1. *Answers should be written in continuous prose. Credit will be given for biological accuracy, the organisation and presentation of the information and the way in which the answer is expressed.*

Cancer may be treated by chemotherapy. This involves using drugs which kill cancer cells but have no effect on normal healthy cells. Unfortunately. cancer cells develop from normal cells so the two types of cell are similar to each other. Trials have begun which involve adding a new gene to the normal cells in the body. This gene makes a protein which protects these healthy cells against the drug being used. The cancer cells do not produce this protein. so they are killed.

(a) Describe the features of a gene which enable it to code for a particular protein.

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(4)

(b) Explain how enzymes and vectors may be used to isolate genes and insert them into another organism.

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(6)

(c) Describe how the new protein is made once the gene has been inserted into the cell.

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(7)
(QWC 3)
(Total 20 marks)

2. *Answers should be written in continuous prose. Credit will be given for biological accuracy, the organisation and presentation of the information and the way in which the answer is expressed.*

Read the following passage.

DNA acts as a template for the synthesis of RNA molecules. Only in this way does the genetic information stored in the DNA molecule become directly useful to the cell. RNA synthesis is a highly selective process. In most mammalian cells only about 1% of the genetic information is transcribed into functional RNA sequences.

Genetic information must be passed on from cell to cell and from generation to generation. Before a cell can divide it must produce a new copy of each of its chromosomes. Thus cell division is preceded by a special "DNA-synthesis phase" during which the DNA is replicated.

In mammals, the process of meiosis forms the gametes through which DNA is passed on to the next generation. Meiosis produces haploid cells which have half the number of chromosomes of the original parent cell and are genetically different from each other.

(a) Describe the similarities and differences between:

(i) the structures of RNA and DNA;

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(5)

(ii) the processes of replication and transcription.

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(6)

(b) Suggest why only about 1% of the genetic information is transcribed into functional RNA sequences in most mammalian cells.

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(2)
(Total 13 marks)

3. (a) Complete **Table 1** to show **three** differences between the structure of DNA and the structure of RNA.

Structure of DNA	Structure of RNA
1.	1.
2.	2.
3.	3.

Table 1

(3)

(b) **Table 2** shows the genetic code as triplets of bases found in mRNA.

Second base

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

Table 2

(i) What is the sequence of amino acids in the peptide coded for by the following length of mRNA?

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

.....

(1)

(ii) What is the sequence of bases in DNA which, when transcribed, gives the above length of mRNA?

.....

(1)

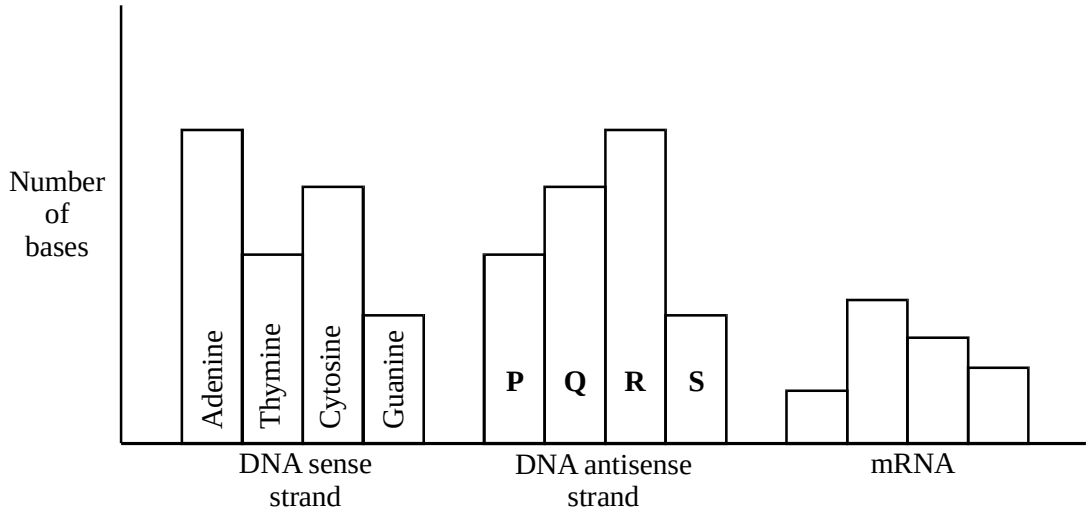
(iii) A mutation occurred in this DNA strand so that adenine in the DNA was replaced by guanine. Using **Table 2**, explain why this mutation had no harmful effect on the organism.

