DNA and Protein Synthesis: AQA A Level Biology Exam Questions by To

18 questions · 39 marks · about 51 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · A level Paper 1 · June 2023 · Q06.1 · 2 marks

0 6 . 1 Define genome and proteome.

[2 marks]

Genome _____

_____

_____

Proteome _____

_____

_____

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Question 2 · AS Paper 1 · November 2020 · Q09.1 · 2 marks

0 9 Channel proteins called aquaporins enable water to be transported across membranes. Aquaporins are produced in cells when genes coding for the proteins are expressed. One aquaporin gene is called *PIP1b*. The expression of *PIP1b* in tobacco plant cells produces an aquaporin located in their cell membranes.

Scientists have produced genetically modified tobacco plants. The scientists inserted a gene from a different species into the DNA of tobacco plant cells. This gene causes an increase in the rate of transcription of the *PIP1b* gene.

The scientists found that the stomatal density of leaves from tobacco plants with the inserted gene was greater than that of unmodified control plants.

In a different investigation, scientists measured the movement of potassium ions and water molecules through cell-surface membranes and vacuole membranes. They found 6 potassium ions moved for every 150 water molecules across vacuole membranes. They found 3 potassium ions moved for every 1500 water molecules across cell-surface membranes.

Use information from the passage and your own understanding to answer the questions.

0 9 . 1 Explain how the proteome of a cell from a genetically modified tobacco plant (lines 5–7) differs from that of a cell from an unmodified control tobacco plant.

[2 marks]

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Question 3 · AS Paper 1 · June 2018 · Q07.2 · 2 marks

0 7 . 2 Give **two** structural differences between a molecule of messenger RNA (mRNA) and a molecule of transfer RNA (tRNA).

[2 marks]

1 _____

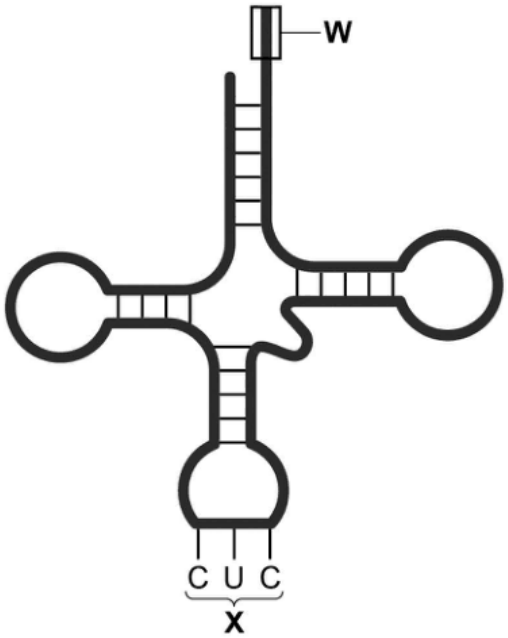
2 _____

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Question 4 · AS Paper 1 · June 2019 · Q01.3 · 1 mark

Figure 1 shows a tRNA molecule.

Figure 1



0 1 . 3 Name the structures labelled **W** and **X** in **Figure 1**.

[1 mark]

W _____

X _____

Question 5 · AS Paper 2 · June 2024 · Q04.1 · 1 mark

0 4 . 1 Where does transcription occur in a eukaryotic cell?

[1 mark]

_____

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Question 6 · A level Paper 1 · November 2020 · Q10.1 · 5 marks

1 0 . 1 Describe how mRNA is formed by transcription in eukaryotes.

[5 marks]

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Question 7 · A level Paper 1 · June 2025 · Q02.1 · 1 mark

0 2 . 1 Describe how mRNA is obtained from pre-mRNA.

[1 mark]

Question 8 · A level Paper 1 · June 2025 · Q02.2 · 2 marks

0 2 . 2 Describe how RNA polymerase joins RNA nucleotides.

[2 marks]

Question 9 · AS Paper 2 · June 2022 · Q01.3 · 2 marks

0 1 . 3 Scientists produced a short, single-stranded, artificial nucleic acid, called PNA. The PNA binds to a small section of DNA.

