Structure of Nucleic Acids: A Comprehensive Review

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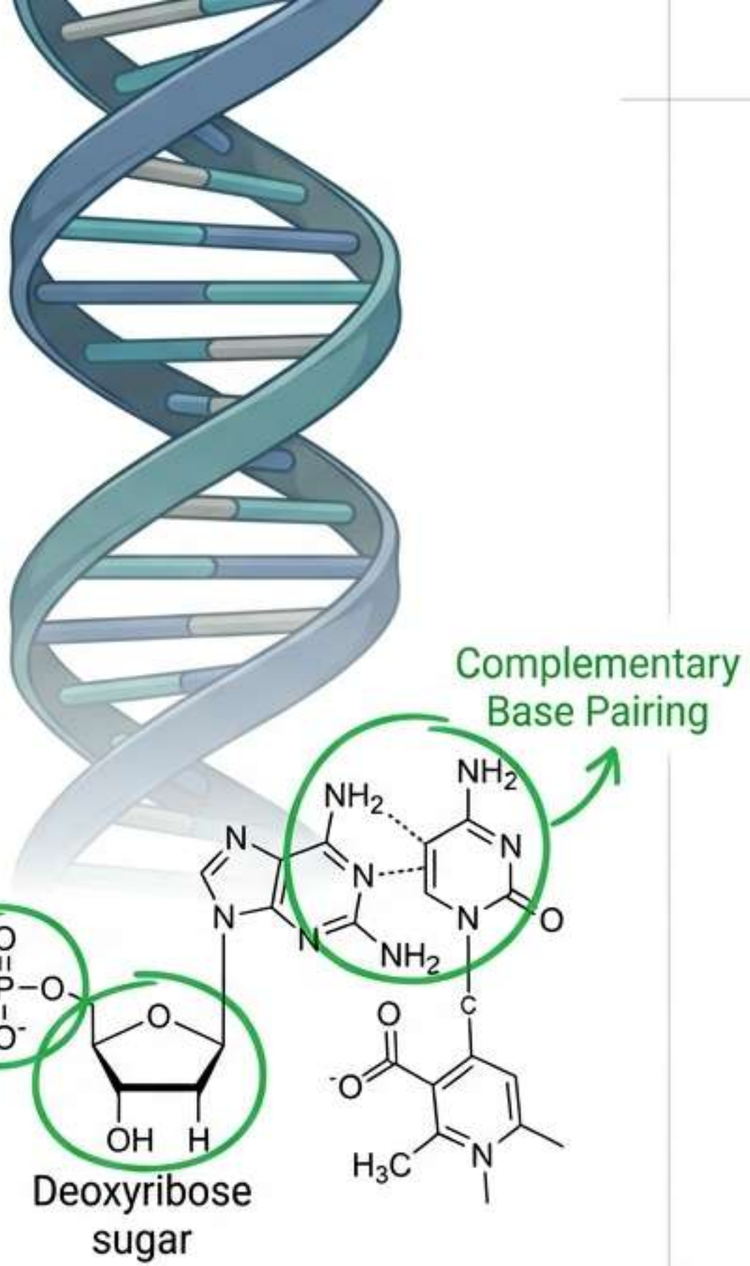


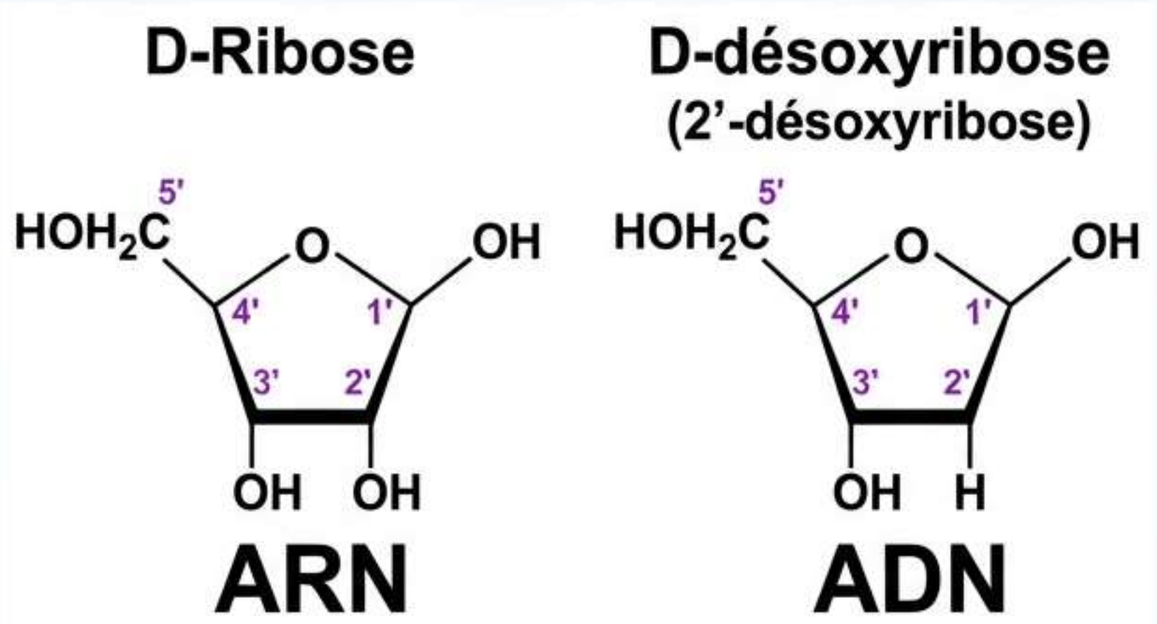
Nucleic acids constitute the **4th class of biomolecules** (alongside carbohydrates, lipids, proteins). Understanding their structure is critical for **diagnosing and treating genetic diseases**.

DNA (Deoxyribonucleic Acid)	RNA (Ribonucleic Acid)
Located in the **Nucleus**. Supports genetic information.	Located in the **Cytoplasm**.

Nucleic acids are macromolecules made of subunits called **Nucleotides**.

