# NUCLEIC ACID

**Biochemistry and Oral biochemistry – DENT 293**

**First Semester**

**5th Week**

**10/11/2024**

➢**Outlines:**

1. Nucleic acid.
2. Nucleosides and Nucleotides.
3. Naming Nucleosides and Nucleotides.
4. Primary Structure of Nucleic Acids.

➢**Objectives:**

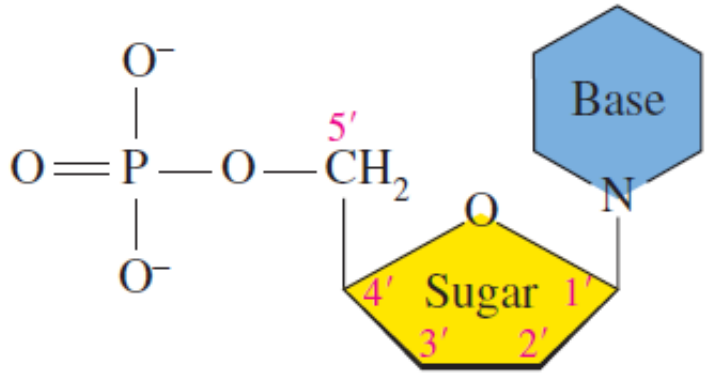
1. Knowing function and structures of nucleic acids.

2. Distinguish between ribose and deoxyribose terms.

3. Knowing how to name nucleosides and nucleotides.

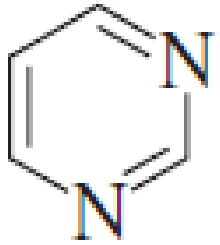
## ➢ Nucleic Acid:

The nucleic acids are large molecules found in the nuclei of the cells in our bodies that store information and direct activities for cellular growth and reproduction. There are two closely related types of nucleic acids: **deoxyribonucleic acid (DNA)**, and **ribonucleic acid (RNA)**. Both are **unbranched** polymers of repeating monomer units known as **nucleotides**. A DNA molecule may contain several million nucleotides; smaller RNA molecules may contain up to several thousand. Each nucleotide has three components: **a base, a five-carbon sugar, and a phosphate group** (see figure).

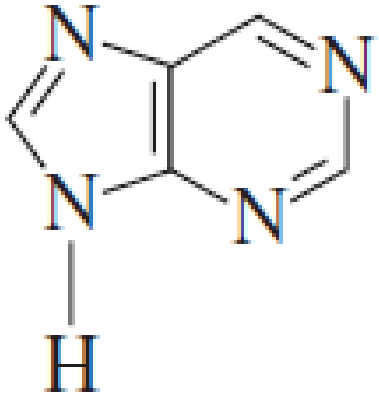


## ➢ Bases:

The nitrogen-containing **bases** in nucleic acids are derivatives of *pyrimidine* or *purine*.



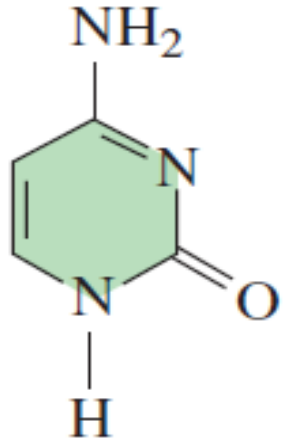

Pyrimidine



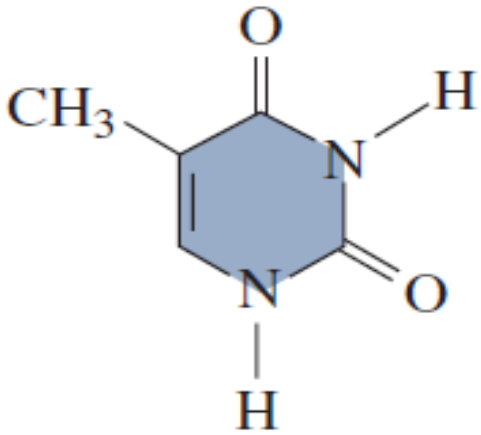

Purine

In DNA, the purine bases with double rings are adenine (A) and guanine (G); and the pyrimidine bases with single rings are cytosine (C) and thymine (T). RNA contains the same bases, except thymine (5-methyluracil) is replaced by uracil (U) (see Figure).

