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Centre number

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Candidate number

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Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS BIOLOGY (9610)

Unit 1 The Diversity of Living Organisms

Tuesday 14 January 2020 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	
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TOTAL	



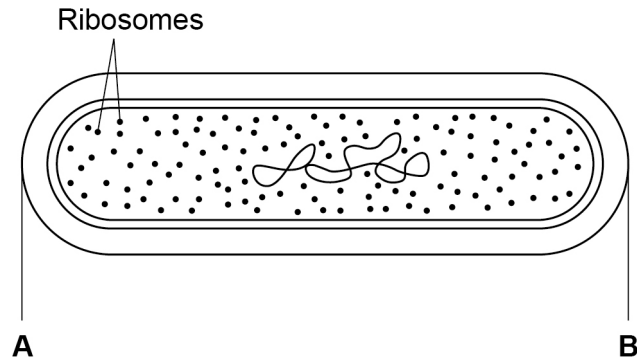
J A N 2 0 B L 0 1 0 1

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

0 1

Figure 1 shows a prokaryotic cell.

Figure 1



0 1 . 1

The actual length of the cell from point **A** to **B** is 4 μm

Calculate the magnification of the image in **Figure 1**.

[1 mark]

$$\text{Measured length A to B} = 80 \text{ mm} = 80\,000 \mu\text{m}$$

$$\text{Magnification} = \text{image size} \div \text{actual size}$$

$$= 80\,000 \div 4 = 20\,000$$

$$\text{Magnification} = \underline{\hspace{2cm} 20\,000 \hspace{2cm}}$$

0 1 . 2

Both prokaryotic and eukaryotic cells can have cell walls and ribosomes.

Complete **Table 1** by stating **one** way in which each feature is different in a prokaryotic cell from that in a eukaryotic cell.

[2 marks]

Table 1

Feature	Prokaryotic cell
Cell wall	<i>Contains murein (peptidoglycan), not cellulose</i>
Ribosomes	<i>Smaller (70S, not 80S), free in the cytoplasm</i>



0 1 . 3

Tetracycline is an antibiotic that attaches to ribosomes.

Suggest how tetracycline stops bacteria from dividing.

[3 marks]

Ribosomes are the site of protein synthesis (translation).

Tetracycline attached to ribosomes stops tRNA (and mRNA) binding to the ribosome, so translation and the production of proteins are prevented.

So no enzymes are made to catalyse reactions needed for division, e.g. DNA replication and respiration (ATP), and no structural proteins are made to form the new cell membrane and cell wall.

6

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0 2

A group of students investigate the effect of temperature on the hydrolysis of lipids in milk.

The students:

- add 5 cm³ of milk and 7 cm³ of sodium carbonate solution to a test tube
- add 5 drops of the pH indicator phenolphthalein to give the mixture a pink colour
- put the test tube in a water bath at 30 °C
- after 5 minutes, add 1 cm³ of lipase to the test tube and start timing immediately
- stir the contents of the test tube continuously
- record the time taken for the pink colour to disappear
- repeat the experiment at three other temperatures.

Phenolphthalein turns a pink colour in alkaline solutions but becomes colourless in solutions with a pH below 8.2

0 2 . 1

The method states how some variables are controlled.

Give **two** other variables the students should control in this investigation.

[2 marks]

- 1 *Concentration of lipid (same fat content / type of milk)*
- 2 *Concentration of lipase (enzyme)*

0 2 . 2

Give **one** reason why the students put the test tube in a water bath for 5 minutes before adding the lipase.

[1 mark]

To allow the milk mixture in the test tube to reach the same temperature as the water bath (30 °C) before the reaction starts.

0 2 . 3

In this investigation, the students did **not** add a buffer solution to the test tubes containing milk.

