Protein Synthesis (6.2): Cambridge (CIE) A Level Biology 9700 Exam Questions by Topic

22 questions · 51 marks · about 61 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 2 · October/November 2025 (22) · Q3(a) · 3 marks

3 The gene *LCT* codes for the enzyme lactase. In babies, lactase synthesis is necessary for digesting lactose, the sugar found in milk.

Another gene, *MCM6*, has introns that have a regulatory role in the expression of gene *LCT*. Gene *MCM6* codes for a protein that has **no** involvement in lactase synthesis.

As children get older, the *MCM6* introns are responsible for a decrease in lactase synthesis. This decrease in lactase synthesis is known as lactase non-persistence.

(a) *LCT* and *MCM6* are located on the same chromosome in humans.

Suggest differences between gene *LCT* and gene *MCM6*, **other than** their locations in different positions on the same chromosome.

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Question 2 · Paper 2 · February/March 2021 (22) · Q2(a)(i) · 2 marks

2 Starch molecules are the main storage molecules in many types of cereal grain, such as the grain of the barley plant.

(a) When the seed inside a barley grain germinates, genes coding for digestive enzymes are switched on. The enzymes that are synthesised catalyse the hydrolysis of storage molecules such as proteins and starch.

(i) Explain what is meant by a gene.

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Question 3 · Paper 2 · May/June 2025 (22) · Q6(b) · 2 marks

(b) Scientists can design synthetic DNA nucleotide sequences to produce a synthetic HRP gene. These sequences will include a start codon and a stop codon so that translation of messenger RNA (mRNA) can occur.

Explain what is meant by a start codon **and** a stop codon.

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Question 4 · information from earlier in the question

3 Baculovirus is a virus that kills some of the insect pests of major crops. When the virus is released to the outside of the insect body, it is contained within stable, protective structures known as polyhedrons.

The main component of the polyhedron is a protein molecule, polyhedrin.

Polyhedrons can be sprayed onto plants as a bioinsecticide. They are ingested by feeding insect larvae and once inside the insect gut they break down to release the virus.

Question 4 · Paper 2 · October/November 2021 (22) · Q3(d) · 3 marks

(d) The sequence of DNA nucleotides for the gene in baculovirus that codes for the polyhedrin polypeptide has been determined.

Explain why the amino acid sequence of the polypeptide **cannot** be used to deduce this sequence of nucleotides in the gene that codes for the polyhedrin polypeptide.

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Question 5 · Paper 2 · February/March 2024 (22) · Q4(a)(i) · 1 mark

4 (a) Table 4.1 shows a sequence of 12 nucleotides in the template strand of a short length of a DNA molecule, the corresponding primary transcript and the four amino acids coded for by the sequence. The table is incomplete.

(i) Complete Table 4.1 to show the sequence of nucleotides in the primary transcript that would result from transcription of this short length of DNA.

Table 4.1

position of nucleotide	1	2	3	4	5	6	7	8	9	10	11	12
DNA template strand	C	A	C	T	A	C	T	C	C	A	A	C
primary transcript												
amino acid	aa1			aa2			aa3			aa4		

[1]

Question 6 · Paper 2 · February/March 2024 (22) · Q4(a)(ii) · 1 mark

(ii) Table 4.2 shows all the possible template strand DNA triplets that code for the amino acids labelled aa1, aa2, aa3 and aa4 in Table 4.1.

Table 4.2

amino acid	DNA triplets
val	CAA, CAG, CAT, CAC
arg	GCA, GCG, GCT, GCC, TCT, TCC
met	TAC
leu	AAT, AAC, GAA, GAG, GAT, GAC

Complete Table 4.3 to identify the four amino acids labelled aa1, aa2, aa3 and aa4 in Table 4.1.

Table 4.3

	aa1	aa2	aa3	aa4
amino acid				

[1]

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Question 7 · Paper 2 · February/March 2024 (22) · Q4(a)(iii) · 2 marks

(iii) One type of gene mutation is caused by the substitution of a DNA nucleotide.

