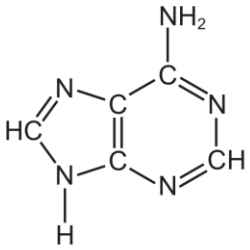
6. Nucleic Acids and Protein Synthesis

6.1 Structure of nucleic acids and replication of DNA

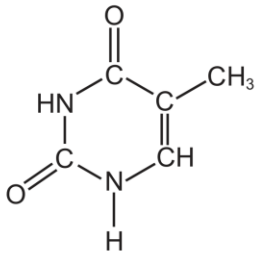
Paper 1

Question Paper

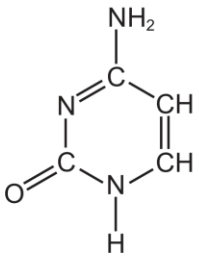
1 The diagrams show the chemical structure of four bases.



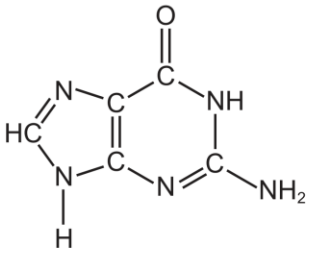
1



2



3



4

Which diagrams show thymine and cytosine?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

2 Which bond formation does DNA polymerase catalyse?

A hydrogen bonds between bases

B hydrogen bonds between nucleotides

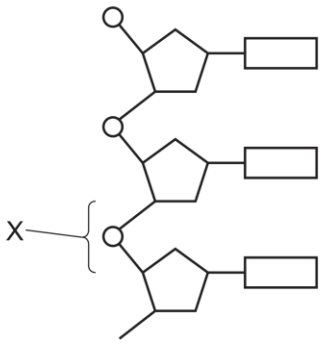
C phosphodiester bonds between bases

D phosphodiester bonds between nucleotides

3 How many hydrogen bonds form when adenine and cytosine each bind to their complementary bases?

	adenine	cytosine
A	2	2
B	2	3
C	3	2
D	3	3

4 The diagram shows a section of a strand of DNA.



Which type of bond is labelled X?

A glycosidic

B hydrogen

C peptide

D phosphodiester

5 Which row correctly describes cytosine?

	ring structure	number of hydrogen bonds it forms with its complementary base	type of base
A	double	three	purine
B	double	two	pyrimidine
C	single	three	pyrimidine
D	single	two	purine

6 Which statement about messenger RNA is correct?

A In eukaryotic cells, mRNA is made by removing exons from the primary RNA transcript.

B mRNA is a single-stranded polynucleotide containing a different purine base than DNA.

C mRNA molecules contain ribose sugars joined to phosphate groups by phosphodiester bonds.

D The monomers of mRNA contain a phosphate group, deoxyribose sugar and a nitrogenous base.

7 Which statement about mRNA is correct?

A It is a polymer made of nucleotides all joined with hydrogen bonds.

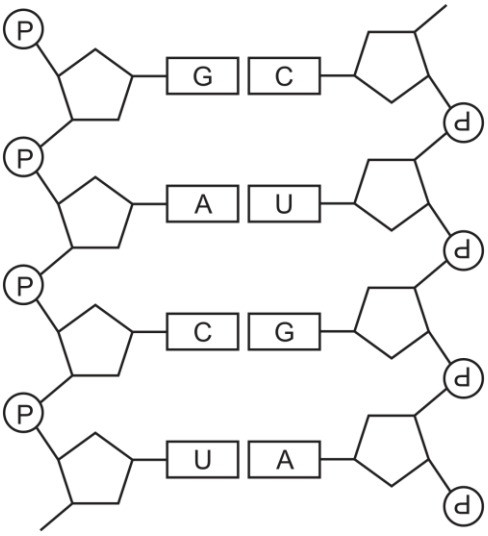
B Each nucleotide subunit contains the sugar ribose.

C It always has an equal proportion of adenine and uracil.

