 1 and 3 only
- C 2 and 3 only
- D 1, 2 and 3

6. The graph shows the percentage of children vaccinated against measles and the number of confirmed cases of measles in children in a region of the UK between 2006 and 2020.



Identify the number of confirmed cases of measles one year after the highest percentage of children were vaccinated.

- A 84.5
- B 92.7
- C 100.0
- D 1720.0

7. Two different colours of peppered moths occur: light and dark.

The moths rest on surfaces during the day and rely on camouflage to avoid predation by birds.

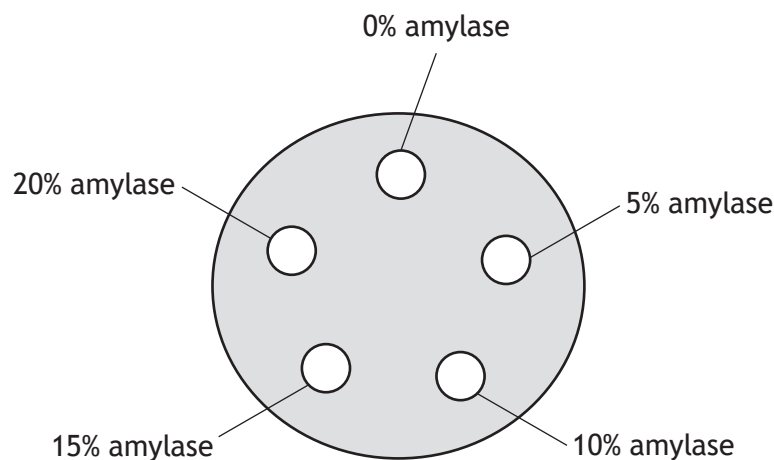
In unpolluted habitats, surfaces are light in colour giving the light moths a selective advantage. The dark moths are predated more by birds in these habitats.

Which row in the table describes the selection and identifies the type of selection involved?

	Description of selection	Type of selection
A	random	disruptive
B	non-random	directional
C	random	directional
D	non-random	disruptive

8. An experiment was set up to investigate the effect of the concentration of amylase on the rate of starch breakdown.

Three starch agar plates, each with five wells containing 100 μL of different amylase concentrations were set up as shown in the diagram.



As the amylase diffuses out of the well it breaks down starch in the agar, turning the agar clear. The plates were incubated at 37 °C for 3 hours and the diameter of the clear zone around each well was measured using a ruler.

Which feature of the design of this experiment would ensure the results were valid?

- A Three plates were set up for each amylase concentration.
- B The same volumes of amylase were used in each well.
- C Different concentrations of amylase were used in each well.
- D The diameter of each clear zone was measured using a ruler.

9. Protease enzymes break down proteins into amino acids.

Which statement about the reaction catalysed by protease enzymes is correct?

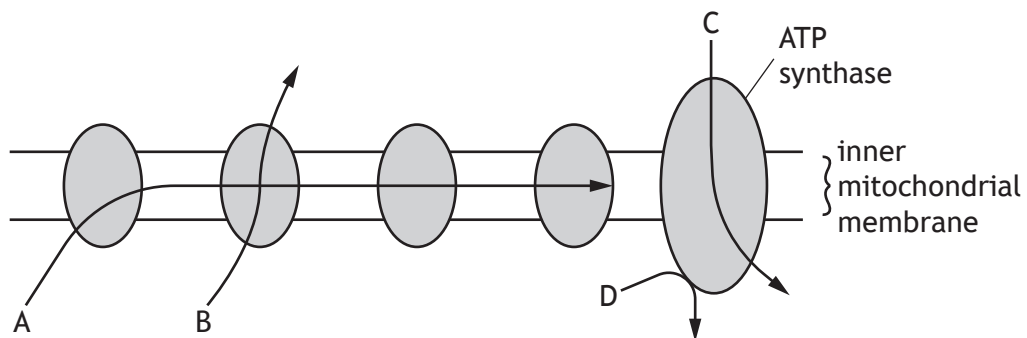
- A Peptide bonds break and energy is released.
- B Peptide bonds break and energy is required.
- C Hydrogen bonds break and energy is released.
- D Hydrogen bonds break and energy is required.

10. Dehydrogenase enzymes catalyse some of the reactions in glycolysis.

Which statement describes the role of these enzymes in glycolysis?

- A They remove hydrogen ions and electrons from NADH.
- B They remove hydrogen ions and electrons from citrate.
- C They transfer hydrogen ions and electrons to glucose.
- D They transfer hydrogen ions and electrons to NAD.

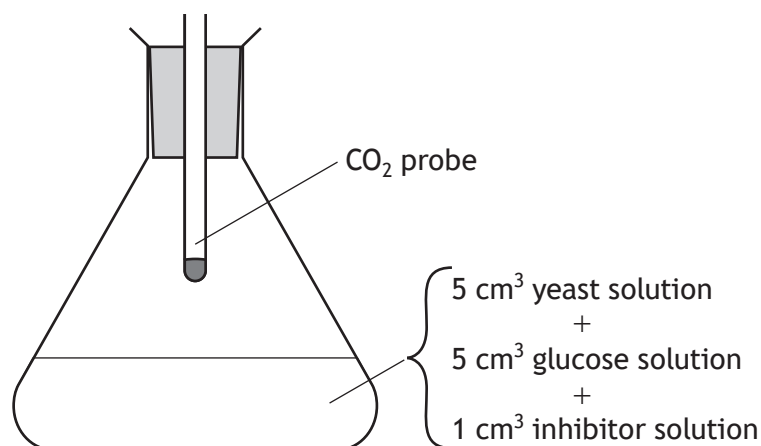
11. The diagram represents some stages of the electron transport chain in aerobic respiration.



Which arrow shows the pumping of hydrogen ions across the inner mitochondrial membrane?

[Turn over

12. An investigation was carried out into the effect of an enzyme inhibitor's concentration on the rate of respiration in yeast. Five different flasks were set up as shown.

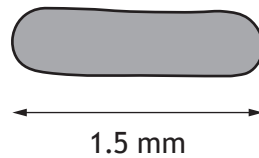


Each flask contained a different concentration of inhibitor. The CO₂ concentration was measured by the probe.

In a suitable control experiment for this investigation the flask should contain

- A 5 cm³ yeast solution and 5 cm³ glucose solution
 - B 5 cm³ yeast solution, 5 cm³ glucose solution and 1 cm³ water
 - C 5 cm³ water, 5 cm³ glucose solution and 1 cm³ inhibitor solution
 - D 5 cm³ yeast solution, 5 cm³ water and 1 cm³ inhibitor solution.
13. Adders are snakes whose body temperature is dependent on the external temperature. Which of these statements about adders are correct?
- 1. They have a wide range of ecological niches.
 - 2. They use behavioural responses to help maintain optimum metabolic rate.
 - 3. They have high energy costs to achieve homeostasis.
- A 2 only
 - B 3 only
 - C 1 and 2 only
 - D 1 and 3 only

14. The diagram represents a species of archaea as viewed under a microscope.

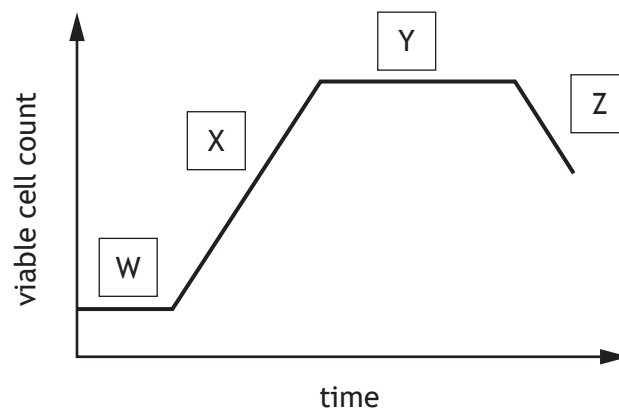


(1 mm = 1000 μm)

The actual length of this cell was 3 micrometres (μm).

The microscope had a total magnification of

- A $\times 5$
 - B $\times 50$
 - C $\times 500$
 - D $\times 5000$
15. The graph shows the phases of growth in a bacterial culture.