Using the information in Table 4.2, state **and** explain the effect on the final protein structure of a substitution of the nucleotide at position 3 in Table 4.1.

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Question 8 · Paper 2 · February/March 2024 (22) · Q4(a)(iv) · 3 marks

(iv) A second type of gene mutation is caused by the deletion of a DNA nucleotide.

Using the information in Table 4.2, state **and** explain the effect on the final protein structure of a deletion of the nucleotide at position 3 in Table 4.1.

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Question 9 · Paper 2 · May/June 2017 (22) · Q6(b) · 2 marks

(b) The base sequence shown in Fig. 6.1 is a short section of a longer length of DNA that is transcribed to produce mRNA. When translated, this short section produces the amino acid sequence threonine (Thr), proline (Pro), cysteine (Cys).

Fill in the two **unshaded** boxes in Fig. 6.1 to show:

- the mRNA codon for Cys
- the tRNA anticodon for Thr.

You do **not** need to give the codon and anticodon sequences in the shaded boxes.

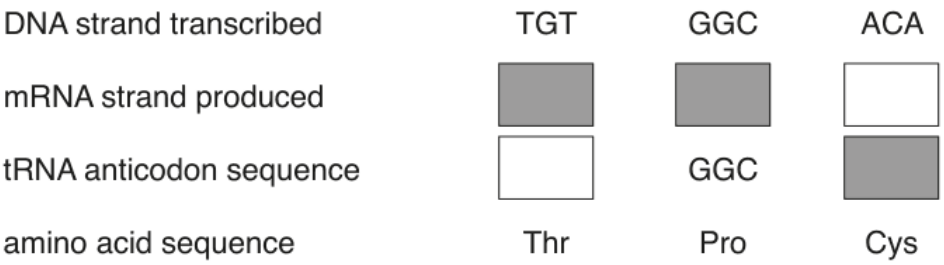


Fig. 6.1

[2]

Question 10 · information from earlier in the question

6 Cotransporter proteins are membrane proteins found in companion cells of phloem tissue.

Messenger RNA (mRNA) is the molecule in cells that carries genetic information in the DNA that codes for cotransporter proteins to the sites of protein synthesis in the cytoplasm.

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(c) Cotransporter molecules are proteins produced in companion cells.

Fig. 6.2 shows what happens in the cytoplasm of a companion cell to a transfer RNA molecule before the cotransporter proteins can be produced.

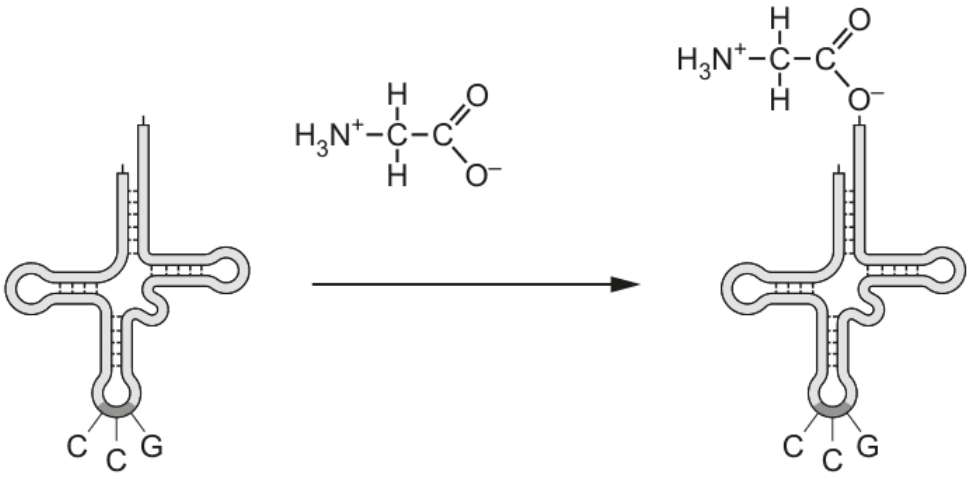


Fig. 6.2

(i) Describe the role of the transfer RNA shown in Fig. 6.2 in the synthesis of a cotransporter protein.

