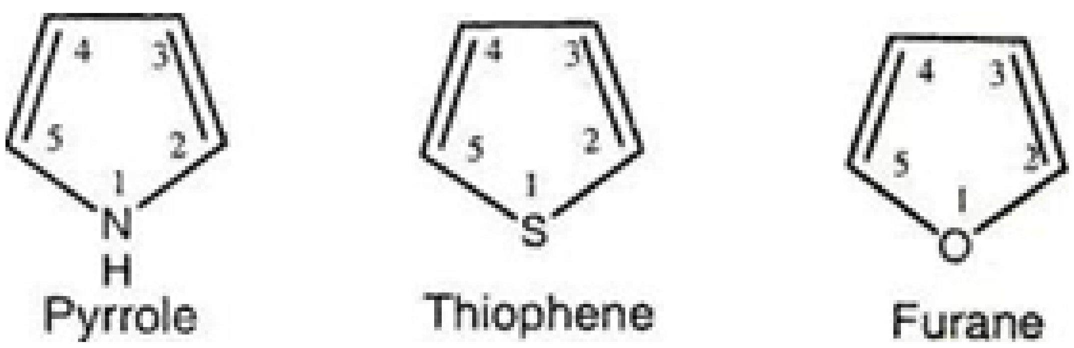
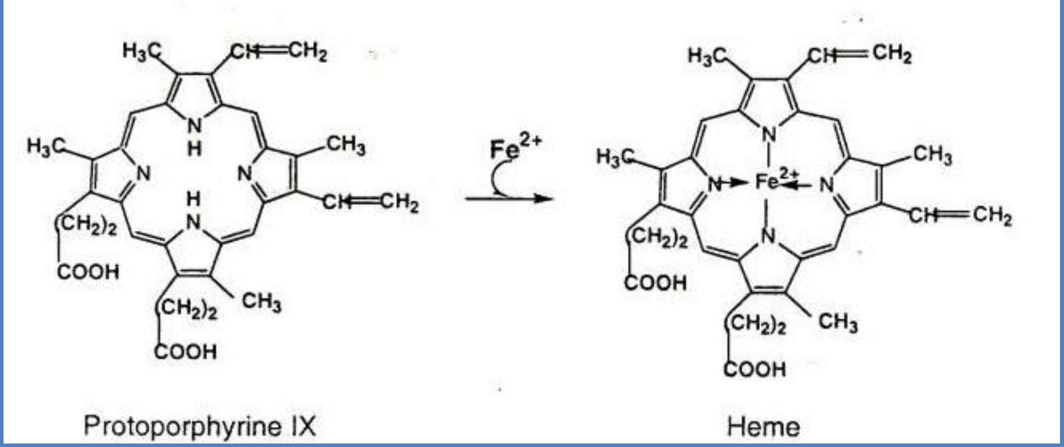
Heterocyclic compounds

- The cyclic compounds which in addition to carbon contain in the ring at least one atom of another element *(heteroatom),* are called *heterocyclic compounds* or simply *heterocycles.*
- The common heteroatoms present in heterocyclic rings are N, O and S.
- There are three, four, five, six and seven membered heterocycles containing one or more (usually two) heteroatoms.

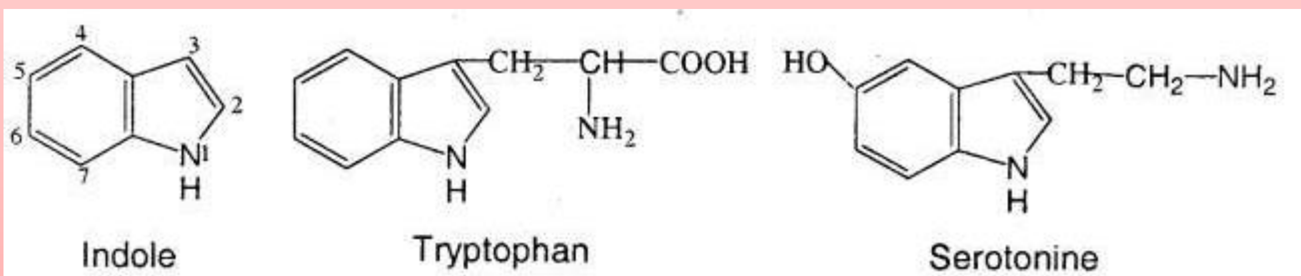
Five membered heterocycles containing the single heteroatom



- *Pyrrole* is widely distributed as a structural component of a great variety of biomolecules and drugs.
- Four pyrrole residues constitute the molecules of the *porphyrines.*

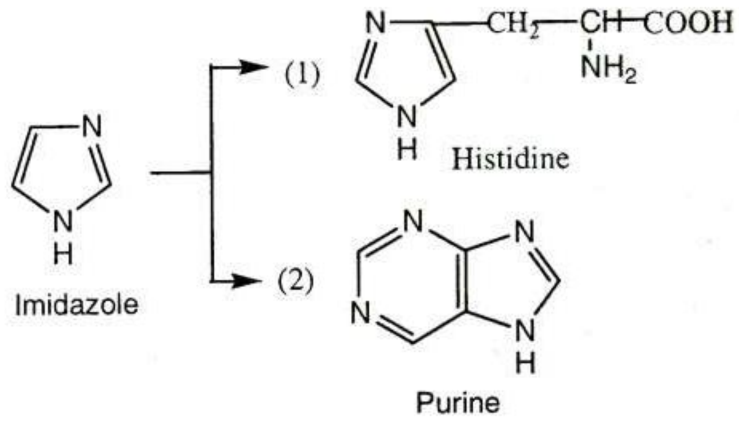


- Pyrrole can also take part in making the condensed ring heterocycle *indole,* which derivatives constitute a group of vital biomolecules, for example amino acid *tryptophan,* neurotransmitter *serotonin*



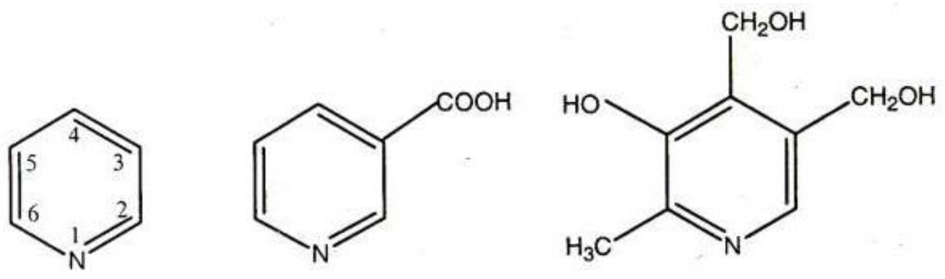
Five membered heterocycles containing two heteroatoms

- The five membered heterocycles which contain two atoms of nitrogen are called *azoles*.



Six membered heterocycles containing the single heteroatom

- The mostly common representative of this group is *pyridine,* the hetero-cyclic compound which contains the single nitrogen atom.



