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VCE Biology ¾

Nucleic Acids & The Structure of Genes [1.2]

Test Solutions

34 Marks. 1 Minute Reading. 21 Minutes Writing.

Results:

Test	_____ / 27
Extension	_____ / 7

Section A: Test Questions (5 Marks)

Question 1 (5 marks)

Tick whether the following statements are **true** or **false**.

	True	False
a. DNA is a single-stranded molecule found in the nucleus.		✓
b. The sugar in RNA nucleotides is ribose, while in DNA nucleotides it is deoxyribose.	✓	
c. Complementary base pairing in DNA involves adenine pairing with thymine and cytosine pairing with guanine.	✓	
d. mRNA is responsible for carrying genetic instructions from the nucleus to the ribosome for protein synthesis.	✓	
e. tRNA is single-stranded but folds into a specific shape to carry amino acids during translation.	✓	
f. Exons are the non-coding regions of a gene that are removed during RNA processing.		✓
g. The genetic code is universal, meaning all organisms use the same DNA base sequences to encode proteins.	✓	
h. Phosphodiester bonds join nucleotides together in a nucleic acid chain.	✓	
i. In RNA, the base thymine is replaced by uracil.	✓	
j. The promoter region of a gene is responsible for terminating transcription.		✓

Section B: Multiple Choice Questions (5 Marks)

Question 2 (1 mark)

A student observed a diagram of single-stranded nucleic acid and determined that it was DNA. A piece of evidence that would support this is the presence of:

A. Uracil.

B. A deoxyribose sugar.

C. A methyl cap and a poly A tail.

D. Anticodons.

Explanation:
Uracil is found in RNA, and a methyl cap and poly A tail are added to mRNA during post-transcriptional modification. Anticodons are present on tRNA. DNA contains a deoxyribose sugar.

Question 3 (1 mark)

The genetic code is considered redundant as:

A. All organisms are coded for by the same nucleotides.

B. Multiple codons code for the same amino acid.

C. All nucleotides are double-ringed purines.

D. It is not required for all cell functioning.

Explanation:
The genetic code is considered redundant, as more than one codon can code for a single amino acid. If all organisms had the same nucleotide sequence, all organisms would be identical, and option A is incorrect.

Question 4 (1 mark)

A canola crop had a gene coding for an omega-3 fatty acid, derived from bacteria, inserted into it: Genome. Individuals who ate the canola gained the benefit of increased omega-3 fatty acids, such as healthier membranes. The characteristic of DNA that allowed this to occur is that the DNA code is:

A. Universal.

B. Redundant.

C. Degenerate.

D. Transferable.

Explanation:
As every living organism contains the same 4-nitrogenous bases for DNA, any organism can receive DNA from a different species, and the same segment of DNA will code for the same protein in any organism.

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Question 5 (1 mark)

A condensation reaction includes:

A. The joining of two nucleotides together.

B. The conversion of ATP into ADP.

C. The digestion of a polypeptide.

D. All of the steps during glycolysis.

Explanation:
Condensation reactions occur when larger molecules are formed from smaller ones. When amino acids join together, a molecule of water is liberated (condensation) as the larger molecule (polymer) is being formed. ATP-forming ADP liberates energy; digesting polypeptides is a hydrolysis reaction (opposite to condensation); and the conversion of glucose to pyruvate during glycolysis is a catabolic reaction.
Study Design Reference:
The synthesis of a polypeptide chain from amino acid monomers by condensation polymerisation.
Web Link
https://www.cengage.com/biology/discipline_content/animations/reaction_types.html

Question 6 (1 mark)

Which one of the following statements about biological macromolecules is correct?

A. Nucleic acids are converted into nucleotides by a condensation reaction.

B. Hydrolysis reactions can convert amino acids into proteins.

C. All amino acids contain the elements C, H, O, N and S.

D. There are five naturally occurring nitrogenous bases.

Explanation:
Condensation reactions involve small molecules joining to make larger molecules, such as amino acids joining to form proteins. Therefore, B is incorrect. Hydrolysis reactions are the opposite of condensation reactions; large molecules are converted into smaller molecules, such as nucleic acids converting into nucleotides. Therefore, A is incorrect. Only one amino acid contains sulphur as an element (cysteine). Therefore, C is incorrect.

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Section C: Short Answer Questions (17 Marks)

Question 7 (3 marks)

There are structural differences between molecules of DNA and RNA.

a. Outline two of these differences by completing the following table. (2 marks)

	DNA	RNA
Difference 1	➢ Double stranded ➢ Contains thymine ➢ Contains deoxyribose sugar	➢ Single stranded ➢ Contains uracil ➢ Contains ribose sugar
Difference 2		

Marks	0	1	2	Average
%	18	25	57	1.4

b. Name one kind of RNA and state its function. (1 mark)

Type _____

Func _____

_____

Question 2b.

