Q1. Lysozyme is an enzyme consisting of a single polypeptide chain of 129 amino acids.

(a) What is the minimum number of nucleotide bases needed to code for this enzyme?

.....

(1)

(b) The diagram shows the sequence of bases in a section of the mRNA strand used to synthesise this enzyme.

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

(i) Give the DNA sequence which would be complementary to the first four bases in this section of mRNA.

.....

(1)

(ii) How many different types of tRNA molecule would attach to the section of mRNA shown in the diagram?

.....

(1)

(c) Give **two** factors which might increase the frequency at which a mutation in DNA occurs.

1 .....

2 .....

(2)

(d) Two single base mutations occurred in the DNA coding for this section of mRNA. These mutations caused an alteration in the sequence of amino acids in the enzyme. The diagram shows the original and altered sequences of amino acids.

Original amino acid sequence	Gly	Leu	Ser	Tyr	Gly	Arg	Tyr
Original mRNA base sequence	GGU	CUU	UCU	UAU	GGU	AGA	UAU

Altered amino acid sequence	Gly	Leu	Tyr	Leu	Trp	Arg	Tyr
Altered mRNA base sequence	GGU	CUU				AGA	UAU

(i) Use the mRNA codons provided in the table to complete the altered mRNA base sequence in the diagram.

Amino acid	mRNA codons which can be used
Arg	AGA
Gly	GGU
Leu	CUU or UUA
Ser	UCU
Trp	UGG
Tyr	UAU or UAC

(1)

(ii) Use the information provided to determine the precise nature of the **two** single base mutations in the DNA.

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(3)
(Total 9 marks)

Q2. (a) (i) What is the role of RNA polymerase in transcription?

.....

.....

(1)

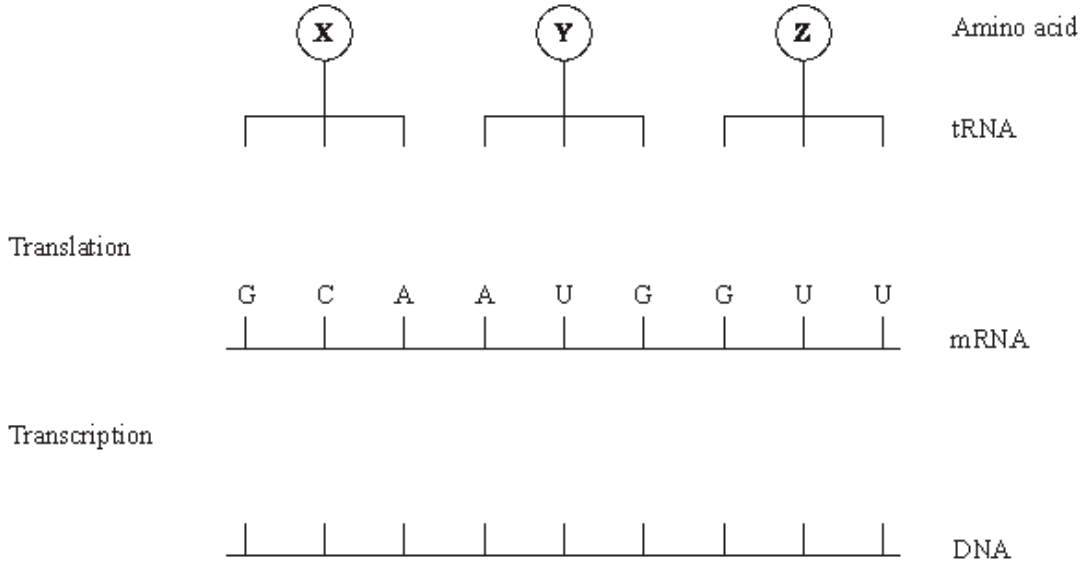
(ii) Name the organelle involved in translation.

.....

(1)

(b) **Figure 1** shows some molecules involved in protein synthesis.

Figure 1



Complete **Figure 1** to show

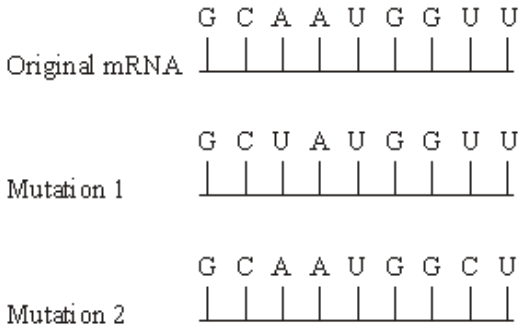
(i) the bases on the DNA strand from which the mRNA was transcribed;

(ii) the bases forming the anticodons of the tRNA molecules.

