

AQA AS BIOLOGY

# TOPIC 4

EVOLUTION



**1**

Organisms can be classified using a hierarchy of phylogenetic groups.

(a) Explain what is meant by:

(i) a hierarchy

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**(2)**

(ii) a phylogenetic group.

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**(1)**

(b) Cytochrome c is a protein involved in respiration. Scientists determined the amino acid sequence of human cytochrome c. They then:

- determined the amino acid sequences in cytochrome c from five other animals
- compared these amino acid sequences with that of human cytochrome c
- recorded the number of differences in the amino acid sequence compared with human cytochrome c.

The table shows their results.

Animal	Number of differences in the amino acid sequence compared with human cytochrome c
A	1
B	12
C	12
D	15
E	21

(i) Explain how these results suggest that animal **A** is the most closely related to humans.

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(2)

(ii) A student who looked at these results concluded that animals **B** and **C** are more closely related to each other than to any of the other animals.

Suggest **one** reason why this might **not** be a valid conclusion.

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(1)

(iii) Cytochrome c is more useful than haemoglobin for studying how closely related different organisms are. Suggest **one** reason why.

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(1)  
(Total 7 marks)

**2**

The Amazonian forest today contains a very high diversity of bird species.

- Over the last 2 000 000 years, long periods of dry climate caused this forest to separate into a number of smaller forests.
- Different plant communities developed in each of these smaller forests.
- Each time the climate became wetter again, the smaller forests grew in size and merged to reform the Amazonian forest.

(a) Use the information provided to explain how a very high diversity of bird species has developed in the Amazonian forest.

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(b) Speciation is far less frequent in the reformed Amazonian forest. Suggest one reason for this.

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(1)  
(Total 6 marks)

3

Malaria is a disease caused by a parasite. Scientists investigated the effect of malaria on competition between two species of *Anolis* lizard on a small Caribbean island. They sampled both populations by collecting lizards from a large number of sites on the island.

(a) (i) Explain the importance of collecting lizards from a large number of sites.

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(1)

(ii) Describe **one** method the scientists could have used to ensure that the sites were chosen without bias.

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(2)

(iii) The population number of both species of lizard varied at different times of the year. Suggest **two** reasons why.

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(2)

The scientists investigated the percentage of lizards of both species that were infected with malaria at different sites on the island. They collected samples of both lizards at intervals of 3 months for 1 year. They also recorded the elevation (height above sea level) of each site. Some of their results are shown in the table.

Site	Elevation of collection site / metres	Total number of <i>A. gingivinus</i> collected in one year	Percentage of <i>A. gingivinus</i> infected with malaria	Total number of <i>A. wattsi</i> collected in one year	Percentage of <i>A. wattsi</i> infected with malaria
1	10	13	0	0	0
2	80	30	0	0	0
3	120	35	23	3	0
4	200	40	30	7	0
5	300	52	46	12	0
6	315	35	31	13	1
7	370	155	37	79	2
8	414	124	44	68	4

(b) When analysing their results, the scientists used the percentage of lizards infected at each site, rather than the number of lizards infected. Explain why.

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(2)

(c) A preliminary study suggested that malarial infections were more common at higher elevations. Use the information provided to evaluate this suggestion.

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(2)

(d) (i) As a result of this investigation, the scientists concluded that the presence of malaria provided a competitive advantage to *A. wattsi*. Use the information provided to explain how they reached this conclusion.

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(2)

(ii) The malarial parasite of *Anolis* lizards destroys both red and white blood cells. Suggest how an increase in the percentage of *A. gingivinus* infected with malaria could result in *A. wattsi* having a competitive advantage.

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(2)

- (iii) The scientists carried out a statistical test to determine whether the correlation between the number of *A. wattsi* collected and the percentage of *A. gingivinus* infected was significant. They obtained a value for P of  $< 0.01$ .

Use the terms **probability** and **chance** to help explain what this means.

