CAMBRIDGE
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A Level Biology A
H420/02 Biological diversity
Sample Question Paper

Date – Morning/Afternoon

Version 3.0

Time allowed: 2 hours 15 minutes

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name (s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

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Section A

You should spend a **maximum** of **20 minutes** on this section.

1 A range of microscopes are available for scientific research. Each type of microscope has a different use.

Which row correctly shows the use of each type of microscope?

	Type of microscope and what it is used to observe		
	Light microscope	**Transmission electron microscope**	**Scanning electron microscope**
A	an object at a certain depth within a cell	organelles	cell surfaces
B	cell surfaces	an object at a certain depth within a cell	whole cells and tissues
C	whole cells and tissues	organelles	cell surfaces
D	organelles	an object at a certain depth within a cell	whole cells and tissues

Your answer ☐ **[1]**

2 Which statement describes an organelle which is **not** membrane bound?

A Contains cristae

B Contains digestive enzymes

C Is made of rRNA and protein

D Modifies and packages proteins

Your answer ☐ **[1]**

3 Which statement best describes the structure of DNA?

A Phosphodiester bonds link adjacent bases.

B Purine bases pair with pyrimidine bases.

C The double helix contains two parallel strands of nucleotides.

D There are always equal amounts of adenine and guanine.

Your answer ☐ **[1]**

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4 A person is bitten by a venomous snake and receives an injection containing the appropriate antibodies as immediate treatment.

What type of immunity does this describe?

A Artificial active immunity

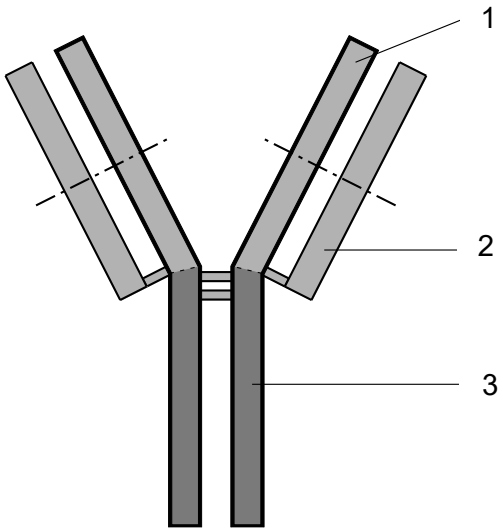
B Artificial passive immunity

C Natural active immunity

D Natural passive immunity

Your answer ☐ **[1]**

5 The diagram represents the general structure of an antibody.



Which number(s) on the diagram represent a part of the antibody that has the same amino acid sequence in all antibodies?

A 1, 2 and 3

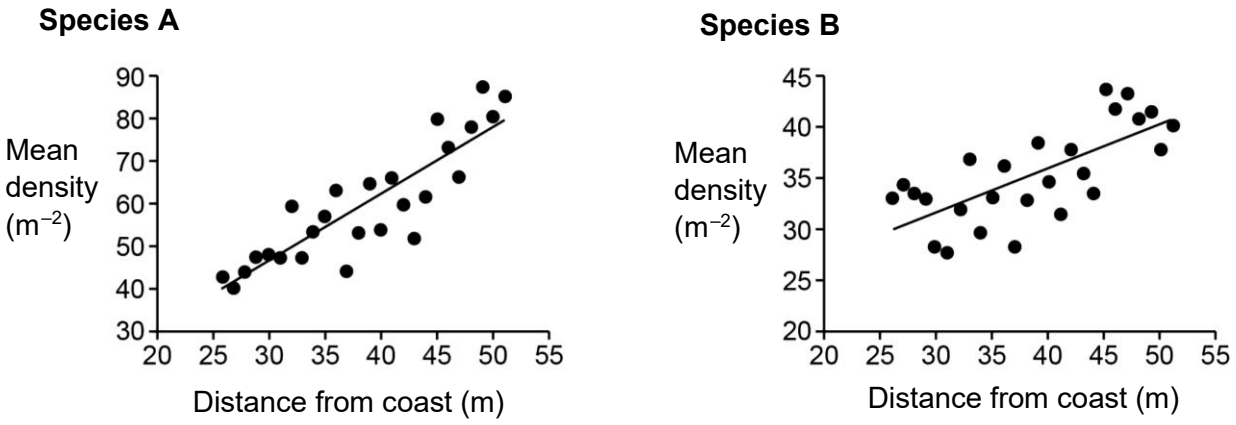
B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

