NUCLEIC ACIDS

Course: Biochemistry for Nursing (BIOC 230)

Instructor: Dr. Mahmoud A. Srour

Textbook:
Lehninger Principles of Biochemistry, 5th Ed. Chapter 8
Moran et al. Principles of Biochemistry, 5th ed. Chap 19

Some basics

- Gene: a segment of a DNA molecule that contains the information required for the synthesis of a functional biological product whether a protein or RNA
- What is the function of DNA ?

Nucleotides

- Nucleotides have three components:
  - A nitrogenous base
  - A pentose
  - Phosphate group
- Nucleoside: a nitrogen base + pentose

Structure of nucleotides

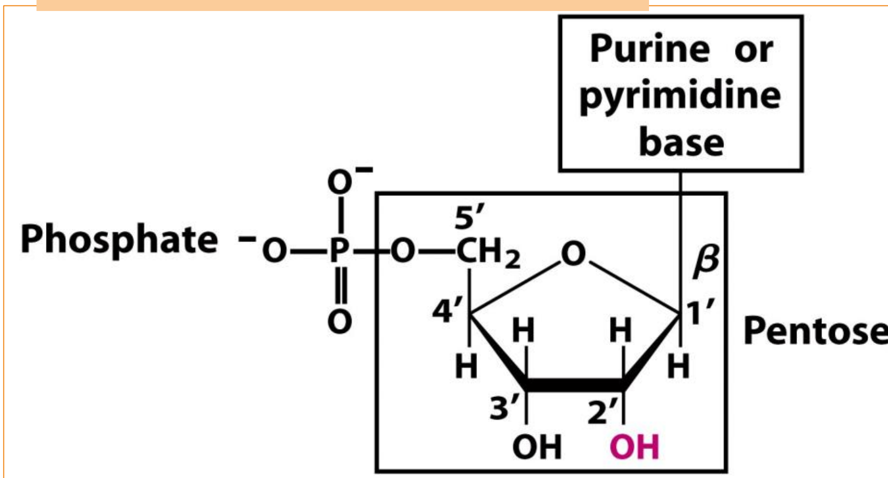

Figure 8-1a
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Note: Carbon atoms of pentose are recognized by adding a (‘)

Major purine bases of nucleic acids

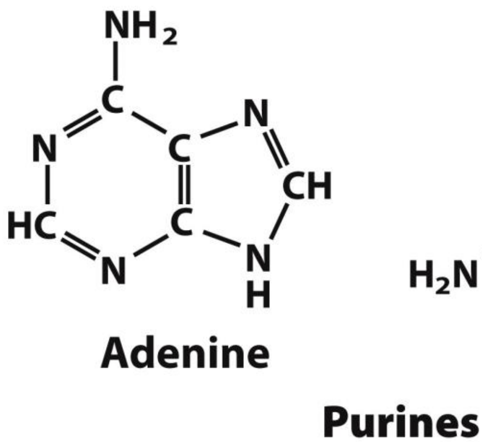

Figure 8-2 part 1
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Major pyrimidine bases of nucleic acids

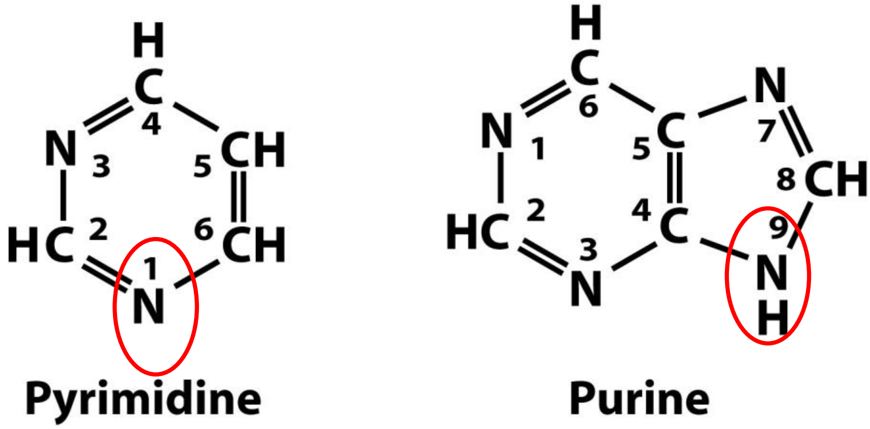

Figure 8-1b
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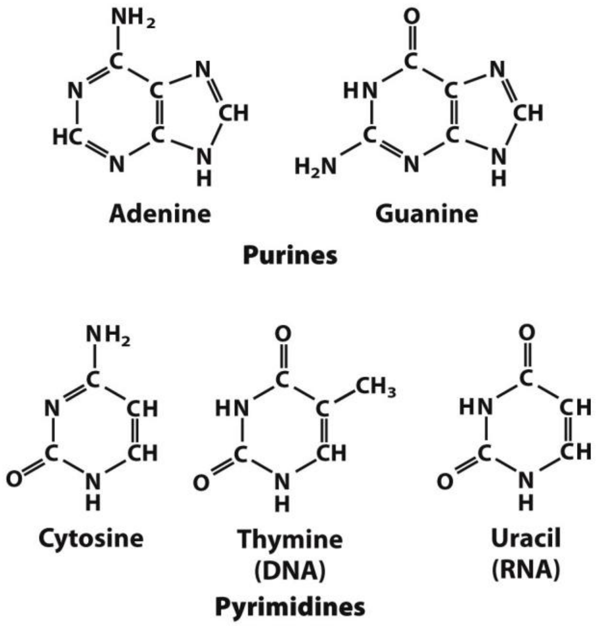

Figure 8-2
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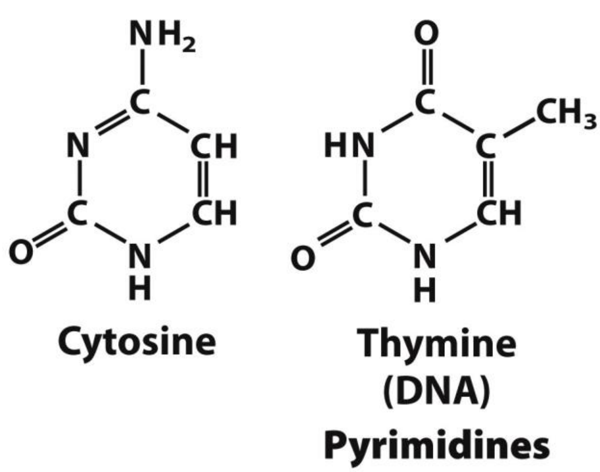

