Cellular and Molecular Biochemistry [FHS1104]

Nucleosides, Nucleotides and Nucleic Acids

Lecture {6}

MBCHB/BDS
1ST YEAR SEM.-1
2026

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{Lecture (6) Outline}

- Introduction to Nucleic Acids
- Functions of Nucleic Acids
- Nucleosides
- Nucleotides
- Types of Nucleotides in nucleic acids
- Functions of Nucleotides

Introduction to Nucleic Acids:

So called because they are made in the nucleus and are acidic.

There are two types of nucleic acids:

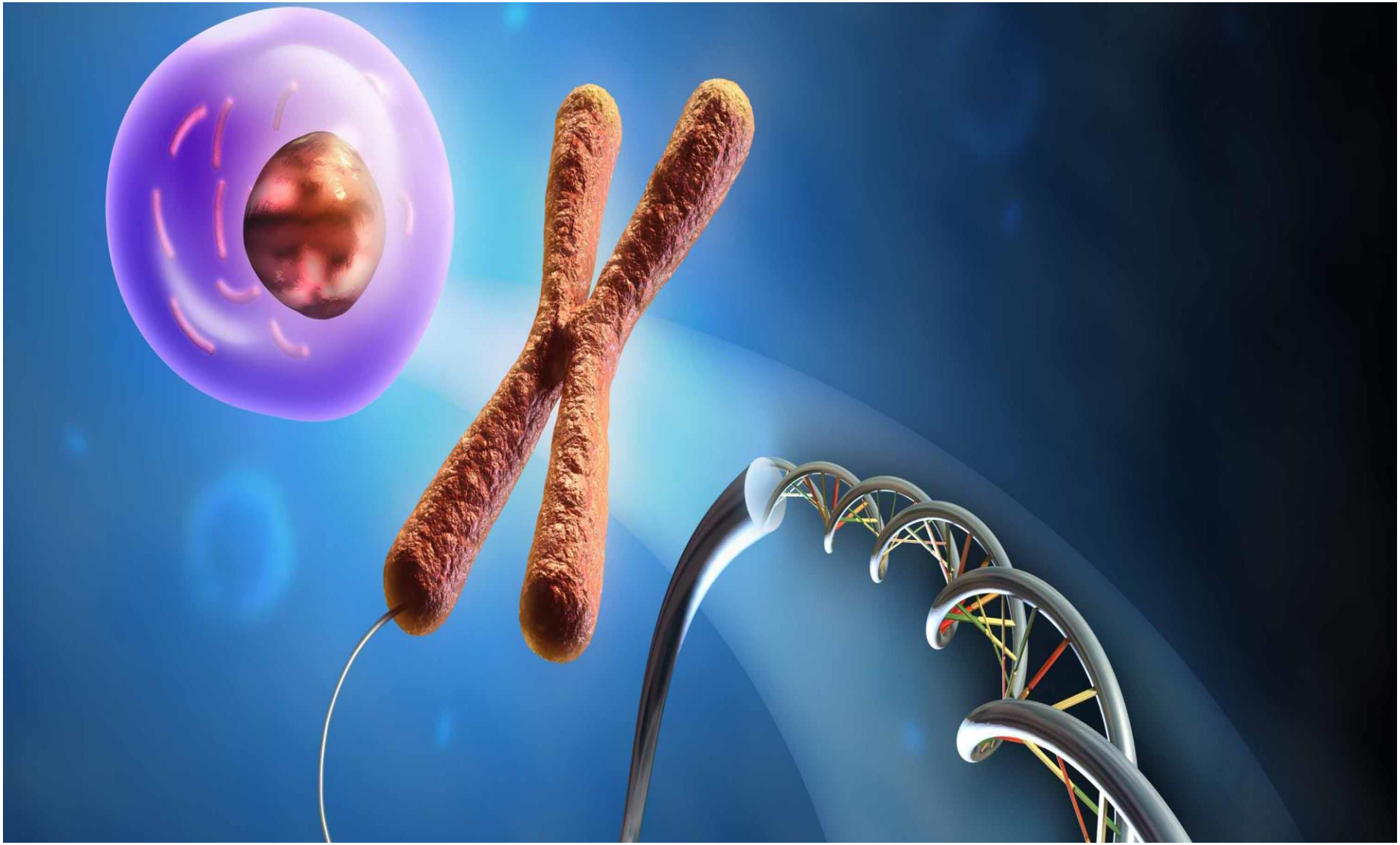
- **Deoxyribonucleic acid (DNA).**
- **Ribonucleic acid (RNA).**

Cellular Location of DNA

- DNA present in **chromosomes** in the nucleus of **eukaryotes**, and also in **mitochondria** and the **chloroplasts** of plants.

- **Prokaryotes**, which lack nucleus, have a **single** chromosome, but may also contain non-chromosomal DNA in the form of **plasmids**.

Cellular Location of DNA



What are Functions of DNA?

Functions of DNA :

- DNA is required for the storage and expression of genetic information.
- The genetic information stored in DNA is copied and transmitted to daughter cells through DNA replication.
- The DNA contained in a fertilized egg encodes the information that directs the development of an organism.

From DNA to Trait



Function of DNA :

- **Expression of genetic information means the flow of information from DNA to RNA to protein, and it is the "central dogma" of molecular biology**

- **Gene expression includes two Stages;**
  - **First: Transcription (synthesis of messenger RNA).**
  - **Second: Translation (synthesis of protein).**

Function of Nucleic Acids:

The central dogma of molecular biology

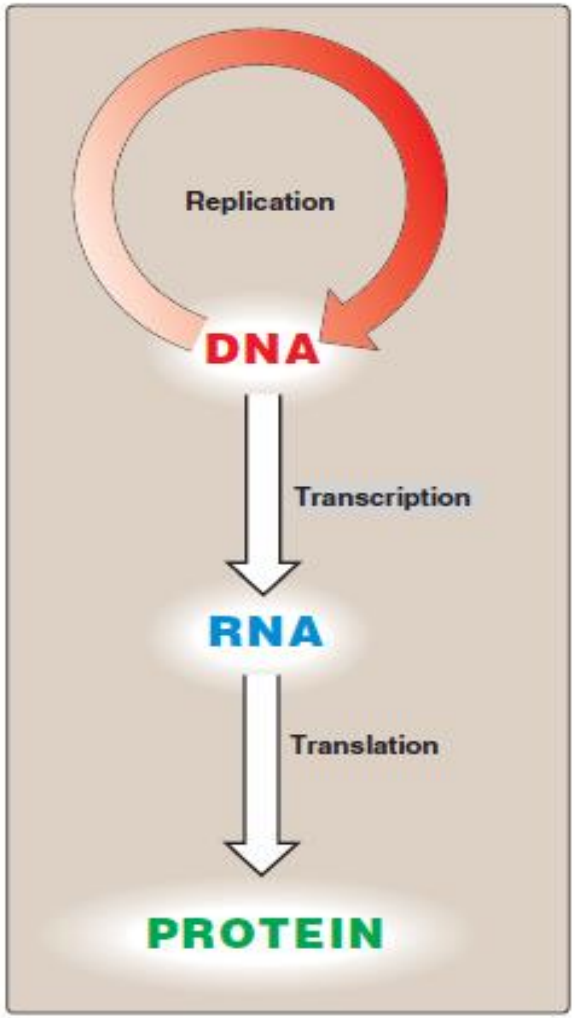
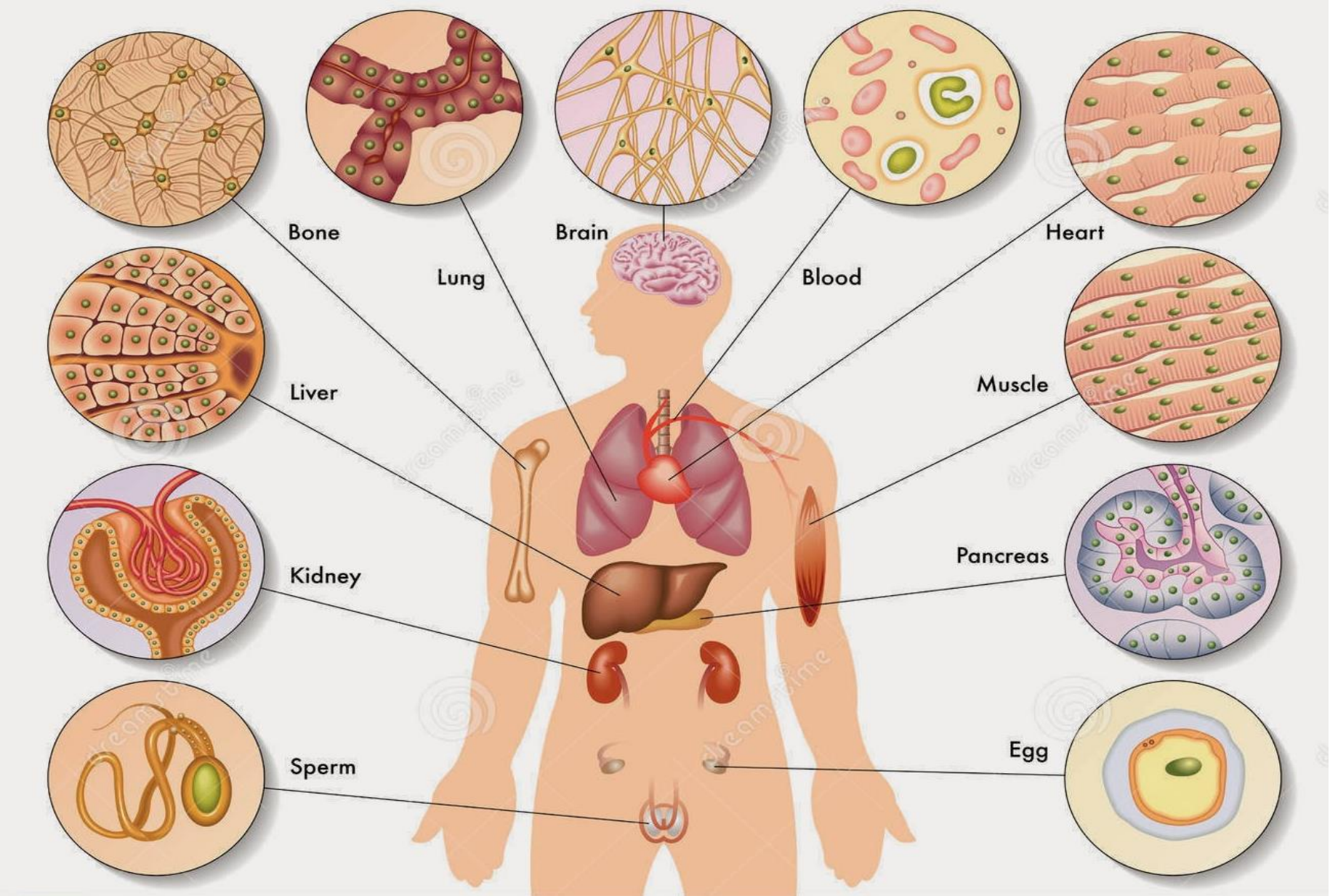


