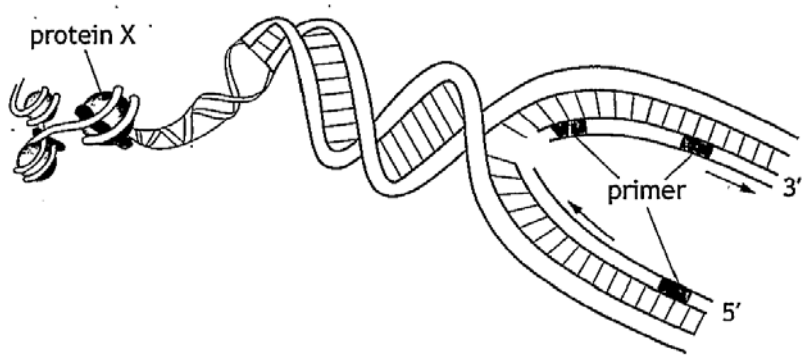
Candidate 1 evidence

Total marks — 95

Attempt ALL questions

Questions 3 and 16 contain a choice.

1. The diagram shows the replication of DNA in a chromosome from a eukaryotic cell. The arrows show the directions of replication.



(a) Name protein X. 1

histones

(b) Explain why primers are necessary for DNA replication. 1

they mark a starting point for DNA polymerase to add nucleotides (3' end of DNA strand)

(c) (i) Explain why only the leading strand can be replicated continuously. 1

DNA polymerase can only add nucleotides to the 3' end of DNA strand, (union is the direction of the leading strand) so it is discontinuous. the lagging strand runs opposites

(ii) Name the enzyme that joins fragments together in the lagging strand. 1

ligase

(d) Describe how DNA is organised in prokaryotes. 2

-Prokaryotes have no membrane bound nucleus, they have circular chromosomes

2. Three different mutated bacteria, X, Y and Z were studied. Each had a mutation in a different region of its DNA that is transcribed to rRNA.

Protein synthesis was measured in cultures of each mutated bacteria and in a culture of unmutated bacteria.

The results are shown in the table.

Bacterial culture	Protein synthesis (%)
Unmutated	100
X	9
Y	15
Z	90

(a) Calculate the simplest whole number ratio of percentage protein synthesis in cultures X, Y and Z. 1

Space for calculation

9 is 90

3 : 5 : 30

(b) Name the other component of ribosomes, apart from rRNA. 1

protein

(c) Using your knowledge of biology, suggest how a change in the sequence of bases in DNA transcribed to **rRNA** in the mutated cultures resulted in a decrease in protein synthesis. 2

There is a change in the genetic code meaning that when that protein is synthesised it produces a different protein, not the required one. the anticodons will not be complementary to the codons on the mRNA meaning that the amino acids will be wrong.

(d) Describe **one** structural difference between DNA and rRNA. 1

DNA is double stranded, rRNA is single stranded

~~DNA contains deoxyribose sugar, RNA contains ribose~~ sugar

3. Attempt **either A or B.** Write your answer in the space below.

A Write an account of ATP synthesis in the electron transport chain during cellular respiration. 4

OR

B Write an account of competitive and feedback inhibition of enzymes. 4

You may use labelled diagrams where appropriate.

B

Competitive inhibitors reduce the rate of an enzyme controlled reaction.
Competitive inhibitors have a similar shape to the substrate molecule and bind to the enzymes active site, preventing the substrate from binding. Increasing substrate concentration reverses effects of competitive inhibition.
Feedback inhibition is when the final product binds with the enzyme at the start of the reaction.
It avoids accumulation and waste of product.

4. Myoglobin and haemoglobin are oxygen-binding proteins in mammals. The myoglobin molecule is a single globin polypeptide. The haemoglobin molecule is composed of both alpha globin and beta globin polypeptides.

(a) Myoglobin consists of a chain of 154 amino acids folded in a specific three-dimensional shape.