Figure 8-2 part 2
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TABLE 8–1	Nucleotide and Nucleic Acid Nomenclature		
Base	**Nucleoside**	**Nucleotide**	**Nucleic acid**
Purines			
Adenine	Adenosine Deoxyadenosine	Adenylate Deoxyadenylate	RNA DNA
Guanine	Guanosine Deoxyguanosine	Guanylate Deoxyguanylate	RNA DNA
Pyrimidines			
Cytosine	Cytidine Deoxycytidine	Cytidylate Deoxycytidylate	RNA DNA
Thymine	Thymidine or deoxythymidine	Thymidylate or deoxythymidylate	DNA
Uracil	Uridine	Uridylate	RNA

Note: "Nucleoside" and "nucleotide" are generic terms that include both ribo- and deoxyribo- forms. Also, ribonucleosides and ribonucleotides are here designated simply as nucleosides and nucleotides (e.g., riboadenosine as adenosine), and deoxyribonucleosides and deoxyribonucleotides as deoxynucleosides and deoxynucleotides (e.g., deoxyriboadenosine as deoxyadenosine). Both forms of naming are acceptable, but the shortened names are more commonly used. Thymine is an exception; "ribothymidine" is used to describe its unusual occurrence in RNA.

Table 8-1
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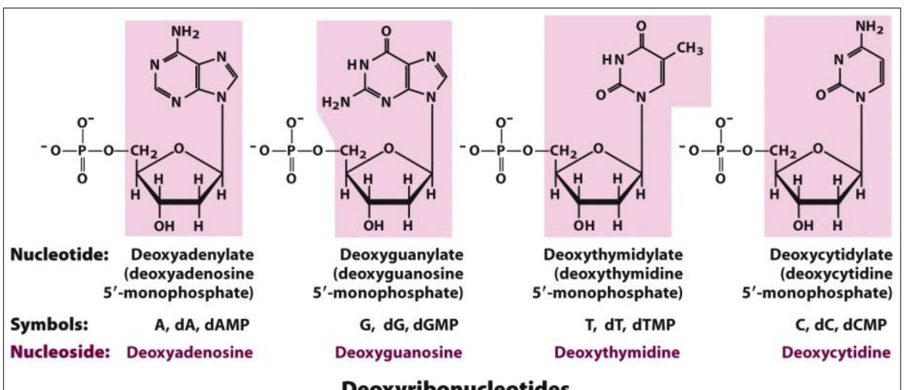

Figure 8-4a
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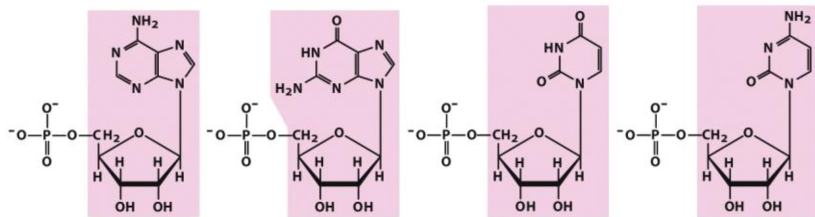

Nucleotide:	Adenylate (adenosine 5′-monophosphate)	Guanylate (guanosine 5′-monophosphate)	Uridylate (uridine 5′-monophosphate)	Cytidylate (cytidine 5′-monophosphate)
Symbols:	A, AMP	G, GMP	U, UMP	C, CMP
Nucleoside:	Adenosine	Guanosine	Uridine	Cytidine

Ribonucleotides

Figure 8-4b
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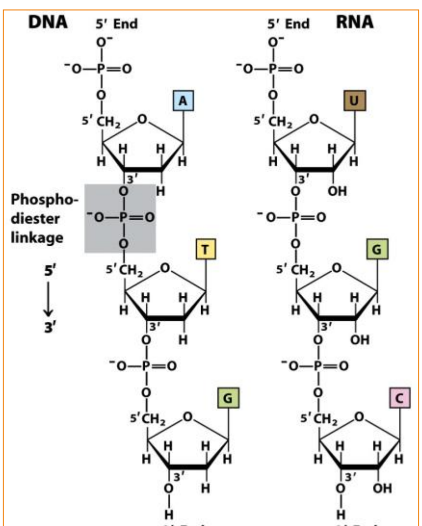
Phosphodiester linkages in the covalent backbone of DNA and RNA



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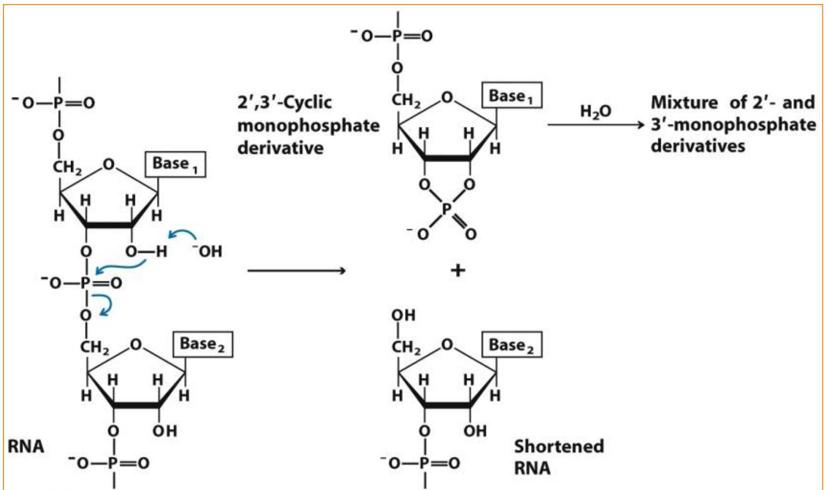
Hydrolysis of RNA under alkaline conditions



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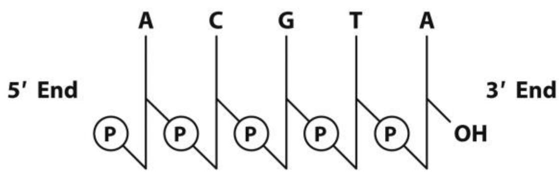
Representation of an oligo-/polynucleotide



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Other simpler form include:
pA-C-G-T-A$_{OH}$
pApCpGpTpA
pACGTA
Or
5’-ACGTA-3’
ACGTA

