Questions

Q1.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Blood type is an example of inherited variation.

Blood types A, B, AB and O are determined by a single gene.

Blood types are due to the presence or absence of antigens on the cell surface membranes of red blood cells.

These antigens are glycoproteins.

The production of the blood type antigens involves molecules of mRNA and tRNA.

(i) Which row in the table describes the structure of tRNA?

(1)

		Bases	Number of strands	Type of sugar
☒	**A**	A, C, G, U	1	deoxyribose
☒	**B**	A, C, G, U	1	ribose
☒	**C**	A, C, G, T	2	deoxyribose
☒	**D**	A, C, G, T	2	ribose

(ii) Mononucleotides all contain a base and a sugar as part of their structure.

Name the other component of all mononucleotides.

(1)

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(iii) The mononucleotides of mRNA are joined together by RNA polymerase.

Which part of the eukaryotic cell is the location for this process?

(1)

☒ **A** cytoplasm
☒ **B** mitochondrion
☒ **C** nucleus
☒ **D** rough endoplasmic reticulum

(iv) Describe the role of the tRNA in the production of the protein part of a glycoprotein.

(2)

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(Total for question = 5 marks)

Q2.

Nandrolone is an anabolic steroid, it is a molecule with a similar shape to testosterone. Nandrolone has been used as a performance-enhancing substance by athletes in the past.

A number of investigations with mice have been carried out to study the effect of nandrolone on the structure and function of the aorta.

In these investigations, all the mice were of one type and were all supplied with the same amount of food and water. These mice were placed into four groups.

Each group was treated differently for eight weeks. The treatments are shown in the table.

Group	Treatment	
	Allowed to exercise	Given nandrolone
P	No	No
Q	No	Yes
R	Yes	No
S	Yes	Yes

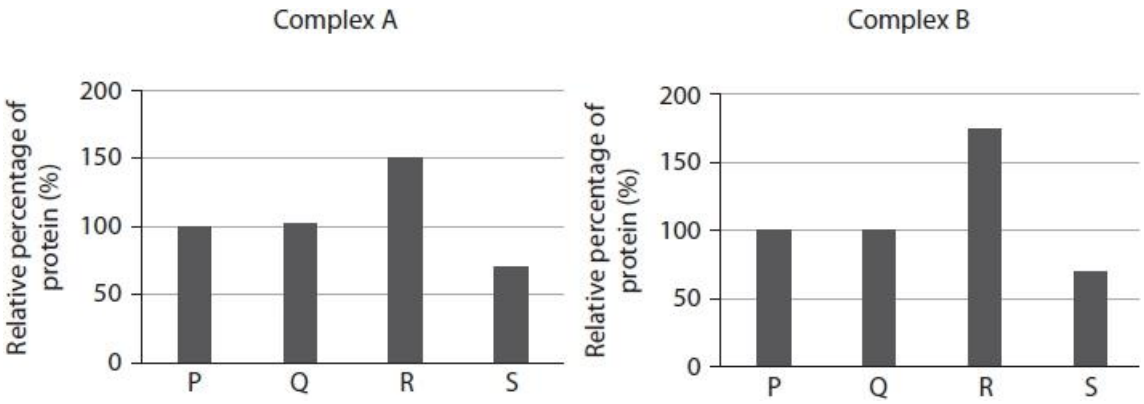
After eight weeks, the aorta of each mouse was studied.

In investigation 1, samples of aorta were put under tension to test elastic recoil.

The tension was removed and the mean maximum percentage recoil for each group was found.
The results are shown in the table.

Group	Mean maximum percentage recoil (%)
P	57
Q	38
R	80
S	53

In investigation 2, some of the cells from the middle layer of the aortas of the mice were removed.
Two protein complexes, A and B, are found in the cells of the middle layer.
These protein complexes are involved in the electron transport chain.
The graphs show the relative percentage of these two protein complexes in each group of mice.



The transcription factor Tfam is involved in the production of mitochondria.

In investigation 3, some of the cells from the middle layer of the aortas of the mice were removed. The quantity of mRNA per cell coding for Tfam was measured. The results are shown in the table.

Group	Quantity of mRNA per cell coding for Tfam / a.u.
P	100 ± 20
Q	75 ± 10
R	170 ± 25
S	85 ± 15

Analyse the data from these three investigations to discuss the advantages of an exercise programme without nandrolone.

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(Total for question = 6 marks)

Q3.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

Individuals infected with M. tuberculosis can be treated with antibiotics.

Four of the antibiotics used to treat TB are shown in the table.

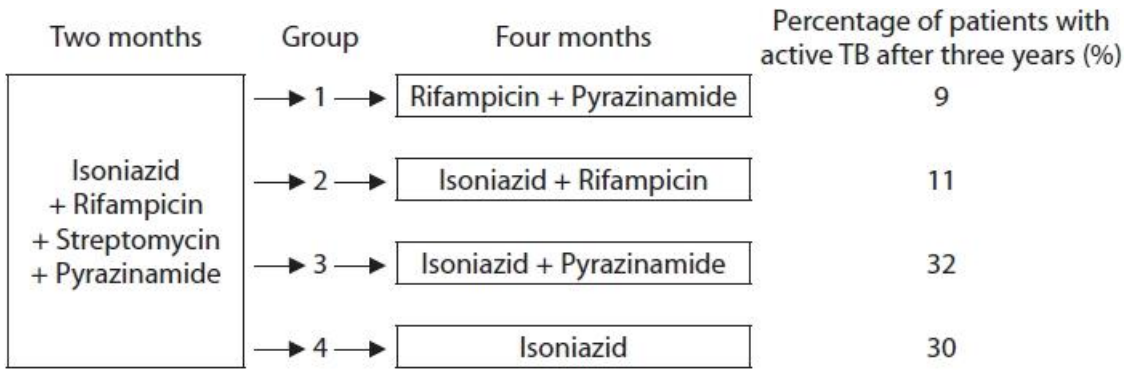
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other three antibiotics

In one clinical trial lasting six months, the effect of treating TB with these antibiotics was investigated.

