1. The diagram shows the sequence of bases in a short length of mRNA.

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

(a) (i) What is the maximum number of amino acids in the polypeptide for which this piece of mRNA could code?

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(1)

(ii) How many different types of tRNA molecule would be used to produce a polypeptide from this piece of mRNA?

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(1)

(iii) Give the DNA sequence which would be complementary to the first five bases in this piece of mRNA.

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(1)

(b) Name the process by which mRNA is formed in the nucleus.

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(1)

(c) 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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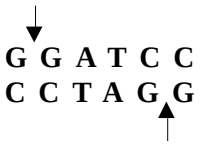
(2)

(Total 6 marks)

2. A restriction endonuclease cuts DNA at a particular base sequence. The restriction endonuclease, *Bam* H1, recognises the sequence of six bases as shown in the diagram and cuts the DNA to form sticky ends. The arrows show where *Bam* H1 cuts the DNA.



(a) Draw the sticky ends which are produced when *Bam* H1 has cut the DNA.

(1)

(b) Describe how the two polynucleotide chains of DNA are normally held together.

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(2)

(c) The enzyme DNA ligase is used to join together pieces of DNA from different sources. Explain why the DNA to be joined together must be cut with the **same** restriction endonuclease before DNA ligase is used.

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(2)
(Total 5 marks)

3. The table shows the mRNA base sequences (codons) which code for specific amino acids. The names of the amino acids have been abbreviated.

UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys
UUA	Leu	UCA	Ser	UAA	stop codon	UGA	stop codon
UUG	Leu	UCG	Ser	UAG	stop codon	UGG	Trp
CUU	Leu	CCU	Pro	CAU	His	CGU	Arg
CUC	Leu	CCC	Pro	CAC	His	CGC	Arg
CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg
CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg
AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
AUC	Ile	ACC	Thr	AAC	Asn	AGC	Ser
AUA	Lie	ACA	Thr	AAA	Lys	AGA	Arg
AUG	Met	ACG	Thr	AAG	Lys	AGG	Arg
GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly
GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly
GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly

(a) (i) Give the amino acid coded for by the DNA base sequence GGT.

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(1)

(ii) Give **one** possible tRNA base sequence for the amino acid Tyr.

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(1)

(b) Describe how cells use the base sequence of a molecule of DNA to produce a polypeptide.

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(7)

(c) Sometimes errors occur during the copying of a sequence of bases. Use the information given to explain why some errors have less severe consequences than others.

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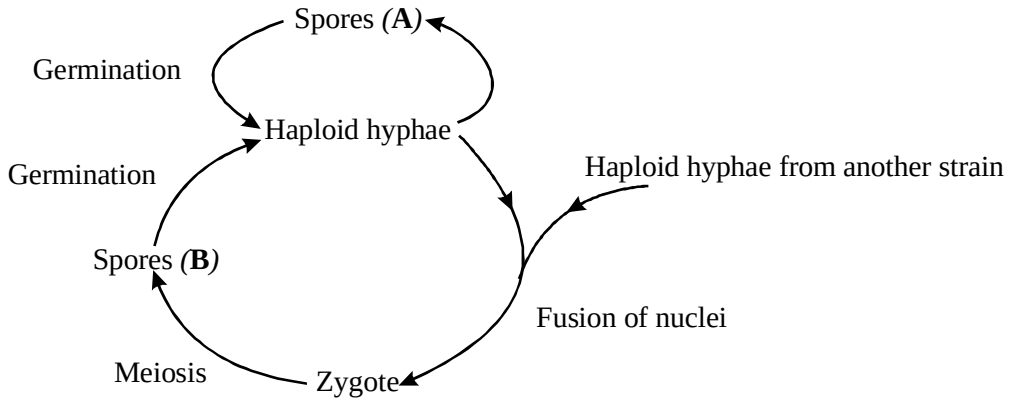
(3)
(Total 12 marks)

4. A fungus consists of a number of thread-like structures called hyphae. Spores are produced when reproduction occurs.
The diagram shows the life cycle of this fungus.



This fungus will normally grow on a medium containing only sucrose, inorganic salts and the vitamin, biotin. There are, however, some strains of the fungus which contain mutant genes. They require amino acids to be added to the medium before growth will take place. Each of these mutant strains lacks one enzyme necessary for synthesising a particular amino acid.
In one investigation three different mutant strains were identified. Each of these strains lacked a different enzyme involved in the pathway by which the amino acid arginine is synthesised. This is shown in the diagram.

Substance X	⟶	Substance Y	⟶	Substance Z	⟶	Arginine
	Enzyme 1		Enzyme 2		Enzyme 3	
	(not found in Strain 1)		(not found in Strain 2)		(not found in Strain 3)	

(a) Explain how mutation of a gene can result in a strain lacking a particular enzyme.

