6. Nucleic Acids and Protein Synthesis

6.2 Protein synthesis

Paper 1

Question Paper

1 The diagram shows the nucleotide sequence of a small section of the transcribed strand of a gene.

CGG GCC CCG CGG

The table shows the amino acids coded for by 10 mRNA codons.

mRNA codon	amino acid
AAG	Lys
ACG	Thr
CGG CGC CGU	Arg
CCG	Pro
GCC GCG	Ala
GGC	Gly
UGC	Cys

What is the sequence of the four amino acids in the polypeptide translated from this small section of a gene?

A Ala-Ala-Cys-Ala

B Ala-Arg-Gly-Ala

C Arg-Ala-Pro-Arg

D Arg-Arg-Thr-Arg

2 What does the process of translation require?

A DNA, free nucleotide bases and mRNA

B DNA, mRNA, amino acids and RNA polymerase

C mRNA, ribosomes and RNA polymerase

D mRNA, ribosomes, amino acids and tRNA

3 The mRNA codons ACU, ACC, ACA and ACG all code for the same amino acid, threonine.

Which anticodons could specify an amino acid other than threonine?

1 UCA

2 ACC

3 UGU

4 UGC

A 1, 3 and 4 **B** 1 and 2 **C** 2 and 3 **D** 3 and 4 only

4 In eukaryotes, the RNA molecules formed during transcription are modified by the removal of non-coding sequences. This is followed by the joining together of coding sequences to form mRNA.

What are the coding sequences also called?

A codons

B exons

C introns

D primary transcripts

5 The statements describe processes that take place in a secretory cell.

1 Modification of the protein occurs in the Golgi body.

2 mRNA leaves the nucleus.

3 Ribosomes bind to mRNA during translation.

4 Transcription of a specific DNA sequence occurs.

5 Vesicles fuse with the cell surface membrane.

6 Vesicles transport the protein to the Golgi body.

Statement 4 is the first process, and statement 5 is the last process.

What is the correct sequence of the middle four processes?

A $2 \rightarrow 3 \rightarrow 1 \rightarrow 6$

B $2 \rightarrow 3 \rightarrow 6 \rightarrow 1$

C $3 \rightarrow 2 \rightarrow 1 \rightarrow 6$

D $3 \rightarrow 2 \rightarrow 6 \rightarrow 1$

6 Which statements describe how a gene mutation can lead to the production of a non-functional protein?

1 During transcription, an incorrect nucleotide is added to a DNA molecule.

2 The mutated gene results in a new codon being transcribed.

3 The order of the bases in an anticodon on tRNA is altered during translation.

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

7 The diagram shows the nucleotide sequence of a small section of the transcribed strand of a gene.

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B Ala-Arg-Gly-Ala

C Arg-Ala-Pro-Arg

D Arg-Arg-Thr-Arg

8 A polypeptide molecule contains the amino acid sequence:

glycine – leucine – lysine – valine.

The table shows DNA triplets for these amino acids.

glycine	leucine	lysine	valine
CCC	GAA	TTT	CAA

Which tRNA anticodons are needed for the synthesis of this polypeptide?

A CCC GAA TTT CAA

B CCC GAA UUU CAA

C GGG CUU AAA GUU

D GGG CUU UUU GUU

9 During the production of protein molecules, only one strand from the DNA double helix is used.

Which name is given to the DNA strand that is used to produce a new protein?

A non-transcribed strand

B leading strand

C template strand

D lagging strand

10 Which structures are involved in transcription only?

	DNA template strand	anticodons	RNA polymerase
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✗
D	✗	✗	✓

key

✓ = involved

✗ = not involved

11 One gene provides the code for the production of which type of molecule?

A amino acid

B DNA

C nucleotide

D polypeptide

12 The table shows some mRNA codons that code for certain amino acids.

mRNA codon	amino acid
GCG, GCA, GCC, GCU	alanine
ACG, ACA, ACC, ACU	threonine
UGC, UGU	cysteine
UAC, UAU	tyrosine
CAG, CAA	glutamine
CGG, CGA, CGC, CGU	arginine

A DNA template strand has the base sequence shown.

ACAGTATTATTTGCAACG

What would the change in the amino acid be if the first base in the fifth DNA triplet was substituted for an A base?

