EXAM PAPERS PRACTICE

DNA and Protein Synthesis Pack

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

Topic: DNA and Protein Synthesis Pack

1 (a) The genetic code is **degenerate** and **non-overlapping**.

Explain the meaning of:

Degenerate _____

_____

Non-overlapping _____

_____

(2)

The table shows a short section of a messenger RNA (mRNA) molecule and the section of a polypeptide for which it codes.

mRNA	G G G	G C U	U C A	C C G	G C A	A C G
Polypeptide	glycine	alanine	serine	proline	alanine	threonine

(b) Name the bases represented in the table by:

A _____

C _____

G _____

U _____

(2)

(c) Use information in the table to give the sequence of bases in **DNA** that codes for serine.

_____

(1)

(Total 5 marks)

2 In a eukaryotic cell, transcription results in a molecule of pre-mRNA that is modified to produce mRNA. In a prokaryotic cell transcription produces mRNA directly.

(a) Explain this difference.

_____

_____

_____

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_____

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(2)

(b) Give **two** differences between the structure of mRNA and the structure of tRNA.

1. _____

_____

2. _____

_____

(2)

(Total 4 marks)

3 The diagram below represents one process that occurs during protein synthesis.

(a) Name the process shown.

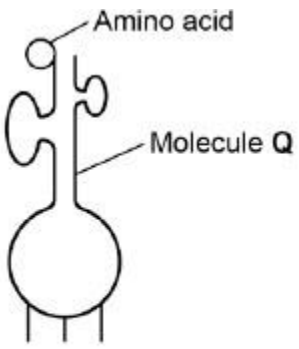
_____

(1)

(b) Identify the molecule labelled **Q**.

_____

(1)



A U G C C G U A C C G A C U

(c) In the diagram above, the first codon is AUG. Give the base sequence of:

the complementary DNA base sequence _____

the missing anticodon _____

(2)

The table below shows the base triplets that code for two amino acids.

Amino acid	Encoding base triplet
Aspartic acid	GAC, GAU
Proline	CCA, CCG, CCC, CCU

(d) Aspartic acid and proline are both amino acids. Describe how two amino acids differ from one another. You may use a diagram to help your description.

_____

_____

_____

(1)

(e) Deletion of the sixth base (G) in the sequence shown in the diagram above would change the nature of the protein produced but substitution of the same base would not. Use the information in the table and your own knowledge to explain why.

_____

_____

_____

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(Extra space) _____

_____

(3)

(Total 8 marks)

4 Read the following passage carefully.

A large and growing number of disorders are now known to be due to types of mitochondrial disease (MD). MD often affects skeletal muscles, causing muscle weakness.

We get our mitochondria from our mothers, via the fertilised egg cell. Fathers do not pass on mitochondria via their sperm. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. These mutations of nuclear DNA produce recessive alleles.

One form of mitochondrial disease is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

There are a number of ways to try to diagnose whether someone has a mitochondrial disease. One test involves measuring the concentration of lactate in a person's blood after exercise. In someone with MD, the concentration is usually much higher than normal. If the lactate test suggests MD, a small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation.

Use information in the passage and your own knowledge to answer the following questions.

(a) Mitochondrial disease (MD) often causes muscle weakness (lines 1–3). Use your knowledge of respiration and muscle contraction to suggest explanations for this effect of MD.

(Extra space) _____

(3)

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrialdisease. The type of mitochondrial disease was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

(b) Use the information in lines 5–9 and your knowledge of inheritance to suggest why:

- all of couple **A**'s children had an MD
- only one of couple **B**'s children had an MD.

Couple **A** _____

_____

_____

_____

Couple **B** _____

_____

_____

_____

(Extra space) _____

_____

_____

_____

(4)

(c) Suggest how the change in the anticodon of a tRNA leads to MD (lines 10–13).

(Extra space)

(3)

(d) If someone has MD, the concentration of lactate in their blood after exercise is usually much higher than normal (lines 15–17). Suggest why.

(Extra space)

(3)

(e) A small amount of DNA can be extracted from mitochondria and DNA sequencing used totry to find a mutation (lines 18–19).

From this sample:

- how would enough DNA be obtained for sequencing?
- how would sequencing allow the identification of a mutation?

(2)

(Total 15 marks)

5 (a) Messenger RNA (mRNA) is used during translation to form polypeptides.
Describe how mRNA is produced in the nucleus of a cell.

(6)

(b) Describe the structure of proteins.

(5)

(c) Describe how proteins are digested in the human gut.

(4)

(Total 15 marks)

6 (a) The table below shows features of a bacterium and the human immunodeficiency virus(HIV) particle.

Complete the table by putting a tick (✓) where a feature is present.

Feature	**Bacterium**	**Human immunodeficiency virus (HIV) particle**
RNA		
Cell wall		
Enzyme molecules		
Capsid		

(2)

(b) When HIV infects a human cell, the following events occur.

- A single-stranded length of HIV DNA is made.
- The human cell then makes a complementary strand to the HIV DNA.

The complementary strand is made in the same way as a new complementary strand is made during semi-conservative replication of human DNA.

Describe how the complementary strand of HIV DNA is made.

(3)

(c) Contrast the structures of DNA and mRNA molecules to give **three** differences.

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(Total 8 marks)

7 Haemoglobin is a protein. It is made of two alpha polypeptides and two beta polypeptides. Each alpha polypeptide has 141 amino acids and each beta polypeptide has 146 amino acids.

(a) What term is used to describe the structure of a protein made of two or more polypeptides?

_____

(1)

(b) Calculate the minimum number of DNA bases needed to code for the number of amino acids in one alpha polypeptide.

Answer = _____

(1)

(c) Describe the role of haemoglobin in supplying oxygen to the tissues of the body.