(i) Name a bond that holds the polypeptide chain in this shape. 1

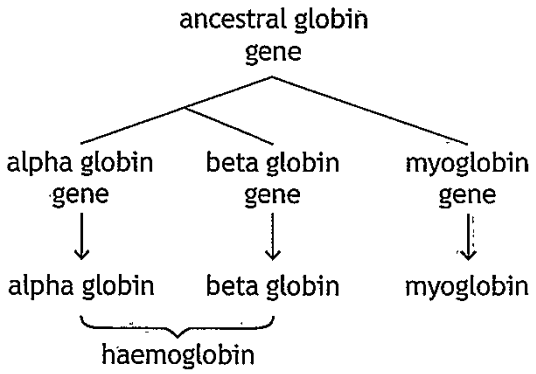
peptide hydrogen

(ii) The gene for myoglobin contains 1154 bases while its mature mRNA transcript contains 462 bases.

Give a reason for this difference. 1

Splicing has occured, the introns (non-coding regions of DNA) have been removed and the exons (coding regions of DNA) have been spliced to form the mature transcript

(b) The genes for myoglobin and haemoglobin have evolved from a single ancestral globin gene as shown in the diagram.



In the genome of mammals there are multiple copies of alpha and beta globin genes.

(i) The multiple copies of alpha and beta globin genes are the result of duplication mutations.

Describe how a duplication mutation occurs. 1

- part of the gene is copied twice due to a mutation that has occured

(ii) Explain the importance of duplication mutations in evolution. 2

- mutations are the only source of new alleles, they allow advantageous genes to be passed to offspring from parent.

5. The Galapagos are a group of islands 600 to 800 miles off the coast of South America. Less than three million years ago some finches of a single ancestral species reached these islands from South America and bred successfully.

The number of islands has increased over time, further isolating groups of finches.

(a) Use this information to name the type of isolation barrier involved in the speciation of these finches and explain its role. **2**

Name: geographical

Explanation: the finches have become genetically isolated and have evolved into different species due to the far distance between them.

(b) The table shows the estimated number of islands and finch species in the Galapagos over the last 2·8 million years.

Time (millions of years ago)	Estimated number of islands in the group	Estimated number of finch species present
2·8	4	0
1·0	6	5
0·5	18	9
0·0	18	14

(i) Calculate the average increase in the number of finch species per million years over this entire period. **1**

Space for calculation

9 species per million years

5. (b) (continued)

(ii) Suggest what could have caused the change in the number of finch species over the last 0·5 million years. 1

An advantageous mutation that has been
passed to ~~offspring~~ daughter generations

(c) A molecular clock was used to estimate the dates of the divergence of each species.

Give one example of the type of data required to generate a molecular clock. 1

~~Sequence divergence~~ phylogenetics

[Turn over

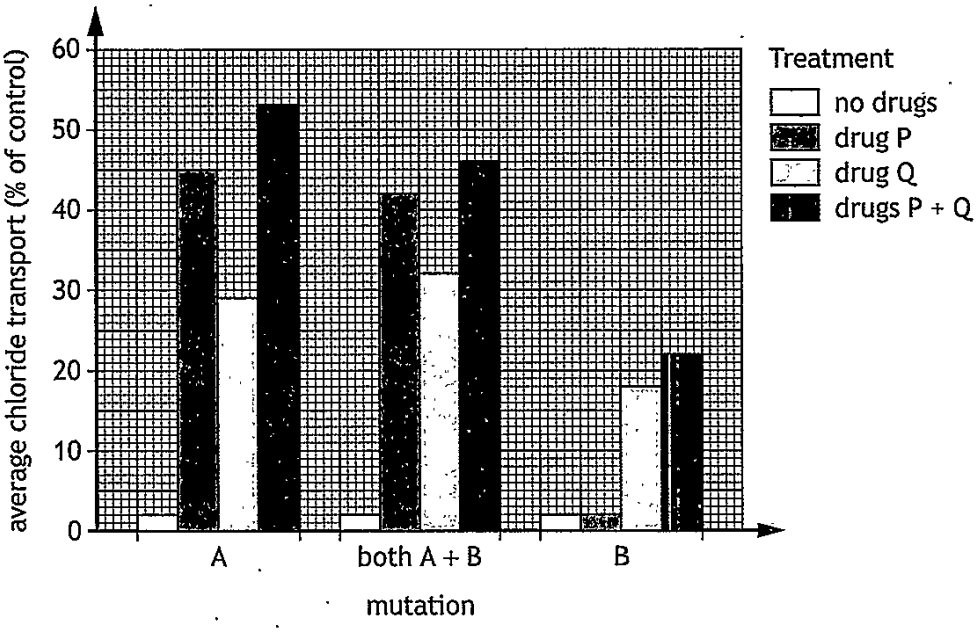
6. Cystic fibrosis in humans is caused by mutations in a gene that reduces chloride transport across the cell membrane.

