

BIOLOGY • CLASS 12

5

CHAPTER

Molecular Basis of Inheritance

CHAPTER NOTES



MOLECULAR BASIS OF INHERITANCE: BIG PICTURE

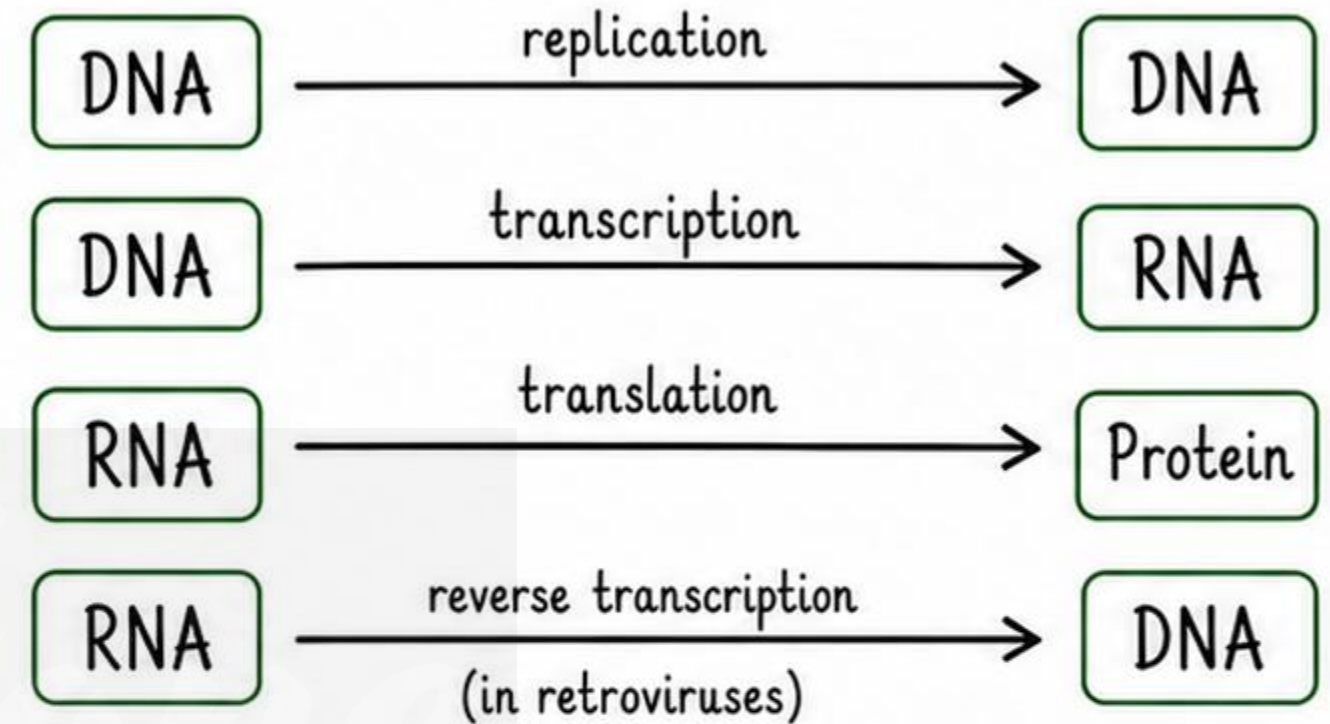
CORE IDEA

- Hereditary information is stored in genetic material and passed from parents to offspring.
- DNA is the genetic material in most organisms.
- RNA acts as genetic material in some viruses.
- A genome is the complete genetic material of an organism.

WHAT GENETIC MATERIAL MUST DO

- ① Replicate accurately.
- ② Be chemically and structurally stable.
- ③ Express information as traits.
- ④ Allow occasional mutation for variation and evolution.