Figure 29.1
The "central dogma" of molecular biology.

Function of DNA

- The development of organism involve the production of billions of cells AND Each cell is specialized, expressing only those functions that are required for it to perform its role in maintaining the organism.
- Therefore, DNA must be able to not only replicate precisely each time a cell divides, but also to have the information it contains be selectively expressed.

Function of DNA :



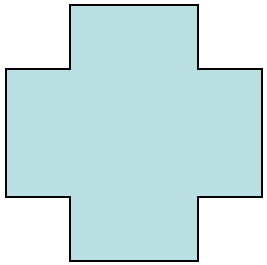
Nucleosides & Nucleotides

Nucleosides & Nucleotides

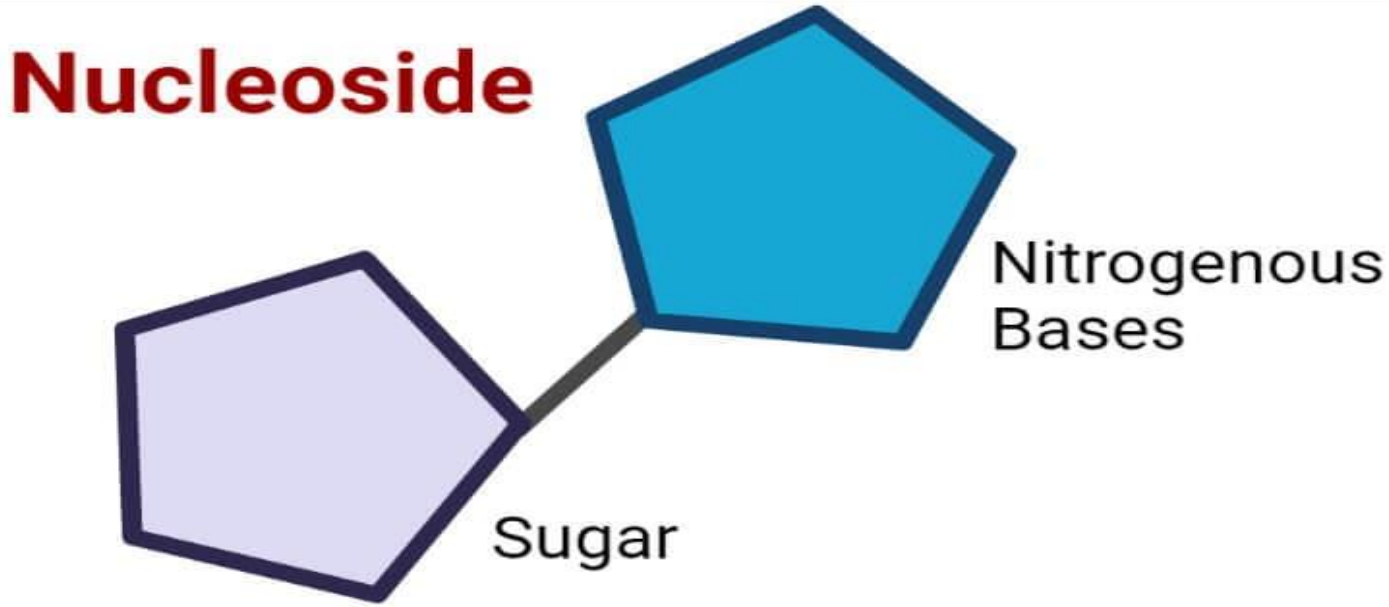
Nucleosides:

Nucleosides made up of of nitrogenous base and pentose sugar.

Pentose Sugar



N. Base



What is a Nucleoside?

A Nucleosides **is composed of a**

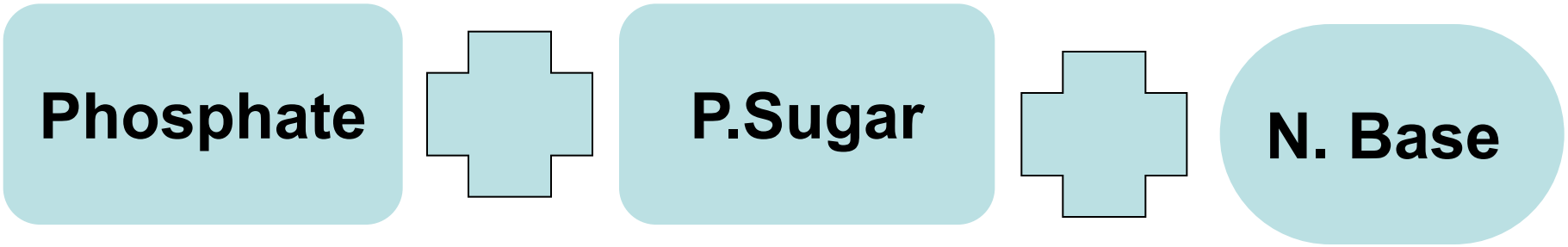
- **Ring of nitrogen base**
- **A pentose sugar (ribose or deoxyribose)**

(together referred to as a Nucleoside**).**

When we add one phosphate group it becomes a Nucleotide .

