Structure of Nucleic Acids and Replication of DNA (6.1): Cambridge (CIE) A Level Biology 9700 Exam Questions by T

22 questions · 62 marks · about 74 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · Paper 2 · February/March 2024 (22) · Q4(d) · 1 mark

(d) Fig. 4.1 shows the structure of an ATP molecule.

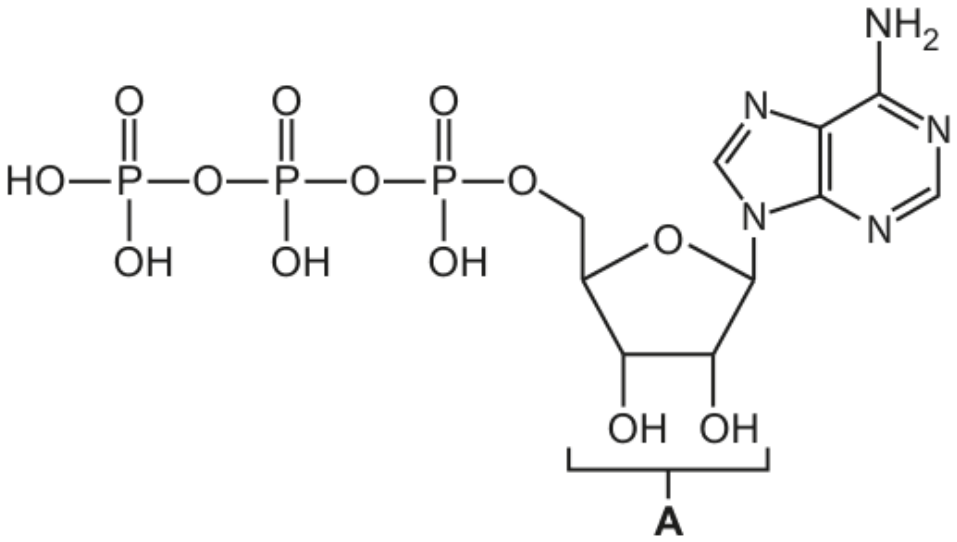


Fig. 4.1

State the name of the part of the ATP molecule labelled **A** in Fig. 4.1.

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 2 · Paper 2 · February/March 2019 (22) · Q6(c) · 5 marks

(c) During the mitotic cell cycle, free nucleotides are used for the synthesis of both types of nucleic acid: RNA and DNA.

Complete sentences **A**, **B**, **C** and **D** to provide information about nucleotides and the synthesis of nucleic acids.

Write the correct term in the spaces provided in each sentence.

A Each nucleotide has three main components: a ..... group, a ..... (5 carbon) sugar and a nitrogenous organic base.

B The nitrogenous organic base of a nucleotide is either a purine or a ..... .

C In a DNA nucleotide, the sugar is deoxyribose and in an RNA nucleotide the sugar is ..... .

D The synthesis of RNA from a template strand of DNA is known as ..... .

[5]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(c) Nucleotides are structural components of nucleic acids. Each nucleotide consists of a pentose sugar, a phosphate group and a nitrogenous organic base.

Complete Table 5.1 to compare DNA nucleotides with RNA nucleotides as structural components of nucleic acids.

Table 5.1

feature	DNA nucleotides	RNA nucleotides
pentose sugar component		
purine bases		
pyrimidine bases		

[3]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Answer **all** the questions.

1 **(a)** ATP and coenzyme A both play important roles in respiration.

Fig. 1.1 represents the molecular structure of coenzyme A.

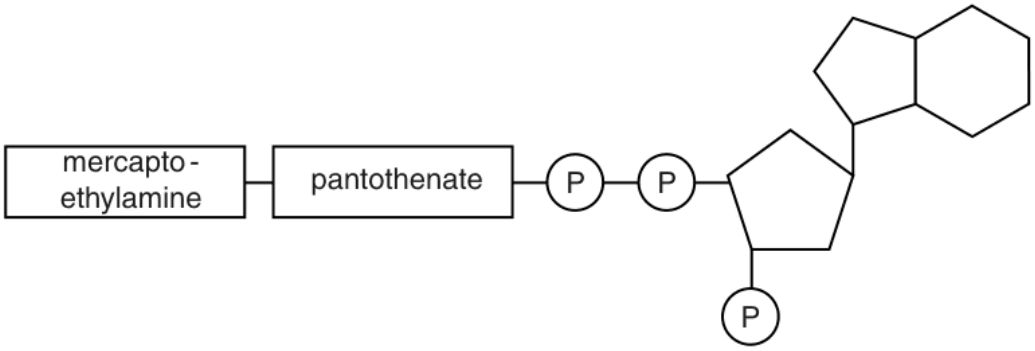


Fig. 1.1

(i) With reference to Fig. 1.1, state two structural **similarities** between coenzyme A and ATP.

1 .....

2 ..... [2]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

5 Nucleotide and nucleoside analogues are therapeutic drugs that have a similar structure to nucleotides or nucleosides of RNA and DNA.

A nucleoside is composed of a nitrogenous organic base (base) and a pentose sugar.

