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REDHILL HIGH SCHOOL

GRADE 12

**LIFE SCIENCE TEST**

**DNA and GENETICS**

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Examiner: Dr Mwaba

Moderator: Mrs M Ho

Time: 60 Min

60 marks

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**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This paper consists of 9 pages. Please check that your question paper is complete.
  2. Answer question 1 in the space provided on the question paper. And answer questions 2-6 on the lined paper provided.
  3. Read the questions carefully.
  4. All questions are compulsory.
  5. Answer the questions using the sources as well as you own knowledge.
  6. Please take note of the mark allocations.
  7. It is in your own interest to write legibly and present your work neatly.
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QUESTION 1: MULTIPLE CHOICE

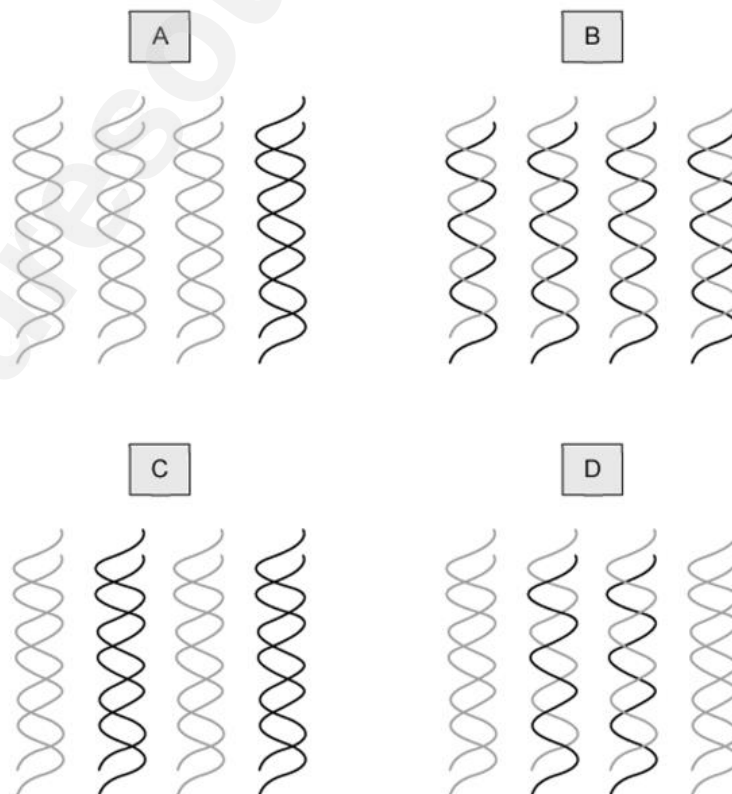
Eight multiple-choice questions are asked below. Choose the most correct answer to each question and write the letter of your choice in the table below.

| Question | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|
| Answer   |     |     |     |     |     |     |     |     |

1.1. Due to non-disjunction in meiosis I, a sperm cell was produced with an abnormal number of autosomes. The biological term for this condition is known as (1)

- A. Trisomy
- B. Autosomy
- C. Monosomy
- D. Aneuploidy

1.2. The diagram shows DNA strands that have undergone replication. The parent DNA is shown in black, and the newly synthesised DNA is shown in grey. Which would be the resulting DNA strands formed after two cycles of semi-conservative replication? (1)



