IB BIOLOGY · A1.2 · SL AND HL

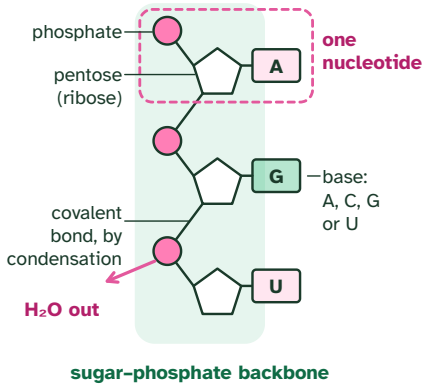
REVISION ON TWO PAGES

Four letters, two *strands*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Nucleotides link into a covalent backbone. Their bases pair, A with T and C with G, so the sequence stores information and can be copied.



Draw it like this. Circle, pentagon, rectangle. Each phosphate joins the lower left corner of the sugar above.

A1.2.2 to 5 START HERE

Nucleotides build a *strand*

- A **nucleotide** is a phosphate, a pentose sugar and a nitrogenous base, joined by covalent bonds. The sugar is in the middle: the base bonds to it, never to the phosphate.
- **Condensation:** the phosphate of each new nucleotide bonds to the sugar of the last one, and water is released. Ten nucleotides make nine bonds and release nine waters.
- Every link is covalent, so each strand is one continuous chain: a strong **sugar–phosphate backbone**. The bases stick out to one side.
- **RNA** is one such strand, a polymer made by condensation. The order of bases, the **base sequence**, is the code: like letters spelling words.

THE BASES: KNOW THE NAMES — *Apples in the Tree, Cars in the Garage*

A Adenine with T or U	**T** Thymine DNA only	**C** Cytosine with G	**G** Guanine with C	**U** Uracil RNA only

A1.2.1

DNA, the *genetic material*

- The genetic material holds the instructions an organism inherits. In **every living organism** it is **DNA**: bacteria, archaea, protists, fungi, plants and animals.
- DNA and RNA are the **nucleic acids**: polymers of nucleotides.
- A gene is one stretch of the base sequence; one DNA molecule carries many genes.

Living organisms made of cells
The genetic material is always DNA.

Some viruses not living
Genes can be RNA (influenza, measles). **Viruses are not living**, so the rule stands.

A1.2.8

Copied and *read*

- Complementarity rests on **hydrogen bonds**, which line up only in the pairs A–T and C–G.

COPY
Replication
The strands part and each is a template, so each new molecule has the same base sequence.

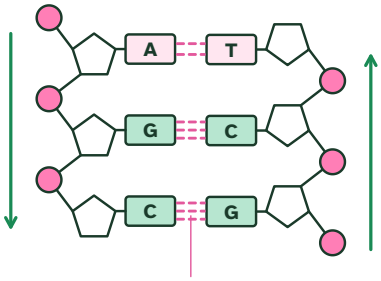
READ
Transcription
A DNA strand is the template for an RNA copy, U opposite A.

READ
Translation
Three mRNA bases pair with three tRNA bases.

A1.2.6

Two *antiparallel* strands

- Two strands, joined by **hydrogen bonds between complementary bases**: A with T, G with C.
- Bases inside, backbones outside. The strands are **antiparallel**: they run in opposite directions.
- They wind into a **double helix**; you need not draw the twist.

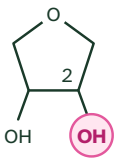


A1.2.7

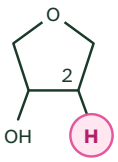
DNA and *RNA* compared

DIFFERENCE	DNA	RNA
Sugar	deoxyribose	ribose
Bases	A, C, G and **T**	A, C, G and **U**
Strands	two	usually one

Remember the three: *Some Bananas Split*



ribose in RNA



deoxyribose in DNA

- **DNA:** the chromosomes, and in mitochondria and chloroplasts.
- **mRNA**: a copy of a gene, taken to a ribosome.
- **tRNA**: brings amino acids; it folds and pairs with itself.
- **rRNA**: part of every ribosome.

One code for all life, and the *evidence*

A1.2.9 and 10

Endless *sequences*

- Any base can follow any other, at any length, so **any sequence is possible**: the capacity is limitless, stored with **great economy**.
- The **genetic code**, a codon of three bases for each amino acid, is **shared by almost all life**.
- The code is arbitrary, so sharing it is evidence of **universal common ancestry**.

