IB · HL · Biology

2 hours 17 questions

Structured Questions

Nucleic Acids

DNA & RNA Structure / Basis of Genetic Code / Nucleic Acid Structure & Function / DNA Structure (HL) / Nucleosomes & Molecular Visualisation Software: Skills (HL) / The Hershey & Chase Experiment (HL) / Chargaff's Data (HL)

Easy (6 questions)	/44
Medium (5 questions)	/43
Hard (6 questions)	/42
Total Marks	**/129**

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Easy Questions

1 (a) Describe the main role of DNA.

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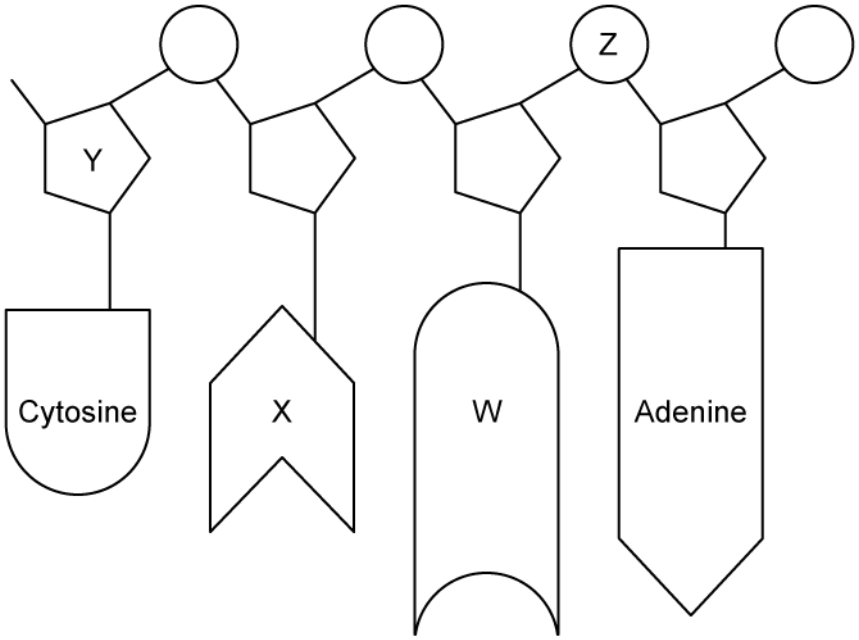
(2 marks)

(b) The image below shows a representation of several nucleotides in a molecule of DNA.



Identify the structures marked **Y** and **Z**.

.....

.....

(2 marks)

(c) Identify the nitrogenous bases in part b) marked **X** and **W**.

.....

.....

(2 marks)

(d) DNA and RNA are referred to as polynucleotides.

State the meaning of the prefix '**poly'** in the term **polynucleotide**.

.....

(1 mark)

2 (a) In a section of DNA 17 % of the nucleotides were found to contain cytosine.

Calculate the percentage of thymine in this section of DNA.

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(2 marks)

(b) State **one** reason why the calculation from part a) could not be performed for a piece of RNA.

