



Fundamentals of Organic Chemistry

CHEM 109

For Students of Health Colleges

Credit hrs.: (2+1)

King Saud University

College of Science, Chemistry Department

Learning Objectives



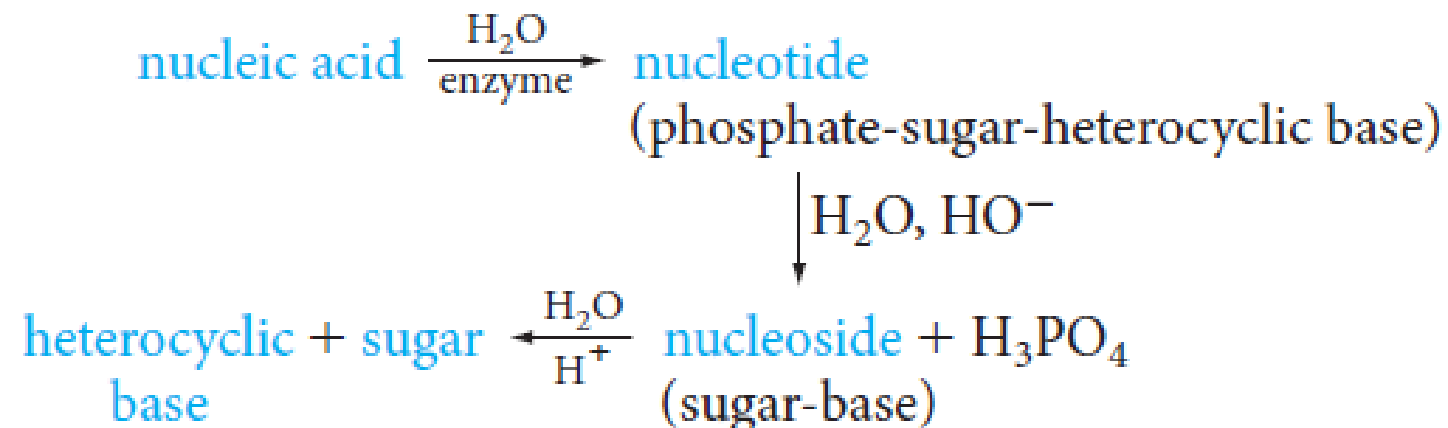
At the end of this chapter, students will able to:

- Describe the structural building blocks of RNA and DNA
- Differentiate between RNA and DNA structure.
- Know the structure of nucleotides and nucleosides.
- Recognize the important of both RNA and DNA

The General Structure of Nucleic Acids

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- **Nucleic acids** are molecules that allow organisms to **transfer genetic information** from one generation to the next.
- **Nucleic acids**, are linear polymers (chains) made out of units called **nucleotides**.
- Hydrolysis of nucleic acids gives **nucleotides**, which are the building blocks of nucleic acids.

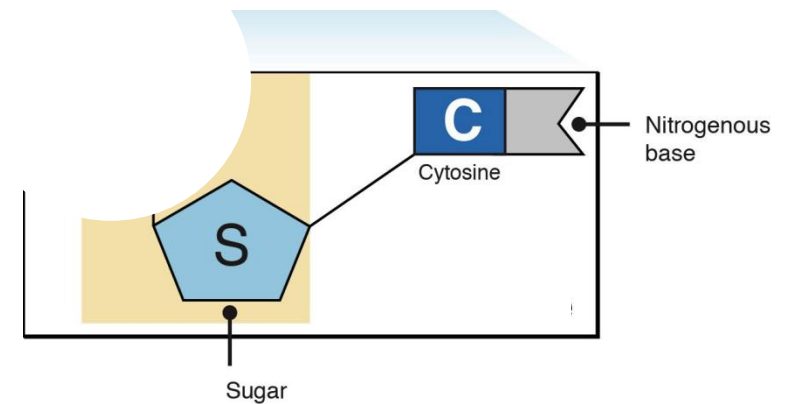
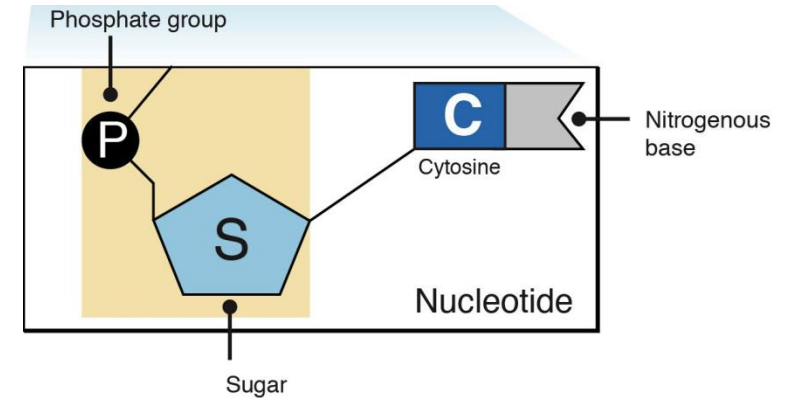


