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Pearson Edexcel GCE
Level 3 GCE

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Biology A (Salters Nuffield)

Advanced Subsidiary

Paper 2: Development, Plants and the Environment

Tuesday 7 June 2016 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

8BN0/02

You may need a ruler, a pencil and a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In questions marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Gametes are specialised for their role in sexual reproduction.

(a) The purpose of the cortical reaction is to

(1)

- ☐ A allow the haploid nuclei to fuse
- ☐ B attract the sperm towards the egg cell
- ☐ C cause the sperm cell membrane to fuse with the egg cell membrane
- ☒ D ensure that only one sperm fertilises the egg

(b) (i) Which adaptation allows a sperm cell to digest the zona pellucida?

(1)

- ☒ A acrosome
- ☐ B flagellum
- ☐ C haploid nucleus
- ☐ D streamlined shape

(ii) Give a reason for the high density of mitochondria found in the midpiece of a sperm cell.

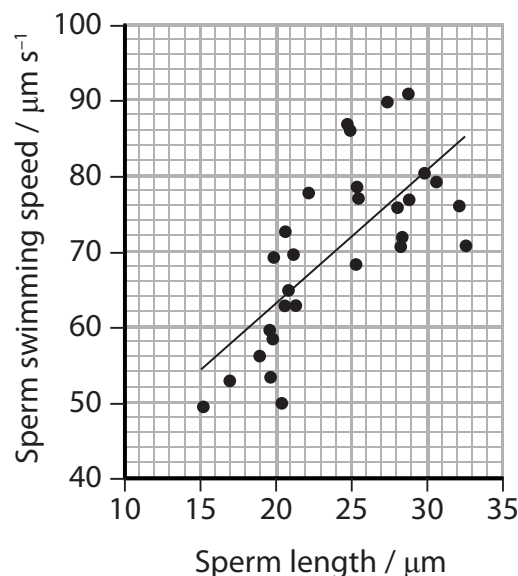
(1)

To release energy (ATP) by aerobic respiration for the movement of the flagellum, so the sperm can swim to the egg.



- (c) The relationship between the length of a sperm cell and the speed at which it can swim was investigated.

The data collected are shown in the graph.



- (i) Calculate the swimming speed of a sperm cell that is $40 \mu\text{m}$ long, as predicted by the line shown on the graph.

(2)

$$\text{gradient} = 18 \div 10 = 1.8 \mu\text{m s}^{-1} \text{ per } \mu\text{m}$$

$$\text{at } 32 \mu\text{m}, \text{ speed} = 84 \mu\text{m s}^{-1}$$

$$84 + (1.8 \times 8) = 98.4$$

Answer $98.4 \mu\text{m s}^{-1}$

- (ii) Explain the limitations of using the line on the graph to predict the swimming speed of sperm cells.

(2)

There is variation about the line, as few data points lie exactly on it, so the predicted speed will not be exact (e.g. sperm may contain different numbers of mitochondria).

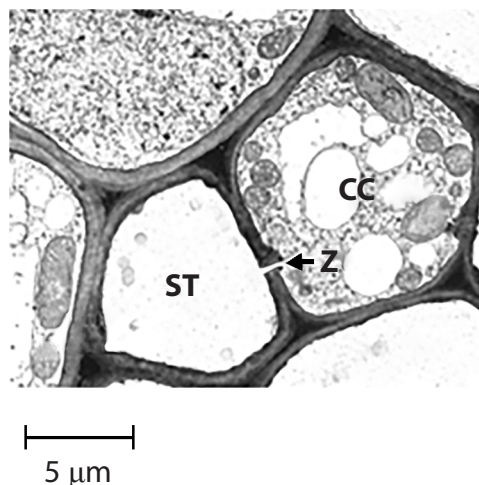
$40 \mu\text{m}$ is outside the range of the data, and the gradient of the line may not remain the same beyond $33 \mu\text{m}$, so extrapolating may be inaccurate.

(Total for Question 1 = 7 marks)



P 4 9 8 3 0 A 0 3 2 4

- 2 The electron micrograph shows a cross-section through part of a vascular bundle, containing phloem tissue.



A sieve tube element is labelled 'ST'. A cell called a companion cell is labelled 'CC'.

