PEARSON EDEXCEL A-LEVEL BIOLOGY B · 9BI0

BIOLOGY



EXAM QUESTION PACK

TOPIC 3: CLASSIFICATION AND BIODIVERSITY

NATURAL SELECTION

SCORE	PERCENTAGE
/157	%

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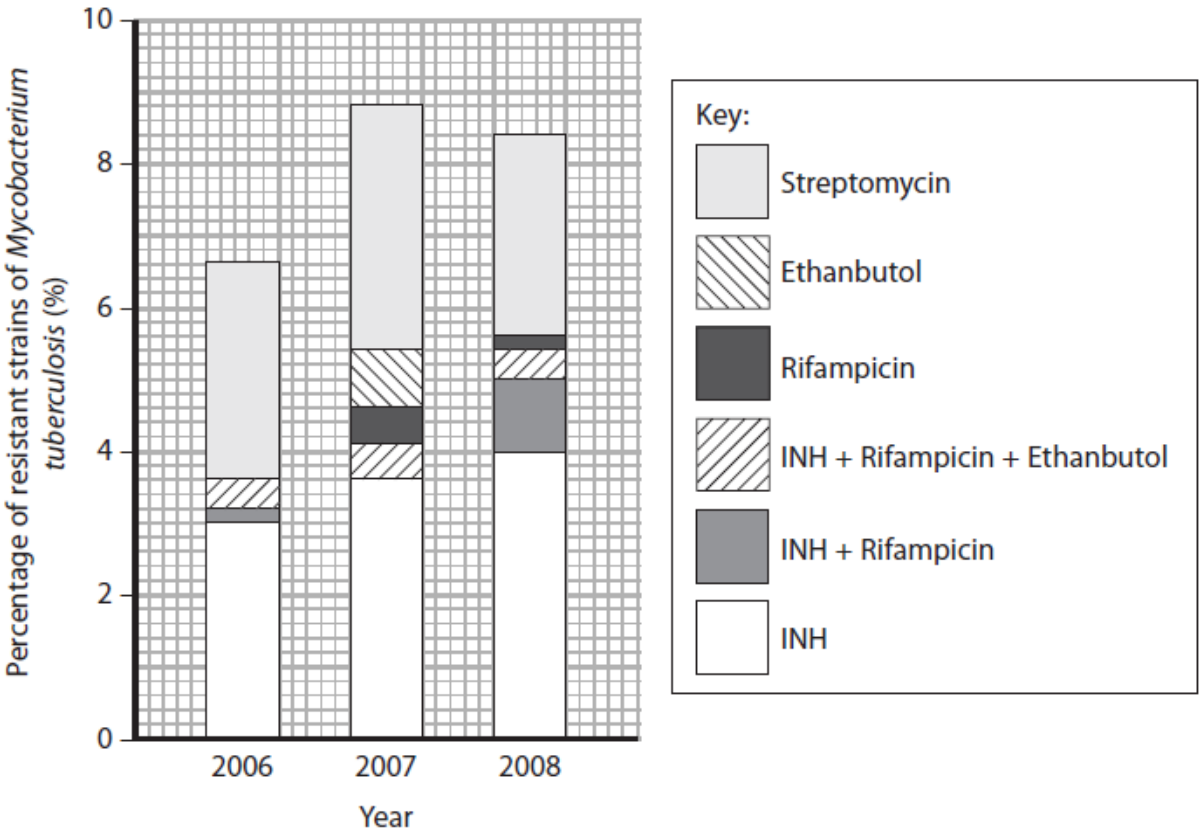
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Q1.

Treating *Mycobacterium tuberculosis* infections can be a problem, as the bacteria are resistant to many antibiotics.

There are many strains of *Mycobacterium tuberculosis*. Different strains are resistant to different antibiotics or combinations of antibiotics.

The chart below shows the percentage of resistant strains of *Mycobacterium tuberculosis* to six different antibiotics, or combinations of antibiotics, in 2006, 2007 and 2008.



(i) Using the information in the graph, compare the types of antibiotics and combinations of antibiotics that the *Mycobacterium tuberculosis* are resistant to in 2006 with 2007.

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(ii) The percentage of strains of *Mycobacterium tuberculosis* resistant to the antibiotic INH has increased during these three years.

Suggest how natural selection could have resulted in this increase.

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(iii) Suggest how hospitals could prevent an increase in the percentage of strains of *Mycobacterium tuberculosis* resistant to antibiotics.

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Q2.

There are drugs that can be taken to reduce the reproduction of HIV.

Explain why a patient is usually given several different drugs at the same time.

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(Total for question = 2 marks)

Q3.

Skin flora include bacteria that live on the skin.

Different parts of the body have different types of bacteria present.

Skin flora are beneficial as they inhibit the growth of pathogenic bacteria on the skin.

Skin flora compete for nutrients and space or secrete toxic chemicals.

The following are types of bacteria found in the female genital tract:

- *Escherichia coli*
- *Klebsiella species*
- *Lactobacillus species*
- *Staphylococcus species.*

(i) Describe how these types of bacteria present in the female genital tract could be identified.