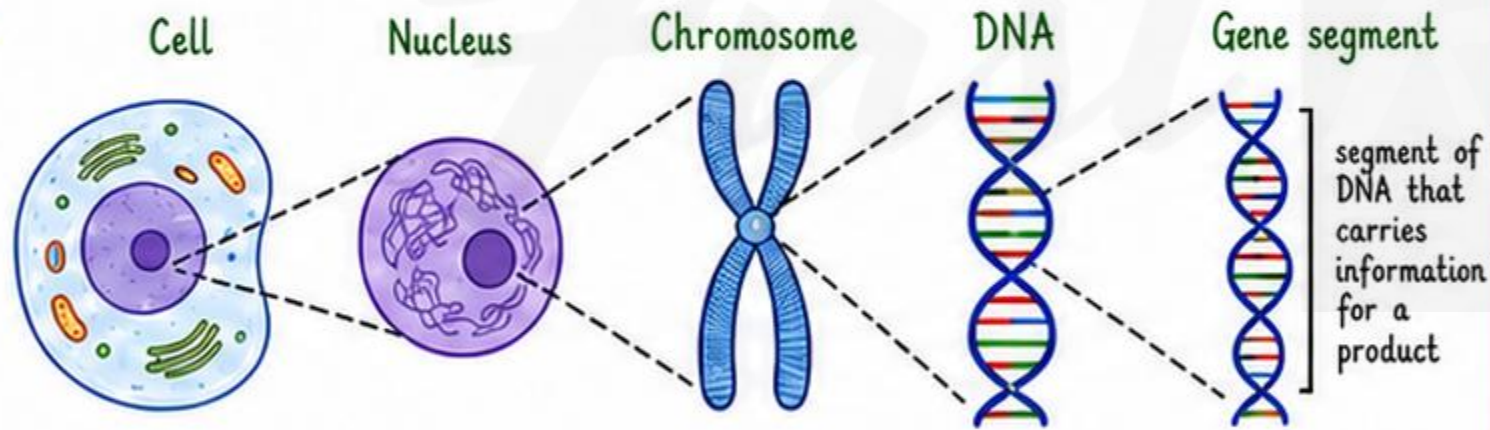
FLOW OF GENETIC INFORMATION



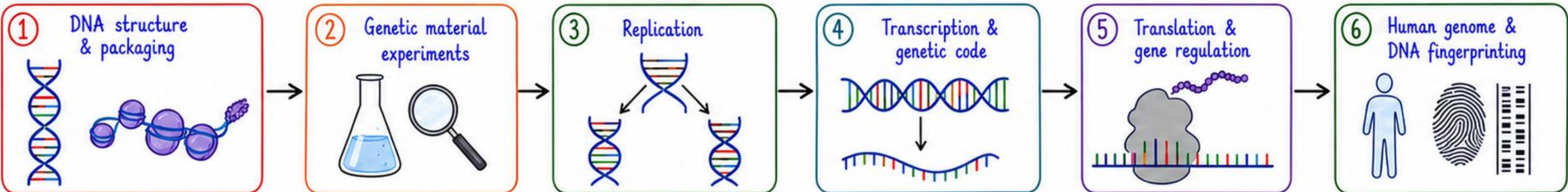
Central dogma proposed by Francis Crick.

DNA, GENES AND CHROMOSOMES

- A gene is a segment of DNA that carries information for a functional product.
- DNA is packaged with proteins to form chromosomes.
- Different genes are expressed at different times and in different cells.



CHAPTER ROADMAP



NUCLEOTIDE & POLYNUCLEOTIDE CHAIN

BASIC UNITS

- Nucleoside = nitrogenous base + pentose sugar.
- Nucleotide = nitrogenous base + pentose sugar + phosphate group.
- The base joins the 1' carbon of sugar by an N-glycosidic bond.
- The phosphate commonly joins the 5' carbon of sugar by a phosphoester bond.