6 The graphs show the density of two different plant species as distance from the coast changes.



Which option describes one aspect of the technique used to collect these data?

A A belt transect has been used to allow calculation of density.

B Abiotic factors were measured at every point of quadrat sampling.

C Larger quadrats were required for species A because their mean density was higher.

D Quadrats were randomly placed using a random number generator and coordinates.

Your answer ☐ **[1]**

7 Selection pressure can be investigated using a model gene pool.

Which option explains why the model gene pool needs to be large?

A Genetic drift can occur if frequency is higher.

B Hardy–Weinberg equilibrium is achieved.

C Homozygous individuals are present in high frequency.

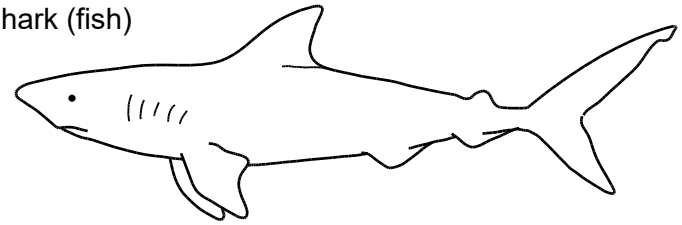
D The effect of chance variations in gene frequencies are minimised.

Your answer ☐ **[1]**

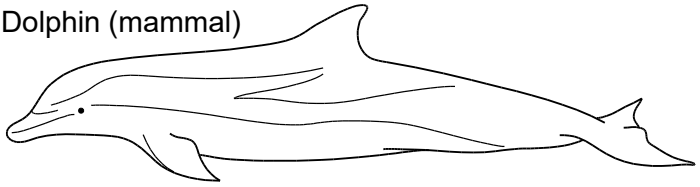
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8 These two organisms show very similar anatomical adaptations but are classified in different taxonomic groups.

Shark (fish)



Dolphin (mammal)



What term can be used to describe this example?

A Convergent evolution

B Divergent evolution

C Disruptive selection

D Stabilising selection

Your answer ☐ **[1]**

9 Which of the following processes are involved in the formation of a new species?

1. Gene mutation

2. Selection pressure

3. A change in the environment

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

10 Which statement describes an operon?

A A cluster of genes under the control of a promoter.

B Any group of genes responsible for the metabolism of lactose in prokaryotes or eukaryotes.

C A regulatory gene.

D The binding site for a repressor protein.

Your answer ☐ **[1]**

11 Which statement describes a difference between somatic and germ line gene therapy?

A Germ line therapy involves the use of liposomes but somatic therapy involves use of viral vectors.

B Long term success is theoretically more likely with somatic cell therapy than with germ line therapy.

C Somatic therapy is most successful when targeting single gene defects but germ line therapy can target multiple defects.

D Somatic therapy can target specific tissues in need of treatment but germ line therapy cannot.

Your answer ☐ **[1]**

12 What method can be used to produce immobilised enzymes?

A Absorbing enzymes onto the surface of a gel.

B Binding enzyme to a soluble matrix.

