Nucleic Acids and their Functions (CC5): Eduqas A Level Biology Exam Questions by Topic

21 questions · 46 marks · about 55 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · A level Component 1 · June 2018 · Q1(a) · 2 marks

1. ATP is regarded as a universal energy currency as it is used in all organisms for cellular processes.

(a) Draw a simple, fully labelled diagram of ATP. [2]

Question 2 · AS Component 1 · June 2024 · Q4(a)(ii) · 3 marks

(ii) Explain why ATP is a suitable 'energy currency' in all living organisms. [3]

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Question 3 · AS Component 1 · June 2018 · Q2(b)(i) · 1 mark

(b) Adenylate kinase (ADK) is a globular protein that acts as an enzyme involved in the regeneration of ATP in muscle. There are several types of this enzyme. One form catalyses the following reaction:

$$2ADP \longrightarrow AMP + ATP$$

(AMP = adenosine monophosphate)

(i) Suggest why the activity of ADK would be an advantage to muscle. [1]

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Question 4 · information from earlier in the question

6. DNP is an insecticide which inhibits ATP production in mitochondria. DNP acts as an agent that can transport protons across biological membranes. It greatly decreases the proton gradient across mitochondrial membranes. Instead of producing ATP, the energy of the proton gradient is lost as heat.

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Question 4 · A level Component 1 · June 2017 · Q6(b) · 2 marks

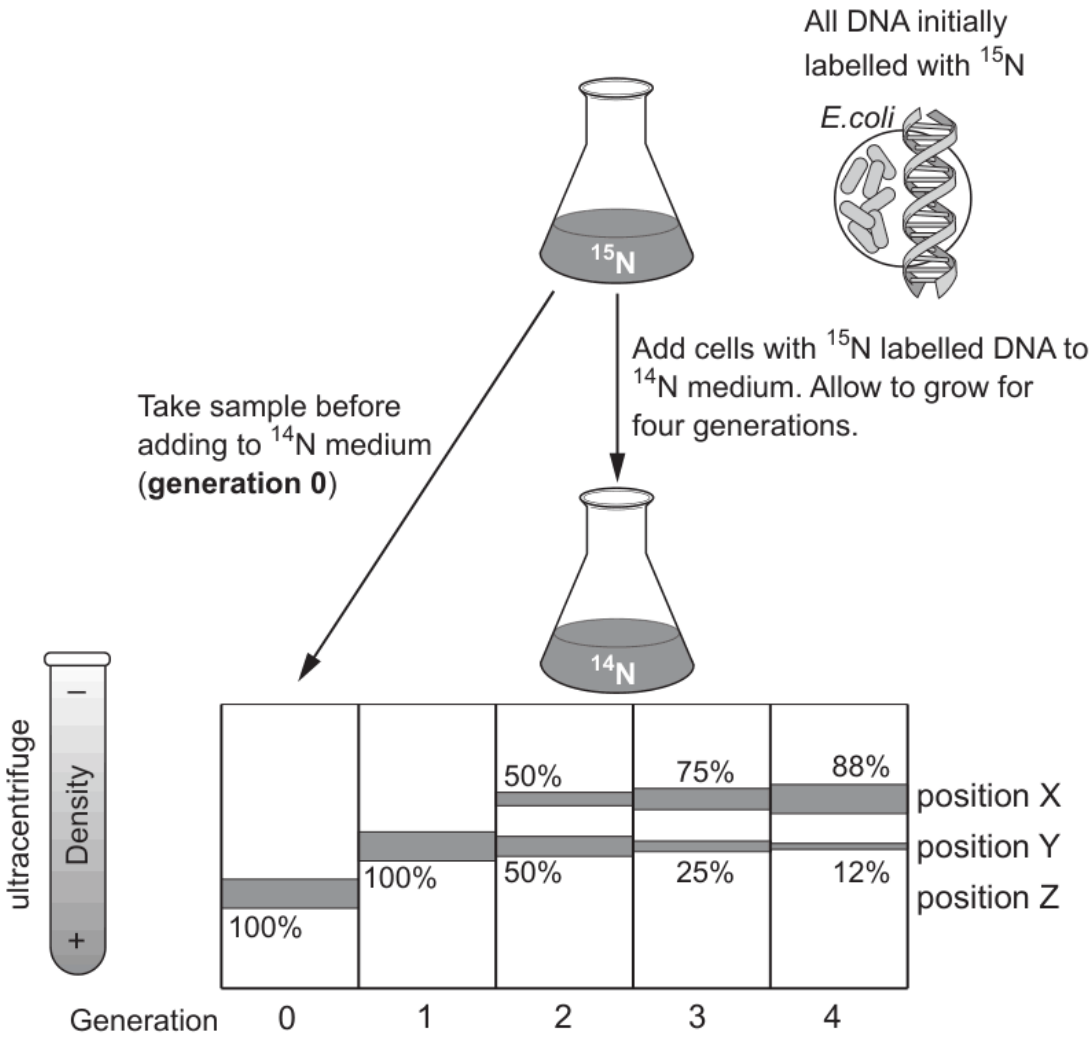
(b) Explain how DNP can act as an insecticide. [2]

