STRUCTURE OF NUCLEIC ACIDS

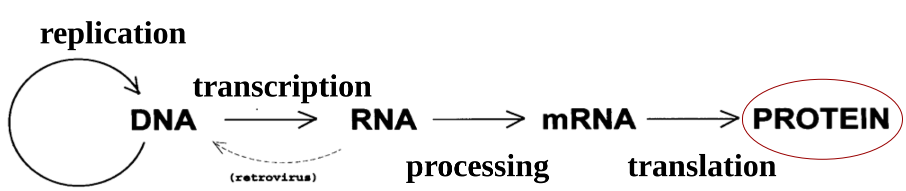
Course: Molecular Biology (02022312)

Instructor: Dr. M A Srour

Textbook:
Watson J, Baker TA, Bell SP, Gann A, Levine M, Losick R (2008). Molecular Biology of the Gene, 6th ed. Chap 6 / pp.101-33

Lec # 1 Wed 18.01.2012

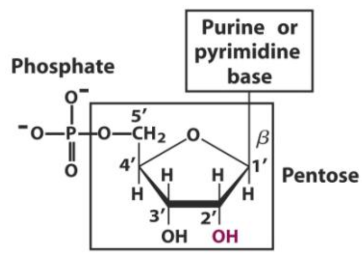
The Central Dogma

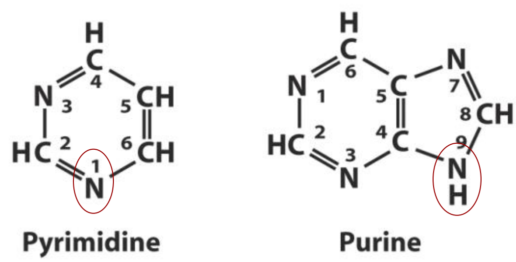


- Cells make exact copies of DNA
- RNA is transcribed from a DNA template
- proteins are translated from RNA template

•Proteins regulate gene expression

Nucleotide structure





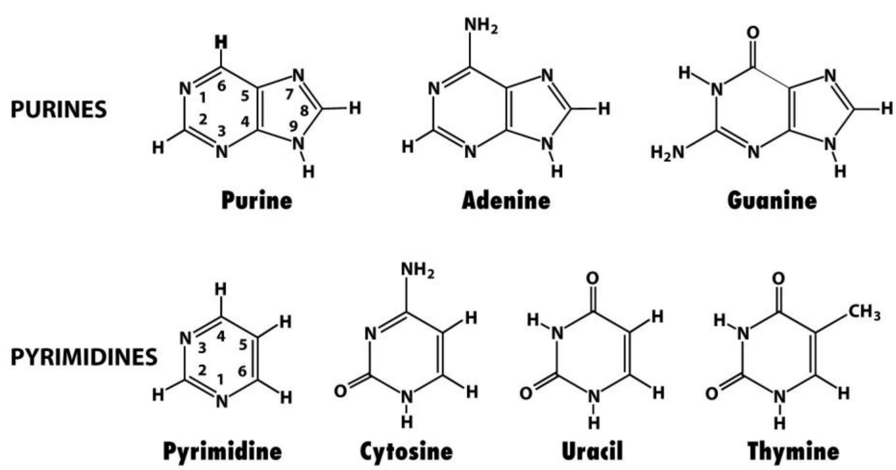


Figure 4-4
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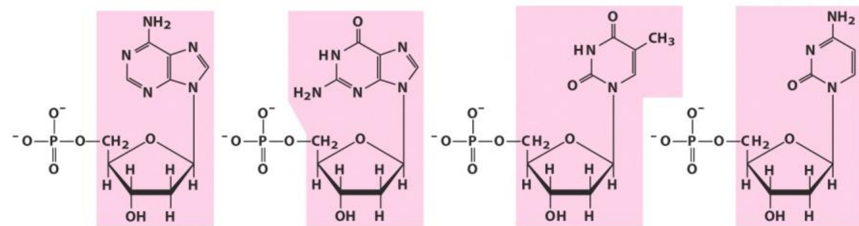
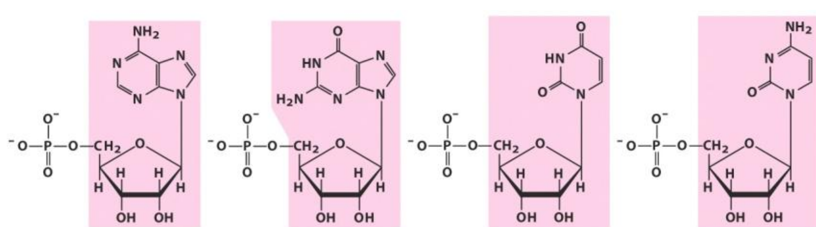


