

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

Date – Morning/Afternoon

Version 2.2

Time allowed: 2 hours 15 minutes

You may use:

- a scientific or graphical calculator



First name

Last name

Centre
number

Candidate
number

INSTRUCTIONS

- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION

- The total mark for this paper is **100**.
- The marks for each question are shown in brackets [].
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **28** pages.

SECTION A

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

Answer **all** the questions.

- 1** If a person is bitten by a venomous snake, the immediate treatment is normally to inject the person with the appropriate antibodies.

This is an example of which type of immunity?

- A** artificial active immunity
- B** artificial passive immunity
- C** natural active immunity
- D** natural passive immunity

Your answer

[1]

- 2** What is an operon?

- A** The binding site for a repressor protein.
- B** Any group of genes responsible for the metabolism of lactose in prokaryotes or eukaryotes.
- C** A cluster of genes under the control of a promoter.
- D** A regulatory gene.

Your answer

[1]

- 3** Which statement correctly describes a difference between somatic and germ line gene therapy?

- A** Germ line therapy involves the use of liposomes; somatic therapy involves use of viral vectors.
- B** Somatic therapy can target specific tissues in need of treatment, germ line therapy cannot.
- C** Somatic therapy is most successful when targeting single gene defects, but germ line therapy can target multiple defects.
- D** Long term success is theoretically more likely with somatic cell therapy than germ line therapy.

Your answer

[1]

- 4 Selection pressure can affect homozygous individuals. The effect can be investigated using a model gene pool.

A large gene pool is necessary to ensure that

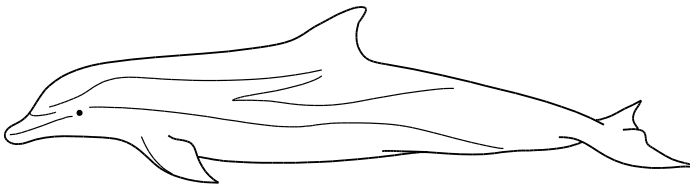
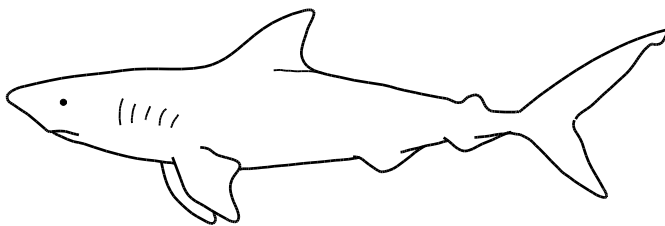
- A genetic drift can occur if frequency is higher.
- B homozygous individuals are present in high frequency.
- C the effect of chance variations in gene frequencies are minimised.
- D Hardy–Weinberg equilibrium is achieved.

Your answer

[1]

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

shark (fish)



dolphin (mammal)

What is this an example of?

- A convergent evolution
- B divergent evolution
- C disruptive selection
- D stabilising selection

Your answer

[1]

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

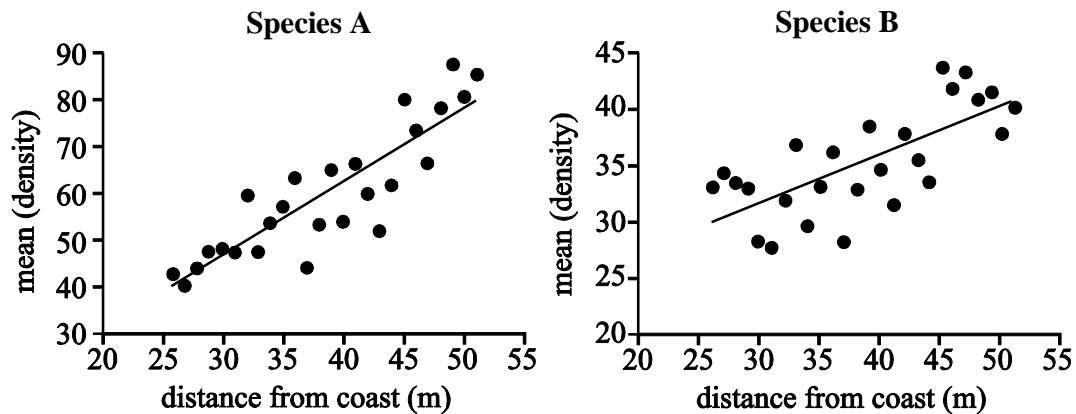
Select the row that shows the correct uses for all the types of microscope.

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

Your answer

[1]

- 7 The graphs below show the density of two different plant species as proximity to the coast changes.



Which of the following statements correctly describes one aspect of the technique used to collect these data?

- A Quadrats were randomly placed using a random number generator and coordinates.
- B Larger quadrats were required for **species A** because their mean density was higher.
- C A belt transect has been used to allow calculation of density.
- D Abiotic factors were measured at every point of quadrat sampling.