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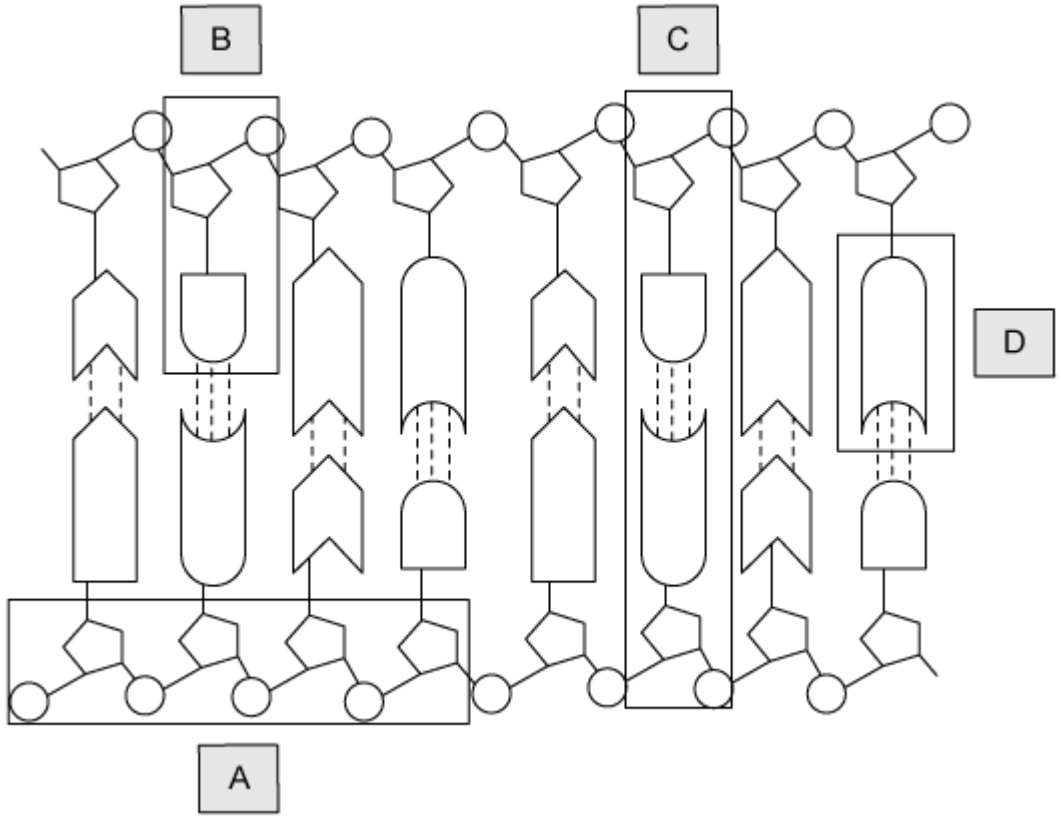
(1 mark)

(c) The diagram below shows a representation of part of a DNA molecule.



Identify the structures labelled **A, B,** and **D**.

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(3 marks)

(d) Identify **one** type of bond found within the structure labelled **C** in the diagram at part c).

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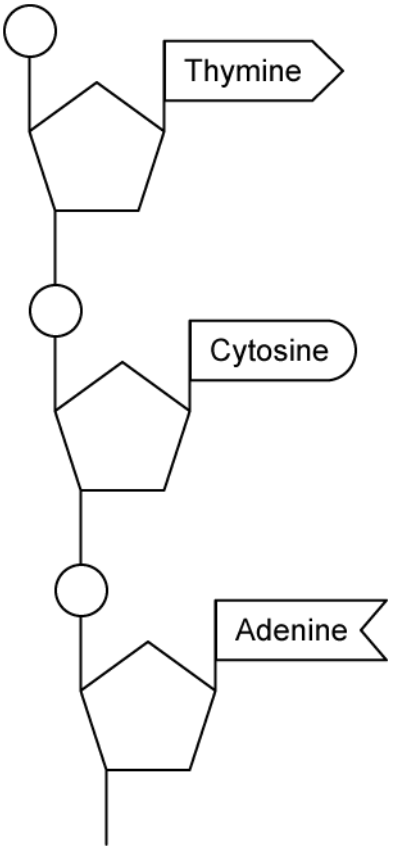
(1 mark)

3 (a) *One mark is available for clarity of communication throughout this question.*

Draw on and annotate the diagram below to show the correct structure of double-stranded DNA.

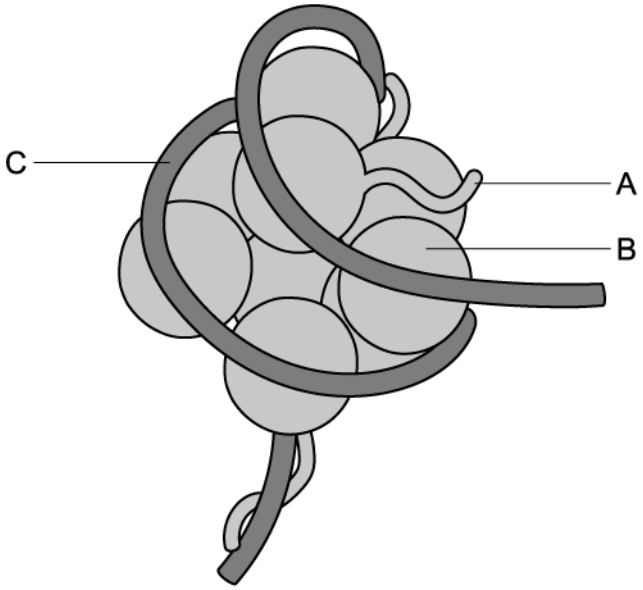


(4 marks)

(b) Compare and contrast the structures of DNA and RNA.