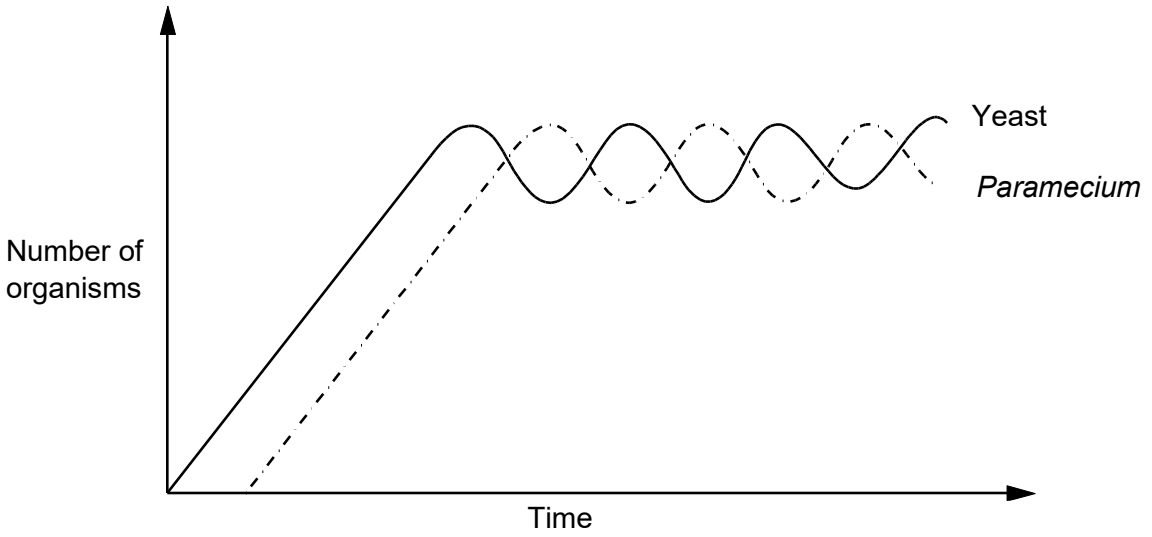
C Enclosing enzymes within a partially permeable membrane.

D Intermolecular hydrogen bonding of enzymes.

Your answer ☐ **[1]**

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13 The graph shows a population of yeast and a unicellular organism, *Paramecium*, grown in a fermentation chamber.



Which option best describes the relationship between the two organisms?

A The *Paramecium* and yeast populations are complementary to each other.

B The *Paramecium* feeds on the yeast and reduces the number in the yeast population.

C The two populations are in equilibrium and stable due to a type of negative feedback.

D The yeast thrives in the relationship at the expense of the *Paramecium* population.

Your answer ☐ **[1]**

14 The last giant Galapagos tortoise died in 2012. Scientists froze some of the tortoise's cells.

The following statements describe processes involved in potential cloning of the giant Galapagos tortoise using the cells. They are **not** in the correct order.

1 A donor egg is enucleated.

2 A somatic cell from the tortoise is defrosted and the nucleus is removed.

3 The somatic cell nucleus is inserted by electrofusion into the enucleated oocyte.

4 The transformed egg divides *in vitro* and develops into a mature egg.

Which option shows the correct order for producing a clone of the giant Galapagos tortoise?

A 1, 2, 4, 3

B 1, 4, 2, 3

C 2, 1, 3, 4

D 2, 3, 1, 4

Your answer ☐ **[1]**

15 Deep sea vents on the ocean floor are surrounded by unusual organisms such as chemosynthetic bacteria and eyeless shrimp.

Which option describes these ecosystems?

A The arrival of a new predator would not affect the balance of these organisms.

B The number of eyeless shrimp found at each vent is constant.

C There is no interaction with other ocean ecosystems.

D The temperature of the vents influences the organisms that live there.

Your answer ☐ **[1]**

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Section B

16 New infectious diseases can arise from mutations in the genomes of existing organisms.

A mutated organism can either be:

- non-pathogenic
- an animal pathogen that has mutated to be able to infect humans.

(a) Identify a feature of a pathogen such as *Mycobacterium tuberculosis* that could be altered by a mutation, making a vaccine ineffective.