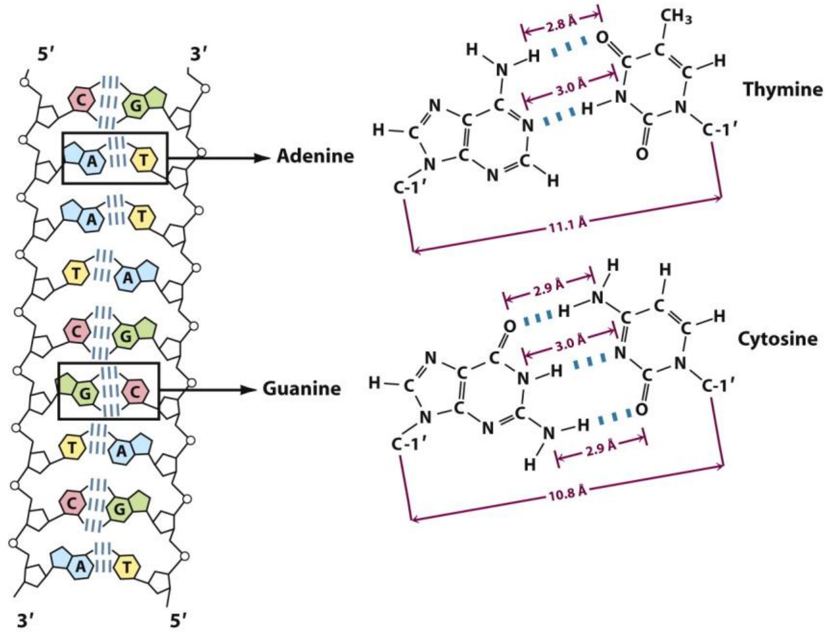

Figure 8-11
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The story of the DNA double helix …

James D. Watson **Francis Crick, 1916–2004**

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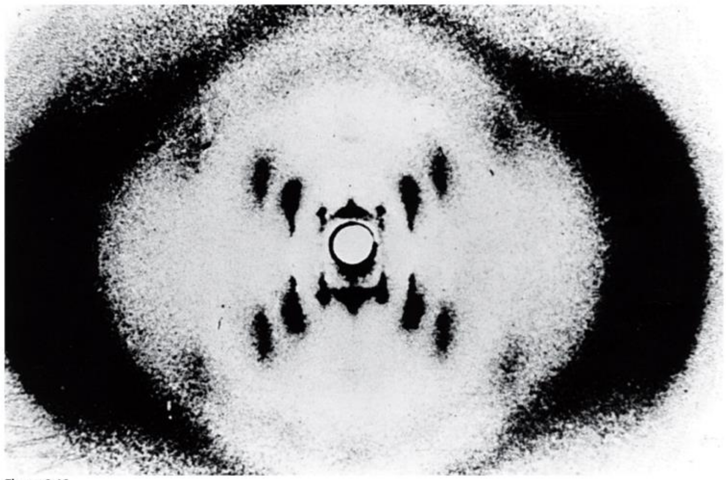
X-ray diffraction pattern of DNA. The spots forming a cross in the center denote a helical structure. The heavy bands at the left and right arise from the recurring bases.



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Rosalind Franklin, 1920–1958

Maurice Wilkins, 1916–2004

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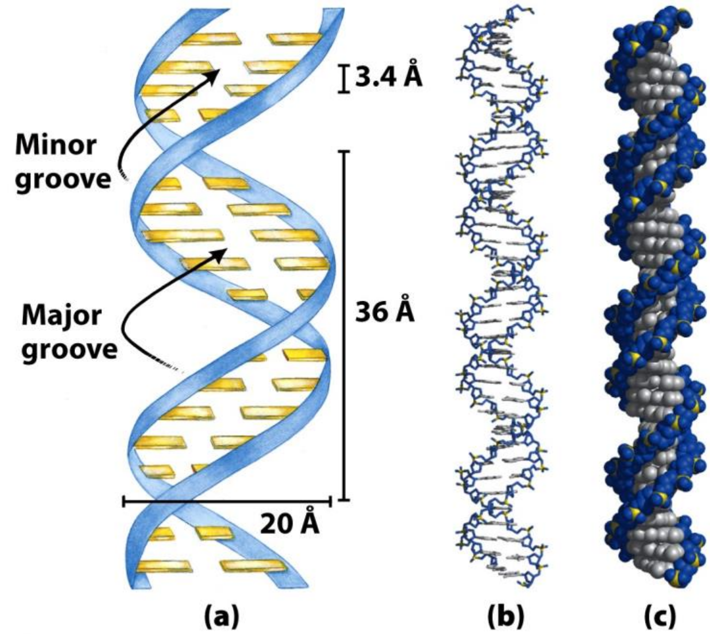

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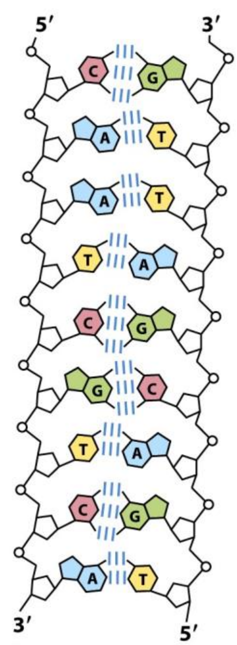

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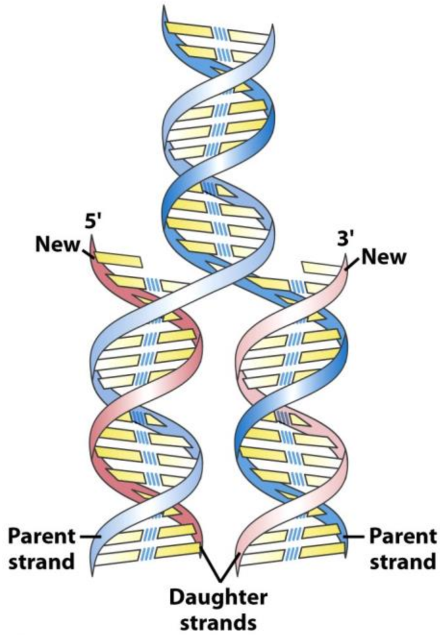