- (a) Calculate the magnification of this image.

(1)

$$14 \text{ mm} = 14\,000 \text{ } \mu\text{m}$$

$$14\,000 \div 5 = 2800$$

Answer: x 2800

- (b) The wall of the sieve tube element contains

(1)

- ☐ A cellulose, lamellae and lignin
- ☐ B cellulose, lignin and pectin
- ☒ C hemicellulose, microfibrils and pectin
- ☐ D hemicellulose, peptidoglycan and pectin



- (c) There is no nucleus in a mature sieve tube element.

Give **two** reasons why a sieve tube element does not require rough endoplasmic reticulum and ribosomes.

(2)

There is no nucleus, so there is no DNA to be transcribed and no mRNA is made, therefore ribosomes are not required for translation.

No proteins are synthesised, so none need to be processed in the endoplasmic reticulum; proteins are provided by the companion cell.

- (d) Companion cells are found next to sieve tube elements.

- (i) Describe the structure labelled **Z** that connects the cytoplasm of the companion cell to the sieve tube element.

(2)

This structure is a plasmodesma (plural plasmodesmata), a narrow channel through the cell wall,

where only a thin primary cell wall is present, lined with membrane and containing a strand of cytoplasm.

- (ii) The electron micrograph shows a difference in the number of mitochondria in the sieve tube element and in the companion cell.

Explain the difference in the number of mitochondria.

(3)

The micrograph shows the companion cell has many mitochondria, whereas the sieve tube element has few or none.

The role of the sieve tube element is to provide a channel for mass flow, so its cellular contents are kept to a minimum.

So the sieve tube element has little or no ability to carry out aerobic respiration, whereas the companion cell respire more.

ATP (energy) is supplied to the sieve tube element from the companion cell, e.g. for active transport of sucrose in phloem loading.

(Total for Question 2 = 9 marks)



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3 Soil contains inorganic ions essential for plant growth.

(a) Which compounds, found in plants, contain nitrogen from nitrate ions?

(1)

- ☐ A cellulose, amino acids and DNA
- ☒ B DNA, enzymes and amino acids
- ☐ C DNA, enzymes and starch
- ☐ D starch, proteins and cellulose

(b) The concentrations of some inorganic ions were measured in soil and in plants.

The table shows the concentration of nitrate ions in the soil and in different parts of a plant.

Site	Nitrate ion concentration / ppm
leaf	250
leaf stalk	990
stem	1200
root	2100
soil	29

(i) Calculate the percentage decrease in nitrate ion concentration from the root to the leaf.

(2)

$$2100 - 250 = 1850 \text{ ppm}$$

$$(1850 \div 2100) \times 100 = 88.1$$

Answer 88.1 %

(ii) Describe how nitrate ions are transported from the root to the leaves.

(2)

Nitrate ions dissolved in water (in solution) are carried up through the xylem vessels, in the transpiration stream, from the root to the leaves.



P 4 9 8 3 0 A 0 7 2 4

(iii) The concentration of magnesium ions in the soil was found to be very low.

Explain the effects of a shortage of magnesium ions on a plant.

(3)

Magnesium ions are needed to make chlorophyll, so a shortage limits the production of chlorophyll.

Less light is absorbed so there is less photosynthesis, causing a lack of glucose and other carbohydrates such as cellulose and starch.

Therefore the leaves will be yellow (pale, not green) and the plant will show slow, stunted growth and may be small.

*(c) Lead ions can be toxic to plants.

Different plants are killed by different concentrations of lead ions.

The toxic concentrations for different plant categories are shown in the table.

Toxic lead ion concentration / ppm	Tolerance category of plant
<300	low
300–999	medium
1000–2000	high
>2000	very high



Devise a laboratory investigation to determine the tolerance category of tomato plants to lead ions.

(6)

Germinate tomato seeds of the same variety and grow similar, healthy seedlings of the same age and size in the same conditions until the start of the experiment.

Grow the plants in a growth medium (e.g. sand or water culture) supplied with a nutrient solution containing an adequate concentration of all other necessary ions.