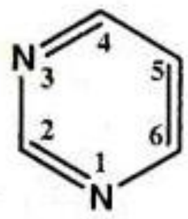
Pyridine

Nicotinic acid (Vitamin PP)

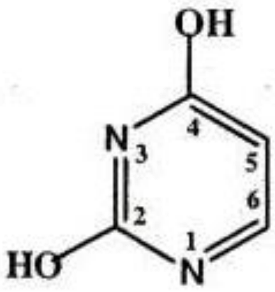
Pyridoxol (Vitamin B_6)

Six membered heterocycles containing two heteroatoms

- The six membered heterocycles which contain two atoms of nitrogen are called *diazines.*



Pyrimidine



Uracil

NUCLEIC ACIDS

- Nucleic acids are polymers of *nucleotides* (or *mononucleotides).*

- In accordance with their structure and properties nucleic acids are divided into two classes: *deoxyribonucleic acids (DNAs)* and *ribonucleic acids (RNAs).*
- The fundamental biological significance of nucleic acids is the storage, intracellular transmission and expression of genetic information.

Nucleic Acids are:

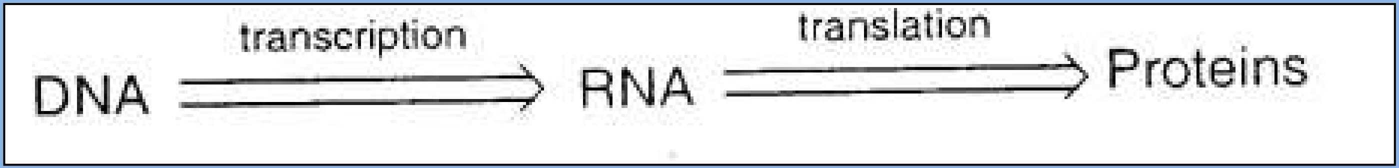
DNA (deoxyribonucleic acid):

- giant polymers that carry instructions for making proteins

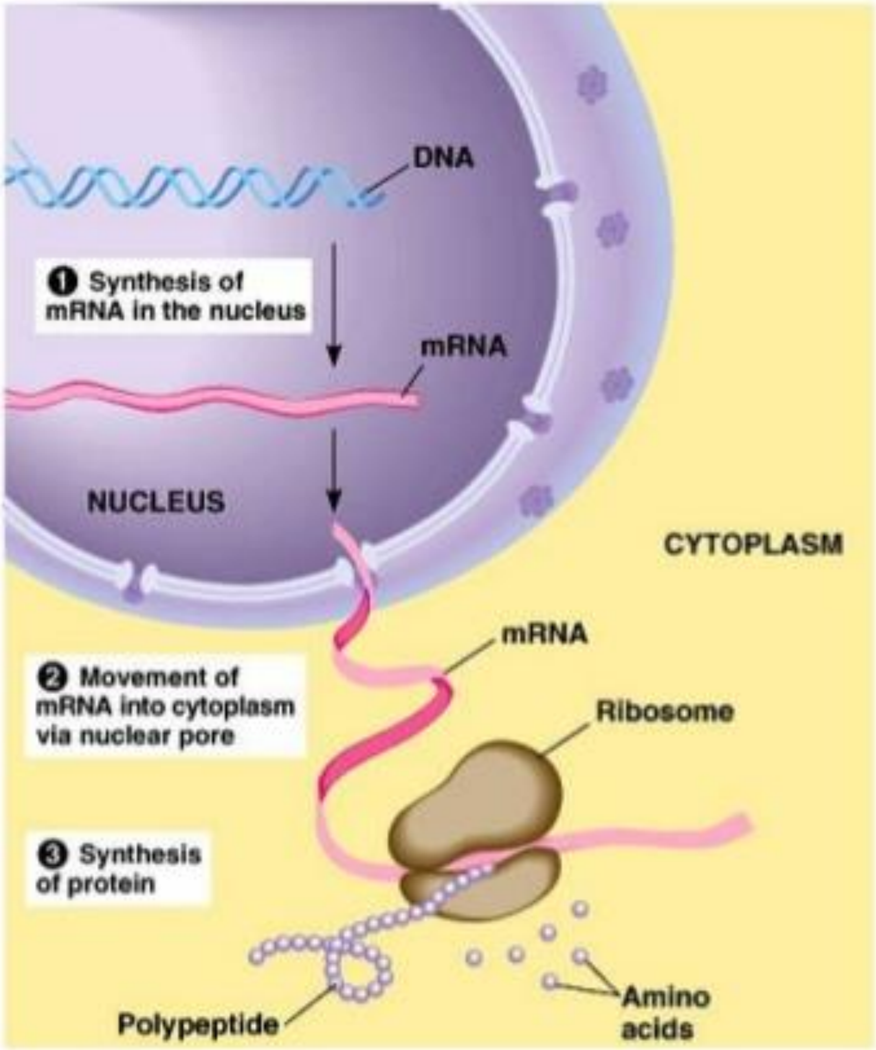
RNA (ribonucleic acid):

- interpret and carry out the instructions coded in the DNA

- The transfer of genetic information from DNA to messenger RNA is called *transcription*
- and the synthesis of proteins according to instructions given by mRNA templates - *translation.*
- Thus, the flow of genetic information in living cells can be represented in this way:



Nucleic acids store the information to make proteins

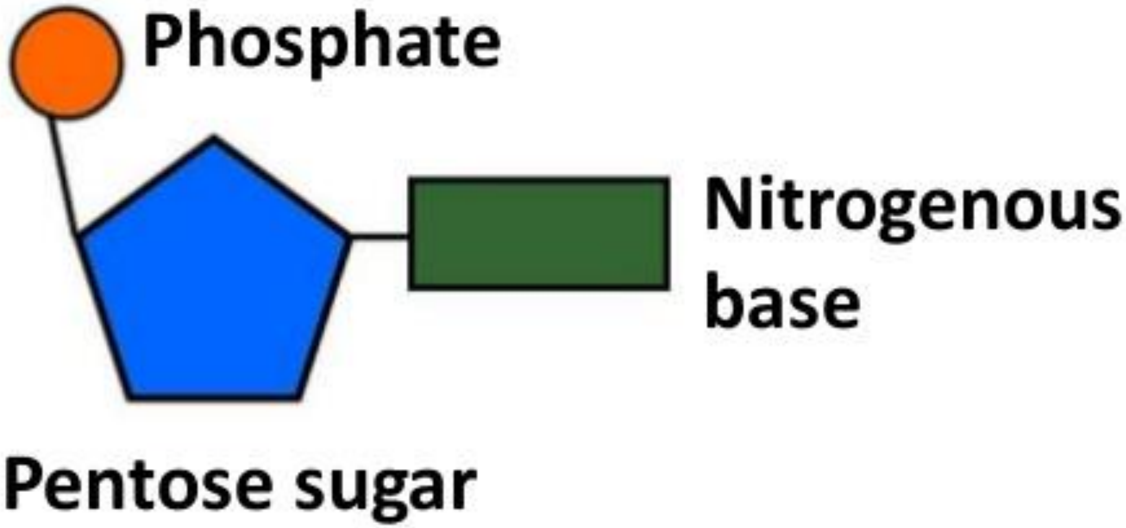


- Each monomeric unit of nucleic acid, that is **nucleotide,** consists of a *nitrogenous base* which is a certain heterocycle *of purine or pyrimidine* class, a *pentose* sugar and a *phosphate residue.*
- **Nucleotide = nitrogenous base + pentose + phosphate; Nucleoside = nitrogenous base + pentose,**
- **Nucleotide = nucleoside + phosphate.**