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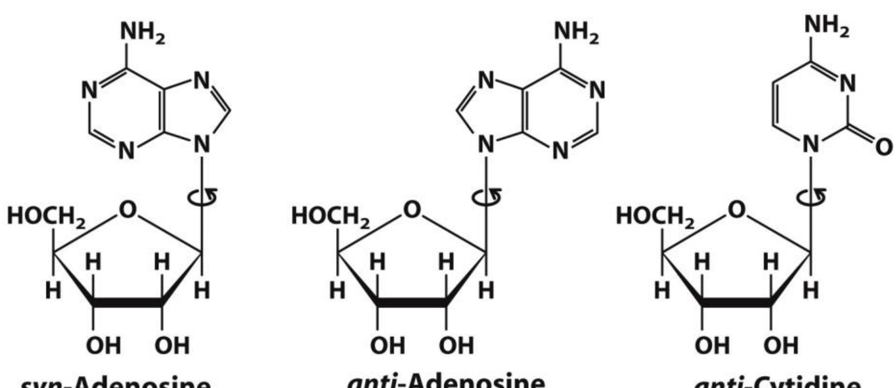

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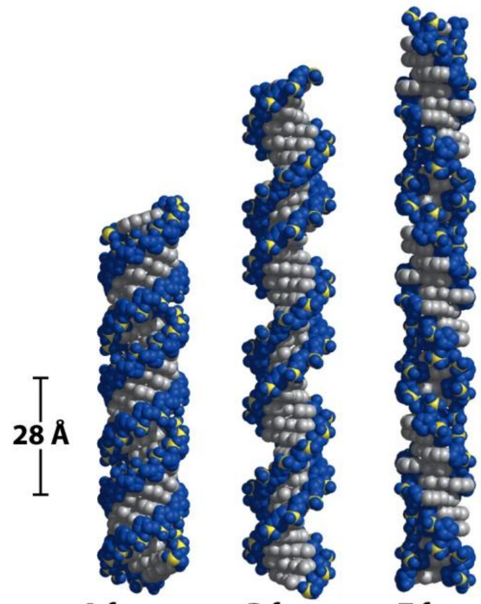

Figure 8-17 part 1
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Comparison of A, B, and Z forms of DNA.

	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

Figure 8-17 part 2
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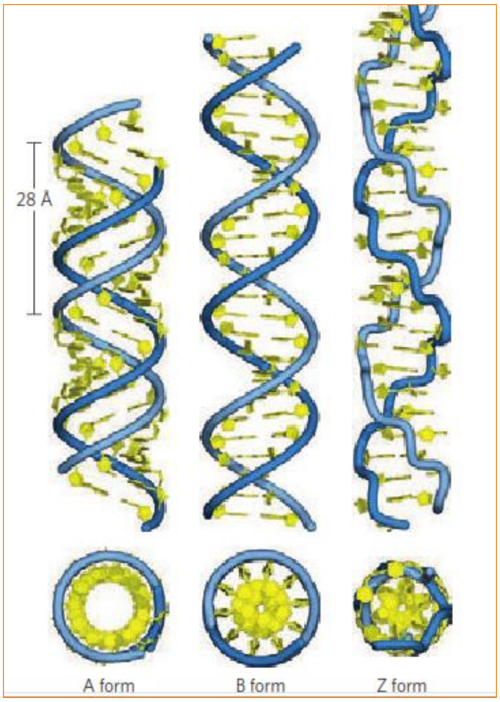
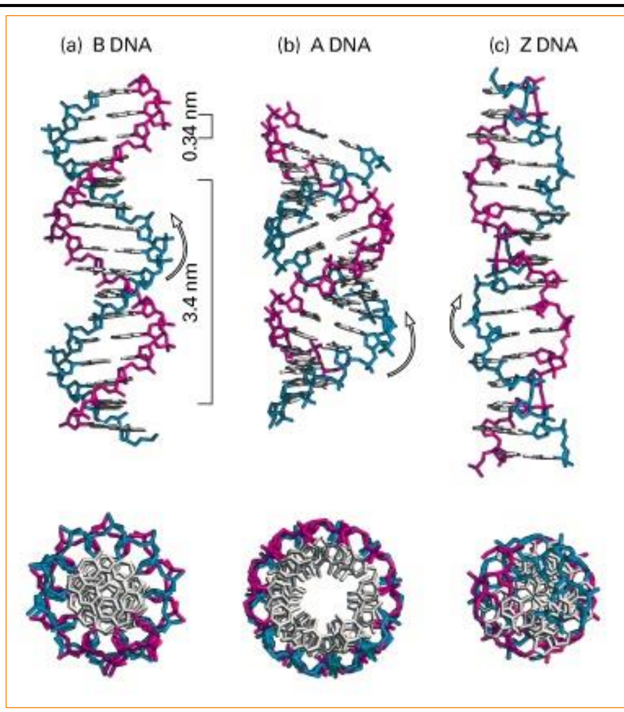


Comparison of A, B, and Z forms of DNA.

Each structure shown here has 36 base pairs.
The riboses and bases are shown in yellow.
The phosphodiester backbone is represented as a blue rope.



DNA conformations

- B-DNA
- The DNA form found in in vivo in cells
- Called Watson-Crick model also

- A-DNA
- Found in cases of RNA-DNA hybrids or under dehydration conditions

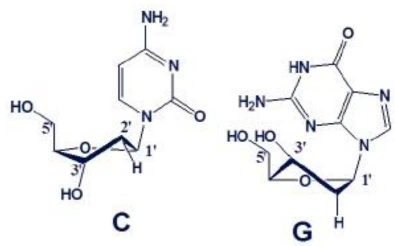
Z-DNA

- Prominent examples are sequences in which pyrimidines alternate with purines, especially alternating C and G or 5-methyl-C and G residues.
- There is evidence for some short stretches (tracts) of Z-DNA in both bacteria and eukaryotes.
- These Z-DNA tracts may play a role (as yet undefined) in regulating the expression of some genes or in genetic recombination.

Z - DNA

5'-GCGCGCGCGCGCG
3'-CGCGCGCGCGCGC

C: sugar is 2'-endo, base is *anti*
G: sugar is 3'-endo, base is *syn*



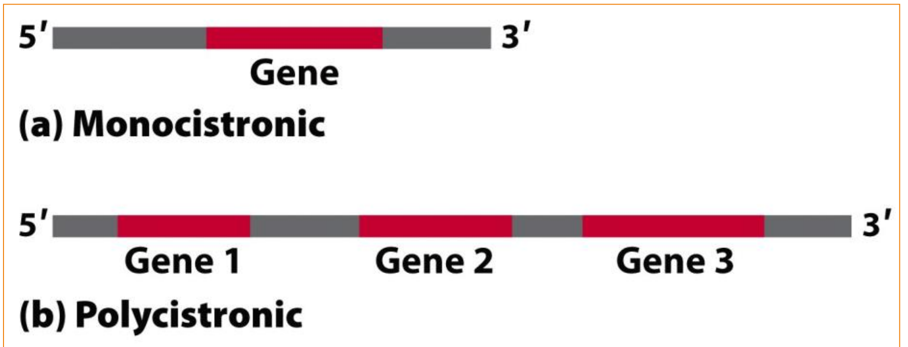
Sugar and base conformations in Z-DNA alternate

Class activity!