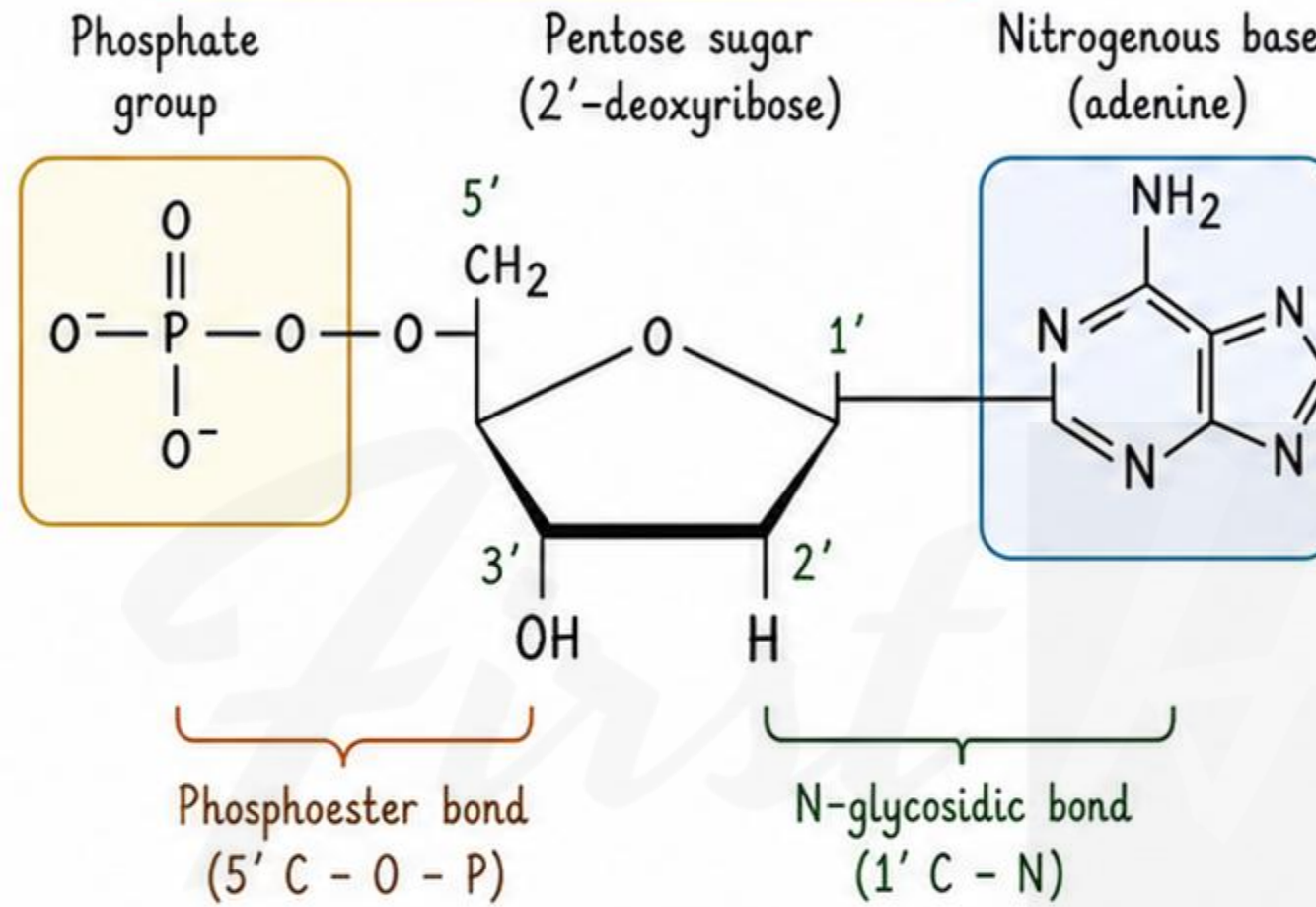
BASES

- Purines: adenine (A) and guanine (G), two rings.
- Pyrimidines: cytosine (C), thymine (T) and uracil (U), one ring.
- DNA contains A, G, C and T.
- RNA contains A, G, C and U.

SUGARS

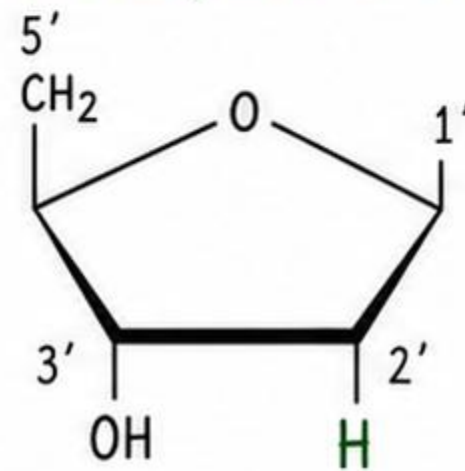
- DNA contains 2'-deoxyribose: H at the 2' carbon.
- RNA contains ribose: OH at the 2' carbon.