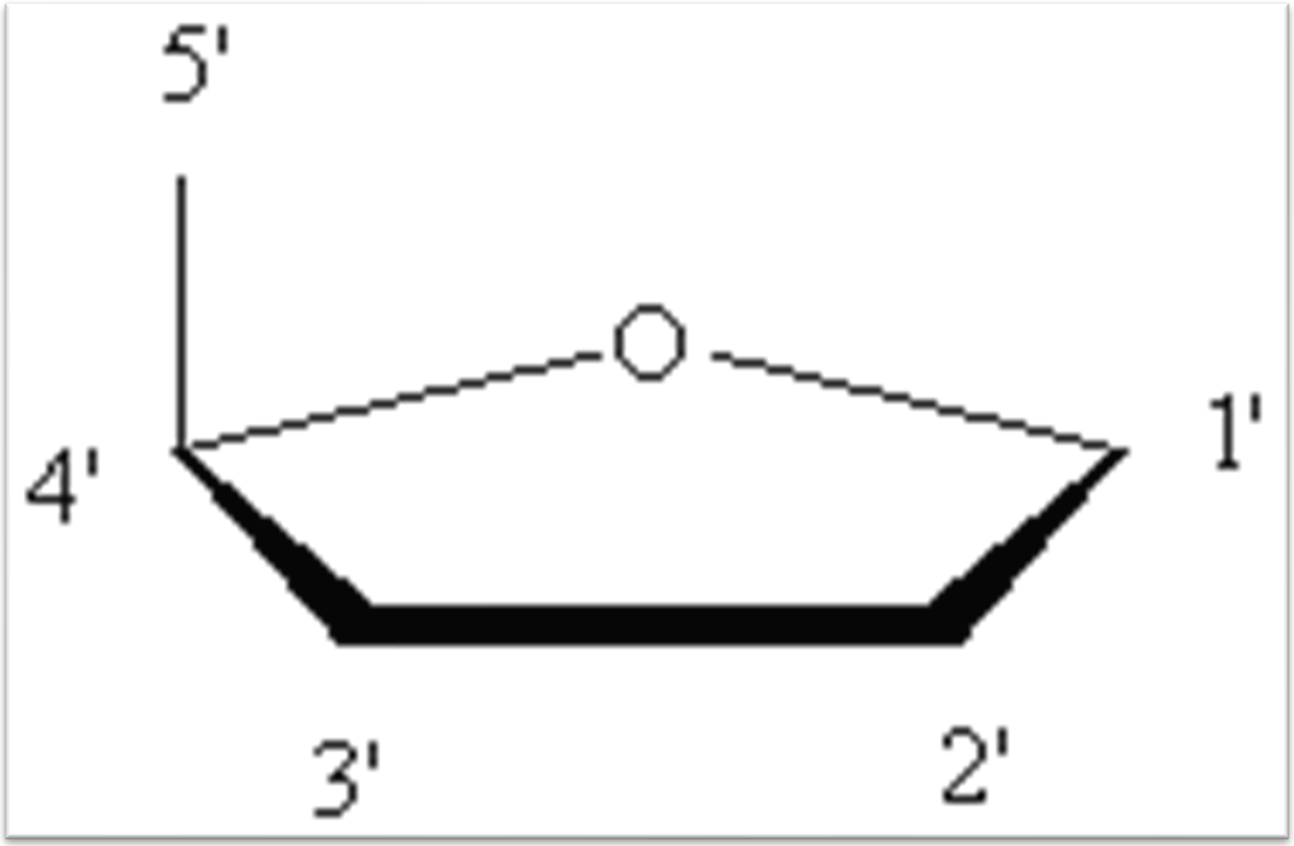
Nucleotides:

- Nucleotides are monomer of nucleic acids (DNA,RNA) that consist of three joined structures: a nitrogenous base, a pentose sugar, and a phosphate group.
- Nucleic acids (DNA & RNA) are polymer of nucleotides.
- Nucleotides are intracellular molecules having the following structure:



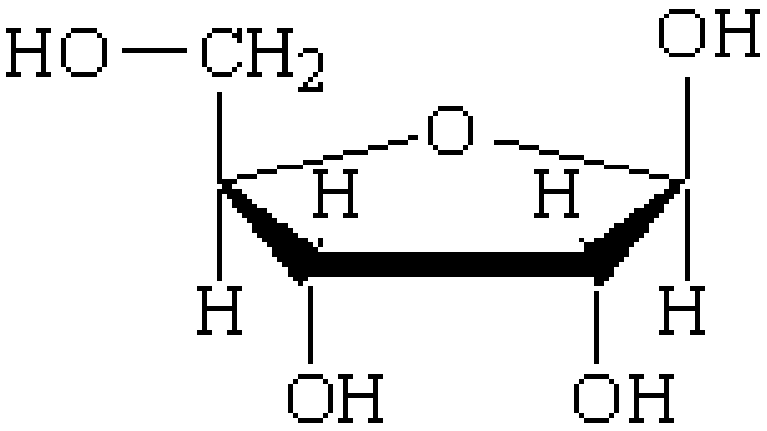
Pentose sugars:

- The sugars in the nucleotides are Pentose sugars (5-Carbon atoms)

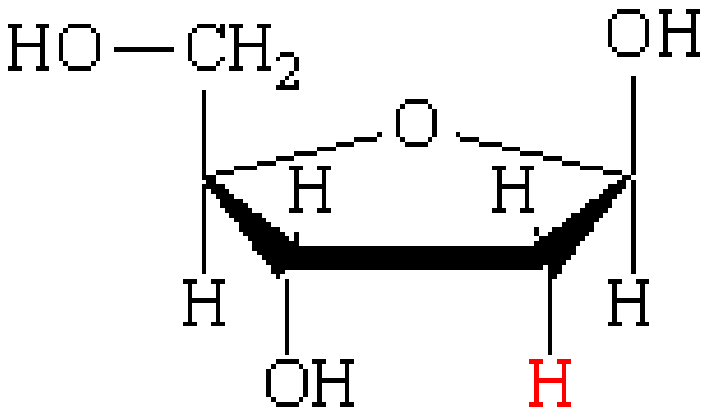


Pentose Sugar:

RNA nucleotides (Ribonucleotides), contain ribose sugar which have a hydroxyl group at Carbon No. 2, while **DNA** lack Oxygen at carbon No. 2 (Deoxyribonucleotides).



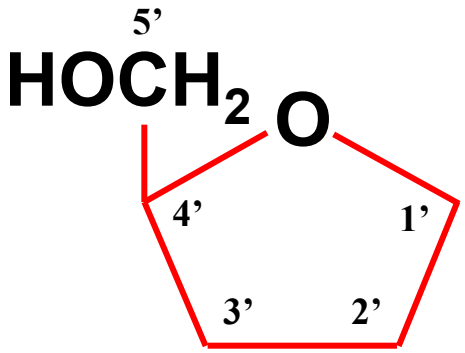
D-Ribose



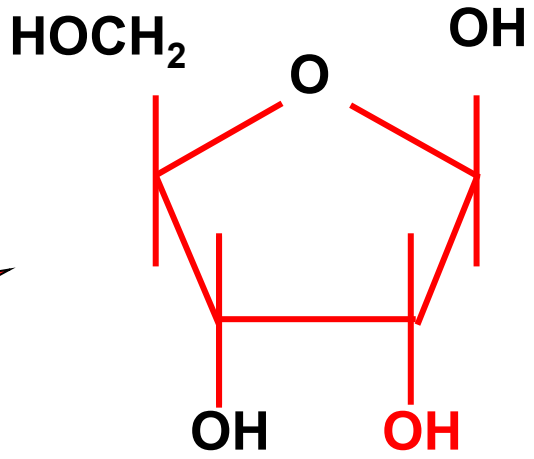
2'-Deoxyribose

Pentose Sugar:

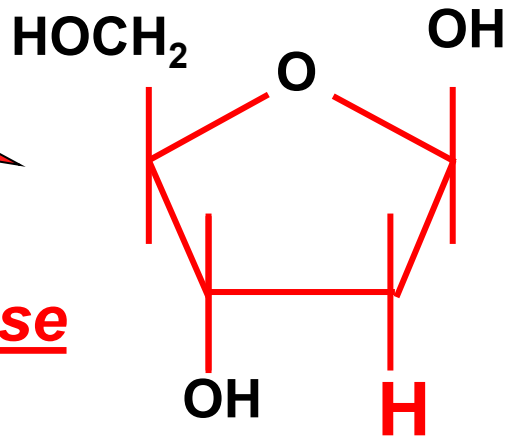
General Ribose & Deoxyribose Structure



Ribose



Deoxyribose



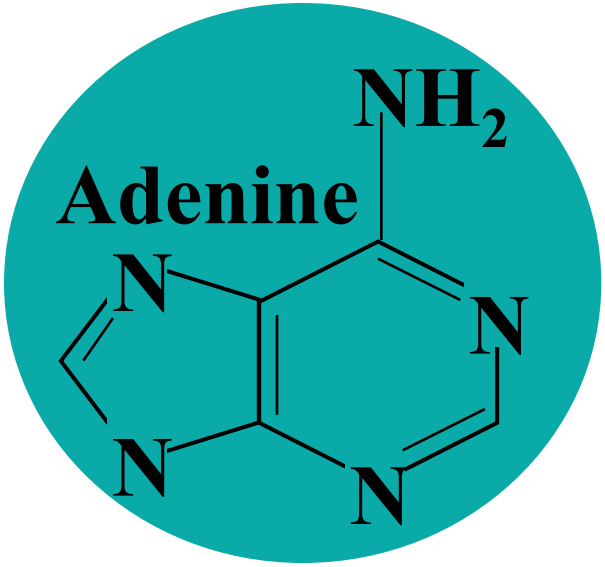
What are nitrogenous bases ?