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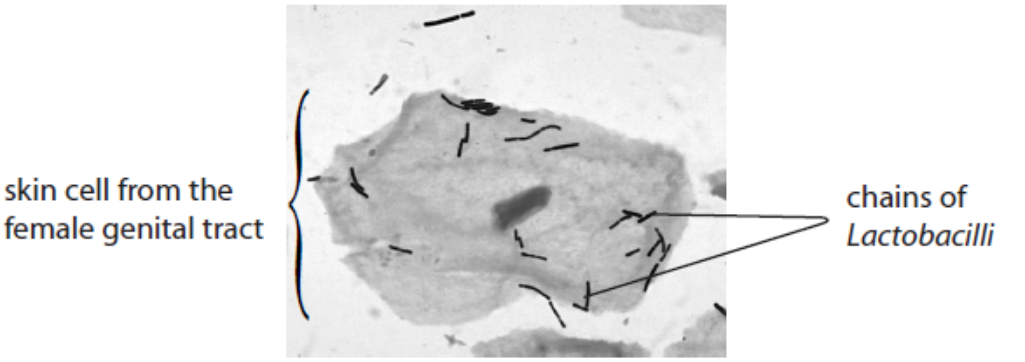
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(ii) The photograph shows *Lactobacilli* on a skin cell from the female genital tract.



Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.

Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

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(Total for question = 7 marks)

Q4.

The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

The table shows some of the measurements made in this investigation.

Measurement	Before drought	10 months into drought	14 months into drought	2 months after rain
Body condition index	.....	0.86	0.76	0.85
Body mass / kg	26.4	25.1	21.2	25.2
Organic matter in stomach / g kg^{-1} dry matter	946	732	704	822
Mineral ion content in stomach	low	high	high	low
Moisture content of faeces / g kg^{-1} wet mass	815	603	522	748

(i) The body condition was expressed as a body condition index (BCI).

The BCI can be calculated using the formula

$$\text{BCI} = \frac{\text{body mass of wombat}}{\text{mass-for-length of wombat (Y)}}$$

The mass-for-length (Y) of a wombat can be calculated using the formula

Y = (body length × 0.73) – 34.5

A wombat before the drought had a body length of 86.4 cm and a mass of 26.4 kg.

Calculate the BCI of this wombat.

(2)

Answer .....

*(ii) Analyse the data to explain the results of this investigation.

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(Total for question = 8 marks)

Q5.

When a mouse is put in a new environment, it will move around to find a safe place to live.

This is called exploratory behaviour.

A student investigated exploratory behaviour by putting a mouse into a large box.

The bottom of the box was marked into squares. There were four corner squares (C), two middle squares (M) and six side squares (S).

The marked bottom of the box is shown in the diagram.

C	S	S	C
S	M	M	S
C	S	S	C

The mouse moved about on the bottom of the box. The square occupied by the mouse was recorded every 10 seconds for 10 minutes.

The table shows the results of this investigation.

Total number of times square occupied by the mouse		
Corner square	**Middle square**	**Side square**
42	6	12

The student tested the null hypothesis that mice show no significant preference for corner, middle or side squares.

(i) Calculate the Chi squared value using the formula shown.

(2)

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

Answer .....

(ii) The table shows some critical values of Chi squared at different degrees of freedom.

Degrees of freedom	*p* value				
	0.900	0.500	0.100	0.050	0.010
1	0.016	0.455	2.706	3.841	6.635
2	0.211	1.386	4.605	5.991	9.210
3	0.584	2.366	6.251	7.815	11.345
4	1.064	3.357	7.779	9.488	13.277

Use your calculated Chi squared value and this table to comment on the conclusion the student should make about the null hypothesis.

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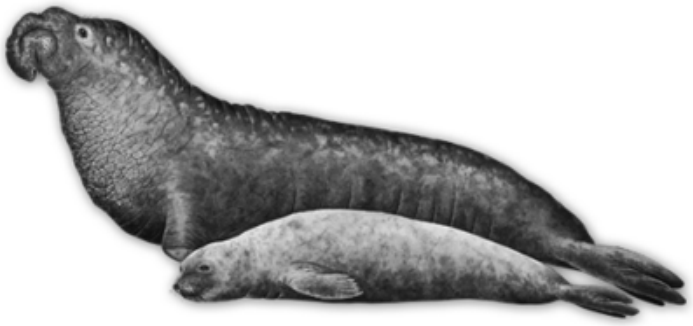
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(Total for question = 6 marks)

Q6.

The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.



In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

Northern elephant seals are able to dive to great depths and hold their breath for up to two hours.

The tables show data for four diving mammals.