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…… **[1]**

(b)

(i) Outline the processes that lead to the production of antibodies against an unfamiliar bacterium.

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…… **[3]**

(ii) Explain how T helper cells act to speed up the processes that lead to the production of antibodies.

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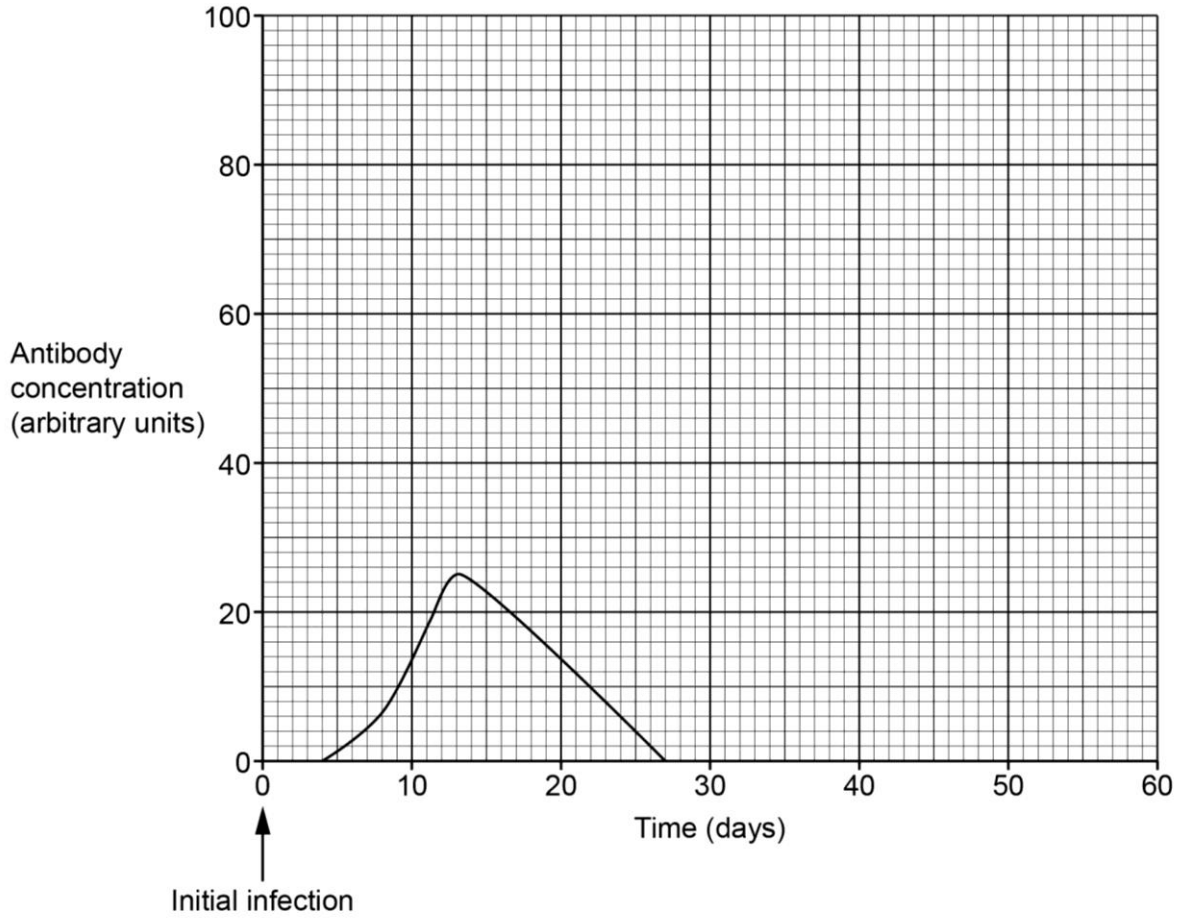
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…… **[2]**

(c) The graph shows the concentration of new antibodies in the blood of a person infected for the first time by a pathogen on day 0. This is their primary response.