The Building Blocks: Oses and Phosphoric Acid

Component 1: The Ose (Pentose)

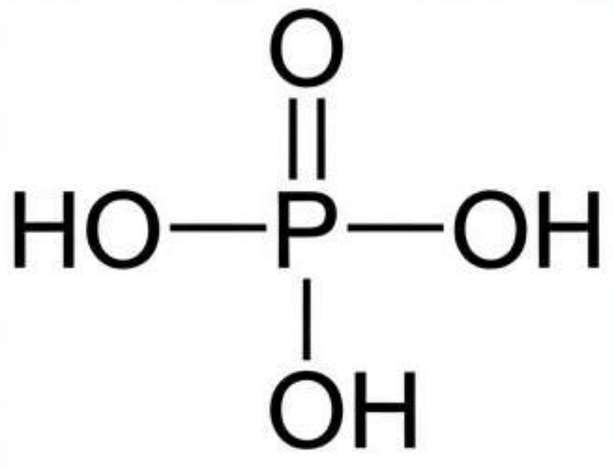


RNA = Ribose. DNA = 2'-Deoxyribose.

Characteristics: D-series, Furanose (cyclic), beta-anomer.

Green Ink

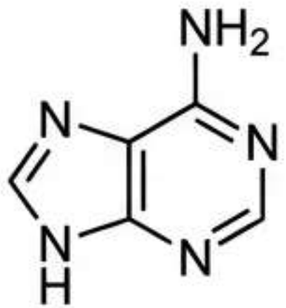
Component 2: Phosphoric Acid (H_3PO_4)



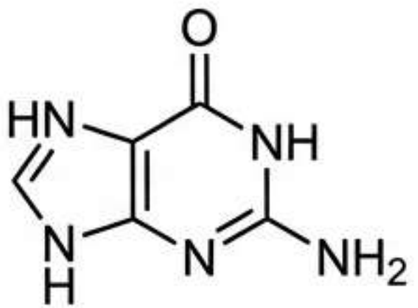
- Responsible for the negative charge (-) of nucleic acids at physiological pH. (Ref: Q31)
- Allows migration toward the Anode (+) during electrophoresis. (Ref: Q31)

Nitrogenous Bases: Purines and Pyrimidines

Purines (Double Ring)



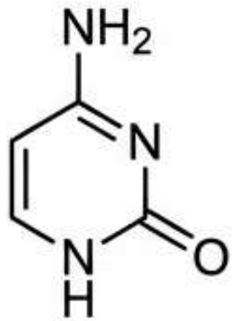
Adenine: 6-aminopurine. (Ref: Q14)



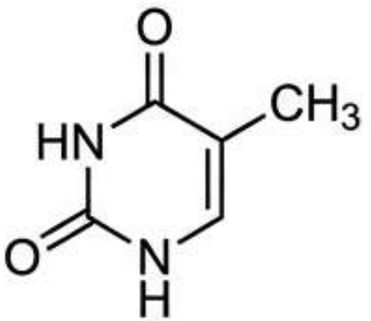
Guanine: 2-amino-6-oxypurine.

TRAP: Guanine contains **5 Nitrogen atoms**. (Ref: Q25)

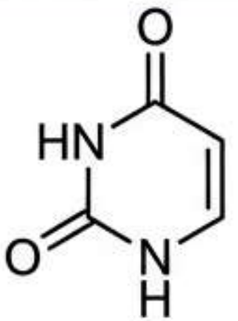
Pyrimidines (Single Ring)



2-oxy-4-aminopyrimidine. Has C=O on C2. (Ref: Q25)



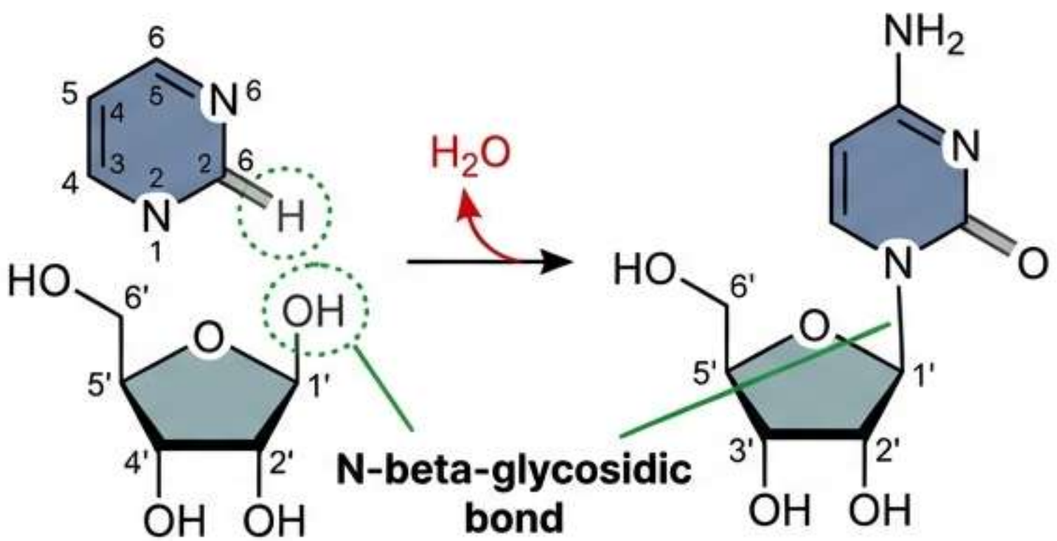
Specific to DNA. 5-methyl-2,4-dioxypyrimidine. Contains **two C=O functions** and **methyl on C5**. (Ref: Q25)



Specific to RNA. Essentially **Thymine demethylated at C5**. (Ref: Q25)

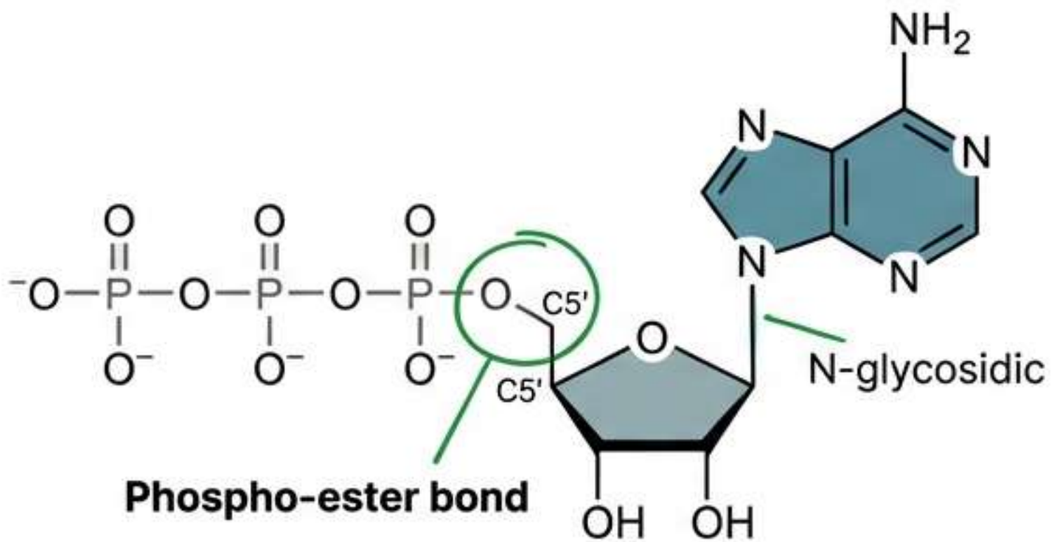
Assembly: Nucleosides vs. Nucleotides

The Nucleoside (Base + Pentose)