All patients were treated with all four antibiotics for two months. Then they were treated with different pairs of antibiotics or isoniazid alone for a further four months.

All patients were free of any signs of active TB at the end of the clinical trial.

The design of the trial and the percentage of these patients with TB three years after the trial ended are shown in the diagram.



Analyse the data to comment on the effectiveness of these antibiotics for the treatment of TB.

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(Total for question = 6 marks)

Q4.

The synthesis of mRNA occurs in a process called transcription.

Compare and contrast the process of transcription with the process of DNA replication.

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(Total for question = 4 marks)

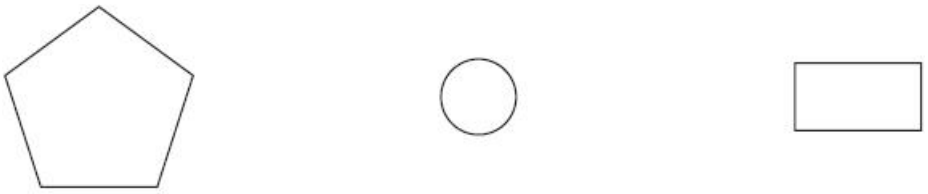
Q5.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Genetic information is encoded in DNA. DNA is made from monomers called nucleotides.

A DNA nucleotide is composed of three molecules joined together in condensation reactions.

(i) These shapes represent the components of DNA.



Draw a DNA nucleotide using these shapes.

(2)

(ii) Which row shows three components that can be found in a DNA molecule?

(1)

☒ **A**	glycosidic bond	thymine	deoxyribose
☒ **B**	glycosidic bond	uracil	ribose
☒ **C**	phosphodiester bond	thymine	deoxyribose
☒ **D**	phosphodiester bond	uracil	ribose

(iii) In a molecule of DNA, 17% of the bases were guanine.

What percentage of the bases in the molecule were thymine?

(1)

☒ **A** 17%
☒ **B** 33%
☒ **C** 66%
☒ **D** 83%

(Total for question = 4 marks)

Q6.

Sickle cell anaemia is a genetic disorder caused by a mutated allele for haemoglobin.

This causes one amino acid to be changed in one type of polypeptide chain in the haemoglobin protein. This affects the function of the red blood cells.

(i) An allele is a version of a gene.

State what is meant by the term gene.

(1)

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Two parents who are both heterozygous for the mutated allele are expecting a child.

Use a genetic diagram to determine the probability of this child being homozygous for the mutated allele.

(2)

Answer .....

(iii) Explain how a change of one amino acid could lead to a change in the structure and properties of the haemoglobin protein.

(4)

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(Total for question = 7 marks)

Q7.

Leptin is a protein hormone with a role in the control of appetite in humans.

The leptin gene is located on chromosome 17.

(i) State what is meant by the term gene.

(2)

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(ii) Describe the role of tRNA in the production of leptin.

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(iii) Describe how the primary structure of leptin enables it to be soluble in water.

(3)

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(Total for question = 8 marks)

Q8.

Leptin is a protein hormone with a role in the control of appetite in humans.

Several mutations of the leptin gene have been identified. All these mutations are frameshift mutations that result in shortened primary structures.

A frameshift mutation involves the insertion or removal of one or two nucleotides from a gene.

Describe how a frameshift mutation could result in the production of leptin with a variety of shorter primary structures.

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(Total for question = 2 marks)

Q9.

One function of DNA is to act as a template for the synthesis of messenger RNA (mRNA) during transcription.

(i) Describe how mRNA is synthesised at a template strand of DNA.

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(ii) Describe the differences between the structure of DNA and the structure of RNA.

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(Total for question = 5 marks)

Q10.

Give three differences between replication of DNA and transcription of DNA.

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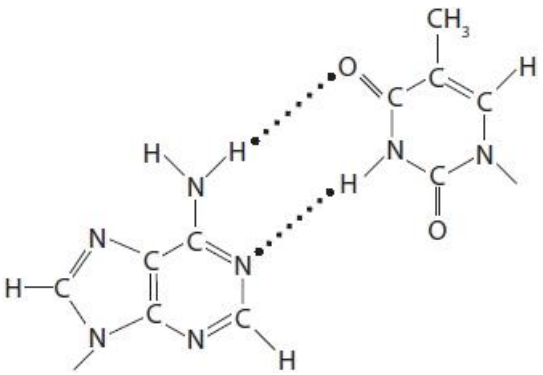
(Total for question = 3 marks)

Q11.

Answer the question with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The diagram shows part of a DNA molecule.



(i) Which part of the DNA molecule is shown?