Marks	0	1	Average
%	61	39	0.4

Any one of:

- mRNA: to carry information from the nucleus to the ribosome for protein synthesis
- tRNA: to carry specific amino acids to the ribosome for protein synthesis
- rRNA: a structural component of the ribosome.

The specific name of the RNA was not required; a letter was a suitable way to distinguish the type. Students should know that tRNA is transferRNA, **not** transportRNA. Students who used this incorrect term were not awarded a mark. Many students also incorrectly used the terms 'transcription' and 'translation'.

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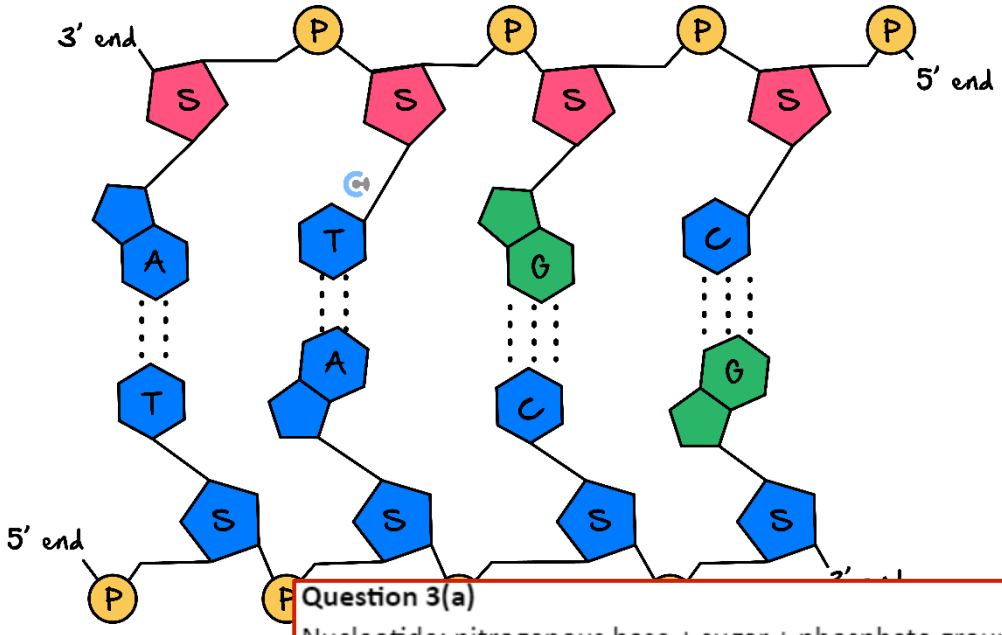
Question 8 (3 marks)

Below is a diagram of part of a DNA molecule.



Question 3(a)
Nucleotide: nitrogenous base + sugar + phosphate group

a. Draw a circle around one nucleotide on the diagram. (1 mark)

b. Complete the table below. (2 marks)

% **of each base**	%	A	C	T	G	**G**
Strand 1	Strand 1	25	5	30	40	
Strand 2	Strand 2	30	40	25	5	

Question 9 (6 marks)

a. A section of one of the stands of a DNA molecule has a sequence of bases shown.

DNA : C T T A C A T T A C T C

In the spaces below, enter the sequence of bases in the corresponding mRNA, which is complimentary to this DNA. (1 mark)

Question 2a.

Marks	0	1	Average
%	42	59	**0.6**

mRNA	G	A	A	U	G	U	A	A	U	G	A	G

Many students transcribed the DNA correctly, however omitted a base or made one mistake and did not gain the mark.
Some students incorrectly transcribed the DNA and gave T (thymine) rather than U (uracil).

mRNA	

b. The percentage of base T in a molecule of DNA is 30%. What is the percentage of G bases in the same DNA molecule? (1 mark)

Question 2b.

Marks	0	1	Average
%	42	58	**0.6**

20 per cent

Another type of nucleic acid is tRNA.

c.

i. Where is tRNA found in the cell? (1 mark)

Question 2ci.
Cytosol or cytoplasm

Many students could not correctly identify where tRNA is found. A common incorrect answer was the nucleus.

ii. Describe the role of tRNA. (1 mark)

Question 2cii.
tRNA (transfer RNA) carries the correct amino acid to the ribosomes.

Answers to this question were not precise enough to gain the mark.

d. The table shows the names of six amino acids together with some of their DNA codes.

