MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah
College Of Medicine

Lecture : Medical Chemistry (2) (Nucleic Acids)

Stage : 1st Stage

Lecturer : Dr. Waleed Khalid Ahmed

Department: Chemistry and Biochemistry department

Date: 7 / 5 / 2026

Learning Objective :

- *Understand the Composition of Nucleic Acids.*
- *Compare DNA and RNA Structures.*
- *Describe Nucleotide and Nucleoside Formation.*
- *Explain the Primary Structure of Nucleic Acids. And Analyze DNA's Double Helix Structure.*
- *Identify Functions of Nucleotides and Nucleic Acids.*

NUCLEIC ACIDS

Nucleic acids consist from nucleotides which are the monomers or the building units for the nucleic acids. Nucleotides also serve as carriers of activated intermediates in the synthesis of some carbohydrates, lipids, and proteins, and are structural components of several essential coenzymes, for example, coenzyme A, FAD, NAD^+, and $NADP^+$.

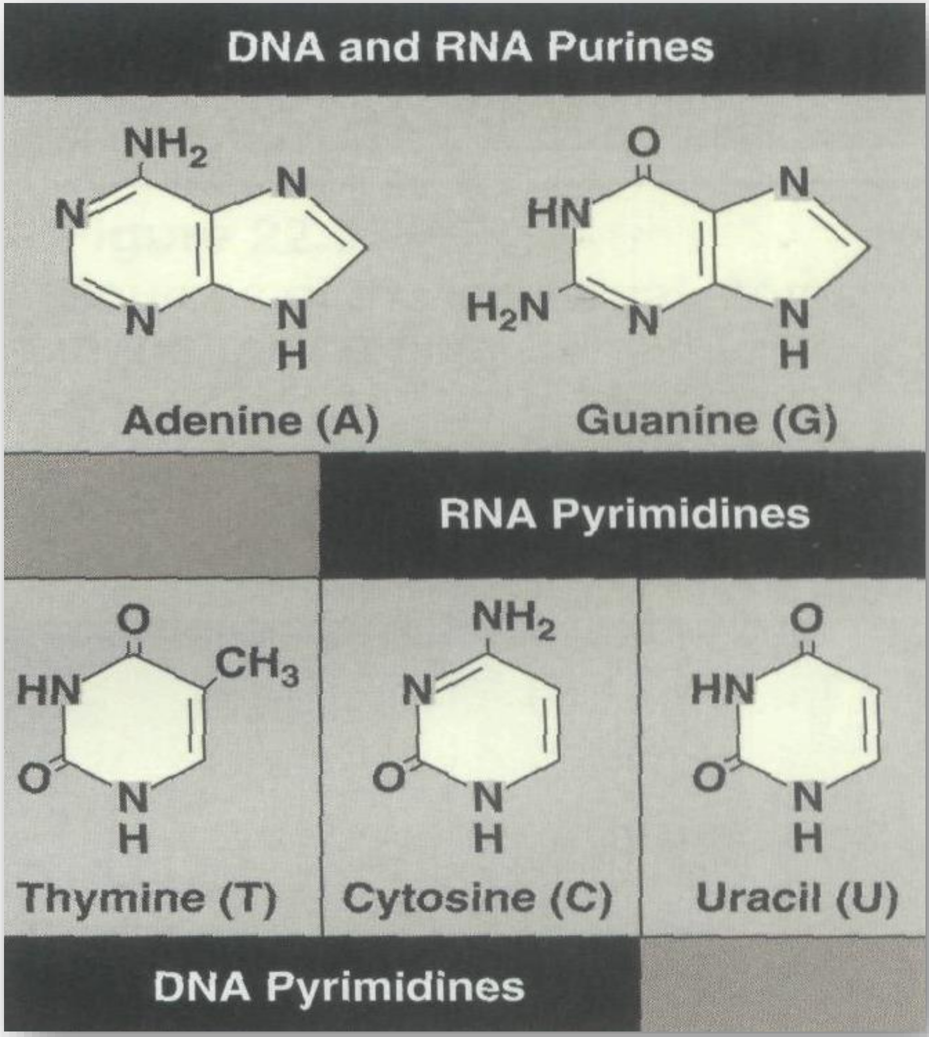
NUCLEOTIDE STRUCTURE

Nucleotides are composed of a nitrogenous base, a pentose monosaccharide, and one, two, or three phosphate groups. The nitrogen-containing bases belong to two families of compounds: the purines and the pyrimidines.

NUCLEIC ACIDS

A. Purine and pyrimidine structures

Both DNA and RNA contain the same purine bases: adenine (A) and guanine (G). Both DNA and RNA contain the pyrimidine cytosine (C), but they differ in their second pyrimidine base: DNA contains thymine (T), whereas RNA contains uracil (U). T and U differ by only one methyl group, which is present on T but absent on U



Note: Unusual bases are occasionally found in some species of DNA and RNA, for example, in some viral DNA, and in transfer RNA. The presence of an unusual base in a nucleotide sequence may aid in its recognition by specific enzymes, or protect it from being degraded by nucleases.

NUCLEIC ACIDS

Note: The conjugated double bonds of purine and pyrimidine bases absorb ultraviolet light. The mutagenic effect of ultraviolet light results from its absorption by nucleotides in DNA with accompanying chemical changes. While spectra are pH dependent, at pH 7 all the common nucleotides absorb light at a wavelength close to **260 nm.** The concentration of nucleotides and nucleic acids thus often are expressed in term of absorbance at **260 nm.**