_____

_____

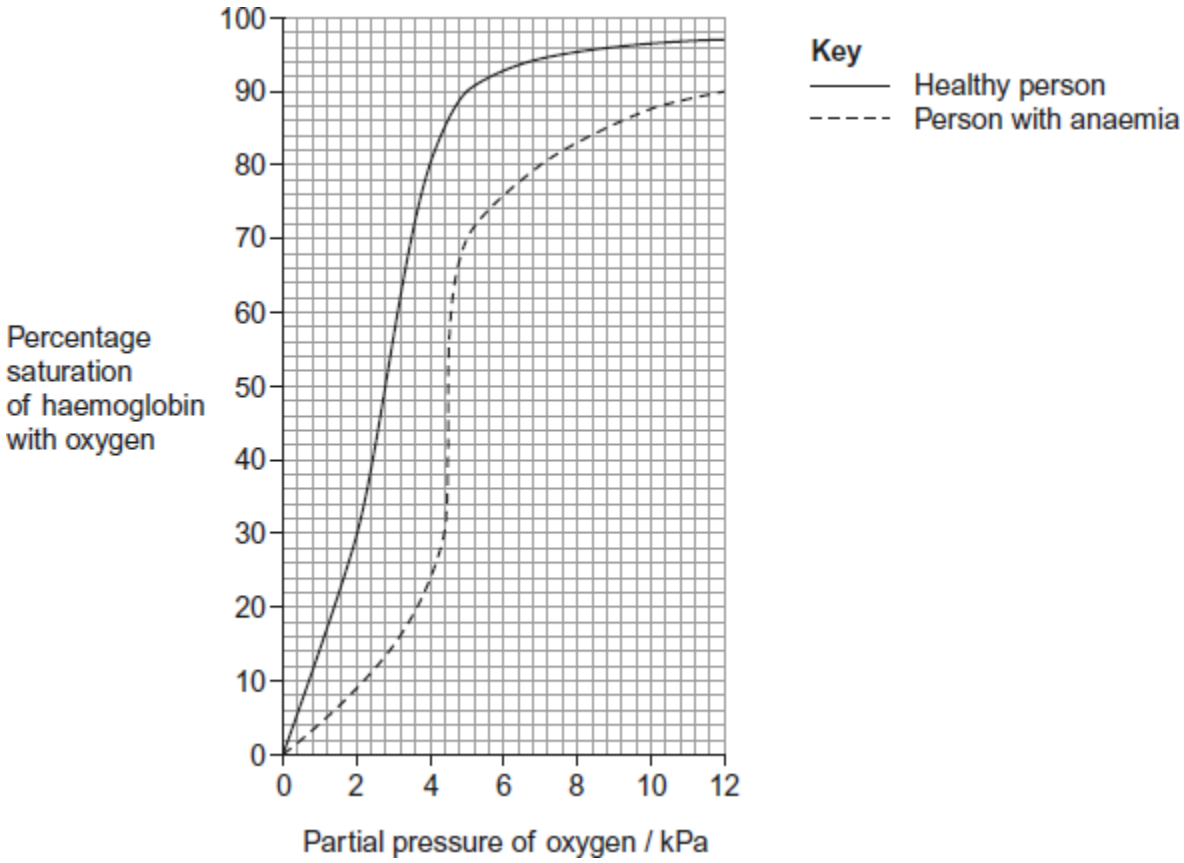
_____

_____

(2)

Anaemia is a condition in which there is a decrease in the concentration of haemoglobin inblood. In some people with anaemia, substances are produced which change the oxygen dissociation curve of haemoglobin.

The graph shows the effect of these substances on the oxygen dissociation curve of haemoglobin.



(d) (i) Use information in the graph to find the difference in the percentage saturation of haemoglobin with oxygen between a healthy person and a person with anaemia at a partial pressure of oxygen of 4 kPa.

Answer = _____

(1)

(ii) Explain the advantage to a person with anaemia of the change shown in the oxygendissociation curve.

(3)

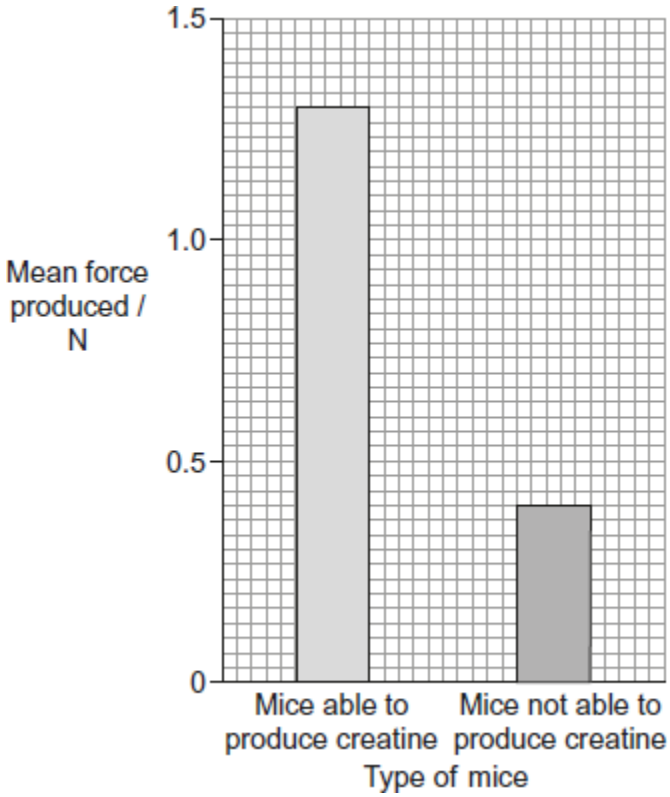
(Total 8 marks)

8 (a) What is the role of ATP in myofibril contraction?

(2)

(b) Scientists investigated the effect of not being able to produce creatine on the force produced by muscle. They used mice with a mutation that made them not able to producecreatine.
The force produced when these mice gripped with their paws was compared with the force produced by normal mice that were able to produce creatine.

The graph shows the scientists' results.



(i) What was the percentage fall in the mean force produced by mice not able to produce creatine, compared with the normal mice? Show your working.

Answer _____ %

(2)

(ii) Suggest an explanation for these results.

(2)

(c) The mice that were not able to produce creatine were homozygous for a recessive allele of a gene. Mice that are heterozygous for this allele are able to produce forces similar to those of normal mice that are homozygous for the dominant allele of the same gene.

Explain why the heterozygous mice can produce forces similar to those of normal mice.

(2)

(Total 8 marks)

9 (a) (i) A mutation of a tumour suppressor gene can result in the formation of a tumour.

Explain how.

(2)

(ii) Not all mutations result in a change to the amino acid sequence of the encoded polypeptide.

Explain why.

(1)

(b) Some cancer cells have a receptor protein in their cell-surface membrane that binds to ahormone called **growth factor**. This stimulates the cancer cells to divide.

Scientists have produced a monoclonal antibody that stops this stimulation.

Use your knowledge of monoclonal antibodies to suggest how this antibody stops the growth of a tumour.

[Extra space]

(3)

(Total 6 marks)

10 (a) (i) Why is the genetic code described as being universal?

(1)

(ii) The genetic code uses four different DNA bases. What is the maximum number of different DNA triplets that can be made using these four bases?

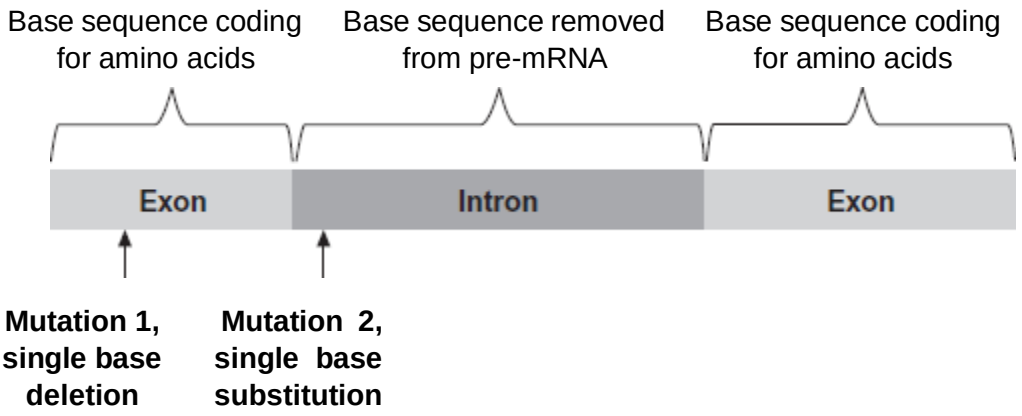
(1)

Transcription of a gene produces pre-mRNA.

(b) Name the process that removes base sequences from pre-mRNA to form mRNA.

(1)

(c) The figure below shows part of a pre-mRNA molecule.
Geneticists identified two mutationsthat can affect this pre-mRNA, as shown in the figure.



(i) **Mutation 1** leads to the production of a non-functional protein.

Explain why.