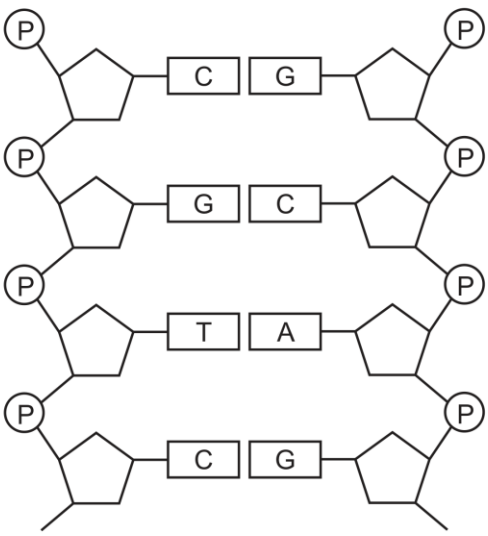
D The mRNA sequence is identical to the template strand of DNA.

8 Which diagram correctly shows the structure of a piece of DNA?

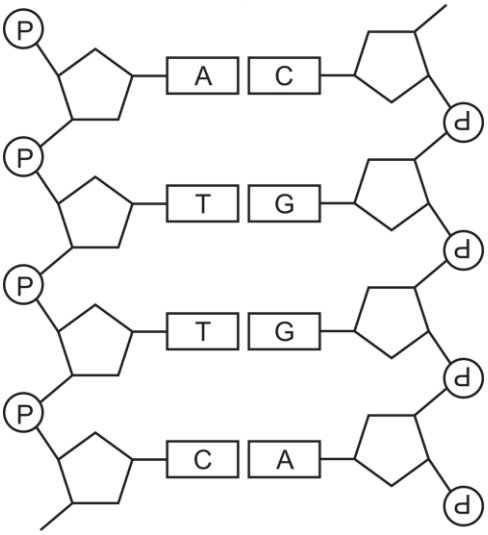
A



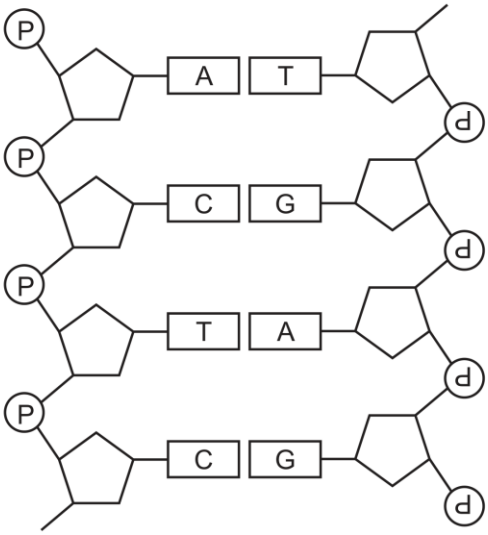
B



C



D



9 Bacteria were grown in a medium containing ^{15}N. After several generations, all of the bacterial DNA contained ^{15}N. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, ^{14}N. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amounts of ^{14}N and ^{15}N.

The remaining bacteria were left in the medium with ^{14}N and allowed to divide one more time. The DNA of some of these bacteria was extracted and analysed.

What is the percentage of hybrid DNA?

A 25% hybrid DNA

B 50% hybrid DNA

C 75% hybrid DNA

D 100% hybrid DNA

10 Which statement correctly describes a feature of a DNA molecule?

A It has two parallel strands twisted into a double helix.

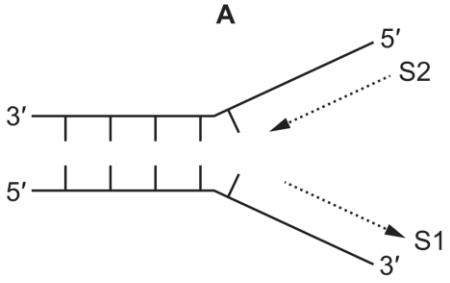
B It has complementary bases all held together by three hydrogen bonds.

C It has phosphodiester bonds that are formed using DNA ligase.

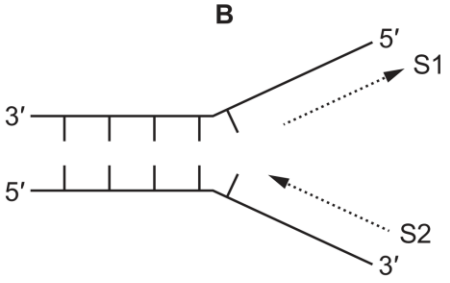
D It has a backbone of phosphate molecules and nucleotides.