(i) On day 30, this person was again infected with the same pathogen.

Sketch a line **on the graph** to show the antibody concentration from day 30 onwards. **[2]**

(ii) Explain how memory cells caused the differences between the two lines on the graph.

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…… **[2]**

(d) Antibodies are used to treat infections caused by bacteria.

(i) State **two** vulnerable groups of people who may be prescribed antibiotics although they are **not** yet showing symptoms of the new disease.

1 ……

2 ……

[2]

(ii) Discuss the implications of the over-use of antibiotics when people do not show symptoms.

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…… **[4]**

17 Domesticated pigs are descended from the wild boar, *Sus scrofa*.

(a) The table shows the taxonomic classification for the wild boar.

(i) Complete the table by:

- adding numbers 2 to 6 to the first column to show the rank order of size of each taxonomic level, with 1 being the largest and 7 being the smallest
- adding names to the third column that illustrate the classification of the wild boar.

Size of level (rank order)	Taxonomic level	Name of wild boar group
.....	Order	Artiodactyla
7	Species	.....
.....	Family	Suidae
1	Kingdom	.....
.....	Genus	.....
.....	Phylum	Chordata
.....	Class	Mammalia

[4]

(ii) DNA evidence shows how organisms are related to each other. This evidence has helped biologists to construct a new classification model: the Domain system.

Suggest what such developments show about the nature of scientific knowledge.

…….....

…… **[1]**

(b) In domesticated pigs, tail shape and skin colour are under genetic control. The following two traits have been studied:

- The allele for curly tail (**T**) is dominant to the allele for straight tail **(t)**.
- The allele for pink skin (**D**) is dominant to the allele for black skin **(d)**.

(i) Draw a genetic diagram to show the results of crossing pigs that are heterozygous for tail shape and skin colour.

Parental genotypes …… ……..

Gametes …… ……..

F_1 offspring genotypes

…….....

F_1 offspring phenotypes

…….....

F_1 phenotype ratio

…….....

[5]

(ii) Describe how this phenotypic ratio might be different if the two genes were autosomally linked.

…….....

…… **[1]**

(c) A farmer crossed pigs that were heterozygous for tail shape and skin colour with pigs that were homozygous recessive for both traits. The farmer expected to get roughly equal numbers of each of the four possible phenotypes.

The actual results are shown in **Table 17.1**.

Table 17.1

Phenotype	Observed	Expected			
Curly pink	20	26			
Curly black	30	26			
Straight pink	21	26			
Straight black	33	26			

(i) The farmer wondered whether the two genes might be autosomally linked.

Calculate the χ^2 value for the students' data.

Use the equation $\chi^2 = \sum \frac{(O-E)^2}{E}$

You may use the empty columns in **Table 17.1** to help with your calculation.

$\chi^2 =$ ..... **[3]**

(ii) The farmer concluded that the genes are autosomally linked.

Table 17.2 shows part of a statistical table for the chi-squared test.

Degrees of freedom	Probability							
	0.95	**0.90**	**0.75**	**0.50**	**0.25**	**0.10**	**0.05**	**0.01**
1	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09

Use your answer to part **(i)** and **Table 17.2** to justify whether the farmer's conclusion can be supported.

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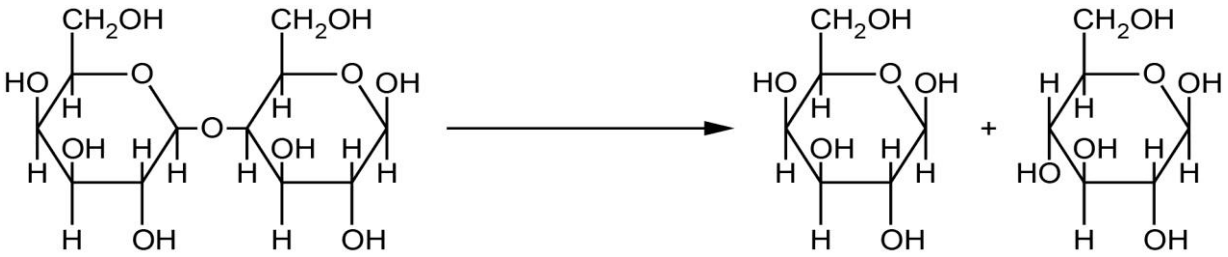
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..... **[1]**