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

_____

(3)

(ii) What effect might **mutation 2** have on the protein produced?

Explain your answer.

_____

_____

_____

_____

(2)

(Total 8 marks)

11 (a) Explain how the structure of DNA is related to its functions.

(Extra space)

(6)

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division.
They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no increased risk.
The following table shows the scientists' results.

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(b) What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

(3)

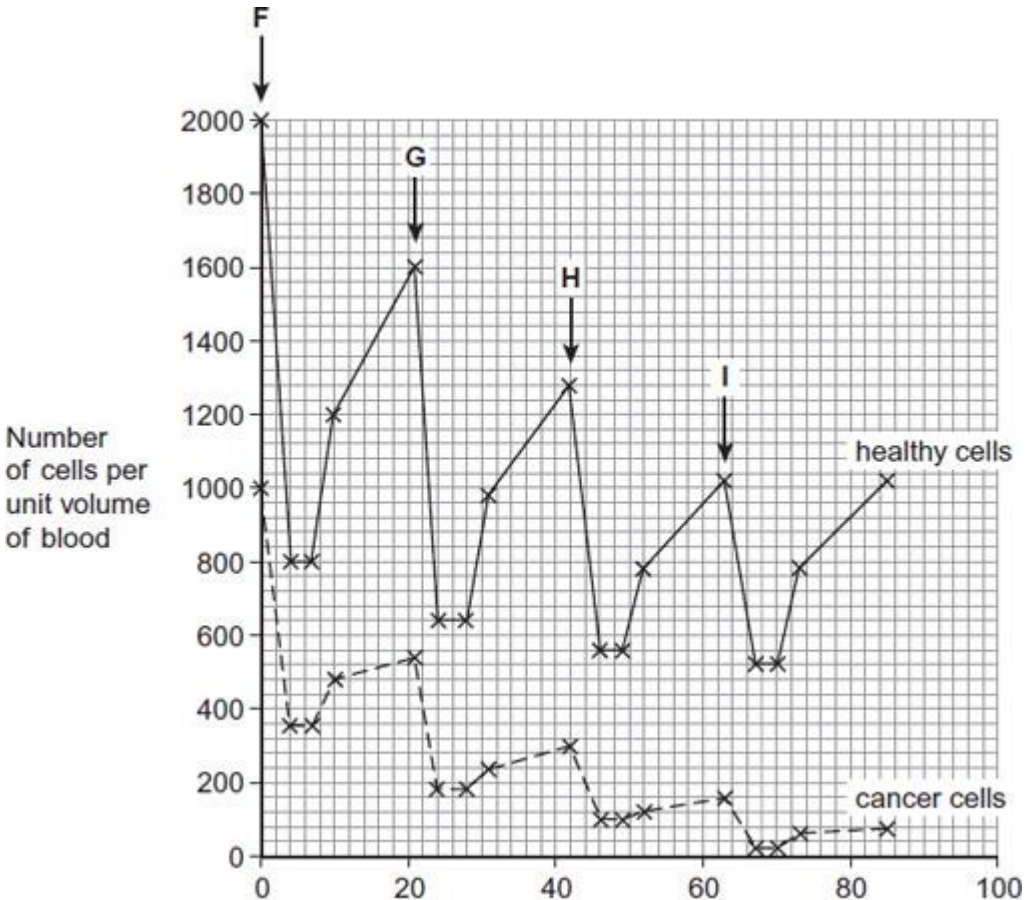
Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.

Time / days

(c) Calculate the rate at which healthy cells were killed between days 42 and 46.

_____cells killed per unit volume of blood per day

(1)



(d) Describe similarities and differences in the response of healthy cells and cancer cells to thedrug between times **F** and **G**.

_____

_____

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_____

_____

(Extra space) _____

_____

_____

(3)

(e) More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

_____

_____

_____

_____

(2)

(Total 15 marks)

12 The Amish are a group of people who live in America. This group was founded by 30 Swiss people, who moved to America many years ago. The Amish do not usually marry people fromoutside their own group.

One of the 30 Swiss founders had a genetic disorder called Ellis-van Creveld syndrome. People with this disorder have heart defects, are short and have extra fingers and toes. Ellis-van Creveld syndrome is caused by a faulty allele.

In America today, about 1 in 200 Amish people are born with Ellis-van Creveld syndrome. This disorder is very rare in people in America who are not Amish.

(a) In America today, there are approximately 1250 Amish people who have Ellis-van Creveld syndrome. Use the information provided to calculate the current Amish population of America.

Amish population _____

(1)

(b) The faulty allele that causes Ellis-van Creveld syndrome is the result of a mutation of a gene called *EVC.* This mutation leads to the production of a protein that has one amino acid missing.

(i) Suggest how a mutation can lead to the production of a protein that has one amino acid missing.

_____

_____

_____

_____

_____

(2)

(ii) Suggest how the production of a protein with one amino acid missing may lead to a genetic disorder such as Ellis-van Creveld syndrome.

_____

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_____

_____

(2)

(Total 5 marks)

13 CREB is a transcription factor in the mitochondria of neurones.

(a) What is a **transcription factor**?

_____

_____

_____

_____

(2)

(b) CREB leads to the formation of a protein that removes electrons and protons from reduced NAD in the mitochondrion.

Huntington's disease (HD) causes the death of neurones. People with HD produce a substance called huntingtin. Some scientists have suggested that binding of huntingtin to CREB may lead to the death of neurones.

Suggest how binding of huntingtin to CREB may lead to the death of neurones.

_____

_____

_____

_____

_____

_____

(Extra space) _____

_____

(3)

(c) CREB is a protein synthesised in the cytoplasm of neurones. Transport of CREB from the cytoplasm into the matrix of a mitochondrion requires two carrier proteins.

Use your knowledge of the structure of a mitochondrion to explain why transport of CREB requires **two** carrier proteins.

(2)

(Total 7 marks)

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

(1)

(b) What is a codon?

(2)

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

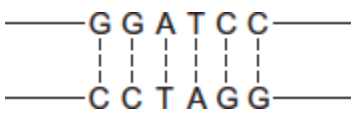
(1)

(ii) mRNA can be converted to cDNA.

Name the enzyme used in this process.

(1)

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



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

_____

_____

_____

(1)

(Total 6 marks)

15 The black mamba is a poisonous snake. Its poison contains a toxin.

The table shows the base sequence of mRNA that codes for the first two amino acids of this toxin.

Base sequence of anticodon on tRNA						
Base sequence of mRNA	**A**	**C**	**G**	**A**	**U**	**G**
Base sequence of DNA						

Complete the table to show

(a) (i) the base sequence of the anticodon on the first tRNA molecule that would bind to this mRNA sequence

(1)

(ii) the base sequence of the DNA from which this mRNA was transcribed.

(1)

(b) The length of the section of DNA that codes for the complete toxin is longer than the mRNA used for translation. Explain why.

_____

_____

_____

(1)

(c) A mutation in the base sequence of the DNA that codes for the toxin would change thebase sequence of the mRNA.

Explain how a change in the base sequence of the mRNA could lead to a change in the tertiary structure of the toxin.