.....

(1)
(Total 6 marks)

4. DNA is made up of two polynucleotide strands, the sense strand and the antisense strand. Messenger RNA is transcribed from the DNA sense strand, which contains the genetic code.

(a) The graph shows the number of bases found in the sense strand and the antisense strand of a short piece of DNA, and the mRNA transcribed from it.



(i) Identify the base represented by each of the following letters.

P .....

Q .....

R .....

S .....

(2)

(ii) Explain why the total number of bases in the DNA sense strand and the total number of bases in the DNA antisense strand are the same.

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.....

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(1)

(iii) Explain why the total number of bases in the DNA sense strand and the total number of bases in the mRNA are different.

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(1)

(b) The mRNA has a sequence of 1824 bases. How many amino acids will join to form the polypeptide chain?

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(1)

(c) Although DNA is double-stranded, only the sense strand determines the specific amino acid sequence of a polypeptide. Suggest a role of the antisense strand.

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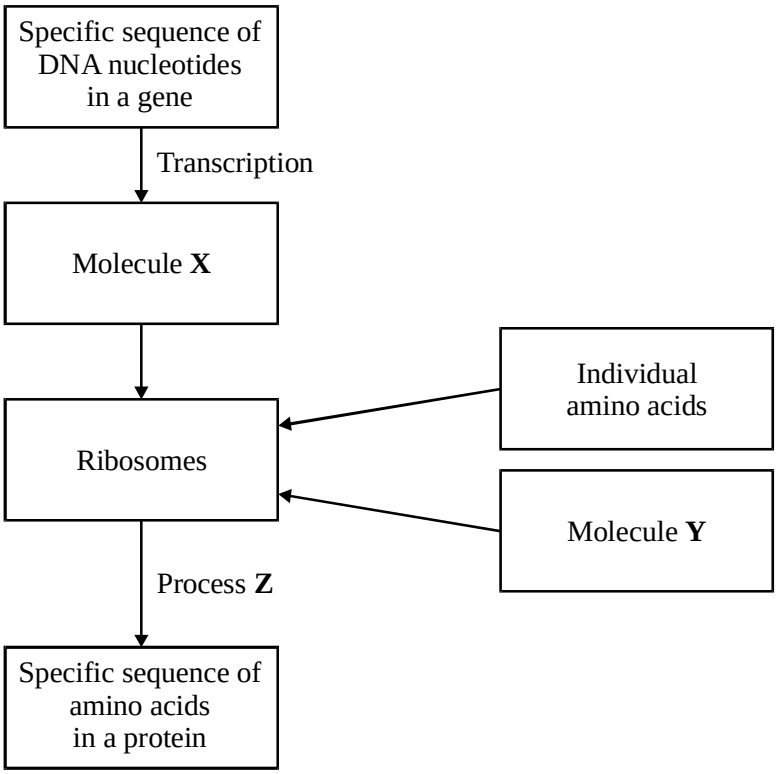
(1)
(Total 6 marks)

5. The flow chart shows some steps in the production of a protein. Specific sequence of



(a) (i) Name the organelle in which transcription occurs.

.....

(1)

(ii) Name Process **Z**.

.....

(1)

(b) (i) Name:

Molecule **X**; .....

Molecule **Y.** .....

(1)

(ii) Explain the role of Molecule **Y**.

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(2)

(c) How many amino acids will be present in the protein produced if Molecule **X** has 282 nucleotides?