The General Structure of Nucleic Acids

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- **Nucleotides** : contain three parts:
 - A Nitrogenous Base (**Nucleobase**)
 - A Five-Carbon Sugar (**Pentose**)
 - A **Phosphate Group**

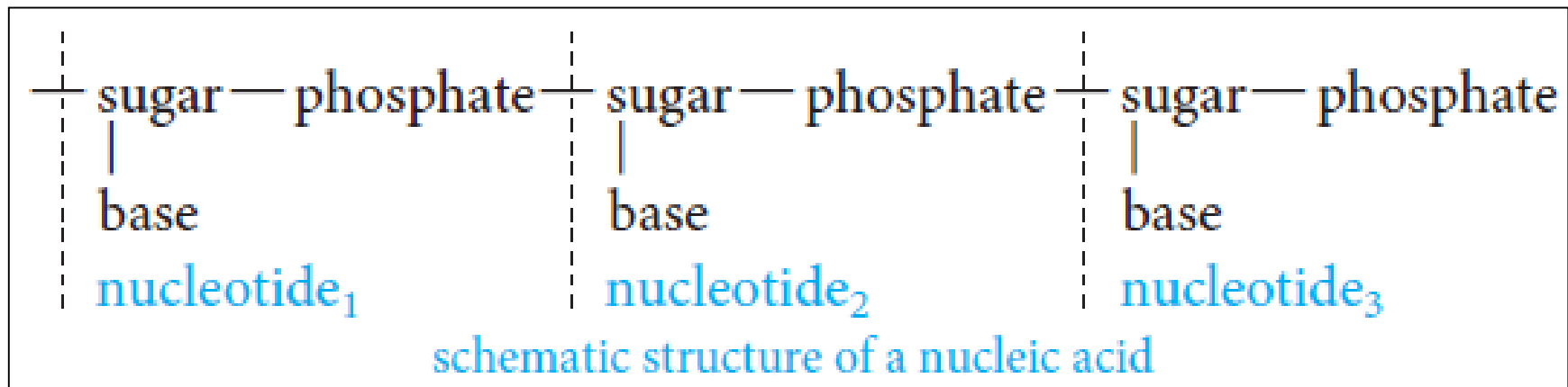
- **Nucleosides** : contain two parts:
 - A Nitrogenous Base (**Nucleobase**)
 - A Five-Carbon Sugar (**Pentose**)



The General Structure of Nucleic Acids

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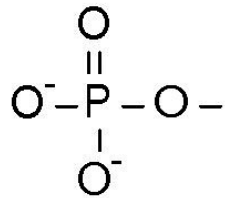
- **The overall structure of the nucleic acid** is a macromolecule with a backbone of sugar molecules connected by phosphate links and with a base attached to each sugar unit.



The General Structure of Nucleic Acids

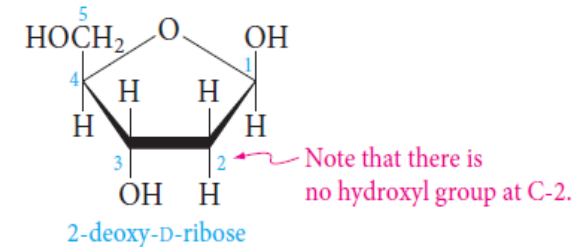
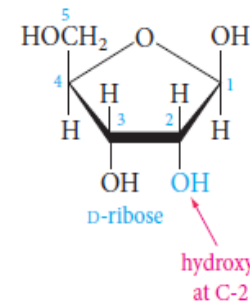
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Phosphate group