- Pyrimidine: N1 linked to C1’. (Ref: Q16)
- Purine: N9 linked to C1’. (Ref: Q16)

The Nucleotide (Nucleoside + Phosphate)



- Esterification of the sugar in a nucleoside produces a nucleotide. (Ref: Q5)

Nomenclature and Physiological Roles

Data Table

	Base	Nucleoside Suffix	Nucleotide Suffix
1	Purines	-osine (e.g., Adenosine)	-ylic acid (e.g., Adenylic acid / AMP)
2	Pyrimidines	-idine (e.g., Thymidine)	-ylic acid (e.g., Thymidylic acid)

Exam Example: Guanylate or **Thymidylic acid** are nucleotides.

"Acid deoxycytidylic" is a DNA nucleotide. (Ref: Q5)

Biological Roles

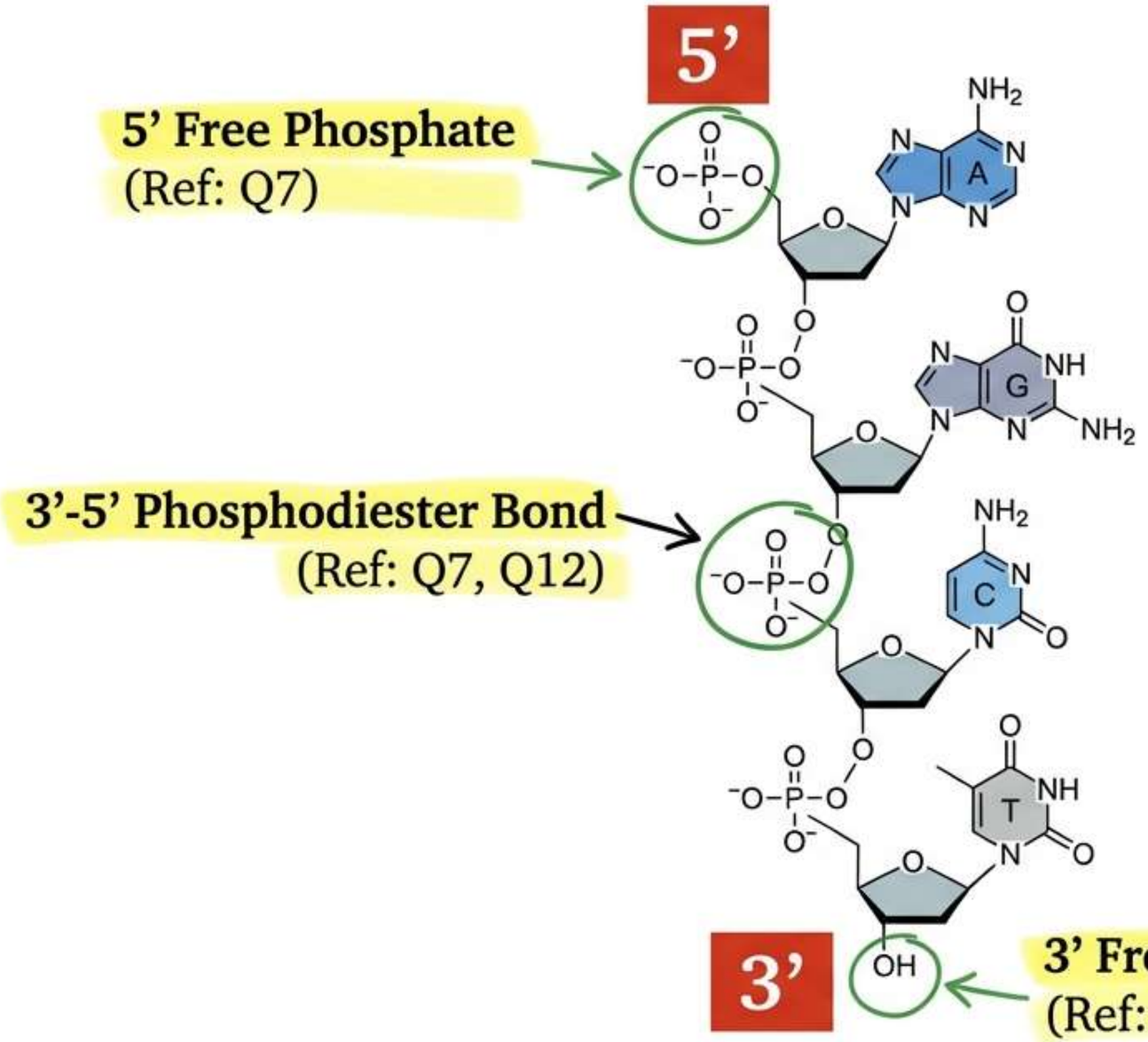
Genetic Support (DNA/RNA)

Energy Storage (ATP/GTP - high hydrolysis energy)

Signaling (cAMP/cGMP second messengers)

Metabolism (UDP-glucose, Coenzymes NAD/FAD)