(5 marks)

4 (a) The diagram below represents a nucleosome.



Label parts **A** to **C** on the diagram.

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(3 marks)

(b) Prokaryotic DNA does not form nucleosomes.

State the reason for this.

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(1 mark)

(c) In eukaryotes, a great length of DNA is packed into a very small nucleus.

Describe how a nucleosome would contribute to make this possible.

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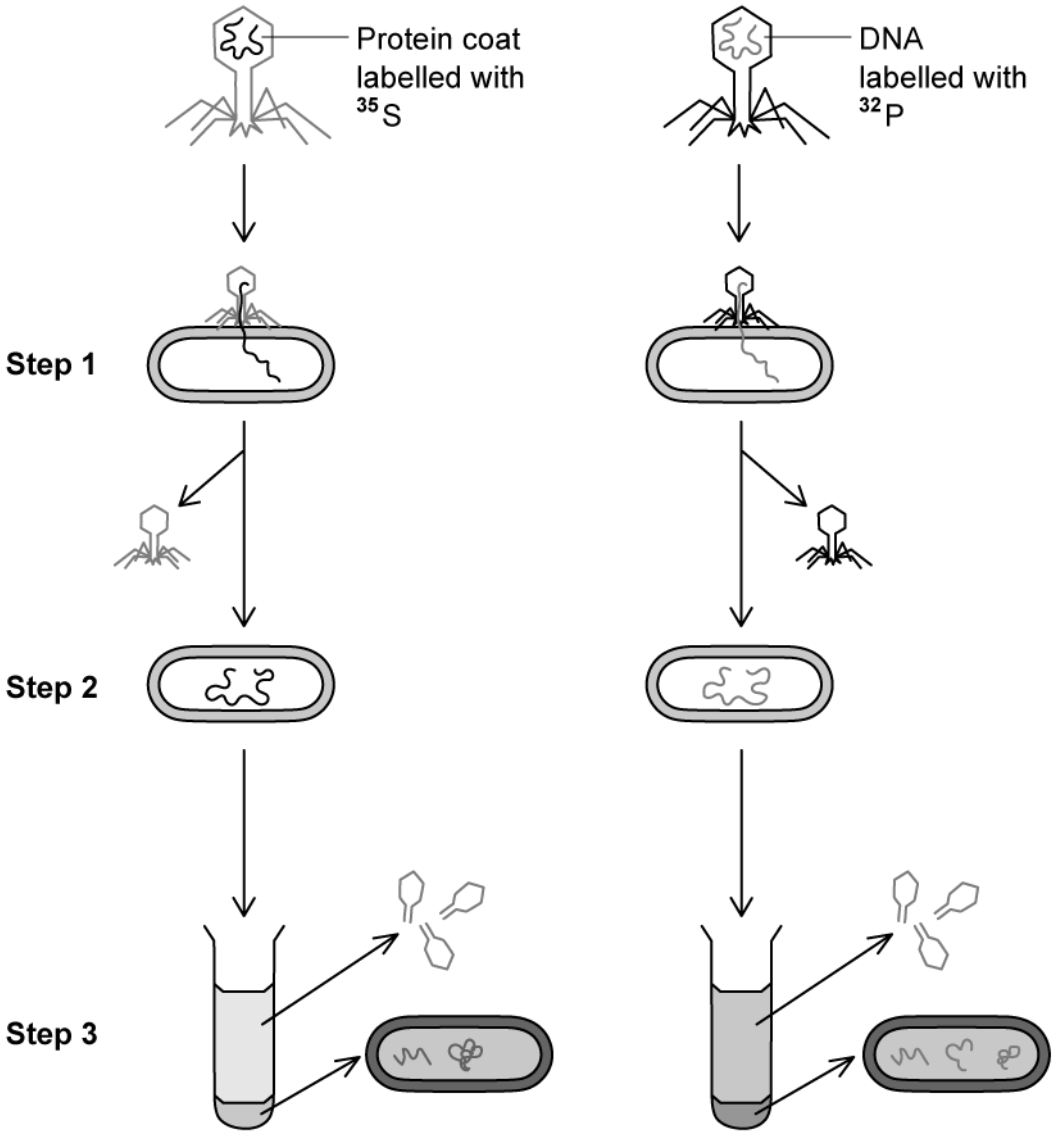
(2 marks)

5 (a) The diagram below shows the experimental procedure followed by Alfred Hershey and Martha Chase.