Your answer

[1]

8 Immobilised enzymes can be produced by which of the following methods?

- A binding enzyme to a soluble matrix
- B intermolecular hydrogen bonding of enzymes
- C absorbing enzymes onto the surface of a gel
- D enclosing enzymes within a partially permeable membrane

Your answer

[1]

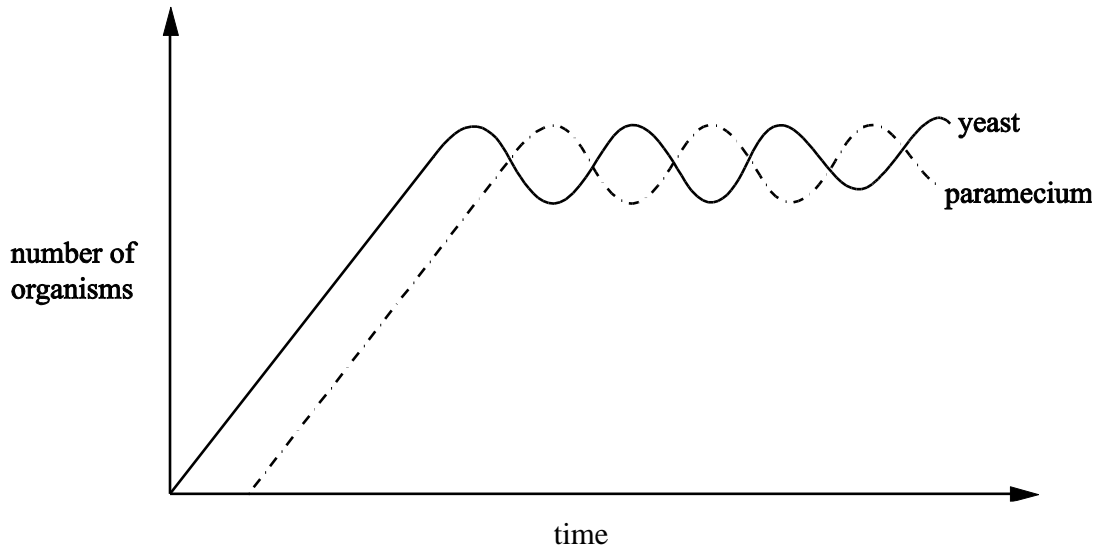
9 Which of the following statements describes an organelle which is **not** membrane bound?

- A contains cristae
- B modifies and packages proteins
- C contains digestive enzymes
- D is made of rRNA and protein

Your answer

[1]

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



Which **one** of the following statements best describes the relationship between the two organisms?

- A The *Paramecium* and yeast populations are complementary to each other.
- B The yeast thrives in the relationship at the expense of the *Paramecium* population.
- C The *Paramecium* feeds on the yeast and reduces the number in the yeast population.
- D The two populations are in equilibrium and stable due to a type of negative feedback.

Your answer

[1]

11 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 The embryo develops into a mature egg, which is incubated.
- 3 A somatic cell from the tortoise is defrosted and the nucleus is removed.
- 4 Electrofusion of the host cell and new nucleus.
- 5 The somatic cell nucleus is inserted into the enucleated oocyte.
- 6 The transformed egg divides *in vitro*.

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

- A** 1, 3, 4, 5, 6, 2
- B** 3, 5, 1, 4, 2, 6
- C** 1, 6, 3, 5, 4, 2
- D** 3, 1, 5, 4, 6, 2

Your answer

[1]

- 12** A number of events occur for a new species to emerge in a population.

Which of the following statements correspond to events that are involved in the formation of a new species?

Statement 1: Gene mutation.

Statement 2: Selection pressure.

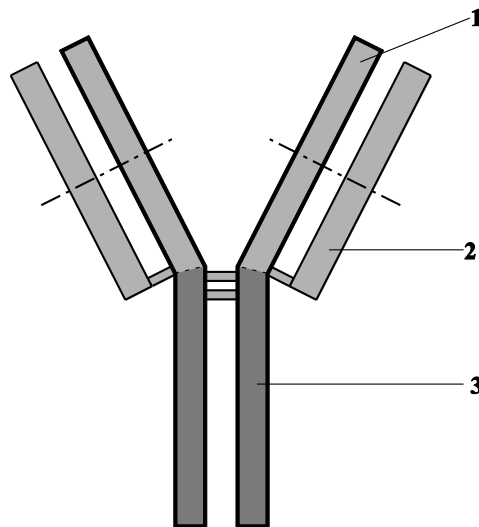
Statement 3: A change in the environment.

- A** 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

[1]

- 13** The diagram represents the general structure of an antibody.



Which of the following numbered part(s) of the diagram represent the part of the antibody that has the same sequence of amino acids in all antibodies?

- A** 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

[1]

- 14** The following statements are about the structure of DNA.
Which of the following statement(s) is/are true?

Statement 1: Purine bases pair with pyrimidine bases.

Statement 2: Phosphodiester bonds link adjacent nucleotides.

Statement 3: There are always equal amounts of adenine and guanine.

- A** 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

[1]

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

Which of the following statement(s) about these ecosystems is/are true?

Statement 1: The temperature of the vents influences the organisms that live there.

Statement 2: A predatory octopus would affect the balance of these organisms.

Statement 3: The number of eyeless shrimp found at each vent is constant.

- A** 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

[1]

SECTION B

Answer **all** the questions.