The scientists introduced PNA into cells and discovered that these cells produced less mRNA than cells that did not contain PNA.

Suggest how PNA affected the transcription of the section of DNA.

[2 marks]

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Question 10 · information from earlier in the question

Recombinant DNA technology can involve the transfer of fragments of human DNA into bacteria. The bacteria are then used to produce human proteins.

Question 10 · A level Paper 3 · June 2022 · Q04.3 · 1 mark

0 4 . 3 Suggest and explain **one** reason why bacteria might **not** be able to produce every human protein.

[1 mark]

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Question 11 · AS Paper 1 · June 2018 · Q07.3 · 5 marks

0 7 . 3 Starting with mRNA in the cytoplasm, describe how translation leads to the production of a polypeptide.

Do **not** include descriptions of transcription and splicing in your answer.

[5 marks]

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Question 12 · AS Paper 1 · June 2023 · Q04.4 · 2 marks

0 4 . 4 The rate of translation is increased in T cells activated by antigens.

Describe the role of tRNA in translation.

[2 marks]

Question 13 · AS Paper 2 · June 2017 · Q03.2 · 3 marks

0 3 . 2 Multiple copies of the *AMY1* gene is an adaptation to a high-starch diet.

Use your knowledge of protein synthesis and enzyme action to explain the advantage of this adaptation.

[3 marks]

[Extra space]

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Question 14 · information from earlier in the question

0 4 This question is about genes and the genetic code.

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0 4 . 2 **Table 2** shows the amino acids coded for by each mRNA codon.

Table 2

First base	Second base				Third base
	Guanine (G)	Adenine (A)	Cytosine (C)	Uracil (U)	
G	Ala	Glu	Ala	Val	G
	Gly	Glu	Ala	Val	A
	Gly	Asp	Ala	Val	C
	Gly	Asp	Ala	Val	U
A	Arg	Lys	Thr	Met	G
	Arg	Lys	Thr	Iso	A
	Ser	Asn	Thr	Iso	C
	Ser	Asn	Thr	Iso	U
C	Arg	Gln	Pro	Leu	G
	Arg	Gln	Pro	Leu	A
	Arg	Hist	Pro	Leu	C
	Arg	Hist	Pro	Leu	U
U	Trp	**stop**	Ser	Leu	G
	stop	**stop**	Ser	Leu	A
	Cyst	Tyr	Ser	Phe	C
	Cyst	Tyr	Ser	Phe	U

Use **Table 2** to complete **Table 3** to show:

- the mRNA base sequence transcribed from the DNA base sequence
- the amino acid sequence translated from the mRNA base sequence.

[2 marks]

Table 3

DNA base sequence	**G**	**C**	**T**	**C**	**T**	**A**	**C**	**A**	**G**
mRNA base sequence									
Amino acid sequence									

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Table 3 shows **mRNA** codons for some amino acids.

Table 3

Serine	Proline	Glycine	Threonine	Alanine
UCU	CCU	GGA	ACU	GCA
UCC	CCA	GGG	ACC	GCG

0 6 . 3 **Figure 6** shows the DNA template nucleotide base sequence that determines the sequence of four amino acids.

Figure 6

AGG CGT CCT GGA

Use information from **Table 3** and **Figure 6** to give the amino acid sequence determined by this sequence of nucleotides.

[1 mark]

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Question 16 · information from earlier in the question

Table 2 shows:

- mRNA codons and the amino acid coded for by each codon
- the type of bond formed by the R group of some of the amino acids.

Table 2

First base	Second base				Third base
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		Stop	Stop	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gln		A
					G
A	Ile	Thr	Asn	Ser	U
					C
	Met		Lys	Arg	A
					G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Key to the type of bond formed by the R group of each amino acid

Hydrogen bonds Ionic bonds Disulfide bridges

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Question 16 · A level Paper 1 · November 2021 · Q03.3 · 2 marks

0 3 . 3 The amino acid replacement of Arg with Gly is caused by a single base substitution mutation in the DNA. The non-mutant DNA triplet is TCC.

Complete **Table 3**.