ONE NUCLEOTIDE (example: dAMP)

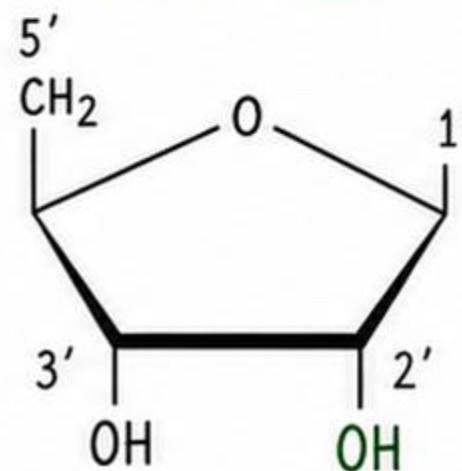


PENTOSE SUGARS

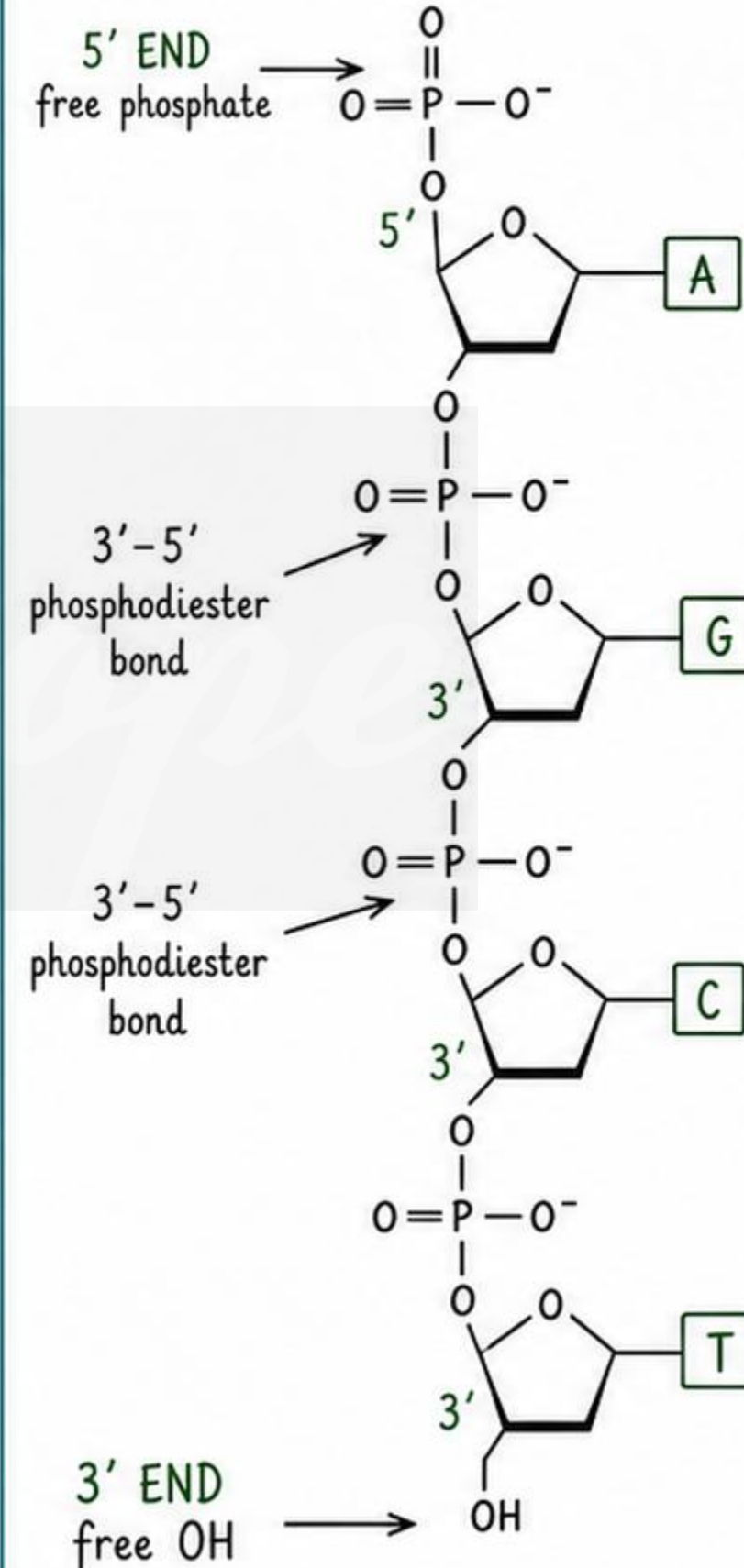
2'-Deoxyribose (DNA)



