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I declare this is my own work.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 3 Populations and Genes

Thursday 13 January 2022 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use	
Question	Mark
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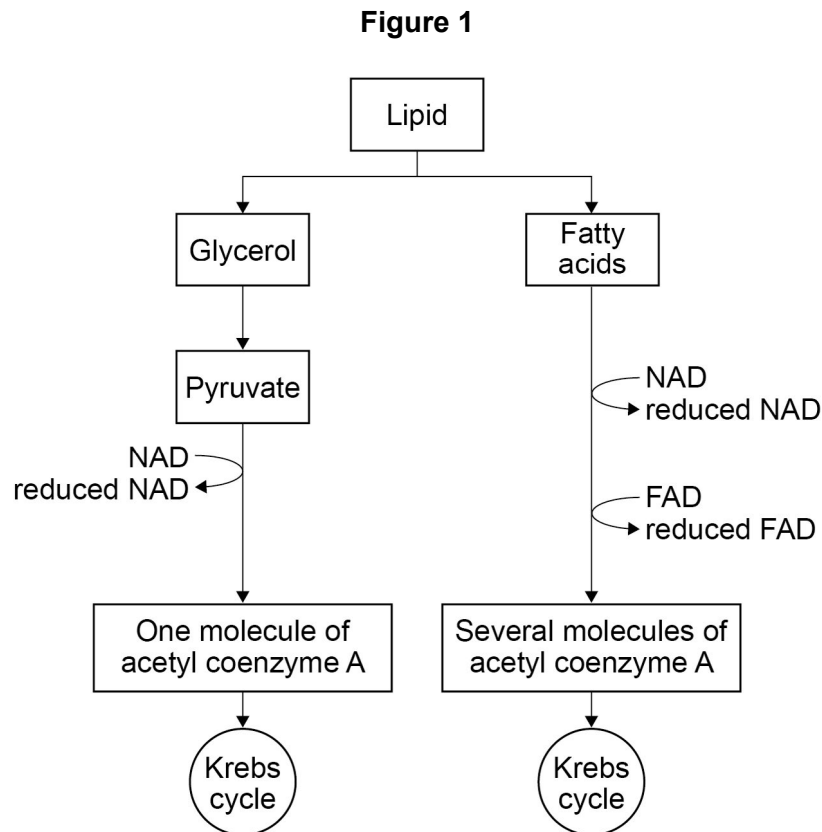
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Answer **all** questions in the spaces provided.

0 1

The breakdown products of lipids can be used as respiratory substrates.

Figure 1 shows some of the steps of aerobic respiration using lipids.



0 1 . 1

Aerobic respiration of one glucose molecule can produce up to 38 molecules of ATP whereas one molecule of a fatty acid can produce up to 130 molecules of ATP.

Give **one** reason why more ATP molecules can be produced from a fatty acid than from glucose.

Use information from **Figure 1**.

[1 mark]

One fatty acid produces several molecules of acetyl coenzyme A, so more turns of the Krebs cycle, so more reduced NAD and reduced FAD (hydrogen) for the electron transfer chain.



0	1	2
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Fatty acids cannot be respired anaerobically.

Explain why fatty acids cannot be used in anaerobic respiration.

Use information from **Figure 1**.

[2 marks]

Fatty acids are converted directly to acetyl coenzyme A, so pyruvate is not produced.

So there is no pyruvate to be reduced (to lactate or ethanol), so NAD is not regenerated from reduced NAD, and without oxygen the reduced NAD/FAD cannot be oxidised, so ATP production stops.

Question 1 continues on the next page

Turn over ►



The Respiratory Quotient (RQ) can be used to identify a respiratory substrate.

Table 1 shows the RQs for amino acids, fatty acids and glucose.

Table 1

Respiratory substrate	RQ
Amino acids	0.8–0.9
Fatty acids	0.7
Glucose	1.0

A student investigates respiration using seeds.

The seeds use 17.1 cm³ of oxygen and produce 13.0 cm³ of carbon dioxide.

0 1 . 3 The student uses the volumes of gas to calculate the RQ.

Give one quantity that can be used instead of volume to calculate the RQ.

[1 mark]

Moles (number of molecules) of gas

0 1 . 4 Show that the seeds are using a mixture of respiratory substrates.

Use information from **Table 1**.

[2 marks]

$$RQ = CO_2 \text{ produced} \div O_2 \text{ used} = 13.0 \div 17.1 = 0.76$$

0.76 is in between the RQ of fatty acids (0.7) and amino acids (0.8 to 0.9), so a mixture of substrates is being respired.



0 1 . 5

Chronic obstructive pulmonary disease (COPD) is a long-term lung disorder. COPD makes breathing difficult.

People with COPD have high levels of carbon dioxide in their blood.

Suggest why people with COPD may be advised to increase the proportion of lipids in their diet.

Use information from **Table 1**.

[2 marks]

Lipids (fatty acids) have a lower RQ (0.7) than glucose (1.0) or amino

acids (0.8 to 0.9),

so less CO₂ is produced for each volume of oxygen used,

so less carbon dioxide builds up in the blood, and breathing is easier.

8

Turn over for the next question

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0 2

Scientists investigate succession after deforestation in the Amazon rainforest. Deforestation means that trees are cut down and removed.

After deforestation, the land becomes either clearcut or pasture.

Clearcut land is abandoned immediately.

