



A-Level Biology

DNA Structure and Replication

Question Paper

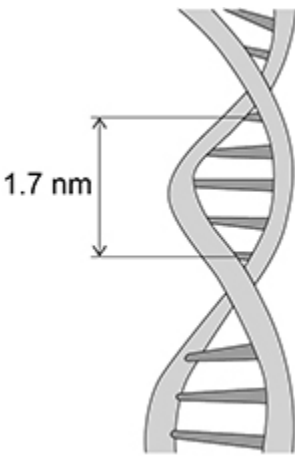
Time available: 70 minutes

Marks available: 55 marks

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1.

The diagram below shows part of a DNA molecule.



- (a) Name the type of bond between:
complementary base pairs _____
adjacent nucleotides in a DNA strand _____

(2)

- (b) The length of a gene is described as the number of nucleotide base pairs it contains.
Use information in above diagram to calculate the length of a gene containing 4.38×10^3 base pairs.

Answer _____ nm

(2)

- (c) Describe **two** differences between the structure of a tRNA molecule and the structure of an mRNA molecule.

1 _____

2 _____

(2)

- (d) In a eukaryotic cell, the structure of the mRNA used in translation is different from the structure of the pre-mRNA produced by transcription.

Describe **and** explain a difference in the structure of these mRNA molecules.

(2)

(Total 8 marks)

2.

(a) Complete the table below with ticks (✓) to show which elements are found in the following biological molecules.

Biological molecules	Element			
	Carbon	Nitrogen	Oxygen	Phosphorus
Galactose				
Phospholipid				
RNA				
Sucrose				

(2)

After Watson and Crick proposed the model of DNA structure, scientists investigated the possible mechanisms for DNA replication.

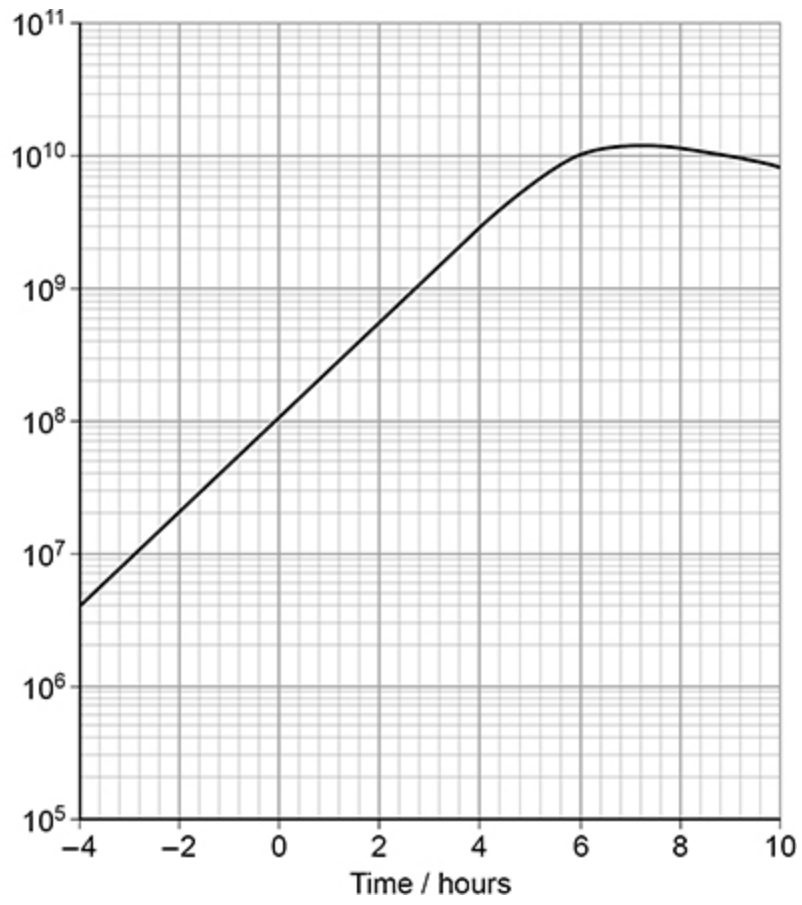
Two scientists grew a bacterial population, providing them with a nitrogen source containing only the heavy isotope of nitrogen, ^{15}N . As soon as all the DNA in this population contained ^{15}N , the scientists changed the nitrogen source to one containing only the lighter isotope of nitrogen, ^{14}N . They changed the nitrogen source at 0 hours.