State the aim of this experiment.

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(1 mark)

(b) Based on the information in the diagram at part a), state **one** reason why viruses were used in this experiment.

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(1 mark)

(c) Describe the events taking place between step **1** and **2** of the experiment.

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.....

(2 marks)

(d) State the results obtained at the end of step **3**.

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(2 marks)

6 (a) *One mark is available for clarity of communication throughout this question.*

Describe the roles of non-coding regions of DNA molecules.

(4 marks)

(b) Molecular visualisation software is a useful tool with which to study the structure of molecules.

State **five** applications of molecular visualisation software in the fields of medicine and science.

(5 marks)

Medium Questions

1 (a) The 3D shape of DNA is know as a double helix.

State whether it is possible for a strand of RNA to form a double helix.

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(1 mark)

(b) State how the two strands of the DNA molecule held together.

.....

(1 mark)

(c) State the part of a DNA molecule that contains nitrogen.

.....

(1 mark)

2 (a) Using appropriate shapes to represent chemical structures, draw **and** label a single RNA nucleotide.

(2 marks)

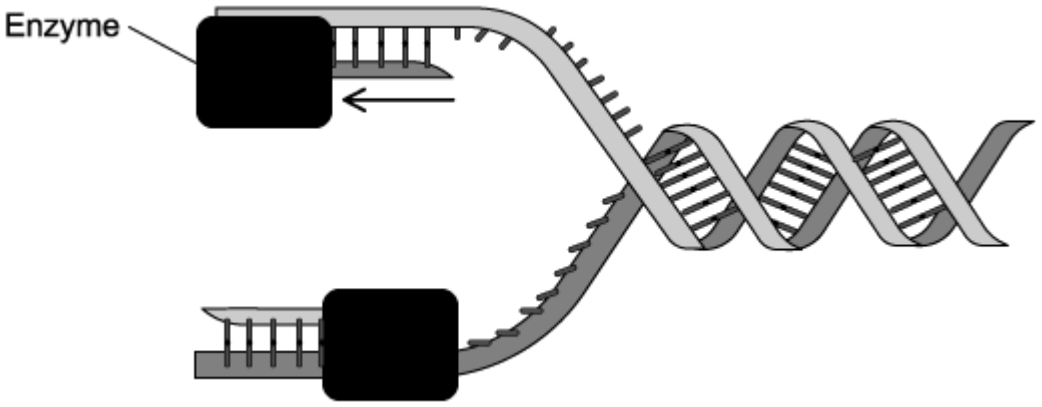
(b) A section of DNA was found to contain the following percentages of bases, as shown in the table below.

	%			
	Adenine	**Cytosine**	**Guanine**	**Thymine**
Sense strand	15			27
Antisense strand		23		

Use your knowledge of DNA structure to complete the table by filling in the missing boxes.

(2 marks)

(c) The diagram below shows DNA replication.



Identify the enzyme shown in the diagram and describe its function.

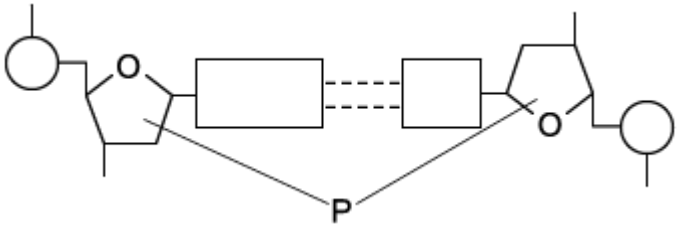
(3 marks)

(d) Indicate with a tick or ticks (✓) in the table below the chemical group(s) that appear(s) at the two ends of a single strand of DNA.

	Deoxyribose sugar	Phosphate
3' (3-prime) end		
5' (5-prime) end		

(1 mark)

3 (a) The diagram below shows a base pair within a molecule of DNA.



Identify part **P** of this section of DNA

.....

(1 mark)

(b) Scientists sequenced the gene for a hormone, in order to understand more about why some individuals stop producing this hormone. The scientists determined that the gene consisted of 1 500 base pairs; 30% of the total bases were cytosine.

How many nucleotides of adenine and guanine were there in this sample of DNA?