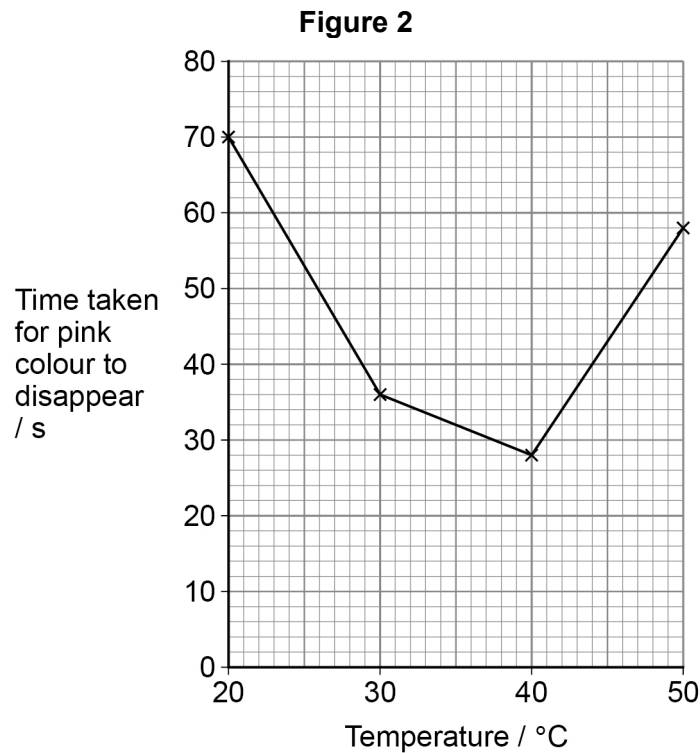
Give the reason why.

[1 mark]

A buffer maintains a constant pH, but the students were measuring a change in pH (with a buffer the solution would stay pink).



Figure 2 shows the students' results.



0 2 . 4 A student concludes that 40 °C is the optimum temperature for lipase.

Explain why this conclusion might **not** be correct.

Use information from **Figure 2**.

[2 marks]

The temperature intervals are large (10 °C intervals), so smaller intervals are needed.

The optimum temperature could be anywhere between 30 °C and 50 °C, e.g. 35 °C or 45 °C.

0 2 . 5 Explain the effect of temperature on lipase activity as shown in **Figure 2**.

[3 marks]

As temperature increases from 20 °C to 40 °C, the enzymes and substrates (lipids) gain kinetic energy and move faster, so there are more successful collisions between enzymes and substrates and more enzyme-substrate complexes form, so the time taken

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decreases.

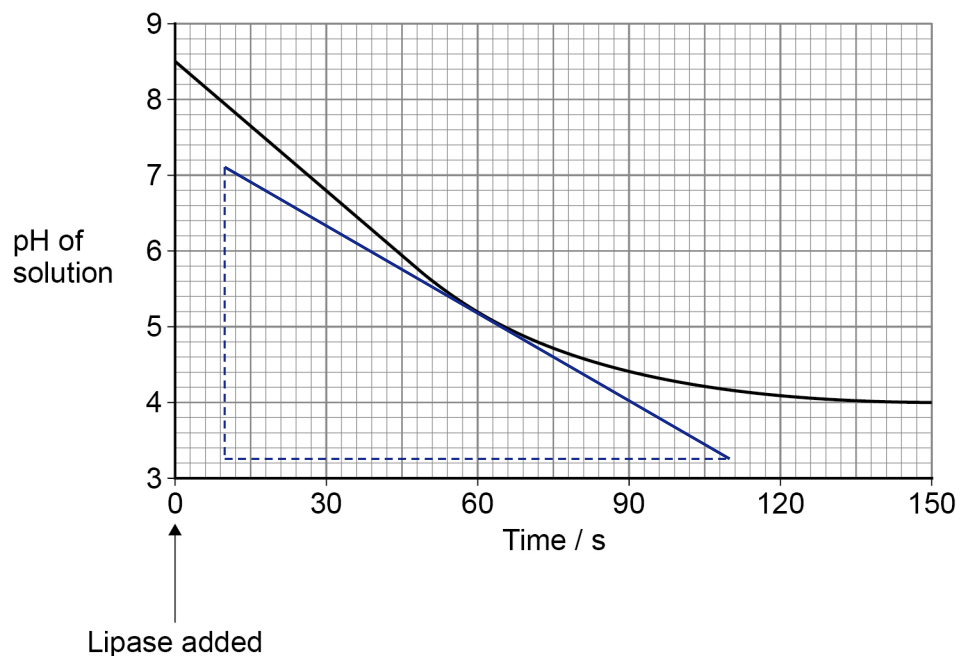
Above 40 °C (at 50 °C) the hydrogen and ionic bonds in the tertiary structure break, so the active site changes shape and the enzyme is denatured.

The students then complete a similar experiment but this time they use a pH probe attached to a data logger instead of adding phenolphthalein.

The data logger records the pH of the solution.

Figure 3 shows the students' results at a temperature of 40 °C

Figure 3



0 2 . 6 Draw a tangent on the graph (**Figure 3**) at 60 seconds.

Calculate the rate of change of pH at 60 seconds using the tangent.