(a) The names of the bases present in RNA and DNA nucleotides can be abbreviated using a single letter. These are shown in Table 5.1.

Complete Table. 5.1 by stating:

- the name of each base
- whether the base is a purine **or** pyrimidine
- whether the base is present
  - **only** in an RNA molecule (write **RNA** in the table)
  - **only** in a DNA molecule (write **DNA** in the table)
  - in RNA **and** in DNA molecules (write the word **both** in the table).

Table 5.1

base	name of base	purine or pyrimidine	present in RNA, DNA, or both
A			
C			
G			
T			
U			

[4]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(b) Abacavir is an analogue drug used in the treatment of some viral diseases. It enters a cell infected by a virus and is metabolised to the analogue carbovir triphosphate.

Fig. 5.1 shows the molecular structure of abacavir and carbovir triphosphate.

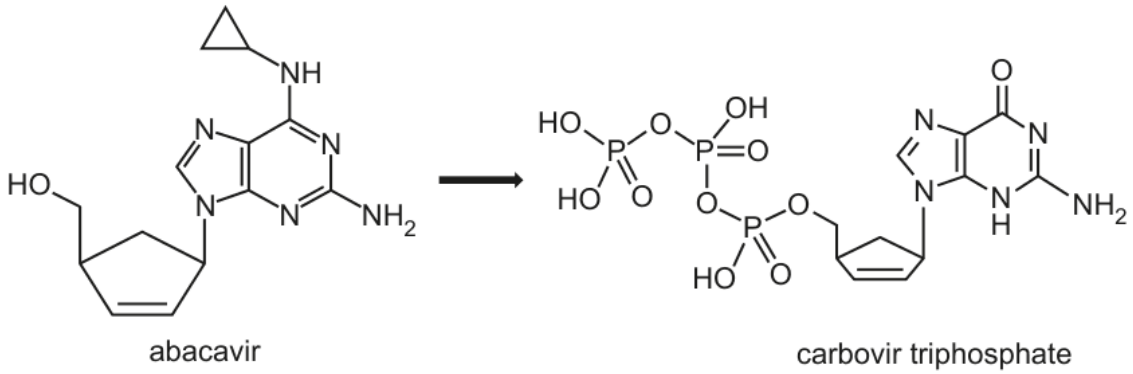


Fig. 5.1

Carbovir triphosphate can be inserted into an elongating polynucleotide chain instead of a nucleotide. This interferes with the action of DNA polymerase during the synthesis of viral DNA.

(i) With reference to Fig. 5.1, explain whether carbovir triphosphate will replace a purine or a pyrimidine nucleotide in the elongating polynucleotide chain.

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(b) A protein such as carbonic anhydrase is coded for by a gene. A gene forms part of a DNA molecule.

Fig. 3.1 is a diagram of a small section of a DNA molecule.

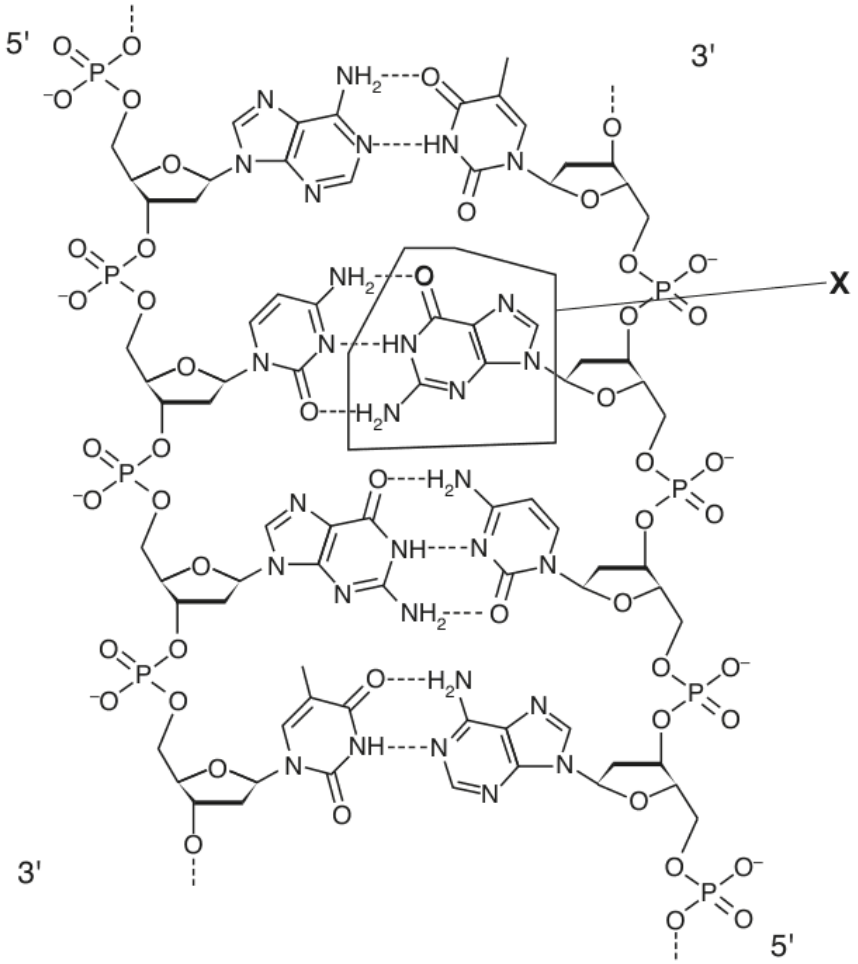


Fig. 3.1

(i) Identify the base **X and** state the evidence in Fig. 3.1 that supports this identification.

base **X** .....

evidence from Fig. 3.1 .....