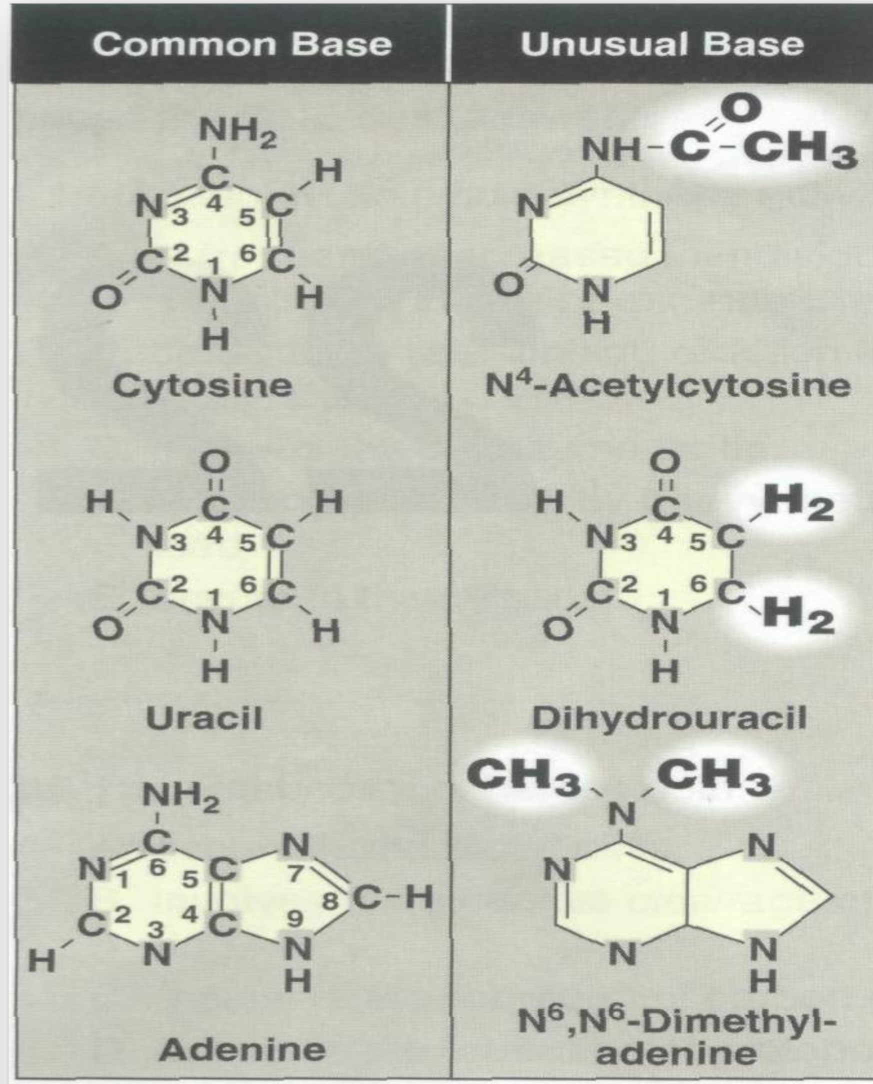
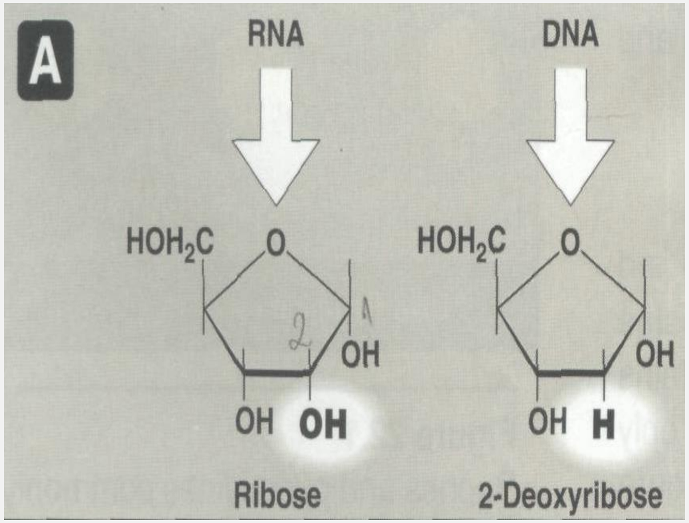


Figure 22.2
Examples of unusual bases.

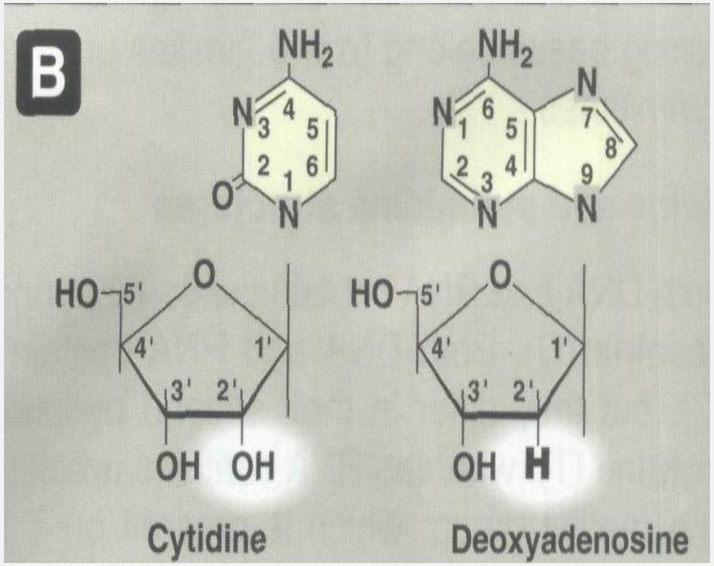
NUCLEIC ACIDS

B. Pentose: There are two types of pentose in the nucleotides; the first one is ribose which is found in nucleotides derived from RNA, while the second is deoxy ribose which is found in the nucleotides derived from DNA.



Nucleosides : The addition of a pentose sugar to a base produces a nucleoside. If the sugar is ribose, a ribonucleoside is produced; if the sugar is 2-deoxyribose, a deoxyribonucleoside is produced. The ribonucleosides of A, G, C, and U are named adenosine, guanosine, cytidine, and uridine, respectively.

The deoxyribonucleoside of A, G, C, and T have the added prefix, "deoxy-", for example deoxyadenosine.



NUCLEIC ACIDS

Notes: *nitrogen base + ribose = nucleoside (like: adenosine and guanosine)

*nucleoside + phosphoryl group = mononucleotide.

*mononucleotide + add. Phosphoryl groups = nucleoside di or tri phosphate.

