
بسم الله الرحمن الرحيم

By the end of lecture we will able to know : (basic chemistry of genetic)

Nucleic acid (chemistry and structure)

- Chemical structure of Nucleoside
- Chemical structure of Nucleotide
- Biomedical importance


KEEP
CALM
AND
ACTIVATE PRIOR
KNOWLEDGE

Nucleic Acids

Nucleic acids are a group of biomolecules present in the cell's nucleus. These nucleic acids are long polymers made of monomeric units called nucleotides.
There are two types of nucleic acids within the cells: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Both of them have vital functions within the cells.

Importance of Nucleic Acids

The DNA is the biological molecule that stores all the genetic information of the **cell.**
DNA carries on the genetic information from parent to offspring.
RNA is a key factor for protein synthesis. RNA is responsible for transferring the information contained in the DNA to make a particular protein needed in a specific process for a specific function.

HISTORY

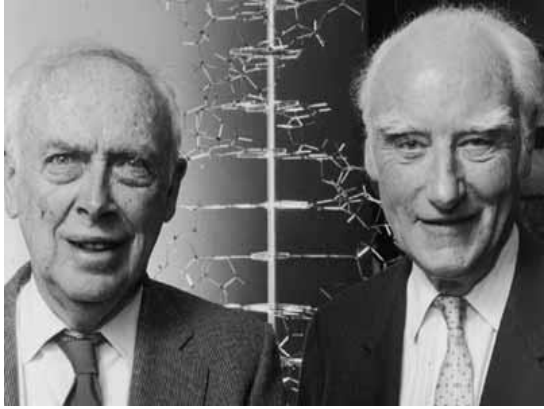
Rosalind Franklin - X-ray photo of DNA.

(1952)

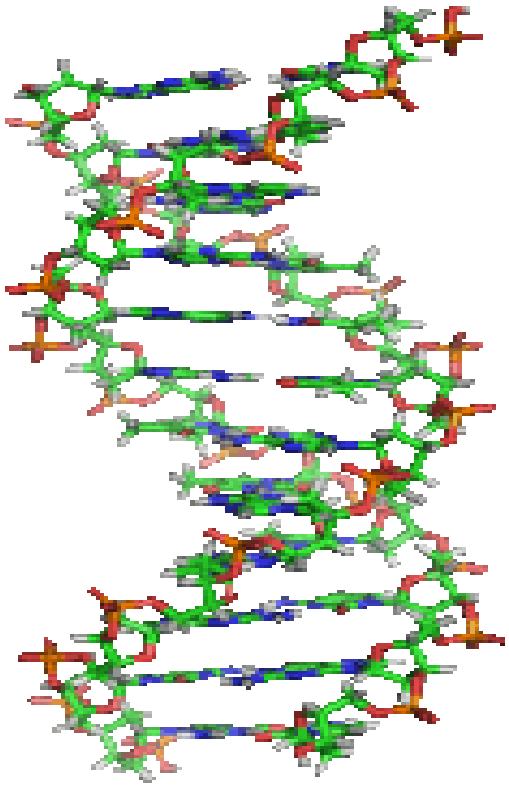
Watson and Crick - described the DNA molecule from Franklin's X-ray.

(1953)

1962 Nobel Prize

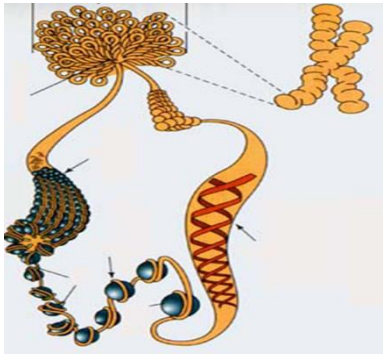


- *For their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material"*



NUCLEOPROTIENS

(proteolytic enzyme)



PROTEINS

(histones / protamine)

NUCLEIC ACID

DEOXYRIBONUCLEIC ACID

(deoxyribonuclease) | (DNA)

DEOXYRIBONUCLEOTIDE

deoxyribonucleotidos

Pi

DEOXYRIBONUCLEOSIDE

- deoxyribose sugar
- adenine
- guanine
- cytosine
- thymine

RIBONUCLEIC ACIDS

(ribonuclease) | (RNA)

RIBONUCLEOTIDE

(ribonucleotidase)

Pi

RIBONUCLEOSIDE

- ribose sugar
- adenine
- guanine
- cytosine
- uracil

NUCLEOPROTEINS

Nucleic acid + Proteins (Histone or protamine)
(Prosthetic group)

"Nuclease"

(Ribonuclease or deoxyribonuclease)
hydrolyses phosphodiester bond

Aqueous NH_3
115°C or
$Ba(OH)_2$

Nucleotides

Mononucleotidase (phosphatase)