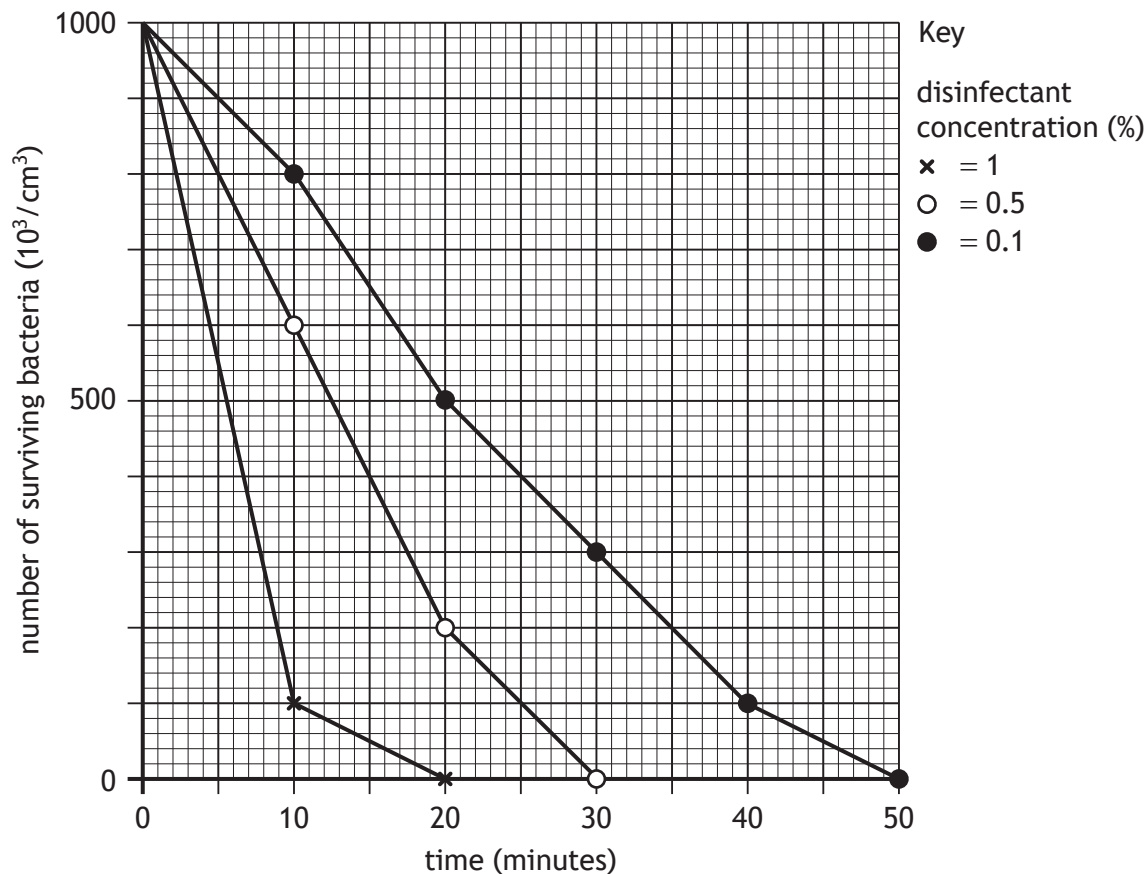
Which statement is correct?

- A X is the log phase and enzymes are being induced.
 - B Z is the death phase where total cell count is decreasing.
 - C Y is the stationary phase and nutrients are starting to run out.
 - D W is the lag phase and secondary metabolites are being produced.
16. Which statement about culturing micro-organisms is **not** correct?
- A Some micro-organisms can use light as an energy source.
 - B All micro-organisms require a chemical substrate as an energy source.
 - C Sterility, pH, temperature, and oxygen levels can be monitored.
 - D Some micro-organisms can synthesise their own amino acids and vitamins.

17. The effect of concentration of disinfectant on survival of bacteria was investigated.

Cultures of bacteria were grown in media containing different concentrations of disinfectant and the number of bacteria surviving in each culture was recorded every 10 minutes for 50 minutes.

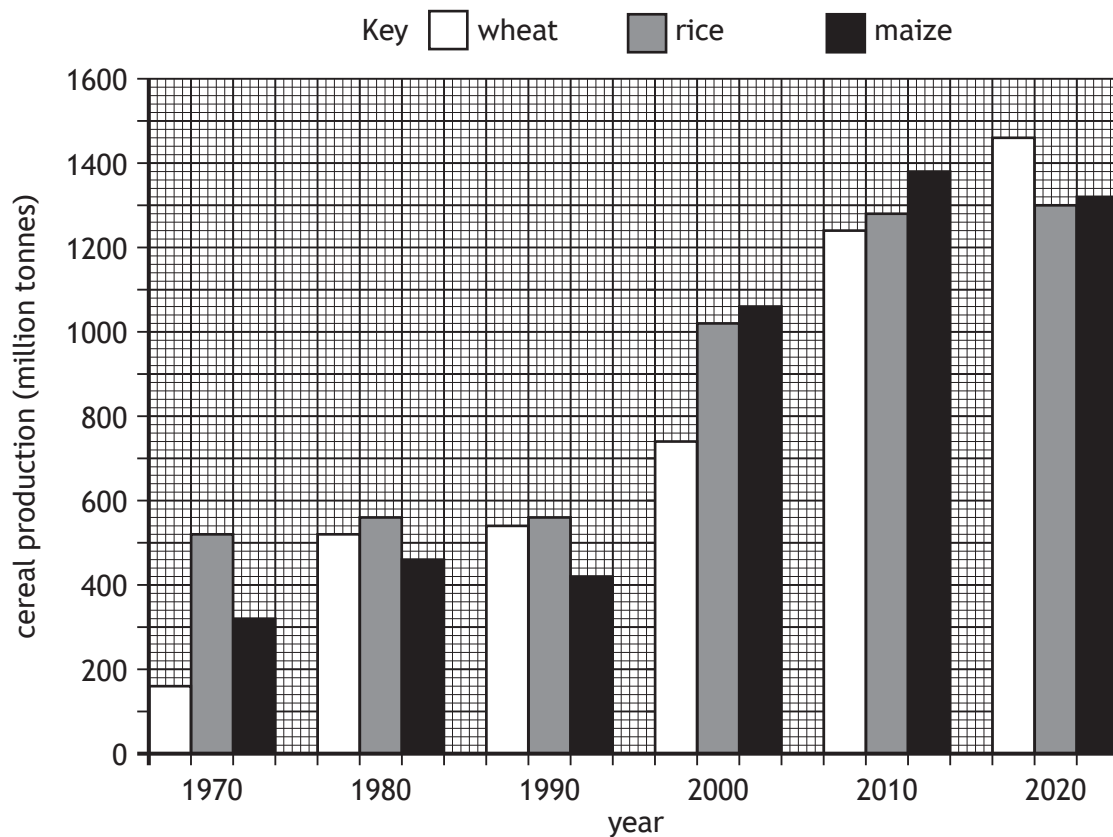
The results are shown in the graph.



Which statement is supported by the data?

- A 1% disinfectant kills all bacteria twice as fast as 0.5%.
- B At 20 minutes 0.1% disinfectant kills more bacteria than 0.5% disinfectant.
- C As concentration of disinfectant increases the length of time taken to kill all bacteria increases.
- D As concentration of disinfectant increases the length of time taken to kill all bacteria decreases.

18. The bar graph shows the world production of three cereals from 1970 to 2020.



Which statement is supported by the data?

- A The total production of the three cereals combined was greatest in 2020.
- B The greatest increase in maize production was between 2000 and 2010.
- C The production of rice increased every 10 years.
- D The production of maize was four times higher in 2020 than in 1990.

19. The role of NADPH in the carbon fixation stage (Calvin cycle) of photosynthesis is to

- A add hydrogen to glyceraldehyde-3-phosphate (G3P)
- B phosphorylate glyceraldehyde-3-phosphate (G3P)
- C add hydrogen to 3-phosphoglycerate (3PG)
- D phosphorylate 3-phosphoglycerate (3PG).

[Turn over

20. The Bt toxin gene can be inserted into maize plants using recombinant DNA technology. As a result of inserting the Bt toxin gene into maize

- A herbicides will kill weeds but not the maize
- B systemic herbicides will be more effective
- C the maize will be resistant to insect pests
- D fungicides will be more effective.

21. The results of a field trial showed a lot of variability within each treatment. The design of this field trial could be improved by

- A dividing the field into plots and randomising the treatments
- B carefully selecting the treatments
- C increasing the number of replicates for each treatment
- D including a control plot with no treatment applied.

22. Adult tapeworms live in the intestine of foxes. Their eggs are passed out in the foxes' waste and survive on the grass for months. The eggs infect rabbits eating the grass and the tapeworms complete their lifecycle inside the rabbits' bodies. Foxes, which prey on the rabbits, are then infected.

Which row in the table identifies the roles of the fox, tapeworm egg and rabbit?