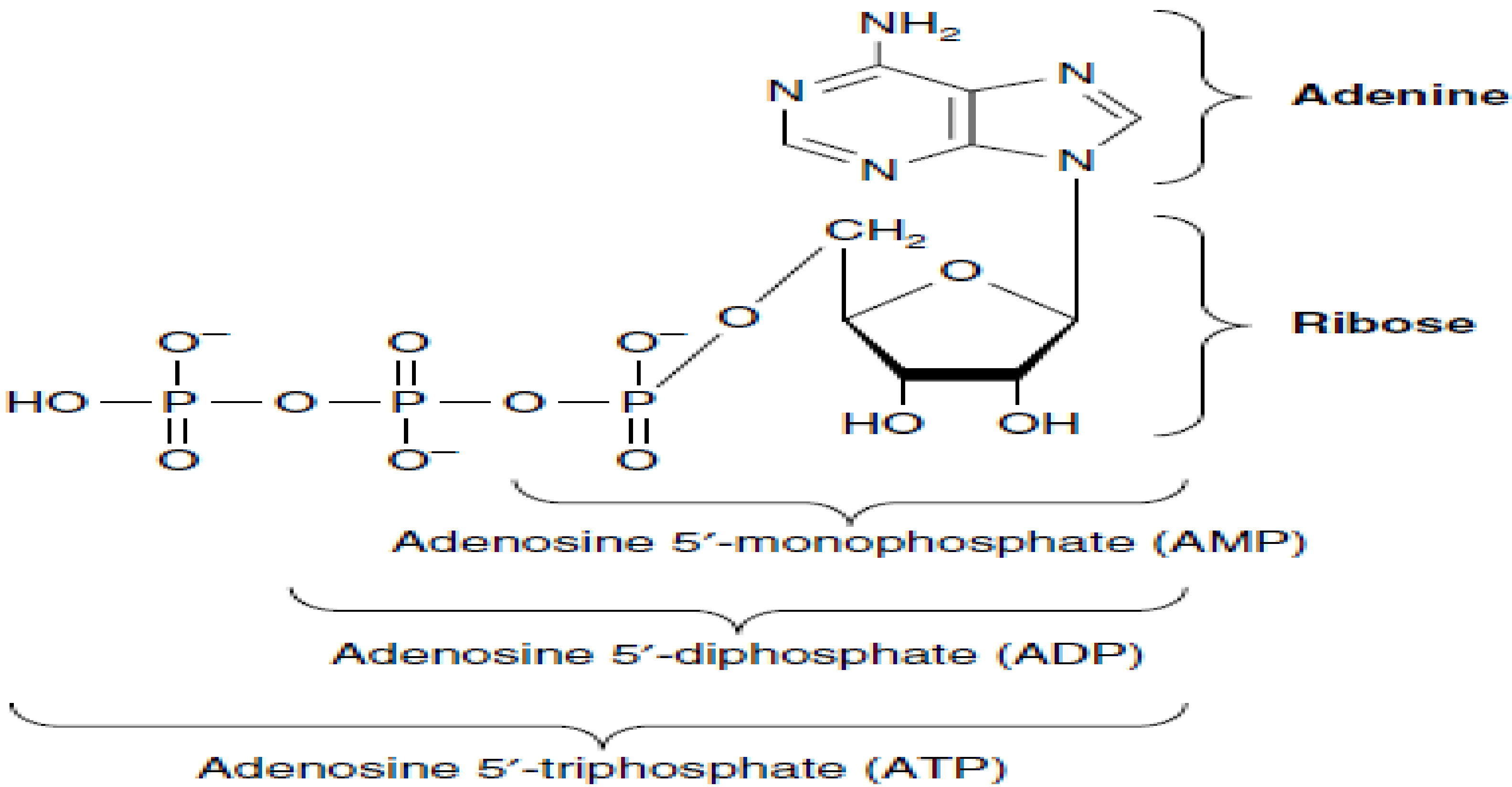


Figure 33–4. ATP, its diphosphate, and its monophosphate.

Functions of Nucleotides and Nucleic Acids

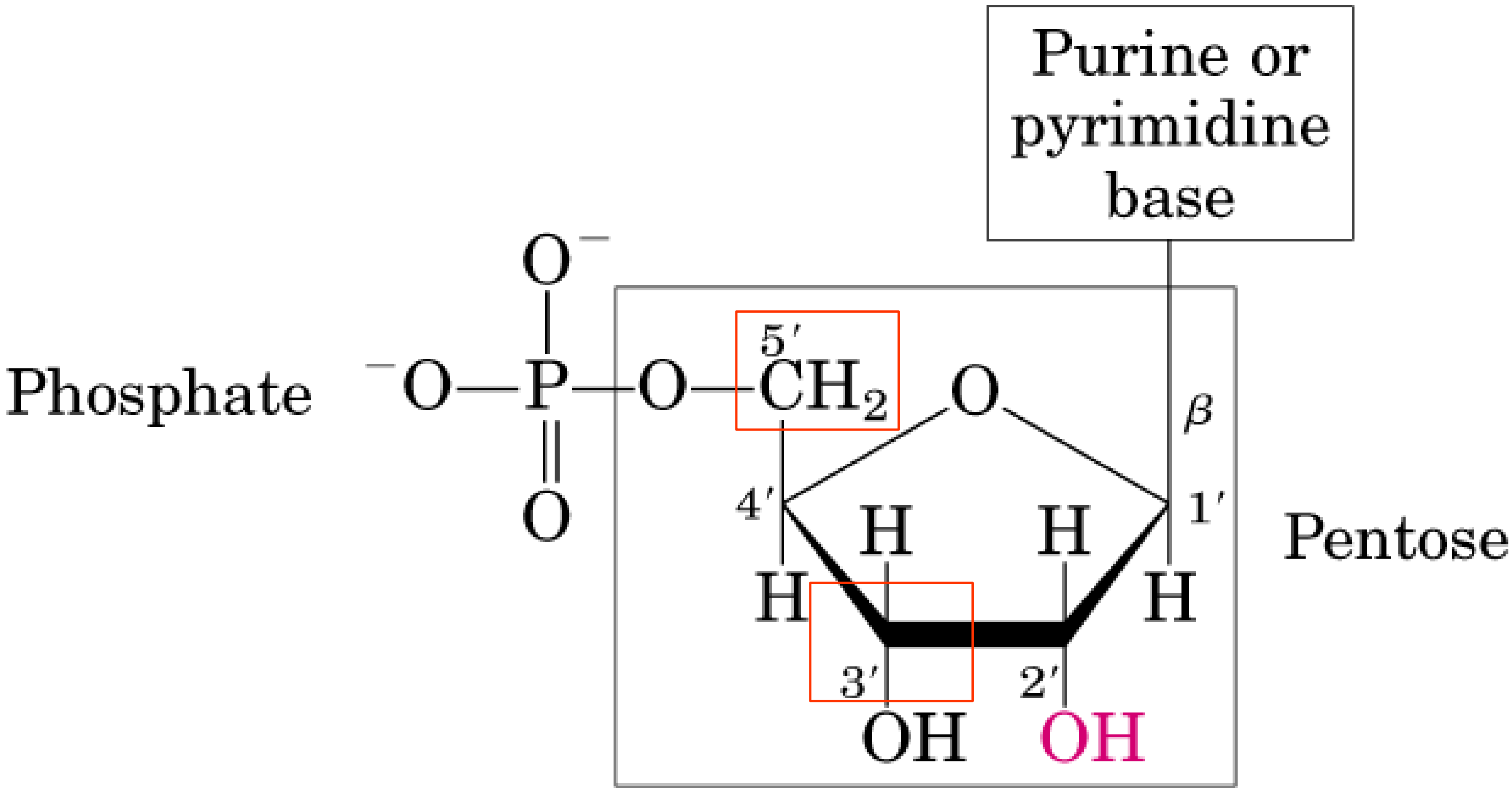
- Nucleotide Functions:
  - Energy for metabolism (ATP)
  - Enzyme cofactors (NAD^+)
  - Signal transduction (cAMP)

- Nucleic Acid Functions:
  - Storage of genetic info (DNA)
  - Transmission of genetic info (mRNA)
  - Processing of genetic information (ribozymes)
  - Protein synthesis (tRNA and rRNA)