Species	Maximum time holding breath / min	Maximum diving depth / m	Mass of animal / kg
bottlenose dolphin	5	20	200
harbour seal	17	19	24
Weddell seal	82	400	400
Northern elephant seal	119	437	400

Species	Volume of oxygen in body / $cm^3\ kg^{-1}$	Concentration of haemoglobin in blood / $g\ dm^{-3}$	Total blood volume / $cm^3\ kg^{-1}$	Percentage of stored oxygen in different body tissues		
				lungs	blood	muscle
bottlenose dolphin	36	14	71	34	27	39
harbour seal	57	21	132	13	54	33
Weddell seal	87	210	173	5	66	29
Northern elephant seal	97	216	207	4	71	25

(i) Calculate the total mass of haemoglobin in a Northern elephant seal.

(3)

Answer .....

* (ii) Analyse the data to explain how marine mammals are adapted for diving.

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(Total for question = 9 marks)

Q7.

The photographs below show three mammals.

Tasmanian wolf (*Thylacinus cynocephalus*)



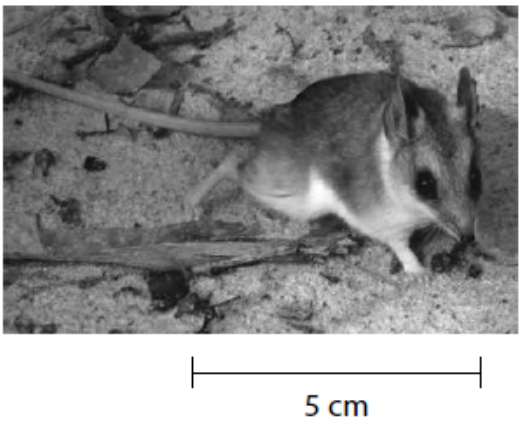
© The Zoological Society

Grey wolf (*Canis lupus*)



(Source: http://www.animalgalleries.org/Large-Land-Mammals/Wolf/Grey+Wolf+Mexican_Wolf_065+Canis+Lupus.jpg.php)

Dunnart (*Sminthopsis crassicaudata*)



(Source: apscience.org.au)

The evolutionary relationships between these three mammals were investigated.
The DNA base sequence of part of the gene for 12S ribosomal RNA from each mammal was analysed.

Tasmanian wolf	CCTGGCCTTACTGTTAATTCTTATTAGACCTAC
Grey wolf	CCTAGCCTTCCTATTAGTTTTTAGTAGACTTAC
Dunnart	CCTAGCCTTACTGTTAATTTTTATTAGACCTAC

(a) Explain which two of these mammals are most closely related in their evolutionary history.

(2)

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(b) The Tasmanian wolf is a marsupial mammal. In marsupials, the young are born in a tiny, immature form and move into a pouch on the abdomen of the mother to develop further.

The grey wolf is a placental mammal. The fetus develops inside the uterus and the larger young are born in a more mature form.

The ancestors of Tasmanian wolves and grey wolves once shared similar habitats.

Explain why grey wolves and their close relatives are now found in many parts of the world but Tasmanian wolves only survived on isolated islands.

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(Total for question = 5 marks)

Q8.

* The photograph shows a tawny owl. These owls live in areas close to the Arctic Circle.



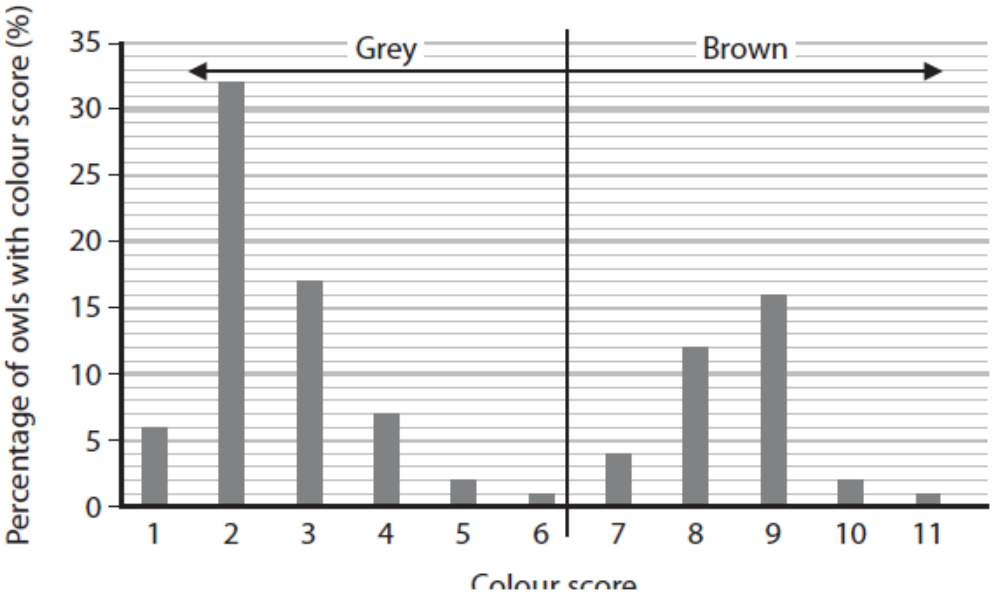
(Source: © LINDA WRIGHT/SCIENCE PHOTO LIBRARY)

Scientists investigated the feather colours of a population of tawny owls. Feather colours of the owls were scored on a scale of 1 to 11, according to how grey or brown they were.