Nucleotide:	Deoxyadenylate (deoxyadenosine 5′-monophosphate)	Deoxyguanylate (deoxyguanosine 5′-monophosphate)	Deoxythymidylate (deoxythymidine 5′-monophosphate)	Deoxycytidylate (deoxycytidine 5′-monophosphate)
Symbols:	A, dA, dAMP	G, dG, dGMP	T, dT, dTMP	C, dC, dCMP
Nucleoside:	Deoxyadenosine	Deoxyguanosine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

(a) Deoxyribonucleotides

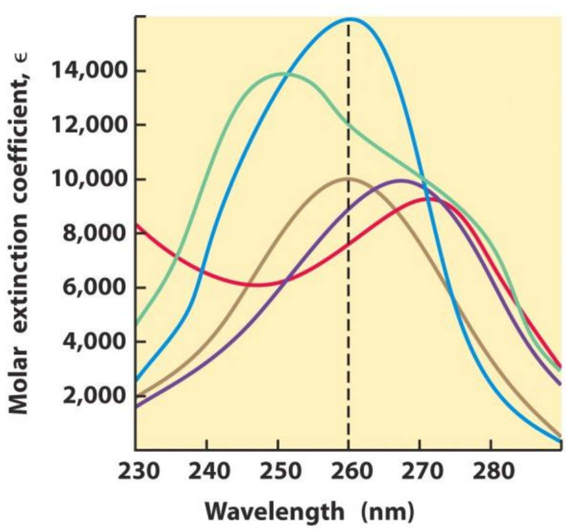


Nucleotide:	Adenylate (adenosine 5′-monophosphate)	Guanylate (guanosine 5′-monophosphate)	Uridylate (uridine 5′-monophosphate)	Cytidylate (cytidine 5′-monophosphate)
Symbols:	A, AMP	G, GMP	U, UMP	C, CMP
Nucleoside:	Adenosine	Guanosine	Uridine	Cytidine

(b) Ribonucleotides

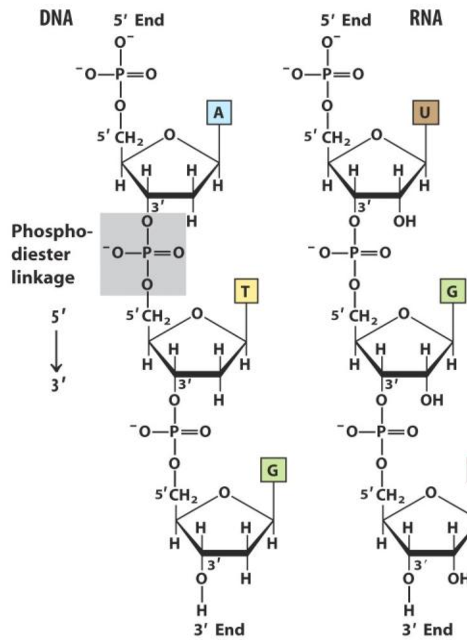
TABLE 8–1 Nucleotide and Nucleic Acid Nomenclature

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



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



Why did DNA evolve to be the carrier of genetic information in the cell as opposed to RNA?