16 There will be outbreaks of new infectious diseases in the future. They will arise from mutations in the genomes of existing organisms. The mutating organisms may not at present be pathogenic, or they may be animal pathogens that mutate to become able to infect humans.

(a) What feature of a pathogen such as *Mycobacterium tuberculosis* 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 helper T cells act to speed up these processes.

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..... [2]

- (c) **Fig. 16.1** 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’.

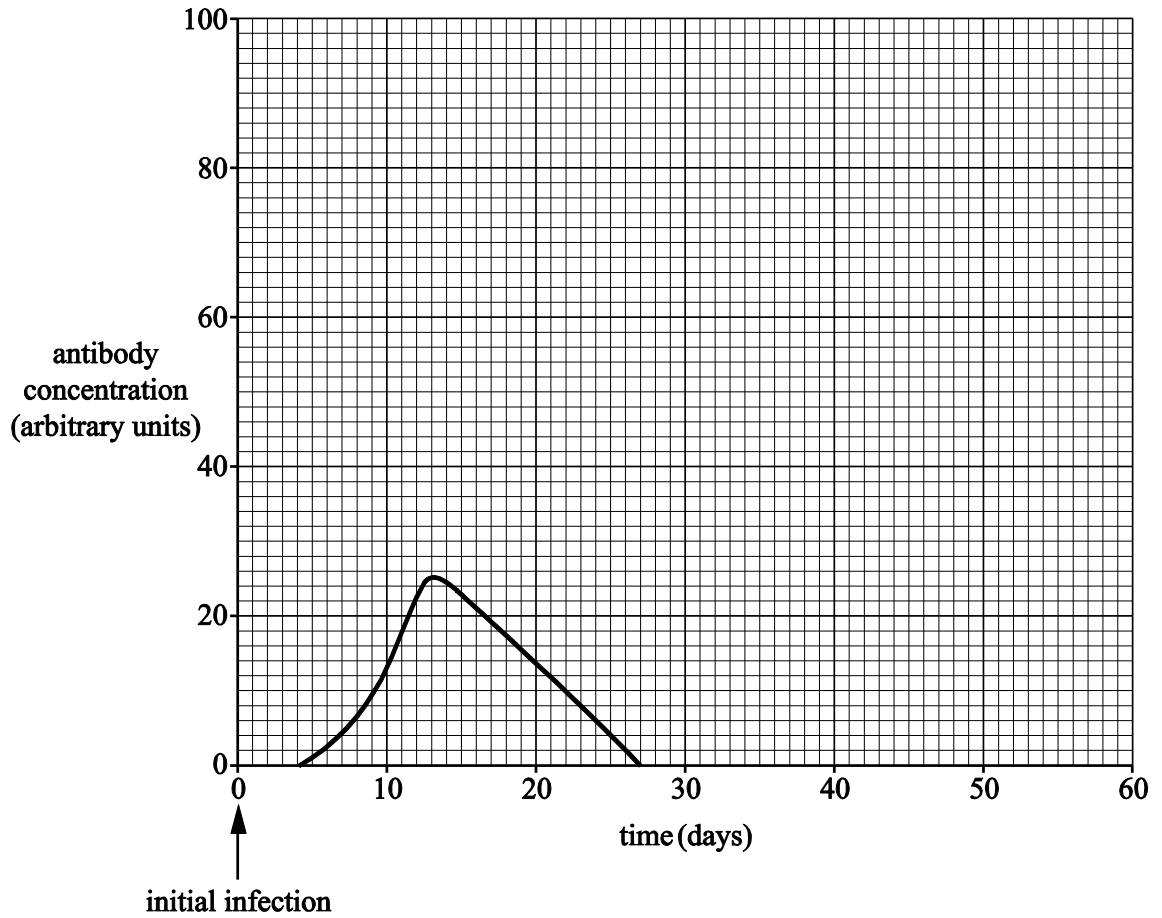


Fig. 16.1

- (i) On day 30, this individual was again infected with the same pathogen. Sketch a line **on Fig. 16.1** 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.

.....

.....

..... [2]

- (d) (i) It takes time for an effective vaccine to be prepared in quantity for a new strain of bacterium.

List two vulnerable groups of people for whom you would advise doctors to prescribe antibiotics although they are **not** yet showing symptoms of the new disease.

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..... [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 *Sus scrofa*, sometimes called the ‘wild boar’.

(a) (i) In Table 17.1

- number the levels in the correct sequence and
- complete the name column.

Sequence of levels	Level	Name
.....	Order	Artiodactyla
.....	Species
.....	Family	Suidae
1	Kingdom
.....	Genus
.....	Phylum	Chordata
.....	Class	Mammalia

Table 17.1

[4]

(ii) We now have DNA evidence of how organisms are related to each other. This evidence has helped biologists to construct a second classification viewpoint: the Domain system.

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

.....

.....

[1]

(b) In domesticated, farmed pigs, 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 (dermis), **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 both traits, tail and skin. Use the letters given above.

parental genotypes

gametes

F₁ offspring genotypes

.....

offspring phenotypes

.....

phenotype ratio

.....

[5]

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

.....

