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**VCE Biology  $\frac{3}{4}$**   
**Nucleic Acids & The Structure of Genes [0.2]**  
**Workshop Solutions**

## Section A: Multiple Choice Questions (15 Marks)

### Question 1 (1 mark)

Which of the following is unique to RNA but not DNA?

A. Contains thymine as a nitrogenous base.

B. Is double-stranded.

C. Contains ribose sugar instead of deoxyribose.

D. Functions exclusively in the nucleus.

c) Contains ribose sugar instead of deoxyribose.  
(RNA has ribose sugar, whereas DNA has deoxyribose.)

### Question 2 (1 mark)

Which type of nucleic acid is most likely to contain uracil?

A. DNA

B. mRNA

C. tRNA

D. Both b and c.

d) Both b and c.  
(RNA molecules, including mRNA and tRNA, contain uracil instead of thymine.)

### Question 3 (1 mark)

Which one of the following correctly matches the nucleic acid molecule with its role?

|    | Molecule | Role                                              |
|----|----------|---------------------------------------------------|
| A. | DNA      | Carries genetic information to ribosomes.         |
| B. | tRNA     | Carries amino acids to ribosomes.                 |
| C. | mRNA     | Structural component of ribosomes.                |
| D. | rRNA     | Contains genetic information that is transcribed. |

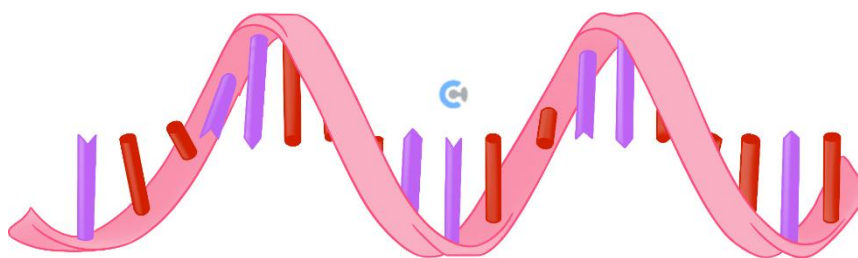
**Question 4** (1 mark)

Which of the following statements concerning DNA and RNA is incorrect?

- A. DNA is double-stranded; RNA is single-stranded.
- B. DNA contains adenine, thymine, cytosine and guanine bases; RNA contains adenine, uracil, cytosine and guanine bases.
- C. In eukaryotic cells, DNA is found in the nucleus; RNA is also found in the nucleus.
- D. DNA contains ribose sugar; RNA contains deoxyribose sugar.**

**Question 5** (1 mark)

The molecule shown below is extracted from the cytosol of a cell.



Source: <http://userscontent2.emaze.com>

If a chemical analysis was done on this molecule, you would expect to see:

- A. Phosphate groups and thymine.
- B. Phospholipid groups and guanine.
- C. Phosphate groups and uracil.**
- D. Phospholipid groups and adenine.

The molecule is RNA, as DNA is not found in the cytosol. Each monomer of RNA contains a phosphate group and one of the bases A, U, G, C.

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**Question 6** (1 mark)

The nucleotide sequence A G U G A C A A could represent:

- A. Part of the DNA template of a particular gene.
- B. The amino acid chain of a polypeptide.
- C. A sequence of mRNA.
- D. A section of double helix.

**Question 4** C

This sequence contains uracil so must be from an RNA molecule. The only RNA molecule present is mRNA.

**Question 7** (1 mark)

Unlike RNA, DNA has:

- A. A uracil base.
- B. A sugar called ribose.
- C. Two strands of nucleotides.
- D. A phosphate group in its nucleotides.

**Question 7** C

Although DNA does have a phosphate group, so does RNA, hence having two nucleotide strands differentiates DNA from RNA.

**Question 8** (1 mark)

Redundancy in the DNA code means that:

- A. The amino acid valine has four possible codons.
- B. The amino acids methionine and isoleucine are both coded for by AUG.
- C. Uracil replaces thymine in the translated nucleic acid.
- D. Each tRNA molecule can carry any amino acid.