(2)

Figure 2 shows the effects of two different mutations of the DNA on the base sequence of the mRNA. The table shows the mRNA codons for three amino acids.

Figure 2



Amino acid	mRNA codon
methionine	AUG
valine	GUC GUU
alanine	GCA GCC GCU

(c) Name the type of mutation represented by mutation 1.

.....

(1)

(d) Use the information in the table to

(i) identify amino acid **X** in **Figure 1**;

.....

(1)

(ii) explain how each mutation may affect the polypeptide for which this section of DNA is part of the code.

Mutation 1 .....

.....

.....

.....

(2)

Mutation 2 .....

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.....

.....

(2)

(Total 10 marks)

Q3. 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.

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(1)

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

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(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.

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(Extra space) .....

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(3)
(Total 7 marks)

Q4. The table shows the sequence of bases on part of the coding strand of DNA.

Base sequence on coding strand of DNA	**C**	**G**	**T**	**T**	**A**	**C**
Base sequence of mRNA						

(a) Complete the table to show the base sequence of the mRNA transcribed from this DNA strand.

(2)

(b) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

(i) Explain this difference in the number of nucleotides.

.....

.....

(1)

(ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer.

Number of amino acids .....

Explanation .....

.....

(2)

(c) Complete the table to give **two** differences between the structure of mRNA and the structure of tRNA.

mRNA	**tRNA**

(2)
(Total 7 marks)

Q5. (a) The table shows the mRNA codons for some amino acids.

Codon	Amino acid
CUA	Leucine
GUC	Valine
ACG	Threonine
UGC	Cysteine
GCU	Alanine
AGU	Serine

(i) Give the DNA sequence coding for cysteine.

.....

(1)

(ii) Name the amino acid coded by the tRNA anticodon UCA.

.....

(1)

(b) A particular gene is 562 base-pairs long. However, the resulting mRNA is only 441 nucleotides long. Explain this difference.

.....

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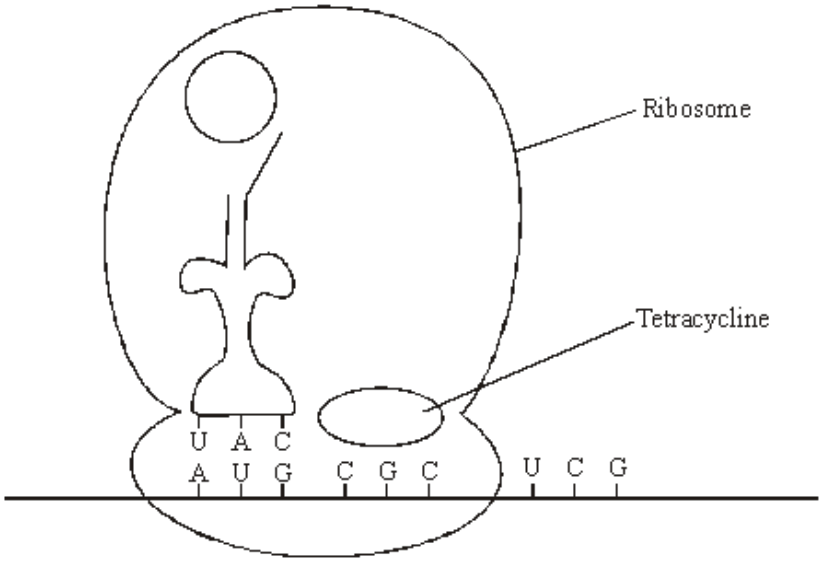
(1)

(c) Tetracycline binds to bacterial ribosomes. This is shown in the diagram.



Protein synthesis in bacteria is similar to that in eukaryotic cells. Explain how tetracycline stops protein synthesis.