Give:

- the mRNA codon complementary to the non-mutant DNA triplet
- the mutated mRNA codon that could cause the change from Arg to Gly in the crystallin protein
- the DNA triplet complementary to this mutated mRNA codon.

[2 marks]

Table 3

mRNA codon for the non-mutant triplet	
Mutated mRNA codon	
Mutated DNA triplet	

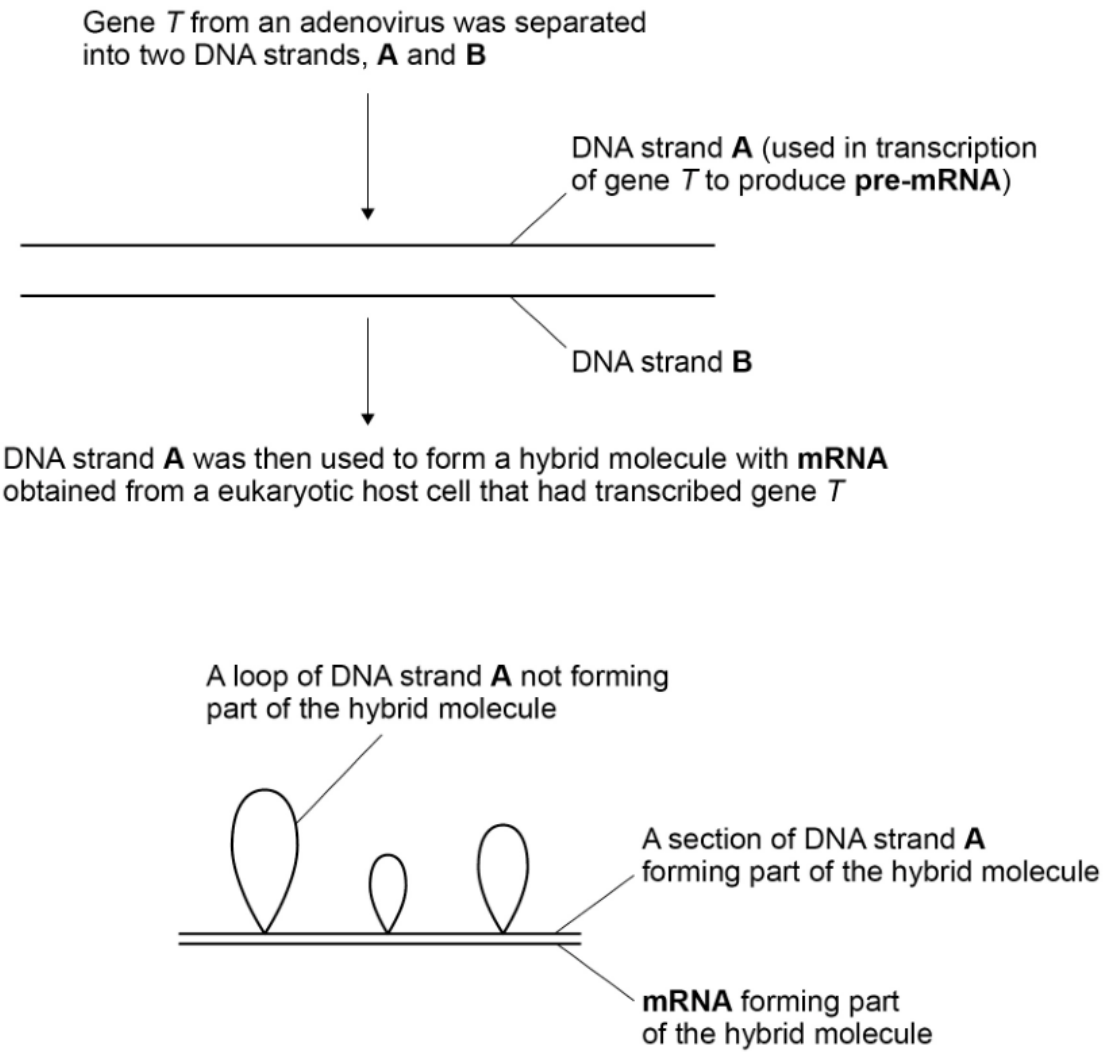
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0 4 . 2 The genome of an adenovirus is a single, linear molecule of double-stranded DNA. Adenoviruses use eukaryotic host cells to transcribe their genes in protein synthesis. The process of transcription of adenovirus genes is similar to the process of transcription of genes in eukaryotes.