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.....

(2 marks)

(c) Describe the conventional numbering system for carbon atoms in a pentose sugar such as the ribose or deoxyribose sugars found in RNA and DNA. You may sketch a diagram to illustrate your answer.

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(3 marks)

(d) Many visualisation techniques have been used to understand and study the structure of DNA. James Watson and Francis Crick used visualisation techniques, such as Rosalind Franklin's X-ray diffraction, to build a physical model of DNA. Their models were also influenced by the findings of other researchers, such as Erwin Chargaff.

Describe how the research findings of Chargaff facilitated Watson, Crick and Franklin to determine the structure of DNA.

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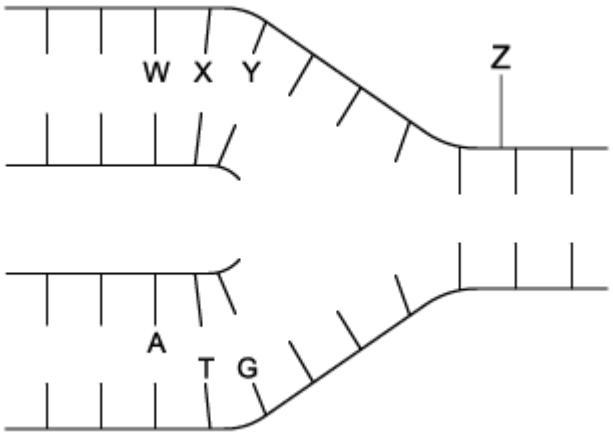
(2 marks)

4 (a) The diagram below shows the process of DNA replication. The horizontal lines represent the positions of bases.



Identify the parts of the DNA molecule represented by the labels **W, X, Y** and **Z**.

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(2 marks)

(b) The table shows the percentage of different bases in the DNA of some organisms.

Organism	Percentage of each base			
	Adenine	Guanine	Cytosine	Thymine
Human	32.8	17.2	17.2	32.8
Caterpillar	33.1	16.9	16.9	33.1
Mouse		22.4		
Virus	24.7	24.1	18.5	32.7

Calculate the missing figures for mouse DNA and complete the table.

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(2 marks)

(c) Humans and caterpillars have very similar percentages of each base in their DNA but are not the same class of organism.

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

(3 marks)

(d) The DNA of the virus is different from that of the human, caterpillar and mouse. Some viruses contain single-stranded DNA that is not base-paired to a complementary strand. Use data from the table in question 4b) to show evidence for this difference.

(2 marks)

5 (a) Some DNA is associated with a protein called histone, which packages the DNA into structures called nucleosomes.

Describe the structure of a nucleosome.

(2 marks)

(b) State the functions of nucleosomes.

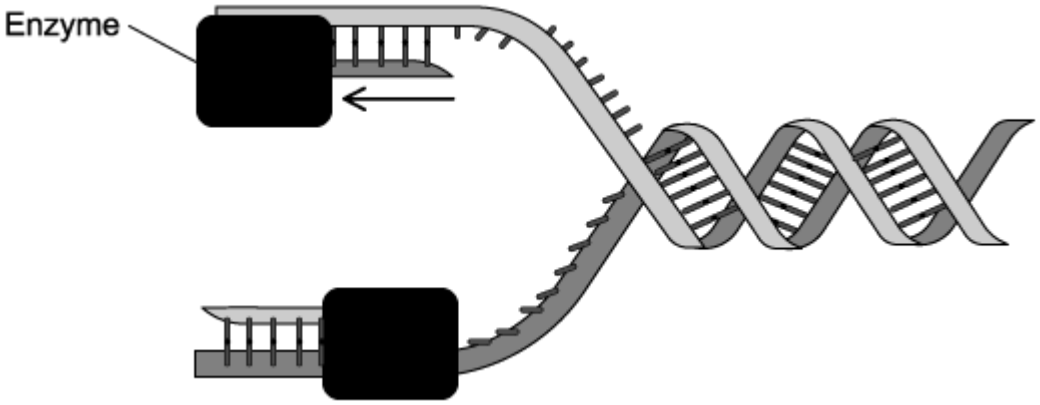
(2 marks)

(c) Within the nucleus, DNA is replicated semi-conservatively in order to produce new cells.

State **two** features of DNA and explain how these features are important in the process of semi-conservative replication of a cell's DNA.