An investigation was carried out to determine the effectiveness of two drugs, P and Q, on improving chloride transport in individuals with cystic fibrosis. Individuals with different mutations, A, B, and both A and B, were treated as follows.

- No drugs
- Drug P alone
- Drug Q alone
- Drug P and drug Q combined

Chloride transport across cell membranes was measured and compared to the chloride transport in a control group with no mutations in the gene.

The results are shown in the graph.



(a) State the purpose of including a control group in this investigation. 1

To show the effects of the drugs given to humans compared to those who did not receive the drug.

6. (continued)

(b) Identify the treatment and mutation for which the drug(s) had no effect. **2**

Treatment P

Mutation B

(c) State how the graph shows that each treatment was carried out on more than one individual with each mutation. **1**

An average was taken for the chloride transport

(d) State the term used to describe the selection of drugs to treat individuals based on their genomic sequence. **1**

pharmacogenomics personal genomics

[Turn over

7. The genome of all organisms contains both protein coding genes and non-coding DNA. The size of the genome varies between different species.

The table shows the size of the genome and the number of protein coding genes in several different organisms.

	Organism	Size of genome (base pairs)	Number of protein coding genes
Eukaryotes	yeast	$1{\cdot}2 \times 10^7$	6600
	fruit fly	$1{\cdot}4 \times 10^8$	14 000
	human	$3{\cdot}2 \times 10^9$	21 000
Prokaryotes	*V. cholera*	$4{\cdot}0 \times 10^6$	3900
	E. coli	$4{\cdot}6 \times 10^6$	4200

(a) (i) Using information from the table, compare the size of genomes of eukaryotes and prokaryotes. 1

3200000000
4600000

Eukaryotes have a larger genome size compared to prokaryotes

(ii) Calculate how many times greater the human genome is compared to the *V. cholera* genome. 1

Space for calculation

3.2×10^9

4.0×10^6

8×10^{14} times greater

(iii) The prokaryote *M. tuberculosis* has a genome size of $4{\cdot}4 \times 10^6$ base pairs.

Predict the number of protein coding genes in *M. tuberculosis*. 1

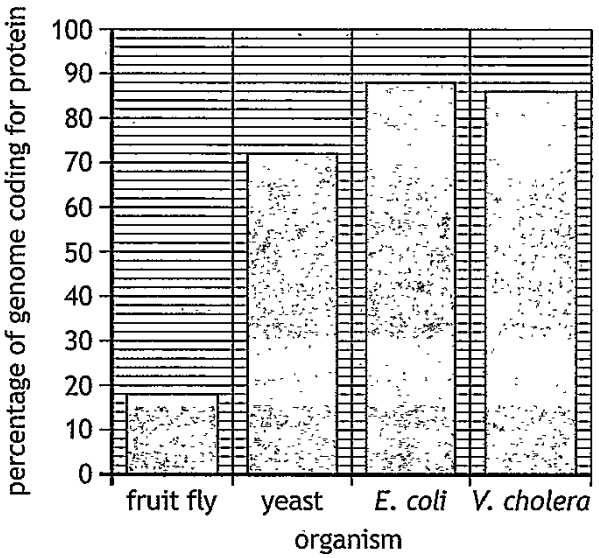
4100

4.0 3900 3950
4.1 4000
.2 4500 4000
.3 5000 4050
.4
.5
.6

7. (continued)

(b) Protein coding genes are used to produce mRNA, which is translated into protein.

The bar graph shows the percentage of the genome that codes for protein in four of the organisms shown in the table.



Use the information in the table and the graph to calculate the size of the genome coding for protein in a fruit fly. 1

Space for calculation

18

14000 18

778 base pairs

(c) Give **one** role of the non-coding DNA in the genome. 1

It is involved in the transcription of mRNA as it is present in the primary mRNA transcript.

(d) In eukaryotes, alternative RNA splicing occurs.

Explain how this results in different proteins being expressed from a single gene. 1

- Different exons splice together to form a different mature mRNA transcript.

eg 1|2|3|4 → 1|3|4 OR 2|3|4

primary mRNA transcript — different mature mRNA transcripts

8. The bacterium *E.coli* was cultured in a growth medium containing 0·6 mM glucose and 0·6 mM lactose for 180 minutes. Glucose and lactose concentrations were measured every 20 minutes.