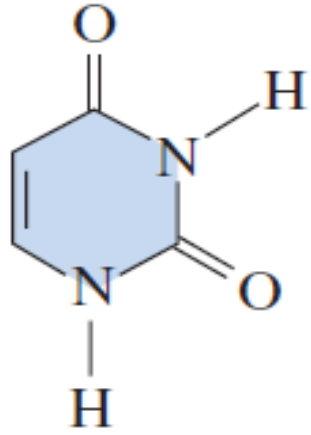
## Pyrimidines




Cytosine (C)
(DNA and RNA)

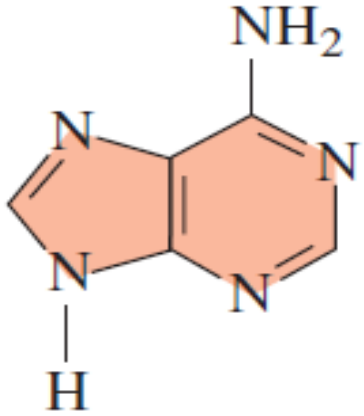



Thymine (T)
(DNA only)

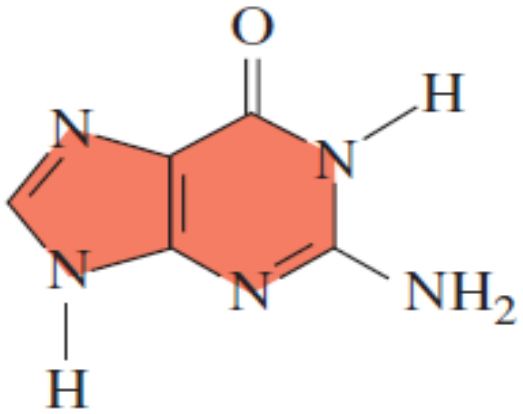



Uracil (U)
(RNA only)

## Purines




Adenine (A)
(DNA and RNA)

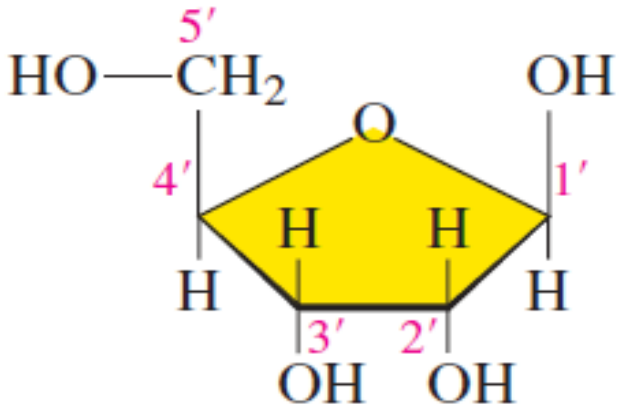



Guanine (G)
(DNA and RNA)

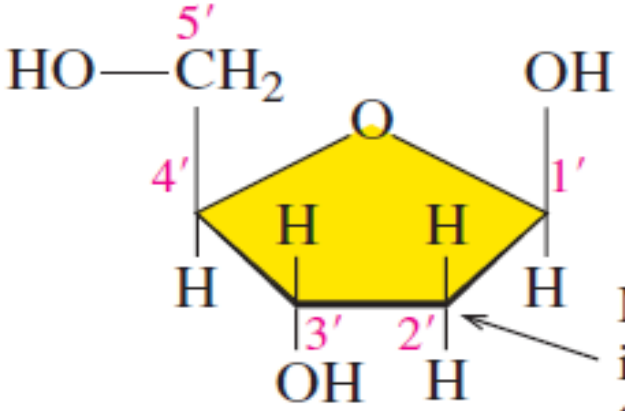
## ➢ Pentose Sugars:

In RNA, the five-carbon sugar is *ribose*, which gives the letter R in the abbreviation RNA. The atoms in the pentose sugars are numbered with primes (1',2',3',4' and 5') to differentiate them from the atoms in the bases (see Figure). In DNA, the five-carbon sugar is *deoxyribose*, which is similar to ribose except that there is no hydroxyl group (-OH) on C2. The *deoxy* prefix means "without oxygen" and provides the D in DNA.