	Fox	Tapeworm egg	Rabbit
A	host	resistant stage	intermediate host
B	host	vector	intermediate host
C	intermediate host	vector	host
D	intermediate host	resistant stage	vector

23. The statements describe symbiotic relationships.

1. Ants feed on sugar-rich liquid produced by aphids and protect aphids from predators.
2. Coral provides nutrients for zooxanthellae, while zooxanthellae produce sugars for coral to feed on.
3. Small fish, called cleaner wrasse, feed on parasites from the skin of sharks.

Which of these statements describes a mutualistic relationship?

- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- D 1, 2 and 3

24. The list shows behaviours carried out by honey bees.

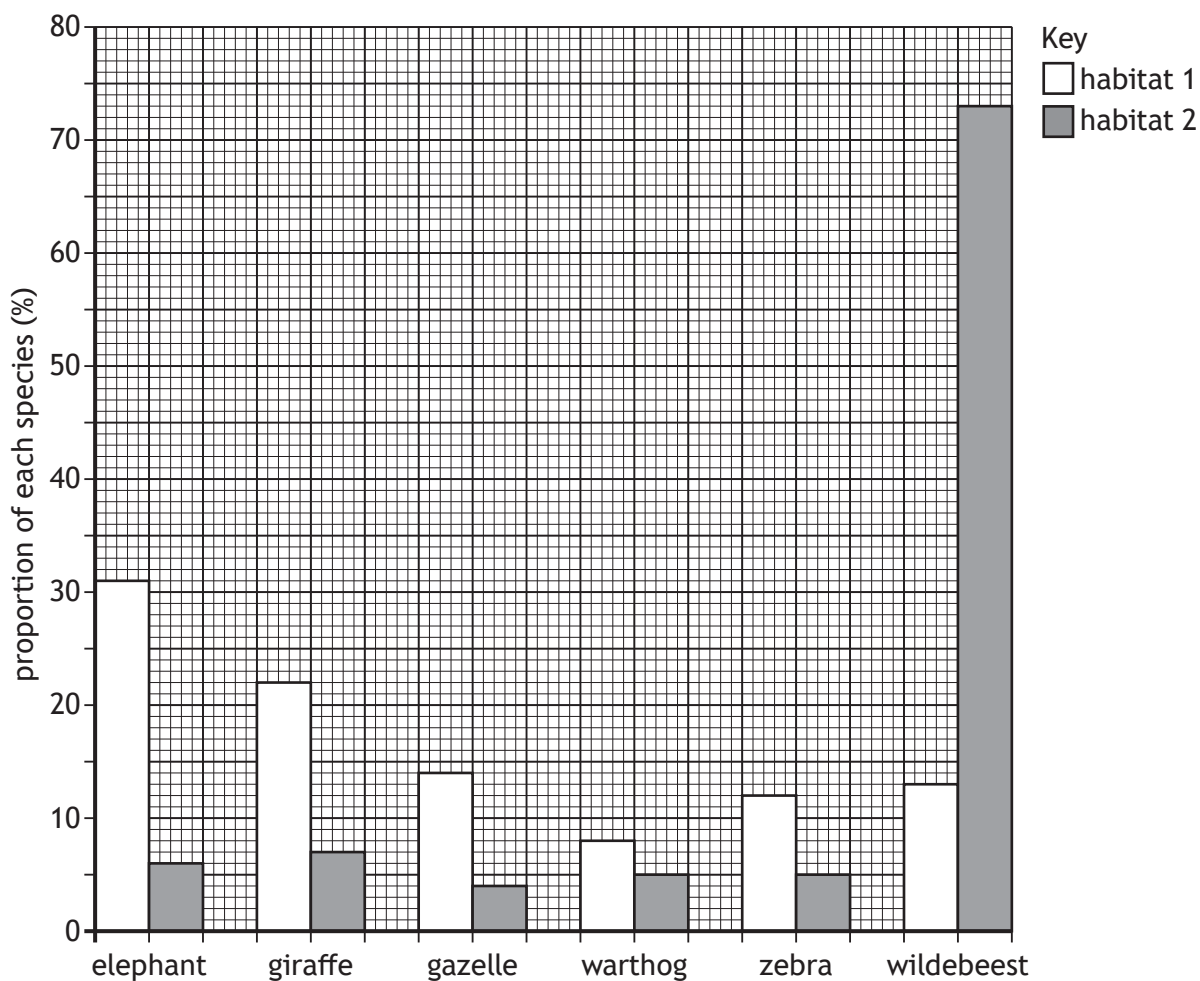
1. Fertilising eggs
2. Collecting pollen
3. Carrying out waggle dances to show the location of food

Which of these behaviours are carried out by drones?

- A 1 only
- B 3 only
- C 1 and 2 only
- D 2 and 3 only

[Turn over

25. The bar chart shows the proportions of different mammal species in two habitats in Africa.



Compared to habitat 2, habitat 1 has

- A a higher species richness and a lower species diversity
- B a lower species richness and a higher species diversity
- C the same species richness and a higher species diversity
- D the same species richness and a lower species diversity.

[END OF QUESTION PAPER]



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National
Qualifications
2024

Mark

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X840/76/01

**Human Biology
Paper 2**

WEDNESDAY, 15 MAY

10:10 AM – 12:30 PM



* X 8 4 0 7 6 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

--

Town

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Forename(s)

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Surname

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Number of seat

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Date of birth

Day

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Month

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Year

--	--

Scottish candidate number

--	--	--	--	--	--	--	--	--

Total marks — 95

Attempt ALL questions.

You may use a calculator.

Question 15 contains a choice.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

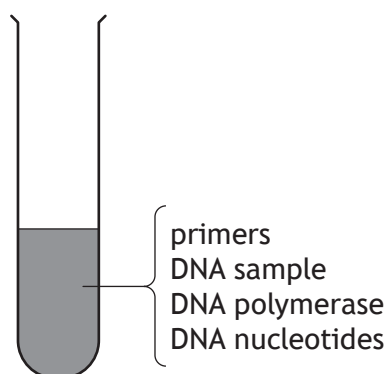


* X 8 4 0 7 6 0 1 0 1 *

Total marks — 95
Attempt ALL questions
Question 15 contains a choice

1. To confirm an individual is infected with the herpes virus, a test to detect viral DNA can be carried out using the polymerase chain reaction (PCR) on a sample from the individual.

The diagram shows substances that are required to allow PCR to take place.



- (a) Give the complementary DNA base sequence for the section of viral DNA shown.

1



- (b) (i) State a temperature used to separate the DNA strands during PCR.

1

_____ °C

- (ii) State the role of primers and DNA polymerase in PCR.

2

Primers _____

DNA polymerase _____



1. (continued)

(c) State two uses of PCR, other than diagnosing viral infections.