The results are shown in the table.

Time (minutes)	Glucose concentration (mM)	Lactose concentration (mM)
0	0·60	0·60
20	0·50	0·60
40	0·38	0·60
60	0·09	0·60
80	0·00	0·55
100	0·00	0·44
120	0·00	0·32
140	0·00	0·15
160	0·00	0·04
180	0·00	0·00

(a) Using values from the table, describe changes in the concentration of lactose over the 180 minutes of the experiment. 2

From 0 minutes to 60 minutes ~~[illegible]~~ the lactose concentration remains constant at 0.60mM but from 80 minutes to 180 minutes the lactose concentration decreases from 0.55mM to 0.00mM

8. (continued)

(b) *E.coli* breaks down lactose using the enzyme beta-galactosidase as shown.

$$\text{lactose} \xrightarrow{\textit{beta-galactosidase}} \text{glucose} + \text{galactose}$$

Beta-galactosidase is produced by *E.coli* only when lactose is present and glucose is absent.

(i) Using information from the table, identify the time when *E.coli* started producing beta-galactosidase. 1

30 minutes

(ii) Suggest a benefit to *E.coli* of producing beta-galactosidase only when lactose is present. 1

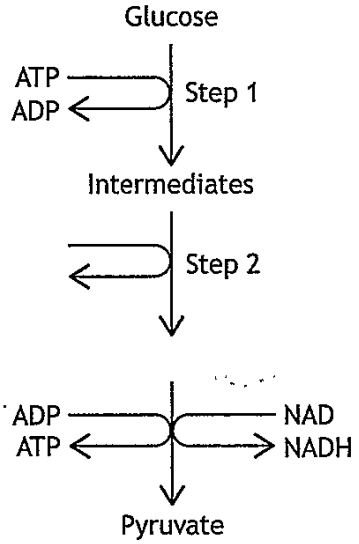
- ~~[illegible]~~ -prevents survival of beta-galactosidase in external environment

(c) In terms of activation energy, state how enzymes increase the rates of reactions in living cells. 1

Enzymes lower the activation energy required to start the reaction, so it is easier for the reaction to begin as less energy is required

[Turn over

9. Respiration is a cellular process that produces ATP. The first stage in this process is glycolysis. Some steps of glycolysis are shown in the diagram.



(a) State the exact location of glycolysis. 1

Cytoplasm

(b) (i) Describe the role of ATP in Step 1. 1

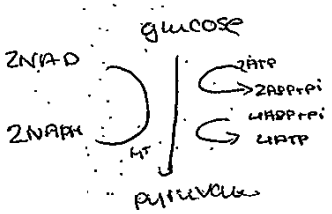
-provides energy for the reaction

(ii) Explain how glycolysis results in a net gain of ATP. 1

-more ATP are produced than are required.

(iii) Describe the role of dehydrogenase enzymes in the conversion of intermediates to pyruvate. 2

removes ~~donates~~ hydrogen ions and electrons, they are passed to NAD to form NADH which moves into the citric acid cycle



9. (continued)

(c) When fermentation occurs in animal cells, pyruvate is converted to lactate as shown.

$$\text{pyruvate} + \text{NADH} \longrightarrow \text{lactate} + \text{NAD}$$

(i) State the conditions required for fermentation. 1

no Oxygen present

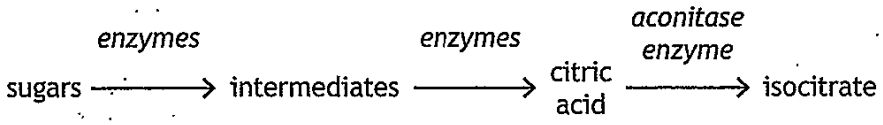
(ii) Using all the information given, suggest why the conversion of pyruvate to lactate is required for glycolysis to continue. 1

- the citric acid cycle requires Oxygen to proceed.

[Turn over

10. The fungus *Aspergillus niger* (*A.niger*) is used to produce citric acid in fermenters using sugars as substrates.

Citric acid is an intermediate in a metabolic pathway as shown.



(a) The aconitase enzyme requires iron to function.