- In samples of DNA isolated from two unidentified species of bacteria, X and Y, adenine makes up 32% and 17%, respectively, of the total bases.
- What relative proportions of adenine, guanine, thymine, and cytosine would you expect to find in the two DNA samples?
- What assumptions have you made? One of these species was isolated from a hot spring (64°C).
- Which species is most likely the thermophilic bacterium, and why?

mRNA codes for polypeptide chains

- One gene → one polypeptide
- mRNA
  - In eukaryotes: mostly monocistronic
  - In prokaryotes: monocitronic or polycistronic



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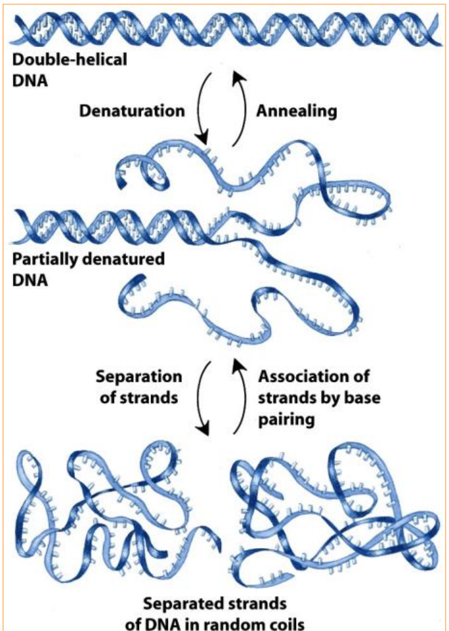
Bacterial mRNA. Schematic diagrams show(a) monocistronic and (b) polycistronic mRNAs of bacteria

Reversible denaturation and annealing (renaturation) of DNA



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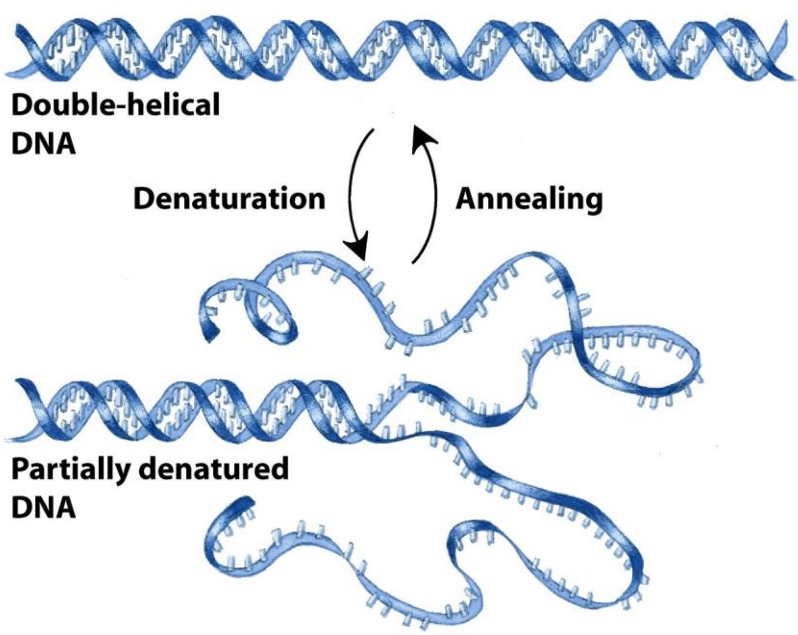

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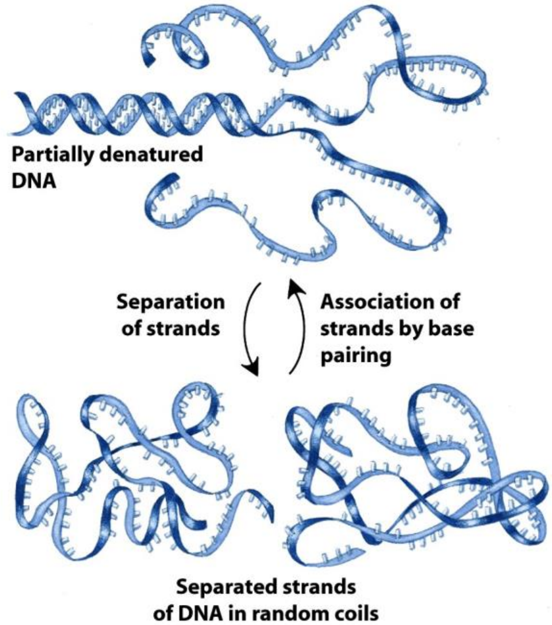

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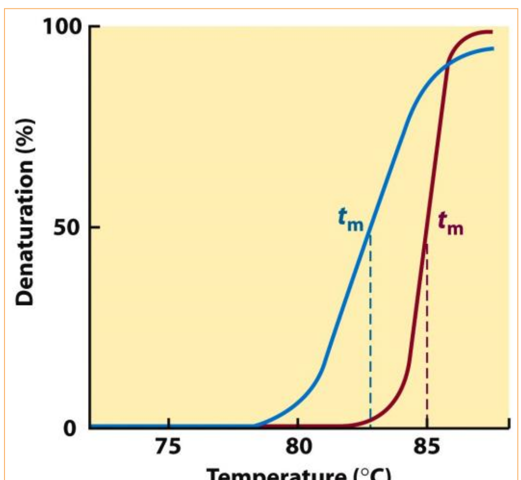
Heat denaturation of DNA.

(a) The denaturation, or melting, curves of two DNA specimens. The temperature at the midpoint of the transition (t_m) is the melting point; it depends on pH and ionic strength and on the size and base composition of the DNA.