2

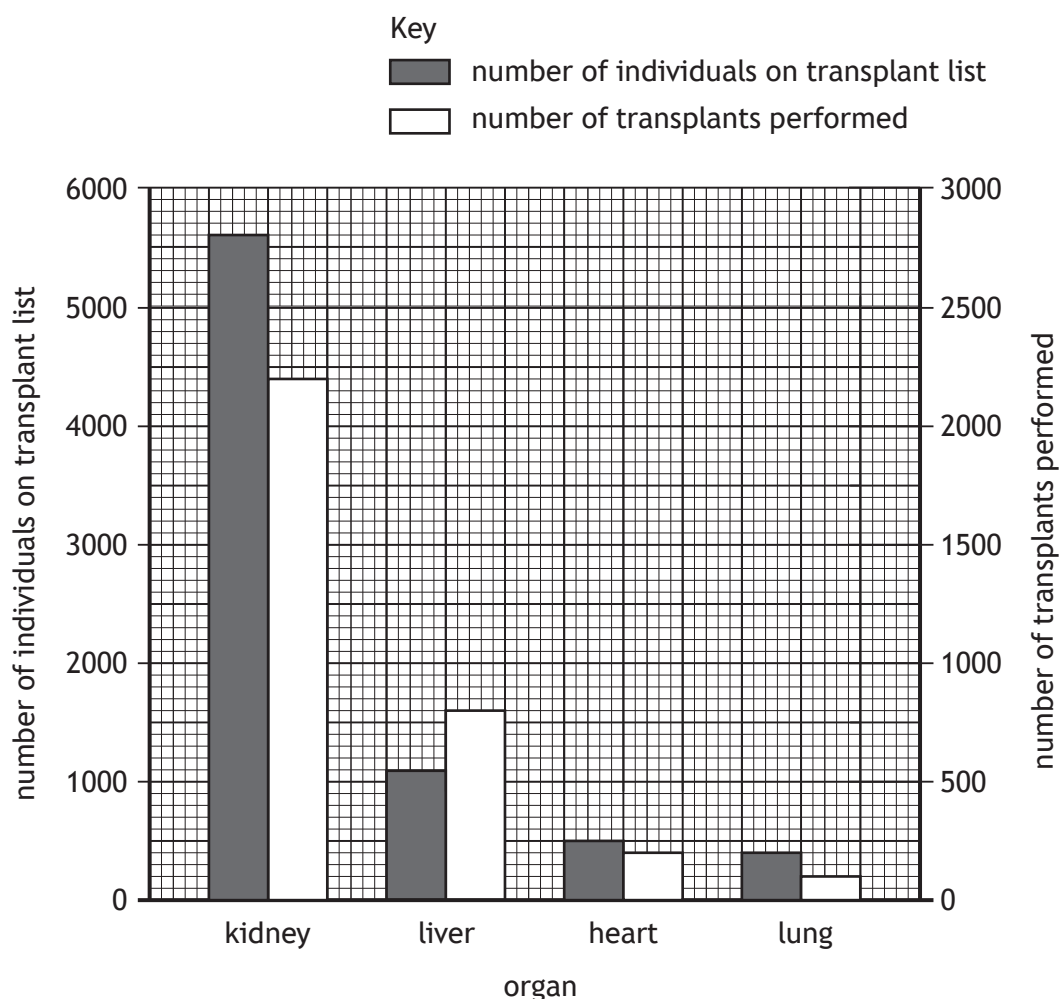
1. _____

2. _____

[Turn over



2. The graph contains information on some organ transplants performed during 2020 in the UK. It also shows the number of individuals waiting on the transplant list at the start of 2020.



- (a) (i) State the number of lung transplants performed in 2020. 1
- _____
- (ii) Use information from the graph to calculate the percentage of individuals who received a kidney transplant after being on the transplant list at the start of 2020. 1
- Space for calculation

_____ %



* X 8 4 0 7 6 0 1 0 4 *

2. (continued)

- (b) The table shows the total number of transplants performed in three different countries in 2020.

Country	Number of transplants performed (per million of the population)
Scotland	72
England	47
Wales	40

- (i) In 2020 the population of England was 57 million.
Calculate how many transplants were performed in England during 2020.
Space for calculation

1

- (ii) Explain why the data are presented as the number of transplants performed per million of the population.

1

[Turn over

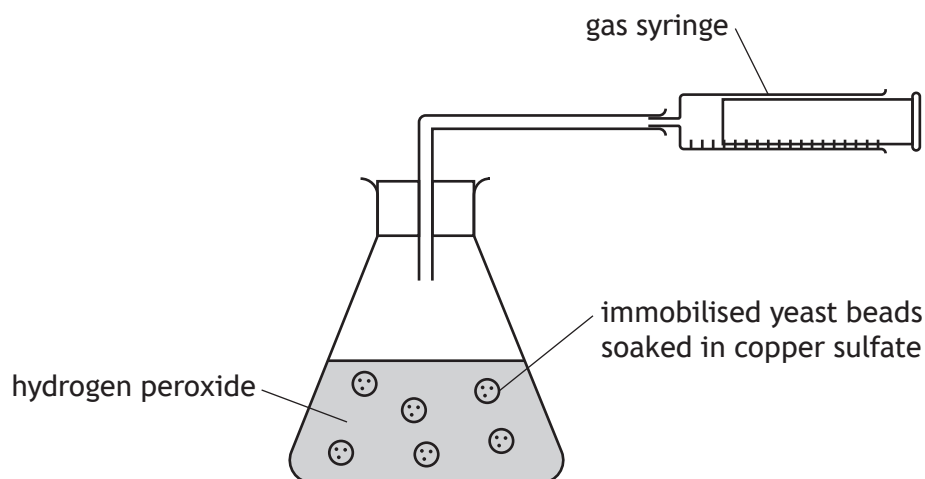


* X 8 4 0 7 6 0 1 0 5 *

3. Catalase is an enzyme that breaks down hydrogen peroxide into oxygen and water. An investigation was carried out into the effect of inhibitor concentration on catalase activity.

Yeast cells containing catalase can be trapped in a gel substance to become 'immobilised' as gel beads. The catalase remains active within these beads.

Immobilised yeast beads were placed in different concentrations of the inhibitor copper sulfate for 24 hours. The beads were then added to a flask of hydrogen peroxide and the oxygen produced was collected in a gas syringe over a five-minute period.



The table shows the results of the investigation.

Concentration of copper sulfate (mmol/l)	Volume of oxygen collected (cm ³)		
	Experiment 1	Experiment 2	Average
0	80	84	82
5	65	71	68
10	45	45	45
25	26	24	25
50	15	17	16

- (a) (i) State two variables, other than those shown above, that should be controlled so that a valid conclusion can be drawn.

2

1. _____

2. _____

3. (a) (continued)

MARKS
DO NOT
WRITE IN
THIS
MARGIN

- (ii) Suggest an advantage of using immobilised yeast beads rather than yeast in solution.

1

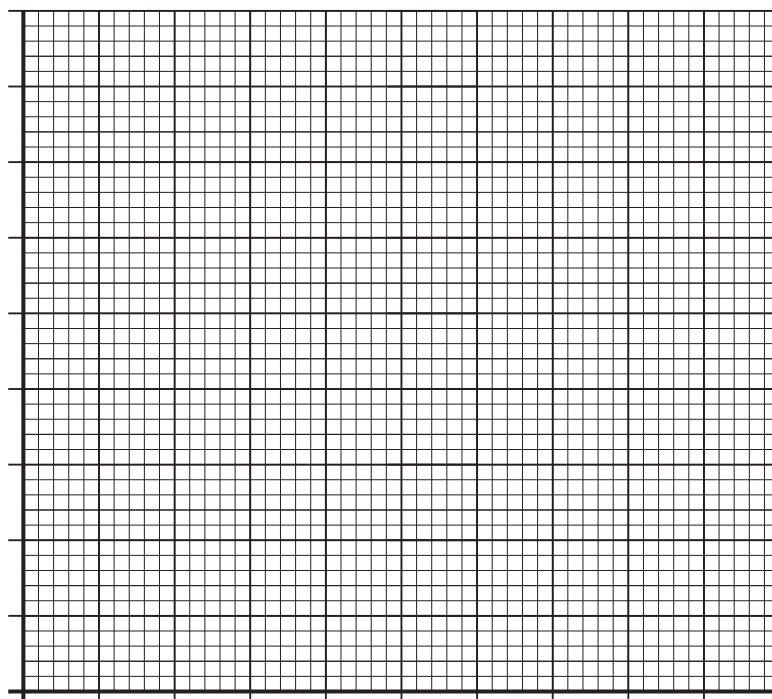
- (iii) Suggest why the immobilised yeast beads were left in the copper sulfate solution for 24 hours before adding them to the hydrogen peroxide.

1

- (b) Using data from the table, draw a line graph to show the average volume of oxygen collected.

2

(Additional graph paper, if required, can be found on *page 31*.)



- (c) State the conclusion that can be drawn from this investigation.

1



* X 8 4 0 7 6 0 1 0 7 *

4. Cellular respiration takes place to generate ATP.

(a) The statements refer to events that occur during respiration in a muscle cell.

Letter	Statement
W	Carbon dioxide is released.
X	An acetyl group combines with coenzyme A.
Y	Glucose is broken down into pyruvate.
Z	Dehydrogenase enzymes remove hydrogen ions and electrons.

(i) Use letters from the table to identify the statements that apply to glycolysis.

1

(ii) Name the substance that is broken down to form the acetyl group that combines with coenzyme A.

1

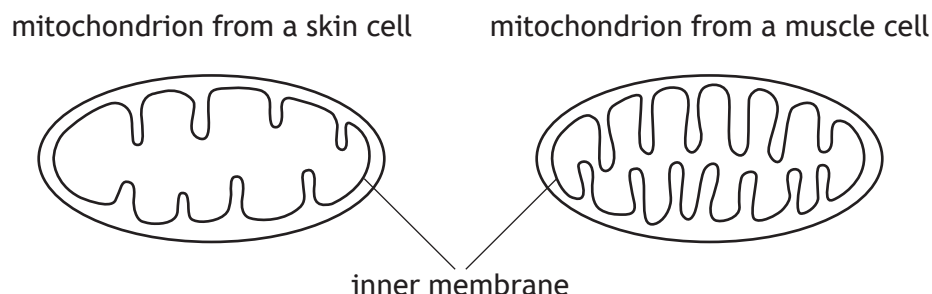
(iii) Oxaloacetate combines with an acetyl group to form another substance. Name this substance.