Scientists investigated the process of transcription of this viral DNA.

Figure 4 shows one of the experiments carried out by these scientists.

Figure 4



Looking at the results of the experiment in **Figure 4**, the scientists concluded that splicing had taken place.

Use **Figure 4** to describe and explain why the scientists' conclusion was justified.

[3 marks]

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Question 18 · AS Paper 2 · June 2024 · Q04.3 · 2 marks

0 4 . 3 Describe and explain how the results of the experiment in **Figure 4** would differ if the scientists had used prokaryotic DNA.

[2 marks]

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Mark schemes

Questions, mark schemes and examiners' report extracts © AQA.

Question 1 · A level Paper 1 · June 2023 · Q06.1 · 2 marks

06.1	(Genome) 1. Complete set of genes in a cell **OR** (All) the DNA in a cell **OR** (All) the genes/alleles/genetic material in a cell **OR** The total number of DNA bases in a cell; (Proteome) 2. (Full) range of proteins that a cell **can produce** **OR** (Full) range of proteins **coded for** by the cell's DNA/genome;	2 (2 x AO1)

1. Reject 'all the DNA/genes within a species/population'

1 and 2. Accept organism for cell

2. For 'full range' accept 'complete set' OR all

2. Do not accept 'number of proteins' unqualified

2. Ignore 'range of proteins that a species/population can produce'

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Question 2 · AS Paper 1 · November 2020 · Q09.1 · 2 marks

09.1	1. Expression of gene from different species; 2. (So) a new/one more protein (in set/range of proteins);	2

Question 3 · AS Paper 1 · June 2018 · Q07.2 · 2 marks

07.2	1. mRNA does not have hydrogen bonds / base pairing, tRNA does; **OR** mRNA is linear / straight chain, tRNA is cloverleaf; 2. mRNA does not have an amino acid binding site, tRNA does; 3. mRNA has more nucleotides; 4. (Different) mRNAs have different lengths, all tRNAs are similar / same length; 5. mRNA has codons, tRNA has an anticodon;	2 max

Statements must be comparative 2. Accept mRNA cannot carry an amino acid, tRNA can 3. Accept mRNA is longer or converse

Question 4 · AS Paper 1 · June 2019 · Q01.3 · 1 mark

01.3	W = amino acid binding site **and** X = anticodon;	1	**W** Idea of binding site needed

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Question 5 · AS Paper 2 · June 2024 · Q04.1 · 1 mark

04.1	Nucleus;	1 (1 x AO1)	

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Question 6 · A level Paper 1 · November 2020 · Q10.1 · 5 marks

10.1	1. Hydrogen bonds (between DNA bases) break; 2. (Only) one DNA strand acts as a template; 3. (Free) RNA nucleotides align by complementary base pairing; 4. (In RNA) Uracil base pairs with adenine (on DNA) OR (In RNA) Uracil is used in place of thymine; 5. RNA polymerase joins (adjacent RNA) nucleotides; 6. (By) phosphodiester bonds (between adjacent nucleotides); 7. Pre-mRNA is spliced (to form mRNA) OR Introns are removed (to form mRNA);	5 max

Ignore DNA helicase.

1. Reject hydrolysing hydrogen bonds.
3. For 'align by complementary base pairing', accept 'align to complementary bases' or 'align by base pairing'.
4. Do not credit use of letters alone for bases.
5. Reject suggestions that RNA polymerase forms hydrogen bonds or joins

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Question 7 · A level Paper 1 · June 2025 · Q02.1 · 1 mark

02.1	Introns removed (and exons joined);	1 (1 x AO1)	Accept description of non-coding DNA for 'introns'

Question 8 · A level Paper 1 · June 2025 · Q02.2 · 2 marks

02.2	1. Phosphodiester bond; 2. (By) <u>condensation</u> (reaction);	2 (2 x AO1)	1. Reject if phosphodiester bond is between incorrect molecules, eg joins AU/GC **OR** complementary nucleotides/bases