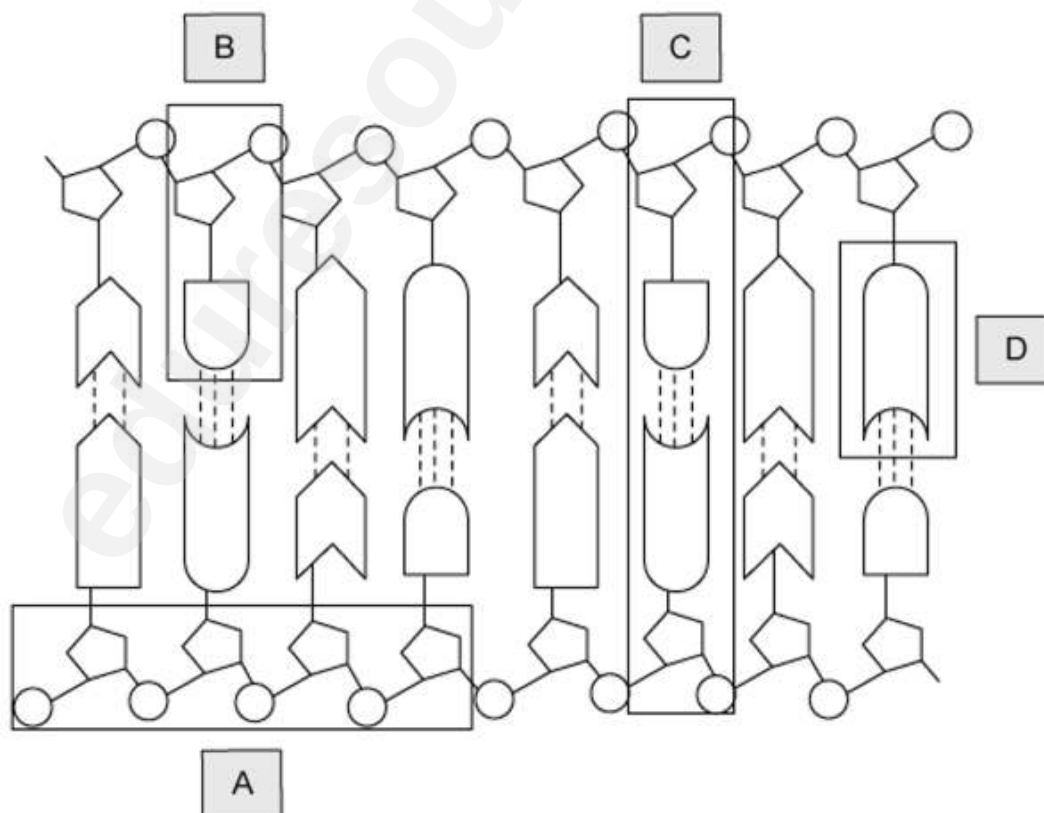
1.3. The following events occur in the replication of DNA. Here are the steps in their experiment in a mixed-up order. (2)

- 1 Opposite strands are separated.
- 2 Free DNA nucleotides pair with complementary nucleotides on each strand.
- 3 Bonds between complementary bases are formed.
- 4 Bonds between complementary bases are broken.
- 5 Phosphodiester bonds are formed.

What is the correct order of the process?

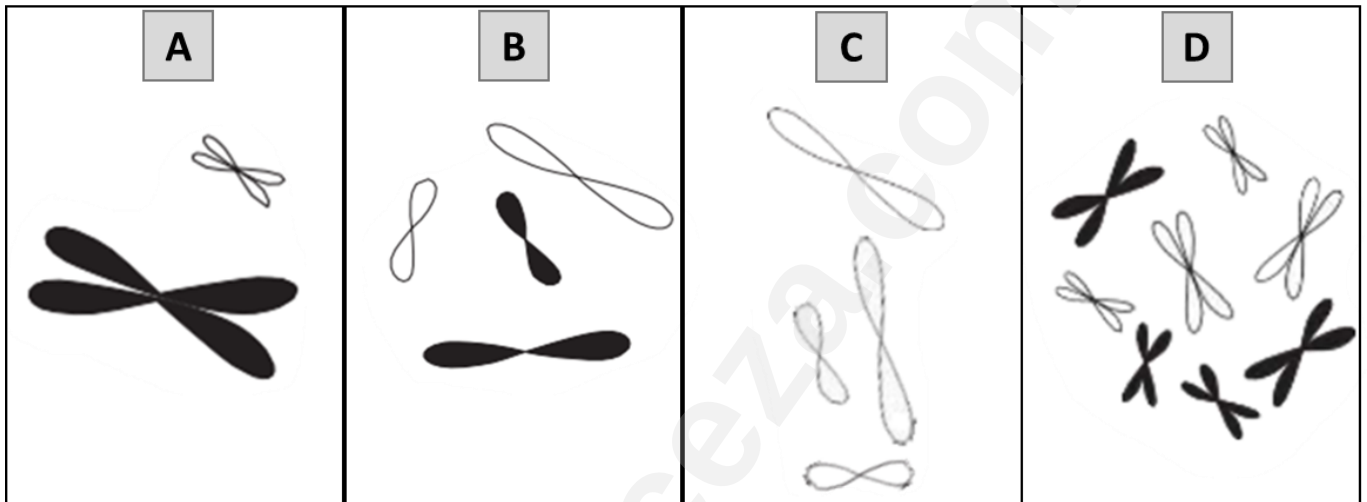
- A. 1 → 3 → 4 → 2 → 5
- B. 3 → 1 → 2 → 4 → 5
- C. 2 → 1 → 3 → 4 → 5
- D. 4 → 1 → 2 → 3 → 5