(2 marks)

(d) The diagram below shows DNA replication.



Name the enzyme shown in the diagram and describe its function.

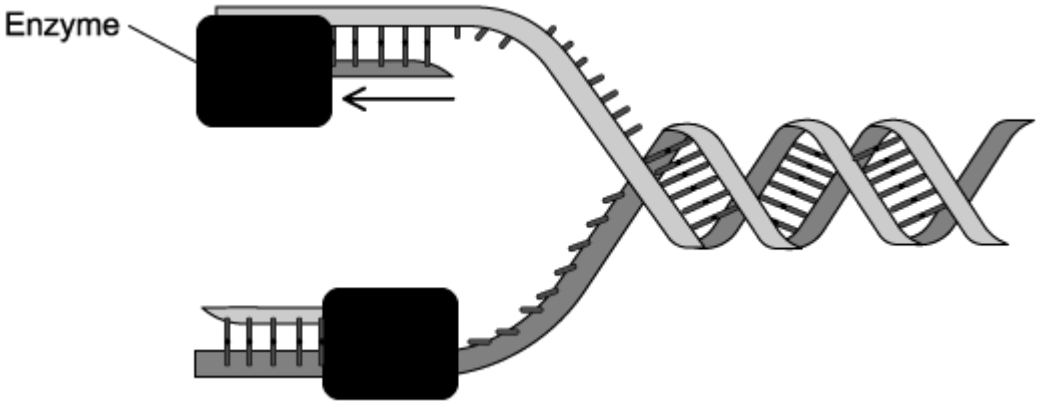
(3 marks)

(e) Today, visualisation software can be utilised to analyse DNA in very high detail. The association between protein and DNA within the nucleosome can be seen.

Describe what may be visualised when analysing a nucleosome.

(3 marks)

(f) The diagram below shows DNA replication.



Name the enzyme shown in the diagram and describe its function.

(3 marks)

Hard Questions

1 (a) The ends of a DNA strand are referred to as the 3′ end and the 5′ end.

Describe the aspects of DNA structure that give rise to this naming system.

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(3 marks)

(b) Adenine/thymine and guanine/cytosine form hydrogen-bonds with each other in complementary base-pairing within the DNA double helix. These bases can also form bonds with other molecules in order to carry out their function.

(i) Suggest **one** other molecule that might form bonds with the bases in a DNA molecule.

[1]

(ii) State the role of the molecule identified in part i).

[1]

.....

.....

(2 marks)

(c) The structure of DNA has many characteristics that enable it to carry out its function.

(i) Identify **two** structural features that help DNA to carry out its function.

[2]

(ii) For each feature identified at part i), explain how it assists with DNA function.

[2]

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(4 marks)

2 (a) Even the smallest DNA molecules are very long.

- A kilobase (Kb) is a unit equivalent to 1000 base pairs of a DNA molecule.
- One Kb of double stranded DNA has a length of 0.34 μm.

The DNA in the nucleus of a cell from a fruit fly (*Drosophila*) is 5.6 cm long.

Calculate the number of Kb in the DNA of the fruit fly. Give your answer to the nearest whole number.

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(2 marks)

(b) The amount of DNA found in the nucleus of cells can vary amongst people, with each human chromosome containing between 5×10^4 and 26×10^4 Kb of DNA.

Suggest **one** reason why people might have different quantities of DNA to each other.

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(1 mark)

(c) Other than for use in replication, explain **one** advantage of DNA molecules having two strands.

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(1 mark)

3 (a) A section of DNA contains 1,200 base pairs.

- The number of guanine molecules on strand one was counted as 156.
- The number of cytosine molecules on strand one was counted as 209.
- The number of adenine molecules on strand two was counted as 264.