1



4. (continued)

- (b) The diagram shows the structure of mitochondria from a skin cell and a muscle cell.



Use the diagram to suggest why mitochondria from muscle cells can generate more ATP than skin cells.

2

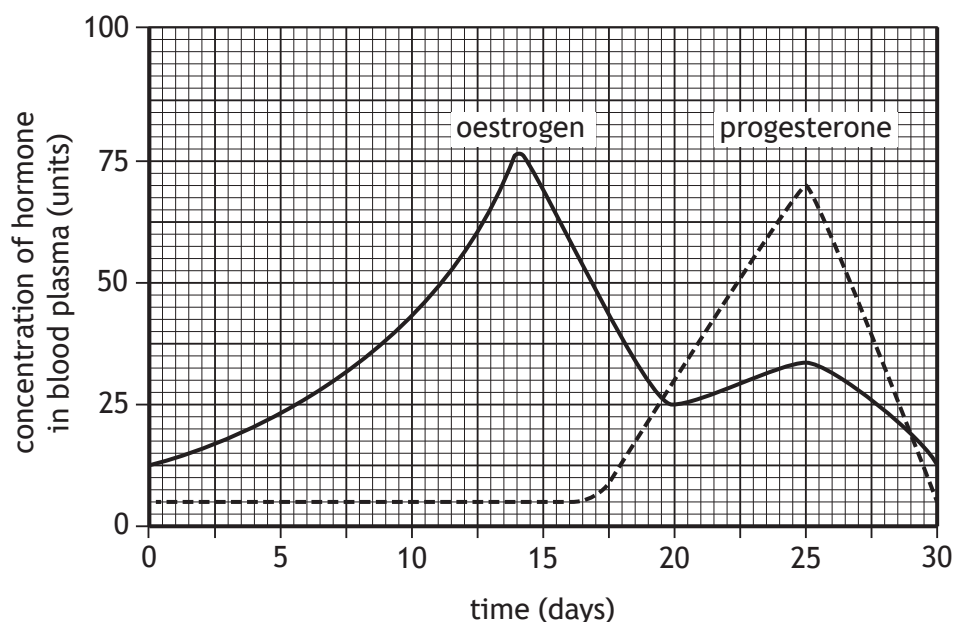
- (c) Slow-twitch muscle fibres are useful for endurance activities as they can sustain contractions for long periods of time.

Describe one structural feature of slow-twitch muscle fibres.

1

[Turn over

5. The graph shows the concentrations of the ovarian hormones, oestrogen and progesterone, in a female's blood plasma during the menstrual cycle.



- (a) During the first half of the cycle, the concentration of oestrogen in the blood plasma increases.

- (i) Describe the role of follicle stimulating hormone (FSH) in causing this increase in oestrogen concentration.

2

- (ii) Describe how this increase in oestrogen concentration would affect the uterus.

1

- (iii) The high concentration of oestrogen at day 14 stimulates a surge in luteinising hormone (LH).

Describe the effect of this surge in LH on the ovary.

1

5. (continued)

- (b) During the second half of the cycle, the concentration of progesterone in the blood plasma increases.

- (i) Calculate how many times greater the concentration of progesterone is on day 25 compared to its concentration on day 15.

1

Space for calculation

_____ times greater

- (ii) Name the structure within the ovary that produces progesterone.

1

- (c) This female is receiving treatment for infertility.

- (i) Describe evidence from the graph which indicates that she has **not** become pregnant during this menstrual cycle.

1

- (ii) It was discovered that her oviducts were blocked, reducing the chance of successful fertilisation.

Identify a suitable treatment and describe how the treatment would increase the chance of fertilisation.

2

Treatment _____

Description _____

[Turn over



* X 8 4 0 7 6 0 1 1 1 *

6. Routine blood tests are carried out throughout pregnancy to monitor the concentration of marker chemicals.

- (a) Describe a problem with the results that could occur if a blood test is carried out at the wrong time during pregnancy.

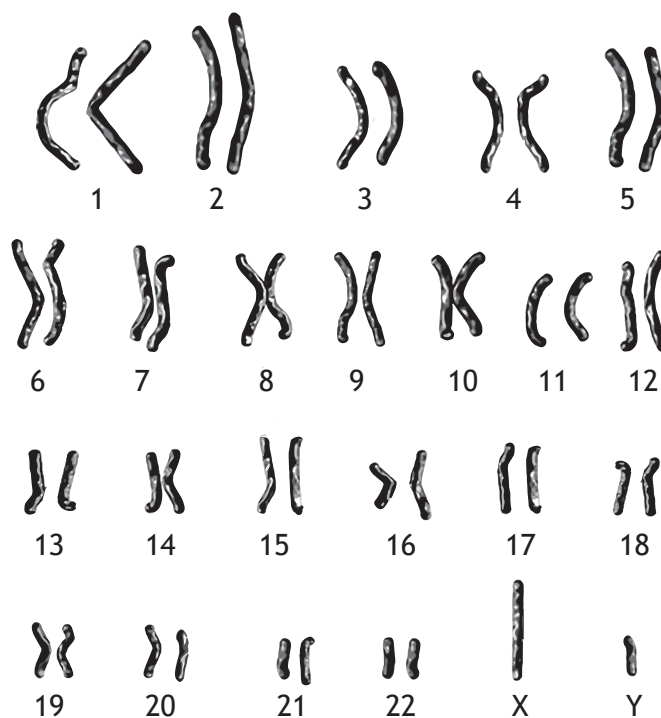
1

- (b) A blood test showed unusually low levels of a protein in a pregnant female's blood. After medical advice, a diagnostic test called amniocentesis was carried out.

Suggest why amniocentesis was carried out instead of chorionic villus sampling (CVS).

1

- (c) Samples taken during amniocentesis were used to culture cells and the following image showing the fetal chromosomes was then produced.



- (i) State the name given to an image of chromosomes arranged in this way.

1

- (ii) State the term used to describe chromosomes 1 to 22.

1



7. The table shows an individual's blood flow rate to different parts of the body at rest and during exercise.

Part of body	Blood flow rate at rest (cm ³ /min)	Blood flow rate during exercise (cm ³ /min)
Brain	450	750
Heart muscle	250	1000
Skeletal muscles	1000	12 000
Intestines	1500	500

- (a) (i) Calculate the percentage increase in the blood flow rate to the heart muscle from rest to exercise.

1

Space for calculation

_____ %

- (ii) Calculate the simple whole number ratio of the blood flow rate to the individual's intestines, skeletal muscles and brain during exercise.

1

Space for calculation

_____ : _____ : _____
intestines skeletal muscles brain

- (iii) During exercise, blood flow to the intestines and skeletal muscles changes.

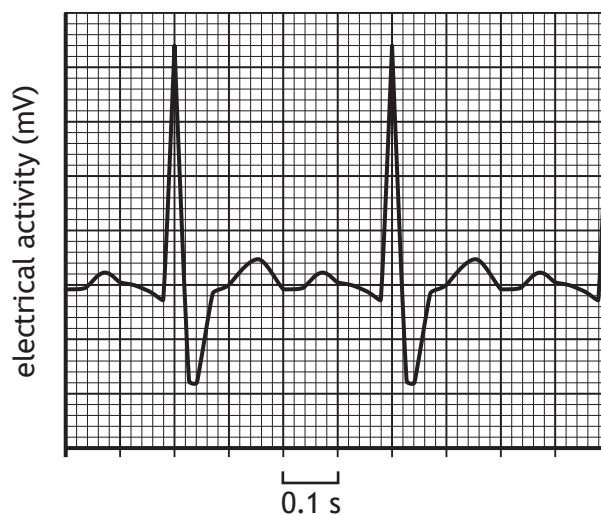
Complete the table to show how these changes would occur.

2

Part of body	Change in blood flow rate	Process controlling blood flow
	decrease	
	increase	

7. (continued)

- (b) (i) The graph shows part of an ECG trace taken when the individual was exercising.



Use information from the ECG trace to calculate their heart rate during exercise.