Use a range of lead ion concentrations, e.g. 0, 150, 300, 600, 999, 1000, 1500, 2000 and 2500 ppm, including the boundary concentrations 300, 999/1000 and 2000 ppm. The 0 ppm plants are the control with no lead.

Use at least five plants at each concentration so that a mean can be calculated.

Control the growing environment for all plants: same light intensity, temperature, volume of solution and watering, e.g. in a growth cabinet.

Measure a dependent variable over the same growing period (e.g. 3 weeks) for all plants; record whether each plant has died, and measure the change in dry mass or height.

Calculate the mean (and percentage of plants killed) at each concentration and find the lowest lead concentration that kills the tomato plants.

Compare this toxic concentration with the table: if plants die below 300 ppm tolerance is low, 300 to 999 ppm medium, 1000 to 2000 ppm high, and if they survive above 2000 ppm tolerance is very high.

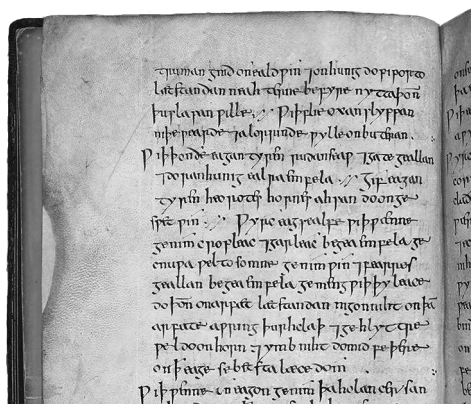
(Total for Question 3 = 14 marks)



P 4 9 8 3 0 A 0 9 2 4

- 4 Bald's Leechbook was written in the 9th Century. This book contains details of medical treatments used over 1000 years ago.

The recipe for a 'salve', used to treat infections, is shown in the photograph.



Scientists followed the recipe to make this salve and tested it in the laboratory.

They found that the salve was very effective against *Staphylococcus aureus*. This bacterium commonly causes infections in humans.

- (a) Describe **two** aseptic techniques that should be used when working safely with bacteria.

(2)

Flame the inoculating loop and the neck of the culture bottle, and work in the updraught of a Bunsen flame.

Disinfect the bench before and after working, and keep Petri dish lids off for the minimum time.



(b) The salve was also tested on mice.

These mice had skin wounds infected with *S. aureus*. The salve was very effective in treating these infections.

(i) Explain why some bacteria can grow rapidly in skin wounds.

(3)

The temperature of the skin and wound is warm, increasing enzyme activity and the rate of reactions in the bacteria.

Blood and tissue fluid provide an energy source such as glucose, and amino acids for growth, and water for bacterial cell functions.

Oxygen availability is good, allowing aerobic respiration (or, where oxygen is limited, some bacteria can respire anaerobically).

(ii) *S. aureus* can cause infections which are difficult to treat in humans.

Describe how scientists, after testing the salve on mice, could test whether the salve is an appropriate treatment for humans with wounds infected with *S. aureus*.

(4)

First apply the salve to a small group of healthy human volunteers to check it is safe.

Then treat one group of patients with infected wounds with the salve and a control group with an existing treatment, e.g. an antibiotic.

The trial should be double blind: neither the doctors nor the patients should know which treatment is being used.

Monitor all participants for side effects and adverse reactions associated with the salve.

Compare the outcomes, e.g. healing time, of patients treated with the salve with the control group.

(Total for Question 4 = 9 marks)



P 4 9 8 3 0 A 0 1 1 2 4

5 Egg cells vary in size between different species of animal.

Egg cells from different animals were measured and some further information about each species was recorded. The data are shown in the table.

Animal	Diameter of egg cell	Mass of adult / kg	Site of fertilisation	Site of offspring development
Domestic cow (mammal)	85 μm	540	inside the body	in the uterus
Human (mammal)	150 μm	62	inside the body	in the uterus
American eel (fish)	1.1 mm	6.8	in the sea	floating in the sea
Hermann's tortoise (reptile)	2.3 cm	3.4	inside the body	inside an egg shell, in a nest
Great spotted kiwi (bird)	7.8 cm	2.3	inside the body	inside an egg shell, in a nest

- (a) The human egg cell and the eel egg cell are approximately spherical.
The formula for the volume of a sphere is

$$V = \frac{4}{3}\pi r^3$$

where V is the volume and r is the radius of the sphere.