Pasture land is planted with grass and the land is grazed by cattle for five to eight years before the land is abandoned.

Succession happens after the land is abandoned.

The scientists investigate if the way land is used before it is abandoned affects succession.

The scientists:

- choose a large study area of deforested, abandoned land
- select several sample sites that were clearcut
- select several sample sites that were pasture
- count the number of plant species in each sample site every year
- collect data from the sample sites for 25 years.

0 2 . 1

Give **one** reason why the scientists' method would give valid results.

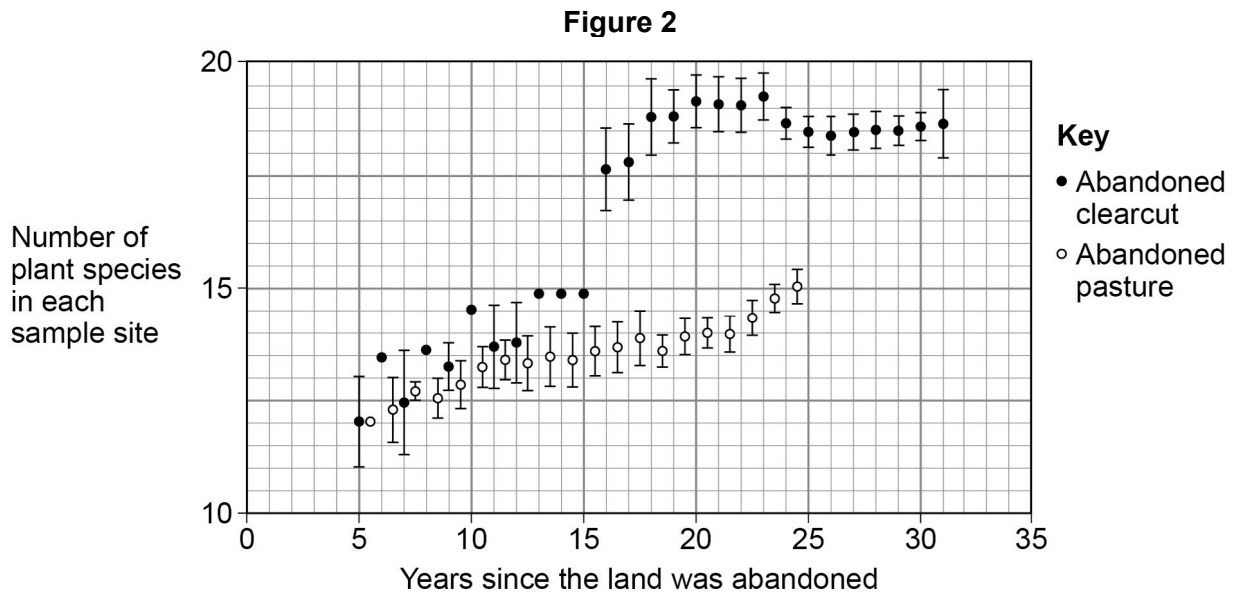
[1 mark]

Several sample sites of each type in the same large study area, so the samples are representative (reduces sampling bias) and abiotic factors are similar.



Figure 2 shows the number of plant species in each sample site at different times since the land was abandoned.

The error bars indicate the standard error.



0 2 . 2

Evaluate if the data indicate that there is a significant difference between the number of plant species found in abandoned clearcut and abandoned pasture.

Use information from **Figure 2**.

[3 marks]

There is a significant difference after 16 years, because the error bars of clearcut and pasture do not overlap (clearcut has more species).

There is no significant difference from 5 to 12 years, when the error bars overlap.

However, there are no error bars for clearcut in some years, eg 13 to 15 years, so significance cannot be judged.

There are no data for pasture in some years, eg 25 to 30 years.

Question 2 continues on the next page

Turn over ►



0 2 . 3

Biodiversity in the abandoned clearcut and in the abandoned pasture increases with time.

Explain why.

[3 marks]

Initial colonisation by pioneer species, which are adapted to the hostile initial conditions.

These organisms change the environmental (abiotic) conditions, eg they add humus, so the soil is deeper with more nutrients and water.

The less hostile (more favourable) conditions allow other organisms to become established, so there are more niches, more habitats and more types of food, so more species.

0 2 . 4

The scientists measure the amount of nitrogen in the leaves of some plants growing in the study area.

The leaves of plants on abandoned pasture have less nitrogen than the leaves of plants on abandoned clearcut.

The scientists suggest that this could be because the soil in abandoned pasture has less nitrogen available than the soil in abandoned clearcut.

Explain why the soil in abandoned pasture could have less nitrogen available.

[2 marks]

Nitrates from the soil are absorbed by the grass and used to make plant protein.

This nitrogen is removed through cattle grazing, so nitrates are removed faster than they are replaced, and there are fewer remains of dead plants and animals to return nitrogen-containing compounds (ammonium) to the soil.



0 2 5

The pioneer species are different in abandoned clearcut and abandoned pasture.

Table 2 shows the main features of the pioneer species.

Table 2

Abandoned clearcut	Abandoned pasture
Dominant pioneer species is <i>Cecropia</i> tree	Dominant pioneer species is <i>Vismia</i> tree
<i>Cecropia</i> trees attract many types of birds and mammals	<i>Vismia</i> trees do not attract many types of birds or mammals
<i>Cecropia</i> tree has a thin crown that lets light pass through	<i>Vismia</i> tree has a dense cone-shaped crown that blocks light

Suggest why *Cecropia* is described as a succession **facilitator** whereas *Vismia* is described as a succession **inhibitor**.