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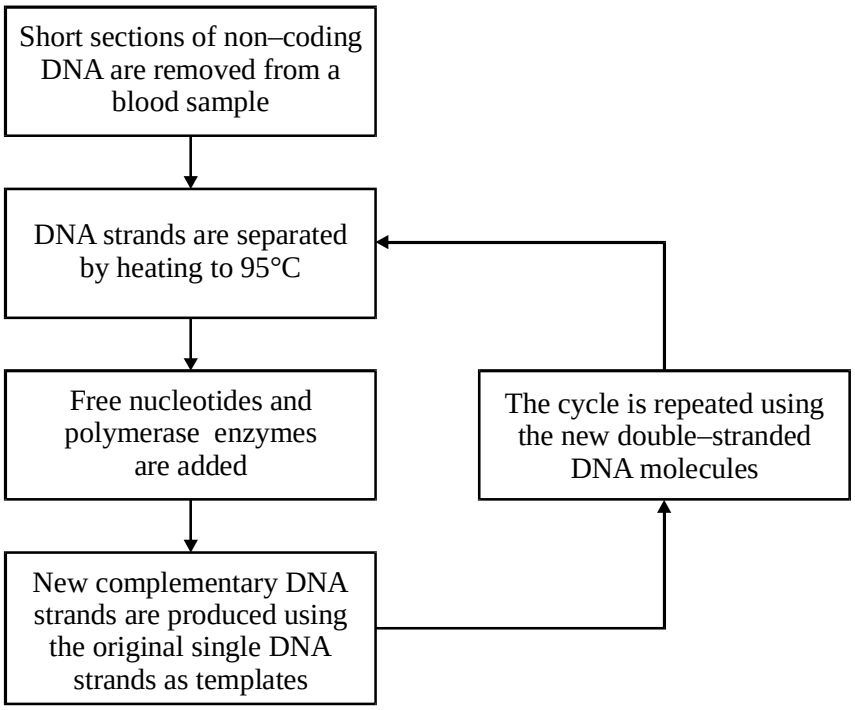
(1)

(Total 6 marks)

6. The flow chart shows some of the steps involved in a single cycle of the polymerase chain reaction (PCR) which is used to increase the amount of DNA for analysis in genetic fingerprinting.



(a) (i) Explain what is meant by *non-coding* DNA

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(1)

(ii) Explain how heating the DNA causes the strands to separate.

.....

(1)

(b) The total number of DNA molecules **(T)** produced is linked to the number of PCR cycles **(C)** and the original number of DNA molecules **(N)**.

Write a simple equation to show the relationship between **C**, **N** and **T**.

.....

(1)

(c) Complete the table with a tick if the statement is true or a cross if it is not.

Statement	**Polymerase chain reaction**	**DNA replication in living organisms**	**Transcription in living organisms**
DNA polymerase is required			
The two strands of the DNA are separated			
Ribosomes are required			

(3)
(Total 6 marks)

7. DNA controls protein synthesis in a eukaryotic cell.

(a) (i) The DNA code is degenerate. What is meant by a *degenerate code?*

.....

(1)

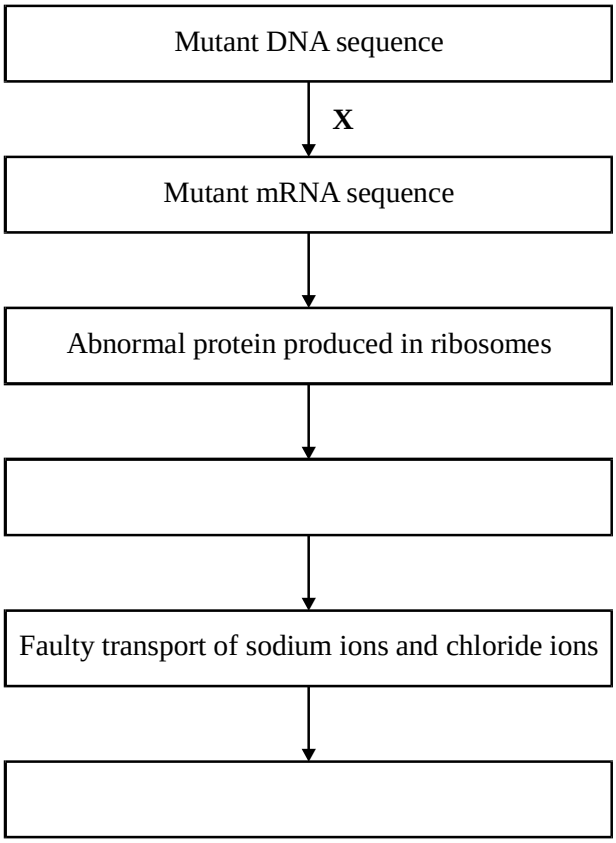
(ii) Complete the table to describe **two** differences between DNA and RNA.