Grey feathered owls were given a score between 6 and 1, with 1 being the most grey.

Brown feathered owls were given a score between 7 and 11, with 11 being the most brown.

The graph shows the percentages of owls in the population with each of the colour scores.



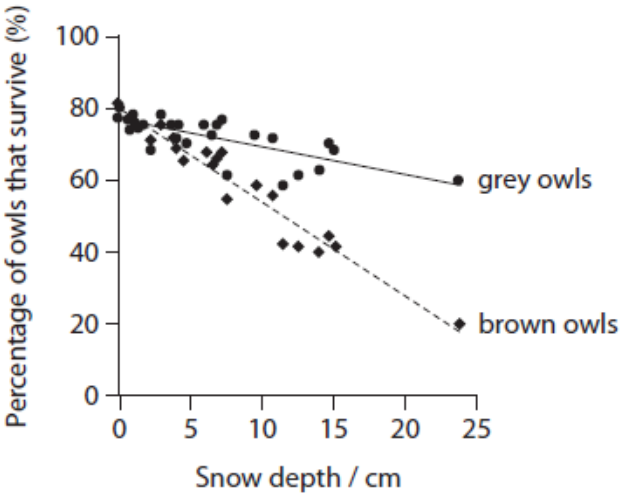
The scientists investigated the effect of climate change on the frequencies of these two alleles for feather colour in populations of tawny owls.

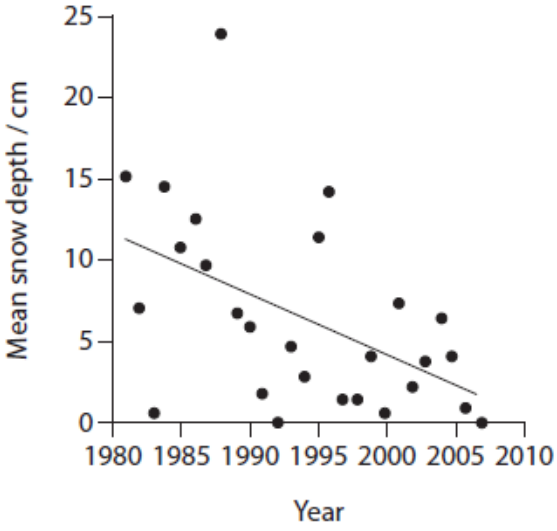
The percentage survival rates of both colours of owl were measured when there were different depths of snow.

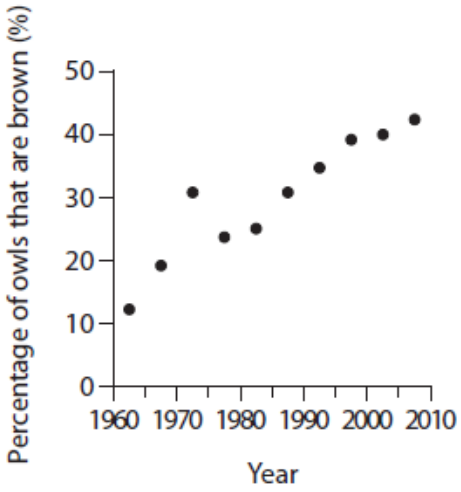
The mean depth of snow was recorded each year between 1980 and 2007.

The percentage of owls that were coloured brown between 1960 and 2007 was also recorded.

The graphs show the results.







The scientists concluded that increased greenhouse gases from human activity are resulting in an increase in the frequency of the brown allele.

Analyse the data to evaluate this conclusion.

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(Total for question = 6 marks)

Q9.

The island of Lanzarote is near the African coast and has a desert climate.

The photograph shows the edge of a lava flow from a volcano that erupted on this island about 200 hundred years ago.

In the foreground is an area that was not covered by the lava flow.

Over a long period of time, the lava will change to look like the climax community seen in the foreground.



King Juba's spurge, *Euphorbia regis-jubae*, is a plant that occupies a niche in the climax community.

Explain the niche occupied by King Juba's spurge.

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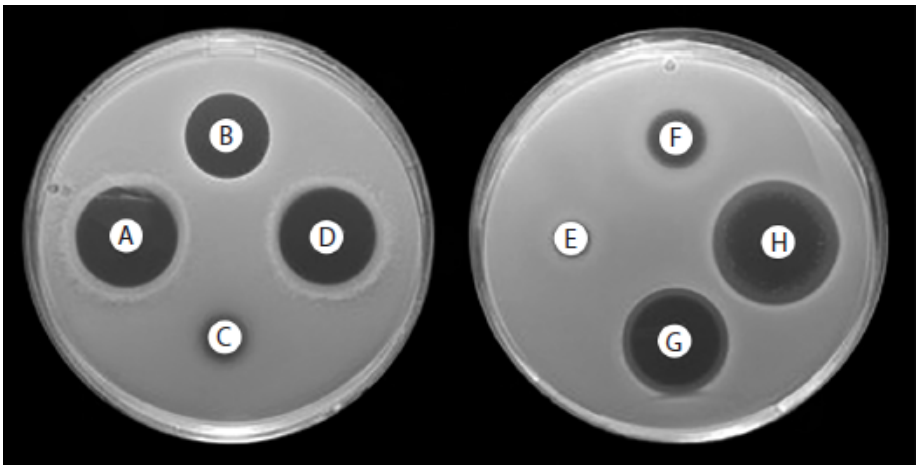
Q10.