**Pentose sugars in RNA and DNA**



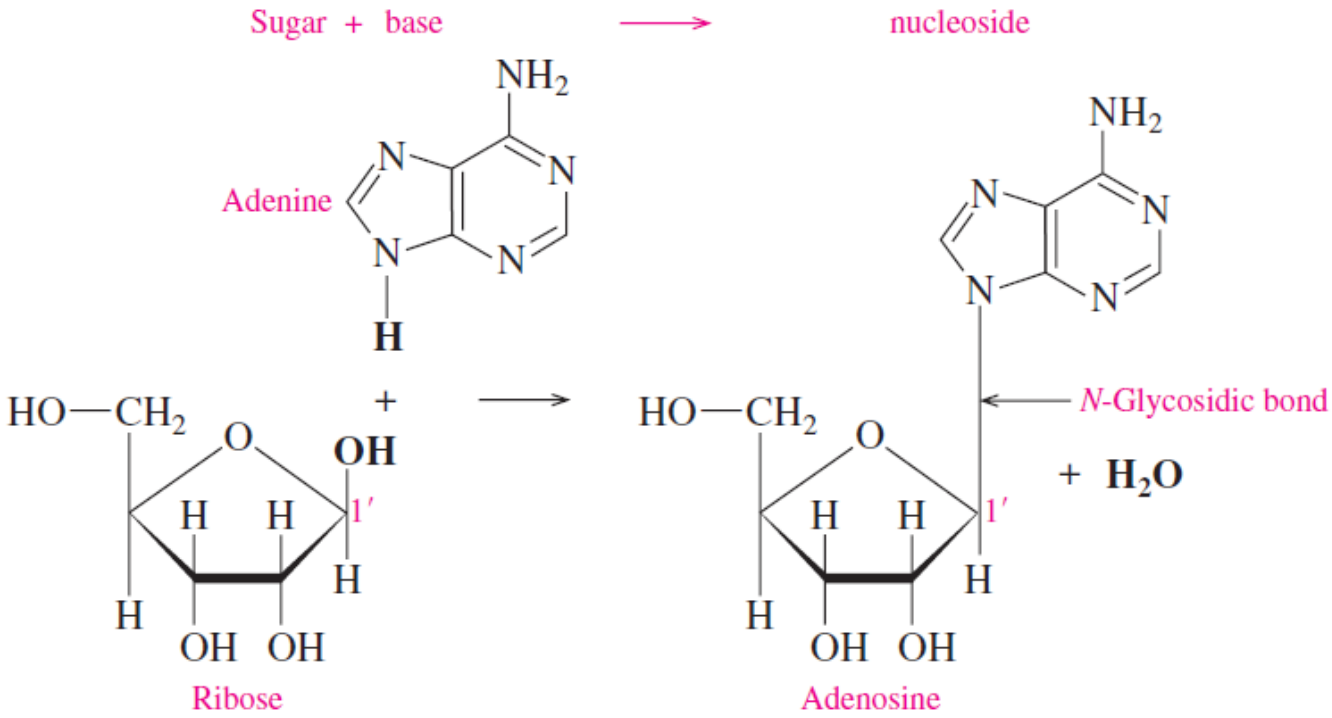

Ribose in RNA




Deoxyribose in DNA

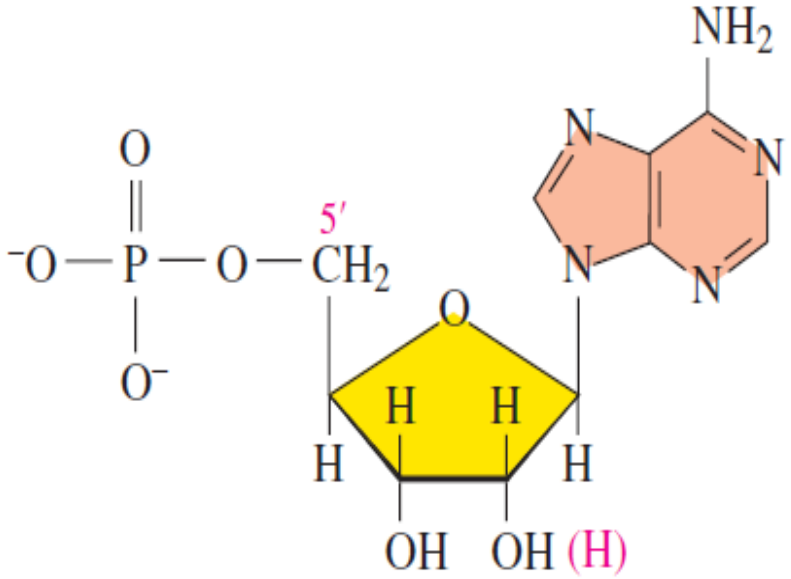
## ➢ Nucleosides and Nucleotides:

**Nucleosides,** which are a combination of a sugar and a base, are produced when the nitrogen atom in a pyrimidine