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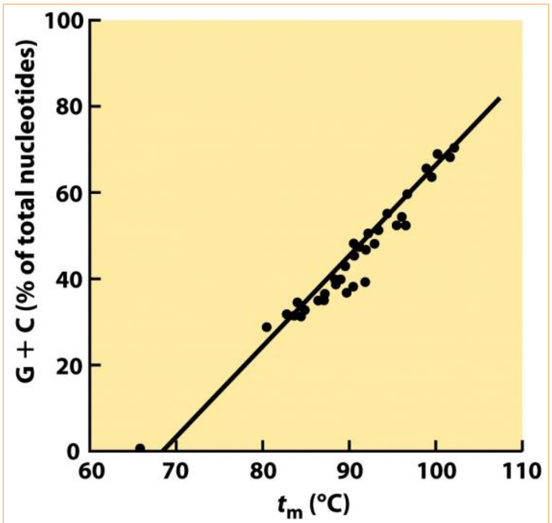
Heat denaturation of DNA.
(b) Relationship between t_m and the G+C content of a DNA.



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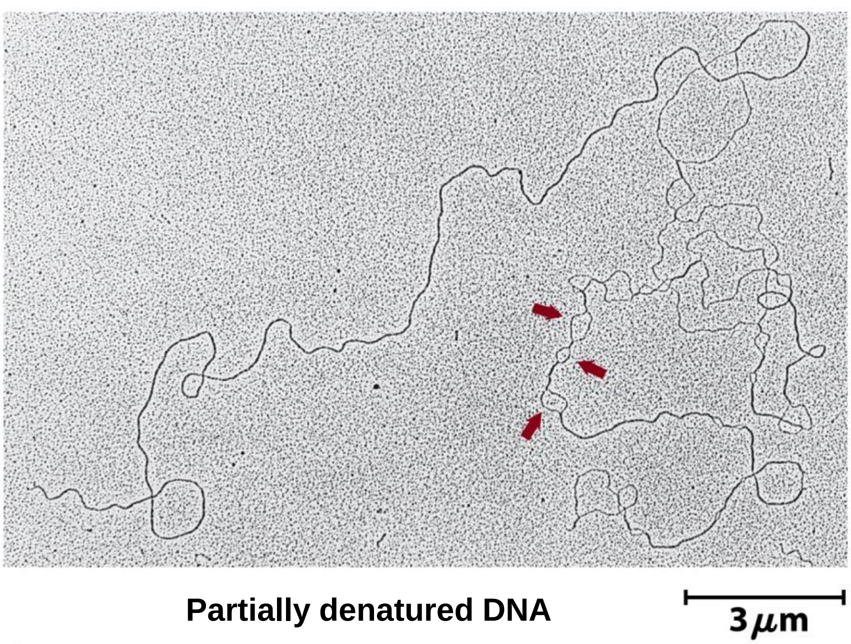

Partially denatured DNA

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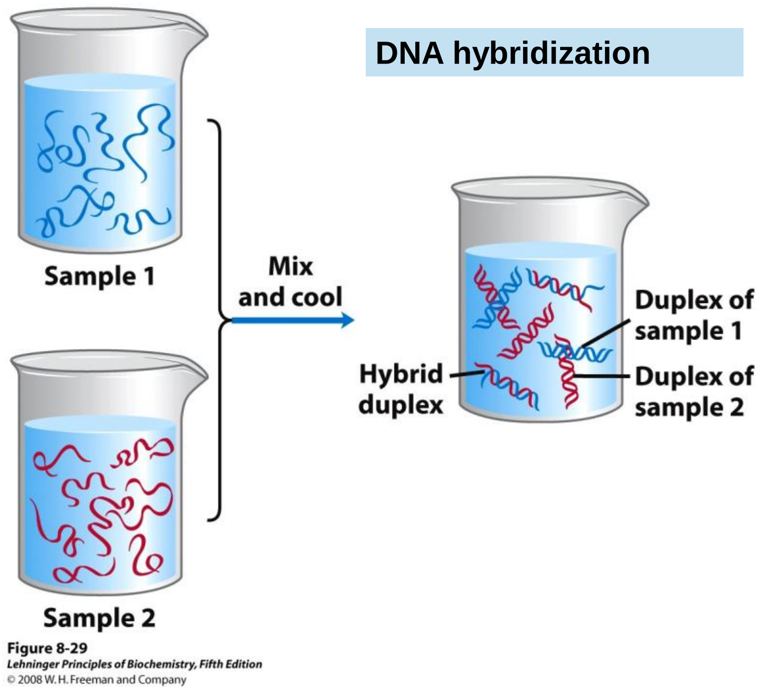
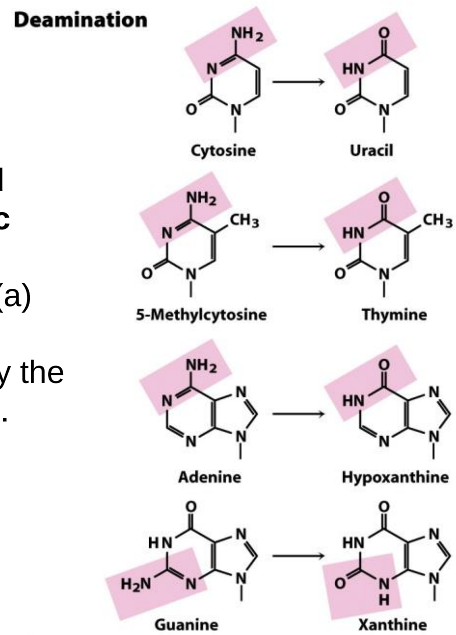


Sources of nucleotide changes or alterations

- Deamination
- Depurination
- UV-light: Thymidine dimers
- Chemical agents: nitrous acid and alkylating agents

Some well-characterized nonenzymatic reactions of nucleotides. (a) Deamination reactions. Only the base is shown.



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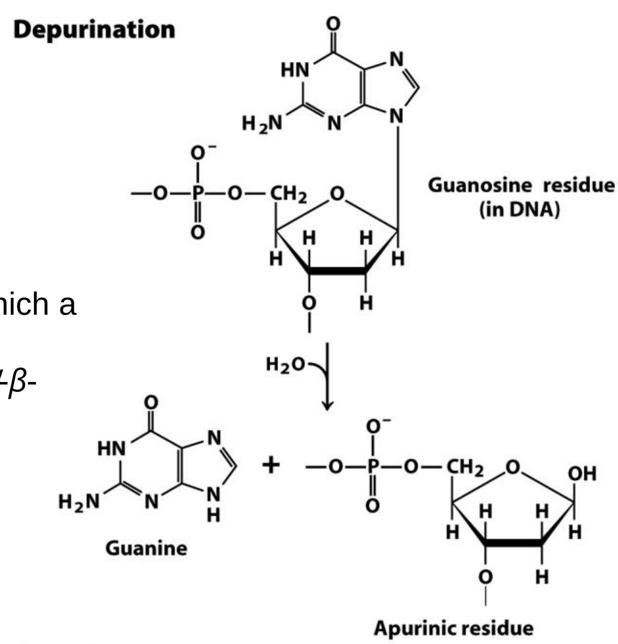
Some well-characterized nonenzymatic reactions of nucleotides. (b) Depurination, in which a purine is lost by hydrolysis of the *N-β*-glycosyl bond.