DNA	**RNA**

(2)

(b) Cystic fibrosis is an inherited condition in which a mutant gene causes the synthesis of an abnormal protein. When incorporated into plasma membranes, this abnormal protein does not transport chloride ions as effectively as the normal protein. One consequence of this is the production of large amounts of viscous mucus

The main stages of this process are summarised in the flow chart .



(i) Complete the flow chart

(2)

(ii) Name the stage of protein synthesis represented by **X**.

.....

(1)

(Total 6 marks)

8. Read the following passage.

Scientists have recently determined the complete base-pair sequence of human DNA. They have found that only parts of the DNA molecule, called exons, are involved with the synthesis of proteins.

In order to find out what a particular part of the DNA molecule does, the DNA molecule must first be broken up into fragments. This is done by the use of restriction enzymes. These fragments can then be separated by electrophoresis. To help study the function of a particular DNA fragment, several copies of the fragment are required.

A plasmid from a bacterial cell can be used as a vector. The plasmid is removed from the bacterial cell to allow the insertion of the DNA fragment. The vector is replaced inside the bacterial host cell. Both the host cell and vector are then allowed to multiply under appropriate conditions. After multiplication, the vectors are removed from the host cell so that the copies of the DNA fragment can be extracted for further study.

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

(a) (i) What is an intron?

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(1)

(ii) Give **one** example of a base-pair found in DNA.

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(1)

(b) (i) Describe how a DNA fragment is inserted into a plasmid.

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(2)

(ii) A DNA fragment can be inserted into a plasmid because the plasmid also contains DNA. Suggest why the functioning of the plasmid DNA may be altered by the insertion of a DNA fragment.

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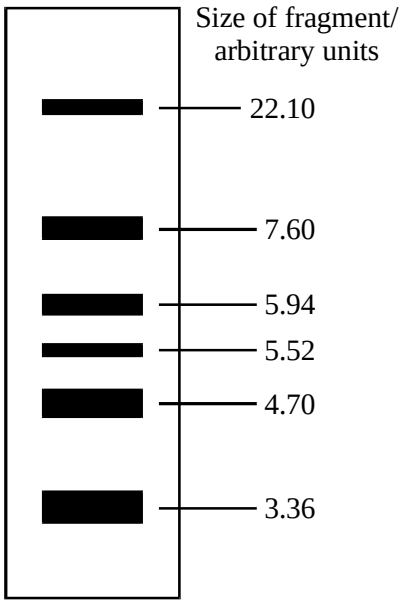
(1)

(c) The DNA molecule was split into fragments using the restriction enzyme *Eco*R1. Electrophoresis was used to separate these fragments of DNA. The diagram shows the result.



(i) Add an arrow to the diagram to show the direction in which the fragments moved during electrophoresis. Explain your answer.

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.....

(1)

(ii) How many times does the sequence of bases recognised by the enzyme *Eco*R1occur in this section of DNA?

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(1)

(iii) The fragments of the DNA molecule contain genes. How can a DNA probe be used to show which fragment contains a particular gene?

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(2)

(d) A gene codes for the production of a specific protein. DNA extracted from a vector can be introduced into a different host cell where it can be transcribed and translated into a protein. Describe the processes of transcription and translation.

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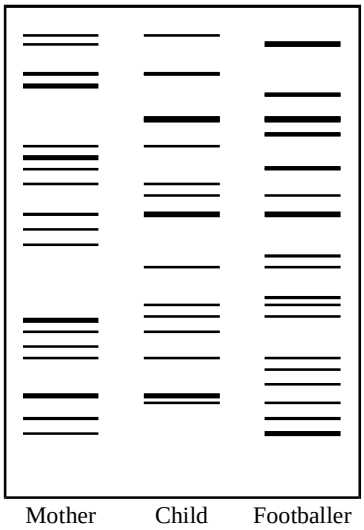
(6)
(Total 15 marks)

9. A woman accused a wealthy footballer of being the father of her child. He said that he was not. To settle the issue, genetic fingerprinting was carried out on DNA from the mother, the child and the footballer. The genetic fingerprints from this test are shown in the diagram.