or a purine base forms an *N*-glycosidic bond to carbon 1 of a ribose or deoxyribose sugar. For example, adenine and ribose form a nucleoside called adenosine.

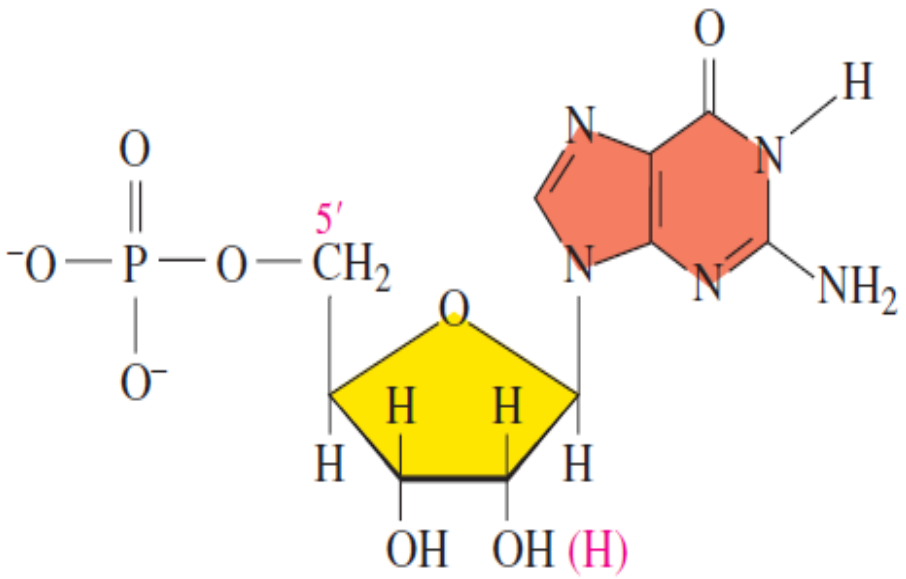



A base forms an *N*-glycosidic bond with a ribose or deoxyribose sugar to form a nucleoside.