.....

.....

.....

.....

[3]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 8 · Paper 2 · October/November 2024 (22) · Q3(a) · 1 mark

3 During transcription, base pairing occurs between nucleotides.

Fig. 3.1 is a diagram to show complementary base pairing between a DNA nucleotide and an RNA nucleotide.

Only the base pair is shown in molecular detail.

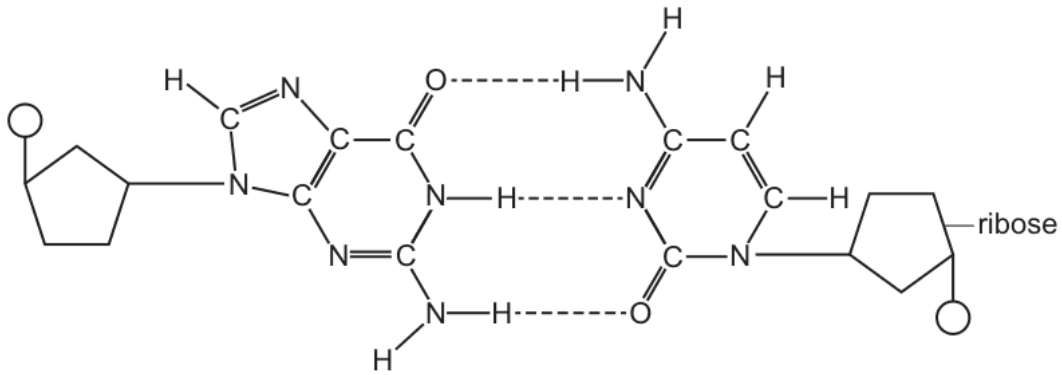


Fig. 3.1

(a) Explain why Fig. 3.1 does **not** include any phosphodiester bonds.

.....

.....

Question 9 · Paper 2 · October/November 2024 (22) · Q3(b) · 4 marks

(b) Identify **and** describe the DNA-RNA nucleotide pair shown in Fig. 3.1.

You may add labels and annotations to Fig. 3.1 if you wish.

.....

.....

.....

.....

.....

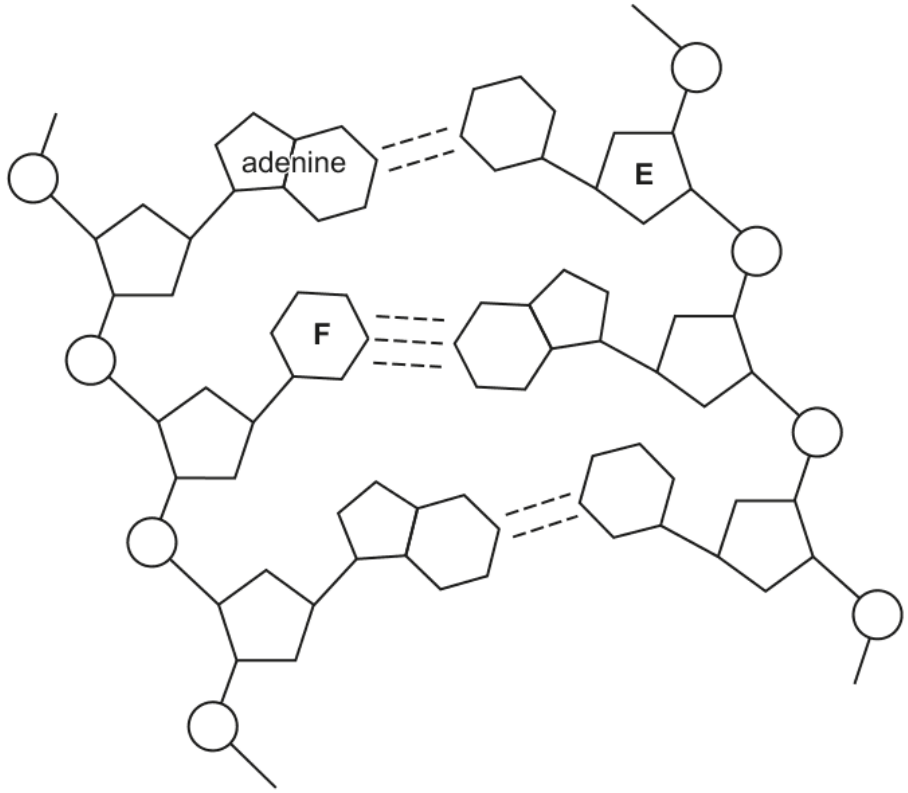
.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 10 · Paper 2 · February/March 2022 (22) · Q6(a)(i) · 2 marks

6 Fig. 6.1 is a diagram showing the structure of part of a DNA molecule.



key

---- one hydrogen bond

Fig. 6.1

(a) (i) Identify structure **E** and structure **F** in Fig. 6.1.

