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VCE Biology ¾

Nucleic Acids & the Structure of Genes [1.2]

Homework Solutions

Homework Outline:

Compulsory	Pg 2 – Pg 12
Solutions	Pg 2 – Pg 12

Section A: Compulsory (25 Marks)

Sub-Section [1.2.1]: Identify and Compare the Characteristic Features of the Structures of Nucleic Acids and Their Monomers, Including DNA, mRNA, tRNA and rRNA, Including Base Pairing

Question 1

Definitions:

a. Nucleic acids.

One of the major classes of biomolecules are polymers composed of nucleotide monomers, responsible for storing genetic information and forming molecules that aid in the synthesis of proteins.

b. DNA.

Deoxyribonucleic Acid is double-stranded and carries the instructions for proteins required to cell survival and function.

c. mRNA.

messenger Ribonucleic Acid, responsible for carrying genetic information from the nucleus to the ribosomes.

d. tRNA.

transfer RNA, responsible for delivering specific amino acids to the ribosome during translation.

e. rRNA.

ribosomal RNA, a key structural component of the ribosomes, which synthesise proteins.

Question 2 (1 mark)

A strand of RNA contains the sequence 5′-AUGGCUAUC-3′. Which of the following corresponds to the tRNA anticodons that would bind to this strand during translation?

A. 5′-UACCGATAG-3′

B. 5′-UACCGAUAG-3′

C. 5′-AUGGCUAUC-3′

D. 5′-GCUAUGUAG-3′

Explanation: tRNA anticodons are complementary to mRNA codons and are written in the 5′-3′ direction.

Question 3 (1 mark)

Which of the following would be most affected by a mutation that damages rRNA?

A. The transcription of DNA to mRNA.

B. The assembly of ribosomes and protein synthesis.

C. The stability of the mRNA transcript.

D. The transport of amino acids to the ribosome.

Explanation: rRNA is critical for ribosome structure and function during protein synthesis.

Question 4 (1 mark)

Which one of the following correctly compares DNA and RNA?

	DNA	RNA
A.	Contains deoxyribose	Contains ribose
B.	Is a shorter molecule	
C.	Found only in the nucleus eukaryotes	
D.	Contains four different mono	

A is correct. As DNA is deoxyribose nucleic acid, the five-carbon sugar in its nucleotides is deoxyribose. As RNA is ribonucleic acid, the five-carbon sugar in its nucleotides is ribose.
B is incorrect. DNA makes up chromosomes, which contain multiple genes; thus, DNA is usually longer than RNA because RNA is generally a copy of a single gene.
C is incorrect. Both DNA and RNA in eukaryotes are located in a variety of cytoplasmic locations.
(for example, mitochondria and chloroplasts).
D is incorrect. Both DNA and RNA have four different monomers (A, G, C, and T in DNA and A, G, C, and U in RNA).

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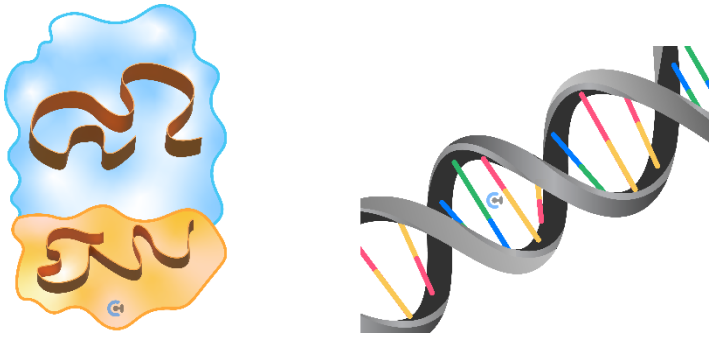
Question 5 (6 marks)

The image below shows 2 different molecules found within cells, rRNA and DNA.



a. Name the location within a eukaryotic cell where each molecule would be found. (1 mark)

Ribosomal RNA is found in the ribosome, whereas DNA is found in the nucleus.