During the investigation, the scientists measured the size of the population of bacterial cells.

Figure 1 shows the scientists' results.

Figure 1

Size of the population / number of bacterial cells per cm^3



- (b) The generation time for a population of bacteria is the time taken for all the bacteria to divide once by binary fission.

Use **Figure 1** and the following equation to calculate the generation time for this population of bacteria. Give your answer in hours.

$$\text{Number of generations} = \frac{\log_{10} \left(\frac{\text{size of population at time +4 hours}}{\text{size of population at time -4 hours}} \right)}{\log_{10} 2}$$

Generation time _____ hours

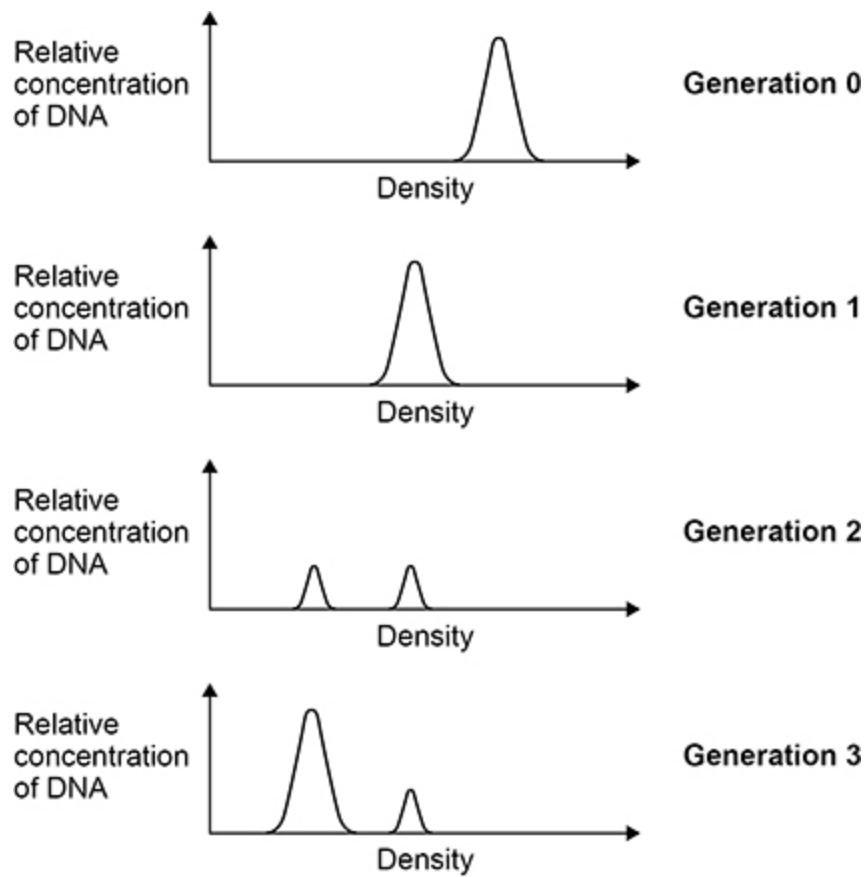
(2)

At intervals during this investigation, the scientists removed samples of the bacterial population, isolated the DNA and measured the density of the DNA.

DNA made using ^{15}N has a higher density than DNA made using ^{14}N .