Chemical Structure of DNA vs RNA

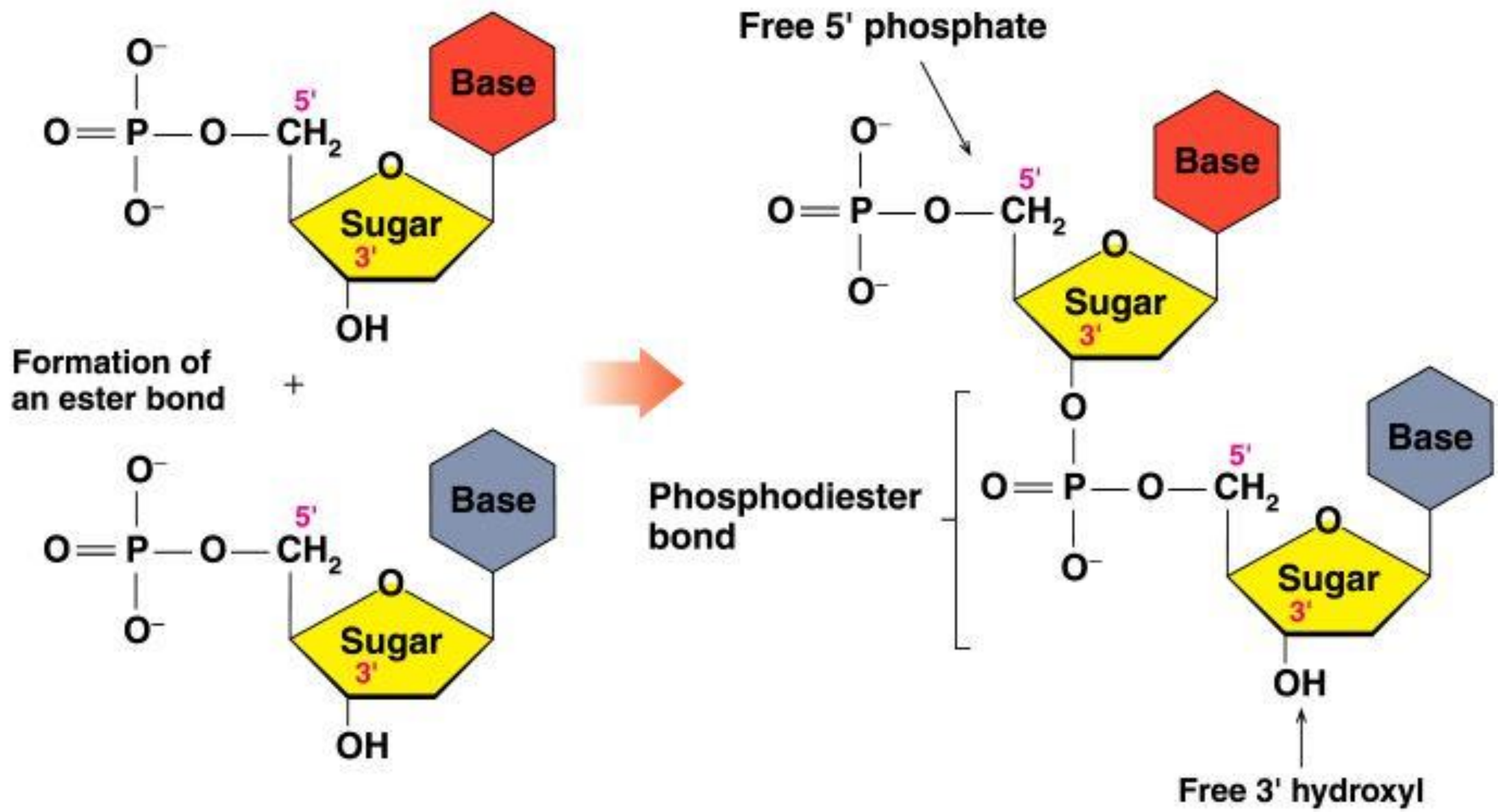
Ribonucleotides have a 2′-OH

Deoxyribonucleotides have a 2′-H



Primary Structure of Nucleic Acids

- The **primary structure** of a nucleic acid is the nucleotide sequence
- The nucleotides in nucleic acids are joined by phosphodiester bonds
- The 3’-OH group of the sugar in one nucleotide forms an ester bond to the phosphate group on the 5’-carbon of the sugar of the next nucleotide



DNA Structure:

Nucleic acids are required for the storage and expression of genetic information. There are two chemically distinct types of nucleic acids: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA, the store house of genetic information, is present not only in chromosomes in the nucleus of eukaryotic organisms, but also in mitochondria and the chloroplasts of plants. Prokaryotic cells, which lack nuclei, have a single chromosome, but may also contain non chromosomal DNA in the form of plasmids.

DNA

DNA stands for **deoxyribose nucleic acid**

This chemical substance is present in the nucleus of all cells in all living organisms

DNA controls all the chemical changes which take place in cells

The kind of cell which is formed, (muscle, blood, nerve etc) is controlled by DNA

DNA molecule

DNA is a very large molecule made up of a long chain of sub-units

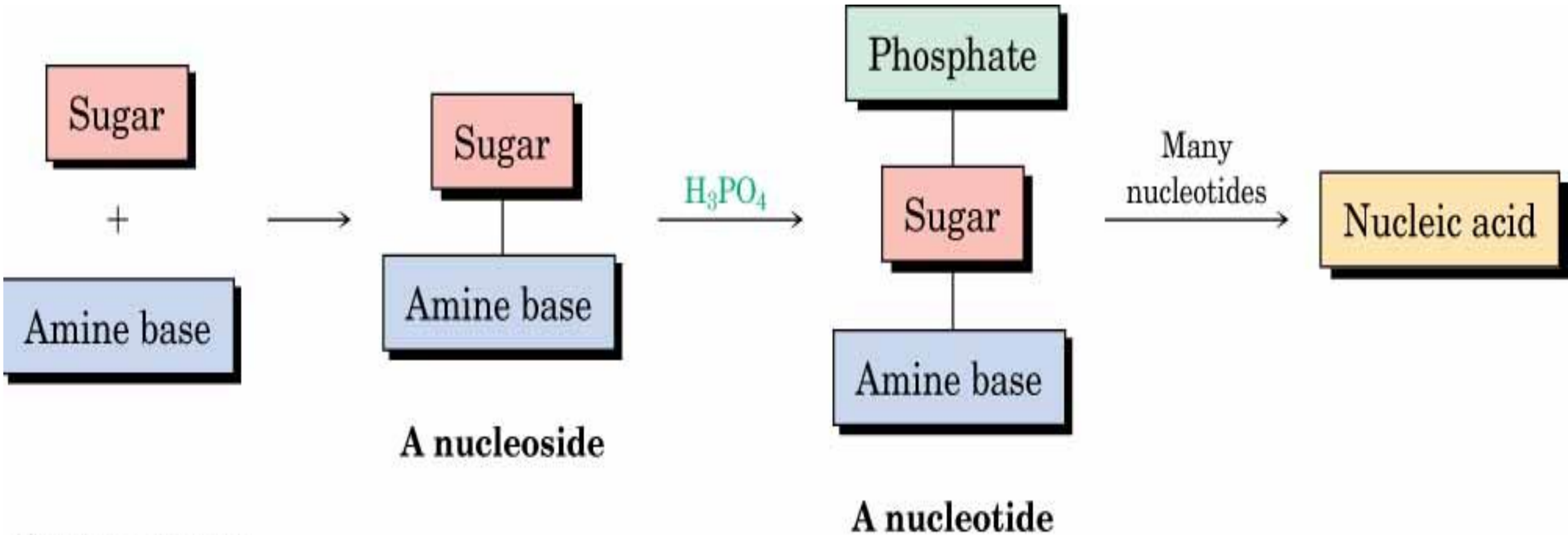
The sub-units are called **nucleotides**

Each nucleotide is made up of

- a sugar called **deoxyribose**
- a phosphate group **$-PO_4$** and
- an **organic base**

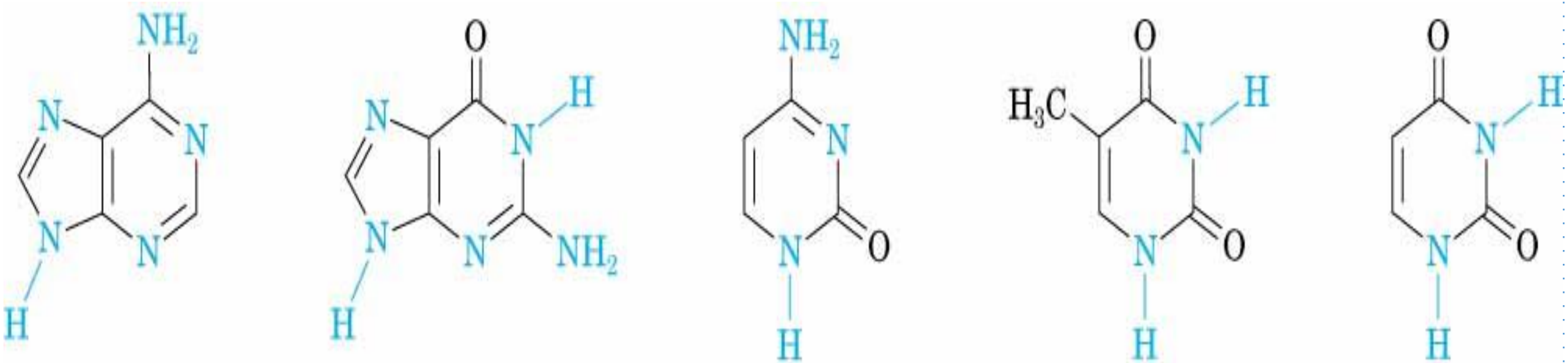
Nucleic Acids and Nucleotides

- Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), are the chemical carriers of genetic information
- Nucleic acids are biopolymers made of nucleotides, aldopentoses linked to a purine or pyrimidine and a phosphate