A student read that more than half of raw chickens on sale in supermarkets are contaminated with bacteria from the genus *Campylobacter*.

Some species of *Campylobacter* cause food poisoning in humans.

The student carried out an experiment to test the effectiveness of various antibiotics against *Campylobacter*.

The photograph shows the student's agar plates at the end of the experiment.



The white circles labelled A–H are filter paper discs. These discs were soaked in different antibiotics then placed on the surface of the agar.

The student concluded that fresh chickens should be sprayed with antibiotic H before being packaged for sale in supermarkets.

Evaluate the student's conclusion.

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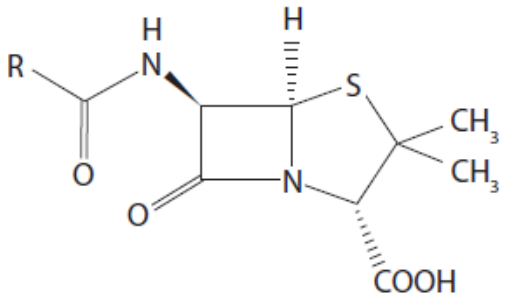
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Q11.

Tetracycline and penicillin are two antibiotics that are commonly used to treat bacterial infections.

The diagram shows the structure of penicillin.



In 2013, an Australian scientist said that 'evolution was winning the antibiotics arms race'.

Comment on the statement made by this scientist.

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Q12.

Malaria is caused by *Plasmodium*, a pathogenic microorganism.

Vaccination is one of many methods being used to control malaria.

In a study, the effectiveness of a vaccine for malaria was tested.

The following method was used:

- samples of *Plasmodium* were exposed to radiation and used to make a vaccine
- two groups of people, A and B, were given different doses of the vaccine
- a third group of people, C, was used as a control
- one month after vaccination, all three groups of people were exposed to mosquitoes known to contain live *Plasmodium*
- the number of people in each group with malaria was recorded.

The results are shown in the table.

Group	Treatment with the vaccine	Number of people in each group	Number of people with malaria
A	low dose	17	16
B	high dose	6	0
C	control	12	11

Anti-malarial drugs can be used to protect people from malaria.

These drugs are not always effective because *Plasmodium* develop resistance.

Explain how drug-resistant *Plasmodium* may evolve.

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(Total for question = 3 marks)

Q13.

Antibiotics have been developed to control bacterial infections.

(a) Name **one** bacterium which causes symptoms of infection by producing exotoxins.

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(b) Explain how an antibiotic has a bacteriostatic effect on bacteria.

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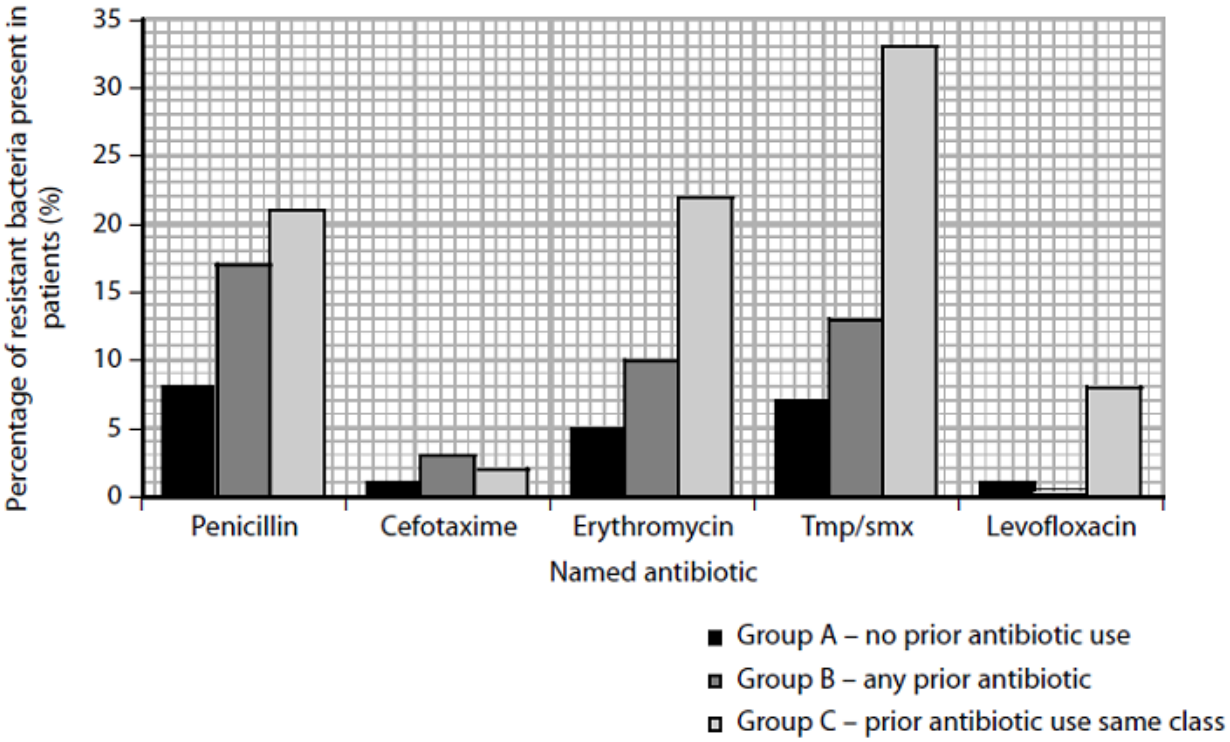
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*(c) Bacterial resistance to common antibiotics is an increasingly serious problem facing doctors treating a wide range of infections.