18 Milk contains lactose. Lactose cannot be absorbed in the small intestine.

The intestinal cells of mammalian infants produce lactase, an enzyme that splits lactose into the monosaccharides galactose and glucose. These monosaccharides can pass into the blood.

The image shows a molecule of the disaccharide lactose and the products of its breakdown in digestion.



Lactose Galactose Glucose

(a)

(i) Suggest why galactose and glucose cannot pass through the plasma membrane into intestinal cells by simple diffusion.

…… **[1]**

(ii) Identify **two** substances that are required to break the glycosidic bond in lactose.

1 ……

2 ……

[1]

(b) A gene codes for the production of lactase. This gene is normally switched off after an infant moves to adult food. Almost all adult mammals are unable to digest lactose. They are said to be lactose intolerant. Humans are an exception.

Most humans have a genetic mutation that prevents the shutdown of lactase production.

State the feature of polypeptide structure that is altered by gene mutations.

…… **[1]**

(c) Some humans are lactose intolerant. Milk can be treated with lactase to reduce the concentration of lactose. Fresh milk is passed over lactase molecules immobilised on a suitable matrix.

Give **two economic** advantages of immobilising enzymes for large-scale production.

1 ……

2 ……

[2]

(d) The mean levels of human lactose intolerance vary in different parts of the world.

The table shows the contrasting levels of lactose intolerance in two ethnic groups from different parts of the world.

Population	**Frequency of lactose intolerance *phenotype***
Europeans	0.05
Australian aborigines	0.97

The Hardy–Weinberg principle states that:

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

where p is the frequency of the dominant allele and q is the frequency of the recessive allele in a population.

The lactose intolerance allele is recessive.

The allele that prevents lactose intolerance is dominant.

Calculate the frequency of the heterozygous genotype in the Australian aborigine population.

Frequency = ... **[2]**

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(e)* Read the following statements.

- Mutations preventing lactose intolerance have occurred in humans around the world many times throughout history.
- The domestication of large milk-producing mammals like goats and cattle arose in Europe and parts of Africa 5000 to 10000 years ago.
- The lowest levels of lactose intolerance are found in areas where a large proportion of the population are of European descent.
- The ability of agricultural populations to digest the milk of animals is advantageous. It adds to their general nutrition.
- Until recent times Australian aborigines had been isolated on their island continent for around 50000 years.

Suggest how the lactose intolerance phenotype came to be present in only 5% of a population like the Europeans, but present in 97% of the Australian aborigines.

Use the information given above and knowledge of Darwin's theory of evolution by natural selection.

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Extra answer space if required.

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(f) An Iron Age farm was excavated by archaeologists. A DNA sample was recovered from the tooth of an animal thought to be a type of domesticated cow.

A farmer keeps rare breed cows similar to those farmed in the Iron Age. A DNA from a cow was obtained.

Name a technique that could be used to compare the DNA fragments from the two samples.

…… **[1]**

19 Laboratory techniques can be used to provide information about a patient's health.

(a) A patient has been coughing blood. It is suspected that bacteria will be found in the blood.

A medical technician cultures the blood on an agar plate.

State **two** precautions the technician should take to keep the agar plate culture sterile.

1 ……

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2 ……

……

[2]

(b) Tissue traces from a crime scene often need to be amplified by the polymerase chain reaction (PCR) to get samples large enough for further analysis.