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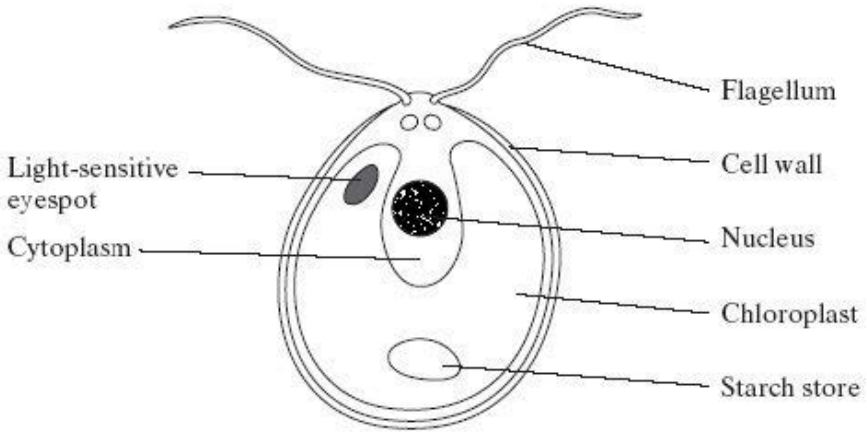
(2)
(Total 5 marks)

Q6. **S** The diagram shows a single-celled organism called *Chlamydomonas*.



(a) *Chlamydomonas* lives in fresh-water ponds. It uses its flagella to swim towards light of moderate intensity but away from very bright light. Using information in the diagram, explain the advantage of this behaviour.

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(2)

(b) A *Chlamydomonas* cell has two flagella. These flagella contain a single sort of protein. A flagellum consists of a bundle of 242 filaments. Each filament consists of 7500 protein molecules. Each protein molecule contains 900 amino acid units.

(i) What would be the minimum number of nucleotides in the coding region of the mRNA used to synthesise this protein?

.....

(1)

(ii) In an investigation, a culture of *Chlamydomonas* was treated in a way that caused them to lose their flagella without any other damage to the cells. The flagella grew back to their original length in 60 minutes.

How many amino acid molecules would be incorporated into each growing flagellum per minute? Show your working.

Answer .....

(2)

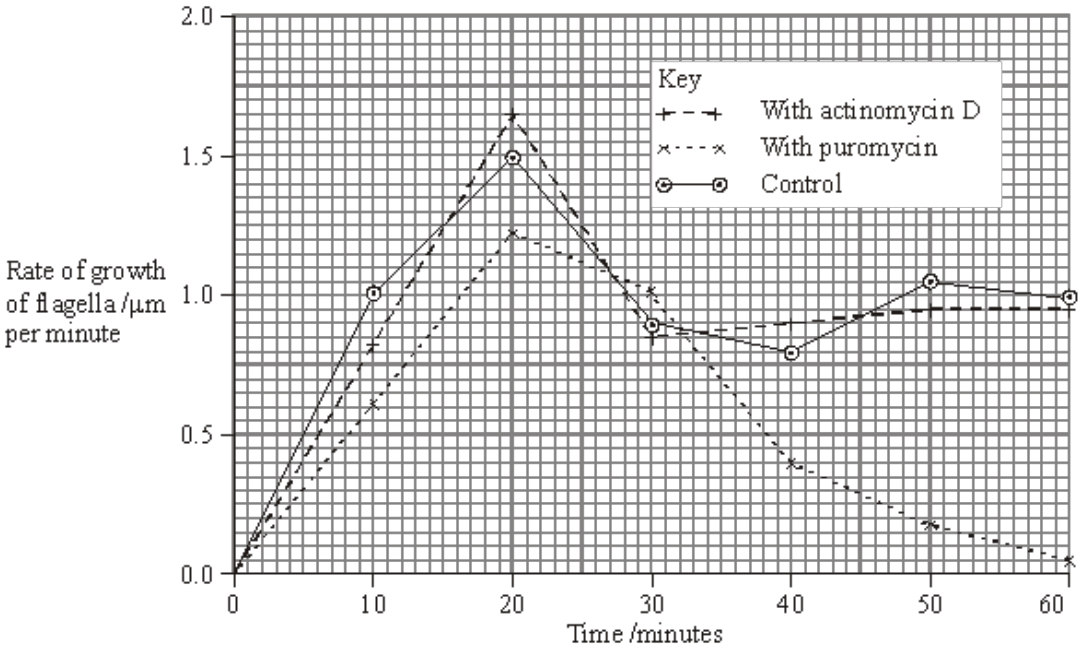
(c) The researchers investigated the rate at which the flagella grew in three different media.

1. A medium containing actinomycin D, which prevents transcription by binding to the guanine in DNA

2. A medium containing puromycin, which prevents translation by attaching to ribosomes

3. A control medium

The results are shown in the graph.