(1)

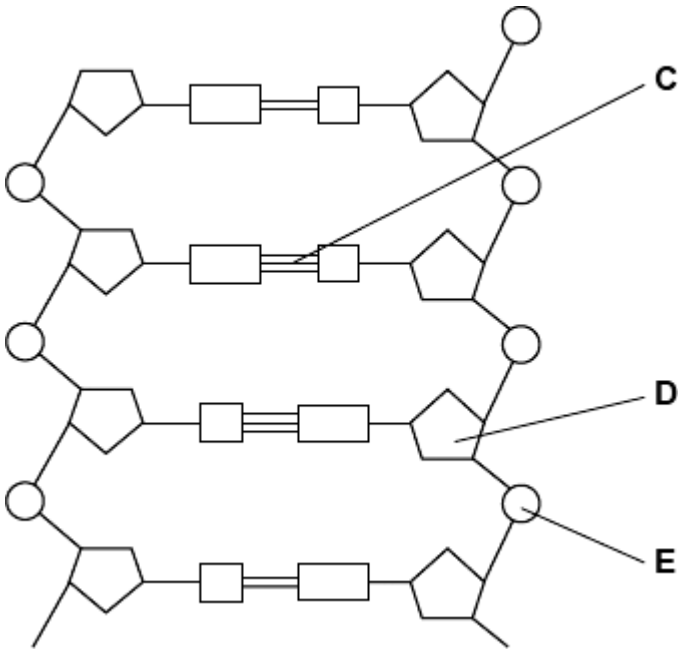
(d) The black mamba's toxin kills prey by preventing their breathing. It does this by inhibiting the enzyme acetylcholinesterase at neuromuscular junctions. Explain how this prevents breathing.

(Extra space)

(3)

(Total 7 marks)

16 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?

_____

_____

_____

(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)

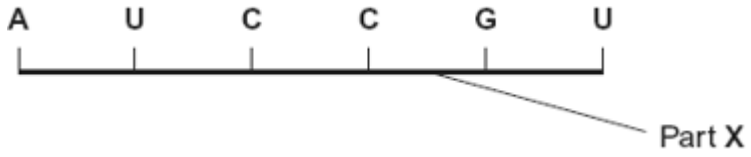
(ii) The gene for this polypeptide contains more than this number of bases.

Explain why

(1)

(Total 8 marks)

17 The diagram shows part of a pre-mRNA molecule.



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

_____ and _____

(1)

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

(1)

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

(1)

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

_____

_____

_____

(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.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

18 The diagram shows a short sequence of DNA bases.

T T T G T A T A C T A G T C T A C T T C G T T A A T A

(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.

_____

_____

(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.

_____

_____

_____

_____

_____

_____

*(Extra space)*_____

_____

_____

(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.

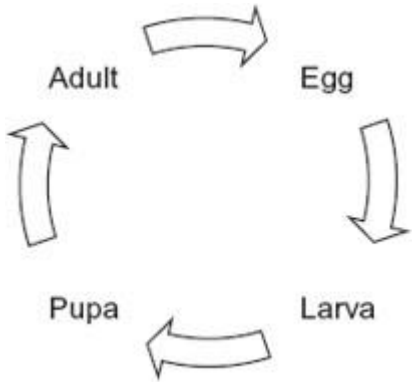
	Number of bases			
	C	G	A	T
Strand **A**	26			
Strand **B**	19		9	

Complete the table by writing in the missing values.

(2)

(Total 7 marks)

19 The diagram shows the life cycle of a fly.



When the larva is fully grown, it changes into a pupa. The pupa does not feed. In the pupa, the tissues that made up the body of the larva are broken down. New adult tissues are formed from substances obtained from these broken-down tissues and from substances that were stored in the body of the larva.

(a) Hydrolysis and condensation are important in the formation of new adult proteins. Explain how.

_____

_____

_____

_____

(2)

(b) Most of the protein stored in the body of a fly larva is a protein called calliphorin. Explain why different adult proteins can be made using calliphorin.

_____

_____

(1)

The table shows the mean concentration of RNA in fly pupae at different ages.

Age of pupa as percentage of total time spent as a pupa	Mean concentration of RNA / µg per pupa
0	20
20	15
40	12
60	17
80	33
100	20

(c) Describe how the concentration of RNA changes during the time spent as a pupa.

(2)

(d) (i) Describe how you would expect the number of lysosomes in a pupa to change with the age of the pupa. Give a reason for your answer.

(2)

(ii) Suggest an explanation for the change in RNA concentration in the first 40% of the time spent as a pupa.

(2)

(e) Suggest an explanation for the change in RNA concentration between 60 and 80% of thetime spent as a pupa.

_____

_____

_____

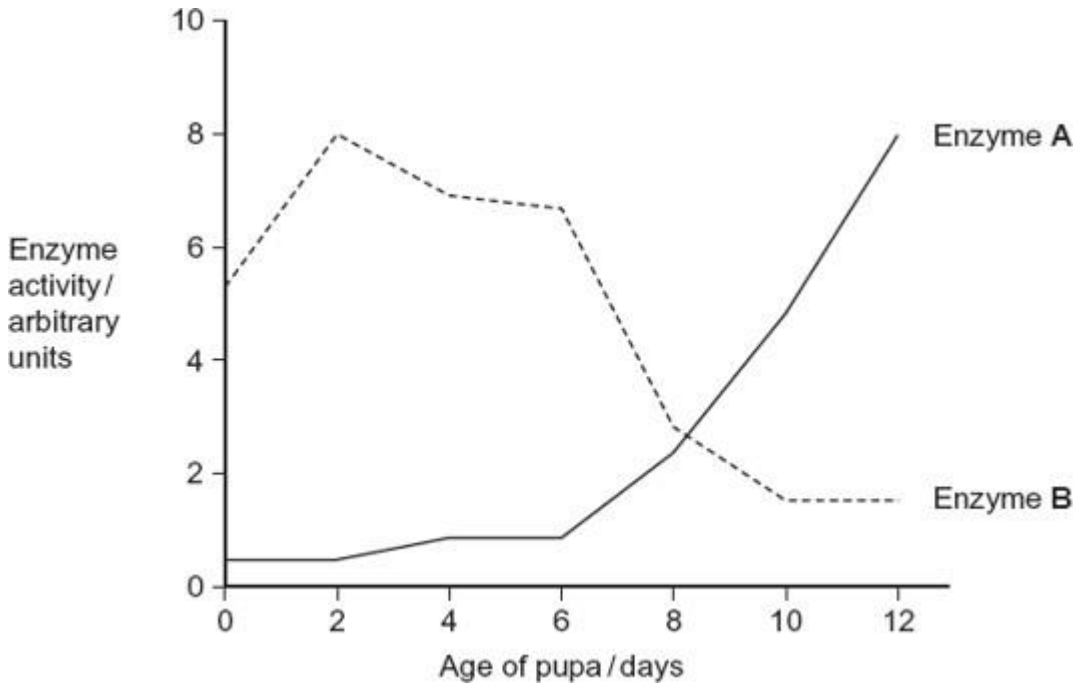
_____

_____

(2)

(f) The graph shows changes in the activity of two respiratory enzymes in a fly pupa.

- Enzyme **A** catalyses a reaction in the Krebs cycle
- Enzyme **B** catalyses the formation of lactate from pyruvate



During the first 6 days as a pupa, the tracheae break down. New tracheae are formed after6 days. Use this information to explain the change in activity of the two enzymes.

(Extra space)

(4)

(Total 15 marks)

20 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

Band number 1 2 3 4 5 6 7

Band width score	3	1		1		4	3	3

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

Figure 2

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

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

_____

_____

(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.

1. _____

_____

2. _____

_____

(2)

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

_____

_____

(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?