(1)

- ☐ **A** deoxyribose molecule
- ☐ **B** one mononucleotide
- ☐ **C** two complementary organic bases
- ☐ **D** two mononucleotides

(ii) Which type of bond holds the strands of DNA together?

(1)

- ☐ **A** disulfide
- ☐ **B** glycosidic
- ☐ **C** hydrogen
- ☐ **D** peptide

(iii) Analysis of a sample of DNA found that 35% of the nucleotides contained thymine.

Determine the percentage of guanine in the same sample of DNA.

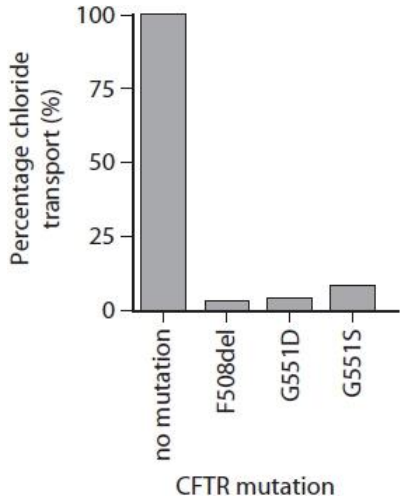
(1)

Answer ..... %

(Total for question = 3 marks)

Q12.
Mutations in genetic material such as DNA often result in the formation of new alleles.

The graph gives information about chloride transport in the human respiratory system with the normal allele for the CFTR protein and with the three mutated CFTR alleles.



The table gives information about the CFTR protein produced by cystic fibrosis (CF) sufferers with mutated alleles.

Mutation	Estimated percentage of CF sufferers who have one or more alleles with this mutation	Problem with CFTR protein channel
F508del	90	Reduced quantity / no CFTR protein
G551D	4	Reduced function
G551S	<1	Reduced function

Assess the effect that these mutations have on the human respiratory system.

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(Total for question = 6 marks)

Q13.

Mutations to DNA can affect the structure of proteins produced in the cell.

Removing one base from a DNA sequence will affect the primary structure of a protein.

Changing one base for another may not affect the primary structure of a protein.

Explain why these two types of mutation have different effects on protein structure.

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(Total for question = 4 marks)

Q14.

A human gene is 27 000 base pairs long. In this section of double-stranded DNA there are 4050 nucleotides containing the base cytosine.

(i) State what is meant by the term gene.

(1)

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(ii) How many nucleotides in this gene contain the base adenine?

(1)

- ☒ **A** 9000
- ☒ **B** 18 000
- ☒ **C** 22 950
- ☒ **D** 45 900

(Total for question = 2 marks)

Q15.

DNA is a polymer made from monomers called nucleotides.

Describe how nucleotides join together to form DNA.

(2)

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(Total for question = 2 marks)

Q16.

DNA is a polymer made from monomers called nucleotides.

Different theories for DNA replication have been suggested. Figure 1 illustrates two of these theories.

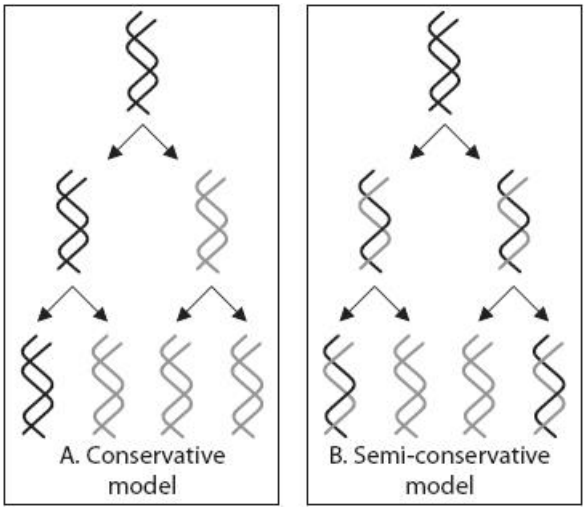

Figure 1

Meselson and Stahl carried out experiments to test these theories for DNA replication.

Figure 2 shows the results from one of their experiments.

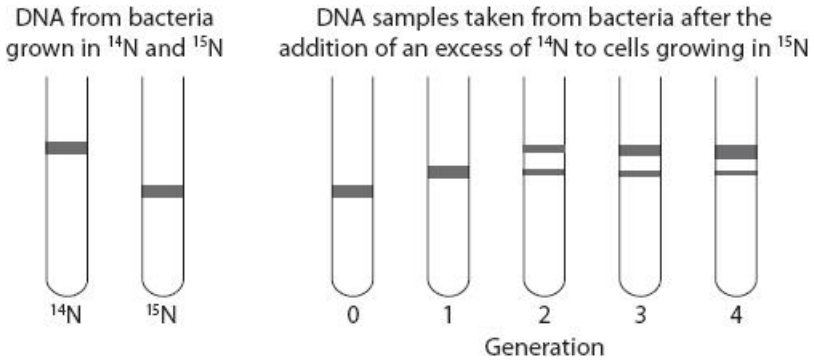

Figure 2

Analyse the data to explain why Meselson and Stahl accepted one of the models for DNA replication and rejected the other.

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(Total for question = 4 marks)

Q17.

Thalassaemia is a recessive genetic disorder that affects the production of haemoglobin. It is caused by a gene mutation.

Scientists are developing methods to repair gene mutations such as the one that causes thalassaemia.

One of the most common mutations causing thalassaemia is the substitution of one adenine base with guanine. The diagram shows the location of the mutation in part of the DNA strand coding for four amino acids.

