Past-paper walk-through

Protein synthesis ▪ 6.2

eXercise

Questions in this set

- 9700/11 N25 Q22 ▪ 1 mark
- 9700/11 N25 Q25 ▪ 1 mark
- 9700/12 N25 Q25 ▪ 1 mark
- 9700/12 N25 Q26 ▪ 1 mark
- 9700/12 N25 Q27 ▪ 1 mark
- 9700/13 N25 Q26 ▪ 1 mark
- 9700/13 N25 Q27 ▪ 1 mark
- 9700/14 N25 Q23 ▪ 1 mark
- 9700/14 N25 Q24 ▪ 1 mark
- 9700/22 N25 Q3 ▪ 13 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 22

9700/11 N25 ▪ Q22 ▪ 1 mark

22 The gene that codes for protein R is 130 kb long.

Protein R is 220 kDa in mass.

The typical mass of an amino acid is 110 Da.

(1000 base pairs = 1 kb, 1000 Da = 1 kDa)

Which row is correct?

Question 22

	approximate length of introns in this gene / base pairs	approximate length of mRNA for this gene / base pairs
A	6000	6000
B	6000	130 000
C	124 000	6000
D	124 000	130 000

Question 22

Solution 22

Answer: **C**

Why

- The protein has $220\,000/110 = 2000$ amino acids.
- Three bases code for each, so the coding mRNA is about $2000 \times 3 = 6000$ bases.
- The gene is $130\,000$ base pairs, so roughly $130\,000 - 6000 = 124\,000$ of them are introns.

Question 25

9700/11 N25 ▪ Q25 ▪ 1 mark

25 The table shows some of the DNA triplet codes for some amino acids.

amino acid	DNA triplet code	amino acid	DNA triplet code
arginine	GCA	glycine	CCA
arginine	GCC	glycine	CCG
arginine	GCG	glycine	CCT
asparagine	TTA	lysine	TTC
asparagine	TTG	lysine	TTT
cysteine	ACA	proline	GGA
cysteine	ACG	proline	GGC

Question 25

STOP	ATC	valine	CAC

The base sequence on the template DNA strand coding for part of a polypeptide is shown.

CCA TTC ACG GCG TTA GCA

Two mutations occur in this sequence during DNA replication.

Which mutated DNA would result in two different amino acids?

A CCA ATC ACG GCG TTG GCA

B CCA TTC ACA GCA TTA GCA

C CCA TTC ACG CCG TTA GCC

D CCA TTC ACG GCG TTC GGA

Solution 25

Answer: **D**

Why

- Use the table to translate the original sequence, then the mutated one.
- Compare the two amino acid sequences to see which triplet changed.
- The type of mutation follows from whether the reading frame shifted or a single base was swapped.

Question 25

9700/12 N25 ▪ Q25 ▪ 1 mark

25 In a gene, the 20 common amino acids are each coded for by three bases in adjacent nucleotides.

Why is there a difference between the number of amino acids and the number of possible triplet codes?

A 44 triplets have **no** functions.

B Some amino acids are coded for by more than one triplet.

C Some triplets have unknown functions.

D There are 44 ‘start’ and ‘stop’ triplets.

Solution 25

Answer: **B**

Why

- Three bases give $4^3 = 64$ possible triplets for only 20 amino acids.
- Most amino acids are coded for by more than one triplet – the code is degenerate.
- The spare triplets are not useless: three of them are stop signals.

Question 26

9700/12 N25 ▪ Q26 ▪ 1 mark

26 How is a primary transcript modified to form mRNA?

A It becomes longer as exons are joined together.

B It becomes shorter as exons are removed.

C It becomes longer as introns are joined together.

D It becomes shorter as introns are removed.

Solution 26

Answer: **D**

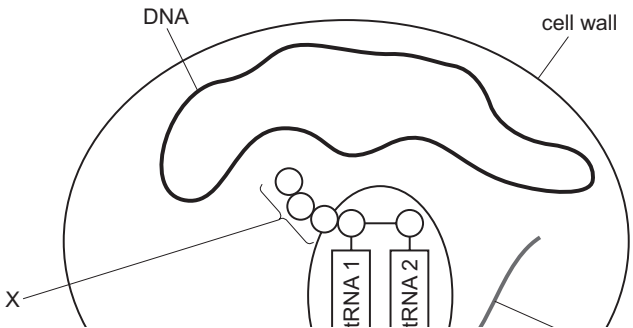
Why

- The primary transcript contains both exons and introns.
- The introns are cut out and the exons are joined together.
- Removing material makes the molecule shorter, so mRNA is shorter than the primary transcript.