Hydrolyses ester bond between sugar and phosphoric acid

MgO in solution

Nucleosides + Phosphoric acid

Inorganic acid

or *Purine/Pyrimidine Nucleosidases*

Bases

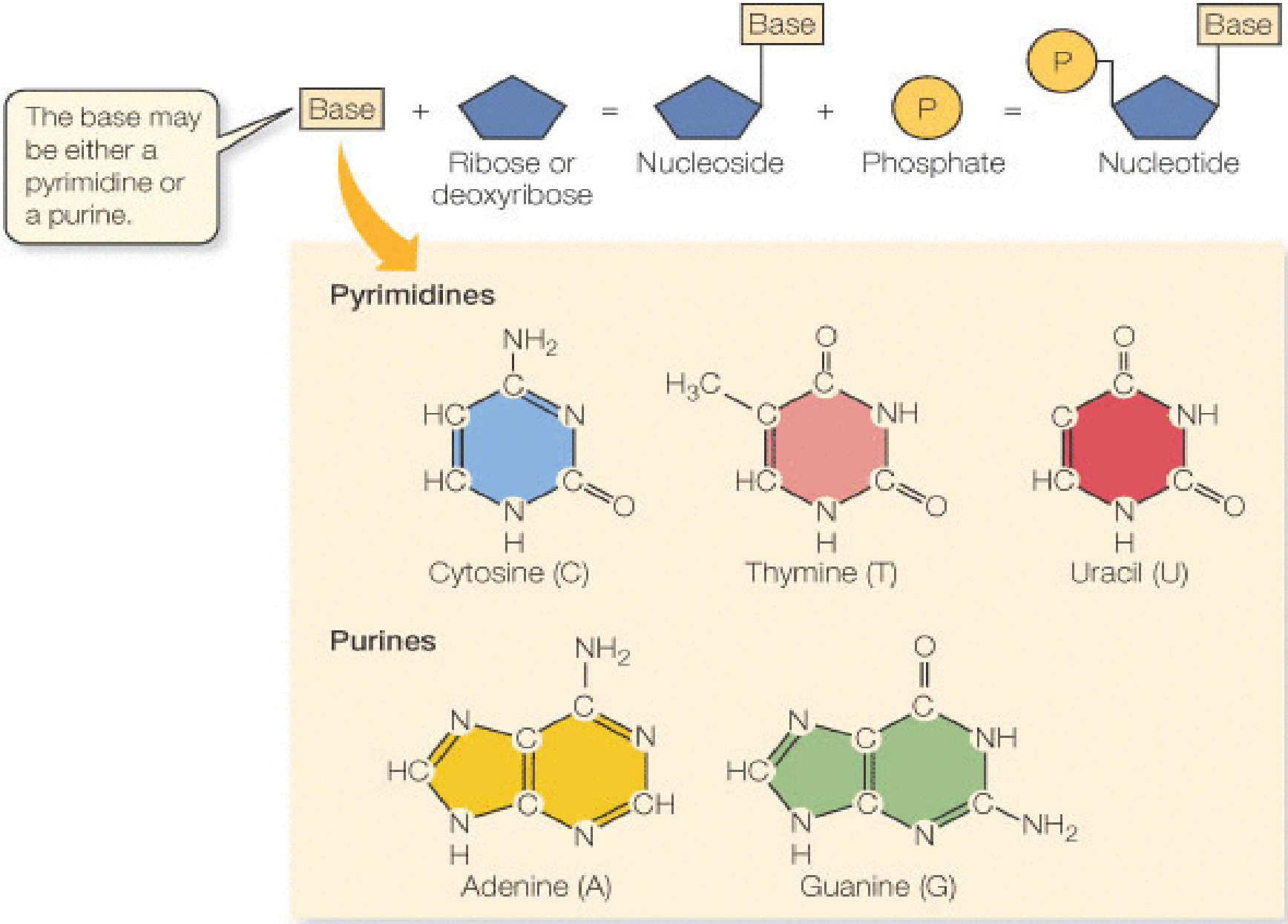
- **Purines or**
- **Pyrimidines**

+

Sugar

- **D-ribose**
- **or D-2-deoxyribose**

‘NUCLEOSIDE’


The base may be either a pyrimidine or a purine.
Base
+
Ribose or deoxyribose
=
Base
Nucleoside
+
P
Phosphate
=
P
Base
Nucleotide
Pyrimidines
Cytosine (C)
Thymine (T)
Uracil (U)
Purines
Adenine (A)
Guanine (G)

NUCLEOSIDE:

Nucleosides are composed of purine or pyrimidine bases linked to either ribose (RNA) deoxyribose (DNA) by **glycosidic bond**.