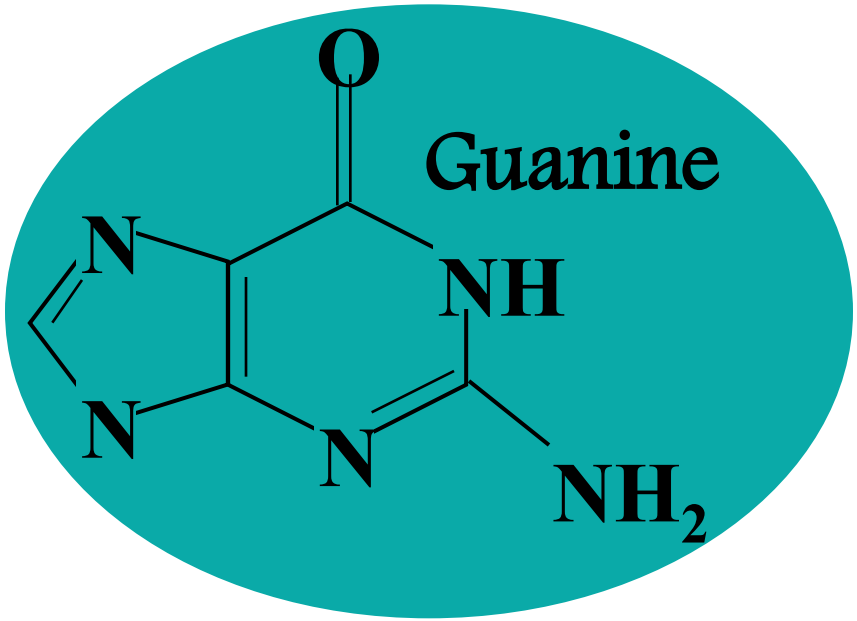
They are 2 types :-

a - Purine bases (Adenine and Guanine)

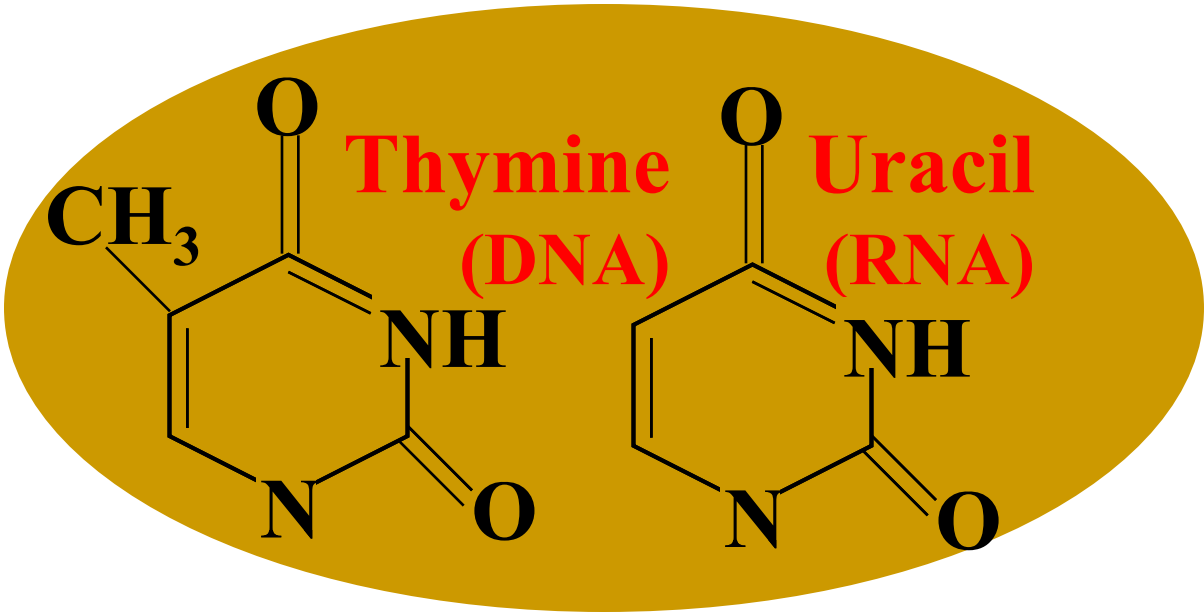
b - Pyrimidine bases (Thymine , Cytosine and Uracil).