A. the amino acid valine has four possible codons.

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**Question 9** (1 mark)

A canola crop had a gene coding for an omega-3 fatty acid, derived from bacteria, inserted into its 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

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

**Question 10** (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.

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).

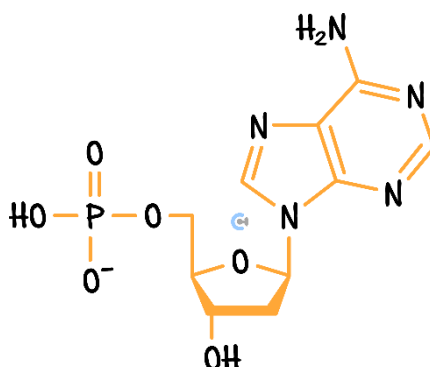
**Question 11** (1 mark)

Which one of the following correctly compares DNA and RNA?

|           | DNA                                      | RNA                                                                        |
|-----------|------------------------------------------|----------------------------------------------------------------------------|
| <b>A.</b> | <b>Contains deoxyribose.</b>             | <b>Contains ribose.</b>                                                    |
| <b>B.</b> | Is a shorter molecule.                   | Is a longer molecule.                                                      |
| <b>C.</b> | Found only in the nucleus in eukaryotes. | Found in the nucleus and a variety of cytoplasmic locations in eukaryotes. |
| <b>D.</b> | Contains four different monomers.        | Contains five different monomers.                                          |

**Question 12** (1 mark)

The diagram below shows the structure of a nucleotide, which is the sub-unit of a nucleic acid.



Which one of the following statements is correct?

- A. All nucleotides are chemically identical.
- B. This nucleotide could contain the amino acid thymine.
- C. The nucleotide shown in the diagram can only be found in DNA.
- D. Adjacent nucleotides are joined together as a result of a condensation reaction.**

**Answer: D**

**Explanatory notes**

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Option A is incorrect because although all nucleotides contain a phosphate group, a sugar and a base, the identity of the sugar and the base are not the same in all nucleotides.

Option B is incorrect because although the nucleotide could contain thymine, thymine is not an amino acid.

Option C is incorrect because there is insufficient information provided to determine whether this nucleotide is located in DNA or RNA. The identity of the sugar and the base would need to be known to make this determination.

Option D is correct because nucleotides join together when condensation occurs.

**Question 13 (1 mark)**

In the United States of America (USA), genetic screening of newborn babies is conducted for around 60 conditions. In the United Kingdom (UK), nine conditions are screened for and in the state of Victoria in Australia, 25 conditions are screened for. The table below provides data on the most frequent genetic conditions identified from screening newborn babies in the USA, the UK and Victoria, Australia.

| Genetic Condition                      | Incidence<br>(No. of babies born with a condition: Total no. of babies born) |              |                     |
|----------------------------------------|------------------------------------------------------------------------------|--------------|---------------------|
|                                        | USA                                                                          | UK           | Victoria, Australia |
| Phenylketonuria (PKU)                  | 1: 10000 - 15000                                                             | 1: 10000     | 1: 12000            |
| Galactosaemia                          | 1: 30000 - 60000                                                             | Not screened | Not screened        |
| Primary congenital hypothyroidism (CH) | 1: 2000 - 4000                                                               | 1: 3000      | 1: 2200             |
| Sickle-cell disease (SCD)              | 1: 500<br>African Americans                                                  | 1: 2000      | Not screened        |
| Congenital adrenal hyperplasia (CAH)   | 1: 15000                                                                     | Not screened | Not screened        |
| Cystic fibrosis (CFTR)                 | 1: 2500 - 3500<br>Caucasians                                                 | 1: 2500      | 1: 3300             |

Data: Genetics Home Reference, <<https://ghr.nlm.nih.gov>>; National Health Service, <[www.nhs.uk/pages/home.aspx](http://www.nhs.uk/pages/home.aspx)>; Victorian Clinical Genetics Services, <[www.vcgs.org.au](http://www.vcgs.org.au)>

From this information, it can be concluded that:

- A. CAH is not present in Australian newborn babies.
- B. The frequency of PKU and CFTR has risen in all countries of the world.
- C. The most frequent genetic condition that affects Victorian newborn babies is CH.**
- D. Cystic fibrosis in newborn babies is more prevalent in Victoria than in the UK.