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[1]

- (c) A pig farmer crossed one group of pigs, heterozygous for both traits, with another group homozygous recessive for both traits. The farmer expected to get roughly equal numbers of each of the four possible mixtures of tail and skin phenotype. The results that actually occurred are shown in **Table 17.2**.

Phenotype	Observed, <i>O</i>	Expected, <i>E</i>			
curly pink	20	26			
curly black	30	26			
straight pink	21	26			
straight black	33	26			

Table 17.2

- (i) The farmer thought from these results that the two genes might be autosomally linked.

Calculate χ^2 . (You may wish to use **Table 17.2** to write figures for steps in your calculation process.)

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

Answer..... [3]

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

Use your calculation and **Table 17.3** to justify whether the farmer’s conclusion can be supported or not.

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

Table 17.3

.....

 [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 glucose and galactose. These monosaccharides can pass into the blood.

Fig. 18.1 shows a molecule of the disaccharide lactose and the products of its breakdown in digestion.

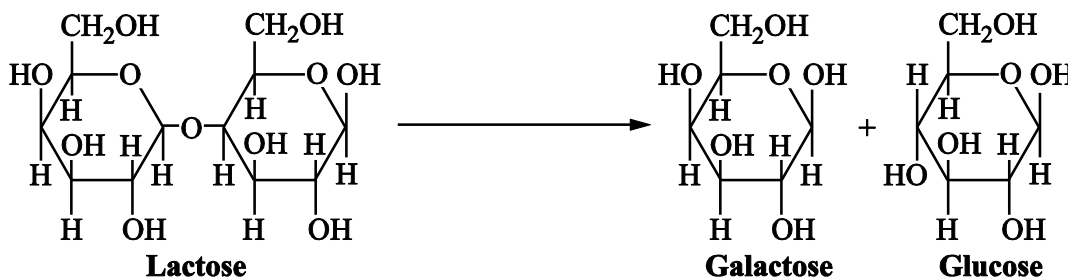


Fig. 18.1

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

..... [1]

- (ii) What two substances 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 what structural detail of a polypeptide is altered by gene mutations.

..... [1]

- (c) Some humans are lactose intolerant. Milk can be treated with lactase to reduce the concentration of lactose present. 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.

Table 18.1 shows the contrasting levels of lactose intolerance in two ethnic groups from different parts of the world.

Population	Frequency of lactose intolerance <i>phenotype</i>
Europeans	0.05
Australian aborigines	0.97

Table. 18.1

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 the genotypes of a population.

The lactose intolerance allele is recessive to the mutant allele, which **prevents** lactose intolerance.

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

Frequency = [2]

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Additional answer space if required.

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

A farmer keeps rare breed cows similar to those farmed on the Iron Age farm. DNA from the cows was obtained.

What technique would you plan to use, to compare digested and amplified fragments from the two DNA samples?

..... [1]

19 Laboratory techniques are used by workers in various professions, and by scientists.

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

A medical technician cultures the blood on an agar plate. What measures should the technician take to keep the agar plate culture sterile?

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..... [2]

(b) Tissue traces from a crime scene often need to be identified. DNA from the tissue is ‘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*. Why is this enzyme 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.

Plan 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, *Ostrinia nubilalis*, is a pest of agriculture. Its larvae develop inside maize stems and eat the contents, weakening 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 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 maize called Bt corn. This makes the plant tissues poisonous to the corn borer moth.

(a) Consider the statement:

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

Outline **one** experiment or 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 maize.

A friend recommends planting genetically-modified Bt corn as it would be more effective against European corn borer larvae rather than spraying unmodified corn with Bt toxin.

Which method would you recommend to the farmer? Justify your answer.

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.....

[1]

(c)* Some students investigated the different ways of protecting maize plants against the corn borer moth. In each of **three** separate but close-together square plots, in the same field, they planted several hundred maize seedlings.

Plot A: untreated (control).

Plot B: sprayed daily with Bt toxin.

Plot C: the seedlings planted were genetically modified Bt corn.

On the first day of each week, one student would walk around the edge of a plot and count the number of maize plants that had collapsed in that plot. Each plot had a student responsible for counting. The results are shown in **Table 20.1**.

Number of maize 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

Table 20.1

The students' tutor raised a number of concerns about the investigation. In summary:

- **The methods were not a valid test of what was being investigated.**
- **The results may not be accurate.**
- **Some variables were not controlled.**

Explain why these concerns are justified and suggest improvements to the investigation.

[6]

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Additional answer space if required.

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- (d) Many plants can produce natural 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 the process called micropropagation.

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

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

(a) Observe the food chain:

phytoplankton (producers) → krill (shrimps etc.) → small fish → large fish → seals

Table 21.1 shows the transfers of energy and the quantities of energy stored as biomasses for the food chain. Magnitudes are given in kilojoules per square metre of sea surface per year.

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

Table 21.1

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

Calculate the energy input to the seal population from large fish. Record your answer in kilojoules per square **kilometre** of sea surface per year.

Answer..... [2]

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

Answer..... [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 trawlers. If over-exploited, the Southern Ocean ecosystem may be permanently altered.

- 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 prevent your two measures from being effective.