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(4)

(b) Explain why Strain 2 will grow only if either Substance Z or arginine is added to the medium.

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(2)

(c) This fungus is haploid. Suggest why mutant genes can be identified more easily in haploid fungi than in diploid ones.

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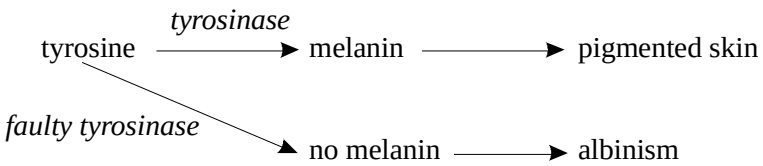
(3)
(Total 9 marks)

5. About one in 20 000 humans has the condition, albinism. This is caused by the absence of melanin, the dark brown pigment normally present in the human skin, hair, and eyes. Albinism arises from a gene mutation that causes skin cells to produce a different version of the enzyme tyrosinase. This different version of tyrosinase is faulty.

These events are shown in the diagram.



(a) Explain how a gene mutation may result in a different version of tyrosinase.

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(4)

(b) The faulty tyrosinase does not produce melanin.

Suggest an explanation for this.

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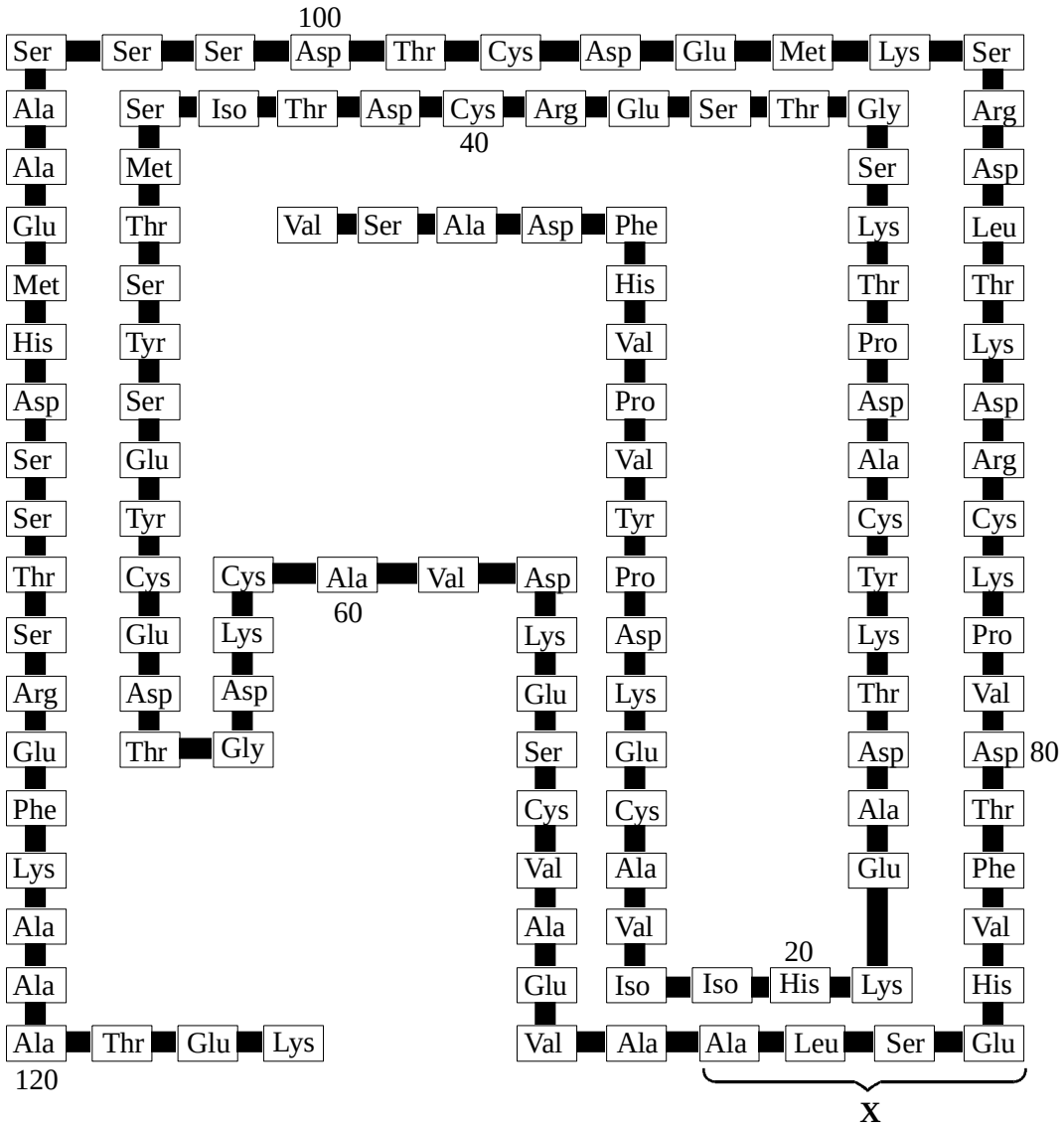
(2)
(Total 6 marks)

6. (a) Draw a labelled diagram to show the structure of an RNA nucleotide.