A alanine to cysteine

B alanine to threonine

C arginine to cysteine

D arginine to threonine

13 One characteristic of DNA is that it is a universal genetic code.

What is meant by a universal genetic code?

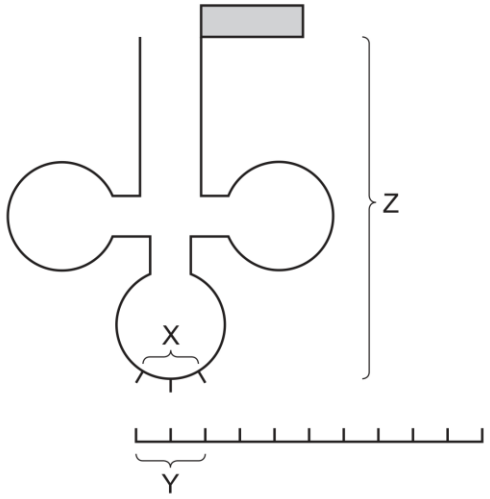
A All living organisms use the same triplet code for amino acids.

B All DNA triplets code for a different amino acid.

C Not all DNA triplets code for an amino acid.

D All living organisms contain the same four nucleic acids.

14 The diagram shows part of the process of translation.



What are the names of the structures labelled X, Y and Z?

	X	Y	Z
A	anticodon	codon	mRNA
B	anticodon	codon	tRNA
C	codon	anticodon	mRNA
D	codon	anticodon	tRNA

15 The DNA triplets of genes are translated as amino acids or stop signals during protein synthesis. The table shows some of these triplets.

DNA triplet	name of amino acid
ATA	tyrosine
ATG	tyrosine
ACA	cysteine
ACG	cysteine
ATC	*stop signal*
ACC	tryptophan

What could be the effects of **one** substitution mutation in a triplet coding for tyrosine?

1 The triplet is translated as cysteine.

2 The triplet is translated as tryptophan.

3 The triplet is translated as tyrosine.

4 Translation stops at this triplet.

A 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

16 Which statements correctly describe the process of transcription?

1 mRNA is decoded by a ribosome to produce a specific amino acid chain.

2 A section of DNA is converted to RNA by RNA polymerase.

3 tRNA transfers amino acids to the ribosome.

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

17 Sickle cell anaemia is caused by a mutation in an allele of the gene that codes for the β-globin polypeptide of haemoglobin.

The diagram shows the sequence of bases in a small section of the template strand of DNA for both the Hb^A (normal) and Hb^S (sickle cell) β-globin alleles.

Hb^A CTGACTCCTGAGGAGAAGTCT

Hb^S CTGACTCCTGTGGAGAAGTCT

Both the polypeptides for Hb^A and Hb^S are the same length.

How will the mutation in the allele result in the production of an altered version of the β-globin polypeptide?

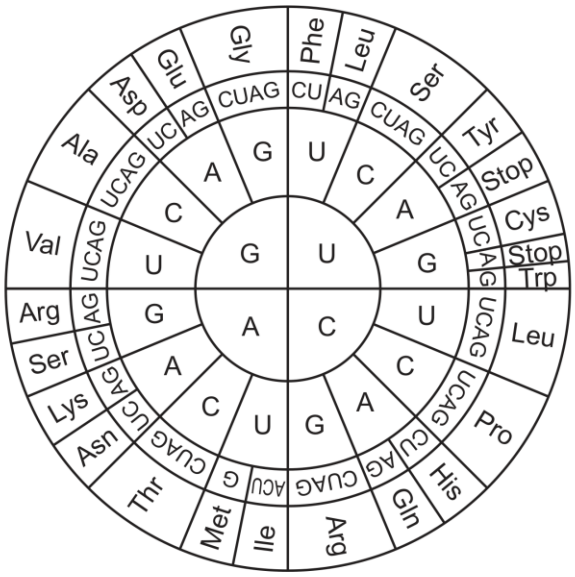
A A tRNA molecule with the anticodon GUG will form hydrogen bonds with the altered codon on mRNA.

B All the amino acids coded for after the mutation will differ from those in the Hb^A protein.

C mRNA transcribed from the Hb^S allele will contain the codon CAC instead of the codon CTC.

