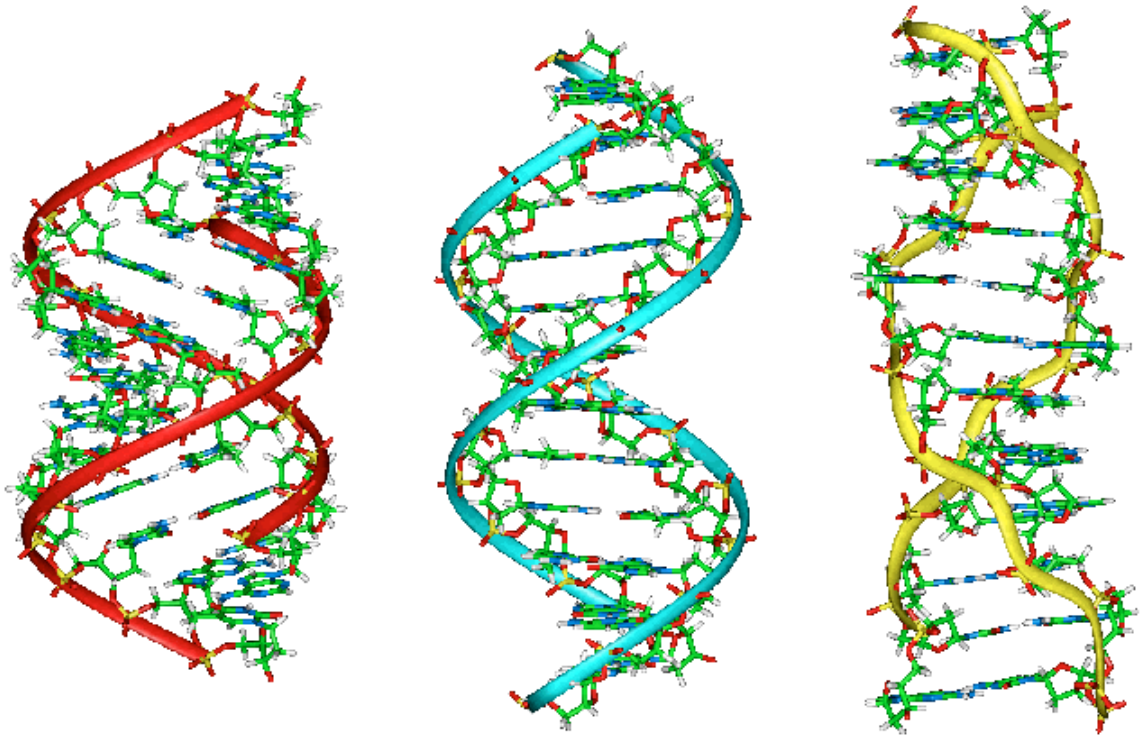
SAPIENZA

Nucleotides and nucleic acids



- DNA - a polymer of deoxyribo nucleotides
- found in chromosomes, mitochondria and chloroplasts
- carries the genetic information

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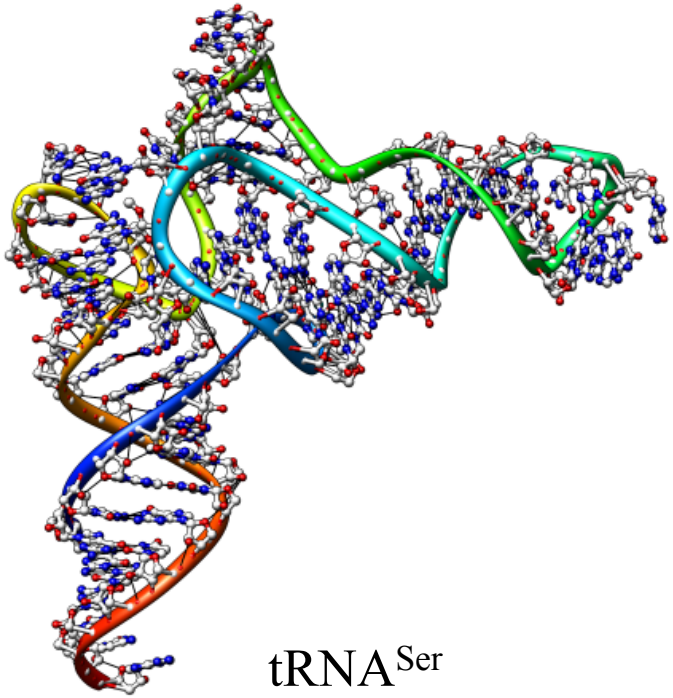
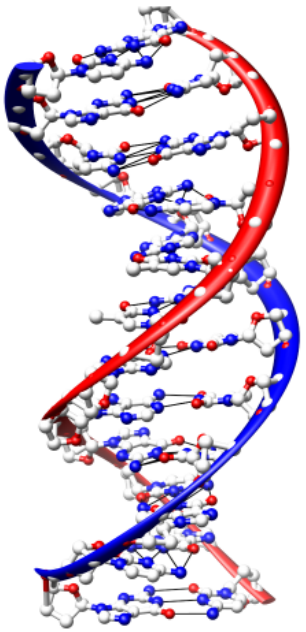
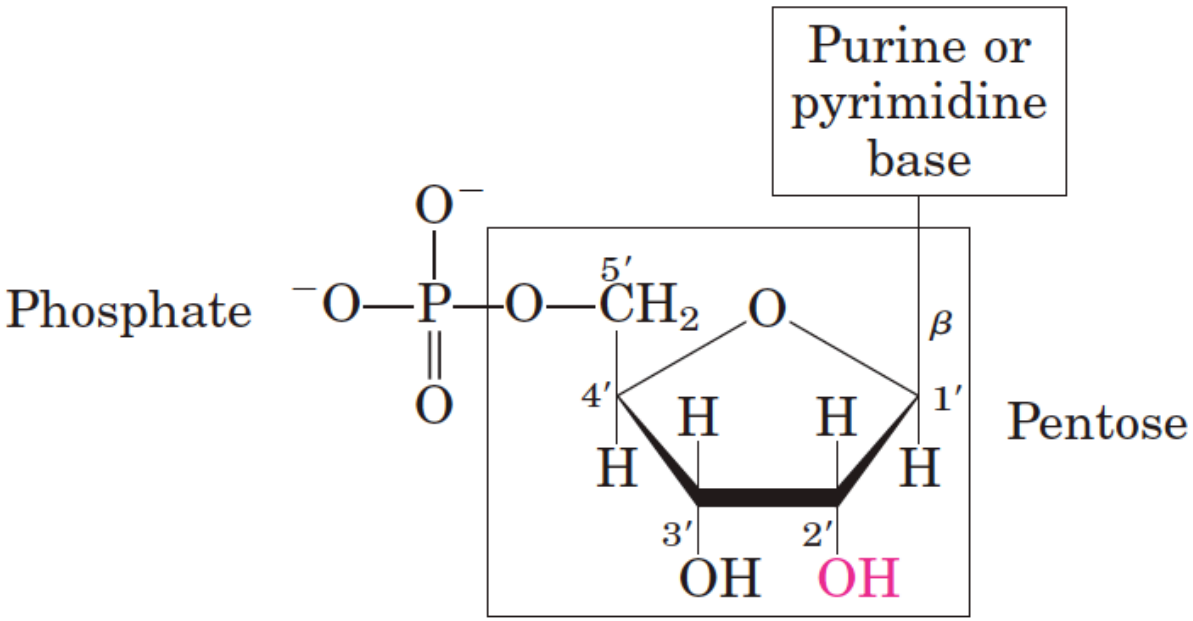