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**Question 14** (1 mark)

A portion of a DNA molecule has the following base sequence:

–ATCTTAGGCCAT–

Which one of the following would be the complementary mRNA strand?

A. UAGAATCCGGUA

B. TAGAATCCGGTA

C. UAGAAUCCGGUA

D. UACAUCCGGUA

**Answer: C**

**Explanatory notes**

Option A is incorrect. There is no thymine in RNA.

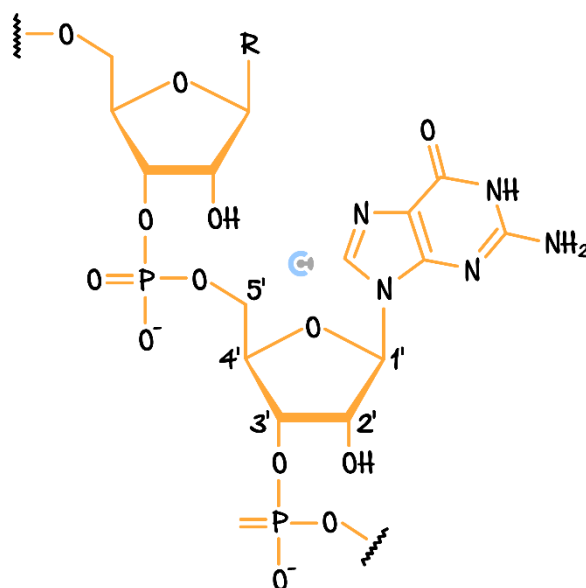
Option B is incorrect. There is no thymine in RNA.

Option C is correct. This sequence has the correct complementary RNA base for every DNA base.

Option D is incorrect. The third and fifth bases in the complementary RNA sequence are incorrect.

**Question 15** (1 mark)

The diagram below shows a small segment of the structure of an organic macromolecule.



Which of the following statements correctly identifies what occurs when this segment is joined to other similar structures?

A. The reaction is catabolic.

B. A net output of energy occurs.

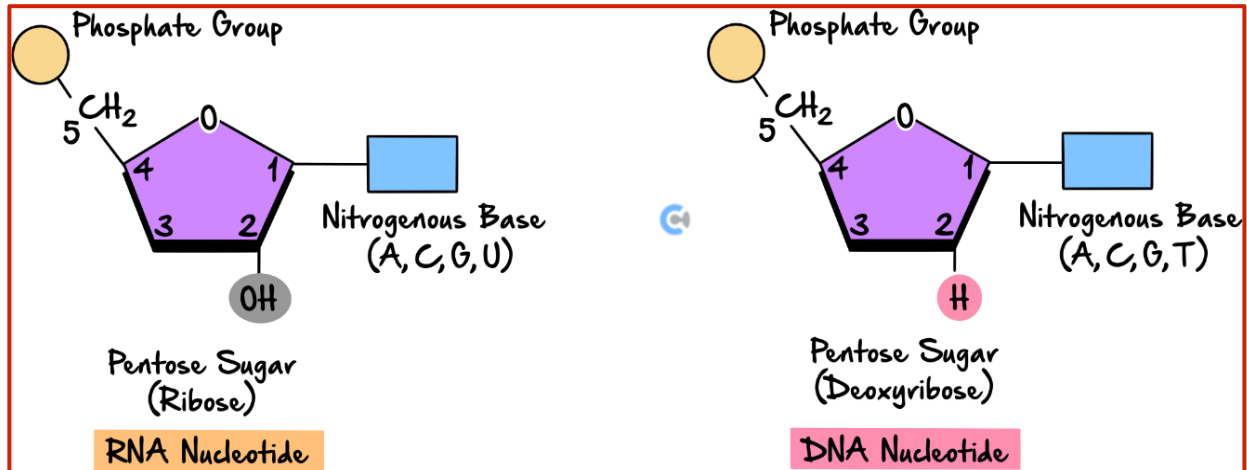
C. A condensation reaction would occur.