Heterocycles in DNA and RNA

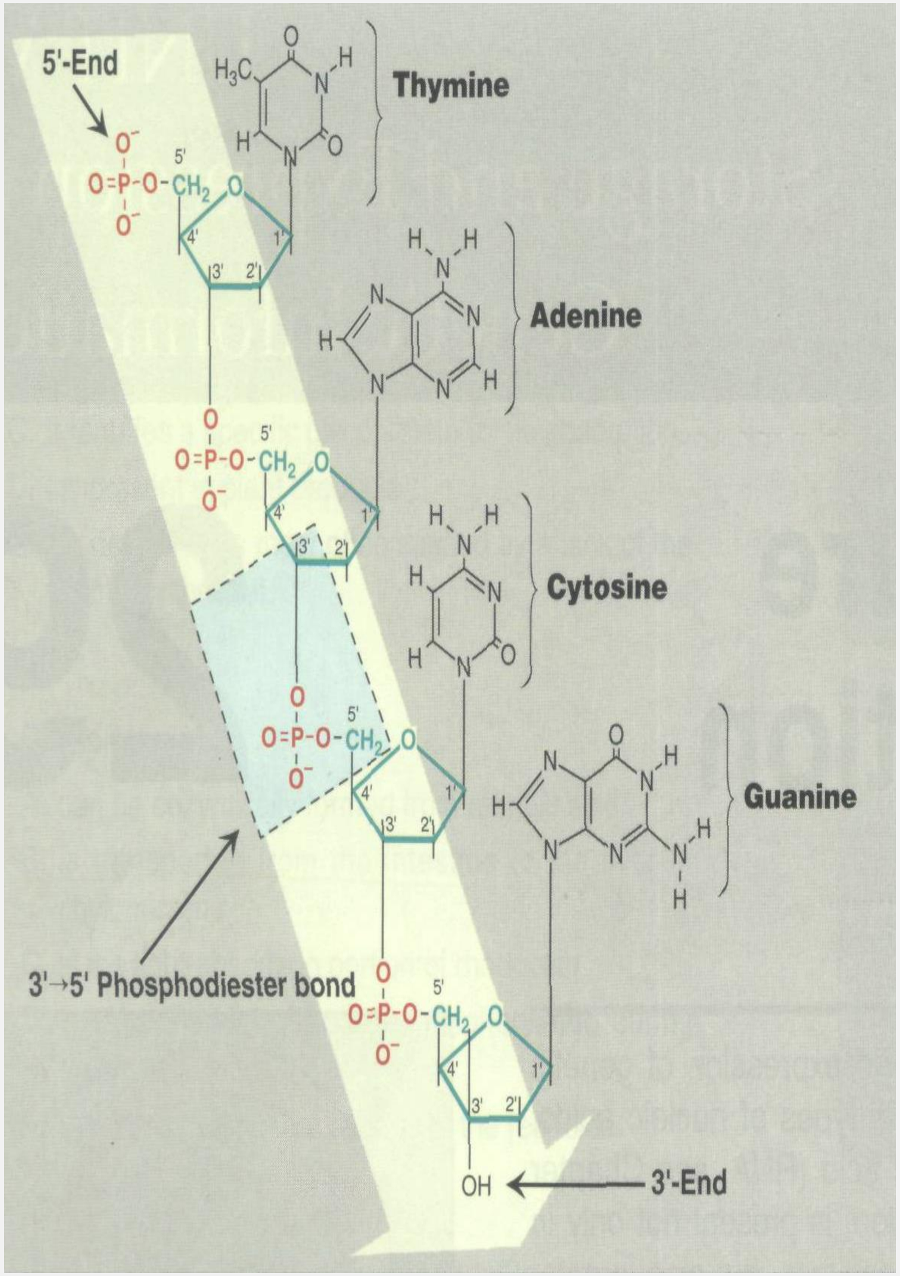
- Adenine, guanine, cytosine and thymine are in DNA
- RNA contains uracil rather than thymine



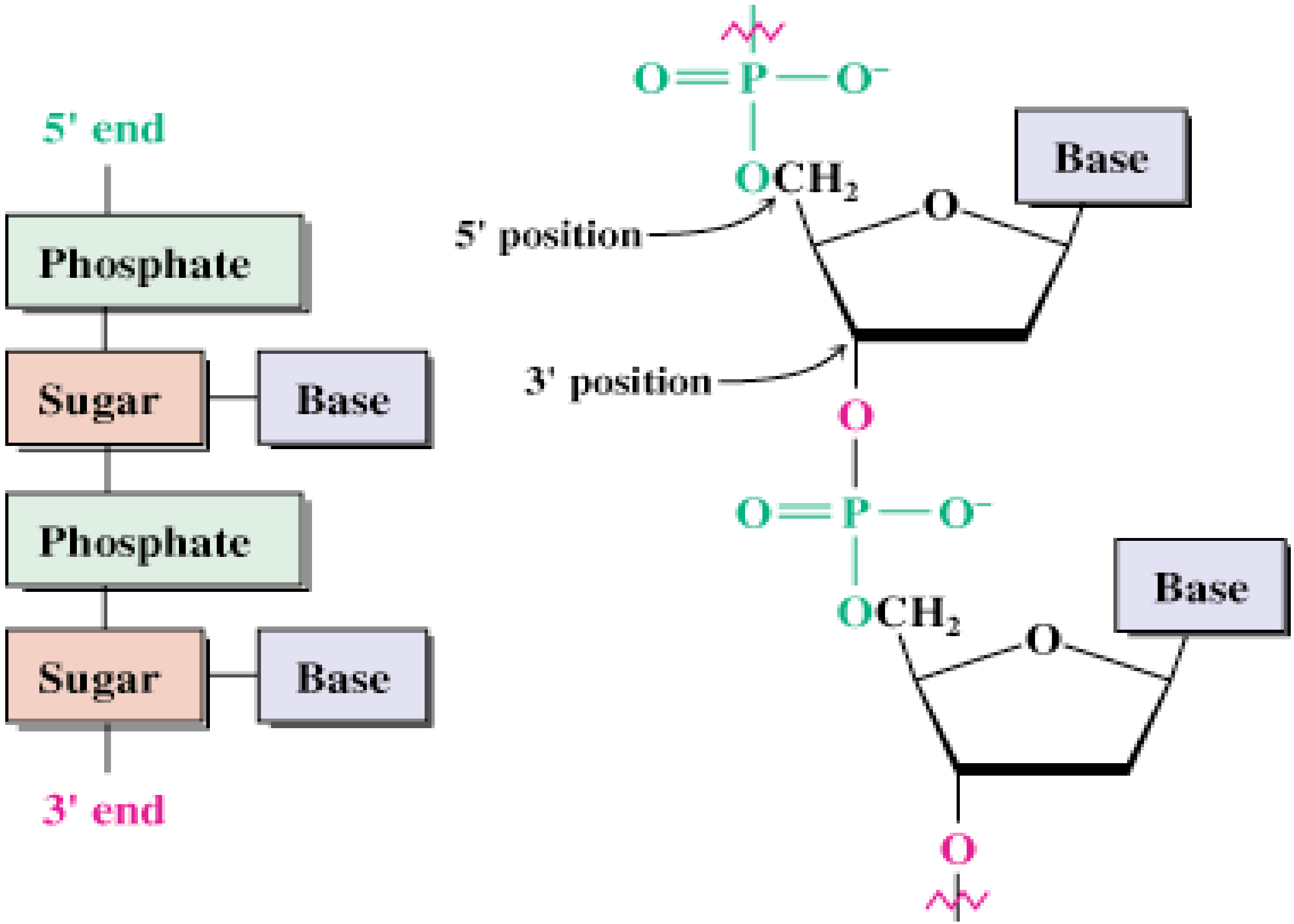
Adenine (A)	Guanine (G)	Cytosine (C)	Thymine (T)	Uracil (U)
DNA	DNA	DNA	DNA	RNA
RNA	RNA	RNA		