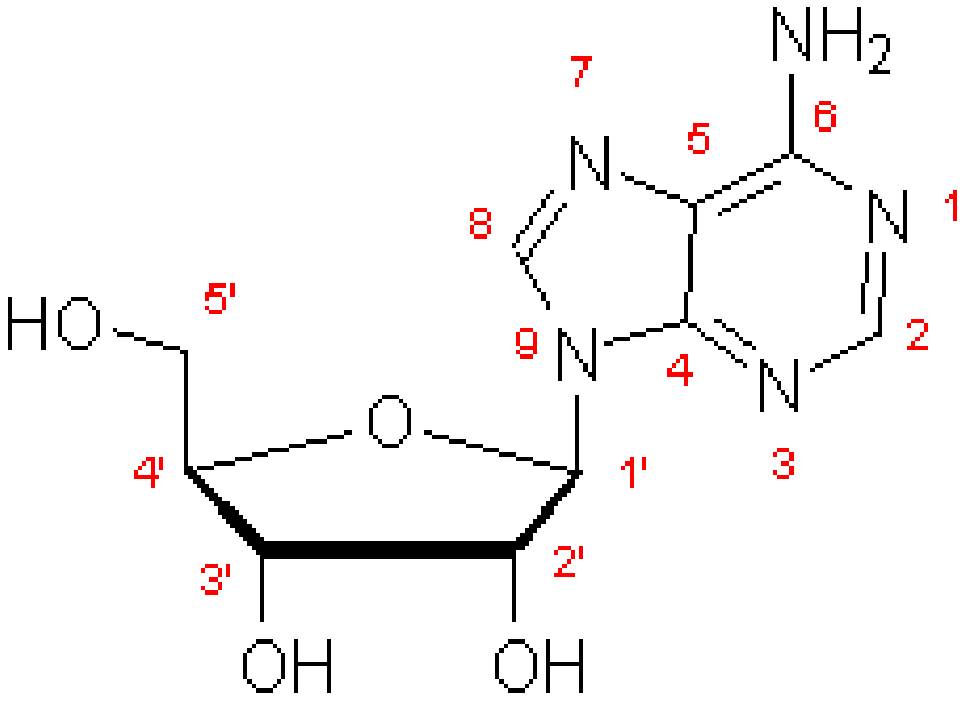
COMPONENTS OF NUCLEOSIDE

- Sugar

1. Ribose (RNA)
2. Deoxyribose (DNA)

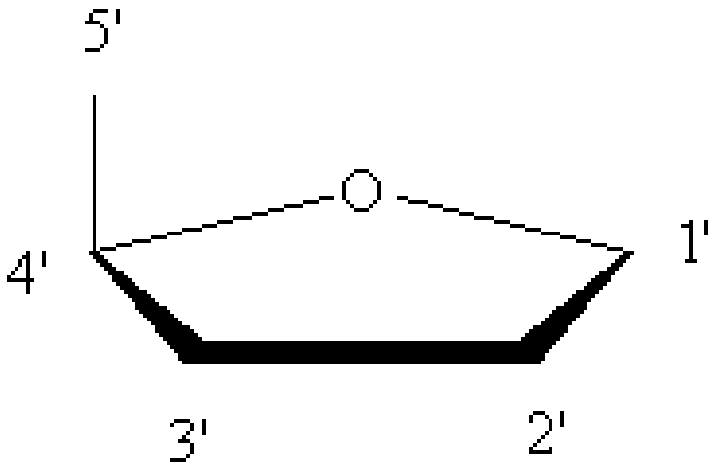
- Nitrogenous base

1. Purine
2. Pyrimidine



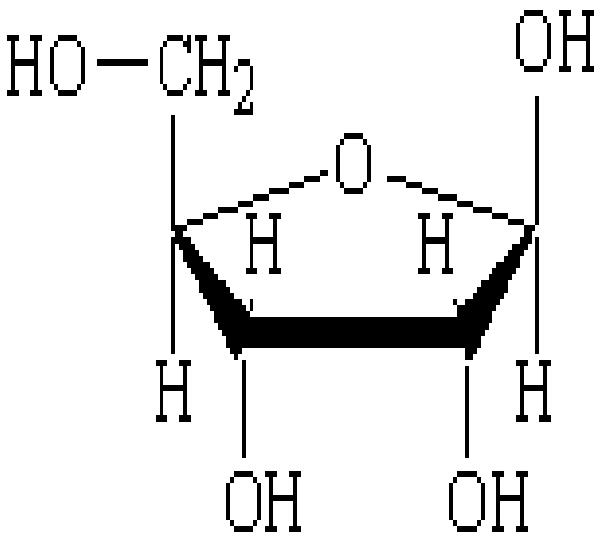
Sugars

- Pentoses (5-C sugars)
- Numbering of sugars is “primed”