[2 marks]

$$\begin{aligned}\text{Gradient of tangent} &= (3.25 - 7.10) \div (110 - 10) \\ &= -3.85 \div 100 = -0.0385\end{aligned}$$

Rate of change at 60 seconds = -0.04 pH units s⁻¹



0 2 . 7

Explain the changes in pH shown in **Figure 3**.**[3 marks]**

The pH decreases because fatty acids are produced from the hydrolysis of lipids by lipase.

At the start the rate of reaction is high (steep fall in pH) because there is a large amount of substrate (lipid).

The curve then plateaus because there is little or no substrate left to be hydrolysed, so no more fatty acids are produced (substrate concentration becomes the limiting factor).

14

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0 3

A dialysis machine is used to treat people with kidney failure.

Inside the dialysis machine are narrow tubes made of artificial membranes.

Artificial membranes and plasma membranes are both partially permeable.

0 3

1

Describe how phospholipids are arranged in a plasma membrane.

[2 marks]

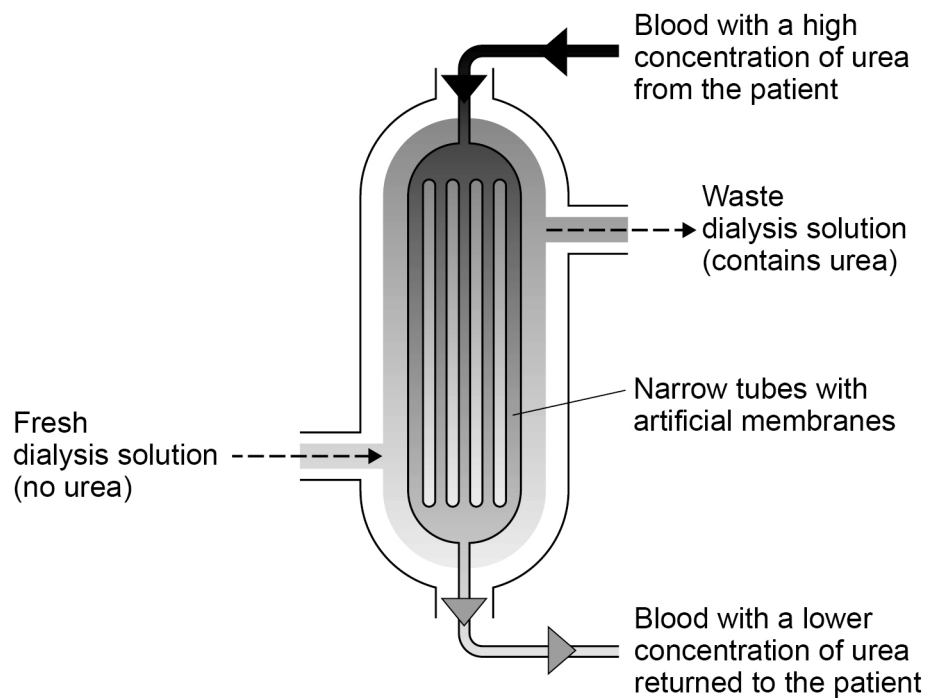
The phospholipids form a bilayer (double layer).

The hydrophilic phosphate heads face outwards (towards the water) and the hydrophobic fatty acid tails point to the inside.

The blood from a person with kidney failure flows through the narrow tubes in the dialysis machine and waste products such as urea are removed.

Figure 4 shows the structure of a dialysis machine.

Figure 4



0 3 . 2

Use information from **Figure 4** to suggest the process by which urea moves from the patient's blood into the dialysis fluid.

[1 mark]

Diffusion

0 3 . 3

Explain **one** way that the dialysis machine shown in **Figure 4** provides an effective exchange surface for removing large amounts of waste products from the body.

[2 marks]

The many narrow tubes give a large surface area,

*so there is a higher rate of diffusion (exchange) of urea into the
dialysis fluid.*

Question 3 continues on the next page

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0 3 . 4

The blood of a patient with kidney failure flows through a dialysis machine at a rate of 220 cm^3 per minute.

Calculate the total volume that flows through the machine in 4 hours.

Give your answer in dm^3

[1 mark]

$$220 \text{ cm}^3 \times 60 = 13\,200 \text{ cm}^3 \text{ per hour}$$

$$13\,200 \times 4 = 52\,800 \text{ cm}^3$$

$$52\,800 \div 1000 = 52.8 \text{ dm}^3$$

Total volume of blood = 52.8 dm^3

The patient's doctor wants to make sure that the patient's dialysis has been adequate. The doctor calculates a value called dialysis adequacy. This value should be greater than 1.2

$$\text{Dialysis adequacy} = \frac{V}{m}$$

V = total volume of blood filtered during the dialysis (dm^3)

m = mass of water in the patient's body (kg)

The patient has a mass of 80 kg and 60% of this is water.