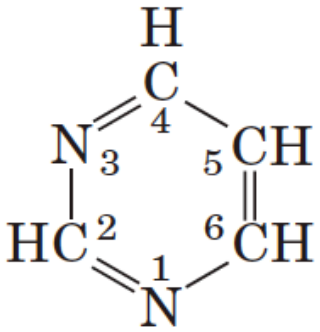
tRNA^{Ser}



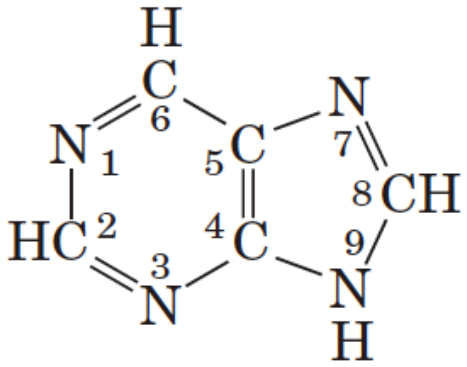
DNA

Nucleotides: the building blocks of nucleic acids





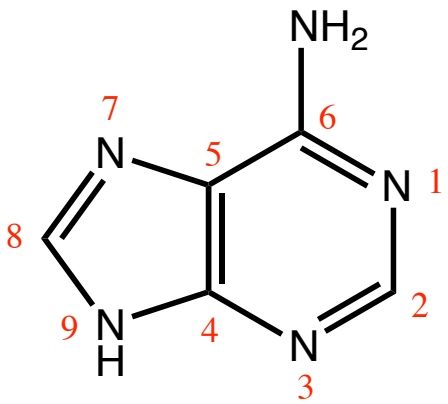
Pyrimidine



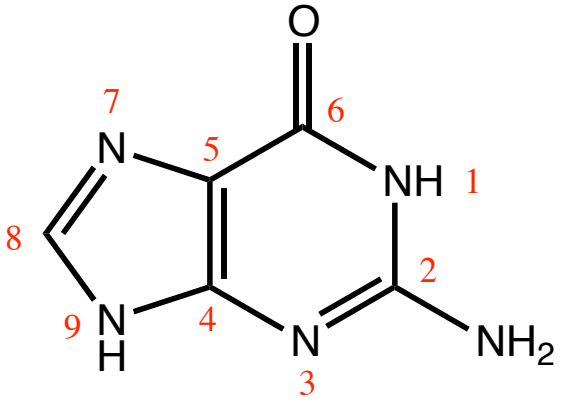
Purine

Major purine and pyrimidine bases of nucleic acids

purines

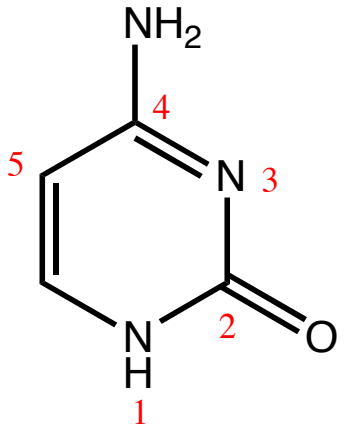


adenine

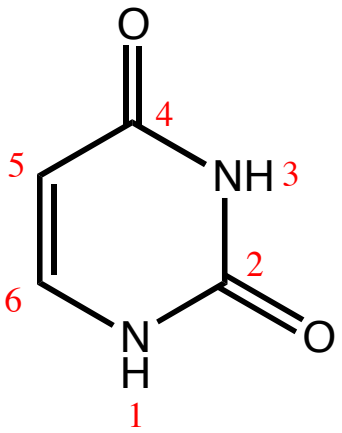


guanine

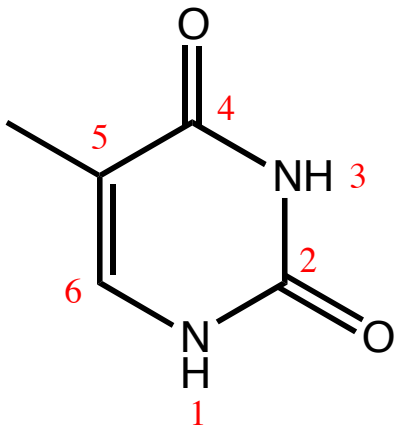
pyrimidines



citosine

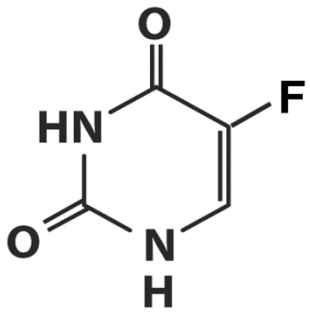


uracil

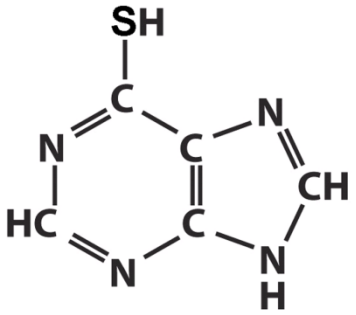


thymine

Nucleoside and base analogs can be used as anti-cancer and anti-virus drugs

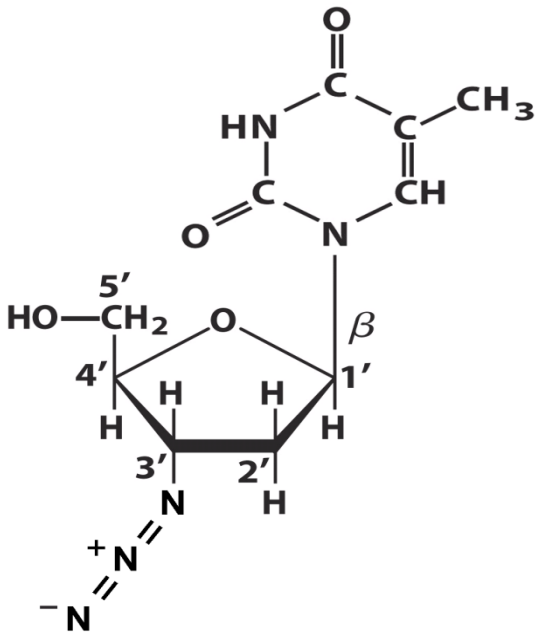


5-Fluorouracil