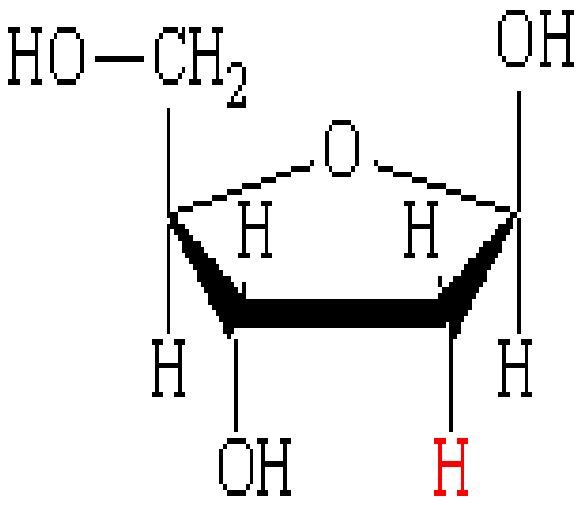
Sugars

D-Ribose



D-Ribose

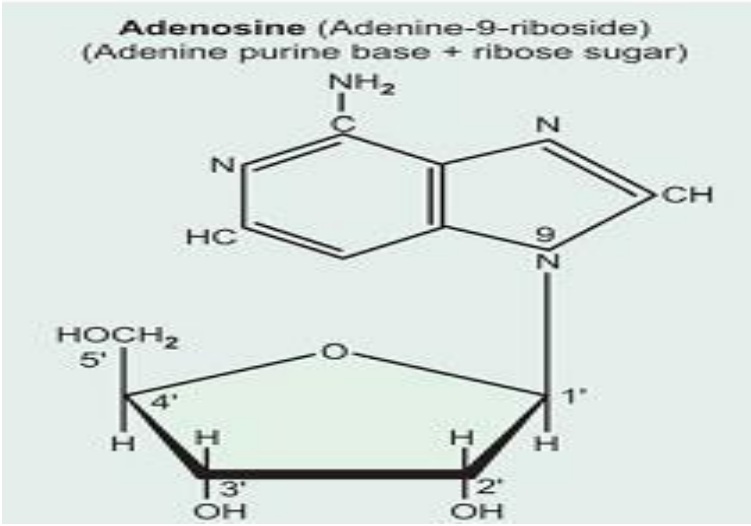
2’-Deoxyribose

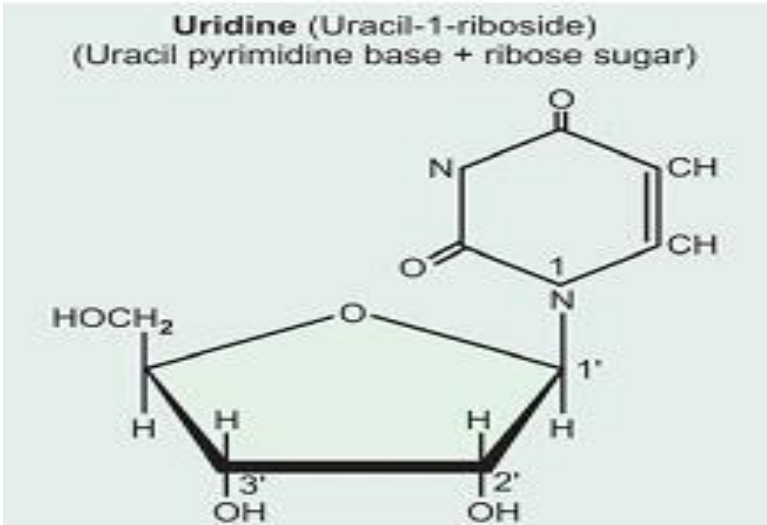


2'-Deoxyribose

Nucleosides

- Result from linking one of the sugars with a purine or pyrimidine base through glycosidic linkage
  - Purines bond to the C1’ carbon of the sugar at their N9 atoms
  - Pyrimidines bond to C1’ carbon of the sugar at their N1 atoms

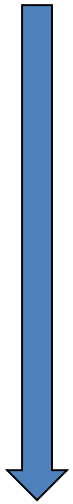


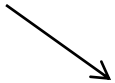


Nitrogenous base+ Pentose suger

(purine , pyrimidine)

(D-ribose,D-2- deoxyribose)