First measure.....

.....

Difficulty.....

.....

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Second measure.....

.....

Difficulty.....

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[4]

(b) (ii) Krill can also be harvested as a human food source.
The fishing industry aims to harvest large fish.
Some environmentalists say that krill harvesting should be increased.

Use this information and **Table 21.1** to put forward arguments for and against harvesting krill instead of large fish as a human food source.

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[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) Why might 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.

What laboratory equipment would you select to make an accurate measurement of the length of *Paramecium caudatum*?

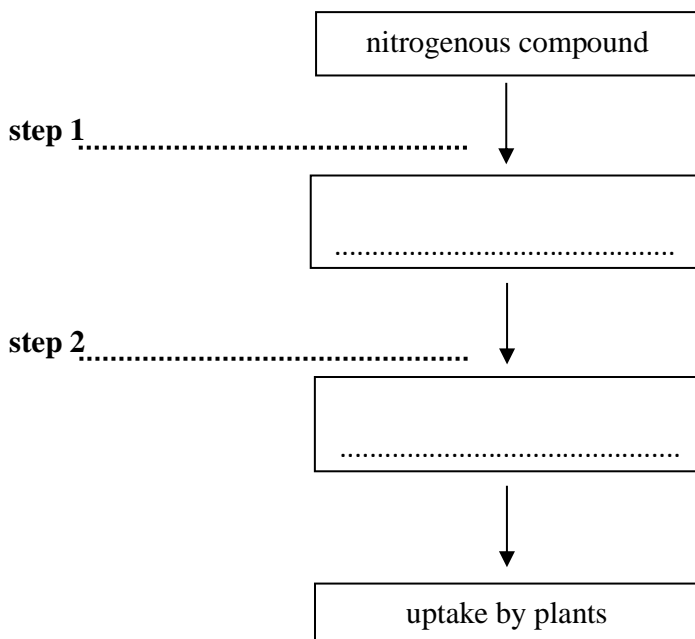
.....
..... [2]

(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) What nitrogenous excretory molecule from the decomposers would pass to the next stage of the nitrogen cycle?

..... [1]

(ii) Complete the flow chart to show what happens to this nitrogenous compound, and name the groups of bacteria involved at steps 1 and 2, as it is converted to a form that plants can take up and use.



[4]

END OF QUESTION PAPER

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...day June 20XX– Morning/Afternoon

A Level Biology A

H420/02 Biological diversity

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100



This document consists of 22 pages

MARKING INSTRUCTIONS**PREPARATION FOR MARKING****SCORIS**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal <http://www.rm.com/support/ca>
3. Log-in to scoris and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
- where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
 - if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.
6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.
7. There is a NR (No Response) option. Award NR (No Response)
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.
- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.
- To select a mark within the level, consider the following:

Higher mark: A good match to main point, including communication statement (in italics), award the higher mark in the level

Lower mark: Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

Level of response questions on this paper are **18(e)** and **20(c)**.

11. Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Section A

Question	Answer	Marks	Guidance
1	B	1	
2	C	1	
3	B	1	
4	C	1	
5	A	1	
6	C	1	
7	C	1	
8	D	1	
9	D	1	
10	D	1	
11	D	1	
12	A	1	
13	C	1	
14	B	1	
15	B	1	
	Total	15	

Section B

Question		Answer	Marks	Guidance
16	(a)	(shape of), proteins / glycoproteins / glycocalyx / antigens of the <u>plasma</u> / <u>cell</u> surface, membrane ✓	1	Look for (change to) that aspect of antigenic configuration that the immune system would recognise as foreign.
	(b) (i)	<i>three from</i> B cells / lymphocytes, have, <u>antigen</u> receptor / carry <u>antibody</u> , on surface, specific / complimentary to, only one <u>antigen</u> ✓ selected / activated, B cell, proliferates / clones / divides by mitosis ✓ forms / differentiates into, plasma / effector, cells ✓ which secrete antibodies specific / complementary, to <u>antigen</u> ✓	3	
	(ii)	<i>two from</i> (helper T cells) stimulated by antigen-presenting cells ✓ release, cytokines / interleukin 2 ✓ stimulate B-cell, proliferation / mitosis / clonal expansion ✓	2	
	(c) (i)	<i>Drawn line should show:</i> higher peak and steeper initial rise ✓ line departs x axis between days 30 and 33 and concentration at 60 days above peak of printed line ✓	2	Peak should be at least 40 AU. ALLOW if nearly vertical. DO NOT ALLOW if actually vertical. ALLOW line start at 30 or 33 days.
	(ii)	<i>one from</i> (memory cells) not acting in, first line / primary response ✓ (memory cells) remained in blood after primary response ✓ <i>one of the above linked to</i> so no wait for / faster, clonal selection ✓	2	