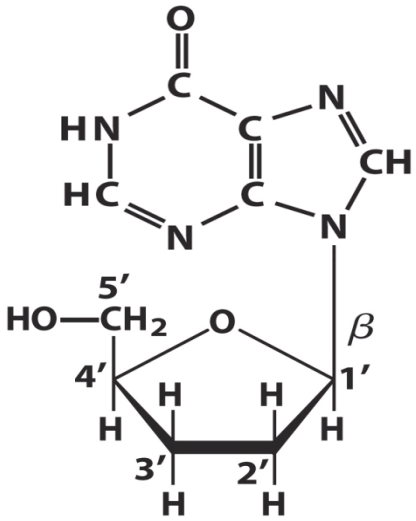


6-Mercaptopurine

Anticancer agents



Azidothymidine

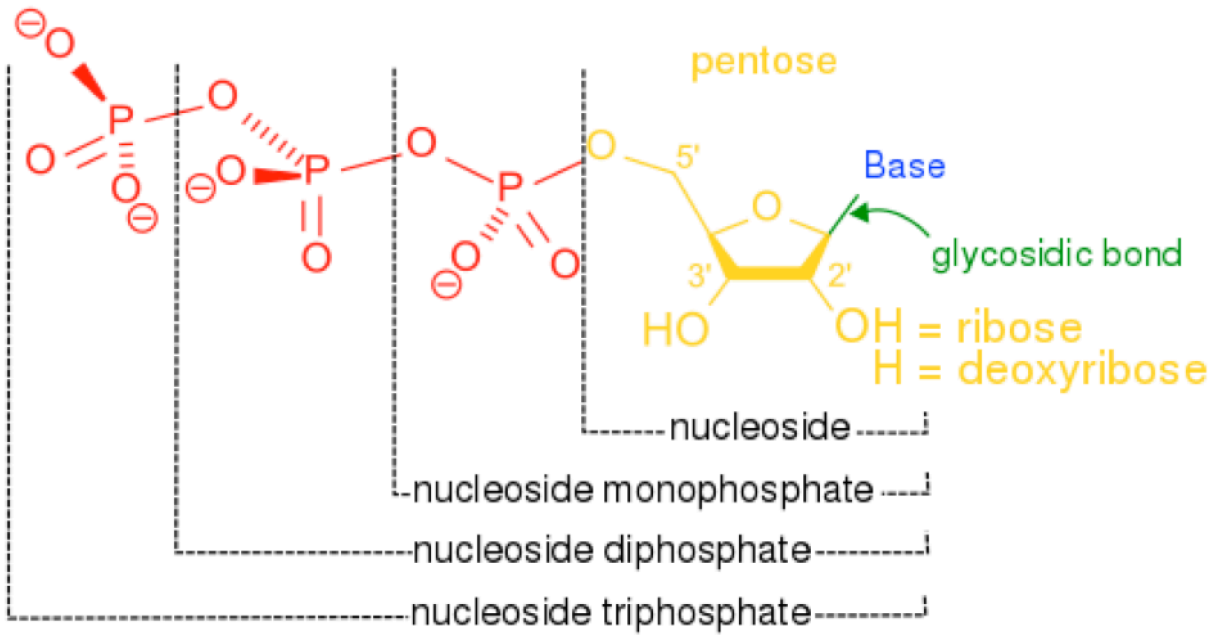


Dideoxyinosine

Antiretroviral agents

Nucleotide and Nucleic Acid Nomenclature

Base	Nucleoside	Nucleotide	Nucleic acid
Purines			
Adenine	Adenosine Deoxyadenosine	Adenylate Deoxyadenylate	RNA DNA
Guanine	Guanosine Deoxyguanosine	Guanylate Deoxyguanylate	RNA DNA
Pyrimidines			
Cytosine	Cytidine Deoxycytidine	Cytidylate Deoxycytidylate	RNA DNA
Thymine	Thymidine or deoxythymidine	Thymidylate or deoxythymidylate	DNA
Uracil	Uridine	Uridylate	RNA

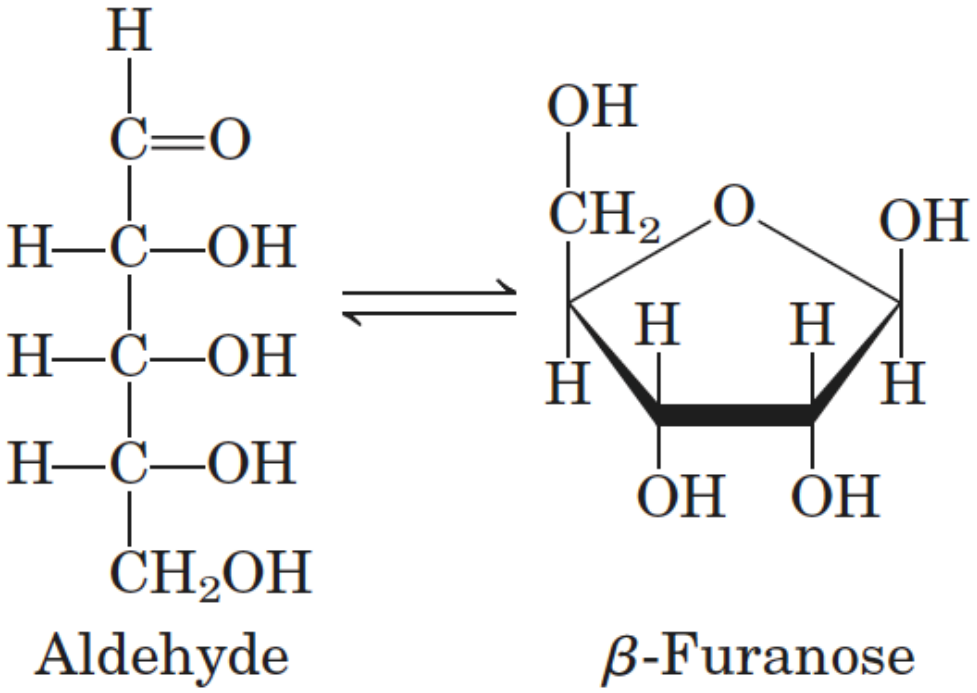


Conformations of ribose

- In solution, the straight chain (aldehyde) and ring (b-furanose) forms of free ribose are in equilibrium.