NUCLEIC ACIDS

DNA is a polydeoxyribonucleotide that contains many monodeoxyribonucleotides covalently linked by 3'-5'-phosphodiester bonds. DNA exists as a double-stranded molecule, in which the two strands wind around each other, forming a double helix.



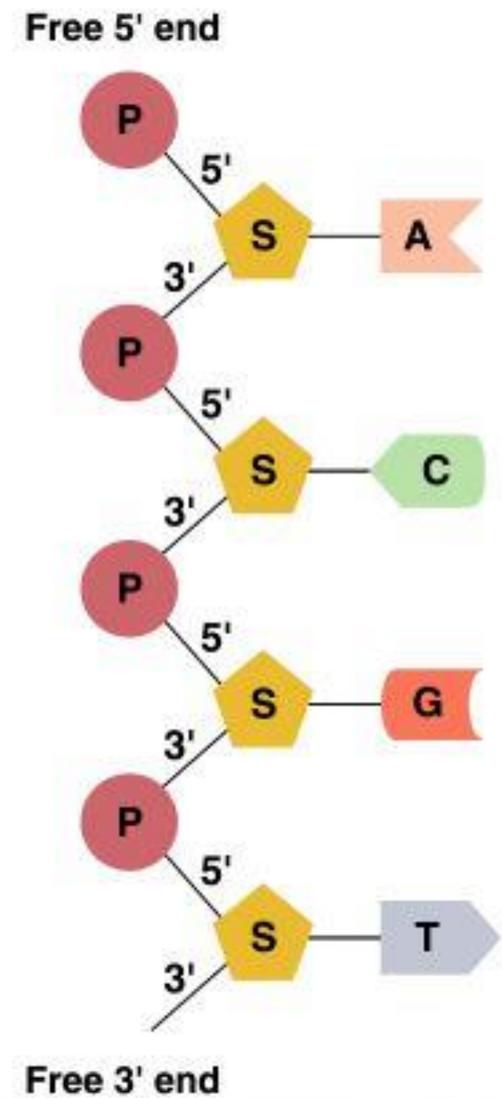
Generalized Structure of DNA



Reading Primary Structure

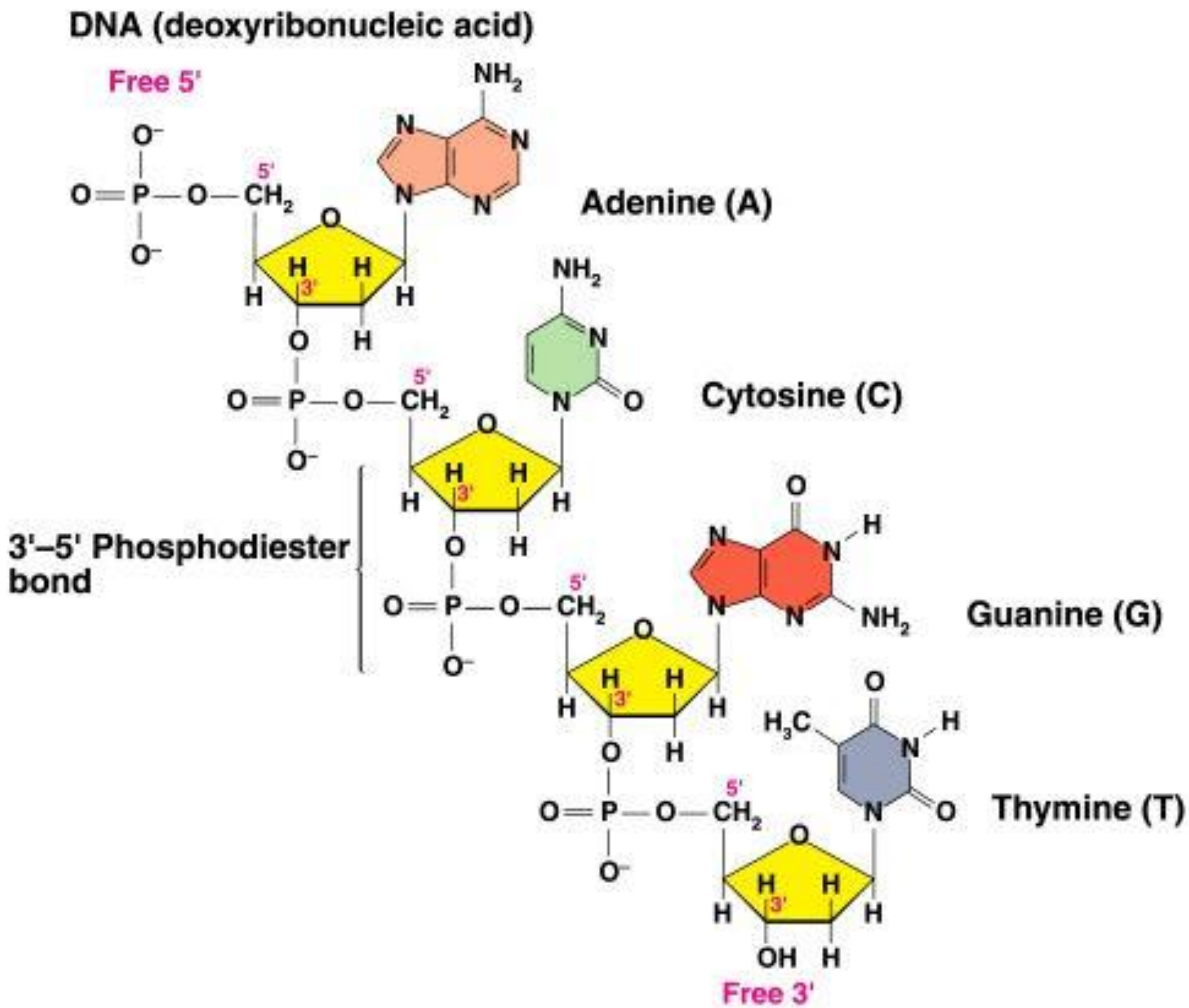
- A nucleic acid polymer has a free 5'-phosphate group at one end and a free 3'-OH group at the other end
- The sequence is read from the free 5'-end using the letters of the bases
- This example reads

  5'—A—C—G—T—3'



Example of DNA Primary Structure

- In DNA, A, C, G, and T are linked by 3’-5’ ester bonds between deoxyribose and phosphate



A. 3'-5'-Phosphodiester bonds

Phosphodiester bonds join the 5'-hydroxyl group of the deoxypentose of one nucleotide to the 3'-hydroxyl group of the deoxypentose of an adjacent nucleotide through a phosphate group. Phosphodiester linkages between nucleotides (in DNA or RNA) can be cleaved hydrolytically by chemicals, or hydrolyzed enzymatically by a family of nucleases: deoxyribonucleases for DNA and ribonucleases for RNA.