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(b) DNA is a very stable molecule which is passed on from generation to generation. Watson and Crick proposed that DNA must be replicated semi-conservatively. Experiments by Meselson and Stahl supported their theory. **Image 4.2** shows the Meselson and Stahl experiment and results. A sample of DNA was taken from each generation of cells and analysed using density gradient centrifugation.

The figures in **Image 4.2** show the percentage of DNA at each position after centrifugation.

Image 4.2



(i) The ^{14}N would be incorporated into the newly synthesised DNA.

State into which part of a DNA nucleotide the ^{14}N would be incorporated. [1]

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Question 6 · A level Component 2 · June 2024 · Q2(d)(i) · 1 mark

(d) Double-stranded DNA can be taken from different species. The molecules are heated to make the DNA single-stranded.

(i) Explain how heating results in single-stranded DNA. [1]

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Question 7 · A level Component 2 · June 2025 · Q5(d)(i) · 1 mark

(d) *FUT1* is a gene that codes for an enzyme that catalyses the final step in the synthesis of carbohydrate **H**.

Image 5.4 shows the sequence of bases in a section of the mRNA strand used to synthesise this enzyme.

Image 5.4

$^{5'}$ CUG GAC UAC GGG $^{3'}$

(i) Give the DNA sequence which would be complementary to this section of mRNA. [1]