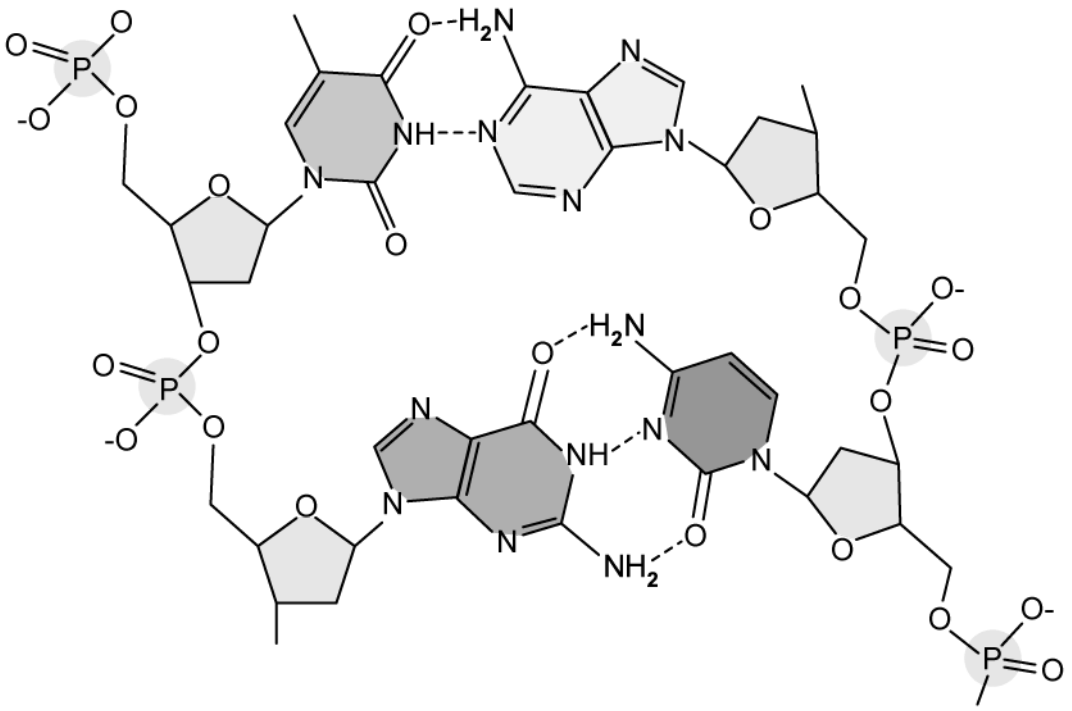
Complete the table below to include the total number of each base present in the section, and the % composition of each base.

	Number of molecules present	**% composition**
Adenine		
Cytosine		
Guanine		
Thymine		

(4 marks)

(b) The image below shows a section of the skeletal formula of a DNA molecule.

Number the carbon atoms of all the pentose sugars shown in the image using the standard numbering format.



(2 marks)

(c) The DNA nucleotides are covalently bonded together in the sugar-phosphate backbone between the pentose sugar and the phosphate group, however, they are hydrogen bonded together between the bases.

Explain why both types of bonds are important for the functioning of DNA.

(2 marks)

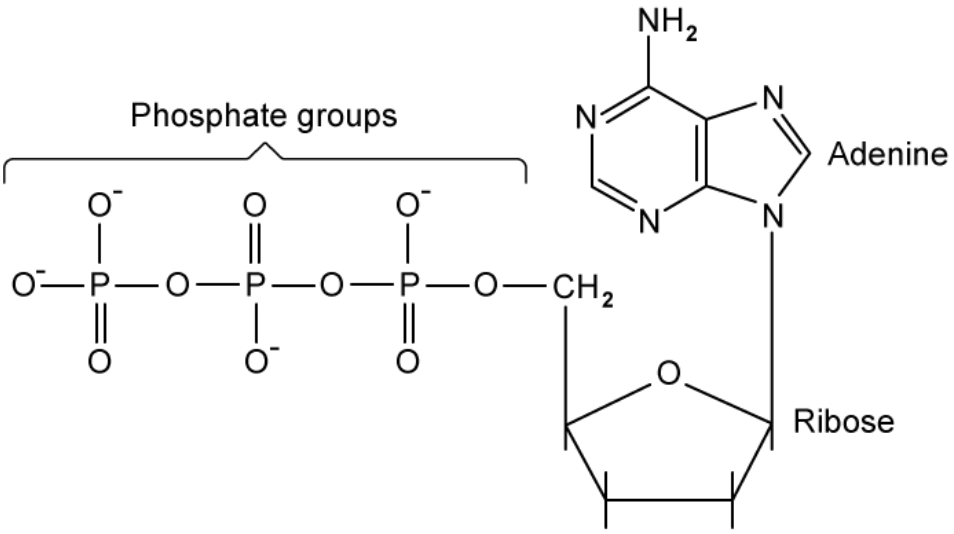
(d) During DNA replication both DNA strands act as a template, whereas in transcription only one strand acts as a template.