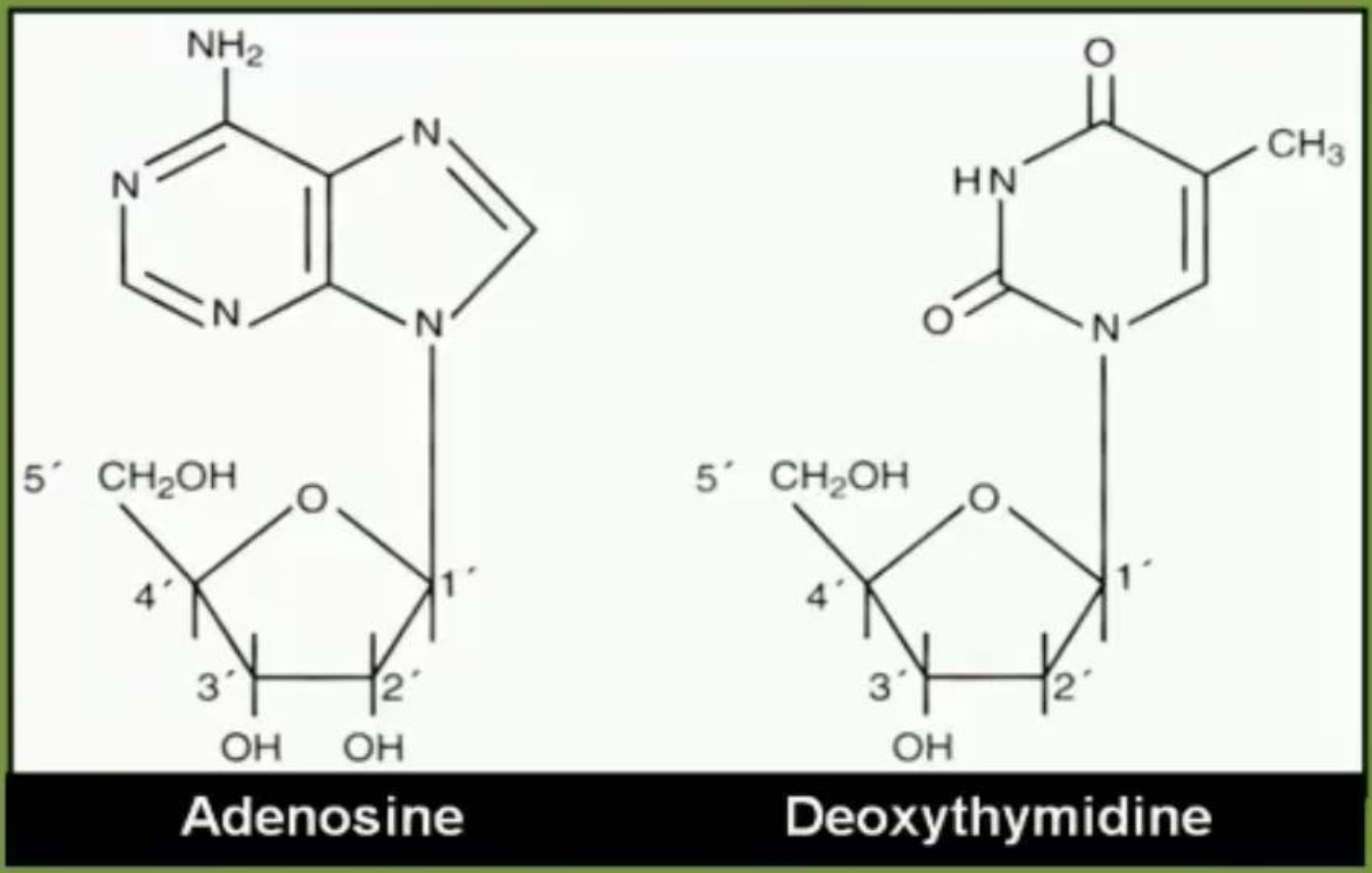


H2O

NUCLEOSIDE

RNA or DNA

Nucleosides



Adenosine Deoxythymidine

Nucleoside = Nitrogen Base + Sugar

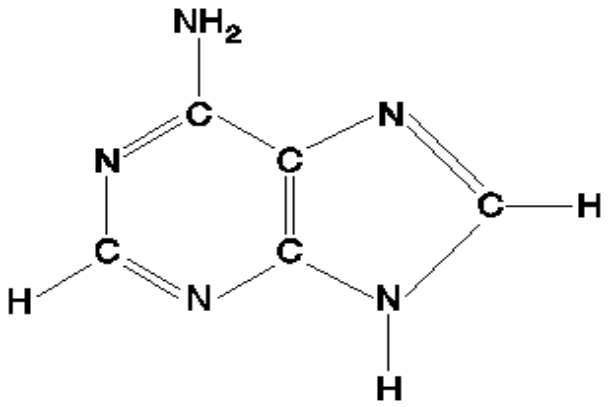
Base is attached to the 1' carbon of the sugar

NUCLEOSIDES BASES

1- **PURINE BASES**:

Adenine

Guanine

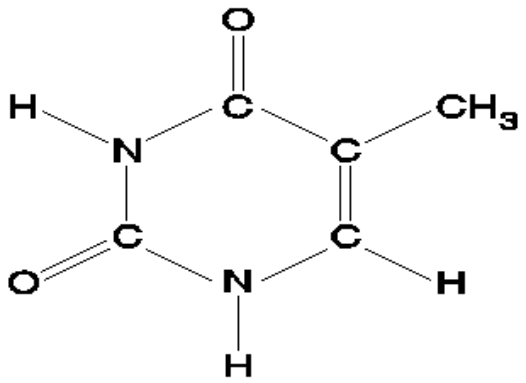


2- **PYIRIMIDINE BASES**:

Cytosine

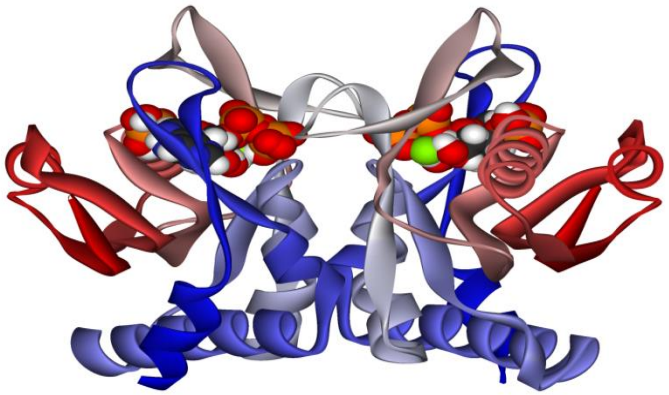
Thymine

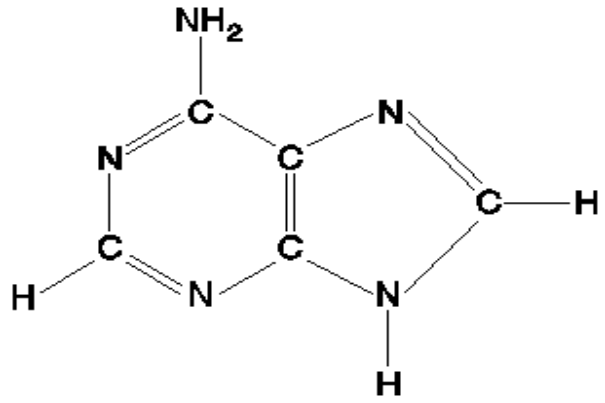
Uracil

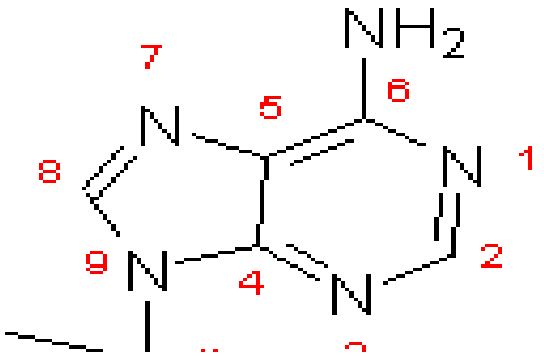


ADENINE

- Adenine is a dicyclic purine ,nitrogenous base it make's base pair with thymine A-T (adenine-thymine) in DNA and uracil A-U (adenine-uracil) in RNA. It is 6-amino purine.