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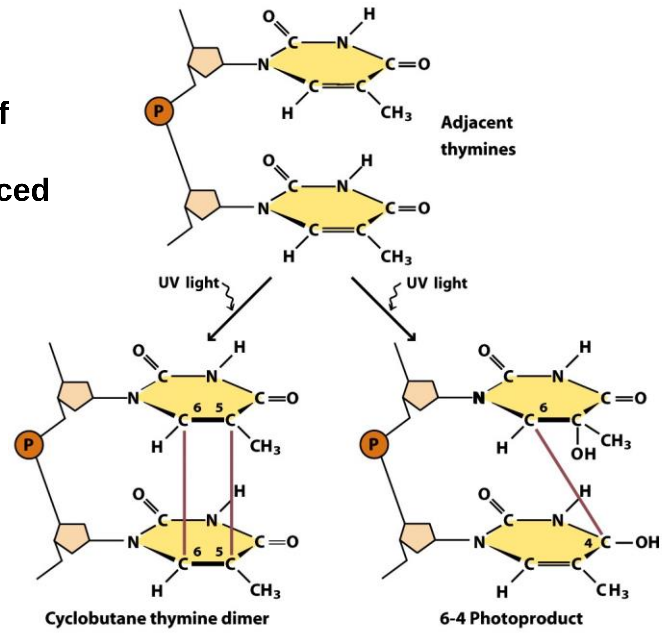
Formation of pyrimidine dimers induced by UV light.



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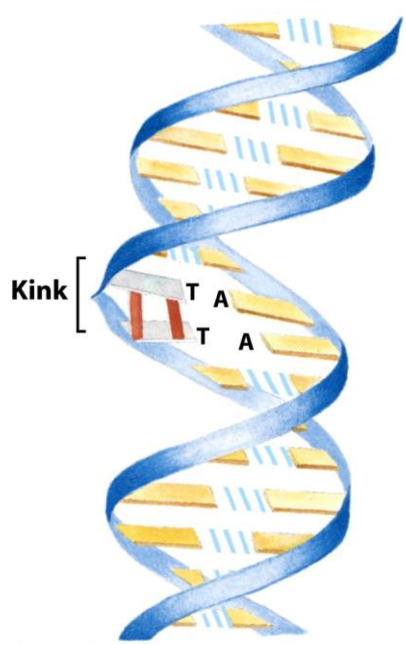

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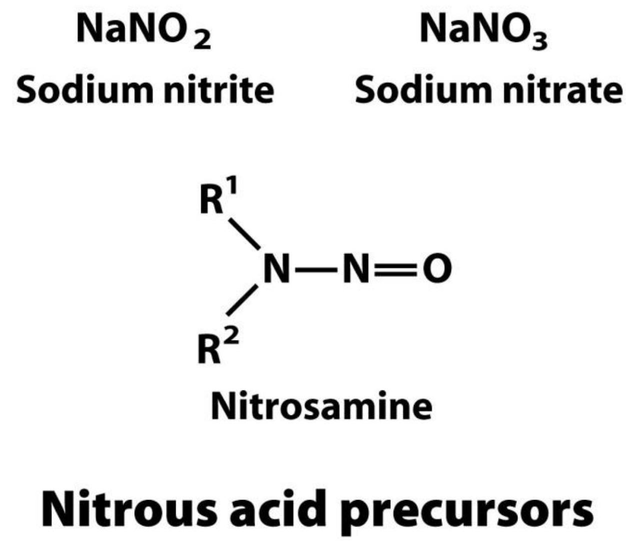
Chemical agents that cause DNA damage. (a) Precursors of nitrous acid, which promotes deamination reactions.



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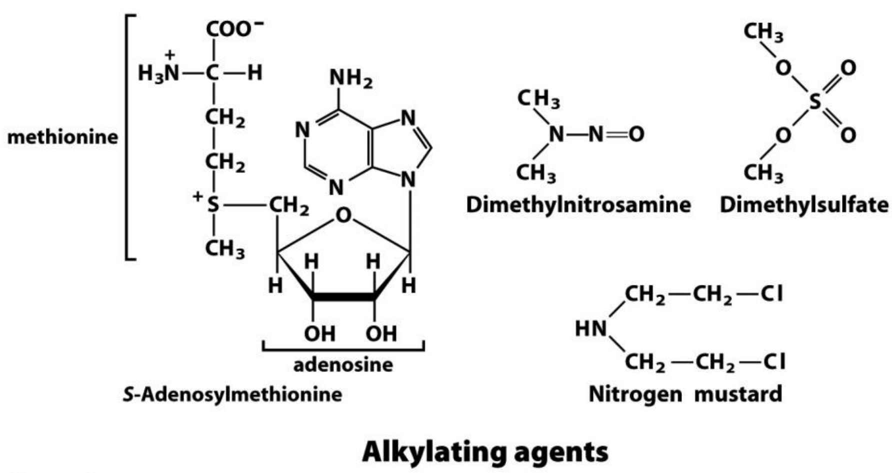
Chemical agents that cause DNA damage. (b) Alkylating agents.