11 Which diagram correctly shows the replication of DNA?

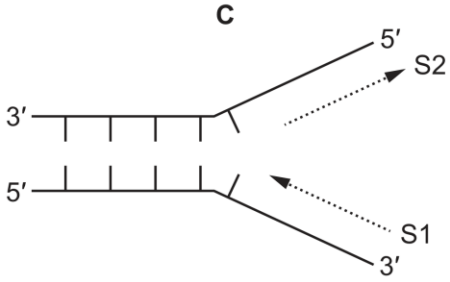
A



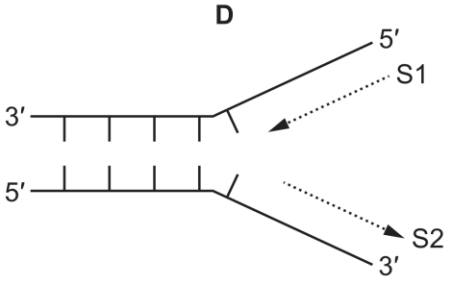
B



C



D



key

⋯▸	direction of replication
S1	leading strand
S2	lagging strand

12 Bacterial cells with DNA containing only the 'heavy' isotope of nitrogen (^{15}N) are allowed to reproduce for three generations in a culture medium containing the normal isotope of nitrogen (^{14}N).

Which percentage of the DNA molecules produced contain strands with the heavy isotope of nitrogen?

	first generation %	second generation %	third generation %
A	50	25	12.5
B	75	50	25
C	100	50	25
D	100	75	50

13 A bacterial circular DNA molecule is 2 600 150 base pairs long. 26% of the bases are adenine.

How many cytosine bases would be in the DNA molecule?

A 624 036 **B** 676 039 **C** 1 248 072 **D** 1 352 078

14 Which statement relating to the structure of DNA is correct?

A Two DNA strands are joined to each other by phosphodiester bonds.

B The alignment of bases to form a double helix is only achieved between antiparallel strands.

C Three hydrogen bonds are formed between all base pairs containing purines.

D The number of cytosine bases always equals the number of thymine bases.

15 Which statement describes the structure of ATP?

A It is a DNA nucleotide with two extra phosphates.

B It is a DNA nucleotide with three extra phosphates.

C It is an RNA nucleotide with two extra phosphates.

D It is an RNA nucleotide with three extra phosphates.

16 Which nitrogenous bases are pyrimidines?

A adenine and thymine

B cytosine and guanine

C thymine and uracil

D uracil and guanine

17 DNA replication in bacteria was investigated. Bacteria were grown in a medium with only heavy nitrogen, ^{15}N, until all of the bacterial DNA was heavy.

These bacteria were moved from the heavy nitrogen medium and cultured in a medium with only light nitrogen, ^{14}N. This formed the first generation.

The bacteria continued to reproduce, and a sample of bacteria was collected from the second generation and the DNA analysed.

Hybrid DNA contains heavy and light DNA.

Which row is correct for the second generation?

	percentage of heavy DNA strands	percentage of hybrid DNA molecules
A	25	25
B	25	50
C	50	25
D	50	50

18 How many statements about semi-conservative replication of DNA in a eukaryotic cell are correct?

1 The process takes place in the cytoplasm.

2 An adenine nucleotide will line up against uracil on the template strand.

3 Each daughter molecule will contain half of the original DNA molecule.

4 If the DNA molecule contained 40% guanine nucleotides, each daughter molecule will contain 20% guanine nucleotides.

A 1 **B** 2 **C** 3 **D** 4

19 Which diagram correctly represents temporary hydrogen bonding during transcription?

A

A ------ U

B

C ------ G

C

G ------ C

D

T ------ U

20 Four nucleotides, **A**, **B**, **C** and **D**, each consist of three phosphate groups, a nitrogenous base and a pentose sugar. Characteristics of the base and sugar components before they are joined to form each nucleotide are shown in the table.