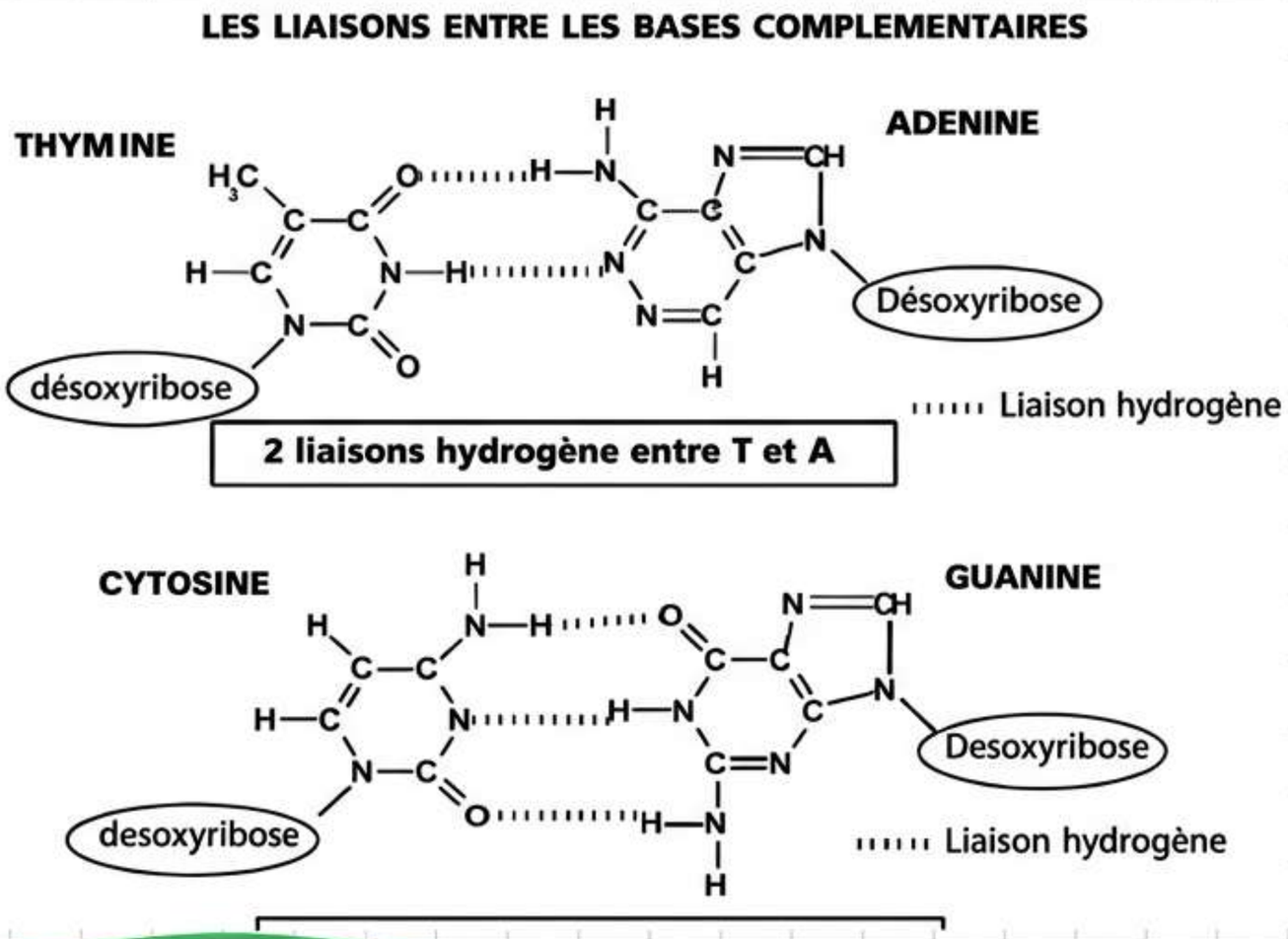
DNA Primary Structure: The Linear Backbone



- **Reading Direction:** By convention, always 5’ to 3’. (Ref: Q10)
- **Orientation:** Backbone is External (Hydrophilic). Bases are Internal (Hydrophobic). (Ref: Q38)

By dentiste web

DNA Secondary Structure: The Double Helix (B-DNA)



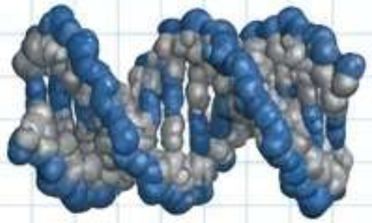
Exam Facts

- **Bicatenaire** (Double-stranded). (Ref: Q18)
- **Antiparallel**: One strand 5'->3', other 3'->5'. (Ref: Q18, Q38)
- **Complementary**: Purine always binds Pyrimidine. (Ref: Q4)
- **Chargaff's Rules**: [A]=[T] and [G]=[C]. (Ref: Q6)

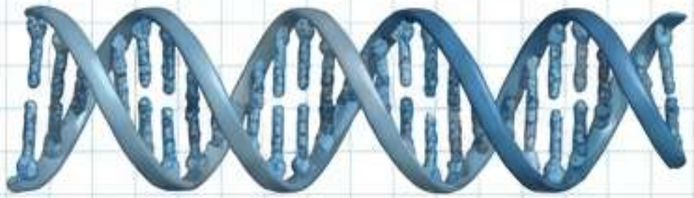
Exam Practice

- If Strand 1 is `5' ATGGTC 3', Strand 2 is `3' TACCAG 5'. (Ref: Q10)

