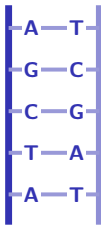


Nucleic Acids & Protein Synthesis

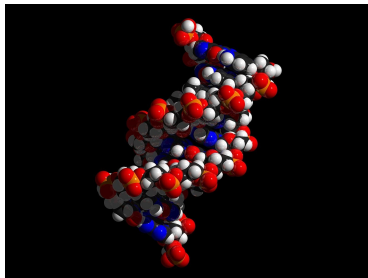
A-Level Biology ■ Topic 6

A-Level Biology



What we will cover

- 1 Nucleotides & bases
- 2 DNA structure
- 3 DNA replication
- 4 The genetic code
- 5 Transcription & translation
- 6 Mutations

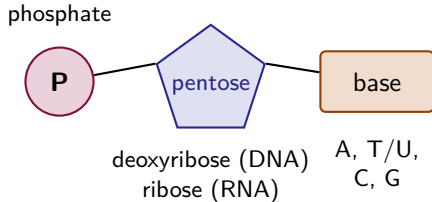


the DNA double helix

1

Nucleotides and DNA

Nucleotides



Nucleotide 核苷酸 a **pentose sugar** + a **phosphate** + a **nitrogenous base**.

Phosphodiester bond 磷酸二酯键 joins the **5' phosphate** of one nucleotide to the **3' OH** of the next – a **condensation** reaction.

The five bases

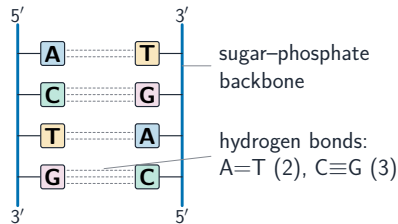


A pairs with T (or U in RNA); G pairs with C. Two H-bonds vs three.

DNA structure

Two **antiparallel** 反平行 strands twist into a **double helix** 双螺旋.

Complementary base pairing 碱基互补配对: A–T by 2 hydrogen bonds, C–G by 3 – joined along a **phosphodiester** 磷酸二酯键 backbone.



the two strands run in opposite directions (antiparallel)

The double helix, and the strands of replication

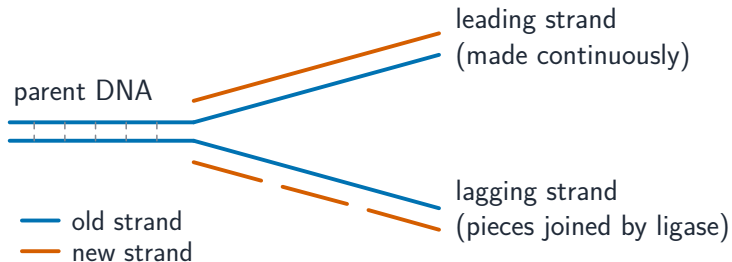
the shape	the flat ladder is twisted into a double helix 双螺旋 – a space-filling model shows the real form
the bases	adenine 腺嘌呤, thymine 胸腺嘧啶, cytosine 胞嘧啶, guanine 鸟嘌呤 – A pairs with T, C with G
purines 嘌呤 and pyrimidines	a large base always pairs with a small one, which keeps the helix a constant width
the leading strand	built continuously toward the unwinding point
the lagging strand 后随链	built in short pieces working away from it; DNA ligase 连接酶 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.

DNA replication

Replication is **semi-conservative** 半保留复制 – each new molecule keeps one old strand.

- **DNA polymerase** 聚合酶 adds nucleotides $5' \rightarrow 3'$
- **leading strand** 前导链 continuous; **lagging strand** 后随链 in pieces, joined by **ligase** 连接酶



2

The genetic code

The genetic code

gene 基因 → polypeptide

triplet 三联体 = 3 bases

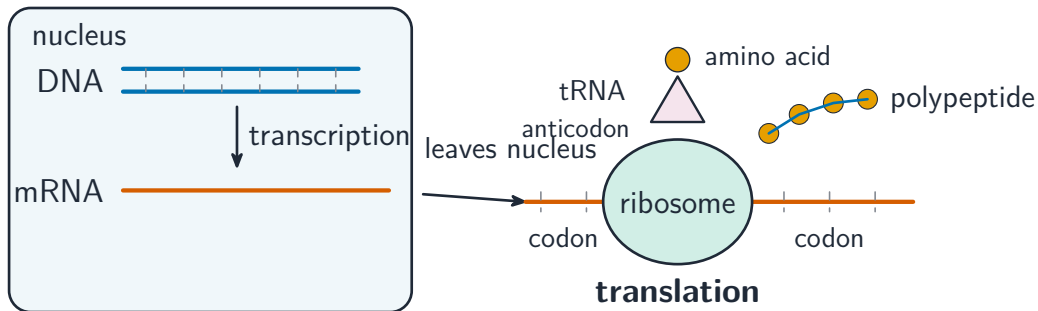
universal 通用

64 triplets, 20 amino acids $\Rightarrow$ most amino acids have more than one triplet

RNA 核糖核酸 is a single strand with the sugar **ribose** 核糖, and uses **uracil** 尿嘧啶 in place of thymine.