Explain why this mutation affects the function of the haemoglobin molecule.

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(Total for question = 3 marks)

Q18.

Penicillin is an antibiotic. It was discovered in 1928. Since then many antibiotics have been identified and are widely used in the treatment of bacterial infections.

Scientists have recently discovered a new class of antibiotics that bind to ribosomes.

(i) Explain why these antibiotics could affect the production of proteins in bacteria.

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(ii) These new antibiotics attach to a site on the ribosome not affected by any known antibiotics.

Deduce why these new antibiotics might be used to treat bacteria that are resistant to other antibiotics.

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* (iii) Scientists have isolated these new antibiotics and tested their effectiveness against bacteria that are resistant to other types of antibiotic.

Devise a laboratory procedure to compare the effectiveness of penicillin with one of the new antibiotics.

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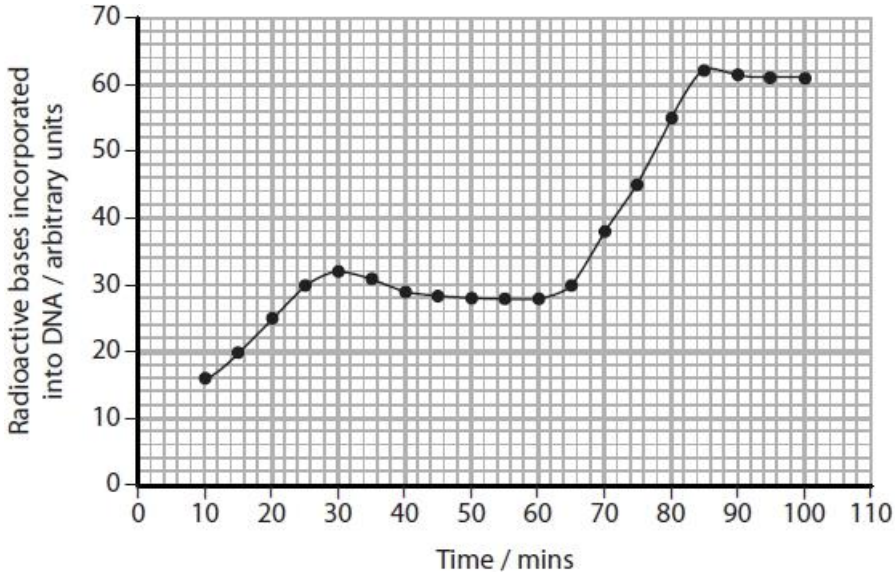
(Total for question = 11 marks)

Q19.

DNA synthesis in bacterial cell cultures has been investigated.

In an experiment, a mixture of radioactive bases was added to a culture of dividing bacteria.

The results are shown in the graph.



(i) Calculate the fastest rate of uptake of bases by these bacteria.

(2)

Answer .....

(ii) Deduce how many times the bacteria in the culture have divided during this experiment.

(2)

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(iii) Explain why the experiment would be improved if all the bases were provided but only the thymine was radioactive.

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(Total for question = 6 marks)

Q20.

All cells have a cell surface membrane.

Some epithelial cells in the lungs secrete mucus. If the mucus is too 'sticky', it cannot be easily removed from the lungs.

Other epithelial cells in the lungs contain CFTR proteins in their cell surface membranes.

(i) Describe the role of the CFTR protein in ensuring that the mucus produced in the lungs has the right consistency.

(3)

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(ii) The table shows part of the gene that codes for the CFTR protein and the corresponding amino acid sequence. Each amino acid is represented by a single letter.

Part of the CFTR gene	ATTAAAGAAAATATCATCTTTGGTGTTTCCTAT										
Amino acid sequence	I	K	E	N	I	I	F	G	V	S	Y

Explain how the information in the table demonstrates the nature of the genetic code.

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(Total for question = 6 marks)

Q21.

Describe the roles of transcription and translation in the synthesis of a globular protein by a muscle cell.

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(Total for question = 5 marks)

Q22.

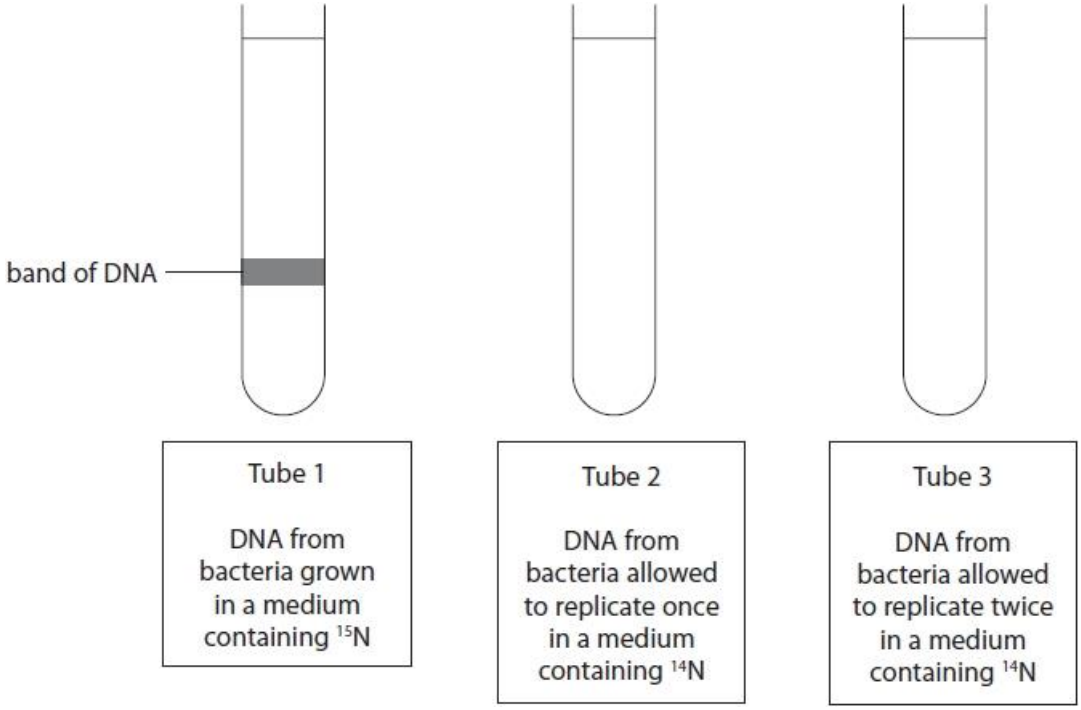
Meselson and Stahl carried out an experiment that demonstrated the semiconservative replication of DNA.