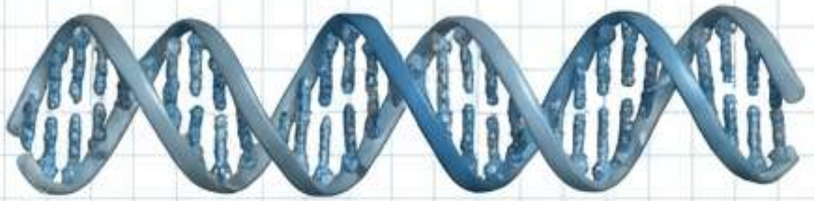
DNA Conformations: Forms A, B, and Z



A-DNA



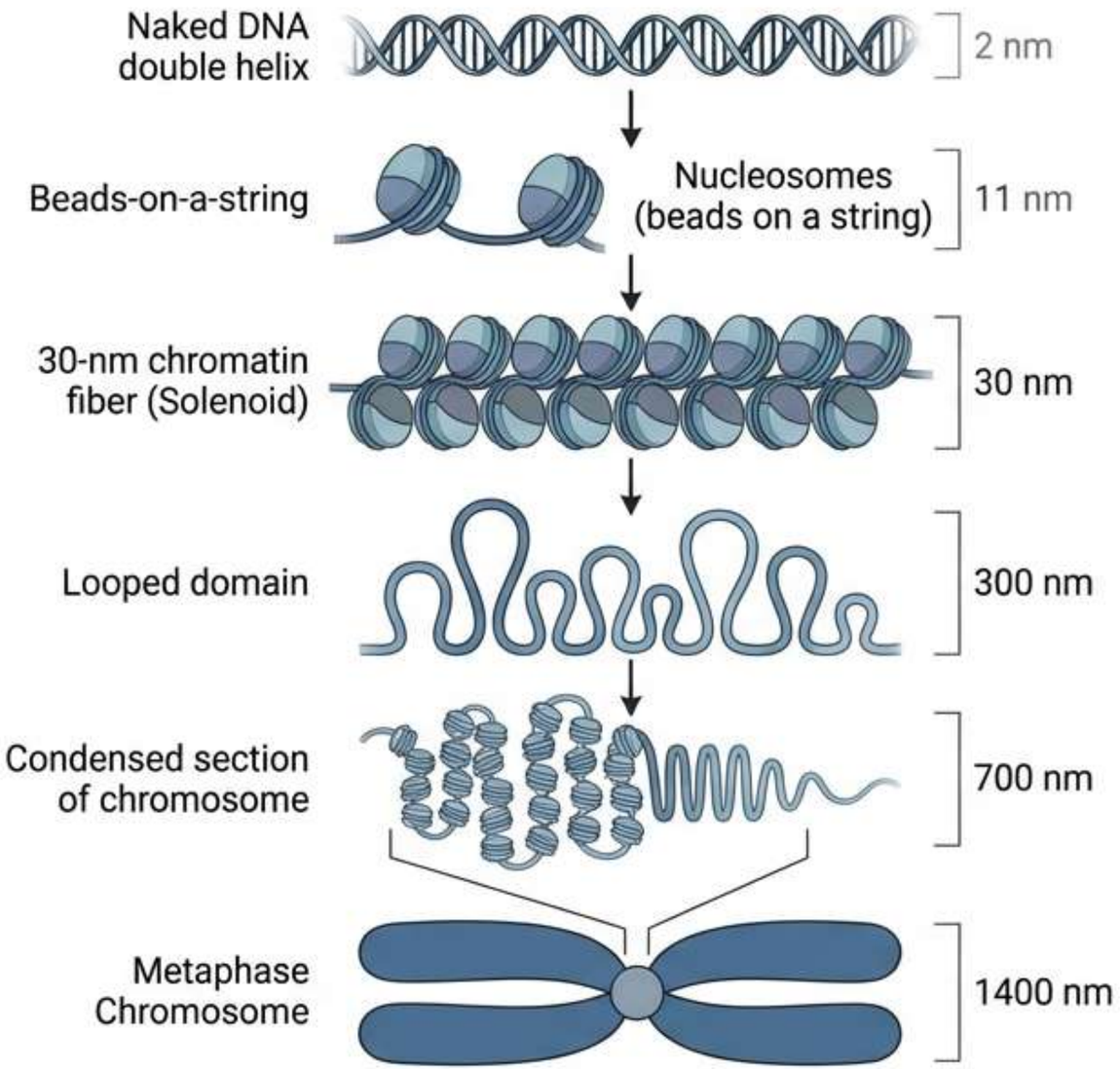
B-DNA (Standard)



Z-DNA (ZigZag)

	B-DNA (Standard)	Z-DNA (ZigZag)	A-DNA
Handedness	Right-handed	Left-handed	Right-handed
Helix Type	Regular, smooth	Elongated, zigzag backbone	Short/Squat, wide
Bp/Turn	~10 bp/turn	12 bp/turn	11 bp/turn
Pitch	3.4 nm	4.5 nm	2.8 nm
Main Biological Form	Yes, most common. (Ref: Q1)	Found in GC-rich, methylated regions. (Silent genes). (Ref: Q1)	Dehydrated conditions. RNA-DNA hybrids.

Eukaryotic Superstructures: Compaction



The Nucleosome

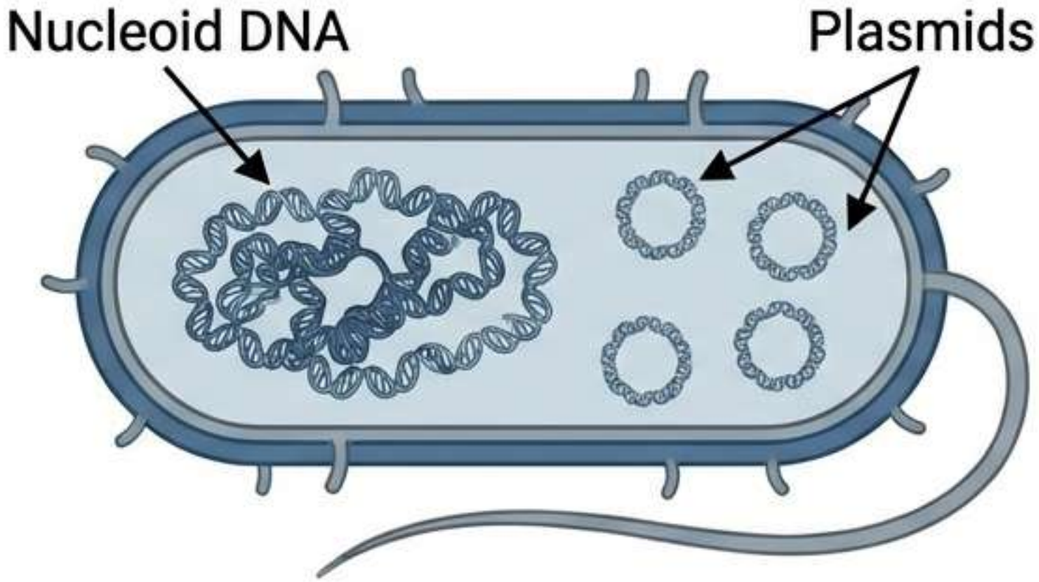
- Basic unit of chromatin. (Ref: Q53)
- Structure: DNA wound around an octamer of Histone proteins. (Ref: Q53) (Yellow Highlight)
- Histones are basic proteins (Lysine/Arginine rich).