Monomers of nucleic acids:

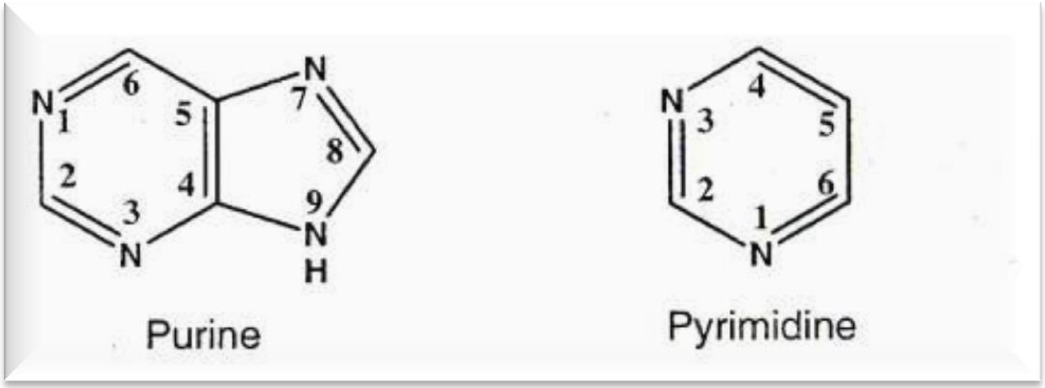
nucleotides

A **nucleotide** consists of a:

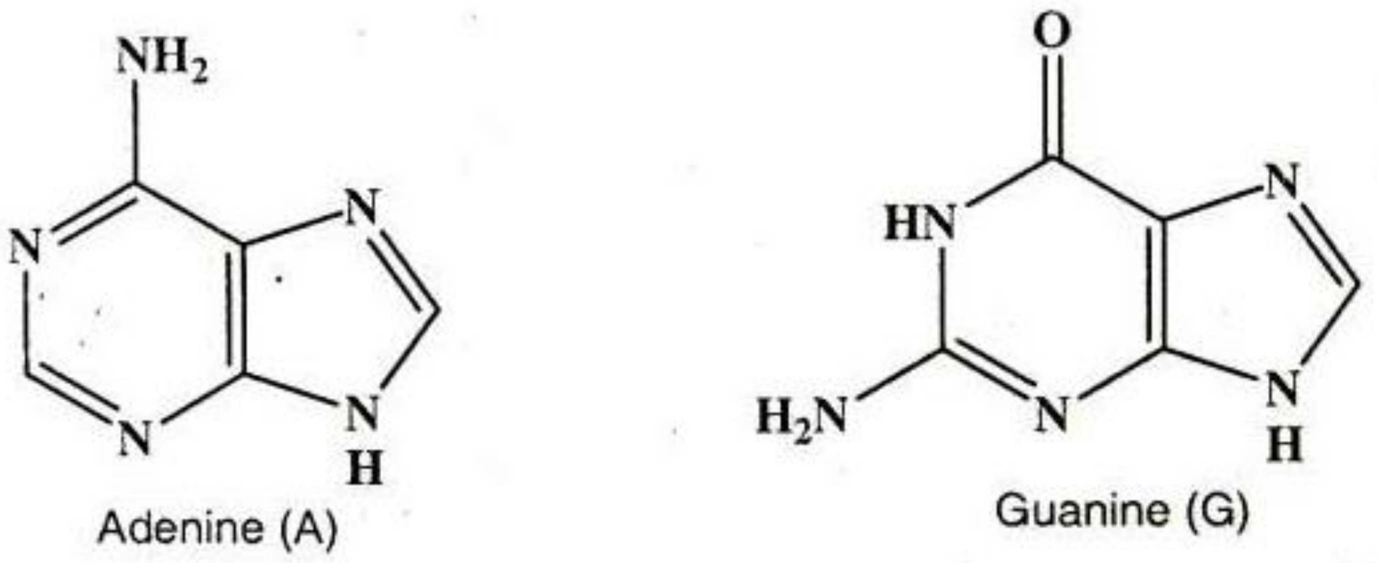


Nitrogenous bases of nucleotides

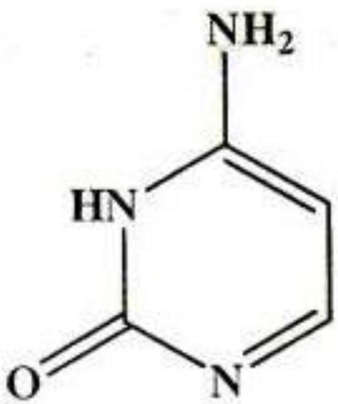
- Nitrogenous bases, the key components of nucleotides and, to proceed from this of nucleic acids, are heterocyclic amines, derivatives of ***purines*** and ***pyrimidines.***



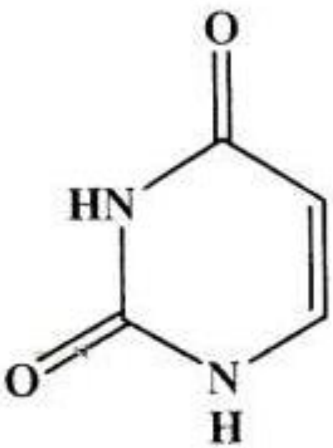
Purines are ***adenine*** (6-aminopurine) *and* ***guanine*** (2-amino-6-oxo-purine):



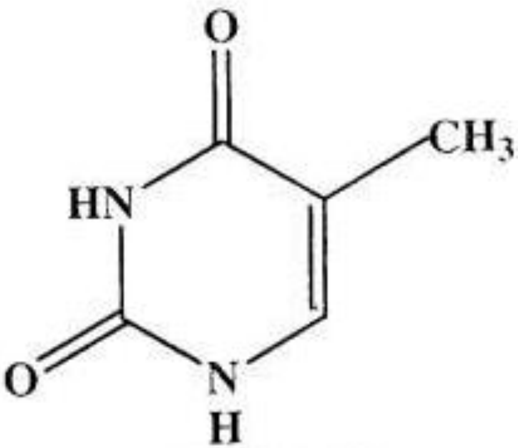
Pyrimidines are cytosine, uracil, thymine:



Cytosine (C)



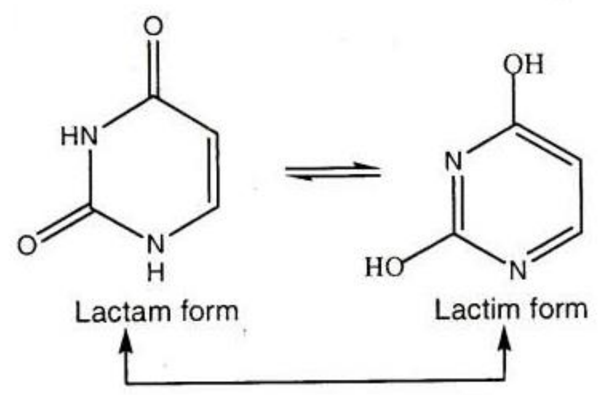
Uracil (U)



Thymine (T)

Tautomeric forms of nucleotides nitrogenous bases

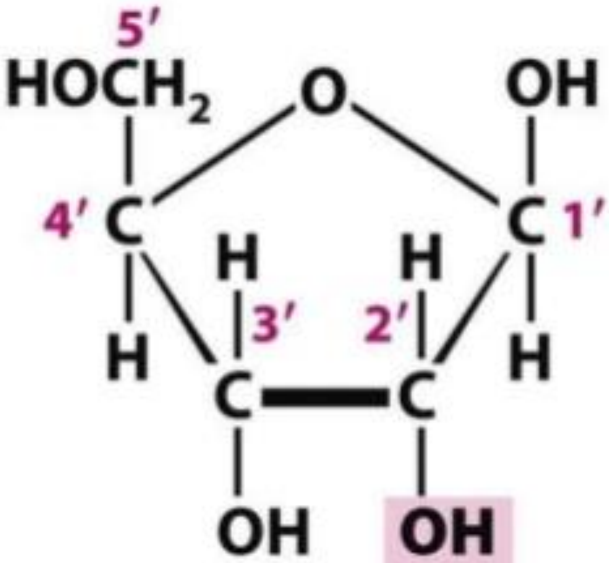
- The variant of structural isomerism is *Tautomerism,* which is characteristic to nitrogenous bases of nucleotides.
- Under *keto-enol* (also called *lactam-lactim)* Tautomerism, the hydrogen atoms on the nitrogenous bases can change their location to produce a tautomer.
- nitrogenous bases exist normally in *keto {lactam)* forms



Tautomeric forms of uracil

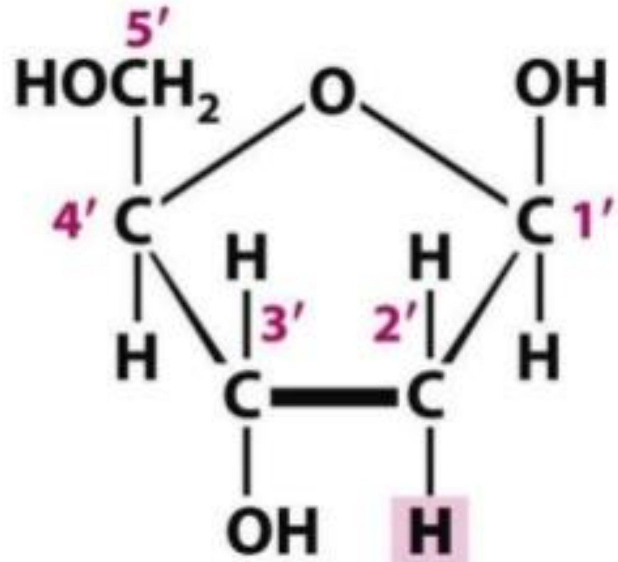
Sugars in:

RNA

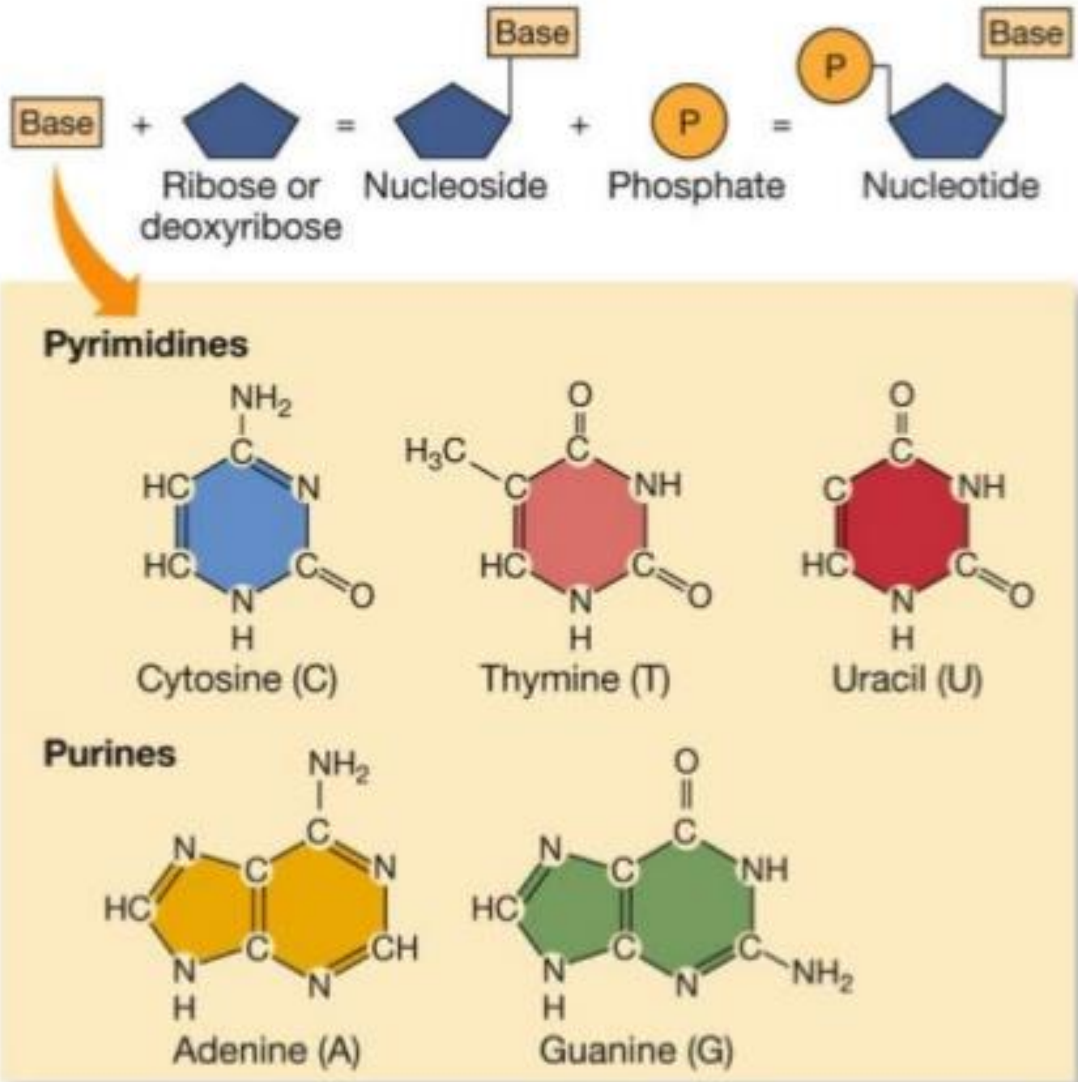


Ribose

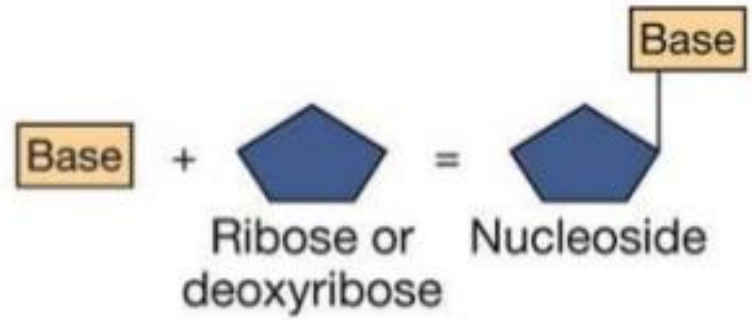
DNA



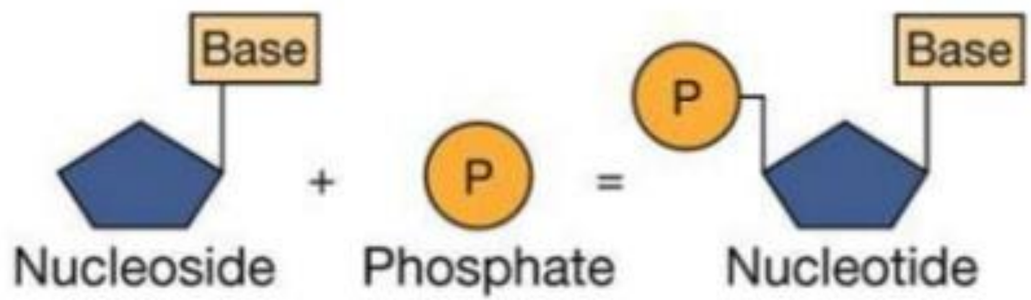
Deoxyribose


Base
Ribose or deoxyribose
Nucleoside
Phosphate
Nucleotide
P
Pyrimidines
Cytosine (C)
Thymine (T)
Uracil (U)
Purines
Adenine (A)
Guanine (G)

A NUCLEOSIDE is a base + sugar:



A nucleoside + a phosphate =

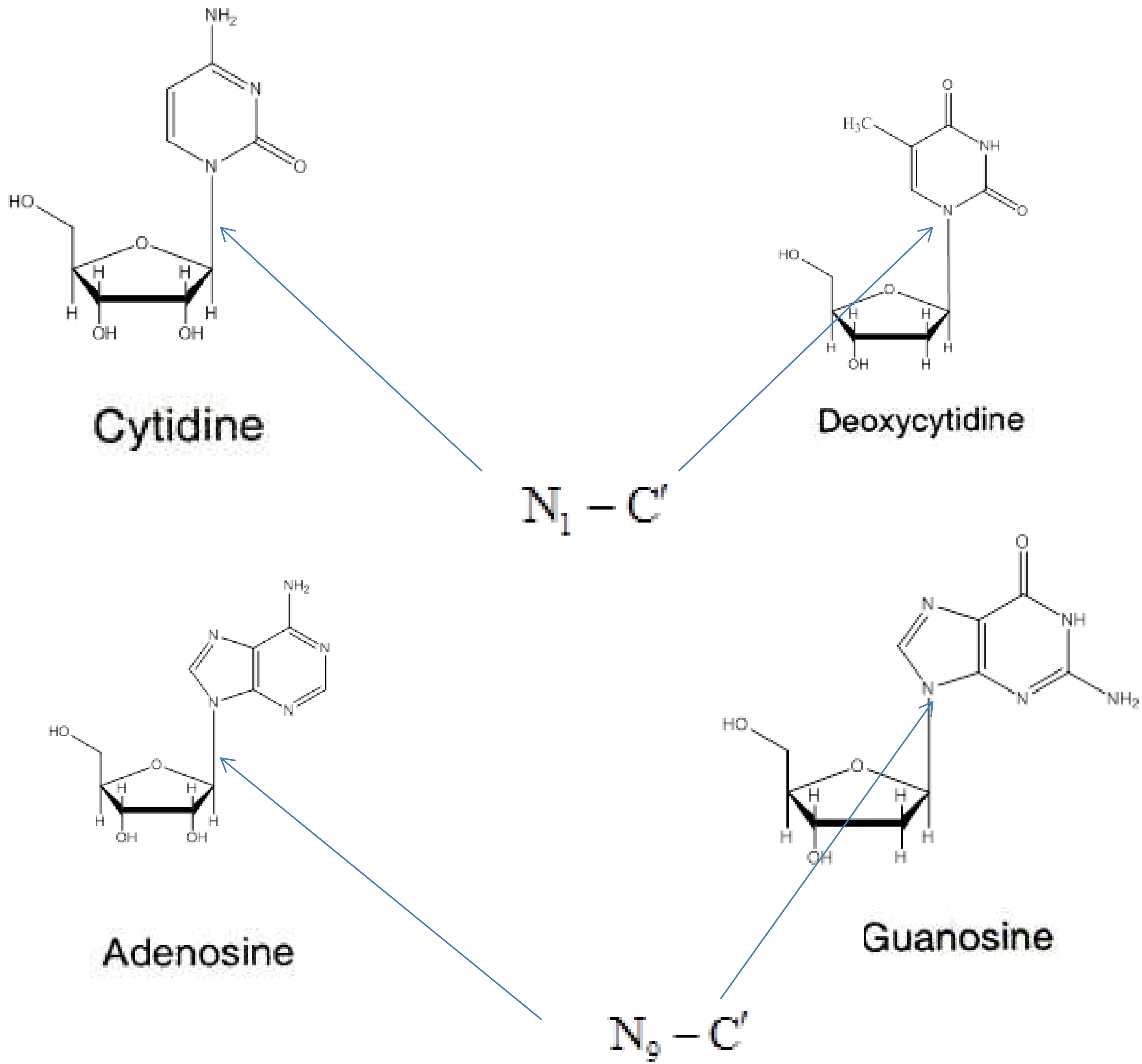


Nucleosides

- Chemically nucleosides are N-glycosides of ribose or 2′-deoxyribose and a certain nitrogenous base. They are *ribonucleosides* and *deoxyribonucleosides.*