(a) Do the results indicate that the footballer is the father of the child? Explain your answer.

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(1)

(b) Explain why all the DNA samples are cut using the same restriction enzyme.

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(1)

(c) A probe is used to locate the bands of DNA. Explain why the probe must be radioactive.

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(2)

(d) Some animals are known as endangered species because there is only a small number of individuals left in the wild. Zoos may try to increase the number of these animals by breeding them in captivity. For greater success, a breeding pair should be unrelated. Explain how genetic fingerprints can be useful in selecting animals for breeding.

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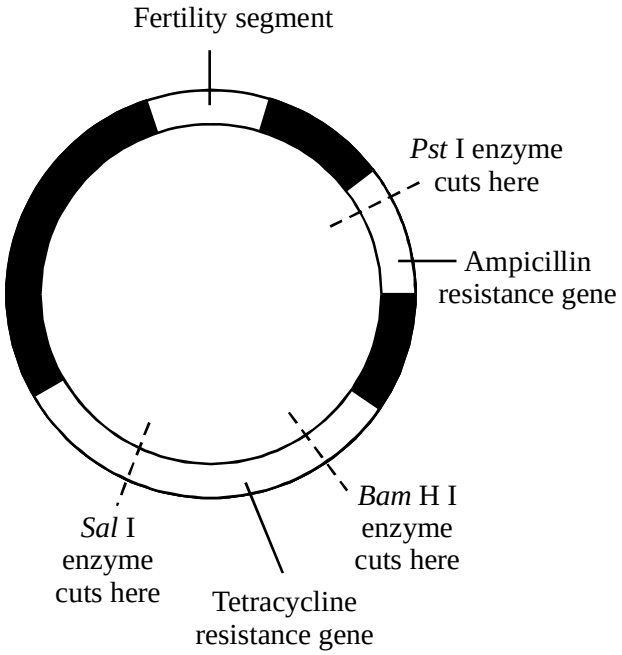
(1)
(Total 5 marks)

10. Read the following passage.

Recombinant DNA technology uses restriction enzymes to cut plasmid DNA at specific places. A gene from a different organism is located and then inserted in the plasmid. The plasmid is replaced in a bacterium which is then allowed to multiply. Plasmids may also contain marker genes. These make it possible to identify and isolate bacterial cells that
5. contain the plasmid with the relevant gene.

A plasmid from the bacterium *Escherichia coli* is often used as a vector in recombinant DNA technology. The diagram shows the structure of this plasmid. It also shows the sites where the plasmid can be cut by different restriction enzymes.



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

(a) Explain why the plasmid is described as a *vector* (line 6).

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(1)

(b) A DNA fragment, containing the gene for insulin, was inserted into this plasmid. To isolate bacteria that contained this recombinant plasmid, the bacteria were added to a culture medium containing the antibiotic ampicillin. Bacteria which contained the recombinant plasmid had lost resistance to ampicillin.

(i) Use the diagram to identify the restriction enzyme which had been used to insert the DNA fragment into the plasmid.

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(1)

(ii) Explain why resistance to ampicillin had been lost.

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(2)

(iii) Describe how a DNA probe could be used to confirm that the insulin gene was present in the DNA fragment.

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(3)

(c) Before a plasmid is used in recombinant DNA technology, the fertility segment is removed. This piece of DNA controls the process of conjugation in which different bacteria can link and pass DNA from one cell to the other. Explain why it is necessary to remove the fertility segment.