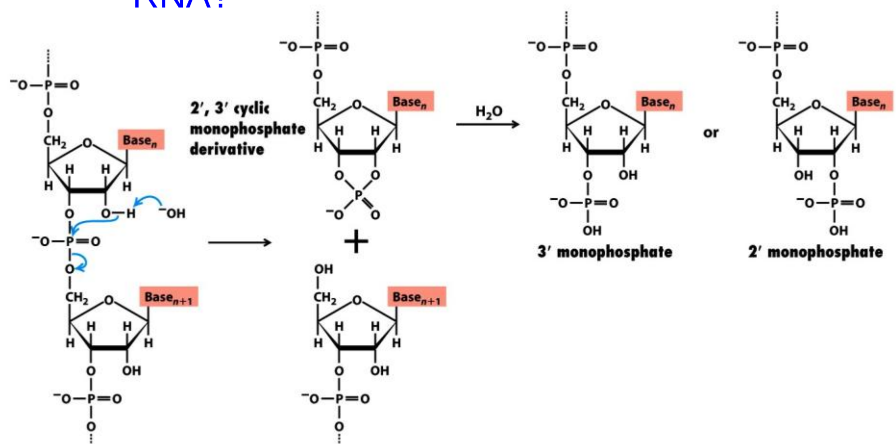


Figure 4-6
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A slow (OH-) catalyzed hydrolysis of RNA at neutral pH

Chemical directionality of a nucleic acid strand

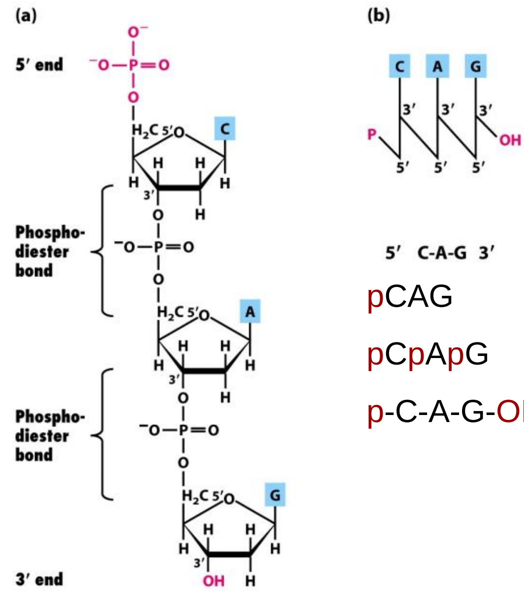
(5'→3')

Backbone: S-P-S…

Phospahet is ionized at pH~7.0

Oligonucleotides <50 nts

Polynucleotides >50 nuts



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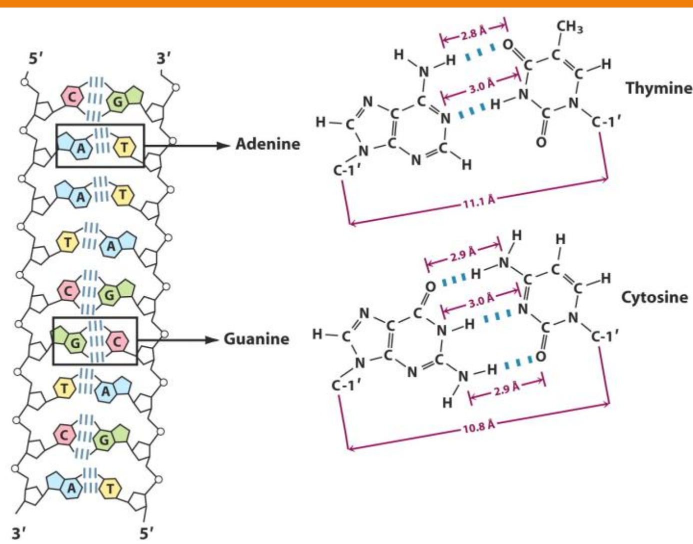
pCAG

pCpApG

p-C-A-G-OH

Watson –Crick model of DNA: hydrogen bonding



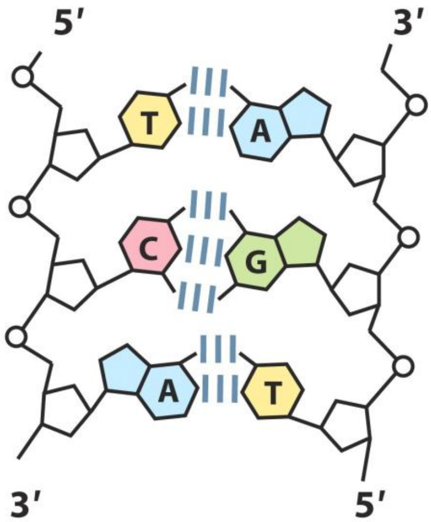
DNA:

Watson-Crick base pairs> G.C & A.T

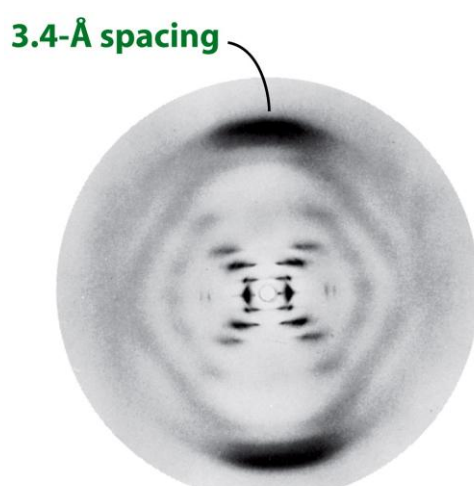
Nonstandard base-pairing > distort the double helix:

G.T & C.T in DNA

G.U in RNA



X-ray diffraction pattern of DNA:
reveals a helical structure with two periodicities of 0.34 & 34 nm



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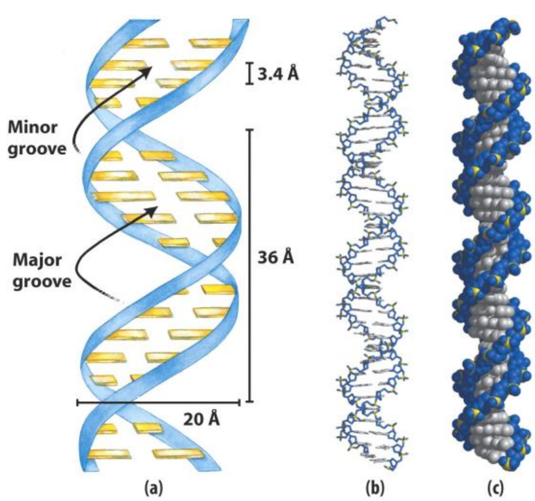
DNA is a double Helix: Watson-Crick model

- Rosalind Franklin & Maurice Wilkins, early 1950s> X-diffraction pattern of DNA> DNA has a helical structure with 2 periodicities 0.34 nm & 3.4 nm
- Chargaff's rules: A=T & G=C, A+G=T+C,
- W&C: right-handed double helix, antiparallel & complementary strands, nt are 0.34 nm apart and 10nt/turn (3.4nm)

W-C model of DNA: a double helix of two complementary antiparallel strands

Chemical structure of DNA double helix

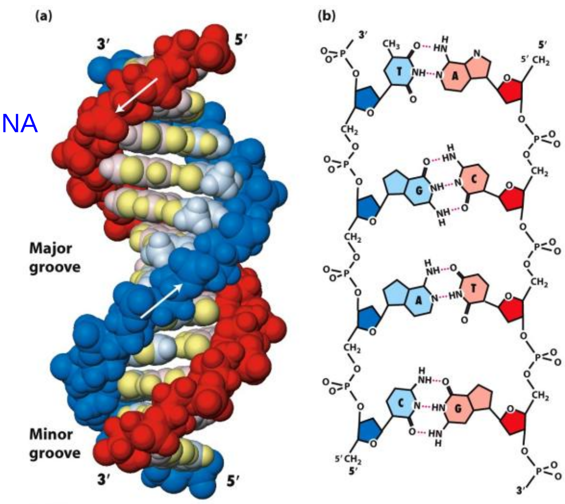


Space-filling model of B DNA

Native DNA: a double helix of two complementary antiparallel strands

(a)