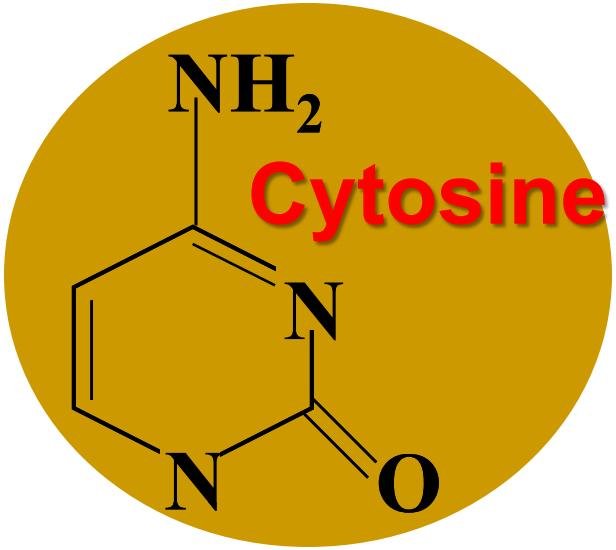
Purines



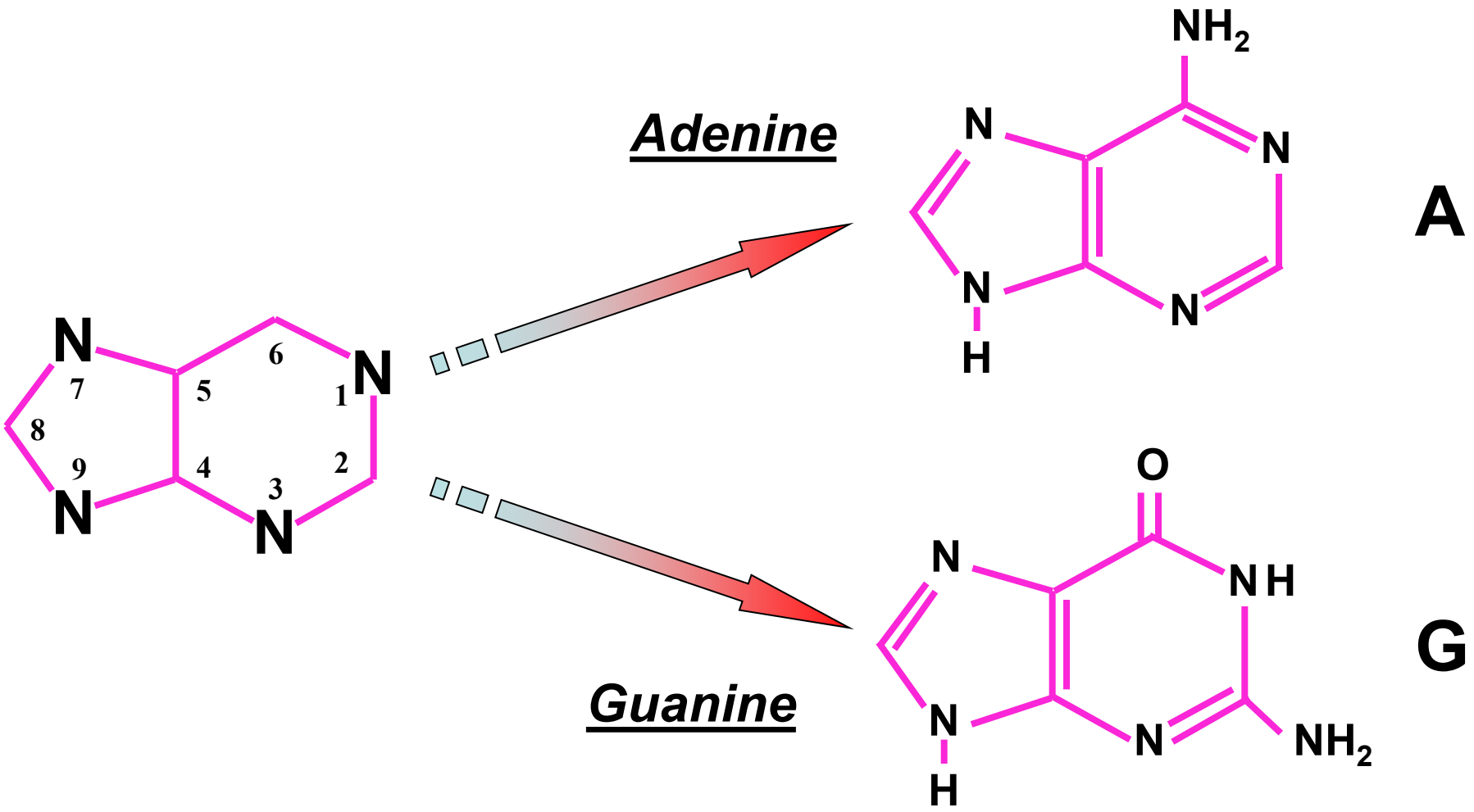


Pyrimidines

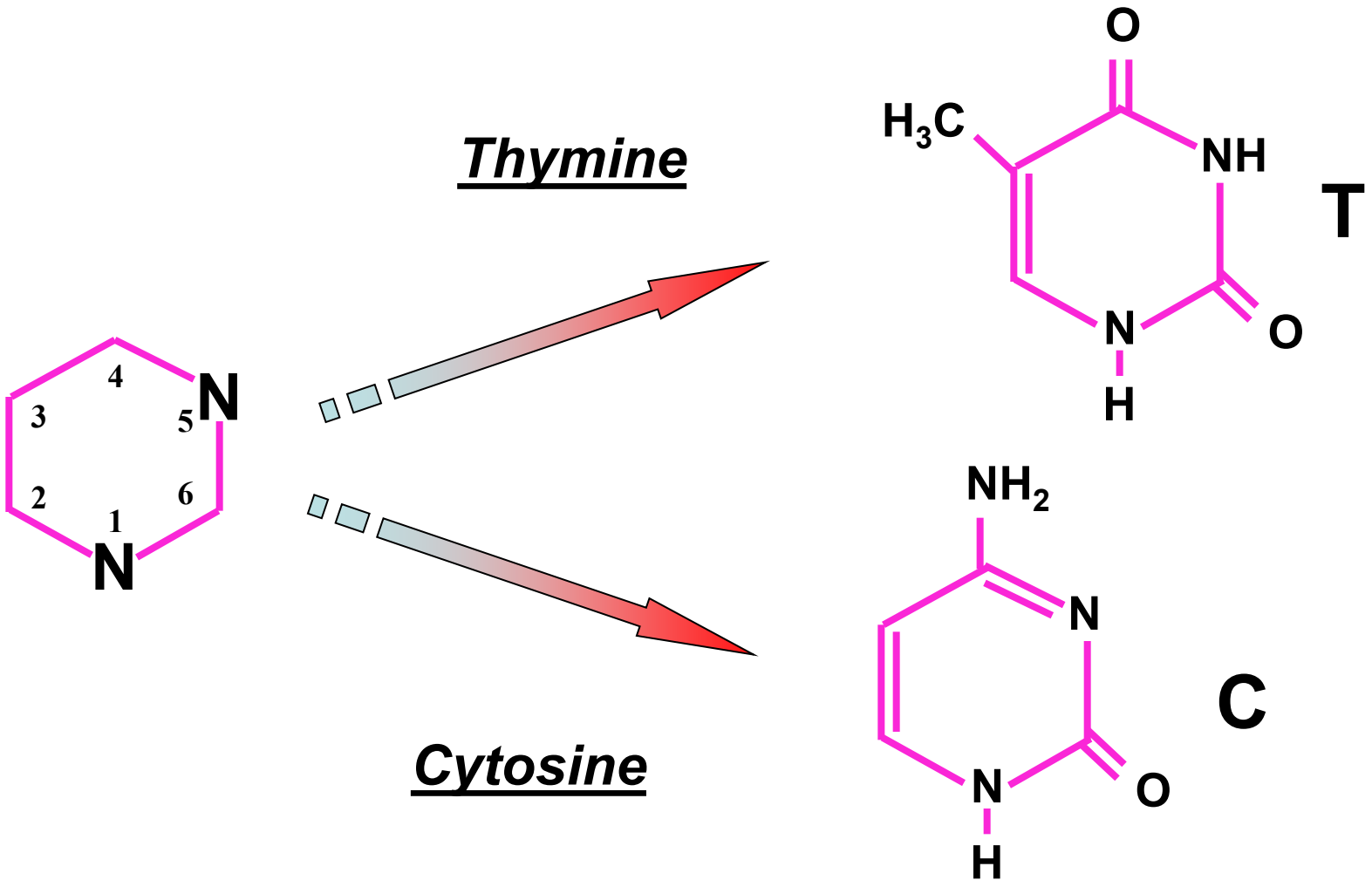




- Bases – Purines: There are two purines commonly found in Nucleic acids.
  - Each can be found in nucleic acid.



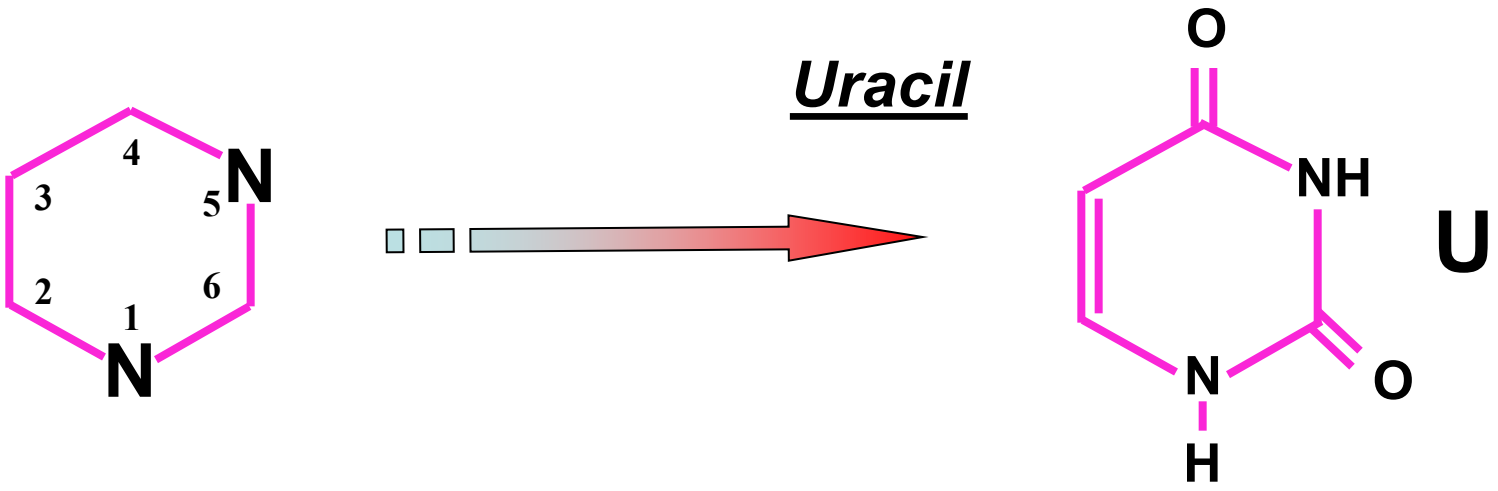
➢ Bases – Pyrimidines:



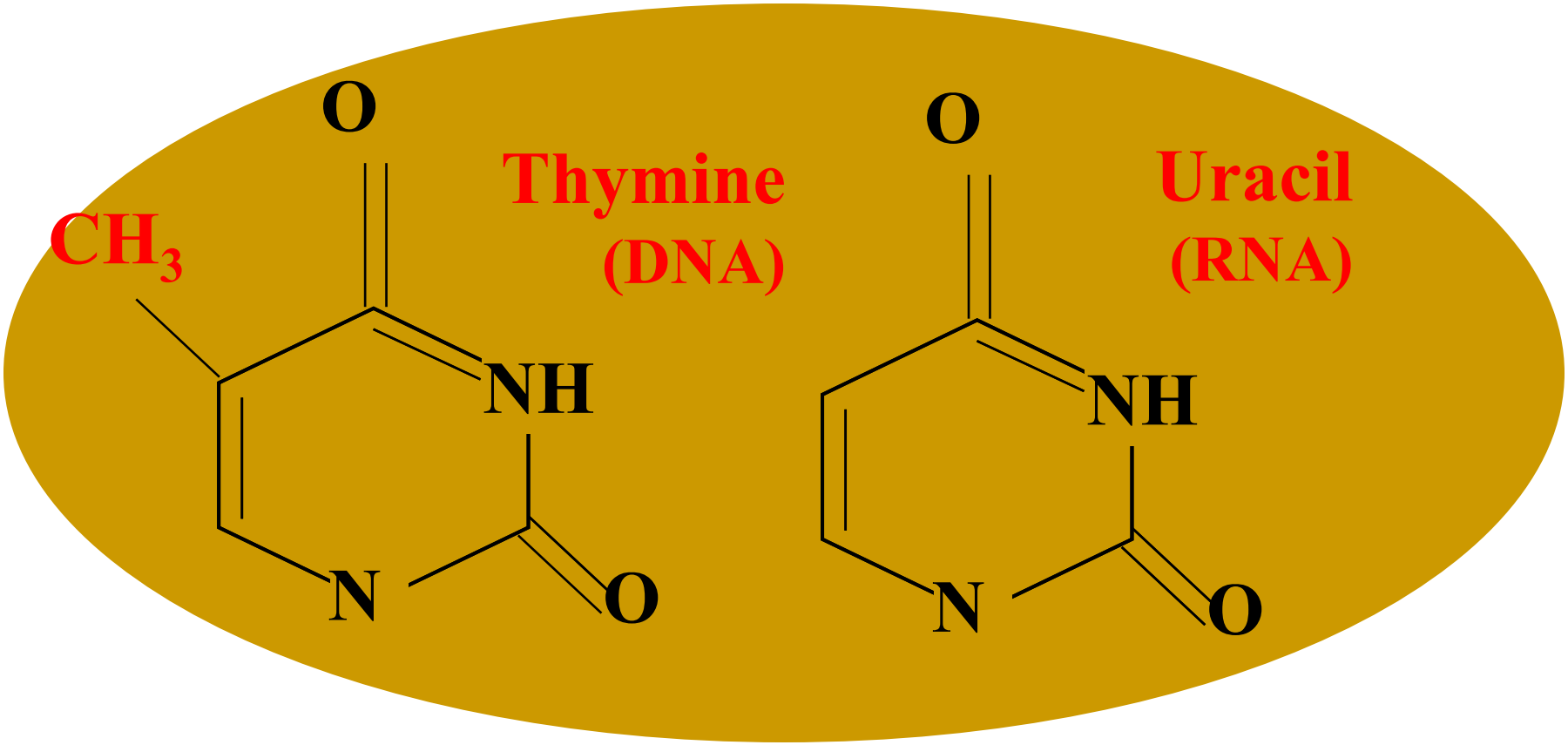
➢ Bases – Pyrimidines:

Thymine is found ONLY in DNA.

In RNA, thymine is replaced by uracil



Uracil and Thymine are structurally similar

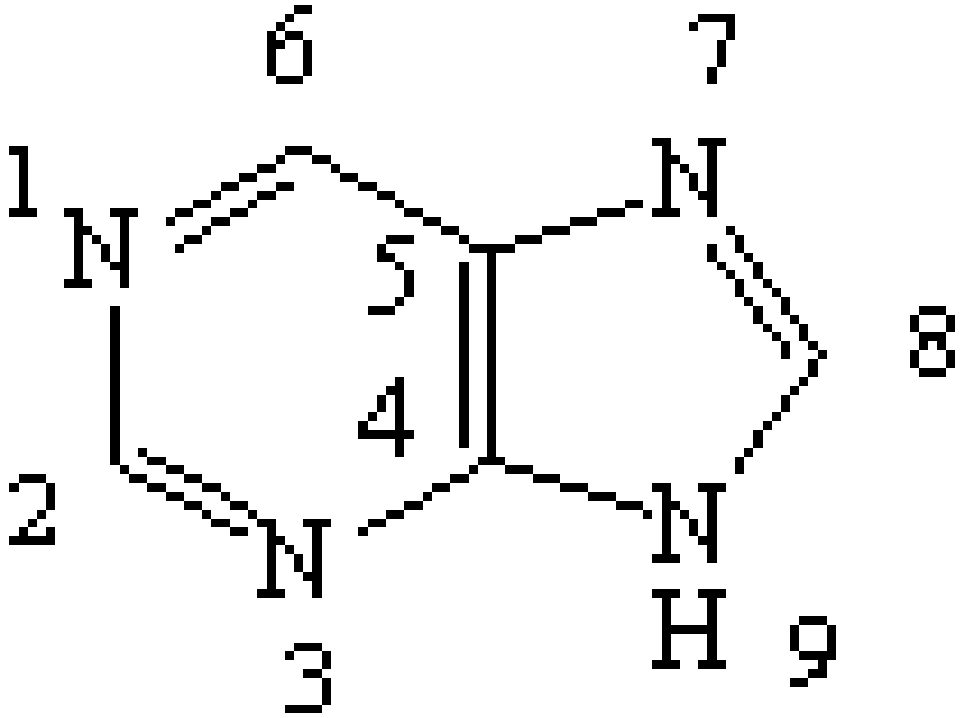


Thymine is produced by adding a methyl group to Uracil).

Purines Bases:

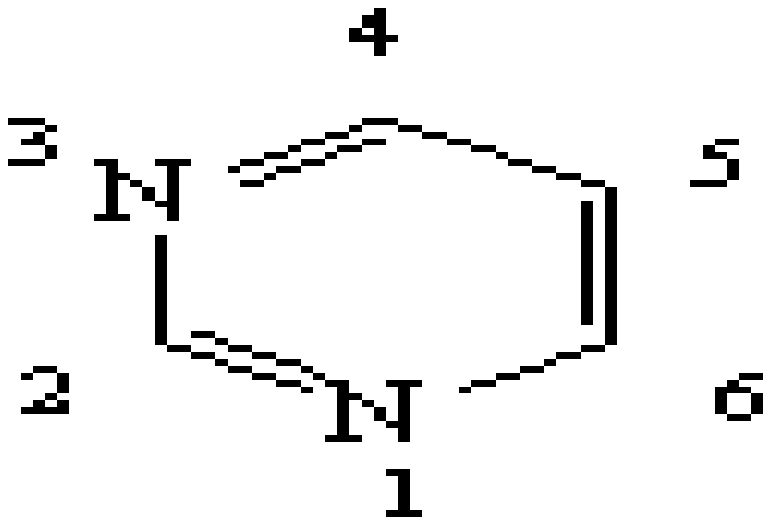
- Purines consist of linked five - membered and six-membered rings.

- Numbering is anticlockwise



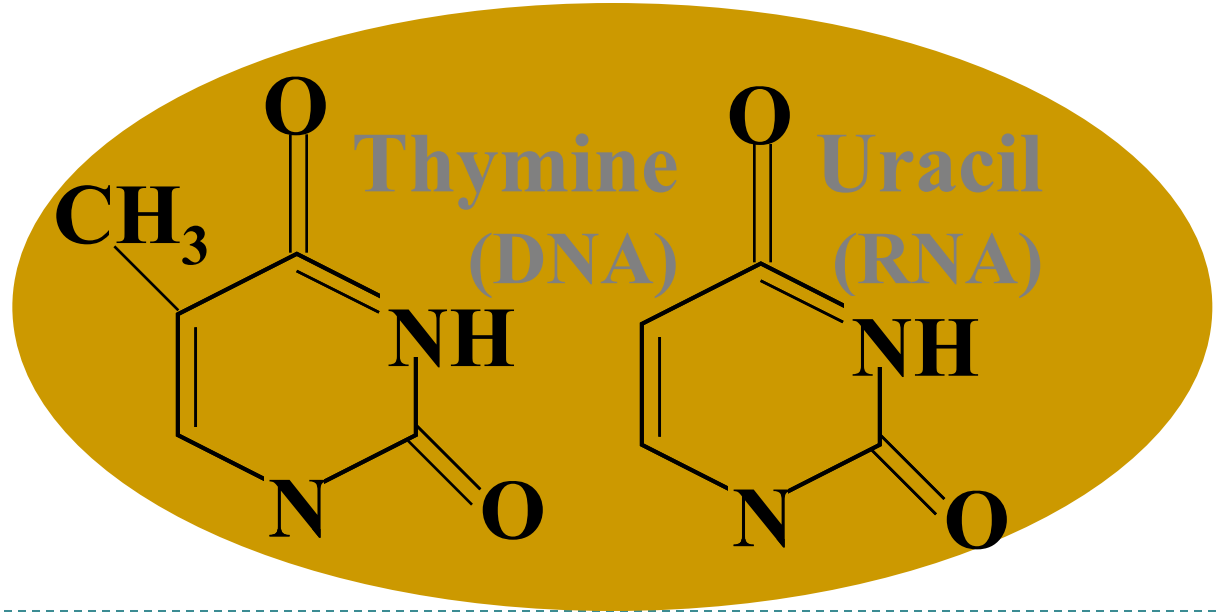
Types of Pyrimidine Bases:

- Pyrimidines in DNA: Cytosine (**C**) & Thymine (**T**).
- Pyrimidines in RNA are Cytosine (**C**) and uracil (**U**).
- **Cytosine** can be found in **DNA** and **RNA**.
- **Thymine** is found only in **DNA**, while **Uracil** found only in RNA.