(2)

(b) The diagram shows a molecule of an enzyme called ribonuclease. Each amino acid in the protein is indicated by a 3-letter symbol e.g. Arg = arginine.



(i) How many nucleotides are there in the mRNA molecule that codes for this enzyme?

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(1)

(ii) The table gives the mRNA code for the four amino acids in the part of the enzyme labelled **X.**

Amino Acid	Symbol	mRNA code
Alanine	Ala	GCU
Glutamine	Glu	GAG
Leucine	Leu	UUA
Serine	Ser	AGU

Give the DNA code for the part of the enzyme labelled **X.**

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(1)

(c) (i) Where does translation occur in a cell?

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(1)

(ii) Describe what happens during translation.

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(3)

(d) Explain how the structure of DNA is related to its function.

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(6)
(Total 14 marks)

7. (a) Name the organelle where proteins are synthesised from amino acids.

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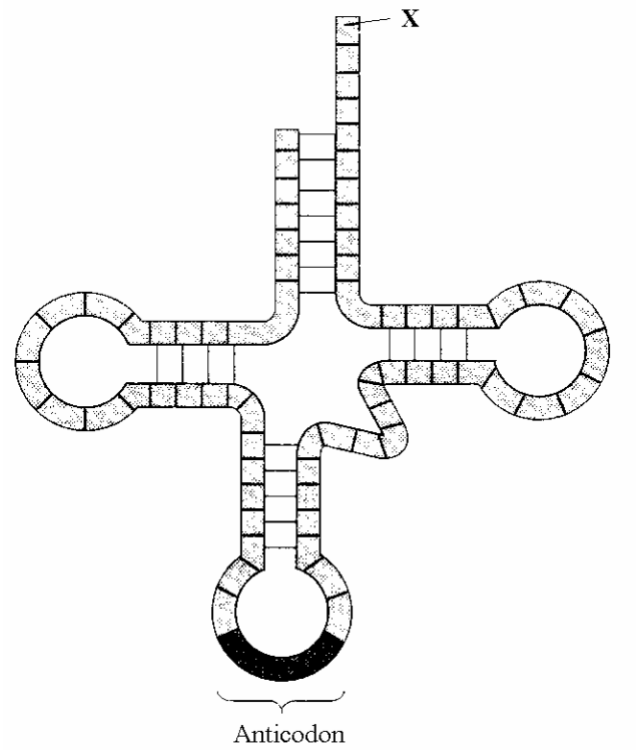
(1)

(b) The diagram shows a transfer RNA molecule (tRNA).



(i) During protein synthesis, which molecule is attached to the TRNA molecule at **X?**

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(1)

(ii) What is an anticodon?

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(1)

(iii) Give **one** way in which the structure of a TRNA molecule is different from an MRNA molecule.

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(1)
(Total 4 marks)

8. (a) (i) Describe how a gene may be taken from a mammalian cell and inserted into bacterial cells.

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(5)

(ii) Describe how bacteria containing the transferred gene can be cultured on a large scale.

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(2)

(b) Mutation of the gene responsible for production of the enzyme galactosidase causes a liver disorder. The liver is unable to metabolise certain carbohydrates, and toxic products accumulate.

(i) Describe **one** way in which the structure of the DNA of a gene may be changed as a result of a mutation.

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(2)

(ii) The disorder can be treated by introducing the gene for galactosidase into a harmless virus, then injecting the transformed virus into the patient. A liver cell containing DNA from the transformed virus produces galactosidase. Describe how a cell synthesises a protein such as galactosidase.

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(5)

(iii) The transformed virus enters liver cells but does not usually enter other cells in the body.

Suggest **one** explanation for this.

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(1)

(Total 15 marks)

9. Insulin is a protein. **Table 1** shows the amino acids from a section of an insulin molecule and the mRNA nucleotide bases which code for them. The identity of one amino acid has not been given.

Amino acid	cysteine	serine	X	tyrosine
mRNA nucleotides	UGU	AGC	UAC	UAU

Table 1

(a) (i) What name is given to the sequence of three mRNA nucleotides which codes for one amino acid?

.....

(1)

Some of the DNA nucleotide sequences coding for amino acids are shown in **Table 2**.