E .....

F .....

[2]

Question 11 · Paper 2 · February/March 2022 (22) · Q6(a)(ii) · 1 mark

(ii) On Fig. 6.1 draw a circle around **one** nucleotide. [1]

Question 12 · Paper 2 · February/March 2022 (22) · Q6(a)(iii) · 1 mark

(iii) State the name of the covalent bond that links two nucleotides together.

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 13 · Paper 2 · February/March 2017 (22) · Q3(c) · 4 marks

Hydrogen peroxide has a harmful effect on cells. One effect is to damage DNA.

(c) Describe the structure of DNA.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(ii) During research, scientists can use modified nucleotides to prevent elongation of a polynucleotide chain during DNA replication.

Fig. 6.1 shows the structure of a DNA nucleotide found in the nucleus of a cell.

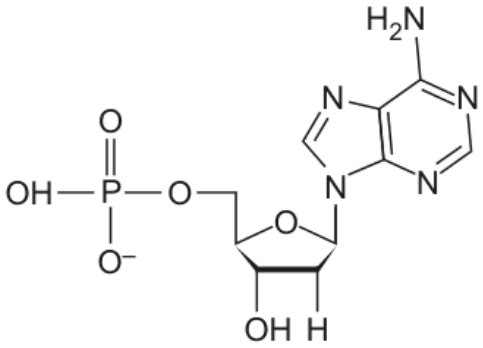


Fig. 6.1

Fig. 6.2 shows the structure of a modified nucleotide.

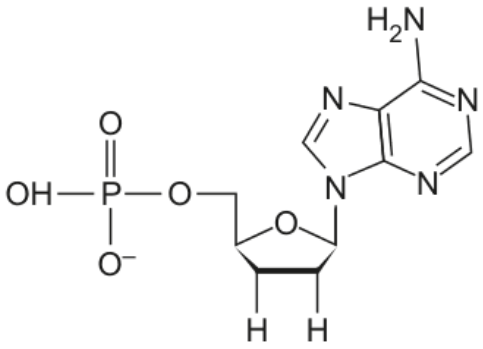


Fig. 6.2

Suggest how the structure of the modified nucleotide prevents DNA polymerase joining it to another nucleotide.

.....

.....

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(b) Fig. 4.2 shows a short length of a DNA molecule. One of the strands of the DNA molecule is labelled **Y**.

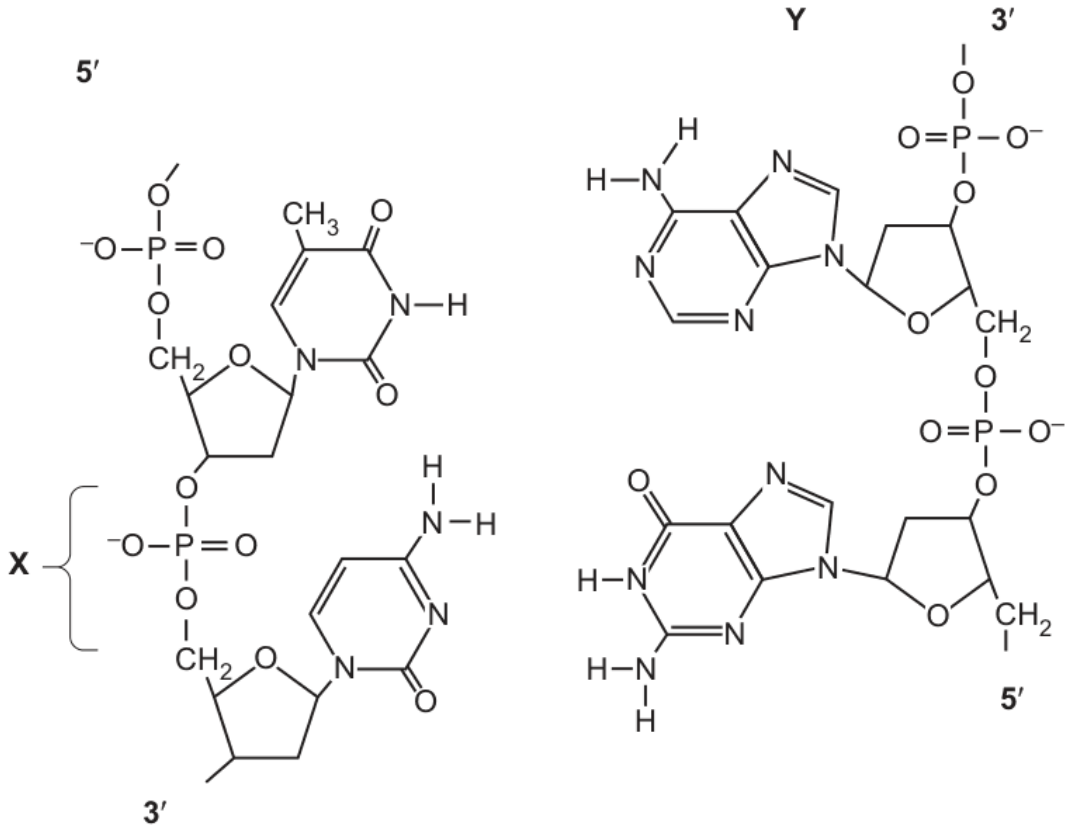


Fig. 4.2

(i) Complete Fig. 4.2 by drawing dotted lines to represent all the hydrogen bonds between the two strands of the DNA molecule. [2]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 16 · Paper 2 · February/March 2024 (22) · Q4(c) · 4 marks