Types of nitrogenous bases:

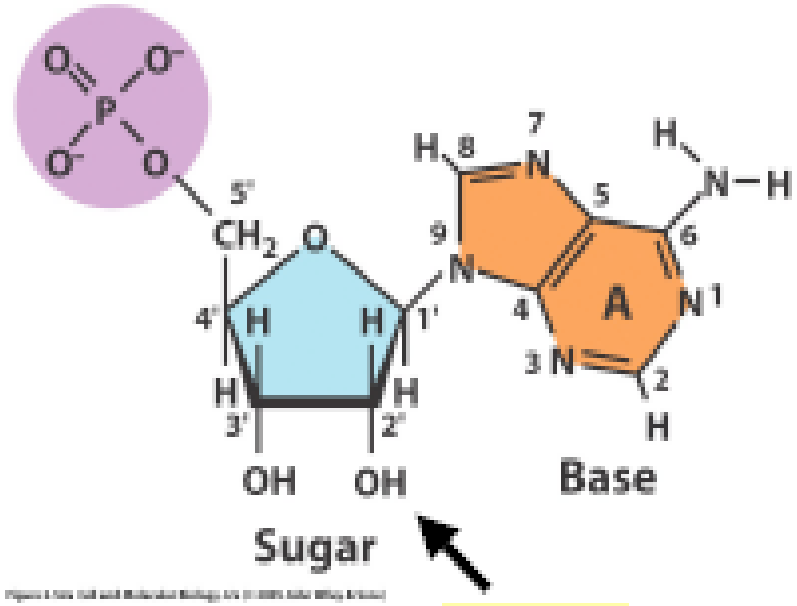
In DNA, the purine bases are adenine and guanine, while the pyrimidines are thymine and cytosine. RNA uses uracil rather than thymine (thymine is produced by adding a methyl to uracil).



Types of nitrogenous bases:

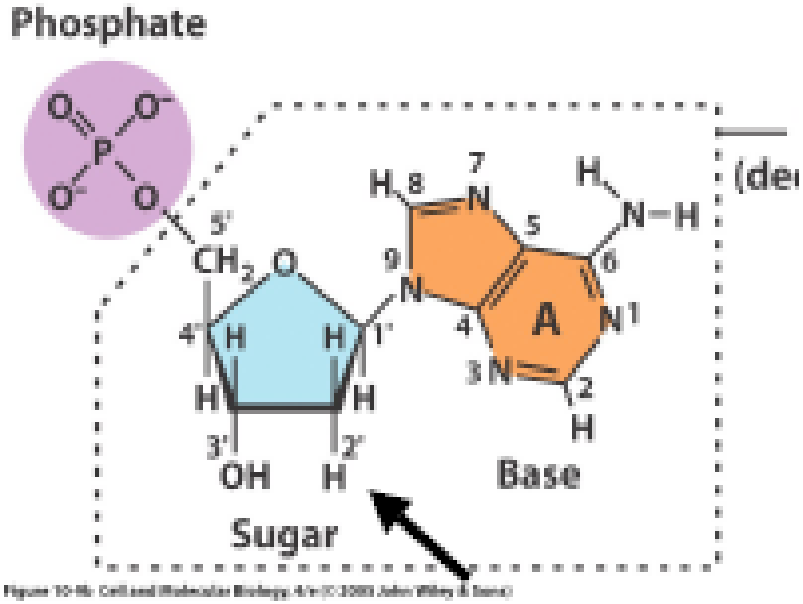
Ribonucleotide

Bases: A U C G



Deoxyribonucleotide

Bases: A T C G

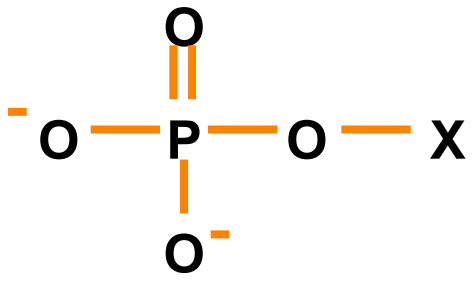


What is Phosphate ?

Phosphate groups are what makes a nucleoside a nucleotide (Nucleoside = Base + sugar).

Phosphate groups are essential for nucleotide polymerization.

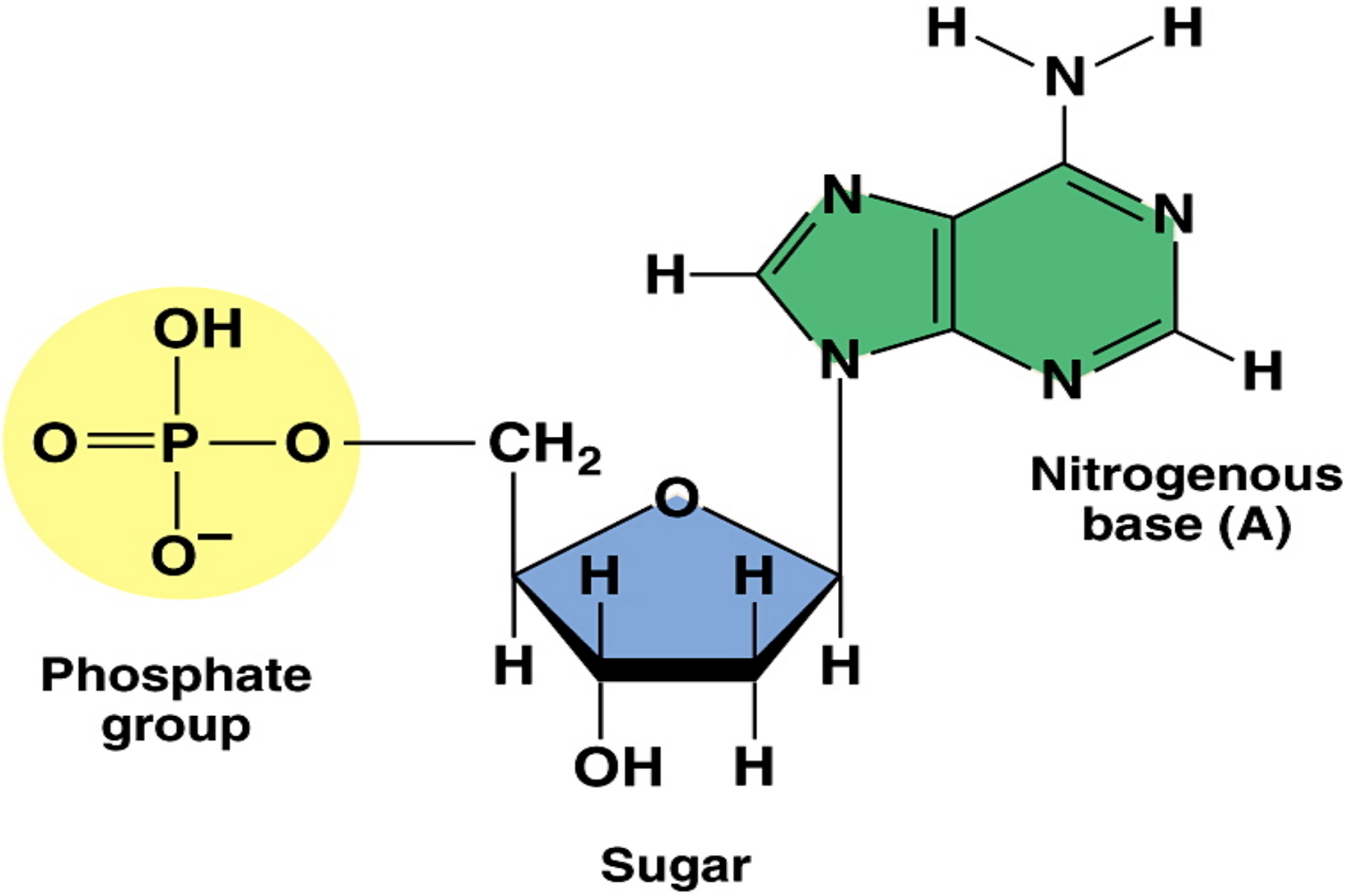
Basic structure:



➢ Phosphate Groups:

- A nucleotide contain a single phosphate group, which gives nucleic acids their acidity and negative charge .
- Phosphates can be attached through the oxygen of the hydroxyl group of either C3 or C5 atoms of the sugar.
- It is more commonly attached to C5.