The graph below shows the percentage of resistant bacteria in patients being treated with antibiotics for *Streptococcus pneumoniae* infections.

Group A had never been given antibiotics.
Group B had been previously treated with other antibiotics.
Group C had been previously treated with the named antibiotic.



Analyse the data and use your knowledge of antibiotic resistance to evaluate the claim that soon doctors will be unable to treat most common bacterial infections with antibiotics.

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(Total for question = 12 marks)

Q14.

Sickle cell anaemia is caused by a mutation in the β-globin gene which codes for part of haemoglobin.

The diagram shows the first 10 amino acids in this part of haemoglobin, in a healthy person and in a person with sickle cell anaemia.

Healthy person:	val – his – leu – thr – pro – glu – glu – lys – ser - ala
Person with sickle cell anaemia:	val – his – leu – thr – pro – val – glu – lys – ser – ala

The allele that leads to sickle cell anaemia is known as HbS.

From 1990 to 1996, all newborn infants in California were screened for the presence of the HbS allele.

The data in the table show the ratio of individuals with and without the HbS allele, in various ethnic groups.

Ethnic group	HbS allele : no HbS allele
African American	1:14
Asian	1:1336
Caucasian	1:625
Hispanic	1:183
Middle Eastern	1:360
Native American	1:176

A chi squared test was used to analyse the raw data.

The null hypothesis was: "There is no difference between the frequency of the HbS allele in

African Americans and in all other ethnic groups combined."

The calculated value of chi squared was 450 615.

The table shows some critical values for the chi squared distribution, with one degree of freedom.

probability, *p*	0.005	0.010	0.025	0.050	0.100
critical value	7.879	6.635	5.024	3.841	2.706

Malaria is a major cause of death in Africa.

Assess the effect that this might have on the frequency of the HbS allele in African populations.

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Q15.

The photograph shows an insect fossilised in amber resin.



(Source: Bjoern Wylezich. 123rf.com/PAL)

Scientists have classified another fossilised insect found in amber resin as a new species of mosquito, *Priscoculex burmanicus*.

This mosquito is anatomically very similar to modern species of mosquito.

Mosquito populations are often controlled using pesticides that inhibit the enzyme acetylcholinesterase.

Long-term use of pesticides often leads to the development of resistance in these mosquitoes.

The ace-1 gene codes for the enzyme acetylcholinesterase.

The ace-1^r allele is a recessive form of this gene that gives resistance to pesticides.

The changes in the numbers of resistant and non-resistant mosquitoes in an area of farmland where pesticides were used in 2007 was investigated.

The use of the pesticides was stopped in 2016.

The table shows the results of this investigation.

Mosquito type	Number of mosquitoes		
	2005	2015	2018
resistant	125	5250	4120
non-resistant	8755	1250	3950

(i) Calculate the number of heterozygous mosquitoes in 2015.

Use the Hardy-Weinberg equation

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

(3)

Answer .....

(ii) Explain why the changes in the numbers of the resistant and non-resistant mosquitoes, from 2005 to 2018, are related to the function of the ace-1 gene.

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(Total for question = 7 marks)

Q16.

When a mouse is put in a new environment, it will move around to find a safe place to live.

This is called exploratory behaviour.

A student investigated exploratory behaviour by putting a mouse into a large box.

The bottom of the box was marked into squares. There were four corner squares (C), two middle squares (M) and six side squares (S).

The marked bottom of the box is shown in the diagram.

C	S	S	C
S	M	M	S
C	S	S	C

The mouse moved about on the bottom of the box. The square occupied by the mouse was recorded every 10 seconds for 10 minutes.

The table shows the results of this investigation.

Total number of times square occupied by the mouse		
Corner square	**Middle square**	**Side square**
42	6	12

The student tested the null hypothesis that mice show no significant preference for corner, middle or side squares.

The method used by the student had limitations.

Justify how the student could modify the investigation to address these limitations.

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(Total for question = 3 marks)

Q17.

The photograph shows a stonechat, *Saxicola dacotiae*.

The species breeds only on the island of Fuerteventura.