They grew bacteria in a medium containing heavy nitrogen (^{15}N) for a period of time. The density of the DNA extracted from these bacteria is shown by the position of the band in tube 1.

The bacteria were then transferred to a medium containing light nitrogen (^{14}N) and allowed to replicate.

Complete the diagram to show the positions of the DNA bands in tubes 2 and 3.

(2)

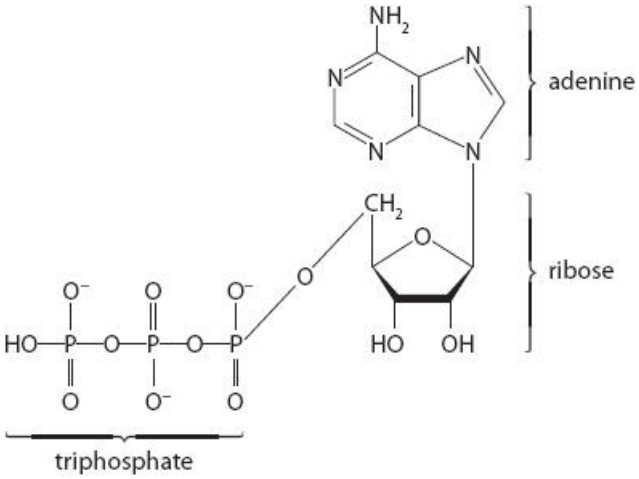


(Total for question = 2 marks)

Q23.

DNA is a polymer made from monomers called nucleotides.

The diagram shows the structure of ATP.



Compare and contrast the structure of ATP and a DNA nucleotide.

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(Total for question = 3 marks)

Q24.

DNA is a double-stranded molecule. During transcription, the antisense and sense strands are separated.

Part of the antisense strand, with base sequence TACGCTGAC, is transcribed.

(i) State where transcription occurs in an animal cell.

(1)

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(ii) Which row shows the correct sequence for the complementary sense strand and the mRNA produced in transcription?

(1)

		Sense strand	mRNA
☒	**A**	ATGCGACTG	ATGCGACTG
☒	**B**	TACGCTGAC	AUGCGACUG
☒	**C**	TACGCTGAC	ATGCGACTG
☒	**D**	ATGCGACTG	AUGCGACUG

(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	B –A,C,G,U / 1 / ribose *A is incorrect because mRNA does not contain deoxyribose* *C is incorrect because mRNA does not contain deoxyribose* *D is incorrect because mRNA does not contain 2 strands*		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	phosphate (group)		(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	C –nucleus *A is incorrect because RNA polymerase is found in the nucleus* *B is incorrect because RNA polymerase is found in the nucleus* *D is incorrect because RNA polymerase is found in the nucleus*		(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	A description that makes reference to two of the following: • each tRNA brings a specific amino acid (to the ribosome) (1) • the tRNA with the complementary anticodon binds to the mRNA codon (1) • tRNA bonds to ribosome (1)	ALLOW tRNA anticodons are complementary to mRNA codons	(2)

Q2.

Question Number	Answer
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content Investigation 1 • comparison of data for no exercise/exercise without nandrolone: maximum recoil of {aorta / artery} is {higher / 23% greater} • discuss outcome of this difference as an advantage: so (oxygen-rich) blood can flow more rapidly (at the correct pressure) {from the heart / to the muscles} • less likely to get atherosclerosis / CVD / strokes Investigation 2 • comparison of data for P and R for both protein complexes: more present due to exercise • discuss advantageous outcome: so more {oxidative phosphorylation / ATP synthesis / chemiosmosis} so more ATP for muscle contraction / breaking of the bond between actin and myosin (in aorta wall) Investigation 3 • compare P and Q for mRNA coding for Tfam: more Tfam per cell so more mitochondria produced so more {respiration / ATP formed }

Level	Marks	Descriptor	Additional Guidance
0	0	No awardable content	
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Results of one investigation described e.g. comparing P and R groups General comments about production of ATP or respiration
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Results of at least two investigations considered Discussion of results of one of these investigations in terms of consequences
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Results of all three investigations discussed Discussion of the consequences of the data from the investigations in terms of respiration / ATP synthesis Links the consequences to muscle contraction

Q3.

