Variation (17.1): Cambridge (CIE) A Level Biology 9700 Exam Questions by Topic

22 questions · 54 marks · about 65 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 4 · May/June 2024 (42) · Q2(a) · 3 marks

2 Variation exists in populations of a species and this may provide the opportunity for evolution to occur.

(a) Phenotypic variation exists in many forms and has a number of possible causes.

Describe the main factors that are the cause of phenotypic variation.

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2 Phenotypic variation exists in many forms.

(a) Some examples of phenotypic variation in plants and animals are described in Table 2.1.

Complete Table 2.1 by stating whether the cause of variation for each described example is likely to be due to:

- genetic factors, V_G
- environmental factors, V_E
- a combination of genetic and environmental factors, $V_G + V_E$.

Table 2.1

description of phenotypic variation	cause of variation
Tomato plants grown in a glasshouse and grown outside vary in the yield of tomatoes they produce. Seventeen genes associated with tomato yield have been identified.	
New strawberry plants from the variety called Sweet Ann are made by asexual reproduction. The new plants grow to different sizes and produce different numbers of fruit.	
The domestic cat has a blood group system with three possible blood types: A, B and AB. The blood types are determined by antigens present on the cell surface membrane of red blood cells.	
Over 50 genes have variants that are associated with excessive weight gain in humans. Other risk factors for excessive weight gain include diet and exercise.	
Resting heart rate in humans varies between different individuals. Some factors that influence resting heart rate include: biological sex, family history of heart disease, number of cigarettes smoked, medication taken.	

[3]

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Question 3 · information from earlier in the question

2 Domestic goats are small, herbivorous animals that provide milk for human use. This is an important source of food for people in rural South Africa.

Three Northern European goat varieties (breeds) have been imported to South Africa because they have higher milk yields than the native South African goats.

Table 2.1 compares the mean daily milk yields of these three breeds of Northern European goat in three locations, Northern Europe, Barbados and South Africa.

Table 2.1

goat breed	mean daily milk yield / kg in different locations		
	Northern Europe	Barbados	South Africa
British Alpine	4.09	2.55	0.75
Saanen	5.17	1.73	1.45
Toggenburg	4.54	3.46	0.56

Question 3 · Paper 4 · October/November 2020 (42) · Q2(b)(i) · 2 marks

(b) (i) Explain how the data in Table 2.1 support the claim that some of the variation in mean daily milk yield in goats is due to **genetic** causes.

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Question 4 · Paper 4 · October/November 2020 (42) · Q2(b)(ii) · 2 marks

(ii) The climate, vegetation and availability of veterinary care for goats in Northern Europe, Barbados and South Africa are different.

Explain how Table 2.1 shows that **environmental** factors can cause variation in mean daily milk yield in goats.

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Question 5 · information from earlier in the question

2 Steelhead trout, *Oncorhynchus mykiss*, are fish that live in streams in North America.

To increase the number of steelhead trout, captive breeding has occurred since 1992. Fish eggs and sperm are mixed and the young fish grow in large tanks of aerated water for the first year of their lives. Most are then released into the wild, however a few male and female fish are kept to become the parents of the next generation of captive-bred fish.

Each tank may hold up to 50 000 fish. The young captive fish are fed processed food. Some young fish are unable to survive these conditions and a proportion die. Death is usually the result of poor wound-healing after accidents due to overcrowding and due to the spread of diseases.

Question 5 · Paper 4 · May/June 2019 (42) · Q2(b) · 3 marks

(b) Suggest **and** explain **three** ways in which the tank environment may make the phenotype of a captive fish different from a wild fish.

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5 Phenotypic variation exists in natural populations. There are many causes of variation. Natural selection determines which phenotypes are advantageous.

(a) Variation in a particular characteristic can be described as either discontinuous or continuous.

Table 5.1 contains a list of statements that apply to discontinuous variation, continuous variation or both.

Complete both columns of Table 5.1. Put a tick (✓) in the box if the statement applies and leave the box empty if the statement does not apply.