Use information from **Table 2**.

[2 marks]

Cecropia is a facilitator because it attracts more types of birds and mammals, so more types of seeds are brought in (dispersed), so more new plant species grow.

Vismia is an inhibitor because its dense crown blocks light, so less light reaches the ground, so less photosynthesis and growth of new plant species.

11

Turn over for the next question

Turn over ►



0 3

Figure 3 shows a chloroplast as seen using an electron microscope.

Figure 3



Stack of
thylakoids

0 3

. 1

Chloroplasts contain DNA and ribosomes.

Give the roles of both DNA and ribosomes in chloroplasts.

[2 marks]

DNA Codes for the proteins needed for chloroplast function, eg enzymes for photosynthesis.

Ribosomes Synthesise (translate) the proteins needed for chloroplast function, eg photosynthesis enzymes such as rubisco.

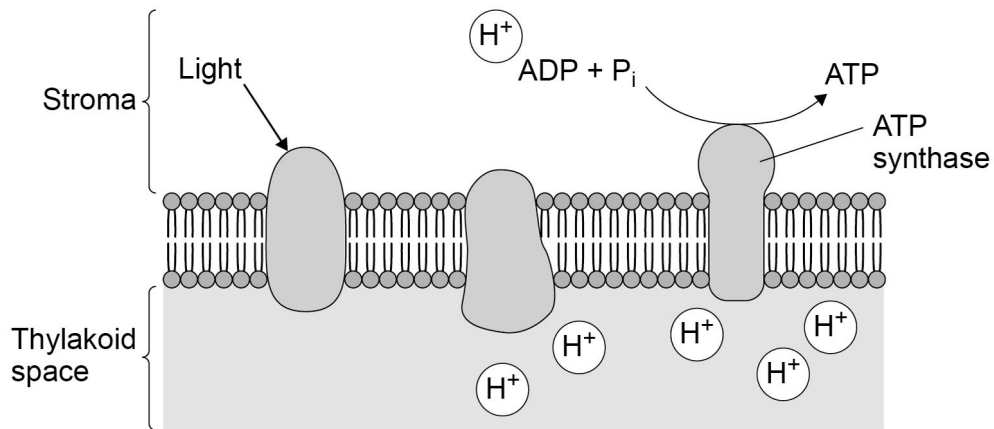


Chloroplasts contain many stacks of discs called thylakoids.

Each thylakoid is surrounded by a membrane.

Figure 4 shows part of a thylakoid membrane.

Figure 4



0 3 . 2

Describe the role of protons in the production of ATP in the chloroplasts.

Use information from **Figure 4**.

[3 marks]

Energy from electron transfer (excited electrons from chlorophyll) is used to pump protons from the stroma into the thylakoid space, which establishes a proton gradient.

Protons (H^+) then diffuse from the thylakoid space into the stroma, down their concentration gradient, through ATP synthase.

The energy released is used to join ADP with inorganic phosphate (P_i) to make ATP.

Question 3 continues on the next page

Turn over ►



0 3 . 3 A chloroplast contains 60 stacks of thylakoids.

There are 25 thylakoids in each stack.

The diameter of each thylakoid is $0.45 \mu\text{m}$

The membrane area of one thylakoid can be estimated using:

$$A = 2 \pi r^2$$

where **A** = area

r = radius

$\pi = 3.14$

Calculate the total area of thylakoid membrane in the chloroplast.

[2 marks]

$$r = 0.45 \div 2 = 0.225 \mu\text{m}$$

$$\text{Area of one thylakoid} = 2 \times 3.14 \times 0.225^2 = 0.317925 \mu\text{m}^2$$

$$\text{Total} = 0.317925 \times 25 \times 60 = 476.8875$$

Area of thylakoid membrane 476.9 μm^2

0 3 . 4 Containing many stacks of thylakoids is an adaptation of chloroplasts for efficient photosynthesis.

Explain how.

[2 marks]

Many stacks give a large area of thylakoid membrane, so more

chlorophyll, so more light is absorbed for the light-dependent reaction.

A large membrane area also holds more proteins of the electron transfer

chain and more ATP synthase, so more ATP (and reduced NADP) is

produced.



0 4

Scientists investigate the effect of changes in temperature and rainfall on the yields of four crop plants.