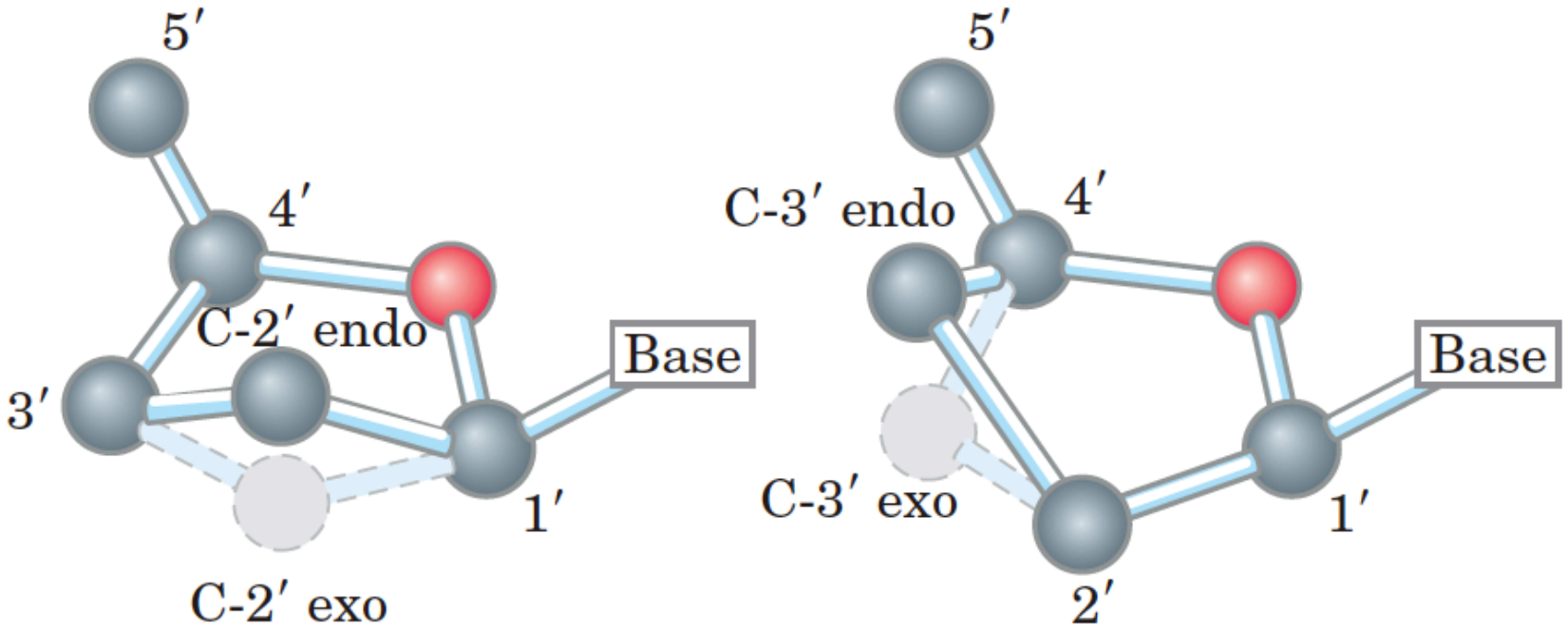
- RNA contains only the b-D-ribofuranose ring form.

- Deoxyribose undergoes a similar interconversion in solution, but in DNA exists solely as b-2-deoxy-D-ribofuranose.

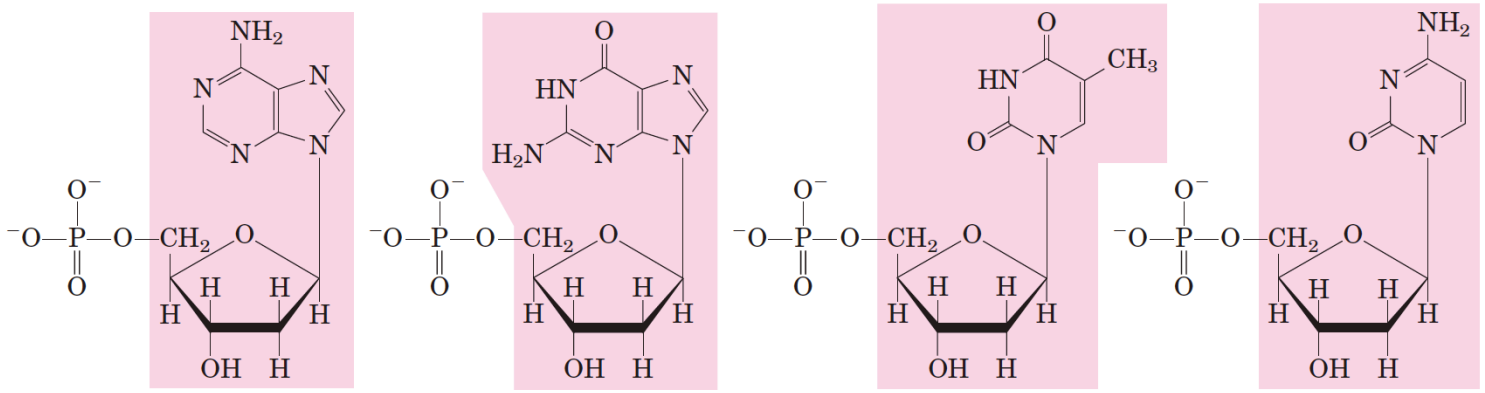


Aldehyde β-Furanose

Ribofuranose rings in nucleotides can exist in four different puckered conformations. In all cases, four of the five atoms are in a single plane. The fifth atom (C-2 or C-3) is on either the same (endo) or the opposite (exo) side of the plane relative to the C-5 atom