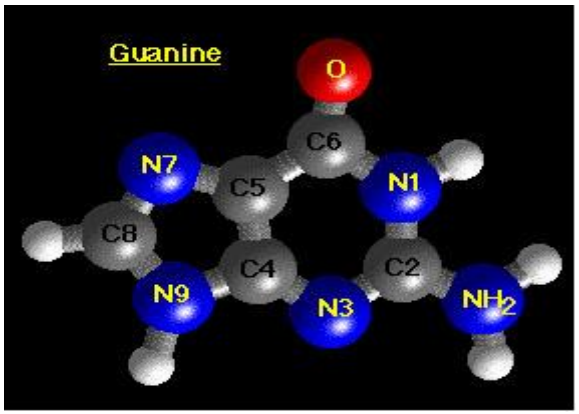


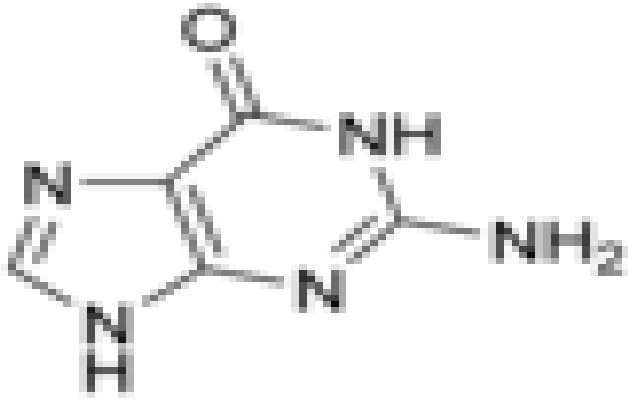




GUANINE

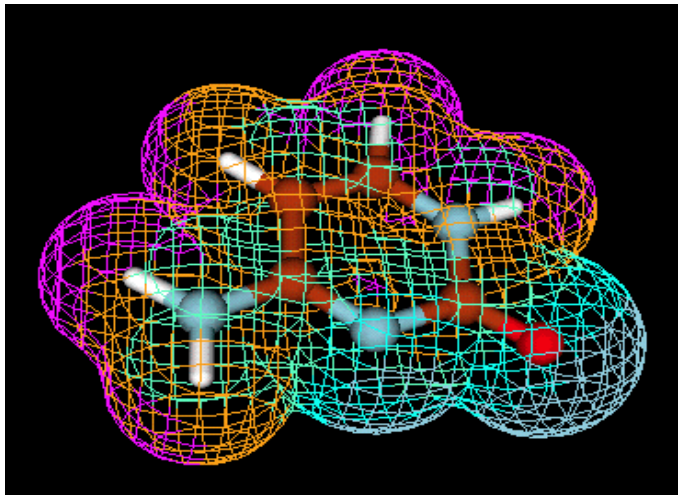
- Guanine is a dicyclic purine ,nitrogenous base it make's base pair with cytocine G-C (guanine and cytosine).It is 2-amino 6-oxy purine .

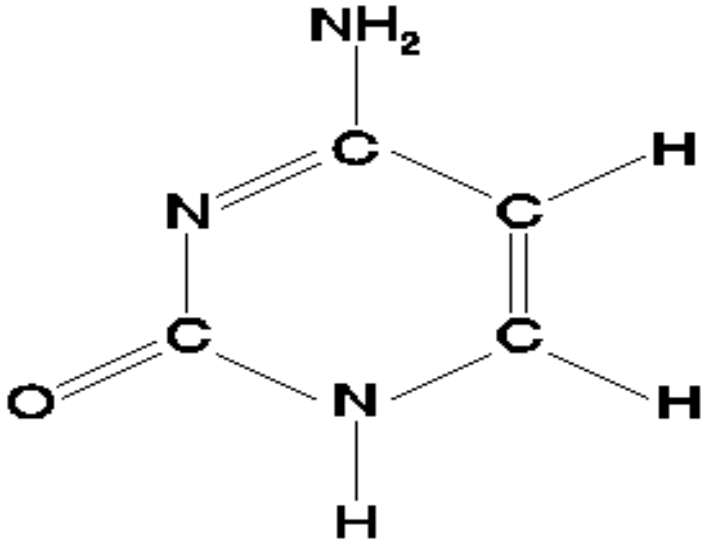




CYTOSINE

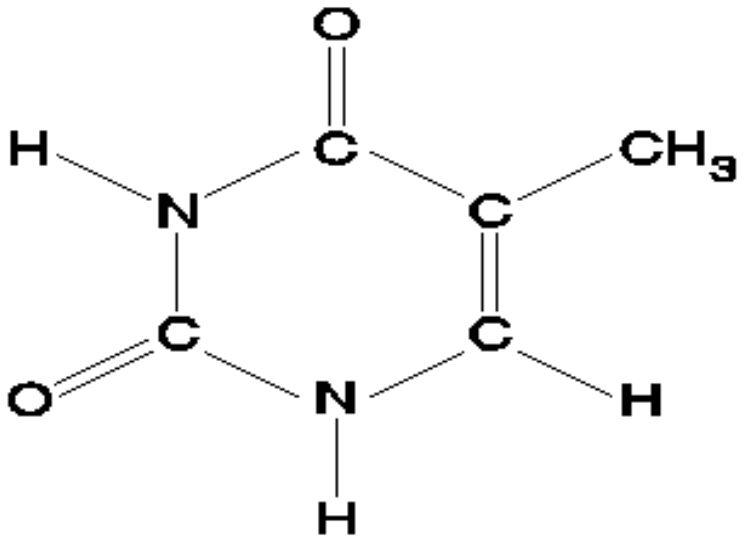
- Cytosine is a single ring pyrimidine ,nitrogenous base it make's a base pair with guanine G-C (guanine and cytosine). It is 2-oxy , 4-amino pyrimidine.