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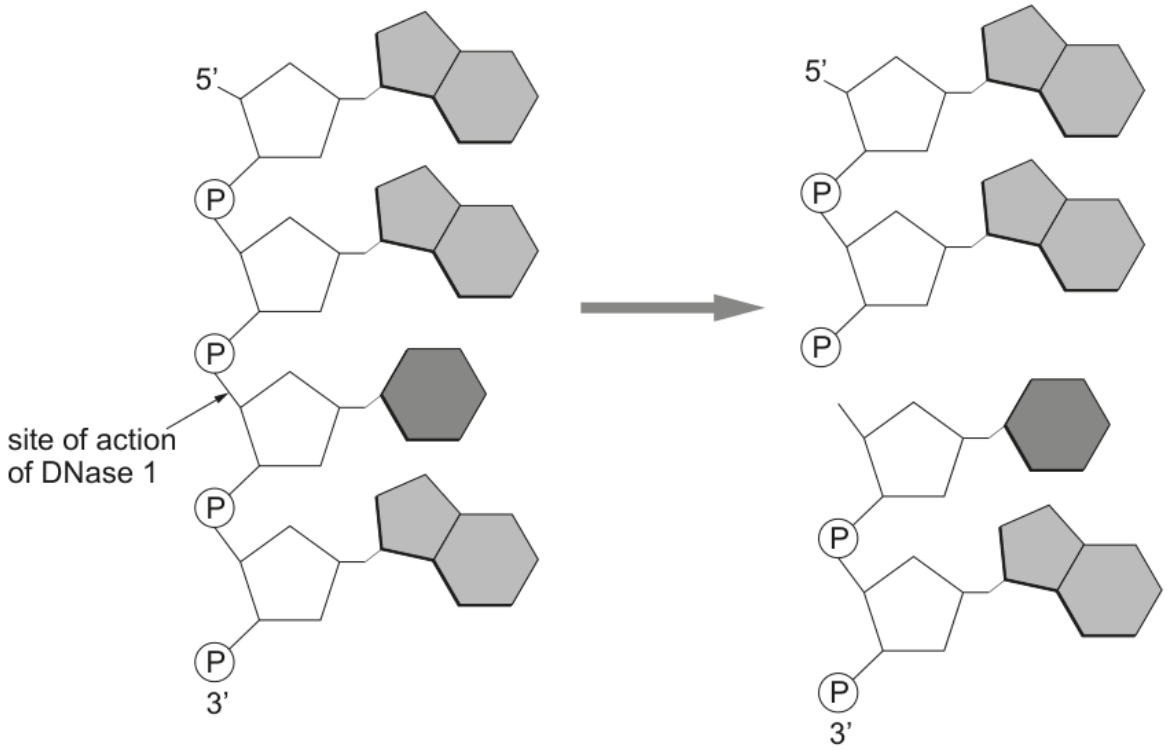
Question 8 · information from earlier in the question

5. In some lung conditions, the DNA from dead cells in the alveoli and bronchioles makes mucus less fluid and difficult to remove from the lungs.

Deoxyribonuclease 1 (DNase 1) is an *endonuclease* enzyme and works in a similar way to an endopeptidase. It digests DNA into fragments ranging from one to four base pairs in length.

It has been suggested that DNase 1 could be used to break down the DNA in mucus. This would make the mucus more fluid and easier for cilia to move from the lungs.

The enzyme causes *hydrolysis* of the bond between a phosphate group attached to carbon atom 5 of a deoxyribose which has a pyrimidine base attached to carbon atom 1. The digestion of a short length of DNA by DNase 1 is shown in the diagram below.



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Question 8 · AS Component 1 · June 2017 · Q5(a)(iii) · 3 marks

(iii) The diagram shows a short length of single stranded DNA that was mixed with a sample of the enzyme DNase 1.



Identify the fragments that would be produced by hydrolysis of this length of DNA by DNase 1 by drawing vertical lines between each fragment on the sequence above. Explain why you chose these positions. [3]