Space-filling model of B DNA



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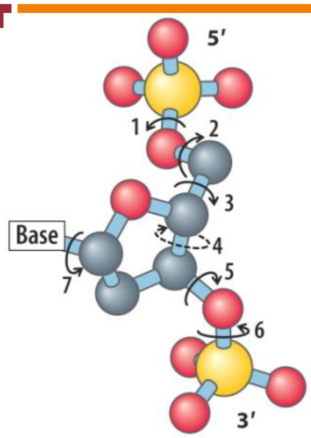
(b)

Chemical structure of DNA double helix

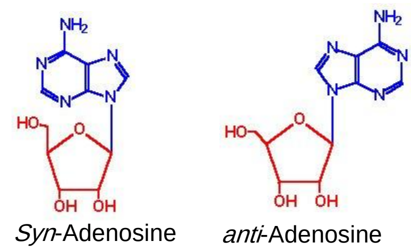
DNA can occur in different 3D forms

- DNA is flexible
- Considerable rotation is possible around a number of bonds in the S-P backbone
- Thermal fluctuations can produce bending, stretching and unpairing (denaturation or melting) of the strands
- Significant deviation in conformation from W-C model exist

Structural variation in DNA



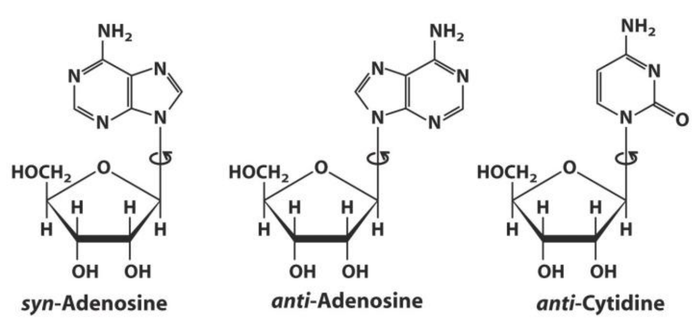
Rotation around different bonds in DNA



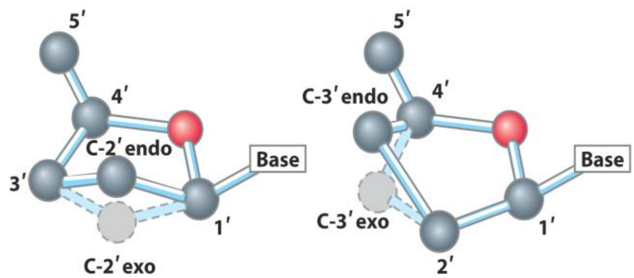
Purines occur in *anti or syn* conformation.

Pyrimidines occur only in *anti* conformation.

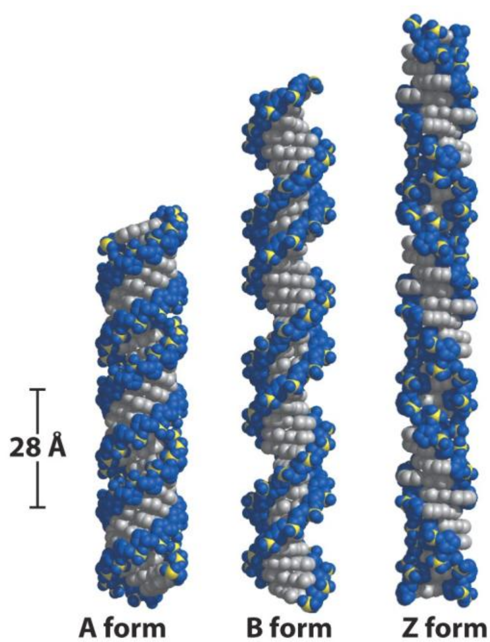
Structural variation in DNA



Different puckered Conformations of Ribose



Exo: opposite; Endo: same plane.