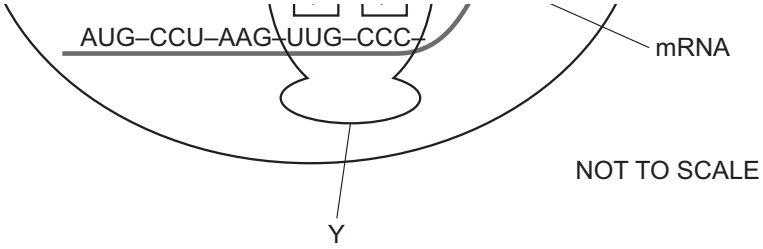
Question 27

9700/12 N25 ▪ Q27 ▪ 1 mark

27 The diagram shows protein synthesis in a prokaryote.



Question 27



Which row is correct for molecule X, structure Y and the anticodon of tRNA 1?

	molecule X	structure Y	anticodon of tRNA 1
A	amino acid	80S ribosome	AAC

Question 27

B	polypeptide	80S ribosome	UUG
C	polypeptide	70S ribosome	AAC
D	protein	70S ribosome	UUG

Solution 27

Answer: **C**

Why

- In a prokaryote there is no nucleus, so transcription and translation happen together in the cytoplasm.
- Prokaryotic ribosomes are 70S, not 80S.
- An anticodon is complementary to the codon, so read the first mRNA codon and pair each base.

Question 26

9700/13 N25 ▪ Q26 ▪ 1 mark

26 Which statement is correct for protein synthesis?

A During translation, the strand of DNA used is the template strand.

B mRNA is formed when introns are removed from the primary transcript.

C The DNA primary transcript is modified by removing exons.

D tRNA has codons which attach to anticodons on the mRNA.

Solution 26

Answer: **B**

Why

- The primary transcript has introns removed to leave the exons, giving mRNA.
- Transcription copies the *template* strand, but translation reads mRNA, not DNA – so A is wrong.
- Exons are kept, not removed, and it is tRNA that carries anticodons, not codons.

Question 27

9700/13 N25 ▪ Q27 ▪ 1 mark

27 A mutation occurred in this original DNA nucleotide sequence.

C T A G A A T C C T C T C C C

After the mutation occurred, the new DNA nucleotide sequence coded for the amino acids Asp, Leu, Gly and Glu.

The table shows the amino acids that are coded for by each DNA triplet.

2nd base

Question 27

1st base	A	G	T	C
A	AAA Phe AAG Phe AAT Leu AAC Leu	AGA Ser AGG Ser AGT Ser AGC Ser	ATA Tyr ATG Tyr ATT *Stop* ATC *Stop*	ACA Cys ACG Cys ACT *Stop* ACC Trp
G	GAA Leu GAG Leu GAT Leu GAC Leu	GGA Pro GGG Pro GGT Pro GGC Pro	GTA His GTG His GTT Gln GTC Gln	GCA Arg GCG Arg GCT Arg GCC Arg
T	TAA Ile TAG Ile TAT Ile TAC Met	TGA Thr TGG Thr TGT Thr TGC Thr	TTA Asn TTG Asn TTT Lys TTC Lys	TCA Ser TCG Ser TCT Arg TCC Arg
C	CAA Val CAG Val	CGA Ala CGG Ala	CTA Asp CTG Asp	CCA Gly CCG Gly

Question 27

	CAT	Val	CGT	Ala	CTT	Glu	CCT	Gly
	CAC	Val	CGC	Ala	CTC	Glu	CCC	Gly

Which type of gene mutation occurred in the DNA nucleotide sequence?

A deletion of one nucleotide

B insertion of one nucleotide

C insertion of two nucleotides

D substitution of one nucleotide

Solution 27

Answer: **A**

Why

- Use the table to read the original sequence as triplets and translate it.
- Then translate the new amino acid sequence back into triplets.
- Comparing the two shows which single base changed and where.

Question 23

9700/14 N25 ▪ Q23 ▪ 1 mark

23 Which statements about anticodons are correct?

1 The base sequence of an anticodon will always be the same as that of the corresponding triplet on the transcribed DNA strand.