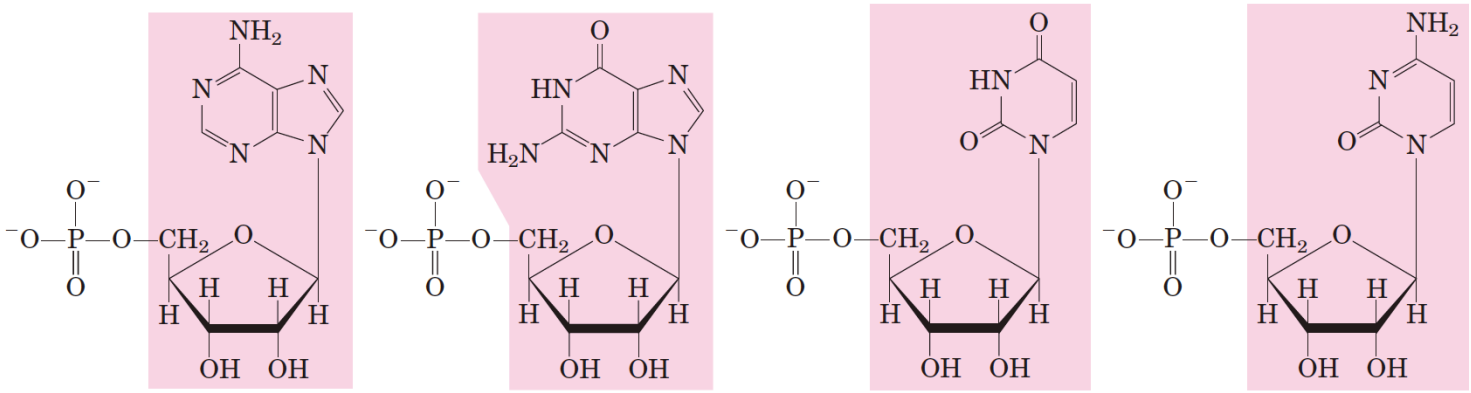


Deoxyribonucleotides



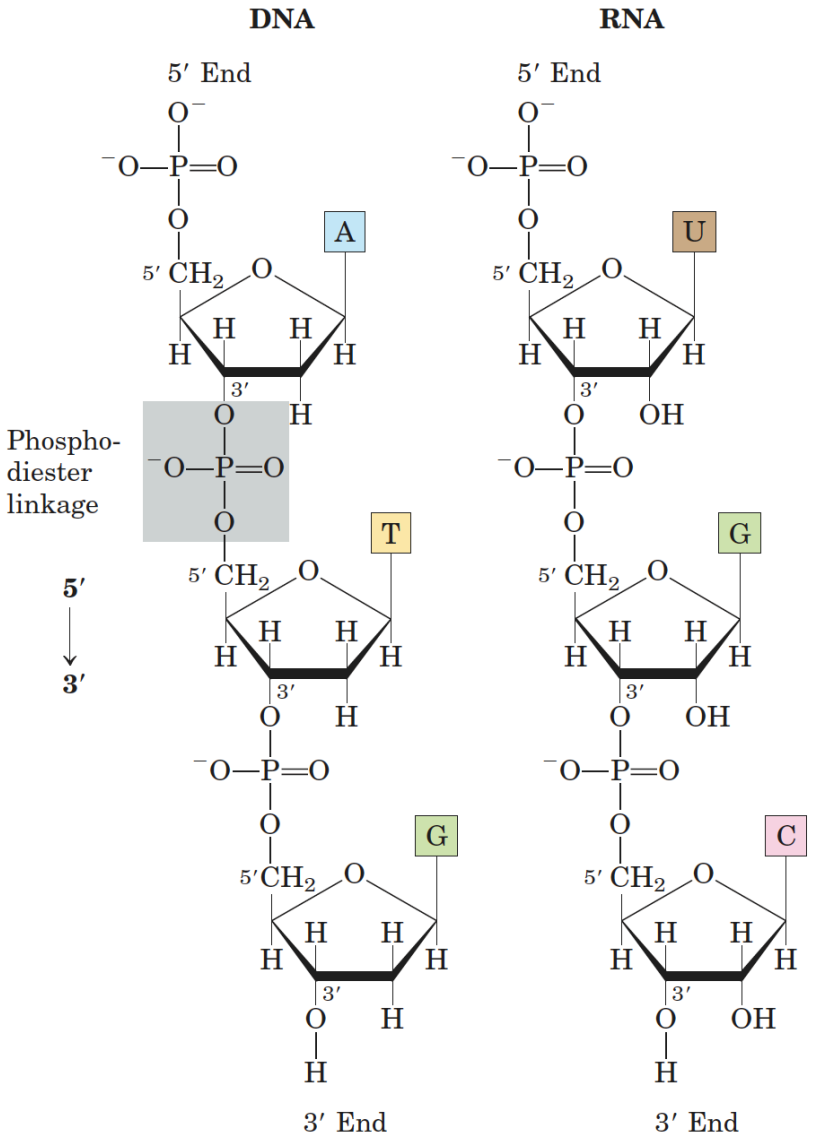
Nucleotide:	Deoxyadenylate (deoxyadenosine 5′-monophosphate)	Deoxyguanylate (deoxyguanosine 5′-monophosphate)	Deoxythymidylate (deoxythymidine 5′-monophosphate)	Deoxycytidylate (deoxycytidine 5′-monophosphate)
Symbols:	A, dA, dAMP	G, dG, dGMP	T, dT, dTMP	C, dC, dCMP
Nucleoside:	Deoxyadenosine	Deoxyguanosine	Deoxythymidine	Deoxycytidine

Ribonucleotides



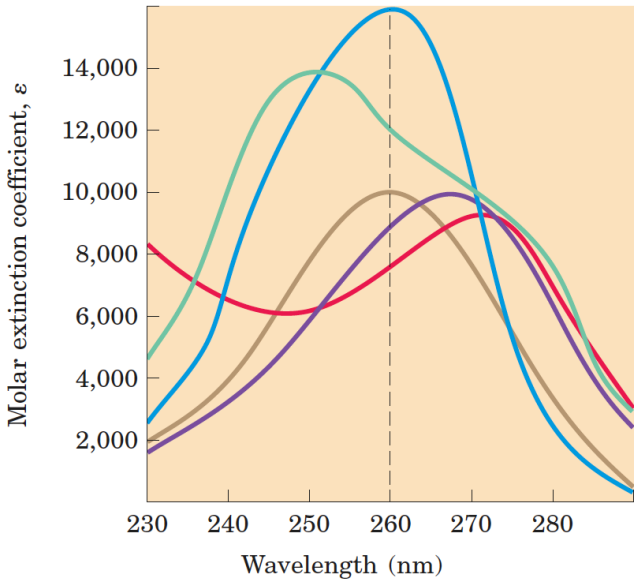
Nucleotide:	Adenylate (adenosine 5′-monophosphate)	Guanylate (guanosine 5′-monophosphate)	Uridylate (uridine 5′-monophosphate)	Cytidylate (cytidine 5′-monophosphate)
Symbols:	A, AMP	G, GMP	U, UMP	C, CMP
Nucleoside:	Adenosine	Guanosine	Uridine	Cytidine

Phosphodiester bonds link successive nucleotide units.