Question		Answer	Marks	Guidance
	(d) (i)	<p><i>two from</i> babies / infants ✓ elderly / infirm ✓ immuno-compromised / on immunosuppressant drugs / HIV positive ✓ known to have been exposed (to the infection) ✓</p>	2	
	(ii)	<p><i>two from</i> (antibiotic is) <u>selective pressure</u> ✓ (bacterial) gene pool / AW, has <u>variation</u> ✓ (only) some bacteria have resistance / some bacteria are more resistant than others ✓ <i>two from</i> when exposed (to antibiotic) most-resistant survive ✓ surviving bacteria continue to reproduce to make a resistant population ✓ <i>idea that</i> over many generations there is an increase in proportion of resistant bacteria (under continued antibiotic pressure) ✓ antibiotic becomes ineffective / new antibiotic needed ✓</p>	4	IGNORE increase in number of resistant bacteria.
Total			16	

Question			Answer	Marks	Guidance																								
17	(a)	(i)	<table border="1"> <thead> <tr> <th>Sequence of Levels ✓</th> <th>Level</th> <th>Name</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>Order</td> <td>Artiodactyla</td> </tr> <tr> <td>7</td> <td>Species</td> <td>scrofa ✓</td> </tr> <tr> <td>5</td> <td>Family</td> <td>Suidae</td> </tr> <tr> <td>1</td> <td>Kingdom</td> <td>Animal(ia) ✓</td> </tr> <tr> <td>6</td> <td>Genus</td> <td>Sus ✓</td> </tr> <tr> <td>2</td> <td>Phylum</td> <td>Chordata</td> </tr> <tr> <td>3</td> <td>Class</td> <td>Mammalia</td> </tr> </tbody> </table>	Sequence of Levels ✓	Level	Name	4	Order	Artiodactyla	7	Species	scrofa ✓	5	Family	Suidae	1	Kingdom	Animal(ia) ✓	6	Genus	Sus ✓	2	Phylum	Chordata	3	Class	Mammalia	4	<p>One mark for level numbers all correct in Column 1.</p> <p>DO NOT ALLOW if scrofa is given capital S.</p> <p>ALLOW “Animals”</p> <p>DO NOT ALLOW if Sus is given lower-case initial s.</p>
			Sequence of Levels ✓	Level	Name																								
			4	Order	Artiodactyla																								
			7	Species	scrofa ✓																								
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3	Class	Mammalia																											
(ii)	science knowledge / it, advances / improves / grows / AW ✓	1	“Develop” is in the question.																										
(b)	(i)	<p><i>parental genotypes</i> TtDd TtDd ✓</p> <p><i>gametes</i> TD, Td, tD, td, (TD, Td, tD, td) ✓</p> <p><i>offspring genotypes</i> TTDD TtDD TTdd TtDd TTdd ttDD ttDd ttdd ✓</p> <p><i>offspring phenotypes</i> curly/pink curly/black straight/pink straight/black ✓</p> <p><i>phenotype ratio</i> 9:3:3:1 ✓</p>	5	<p>ALLOW alternative letters only if clear key given.</p> <p>Mark each line independently but offspring phenotypes must be correctly linked to genotype.</p> <p>ALLOW phenotypes and genotypes in Punnett squares.</p>																									

Question		Answer					Marks	Guidance																																				
	(ii)	higher proportion, heterozygous / like parents OR <u>alleles</u> not completely re-mixed / AW ✓					1	DO NOT ALLOW genes.																																				
(c)	(i)	<table border="1"> <thead> <tr> <th>Phenotype</th> <th>O</th> <th>E</th> <th>O - E</th> <th>(O - E)²</th> <th>$\frac{(O - E)^2}{E}$</th> </tr> </thead> <tbody> <tr> <td>curly pink</td> <td>20</td> <td>26</td> <td>6</td> <td>36</td> <td>1.38</td> </tr> <tr> <td>curly black</td> <td>30</td> <td>26</td> <td>4</td> <td>16</td> <td>0.62</td> </tr> <tr> <td>straight pink</td> <td>21</td> <td>26</td> <td>5</td> <td>25</td> <td>0.96</td> </tr> <tr> <td>straight black</td> <td>33</td> <td>26</td> <td>7</td> <td>49</td> <td>1.88</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>✓</td> <td>✓</td> </tr> </tbody> </table> <p style="text-align: center;">$\chi^2 = 4.84$ ✓</p>					Phenotype	O	E	O - E	(O - E) ²	$\frac{(O - E)^2}{E}$	curly pink	20	26	6	36	1.38	curly black	30	26	4	16	0.62	straight pink	21	26	5	25	0.96	straight black	33	26	7	49	1.88					✓	✓	3	<p>Correct answer with no working shown = 3 marks.</p> <p>ALLOW correct answer in the working if the answer line is left blank.</p> <p>If O - E incorrect, allow ecf for (O - E)² line only</p> <p style="text-align: center;">If (O - E)² incorrect, allow ecf for $\frac{(O - E)^2}{E}$ line only</p>
Phenotype	O	E	O - E	(O - E) ²	$\frac{(O - E)^2}{E}$																																							
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				✓	✓																																							
	(ii)	(conclusion cannot be supported because results) not significantly different from expected (at 95% confidence) ✓					1	<p>ALLOW not significant.</p> <p>IGNORE 'farmer wrong', 'due to chance'.</p> <p>ALLOW ecf from incorrect chi-square result.</p>																																				
Total						15																																						