Table 5.1

statement	discontinuous variation	continuous variation
often involves one gene only		
environmental factors may affect gene expression		
there is an additive effect of genes that contributes to the phenotype		
there are distinct differences between the various forms of a characteristic		

[4]

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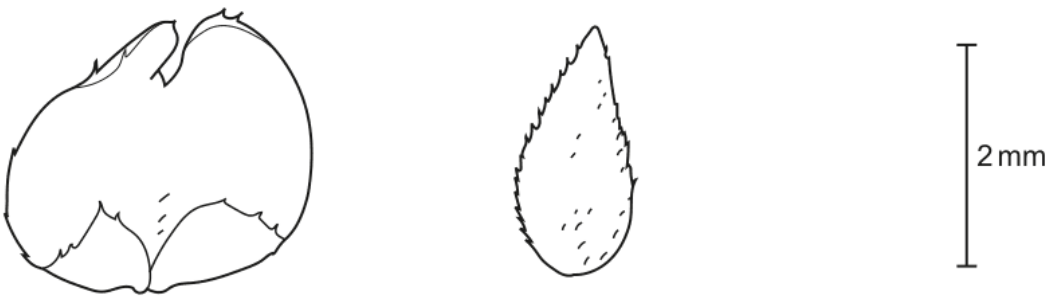
Question 7 · Paper 4 · May/June 2023 (42) · Q3(a)(i) · 1 mark

3 **(a)** The sea blush, *Plectritis congesta*, is a flowering plant that grows on the west coast of North America.

Individual sea blush plants produce fruit that is either winged or wingless. Investigations have shown that this characteristic is controlled by a single gene with two alleles:

- a dominant winged fruit allele
- a recessive wingless fruit allele.

Fig. 3.1 shows the difference in structure between winged fruit and wingless fruit phenotypes.



winged fruit wingless fruit

Fig. 3.1

(i) A large sample of sea blush fruits was collected and their fruit-wing characteristic was recorded.

Name the type of variation that is shown for the fruit-wing characteristic of the sea blush.

Question 8 · Paper 4 · February/March 2023 (42) · Q3(a) · 3 marks

3 Salmon can be genetically modified (GM) to produce increased quantities of growth hormone, which is a protein. GM salmon modified in this way have a faster growth rate and reach their maximum body mass at a younger age than non-GM salmon.

(a) Within any population of salmon there is variation in body mass. This is an example of continuous variation.

Explain what is meant by continuous variation **and** how it can be caused.

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Question 9 · Paper 4 · October/November 2023 (41) · Q3(b) · 2 marks

(b) The Japanese morning glory, *I. nil*, has over 20 different flower colour phenotypes, including shades of blue, purple, red and pink.

The flower colour of *I. nil* is controlled by at least four genes. The flower colour can change gradually after the flowers open each morning and can change with fluctuations in the carbon dioxide concentration of the surrounding air.

A student concluded that the flower colour phenotype in *I. nil* shows continuous variation.

Suggest **two** reasons why the student made this conclusion.

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2 .....

Question 10 · Paper 4 · October/November 2019 (42) · Q2(a) · 2 marks

2 The stickleback fish, *Gasterosteus aculeatus*, has two distinct forms, the saltwater form and the freshwater form. The larger, freshwater form is thought to have evolved from the smaller, saltwater form. Both forms have armour plating on each side of the body. The plates are made of bone and contain a high proportion of calcium.

The ectodysplasin gene, *EDA*, codes for a protein involved in the development of armour plates. The *EDA* gene has two alleles, low armour and high armour.

Three main morphs of armour plating have been described.

Complete morph armour plating:

- is found mainly in the saltwater form
- has many plates from head to tail to cover most of the body
- provides defence against large, predatory fish
- limits the growth of the fish.

Partial morph armour plating:

- is found mainly in the freshwater form
- has a reduced number of plates to cover only part of the body.

Low morph armour plating:

- is found mainly in the freshwater form
- has very few, undeveloped plates and no body cover.

(a) Explain why the variation in armour plating in stickleback fish can be described as discontinuous.

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Question 11 · Paper 4 · May/June 2024 (41) · Q9(a) · 2 marks

9 The harlequin ladybird, *Harmonia axyridis*, is an insect that shows discontinuous variation in colour pattern and continuous variation in body size.

(a) Within a species, the variation that is observed for a particular characteristic can be described as discontinuous or continuous.
Discontinuous variation has a different genetic basis from continuous variation.