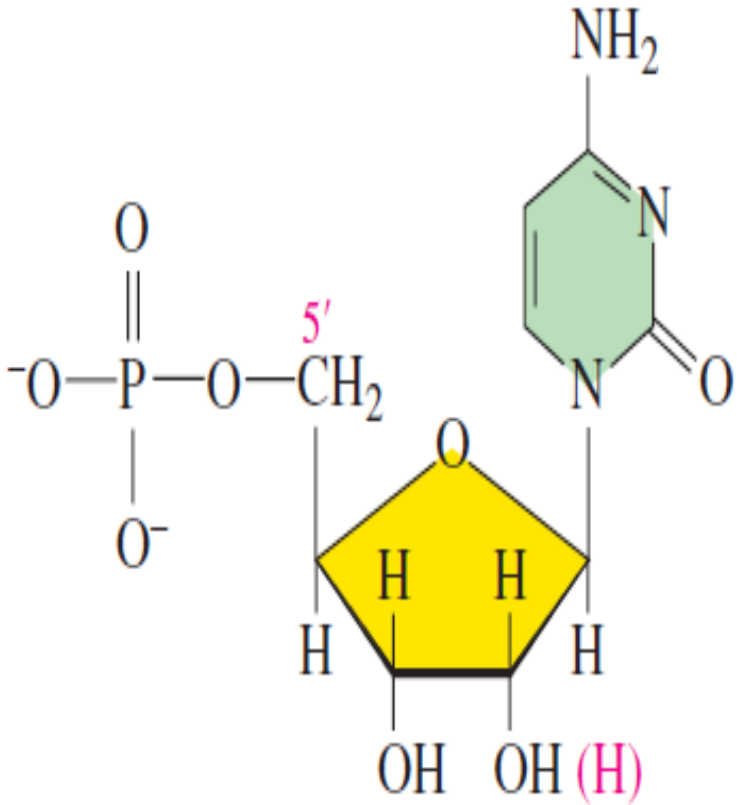
- **Nucleotides** are nucleosides in which a phosphate group bonds to - OH on carbon 5 (C5') of a ribose or deoxyribose sugar. The product is a **phosphate ester**. Other hydroxyl groups on ribose can form phosphate esters too, but only the 5'-monophosphate nucleotides are found in RNA and DNA. All the nucleotides in RNA and DNA are shown in Figure:




Adenosine-5′-monophosphate (AMP)
Deoxyadenosine-5′-monophosphate (dAMP)

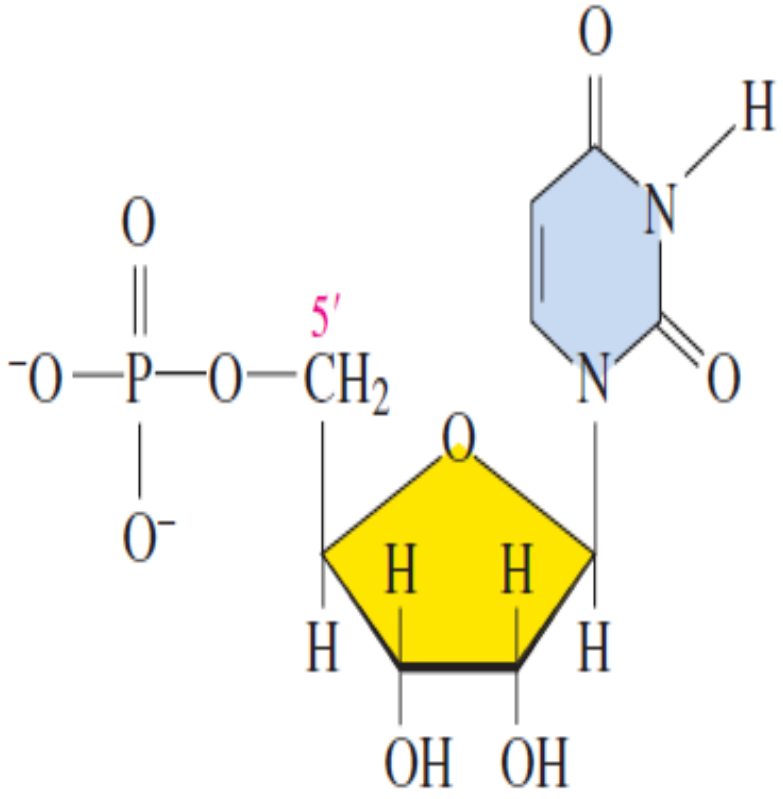



Guanosine-5′-monophosphate (GMP)
Deoxyguanosine-5′-monophosphate (dGMP)