Question			Answer	Marks	Guidance
18	(a)	(i)	too large / not fat soluble ✓	1	IGNORE 'no channels'
		(ii)	<u>water</u> / <u>H₂O</u> , and , lactase / enzyme ✓	1	Mark the first two answers. If they are correct and any other word is written that is incorrect or contradicts the correct answer then 0 marks . DO NOT ALLOW H ₂ O with incorrect case or subscript IGNORE refs to pH, buffers, hydrocarbonate etc.
	(b)		sequence / order, of amino acids ✓	1	ALLOW primary structure.
	(c)		<i>two from</i> (enzymes) re-used so less, money / cost (for new ones) ✓ downstream processing / purifying, cost / expense , reduced ✓ (higher temperature allows) more profit from faster yield ✓	2	Mark the first answer on each prompt line. If the prompt numbers are ignored, mark the first two answers as prose. Answers must refer to reduced cost / losses / expense, or increased profit. ALLOW ORA for any point if clearly stated IGNORE 'more economic' in general e.g. 'Continuous processing is more economic'. Look for the details listed.
	(d)		0.04 ✓✓	2	ALLOW correct answer in the working if the answer line is left blank. If the answer is 0.03, award 2 marks for rounding from calculations using more than 2 decimal places. If the answer is incorrect, award 1 mark for (2pq =) 2 x 0.02 x 0.98. If the answer is not given to 2 decimal places, max 1 mark .

Question	Answer	Marks	Guidance
(e)*	<p>Level 3 (7–9 marks) Extensive reference has been made to the (pre-) historical circumstances of both populations. Inferences have been clearly drawn in terms of natural selection. Learner demonstrates a holistic grasp of the Darwinian theory and the information given; reaching reasoned conclusions that explain how the different phenotypic frequencies occurred.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (4–6 marks) Reference has been made to the (pre-) historical circumstances of both populations. Some inferences have been drawn in terms of natural selection. There is partial structuring of the ideas with the connections between Darwinian theory and information generally clear. Conclusions are used to explain how the different phenotypic frequencies occurred.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i></p> <p>Level 1 (1–3 marks) Reference has been made to the (pre-) historical circumstances of at least one of the populations. At least one inference has been stated in terms of natural selection.</p>	9	<p>Indicative scientific principles may include:</p> <p>Europeans:</p> <ul style="list-style-type: none"> • (pre-agricultural) gene pool/genetic variation, included mutant / non-intolerance, <u>allele</u> • availability of milk acted as (positive) <u>selection pressure</u> • individuals / groups, with mutant / non-intolerance, allele had better, chance of survival / success in reproduction • <u>directional selection</u> • mutant / non-intolerance, allele accumulated (in gene pool) • <u>genetic drift</u> (in small prehistoric population) • mutant / non-intolerance, <u>allele</u> is dominant • so expressed in heterozygotic individuals (increasing phenotype frequency). <p>Australian aborigines:</p> <ul style="list-style-type: none"> • ancestral population pre-agricultural • so no selection for mutant / non-intolerance, allele • no suitable mammals to domesticate / milk • island, so no borders for suitable mammals to come in • no contact / breeding, with non-Aboriginal peoples • no <u>gene flow</u> (from other human populations) • no <u>selection pressure</u> • to increase mutant / non-intolerance, allele / phenotype, frequency.

Question		Answer	Marks	Guidance
		<p>The ideas expressed are poorly structured but some relevant points are made.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>		
	(f)	<u>electrophoresis</u> ✓	1	
Total			17	

Question		Answer	Marks	Guidance
19	(a)	<p><i>two from</i> work in an inoculating cabinet / maintain minimum plate-opening time ✓ flame inoculating loop / use sterile, pipette tip / implement of transfer ✓ seal the plates for incubation ✓</p>	2	<p>IGNORE refs to safety – question is about sterile practice. IGNORE autoclave, irradiation etc., as done before technician gets sample.</p>
	(b)	<p><u>thermostable</u> OR does not, denature / AW, at <u>95 °C</u> (during DNA strand separation) ✓ so PCR can be cycled repeatedly without stopping (to reload with enzyme) ✓</p>	2	<p>ALLOW temperature values 93 – 97 °C in correct context. DO NOT ALLOW “killed” for denatured. IGNORE refs to optimum working temperature, which would apply equally to less thermostable polymerases.</p>
	(c)	<p><i>three from</i> (paper) <u>chromatography</u> ✓ Set, blots / AW, of the two (urine) samples ✓ separate / AW, with (aqueous / hydrophilic) solvent ✓ (use a) stain / ninhydrin to visualise the spots ✓ compare patterns (of separated components / colours) ✓</p>	3	<p>Max 2 marks if chromatography is not mentioned. IGNORE further detail of blot placement.</p> <p>The idea of overall pattern is wanted here, not just “compare colours, streaks” etc.</p>
Total			7	