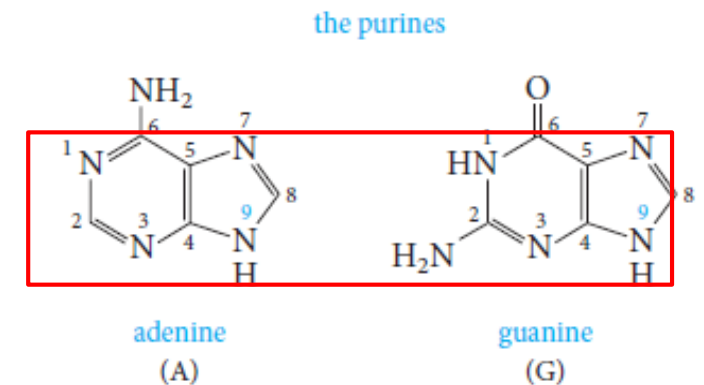
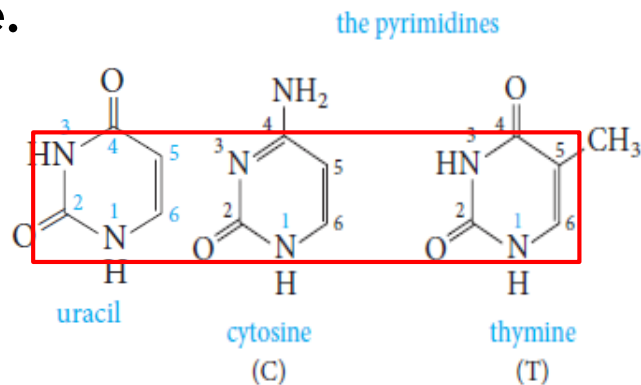
Pentose Sugar

- **Ribonucleic acid (RNA)** contains the pentose ribose.
- **Deoxyribonucleic acid (DNA)** contains the pentose deoxyribose.



Heterocyclic Base

The sugars also contain a pyrimidine or purine base present on the 1-carbon replacing the hydroxyl group with a base.



The General Structure of Nucleic Acids



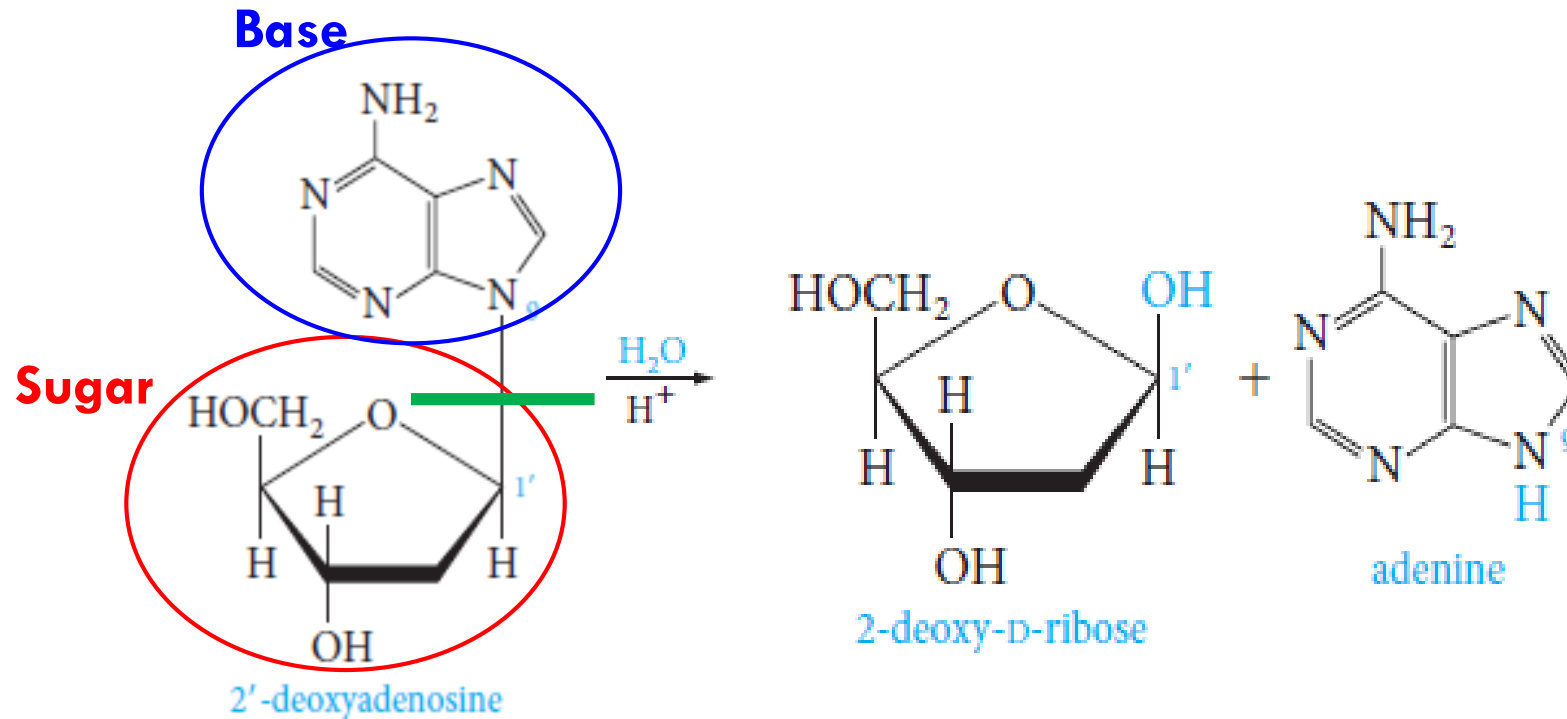
Differences Between DNA and RNA Composition