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Question 11 · Paper 2 · February/March 2022 (22) · Q6(b) · 1 mark

(b) Fig. 6.2 shows the RNA base sequence of a short length of primary transcript.

Complete Fig. 6.2 by writing the DNA base sequence of the template strand used to form the primary transcript.

DNA base sequence used to form the primary transcript				
primary transcript	G G U	G C U	A A U	C U A

Fig. 6.2

[1]

Question 12 · Paper 2 · February/March 2022 (22) · Q6(c) · 2 marks

(c) In eukaryotic cells, the primary transcript is modified to form mRNA.

Explain how the primary transcript is modified to form mRNA.

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Question 13 · Paper 2 · February/March 2022 (22) · Q6(d) · 5 marks

(d) The mRNA strand is translated at the ribosome to form a polypeptide.

Describe how the process of translation results in the formation of a polypeptide.

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Question 14 · Paper 2 · February/March 2025 (22) · Q5(b)(i) · 1 mark

(b) Fig. 5.1 shows transcription of the first six nucleotides of a gene by the enzyme RNA polymerase. The bases of the first six nucleotides on DNA strand **X** are shown, but the bases on the template DNA strand are **not** shown.

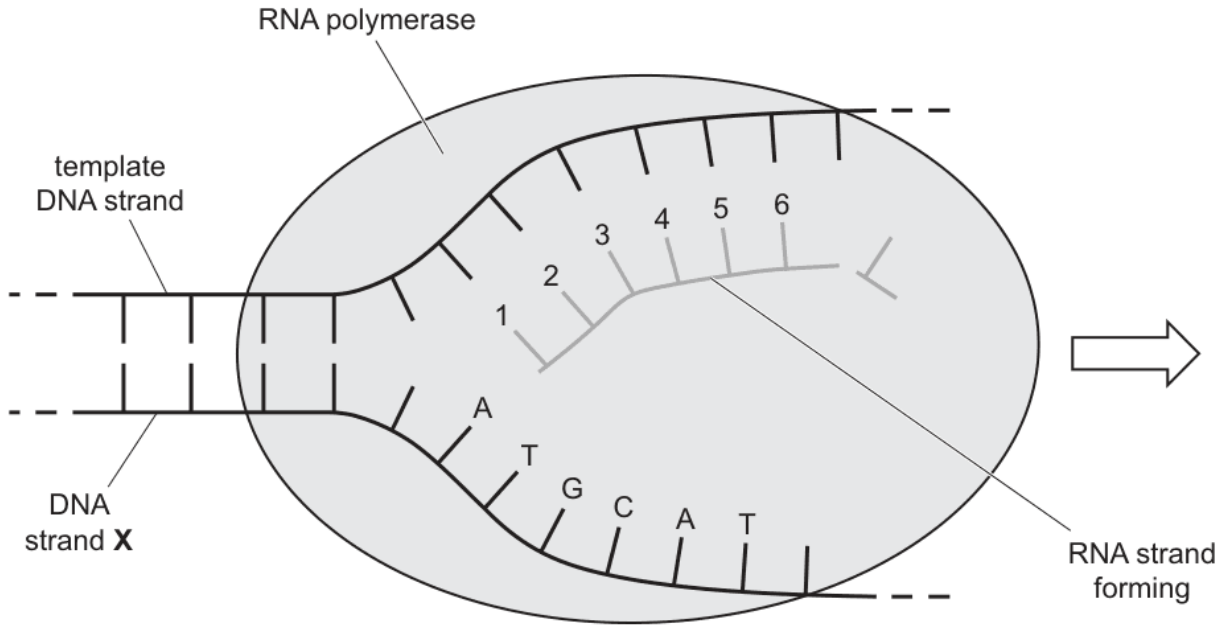


Fig. 5.1

(i) State the term used to describe the non-template DNA strand labelled **X** in Fig. 5.1.