Amino acid	DNA nucleotide sequence
Phenylalanine	AAA AAG
Cysteine	ACA ACG
Serine	TCA TCG
Tyrosine	ATA ATG

Table 2

(ii) Name amino acid X in **Table 1**.

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(1)

(b) Some mutations occur when one nucleotide is substituted by a different nucleotide in a strand of DNA.

(i) Explain how the substitution of a nucleotide may cause a gene to code for a different protein.

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(3)

(ii) Some nucleotide substitutions have no effect on the protein coded by the gene. Use information given in **Table 2** to explain why.

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(2)

(c) A recombinant plasmid is produced by inserting a fragment of foreign DNA into a plasmid. Explain how enzymes are used to produce a recombinant plasmid.

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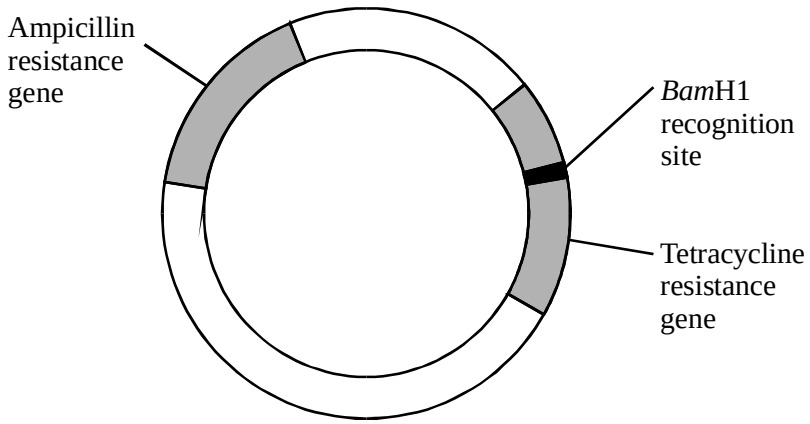
(3)

(d) The plasmid pBR322 is used in genetic engineering. The plasmid contains resistance genes for the antibiotics ampicillin and tetracycline and a recognition site for the restriction endonuclease *Bam*H1.



Recombinant plasmids were produced by inserting a fragment of foreign DNA into pBR322 using *Bam*H1. The recombinant plasmids were mixed with a culture of bacteria. Some bacteria took up the plasmid.

Explain how bacteria that contain the pBR322 recombinant plasmid could be separated and identified using the technique of replica plating.

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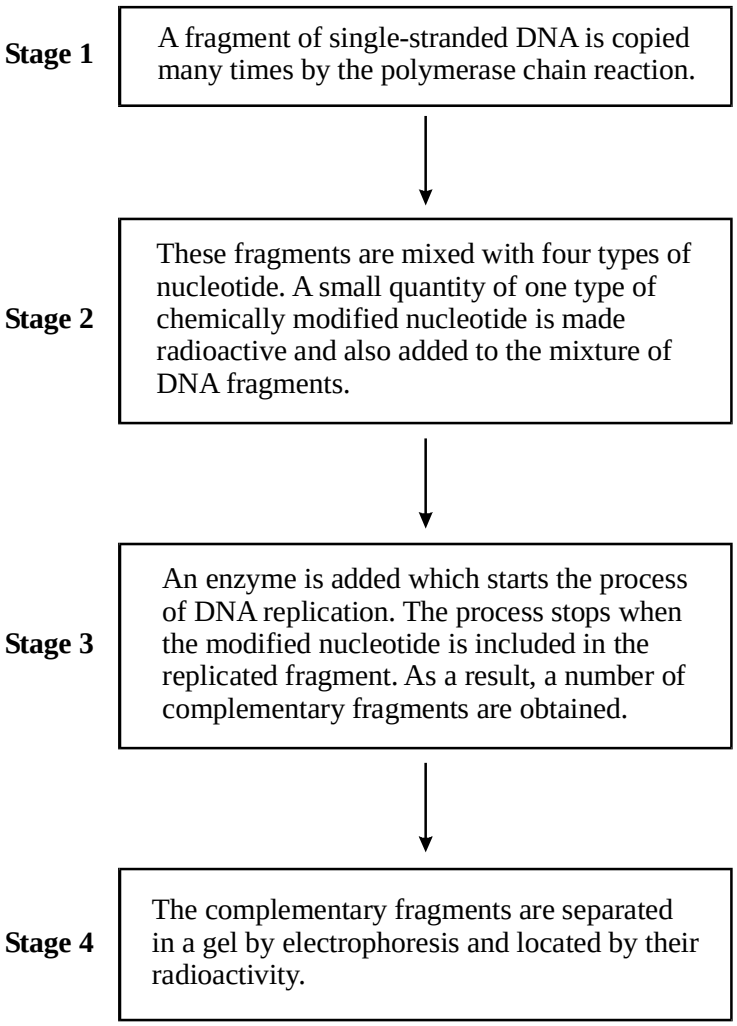
(5)
(Total 15 marks)

10. The flow chart shows one method of finding the sequence of nucleotides in DNA.



(a) Name the enzyme used in **Stage 3**.