	DNA	RNA
Five-Carbon Sugar	Deoxyribose	Ribose
Nitrogenous Bases	Adenine, Guanine, Cytosine, and Thymine or methyluracil	Adenine, Guanine, Cytosine, and Uracil

The General Structure of Nucleic Acids

○ Nucleoside

The **combination of the pentose sugar and** a purine or pyrimidine **base**.



The General Structure of Nucleic Acids

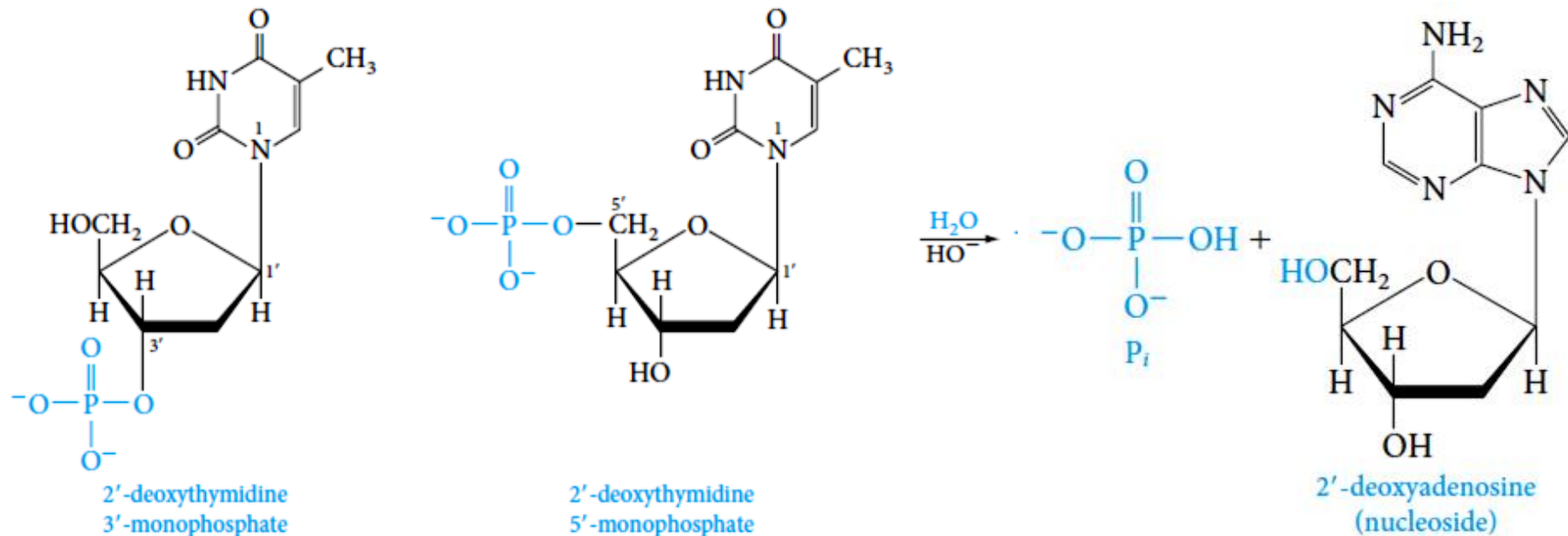
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- **Nucleotides** are **phosphate esters of nucleosides**.