_____

_____

(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.

(Extra space)

(3)

(Total 8 marks)

21 (a) What name is used for the non-coding sections of a gene?

(1)

Figure 1 shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. **Figure 2** shows DNA triplets that code for different amino acids.

Figure 1

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Amino acid sequence												
Mutation **1** DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation **2** DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Figure 2

DNA triplets	Amino acid
GGT, GGC, GGA, GGG	Gly
GTT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

(b) Complete **Figure 1** to show the sequence of amino acids coded for by the original DNA base sequence.

(1)

(c) Some gene mutations affect the amino acid sequence. Some mutations do not.
Use the information from **Figure 1** and **Figure 2** to explain

(i) whether mutation **1** affects the amino acid sequence

_____

_____

_____

_____

(2)

(ii) how mutation **2** could lead to the formation of a non-functional enzyme.

_____

_____

_____

_____

_____

_____

(3)

(d) Gene mutations occur spontaneously.

(i) During which part of the cell cycle are gene mutations most likely to occur?

_____

(1)

(ii) Suggest an explanation for your answer.

_____

_____

(1)

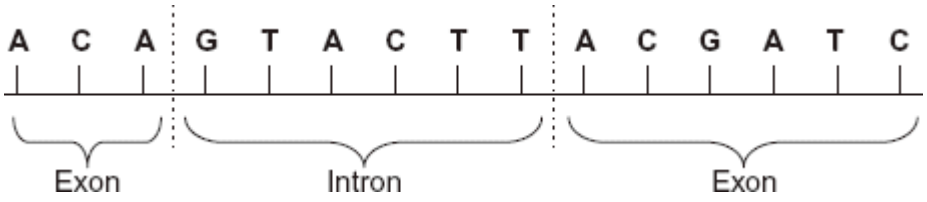
(Total 9 marks)

22 (a) Complete the table to show the differences between DNA, mRNA and tRNA.

Type of nucleic acid	Hydrogen bonds present (✓) or not present (✗)	Number of polynucleotide strands in molecule
DNA		
mRNA		
tRNA		

(2)

(b) The diagram shows the bases on one strand of a piece of DNA.



(i) In the space below, give the sequence of bases on the pre-mRNA transcribed from this strand.

(2)

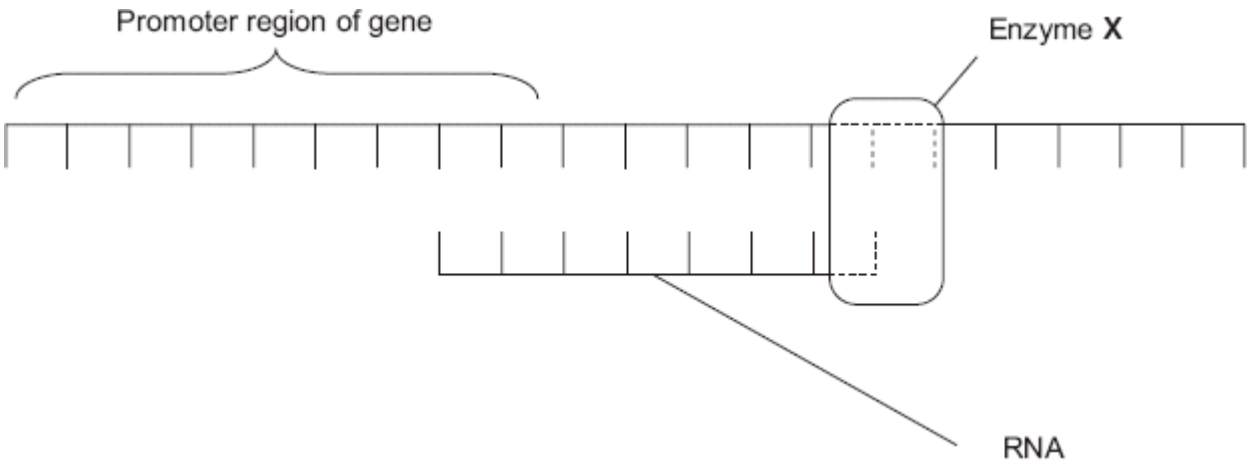
(ii) In the space below, give the sequence of bases on the mRNA produced by splicing this piece of pre-mRNA.

(1)

(Total 5 marks)

23 **Figure 1** shows part of a gene that is being transcribed.

Figure 1



(a) Name enzyme **X**.

_____

(1)

(b) (i) Oestrogen is a hormone that affects transcription. It forms a complex with a receptor in the cytoplasm of target cells. Explain how an activated oestrogen receptor affects the target cell.

_____

_____

_____

_____

(2)

(ii) Oestrogen only affects target cells. Explain why oestrogen does not affect other cells in the body.

_____

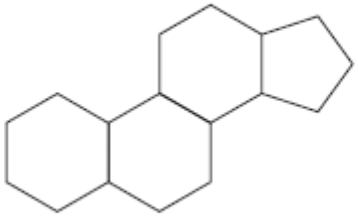
_____

(1)

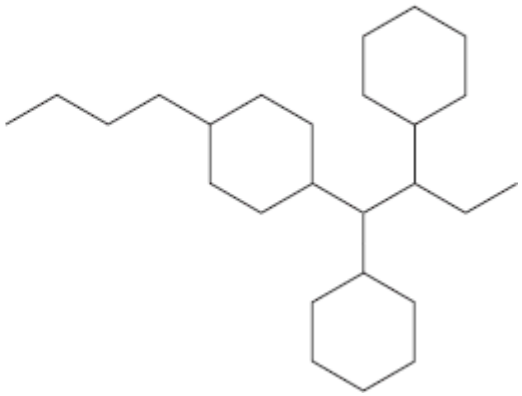
(c) Some breast tumours are stimulated to grow by oestrogen. Tamoxifen is used to treat these breast tumours. In the liver, tamoxifen is converted into an active substance called endoxifen. **Figure 2** shows a molecule of oestrogen and a molecule of endoxifen.

Figure 2

Oestrogen



Endoxifen



Use **Figure 2** to suggest how endoxifen reduces the growth rate of these breast tumours.

_____

_____

_____

_____

(2)

(Total 6 marks)

24 SCID is a severe inherited disease. People who are affected have no immunity. Doctors carried out a trial using gene therapy to treat children with SCID. The doctors who carried out the trial obtained stem cells from each child's umbilical cord.

(a) Give **two** characteristic features of stem cells.

1. _____

_____

2. _____

_____

(2)

The doctors mixed the stem cells with viruses. The viruses had been genetically modified to contain alleles of a gene producing full immunity. The doctors then injected this mixture into thechild's bone marrow.

The viruses that the doctors used had RNA as their genetic material. When these viruses infect cells, they pass their RNA and two viral enzymes into the host cells.

(b) One of the viral enzymes makes a DNA copy of the virus RNA. Name this enzyme.

_____

(1)

The other viral enzyme is called integrase. Integrase inserts the DNA copy anywhere in the DNA of the host cell. It may even insert the DNA copy in one of the host cell's genes.

(c) (i) The insertion of the DNA copy in one of the host cell's genes may cause the cell to make a non-functional protein. Explain how.

_____

_____

_____

_____

(2)

(ii) Some of the children in the trial developed cancer. How might the insertion of the DNA have caused cancer?