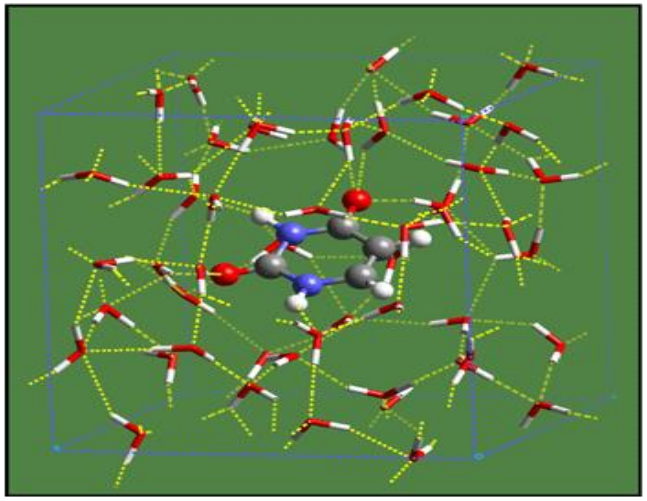
THYMINE

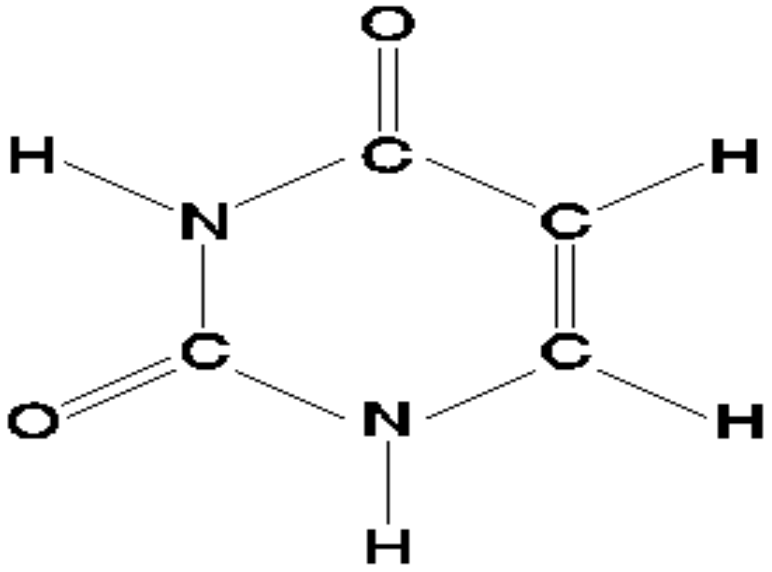
- A single-ring, pyrimidine nitrogenous base that make's base pair with adenine A-T (adenine-thymine) in DNA. It is 2, 4-dioxy 5- methyl pyrimidine.



URACIL

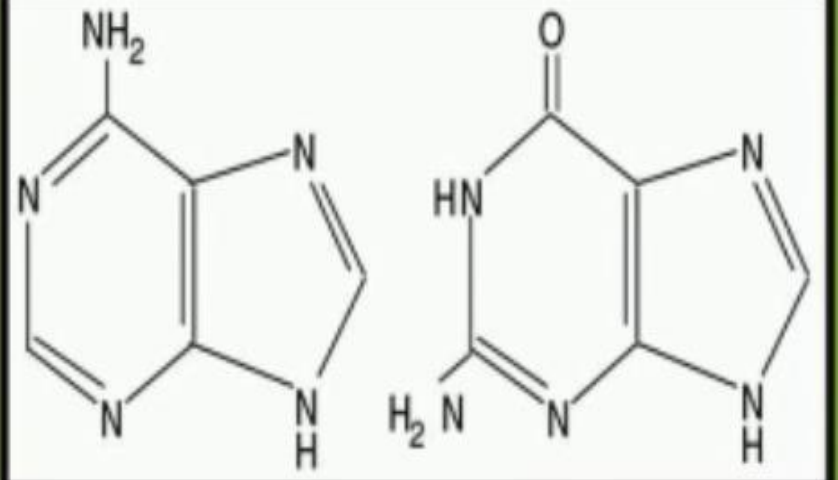
Uracil is a singl ring pyrimidine ,nitrogenous base that make's base pair with adenine A-U(adenine-uracil) in RNA . It is 2,4 dioxy pyrimidine.