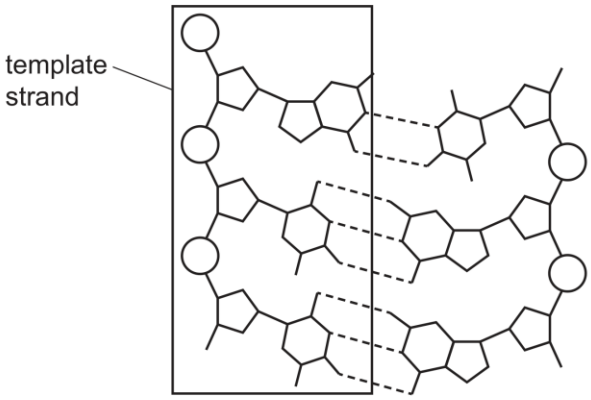
D The ribosome will be unable to continue translation of the Hb^S mRNA after the altered codon.

18 The RNA codon wheel is a tool used to find which amino acid would be translated from an mRNA sequence.



Codon position 1 is in the centre of the wheel, codon position 2 is in the middle of the wheel and codon position 3 is near the edge of the wheel. The three letters on the outside edge of the wheel identify the amino acid.

The diagram shows a section of DNA coding for one amino acid. The template strand is outlined in a box and the DNA base sequence is read in the 5′ to 3′ direction.

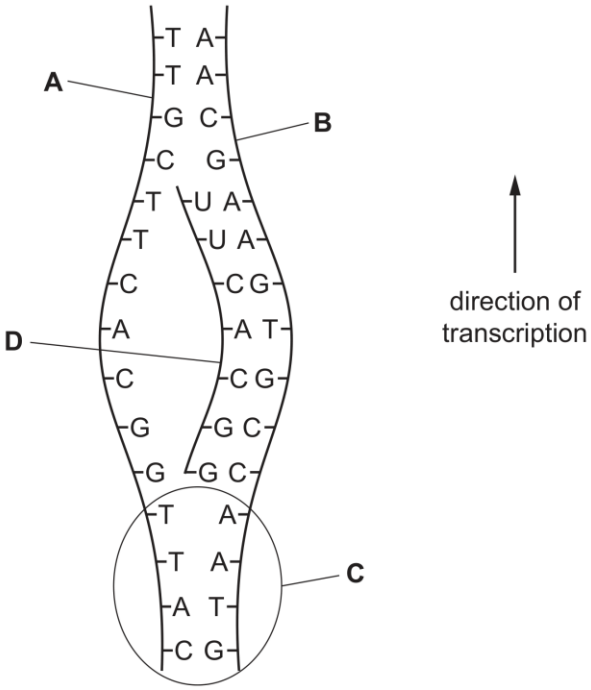


Which amino acid is coded for by this section of DNA?

A Gly **B** Pro **C** Trp **D** Thr

19 A student sketched a diagram to represent the process of transcription.

Which part of their diagram shows the non-transcribed strand?



20 Rifampicin is an antibiotic used to treat tuberculosis.

It works by inhibiting RNA polymerase in bacteria.

Which processes are directly inhibited by this antibiotic?

1 DNA replication

2 enzyme synthesis

3 ATP synthesis

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

21 The table shows 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
STOP	ATC	valine	CAC

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

CCA ACG GCG TTA TTC GCA

Two mutations occur in this sequence during DNA replication.

Which mutated template DNA strand would result in a shorter polypeptide?

A CCA ACA GCA TTA TTC GCA

B CCA ACG CCG TTA TTC GCC

C CCA ACG GCG TTG ATC GCA

D CCT ACG GCG TTA TTC GGA

22 The sequence shows the series of bases at the start of a gene.

TAC CGA CCA CCA CAA CCA CGA...

After transcription, the mRNA was translated via tRNA into a sequence of amino acids. When this part of the polypeptide was analysed, it was found to contain the amino acids in the table.

amino acid	number present
Ala	2
Gly	3
Met	1
Val	1

What is the sequence of amino acids in this part of the polypeptide?

A Met Ala Gly Ala Gly Gly Val

B Met Ala Gly Gly Val Gly Ala

C Met Gly Ala Ala Val Ala Gly

D Met Gly Ala Ala Gly Gly Val

23 The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

antibacterial drug	rifampicin	streptomycin
mode of action	binds to RNA polymerase	causes errors in translation

If bacteria are treated with the drugs rifampicin **and** streptomycin, what will be the immediate effects?