_____

_____

_____

_____

(2)

(d) Five out of the 20 children in the trial developed cancer. Although the cancer was treated successfully, the doctors decided to stop the trial in its early stages. They then reviewed the situation and decided to continue. Do you agree with their decision to continue? Explain your answer.

_____

_____

_____

_____

(2)

(Total 9 marks)

Mark schemes

1

(a) 1. Degenerate: more than one (base) triplet for each amino acid;

2. Non-overlapping: each base is part of only one triplet.

Accept codon (as would be applicable to mRNA code)

2

(b) A = adenine

C = cytosine

G = guanine

U = uracil

All four correct = 2
One error = 1
Two or more errors = 0

2 max

(c) AGT;

1

[5]

2

(a) 1. DNA of eukaryotic cell has non-coding regions / introns within gene

Allow converse: (But) a prokaryotic cell does not have non-coding regions / introns in DNA;

OR

pre-mRNA contains non-coding regions / introns;

2. (After transcription / during modification) these regions are removed from (pre-)mRNA;

Ignore references to 'cells need / bacteria do not need'

2

(b) 1. mRNA longer

OR

Has more nucleotides than tRNA;

2. mRNA is a straight molecule but tRNA is a folded molecule / clover-leaf shaped molecule;

3. mRNA contains no paired bases / hydrogen bonds but tRNA has some paired bases / hydrogen bonds.

3

(a) Translation.

(b) T
r
a

r RNA / tRNA. **2 max**

[4]

1

1

(c) TAC;

UAC.

2

(d) Have different R group.

Accept in diagram

1

(e) 1. Substitution would result in CCA / CCC / CCU;
2. (All) code for same amino acid / proline;
3. Deletion would cause frame shift / change in all following codons / change next codon from UAC to ACC.

3

[8]

4

(a) 1. Reduction in ATP production by aerobic respiration;
2. Less force generated because fewer actin and myosin interactions in muscle;
3. Fatigue caused by lactate from anaerobic respiration.

3

(b) Couple **A**,
1. Mutation in mitochondrial DNA / DNA of mitochondrion affected;
2. All children got affected mitochondria from mother;
3. (Probably mutation) during formation of mother's ovary / eggs;

Couple **B**,
4. Mutation in nuclear gene / DNA in nucleus affected;
5. Parents heterozygous;
6. Expect 1 in 4 homozygous affected.

4 max

(c) 1. Change to tRNA leads to wrong amino acid being incorporated into protein;
2. Tertiary structure (of protein) changed;
3. Protein required for oxidative phosphorylation / the Krebs cycle, so less / no ATP made.

3

(d) 1. Mitochondria / aerobic respiration not producing much / any ATP;
2. (With MD) increased use of ATP supplied by increase in anaerobic respiration;
3. More lactate produced and leaves muscle by (facilitated) diffusion.

3

(e) 1. Enough DNA using PCR;
2. Compare DNA sequence with 'normal' DNA.

2

[15]

5

(a)
1. Helicase;
2. Breaks hydrogen bonds;
3. Only one DNA strand acts as template;
4. RNA nucleotides attracted to exposed bases;
5. (Attraction) according to base pairing rule;
6. RNA polymerase joins (RNA) nucleotides together;
7. Pre-mRNA spliced to remove introns.

6 max

(b)
1. Polymer of amino acids;
2. Joined by peptide bonds;
3. Formed by condensation;
4. Primary structure is order of amino acids;
5. Secondary structure is folding of polypeptide chain due to hydrogen bonding;

Accept alpha helix / pleated sheet

6. Tertiary structure is 3-D folding due to hydrogen bonding and ionic / disulfide bonds;
7. Quaternary structure is two or more polypeptide chains.

5 max

(c)
1. Hydrolysis of peptide bonds;
2. Endopeptidases break polypeptides into smaller peptide chains;
3. Exopeptidases remove terminal amino acids;
4. Dipeptidases hydrolyse / break down dipeptides into amino acids.

4

[15]

6

(a)

Feature	Bacterium	Human immunodeficiency virus (HIV) particle
RNA	✓	✓
Cell wall	✓	
Enzyme molecules	✓	✓
Capsid		✓

1 mark for each correct vertical column

2

(b) 1. (Complementary) nucleotides/bases pair
OR
A to T **and** C to G;

Ignore '(DNA polymerase) forms base pairs/nucleotide pairs'

2. DNA polymerase;
3. Nucleotides join together (to form new strand)/phosphodiester bonds form;

Ignore '(DNA polymerase) forms base pairs/nucleotide pairs'

*If clearly writing rote answer about DNA replication **2 max** e.g. helicase or separating strands*

3

(c) 1. DNA double stranded/double helix **and** mRNA single-stranded;

Contrast requires both parts of the statement

2. DNA (very) long **and** RNA short;

*Accept 'RNA short**er**' or 'DNA bigg**er**/long**er**'*

3. Thymine/T in DNA **and** uracil/U in RNA;

4. Deoxyribose in DNA **and** ribose in RNA;

***R** Deoxyribonucleic/ ribonucleic acid*

***Ignore** ref. to histones*

***Ignore** ref. to helix and straight chain alone*

5. DNA has base pairing **and** mRNA doesn't/ DNA has hydrogen bonding and mRNA doesn't;

6. DNA has introns/non-coding sequences **and** mRNA doesn't;

***Ignore** ref to splicing*

3 max

[8]

7

(a) Quaternary (structure);

Accept phonetic spelling eg quarternary/quarternery /4°

Award no mark for quaternary as part of a list

1

(b) 423;

1

(c) 1. Oxyhaemoglobin formed/ haemoglobin is loaded/ uptakes/associates/binds with oxygen in area of higher ppO_2 / in gas exchange surface/lungs/gills;

Reference to "react with" = max 1

Accept: reversible interaction with oxygen

Ignore: haemoglobin is carried / contained in red blood cells

2. (oxygen) unloaded/dissociates from/released (in area of lower ppO_2 / in capillaries/to cells/tissues);

2

(d) (i) 56(%);

Accept responses in the range 54-58(%)

1

(ii) 1. (Anaemia curve shifted to right) haemoglobin has lower affinity for oxygen / binds less tightly;

Assume reference is to haemoglobin of anaemia unless stated

2. releases more oxygen / oxygen is released quicker / oxygen dissociates/ unloads more readily to muscles/tissues/cells;

3. (For) respiration;

Accept: even with a lower haemoglobin concentration / meet demand for ATP/energy;

3

[8]

8

(a) 1. (Reaction with ATP) breaks/allows binding of myosin to actin/ actinomyosin bridge;

2. Provides energy to move myosin head;

1. Credit 'breaks' or 'allows' binding to actin (because cyclical)

2. Allow in context of 'power stroke' or 're-cocking' (because cyclical)

2. Ignore contraction on its own

2

(b) (i) Any value between 68.5 and 69.49 (%);;

If get difference of 0.9 but calculation of percentage incorrect, then award 1 mark;

2

(ii) (Mutant mice)

1. Unable to make phosphocreatine/ less phosphate available to make/recycle ATP;
2. So less energy/so less ATP available for contraction/fast muscle fibres;

1 and 2. Reject production/creation of energy once

2. Accept less energy for grip

2. Accept no energy/no ATP for contraction/fast muscle fibres

2

(c) 1. (Heterozygous) have one dominant/normal allele (for creatine production);

2. (This) leads to production of enough/normal amount of creatine;

1. Accept has one allele/one copy of the gene for/that is making creatine

2

[8]