(i) Describe how the rate of growth was affected by puromycin.

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.....

.....

(2)

(ii) The researchers concluded

1. that the cells used mRNA that is already present in the cytoplasm for the regrowth of the flagella;

2. that some of the regrowth uses protein molecules already present in the cell.

Explain the evidence for each of these conclusions.

1 .....

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2 .....

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(4)
(Total 11 marks)

Q7. (a) **Table 1** shows some of the events which take place in protein synthesis.

A	tRNA molecules bring specific amino acids to the mRNA molecule
B	mRNA nucleotides join with exposed DNA bases and form a molecule of mRNA
C	The two strands of a DNA molecule separate
D	Peptide bonds form between the amino acids
E	The mRNA molecule leaves the nucleus
F	A ribosome attaches to the mRNA molecule

Table 1

(i) Write the letters in the correct order to show the sequence of events during protein synthesis, starting with the earliest.

....

(2)

(ii) In which part of a cell does **C** take place?

.....

(1)

(iii) Which of **A - F** are involved in translation?

.....

(1)

(b) **Table 2** shows some mRNA codons and the amino acids for which they code.

mRNA codon	Amino acid
GUU	Valine
CUU	Leucine
GCC	Alanine
AUU	Isoleucine
ACC	Threonine

Table 2

(i) A tRNA molecule has the anticodon UAA. Which amino acid does the tRNA molecule carry?

.....

(1)

(ii) Give the DNA base sequence that codes for threonine.

.....

(1)

(Total 6 marks)

Q8. (a) The table shows the mRNA codons for some amino acids.

Codon	Amino Acid
CUA	Leucine
GUC	Valine
ACG	Threonine
UGC	Cysteine
GCU	Alanine
AGU	Serine

(i) Give the DNA sequence for cysteine.

.....

(1)

(ii) Name the amino acid coded by the tRNA anticodon UCA.

.....

(1)

(b) A particular gene is 652 base pairs long. The mRNA produced from this gene is only 441 nucleotides long. Explain this difference.

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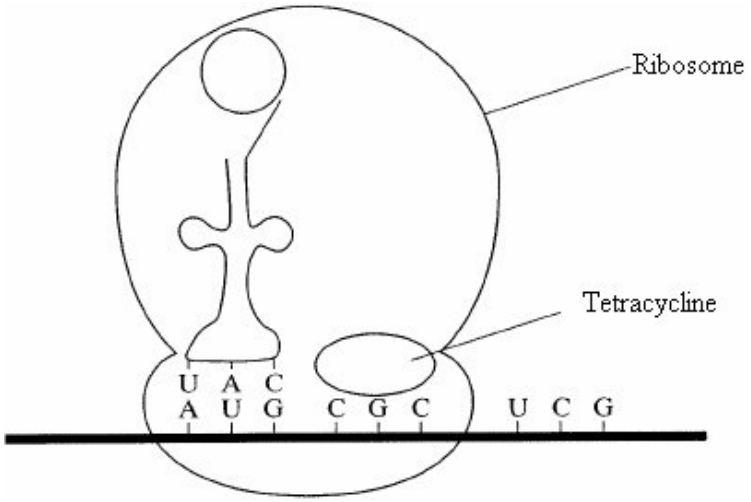
(1)

(c) Tetracycline is an antibiotic. The diagram shows how tetracycline binds to bacterial ribosomes.



Protein synthesis in bacteria is similar to that in eukaryotic cells. Explain how tetracycline stops protein synthesis in bacteria.

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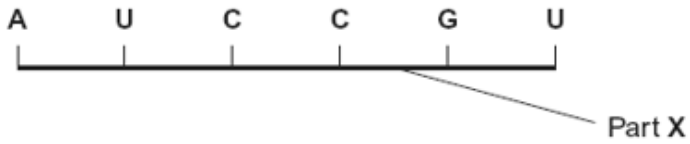
(2)
(Total 5 marks)

Q9. 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.

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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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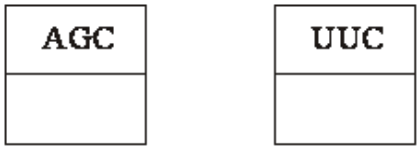
(2)
(Total 7 marks)

Q10. (a) **Figure 1** shows the exposed bases (anticodons) of two tRNA molecules involved in the synthesis of a protein.

Figure 1



Complete the boxes to show the sequence of bases found along the corresponding section of the coding DNA strand.