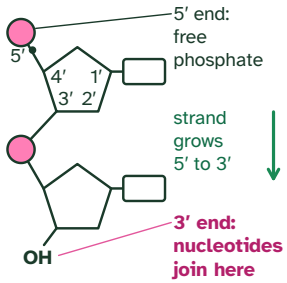
4^{10}
over a million sequences of 10 bases

2 m
of DNA in each human nucleus

A1.2.11 HIGHER LEVEL

5′ and 3′ *ends*

- Sugar carbons are 1′ to 5′. Each 5′ phosphate bonds to the **3′ carbon** before it: a **5′ end** and a **3′ end**.
- Nucleotides join only at the 3′ end, so replication and transcription **build 5′ to 3′**; ribosomes read mRNA 5′ to 3′.



A1.2.12 HIGHER LEVEL

Big base, *small base*

- **Purines** (A, G) have two rings; **pyrimidines** (C, T, U) have one.
- Every pair is **a purine with a pyrimidine**, so A–T and C–G are the same length.
- So the helix has the **same 3D shape** whatever the sequence: stable, and any sequence fits.

TWO SHAPES — *Pure As Gold, CUT*

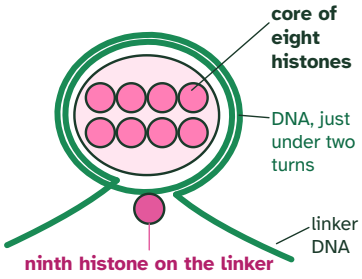
P Purines — two rings

C CUT — one ring each

A1.2.13 HIGHER LEVEL

A *nucleosome*

- DNA wraps just under two turns round a **core of eight histones**.
- A **ninth histone**, on the **linker DNA**, holds it in place.
- **Skill:** study a nucleosome in molecular visualisation software.



A1.2.14 HIGHER LEVEL

Hershey and *Chase*

- Phage T2 is only a protein coat and DNA; what it injects into *E. coli* carries the genes.
- A blender shook coats off; a centrifuge spun bacteria into a **pellet**; coats stayed in the supernatant.
- It became possible once **radioisotopes** were available.

^{35}**S** labels protein	Found in the supernatant: the coats stayed outside.
^{32}**P** labels DNA	Found in the pellet: **DNA entered**, so DNA carries the genes of T2.

A1.2.15 HIGHER LEVEL

Chargaff's *data*

- In every species **A = T and G = C**; the proportions differ between species.
- This **falsified** the tetranucleotide hypothesis (25% of each base).
- Many observations never prove a claim (the problem of **induction**); one reliable contradiction rejects it with certainty.

%	A	T	G	C
Human	30.9	29.4	19.9	19.8
Wheat	27.3	27.1	22.7	22.8
E. coli	24.7	23.6	26.0	25.7

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Hydrogen bonds join the two strands, not a strand.** Inside a strand every link is covalent.
- ✕ **A nucleotide is not a base.** It is base, sugar and phosphate; the base bonds to the sugar.
- ✕ **Complementary is not identical.** The two strands differ; the two molecules made by copying are identical.
- ✕ **Deoxyribose keeps its ring oxygen.** It lacks the oxygen on carbon 2.
- ✕ **Sulfur labels protein, phosphorus labels DNA.** The pellet is the bacteria, not the phages.
- ✕ **Chargaff's rule is A = T and G = C.** Not A = G, and only in double-stranded DNA.

COVER THE SHEET

Can you *answer these?*

1. State why RNA viruses do not break the DNA rule.
2. Draw an RNA strand of three nucleotides.
3. Draw two antiparallel strands, three base pairs long.
4. Distinguish between DNA and RNA in three ways.
5. Explain how base pairing lets DNA be copied.
6. Explain why a shared code suggests a common ancestor.
7. Outline what the 5′ and 3′ ends are. HL
8. Explain why the helix is the same width throughout. HL
9. Describe the structure of a nucleosome. HL
10. Explain what the Hershey–Chase results show. HL
11. Explain how Chargaff falsified a hypothesis. HL

IN THE EXAM

Draw the second strand **upside down**, bases paired A–T and G–C, and write **"hydrogen bonds between complementary bases"**, never just "bonds".

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.