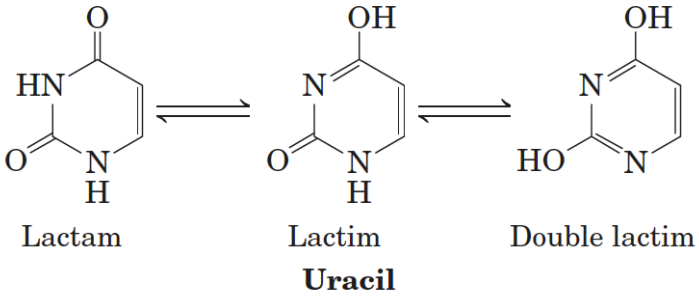


The properties of nucleotide bases affect the three-dimensional structure of nucleic acids

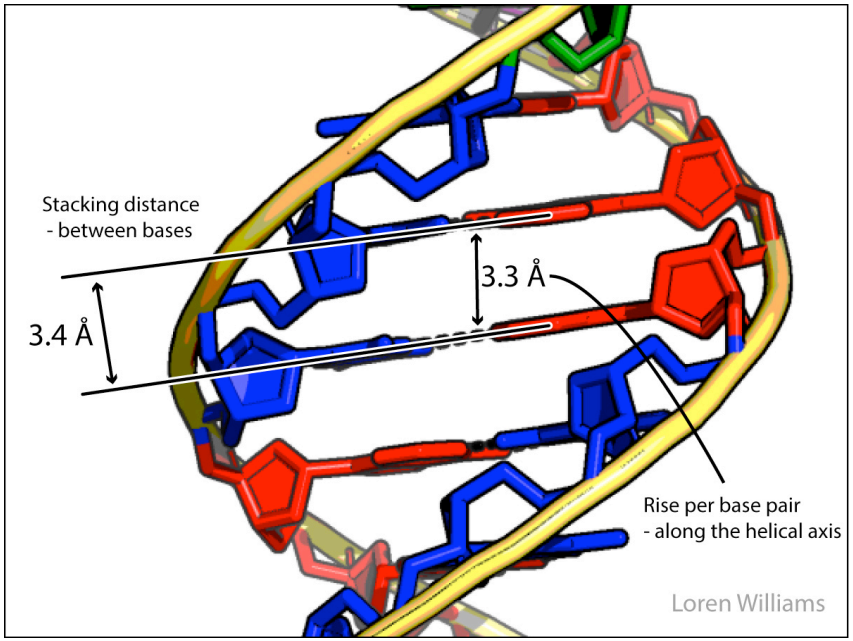
- free pyrimidines and purines are hydrophobic weak bases.
- the purines and pyrimidines common in DNA and RNA are aromatic molecules, a property with important consequences for the structure, electron distribution, and light absorption of nucleic acids.
- electron delocalization among atoms in the ring gives most of the bonds partial double-bond character, resulting in planar pyrimidines and purines that are very nearly planar, with a slight pucker.
- free pyrimidine and purine bases may exist in two or more tautomeric forms depending on the pH.

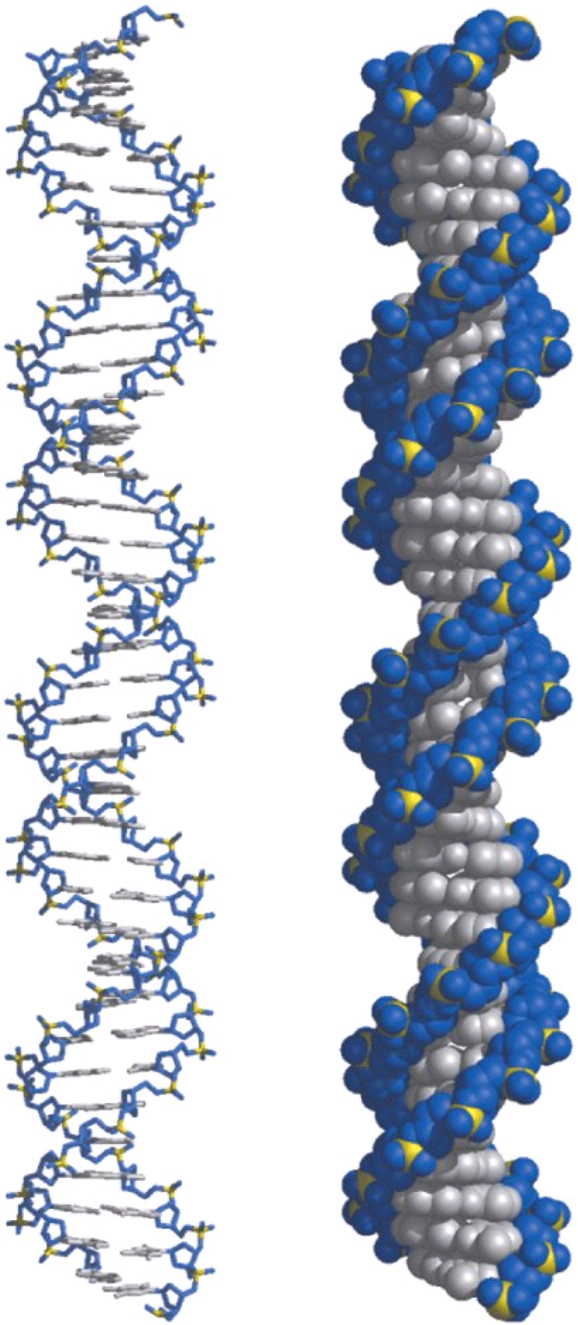


Molar extinction coefficient at 260 nm, ε_{260} ($M^{-1}cm^{-1}$)	
AMP	15,400
GMP	11,700
UMP	9,900
dTMP	9,200
CMP	7,500



- The purine and pyrimidine bases are hydrophobic and relatively insoluble in water at the near-neutral pH of the cell.
- At acidic or alkaline pH the bases become charged and their solubility in water increases.
- Hydrophobic stacking interactions in which two or more bases are positioned with the planes of their rings parallel (like a stack of coins) are one of two important modes of interaction between bases in nucleic acids.
- The stacking also involves a combination of van der Waals and dipole-dipole interactions between the bases.
- Base stacking helps to minimize contact of the bases with water, and base-stacking interactions are very important in stabilizing the three-





