

Exercise walk-through

6.1

Structure of nucleic acids and replication of DNA

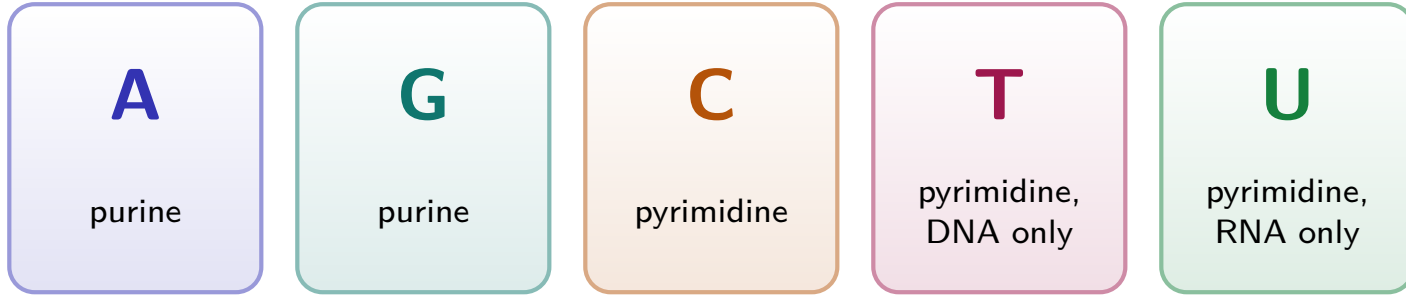
A-Level Biology

Nucleotides

A **nucleotide** has three parts: a pentose sugar, a phosphate, and a nitrogenous base. DNA uses deoxyribose; RNA uses ribose. Nucleotides join by

phosphodiester bonds between the 5' phosphate of one and the 3' OH of the next.

The five bases



A pairs with T (or U in RNA); G pairs with C. Two H-bonds vs three.

DNA structure

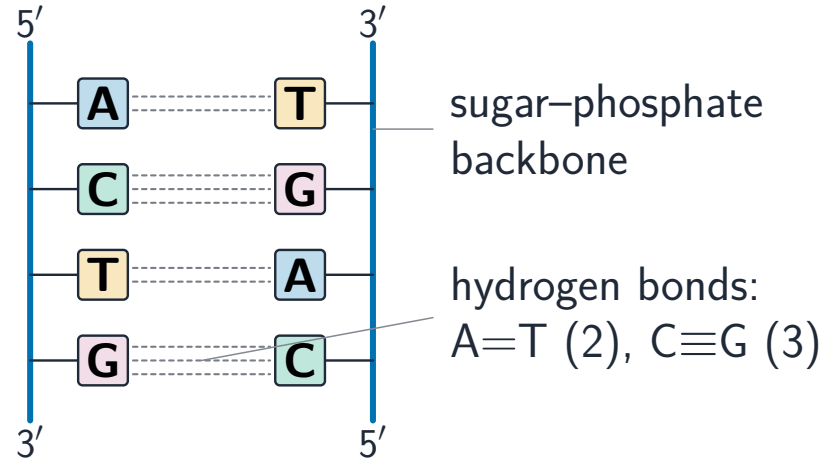
Two **antiparallel** strands twist into a **double helix** .

Complementary base pairing

3 – joined along a **phosphodiester**

: A–T by **2** hydrogen bonds, C–G by backbone.

DNA structure, in detail



the two strands run in opposite directions (antiparallel)

Two **antiparallel**

strands twist into a **double helix**

.

The double helix, and the strands of replication

the shape	the flat ladder is twisted into a double helix – a space-filling model shows the real form
the bases	adenine , thymine , cytosine , guanine – A pairs with T, C with G
purines and pyrim- idines	a large base always pairs with a small one, which keeps the helix a constant width
the leading strand	built continuously toward the unwinding point
the lagging strand	built in short pieces working away from it; DNA lig- ase joins them
why two ways	DNA polymerase can only build in one direction, and the two strands are antiparallel

The lagging strand exists because of the enzyme's one-way constraint, not because the two strands differ chemically. That is the explanation the mark scheme wants.