Chromatin States

Euchromatin	**Heterochromatin**
Decondensed	Condensed
Active transcription	Inactive
Early S-phase replication	Late S-phase replication

Prokaryotic and Mitochondrial DNA

Prokaryotic DNA



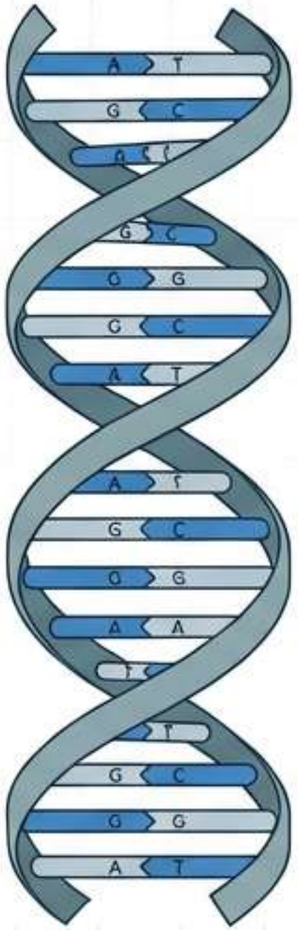
- Located in Cytoplasm.
- Circular, Double-stranded.
- Plasmids carry antibiotic resistance.

Mitochondrial DNA (mtDNA)

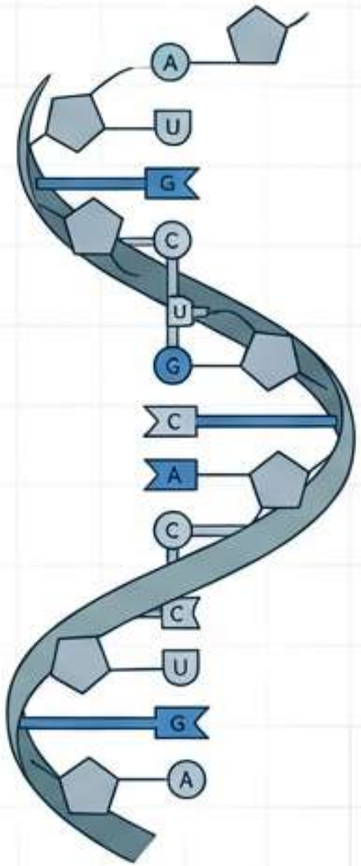
- Circular, Double-stranded. (Ref: Q2)
- Codes for 13 proteins, 22 tRNAs, 2 rRNAs. (Ref: Q2)
- No Introns.
- Maternal Inheritance (transmitted by mother only).

Ribonucleic Acids (RNA): Structure & mRNA

DNA Helix



RNA Chain



General Structure

- **Sugar:** Ribose.
- **Bases:** Uracil (U) replaces Thymine.
- **Strands:** Single-stranded (Monocatenaire).
- **Alkaline Sensitivity:** Hydrolyzed by NaOH (due to 2'-OH). DNA is resistant. (Ref: Q12)

Messenger RNA (mRNA)

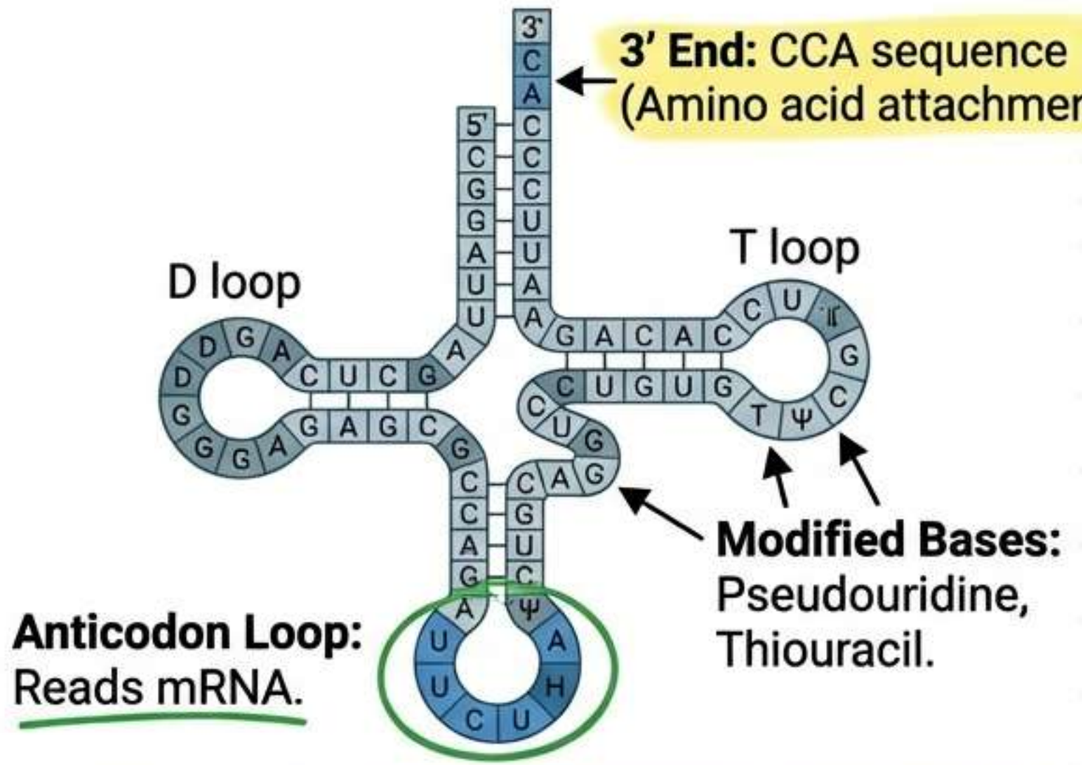
- Carries genetic info from Nucleus to Cytoplasm.
- Linear, Short lifespan.
- Synthesized as hnRNA -> Splicing -> mRNA.

Functional RNAs: rRNA and tRNA

Ribosomal RNA (rRNA)

- 80% of total RNA. Site of Translation.
- Eukaryotic Ribosome (80S) = 60S Large Subunit + 40S Small Subunit.

Transfer RNA (tRNA)



- 15% of total RNA. Transports Amino Acids.