A hydroxyl group in the sugar part of a nucleoside is esterified with phosphoric acid.

In DNA nucleotides, either the 3' or the 5' hydroxyl group of 2-deoxy-d-ribose is esterified.

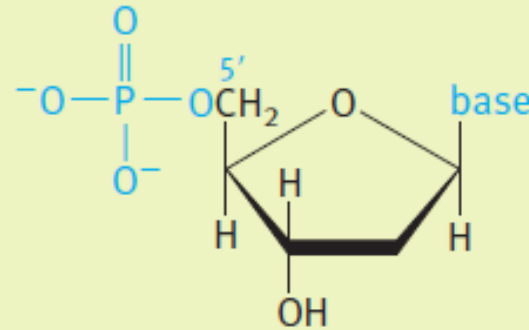
- **Nucleotides** can be **hydrolyzed** by aqueous base (or by enzymes) to **nucleosides and phosphoric acid**.



The General Structure of Nucleic Acids

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- In these abbreviations, **letter d** stands for 2-deoxy-d-ribose, the **next letter** refers to the heterocyclic base, and **MP** stands for monophosphate.



Base	Monophosphate name	Abbreviation
cytosine (C)	2'-deoxycytidine 5'-monophosphate	dCMP
thymine (T)	2'-deoxythymidine 5'-monophosphate	dTMP
adenine (A)	2'-deoxyadenosine 5'-monophosphate	dAMP
guanine (G)	2'-deoxyguanosine 5'-monophosphate	dGMP

The General Structure of Nucleic Acids

- **Nucleic acids** are polynucleotides attached by the phosphate moieties through the 3' and 5' sites on the pentose.
- The **name nucleic acid** is derived from the fact that they are acidic, containing a phosphoric acid moiety, and are found in the nuclei of cells.
- **Pure nucleic acid** was isolated by Levene in the early 1900s.
- He showed that either D-ribose or D-deoxyribose was present in what are now known as **ribonucleic acid (RNA)** and **deoxyribonucleic acid (DNA)**.
- **There are two major types of nucleic acids:**
 - **Deoxyribonucleic acid (DNA)**
 - **Ribonucleic acid (RNA).**

The Primary Structure of DNA

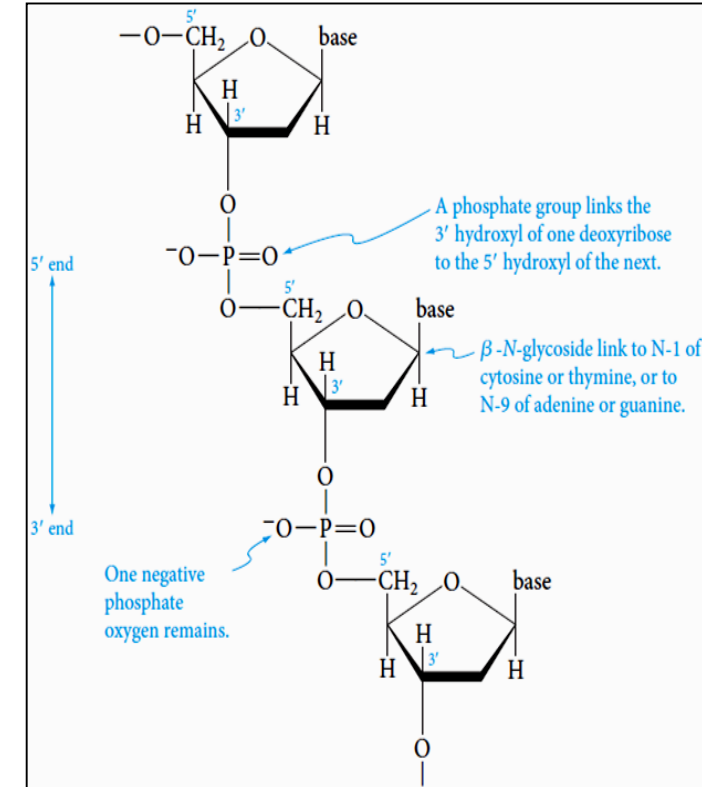
Deoxyribonucleic Acid (DNA)