2 There are 20 naturally occurring amino acids, so therefore there are only 20 anticodons as each anticodon is specific for only one amino acid.

3 The formation of hydrogen bonds between the bases of the anticodon with those of the complementary mRNA codon must occur before the new peptide bond can form.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 3 only

Solution 23

Answer: **D**

Why

- An anticodon is complementary to the mRNA codon, and mRNA is itself complementary to the template DNA strand.
- So the anticodon matches the *coding* strand, except that U replaces T – statement 1 is wrong.
- There are more anticodons than amino acids because the code is degenerate, so statement 2 is wrong too.

Question 24

9700/14 N25 ▪ Q24 ▪ 1 mark

24 Part of a DNA molecule is transcribed to form an RNA molecule that is then modified.

Which row describes the RNA molecule before and after modification?

	before modification	after modification
A	contains exons and introns	contains exons only
B	contains exons and introns	contains introns only
C	contains exons only	contains introns only
D	contains introns only	contains exons only

Solution 24

Answer: **A**

Why

- The primary transcript contains both exons and introns.
- Splicing removes the introns.
- What is left, the mRNA, contains exons only.

Question 3

9700/22 N25 ▪ Q3 ▪ 13 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.

Question 3

(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).

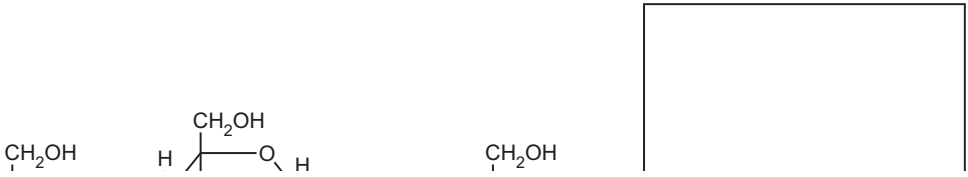
Question 3

(c) A mutation in a regulatory intron of *MCM6* allows lactase synthesis to continue. This is known as lactase persistence. In this mutation, the number of nucleotides in the intron remains the same, but one of the nucleotides is different to the original nucleotide.

State the type of mutation that is the cause of lactase persistence.

Question 3

(d) Fig. 3.1 summarises the reaction catalysed by lactase.



Question 3

Question 3

Question 3

lactose galactose α-glucose

Fig. 3.1

Draw the ring structure of α-glucose in the box provided to complete Fig. 3.1. [1]

(e) Some people with lactase non-persistence may be lactose intolerant. They may have symptoms, such as abdominal pain, if their diet contains lactose.

(i) Lactase supplements (tablets) can be taken before milk or milk-based products are consumed to avoid symptoms of lactose intolerance.

A student compared the activity of two different concentrations of a lactase supplement using an artificial substrate, ONPG, instead of lactose.

A solution of ONPG is colourless, but the hydrolysis of ONPG by lactase releases a coloured product.

The student planned to follow the progress of the reaction for each concentration of

Question 3

The student planned to follow the progress of the reaction for each concentration of

Question 3

lactase using a colorimeter.

Explain why the student chose to use a colorimeter to follow the progress of the reaction for each concentration of lactase.

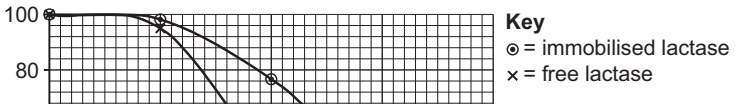
Question 3

(ii) The lactose in milk can be hydrolysed using immobilised lactase or using lactase free in solution (free lactase). This results in milk and milk products that do not contain lactose and so are suitable for lactose-intolerant people.

Scientists carried out an investigation to compare the activity of lactase immobilised in very small magnetic beads (magnetic microspheres) with free lactase, at different temperatures and at different pH values.

Fig. 3.2 shows the activity of immobilised lactase and the activity of free lactase at 5 different temperatures.

Fig. 3.3 shows the activity of immobilised lactase and the activity of free lactase at 8 different pH values.