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(2)  
(Total 15 marks)

4

- (a) The genetic code is described as being degenerate. What does this mean?

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(1)

- (b) What is a codon?

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(2)

- (c) (i) What is the role of RNA polymerase during transcription?

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(1)

- (ii) mRNA can be converted to cDNA.

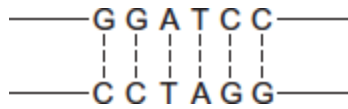
Name the enzyme used in this process.

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(1)



- (d) The diagram shows the base sequence on DNA where a restriction endonuclease cuts DNA.



Use evidence from the diagram to explain what is meant by a palindromic recognition sequence on DNA.

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(1)  
(Total 6 marks)

5

- (a) There are ethical and economic arguments for maintaining biodiversity.

- (i) Suggest **one** ethical argument for maintaining biodiversity.

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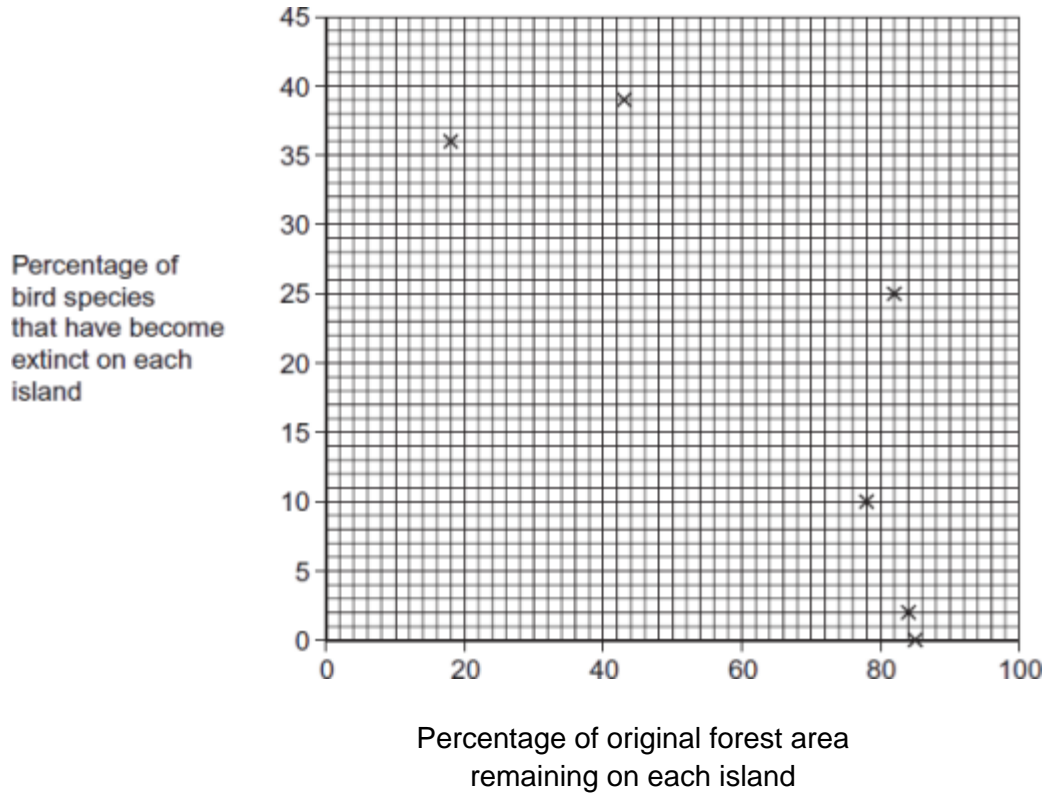
(1)

- (ii) Suggest **one** economic argument for maintaining biodiversity.

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(1)

Ecologists calculated the percentage of bird species that have become extinct on six islands in the last one hundred years. They also calculated the percentage of original forest area remaining on each island after the same time period. The graph shows their results.



(b) Explain the relationship between the percentage of original forest area remaining and the percentage of bird species that have become extinct.