Modern PCR technique uses DNA polymerase from the bacterium *Thermus aquaticus*.

Explain why this enzyme is chosen.

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…… **[2]**

(c) Valine, citrulline, hydroxyproline and glutamic acid are amino acids that are normally found in considerable amounts in urine. Following certain diets can result in a change in the amino acids present in the urine of some people.

Outline a method to compare the amino acids present in the urine of a person who has been following one of these diets with that of a person who has not.

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…… **[3]**

20 The European corn borer moth is considered a pest by farmers. Its larvae develop inside the stems of corn plants and eat the contents. This weakens the stems so that the plants collapse.

The bacterium *Bacillus thuringiensis* (Bt) produces a protein that poisons the larvae of moths and butterflies. This protein can be isolated from cultures of Bt and packaged in fluids, called Bt toxin, to be sprayed on the surface of plants.

The gene coding for the toxic protein has also been isolated. It has been incorporated into a genetically modified strain of corn plant called Bt corn. This makes the plant tissues poisonous to the corn borer moth.

(a) An article suggests:

'Genetically modified plants and animals should be classed as new species'.

Outline **one** investigation that would provide evidence to support or contradict the statement.

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…… **[3]**

(b) A farmer wants to increase the yield of corn.

They consider using two different methods:

1. Planting genetically modified Bt corn
2. Spraying unmodified corn with Bt toxin.

State **one** advantage of choosing method 1.

……

…… **[1]**

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(c)* Some students investigate different ways of protecting corn plants against the corn borer moth.

This is the method they use.

Set up three square plots close together in the same field. In each plot, plant several hundred corn seedlings.

Plot A: plant unmodified corn plants and do not treat (control).

Plot B: plant unmodified corn plants and spray daily with Bt toxin.

Plot C: plant genetically modified Bt corn and do not treat.

On the first day of each week, one student walks around the edge of a plot and counts the number of corn plants that have collapsed in that plot. Each plot has one student responsible for counting.

The results are shown in the table.

	Number of corn plants collapsed since the last weekly count		
Week number	**Plot A**	**Plot B**	**Plot C**
1	0	0	1
2	0	0	0
3	18	22	21
4	0	0	0
5	5	1	0
6	14	11	12
7	5	2	1
8	12	0	1
9	17	1	0
10	30	6	0
11	32	13	1
12	41	17	0
13	38	26	1
14	47	31	1
15	50	44	2
16	49	47	0

A teacher raises the following concerns about the investigation:

- The methods are not a valid test of what is being investigated
- The results may not be accurate
- Some variables are not controlled.

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Explain why these concerns are justified.

Suggest improvements to the investigation.

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Extra answer space if required.

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(d) Many plants can produce clones of themselves. Gardeners and farmers take advantage of this natural process by taking cuttings.

When a genetically modified plant is created, it may be cloned into many plantlets in a process called micropropagation.

Compare the equipment and techniques of taking cuttings with those used for micropropagation.

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…… **[2]**

21 This question is about ecosystems in the Southern (Antarctic) Ocean.

(a) This food chain occurs in the Southern Ocean:

Phytoplankton (producers) → Krill (shrimps etc.) → Small fish → Large fish → Seals

The table shows the transfers of energy and the quantities of energy stored as biomass for the food chain.

	Phyto-plankton	**Krill**	**Small fish**	**Large fish**	**Seals**
Energy input, by photosynthesis or feeding ($kJm^{-2}y^{-1}$)	900	80	11	1.4	
Energy lost to surroundings by respiration ($kJm^{-2}y^{-1}$)	180	64	8.8	1.2	0.105
Energy converted to biomass ($kJm^{-2}y^{-1}$)	720	16	2.2	0.2	0.005
Biomass energy lost to other consumers or decomposers ($kJm^{-2}y^{-1}$)	640	5	0.8	0.09	0.005

(i) For larger and less numerous organisms, such as seals, it is more appropriate to record energy transfers per square kilometre.