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(1)

(b) The complementary DNA fragments obtained using one type of radioactive nucleotide in **Stage 3** have sequences that differ.
Explain how the nucleotide sequences differ.

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(2)

(c) Explain how the fragments separated in gel electrophoresis may be located by their radioactivity (**Stage 4**).

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(2)
(Total 5 marks)

11. (a) (i) Name **one** type of mutagenic agent.

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(1)

(ii) Explain how exposure to a mutagenic agent may result in an inactive enzyme being produced by a cell.

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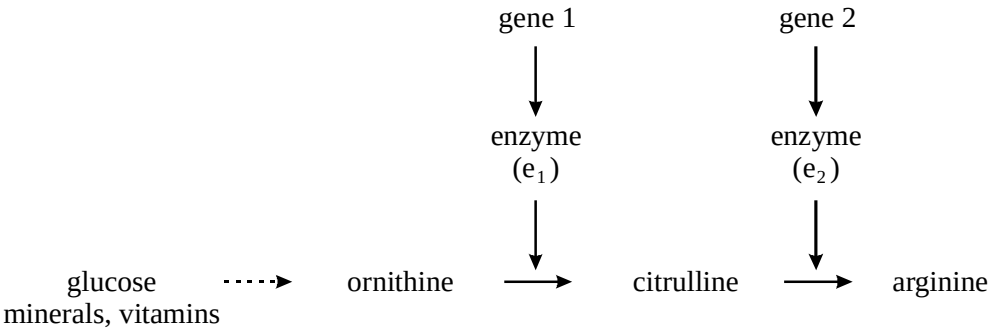
(3)

(b) A type of fungus grows well on a medium containing glucose, minerals and vitamins. The fungus uses these nutrients in different biochemical pathways to produce other substances needed for growth.

The diagram shows the pathway by which the fungus produces the amino acid, arginine.



After exposure to a mutagenic agent, a population of this fungus would only grow on a medium that contained either citrulline or arginine. Use information given in the diagram to explain why.

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(4)
(Total 8 marks)

12. (a) Starting from the base sequence of DNA, describe how a polypeptide is produced.

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(6)

(b) The protein haemoglobin is formed from two types of polypeptide chain. In people with sickle cell anaemia, one type of polypeptide chain has one amino acid which is different from normal. This is due to a mutation which produces the base sequence CAT instead of CTT.

(i) Give **one** factor which may increase the frequency of mutation.

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(1)

(ii) What type of gene mutation produced the sickle cell anaemia allele?

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(1)

(c) Explain why the mutation resulted in only one different amino acid in the affected polypeptide chains.

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(2)

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

mRNA codon	Amino acid
CAU	histidine
CAA	glutamine
GUA	valine
GAA	glutamic acid
CUU	leucine
GAU	aspartic acid

Use the information in the table to determine the change in the amino acid which occurred as a result of the mutation of the haemoglobin gene.

Amino acid present in normal haemoglobin.

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(1)

Amino acid present in sickle cell haemoglobin.

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(1)

(e) People with sickle cell anaemia have brittle red blood cells that are able to carry less oxygen. Explain how changing one amino acid affects the properties of haemoglobin.

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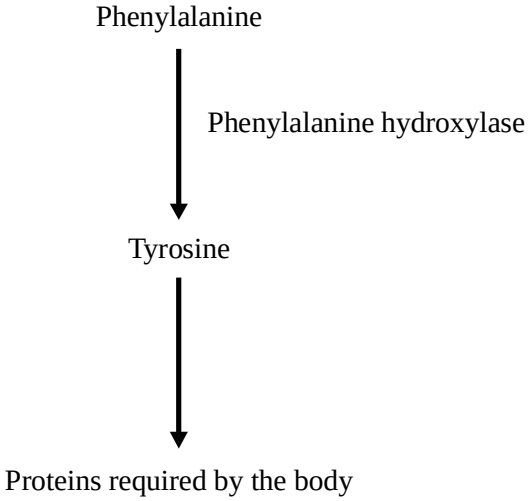
(3)

(Total 15 marks)

13. Phenylalanine is an amino acid found in many proteins in the diet. In most people it is converted to another amino acid, tyrosine, by the pathway shown.



People with phenylketonuria cannot produce the enzyme phenylalanine hydroxylase. This disorder is the result of a gene mutation. Affected people accumulate phenylalanine and this leads to brain damage.