The volume of the human egg cell is $1.8 \times 10^6 \mu\text{m}^3$.

Calculate how many times larger the volume of the eel egg cell is than the volume of the human egg cell.

$$\text{eel radius} = 1.1 \text{ mm} \div 2 = 0.55 \text{ mm} = 550 \mu\text{m}$$

(3)

$$V = \frac{4}{3} \times \pi \times 550^3$$

$$V = 6.97 \times 10^8 \mu\text{m}^3$$

$$6.97 \times 10^8 \div 1.8 \times 10^6 = 387$$

Answer 387..... times larger



- (b) The eel egg cell is larger than the human egg cell, yet an adult eel is smaller than an adult human.

Analyse the data in the table to explain why it is advantageous for the eel to have a larger egg cell.

(2)

Eels are fertilised and develop floating in the sea, with no uterus or parental care, so a larger egg contains more lipid droplets (food store), therefore providing more energy and resources for the development of the embryo. A larger egg is also a bigger target for sperm, aiding fertilisation in open water.

- (c) (i) Deduce the relationship between egg cell diameter and the mass of the adult animal shown by the data.

(1)

As the mass of the adult increases, the egg cell diameter decreases (a negative correlation).



P 4 9 8 3 0 A 0 1 3 2 4

- (ii) Criticise this data set as evidence for a relationship between egg cell diameter and the mass of the adult.

(4)

The data set includes only a few (five) species, which is too small a sample, so more species are needed.

The species are from different taxonomic groups (mammal, fish, reptile, bird); similar species should be used.

There are no repeats, and only one value per species, so the data may not be representative of each species.

The reproductive strategy should be controlled, as it is likely to influence egg size, e.g. site of fertilisation and whether the embryo develops in the uterus or in an egg shell.

Other factors that may affect egg size or adult mass are not controlled, e.g. maternal diet, health, age or predation risk.

(Total for Question 5 = 10 marks)



- 6 Svalbard Global Seed Vault (SGSV) is a seed bank. It keeps seeds from almost 4000 species of plants, focussing on food crops such as wheat, rice and maize.

(a) State suitable conditions for keeping seeds in a seed bank.

(2)

Cold, a low temperature such as -20°C (frozen).

Dry, with seeds desiccated so they contain very little moisture.

(b) Many seeds in SGSV store food in the form of starch.

(i) Why does the food store in seeds contain starch rather than cellulose?

(1)

- ☐ A starch can be stored for longer because it has 1–4 bonds
- ☐ B starch has more mineral ions than cellulose
- ☒ C starch is branched and supplies energy more quickly than cellulose
- ☐ D starch is more compact than cellulose because it has 1–6 bonds

(ii) Explain why starch must be broken down before it can be used by the cells of the growing plant.

(2)