Figure 2 shows the scientists' results.

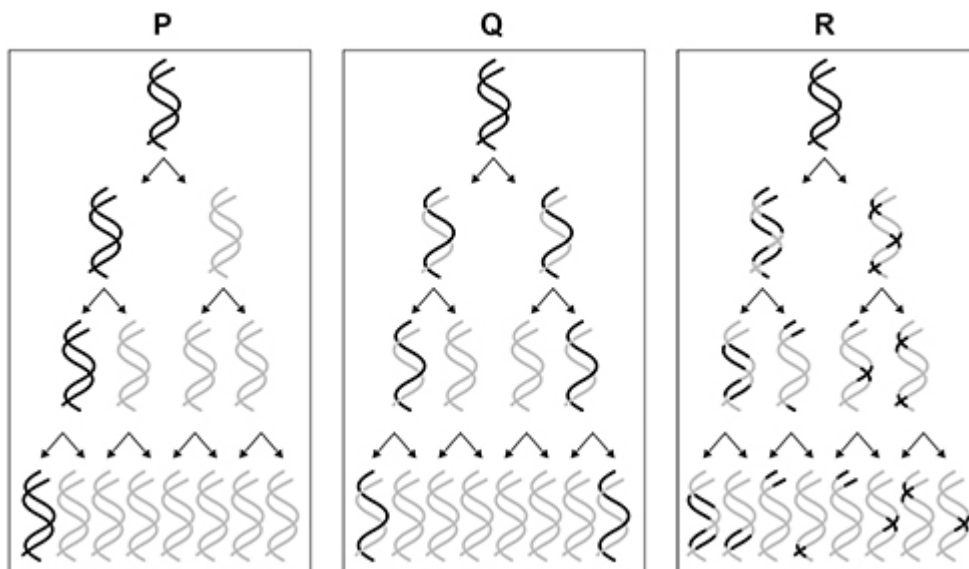
Figure 2



There are **three** possible models of DNA replication.

These models are shown in **Figure 3**.

Figure 3



(c) Which of these models, **P**, **Q** or **R**, is supported by the results shown in **Figure 2**?

Give the letter and name of the model supported and explain why the results do **not** support the other models.

Model _____

Name _____

Explanation for first **unsupported** model _____

Explanation for second **unsupported** model _____

(3)

(Total 7 marks)

3.

(a) Describe how a phosphodiester bond is formed between two nucleotides within a DNA molecule.

(2)

- (b) The two DNA strands of a particular gene contain 168 guanine bases between them. The relationship between the numbers of guanine bases (G), adenine bases (A), thymine bases (T) and cytosine bases (C) in these two strands of DNA is shown in the following equation.

$$G = 4(A + T) - C$$

Use this information and your understanding of DNA structure to calculate the maximum number of amino acids coded by this gene.

Show your working.

Answer _____

(2)

- (c) Name the protein associated with DNA in a chromosome.

(1)

- (d) In the process of semi-conservative DNA replication, the two strands within a DNA molecule are separated. Each then acts as a template for the formation of a new complementary strand.

Describe how the separation of strands occurs.

(2)

(Total 7 marks)

4.

(a) Name the **two** scientists who proposed models of the chemical structure of DNA and of DNA replication.

(1)

A scientist replicated DNA in a test tube. To do this, he mixed an enzyme with identical single-stranded DNA fragments and a solution containing DNA nucleotides.

(b) Name the enzyme used in this DNA replication.