Which nucleotide could pair with an adenine base during DNA replication?

	ring structure of nitrogenous base	ratio of carbon to oxygen atoms in pentose sugar
A	double	1 : 1
B	double	5 : 4
C	single	1 : 1
D	single	5 : 4

21 A short piece of DNA, 18 base pairs long, was analysed to find the number of nucleotide bases in each of the polynucleotide strands.

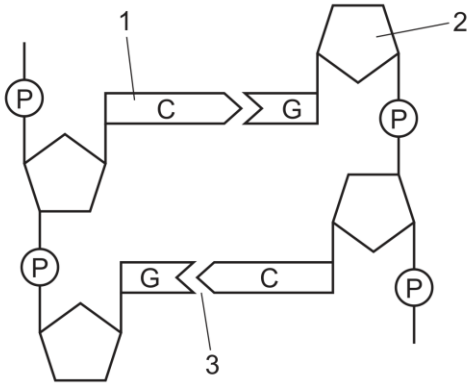
Some of the results are shown in the table.

	number of nucleotide bases			
	adenine	cytosine	guanine	thymine
strand 1		4		7
strand 2		5		

How many nucleotides containing thymine were present in strand 2?

A 2 **B** 4 **C** 5 **D** 7

22 The diagram shows a strand of DNA and mRNA during transcription.



Which row correctly identifies 1, 2 and 3?

	1	2	3
A	purine	deoxyribose	two hydrogen bonds
B	purine	ribose	three hydrogen bonds
C	pyrimidine	deoxyribose	two hydrogen bonds
D	pyrimidine	ribose	three hydrogen bonds

23 Which statement helps to explain why the two sugar-phosphate chains in a DNA molecule are a constant distance apart?

A Adenine and thymine are held together by the same number of hydrogen bonds as cytosine and guanine.

B Each nucleotide molecule is the same size.

C Each purine base is linked to a pyrimidine base.

D The sugar-phosphate strands of the helix are held together by sulfur bridges.

24 During DNA replication, what must happen **before** a newly added nucleotide is bonded to the next nucleotide in the strand?

1 complementary base pairing

2 hydrogen bond formation

3 phosphodiester bond formation

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

25 A piece of a DNA molecule contains 84 base pairs. The table shows the number of adenine and cytosine bases in one or both of the DNA strands in this piece of DNA molecule.

base	strand 1	strand 2
adenine	28	23
cytosine	15	

How many guanine bases are present in this piece of DNA molecule?

A 18 **B** 33 **C** 36 **D** 41

26 What is correct for thymine?

	has a single ring structure	is a pyrimidine	joins its complementary base with 3 hydrogen bonds
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✗
D	✗	✗	✓

key
✓ = correct
✗ = incorrect

27 A short piece of DNA 15 base pairs long was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown below.

	number of nucleotide bases			
	A	C	G	T
strand 1		6		3
strand 2				4

How many nucleotides containing guanine were present in strand 1?

A 2 **B** 3 **C** 4 **D** 6

28 Scientists grew bacteria in a medium containing heavy nitrogen, ^{15}N, as the only source of nitrogen.

After many generations, all of the bacterial DNA contained heavy nitrogen.

These bacteria were then moved from the heavy nitrogen medium into a medium with only light nitrogen, ^{14}N.

Some bacteria were collected from each of the **next** three generations and their DNA was analysed.

Hybrid DNA contains both heavy and light nitrogen.

Which row shows the correct DNA of the first and third generations?

	DNA of first generation	DNA of third generation
A	all hybrid	half hybrid, half light
B	all hybrid	one quarter hybrid, three quarters light
C	half hybrid, half heavy	half hybrid, one quarter heavy, one quarter light
D	half hybrid, half light	one quarter hybrid, three quarters light

29 Some viruses have single-stranded DNA as their genetic material. This DNA molecule has to be folded to fit in the protein coat.

Which statements about single-stranded DNA are correct?

1 Single-stranded DNA cannot replicate semi-conservatively.

2 If only the percentage of cytosine is known, then the percentage of guanine can be calculated, but the percentage of adenine and thymine cannot be calculated.