Explain why the growth medium used to produce citric acid should not contain iron. **1**

- the citric acid will not be produced and then there will be no production of isocitrase.

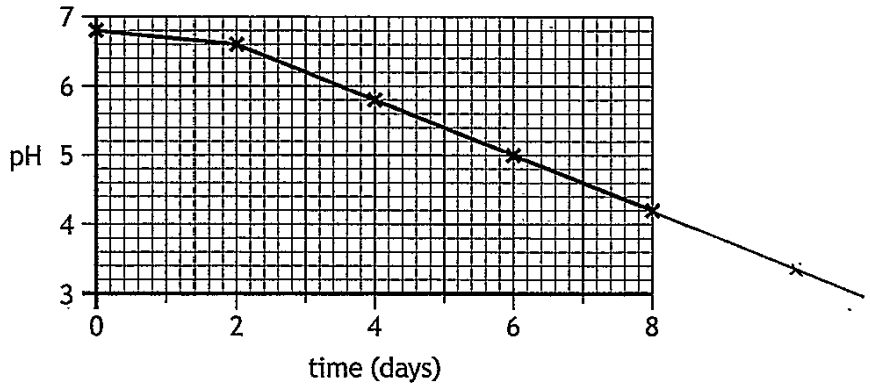
(b) The optimum temperature for citric acid production by *A.niger* is 30 °C.

Explain why less citric acid would be produced if the temperature in the fermenter was reduced. **1**

- Enzymes work best at their optimum conditions,

10. (continued)

(c) *A.niger* was grown in a fermenter over an 8 day period and the pH was measured every 2 days. The results are shown in the graph.



(i) Predict the pH at 10 days. **1**

3.4

(ii) Suggest a reason for the change in the pH observed. **1**

- ~~Carbon dioxide build up~~ caused the pH to decrease
- there was a growth of microorganisms which

(iii) State a variable, other than temperature or pH, that should be monitored and controlled in this process. **1**

Carbon dioxide concentration

(iv) Explain why it was necessary to sterilise the fermenter before *A.niger* was added. **2**

- To prevent contamination (which could alter the final product of the reaction
- microorganisms ~~bacteria~~ require a sterile conditions in order to successfully grow

[Turn over

11. Djungarian hamsters (*Phodopus sungorus*) are small mammals with high metabolic rates. Under certain conditions they will enter torpor.

An experiment was carried out to investigate the effect of daily food intake on torpor frequency. Four groups of six hamsters were fed different masses of food each day and the number of times they entered torpor in one week was recorded.

The results are shown in the table.

Group	Mass of food eaten each day (g)	Average torpor frequency (number of times entering torpor in the week)
1	2·5	42
2	3·0	25
3	3·5	15
4	4·0	7

(a) State an advantage to the hamsters of entering torpor. **1**

they can conserve energy

(b) Suggest a measurement that could have been taken to determine whether the hamsters had entered torpor. **1**

- measuring heart rate as a heart rate decreases when in torpor

(c) The average time spent in each period of torpor was 120 minutes.

Calculate the average time spent in torpor **per day** by a hamster with a daily food intake of 2·5 g. **1**

Space for calculation

6 minutes

11. (continued)

(d) State how the design of the experiment ensured that the results were reliable. 1

the experiment was repeated by using different hamsters and on average was taken.

(e) Suggest a factor, other than daily food intake, which could affect torpor frequency. 1

length of day

(f) Daily torpor is a way in which animals survive adverse conditions.

Give **one** way in which animals avoid adverse conditions. 1

migration

[Turn over

12. An investigation was carried out into the effect of increasing time of exposure to UV light on the survival of wild type (WT) and mutant (M) yeast cells.

Each type of yeast cell was grown in separate liquid media at 30 °C for 24 hours, diluted and plated onto separate agar plates. They were then exposed to a UV light source for between 0 and 30 seconds in a darkened room.

The plates were incubated for four days at 20 °C and the number of yeast colonies that had grown was counted. Each colony grew from a single cell.

The results are shown in the table.