1.4. The diagram below shows part of a DNA molecule. Which option (A, B, C or D) show a DNA nucleotide. (1)



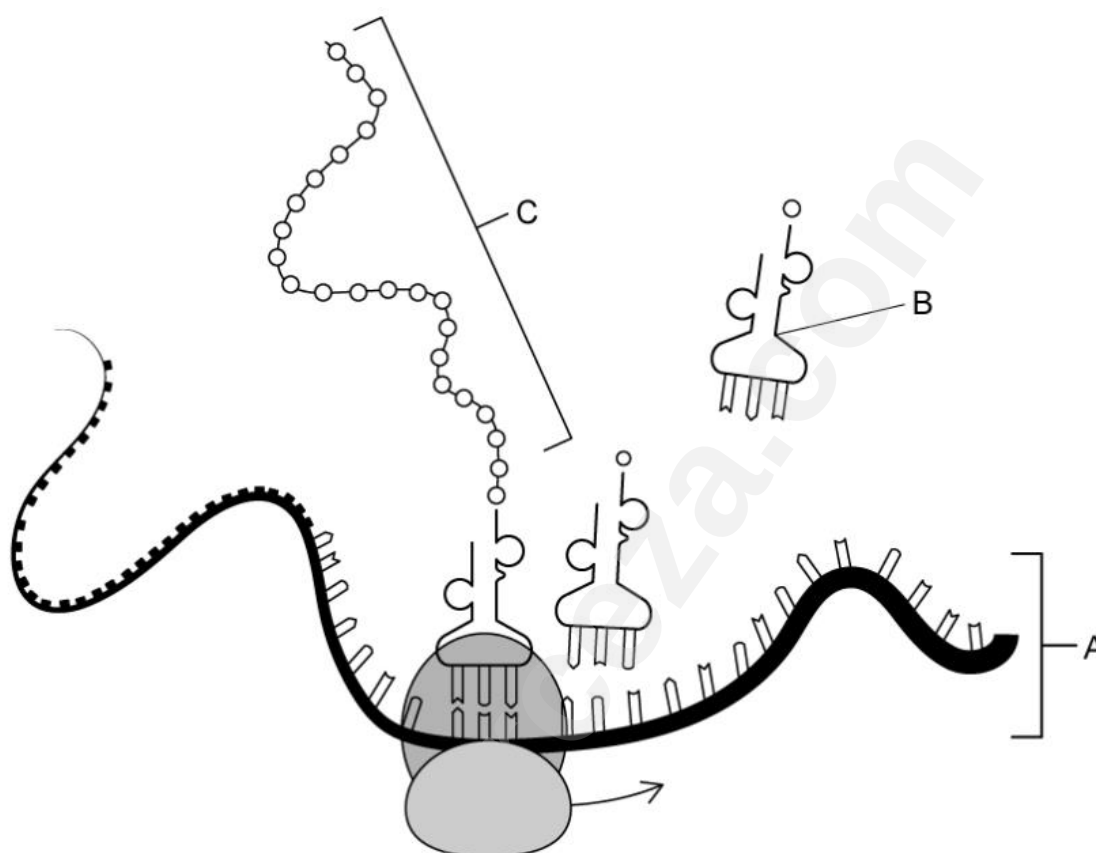
- 1.5. Sickle cell disease is caused by a change in the DNA sequence. The haemoglobin of affected people has a valine amino acid in its beta chain rather than glutamic acid. What is the MINIMUM number of base substitution required to change the normal haemoglobin allele to the sickle cell allele. (1)
- A. 4
  - B. 2
  - C. 1
  - D. 3
- 1.6. Which one of the following outcomes is associated with mitosis but NOT meiosis? (1)
- A. Homologous chromosomes are separated.
  - B. Sister chromatids are separated.
  - C. The number of chromosomes in a daughter cell is different from the number of chromosomes in the parent cell.
  - D. The cells produced are diploid.
- 1.7. Which statement is not a description of a gene? (1)
- A. A length of DNA which carries coded information as a sequence of nucleotides that can result in the formation of a polypeptide chain.
  - B. A sequence of nucleotides which can be copied by complementary base pairing and then be translated at a ribosome.
  - C. Any section of a double stranded DNA molecule with a sequence of complimentary nucleotides, held together by hydrogen bonding.
  - D. A sequence of nucleotides that can be transcribed using a polymerase enzyme and free activated nucleotides, which results in the formation of mRNA.