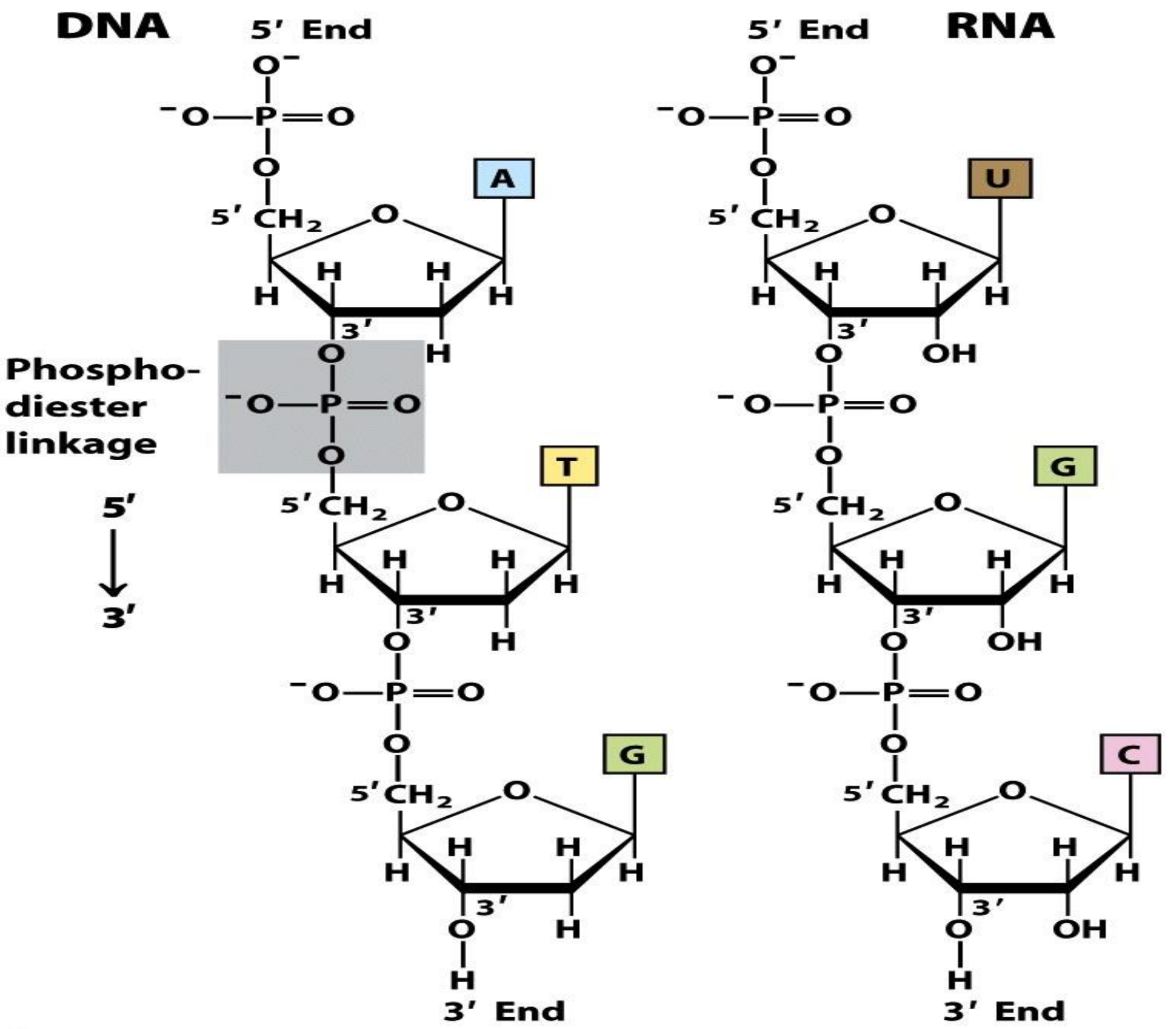


FIGURE 8-7 Phosphodiester linkages in the covalent backbone of DNA and RNA. The phosphodiester bonds (one of which is shaded in the DNA) link successive nucleotide units. The backbone of alternating pentose and phosphate groups in both types of nucleic acid is highly polar. The 5′ end of the macromolecule lacks a nucleotide at the 5′ position, and the 3′ end lacks a nucleotide at the 3′ position.

B. Double helix

In the double helix, the two chains are coiled around a common axis called the axis of symmetry. The chains are paired in an antiparallel manner, that is, the 5'-end of one strand is paired with the3'-end of the other strand (Figure 29.3).