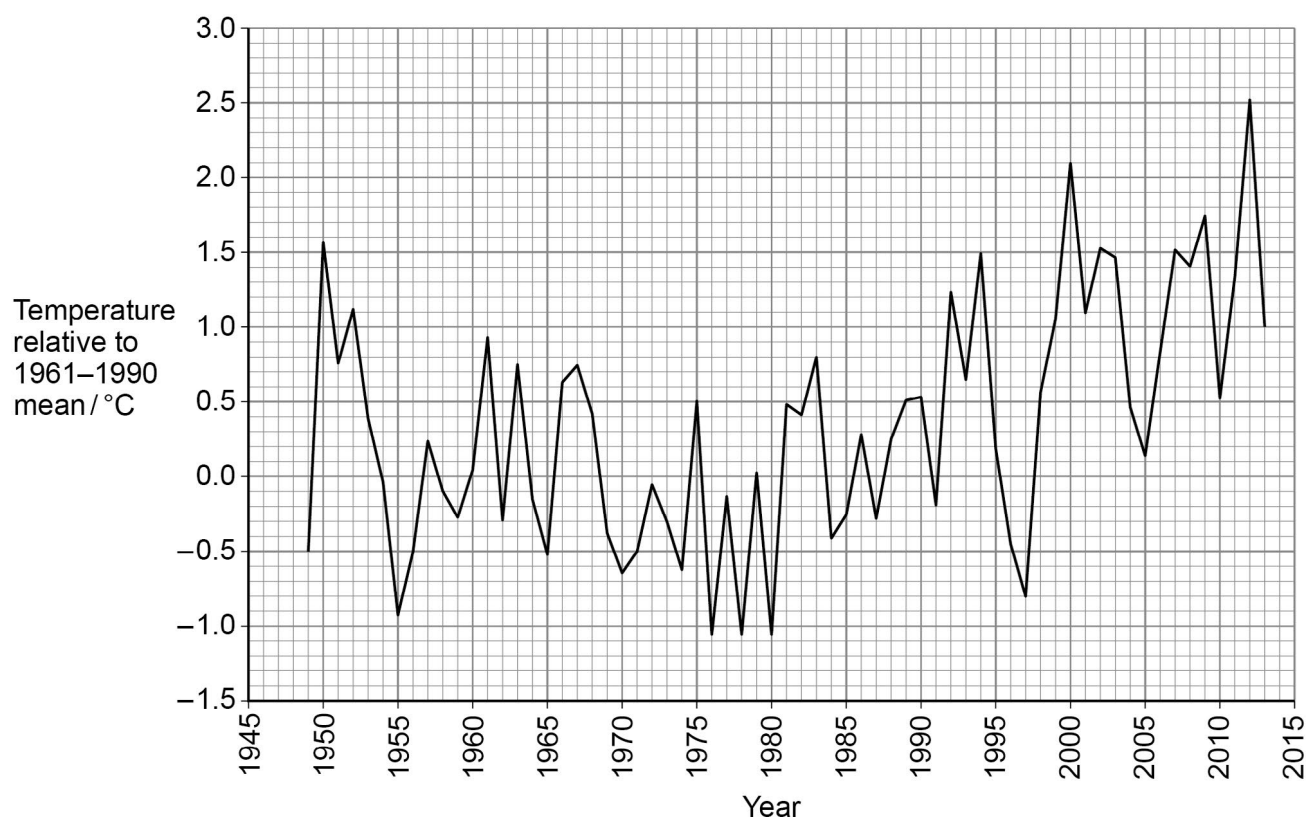
The scientists collect data from 1949 to 2013.

The scientists:

- compare the temperature and rainfall to the mean value for 1961 to 1990
- measure the yield of each crop.

Figure 5 shows the scientists' results for temperature.

Figure 5



0 4

1

Calculate the temperature change from 1949 to 2013.

Use data from **Figure 5**.

[1 mark]

2013: 1.0 °C, 1949: -0.5 °C

$1.0 - (-0.5) = 1.5$

Temperature change = 1.5 °C

Question 4 continues on the next page

Turn over ►



Figure 6 shows the scientists' results for rainfall.