Question		Answer	Marks	Guidance
20	(a)	<p><i>Fertility</i> breed GM stock with non-modified stock ✓ see if offspring fertile ✓ if so they should be classed as the same species ✓ ora</p> <p><i>Morphology</i> Compare several individuals from GM and non-GM groups ✓ in respect of several physical structures ✓ if similar they should be classed as one species ✓ ora</p> <p><i>Ecology</i> observe how both function in the wild ✓ occupy the same or different <u>niche(s)</u> ✓ if same niche they should be classed as one species ✓ ora</p> <p><i>Genetics</i> compare DNA ✓ by electrophoresis ✓ same pattern should be classed as one species ✓ ora</p>	3	Marks awarded should be from one outlined investigation and the conclusion from its results. If more than one investigation suggested, mark the first investigation and IGNORE the others.
	(b)	recommend GM Bt corn, because spray may not reach all larvae / larvae are inside plant (stem) / shielded from spray ✓	1	

Question	Answer	Marks	Guidance
(c)*	<p>Level 3 (5–6 marks) A complete explanation detailing objections and improvements for validity, accuracy and control. The evaluation of the data / procedures is critical, providing refinements that address all the significant issues concerned.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) A partial explanation detailing objections and improvements for some of the teachers concerns OR objections and improvements for all of the teachers concerns. A range of aspects of the data / procedures are evaluated resulting in sound but not comprehensive refinements.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) A simple explanation, linking some objections or improvements to some of the teachers concerns. Evaluation and/or refinement, links to data / procedure in some respects but links are not clearly shown.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p>	6	<p>IGNORE professions of agreement with the tutor.</p> <p>Indicative scientific points may include: <u>Results not valid</u> Objections:</p> <ul style="list-style-type: none"> • cause of collapse not recorded / plants may have collapsed for different reasons • number of collapsed less meaningful than percent <p>Improvements:</p> <ul style="list-style-type: none"> • determine which plants collapsed due to corn borer • dissect stems to seek larvae • use percent collapsed out of, original / still standing, numbers. <p><u>Results may not be accurate</u> Objections:</p> <ul style="list-style-type: none"> • collapsed plants may have been counted twice from plot-edge • some collapsed plants may not have been noticed from plot-edge • students may have counted differently from each other <p>Improvements:</p> <ul style="list-style-type: none"> • remove / mark, collapsed when counted • use narrow strips as plots so that collapsed not missed • have all plots counted by the same student • have more than one student counting • average the counts. <p><u>Variables not controlled</u> Objections:</p> <ul style="list-style-type: none"> • no account of natural variation in plant susceptibility • genetic variations between Bt and regular corn <p>Improvements:</p> <ul style="list-style-type: none"> • use, cloned / genetically identical, plants in each plot.

Question		Answer	Marks	Guidance
		<p>0 marks No response or no response worthy of credit.</p>		<ul style="list-style-type: none"> perform genetic modification to Bt on same clones as used for other plots. <p>ALLOW references to repeating the procedure.</p>
	(d)	<p><i>two from</i> cutting needs less / micropropagation needs more, (expensive) equipment ✓ cutting needs less / micropropagation needs more, (expensive) skills / staff / AW ✓ cutting produces less / micropropagation produces more, clone offspring ✓ AVP ✓</p>	2	<p>Answers must be comparative Look for two separate ideas IGNORE refs to time, one or other method may be quicker.</p> <p>e.g. cutting needs less / micropropagation needs more aseptic discipline.</p>
Total			12	

Question			Answer	Marks	Guidance
21	(a)	(i)	110 000 / 1.1×10^5 ✓ kJ km ⁻² y ⁻¹ ✓	2	ALLOW the word or any reasonable symbol for year ALLOW kJ y ⁻¹ km ⁻²
		(ii)	2.5 ✓✓	2	ALLOW correct answer in the working if the answer line is left blank. If answer is incorrect, award 1 mark for $0.005 \div 0.2 \times 100$
	(b)	(i)	<u>Measures</u> fishing quotas ✓ mesh size ✓ species restriction ✓ trawler size / days at sea ✓ penalties / sanctions ✓ monitoring / surveillance ✓ publicity / public education ✓ <u>Difficulties</u> area too large ✓ expense of monitoring ✓ monitoring hampered by, weather / seasons ✓ false reporting of, catches / trawler size / mesh size / days ✓ death of fish caught but not kept (because of restrictions) ✓	4	The difficulties should relate to the measures proposed.
		(ii)	<i>argument for</i> comparison of the energy in large fish and krill shows humans would get 100x more kJ/energy from krill than large fish ✓ <i>argument against</i> would require large change to fishing industry / consumer habits or could impact ecosystem at first trophic level ✓	2	ALLOW the use of figures to illustrate the data comparison.
Total				10	

Question		Answer	Marks	Guidance
22	(a)	(pond community is) final / stable / not subject to further succession ✓	1	IGNORE 'permanent', it is in the rubric.
	(b)	<u>light microscope</u> ✓ <u>graticule</u> ✓	2	
	(c) (i)	urea / uric acid ✓	1	ALLOW ammonia, ammonium (ions).
	(ii)	<u>Nitrosomonas</u> ✓ <u>nitrite</u> ✓ <u>Nitrobacter</u> ✓ <u>nitrate</u> ✓	4	
		Total	8	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions
May 2020	2.1	Updated copyright acknowledgements.
October 2020	2.2	Correction to the values in the 'Seals' column in Table 21.1 of Question 21