Explain how this species of stonechat may have evolved on the island of Fuerteventura.

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Q18.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The photograph shows an insect fossilised in amber resin.



(Source: Bjoern Wylezich. 123rf.com/PAL)

Scientists have classified another fossilised insect found in amber resin as a new species of mosquito, *Priscoculex burmanicus*.

This mosquito is anatomically very similar to modern species of mosquito.

(i) Which of these processes produces new species without geographically separating populations?

(1)

☒ **A** allopatric speciation

☒ **B** genetic speciation

☒ **C** stabilising speciation

☒ **D** sympatric speciation

(ii) *Priscoculex burmanicus* became extinct about 100 million years ago.

State why it was difficult for scientists to decide if this insect belonged to a different species from modern mosquitoes.

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(iii) State how scientists would have reached agreement on classifying this mosquito.

(1)

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(iv) Complete the classification table for *Priscoculex burmanicus*.

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Taxon	Name
Domain	Eukarya
Kingdom	Animalia
	Arthropoda
	Diptera
Order	Culicidae
Family	Anophelinae
Genus	
Species	

(Total for question = 5 marks)

Q19.

A student carried out an investigation to test the hypothesis that the surface area to mass ratio of leaves is affected by the amount of light they receive.

A nettle plant growing in sunlight and a second nettle plant growing in shade in a wood were selected.

The surface area and mass of several leaves were measured and the surface area to mass ratio was calculated. The table below shows the results.

Leaf	Surface area to mass ratio / $cm^2\ g^{-1}$	
	Nettle plant growing in sunlight	Nettle plant growing in shade
1	114.5	118.9
2	114.0	117.8
3	115.2	118.1

(a) Explain how the data shows how nettle plant leaves grown in the shade are adapted to growing in low light intensities.

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(b) The student was told that his method was not valid and that some biotic and abiotic variables may not be controlled.

Give five ways in which the student could modify the investigation to address these concerns.

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(Total for question = 8 marks)

Q20.

The polar bear, *Ursus maritimus*, preys on seals and fish. Polar bears are adapted to live in cold Arctic regions.



Polar bear
Magnification ×0.04

A recent study has shown that all polar bears are descended from populations that diverged from the Irish brown bear, *Ursus arctos*, approximately 120 000 years ago.

In this study, DNA from modern polar bears, the remains of historic polar bears and the remains of Irish brown bears was analysed.

(a) The first part of the study involved the amplification of DNA to give large enough samples for analysis.

(i) Describe how small samples of DNA can be amplified.

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(ii) Name **one** technique that could be used to analyse the amplified DNA samples.

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(b) Suggest how the scientists who conducted the study had their results accepted by other scientists.

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(c) Suggest how each of the following may have contributed towards the divergence of polar bears and Irish brown bears into two separate species.

(i) Separation of the Arctic and Irish regions by sea

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(ii) Genetic mutation

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(Total for question = 11 marks)

Q21.

Macroalgae and microalgae are photosynthetic organisms.

Seaweeds are macroalgae that live attached to rock in coastal areas.

Some seaweeds are green, some are brown and some are red.

The colour of seaweeds depends on the photosynthetic pigments contained in their cells.

Green seaweeds contain chlorophyll, brown seaweeds contain chlorophyll and fucoxanthin and red seaweeds contain chlorophyll and phycoerythrin.

(i) Explain why these seaweeds have different absorption spectra and action spectra.

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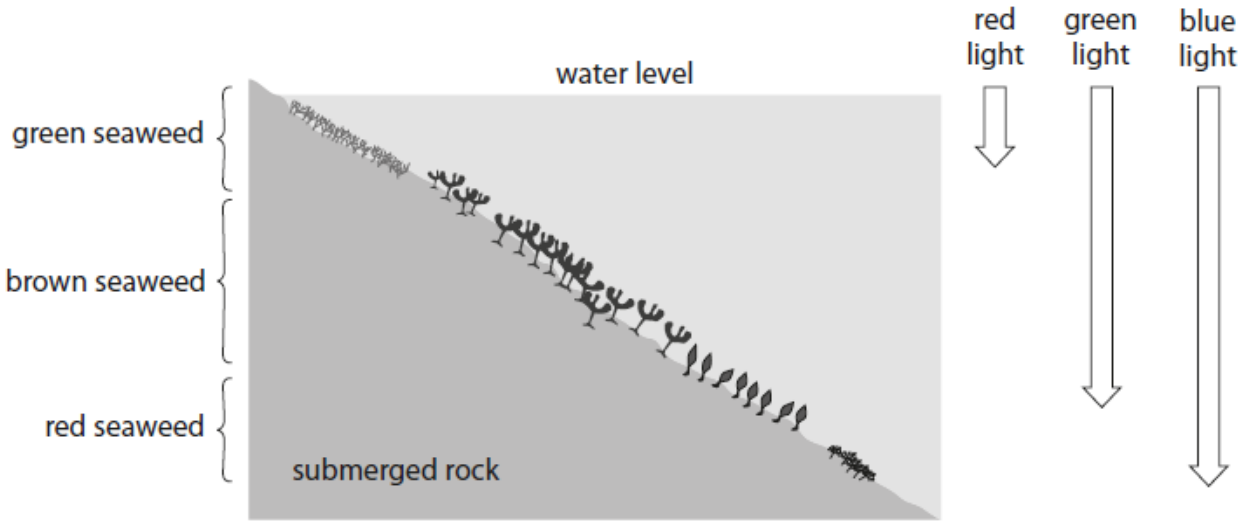
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(ii) The diagram shows the position that these seaweeds occupy on submerged rock and the depth to which different wavelengths of light penetrate into the water.