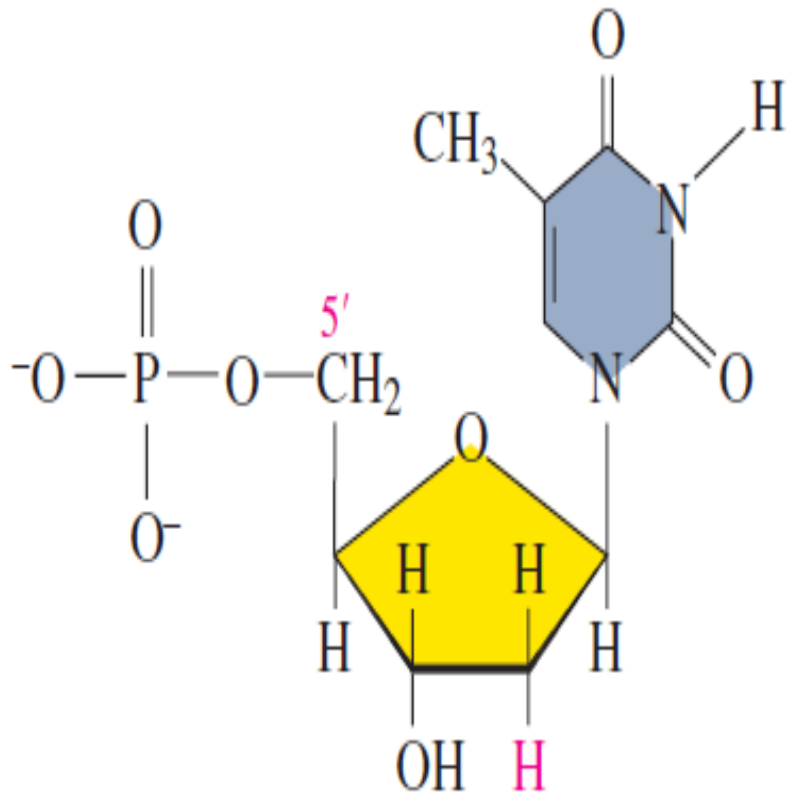



Cytidine-5′-monophosphate (CMP)

Deoxycytidine-5′-monophosphate (dCMP)




Uridine-5′-monophosphate (UMP)




Deoxythymidine-5′-monophosphate (dTMP)