Outline what is meant by the word 'template' in this context.

(1 mark)

4 (a) ATP is a source of energy used in cells and is produced from processes such as respiration.

The structure of ATP is shown in the diagram below.



Use the information in the diagram, as well as your own knowledge, to compare and contrast the structure of ATP with an adenine DNA nucleotide.

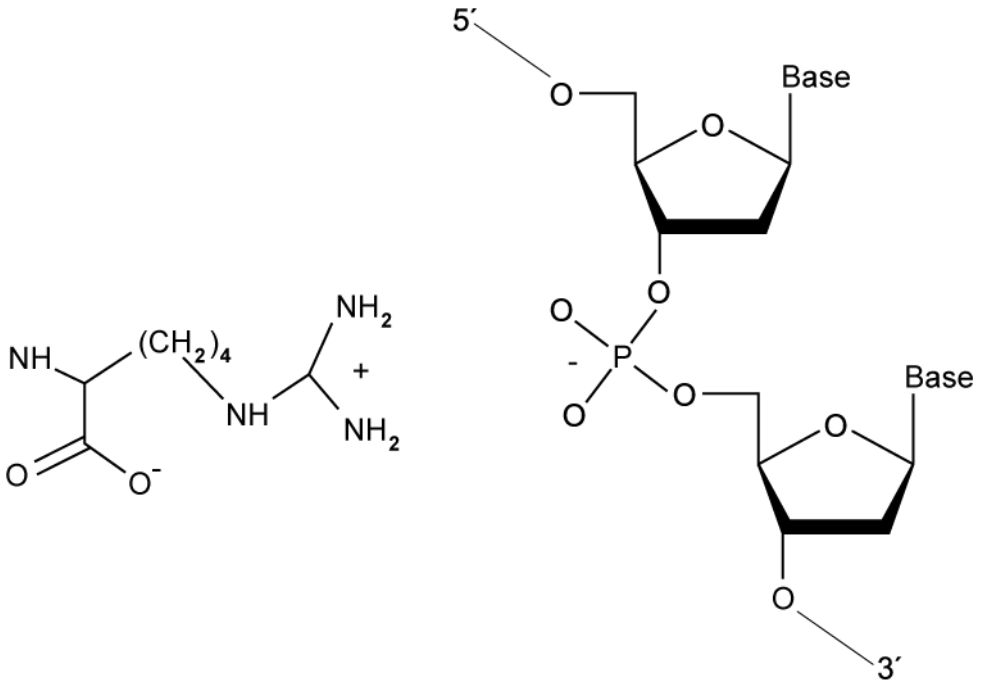
(4 marks)

(b) Explain how the structure of DNA allows replication.

(4 marks)

5 (a) Arginine is an amino acid found in histone proteins and plays an important role in the interaction between histones and DNA within nucleosomes.

The diagram below shows the structure of arginine and a section of DNA within a nucleosome.



Suggest how arginine facilitates the interaction between histones and DNA, by using the information in the diagram.

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(2 marks)

(b) Explain the role of nucleosomes in chromosome structure.

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(2 marks)

(c) Packing ratio is determined by dividing the length of DNA packed into a structure by the length of the structure.

Chromosome 11 consists of about 1.35×10^8 base pairs and the distance between adjacent base pairs is 3.4 nm. The chromosome is about 5 μm in length during metaphase.

Calculate the packing ratio of chromosome 11. Show your working.

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.....

(2 marks)

6 (a) The following table shows the DNA base composition of different organisms. Note that for *E. coli*, the %C and %T has deliberately been left out.

Organism	%A	%C	%T	%G
Maize	26.7	23.3	27.0	23.0
Chicken	28.0	21.9	27.8	22.3
Octopus	33.0	17.2	32.1	17.7
Grasshopper	29.8	20.2	29.2	20.8
Sea urchin	32.6	16.9	33.1	17.4
Yeast	31.5	18.1	32.1	18.3
E. coli	24.7	-	-	**X**

State **two** deductions that can be made from the data.

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(2 marks)

(b) Calculate the possible value of **X** in the table in part a).

Show your working.

.....

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(2 marks)

(c) The results from part a) are similar to those first obtained by Erwin Chargaff in the 1950s.

Suggest how Chargaff's research may have impacted the work of Crick and Watson.

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(2 marks)