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(2)

(c) What **two** measurements would the ecologists have needed to obtain to calculate the index of diversity of birds on each island?

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(2)

- (d) The ecologists noted that the species of birds surviving on the coldest islands had a larger body size than those surviving on warmer islands.

Explain how a larger body size is an adaptation to a colder climate

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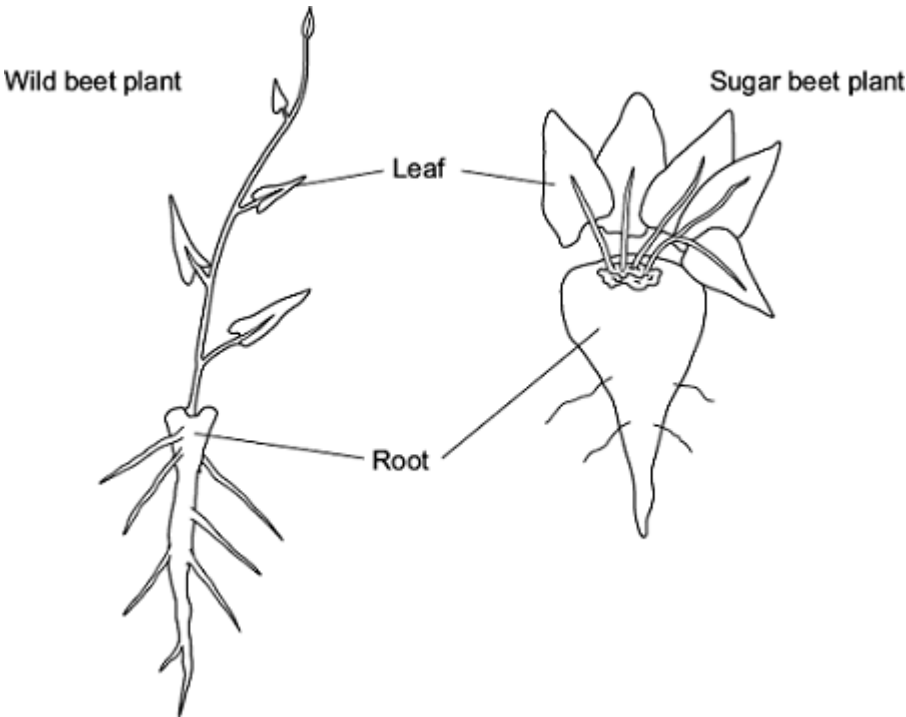
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**(2)**  
**(Total 8 marks)**

6

Sugar beet is a crop grown for the sugar stored in its root. The sugar is produced by photosynthesis in the leaves of the plant. Plant breeders selected high-yielding wild beet plants. They used these plants to produce a strain of sugar beet to grow as a crop.

The drawings show a wild beet plant and a sugar beet plant. The drawings are to the same scale.



(a) Use the drawings to describe **two** ways in which a sugar beet plant is different from a wild beet plant.

Explain how each of these differences would give an increased yield of sugar.

Difference 1 .....

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Explanation .....

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Difference 2 .....

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Explanation .....

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(4)

(b) Sugar beet plants have been selected for a faster rate of growth.

Suggest how the faster rate of growth may increase profit for a farmer.

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**(1)**

(c) Describe and explain how selection will have affected the genetic diversity of sugar beet.