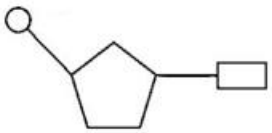
Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Basic information • All the treatment combinations were effective at treating TB • All treatments had some { relapses / individuals with TB } 3 years after treatment • { Group 1 / Groups 1 and 2 / Rifampicin + Pyrazinamide / Rifampicin + Isoniazid } had the lowest number of patients with TB (3 years later) Evidence for linkages made • Percentage relapse varies depending on second part of treatment • Combinations involving Rifampicin most effective • The antibiotics tested act on different targets in bacteria • Gaps in information - not all combinations tested, other combinations might be more effective • Other time scales may have been more effective Evidence for sustained scientific reasoning • Could be other reasons for infections with TB 3 years later not due to the antibiotic treatment • No information about dormant TB (only percentage of active cases) • Bacterial RNA polymerase possibly the best target for antibiotics • Antibiotics targeting synthesis of cell wall fatty acids least effective in terms of relapses • Idea of combination of antibiotics with different mode of activity most effective

Level	Mark	Descriptor	
Level 0	Marks	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and understanding to the given context.	Reference to effectiveness of different combinations of antibiotics.
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.	Reasons for differences in effectiveness considered.
Level 3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Information about action of antibiotics related to effectiveness. Evaluation of study design considered.

Q4.

Question Number	Answer	Additional Guidance	Mark
	An answer which includes reference to four of the following: Similarities • involve formation of {polynucleotide / phosphodiester bonds} (1) • involve DNA helicase (unzipping the DNA) (1) Differences • transcription uses RNA nucleotides whereas replication uses DNA nucleotides (1) • transcription uses RNA polymerase whereas replication uses DNA polymerase (1) • transcription {produces single strand of mRNA / only copies template strand of DNA} whereas replication {produces double stranded DNA / copies both strands of DNA} (1)	ALLOW condensation reaction occurs ALLOW transcription involves pairing of A with U whereas replication involves pairing of A with T	(4)

Q5.

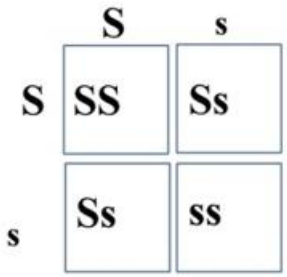
Question Number	Answer	Additional guidance	Mark
(i)	• phosphate group bonded correctly to pentose sugar (1) • base bonded correctly to pentose sugar (1)		(2)

Question Number	Answer	Mark
(ii)	The only correct answer is – C (phosphodiester bond, thymine, deoxyribose) A is incorrect because a DNA molecule does not contain a glycosidic bond B is incorrect because a DNA molecule does not contain glycosidic bond, uracil or ribose D is incorrect because a DNA molecule does not contain uracil or ribose	(1)

Question Number	Answer	Mark
(iii)	The only correct answer is – B 33% A is incorrect because there would be 17% cytosine C is incorrect because that is the answer for A and T together D is incorrect because that is A and C and T percentages added together	(1)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer which makes reference to the following: • sequence of {bases / nucleotides} in DNA coding for a {sequence of amino acids / polypeptide / protein}	ALLOW section of DNA coding for a {sequence of amino acids / polypeptide / protein}	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct genetic diagram with reference to parental and offspring genotypes (1)	ALLOW correct gametes and offspring genotypes e.g. S and s for gametes, offspring SS, Ss and ss (or other letters)  	
	• correct probability (1)	0.25 / 25% / ¼ IGNORE ratios	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: • different {sequence of amino acids / primary structure} (1) • (a different amino acid will have a) different R group (1) • (therefore) {secondary / tertiary / quaternary} structure will change (1) • (due to a) change in a named bond (holding molecule in its three-dimensional shape) (1) • (haemoglobin) may not bond to oxygen (1)	ALLOW different polypeptide chain i.e. hydrogen bonds, disulfide bridges, ionic bonds DO NOT ALLOW peptide bonds ALLOW may not bond to haem group ALLOW may not carry oxygen	(4)

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer the makes reference to the following: • sequence of {bases / nucleotides} in DNA • that codes for the {primary structure / amino acid sequence / polypeptide}	ALLOW that codes for a protein	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to the following: • tRNA molecules {transport amino acids to the ribosome} • tRNA molecule has an anticodon that {binds to / recognises} a codon on the mRNA • each tRNA carries a particular amino acid	ALLOW the amino acid on the tRNA is determined by the anticodon	**(3)**

Question Number	Answer	Additional Guidance	Mark
(iii)	A description that makes reference to three of the following: • {primary structure / sequence of the amino acids} determines the folding (of the polypeptide) • forming a globular structure • hydrophobic (R) groups located in the centre of the protein / hydrophilic (R) groups located on the outside of the protein • water forms hydrogen bonds with { protein / hydrophilic groups}	ALLOW position of R groups ALLOW determines tertiary structure ALLOW polar for hydrophilic / non-polar for hydrophobic ALLOW dipole-dipole / hydrophilic interactions (between water and the protein)	**(3)**

Q8.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to two of the following: • (adding or removing one or two nucleotides) changes the triplet code • introducing a new {start / stop} codon • coding for a shorter sequence of amino acids (1)	ALLOW different codons produced (1) ALLOW one amino acid shorter	**(2)**

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	A description which makes reference to two of the following: • (RNA) nucleotides align with complementary bases (on DNA) (1) • RNA nucleotides joined together by {RNA polymerase / phosphodiester bonds} (1)	ALLOW correct description of base pairing (A-U / C-G)	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description which includes reference to the following: • DNA is double stranded whereas RNA is single stranded (1) • DNA contains deoxyribose whereas RNA contains ribose (1) • DNA contains {thymine / T} whereas RNA contains {uracil / U} (1)		**(3)**

Q10.