Summary Comparison: DNA vs. RNA

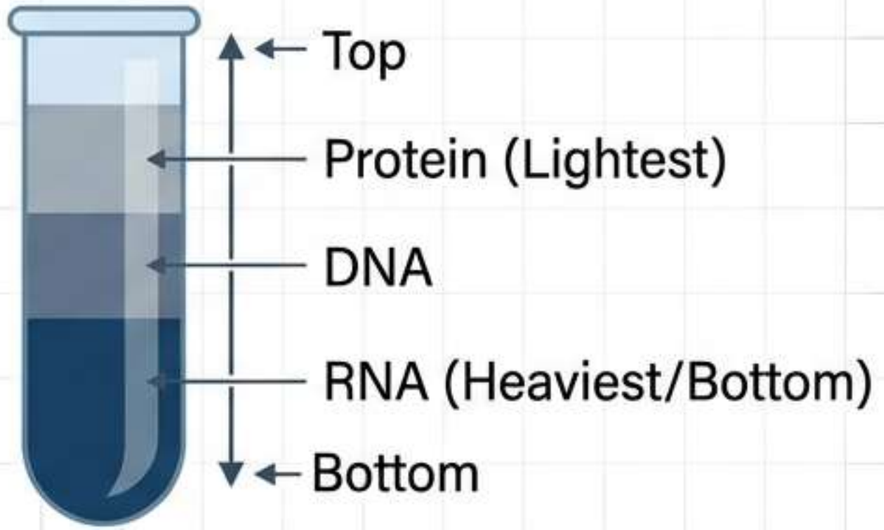
	DNA	RNA
Sugar	2’-Deoxyribose	Ribose
Bases	A, C, G, **Thymine**	A, C, G, **Uracil**
Structure	Double-stranded (Stable)	Single-stranded (Unstable/Hydrolyzable)
Location	Nucleus (Mitochondria)	Nucleus → Cytoplasm
Function	Genetic Archive	Protein Synthesis

Physical Properties: Charge and Density

Ionic Charge

- At physiological pH, DNA/RNA are Negatively Charged (-) due to Phosphate groups. (Ref: Q31)
- Electrophoresis: Migrate toward the Anode (+). (Ref: Q31)

Density (Ultracentrifugation)



- Separation by CsCl gradient density. Order: RNA > DNA > Protein. (Ref: Q54)

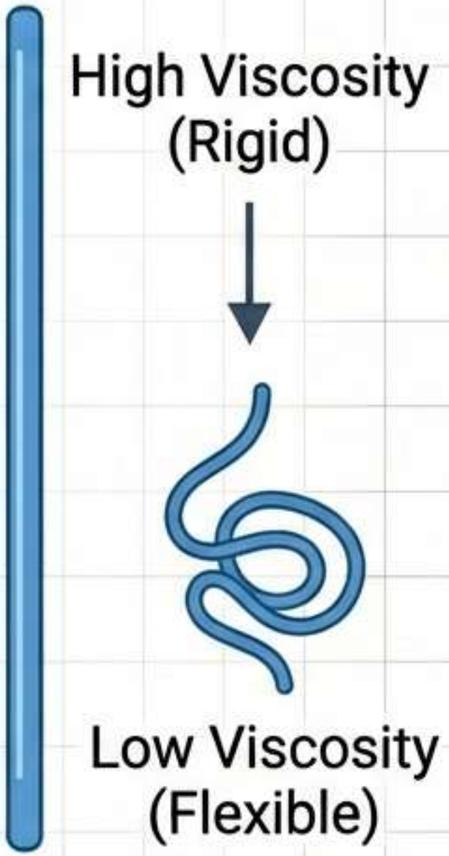
Physical Properties: Solubility and Viscosity

Solubility

- Soluble in water/salt. Precipitates in Alcohol. (Ref: Q31)

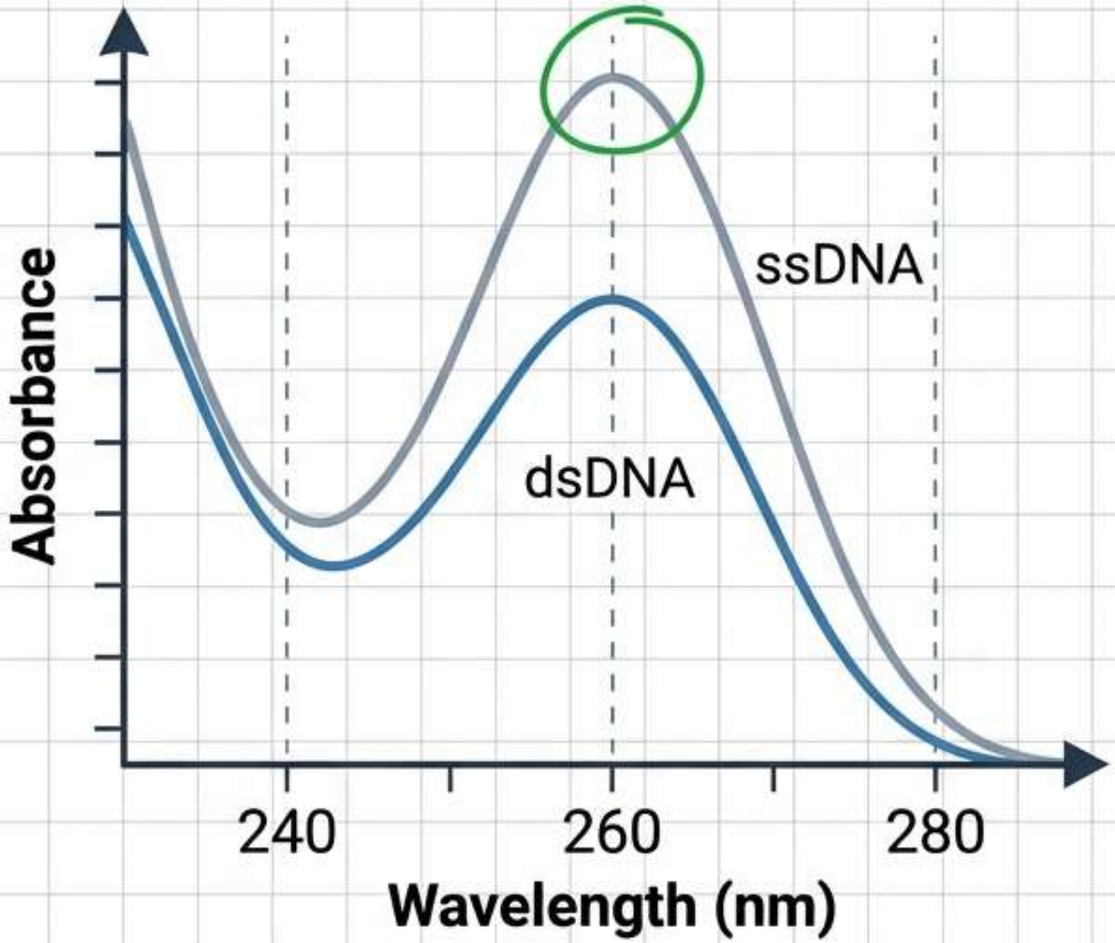
Viscosity

- Viscosity depends on rigidity.
- dsDNA (Double Strand): High viscosity (Rigid). (Ref: Q31)
- ssDNA/RNA (Single Strand): Lower viscosity (Flexible). (Ref: Q8, Q31)
- Denaturation: Causes a Decrease in viscosity. (Ref: Q8)