Starch is hydrolysed to produce maltose and glucose,

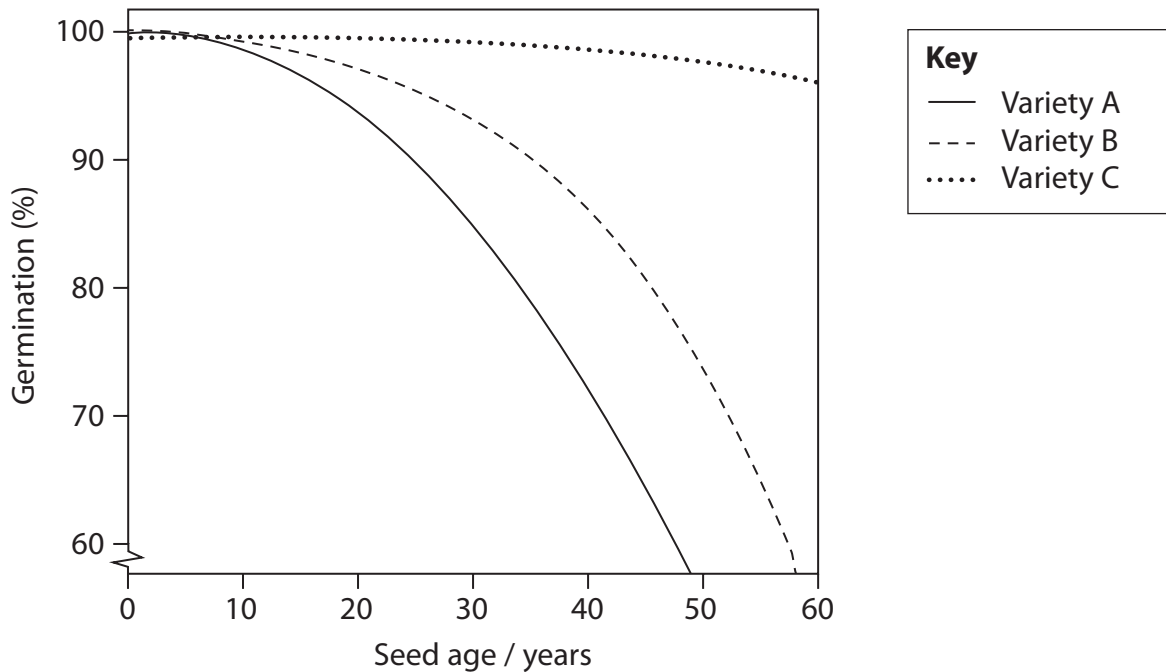
which are soluble so can be transported to and enter cells easily, and glucose is used in respiration; starch is insoluble.



P 4 9 8 3 0 A 0 1 5 2 4

(c) The purpose of SGSV is to store seeds for use in the future, 50 or more years from now.

Seeds from three varieties of maize were tested to see the effects of long periods of storage. The results of these tests are shown in the graph.



Explain how SGSV could make use of these results.

(3)

Seeds that have been kept for long periods will no longer grow, so will not be useful.

Different types of seed lose viability at different rates: variety C still germinates well at 60 years but A falls sharply after about 20 years.

Therefore regular testing of germination is needed, and SGSV can use the results to predict when testing or replanting is needed for each variety.

Seeds from the seed bank can then be grown to produce fresh seeds to replace the old seeds.



- (d) SGSV keeps seeds from more than 865 000 varieties of plant, including 200 000 varieties of wheat and rice. Some of these varieties are rare or extinct in the wild.

Since 2004, more than 410 million dollars have been spent on SGSV and other seed banks around the world.

However, it is estimated that 75% of global crop diversity is not stored in international seed banks.

Critics argue that many crop varieties stored in SGSV are not actually used for food, and that the money would be better spent supporting farmers who are growing food crops.

Justify the continued funding of SGSV.

(3)

SGSV conserves the genetic diversity of crops, including varieties that are rare or extinct in the wild.

Crop varieties kept in SGSV are protected from natural disasters, drought, mismanagement, economic factors and the effects of climate change, which can threaten the varieties grown by farmers.

Varieties in SGSV may have traits useful in the future, such as drought resistance, pest or disease resistance, or tolerance of changing environmental conditions, for breeding new crops.

So SGSV helps to ensure future food security if the crop varieties currently grown were to fail.

(Total for Question 6 = 11 marks)



P 4 9 8 3 0 A 0 1 7 2 4

7 Some fish live in very cold parts of the sea where ice can form.

Many of these fish produce anti-freeze proteins, which help to stop ice forming inside the fish.

(a) The production of anti-freeze proteins is an example of

(1)

- ☐ A anatomical adaptation
- ☐ B change in allele frequency
- ☒ C physiological adaptation
- ☐ D reproductive isolation

(b) Anti-freeze glycoprotein (AFGP) is one type of anti-freeze protein.

Messenger RNA coding for AFGP is translated at a ribosome to produce a polypeptide.

Describe how this polypeptide is then processed to make AFGP.

(4)

The polypeptide moves into the rough endoplasmic reticulum (rER), where it is folded into its secondary and tertiary structure (three-dimensional shape).

It is transported from the rER to the Golgi apparatus in a vesicle.

In the Golgi apparatus carbohydrate (sugar groups) is added to the polypeptide to make the glycoprotein,

and the AFGP is then packaged and transported around the cell in a vesicle.



- (c) Some fish produce another anti-freeze protein, called AFP II.