(1)

(c) Use your knowledge of semi-conservative replication of DNA to suggest:

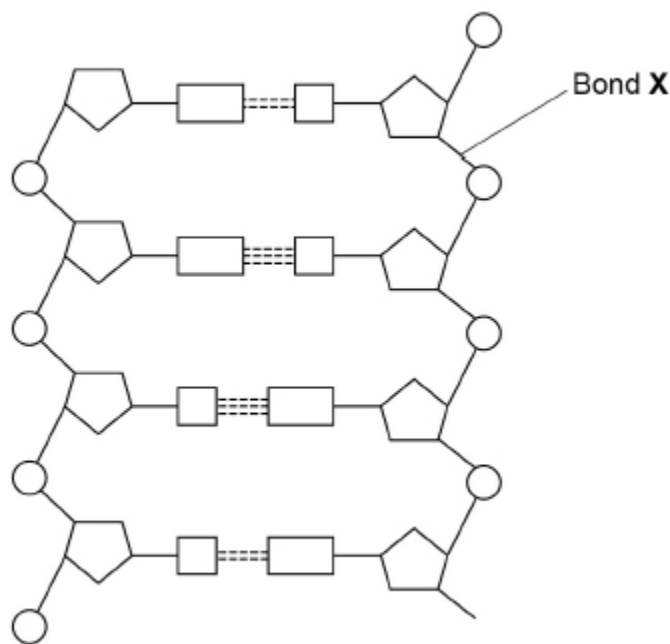
1. the role of the single-stranded DNA fragments _____

2. the role of the DNA nucleotides. _____

(3)

(Total 5 marks)

5. The diagram shows part of a DNA molecule.



(a) How many nucleotides are shown in the diagram above?

(1)

(b) Name the type of bond labelled **X** in the diagram.

(1)

(c) The enzymes DNA helicase and DNA polymerase are involved in DNA replication. Describe the function of each of these enzymes.

DNA helicase _____

DNA polymerase _____

(2)

(d) Adenosine triphosphate (ATP) is a nucleotide derivative.

Contrast the structures of ATP and a nucleotide found in DNA to give **two** differences.

1. _____

2. _____

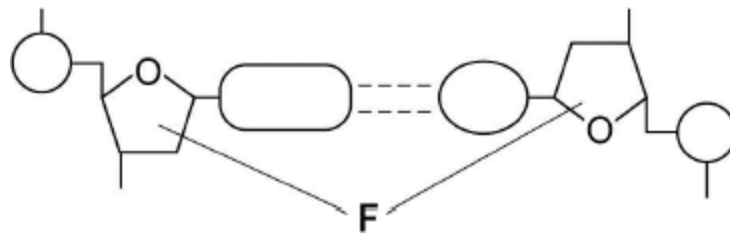
(2)

(Total 6 marks)

6.

Figure 1 shows one base pair of a DNA molecule.

Figure 1



(a) Name part **F** of each nucleotide.

(1)

(b) Scientists determined that a sample of DNA contained 18% adenine.

What were the percentages of thymine and guanine in this sample of DNA?

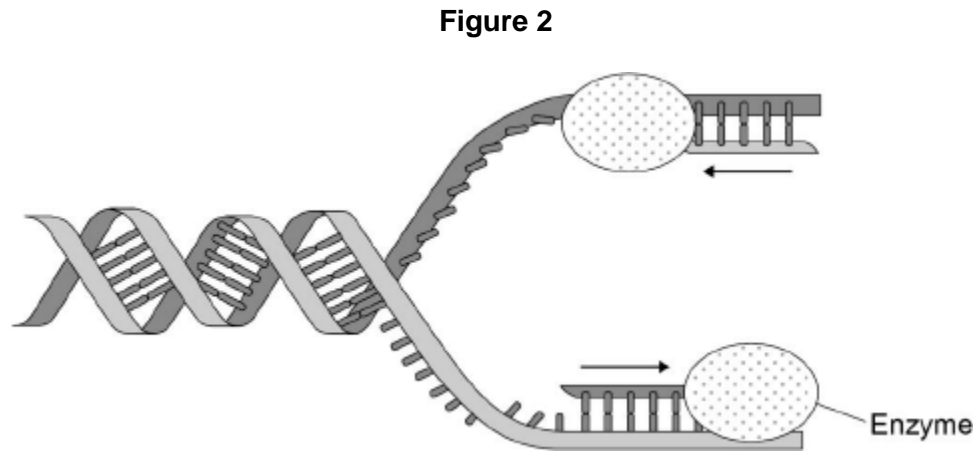
Percentage of thymine

Percentage of guanine

(2)

During replication, the two strands of a DNA molecule separate and each acts as a template for the production of a new strand.