Nucleosides

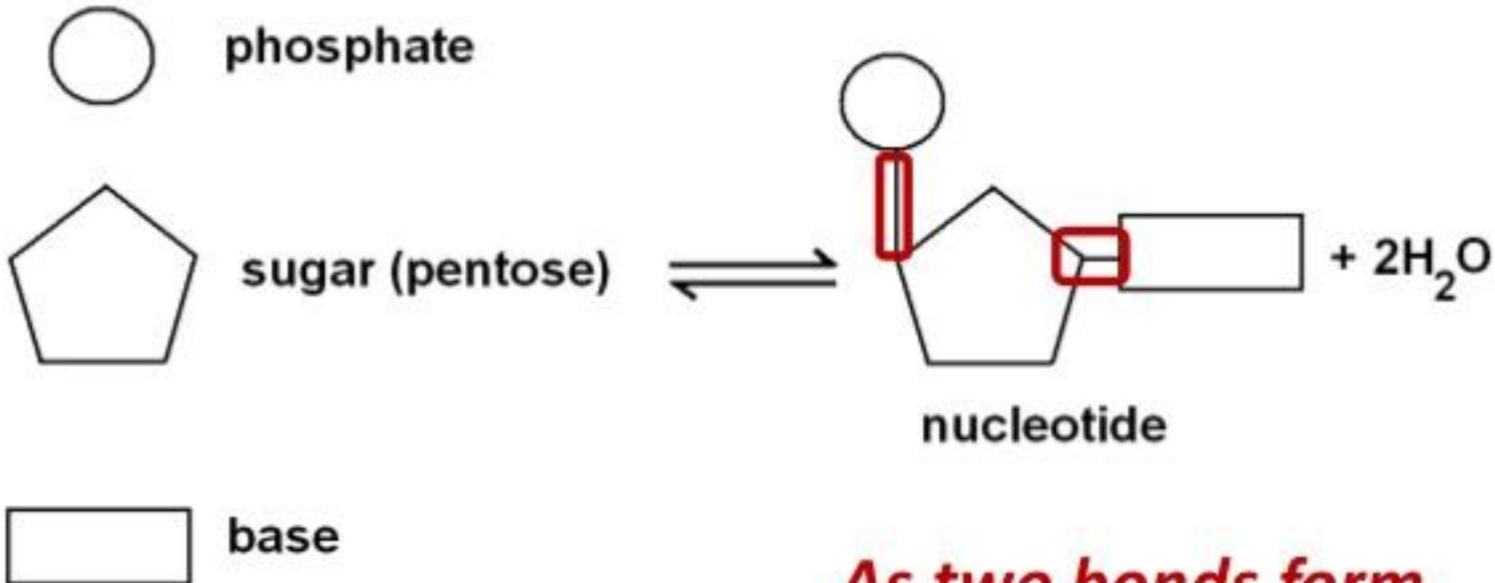
- In *ribonucleosides* N-9 of a purine or N-l of a pyrimidine is attached to C-l of ribose.
- In *deoxyribonucleosides* N-9 of a purine or N-l of a pyrimidine is attached to C-l of 2'-deoxyribose



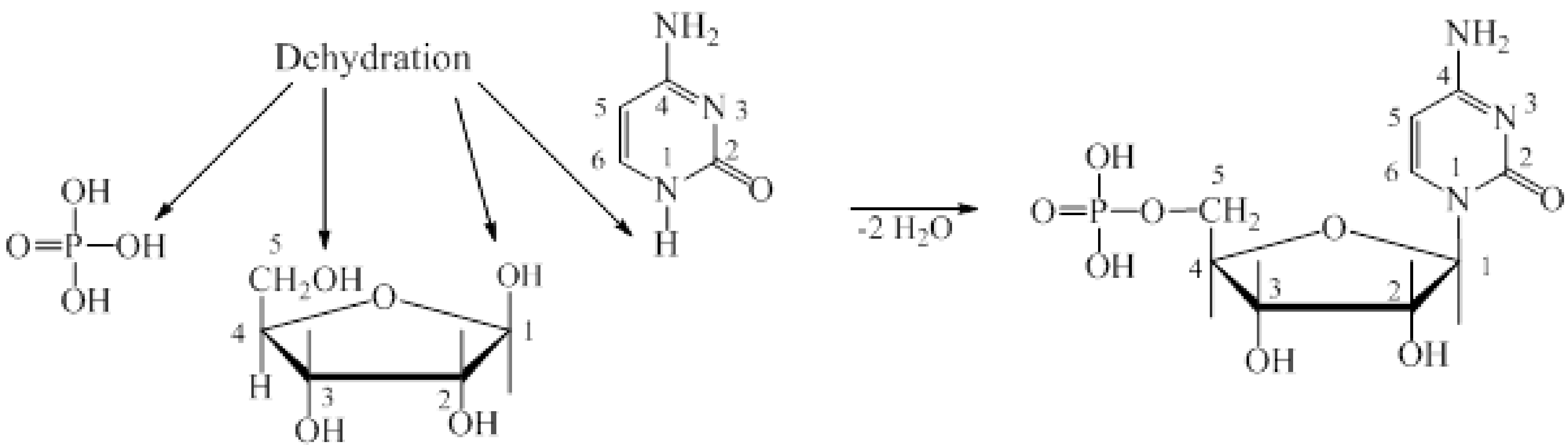
Cytidine
Deoxycytidine
$N_1 - C'$
Adenosine
Guanosine
$N_9 - C'$

NUCLEOTIDES FORMATION

Why are *two* water molecules formed?

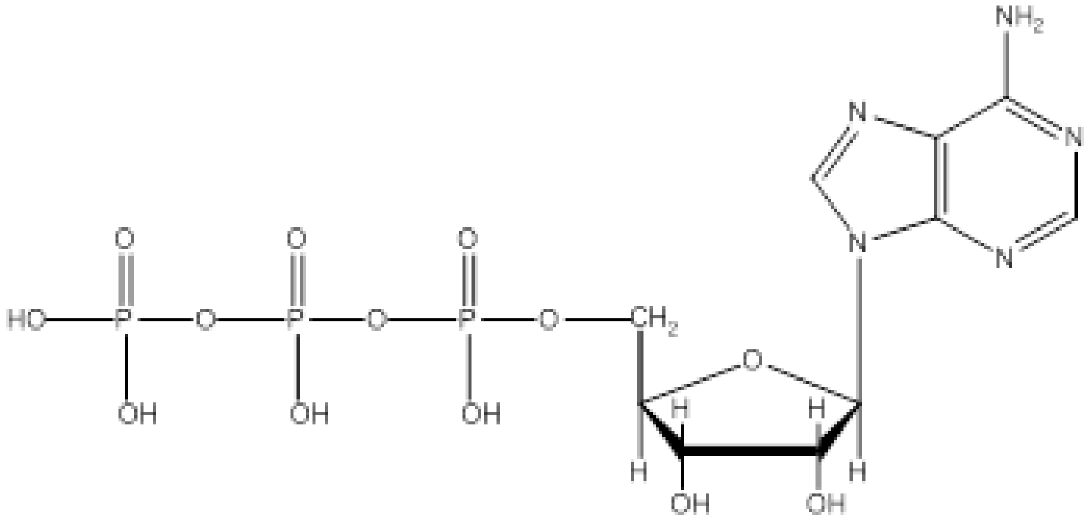


As two bonds form.