The tissues of these fish were tested for the presence of AFP II and the mRNA coding for AFP II.

The results are shown in the table.

Molecule	Present in
AFP II protein	all tissues
AFP II mRNA	liver tissue only

Explain the distribution of the AFP II protein and AFP II mRNA.

(4)

The AFP II gene is activated (switched on) only in liver cells and deactivated in all other cells, e.g. by DNA methylation or histone modification.

So transcription of the AFP II gene to make mRNA occurs only in liver cells, and translation (protein synthesis) of AFP II also takes place only in liver cells.

The protein is then secreted from the liver cells and transported around the body in the blood,

so AFP II is present in all tissues, preventing ice forming (freezing) in all parts of the body.



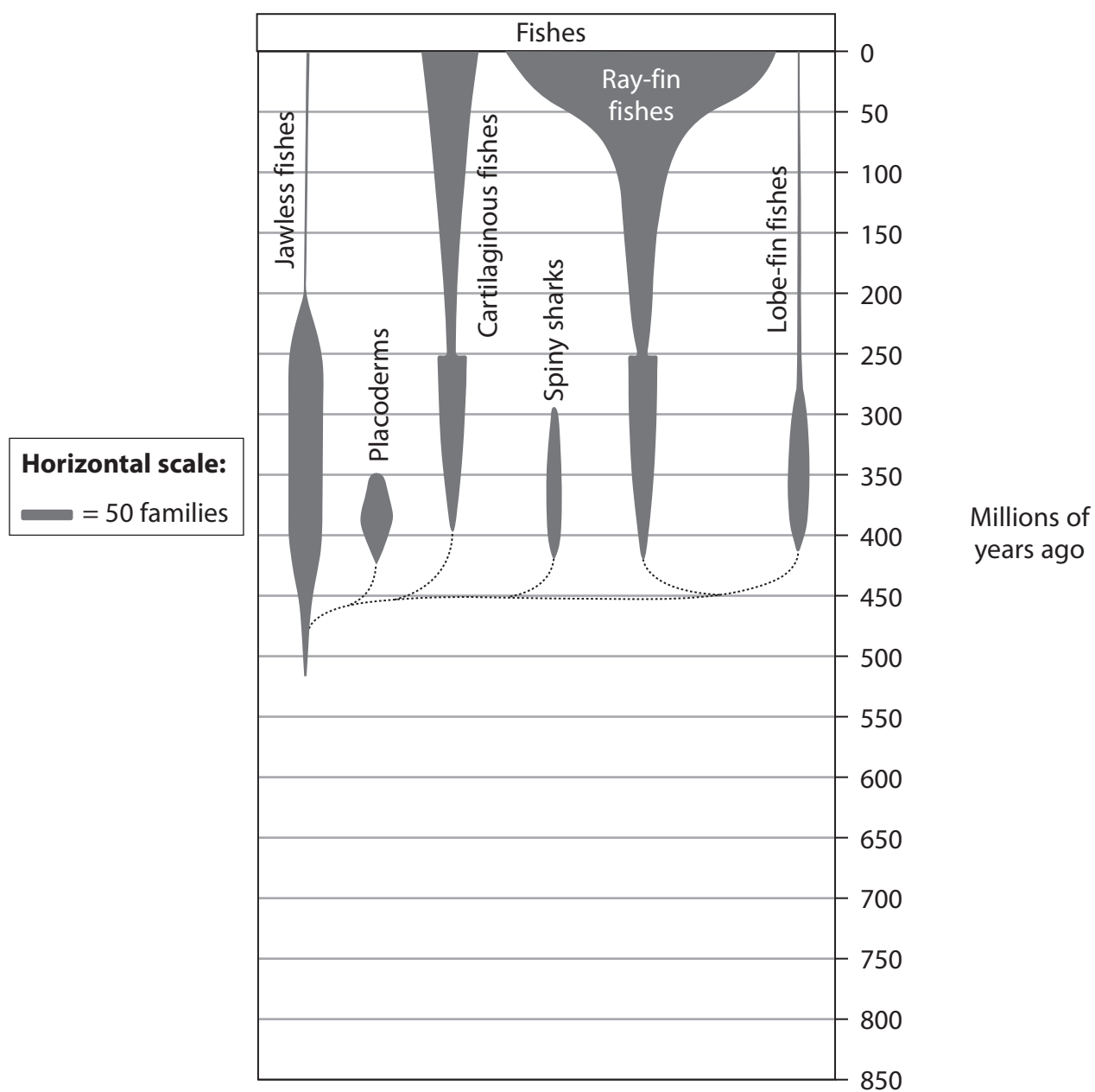
P 4 9 8 3 0 A 0 1 9 2 4

(d) Sea ice forms only during ice ages.