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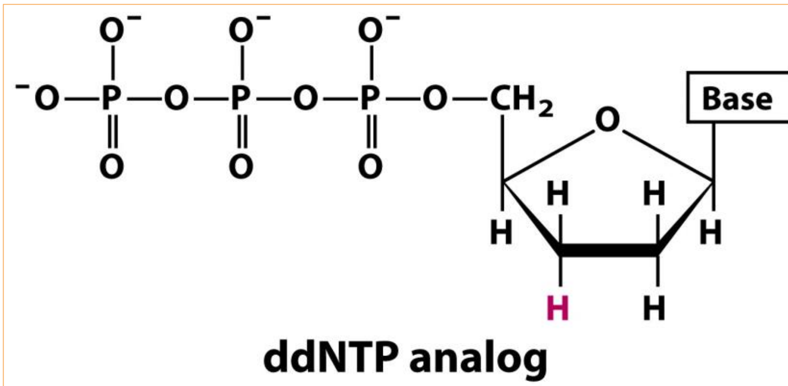
DNA sequencing by the Sanger method



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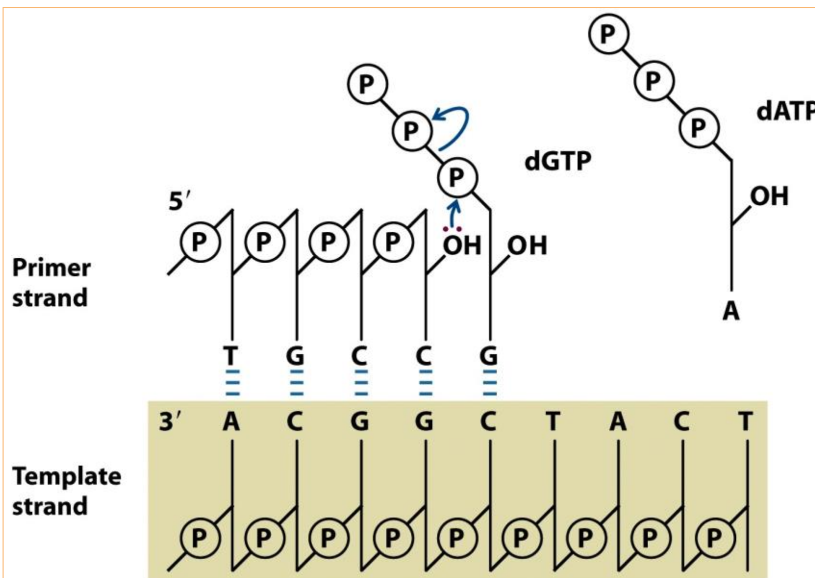

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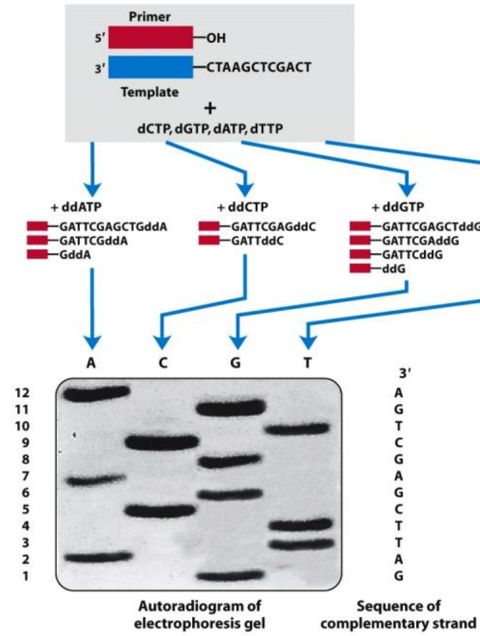

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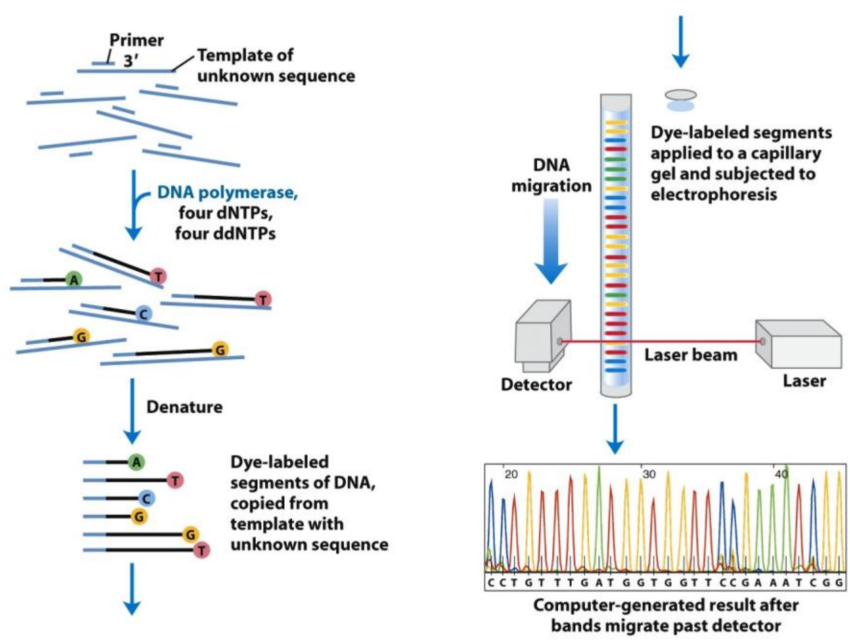

Figure 8-34
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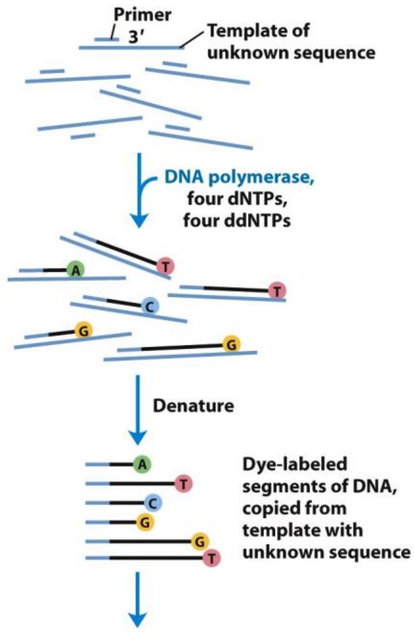

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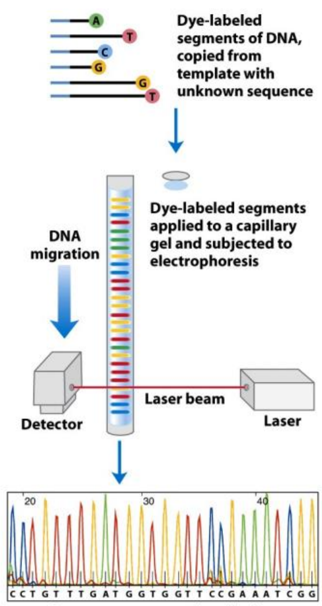

Computer-generated result after bands migrate past detector

Figure 8-34 part 2
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