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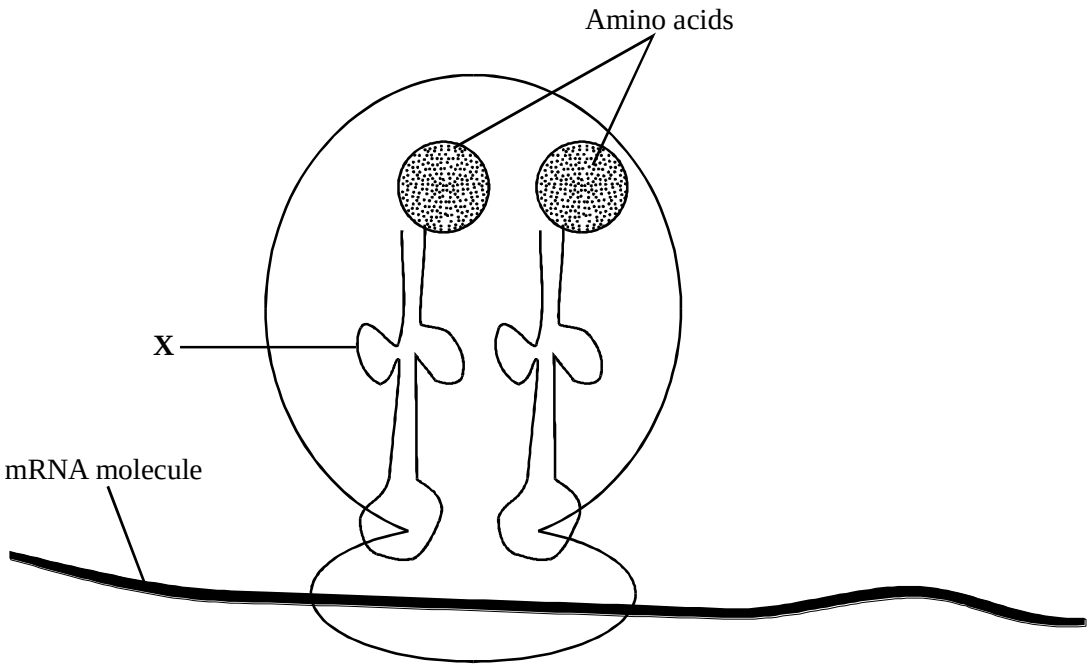
(2)

(Total 9 marks)

11. The diagram shows part of a molecule of mRNA bound to a ribosome.



(a) (i) Molecule **X** carries an amino acid molecule to the ribosome. Name molecule **X.**

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(1)

(ii) The mRNA codon below molecule **X** is AUC. Give the sequence of bases in molecule **X** which would bind to the MRNA at this site.

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(1)

(b) Explain the roles of mRNA and molecule **X** in producing a particular type of protein.

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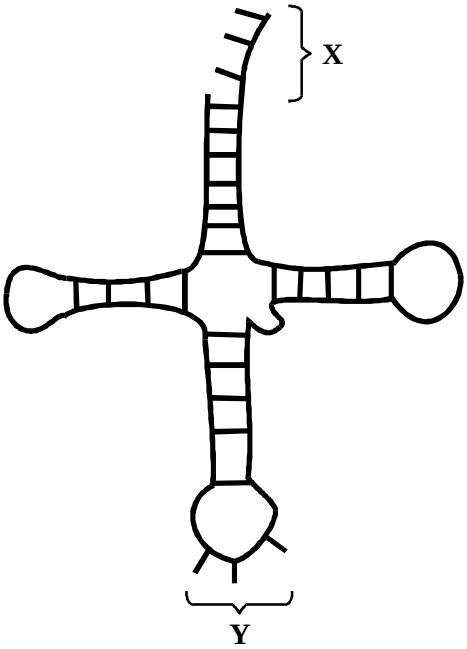
(3)
(Total 5 marks)

12. (a) Complete the table to give **three** structural differences between a DNA molecule and an RNA molecule.

DNA molecule	RNA molecule

(3)

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



Describe the function of

(i) part **X**;

.....

.....

(1)

(ii) part **Y**.

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.....

(2)

(c) Explain why the genetic code is described as

(i) non-overlapping;

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(1)

(ii) degenerate.