Figure 6

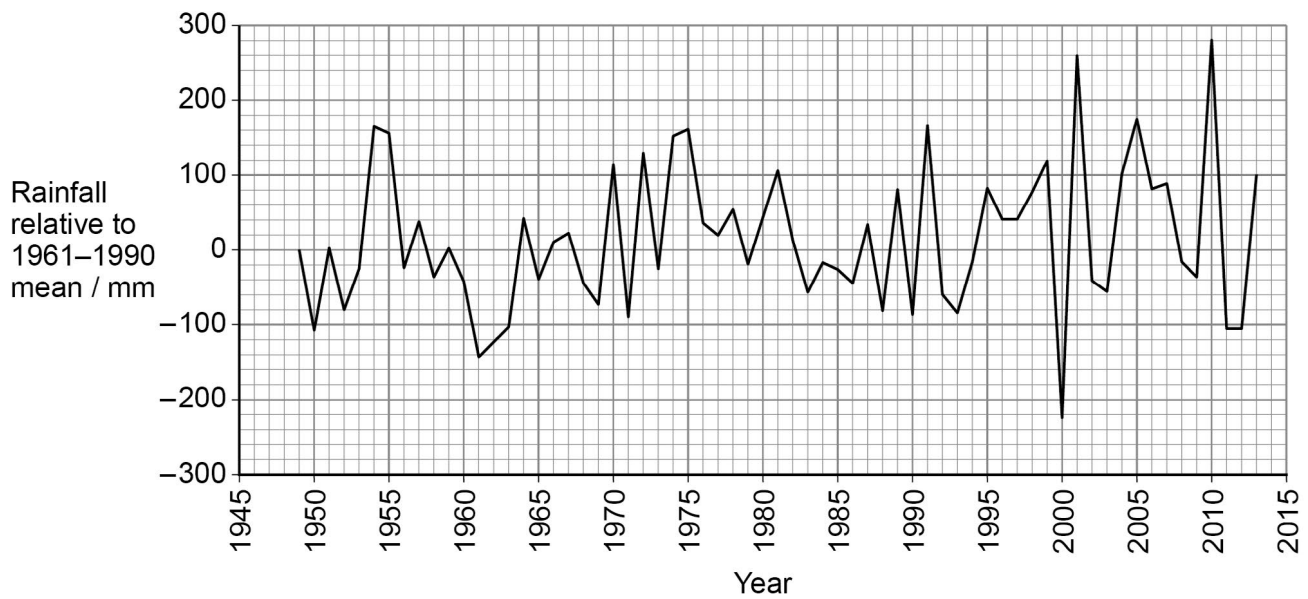
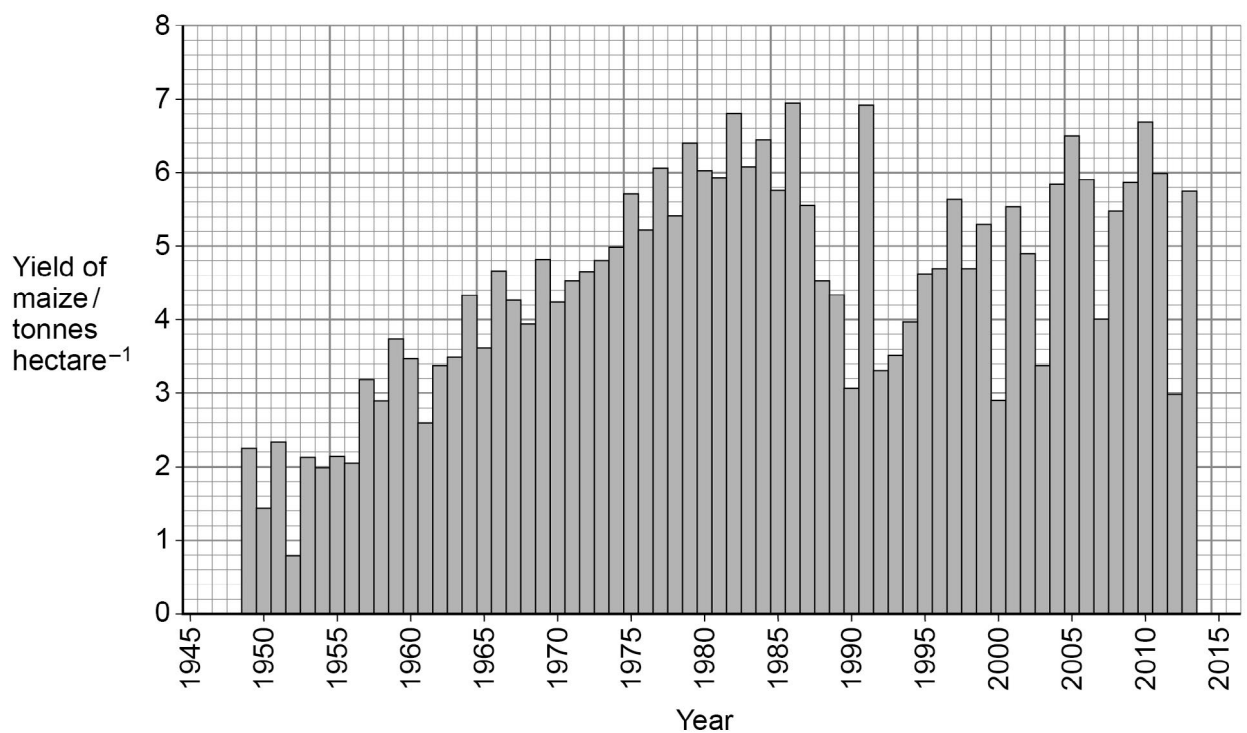


Figure 7 shows the scientists' results for the yield of maize.

Figure 7



0 4 . 2

One conclusion from the investigation is:

'An increase in rainfall increases the yield of maize.'

Evaluate this conclusion.

Use data from **Figure 6** and **Figure 7**.

[3 marks]

Partly supported: both rainfall and maize yield show an overall increase from 1949 to 2013.

In some years rainfall and yield are correlated, eg in 2010 rainfall was high (+280 mm) and yield was high (6.7 tonnes hectare⁻¹), and in 2012 both were low (−105 mm, 3.0 tonnes).

But there are fluctuations and years with no correlation, eg in 1954 rainfall was high (+160 mm) but yield was low (about 2 tonnes).

Correlation does not mean causation: other factors (eg temperature) affect yield.

0 4 . 3

The scientists use a statistical test to analyse the effect of temperature and rainfall on maize yield.

Name a statistical test the scientists should use.

Give a reason for your choice.

[2 marks]

Name of test *Spearman's rank correlation coefficient*

Reason for choice of test *We are testing for a (significant) correlation (relationship) between two sets of data: temperature or rainfall and maize yield.*

Question 4 continues on the next page

Turn over ►



The scientists investigated the effect of changes in temperature and rainfall on the yields of maize, soybean, sugar beet and sunflower.

The scientists calculate the test statistic and find the p values.

Table 3 shows the p values.

Table 3

Crop plant	p values	
	Rainfall and crop yield	Temperature and crop yield
Maize	< 0.01	0.01
Soybean	0.69	0.06
Sugar beet	< 0.01	< 0.01
Sunflower	< 0.01	0.01

0 4 . 4 Explain what the scientists can conclude from the p values.

[2 marks]

Temperature and rainfall have a significant correlation with crop yield in maize, sugar beet and sunflower (not due to chance), because $p < 0.05$ (5%).

Temperature and rainfall have no significant correlation with crop yield in soybean (due to chance), because $p > 0.05$.