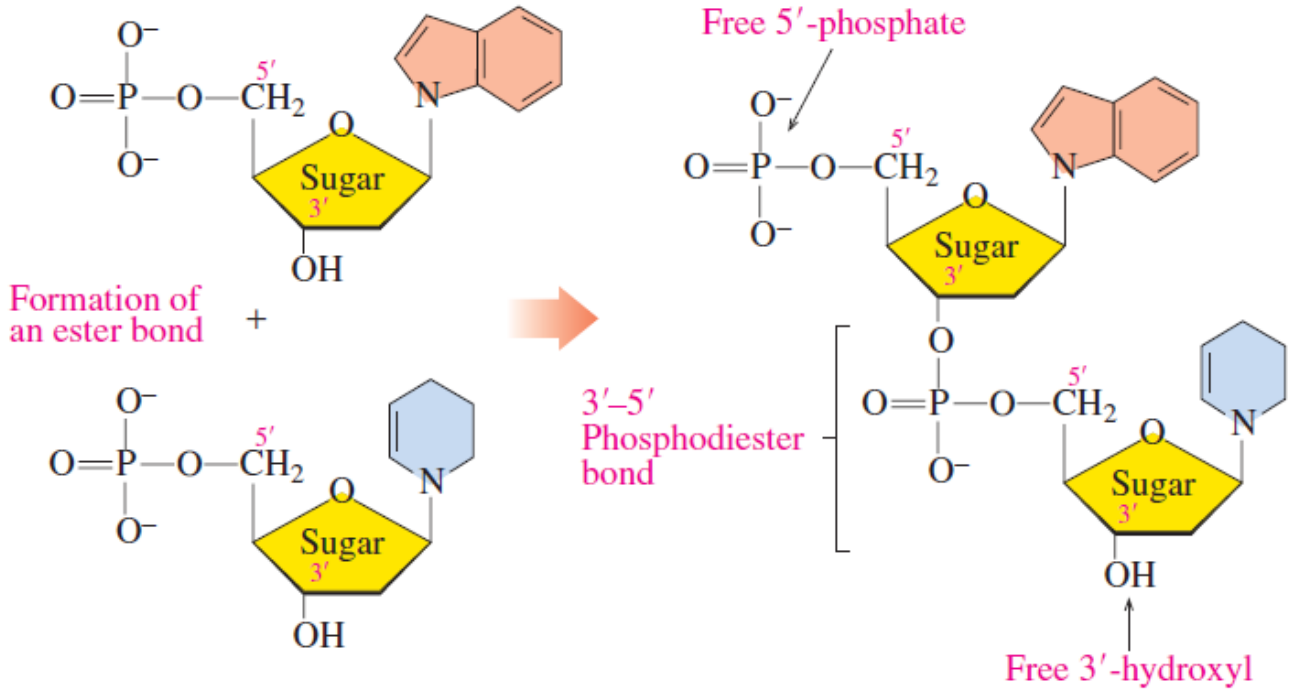
# Naming Nucleosides and Nucleotides

The name of a nucleoside that contains a purine ends with ***(-osine)*** whereas a nucleoside that contains a pyrimidine ends with ***(-idine)***. The names of the nucleosides of DNA add *deoxy* to the beginning of their names. The corresponding nucleotides in RNA and DNA are named by adding – *5' -monophosphate*. Although the letters A, G, C, U, and T represent the bases, they are often used in the abbreviations of the respective nucleosides and nucleotides. The names and abbreviations of the bases, nucleosides, and nucleotides in DNA and RNA are listed in Table (next slide).