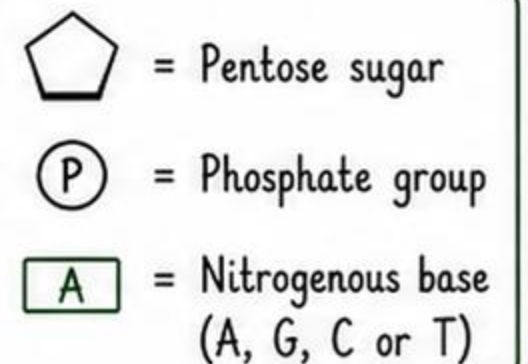
Ribose (RNA)



POLYNUCLEOTIDE CHAIN (example DNA strand)



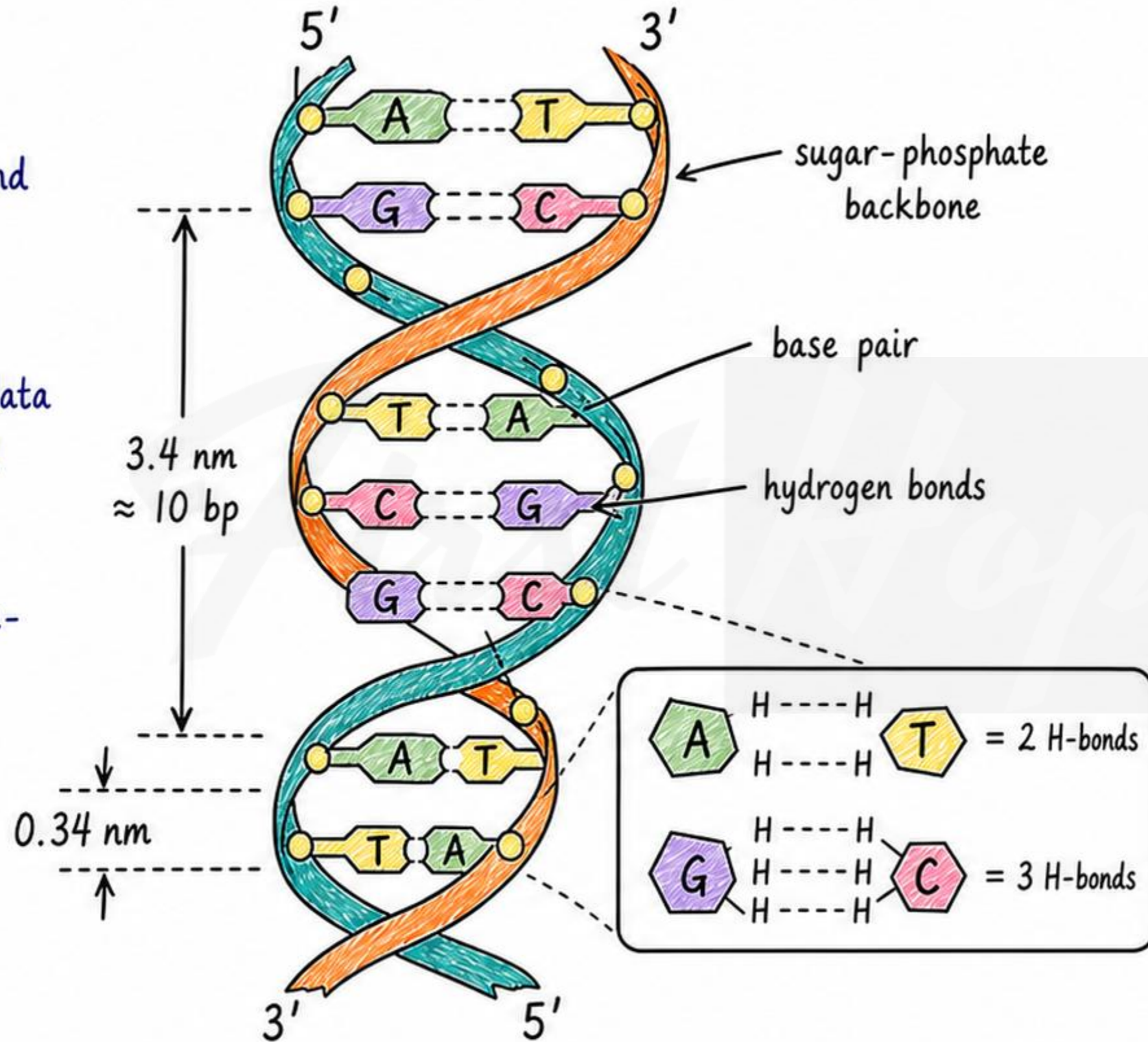
- Nucleotides are joined by 3'-5' phosphodiester bonds.
- One bond joins the 3'-OH of one sugar to the 5' phosphate of the next nucleotide.
- Repeating sugar and phosphate groups form the backbone; bases project from it.
- The chain has polarity: a 5' end with free phosphate and a 3' end with free OH.
- Phosphate groups give nucleic acids a negative charge.