The table shows Earth's ice ages over the last 1000 million years.

Ice age	Time / millions of years ago
Quaternary	0 to 2.6
Karoo	260 to 360
Andean-Saharan	420 to 460
Cryogenian	630 to 850

The diagram shows how the number of families of fishes has changed over time.



(i) At which time does the diagram show a major loss of biodiversity?

(1)

- ☐ A 65 million years ago
- ☒ B 252 million years ago
- ☐ C 359 million years ago
- ☐ D 419 million years ago

(ii) Many different types of anti-freeze protein are produced by ray-fin fishes.

Analyse the data to explain when these ray-fin fish are likely to have evolved the ability to produce anti-freeze proteins.

(3)

Sea ice is a selection pressure for anti-freeze proteins: AFPs are advantageous only when there is sea ice, allowing fish to survive the ice age.

So AFPs are likely to have appeared and increased in frequency during an ice age.

The ray-fin fishes appear about 420 million years ago, so the only ice ages since they existed are the Karoo and the Quaternary.

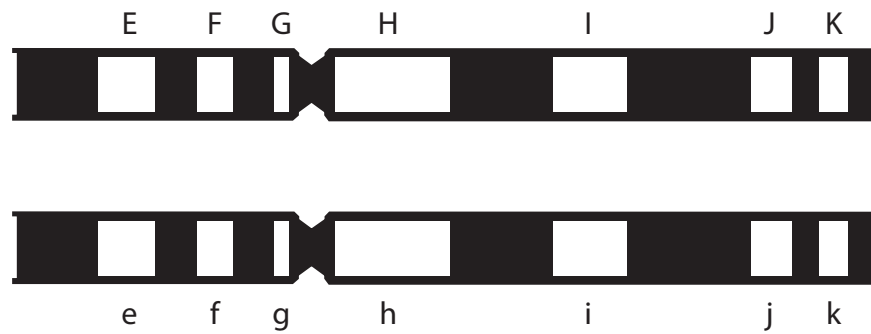
Therefore ray-fin fish producing AFPs are likely to have evolved in the last 2.6 million years or between 260 and 360 million years ago.

(Total for Question 7 = 13 marks)



P 4 9 8 3 0 A 0 2 1 2 4

8 The diagram shows two homologous chromosomes from a man.



The white regions are the loci of seven genes involved in different phenotypic traits. The letters E-K and e-k represent the alleles present at each locus.

(a) Alleles F and G are

(1)

- ☐ A autosomal and complementary
- ☒ B autosomal and linked
- ☐ C sex-linked and dominant
- ☐ D sex-linked and epigenetic

(b) This man produces gametes. Each gamete contains only one allele of each gene.

Describe how each gamete receives only one allele of each gene.

(2)

In meiosis the homologous chromosomes, carrying alleles for the same genes, are separated from one another into different cells.

Then the sister chromatids, containing copies of the same alleles, are separated, as spindle fibres pull them to opposite poles of the cell.



(c) The gametes produced by this man may have different combinations of alleles.
Possible combinations of alleles are:

- E and K
- e and K
- h and i
- H and i

Assess the relative chances of this man's gametes containing these combinations of alleles.

(4)

Combinations of alleles on the same chromosome (E and K, h and i) are more likely, as linked alleles are inherited together.

e and K or H and i can only result from crossing over between the loci during meiosis.

The loci of H and i are closer together than those of e and K, and a greater distance between loci gives a greater likelihood of crossing over, so e and K is more likely than H and i.

So the relative chances, from most likely to least likely, are: h and i, E and K, e and K, H and i.

(Total for Question 8 = 7 marks)

TOTAL FOR PAPER = 80 MARKS

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