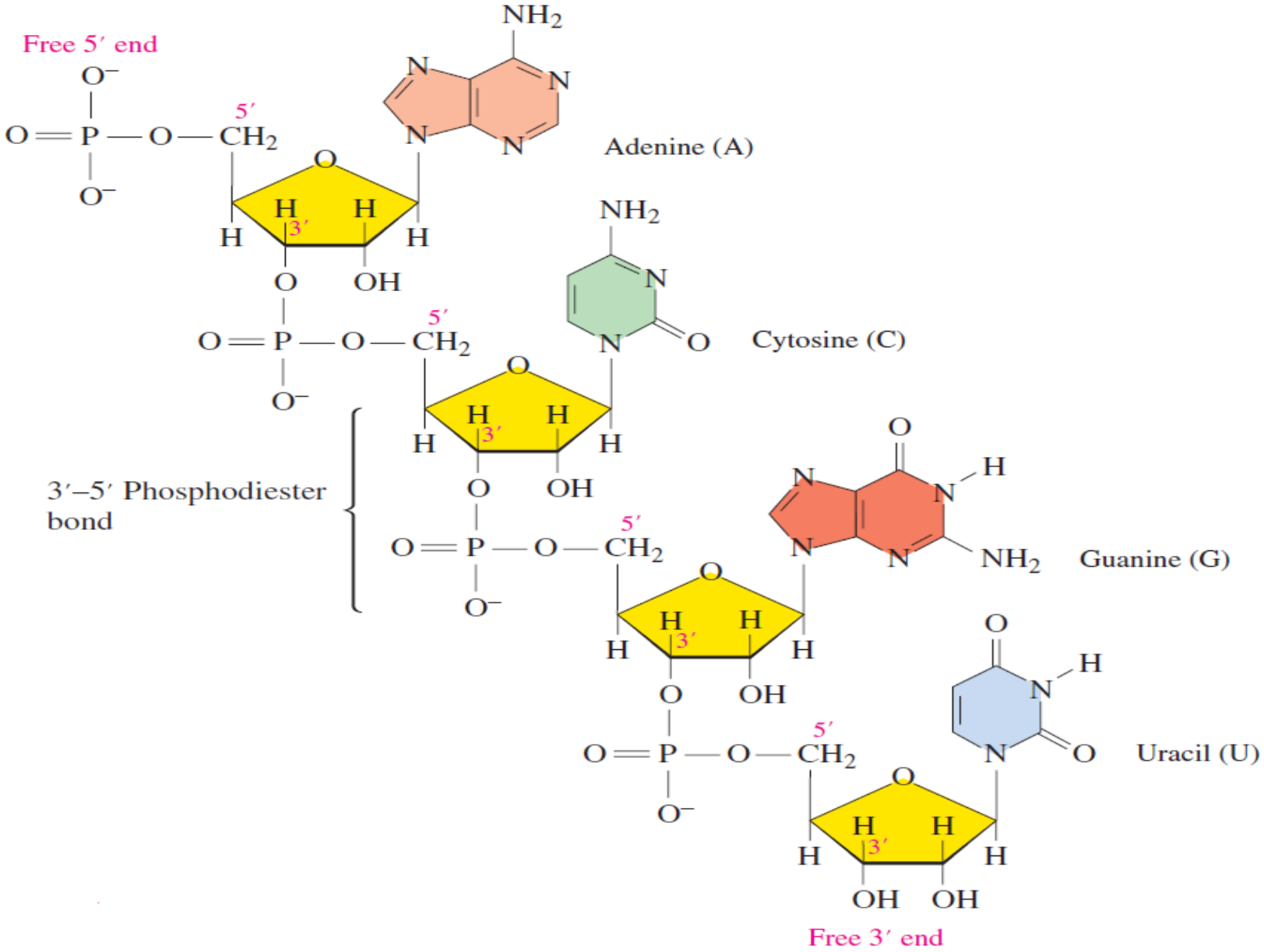
| Base | Nucleosides | Nucleotides |
|---|---|---|
| **DNA** | | |
| Adenine (A) | Deoxyadenosine (A) | Deoxyadenosine-5′-monophosphate (dAMP) |
| Guanine (G) | Deoxyguanosine (G) | Deoxyguanosine-5′-monophosphate (dGMP) |
| Cytosine (C) | Deoxycytidine (C) | Deoxycytidine-5′-monophosphate (dCMP) |
| Thymine (T) | Deoxythymidine (T) | Deoxythymidine-5′-monophosphate (dTMP) |
| **RNA** | | |
| Adenine (A) | Adenosine (A) | Adenosine-5′-monophosphate (AMP) |
| Guanine (G) | Guanosine (G) | Guanosine-5′-monophosphate (GMP) |
| Cytosine (C) | Cytidine (C) | Cytidine-5′-monophosphate (CMP) |
| Uracil (U) | Uridine (U) | Uridine-5′-monophosphate (UMP) |

# ➢ Primary Structure of Nucleic Acids:

The **nucleic acids** are polymers of many nucleotides in which the 3' - OH group of the sugar in one nucleotide bonds to the phosphate group on the 5' - carbon atom in the sugar of the next nucleotide. This phosphate link between the sugars in adjacent nucleotides is referred to as a **phosphodiester bond**.



Each nucleic acid has its own unique sequence of bases, which is known as its **primary structure**. It is this sequence of bases that carries the genetic information from one cell to the next. Along a DNA or RNA chain, the bases attached to each of the sugars extend out from the nucleic acid backbone. *In any nucleic acid, the sugar at the one end has an unreacted or free 5' -phosphate terminal end, and the sugar at the other end has a free 3' -hydroxyl group*. A nucleic acid sequence is read from the sugar with free 5' -phosphate to the sugar with the free 3' -hydroxyl group. The order of nucleotides is often written using only the letters of the bases. For example, the nucleotide sequence starting with adenine (free 5' - phosphate end) in the section of RNA shown in Figure (next Slide) is 5’- A-C-G-U-3'.


Free 5′ end
Adenine (A)
Cytosine (C)
3′–5′ Phosphodiester bond
Guanine (G)
Uracil (U)
Free 3′ end

## ➢ References:


1. Lehinger principles of biochemistry, 5th edition.
2. W.H. Freeman and company harpers illustrated biochemistry, 28th edition.
3. An introduction to general, organic and biological chemistry by Timberlake, 11th edition.