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- In DNA, **2-deoxy-d-ribose** and **phosphate units** alternate in the backbone.
- The 3' hydroxyl of one ribose unit is linked to the 5' hydroxyl of the next ribose unit by a **phosphodiester bond**.
- The **heterocyclic base** is connected to the anomeric carbon of each deoxyribose unit by a **β -N-glycosidic bond**.
- In DNA, there are **no remaining hydroxyl groups** on any deoxyribose unit.
- Each phosphate, however, still has one acidic proton that is usually ionized **at pH 7**, leaving a negatively charged oxygen.
- A **complete description of any particular DNA molecule**, which may contain thousands or even millions of nucleotide units, would have to include the exact **sequence of heterocyclic bases (A, C, G, and T)** along the chain.



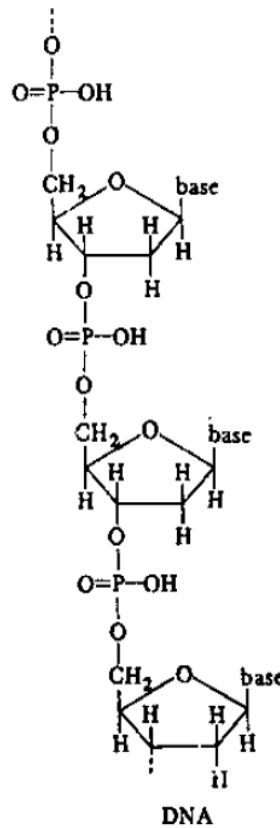
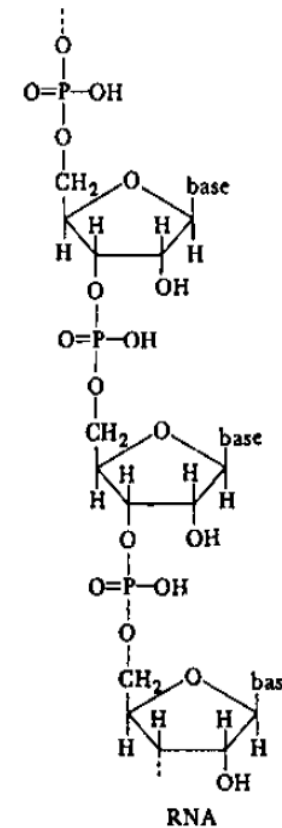
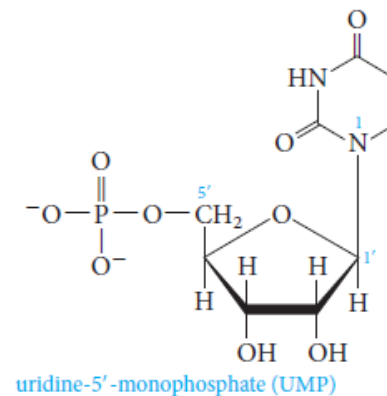
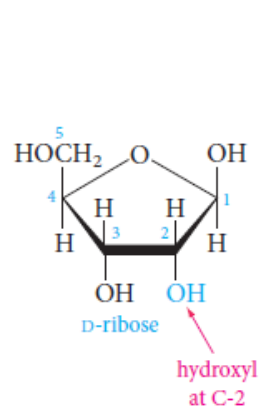
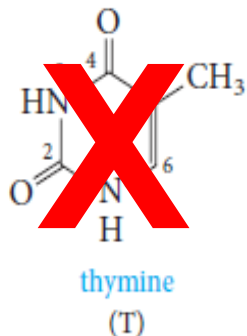
A segment of a DNA chain

Ribonucleic Acid (RNA)

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○ Ribonucleic acids (RNA) differ from DNA in three important ways:

- (1) The sugar is **D-ribose**;
- (2) **Uracil replaces thymine** as one of the four heterocyclic bases
- (3) Many RNAs are
 - **Single-stranded segments,**
 - **Combinations of complementary two-stranded helices,**
 - **Complex structures.**



Importance of DNA and RNA



- Heredity is encoded in DNA within the chromosomes.
- RNA (ribonucleic acid) is the messenger of DNA within the cell.
- Forms of RNA direct the cell to manufacture specific enzymes and other proteins.
- DNA functions by carrying the template or "map" of chemical compounds, amino acids, that are used to build proteins.
- DNA directs the production of proteins by providing the sequence of amino acids necessary to produce specific proteins.