3 Hydrogen bonds may be present within the DNA molecule.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

30 How many statements are true for semi-conservative replication of DNA in a eukaryotic cell?

1 The process takes place in the nucleus.

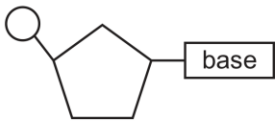
2 Adenine will line up against uracil on the complementary strand.

3 Each new molecule will contain one strand of the original molecule.

4 If the original molecule contained 40% guanine each new molecule will contain 20% guanine.

A 1 **B** 2 **C** 3 **D** 4

31 The diagram represents a nucleotide containing cytosine.



Which statements about this nucleotide are correct?

1 The carbohydrate could be ribose.

2 The organic base contains nitrogen.

3 Base pairing occurs with guanine.

4 Cytosine is a purine.

A 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

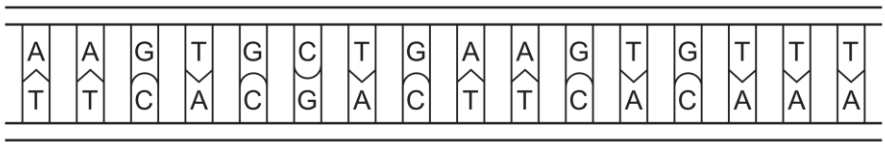
32 A section of DNA contains 73 base pairs.

	number of bases on each strand			
	adenine	cytosine	guanine	thymine
strand 1	29	V	14	W
strand 2	21	X	Y	Z

Which row represents the correct number of bases?

	V	W	X	Y	Z
A	9	21	14	9	29
B	14	29	9	9	21
C	21	9	29	9	14
D	29	9	29	14	9

33 How many hydrogen bonds are holding the two strands of this section of a DNA molecule together?



A 16 **B** 32 **C** 38 **D** 48

34 A short piece of DNA, 19 base pairs long, was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown below.

	number of nucleotide bases			
	A	C	G	T
strand 1				4
strand 2		7		5

How many nucleotide bases containing C were present in strand 1?

A 2 **B** 3 **C** 5 **D** 7

35 Which nucleic acid bases are purines?

A adenine and cytosine

B cytosine and thymine

C guanine and adenine

D uracil and cytosine

36 Which statement correctly describes the base pairing in a molecule of DNA?

A The purine adenine forms bonds with the pyrimidine thymine.

B The purine adenine forms bonds with the pyrimidine uracil.

C The purine cytosine forms bonds with the pyrimidine guanine.

D The purine guanine forms bonds with the pyrimidine thymine.

37 Which statements about complementary base pairing are correct?

1 It allows translation to occur.

2 Purines and pyrimidines are the same size.

3 The base pairs are of equal length.

4 Uracil forms two hydrogen bonds with adenine.

A 1, 2, 3 and 4

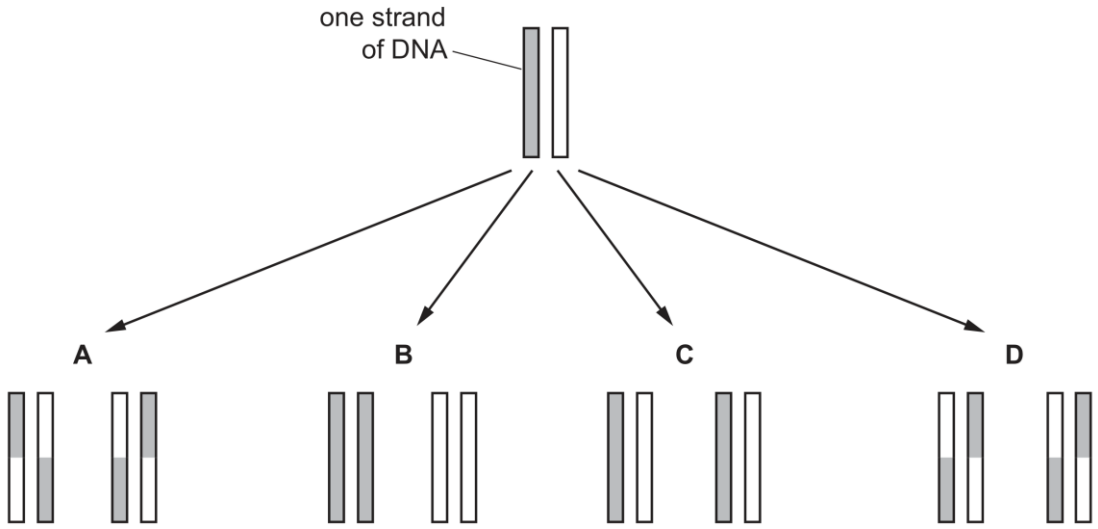
B 1, 3 and 4 only

C 1 and 4 only

D 2 and 3 only

38 The diagram shows the possible organisation of DNA molecules after one replication.

Which organisation is correct?