State **two** differences between discontinuous variation and continuous variation, **other than** having a different genetic basis.

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Question 12 · Paper 4 · May/June 2024 (41) · Q9(b) · 2 marks

(b) Fig. 9.1 shows three of the colour patterns seen in *H. axyridis* and the percentage of each in a population.

colour pattern	 *conspicua*	 *spectabilis*	 *succinea*
percentage	5	13	82

Fig. 9.1

Suggest the genetic basis of the variation in colour pattern in *H. axyridis*.

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Question 13 · Paper 4 · May/June 2024 (41) · Q9(c) · 2 marks

(c) The body size of adult *H. axyridis* varies from 5 mm to 8 mm. Adult ladybirds do **not** grow or change size. Adults develop from larvae that hatch from eggs.

State **two** environmental factors that may affect adult body size in *H. axyridis*.

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Question 14 · information from earlier in the question

2 *Exserohilum turcicum* is a fungal pathogen. The growth of the mycelium of the fungus damages the leaves of maize plants, *Zea mays*. Leaf damage reduces crop yield.

(b) Two inbred varieties of maize, SKV50 and CML153, were crossed. The resulting F1 hybrids were self-crossed to produce F2 offspring. The F2 plants were grown, and the percentage area of leaf damage caused by *E. turcicum* was measured.

Fig. 2.1 shows the results for the F2 generation. The arrows show the mean percentage area of leaf damage for the two parent varieties.

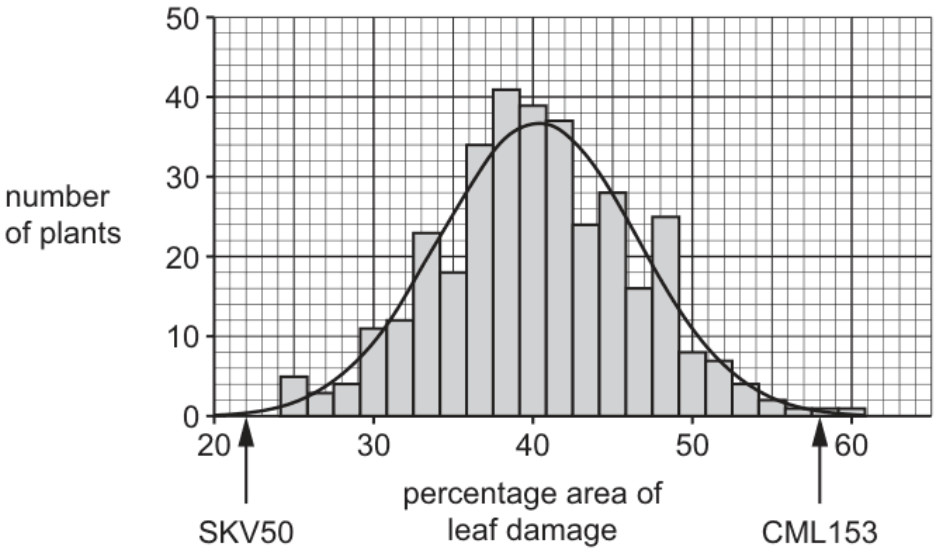


Fig. 2.1

Question 14 · Paper 4 · October/November 2025 (41) · Q2(b)(ii) · 1 mark

(ii) State the name of the type of variation shown by the maize F2 generation in Fig. 2.1.

Question 15 · Paper 4 · October/November 2025 (41) · Q2(b)(iii) · 4 marks

(iii) Explain the **genetic** basis of the type of variation shown by the maize F2 generation.

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Question 16 · Paper 4 · May/June 2021 (42) · Q8(a) · 3 marks

8 **(a)** In continuous variation, a population shows a range of phenotypes between two extremes with no distinct groups. Height and mass are examples of phenotypic traits that show continuous variation.

Describe the genetic basis for continuous variation.

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Question 17 · Paper 4 · May/June 2021 (42) · Q8(b) · 2 marks

(b) Environmental factors can contribute to continuous variation.

Suggest **two** environmental factors that may affect the body mass of an animal.

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Question 18 · information from earlier in the question

3 Salmon can be genetically modified (GM) to produce increased quantities of growth hormone, which is a protein. GM salmon modified in this way have a faster growth rate and reach their maximum body mass at a younger age than non-GM salmon.