D. An input of water is required for this reaction to occur.

## Section B: Warm Up Questions (20 Marks)

### Question 16 (4 marks)

- a. In the space below, draw and label the structure of both an RNA nucleotide and a DNA nucleotide. (2 marks)



- b. Name two different types of nucleic acids and describe two differences between them. (2 marks)

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Differences could include their function or their structure.

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**Question 17** (3 marks)

Describe what is meant by “degenerate” in reference to the genetic code, and explain its significance.

Degeneracy in the genetic code refers to the fact that there are more possible combinations of 3 bases (codons) than there are amino acids used in protein synthesis.

This means that there will be multiple codons that correspond to a single amino acid.

This is significant as in the case of mutation, the same amino acid may still be produced despite a change in the base sequence in DNA or RNA.

**Question 18** (2 marks)

Explain what feature of the genetic code makes it possible for viruses to infect cells.

Viruses infect cells by injecting cells with their genetic information and relying on cellular machinery to replicate.

This takes advantage of the universality of DNA, that is, that all organisms rely on the same genetic code and can therefore execute instructions from a range of sources.

**Question 19** (2 marks)

Describe the difference in the function of mRNA and rRNA.

Ribosomal RNA performs more of a structural role in forming the ribosome, which is responsible for the synthesis of a polypeptide, whereas messenger RNA is responsible for transferring the genetic information to the ribosome from the nucleus.

**Question 20** (2 marks)

Scientists often want to visualise organic molecules under microscopes and in cultures, by adding a fluorescent dye which binds to specific features of a molecule.

Explain how a scientist could make a dye tag to DNA only and not RNA.

The scientist could tag the fluorescent dye to thymine. RNA does not have thymine, it has uracil instead, so a tag would not attach to it, and thus, could be distinguished from DNA.

**Question 21** (2 marks)

Explain why the genetic code could not be a 'doublet' code.

There are 20-21 amino acids that are required for the diversity of proteins, a doublet code would only have 16 possible combinations which is not enough.

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**Question 22** (5 marks)

Describe the structure of genes, referencing the key binding sites and regions in your answer and explain their relevance.

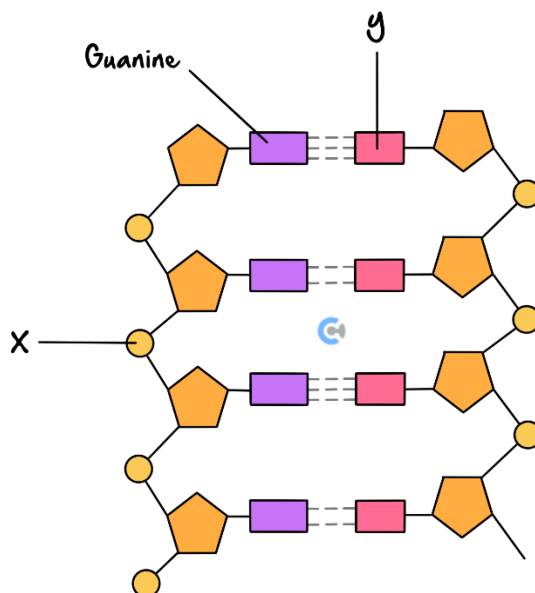
Refer to:

- Define Gene.
- Promotor.
- Exons and Introns.
- Terminator Sequence.

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## Section C: Exam Style Questions (30 Marks)

### Question 23 (8 marks)



- a. List the full name of the molecule in the diagram above. (1 mark)

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

#### Question 1a (1 mark)

List the full name of the molecule in the diagram above.

Answer:

- Deoxyribonucleic acid.