(a) What is a *gene mutation*?

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(1)

(b) Explain how the gene mutation results in failure to produce the enzyme phenylalanine hydroxylase.

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(3)

(c) From birth, children with phenylketonuria are given a special diet which is low in phenylalanine.

(i) Explain how such treatment prevents brain damage in the children.

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(1)

(ii) Suggest **one** reason why the diet must contain some phenylalanine.

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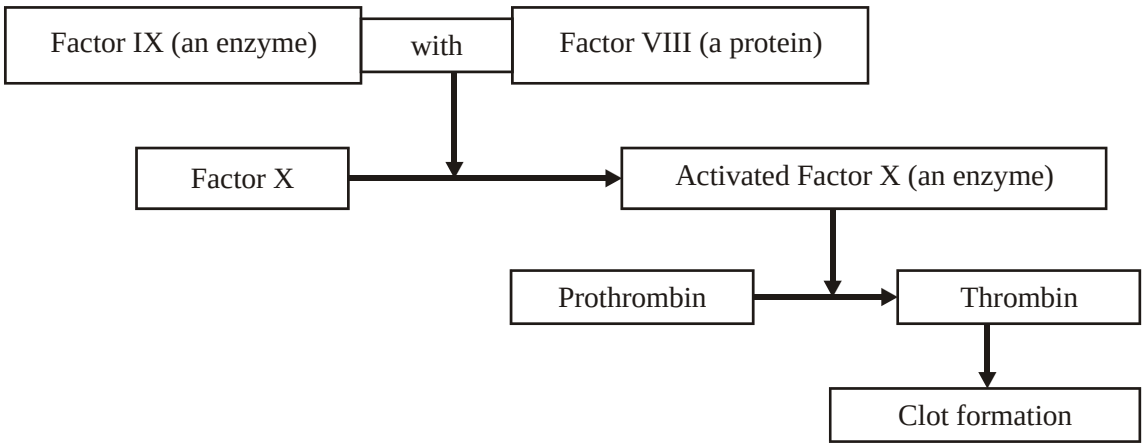
(1)

(Total 6 marks)

14. 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)

15. 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)

16. (a) CFTR is a transmembrane regulator protein. Its molecules have 1480 amino acids. People with cystic fibrosis produce defective CFTR protein which is missing one amino acid from its structure.

(i) What is the minimum number of bases on DNA which would code for the normal CFTR protein? Explain your answer.

Number of bases .....

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(2)

(ii) Which type of gene mutation produced the cystic fibrosis allele?
Explain your answer.

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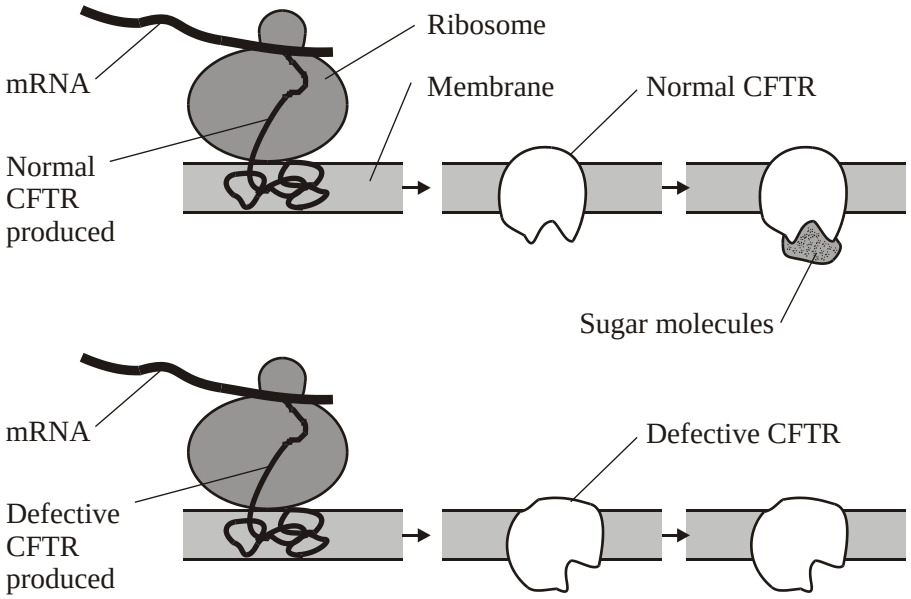
(2)

(b) The diagram shows part of the process of making normal and defective CFTR in a cell.
A normal CFTR protein molecule has sugar molecules attached to it which make it functional.



(i) Describe how the information on mRNA is translated into CFTR at the ribosome.