DNA DOUBLE HELIX: WATSON-CRICK MODEL

KEY EVIDENCE

- 1953: James Watson and Francis Crick proposed the model.
- Used X-ray diffraction data of Rosalind Franklin and Maurice Wilkins.
- Chargaff's rule for double-stranded DNA: $A = T$ and $G = C$.



SALIENT FEATURES

- Two polynucleotide strands with sugar-phosphate backbones outside and bases inside.
- Antiparallel polarity: one 5'→3', the other 3'→5'.
- A pairs with T by 2 H-bonds; G pairs with C by 3 H-bonds.
- Purine pairs with pyrimidine, keeping the width nearly constant.
- Right-handed helix; about 10 bp per turn.
- Pitch = 3.4 nm; distance between adjacent base pairs = 0.34 nm.
- Base-pair stacking plus H-bonds stabilises the helix.

Complementary strands allow accurate prediction and copying of genetic information.

PACKAGING OF DNA HELIX

WHY PACKAGING IS NEEDED

$$6.6 \times 10^9 \text{ bp} \times 0.34 \times 10^{-9} \text{ m/bp} = 2.244 \text{ m} \approx 2.2 \text{ m}$$

A typical mammalian nucleus is only about 10^{-6} m across.

PROKARYOTES

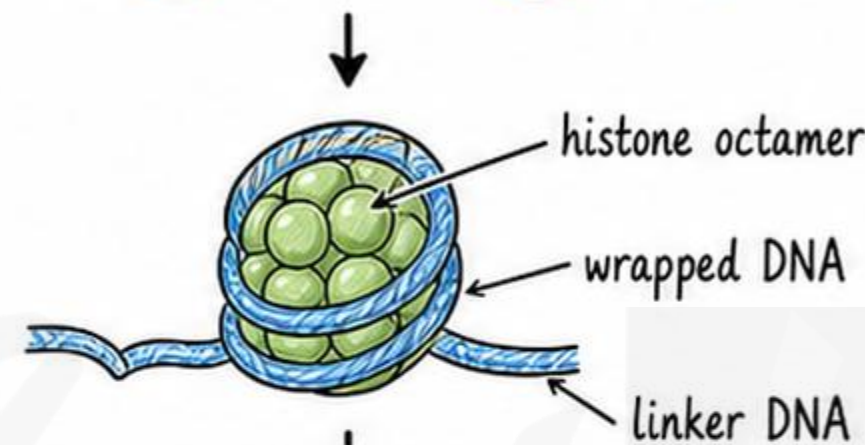
- No membrane-bound nucleus.
- Negatively charged DNA lies in a nucleoid.
- DNA forms large loops held by positively charged proteins.