Question Number	Answer	Additional guidance	Mark
	An answer which makes reference to three of the following: • replication involves DNA nucleotides whereas transcription involves RNA nucleotides (1) • replication produces double stranded DNA molecules whereas transcription produces a single stranded RNA molecule (1) • replication uses DNA polymerase whereas transcription requires RNA polymerase (1) • replication produces identical copies whereas transcription produces a complementary copy (1)	ALLOW mRNA nucleotides ALLOW replication copies the all the DNA whereas transcription copies {part of the DNA / one gene}	(3)

Q11.

Question Number	Answer	Mark
(i)	**The only correct answer is C two complementary organic bases** ***A*** *is incorrect because there is not a deoxyribose molecule shown.* ***B*** *is incorrect because there is not a mononucleotide shown* ***D*** *is incorrect because there are not two mononucleotides shown*	**(1)**

Question Number	Answer	Mark
(ii)	**The only correct answer is C hydrogen** ***A*** *is incorrect because a disulphide bond is not found between DNA molecules* ***B*** *is incorrect because a glycosidic bond is not found between DNA molecules* ***D*** *is incorrect because a peptide bond is not found between DNA molecules*	**(1)**

Question Number	Answer	Mark
(iii)	• 15 (%)	**(1)**

Q12.

Question Number	Answer	Mark
	Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Basic information • cilia struggle to move mucus out of lungs • increased risk of lung infections • 100% chloride ion transport without mutation • all three mutations reduce chloride transport • F508del results in lower chloride transport than {the other mutations / G551D / G551S } • G551S mutation is less severe than G551D Evidence for linkages made • F508del mutation results in { no / fewer } CFTR protein channels being produced • G551D and G551S have higher chloride transport (than F508del) because { the correct number of protein channels are produced / CFTR protein present but function reduced } • {no/fewer} CFTR protein channels results in less transport of chloride ions • effects of thicker mucus on gas exchange in the respiratory system explained e.g. increased diffusion distance, reduced surface area, reduced concentration gradient Evidence for sustained scientific reasoning • with the G551D and G551S mutations the CFTR protein channels have an incorrect shape • incorrect shape of CFTR protein results in reduced function (of transporting chloride ions) • a different part of the protein structure is affected in G551S which interferes less in the transport of chloride ions • mutation may affect the tertiary structure of the CFTR protein e.g. the positioning of hydrophilic parts of the protein channel	**(6)**

			Additional guidance
Level 0	0	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Basic description of the effects of the mutations on CFTR protein production. E.g. comparisons between mutations and no mutations on CFTR production Effects of CFTR protein problems on mucus described
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Explanation of how the different types of mutation will have different effects on CFTR and chloride ion transport. Effects of CFTR protein problems on respiratory system described
Level 3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Explanation of effects of mutations related to shape of protein produced. Reasons for reduced function of CFTR protein related to G551S and G551D mutations.

Q13.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to four of the following: • deletion could affect every codon (on the mRNA) / substitution will only affect one codon (1) • deletion more likely to affect the position of { stop codon / start codon } (1) • deletion results in a different sequence of amino acids / substitution may not affect the sequence of amino acids (1) • substitution may code for the same amino acid (1) • (same amino acid) due to the degenerate nature of the genetic code (1)	Allow reference to 'frame shift'	**(4)**

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	sequence of { bases / nucleotides } in DNA coding for a {polypeptide / protein}		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	C – 22 950		(1)

Q15.

Question Number	Answer	Additional Guidance	Mark
	A description which includes two of the following: • condensation reaction (1) • phosphodiester bonds (1) • DNA polymerase (1)	Must be in context of forming a DNA strand ALLOW hydrogen bonding between bases (in context of double strand) ALLOW bonds forming between phosphate and deoxyribose	(2)

Q16.

Question Number	Answer	Additional Guidance	Mark
	An explanation which includes the following: • The conservative model was rejected / the semi-conservative model was accepted (1) • (due to) generation 1 has a single band which is halfway between ^{15}N and ^{14}N (1) • (because) the DNA has one strand containing ^{15}N and one strand containing ^{14}N (1) • (in semi-conservative model) further generations would have {a band which is halfway between ^{15}N and ^{14}N / no band at ^{15}N } (1)	ALLOW light band for ^{14}N and heavy band for ^{15}N ALLOW nitrogen – 14 / nitrogen – 15 ALLOW the evidence {supports semi-conservative model / does not support conservative model} ALLOW medium density ALLOW DNA contains half heavy nitrogen and half light ALLOW (in conservative model) further generations would have { no band halfway between ^{15}N and ^{14}N / a band at ^{15}N }	**(4)**

Q17.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following • (because) { one triplet is affected / a different triplet code is produced } (1) • (the mutation) could change one of the amino acids (1) • this would {change the bonds formed between the R groups / cause a change in the tertiary structure}(1) • the haemoglobin would no longer be able to bind to oxygen (1)	ALLOW produce a stop codon IGNORE reference to secondary or quaternary structure	**(3)**