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(4)

(ii) Using information in the diagram and your own knowledge, suggest why defective CFTR, missing one amino acid, is not functional.

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(2)
(Total 10 marks)

17. 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?

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(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?

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(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)

18. (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.

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(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)

19. 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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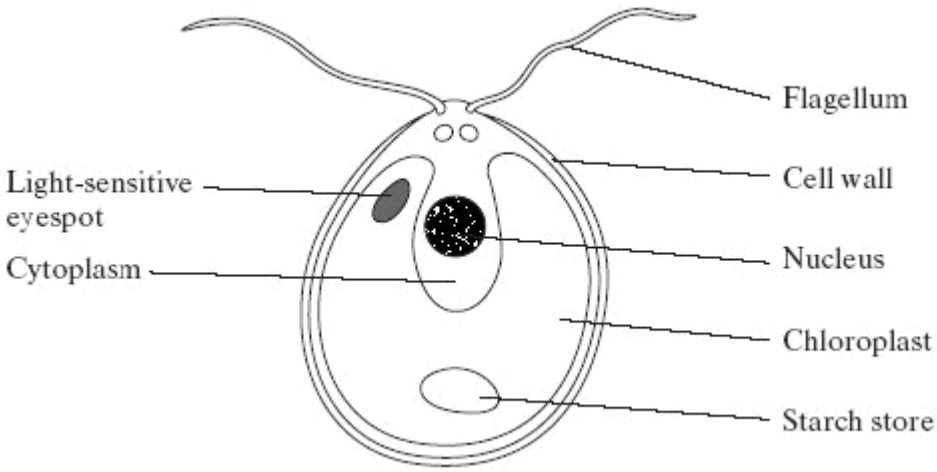
(3)
(Total 8 marks)

20. 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)

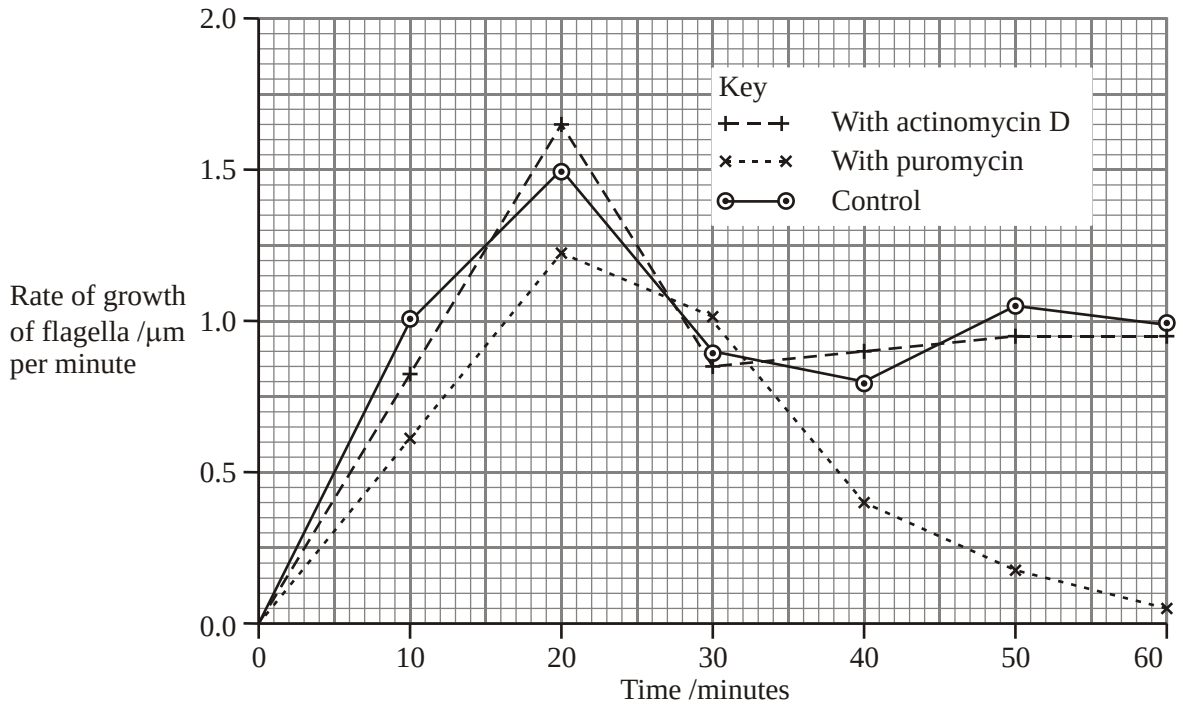
(c) The researchers investigated the rate at which the flagella grew in three different media.