8



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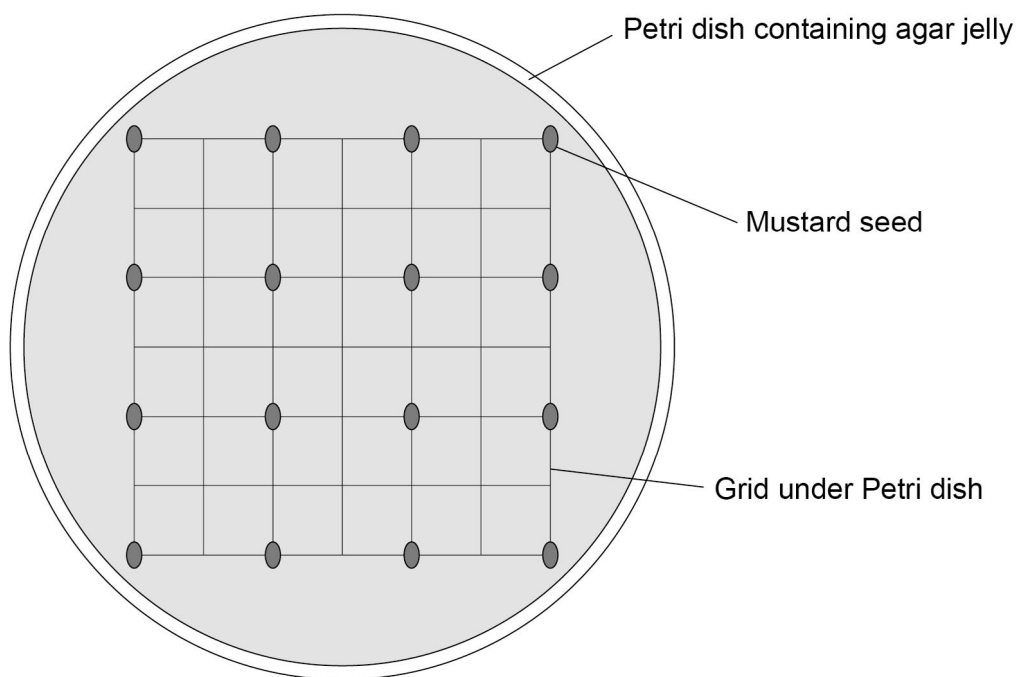
0 5

A student investigates the effect of competition on seed germination.

The student:

1. washes mustard seeds in a dilute bleach solution
2. takes five Petri dishes containing sterile agar jelly
3. puts a 6 cm x 6 cm grid under each Petri dish
4. washes forceps in bleach and uses the forceps to pick up seeds
5. puts different numbers of seeds into each Petri dish spread evenly across the 6 cm x 6 cm grid – an example with 16 seeds is shown in **Figure 8**
6. puts the Petri dishes in a dark cupboard
7. counts the number of seeds that have germinated after 24 hours.

Figure 8

**0 5 . 1**

Explain why the student washes the seeds and forceps in bleach.

[2 marks]

*To sterilise the seeds and forceps, to prevent contamination with mould
(fungi) or bacteria,
as the microorganisms would compete with the seeds for resources, kill
the seeds (cause disease) or prevent germination.*



0 5 . 2

The student needs to control several variables to collect valid results.

Give **two** variables the student needs to control.

[2 marks]

1 *Type (species) and age of seed*

2 *Temperature*

0 5 . 3

Suggest why the student puts the Petri dishes in a dark cupboard.

[1 mark]

So the seeds are not competing for light (they do not receive different amounts of light).

0 5 . 4

Explain how putting the Petri dishes in a refrigerator at 4 °C would affect germination.

[2 marks]

*It would prevent germination or slow germination down,
because 4 °C is below the optimum temperature for enzymes, so there
are fewer collisions and fewer enzyme-substrate complexes, so a reduced
rate of reaction (enzymes inactive).*

Question 5 continues on the next page

Turn over ►

The student calculates:

- sowing density of the seeds in the 6 cm x 6 cm grid
- percentage germination.

Table 4 shows the student's results.

Table 4

Number of seeds in the Petri dish	Sowing density / number of seeds cm^{-2}	Number of seeds that germinated	Percentage germination
9	0.25	5	56
16	0.44	14	88
25	0.69	21	84
36	<i>1.00</i>	26	72
49	<i>1.36</i>	30	61

- 0 5 . 5** Complete **Table 4** by calculating the sowing densities for the Petri dishes with 36 and 49 seeds.

[2 marks]

- 0 5 . 6** Give the reason why the student calculates germination as a percentage.