(c) Outline how DNA is replicated inside the nucleus.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 17 · information from earlier in the question

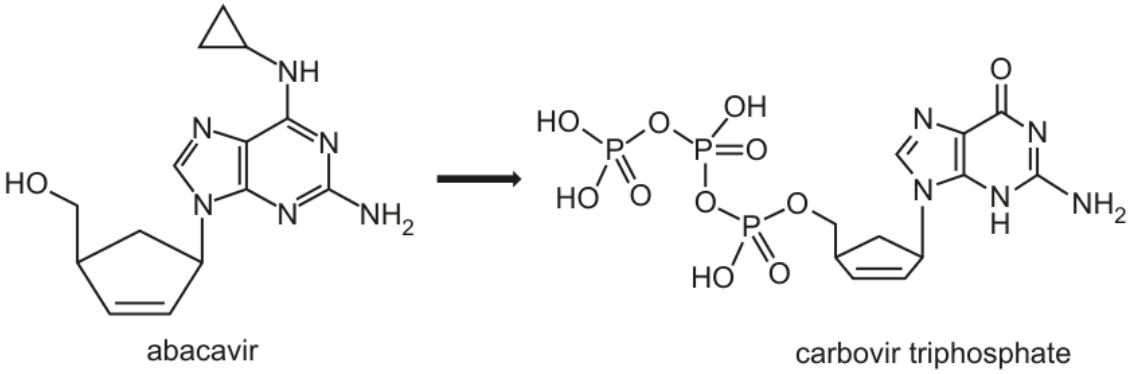
5 Nucleotide and nucleoside analogues are therapeutic drugs that have a similar structure to nucleotides or nucleosides of RNA and DNA.

A nucleoside is composed of a nitrogenous organic base (base) and a pentose sugar.

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(b) Abacavir is an analogue drug used in the treatment of some viral diseases. It enters a cell infected by a virus and is metabolised to the analogue carbovir triphosphate.

Fig. 5.1 shows the molecular structure of abacavir and carbovir triphosphate.



abacavir carbovir triphosphate

Fig. 5.1

Carbovir triphosphate can be inserted into an elongating polynucleotide chain instead of a nucleotide. This interferes with the action of DNA polymerase during the synthesis of viral DNA.

Question 17 · Paper 2 · May/June 2023 (22) · Q5(b)(ii) · 2 marks

(ii) With reference to Fig. 5.1 **and** the action of DNA polymerase, suggest why the conversion of abacavir to carbovir triphosphate increases the chance of the analogue being added to the viral polynucleotide chain.

.....

.....

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 18 · Paper 2 · May/June 2023 (22) · Q5(b)(iii) · 4 marks

(iii) Suggest **and** explain how carbovir triphosphate interferes with the action of DNA polymerase **and** how this may prevent the synthesis of viral DNA.

.....

.....

.....

.....

.....

.....

.....

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 19 · Paper 2 · May/June 2021 (22) · Q1(b) · 4 marks

(b) Semi-conservative replication of DNA occurs during interphase, before mitosis begins.

Write the correct term in the spaces provided to complete each of statements **A** to **D**.

A The DNA double helix unwinds and is separated into two template strands when ..... bonds holding the two strands together are broken.

B One of the template strands of DNA is copied in fragments. The enzyme ..... is required to join the fragments together to form a continuous strand of DNA.

C Complementary DNA nucleotides are added to the template strands, catalysed by the enzyme ..... .

D ..... are regions of repeating nucleotide sequences at the ends of chromosomes that allow the continued replication of DNA, without the loss of genes.

[4]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

(b) Two enzymes, DNA polymerase and DNA ligase, are involved in the replication of DNA.

Fig. 4.1 shows the replication of part of human chromosome 11 by DNA polymerase. The arrows show the direction of synthesis of the new polynucleotides by DNA polymerase.