DNA can occur in different 3D forms

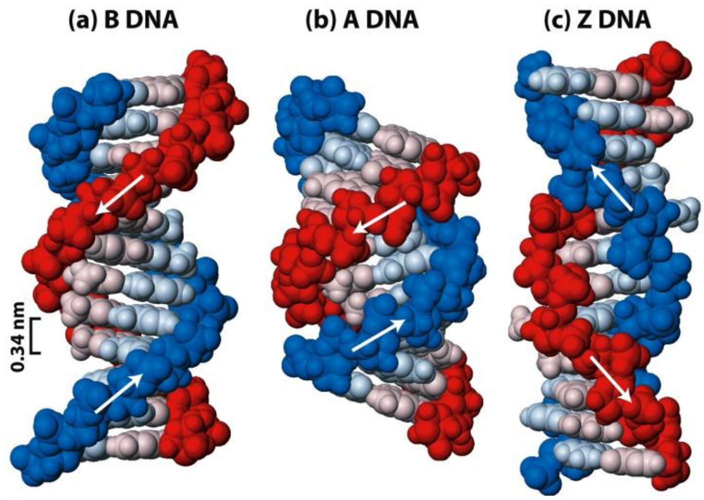


Figure 4-4
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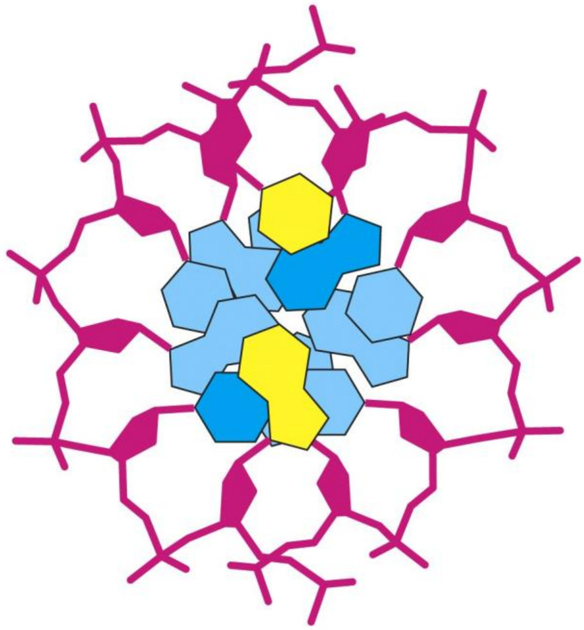
	A form	*B form*	*Z form*
Helical sense	Right handed	Right handed	Left handed
Diameter	~26 Å	~20 Å	~18 Å
Base pairs per helical turn	11	10.5	12
Helix rise per base pair	2.6 Å	3.4 Å	3.7 Å
Base tilt normal to the helix axis	20°	6°	7°
Sugar pucker conformation	C-3′ endo	C-2′ endo	C-2′ endo for pyrimidines; C-3′ endo for purines
Glycosyl bond conformation	Anti	Anti	Anti for pyrimidines; syn for purines



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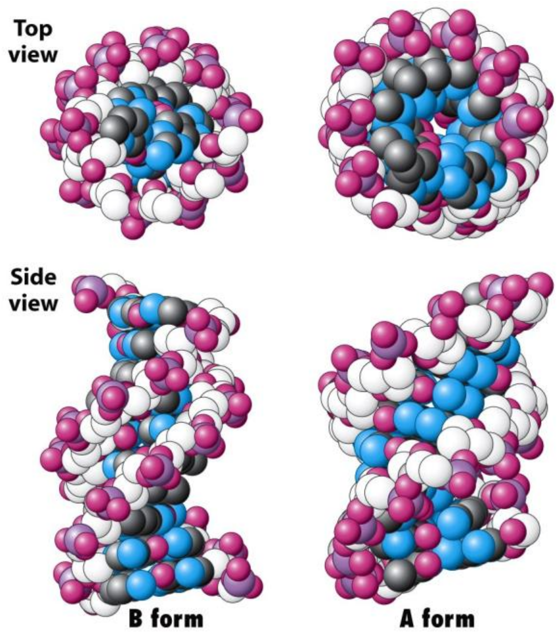