[1 mark]

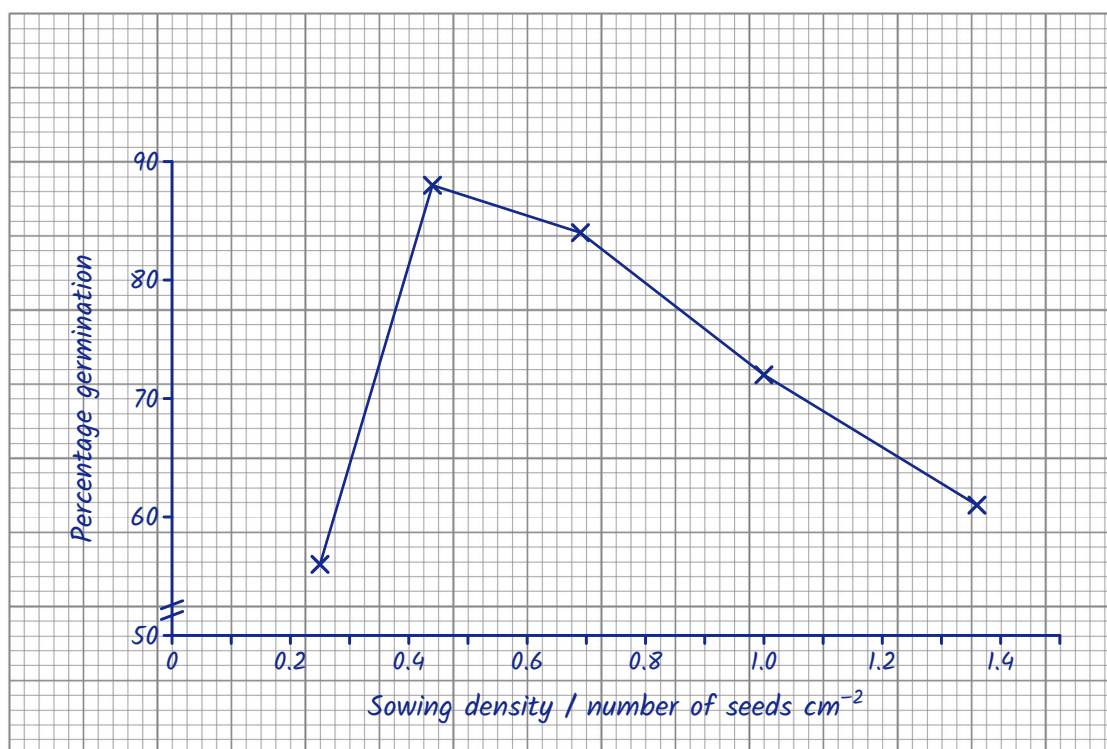
To allow comparison between Petri dishes with different numbers of seeds.



0 5 . 7

Plot a graph of the student's results to show how percentage germination is dependent on sowing density.

[3 marks]



0 5 . 8

The student wants to use the results from this investigation to find the optimum sowing density for all seeds.

The student concludes that $0.44 \text{ seeds cm}^{-2}$ is the optimum sowing density.

Evaluate the student's conclusion.

[3 marks]

$0.44 \text{ seeds cm}^{-2}$ does give the highest percentage germination (88%).

But there were no repeats, and no statistical test (no standard deviation), so we cannot tell if the difference from 0.69 (84%) is significant.

Only one type of seed (mustard) was used, so it cannot apply to all seeds.

Artificial conditions in a laboratory (agar, not soil), and intermediate sowing densities (eg between 0.25 and 0.69) were not tested.



0 6

Snow geese are large birds found in North America.

Figure 9 shows a snow goose.

Figure 9



The females lay eggs in a nest on the ground and sit on the eggs to keep them warm. The eggs hatch and the young birds leave the nest a few hours after hatching. The two parents protect the young birds, but the young birds must find their own food. Predators may eat the eggs and young birds.

Scientists study a large population of snow geese for 1 year.

The scientists record the:

- number of eggs in each nest (clutch size)
- number of nests with each clutch size
- number of eggs that hatch
- percentage of eggs that hatch.

Table 5 shows the scientists' results.

Table 5

Number of eggs in each nest (clutch size)	Number of nests with each clutch size	Number of eggs that hatch	Percentage of eggs that hatch
2	3	2	33.3
3	21	49	77.8
4	37	110	74.3
5	20	71	71.0
6	10	30	50.0
7	1	6	85.7
8	0	-	-
9	1	5	55.6
10	1	6	60.0



0 6 . 1

Natural selection affects the number of eggs in a nest.

Name the type of selection shown in **Table 5**.

Give the reason for your choice.

[2 marks]

Type of selection Stabilising selection

Reason for choice It selects against extremes: few nests have very small or very large clutch sizes, most have 4 eggs.

0 6 . 2

One conclusion from the investigation is that 7 is the optimum clutch size for snow geese.

Evaluate this conclusion.

Use information from **Table 5**.

[3 marks]

Yes: a clutch size of 7 has the highest percentage of eggs that hatched (85.7%).

No: there is only one nest with a clutch size of 7, so the data are not reliable,

and there were no clutches of 8, so 8 could not be compared.

Only one population was studied, in only one location, for only one year.

0 6 . 3

Suggest **three** reasons why snow geese with clutch sizes above 7 could be at a selective disadvantage.

[3 marks]

