

6.1 Structure of nucleic acids and replication of DNA

Name: _____ Class: _____ Date: _____

Total: 14 marks

KEY WORDS strand 链 • nucleotide 核苷酸 • replication 复制 • adenine 腺嘌呤 • hydrogen bond 氢键

Objective

Build the skills to answer exam questions on the **structure of nucleic acids and replication of DNA** — **nucleotides** 核苷酸, **complementary base pairing** 碱基互补配对, and **semi-conservative replication** 半保留复制.

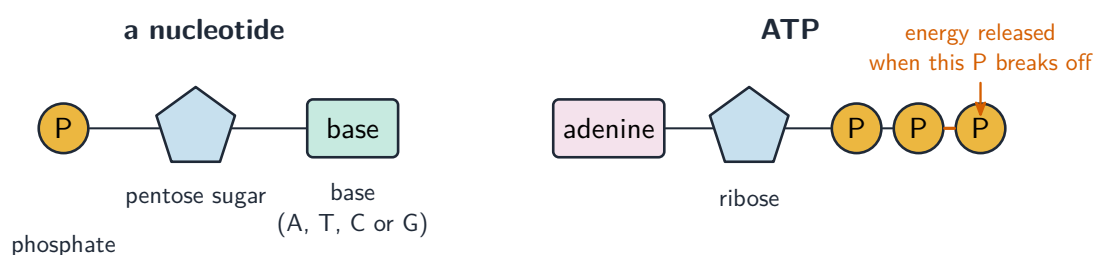
You must be able to:

- 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

1 Worked examples

■ 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.

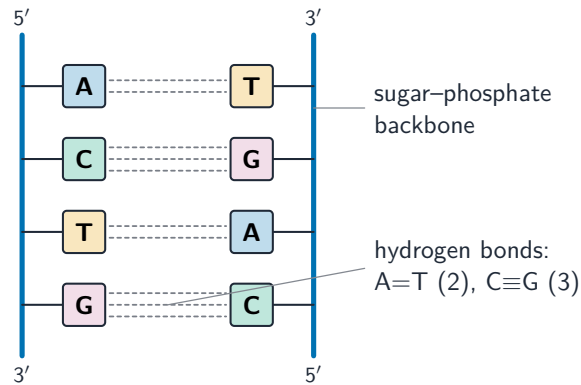


A nucleotide; ATP has three phosphates

Bases come in two groups: **purines** (double ring) = adenine, guanine; **pyrimidines** (single ring) = cytosine, thymine, uracil.

■ 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).



the two strands run in opposite directions (antiparallel)

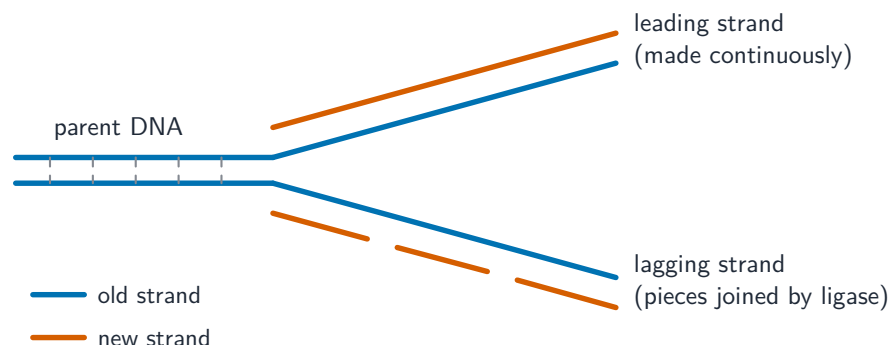
A pairs with T (2 H-bonds), C with G (3); the strands are antiparallel

■ 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 $\%G = 22\%$.

■ 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'→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.



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

Semi-conservative: each new molecule keeps one old strand and one new strand

2 Practice

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]

3 Exam-style questions

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%

3.3 DNA replication is described as semi-conservative.

(a) Explain what “semi-conservative” means. [2]

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

3.4 A DNA molecule contains 1200 bases, of which 360 are guanine. Calculate the number

of adenine bases. Show your working.

[3]

Solutions

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

2.2 (a) 2; (b) 3.

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

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

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

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

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