Calculate the energy input by feeding for the seal population.

Give your answer in kilojoules per square **kilometre** of sea surface per year.

Energy transfer = …… Unit = …… **[2]**

(ii) Calculate the percentage of energy stored in large fish biomass that is converted to energy in seal biomass.

Percentage energy stored = …… **[2]**

(b)

(i) The biomass of large fish in the Southern Ocean is a food resource for humans. It is increasingly harvested by powerful, long-distance fishing boats. If over-exploited, the Southern Ocean ecosystem may be permanently damaged.

Suggest **two** measures that an international treaty might impose, to prevent fishing from causing permanent damage to the Southern Ocean.

Identify the practical difficulties that might stop these measures being effective.

Measure 1 ……..

……

Difficulty 1 ……

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Measure 2 ……..

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Difficulty 2 ……

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[4]

(ii) Krill can also be harvested as a food source for humans.

The fishing industry aims to harvest large fish.

Some environmentalists say that krill harvesting should be increased.

Use this information and the table in part **(a)** to suggest **one** argument for **and one** argument against harvesting krill instead of large fish as a food source for humans.

Argument for …….

……

Argument against ...…….

……..

[2]

22 A small, permanent pond is the habitat for a climax community of producers (aquatic plants and algae) and consumers (bacteria, protoctista, worms, snails, arthropods and small vertebrates like newts and fish).

(a) Suggest why ecologists call this a climax community.

……

…… **[1]**

(b) The protoctist *Paramecium caudatum* is usually between 200 and 300 μm in length. An accurate measurement would help in the correct identification of a specimen from this pond.

State the laboratory equipment you would use to make an accurate measurement of the length of *P. caudatum*.

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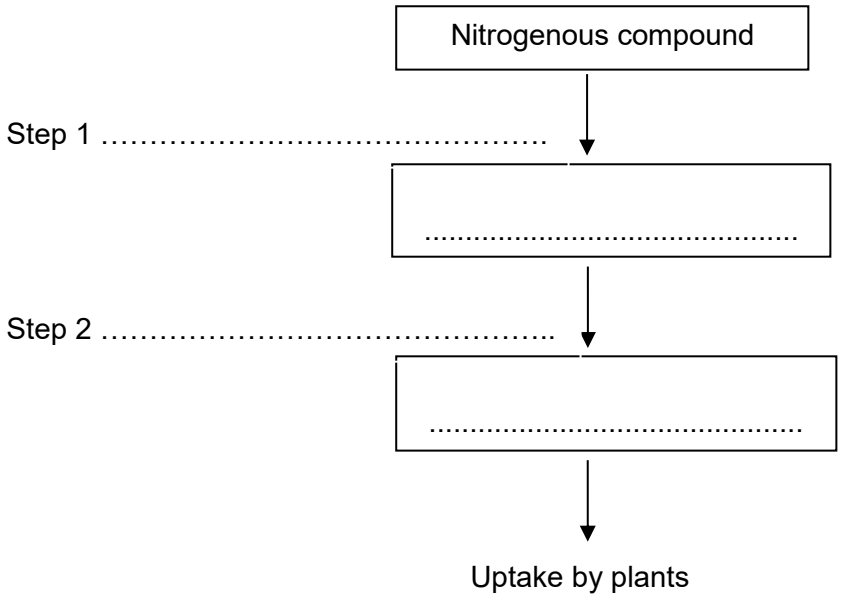
…… **[2]**

(c) An animal fell into the pond. It drowned and decayed. Within a year the biological compounds in its body had been completely recycled.

(i) Name the nitrogenous excretory molecule that passes from the decomposers to the next stage of the nitrogen cycle.

…… **[1]**

(ii) Complete the flow chart to show what this nitrogenous compound is converted into **and** name the groups of bacteria involved at steps 1 and 2.



[4]

END OF QUESTION PAPER

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