b. Only one example is needed for each. Two correct responses must be given for the differences to attain one mark.

ecules of rRNA and DNA. (2 marks)

	rRNA	DNA
Difference	Ribose sugar Single stranded Uracil	Deoxyribose sugar Double stranded Thymine
Similarity	Pentose sugar Both composed of nucleotides	

c. How would DNA differ in prokaryotic and eukaryotic organisms? (1 mark)

One of:
In prokaryotes, DNA is circular, whereas in eukaryotes, DNA is linear.
In prokaryotes, DNA is found in the cytosol, and in eukaryotes, it is found in the nucleus.

d. Adenine and guanine are both classified as purines, double-ringed structures of nucleic acids. A cell was found to contain 10% guanine. What percentage of thymine would be found in the cell? Explain. (2 marks)

As 10% of the cell is guanine, 10% must also be cytosine due to complementary base pairing (1). The remaining nucleotides would be 40% adenine and 40% thymine (1).

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Sub-Section [1.2.2]: Identify and Describe the Structure of a Nucleotide in DNA and RNA

Question 6

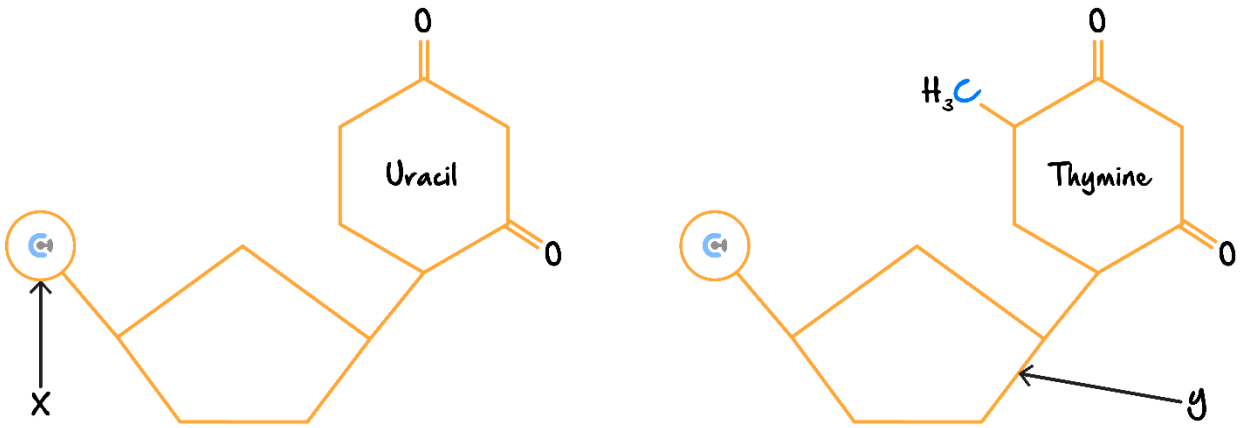
Definitions:

Nucleotide.

The monomer subunit of nucleic acids, with a general structure of a sugar group attached to a phosphate group and a nitrogenous base.

Question 7 (1 mark)

The basic structure of two nucleotides is shown below. Each nucleotide has three subunits.



It can be concluded that the:

A. Subunit labelled *X* is a nitrogen base.

B. Subunit labelled *Y* is a ribose sugar.

C. Nucleotide with the subunit labelled uracil can be found in DNA.

D. Nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

Question 8 (5 marks)

Draw the structure of a nucleotide chain, labelling the key features. In your diagram, make sure to label the bonds between nucleotides and the components of the nucleotide.

Solution Pending

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Sub-Section [1.2.3]: Define the Key Components of a Gene, Including a Comparison Between the Structure of Genes in Eukaryotes and Prokaryotes

Question 9

Definitions:

a. Gene.

A specific sequence of nucleotides in DNA that codes for a protein or functional RNA molecule.

b. Key Components of a Gene.