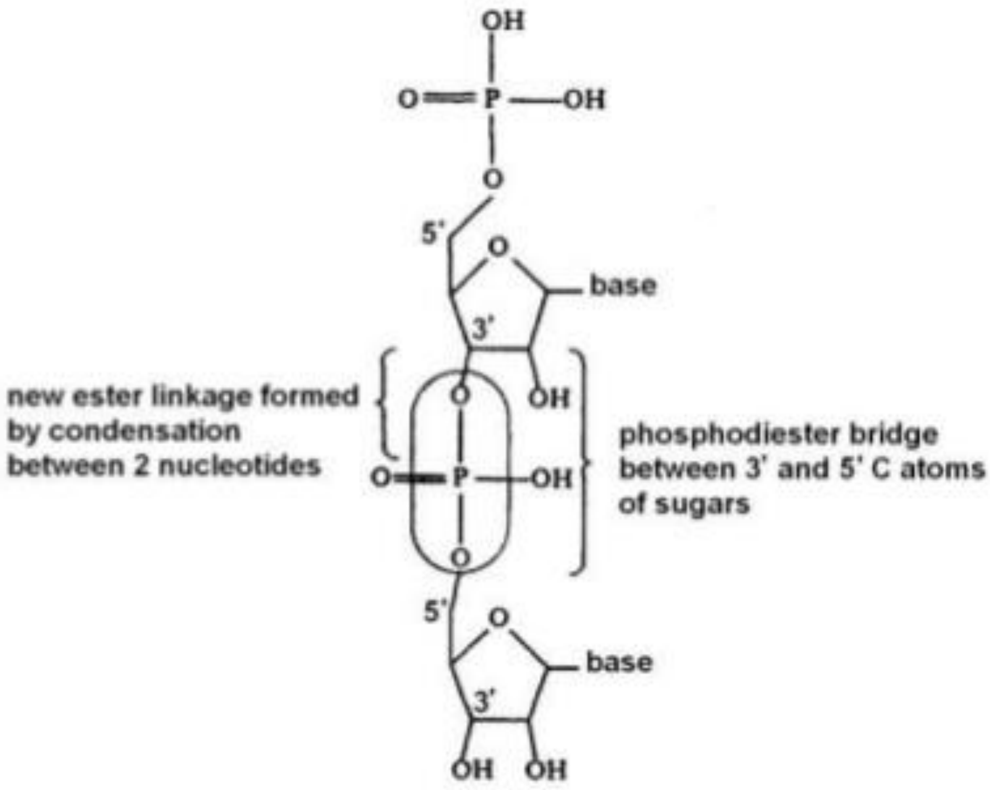


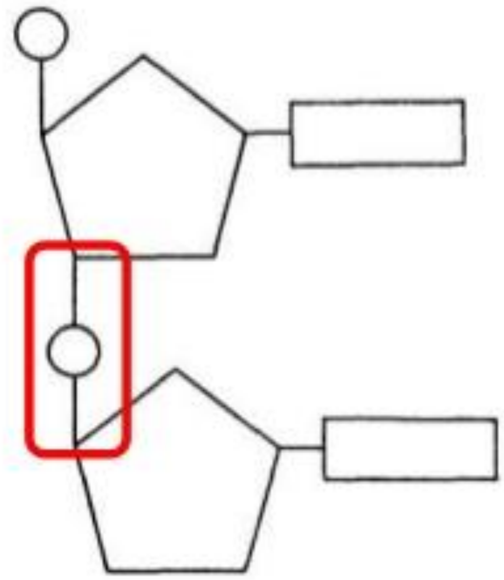
cytidine monophosphate
or cytidylic acid (CMP)

The universal currency of free energy in biological systems is nucleotide *adenosine triphosphate (ATP)*