Time of exposure to UV light (seconds)	Number of yeast colonies	
	WT	M
0	360	400
5	210	120
10	90	25
15	45	10
20	20	0
30	10	0

(a) (i) State an independent variable in this experiment. 1

time of exposure to UV light

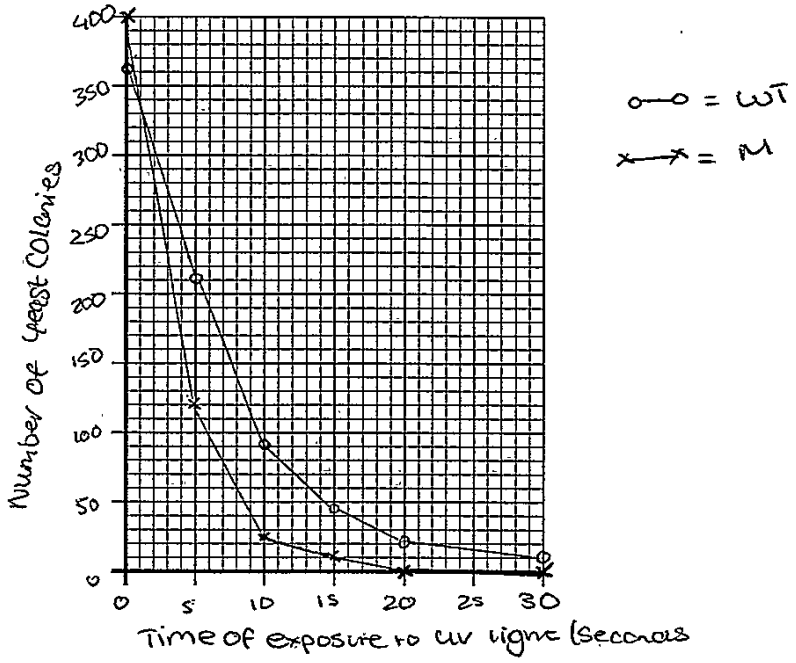
(ii) Suggest why exposure to UV light was carried out in a darkened room. 1

UV light
TO ensure that it was any the UV light that
affected the experiment.

12. (continued)

(b) On the grid, draw a line graph using the results in the table for **both** WT yeast and M yeast.

(Additional graph paper, if required, can be found on *page 31*) **3**



(c) Draw **one** conclusion from the results of this investigation. **1**

As the time of exposure to UV light increased, the number of yeast colonies in both WT and M decreases

(d) Sunscreen lotions can protect cells from UV damage.

Suggest how the investigation could be modified to test the effectiveness of a sunscreen lotion using M yeast as model cells. **2**

- Apply sunscreen lotion to one 'M yeast' colony
Compare the number of yeast colonies produced when exposed to UV light

both colonies with & without sunscreen are

[Turn over

13. Apples and plums are grown in North America as food crops. Brown stink bugs (*Halyomorpha halys*) feed on apples and plums reducing fruit yield. Insecticides are often sprayed onto fruit crops to help control these pests.

(a) State how the use of insecticides can be harmful to the environment. 1

- It can cause biomagnification that can build up between trophic levels in a foodchain.

(b) Wheel bugs (*Arilus cristatus*) are a species of insect native to North America that prey on many different insects, including brown stink bugs. Wheel bugs are used along with insecticides to reduce the number of brown stink bugs.

(i) Explain why this method of control would require the use of less insecticide. 1

A biological control has been introduced, with prey upon brown stink bug and biological controls ~~[illegible]~~ will reduce its population, meaning less insecticide is required

(ii) Name the method of control that involves using both insecticides and wheel bugs. 1

integrated pest control

(c) If brown stink bugs spread to the UK, introducing the non-native wheel bugs from North America could be used as a method of control. If this method of control was used, wheel bugs could become an invasive species.

(i) Describe evidence that could suggest the wheel bugs had become an invasive species. 2

- they spread rapidly
- they reduce the amount of native species.

(ii) Give **one** reason why invasive species are more successful in their new habitat. 1

~~[illegible]~~ therefore free from ~~[illegible]~~ prey or parasites that they would have in their normal habitat

14. A tick is a small invertebrate. Some ticks carry the bacteria *Borrelia burgdorferi* (*B.burgdorferi*) in their gut after biting infected animals. If these ticks bite humans to feed on blood, the bacteria may enter the human bloodstream and cause Lyme disease.

(a) Use the information given to suggest why ticks can be described as

(i) vectors 1

they carry the bacteria Borrelia burgdorferi from one organism to another

(ii) parasites. 1

they benefit from the parasitic relationship when the human is harmed.