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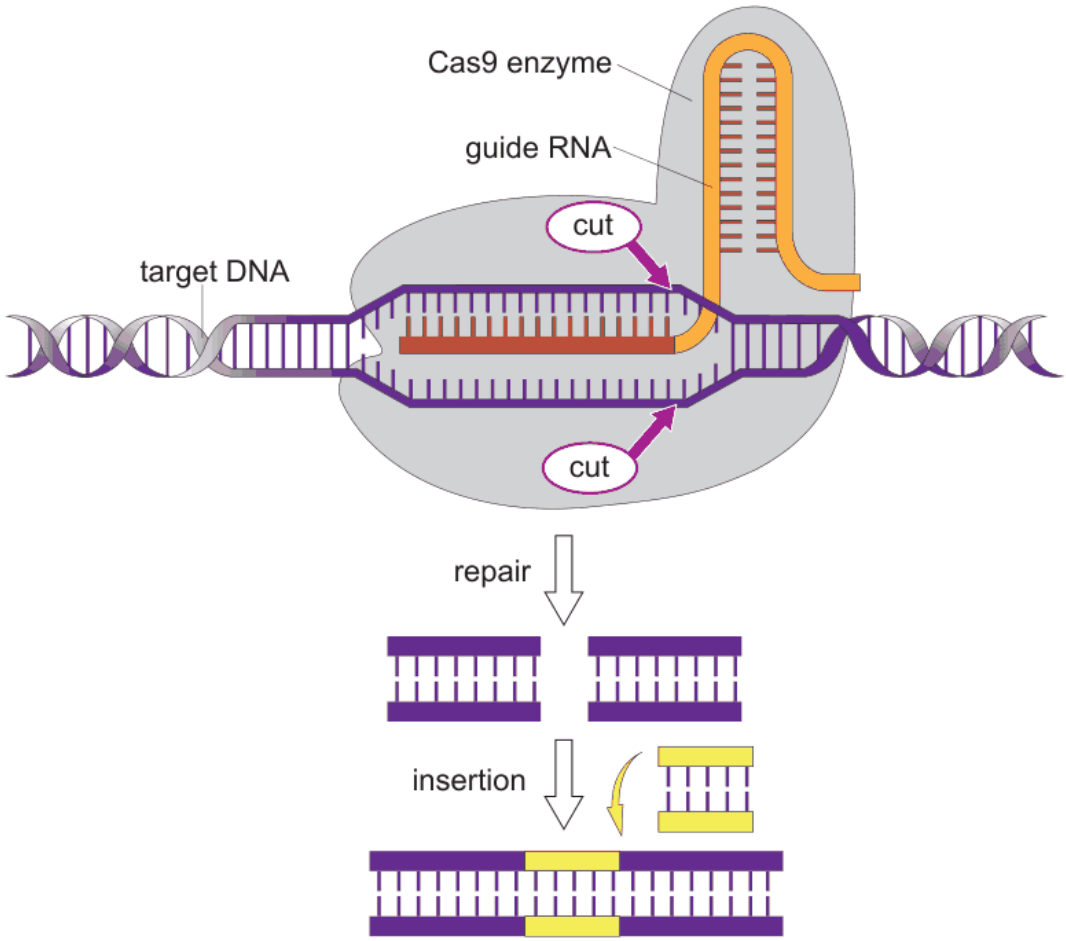
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5. Cas9 is a DNA endonuclease that is associated with a strand of guide RNA (gRNA). The enzyme unwinds DNA and breaks the hydrogen bonds between the DNA strands. The base sequence on part of the gRNA then aligns next to a specific target sequence on the DNA. The endonuclease then makes a double stranded cut at this target sequence. During the repair of the DNA molecule a double-stranded length of DNA can be inserted. This is shown in **Image 5**.

Image 5



(a) (i) State **two** differences between nucleotides of RNA and nucleotides of DNA. [2]

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Question 10 · information from earlier in the question

(b) A group of vets gathered data from 160 dogs with MCTs.

The MCTs were classified as one of three different grades, which have different effects on the survival of dogs. These are shown in **Table 6.2**.

Table 6.2

MCT grade	Effect of MCT
I	long term survival and most were cured with surgical removal
II	may survive a long time but the tumour could potentially start growing faster and spread throughout the body
III	median survival time of 6 months as they are faster-growing tumours

It has been proposed that MCTs could be classified according to the number of cells in different stages of mitosis. This is done by examining samples of tumour tissues under a light microscope.

(d) It has been suggested that the rate of mitosis in a tumour could be estimated by measuring the uptake of radioactive thymine. A sample of the tumour is added to a nutrient solution containing radioactive thymine. After three days the tumour is removed and the level of radioactivity of the tumour is measured.