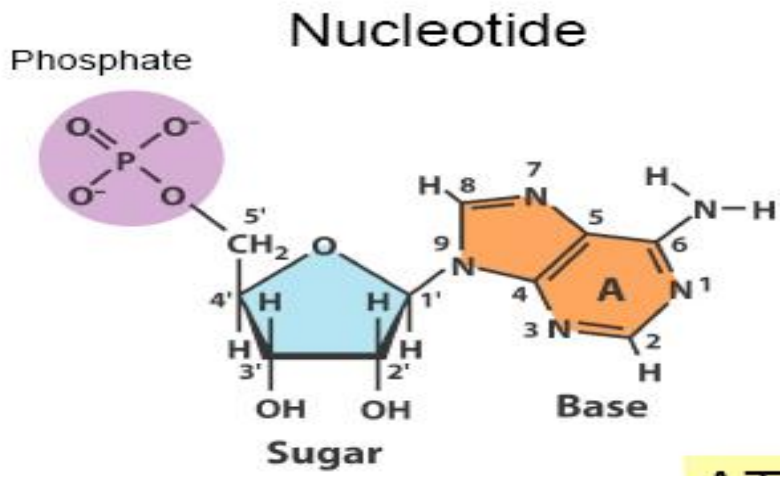
General Structure of Nucleotides:

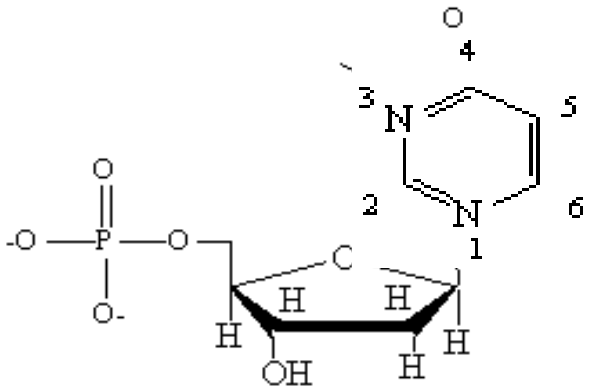


Structure of Nucleotides:

- **Result from linking C1 ribose with a purine or pyrimidine base through an N- glycosidic linkage.**

- **Purines bond with N9 atoms.**
- **Pyrimidines N1 atom.**





Naming Conventions:

- Nucleosides:
  - Purine nucleosides end in "-sine"
    - Adenosine, Guanosine.
  - Pyrimidine nucleosides end in "-dine"
    - Thymidine, Cytidine, Uridine

Naming Conventions:

- Nucleotides:
  - Start with the nucleoside name from above and add "mono-", "di-", or "triphosphate"
  - Adenosine Monophosphate, Cytidine Triphosphate, Deoxythymidine Diphosphate

Naming Conventions:

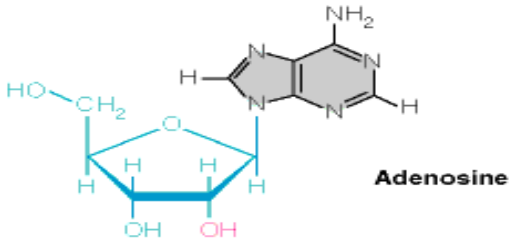
Purine Base	Nucleoside	Nucleotide
Adenine (A)	Adenosine	Adenosine mono phosphate (AMP)
Guanine (G)	Guanosine	Guanosine Mono P. (GMP)

Naming Conventions:

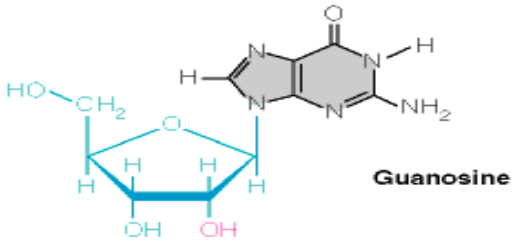
Pyrimidine Base	Nucleoside	Nucleotide
Cytosine (C)	Cytidine	CMP
Uracil (U)	Uridine	UMP
Thiamine (T)	Thymidine	TMP

Differences between Nucleosides and Nucleotides:

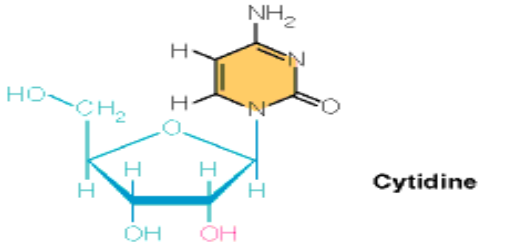
NUCLEOSIDES



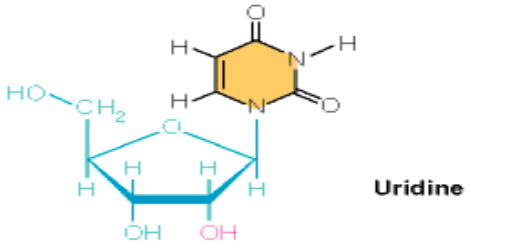
Adenosine



Guanosine

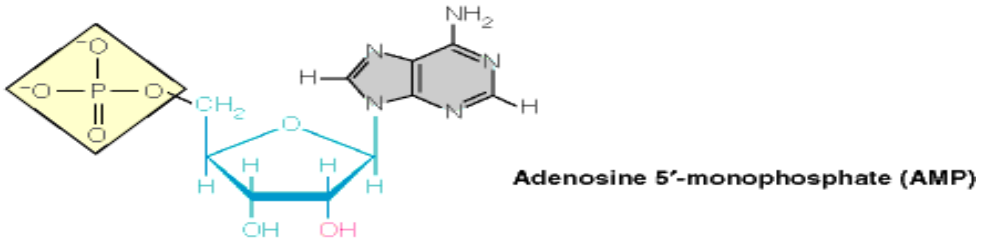


Cytidine

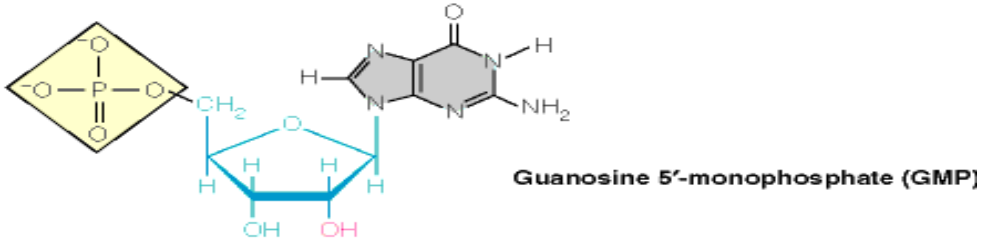


Uridine

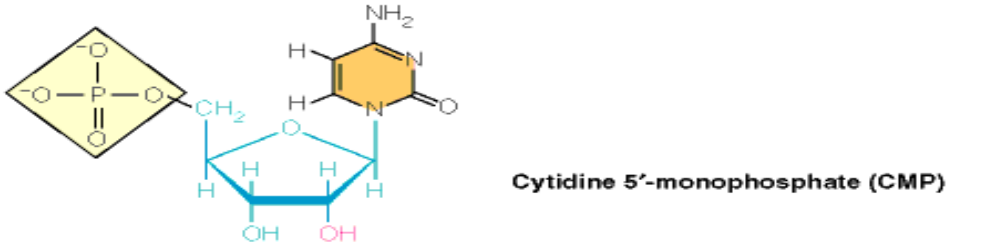
NUCLEOTIDES



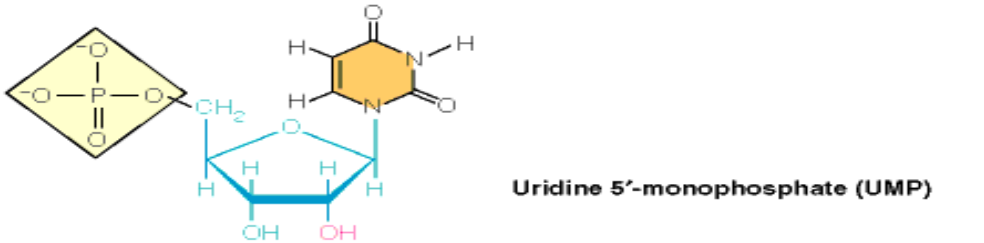
Adenosine 5′-monophosphate (AMP)



Guanosine 5′-monophosphate (GMP)



Cytidine 5′-monophosphate (CMP)



Uridine 5′-monophosphate (UMP)

Functions of Nucleotides

Functions of Nucleotides:

1.Bluiding blocks of nucleic acids (DNA , RNA).

2. Nucleotide triphosphates are major biologic transducer of free energy (ATP, GTP).

3. Important components of Co-enzymes: FAD+, NAD+ .

4. Acts as a second messenger, (c-AMP).

Functions of Nucleotides:

5. UDP- Glucuronic acid is donor for conjugation reactions that requires for conjugates of bilirubin.

6. Activation of metabolic Intermediates (e.g. UDP-glucose, act as glucose donor for synthesis glycogen.

Summary

- Nucleosides are found in the cell primarily in their phosphorylated form. Called nucleotides
- Nucleotide = Base + sugar(nucleosides) +Phosphate
- The most common site of phosphorylation of nucleotides found in cells in the hydroxyl group attached to the 5'-carbon of the ribose.
- Nucleotides can exist in the mono-, di-, or tri-phosphorylated forms.

References:

1-lipincotts biochemistry 8th edition 2022

2. Harpers 25th , 27th and 32nd edition 2023

3- Lehninger principles biochemistry 8th edition 2021

4- Medical biochemistry 6th edition 2023

5- Mark Basic Medical biochemistry 6th edition 2023

6- Stryer biochemistry


Thank You