14. (continued)

(b) The tables show the average global temperatures between 1981 and 2010, and the number of cases of Lyme disease in the UK between 1999 and 2009.

Table 1

Year	Average global temperature (°C)
1981–1990	14·12
1991–2000	14·26
2001–2010	14·47

Table 2

Year	Number of cases of Lyme disease in the UK
1999	200
2004	515
2009	870

(i) Calculate the percentage increase in cases of Lyme disease in the UK between 1999 and 2009. 1

Space for calculation

335 %

(ii) It was concluded from the information in Table 1 and Table 2 that the increase in the number of cases of Lyme disease in the UK was caused by an increase in temperature.

Suggest why this conclusion may **not** be valid. 1

- there was a great increase between 1999 and 2004 even though the temp increase was greater between 1991-2000 and 2001 to 2010

(c) Two methods used to reduce the number of cases of Lyme disease in humans were suggested.

Method 1 Use pesticide to kill ticks

Method 2 Treat infected animals with antibiotics

Explain how each method could reduce the number of cases of Lyme disease in humans. 2

Method 1 - there would be less ticks as they would be killed, reducing amount of people being bitten and catching the disease

Method 2 - there would be less infected animals meaning that humans that are bitten are less likely to ~~catch~~ contract the disease as the animal is less likely to have the disease

15. White-faced capuchin monkeys (*Cebus capucinus*) are primates that live in large social groups in tree tops in South America. Their predators include humans, birds of prey and snakes.

If a capuchin sees a predator it gives an alarm call to warn others in the group. Capuchins give a different alarm call for each predator they encounter. Scientists recorded these alarm calls from adult monkeys.

The results are shown in the table.

Predator	Total number of encounters	Percentage of encounters when only one monkey called	Percentage of encounters when more than one monkey called
Birds of prey	155	60	40
Humans	12	67	33
Snakes	65	15	85

(a) (i) Calculate the number of encounters with birds of prey when only one monkey called. 1

Space for calculation

60

39

(ii) Using the information given, suggest why the highest number of encounters were with birds of prey. 1

- that birds of prey pose the most threat to the monkeys & live closely by.

(b) Explain why giving alarm calls can be described as altruistic behaviour. 2

- altruistic behaviour is unselfish behaviour, the monkey will warn other monkeys if there is danger close in hopes that the favour is returned if danger is close again.

15. (continued)

(c) Primates, such as capuchin monkeys, have a long period of parental care.

Explain why the scientists only recorded the calls from adult monkeys. **1**

Adult monkeys teach complex behaviours to their young, they will give alarm calls to protect their young

(d) Primates often form alliances with others and carry out appeasement behaviour within their group.

State the advantages of these behaviours. **2**

Forming alliances - all members receive more protection, it is easier to find a mate, easier to catch prey

Appeasement - reduces conflict. Grooming is an appeasement behaviours carried out in order to reduce tension & conflict.

[Turn over for next question

16. Attempt **either A or B.** Write your answer in the space below and on *pages 29* and *30*.

A Write notes on photosynthesis under the following headings.

(i) Use of energy absorbed by photosynthetic pigments **3**

(ii) Carbon fixation **4**

OR

B Write notes on the effects of the following on biodiversity.

(i) The bottleneck effect **2**

(ii) Habitat fragmentation and habitat corridors **5**

You may use labelled diagrams where appropriate.

B

A bottle neck event is when a significant amount of a species is killed due to an event that has taken place such as a natural disaster. ~~recovery~~ recovery is possible but if the population are closely related this is equivalent to inbreeding, meaning that there is a lack of genetic diversity.

Cheetahs lack genetic diversity due to an incident that killed many cheetahs.

Habitat fragmentation is when a habitat is divided into smaller sections potentially due to humans activities that occur too fast for animals living in that area to be able to adapt to.

- ~~to separate species which can't interact~~
- the geographical barrier prevents organisms from ~~in~~ interbreeding, ~~reducing~~ to
- can lead to inbreeding depression if the organisms in the habitat fragment are genetically similar, which results in a loss of heterozygous ~~gene~~ alleles and a build up of recessive, deleterious genes.

carried on next page

SPACE FOR ANSWERS

Habitat corridors allow organisms to move between habitat fragments ~~safely~~ safely.

However, this could cause a spread of disease between habitat fragments

- Habitat fragments can increase generic diversity.