Question 10 · A level Component 2 · June 2024 · Q6(d)(ii) · 2 marks

(ii) Explain why **radioactive thymine** would be used to measure the rate of mitosis and **not radioactive guanine**. [2]

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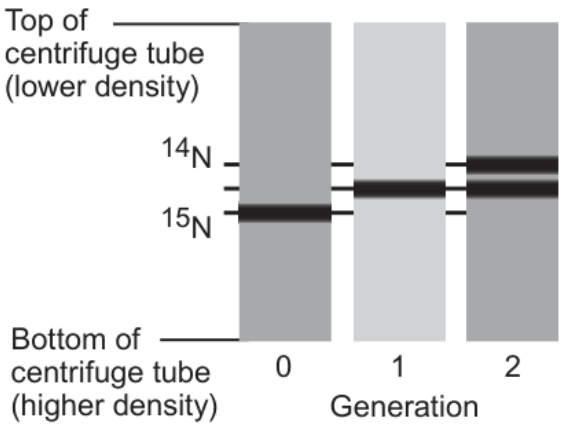
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(c) During the cell cycle, DNA has been shown to replicate semi-conservatively. Meselson and Stahl were the first scientists to prove this experimentally.

In their experiments they cultured bacteria with a nitrogen source containing only ^{15}N – a heavy isotope of nitrogen. The bacteria were then transferred to a culture medium containing ^{14}N – a light isotope of nitrogen. Samples of DNA were extracted from the initial ^{15}N culture (generation 0) and after one and two replications with ^{14}N (generations 1 and 2). The DNA from each sample was spun in an ultracentrifuge.

Image 2.2 shows the positions of the DNA in each sample.

Image 2.2



Explain how the evidence shown in **image 2.2** proved that DNA replicates semi-conservatively. [2]

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Question 12 · AS Component 1 · June 2022 · Q5(b)(ii) · 4 marks

(ii) Using your knowledge of DNA replication, describe the process by which the viral DNA is replicated. [4]

Question 13 · A level Component 1 · Autumn 2020 · Q2(a)(ii) · 2 marks

The genetic code for the long chain polypeptides is found in the chloroplast genome and the genetic code for the short chain polypeptides is found in the nucleus.

(ii) State **two** features of the genetic code. [2]

Question 14 · A level Component 3 · June 2022 · Q1(a) · 1 mark

1. Melittin is a protein found in a toxin produced by bees. It consists of a chain of twenty six amino acids.

(a) State the minimum number of nucleotides on the DNA strand coding for melittin. [1]