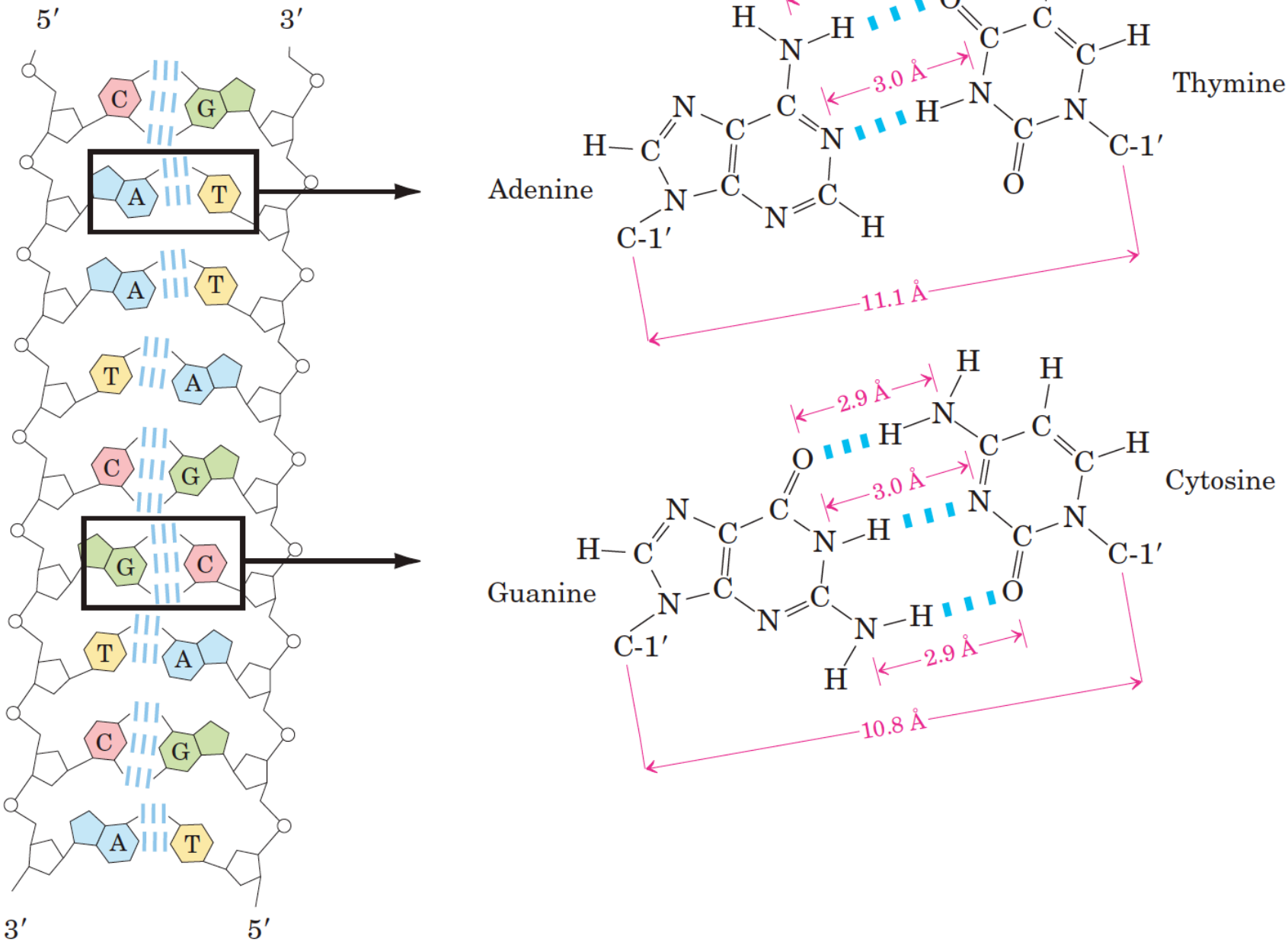
The secondary structure of DNA

Two anti-parallel polynucleotide chains wound around the same axis.

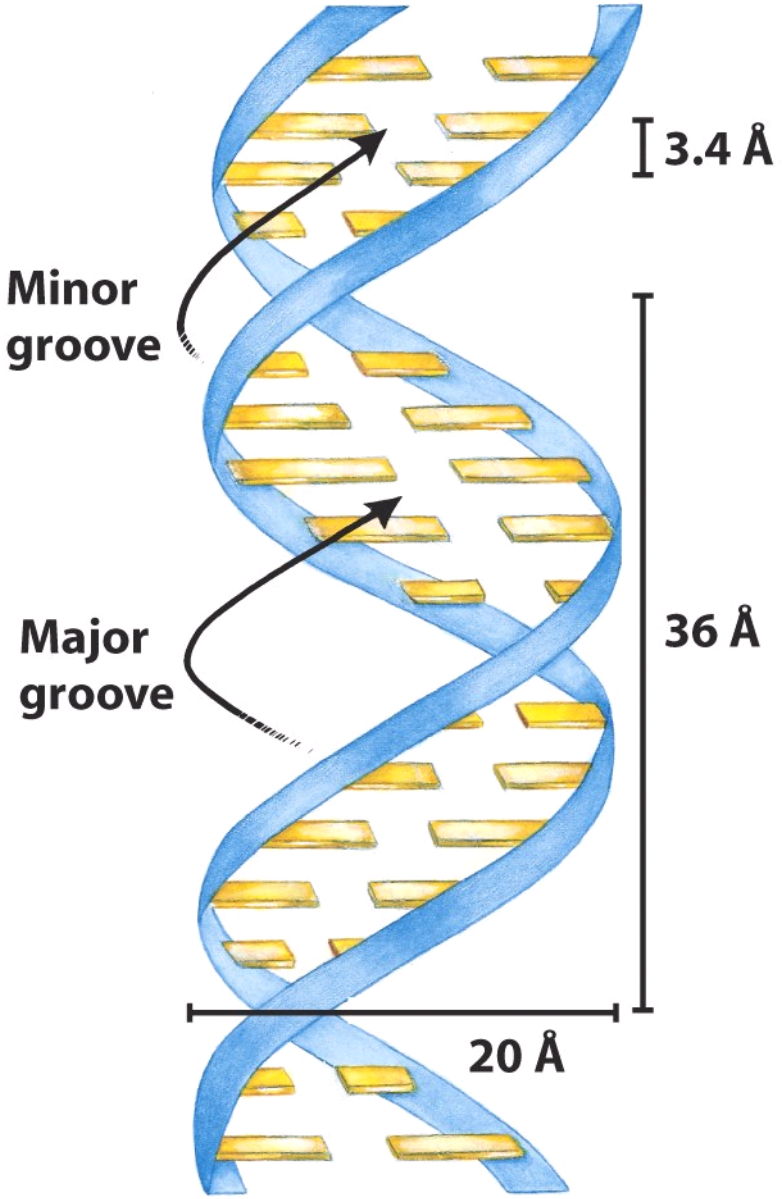
Sugar-phosphate chains wrap around the periphery.

Bases (A, T, C and G) occupy the core, forming complementary A · T and G · C Watson-Crick base pairs.