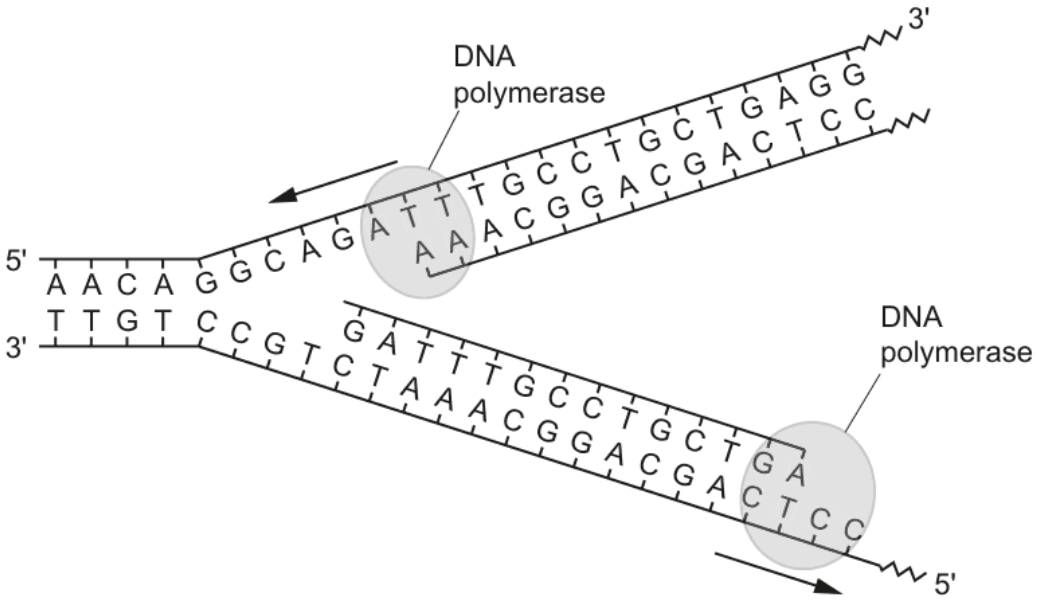


Fig. 4.1

(i) Describe the roles of DNA polymerase and DNA ligase in the replication of DNA.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 21 · Paper 2 · October/November 2021 (22) · Q5(a) · 4 marks

5 The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(a) The genetic material of *Morbillivirus* is a strand of RNA.

Statements **A**, **B** and **C** relate to the structure of RNA.

State the correct term or terms to match each of statements **A** to **C**.

A The names of the two purines and two pyrimidines in RNA.

purines .....

.....

pyrimidines .....

.....

B The type of covalent bond between RNA nucleotides.

.....

C The pentose sugar of the RNA nucleotide.

.....

[4]

Question 22 · Paper 2 · May/June 2024 (23) · Q6(a) · 3 marks

6 DNA and RNA are polynucleotides.

(a) Describe **three** ways in which the structure of messenger RNA (mRNA) differs from the structure of DNA.

In each of your answers, include information about the structure of mRNA **and** the structure of DNA.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Mark schemes

Question 1 · Paper 2 · February/March 2024 (22) · Q4(d) · 1 mark

4(d)	ribose ; **I** pentose	1

Question 2 · Paper 2 · February/March 2019 (22) · Q6(c) · 5 marks

6(c)	**A** phosphate ; pentose ; **B** pyrimidine ; **C** ribose ; **D** transcription ;	5

Question 3 · Paper 2 · October/November 2018 (22) · Q5(c) · 3 marks

5(c)

feature	DNA nucleotide	RNA nucleotide
sugar component	deoxyribose	ribose ;
purine bases	adenine / A guanine / G	adenine / A guanine / G ;
pyrimidine bases	cytosine / C thymine / T	cytosine / C uracil / U ;

3

R *thiamine for thymine*

Question 4 · Paper 4 (A level) · May/June 2016 (42) · Q1(a)(i) · 2 marks

1 (a) (i) <u>three</u> phosphates ;
ribose / pentose ;
adenine ; **I** nitrogenous base [max 2]

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 5 · Paper 2 · May/June 2023 (22) · Q5(a) · 4 marks

5(a)

1 four DNA bases named correctly **;** *correct spellings*
2 purine or pyrimidine column correct for **A**, **C**, **G**, **T ;**

3 final column correct **;**
4 uracil (*spelled correctly*) and pyrimidine **;**

if 0 or 1 mark gained, can increase to max 2:
- if 0 marks, can check for two correct rows
- only mp 1, 2 or 3 correct, check for one correct row
- only mp 4 correct, check for a correct **A** / **C** / **G** / **T** row

base	name of base	purine or pyrimidine	RNA or DNA or both
A	adenine	purine	both
C	cytosine	pyrimidine	both
G	guanine	purine	both
T	thymine	pyrimidine	DNA
U	uracil	pyrimidine	RNA

4

Question 6 · Paper 2 · May/June 2023 (22) · Q5(b)(i) · 1 mark

5(b)(i)

purine because it is a, double ring structure / has two rings **;**
A purine because similar structure to, adenine / guanine

1

Question 7 · Paper 2 · October/November 2022 (21) · Q3(b)(i) · 3 marks

3(b)(i)

guanine **;**

*any **two** from:*

double ring (base) / purine (base) **;**
forms three hydrogen bonds with complementary base **;**
AVP **;**
e.g. detail of difference between adenine and guanine

3

Question 8 · Paper 2 · October/November 2024 (22) · Q3(a) · 1 mark

3(a)

do not allow 'base' as AW for 'nucleotide'

*any **one** from:*

idea that phosphodiester bond forms,
between nucleotides on the same strand /
between adjacent nucleotides /
during polynucleotide formation /
to form a sugar-phosphate backbone **;** AW
look for understanding that more than one nucleotide needs to be present on the same strand

idea that phosphates, shown are only bound to one (pentose) sugars / each phosphate needs to be bound to two (pentose) sugars **;**