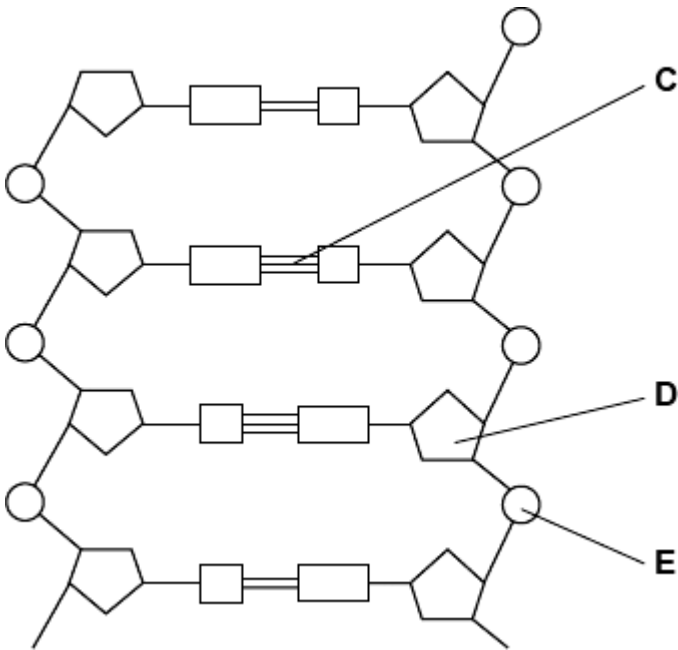
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**(2)**

**(Total 7 marks)**

7

The diagram shows part of a DNA molecule.



(a) (i) DNA is a polymer. What is the evidence from the diagram that DNA is a polymer?

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(1)

(ii) Name the parts of the diagram labelled C, D and E.

Part C .....  
Part D .....  
Part E .....

(3)

(iii) In a piece of DNA, 34% of the bases were thymine.

Complete the table to show the names and percentages of the other bases.

Name of base	Percentage
Thymine	34
	34

(2)

(b) A polypeptide has 51 amino acids in its primary structure.

(i) What is the minimum number of DNA bases required to code for the amino acids in this polypeptide?

(1)

(ii) The gene for this polypeptide contains more than this number of bases.

Explain why

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(1)

(Total 8 marks)

8

Hummingbirds belong to the order Apodiformes. One genus in this order is *Topaza*.

(a) (i) Name **one** other taxonomic group to which all members of the Apodiformes belong.

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(1)

(ii) Name the taxonomic group between order and genus.

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(1)

The crimson topaz and the fiery topaz are hummingbirds.

Biologists investigated whether the crimson topaz and the fiery topaz are different species of hummingbird, or different forms of the same species.

They caught large numbers of each type of hummingbird. For each bird they

- recorded its sex
- recorded its mass
- recorded the colour of its throat feathers
- took a sample of a blood protein.

The table shows some of their results.

	Crimson topaz		Fiery topaz	
	Male	Female	Male	Female
Mean mass / g ( $\pm$ standard deviation)	13.6 ( $\pm$ 1.9)	10.8 ( $\pm$ 1.3)	14.2 ( $\pm$ 1.6)	11.6 ( $\pm$ 0.63)
Colour of throat feathers	Green	Grey edges	Yellowish green	No grey edges

(b) Explain how the standard deviation helps in the interpretation of these data.

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(2)



- (c) The biologists analysed the amino acid sequences of the blood protein samples from these hummingbirds.

Explain how these sequences could provide evidence as to whether the crimson topaz and the fiery topaz are different species.

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**(2)**  
**(Total 6 marks)**

**9**

Scientists investigated the species of insects found in a wood and in a nearby wheat field. The scientists collected insects by placing traps at sites chosen at random both in the wood and in the wheat field.

The table shows the data collected in the wood and in the wheat field.

Species of insect	Number of organisms of each species	
	Wood	Wheat field
Bird-cherry oat aphid	0	216
Beech aphid	563	0
Large white butterfly	20	0
Lacewing	12	3
7-spot ladybird	36	0
2-spot ladybird	9	1
Total number of organisms of all species	640	220

- (a) The scientists collected insects at sites chosen at random. Explain the importance of the sites being chosen at random.

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**(1)**

- (b) (i) Use the formula

$$d = \frac{N(N-1)}{\sum n(n-1)}$$

to calculate the index of diversity for the insects caught in the wood, where

$d$  = index of diversity

$N$  = total number of organisms of all species

$n$  = total number of organisms of each species

Show your working.