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(b) Scientists investigated whether injection of very young non-GM salmon with recombinant growth hormone could cause an increase in the growth rate of the salmon.

The scientists used two groups of non-GM salmon:

- a control group of salmon that were not injected with recombinant growth hormone
- an experimental group of salmon that were injected with 1.0 μg of recombinant growth hormone at the start of the experiment and once a week for the next six weeks.

The mean body mass of the salmon in the two groups at the start of the experiment was the same (5.3 g).

After six weeks, the body mass of every salmon was measured again. The results are summarised in Table 3.1.

Table 3.1

		no injection with recombinant growth hormone	**injected with recombinant growth hormone**
number of non-GM salmon (n)		28	27
body mass /g	range	6.5–8.6	7.2–12.7
	mean ($\bar{x}$)	7.7	9.4
	standard deviation (s)	0.4	1.1

A student decided that a *t*-test should be performed on the results shown in Table 3.1.

(i) Calculate the value of *t* for the results shown in Table 3.1 using the formula for the *t*-test:

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Give your answer to **two** decimal places.

Show your working.

t = ...

[3]

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Question 19 · Paper 4 · February/March 2023 (42) · Q3(b)(ii) · 3 marks

(ii) The critical value at $p = 0.05$ for these data is 2.01.

The student used the results in Table 3.1 and the *t*-test to conclude that the injections of recombinant growth hormone cause an increase in the growth rate of the non-GM salmon.

Comment on the extent to which the conclusion made by the student can be supported.

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Question 20 · information from earlier in the question

(b) There is variation in the quantity of vitamin D stored in the body.

Vitamin D has an important role in keeping bones healthy. The main storage form of vitamin D in the body is serum 25-hydroxyvitamin D (serum 25-OHD).

A study was carried out on 262 healthy women to investigate if the concentration of serum 25-OHD varied between summer and winter. The women had taken no vitamin D supplements. The age range of the women in the sample was 40 to 72 years old.

Table 5.2 shows the results of the study.

Table 5.2

group	mean concentration of serum 25-OHD / ng cm^{-3}	standard deviation
sampled during summer n = 138	32.7	7.6
sampled during winter n = 124	28.5	8.3
whole sample n = 262	30.7	8.2

Additional analysis showed that there was no significant correlation between age and serum 25-OHD concentration.

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Question 20 · Paper 4 · October/November 2024 (42) · Q5(b)(ii) · 3 marks

(ii) The *t*-test was used to compare the mean concentration of serum 25-OHD when sampled during the summer with the mean concentration of serum 25-OHD when sampled during the winter, as shown in Table 5.2.

Calculate the value of *t* using the formula provided.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

key to symbols:
$\bar{x}$ = mean
s = sample standard deviation
n = sample size (number of observations)

Give your answer to **four** significant figures.

There is space for your working.

t-test value ..... [3]

Question 21 · Paper 4 · October/November 2024 (42) · Q5(b)(iii) · 3 marks

(iii) The critical value at the 0.0001 probability level is 3.773.

State the conclusion that can be made about the results of the study shown in Table 5.2 **and** explain how the result of your calculation in **(b)(ii)** can be used to support this conclusion.

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Question 22 · Paper 4 · October/November 2024 (42) · Q5(b)(iv) · 1 mark

(iv) Suggest the likely **causes** of variation in quantity of vitamin D stored in the body in this sample of women.

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Mark schemes

Question 1 · Paper 4 · May/June 2024 (42) · Q2(a) · 3 marks

2(a)	1	genetic / genotype / alleles **or** example **;** mutation / crossing over / independent assortment / random fertilisation / random mating	**3**
	2	environmental **or** example **;** climate / disease / food availability / soil pH / selection pressure	
	3	combination / interaction, of genes and environment **or** example **;** gene (expression) is modified by environment	