1

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 9 · Paper 2 · October/November 2024 (22) · Q3(b) · 4 marks

3(b)	base / nucleotide, on left identified as guanine and, base / nucleotide, on right identified as cytosine ; **A** guanine and cytosine *as question has DNA-RNA* **I** cytosine and guanine *unless further qualified* dotted line as hydrogen bond / annotation related to dotted lines as hydrogen bonds / there are three hydrogen bonds between the bases**; A** H-bond *circle is* phosphate ; *pentagon / pentose, on left is* deoxyribose ; *also AVP if 'pentose'* double ring / base on left, identified as purine ; **A** guanine is a purine if mp1 gained single ring / base on right, identified as pyrimidine ; **A** cytosine is a pyrimidine if mp1 gained AVP ; e.g. label to any solid line bond as covalent bond phospho-ester bond, labelled / described pentose sugar, label to / described for, deoxyribose / ribose box drawn around one completed nucleotide and labelled 5' and 3' shown annotated ref. to antiparallel nature of base-pair	**4**

Question 10 · Paper 2 · February/March 2022 (22) · Q6(a)(i) · 2 marks

6(a)(i)	**E** = deoxyribose ; **F** = cytosine ;	**2**

Question 11 · Paper 2 · February/March 2022 (22) · Q6(a)(ii) · 1 mark

6(a)(ii)	a ring drawn around 1 base, 1 deoxyribose and 1 phosphate on the same strand and passing through the H bonds ;	**1**

Question 12 · Paper 2 · February/March 2022 (22) · Q6(a)(iii) · 1 mark

6(a)(iii)	phosphodiester ;	**1**

Question 13 · Paper 2 · February/March 2017 (22) · Q3(c) · 4 marks

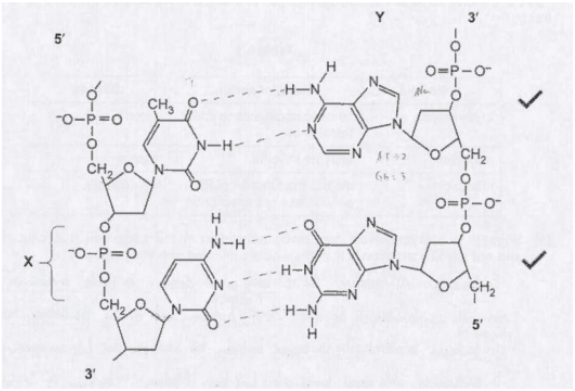
3(c)	*four from:* 1 double helix ; 2 strands are held together by hydrogen bonds (between bases) ; 3 complementary base pairing / described as A-T and C-G ; **A** purine pairs with pyrimidine R thiamine 4 antiparallel stands / strands are 3' to 5' and 5' to 3' ; **A** strands run in opposite directions 5 (each strand has a sugar phosphate backbone with) phosphodiester bonds ; 6 (monomers / units / DNA) are (DNA) nucleotides / polynucleotide strands ; 7 (nucleotide =) deoxyribose sugar, phosphate, nitrogenous (organic) base ; ***A** points from a diagram*	**4**

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 14 · Paper 2 · October/November 2023 (21) · Q6(a)(ii) · 2 marks

6(a)(ii)	*any **two** from:* does not have an OH group (on C3) so condensation reaction cannot occur ; phosphodiester bond cannot form between deoxyribose and phosphate of adjacent nucleotide ; is a different shape because it has H instead OH (on C3) ; shape not complementary to the active site of DNA polymerase **or** no, enzyme substrate complexes / ESCs, can form ;	**2**

Question 15 · Paper 2 · October/November 2025 (23) · Q4(b)(i) · 2 marks

4(b)(i)	two hydrogen bonds drawn correctly between A and T ; three hydrogen bonds drawn correctly between C and G ; *for positioning of H bonds on C-G, **A** from either H on amine group on C to link with oxygen on G*  *if no marks gained but A-T has two lines and C-G has three lines between bases award 1 mark*	**2**

Question 16 · Paper 2 · February/March 2024 (22) · Q4(c) · 4 marks

4(c)	*any **four** from:* *max three if points about transcription also given* 1 double helix unwinds, qualified ; e.g. using, enzyme / helicase breaking hydrogen bonds between strands 2 both strands act as templates ; 3 ref, activated (free DNA) nucleotides ; 4 DNA polymerase, plus example of role ; e.g. adds complementary nucleotides to exposed strand forms phosphodiester bonds (between adjacent nucleotides) proofreading / checking for errors / checking for mismatches 5 leading strand synthesised continuously / AW ; 6 lagging strand synthesised in (Okazaki) fragments ; 7 ligase connects (lagging strand), fragments / nucleotides, (with phosphodiester bonds) ; 8 semi-conservative replication / AW ; e.g. both new double helices have one, parental / conserved, strand and one newly synthesised strand	**4**

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 17 · Paper 2 · May/June 2023 (22) · Q5(b)(ii) · 2 marks