Answer .....

**(2)**

- (ii) Without carrying out any further calculations, estimate whether the index of diversity for the wheat field would be higher or lower than the index of diversity for the wood.

Explain how you arrived at your answer.

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**(2)**

- (c) A journalist concluded that this investigation showed that farming reduces species diversity. Evaluate this conclusion.

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**(2)**

- (d) Farmers were offered grants by the government to plant hedges around their fields. Explain the effect planting hedges could have on the index of diversity for animals.

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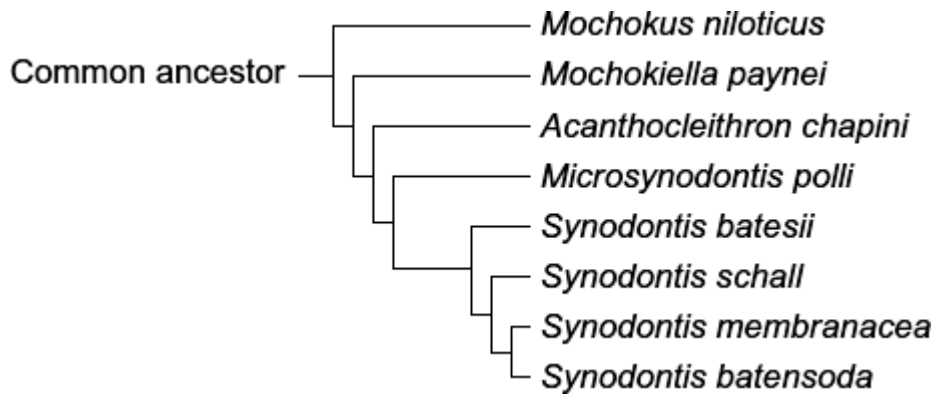
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(2)  
(Total 9 marks)

10

There are over 200 species of catfish. All catfish evolved from a common ancestor. The diagram shows how some species of catfish are classified. This diagram is based on the evolutionary links between these species.



- (a) (i) Which species of catfish is most closely related to *Synodontis membranacea*?

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(1)

- (ii) Which species of catfish is most distantly related to *Synodontis membranacea*?

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(1)

- (b) How many different genera are shown in this diagram?

(1)

- (c) (i) A scientist carried out breeding experiments with catfish from different populations. Describe how the results could show that the catfish belong to the same species.

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(1)

- (ii) The variety of colours displayed by catfish is important in courtship. Give **two** ways in which courtship increases the probability of successful mating.

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2 .....

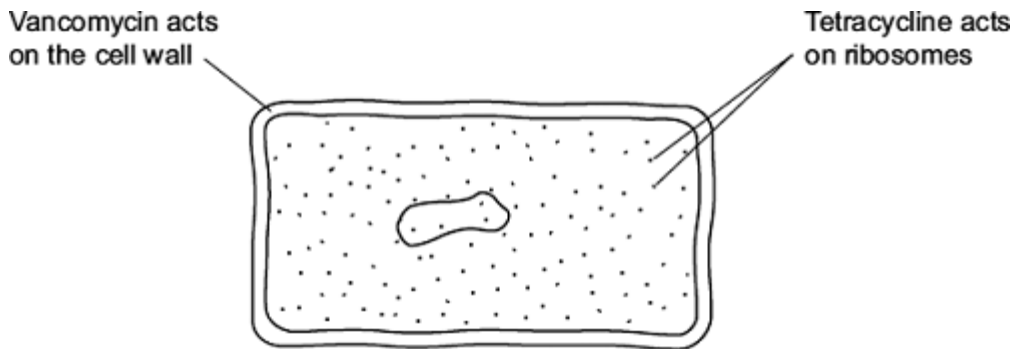
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(2)

(Total 6 marks)

11

The diagram shows the structure of a bacterium and the sites of action of two antibiotics.



- (a) (i) Use information in the diagram to explain why vancomycin does **not** affect human cells.