1

Space for calculation

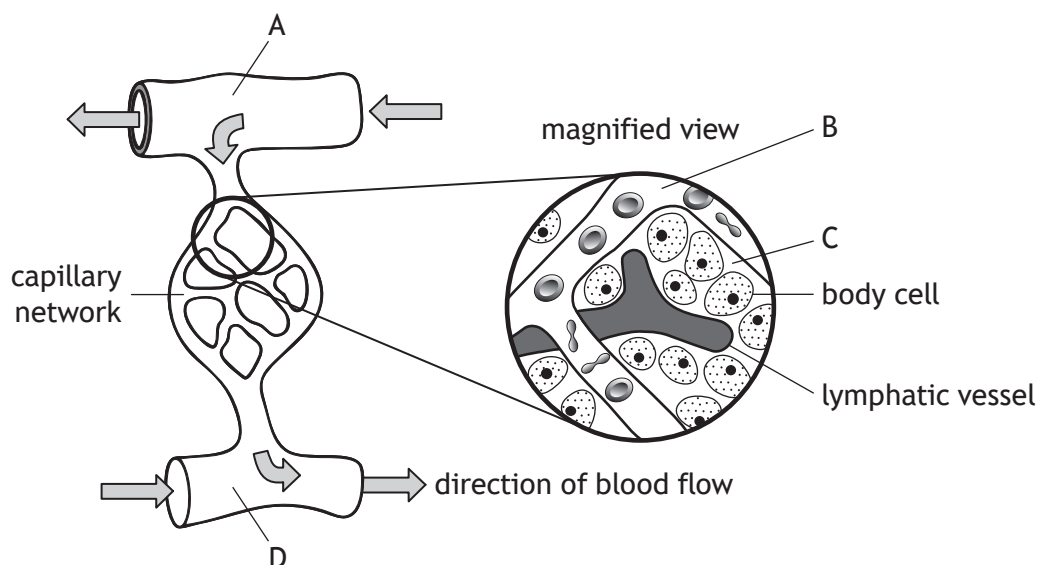
_____ beats/minute

- (ii) Describe the role of nerves in the autonomic nervous system to bring about an increase in heart rate.

1

[Turn over

8. The diagram represents a capillary network and its associated blood vessels.



(a) (i) Name liquid B.

1

(ii) Name the process that forms liquid C.

1

(b) Explain why blood vessel A requires a thicker muscular wall than blood vessel D.

1

(c) (i) Describe a feature of blood capillaries that allows the rapid diffusion of molecules into and out of the bloodstream to occur.

1

(ii) Name a type of molecule that is normally unable to leave the bloodstream in a capillary network.

1



* X 8 4 0 7 6 0 1 1 6 *

8. (continued)

- (d) (i) Describe the function of the lymphatic vessel shown in the diagram.

1

- (ii) Suggest a reason why lymphatic vessels contain valves.

1

[Turn over



9. A medical investigation was carried out into the effect of energy drinks on blood pressure. Energy drinks contain glucose and caffeine.

20 participants were divided into two groups.

Group 1 participants consumed 250 cm³ of an energy drink.

Group 2 participants consumed 250 cm³ of water.

Each participant's blood pressure was measured before consuming the drink and again three hours later.

- (a) Describe how a sphygmomanometer is used to measure systolic blood pressure.

2

- (b) Table 1 shows the average blood pressures of both groups.

Table 1

Group	Average blood pressure (mmHg)	
	Before consuming drink	Three hours after consuming drink
1	123/75	123/84
2	122/74	122/74

- (i) Identify the dependent variable in this investigation.

1

- (ii) State one conclusion that can be drawn from these results.

1



* X 8 4 0 7 6 0 1 1 8 *

9. (b) (continued)

- (iii) The mean arterial blood pressure (MAP) can be calculated using the formula:

$$\text{MAP} = \text{diastolic pressure} + \left(\frac{\text{pulse pressure}}{3} \right)$$

Pulse pressure is the difference between systolic and diastolic pressure.
Three calculated MAP values are shown in **Table 2**.

Table 2

Group	MAP (mmHg)	
	Before consuming drink	Three hours after consuming drink
1	91	
2	90	90

Use the information in **Table 1** to complete **Table 2** to show the MAP for group 1 after consuming the energy drink.

Space for calculation

1

- (c) Name the condition in which an individual has sustained high blood pressure.

1

[Turn over



* X 8 4 0 7 6 0 1 1 9 *

10. A study was carried out to determine if there is a link between low levels of vitamin D and type 1 diabetes.

Vitamin D blood concentrations were measured in a group of individuals with type 1 diabetes and in a control group. There were equal numbers in both groups.

The results are shown in the table.

Group	Individuals with low concentrations of vitamin D (%)
Individuals with type 1 diabetes	91
Control	59

- (a) (i) State one variable that would have to be taken into account when allocating individuals to the groups in this study. 1

- (ii) A student concluded from these results that low concentrations of vitamin D increases the risk of developing type 1 diabetes. 1
Suggest why this conclusion may be incorrect.

- (iii) The total number of individuals involved in the study was 400. 1
Calculate the number of individuals in the control group who had low concentrations of vitamin D.

Space for calculation

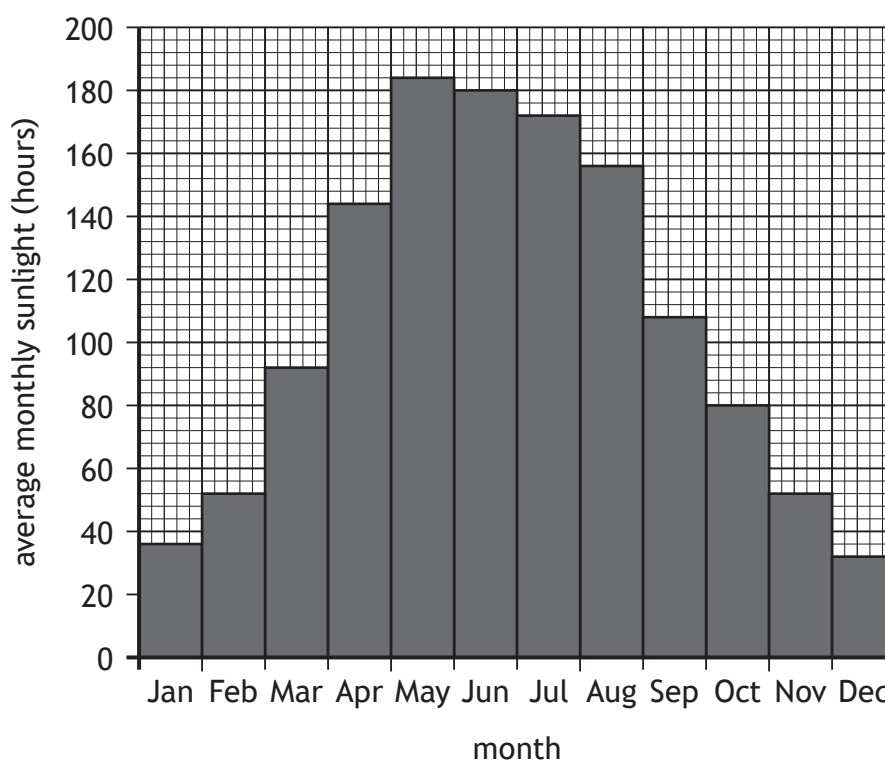
- (iv) Describe how the reliability of the study could be increased. 1



10. (continued)

- (b) When skin is exposed to sunlight the production of vitamin D increases.

The graph shows the average monthly hours of sunlight in a city in Scotland throughout the year.



- (i) Use data from the graph to describe the changes that occur in the average monthly hours of sunlight throughout the year.

2

- (ii) Most individuals produce enough vitamin D in their skin when the levels of sunlight are higher than 100 hours per month.

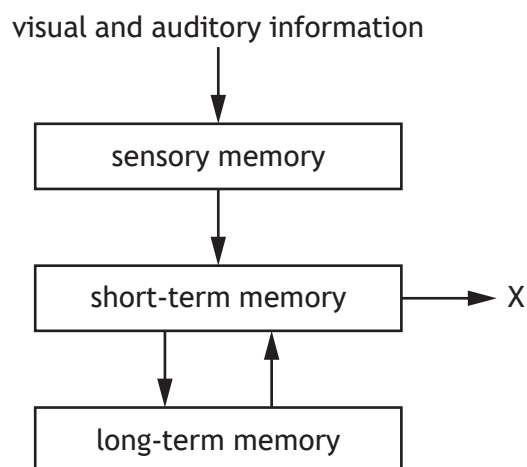
During which months would an individual living in this city need to obtain more of their vitamin D from their diet?

1

[Turn over



11. The diagram represents the flow of information from the environment through memory.



- (a) Name process X. 1
- _____
- (b) Name the model that is used to explain the ability of the short-term memory to perform simple cognitive tasks. 1
- _____
- (c) A mobile phone number typically consists of 11 numbers. 1
 Explain why it is difficult to store a mobile phone number in the short-term memory.
- _____
- _____

11. (continued)

- (d) In an investigation into the recall of information from long term memory, a large group of students was divided into two sub-groups.