0 3 . 5

The doctor has determined that the patient's current dialysis treatment is **not** adequate.

Calculate the dialysis adequacy value to show how the doctor determined this.

[2 marks]

$$m = 0.6 \times 80 = 48 \text{ kg of water}$$

$$\text{Dialysis adequacy} = 52.8 \div 48 = 1.1$$

1.1 is less than 1.2, so dialysis is not adequate

Dialysis adequacy = 1.1

8



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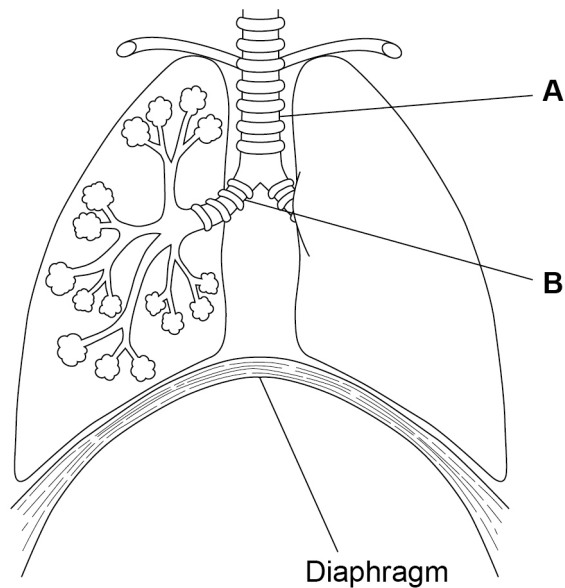
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0 4

Figure 5 shows the structure of the human gas exchange system.

Figure 5



0 4 . 1

Name the structures labelled **A** and **B**.

[1 mark]

A Trachea

B Bronchus

0 4 . 2

Describe the mechanisms that cause air to move into the lungs.

[3 marks]

The diaphragm (muscles) contracts and the diaphragm flattens (moves downwards).

The external intercostal muscles contract, raising the ribcage up and out.

This increases the volume of the thoracic cavity (lungs), so the pressure inside the lungs decreases below atmospheric pressure and air moves in.



0 4 . 3

A student plans an investigation to compare the resting breathing rates of people with different fitness levels.

The student suggests the hypothesis:

‘People with higher fitness levels have lower resting breathing rates.’

Describe a method that could be used to test if this hypothesis is valid.

Include a statistical test that the student could use to analyse the results.

[5 marks]

Determine the fitness level of each volunteer, e.g. by measuring their resting heart rate or by a standard exercise test, and put them into fitness groups.

Use a large number of participants in each group (at least 10 people).

Match the participants for age, sex and smoking (all non-smokers).

Measure the resting breathing rate by counting the number of breaths per minute while sitting still for 5 minutes, repeating several times for each person.

Calculate the mean (and standard deviation) breathing rate for each group.

Use a t-test (or standard error and 95% confidence limits) to see whether there is a significant difference between the means of the groups.

9

Turn over ►



0 5

All living organisms have genetic information in the form of DNA. This DNA contains genes arranged in a genome.

0 5

1

Define the terms **gene** and **genome**.

[2 marks]

Gene A section of DNA that codes for a polypeptide (protein).

Genome The complete set of genes in a cell (organism).

0 5

2

There are differences in the DNA found in different organisms.

Put a tick (✓) in each box on **Table 2** if the statement is true.

[3 marks]

Table 2

	Prokaryotic cell	Eukaryotic cell	Mitochondrial DNA
Genetic material held in a nucleus		✓	
Histones present		✓	
DNA in the form of linear molecules		✓	
DNA found as a double helix structure	✓	✓	✓

5



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0	6
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Scientists investigate the effect of disulfide bonds on the structural strength of a human cardiac muscle protein called titin.

The scientists:

- artificially place disulfide bonds into some titin molecules
- apply a force to stretch these modified titin molecules
- repeat the procedure for naturally-occurring titin proteins that did not contain any disulfide bonds
- measure the final lengths of the stretched titin molecules with and without disulfide bonds.

0	6	.	1
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The method used by the scientists alters the tertiary structure of the titin protein.

What is meant by the term **tertiary structure**?