39 Which components could be found in nucleotides of rRNA?

1 any one of two different nitrogenous bases with a double ring structure

2 any one of two different purine bases

3 any one of three different nitrogenous bases with a single ring structure

4 any one of three different pyrimidine bases

A 1, 2, 3 and 4 **B** 1 and 2 only **C** 1 and 4 only **D** 3 and 4 only

40 How many statements are true for semi-conservative replication of DNA in a prokaryotic cell?

1 the process takes place in the cytoplasm

2 an adenine nucleotide will line up against a uracil on the template strand

3 each new DNA molecule will contain one strand from the parent molecule

4 if the parent molecule contained 40% guanine nucleotides each new DNA molecule will contain 20% guanine nucleotides

A 1 **B** 2 **C** 3 **D** 4

41 What is correct for uracil?

	It has a single ring structure	It is a purine	It joins its complementary base with 2 hydrogen bonds
A	✓	✓	✓
B	✓	✗	✓
C	✗	✓	✗
D	✗	✗	✓

key

✓ = correct

✗ = not correct

42 Which row is correct for guanine?

	has a double ring structure	is a purine	joins its complementary base with three hydrogen bonds
A	✓	✓	✓
B	✓	✗	✓
C	✗	✓	✗
D	✗	✗	✓

key

✓ = correct

✗ = incorrect

43 Meselsohn and Stahl investigated DNA in bacteria. They grew bacteria in a medium with only heavy nitrogen, ^{15}N, until all of the bacterial DNA was heavy.

These bacteria were moved from a heavy nitrogen medium and cultured in a medium with only light nitrogen, ^{14}N.

A sample of bacteria was collected from the first generation in the medium containing light nitrogen and their DNA was analysed.

Hybrid DNA contains both heavy and light DNA.

Which row shows the percentage of heavy DNA strands and the percentage of hybrid DNA molecules in the first generation produced in the medium containing light nitrogen?

	percentage of heavy DNA strands	percentage of hybrid DNA molecules
A	25	50
B	50	50
C	50	100
D	75	100

44 Which statement explains why DNA replication is described as semi-conservative?

A Half of each original strand is conserved in each new molecule of DNA.

B Half of the base sequence of each strand is conserved in each new molecule of DNA.

C Only one strand of DNA is used as a template during replication.

D The template for each new molecule of DNA is one strand of the original molecule.

45 A section of a DNA molecule has the coding sequence: AGGCAATGGC.

Which statements are correct?

1 This coding sequence contains 3 pyrimidines.

2 The double-stranded DNA of this section contains 26 hydrogen bonds between complementary bases.

3 The double-stranded DNA of this section has 20 sugar-phosphate bonds.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

46 XNA is a laboratory-made nucleic acid made of nucleotides in which one component has been replaced by chemical X. The chemical X is not found in nature. The part of the molecule responsible for coding is not changed.

Which organic component of a DNA or RNA nucleotide has been replaced by X?

A five-carbon sugar

B phosphate group

C purine base

D pyrimidine base

47 What are the products when a DNA molecule replicates?

A two molecules of DNA each made of a paired sequence of bases

B two molecules of DNA each made of a paired sequence of nucleotides

C two strands of DNA each made of a paired sequence of bases

D two strands of DNA each made of a paired sequence of nucleotides

48 What is the maximum number of hydrogen bonds in a length of DNA containing 700 base pairs?

A 350 **B** 700 **C** 1400 **D** 2100

49 What is the common component of the three molecules RNA, DNA, and ATP?

A adenosine

B hydrogen bonds

C phosphate

D ribose