EUKARYOTES

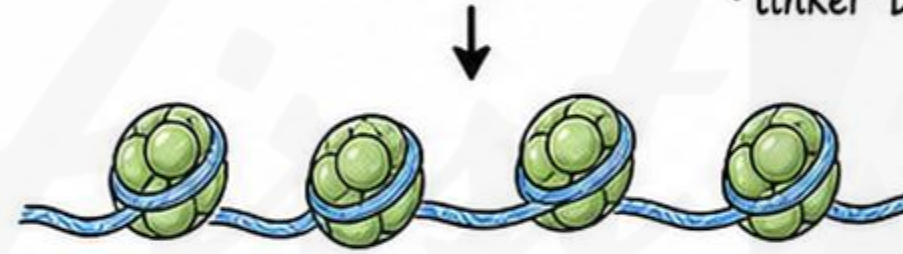
- Histones are basic, positively charged proteins rich in lysine and arginine.
- Eight histone molecules form a histone octamer.
- Negatively charged DNA wraps around it to form a nucleosome.
- A typical nucleosome contains about 200 bp of DNA.



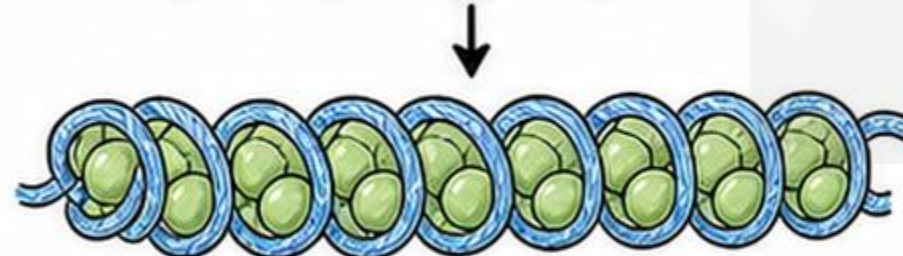
DNA double helix



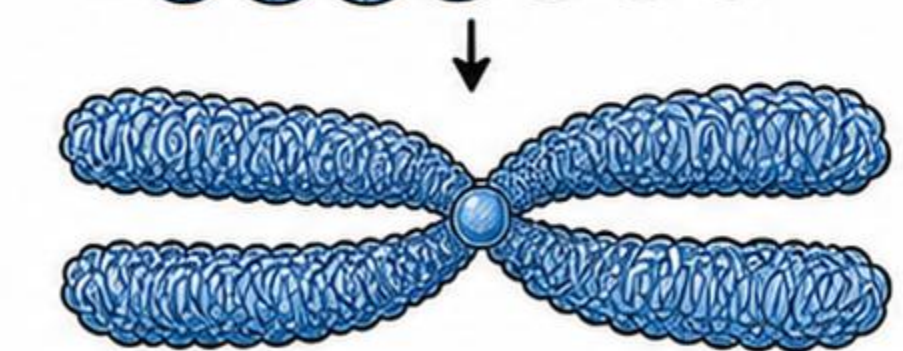
nucleosome ('bead')



beads-on-string chromatin



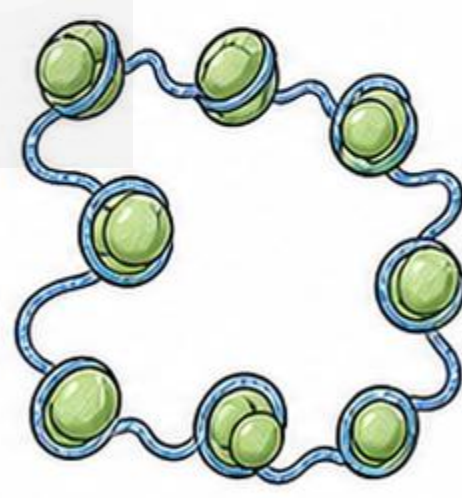
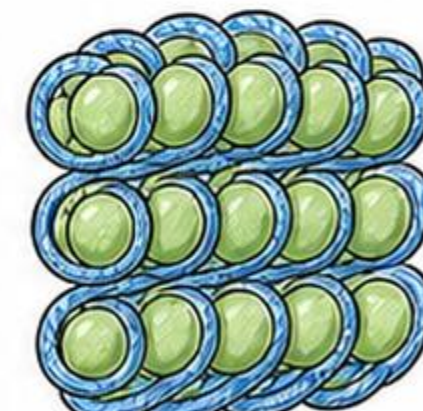
chromatin fibre



condensed chromosome

Higher-order packaging also needs non-histone chromosomal (NHC) proteins.

CHROMATIN TYPES

EUCHROMATIN	HETEROCHROMATIN
loosely packed; stains light; transcriptionally active.	densely packed; stains dark; transcriptionally inactive.
	



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