Transcription and translation

- **transcription** 转录 – DNA → **mRNA** 信使 RNA in the nucleus
- **translation** 翻译 – the ribosome reads **codons** 密码子; **tRNA** 转运 RNA **anticodons** 反密码子 bring amino acids



Which strand is copied, and what happens next

the template strand 模板链

the strand of DNA that is **copied**

the non-transcribed strand 非转录链

its partner – and its base sequence matches the mRNA, with U for T

the primary transcript 初级转录本

the first RNA made, still containing introns

splicing

introns are cut out and exons joined, giving mature mRNA

translation

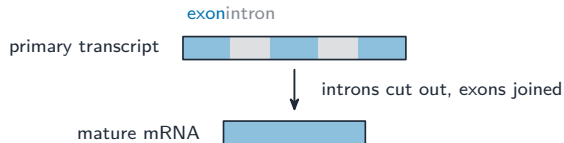
ribosomes read codons; tRNA brings the matching amino acid;
peptide bonds 肽键 join them

the energy 能量

ATP is needed at several steps – transcription, tRNA loading, and each peptide bond

Name **which** strand is the template. Reading the wrong one gives a sequence that is complementary to the right answer, and scores nothing.

Splicing



In eukaryotes the first transcript has coding **exons** 外显子 and non-coding **introns** 内含子.

Splicing 剪接 cuts out the introns and joins the exons to make the finished mRNA.

3

Mutations

Gene mutations

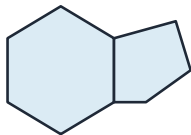
original **A****T****G** **C****A****T** **T****A****C**
substitution **A****A****G** **C****A****T** **T****A****C**
deletion **A****T****G** **A****T****T** **A****C**
insertion **A****T****G** **G****C****A** **T****T****A** **C**

red = changed base; shaded = shifted by a frameshift (deletion or insertion)

A **mutation** 突变 changes the base sequence:

- **substitution** 替换 – swaps one base (small effect)
- **deletion** 缺失 / **insertion** 插入 – shift every later triplet (a **frameshift** 移码)

Nucleotides – the building blocks



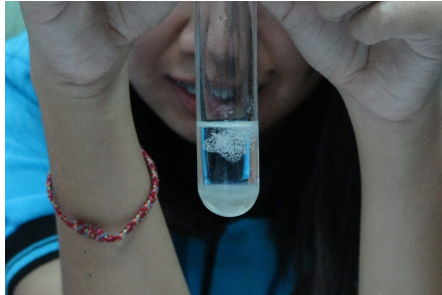
purine
double ring (A, G)



pyrimidine
single ring (C, T, U)

The two groups differ in shape: a purine is a double ring, a pyrimidine a single ring – which is why a purine always pairs with a pyrimidine

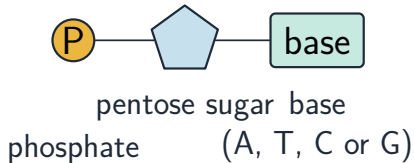
Extracted DNA: nucleotide polymers you can see



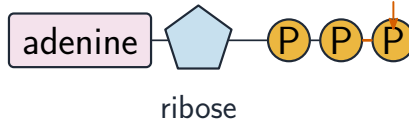
DNA extracted from cells appears as pale, stringy strands of these nucleotide polymers

Nucleotides – the building blocks, continued (2)

a nucleotide

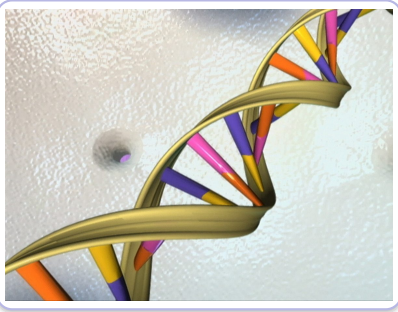


ATP energy released when this P breaks off



A nucleotide is a phosphate, a sugar and a base; ATP is a nucleotide with three phosphates

RNA



DNA double helix: RNA is a related nucleic acid that carries genetic information into protein synthesis

Exam tips

- DNA is **antiparallel**, held by hydrogen bonds (A=T two, C≡G three); replication is **semi-conservative** (each product keeps one old strand).
- State **where** and **what**: transcription (nucleus → mRNA), translation (ribosome, mRNA + tRNA → polypeptide).
- Describe the code with all four terms: **triplet, non-overlapping, degenerate, universal**.
- For a **gene mutation** (substitution, insertion, deletion) explain the effect on the protein – and why a substitution can be silent (degeneracy).

4

Recap

Worked example – transcribe and translate

A DNA template strand reads TAC GGA TTT. Give the mRNA and say how many amino acids result.

- mRNA is built **complementary** to the template, with **U in place of T**.
- TAC → AUG; GGA → CCU; TTT → AAA.
- mRNA: AUG CCU AAA – and **AUG is always the start codon**.
- 3 codons ⇒ **3 amino acids**; each tRNA anticodon pairs with one codon.

A → U (never T) when transcribing. **Codon** is on the mRNA, **anticodon** on the tRNA, and the **triplet** on the DNA – do not mix the three names.

Topic 6 – key takeaways

1

Base pairing

A–T (2 bonds), C–G (3);
antiparallel

2

Replication

semi-conservative; leading &
lagging strands

3

Code

triplets; transcription then
translation

4

Mutations

substitution vs frameshift (indel)

Check yourself

- 1 How many hydrogen bonds join C and G?
- 2 What does “semi-conservative” mean?
- 3 Where does translation take place?
- 4 Which mutation causes a frameshift?



Answers 1. three 2. each new molecule keeps one old strand 3. at the ribosome
4. deletion or insertion