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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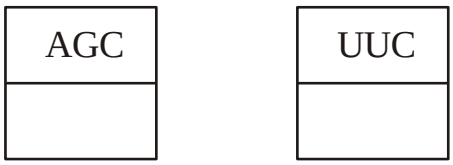
(4)
(Total 11 marks)

21. (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)

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

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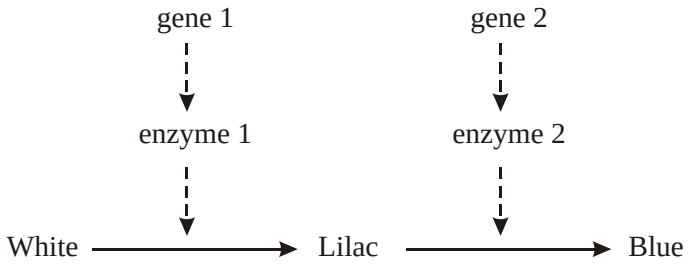
(1)

(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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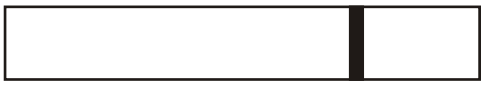
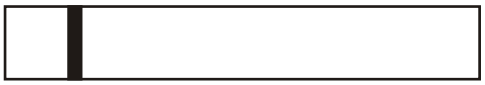
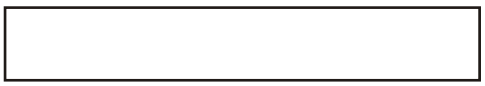
.....

(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)

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

.....

.....

(1)

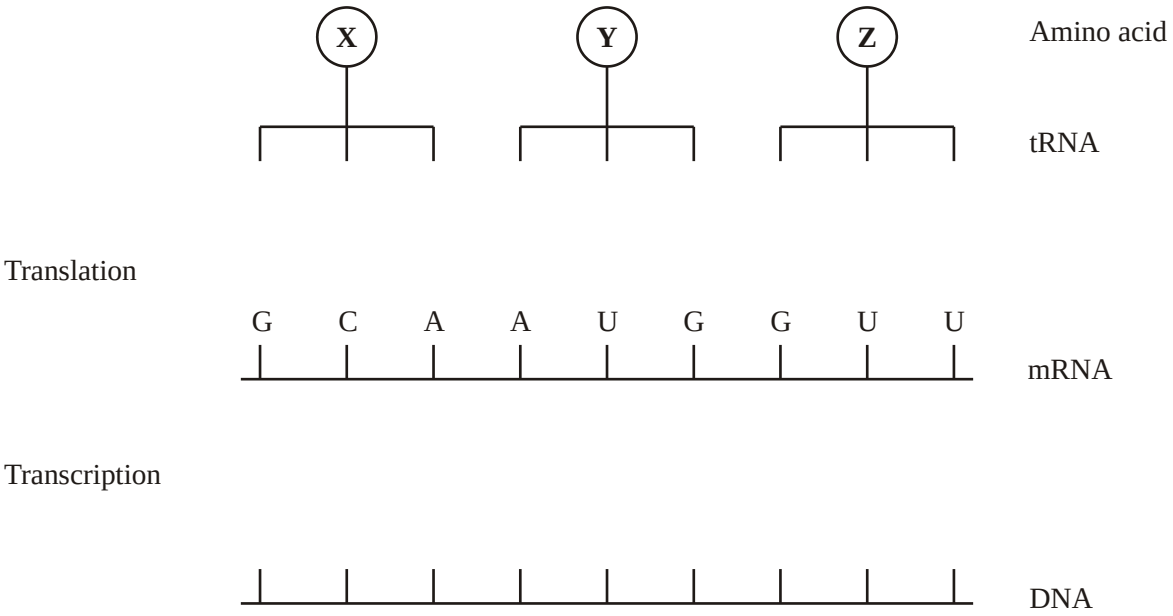
(ii) Name the organelle involved in translation.

.....

(1)

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

Figure 1



Complete **Figure 1** to show

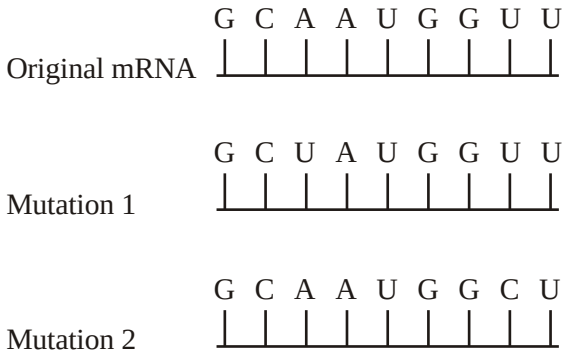
(i) the bases on the DNA strand from which the mRNA was transcribed;

(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 .....

.....

.....

.....

(2)

(Total 10 marks)