(2)

(b) Describe the role of tRNA in the process of translation.

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.....

(3)

(c) **Figure 2** shows the sequence of bases in a section of DNA coding for a polypeptide of seven amino acids.

Figure 2

TACAAGGTCGTCTTTGTCAAG

The polypeptide was hydrolysed. It contained four different amino acids. The number of each type obtained is shown in the table.

Amino acid	Number present
Phe	2
Met	1
Lys	1
Gln	3

Use the base sequence shown in **Figure 2** to work out the order of amino acids in the polypeptide. Write your answer in the table below.

Met						

(2)
(Total 7 marks)

Q11. New alleles arise as a result of mutations in existing genes. These mutations may occur during DNA replication.

(a) Explain what is meant by an allele.

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(1)

(b) Explain how DNA replicates.

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(4)

(c) Explain why a mutation involving the deletion of a base may have a greater effect than one involving substitution of one base for another.

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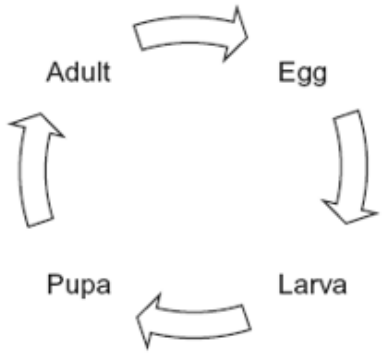
(3)
(Total 8 marks)

Q12. 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.

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.....

(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.

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(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.

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(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.

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(2)

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

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(2)

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

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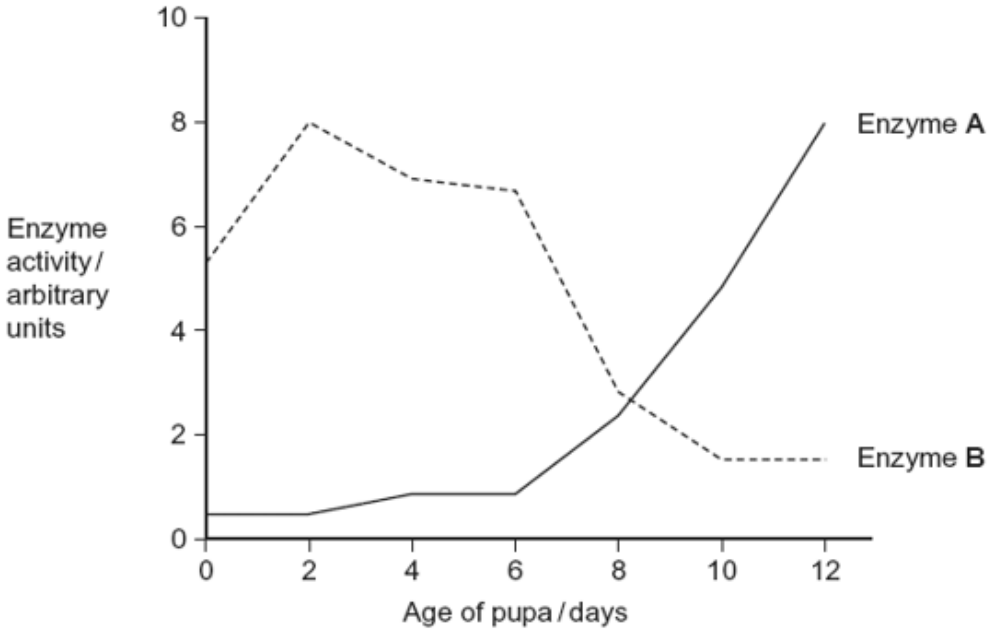
(2)

(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 after 6 days. Use this information to explain the change in activity of the two enzymes.

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(Extra space) .....

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(4)
(Total 15 marks)

Q13. (a) The mRNA codon for the amino acid tyrosine is UAU.

(i) Give the DNA triplet for tyrosine.

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(1)

(ii) Give the tRNA anticodon for tyrosine.

.....

(1)

(b) Give **two** ways in which the structure of a molecule of tRNA differs from the structure of a molecule of mRNA.

1 .....

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2 .....

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(2)
(Total 4 marks)

Q14. Read the following passage.

The sequence of bases in a molecule of DNA codes for proteins. Different sequences of bases code for different proteins. The genetic code, however, is degenerate. Although the base sequence AGT codes for serine, other sequences may also code for this same amino acid. There are four base sequences which code for the amino acid glycine. These are CCA, CCC, CCG and CCT. There are also four base sequences coding for the amino acid proline. These are GGA, GGC, GGG and GGT.