Marking protocol:

One mark the above point.

- b. Identify the labels X and Y. (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 1b (2 marks)

Identify the labels X and Y.

Answer:

- X: Phosphate group.
- Y: Cytosine.

Marking protocol:

One mark for each of the above points.

- c. In reference to this molecule, 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.

d. Identify three places in a plant cell where this molecule 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.

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**Question 24** (4 marks)

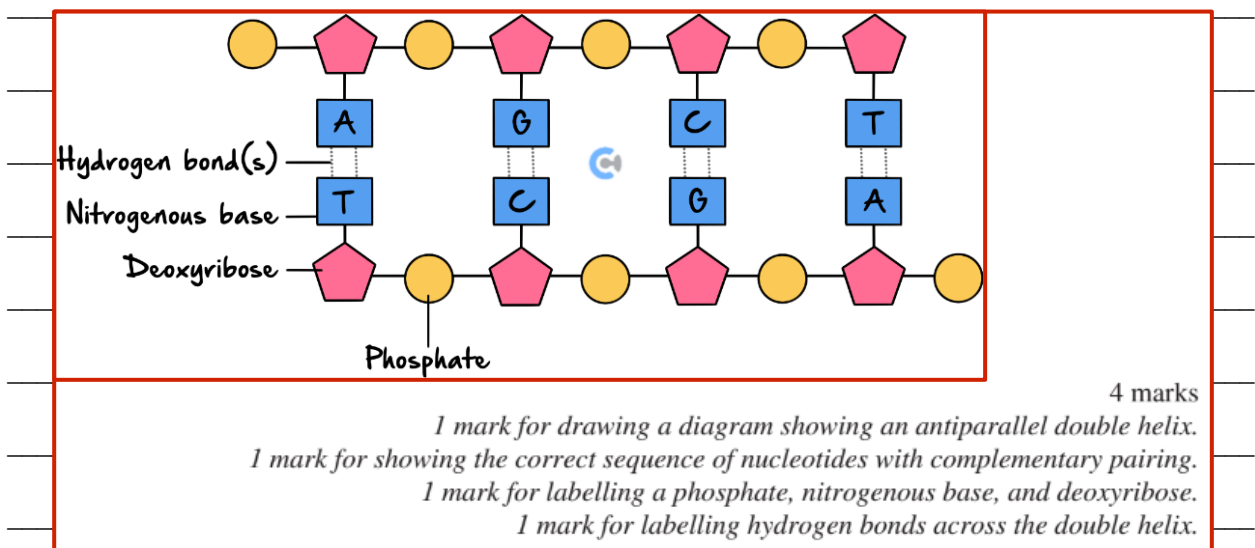
The table below represents a small section of a DNA template sequence that is about to be transcribed.

|   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| A | G | T | C | C | G | T | A | G | C  | T  | G  | A  | A  | T  | C  | C  | G  | G  | T  | T  | G  |

Draw a diagram of the DNA molecule that includes the first four nucleotides from the table.

On your diagram, label the:

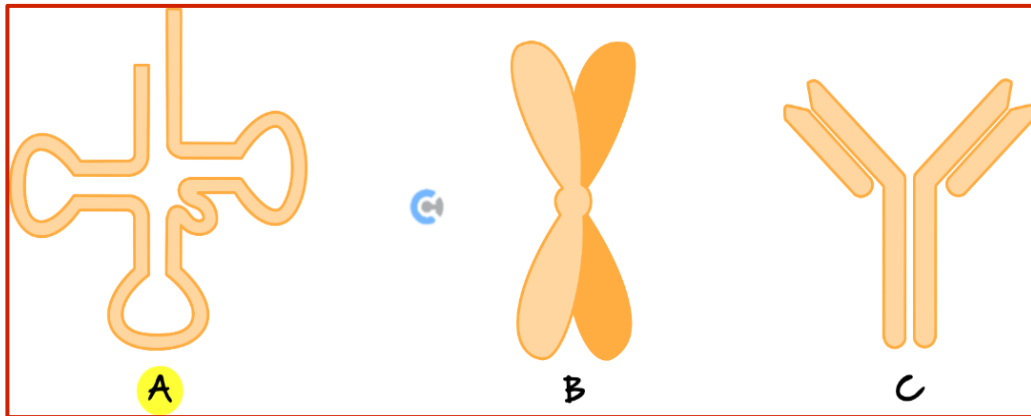
- Phosphate, nitrogenous base and deoxyribose of the DNA molecule.
- Hydrogen bond(s).