Question 15 · Paper 2 · February/March 2025 (22) · Q5(b)(ii) · 1 mark

(ii) Name the RNA strand formed during transcription of a eukaryotic gene.

Question 16 · Paper 2 · February/March 2025 (22) · Q5(b)(iii) · 1 mark

(iii) Complete Table 5.1 to show the letters of the six bases indicated on Fig. 5.1 by the numbers 1 to 6.

Table 5.1

1	2	3	4	5	6

[1]

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Question 17 · information from earlier in the question

3 The gene *LCT* codes for the enzyme lactase. In babies, lactase synthesis is necessary for digesting lactose, the sugar found in milk.

Another gene, *MCM6*, has introns that have a regulatory role in the expression of gene *LCT*. Gene *MCM6* codes for a protein that has **no** involvement in lactase synthesis.

As children get older, the *MCM6* introns are responsible for a decrease in lactase synthesis. This decrease in lactase synthesis is known as lactase non-persistence.

Question 17 · Paper 2 · October/November 2025 (22) · Q3(b) · 2 marks

(b) With reference to the process of lactase synthesis, explain the relationship between:

- a transcribed strand and a primary transcript
- a primary transcript and messenger RNA (mRNA).

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Question 18 · information from earlier in the question

4 The enzyme carbonic anhydrase has been found in a wide range of organisms and acts as a catalyst in many tissues.

Studies have shown that there are differences in the protein structure of the enzyme and differences in the number and organisation of introns and exons of the gene coding for the enzyme.

All carbonic anhydrase enzymes catalyse the same reversible reaction, shown in Fig. 4.1.

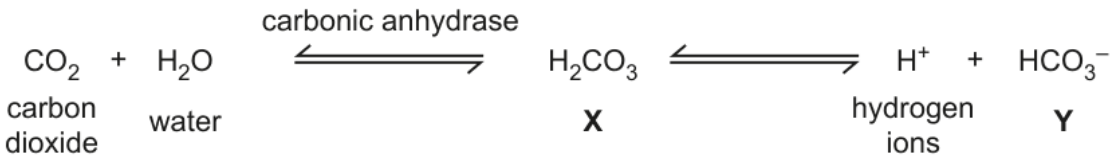


Fig. 4.1

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Question 18 · Paper 2 · May/June 2022 (22) · Q4(c) · 3 marks

(c) Genes coding for proteins in eukaryotes consist of introns and exons.

Outline the similarities and differences between the introns and the exons of genes coding for proteins such as carbonic anhydrase.

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Question 19 · information from earlier in the question

1 Smooth muscle is a tissue composed of smooth muscle cells. The cells contain cytoplasm packed with proteins that are involved in contraction and relaxation.

Question 19 · Paper 2 · May/June 2024 (22) · Q1(d)(i) · 2 marks

(d) Caldesmon is a large protein with a number of binding sites to attach to other proteins.

Caldesmon exists in two different forms, H-caldesmon and L-caldesmon.

H-caldesmon helps to regulate contraction and relaxation in smooth muscle cells.

L-caldesmon is found in some non-muscle cells, where it also acts as a regulatory protein.

- Caldesmon is coded for by a gene known as *CALD1*.
- *CALD1* has 17 exons.
- The primary structure of H-caldesmon has a repeating sequence in the middle of the amino acid chain that is **not** present in L-caldesmon.

(i) Researchers have discovered that a gene mutation is **not** the cause of the two different forms of caldesmon.

Explain what is meant by a gene mutation.

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Question 20 · Paper 2 · May/June 2024 (22) · Q1(d)(ii) · 2 marks

(ii) Researchers now know that the two different forms of caldesmon are the result of events occurring **directly after** transcription of DNA. Changes occur to the primary transcript that is formed by DNA transcription.

Suggest how the smooth muscle cells and non-muscle cells can produce different forms of caldesmon from the same primary transcript.

