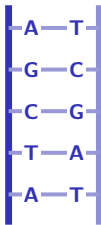


Nucleic Acids & Protein Synthesis

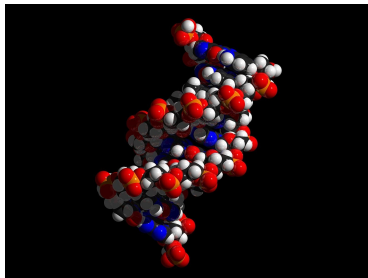
A-Level Biology ■ Topic 6

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



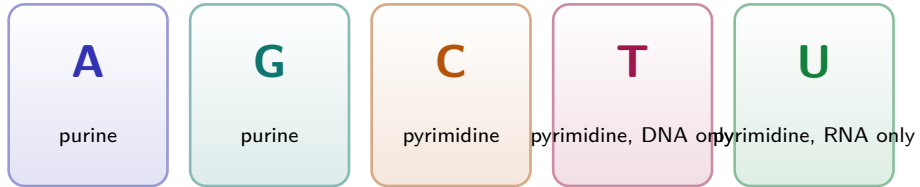
the DNA double helix



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



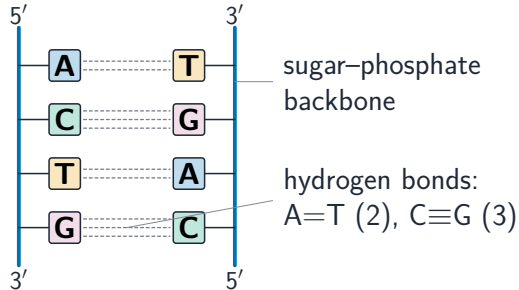
A pairs with T (or U in RNA); G pairs with C. Two H-bonds vs three.

DNA structure

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

Complementary base pairing : A–T by 2 hydrogen bonds, C–G by 3 – joined along a **phosphodiester** 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

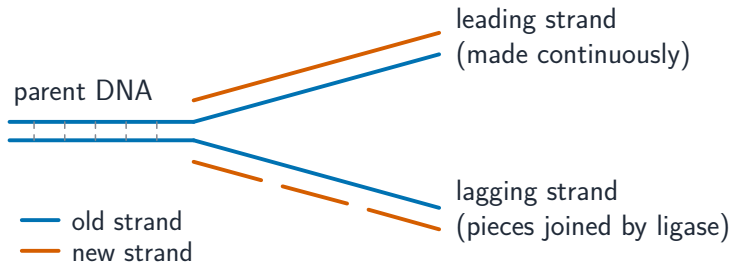
the shape	the flat ladder is twisted into a double helix – a space-filling model shows the real form
the bases	adenine , thymine , cytosine , guanine – A pairs with T, C with G
purines and pyrimidines	a large base always pairs with a small one, which keeps the helix a constant width
the leading strand	built continuously toward the unwinding point
the lagging strand	built in short pieces working away from it; DNA ligase 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** – each new molecule keeps one old strand.

- **DNA polymerase** adds nucleotides $5' \rightarrow 3'$
- **leading strand** continuous; **lagging strand** in pieces, joined by **ligase**



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



The genetic code

gene → polypeptide

triplet = 3 bases

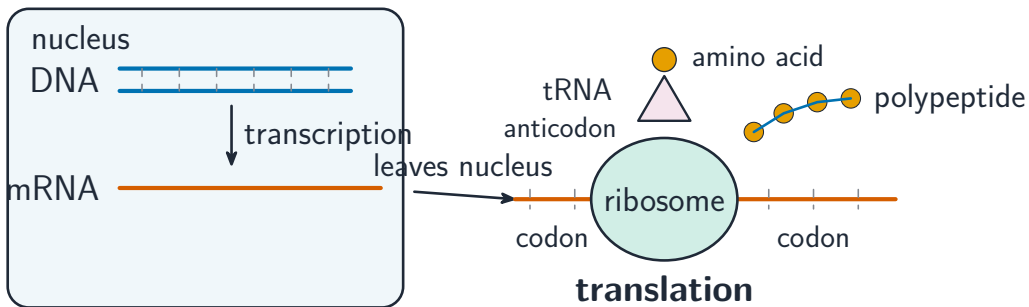
universal

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

RNA is a single strand with the sugar **ribose** , and uses **uracil** in place of thymine.

Transcription and translation

- **transcription** – DNA → **mRNA** RNA in the nucleus
- **translation** – the ribosome reads **codons** ; **tRNA** RNA **anticodons** bring amino acids



Which strand is copied, and what happens next

the template strand

the strand of DNA that is **copied**

the non-transcribed strand

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

the primary transcript

the first RNA made, still containing introns

splicing

introns are cut out and exons joined, giving mature mRNA

translation

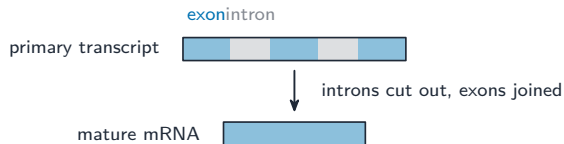
ribosomes read codons; tRNA brings the matching amino acid; **peptide bonds** join them

the energy

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** and non-coding **introns** .

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



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**

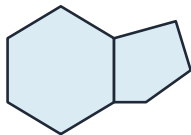
insertion **A****T****G** **G****C****A** **T****T****A** **C**

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

A **mutation** changes the base sequence:

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

Nucleotides – the building blocks



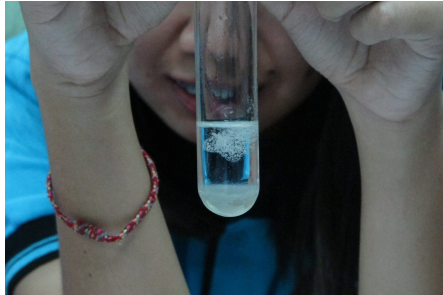
purine
double ring (A, G)



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

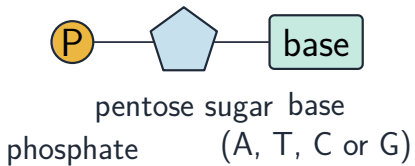
Nucleotides – the building blocks, continued



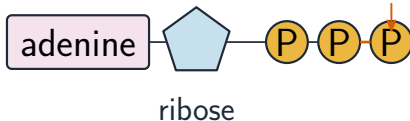
DNA extracted from cells appears as pale, stringy strands of these nucleotide polymers

Nucleotides – the building blocks, continued (2)

a nucleotide

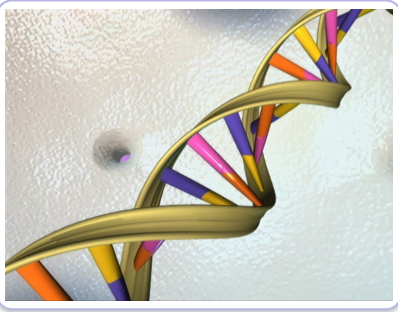


ATP energy released
when this P breaks off



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).



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