Question 2 · Paper 4 · May/June 2024 (43) · Q2(a) · 3 marks

2(a) **3**

description of phenotypic variation	cause of variation
Tomato plants grown in a glasshouse and grown outside vary in the yield of tomatoes they produce. Seventeen genes associated with tomato yield have been identified.	$V_G + V_E$
New strawberry plants from the variety called Sweet Ann are made by asexual reproduction. The new plants grow to different sizes and produce different numbers of fruit.	V_E
The domestic cat has a blood group system with three possible blood types: A, B and AB. The blood types are determined by antigens present on the cell surface membrane of red blood cells.	V_G
Over 50 genes have variants that are associated with excessive weight-gain in humans. Other risk factors for excessive weight-gain include diet and exercise.	$V_G + V_E$
Resting heart rate in humans varies between different individuals. Some factors that influence resting heart rate include: biological sex, family history of heart disease, number of cigarettes smoked, medication taken.	$V_G + V_E$

five correct = 3 marks **;;;**

four or three correct = 2 marks

two or one correct = 1 mark

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Question 3 · Paper 4 · October/November 2020 (42) · Q2(b)(i) · 2 marks

2(b)(i)	*any **two** from:* **1** different breeds at, **same** / named, location / environmental conditions, / have different milk yields **;** **2** comparative data quote including units **;** **3** (different breeds have) different gene pools / different alleles **;** **4** due to selective breeding **;**	**2**

Question 4 · Paper 4 · October/November 2020 (42) · Q2(b)(ii) · 2 marks

2(b)(ii)	*any **two** from:* **1** same breed has different milk yields in, different location / named location / environmental conditions**;** **2** comparative data quote including units **;** **3** how, climate / vegetation / veterinary care, affects milk yield **;**	**2**

Question 5 · Paper 4 · May/June 2019 (42) · Q2(b) · 3 marks

2(b)	*any **three** from:* *captive fish:* 1 controlled conditions **so** phenotype less varied **;** 2 more oxygen **so** larger **;** 3 less space / overcrowding, **so** smaller **;** 4 less space / overcrowding, **so** (signs of) disease / wounds **;** 5 food qualified **linked to**, size / muscle / fat **;** 6 AVP **;** e.g. named tank condition **linked to** skin colour / no predators linked to increase in size / temperature linked to size	**3**

Question 6 · Paper 4 · October/November 2024 (42) · Q5(a) · 4 marks

5(a)

statement	**discontinuous variation**	**continuous variation**
often involves one gene only	✓	
environmental factors may affect gene expression		✓
there is an additive effect of genes that contributes to the phenotype		✓
there are distinct differences between the various forms of a characteristic	✓	

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Question 7 · Paper 4 · May/June 2023 (42) · Q3(a)(i) · 1 mark

3(a)(i)	discontinuous **;**	**1**

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Question 8 · Paper 4 · February/March 2023 (42) · Q3(a) · 3 marks

3(a)	*any **three** from:* *max **two** from:* 1 (phenotype has) range of values / intermediates ; 2 (phenotypes) not, in groups / in classes / categoric / discrete / qualitative **or** (phenotypes are) quantitative ; 3 normal distribution ; *max **two** from:* 4 polygenic / controlled by many genes ; 5 different genes / alleles, have additive effect ; 6 (named) environmental factors (contribute to the variation) ;	**3**

Question 9 · Paper 4 · October/November 2023 (41) · Q3(b) · 2 marks

3(b)	*any **two** from:* 1 colours / shades / categories / phenotypes, not distinct / not discrete / overlap / form a (gradual) range / include intermediates ; 2 >1 / 4 / several / many, genes ; 3 environment affects, it / colour / phenotype ;	**2**

Question 10 · Paper 4 · October/November 2019 (42) · Q2(a) · 2 marks

2(a)	*any **two** from:* 1 discrete / distinct, categories / phenotypes / morphs / groups ; **A** (only) 3 groups 2 no range of phenotypes / no intermediates / no normal distribution ; 3 (only) one gene / only *EDA*, involved ; 4 not affected by environment ;	**2**

Question 11 · Paper 4 · May/June 2024 (41) · Q9(a) · 2 marks

9(a)	*any **two** from:*	**2**

discontinuous	*continuous*
(forms / phenotypes / categories) distinct / discrete / categoric / do not overlap / do not form a (gradual) range / no intermediates / two or few different forms	(forms / phenotypes / categories) not distinct / not discrete / overlap / form a (gradual) range / include intermediates / many different forms / many values on a spectrum ;
not a normal distribution / few bars (on bar chart)	normal distribution **or** normal / bell-shaped curve (on graph) ;
no / little, effect from environment **A** genes only	some / large, effect from environment ;