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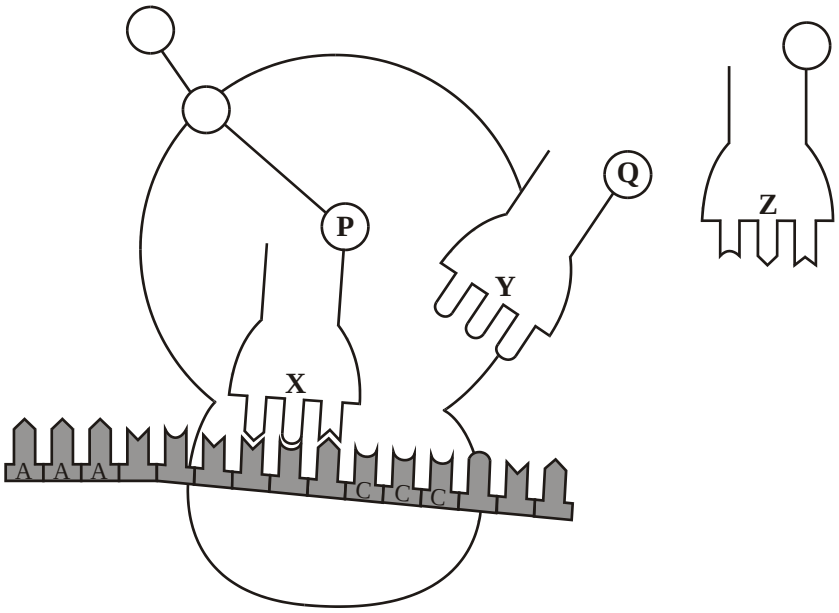
(1)
(Total 8 marks)

13. The diagram shows a stage in protein synthesis.



(a) (i) Name this stage.

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(1)

(ii) What type of molecule is **Q**?

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(1)

(b) Give the base sequence on the anticodon of molecule **Z**.

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(2)

(c) Describe what will happen next to

(i) molecule **Y**;

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(ii) molecule **Q**.

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(3)

(Total 7 marks)

14. (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.

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(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)

15. 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)

16. *Write an essay on the following topic. You should select and use information from different parts of the specification. Credit will be given not only for the biological content, but also for the selection and use of relevant information, and for the organisation and presentation of the essay.*

Condensation and hydrolysis and their importance in biology.

(Total 25 marks)

17. (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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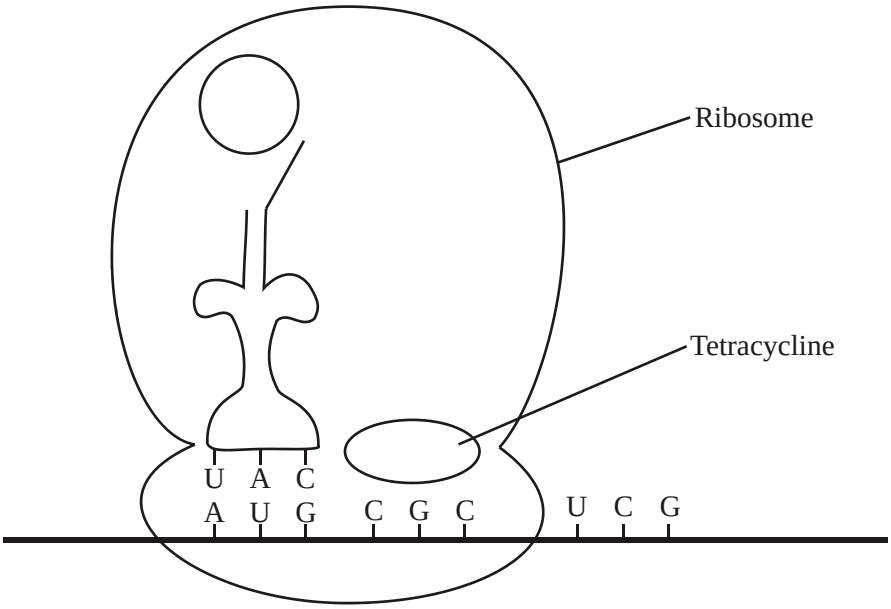
(1)

(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)

18. *Write an essay on the following topic. You should select and use information from different parts of the specification. Credit will be given for the biological content. It will also be given for the selection and use of relevant information, and for the organisation and presentation of the essay.*

Inorganic ions include those of sodium, phosphorus and hydrogen.
Describe how these and other inorganic ions are used in living organisms.