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(1)

- (ii) Use information in the diagram to explain how tetracycline prevents bacterial growth.

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(1)

(b) Frequent treatment with vancomycin can result in resistant strains of bacteria. Explain how.

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(2)  
(Total 4 marks)

12

(a) A student investigated the diversity of plants at several sites on a golf course. At each site she took a large number of random samples.

(i) Explain the importance of taking a large number of samples at each site.

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(1)

(ii) Explain the importance of taking samples at random.

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(1)

The student collected data from one part of the golf course and calculated an index of diversity.

The table shows her data.

Species	Number of plants per m <sup>2</sup>
Sheep's fescue	11
Creeping buttercup	6
Clover	5
Dandelion	2
Sheep's sorrel	1
Lady's bedstraw	7
Stemless thistle	4

The index of diversity can be calculated from the formula

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

where

$d$  = index of diversity

$N$  = total number of organisms of all species

$n$  = total number of organisms of each species

- (b) Use the formula to calculate the index of diversity for the plants on this part of the golf course. Show your working.

Answer .....

(2)

(c) The golf course was surrounded by undeveloped grassland from which it had been produced.

The golf course had

- some areas of very short grass which was cut frequently
- some areas of longer grass which was cut less frequently
- some areas of long grass and shrubs which were never cut.

The index of diversity for the insects on the golf course was higher than that for the surrounding undeveloped grassland.

Explain the effect of developing this golf course on the index of diversity of insects.

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**(3)**  
**(Total 7 marks)**

**13**

(a) Explain what is meant by genetic diversity.

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**(1)**

(b) Apart from genetic factors what other type of factor causes variation within a species?

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**(1)**

- (c) The spotted owl is a bird. Numbers of spotted owls have decreased over the past 50 years. Explain how this decrease may affect genetic diversity.

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(2)  
(Total 4 marks)

14

The diagram shows a short sequence of DNA bases.

**TTTGTATACTAGTCTACTTCGTTAATA**

- (a) (i) What is the maximum number of amino acids for which this sequence of DNA bases could code?

(1)

- (ii) The number of amino acids coded for could be fewer than your answer to part (a)(i).

Give **one** reason why.

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(1)



(b) Explain how a change in the DNA base sequence for a protein may result in a change in the structure of the protein.

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(3)

(c) A piece of DNA consisted of 74 base pairs. The two strands of the DNA, strands **A** and **B**, were analysed to find the **number** of bases of each type that were present. Some of the results are shown in the table.

	Number of bases			
	C	G	A	T
Strand <b>A</b>	26			
Strand <b>B</b>	19		9	

Complete the table by writing in the missing values.

(2)  
(Total 7 marks)

**15**

Costa Rica is a Central American country. It has a high level of species diversity.

(a) There are over 12 000 species of plants in Costa Rica. Explain how this has resulted in a high species diversity of animals.

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**(2)**

(b) The number of species present is one way to measure biodiversity. Explain why an index of diversity may be a more useful measure of biodiversity.

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**(2)**

(c) Crops grown in Costa Rica are sprayed with pesticides. Pesticides are substances that kill pests. Scientists think that pollution of water by pesticides has reduced the number of species of frog.

(i) Frogs lay their eggs in pools of water. These eggs are small. Use this information to explain why frogs' eggs are very likely to be affected by pesticides in the water.

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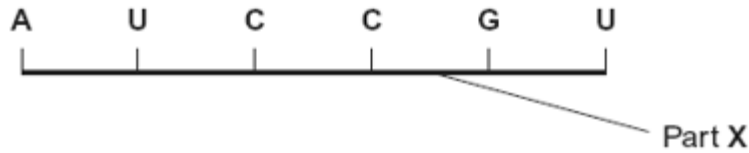
**(2)**

- (ii) An increase in temperature leads to evaporation of water. Suggest how evaporation may increase the effect of pesticides on frogs' eggs.