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Question 21 · Paper 4 (A level) · October/November 2017 (42) · Q8(c) · 3 marks

(c) Different alleles affecting flower colour in the sweet pea plant are the result of gene mutations.

State how a gene mutation may occur.

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Question 22 · Paper 4 (A level) · February/March 2019 (42) · Q3(b) · 5 marks

(b) Transcription factors are proteins. Genes that code for proteins can become mutated.

Describe how different types of gene mutation can cause changes in the protein that is synthesised.

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Mark schemes

Question 1 · Paper 2 · October/November 2025 (22) · Q3(a) · 3 marks

3(a)	*any **three** from:* different sequence of, (DNA) nucleotides / bases **;R** RNA nucleotides code for / result in, different, polypeptides / proteins **;** **A** result in different sequences of amino acids **A** *LCT*, codes for / AW, lactase / enzyme, and, *MCM6*, codes for a different protein / involved in regulation have different numbers of, introns / exons **;** different, lengths / number of nucleotides / number of bases **;** *context is DNA* AVP **;** e.g. one may be continually expressed, the other switched on and off *MCM6* associated with different regulatory sequences	**3**

Question 2 · Paper 2 · February/March 2021 (22) · Q2(a)(i) · 2 marks

2(a)(i)	sequence of nucleotides **or** length / section / AW, of DNA **;** **A** bases for nucleotides (a gene can) code for a polypeptide **;** **A** protein for polypeptide	**2**

Question 3 · Paper 2 · May/June 2025 (22) · Q6(b) · 2 marks

6(b)	*start codon* triplet of / three, (RNA / DNA) bases / nucleotides (begins translation), qualified e.g. coding for, methionine / first amino acid first codon attaching to ribosome **or** (codon to begin translation is) AUG (for RNA) **or** TAC (for DNA transcribed strand) **or** ATG (for DNA non-transcribed strand) **;** *stop codon* triplet of / three, (RNA / DNA) bases / nucleotides, (ending translation), qualified **;** *codon meaning only needed once* e.g. does not code for amino acid stops, chain elongation / addition of amino acids allows / AW, polypeptide to detach (from ribosome) recognised by releasing factors **or** (codon to end translation) UAG UAA / UGA (for RNA) **or** ATC / ATT / ACT (for DNA transcribed strand) **or** TAG / TAA / TGA for DNA non-transcribed strand) *if more than one codon given, all must be correct*	**2**

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Question 4 · Paper 2 · October/November 2021 (22) · Q3(d) · 3 marks

3(d)	*any **three** from:* *ref. to* genetic code ; *in correct context* amino acids coded for by more than one codon / two or more codons for (most) amino acids ; **A** triplet (of, bases / nucleotides) 64 codons and 20 amino acids ; third base in codon can be different / only first two bases in codon are same ; AVP ; *idea that* amino acid sequence is only the result of exons / gives information only about introns only sure of sequence for, two amino acids / met and trp degenerate code / degeneracy of code **R** degenerative *ref. to* control sequences STOP codons (also) have more than one triplet (of bases) STOP codons do not specify amino acids	**3**

Question 5 · Paper 2 · February/March 2024 (22) · Q4(a)(i) · 1 mark

4(a)(i) all correct ; **1**

position of nucleotide	1	2	3	4	5	6	7	8	9	10	11	12
DNA template strand	C	A	C	T	A	C	T	C	C	A	A	C
primary transcript	G	U	G	A	U	G	A	G	G	U	U	G

Question 6 · Paper 2 · February/March 2024 (22) · Q4(a)(ii) · 1 mark

4(a)(ii) all 4 correct ; **1**

	aa1	aa2	aa3	aa4
amino acid	val / valine	met / methionine	arg / arginine	leu / leucine

Question 7 · Paper 2 · February/March 2024 (22) · Q4(a)(iii) · 2 marks

4(a)(iii)	*any **two** from:* no effect on the protein structure ; (because) all 4 triplets beginning with CA code for valine / CAA, CAG, CAT, CAC all code for valine ; idea of the genetic code is, redundant / degenerate ;	**2**