Figure 28-3
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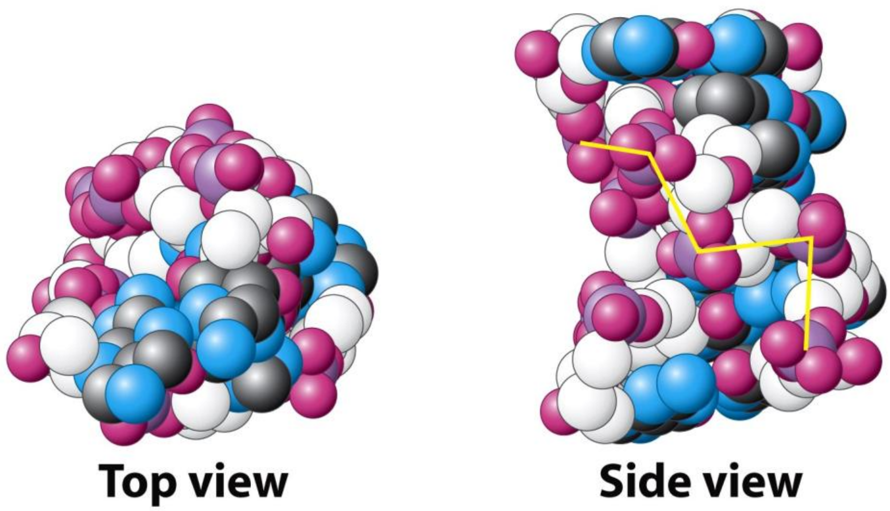

Figure 28-8
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	A form	*B form*	*Z form*
Helical sense	Right handed	Right handed	Left handed
Diameter	~26 Å	~20 Å	~18 Å
Base pairs per helical turn	11	10.5	12
Helix rise per base pair	2.6 Å	3.4 Å	3.7 Å
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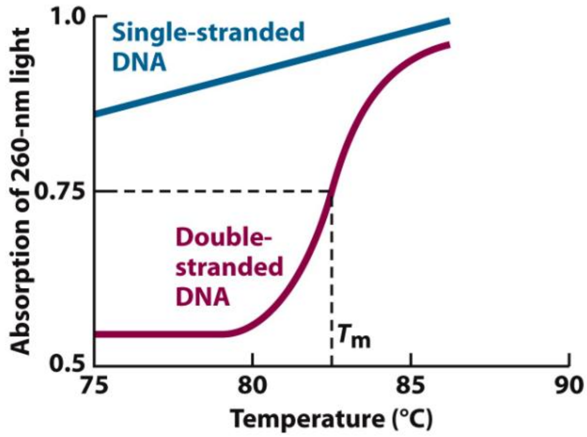
Sugar pucker conformation	C-3′ endo	C-2′ endo	C-2′ endo for pyrimidines; C-3′ endo for purines
Glycosyl bond conformation	Anti	Anti	Anti for pyrimidines; syn for purines

DNA can undergo reversible strand separation: the hyperchromic effect



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DNA can undergo reversible strand separation: Tm is affected by GC content

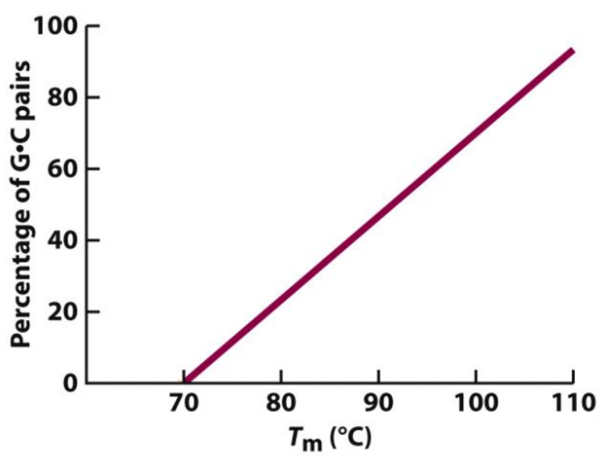

Figure 4-7b
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