Explain why the seaweeds occupy different positions on the submerged rock.

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(Total for question = 6 marks)

Q22.

Fritillaria delavayi is a small plant (height 7 cm), that grows on rocky slopes on mountains in China.

The image shows *Fritillaria delavayi*.



For at least 2 000 years, this plant has been collected and used in Chinese medicine.
It is not known to be eaten by animals.

In less accessible regions, where few humans go, the plants are bright green with bright yellow flowers.

In locations where bulbs are collected in high numbers, most plants have greyish-brown leaves and flowers.

Scientists believe that the greyish-brown plants are the same species as the brightly-coloured plants.

Explain why most of the plants in areas where bulbs are collected in high numbers have greyish-brown leaves and flowers.

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(Total for question = 4 marks)

Q23. The group of birds, known as warblers, contains many species which are very similar in external appearance.

Two of these species, the chiffchaff, *Phylloscopus collybita*, and the willow warbler, *Phylloscopus trochilus*, are so similar that many experts can identify them only by listening to their individually-characteristic songs.
These songs are used during breeding to mark territory and attract mates.

The photographs below show these two warblers.



Chiffchaff Willow warbler

Magnification × 0.75

(a) Although chiffchaffs and willow warblers are often found at the same time in the same woodlands, they do not interbreed.

(i) Suggest why successful interbreeding between chiffchaffs and willow warblers would make some scientists doubt their classification as separate species.

(3)

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(ii) Suggest reasons why the two species do not interbreed.

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(b) Records show that very little change in the appearance of chiffchaffs and willow warblers has occurred during the last two hundred years.

Suggest why the rate of change in the appearance of these two species is relatively slow.

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(Total for Question = 9 marks)

Q24. The group of birds, known as warblers, contains many species which are very similar in external appearance.

The chiffchaff, *Phylloscopus collybita*, and the willow warbler, *Phylloscopus trochilus* are two species of warbler.

These warblers are so similar that many experts can identify them only by listening to their characteristic songs. Their songs are used during breeding to mark territory and attract mates.

The photographs below show these two warblers.



Chiffchaff



Willow warbler

Magnification × 0.75

(a) Explain the meaning of the term **species**.

(1)

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(b) Suggest how these two types of warbler became separate species.

(4)

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(c) Suggest why these two species of warbler are so similar in external appearance.

(3)

(Total for Question = 8 marks)

Q25.

Frogs are ectothermic animals. This means that their body temperature will vary as the environmental temperature varies.

(a) Explain why body temperature affects the rate of development of animals.

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(b) Several species of the frog genus, *Rana*, can be found in North America. Many of these species inhabit areas within a range of latitudes from the colder north to the warmer south.

The table below shows data for four of these species, *R. clamitans*, *R. palustris*, *R. pipiens* and *R. sylvatica*.

Species	Body temperature of frog / °C			
	Lower lethal, below which frog dies	Minimum to start development	Maximum to complete development	Upper lethal, above which frog dies
R. clamitans	10.0	11.0	35.0	37.0
R. palustris	5.0	7.0	30.0	31.0
R. pipiens	3.0	6.0	28.0	30.0
R. sylvatica	0.0	2.0	24.0	25.0

Using the information, suggest why the lower and upper lethal temperatures limit the range of latitudes inhabited by each species of frog.

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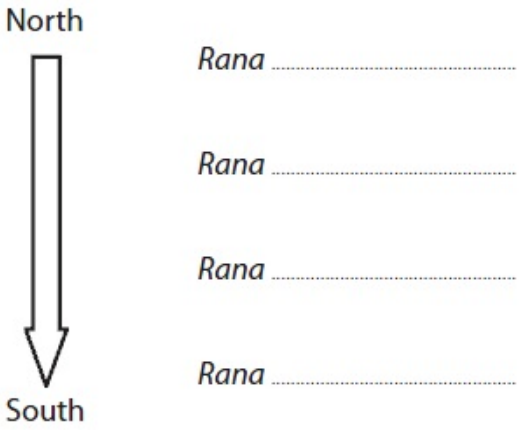
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(c) Complete the species names in the diagram below to show the most likely distribution of

Rana from north to south.

(2)



(d) Populations of the different species overlap on the boundaries of each latitude range.

Suggest why interbreeding does not take place between these populations.

(3)

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(e) Suggest how global warming may affect the distribution of these species of Rana in North America.

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(Total for question = 13 marks)