(Total 25 marks)

19. 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)

20. Read the following passage.

The idea that bacteria could be used as a cancer treatment originated over 100 years ago. A doctor noticed that some cancer patients with bacterial infections showed signs of recovery from the cancer. Attempts to use the bacteria as a treatment were disappointing, however. Experiments showed that the bacteria made an impressive onslaught on tumours, but a ring of cancerous tissue around the edge usually survived.

Bacteria are once again being used in the war on cancer. Scientists have genetically engineered a harmless strain of *Clostridium* to carry the gene for an enzyme. This enzyme converts a harmless "prodrug" into an active drug which acts as a powerful toxin. In people, this strain of *Clostridium* will only grow in tumours. Scientists hope that when they inject the prodrug into a cancer patient's blood, the bacteria will convert it into an active drug. This will destroy tumours from the inside, leaving healthy tissues unharmed.

The idea of converting a harmless prodrug into an active drug that only kills cancer cells is not new. Apart from the use of genetically modified *Clostridium*, other methods have been tried. One of these involved attaching an enzyme to an antibody that binds only to cancer cells. This enzyme then activates the drug. Unfortunately, different types of cancer require different antibodies, making the treatment expensive to develop. Scientists hope their bacterial approach will offer a way of delivering the enzymes to any cancer cell.

(a) Describe how scientists could genetically engineer *Clostridium* bacteria to produce the enzyme which activates the prodrug. (lines 7-8)

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(6)

(b) Explain why it is important to destroy all the cancer cells in a tumour.

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(2)

(c) Explain how the use of antibodies (lines 16-17) results in a drug only killing cancer cells.

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(3)

(d) Cancer drugs usually interfere with DNA replication. Use this information to explain why the cancer drugs are administered as prodrugs and not the active form.

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(4)
(Total 15 marks)

21. Describe the processes by which the sequence of subunits in DNA determines the mRNA and protein products in a cell.

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(Total 8 marks)

22. (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)

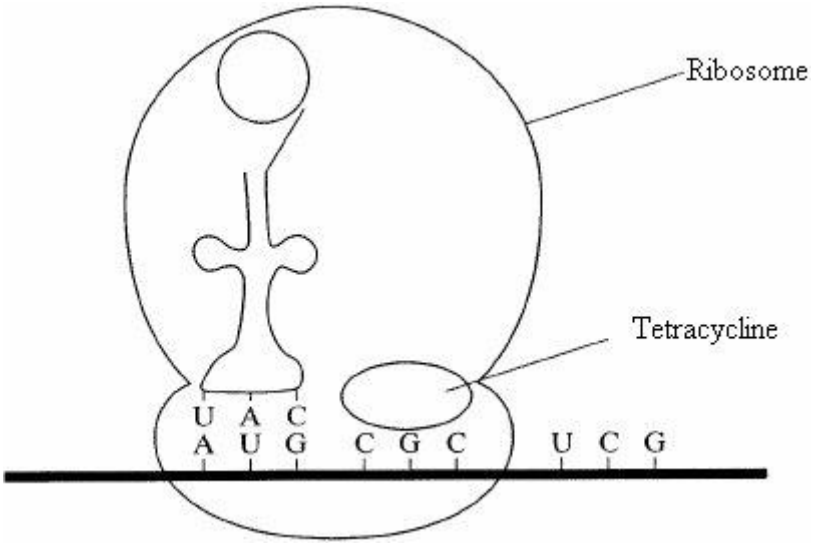
(b) A particular gene is 652 base pairs long. The mRNA produced from this gene is only 441 nucleotides long. Explain this difference.

.....

.....

(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)

23. (a) What is a gene probe?

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(3)

(b) Give **two** ways in which the information obtained from the use of gene probes might be helpful to a doctor who is counselling someone with a family history of cancer.

1 .....

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2 .....

.....

(2)
(Total 5 marks)