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(1)  
 (Total 7 marks)

**16** The diagram shows part of a pre-mRNA molecule.



- (a) (i) Name the **two** substances that make up part **X**.

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(1)

- (ii) Give the sequence of bases on the DNA strand from which this pre-mRNA has been transcribed.

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(1)

- (b) (i) Give one way in which the structure of an mRNA molecule is different from the structure of a tRNA molecule.

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(1)

- (ii) Explain the difference between pre-mRNA and mRNA.

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(1)

- (c) The table shows the percentage of different bases in two pre-mRNA molecules. The molecules were transcribed from the DNA in different parts of a chromosome.

Part of chromosome	Percentage of base			
	A	G	C	U
Middle	38	20	24	
End	31	22	26	

- (i) Complete the table by writing the percentage of uracil (U) in the appropriate boxes.

(1)

- (ii) Explain why the percentages of bases from the middle part of the chromosome and the end part are different.

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(2)

(Total 7 marks)

17

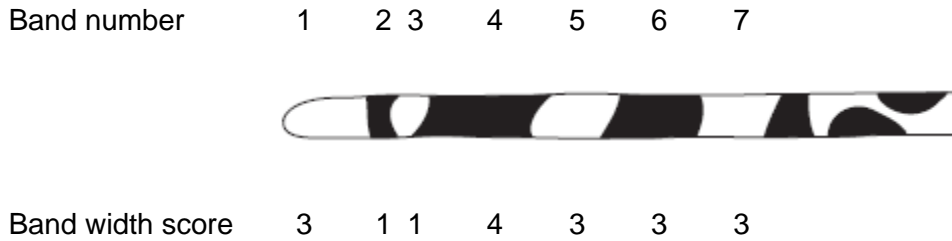
The body markings of cheetahs vary, in particular the pattern of bands on their tails. Cheetahs are solitary animals but the young stay with their mother until they are between 14 and 18 months old.

Scientists investigated the banding pattern on the tails of cheetahs living in the wild.

- They drove a car alongside a walking cheetah and used binoculars to study the tail pattern.
- They gave each cheetah a banding pattern score based on the width of the dark and light bands on the end of the tail.
- They scored the width of the bands on the right and left side of the tail using a 5 point scale of width.

A typical pattern on the right side of one cheetah's tail is shown in **Figure 1**.

**Figure 1**



The scientists collected data from each cheetah on four separate occasions. **Figure 2** shows the data for one of the cheetahs.

**Figure 2**

Side of tail	Mean band width score ( $\pm$ standard deviation)						
	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7
Right	3.00 ( $\pm$ 0.82)	1.00 ( $\pm$ 0.00)	1.00 ( $\pm$ 0.00)	3.75 ( $\pm$ 0.50)	2.75 ( $\pm$ 0.50)	3.00 ( $\pm$ 0.00)	3.00 ( $\pm$ 0.00)
Left	3.75 ( $\pm$ 0.50)	3.25 ( $\pm$ 0.50)	2.00 ( $\pm$ 0.50)	3.00 ( $\pm$ 0.00)	2.00 ( $\pm$ 0.00)	2.50 ( $\pm$ 0.50)	3.00 ( $\pm$ 0.50)

(a) The scientists only used data from cheetahs which were fully grown. Suggest why.

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**(1)**

(b) The scientists estimated the width of the bands on the same cheetah on four separate occasions. They did not always get the same score.

(i) Give **two** pieces of evidence from **Figure 2** which show that the scientists sometimes obtained different scores for the same band.

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**(2)**

(ii) The method the scientists used resulted in them getting different scores for the same band. Suggest why.

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(1)

(c) What is the evidence from **Figure 2** that the dark and light bands do **not** form rings of equal width around the tail?

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(1)

(d) The scientists found the difference in banding pattern between

- offspring in the same family
- cheetahs chosen randomly.

Explain how scientists could use this information to show that some variation in tail banding was genetic.

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(3)  
(Total 8 marks)