Figure 2 represents DNA replication.



(c) Name the enzyme shown in **Figure 2**.

(1)

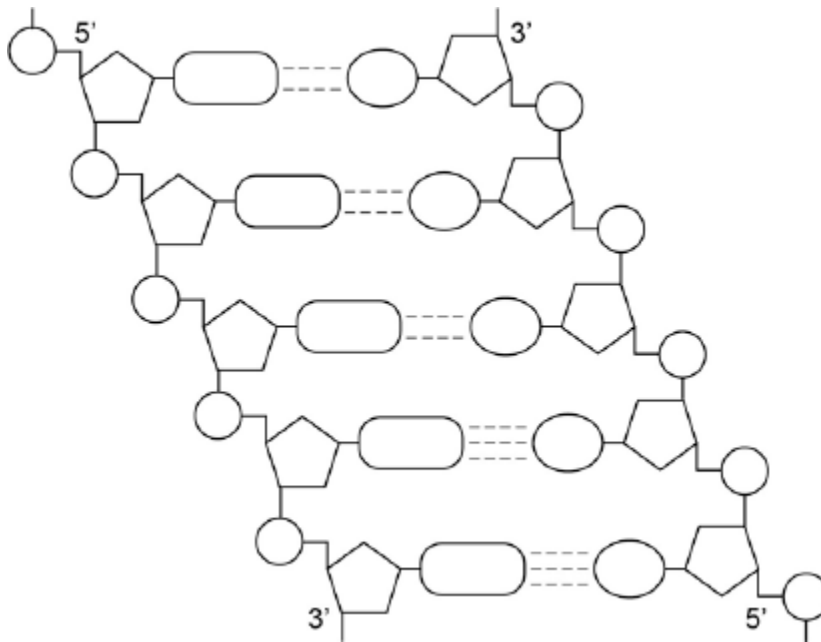
The arrows in **Figure 2** show the directions in which each new DNA strand is being produced.

(d) Use **Figure 1**, **Figure 2** and your knowledge of enzyme action to explain why the arrows point in opposite directions.

(4)

(Total 8 marks)

7. The following figure represents part of a DNA molecule.



(a) Draw a box around a single nucleotide.

(1)

The table below shows the percentage of bases in each of the strands of a DNA molecule.

DNA strand	Percentage of each base			
	A	C	G	T
Strand 1	16			
Strand 2		21	34	

(b) Complete the table by adding the missing values.

(2)

- (c) During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5' to 3' direction.

Use the figure in part (a) and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5' to 3' direction.

(4)

(Total 7 marks)

8.

- (a) (i) Describe the role of DNA polymerase in DNA replication.

(1)

- (ii) Other than being smaller, give **two** ways in which prokaryotic DNA is different from eukaryotic DNA.

1. _____

2. _____

(2)

- (b) The table shows the percentage of each base in the DNA from three different organisms.

Organism	Percentage of each base in DNA			
	Adenine	Guanine	Thymine	Cytosine
Human	30.9	19.9	29.4	19.8
Grasshopper	29.4	20.5	29.4	20.7
Virus	24.0	23.3	21.5	31.2

- (i) Humans and grasshoppers have very similar percentages of each base in their DNA but they are very different organisms.

Use your knowledge of DNA structure and function to explain how this is possible.

(2)

- (ii) The DNA of the virus is different from that of other organisms. Use the table above and your knowledge of DNA to suggest what this difference is. Explain your answer.

(2)

(Total 7 marks)