Amino acids	DNA triplet(s)
Cysteine	ACA, ACG
Glutamic acid	CTT, CTC
Aspartic acid	CTA, CTG
Asparagine	TTA, TTG
Leucine	GGA, GAG, GAT, GAC
Methionine	TAC

Use the information in the table and write the order of amino acids coded for by the DNA sequence given in **part a.** (1 mark)

Question 2d.

Marks	0	1	Average
%	22	78	**0.8**

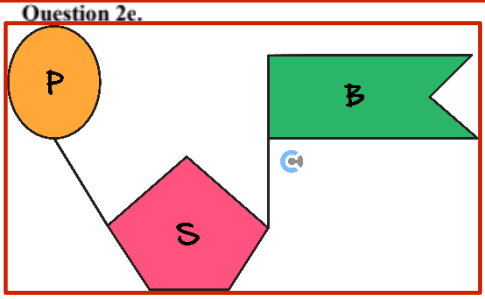
Glutamic acid, cysteine, asparagine, glutamic acid

Students should be aware that if they choose not to write the complete answer and give abbreviations, these abbreviations must be recognisable. For example, 'asp' could represent aspartic acid **or** asparagine, and as a consequence these answers could not gain the mark.

Nucleic acids are made up of nucleotides. Each nucleotide consists of three components, sugar (S), phosphate (P) and nitrogen base (B), linked together in a particular way.

e. In the empty box, draw a diagram to show the way the three components are joined to make a nucleotide. (1 mark)

Question 2e.



To gain the mark, students needed to join the other two components on either side of the sugar. Most students demonstrated a pleasing level of understanding of the structure, function and role of nucleic acids.

Question 10 (5 marks)

a. In reference to DNA, explain the meaning of the term 'anti-parallel'. (2 marks)

The structure of DNA and the three forms of RNA including similarities and differences in their subunits, and their synthesis by condensation polymerisation

Question 1c (2 marks)
In reference to this molecule, explain the meaning of the term 'anti-parallel'.

Answer:
- *The strands of a DNA double helix are said to be 'anti-parallel' because they have the same chemical structure, but run in opposite in directions.*
- *One runs in the 3' to 5' direction and the other in the 5' to 3' direction.*

Marking protocol:
One mark for each of the above points.

b. Identify three places in a plant cell where DNA can be located. (3 marks)

The role of different organelles including ribosomes, endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of a protein product from the cell through exocytosis

Question 1d (3 marks)
Identify three places in a plant cell where this molecule can be located.

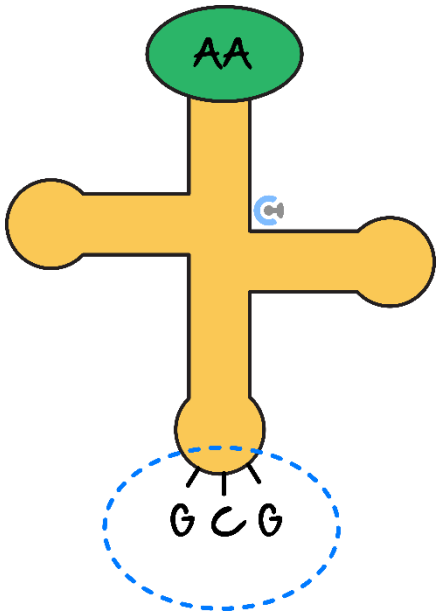
Answer:
- *Nucleus.*
- *Chloroplast.*
- *Mitochondria.*

Marking protocol:
One mark for each of the above points.

Section D: Extension (7 Marks)

Question 11 (7 marks)

RNA typically occurs as single-stranded molecules, but tRNA molecules usually take the shape shown in the **figure below**.



a. What does the term tRNA stand for? (1 mark)

Question 2 (7 marks)
a. Transfer ribonucleic acid **(1 mark)**.

b. Name **two** other forms of RNA involved in protein synthesis. (1 mark)

b. Messenger ribonucleic acid (mRNA) and ribosomal ribonucleic acid (rRNA) **(1 mark)**.

c. Explain what structural features of the tRNA molecule enable it to form the functional shape shown in the **above figure** rather than remaining as a linear strand. (2 marks)

c. Hydrogen bonds form between neighbouring nucleotides in the ribonucleic acid strand **(1 mark)**.
Adenine bonds to uracil and cytosine bonds to guanine **(1 mark)**.

d. What term is given to the three nucleotides that are circled in the **above figure**? (1 mark)

d. Anticodon **(1 mark)**.

e. Describe the role of tRNA in translation. (2 marks)

e. tRNA brings a *specific* amino acid to the ribosome for translation **(1 mark)**. The anticodon that is complementary to the codon of the mRNA strand binds at the ribosome and the amino acid is removed to join the growing polypeptide chain **(1 mark)**.

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