[1 mark]

Further folding (coiling) of the secondary structure of a polypeptide due to interactions between R groups (ionic, hydrogen and disulfide bonds).

0	6	.	2
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The scientists modified some of the amino acids in the protein to create disulfide bonds.

Name the part of these amino acids that the scientists modified.

[1 mark]

The R group (side chain)



0 6 . 3

Name **two** types of bonds that are most likely to have been broken during the stretching process.

[1 mark]

1 *Hydrogen bonds*

2 *Ionic bonds*

Table 3 shows the scientists' results.

Table 3

	Stretched length / nm
Titin without disulfide bonds	28.4
Titin with disulfide bonds	12.7

0 6 . 4

The final length of the stretched titin molecules **without** the disulfide bonds was longer than the titin with disulfide bonds.

Suggest why.

[2 marks]

*The disulfide bonds are too strong to be broken by the stretching force,
so the disulfide bonds hold the molecule together and reduce stretching,
so the titin is not fully stretched to its secondary (primary) structure.*

Question 6 continues on the next page

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0 6 . 5

Describe briefly **four** ways the scientists could have ensured valid and accurate results.

[4 marks]

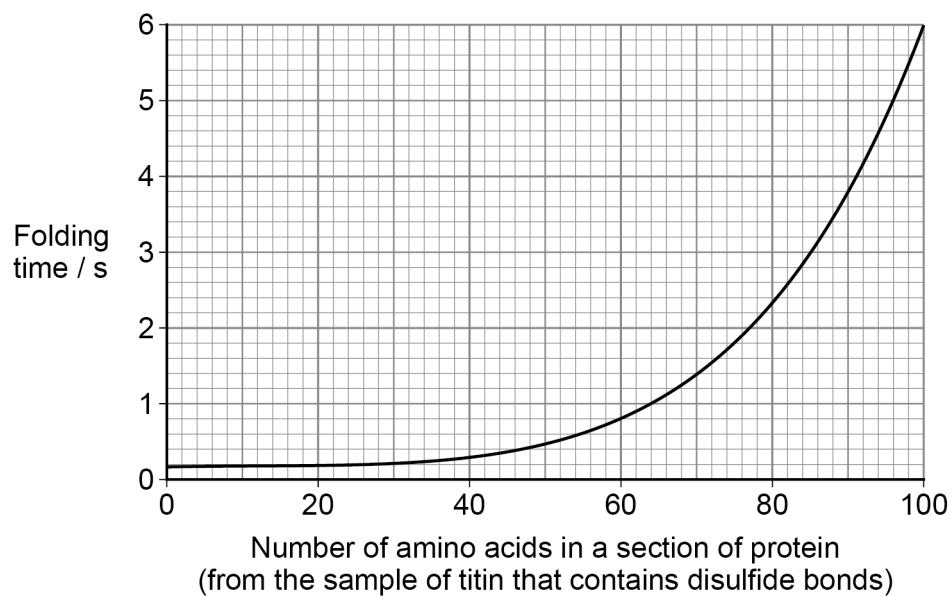
- 1 *Use a large number of titin molecules (large sample size) for each group.*
- 2 *Keep the temperature constant using a water bath (and the pH constant with a buffer).*
- 3 *Apply the same force for the same length of time.*
- 4 *Use titin from the same source (same species and section of the heart).*

The scientists do a second experiment to measure the time needed for the sections of the stretched titin proteins containing disulfide bonds to refold back into their tertiary structure.

The scientists find that the number of amino acids in the section of the protein that had to refold affects the folding times.

Figure 6 shows the scientists' results.

Figure 6



0 6 . 6

Describe the relationship between folding time and the number of amino acids.

Use data from **Figure 6**.**[2 marks]**

Folding time rises very slowly at first, then rises rapidly (exponentially) with more amino acids.

Up to 60 amino acids it takes less than 1 second, but there is a 6-fold increase between 60 and 100 amino acids (1 s to 6 s).

0 6 . 7

Name the molecules found in cells that ensure the correct folding of polypeptide chains.

[1 mark]

Chaperone proteins

The scientists find that it takes 150 times longer to refold the titin proteins which did not contain the disulfide bonds compared with the ones with disulfide bonds.

0 6 . 8

Calculate the time it would take to refold 80 amino acids from a titin protein that does **not** contain disulfide bonds.Use information from **Figure 6**.**[2 marks]**

Folding time for 80 amino acids with disulfide bonds = 2.3 s

Without disulfide bonds = $2.3 \times 150 = 345$ s

Answer = 345 seconds

0 6 . 9

Suggest why a stretched protein with disulfide bonds takes less time to refold than a protein without disulfide bonds.