- **Promoter Region:** A sequence where RNA polymerase binds to initiate transcription.
- **Exons:** Coding regions of a gene that are expressed as proteins.
- **Introns:** Non-coding regions that are removed during RNA processing in eukaryotes.
- **Terminator:** A sequence signalling the end of transcription.

c. Gene Structure in Eukaryotes vs. Prokaryotes.

- **Eukaryotes:** Genes have introns and exons, and transcription occurs in the nucleus.
- **Prokaryotes:** Genes lack introns, and transcription occurs in the cytoplasm.

Question 10 (1 mark)

A researcher isolates a gene with introns and exons and observes that RNA processing is required before translation. From which type of organism is this gene most likely derived?

A. A eukaryotic organism, because only eukaryotic genes contain introns and undergo RNA processing.

B. A prokaryotic organism, because prokaryotes require RNA processing to remove non-coding regions.

C. Either a eukaryotic or prokaryotic organism, because introns are found in both.

D. A viral genome, because introns and exons are characteristic of viruses.

Explanation: Only eukaryotic genes contain introns, which are removed during RNA splicing.

Question 11 (2 marks)

Explain the role of the promoter region in gene expression.

Promoter is where the transcription of a gene begins; RNA polymerase will bind to allow gene expression to occur.

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Sub-Section [1.2.4]: Identify and Practically Apply the Characteristics of the Genetic Code - Universal, Unambiguous, Degenerate, Triplet - to Real-Life Examples

Question 12

Definitions:

a. Universal.

The same codons specify the same amino acids in almost all organisms, e.g., AUG codes for methionine in humans and bacteria.

b. Unambiguous.

Each codon corresponds to only one specific amino acid, e.g., UUU always codes for phenylalanine.

c. Degenerate.

Multiple codons can code for the same amino acid, e.g., GGU, GGC, GGA, and GGG all code for glycine.

d. Triplet Code.

A sequence of three nucleotide bases (a codon) codes for one amino acid, e.g., AUG (start codon) codes for methionine.

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Question 13 (1 mark)

A mutation changes the codon UUU (phenylalanine) to UUC. What is the most likely effect on the resulting protein?

A. The mutation is silent, and the protein remains unchanged.

B. The mutation introduces a stop codon, prematurely ending translation.

C. The mutation changes the structure of the protein by replacing phenylalanine with leucine.

D. The mutation causes the ribosome to stall during translation.

Question 14 (1 mark)

Which of the following examples illustrates the degenerate nature of the genetic code?

A. AUG functions as the start codon in both humans and bacteria.

B. UAA, UAG, and UGA are all stop codons that terminate translation.

C. A single codon always specifies only one amino acid.

D. Some amino acids, like leucine, are coded for by multiple codons.

Question 15 (1 mark)

A pharmaceutical company tests a drug on human cells and bacterial cells. Both show the same response to the drug, which binds to mRNA codons during translation. What property of the genetic code is most relevant to this finding?

A. The genetic code is unambiguous.

B. The genetic code is unambiguous.

C. The genetic code is degenerate.

D. The genetic code is universal.

Explanation: The universal nature of the genetic code means codons are interpreted the same way in humans and bacteria.

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Question 16 (4 marks)

a. A mutation changes a codon in a human gene from GGU to GGC. There is no effect on the protein produced. Why is this the case? (2 marks)

There is no effect on the protein because GGU and GGC could both code for the same amino acid. This illustrates the degenerate nature of the genetic code, where multiple codons can specify the same amino acid.

b. Why is the universal nature of the genetic code important in modern biotechnology? Provide one example of its application. (1 mark)

The universal nature of the genetic code allows genes from one organism to be expressed in another. For example, the human insulin gene can be inserted into bacterial plasmids, and the bacteria can then produce human insulin for medical use.

c. A pharmaceutical researcher is designing a drug that binds specifically to the mRNA codon AUG in a bacterial cell. Why would this drug potentially affect protein synthesis in humans? (1 mark)

The drug could affect protein synthesis in humans because AUG serves as the start codon in both humans and bacteria, illustrating the universal nature of the genetic code. This means the drug may interfere with translation initiation in human cells as well.

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