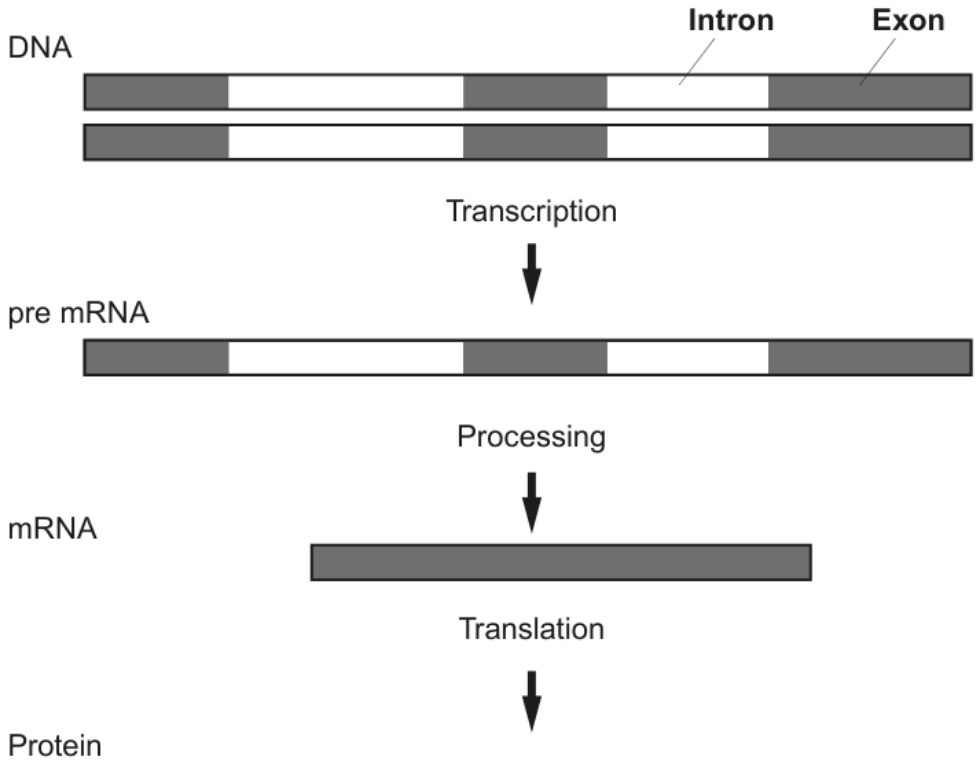
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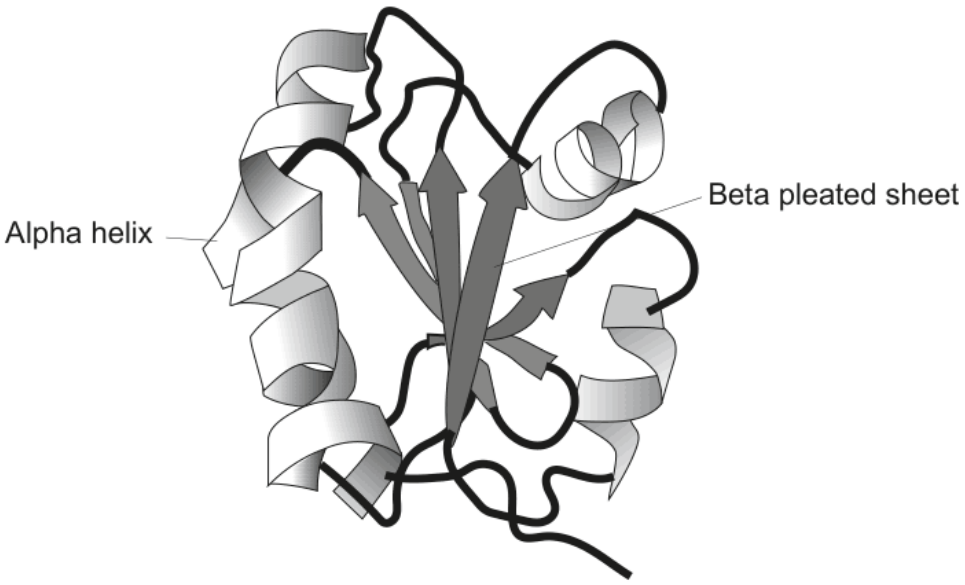
Question 15 · AS Component 1 · June 2018 · Q3(a)(iii) · 3 marks

(iii) Explain why there would be large numbers of different mRNA molecules in a rabbit cell but only a maximum of 64 different tRNA molecules. [3]

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6. In most eukaryotic genes, coding regions (exons) are interrupted by non-coding regions (introns). During transcription, the entire gene is copied into a pre-mRNA molecule, which includes exons and introns. During the process of RNA splicing, introns are removed and exons joined to form a continuous coding sequence. This "mature" mRNA is ready for translation.





(a) Explain the process of transcription including the roles of the enzymes involved. [3]

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Question 17 · AS Component 1 · June 2016 · Q6(b)(i) · 2 marks

(b) (i) Explain why it is important that the RNA which is finally translated, consists only of exons. [2]

Question 18 · AS Component 1 · June 2019 · Q4(d) · 3 marks

(d) Describe the process of transcription. [3]

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Question 19 · AS Component 1 · June 2023 · Q4(b)(ii) · 5 marks

(ii) Using your own knowledge of protein synthesis suggest how the host cell uses the mRNA to produce viral membrane protein **M**. [5]

Question 20 · A level Component 2 · Autumn 2020 · Q4(c)(ii) · 2 marks

(ii) Explain how post transcriptional modification of mRNA (splicing) in eukaryotic cells provides evidence against the 'one gene one polypeptide' hypothesis. [2]

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Question 21 · information from earlier in the question

Many organisms use haemoglobin to transport oxygen from the respiratory surface to the tissues.