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**Question 25** (4 marks)

- a. Identify which of the following molecules (A, B or C) could represent a molecule of tRNA. (1 mark)



- b. Identify the function of the two different forms of RNA below. (2 marks)

rRNA

*rRNA forms a protein when the ribosome combines amino acids coded by mRNA (1).*

mRNA carries the genetic code / codon code for a protein from DNA to the ribosome (1).

2 marks

- c. Describe what is meant by the term 'universal genetic code'. (1 mark)

*Universal genetic codes is the DNA triplet or RNA codon that will code for the same amino acid in any organism.*

1 mark

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**Question 26** (6 marks)

The sequence of the first part of an exon in a piece of pre-mRNA has the following sequence:

AUGCUCaucgagccg

The pre-mRNA molecule will produce a polypeptide known as protein

**Worked solution**

An exon is a coding region of DNA that will be transcribed and translated. An intron is a non-coding region that will be transcribed but not translated.

**Mark allocation: 1 mark**

a. Explain the difference between an intron and an exon

- 1 mark for correctly comparing an intron and an exon


**Tip**

- Care needs to be taken with comparison questions because the word 'compare' may not be included in the question. The requirement for a comparison may be implied, as in this question. It is essential that both of the items being compared are mentioned in the response.

b. Give one difference between the structures of (i) DNA and mRNA, and (ii) mRNA and tRNA. (2 marks)

**Worked solution**

DNA is double stranded and mRNA is single stranded.

mRNA has a polyA tail (or methylated cap) while tRNA does not (it has an amino acid attachment site).

**Mark allocation: 2 marks**

- 1 mark for providing a correct structural comparison between DNA and mRNA
- 1 mark for providing a correct structural comparison between mRNA and tRNA

c. When the exons are spliced together, adjacent nucleotides need to be joined in the mRNA molecule. Name the type of reaction that joins these adjacent nucleotides. (1 mark)

**Worked solution**

A condensation reaction

**Mark allocation: 1 mark**

- 1 mark for correctly stating the type of reaction

- d. A company wishes to patent the sequence of DNA that codes for the production of protein X but they need to change the sequence of the exon to do so.

As previously supplied, the sequence of the pre-mRNA is:

AUGCUCAUCGAGCCG

Explain the feature of the genetic code that would enable the company to do this. Identify one alteration that could be made to the sequence of the pre-mRNA that would not affect the structure of the protein. Use the codon table below to assist in answering this question. (2 marks)

|   | U                      | C             | A                 | G              |   |
|---|------------------------|---------------|-------------------|----------------|---|
| U | UUU Phenylalanine      | UCU Serine    | UAU Tyrosine      | UGU Cysteine   | U |
|   | UUC Phenylalanine      | UCC Serine    | UAC Tyrosine      | UGC Cysteine   | C |
|   | UUA Leucine            | UCA Serine    | UAA Stop          | UGA Stop       | A |
|   | UUG Leucine            | UCG Serine    | UAG Stop          | UGG Tryptophan | G |
| C | CUU Leucine            | CCU Proline   | CAU Histidine     | CGU Arginine   | U |
|   | CUC Leucine            | CCC Proline   | CAC Histidine     | CGC Arginine   | C |
|   | CUA Leucine            | CCA Proline   | CAA Glutamine     | CGA Arginine   | A |
|   | CUG Leucine            | CCG Proline   | CAG Glutamine     | CGG Arginine   | G |
| A | AUU Isoleucine         | ACU Threonine | AAU Asparagine    | AGU Serine     | U |
|   | AUC Isoleucine         | ACC Threonine | AAC Asparagine    | AGC Serine     | C |
|   | AUA Isoleucine         | ACA Threonine | AAA Lysine        | AGA Arginine   | A |
|   | AUG Methionine [Start] | ACG Threonine | AAG Lysine        | AGG Arginine   | G |
| G | GUU Valine             | GCU Alanine   | GAU Aspartic Acid | GGU Glycine    | U |
|   | GUC Valine             | GCC Alanine   | GAC Aspartic Acid | GGC Glycine    | C |
|   | GUA Valine             | GCA Alanine   | GAA Glutamic Acid | GGA Glycine    | A |
|   | GUG Valine             | GCG Alanine   | GAG Glutamic Acid | GGG Glycine    | G |