The students were then given a list of 20 words to memorise in one minute.

Group 1 was given a list of the words arranged into four different categories.

Group 2 was given a list that contained the same words but in a random order.

Five minutes later the students had to write down all the words they could recall from the list.

- (i) Suggest a method that could be used to randomly allocate the students to each sub-group.

1

- (ii) Explain why students in group 1 recalled more words than students in group 2.

1

- (e) Recalling the events that occurred when information was encoded into long term memory can help the later retrieval of the information.

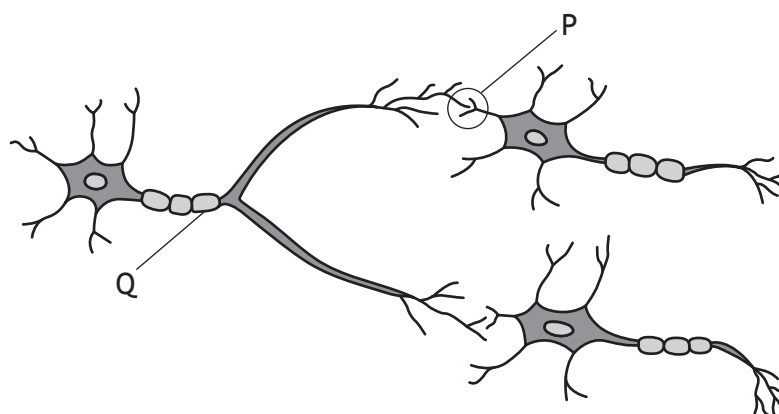
Name the term that is used to describe these events.

1

[Turn over



12. The diagram shows the arrangement of some motor neurons.



(a) Name structure P.

1

(b) (i) Name the type of neural pathway shown in the diagram.

1

(ii) Explain how this arrangement of neurons helps with fine motor control when writing.

1

(c) (i) Name structure Q.

1

(ii) Structure Q develops from birth to adolescence.

Describe why this development allows children to become more coordinated as they get older.

1

12. (continued)

- (d) (i) Myasthenia gravis is a disease where the neurotransmitter receptors on skeletal muscles are destroyed.

Suggest how this results in problems with movement.

1

- (ii) Myasthenia gravis is an autoimmune disease.

Describe the immune response that results in an autoimmune disease.

2

- (iii) The populations of three countries are shown in the table.

Country	Population (million)
Scotland	5.4
England	57.0
Wales	3.1

The incidence of Myasthenia gravis throughout the UK is 20 per 100 000.

Calculate how many more people suffer from the disease in England compared to Scotland.

1

Space for calculation

[Turn over



13. B lymphocytes form part of the specific immune system.

(a) Describe the mechanism of action of B lymphocytes against pathogens.

3

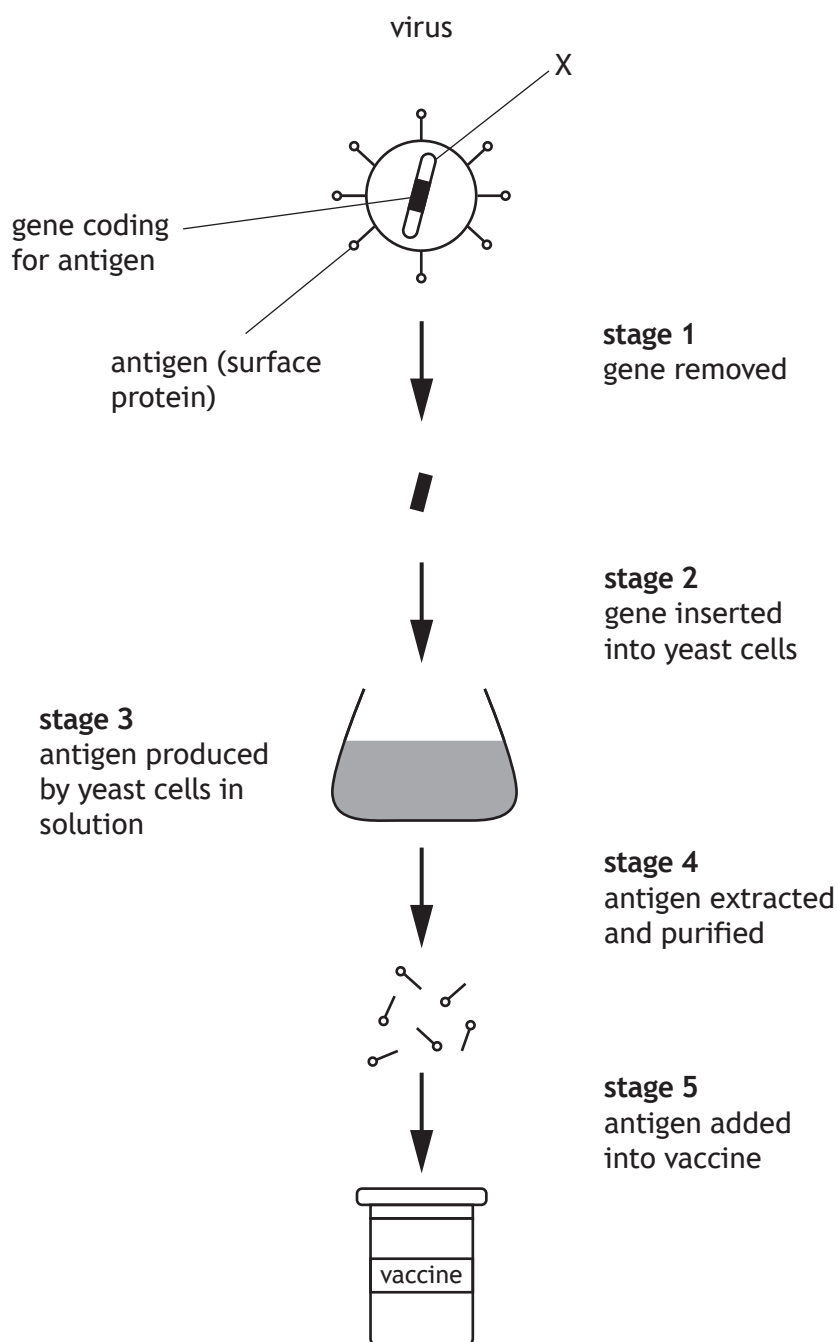
(b) The specific immune system can respond to substances that are harmless to the body.

State the term used for this response.

1



14. The diagram shows stages in the development of a vaccine against a virus.



(a) Suggest what structure X represents.

1

[Turn over

14. (continued)

- (b) The development of this vaccine involves using part of the virus as an antigen. State another source of antigens that can be used to produce vaccines.

1

- (c) (i) Explain why new vaccines must be subjected to clinical trials before being licensed for use.

1

- (ii) Describe how a double-blind procedure prevents a biased interpretation of the results from a clinical trial.

1

- (d) A new influenza vaccine is developed every year. Explain why this is required to protect the body from the influenza virus.

2



15. Attempt **either** A or B.

Write your answer in the space below and on *page 30*.

A Write notes on somatic and germline cells, including cell division in both these cell types.

8

OR

B Write notes on the production of the primary and mature mRNA transcripts.

8

You may use labelled diagrams where appropriate.





National
Qualifications
2024

X807/77/11

**Biology
Supplementary sheet**

WEDNESDAY, 15 MAY
9:00 AM – 12:00 NOON

Supplementary sheet for question 1



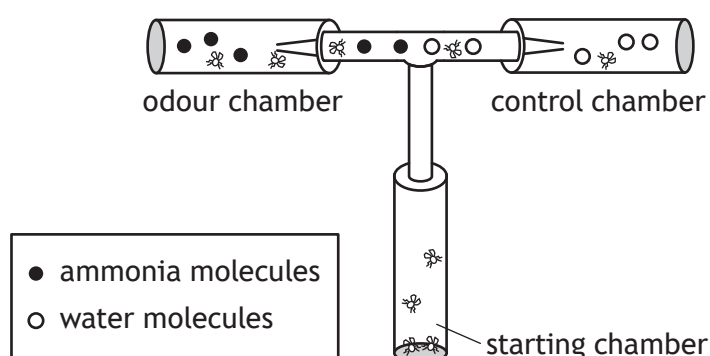
1. Olfaction (sense of smell) is an important way in which animals interact with their environment. In insects, olfaction plays a role in behaviours such as finding food or mating partners, and the avoidance of predators.