1 Transcription will stop but faulty proteins may continue to be synthesised.

2 If translation has started, proteins may be faulty.

3 Translation will be inhibited.

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

24 A section of the polypeptide coding for the haemoglobin β-chain contains the following amino acids.

– Pro – Glu – Glu –

Patients with sickle cell anaemia have mutated β-polypeptide chains. The section of the mutated polypeptide contains the following amino acids.

– Pro – Val – Glu –

The table shows the possible anticodons for Val.

amino acid	anticodon
Val	C A A
Val	C A G
Val	C A C
Val	C A U

What is the corresponding DNA triplet code for the substituted amino acid in the mutated polypeptide?

A G T T **B** G A C **C** C T C **D** C A T

25 The diagram shows part of the DNA sequence of a gene and a mutated sequence of the same gene.

normal DNA sequence ...CCG GAT TAT TGC GAG AAA TGG CAT TCT AGG...

mutated DNA sequence ...CCG GAT GTA TTG CGA GAA ATG CAT TCT AGG...

What are possible effects of the mutated sequence?

1 the presence of mRNA stop codons, UAG, UAA or UGA

2 a change in the sequence of amino acids

3 a non-functional protein

4 ribosomes cannot translate the mRNA

A 1, 2 and 3 **B** 1, 3 and 4 **C** 1 and 4 only **D** 2 and 3 only

26 The statements describe the process of translation.

1 A peptide bond forms between adjacent amino acids.

2 Hydrogen bonds form between the anticodon and the codon.

3 mRNA binds to the ribosome.

4 tRNA enters the ribosome carrying a specific amino acid.

In which order does this process take place?

A $3 \rightarrow 2 \rightarrow 1 \rightarrow 4$

B $3 \rightarrow 4 \rightarrow 2 \rightarrow 1$

C $4 \rightarrow 2 \rightarrow 1 \rightarrow 3$

D $4 \rightarrow 2 \rightarrow 3 \rightarrow 1$

27 The sequence of amino acids in a section of a polypeptide is:

… histidine–proline–aspartic acid–leucine...

amino acid	possible DNA triplet codes	
aspartic acid	CTA	CTG
histidine	GTA	GTG
leucine	GAT	GAC
proline	GGA	GGG

What is a correct sequence of mRNA codons for this polypeptide section?

A …CAC CCC GAA CUG…

B …CAU CCU GAC CUA…

C …GTA CCA CTG GAT…

D …GUA GGA CUG GAU…

28 Two students were discussing the involvement of DNA and RNA in transcription and translation.

- Student 1 always stated correct facts.
- Student 2 gave further information, which was sometimes correct.

	correct facts given by student 1	further information given by student 2
1	A length of mRNA is 747 nucleotides long, including stop and start codons.	This mRNA can produce a polypeptide that is 249 amino acids long.
2	Adjacent mRNA codons of AAU and CUG bind to complementary tRNA anticodons.	There is a total of 14 hydrogen bonds formed between these two codons and their anticodons.
3	RNA polymerase catalyses the formation of the mRNA from the template strand of DNA.	During translation, an RNA adenine nucleotide will pair with a DNA thymine nucleotide.
4	A DNA adenine nucleotide is structurally different to an RNA adenine nucleotide.	The difference is in the hexose sugars; DNA is deoxyribose and RNA is ribose.

Which further information, given by student 2, is correct?

A 1 and 4 **B** 2 and 3 **C** 2 only **D** 4 only

29 An antibiotic enters bacterial cells through a membrane channel protein, P.

Some bacterial cells have shown resistance to this antibiotic by acquiring a mutation which alters P. This mutation prevents the entry of the antibiotic into the cell.

Which conclusions can be drawn about how resistance to this antibiotic developed in these bacteria?