(d) There are three different types of haemoglobin molecules that can be found in normal adult humans. Each consists of a combination of polypeptide chains, α, β, γ and δ, as shown in **Table 3.3**.

Table 3.3

	Haemoglobin type		
	HbA	HbF	HbA_2
Polypeptide type	2α 2β	2α 2γ	2α 2δ

Question 21 · A level Component 3 · June 2023 · Q3(d)(ii) · 1 mark

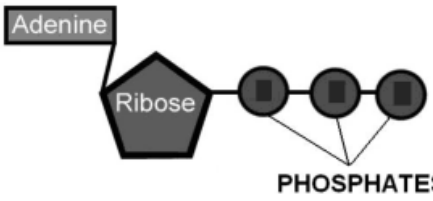
(ii) Use **Table 3.3** to suggest the minimum number of genes that are involved in the production of haemoglobin. [1]

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Mark schemes

Question 1 · A level Component 1 · June 2018 · Q1(a) · 2 marks

1	(a)	 Only one phosphate need be labelled. Pentagon shape with adenine and 3 phosphates coming off at correct points (1) Ignore shape of adenine Correct labels = ribose + adenine + phosphate (1) Accept adenosine if structures bracketed Reject pentose Reject base	2	2	

Question 2 · AS Component 1 · June 2024 · Q4(a)(ii) · 3 marks

	(ii)	Single reaction to release energy (1) Only one enzyme needed / ATPase (1) Small amounts of energy released / 30.6kJ (1)	3	3	

Question 3 · AS Component 1 · June 2018 · Q2(b)(i) · 1 mark

(b)	(i)	ATP can be regenerated quickly/More ATP for <u>muscle contraction</u> (1) Not: more energy produced	1	1	

Question 4 · A level Component 1 · June 2017 · Q6(b) · 2 marks

(b)	Cannot produce enough/lower yield of ATP/ no ATP produced (1) For {flight/muscle contraction/active transport / transmission of nerve impulses/ no protein synthesis/ cell division} (1) NOT overheating/ denaturation of proteins	2	2	

Question 5 · AS Component 1 · June 2024 · Q4(b)(i) · 1 mark

(b)	(i)		{Organic / Nitrogenous} bases / named base / base (1)	1	1	

Question 6 · A level Component 2 · June 2024 · Q2(d)(i) · 1 mark

(d)	(i)		Used to break the hydrogen (allow H) bonds.	1	1	

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Question 7 · A level Component 2 · June 2025 · Q5(d)(i) · 1 mark

(d)	(i)	GAC CTG ATG CCC	1	1

Question 8 · AS Component 1 · June 2017 · Q5(a)(iii) · 3 marks

(iii)	AGA¦TA¦TGGA¦CG¦TAA (1) bonds broken on 5' side of each nucleotide with a pyrimidine (1) C and T are pyrimidines (1) Accept on diagram	1 1 1	3	

Question 9 · A level Component 2 · June 2023 · Q5(a)(i) · 2 marks

5	(a)	(i)	Ribose v deoxyribose (1) Uracil v thymine (1)	2			2		

Question 10 · A level Component 2 · June 2024 · Q6(d)(ii) · 2 marks

(ii)	Thymine is {only present in DNA / not in RNA} (1) Guanine is present (in DNA and) RNA (1) Accept T and G for the bases		2	2	

Question 11 · A level Component 2 · Autumn 2020 · Q2(c) · 2 marks

	(c)			**Any 2 (x1) from:** Each strand acts as a template (1) So each time DNA is replicated the molecule contains one original and one new strand (1) Suitable example from generation 0 to 1 or 1 to 2 (1) e.g. generation 1 all DNA is intermediate in mass/ must contain one strand of ^{14}N DNA and 1 strand of ^{15}N DNA generation 2 half of the DNA is intermediate and half is light Accept arguments against conservative would always have 15N band at bottom (1) dispersive a single broad band at 1 and 2 but getting lighter in mass (1)	1	1		2		