9

(a) (i) 1. (Tumour suppressor) gene inactivated / not able to control / slow down cell division;

Ignore: references to growth

2. Rate of cell division too fast / out of control.

1 and 2 Accept: mitosis

1 and 2 Reject: meiosis

(ii) 1. (Genetic) code degenerate;

Accept: codon for triplet

Accept description of degenerate code, e.g. another triplet codes for the same amino acid

2. Mutation in intron.

ion in non-coding DNA

2

1 max

(b) 1. Antibody has specific tertiary structure / binding site / variable region;

Do not accept explanations involving undefined antigen

2. Complementary (shape / fit) to receptor protein / GF / binds to receptor protein / to GF;

Ignore: same shape as receptor protein / GF

3. Prevents GF binding (to receptor).

3

[6]

10 (a) (i) (In all organisms / DNA,) the same triplet codes for the same amino acid;

Accept codon / same three bases / nucleotides

Accept plurals if both triplets and amino acids

Reject triplets code for an amino acid

Reject reference to producing amino acid

1

(ii) 64;

1

(b) Splicing;

Ignore deletion references

Accept RNA splicing

1

(c) (i) 1. (Mutation) changes triplets / codons after that point / causes frame shift;

Accept changes splicing site

Ignore changes in sequence of nucleotides / bases

2. Changes amino acid sequence (after this) / codes for different amino acids (after this);

Accept changes primary structure

Reject changes amino acid formed / one amino acid changed

3. Affects hydrogen / ionic / sulfur bond (not peptide bond);

4. Changes tertiary structure of protein (so non-functional);

Neutral 3-D structure

3 max

(ii) 1. Intron non- coding (DNA) / only exons coding;

*Context is the **intron***

Do not mix and match from alternatives

Neutral references to introns removed during splicing

1. and 2. Ignore ref. to code degenerate and get same / different amino acid in sequence

2. (So) not translated / no change in mRNA produced / no effect (on protein) / no effect on amino acid sequence;

Accept does not code for amino acids

OR

3. Prevents / changes splicing;

4. (So) faulty mRNA formed;

Accept exons not joined together / introns not removed

5. Get different amino acid sequence;

2 max

[8]

11 (a) 1. Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;

Must be a direct link / obvious to get the mark

Neutral: reference to histones

2. Long / large molecule **so** can store lots of information;

3. Helix / coiled **so** compact;

Accept: can store in a small amount of space for 'compact'

4. Base sequence allows information to be stored / base sequence codes for amino acids / protein;

Accept: base sequence allows transcription

5. Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6. (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;

Accept: 'H-bonds' for 'hydrogen bonds'

6

(b) 1. (Mutation) in **E** produces highest risk / 1.78;

2. (Mutation) in **D** produces next highest risk / 1.45;

3. (Mutation) in **C** produces least risk / 1.30;

Must be stated directly and not implied

E *>* ***D*** *>* ***C*** *= 3 marks*

Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively

If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk

3

(c) **180**;

1

(d) (Similarities):

1. Same / similar pattern / both decrease, stay the same then increase;

2. Number of cells stays the same for same length of time;

Ignore: wrong days stated

(Differences):

(Per unit volume of blood)

3. Greater / faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster;

Accept: converse for cancer cells

Accept: greater <u>percentage</u> decrease in number of cancer cells / greater <u>proportion</u> of cancer cells killed

4. Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;

Accept: converse for cancer cells

For ***differences****, statements made must be comparative*

3 max

(e) 1. More / too many healthy cells killed;

2. (So) will take time to replace / increase in number;

Neutral: will take time to 'repair'

3. Person may die / have side effects;

2 max

[15]

12 (a) 250 000;

1

(b) (i) Loss of 3 bases / triplet = 2 marks;;

'Stop codon / code formed' = 1 mark max unless related to the last amino acid

Loss of base(s) = 1 mark;

eg triplet for last amino acid is changed to a stop codon / code = 2 marks

3 bases / triplet forms an intron = 2 marks

Accept: descriptions for 'intron' eg non-coding DNA

'Loss of codon' = 2 marks

2

(ii) 1. Change in tertiary structure / active site;

Neutral: change in 3D shape / structure

2. (So) faulty / non-functional protein / enzyme;

Accept: reference to examples of loss of function eg fewer E-S complexes formed

13 (a) 1. (Protein / molecule) that moves from cytoplasm to DNA;

Accept 'it' as TF.

Accept moves into nucleus

2. (TF) binds to specific gene / genes / to specific part of / site on DNA / binds to promoter / RNA polymerase;

Accept regulator / enhancer region

3. Leads to / blocks (pre)mRNA production / allows / blocks binding of RNA polymerase (to DNA) / allows RNA polymerase to work;

Ignore translation unless context wrong

Max 1 if refer to oestrogen as a transcription factor

(b) 1. (Binding to CREB) prevents transcription / mRNA formation;

Accept that lack of protein leaves NAD reduced

2. (Binding of huntingtin) prevents production / translation of protein (that removes electrons / protons from NAD);

3. Fewer electrons to electron transport chain / electron transport chain slows / stops / stops / slower oxidative phosphorylation;

4. Fewer protons for proton gradient;

5. Not enough ATP produced / energy supplied to keep cells alive / anaerobic respiration not enough to keep cell alive;

Accept neurones require ATP for active transport of ions

2

[5]

2 max

3 max

(c) 1. Mitochondrion has two membranes / inner and outer membranes;
Accept cristae for inner membrane

2. For each (different) membrane a (different) carrier required;
Ignore reference to channel proteins

2

[7]

14 (a) One / an amino acid (can be) coded for by more than one triplet;
Accept codon for triplet
Accept description of triplet − <u>three</u> bases / nucleotides

1

(b) 1. Triplet / three bases on mRNA;
1. Accept nucleotide for base
1. Accept DNA for mRNA
1. Ignore references to RNA unqualified

2. That code for an amino acid;
2. Accept code for stop / start

2

(c) (i) To join <u>nucleotides</u> together to form mRNA / premRNA / RNA;
Reject forming base pairs
Accept checking and correcting mismatched base pairs

1

(ii) Reverse transcriptase;
If they give two enzymes, no mark

1

(d) GGATCC same as CCTAGG in opposite direction;
Accept reads same both ways / same forward and back
Neutral bases are the opposite of each other / reference to base pairs

1

[6]

15 (a) (i) UGC;

1

(ii) TGCTAC;

1

(b) (DNA) contains introns / non-coding bases / mRNA only contains exons / codingbases;

Assume that 'it' refers to DNA

Neutral: DNA contains introns and exons

Neutral: 'splicing'

Neutral: pre-mRNA contains introns

Ignore refs. to start and stop codons

1

(c) Different primary structure / amino acid sequence / amino acid coded for;

Reject: different amino acids produced / formed

Neutral: refs. to bonds

1

(d) 1. Acetylcholine not broken down / stays bound to receptor;

2. Na^+ ions (continue to) enter / (continued) depolarisation / Na^+ channels (kept) open / action potentials / impulses fired (continuously);

3. (Intercostal) muscles stay contracted / cannot relax;

'Muscles contract' is not enough

Accept: diaphragm stays contracted / cannot relax

3

[7]

16 (a) (i) Repeating units / nucleotides / monomer / molecules;

Allow more than one, but reject two

1

(ii) 1. C = hydrogen bonds;

2. D = deoxyribose;

Ignore sugar

3. E = phosphate;

Ignore phosphorus, Ignore molecule

3

(iii)

Name of base	Percentage
Thymine	34
Cytosine / Guanine	16
Adenine	34
Cytosine / Guanine	16

Spelling must be correct to gain MP1

First mark = names correct

Second mark = % correct, with adenine as 34%

2

(b) (i) 153;

1

(ii) Some regions of the gene are non-coding / introns / start / stop code / triplet / there are two DNA strands;

Allow addition mutation

Ignore unqualified reference to mutation

Accept reference to introns and exons if given together

Ignore 'junk' DNA / multiple repeats

1

[8]

17 (a) (i) Phosphate and ribose;

Accept in either order. Both correct for one mark.