Q18.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following • ribosome shape is altered (1) • mRNA is prevented from binding (to the ribosome) / causingchange in tRNA binding (1) • therefore translation cannot occur (1) • { protein / polypeptide } is not synthesised (1)	ALLOW translation is affected /reduced / altered ALLOW faulty protein produced	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to two of the following • bacteria have not been exposed to new antibiotics before /bacteria do not have mechanisms to make them resistant to the new antibiotics (1) • bacteria have developed resistance (to other antibiotics) by { evolving / natural selection } (1) • therefore there has been {no advantage to possessing amutation to bypass the new antibiotic / no mutation present to give resistance } (1)		**(2)**

Question Number	Answer	Mark
(iii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the genericmark scheme. The indicative content below is not prescriptive and candidates are not required to include all thematerial which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content • prepare agar plates with bacterial cultures / bacterial lawn / seeded with bacteria –use bacteria that are resistant to other antibiotics • prepare solutions of new antibiotic and penicillin • place onto paper discs / into wells in the agar / prepare mast rings • control time and temperature of incubation • same concentration and volume of both antibiotics • measure the area of inhibition • repeat for effective antibiotics • description of serial dilution of each antibiotic • range of dilutions on each plate-one antibiotic per plate • statistical test to determine which is the most effective • repeat with different strains of resistant bacteria	**(6)**

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation of how the investigation should be modifiedmay be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Preparation of agar plates Method of adding antibiotic Use of new antibiotic and penicillin Measure zone of inhibition
2	3-4	An explanation of how the investigation should be modified willbe given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientificreasoning with some structure.	Incubated for stated time 24-72 hours Incubated at stated temperature 25-37^{0}C Method of culturing bacteria on agar plates/preparing a lawn Repeats to calculate the mean Larger zone of inhibition-more effective antibiotic
3	5-6	An explanation of how the investigation should be modified isgiven which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line ofscientific reasoning which is clear, coherent and logically structured.	Strain of bacteria known to be resistant topenicillin/other antibiotics Same volume/concentration of bothantibiotics Several strains of resistant bacteria testedwith new antibiotic Preparation of serial dilutions for bothantibiotics Range of concentrations give minimum effective dose Named statistical test eg T-test

Q19.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct values taken from the graph (1) • correct answer with units (1)	Example of calculation 55 – 45 (= 10) = 2 au min^{-1} ALLOW an answer between 1.6 au and 2 au per minute or 0.0267 to 0.0333 au per second Correct answer with units, with no working gains full marks Correct answer with no units, gains one mark only	2

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • DNA contents doubles twice / two stages of DNA synthesis (1) • therefore two divisions (1)	ALLOW two increases in uptake of bases ALLOW twice	2

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to two of the following: • because thymine is found only in DNA (1) • other radioactive bases taken up by all nucleic acids (1) • only DNA would be measured (1)	ALLOW RNA does not contain thymine ALLOW other bases taken up by RNA ALLOW no need to separate DNA from RNA	2

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: • chloride ions leave cells (through the CFTR channel protein) (1) • sodium ions leave the cells (following the chloride ions) (1) • increasing the solute concentration in the mucus (1) • water moves out of the cells by osmosis (into the mucus) (1)	NOT active transport of chloride ions ALLOW chloride ions move into the mucus ALLOW NaCl, Na^+ or Cl^- instead of solute ALLOW description of osmosis	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • (triplet code) is shown by three bases coding for an amino acid (1) • non-overlapping code e.g. ATT codes for amino acid I and then AAA code for amino acid K (1) • degenerate code as both ATT and ATC code for amino acid I (1)		3

Q21.

Question Number	Answer	Additional Guidance	Mark
	A description which makes reference to five of the following: • the { gene / sequence of DNA } for the (globular) protein is transcribed (1) • complementary base pairing between RNA nucleotides and DNA (to produce mRNA) (1) • mRNA leaves the nucleus and attaches to a ribosome (1) • pairing between codons on mRNA and anticodons on tRNA (1) • tRNA provides specific amino acids (1) • the sequence of { bases / codons } determines the {sequence of amino acids / primary structure of the protein } (1)	Do not allow reference to 'transcripted' Allow a description of complementary base pairing Allow reference to triplet code	(5)

Q22.

Question Number	Answer	Additional guidance	Mark
	• tube 2 with a band above the level of the band in tube 1 (1) • tube 3 with 2 bands, one the same height as in tube 2 and the other higher (1)		(2)

Q23.

Question Number	Answer	Additional Guidance	Mark
	An answer that that makes reference to the following: Similarity • both contain phosphate, pentose sugar and a base (1) and two of the following Differences • a DNA nucleotide contains deoxyribose whereas ATP contains ribose (1) • a DNA nucleotide could contain other bases whereas ATP contains only {adenine / one base type} (1) • a DNA nucleotide contains one phosphate whereas ATP {contains three phosphates / is a triphosphate} (1)	ACCEPT DNA could contain C, T or G whereas ATP only contains A	(3)

Q24.

Question Number	Answer	Additional Guidance	Mark
(i)	Nucleus	Allow phonetic spelling Do not allow Nuclease, nucleolus, nuclears	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	**D** ATGCGACTG / AUGCGACUG		(1)