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Question 12 · AS Component 1 · June 2022 · Q5(b)(ii) · 4 marks

	(ii)	**Any four (×1) from:** A. DNA helicase/ polymerase unzips the DNA (double helix)/ breaks bonds between (complementary) base pairs B. {DNA nucleotides} line up along template/ pair up with exposed bases by <u>complementary base pairing</u> C. Both strands act as templates D. DNA polymerase joins nucleotides/ catalyses formation of covalent bonds to form (sugar-phosphate backbone of) new strand E. DNA polymerase moves up leading and down lagging strand/ in 5' to 3' direction F. Semi-conservative replication/ new DNA molecule made of <u>one original and one new strand</u>	4	4

Question 13 · A level Component 1 · Autumn 2020 · Q2(a)(ii) · 2 marks

	(ii)	Any **two** (×1) from Linear (1) triplet (1) nonoverlapping (1) degenerate (1) unambiguous (1) universal code (1)	2	2

Question 14 · A level Component 3 · June 2022 · Q1(a) · 1 mark

1	(a)	3x26= 78, but may include start and or stop so allow 81 and 84	1	1

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Question 15 · AS Component 1 · June 2018 · Q3(a)(iii) · 3 marks

(iii)		different mRNA for every {protein/polypeptide}/many different genes/one gene one polypeptide/OWTTE (1) ref to base triplet code hypothesis (in mRNA/DNA) giving {64/4^3} triplets (1) tRNA molecules have anticodons which have three bases (which are complementary to codons)/tRNA are specific to one amino acid(1)	3	3

Question 16 · AS Component 1 · June 2016 · Q6(a) · 3 marks

6	(a)	• {RNA polymerase/ helicase} {unwinding/ unzips} DNA (1) • complementary RNA nucleotides base pair (or indicated with A-U, C-G) with DNA {nucleotides/ template} (1) • Correct role of RNA polymerase in joining nucleotides (1)	3	3

Question 17 · AS Component 1 · June 2016 · Q6(b)(i) · 2 marks

(b)	(i)		Introns do not code for the {amino acid (sequence) in / primary structure of} the protein/ only exons code for the amino acid (sequence) in the protein / OWTTE(1) if introns are included a different protein (structure) would be produced/ OWTTE (1)	2	2

Question 18 · AS Component 1 · June 2019 · Q4(d) · 3 marks

(d)	<u>DNA helicase</u>,{unzips DNA helix / breaks hydrogen bonds between complementary base pairs} (1) One strand of DNA acts as a template / exposing unpaired bases (1) <u>RNA polymerase,</u> adding complementary (RNA) nucleotides or named examples and forming bonds between them (1)	3	3

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Question 19 · AS Component 1 · June 2023 · Q4(b)(ii) · 5 marks

(ii)	**Any five (x1) from:** A. Translation (1) B. mRNA attaches to a ribosome (1) C. tRNA brings a (specific) amino acid (1) D. Complementary base pairing between mRNA codon and tRNA anticodon/ codon anticodon interaction (or description of) (1) E. Ribosome has room for two tRNA molecules/Brings two amino acids into close proximity/ or description of (1) F. Condensation reaction occurs/peptide bond formed (between amino acids) (1) G. Ribosome moves to the next codon (or description of)/ reference to stop codon (1) H. Post translation processing/ or description of e.g. folding of polypeptide chain/ role of Golgi (1)	5	5

Question 20 · A level Component 2 · Autumn 2020 · Q4(c)(ii) · 2 marks

		(ii)		mRNA can be modified/ spliced in different ways/ exons can also be removed during splicing (1) each mRNA would {have a different base sequence/ code for a different polypeptide} (1)		1 1		2			

Question 21 · A level Component 3 · June 2023 · Q3(d)(ii) · 1 mark

	(ii)	4 (one gene for each pp chain)		1		1	

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