For phosphate accept PO_4 / Pi / Ⓟ but not P.

Do not accept phosphorus.

Ignore references to pentose / sugar.

1

(ii) TAGGCA;

1

(b) (i) Does not contain hydrogen bonds / base pairs / contains codons / does not contain anticodon / straight / not folded / no amino acid binding site / longer;

Assume that "it" refers to mRNA.

Do not accept double stranded.

1

(ii) (pre-mRNA) contains introns / mRNA contains only exons;

Assume that "it" refers to pre-mRNA.

Accept non-coding as equivalent to intron.

1

(c) (i)

Part of chromosome	U
Middle	18
End	21

One mark for both figures correct

1

(ii) 1. Have different (base) sequences / combinations of (bases);

2. (Pre-mRNA) transcribed from different DNA / codes for different proteins;

2

18 (a) (i) 9;

Accept: nine

1

(ii) Introns / non-coding DNA / junk DNA;

Start / stop code / triplet;

Neutral: Repeats.

Accept: 'Introns and exons present'.

Reject: 'Due to exons'.

1 max

(b) Change in amino acid / s / primary structure;

Change in hydrogen / ionic / disulfide bonds;

Alters tertiary structure;

Reject: 'Different amino acid is formed' – negates first marking point.

Neutral: Reference to active site.

3

(c) Number of bases

	Number of bases			
	C	G	A	T
Strand A	26	**19**	**20**	**9**
Strand B	19	**26**	9	**20**

Second column correct;

Columns three and four correct;

2

[7]

[7]

19

(a) 1. Hydrolysis breaks proteins / hydrolyses proteins / produces amino acids (fromproteins);

2. Protein synthesis involves condensation;

2

(b) Amino acids (from calliphorin) can be joined in different sequences / rearranged;

1

(c) 1. Fall, rise and fall;

2. Rise after 40 and fall after 80;

Ignore concentration values.

2

(d) (i) Fall / increase then fall;

Lysosomes associated with tissue breakdown;

2

(ii) 1. Tissues / cells are being broken down;

2. RNA is digested / hydrolysed / broken down;

3. By enzymes from lysosomes;

4. New proteins not made / no new RNA made;

2 max

(e) 1. (RNA) associated with making protein;

2. New / adult tissues are forming;

2

(f) 1. In the first 6 days no / little oxygen supplied / with breakdown of tracheae, no / little oxygen supplied;

2. (Without tracheae) respire anaerobically;

3. Anaerobic respiration involves reactions catalysed by enzyme **B** / conversion of pyruvate to lactate / involves lactate production;

4. Enzyme **A** / Krebs cycle is part of aerobic respiration;

Or, with emphasis on aerobic respiration:

1. Tracheae supply oxygen / after 6 days oxygen supplied;

2. (With tracheae) tissues can respire aerobically.

4

[15]

20

(a) Banding pattern changes as cheetah gets older / difficult to judge as tail is short / fluffy;

1

(b) (i) Mean not (always)
a whole number; Standard deviation
not (always) zero;

(ii) Movement of tail / angle of sight / confused it with another band / subjective estimation;

Accept reference to ***Figure 1***

E.g. Bands 2 and 3 have same thickness but look different

(c) Band width not the same on both sides of tail;

(d) Offspring of the same family will be more similar genetically;
As have same mother (and father) / parent;
Expect to see more differences in randomly chosen cheetahs;

21 (a) Introns;

(b) Ile Gly Val Ser;

(c) (i) Has no effect / same amino acid (sequence) / same primary structure;

Q *Reject same amino acid formed or produced.*

Glycine named as same amino acid;

It still codes for glycine = two marks.

(ii) Leu replaces Val / change in amino acid (sequence) / primary structure;

Change in hydrogen / ionic bonds which alters tertiary structure / active site;

Q *Different amino acid formed or produced negates first marking point.*

Substrate cannot bind / no longer complementary /
no enzyme-substrate complexes form;

Active site changed must be clear for third marking point but does not need reference to shape.

(d) (i) Interphase / S / synthesis (phase);

(ii) DNA / gene replication / synthesis occurs / longest stage;

Allow 'genetic information' = DNA.

1

[9]

2

1

1

3

[8]

1

1

1

1

3

1

22 (a)

DNA	✓	2
mRNA	✗	1
tRNA	✓	1

One mark for each correct column
Regard blank as incorrect in the context of this question
Accept numbers written out: two, one, one

2

(b) (i) Marking principles
1 mark for complete piece transcribed;

Correct answer
UGU CAU GAA UGC UAG

1 mark for complementary bases from sequence transcribed;

but allow 1 mark for complementary bases from section transcribed, providing all four bases are involved

2

(ii) Marking principle
1 mark for bases corresponding to exons taken from (b)(i)

Correct answer
UGU UGC UAG
If sequence is incorrect in (b)(i), award mark if section is from exons. Ignore gaps.

1

[5]

23 (a) RNA polymerase;

DNA polymerase is incorrect
Ignore references to RNA dependent or DNA dependent
Allow phonetic spelling

1

(b) (i) (Receptor / transcription factor) binds to promoter which stimulates RNA polymerase / enzyme X;

Transcribes gene / increase transcription;

2

(ii) Other cells do not have the / oestrogen / ERα receptors;

But do not accept receptors in general.

1

(c) Similar shape to oestrogen;

Binds receptor / prevents oestrogen binding;

Receptor not activated / will not attach to promoter / no transcription;

Accept alternative
Complementary to oestrogen;
Binds to oestrogen;
Will not fit receptor;

2 max

[6]

24 (a) Will replace themselves / keep dividing / replicate;

Undifferentiated / can differentiate / develop into other cells / totipotent / multipotent / pluripotent;

Accept tissues

2

(b) Reverse transcriptase;

Allow phonetic spelling

1

(c) (i) Alters base / nucleotide sequence / causes frame shift;

Different sequence of amino acids in polypeptide / protein / primary structure alters the tertiary structure;

Accept any reference, such as adding bases, to changing the base sequence of the gene. Reject deletion / substitution.
Idea of sequence essential so not makes different amino acids.
Accept answers involving stop / start codons and effect on protein.

2

(ii) Affects tumour suppressor gene;

Inactivates (tumour suppressor) gene;

Rate of cell division increased / tumour cells continue to divide;

Ignore answers relating to oncogenes. May gain third point.

2 max

(d) Yes
SCID patients unlikely to survive / quality of life poor unless treated;
Cancer that develops is treatable / only affects 25% / five children;

No
Risk of developing cancer is high / 25%;
Cancer may recur / may not be treated successfully in future / only short time scale so more may develop cancer;

No mark for yes or no. Marks are for supporting argument based on biological reasoning.
Accept any points

2 max

[9]