1 Too many eggs for the female to sit on and keep warm.

2 Too many young for the parents to protect (more attract predators).

3 More competition between the young for food, so fewer survive.

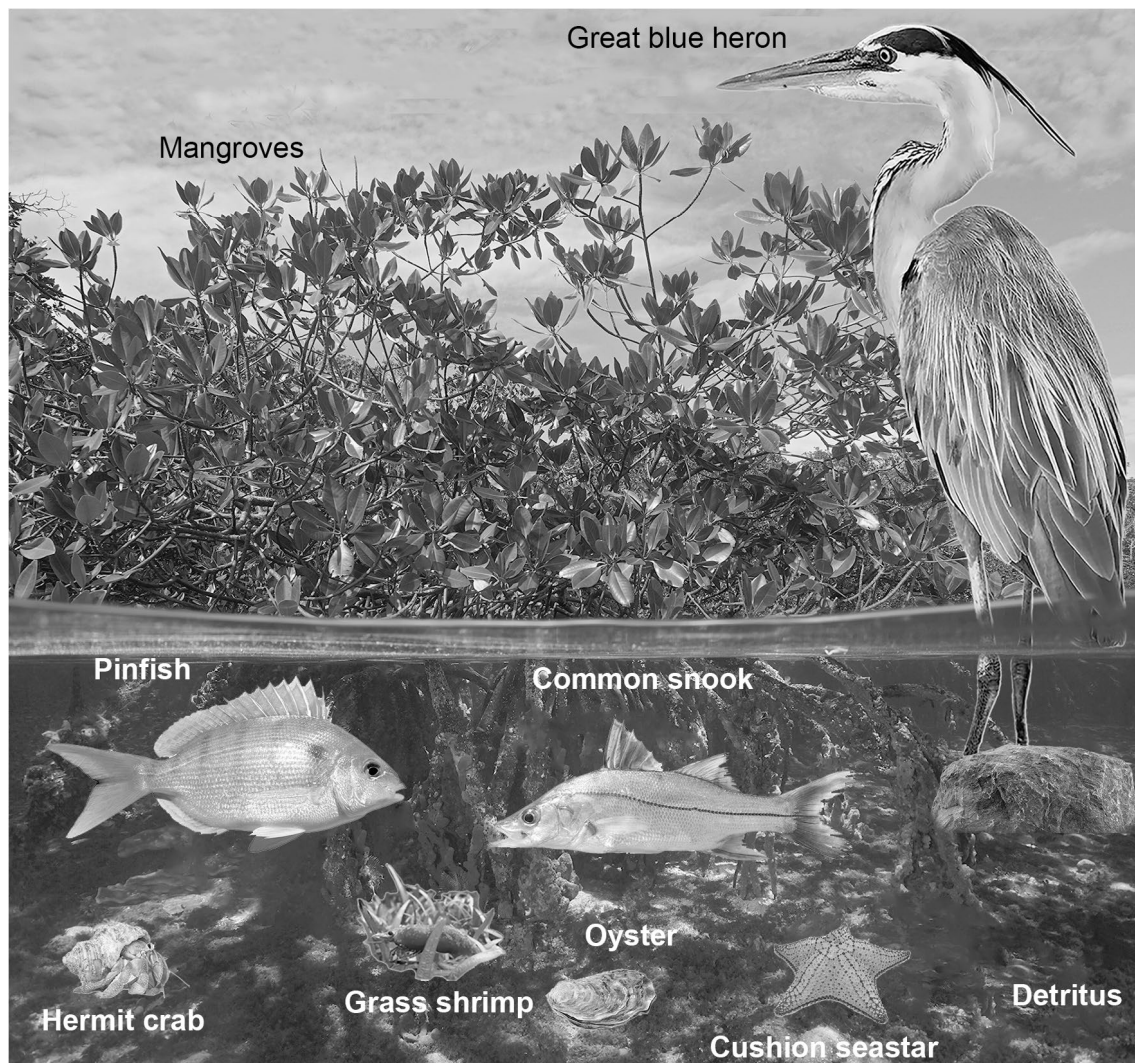


0 7

Mangroves are tropical trees that live in salty water near coasts.

Figure 10 shows part of a mangrove ecosystem.

Figure 10



0 7 . 1

Describe the structure of an ecosystem.

Give examples from **Figure 10**.**[4 marks]***An ecosystem is made up of the community: all the biotic (living)**components of an area, eg mangroves, great blue heron, pinfish, common snook, oysters and grass shrimp.**The organisms are linked by feeding relationships, eg the great blue heron eats fish such as pinfish and common snook.**It also includes the non-living (abiotic) components of the area, the habitat,**eg the salt concentration of the water, light intensity, temperature and pH.*

0 7 . 2

Describe how **biotic** (living) factors can cause variation in a population size.**[5 marks]***Intraspecific competition: individuals of the same species compete with one another for resources, eg food, space and mates, eg common snook competing for pinfish, so the population size falls.**Interspecific competition: individuals of different species compete for resources, eg food, eg great blue heron and common snook both eating pinfish.**Predation: more predators reduce the prey population, so predator and prey populations fluctuate in predator-prey cycles.**Human activity, eg hunting (fishing) or pesticides, reduces population size.**Disease or parasites kill individuals, so the population size decreases.***Question 7 continues on the next page****Turn over ►**

07.3

Photosynthesis is the main route for energy to enter an ecosystem.

Explain how **abiotic** (non-living) factors affect the rate of photosynthesis.

[6 marks]

Increasing light intensity increases the rate of photosynthesis, until another factor becomes limiting,

because more electrons are excited from chlorophyll (and from photolysis of water), so more energy to generate ATP and reduced NADP.

Increasing carbon dioxide concentration increases the rate of photosynthesis, until another factor becomes limiting,

because more carbon dioxide combines with ribulose bisphosphate (RuBP), catalysed by rubisco, to form glycerate 3-phosphate (GP).

Increasing temperature increases the rate of photosynthesis until the optimum is reached, because there are more collisions between rubisco (enzymes) and carbon dioxide (substrates);

above the optimum the rate decreases as rubisco (enzymes) are denatured.

15

END OF QUESTIONS



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