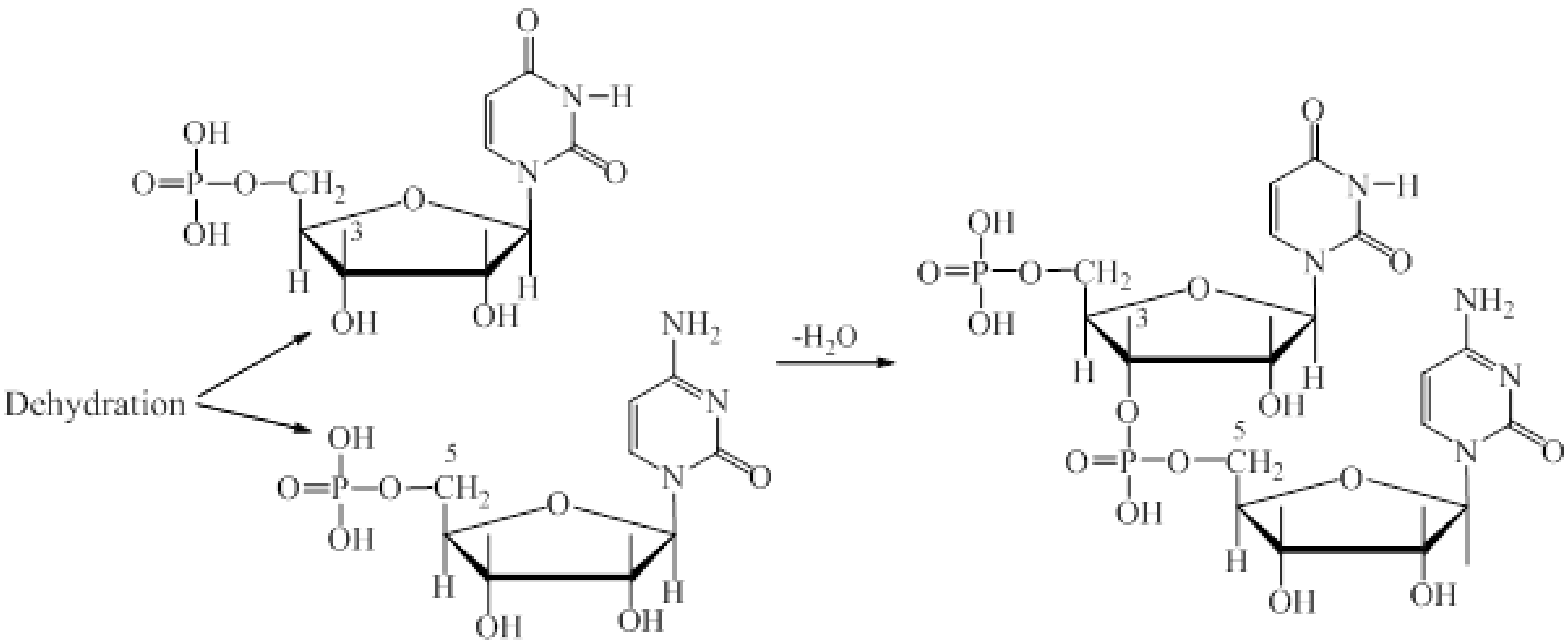
Formation of a dinucleotide





diagrammatically

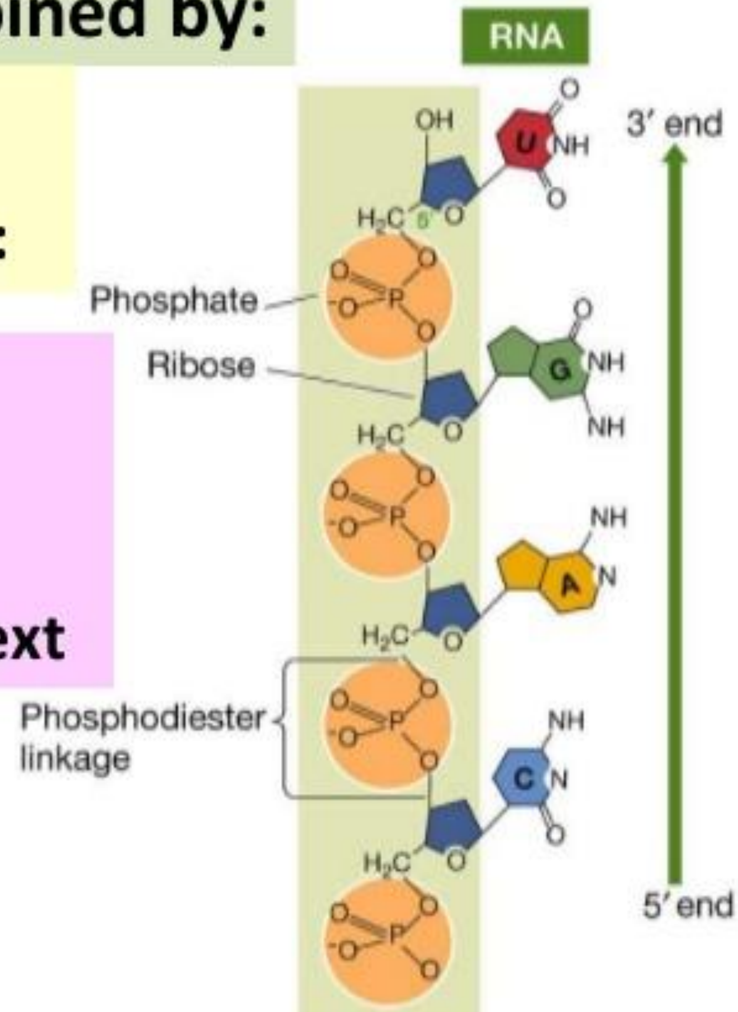
Phosphodiester bridge


Dehydration
$-H_2O$

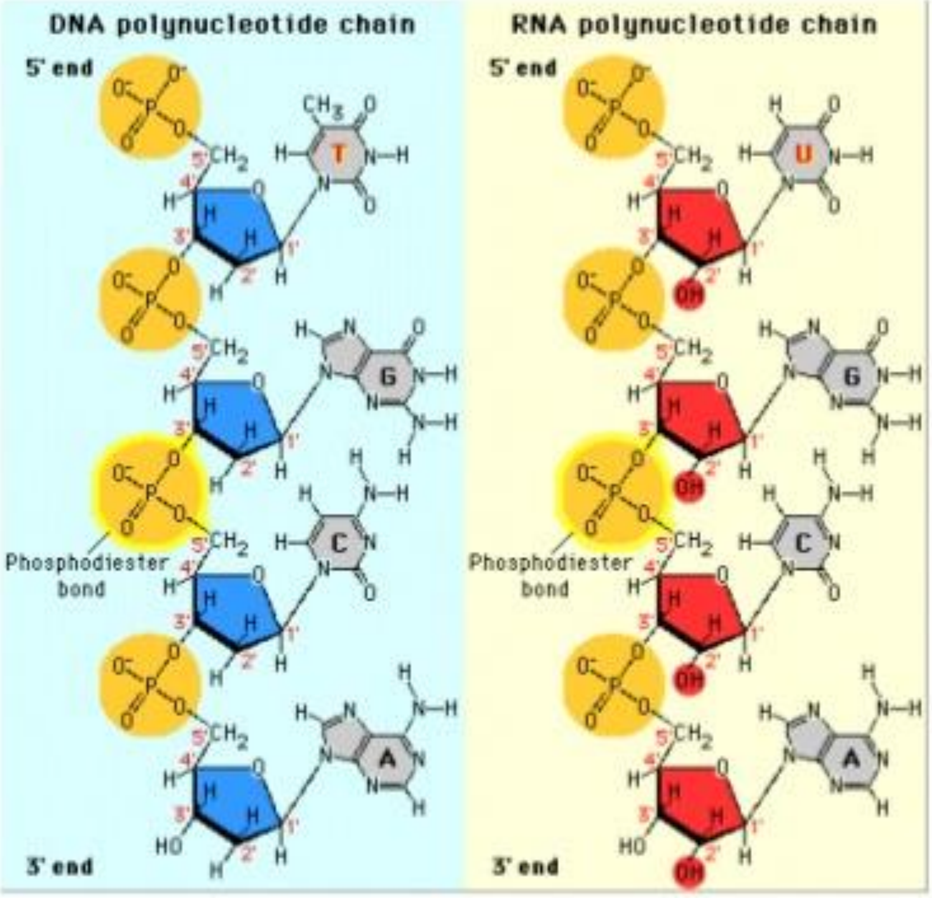
The nucleotides are joined by:

phosphodiester linkages between the:

- **sugar of one nucleotide**
- **phosphate of the next**



Two nucleotides join together to form a dinucleotide and many form a polynucleotide



The characteristic properties of DNA structure

- as proposed by Watson and Crick ("double helix" model) are as follows:
- **DNA molecule consists of two antiparallel polydeoxyribonucleotide chains.**
- **The two polydeoxyribonucleotide chains are held together by hydrogen bonds between pairs of bases (purines and pyrimidines).**
- ***adenine*** is always paired with ***thymine***, ***guanine*** is always paired with ***cytosine***.
- The corresponding bases are known as *comple-mentary.*

- According to this, in each DNA molecule the content *of* ***adenine*** equals the content of ***thymine,*** and the content of ***guanine*** equals the content of *cytosine,* which was long before known as ***Chargaff ʄs rules:***
- **A=T;G = C**

Structure of DNA