[2 marks]

The disulfide bonds are not broken, which reduces the amount of unfolding of the protein, and they hold adjacent parts of the polypeptide chain in place for the R group bonds to re-form.

Turn over ►



07

To pass genes to their children, parents use cells called germ cells to create gametes. Germ cells undergo two divisions in meiosis to produce sperm and egg cells.

Crossing over occurs during meiosis. The process of crossing over introduces genetic variation. Data has now shown that crossing over can also affect the rate at which genes mutate. 5

Using genetic data from 155 280 people living in Iceland, researchers at a biotechnology company located in Reykjavík have created the most detailed map yet of the relative locations of genes in the human genome. By looking at the differences in parent and child DNA, the researchers could trace both crossing over and mutations in DNA as it passed from parent to child. Mutations were approximately 50 times more common in sections of DNA within about 1000 base pairs of where crossovers had happened. The number of mutations decreased with increasing distance from a crossover site. 10

Understanding how mutations happen can help biologists study how genetic diversity is created and give insights into disorders caused by mutations. 15

Use information from the passage and your own knowledge to answer the questions.

07.1

Explain why germ cells need to undergo two divisions in meiosis to produce sperm and egg cells (lines 1–2).

[3 marks]

The first division separates the homologous chromosomes, so each daughter cell receives one chromosome from each pair.

The second division separates the (sister) chromatids, producing haploid cells (with half the number of chromosomes).

So at fertilisation the diploid number is restored and a constant number of chromosomes is maintained across generations.



07.2

Crossing over, independent segregation and mutation all result in genetic diversity.

Name **one** other process that can further increase genetic variation within a species.

[1 mark]

Random fertilisation (random fusion of gametes)

07.3

In Iceland, 1 in 80 people have some kind of genetic disease.

Calculate the number of people who have a genetic disease in the data set used in this study.

[1 mark]

$$155\,280 \div 80 = 1941$$

Answer = 1941

07.4

'Crossing over occurs during meiosis' (line 4).

Explain how the process of crossing over results in genetic variation.

[4 marks]

Homologous chromosomes pair up (associate) to form a bivalent.

The non-sister chromatids twist round each other and chiasmata form.

Equal lengths of non-sister chromatids (alleles) break off and are exchanged.

This produces new combinations of alleles on the chromatids.

Question 7 continues on the next page

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0 7 . 5

Which row in **Table 4** shows the stages in cell division when independent segregation and crossing over take place?

Tick (✓) **one** box.

[1 mark]

Table 4

	Independent segregation	Crossing over	Tick (✓) one box
A	anaphase I	prophase I	
B	metaphase I	anaphase I	
C	metaphase I	prophase I	✓
D	prophase I	metaphase I	

10



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0 8

Keratin is a structural protein found in the hair of mammals.

Scientists have determined the sequence of the amino acids in keratin from different species.

Table 5 shows the sequences of amino acids in one section of keratin from the hair of humans and some apes.

Table 5

Mammal	Amino acid name						
Chimpanzee	Met	Trp	Phe	Glu	Pro	Ala	Glu
Gorilla	Met	Trp	Phe	Lys	Pro	Pro	Glu
Human	Met	Trp	Phe	Glu	Pro	Ala	Glu
Orangutan	Met	Trp	Phe	Glu	Pro	Pro	Glu

0 8 . 1

Give the number of nucleotides that code for the amino acid sequence of human keratin shown in **Table 5**.

[1 mark]

21

0 8 . 2

Explain the conclusions the scientists could make about the evolutionary relationships between humans and apes.

Use the information from **Table 5**.

[3 marks]

Humans are most closely related to chimpanzees, as the amino acid sequence is the same (no differences), so they share the most recent common ancestor.

Humans are more closely related to orangutans than to gorillas, as there is only one difference in the amino acid sequence.

Humans are least closely related to gorillas, as there are two differences in the amino acid sequence.



0 8 . 3

Any conclusions made by the scientists based **only** on the data in **Table 5** may not be valid.

Discuss why.

[3 marks]

The genetic code is degenerate, as more than one triplet codes for each amino acid, so the DNA base sequences may differ even where amino acids are the same.

The data only show part of the amino acid sequence, and other parts of the sequence may show more or fewer differences.

The data only show the sequence of one protein; other proteins may show more or fewer differences, and differences may be found within introns (non-coding DNA).

7

END OF QUESTIONS

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