Exercise walk-through

Structure of nucleic acids and replication of DNA ▪ 6.1

eXercise

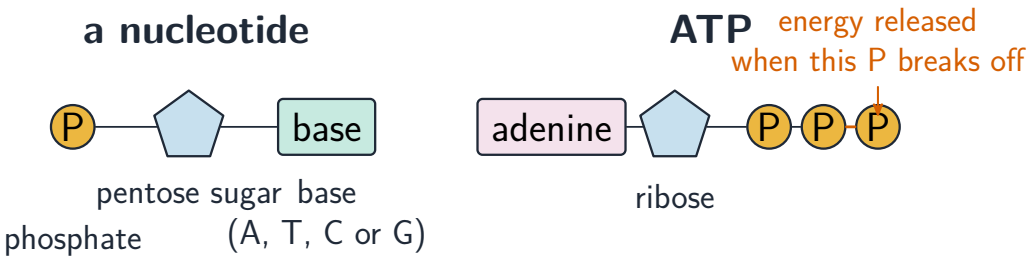
You must be able to

- describe a nucleotide (including ATP) and classify bases as **purines** 嘌呤 or **pyrimidines** 嘧啶
- describe the DNA double helix (base pairing, hydrogen bonds, antiparallel strands, phosphodiester bonds)
- use base-pairing ratios in calculations and describe semi-conservative replication

Method — Nucleotides and bases

A **nucleotide** is a **phosphate** 磷酸 + a 5-carbon sugar + a nitrogen **base** 碱基. **ATP** is a nucleotide with adenine, ribose and **three** phosphates.
Bases come in two groups: **purines** (double ring) = adenine, guanine; **pyrimidines** (single ring) = cytosine, thymine, uracil.

Method — Nucleotides and bases

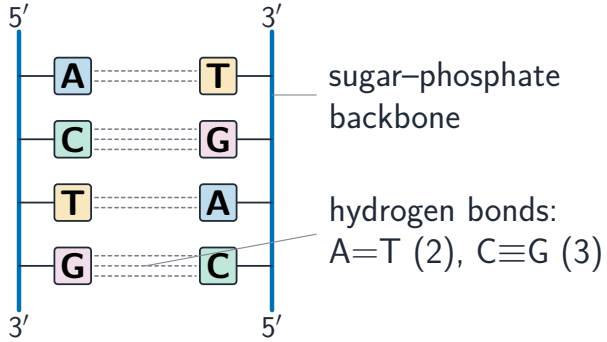


A nucleotide as a phosphate, sugar and base; ATP as adenine, ribose and three phosphates

Method — DNA structure and base pairing

Two **antiparallel 反平行** strands (one 5′→3′, one 3′→5′) twist into a **double helix 双螺旋**. Backbones are sugar–phosphate joined by **phosphodiester bonds 磷酸二酯键**. The strands are held by base pairs: **A=T** (2 hydrogen bonds), **C≡G** (3 hydrogen bonds).

Method — DNA structure and base pairing



the two strands run in opposite directions (antiparallel)

A DNA ladder: two antiparallel backbones with A=T (two hydrogen bonds) and C=G (three)

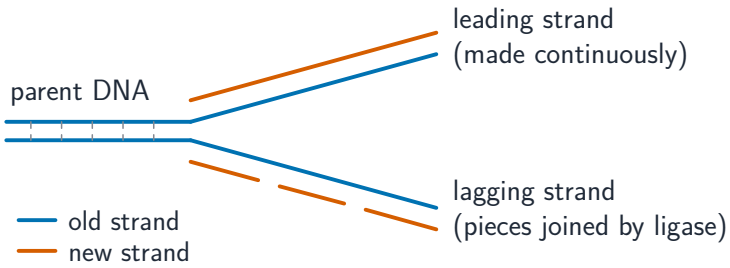
Method — Base-ratio calculations

Because A pairs with T and C pairs with G, **%A = %T** and **%C = %G**, and all four add to 100%. So if 28% of bases are adenine: %T = 28, so %A + %T = 56, leaving %C + %G = 44, so %G = 22%.

Method — Semi-conservative replication

In the S phase the helix unwinds; each old strand is a template; **DNA polymerase** 聚合酶 adds nucleotides only $5' \to 3'$. So the **leading strand** is made continuously and the **lagging strand** in pieces joined by **DNA ligase** 连接酶. Each new molecule keeps one old and one new strand.

Method — Semi-conservative replication



each new molecule = one old strand + one new strand (semi-conservative)

Practice 2.1 ▪ 3 marks

State the three parts of a nucleotide.

Solution 2.1

Method: Nucleotides and bases

Worked steps

a phosphate group; a (5-carbon/pentose) sugar; a nitrogen-containing base **B1** *each*.

Practice 2.2 ▪ 2 marks

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

Solution 2.2

Method: DNA structure and base pairing

Worked steps

(a) 2; (b) 3 B1 *each*.

Exam-style 3.1 ▪ 1 mark

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

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

Solution 3.1

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

Worked steps

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

Exam-style 3.2 ▪ 1 mark

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

A 20%

B 30%

C 40%

D 60%

Solution 3.2

Method: Nucleotides and bases

A 20%

B 30% ✓

C 40%

D 60%

Worked steps

B. %C = %G = 20, so C+G = 40; A+T = 60, so %A = 30.

Exam-style 3.3 ▪ 2 marks

DNA replication is described as semi-conservative.
(a) Explain what “semi-conservative” means.
(b) Explain why one new strand (the lagging strand) is made in short pieces.

Solution 3.3

Method: Semi-conservative replication

Worked steps

(a) each new DNA molecule contains one original (old) strand and one newly made strand **M1** **A1**.

(b) DNA polymerase can only add nucleotides in the $5' \rightarrow 3'$ direction **M1**, so on the strand running the "wrong" way it must work in short pieces away from the fork, later joined by ligase **A1**.

Exam-style 3.4 ▪ 3 marks

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

Solution 3.4

Method: Nucleotides and bases

Worked steps

guanine $= 360$, so cytosine $= 360$ M1; C+G $= 720$, so A+T $= 1200 - 720 = 480$ M1; adenine $= 480/2 = 240$ A1.