Pieces of DNA which have a sequence where the same base is repeated many times are called "slippery". When "slippery" DNA is copied during replication, errors may occur in copying. Individual bases may be copied more than once. This may give rise to differences in the protein which is produced by the piece of DNA containing the errors.

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

(a) Different sequences of bases code for different proteins (lines 1 – 2). Explain how.

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(2)

(b) The base sequence AGT codes for serine (lines 2 – 3). Give the mRNA codon transcribed from this base sequence.

.....

(2)

(c) Glycine-proline-proline is a series of amino acids found in a particular protein. Give the sequence of DNA bases for these three amino acids which contains the longest "slippery" sequence.

.....

(2)

(d) (i) Explain how copying bases more than once may give rise to a difference in the protein (lines 9 – 10).

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(2)

(ii) At what stage in the cell cycle would these errors in copying DNA bases occur?

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(1)

(e) Starting with mRNA in the nucleus of a cell, describe how a molecule of protein is synthesised.

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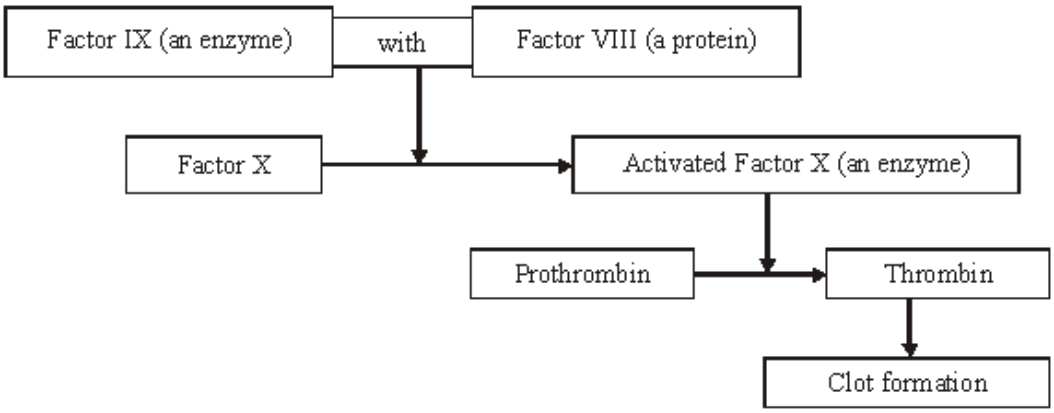
(6)
(Total 15 marks)

Q15. The diagram shows part of the metabolic pathway involved in the clotting of blood in response to an injury.



Haemophilia is a condition in which blood fails to clot. This is usually because of a mutant allele of the gene for Factor VIII.

(a) Explain how mutation could lead to faulty Factor VIII.

.....

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.....

(2)

(b) Use information in the diagram to explain how faulty Factor VIII causes haemophilia.

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(2)

(c) A boy had haemophilia caused by faulty Factor IX. When his blood was mixed with blood from a haemophiliac with faulty Factor VIII, the mixture clotted. Suggest an explanation for clotting of the mixture.

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(2)
(Total 6 marks)

Q16. This question should be answered in continuous prose.
Quality of Written Communication will be assessed in the answer.

(i) Starting with mRNA, describe how the process of translation leads to the production of a polypeptide.

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(4)

(ii) Normal tomato plants have an enzyme that softens tomatoes as they ripen. Genetically engineered tomatoes ripen and soften more slowly. A gene was inserted which reduces the amount of softening enzyme produced.

The diagram shows matching parts of the base sequences for the mRNA produced by the gene for the softening enzyme and that produced by the inserted gene.

Softening gene mRNA …AAUCGGAAU…

Inserted gene mRNA …UUAGCCUUA…

Suggest how the inserted gene reduces the production of the softening enzyme.