Question 9 · AS Paper 2 · June 2022 · Q01.3 · 2 marks

01.3	1. PNA is complementary to DNA **OR** PNA forms base pairs with DNA; 2. Preventing/reducing RNA polymerase activity/binding **OR** Prevents RNA nucleotides binding **OR** Reducing/stopping transcription;	2 (2 x AO2)

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Question 10 · A level Paper 3 · June 2022 · Q04.3 · 1 mark

04.3	Cannot splice (pre-mRNA), **so** cannot remove introns **OR** Do not have Golgi (apparatus), **so** cannot process/modify (proteins) **OR** Do not have transcriptional factors (required), **so** cannot carry out transcription/produce mRNA;

1 (AO2)	Accept do not have spliceosomes/ spliceozyme for cannot splice Accept 'rough endoplasmic reticulum' for 'Golgi' Accept (human protein) is too complex and bacteria do not have Golgi (apparatus)

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Question 11 · AS Paper 1 · June 2018 · Q07.3 · 5 marks

07.3	1. mRNA associates with a ribosome / ribosome attaches to mRNA; 2. Ribosome moves to / finds the start codon / AUG; 3. tRNA brings / carries (appropriate / specific) amino acid; 4. Anticodon (on tRNA complementary) to codon (on mRNA); 5. Ribosome moves along to next codon; **OR** Ribosome 'fits' around two codons / can fit two tRNAs; 6. (Process repeated and) amino acids join by peptide bonds / condensation reaction (to form polypeptide); **OR** (Process repeated and) amino acids joined using (energy from) ATP (to form polypeptide);	5 max

1. Idea of association is required

3. and 5. Must be explicitly stated and not inferred.

Question 12 · AS Paper 1 · June 2023 · Q04.4 · 2 marks

04.4	1. Anticodon (on tRNA) binds to (complementary) codon (on mRNA); 2. (tRNA) brings/carries specific amino acid (to ribosome);	2 (2 x AO1)

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Question 13 · AS Paper 2 · June 2017 · Q03.2 · 3 marks

03.2	1. More mRNA / more transcription; 2. More translation / enzyme; 3. So reaction faster;	3	The idea of "more" must be stated at least once. 2. Accept 'amylase' for enzyme 3. "More starch digested" is insufficient

Question 14 · AS Paper 1 · June 2025 · Q04.2 · 2 marks

04.2

1. Correct mRNA sequence;
2. Correct amino acid sequence;

DNA base sequence	G	C	T	C	T	A	C	A	G
mRNA base sequence	**C**	**G**	**A**	**G**	**A**	**U**	**G**	**U**	**C**
Amino acid sequence	**ARG**			**ASP**			**VAL**		

2 (2 x AO2)

Question 15 · AS Paper 1 · November 2020 · Q06.3 · 1 mark

06.3	Serine Alanine Glycine Proline;	1	Must be in this order Accept Ser Ala Gly Pro / S A G P

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Question 16 · A level Paper 1 · November 2021 · Q03.3 · 2 marks

03.3

3 correct = 2 marks;;
2 correct = 1 mark;
0 or 1 correct = 0 marks

mRNA codon for the non-mutant triplet	AGG
Mutated mRNA codon	GGG
Mutated DNA triplet	CCC

2

Question 17 · AS Paper 2 · June 2024 · Q04.2 · 3 marks

04.2

1. Loops (of DNA) contain introns;
2. DNA forming hybrid (molecule) contain exons;
3. Complementary base pairing occurs between DNA and mRNA

   OR

   Hydrogen bonding occurs between DNA and mRNA;
4. Introns removed during splicing

   OR

   Introns removed to produce mRNA;
5. (The) mRNA is shorter (than original DNA/pre-mRNA strand) due to splicing;

3 max (3 x AO3)

1. Accept 'non-coding' for introns, but only for mark point 1.

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Question 18 · AS Paper 2 · June 2024 · Q04.3 · 2 marks

04.3	1. No loops (of DNA); 2. (Because) no introns (in prokaryotic DNA);	2 (2 x AO2)

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