Watson and Crick hydrogen-bonding patterns in the base pairs



Normally hydrated DNA: B-form DNA



Helical sense: right handed

Base pairs: almost perpendicular to the helix axis; 3.4 Å apart

One turn of the helix: 36 Å; ~10.4 base pairs

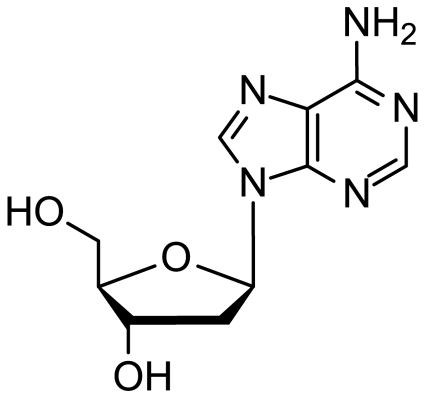
Minor groove: 12 Å across

Major groove: 22 Å across

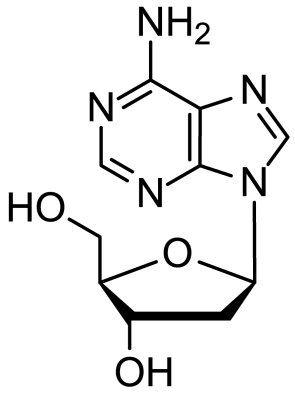
Structural forms of DNA

Property	A-DNA	B-DNA	Z-DNA
Helix Handedness	Right	Right	Left
Base Pairs per turn	11	10.4	12
Rise per base pair along axis	0.23nm	0.34nm	0.38nm
Pitch	2.46nm	3.40nm	4.56nm
Diameter	2.55nm	2.37nm	1.84nm
Conformation of Glycosidic bond	anti	anti	Alternating anti and syn
Major Groove	Present	Present	Absent
Minor Groove	Present	Present	Deep cleft

Anti and syn conformations

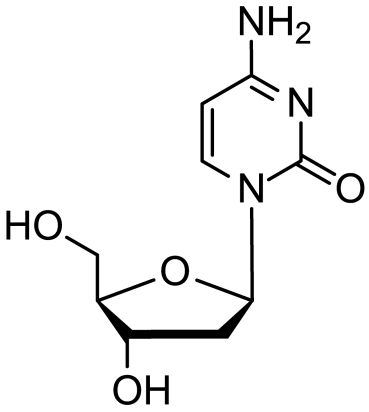


anti

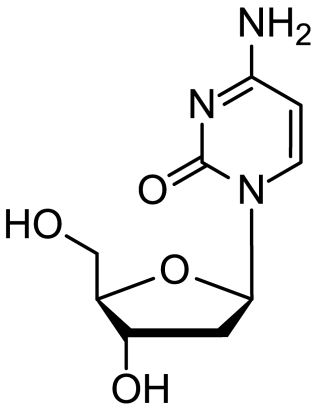


syn

deoxyadenosine (a purine nucleoside)



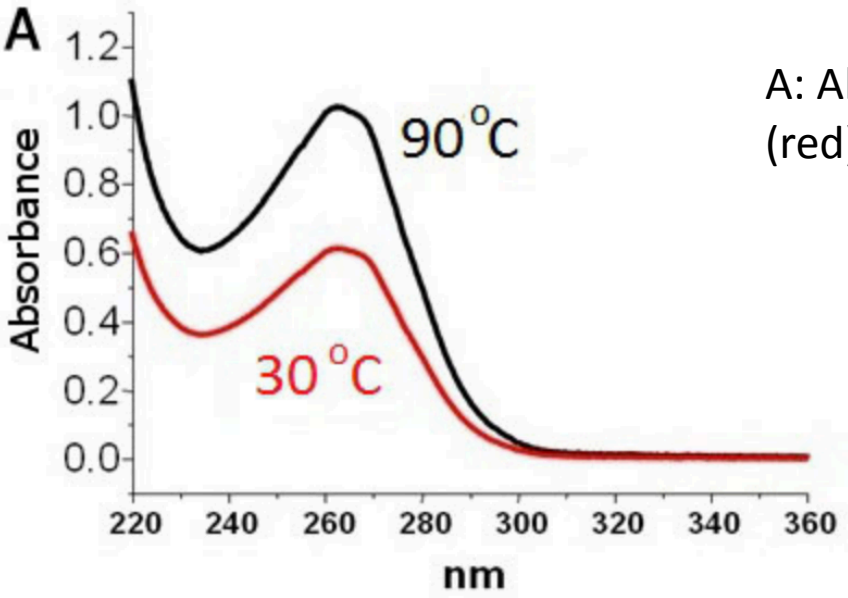
anti



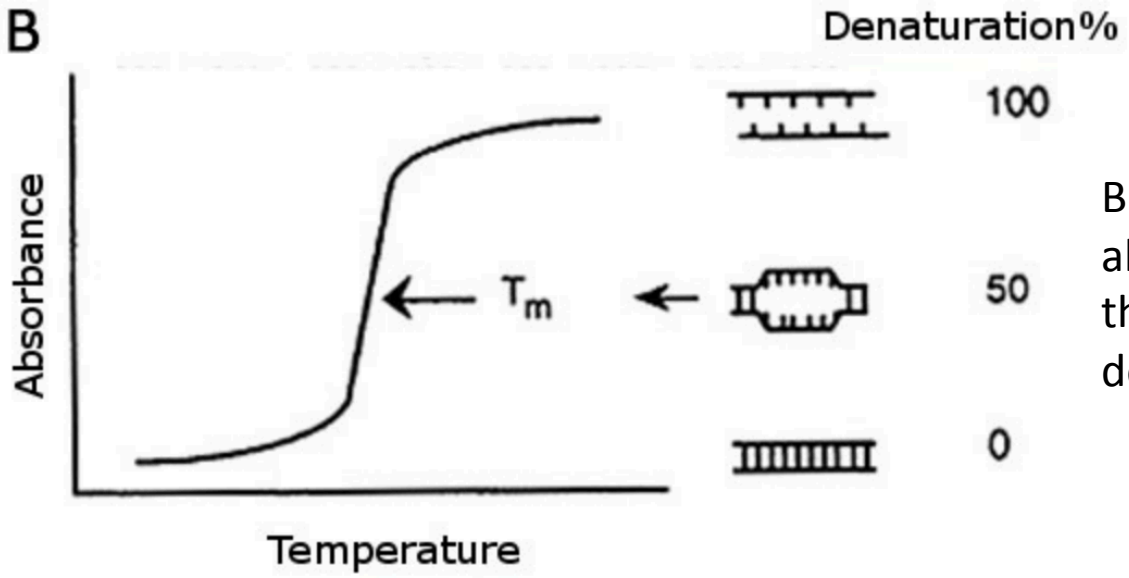
syn

deoxycytidine (a pyrimidine nucleoside)

Hyperchromicity of DNA



A: Absorption spectra of a DNA molecule at 30°C (red) and 90°C (black).



B: Temperature-induced change in absorbance at 260 nm, reflecting the denaturation (melting) of the double-stranded DNA structure.