Question 3

Question 3

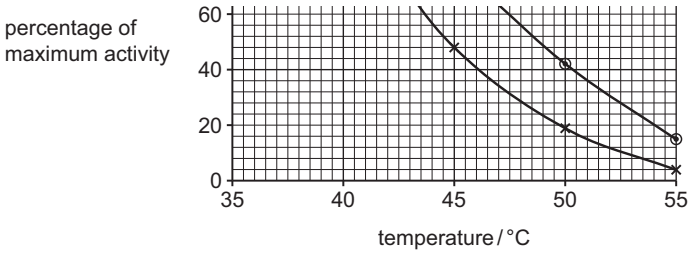
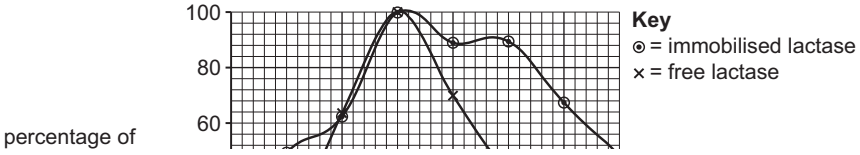


Fig. 3.2



Question 3

maximum activity

Question 3

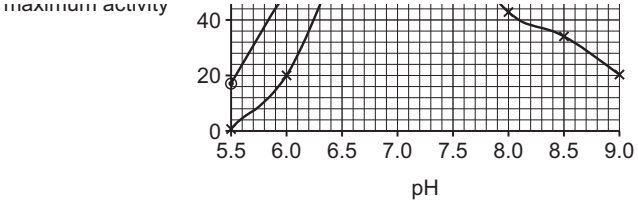


Fig. 3.3

One advantage of using magnetic microspheres with immobilised lactase is that they can be easily recovered using an electric field and reused.

With reference to Fig. 3.2 and Fig. 3.3, explain why the results indicate that there are **other** advantages in using immobilised lactase instead of free lactase to produce lactose-free products.

Question 3

[Total: 13]

Solution 3

(a) Mark scheme

- 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 ;

Solution 3

- 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

Solution 3

(b) Mark scheme

- 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.

Solution 3

- 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

Solution 3

(c)

Mark scheme

- base substitution / substitution (mutation) ; I missense
- 1

Solution 3

(d)

Mark scheme

- 1
- all correct for one mark – if deciding to leave out the H, then this
- must be for all C1 to C5 hydrogens – leaving out only the C5 H is
- zero marks
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Solution 3

(e)(i) Mark scheme

- any two from:
- idea of can, detect increase in / distinguish between, the intensity of colour (as products form) ;
- can obtain quantitative results (for coloured product of ONPG) ;
- A can provide numerical, values / readings / results / measurements
- R if stated that the results are wavelengths
- ref. to not subjective / AW ; idea of not by-eye judgments / difficulty in describing different colour shades

Solution 3

- can obtain accurate, results / readings / values ;
- A idea of greater accuracy in obtaining results
- vague references to accuracy should be considered for ideas linked to 'not subjective'
- can construct numerical graphs of results to compare curves of each (lactase) concentration ; AW
- AVP ; e.g. more sensitive to small colour changes at the beginning of the experiment
- not able to see initial reaction proceeding by eye
- ref. to use of a (prepared) calibration, curve / graph (to compare rates / product concentrations)

Solution 3

- 2
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Solution 3

(e)(ii) Mark scheme

- any four from:
- accept activity for percentage of maximum activity
- 1
- immobilised (overall) greater, productivity / yield / hydrolysis (of lactose in milk) ; I activity
- 2
- (process / immobilised) more tolerant to, temperature / pH, fluctuations / changes ; AW

Solution 3

- A idea that can be used in processes covering a wide range of, temperature / pH
- 3
- detail immobilised vs free lactase from Fig. 3.2 ; e.g.
- (at temperatures) above optimum / higher than 38 / 39 °C, (immobilised) has a higher activity AW
- above optimum / higher than 38 / 39 °C, (partial / extent of) denaturation (for immobilised) is less at each temperature
- AW
- A higher than 40 °C if accompanying context is correct
- R if optimum stated as 35 °C
- 4

Solution 3

- data from Fig. 3.2 to support ; any one comparison (units only for temperature required)
- 5
- detail immobilised vs free lactase from Fig. 3.3 ; e.g. higher activity at all pHs except pH 6.5 and pH 7.0
- higher activity, below pH 6.5 / above pH 7.0
- free not active at pH 5.5 but immobilised active, at all pHs / for a wider
- pH range
- 6
- data From Fig. 3.3 to support ;
- 7

Solution 3

- AVP ;; e.g. can use a lower temperature / cheaper, for same quantity of product
- 8
- more, heat stable / thermostable / stable at high temperatures I longer shelf-life R thermostatic
- better in alkaline pHs
- 4
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