- 1.8. *Dimorphotheca ecklonis*, also known as Cape marguerite, is a South African native daisy plant. Cape marguerite has a diploid number of 4. In the diagrams below, maternal chromosomes are shown in white, and paternal chromosomes are shown in black. Which one of the following diagrams represents the chromosomes in a leaf cell of this plant? (1)



## QUESTION 2

2.1 A step in protein synthesis is shown in the image below.



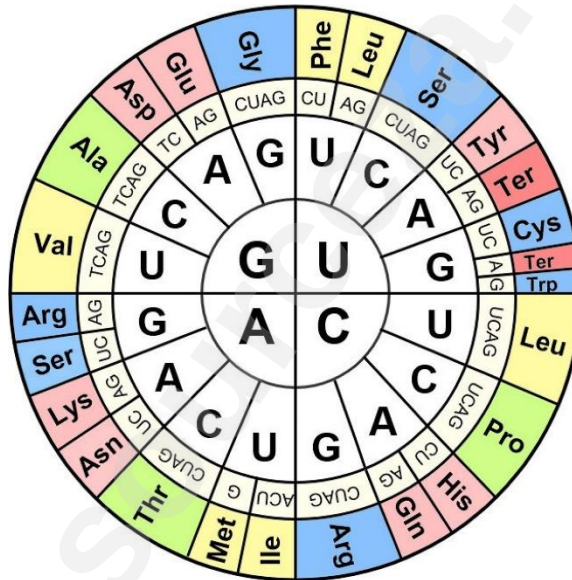
- 2.1.1 Name the process shown in the diagram above. (1)
- 2.1.2 Where in the cell does this process take place? (1)
- 2.1.3 Identify molecules A, B and C. (3)
- 2.1.4 Outline the importance of B in the stage shown above. (2)
- 2.1.5 If molecule C consisted of 380 amino acids, calculate the number of nucleotides on the DNA molecule that codes for molecule C. Show your working. (2)
- 2.1.6 If the nucleotides on molecule B was CAU, state the corresponding base sequence that would be found on molecule A. (1)

### QUESTION 3

3.1 A section of mRNA is shown below.

C C G A C C G A U U U G U A C

- 3.1.1 How many codons are there in the mRNA sequence above. (1)
- 3.1.2 Using the codon wheel below, identify the peptide sequence produced from the mRNA in 3.1. (2)

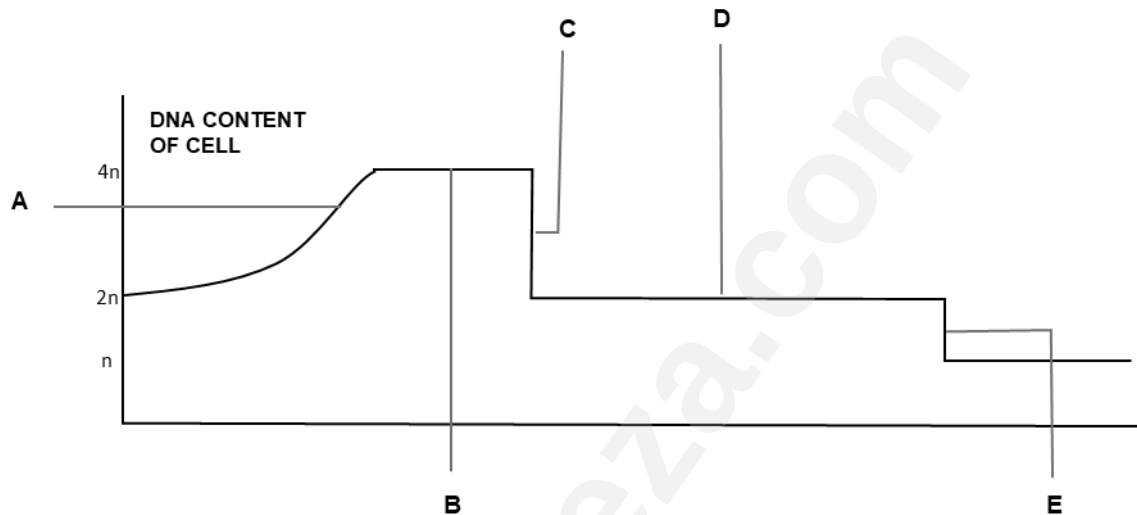


- 3.1.3 Explain FULLY the consequence of a mutation that deletes the first C (underlined) in the mRNA sequence above. (3)
- 3.1.4 Give a reason why a substitution mutation is more likely less severe than the mutation in answer 3.1.3 above. (2)
- 3.1.5 Can mutations such as those in question 3.1.3 and 3.1.4 be detected using a Karyotype analysis? Give a reason for your answer. (2)

#### QUESTION 4

4.1 Read the information below and answer the questions that follow.

This is a graphical depiction of the amount of DNA / the DNA content of a cell undergoing the process of meiosis. Not all the phases of meiosis are shown by the letters on the graph.