Question 8 · Paper 2 · February/March 2024 (22) · Q4(a)(iv) · 3 marks

4(a)(iv)	*any **three** from:* first amino acid, unchanged / still val ; changes the reading frame / described ; **A**.all codons (from mutation on) will change / frameshift mutation deletion alters, all amino acids after the mutation / amino acid sequence / primary structure ; ref. to, stop codon, causing premature chain termination / leading to shorter polypeptide ; (leading to) changes, in the tertiary structure / active site / AW ;	**3**

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Question 9 · Paper 2 · May/June 2017 (22) · Q6(b) · 2 marks

6(b)	*mRNA strand produced* UGU ; *tRNA anticodon sequence* UGU ;	**2**

Question 10 · Paper 2 · May/June 2022 (21) · Q6(c)(i) · 4 marks

6(c)(i)	*any **four** from:* **1** *ref. to* amino acid activation / charging amino acids before attachment to tRNA / AW ; **A** aminoacylation **2** tRNA attached to, specific amino acid / glycine ; **R** 'picks up' **3** *idea that* anticodon / CCG, identifies specific amino acid ; **4** tRNA transports / AW, amino acid to ribosome ; **5** *ref. to* (tRNA) entering the A (aminoacyl) site in ribosome ; **6** tRNA, anticodon / CCG, binds to mRNA, codon / GGC ; **A** correct ref. to, complementary pairing / base pairing / H bond formation *as AW for binding* **7** (specific) amino acid / glycine, in correct position in the polypeptide chain / AW ; **A** helps to form / AW, primary structure of cotransporter protein **8** AVP ; e.g. tRNA, recycled / reused forms aminoacyl tRNA / amino acid-tRNA complex tRNA-ligase / aminoacyl-tRNA synthetase	**4**

Question 11 · Paper 2 · February/March 2022 (22) · Q6(b) · 1 mark

6(b)	All 4 triplets must be correct ; CCA CGA TTA GAT GGU GCU AAU CUA	**1**

Question 12 · Paper 2 · February/March 2022 (22) · Q6(c) · 2 marks

6(c)	*any **two** from:* removal of introns / non-coding sequences ; leaving, exons / coding sequences (joined) ; ref. to splicing RNA transcript = 1 mark AVP ; e.g. adding a 5′ cap / 3′ poly A tail	**2**

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Question 13 · Paper 2 · February/March 2022 (22) · Q6(d) · 5 marks

6(d)	*any **five** from:* 1 two codons at a time are exposed (to the large subunit) ; 2 (idea of) a specific tRNA brings a specific amino acid ; 3 a tRNA anticodon binds to the mRNA codon ; 4 complementary base pairing occurs (by hydrogen bonding) ; 5 a second tRNA brings another amino acid (next to the first amino acid) ; 6 peptide bond formation between the two amino acids ; 7 ribosome moves along the mRNA, one codon at a time / and next codon is 'read' ; 8 the first tRNA leaves the ribosome ; 9 AVP ; e.g. first codon is always AUG first anticodon is always UAC first amino acid is always methionine ribosome moves along mRNA in a 5' to 3' direction role of peptidyl transferase eventually a stop codon is reached (and translation stops)	**5**

Question 14 · Paper 2 · February/March 2025 (22) · Q5(b)(i) · 1 mark

5(b)(i)	non-transcribed strand ;	**1**

Question 15 · Paper 2 · February/March 2025 (22) · Q5(b)(ii) · 1 mark

5(b)(ii)	primary transcript ;	**1**

Question 16 · Paper 2 · February/March 2025 (22) · Q5(b)(iii) · 1 mark

5(b)(iii)

1	2	3	4	5	6
A	U	G	C	A	U

; **1**

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Question 17 · Paper 2 · October/November 2025 (22) · Q3(b) · 2 marks