### Question 3e.

#### Worked solution

The genetic code is redundant (or degenerate).

Change the second codon from CUC to CUU. Both of these codons code for leucine, so the DNA sequence would change but the structure of the protein would be unaffected.

**Mark allocation: 2 marks**

- 1 mark for stating that the genetic code is redundant or degenerate
- 1 mark for providing an example where two codons code for the same amino acid



#### Tip

- Questions such as this will often ask for an example. This must be provided to be awarded the mark. For example, an answer such as 'changing a single codon would alter the DNA sequence without altering the polypeptide chain' would not be acceptable because, although a correct understanding of the concept has been demonstrated, correct interpretation of the question has not.

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**Question 27** (2 marks)

An organism has a template DNA strand sequence of bases:

TATATACGGGCGATGACTCATAGG

- a. Write the complementary mRNA sequence to this strand. (1 mark)

AUAUAUGCCCGCUACUGAGUAUCC

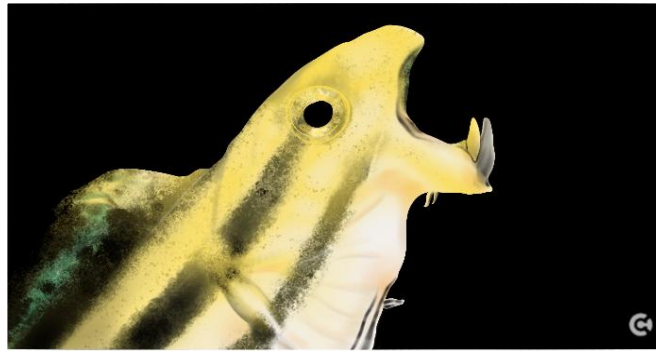
- b. How many amino acids does this code for? (1 mark)

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**Question 28** (3 marks)

Fang blennies (*Meiacanthus grammistes*) are little fish that have large fangs capable of delivering venom to their victims. The venom is made up of a number of substances, including an opioid peptide. It is thought that when the fang blennies bite the 'would-be' predator the opioid causes a drop in blood pressure. This would then disorientate and slow the predator down, giving the fang blennies a chance to escape. It could also relax the jaws and allow them to escape.



Source: <https://s-media-cache-ak0.pinimg.com>

Nucleic acids found in the cells of the fang blennies are needed for the synthesis of the opioid proteins found in the cells of the blennies.

Explain how the roles of the three different types of RNA within the cells of the blennies that are needed to produce the venom.

|      |                                                                                                          |
|------|----------------------------------------------------------------------------------------------------------|
| rRNA | <i>Produce ribosomes that are the sight of protein synthesis.</i>                                        |
| mRNA | <i>Are the temporary copy of the DNA that are needed to transfer the code to outside of the nucleus.</i> |
| tRNA | <i>Bring in a specific amino acid (as the anti-codon joins to the codon) to add to the polypeptide.</i>  |

(3 marks)

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**Question 29** (3 marks)

How is DNA oriented? Explain and describe its importance to DNA's function.

- DNA is oriented by referring to its 3' and 5' ends.
- The 3' end is determined by.
- The 5' end is determined by.
- This is important as it ensures DNA is read in the right direction.

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