5(b)(ii)	*mp1 / 2 / 4 idea that carbovir triphosphate is more similar to the (activated) DNA nucleotides that are added to the elongating chain by DNA polymerase* *mp3 justifying why it is better to have a nucleotide analogue (carbovir triphosphate) by explaining the role of DNA nucleotides* *look for ora for abacavir* *any **two** from:* **1** carbovir triphosphate is (similar to / same as), an activated nucleotide / a nucleotide / not a nucleoside **;** **A** similar to, A / G, nucleotides **I** *ref. to* purine **2** carbovir triphosphate, has (three) phosphates / is activated / is phosphorylated **;** **3** detail of, (DNA) polymerase action / (activated DNA) nucleotides **;** e.g. (nucleotides are) added to the, growing / elongating, chain (nucleotides) form H bonds with, complementary base / AW (nucleotides are) substrates for DNA polymerase phosphodiester bonds form between nucleotides *allow mp3 in context of carbovir triphosphate (link to mp1)* **4** *ref. to* triangle / triangular cycloalkane, no longer present / not on DNA nucleotides **;** **5** AVP **;** e.g. carbovir triphosphate better fit to active site of enzyme / AW	**2**

Question 18 · Paper 2 · May/June 2023 (22) · Q5(b)(iii) · 4 marks

5(b)(iii)	*any **four** from:* *carbovir triphosphate can be inserted into a growing chain…* **1** prevents polymerase from adding DNA nucleotide to growing chain / AW **;** **A** *idea of* complete (viral) DNA not made if, chain does not elongate / no more nucleotides added **R** adding base **R** *if in context of stop codon / transcription* **I** *ref. to* complementary base pairing **2** similar <u>shape</u> to, substrate / (activated / phosphorylated) nucleotide **;** **A** complementary shape to active site of, DNA polymerase / enzyme **3** acts as an inhibitor **;** **4,5** further detail of how, inhibitor / carbovir triphosphate, may act **;;** *two from = 2 marks* e.g. may be irreversible fits into / binds to, active site of, enzyme / DNA polymerase competes with (DNA) nucleotide for active site **R** base fewer ES complexes form *in context of enzyme with DNA nucleotide* *idea of* fewer enzyme molecules available to bind to nucleotides may cause change in, shape / tertiary structure / 3D structure, of (DNA) polymerase / enzyme **I** *ref. to* complementary base pairing **6** (DNA polymerase) may not form phosphodiester bonds **;** **R** between, bases / complementary bases / complementary nucleotides **7** *ref. to* proofreading mechanism **;** e.g. error may cause breakdown of (newly synthesised) DNA may be too similar to be noticed as error and not repaired **8** AVP **;** e.g. (viral) DNA containing analogue may not be further replicated DNA polymerase cannot move along DNA template strand AW DNA polymerase may become detached from template strand *idea that* carbovir triphosphate, introduces a mutation / changes DNA formed / changes nucleotide sequence	**4**

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 19 · Paper 2 · May/June 2021 (22) · Q1(b) · 4 marks

1(b)	**R** *any answers where a choice is given* **A** hydrogen ; **B** (DNA) ligase ; **C** DNA polymerase ; **R** RNA polymerase **I** roman numerals, e.g. DNA polymerase I **D** telomeres ;	**4**

Question 20 · Paper 2 · May/June 2023 (21) · Q4(b)(i) · 5 marks

4(b)(i)	*must attempt both DNA polymerase and DNA ligase to gain max* *any **five** from:* *DNA polymerase* **1** addition of, activated / phosphorylated, nucleotides ; **2** *ref. to* complementary, nucleotides / bases / strands ; **3** forms phosphodiester bonds ; **4** (between adjacent nucleotides and) elongating / growing, polynucleotide / strand / AW ; **5** *ref. to* proofreading ability of DNA polymerase ; *DNA ligase* **6** joins / AW, Okazaki fragments ; **7** on lagging strand ; **8** forms phosphodiester bonds, between the fragments / to complete phosphate-sugar backbone ;	**5**

Question 21 · Paper 2 · October/November 2021 (22) · Q5(a) · 4 marks

5(a)	*ignore single letters for the bases* **A** *purines* = adenine and guanine ; *in either order* *pyrimidines* = cytosine and uracil ; *in either order* **B** phosphodiester (bond) ; **C** ribose ;	**4**

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.

Question 22 · Paper 2 · May/June 2024 (23) · Q6(a) · 3 marks

6(a) — **3**

must have correct matching information about mRNA and DNA

*any **three** correct (rows) from*:

mRNA	**DNA**
one strand / single-stranded / one polynucleotide chain	two strands / double-stranded / two polynucleotide chains ; **A** double helix
RNA, bases not paired / base pairing not present	DNA base pairing present ;
ribose (sugar)	deoxyribose (sugar) ;
uracil, (adenine, cytosine, guanine) (base(s) / nucleotide(s))	thymine, (adenine, cytosine guanine) (base(s) /nucleotide(s)) ;
shorter / fewer nucleotides	longer / more nucleotides ;

Questions, mark schemes and examiners' report extracts © Cambridge University Press & Assessment.