3(b)	statement showing relationship between transcribed strand and primary transcript ; e.g. (transcribed strand is the) DNA (strand) / template (strand), used to form the primary transcript primary transcript is RNA (molecule first) formed from transcription of transcribed strand primary transcript is a complementary copy of the transcribed strand (but uracil replaces thymine) statement showing relationship between primary transcript and mRNA ; e.g. primary transcript undergoes, gene / RNA, splicing, to form mRNA primary transcript undergoes modification to produce mRNA mRNA formed by removal of introns from primary transcript mRNA formed only from exons of primary transcript *one mark for a response that has correct ideas but does not show a direct relationship*	**2**

Question 18 · Paper 2 · May/June 2022 (22) · Q4(c) · 3 marks

4(c) *allow pre-RNA for primary transcript* **3**

*either exon **or** intron statement required for mp2 to 7, one mark each row*
*any **three** from:*

	exons	introns
1	both, are (nucleotide sequences that are) transcribed / form part of the primary transcript ;	
2	(DNA/RNA) coding (sequences) **R** coding genes **I** exons have the genetic code	(DNA/RNA) non-coding (sequences) **R** non-coding genes
3	(RNA exons) needed / involved / AW, in translation **or** for formation of, polypeptides / proteins / carbonic anhydrase	not involved in translation / AW
	if mps 2 and 3 not gained 'exons code for proteins' or ora 1 mark	
4	not removed, from primary transcript / from RNA / during gene splicing / during RNA splicing	removed, from primary transcript / from RNA /during gene splicing / during RNA splicing
5	(join to) form mRNA / contain mRNA codons **A** remain in mRNA	not part of mRNA / in primary transcript only
6	not involved in regulating activity of genes / AW	may have regulatory roles **A** other suggestions for role
7	AVP e.g. (as part of mRNA) leave the nucleus / go to cytoplasm / go to ribosomes	AVP e.g. remain in nucleus

if all are differences and all statements are reversed (i.e. introns for exons and vice versa) max 2 marks

Question 19 · Paper 2 · May/June 2024 (22) · Q1(d)(i) · 2 marks

1(d)(i)	(a gene mutation is a) change in the sequence of base pairs in a DNA molecule ; **A** change in the DNA, base / nucleotide, sequence **I** change in RNA base sequence **I** names of mutations codes for / may result in / results in / AW, an altered / a different / a changed, polypeptide ; **A** protein / amino acid sequence / primary structure, *for polypeptide*	**2**

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Question 20 · Paper 2 · May/June 2024 (22) · Q1(d)(ii) · 2 marks

1(d)(ii)	*any **two** from:* differences owing to, RNA / gene, splicing ; **A** primary transcript for RNA **A** *ref. to* alternative splicing **R** DNA splicing **R** mutation occurring during gene splicing (differences occur during) removal of, introns / non-coding sequences ; **R** if introns described as bases / nucleotides / codons **R** different number of introns removed / some introns remain exons / coding sequences, detail ; e.g. joined differently / in a different combination in middle (of transcript), removed / not included for repeating sequence, removed / not included (so) messenger RNA / mRNA, formed is different ;	**2**

Question 21 · Paper 4 (A level) · October/November 2017 (42) · Q8(c) · 3 marks

8(c)	*three from:* 1 change in, base (pair) / nucleotide, sequence in DNA ; 2 random / spontaneous ; *due to* 3 *ref. to* base, substitution / deletion / insertion ; 4 (during) DNA replication ; 5 failure of proof reading mechanism ; 6 *ref. to* mutagenic agents ; e.g. ionising radiation / UV radiation	**3**

Question 22 · Paper 4 (A level) · February/March 2019 (42) · Q3(b) · 5 marks

3(b)	*any **five** from:* 1 base substitution / mis-sense mutation ; 2 changes, triplet / codon ; 3 base, deletion / insertion ; 4 (results in) frame shift / description ; 5 change in, protein primary structure / amino acid sequence ; 6 protein folds incorrectly / changes tertiary or 3-D structure ; 7 changes protein function / prevents protein function / makes protein unstable; 8 *idea of* new STOP codon ; 9 only, short / first part of / no, protein is produced ;	**5**

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