Ammonia and amines are chemicals released during the decomposition of nitrogen-containing molecules. Many species, including *Drosophila* species (fruit flies), use ammonia and amines as olfactory signals, possibly because they indicate the presence of a protein-rich food source.

Figure 1 shows a piece of apparatus called a T-maze, which was used to study the response of the fruit fly *Drosophila melanogaster* to ammonia and amines.

Flies are released into the starting chamber and allowed to choose between the odour and the control chamber. After a period of time, the number of flies in each tube is counted and a preference index (PI) calculated using the formula given.

Figure 1



$$PI(\%) = \frac{\text{number of flies in odour chamber} - \text{number of flies in control chamber}}{\text{total number of flies in odour and control chambers}} \times 100$$

Table 1 shows raw data for one experiment using a T-maze to study the response of *Drosophila melanogaster* to ammonia.

Table 1

Trial number	Number of flies in odour chamber	Number of flies in control chamber
1	20	4
2	18	3
3	21	2
4	19	4
5	21	1

1. (continued)

Figure 2A shows how changing the ammonia concentration affected the olfactory response of *Drosophila melanogaster*. The responses of flies to a variety of amines, as well as carbon dioxide, was also studied, and the results of these experiments are shown in Figure 2B.

Figure 2A

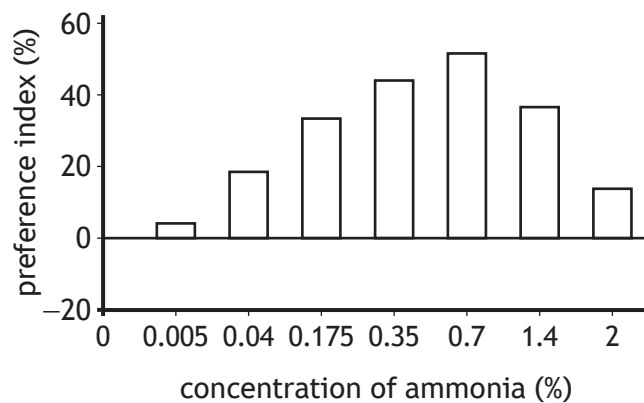
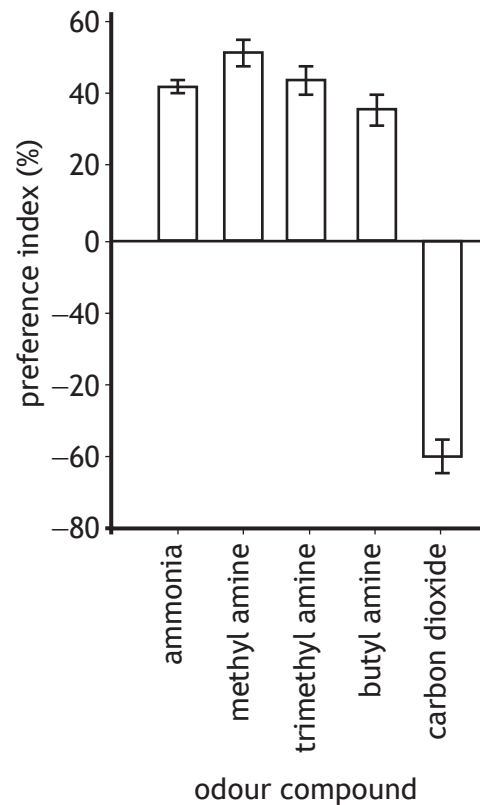
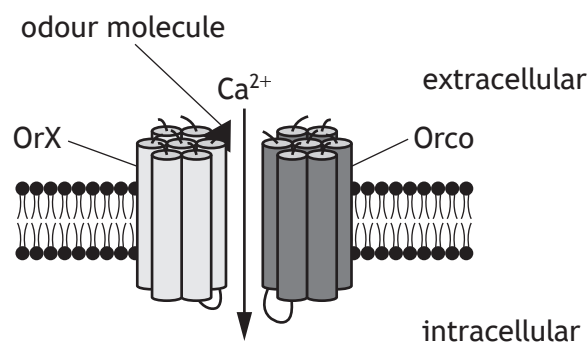


Figure 2B



Flying insects contain a type of olfactory receptor (OR) in their antennae that is not found in other organisms. Flying insect ORs are ligand-gated ion channels that allow calcium ions (Ca^{2+}) to enter cells. Insect ORs are made up of a protein that binds odour molecules (OrX) and another protein called Orco, as shown in Figure 3.

Figure 3

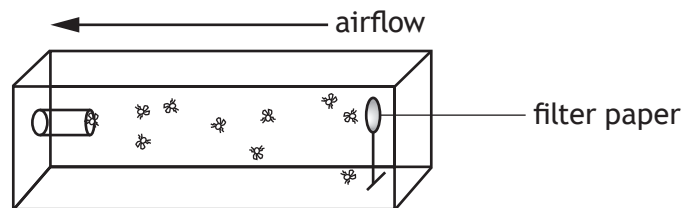


1. (continued)

A recent study investigated the role of an intracellular protein called calmodulin in the function of ORs in *Drosophila melanogaster*. Calmodulin acts as a Ca^{2+} sensor by binding to Ca^{2+} in the cell. This binding switches calmodulin from an inactive to an active state; active calmodulin then binds to and modifies the activity of many target proteins including Orco.

One experiment in this study used a wind tunnel assay in which grape juice was pipetted onto filter paper attached to a metal stand as shown in **Figure 4**. Flies were released into the chamber and the number of flies landing on the filter paper was counted and used to calculate a landing percentage.

Figure 4



Flies with a mutation in the calmodulin binding-site of Orco (Orco MUT) and flies lacking the Orco protein (Orco⁻) were compared to Wild-type (WT) flies with normal phenotype. The results are shown in **Figure 5A**.

In a second experiment, the Ca^{2+} levels inside the cells of antennae were measured following exposure of wild-type and mutant *Drosophila* to different concentrations of grape juice. The results are shown in **Figure 5B**.

Figure 5A

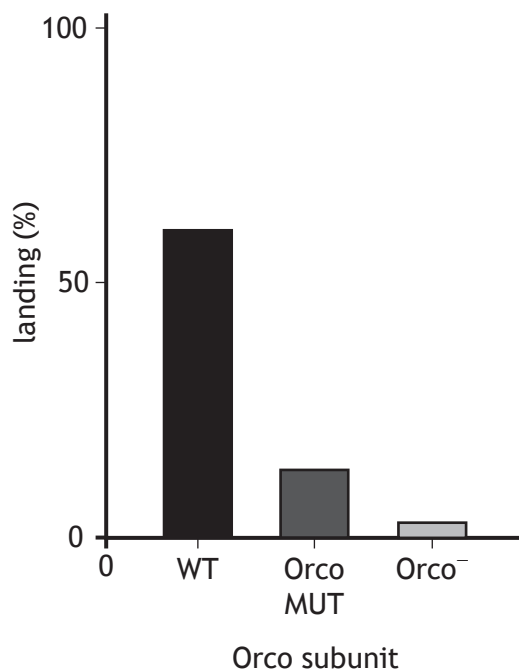
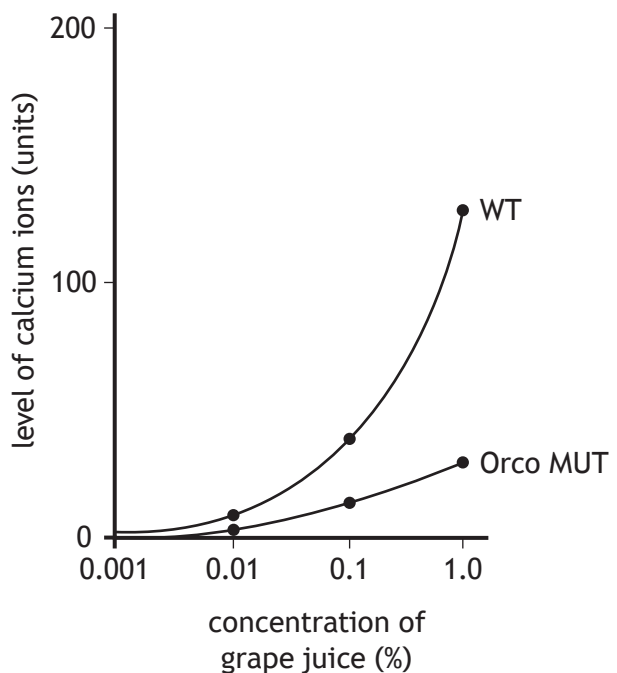


Figure 5B



[END OF SUPPLEMENTARY SHEET]