Exercises 2.1·2.2

2.1 State the three parts of a nucleotide.

[3]

2.2 State the number of hydrogen bonds between (a) A and T, and (b) C and G.

[2]

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2.1

- a phosphate group; a (5-carbon/pentose) sugar; a nitrogen-containing base

2.2 State the number of hydrogen bonds between (a) A and T, and (b) C and G.

[2]

2.2

(a)

- 2

(b)

- 3

Exercises 3.1-3.2

3.1 Which statement about the two strands of a DNA molecule is correct?

[1]

☐

A they are identical in base sequence

B they run in the same direction

C they are antiparallel and complementary

D they are joined by phosphodiester bonds between bases

3.2 In a sample of DNA, 20% of the bases are cytosine. What percentage are adenine?[1]

☐

A 20%

B 30%

C 40%

D 60%

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- A they are identical in base sequence
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3.1 C

- The strands are antiparallel and complementary; bases pair by hydrogen bonds, and phosphodiester bonds are within each backbone

3.2 In a sample of DNA, 20% of the bases are cytosine. What percentage are adenine?[1]

☐

- A 20%
- B 30%
- C 40%
- D 60%

3.2 B

- $\%C = \%G = 20$, so $C+G = 40$; $A+T = 60$, so $\%A = 30$

Exercise 3.3 (a)

3.3 DNA replication is described as semi-conservative.

(a) Explain what “semi-conservative” means.

[2]

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[2]

(a)

- each new DNA molecule contains one original (old) strand and one newly made strand

Exercise 3.3 (b)

3.3 DNA replication is described as semi-conservative.

(b) Explain why one new strand (the lagging strand) is made in short pieces. [2]

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(b) Explain why one new strand (the lagging strand) is made in short pieces. [2]

(b)

- DNA polymerase can only add nucleotides in the 5'
- 3' direction, so on the strand running the “wrong” way it must work in short pieces away from the fork, later joined by ligase

Exercise 3.4

3.4 A DNA molecule contains 1200 bases, of which 360 are guanine. Calculate the number of adenine bases. Show your working. [3]

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3.4

- guanine = 360, so cytosine = 360; $C+G = 720$, so $A+T = 1200 - 720 = 480$; adenine = $480/2 = 240$

Exercise 3.5 (a)

3.5 A short length of one DNA strand has the base sequence **T A C G G A T C A A T**.

- (a) Write the sequence of the complementary strand, and state the rule you used. [2]

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(a)

- **A T G C C T A G T T A**; complementary base pairing – adenine always pairs with thymine and cytosine with guanine

Exercise 3.5 (b)

3.5 A short length of one DNA strand has the base sequence **T A C G G A T C A A T**.

(b) Describe the structure of a DNA nucleotide, and explain how nucleotides are joined into a strand. [4]

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(b) Describe the structure of a DNA nucleotide, and explain how nucleotides are joined into a strand. [4]

(b)

- A nucleotide is a deoxyribose sugar, a phosphate group and one of four nitrogenous bases. Nucleotides join by **condensation** between the phosphate on carbon 5 of one sugar and the hydroxyl on carbon 3 of the next, giving a sugar–phosphate backbone linked by phosphodiester bonds

Exercise 3.5 (c)

3.5 A short length of one DNA strand has the base sequence **T A C G G A T C A A T**.

(c) Explain what is meant by *semi-conservative* replication, and describe the roles of DNA helicase and DNA polymerase. [4]

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3.5 A short length of one DNA strand has the base sequence **T A C G G A T C A A T**.

(c) Explain what is meant by *semi-conservative* replication, and describe the roles of DNA helicase and DNA polymerase. [4]

(c)

- Each new double helix contains **one** original strand and one newly made strand. DNA helicase unwinds the helix and breaks the hydrogen bonds between the base pairs, separating the two strands; free nucleotides then pair with the exposed bases; DNA polymerase joins those nucleotides together by forming the phosphodiester bonds of the new backbone

Exercise 3.5 (d)

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(d) In one organism 22% of the bases in its DNA are adenine. Calculate the percentage that is guanine, and explain your reasoning. [3]

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(d)

- Adenine pairs only with thymine, so thymine is also 22%; $A + T = 44\%$, leaving 56% for $C + G$; C and G are equal, so guanine is 28%