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Question 12 · Paper 4 · May/June 2024 (41) · Q9(b) · 2 marks

9(b)	*any **two** from:* **1** one / two, genes (control colour pattern) ; **2** different alleles of a gene have a large effect ; **3** multiple / three, alleles ; **4** gene interaction / epistasis ; **5** AVP ;	**2**

Question 13 · Paper 4 · May/June 2024 (41) · Q9(c) · 2 marks

9(c)	*any **two** from:* **1** temperature / food (supply) ; **2** of larva / during larval development ; **3** egg size / diet of mother / size of mother ;	**2**

Question 14 · Paper 4 · October/November 2025 (41) · Q2(b)(ii) · 1 mark

2(b)(ii)	continuous ; **1**

Question 15 · Paper 4 · October/November 2025 (41) · Q2(b)(iii) · 4 marks

2(b)(iii)	*any **four** from:* **1** many / different / several / multiple, genes ; **2** affect, same trait / (percentage) area of leaf damage / resistance ; **3** <u>alleles</u> of, one / each, gene have a small effect ; **4** (different) <u>genes</u> have, additive / combined / interactive, effects ; **5** mathematical treatment to illustrate additive effect ;	**4**

Question 16 · Paper 4 · May/June 2021 (42) · Q8(a) · 3 marks

8(a)	**1**	different alleles at a single gene locus have small effects (on the phenotype) ;	**3**
	2	different genes may have an, additive / combined, effect (on the phenotype) ;	
	3	*ref. to* multiple genes / polygenes / description ;	

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Question 17 · Paper 4 · May/June 2021 (42) · Q8(b) · 2 marks

8(b)	*any **two** from:* **1** quantity / availability, of, food / nutrients ; **A** competition for food **2** quality of food / malnutrition ; **3** disease ; **4** temperature ;	**2**

Question 18 · Paper 4 · February/March 2023 (42) · Q3(b)(i) · 3 marks

3(b)(i)	difference between means = 9.4 – 7.7 **or** 1.7 ; denominator = $\sqrt{\frac{0.4^2}{28} + \frac{1.1^2}{27}}$ **or** $\sqrt{\frac{0.16}{28} + \frac{1.21}{27}}$ **or** 0.22 / 0.23 (no limit on number of decimal places) ; t = 7.56 ; must be to 2 decimal places **allow** ECF	**3**

Question 19 · Paper 4 · February/March 2023 (42) · Q3(b)(ii) · 3 marks

3(b)(ii)	1 *t*-value / 7.56, is greater than, 2.01 / critical value ; 2 difference between two groups **is**, significant / not due to chance **or** null hypothesis rejected ; *any **two** from:* 3 overlap in, data range / error bars ; 4 ref. to correlation does not prove causation ; 5 only a single investigation / needs repeating / small sample size ; 6 ref. to this is only at 5% probability so may not actually be different / AW ; 7 *t*-test may not be valid due to unequal, standard deviations / variances;	**3**

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Question 20 · Paper 4 · October/November 2024 (42) · Q5(b)(ii) · 3 marks

5(b)(ii)	t = 4.255 **;;;** *give 2 marks:* *if answer is 4.25 or 4.26* *if answer is more than 4 significant figures e.g. 4.255439871* *if answer is incorrectly rounded to 4 significant figures e.g. 4.256* *if answer incorrect then max 2 for working* numerator = 4.2 denominator = 0.986972 ecf - if no working mark given then allow one mark for 12.02 as the answer	**3**

Question 21 · Paper 4 · October/November 2024 (42) · Q5(b)(iii) · 3 marks

5(b)(iii)	1 there is a higher (mean) concentration of serum 25-OHD in summer **; ora** *any **two** from:* 2 value of t / 4.255 > critical value / 3.773 **;** 3 there is a significant difference between the two means **;** 4 any difference is not due to chance / difference due to chance less than 0.0001% **;** ecf from incorrect answer to 5bii	**3**

Question 22 · Paper 4 · October/November 2024 (42) · Q5(b)(iv) · 1 mark

5(b)(iv)	genetic **AND** environmental **OR** an example of a genetic cause **AND** an example of an environmental cause **;**	**1**

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