1 The mutation changed the order of the amino acids in the gene coding for P.

2 The mutation resulted in the production of P with an altered tertiary structure.

3 The antibiotic is a hydrophobic molecule and so cannot cross the phospholipid bilayer to enter the cell.

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

30 What is the correct tRNA anticodon coding for the amino acid proline?

amino acid	DNA triplet code on transcribed strand
alanine	CGT
histidine	GTG
proline	GGT

A CCA **B** CCU **C** GGT **D** GGU

31 The mRNA sequences of the three stop codons are shown.

UAA UAG UGA

Which mutation in the template (transcribed) strand of a DNA sequence that codes for a polypeptide would cause translation to stop prematurely?

A ATT changed to ATC

B ACT changed to ACA

C ACC changed to ATT

D ATC changed to TAG

32 A population of bacteria is exposed to the antibiotic penicillin. Most of the bacteria die.

However, some bacteria in the population have an allele coding for an enzyme that breaks down penicillin. These bacteria are able to survive.

Which could explain how these bacterial cells acquired this allele?

1 An error during DNA replication.

2 An error during transcription.

3 An error during translation.

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

33 Part of the nucleotide sequence of an mRNA molecule is shown, with spaces between the codons.

CAG UAC AGC AAU CUA UAA

The translation of the codons is provided.

codon	amino acid or STOP
AAU	asn
AGC	ser
CAG	gln
CUA	leu
UAA	STOP
UAC	tyr
UAU	tyr

Which events will cause the termination of polypeptide synthesis during translation?

1 Deletion of C from the leu codon.

2 Deletion of C from the tyr codon.

3 The ribosome reaching the UAA codon.

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

34 Which description of a eukaryotic gene is correct?

A a sequence of bases that forms part of a DNA molecule and codes for a protein

B a sequence of nucleotides that forms part of a DNA molecule and codes for a polypeptide

C a sequence of bases that forms part of an RNA molecule and codes for a protein

D a sequence of nucleotides that forms part of an RNA molecule and codes for a polypeptide

35 The DNA sequence CCAAGAAGTCGACAAACA is translated to synthesise the amino acid chain gly-ser-ser-ala-val-cys.

As a result of a mutation, the sequence length of the amino acid chain is shortened from six to two amino acids. A stop codon in mRNA is UGA.

Which base in the DNA sequence was changed by the mutation?

A A **B** C **C** G **D** T

36 In a genetic engineering experiment a piece of double-stranded DNA containing 6000 nucleotides coding for a specific polypeptide is transcribed and translated.

What is the total number of amino acids in this polypeptide?

A 500 **B** 1000 **C** 2000 **D** 3000

37 Which statements about tRNA are correct?

1 Hydrogen bonds between bases temporarily hold tRNA against mRNA.

2 The base sequences in the tRNA molecules are the same as the base sequences in the mRNA that is being translated.

3 tRNA translates the base sequence in mRNA into the amino acid sequence in a protein.

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

38 Sickle cell anaemia is caused by a mutation in an allele of the gene that codes for the β-globin polypeptide of haemoglobin.

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How will the mutation in the allele result in the production of an altered version of the β-globin polypeptide?

A A tRNA molecule with the anticodon GUG will hydrogen bond to the altered codon on mRNA.

B All the amino acids coded for after the mutation will differ from those in the Hb^A protein.

C mRNA transcribed from the Hb^S allele will contain the codon CAC instead of the codon CTC.

D The ribosome will be unable to continue translation of the Hb^S mRNA after the altered codon.

39 The RNA triplet UAG acts as a stop codon terminating the synthesis of a polypeptide. The diagram shows a strand of DNA which codes for four amino acids.

Where would an insertion mutation of a thymine nucleotide result in the termination of translation?



40 Which is the correct DNA triplet on the original DNA template that codes for the amino acid histidine (His)?

amino acid	anticodon
Ala	CGU
His	GUA
Ser	UCA

A CAU **B** CGT **C** GTA **D** GUA

41 Which statements about tRNA are correct?

1 Hydrogen bonds between bases temporarily hold tRNA against mRNA.

2 The base sequences in the tRNA molecules are the same as the base sequences in the mRNA that is being translated.

3 The specificity of the tRNA molecule for glycine and the specificity of the enzyme that loads glycine are both necessary for correct loading.

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

42 Following translation, the alpha polypeptide chain of haemoglobin, α-globin, undergoes modification. During this modification, the first amino acid is removed, leaving 141 amino acid residues.

How many nucleotides does the gene coding for α-globin contain?

A 141 **B** 142 **C** 423 **D** 426