4.1.1 The label for the y-axis of the graph is the *DNA content of the cell*. Supply a suitable label for the x-axis of the graph. (1)

4.1.2 Use the descriptions below to match the correct number for labels A and C. You need only write the letter and the corresponding number. (4)

1 – where homologous pairing occurs.

2 – where DNA replication takes place.

3 – where double stranded chromosomes align themselves in a double row at the equator.

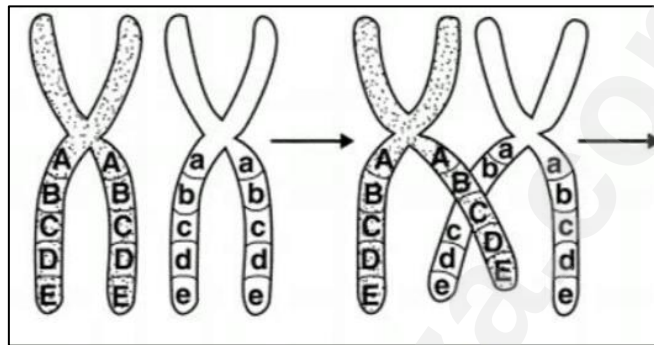
4 – where homologous chromosome pairs undergo anaphase.

4.1.3 Give an alternative name for 2n. (1)

4.1.4 What is the significance of the DNA content that is formed at the end of meiosis? (2)

4.1.5 Interphase **only** occurs before meiosis I. Using your own knowledge and the information included in the source, explain what the consequence would be, should interphase occur both before the start of meiosis I and meiosis II. (2)

4.1.6 During Stage B, an important process (shown below) occurs between one pair of homologous chromosomes ( $2n = 2$ ).



4.1.6.1 Name this process. (1)

4.1.6.2 Why is this process so important? (2)

4.1.6.3 Make a biological drawing of the TWO daughter cells produced at the end of meiosis II that have the recombinant chromosomes. Provide any 2 correct labels to your drawing and indicate the correct order of alleles. (6)

## QUESTION 5

5.1 Read the source below and answer the questions that follow.

**A Genetic Defect and its Management**

By Dagny Vidinsh

All animals, including dairy goats, have numerous genetic defects of varying severity. A recently discovered genetic disorder called mucopolysaccharidosis is caused by the deficiency of the G-6-Sulfase (G-6-S) enzyme. It was first identified in 1987 at Michigan State University, who tested many goat breeds and found that it only occurs in the Nubian breed of which about 25% of Nubians carry this gene. All cases are the result of a single mutation that is only expressed if the kid (young goat) has inherited the mutated gene from both parents.

The affected goats lack an enzyme (G-6-S) and therefore are not able to degrade a complex polysaccharide known as heparin-sulfate glycosaminoglycans (HS-GAGs) which then abnormally accumulate in tissues. Clinically, affected goats exhibit delayed nervous system development, growth retardation, and early death usually due to heart failure. The longest-lived goat known to be G-6-S affected died at just under four years of age.

(Adapted from: <https://www.vgl.ucdavis.edu/services/G6S.php>; <http://www.goatworld.com/articles/g6s.shtml>)

5.1.1 Give the correct genetic or biological term for the following statements.

- 5.1.1.1 Is only expressed if the kid (young goat) has inherited the mutated gene from both parents. (1)
- 5.1.1.2 Carrier of this recessive gene. (1)
- 5.1.1.3 A single mutation in the nucleotide sequence. (1)

5.2 Two Nubian goats, one male and one female, were used to initiate a breeding program. Both parents were in good health. They produced two offspring, one of which was healthy, and the other was affected.

- 5.2.1 Using the letters "G" and "g," list all the possible genotypes for the affected and healthy kid. (3)
- 5.2.2 Using a punnet square and the letters 'G' or 'g' determine the probability that a cross between a male goat affected by G-6-S deficiency and a homozygous dominant female goat, will have kids that are carriers for G-6-S. (5)