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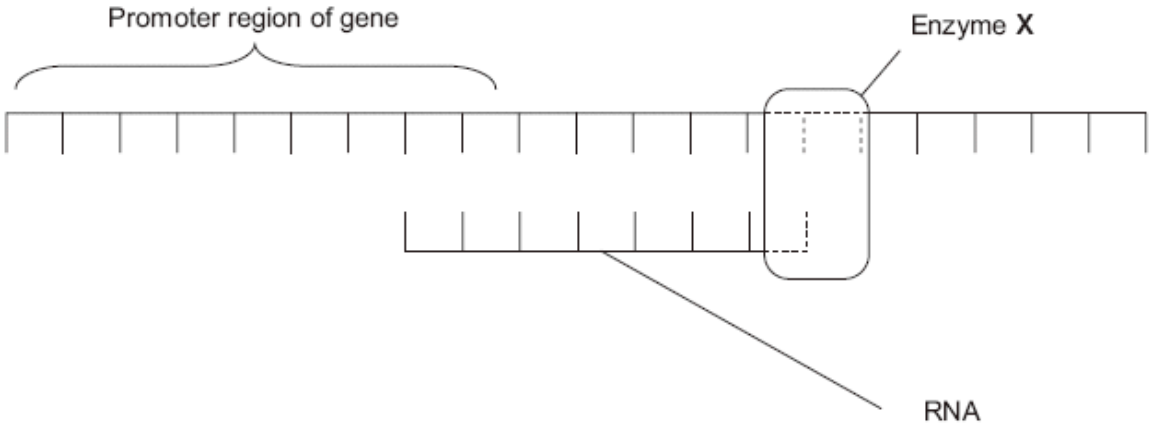
(2)
(Total 6 marks)

Q17. **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.

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(2)

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

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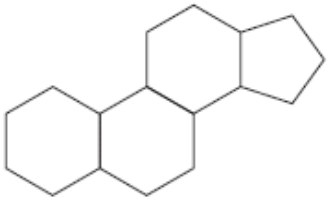
(1)

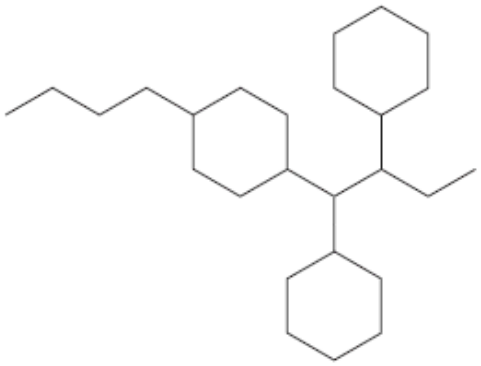
(c) Some breast tumours are stimulated to grow by oestrogen. Tamoxifen is used to treat these breast tumours. In the liver, tamoxifen is converted into an active substance called endoxifen. **Figure 2** shows a molecule of oestrogen and a molecule of endoxifen.

Figure 2

Oestrogen



Endoxifen



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

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(2)
(Total 6 marks)

Q18. (a) Name **one** mutagenic agent.

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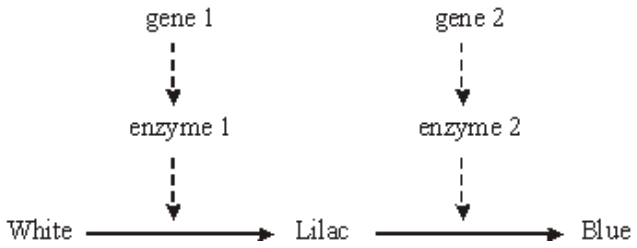
(1)

(b) In flax plants the flowers are white, lilac or blue. The diagram shows the pathway by which the flower cells produce coloured pigments.



(i) A deletion mutation occurs in gene 1. Describe how a deletion mutation alters the structure of a gene.

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(2)

(ii) Describe and explain how the altered gene could result in flax plants with white-coloured flowers.

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(4)

(iii) Electrophoresis was used to separate the enzymes involved in this pathway. When extracts of the differently coloured flax petals were analysed, four different patterns of bands were produced. In the table, only bands that contain functional enzymes are shown.

Result of electrophoresis	Colour of petal
	White
	
	
	

Complete the table to give the colour of the petal from which each extract was taken.

(2)

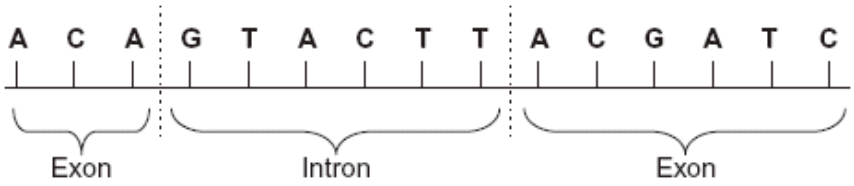
(Total 9 marks)

Q19. (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)