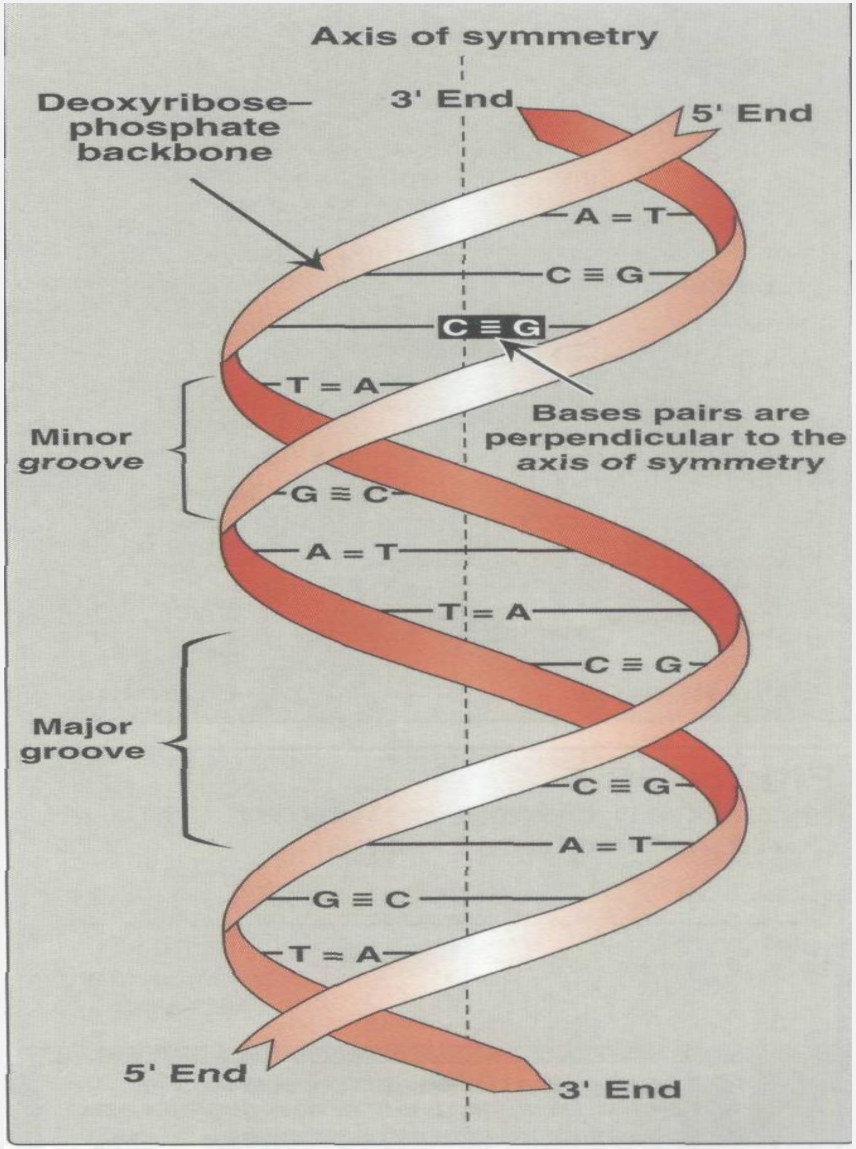
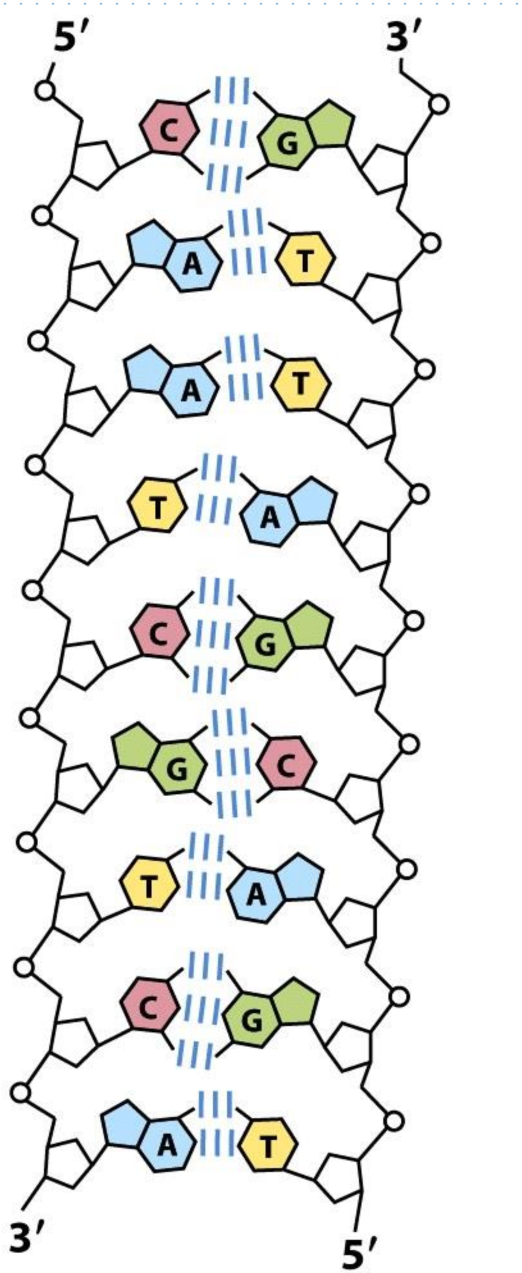


Figure 29.3
DNA double helix, illustrating some of its major structural features.



Properties of a DNA double helix

The strands of DNA are antiparallel

The strands are complimentary

There are Hydrogen bond forces

There are base stacking interactions

There are 10 base pairs per turn

NUCLEIC ACIDS

[**Note:** The specific base pairing in DNA leads to Chargaff's Rules: In any sample of double-stranded DNA, the amount of adenine equals the amount of thymine, the amount of guanine equals the amount of cytosine, and the total amount of purines equals the total amount of pyrimidines.]

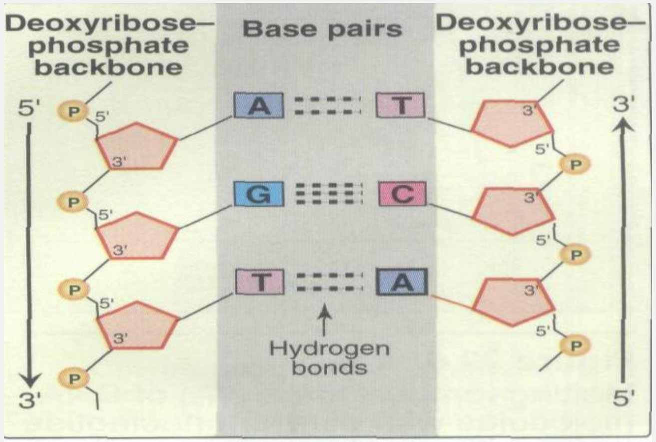


Figure 29.4
Two complementary DNA sequences.

The base pairs are held together by hydrogen bonds: two between A and T and three between G and C (Figure 29.5).These hydrogen bonds, plus the hydrophobic interactions between the stacked bases, stabilize the structure of the double helix.

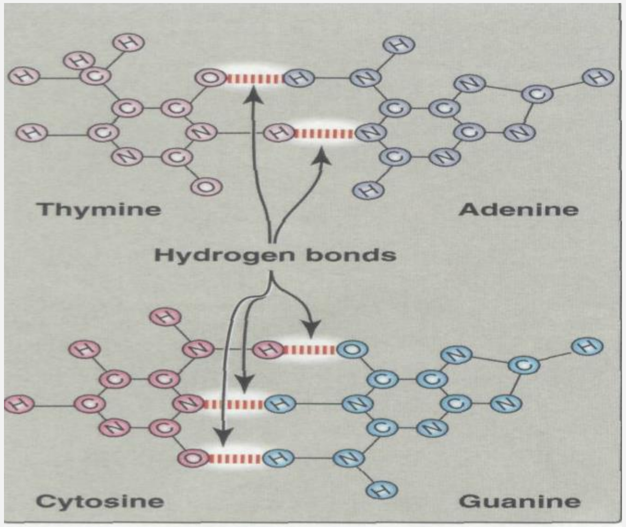


Figure 29.5
Hydrogen bonds between complementary bases.

Base Pairing in DNA: The Watson–Crick Model

- In 1953 Watson and Crick noted that DNA consists of two polynucleotide strands, running in opposite directions and coiled around each other in a double helix
- Strands are held together by hydrogen bonds between specific pairs of bases
- Adenine (A) and thymine (T) form strong hydrogen bonds to each other but not to C or G
- (G) and cytosine (C) form strong hydrogen bonds to each other but not to A or T

The Difference in the Strands

- The strands of DNA are complementary because of H-bonding
- Whenever a G occurs in one strand, a C occurs opposite it in the other strand
- When an A occurs in one strand, a T occurs in the other

STRUCTURE OF RNA :

There are three major types of RNA that participate in the process of protein synthesis ribosomal RNA (rRNA), transfer RNA (tRNA), and messenger RNA (mRNA). However, they differ as a group from DNA in several ways, for example, they are considerably smaller than DNA, and they contain ribose instead of deoxyribose and uracil instead of thymine. Unlike DNA, most RNAs exist as single strands that are capable of folding into complex structures. The three major types of RNA also differ from each other in size, function, and special structural modifications.

Types of RNA

Table 22.3 Types of RNA Molecules

Type	Abbreviation	Percentage of Total RNA	Function in the Cell
Ribosomal RNA	rRNA	75	Major component of the ribosomes
Messenger RNA	mRNA	5–10	Carries information for protein synthesis from the DNA in the nucleus to the ribosomes
Transfer RNA	tRNA	10–15	Brings amino acids to the ribosomes for protein synthesis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