Optical Properties: UV Absorption

Absorption Spectrum



Key Facts

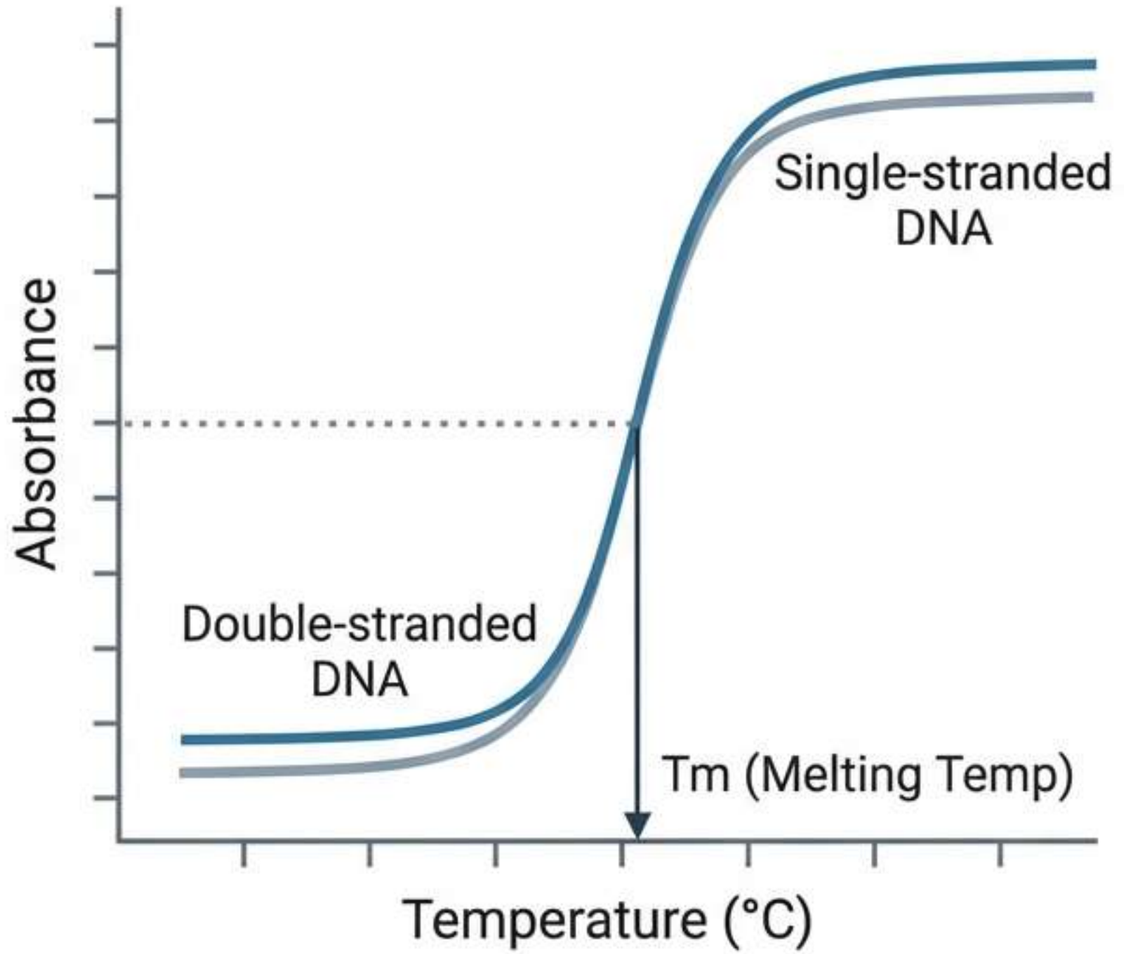
- Nucleic acids absorb at **260 nm**. (Ref: Q15)
- Purity Ratio: A260/A280 > 1.8.

Hyperchromic Effect

dsDNA absorbs **LESS** than ssDNA. (Ref: Q15, Q8)

Denaturation (Melting) leads to an **Increase** in Absorbance.

Denaturation (Melting) and *Tm*



- **Denaturation**: Rupture of H-bonds (Strand separation). Primary structure remains INTACT. (Ref: Q8)
- Tm (Melting Temp): Temperature where 50% is denatured. (Ref: Q15)
- Factors increasing Tm: High GC Content (3 H-bonds) and Length.
- **Renaturation**: Reversible process (Hybridization).

Hydrolysis: Chemical and Enzymatic

Alkaline Hydrolysis (NaOH)

- RNA: Rapidly destroyed (due to 2’-OH). (Ref: Q12)
- DNA: Resistant (No 2’-OH). (Ref: Q12)
- Use: Remove RNA from DNA samples.

Enzymes Section

- Endonucleases (cut inside) vs Exonucleases (cut ends).
- Topoisomerases: Type I (cuts 1 strand), Type II (cuts 2 strands). (Ref: Q3)

EXAM MASTERY: Traps & Professor's Style (Part 1)

The Polarity Flip

- **Trap:** Forgetting antiparallel strands.
- **Example:** If 5'-ATGGTC-3', the answer is NOT TACCAG.
- ****Correct Answer:** 3'-TACCAG-5'. Always check the 5'/3' labels! (Ref: Q10)

Atom Counting

- **Trap:** Mixing up base chemistry details.
- **Fact:** Guanine has 5 Nitrogens. (Ref: Q25)
- **Fact:** Thymine has 2 C=O groups. (Ref: Q25)

EXAM MASTERY: Traps & Professor's Style (Part 2)

Denaturation Effects

- **Trap:** Confusing Absorbance vs Viscosity.
- **When DNA Melts:** Absorbance INCREASES (Hyperchromic). Viscosity DECREASES. (Ref: Q8, Q15)

The Alkaline Test

- **Trap:** Thinking NaOH destroys all nucleic acids.
- **Fact:** NaOH destroys RNA only. DNA is resistant. (Ref: Q12)

Final Tip: Watch for exceptions like Mitochondrial DNA (Circular, Maternal) or Z-DNA (Left-handed).