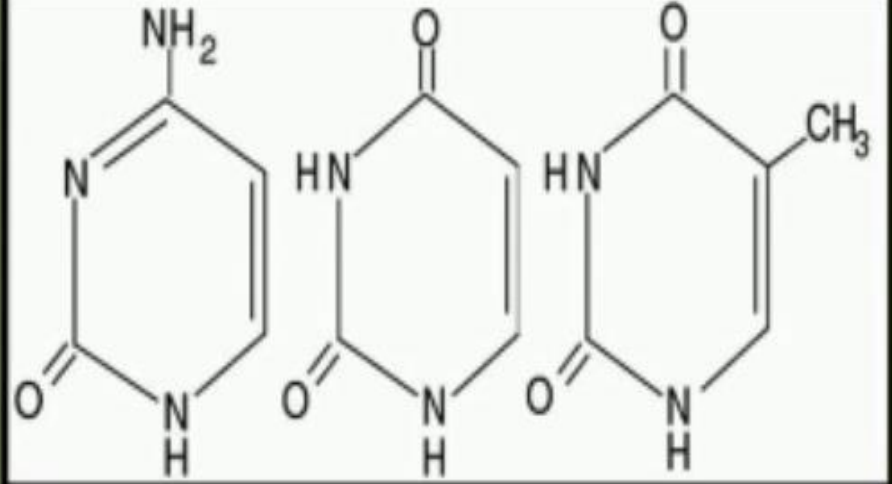


Bases in Nucleotides

Purines

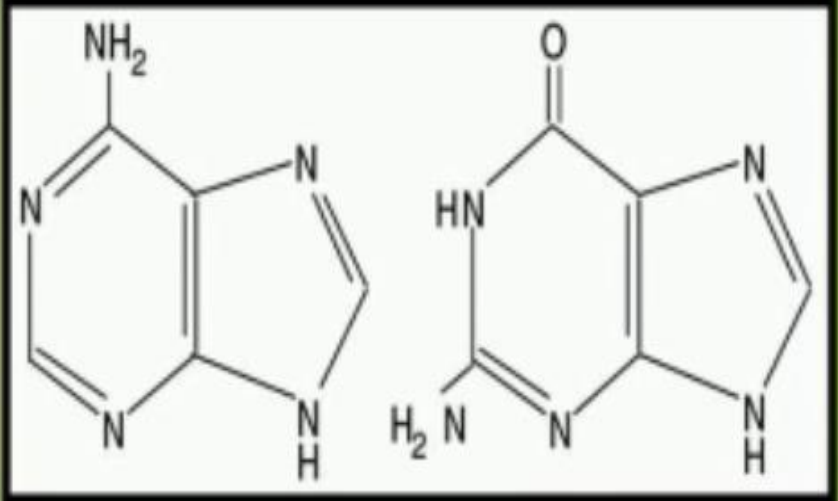


Pyrimidines



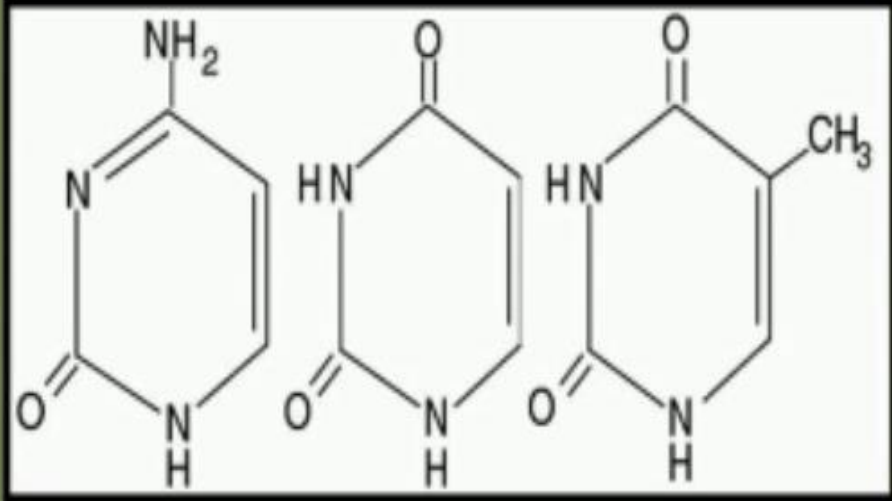
Bases in Nucleotides

Purines



Adenine Guanine

Pyrimidines

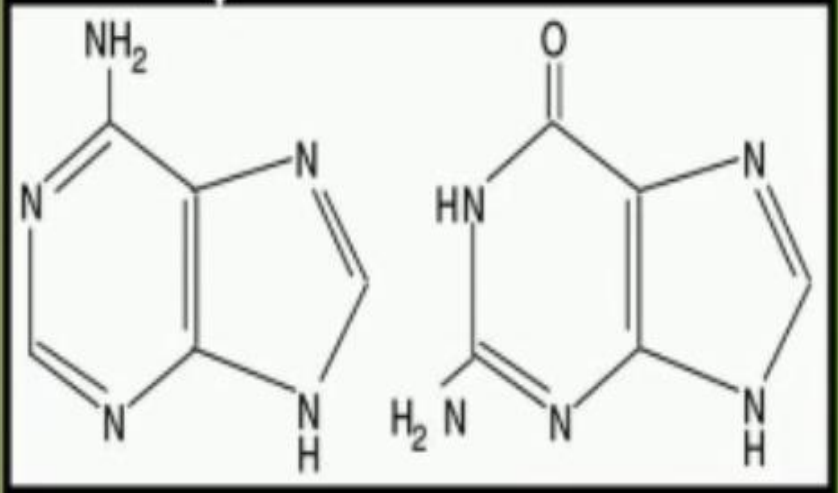


Cytosine Uracil Thymine

Bases in Nucleotides

Pure As Gold

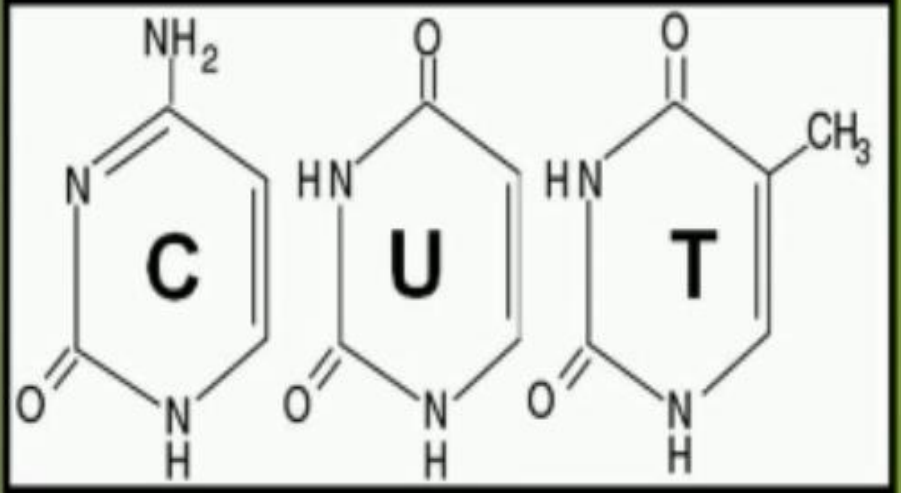
Purines



Adenine — DNA

Guanine — DNA

Pyrimidines



Cytosine — DNA

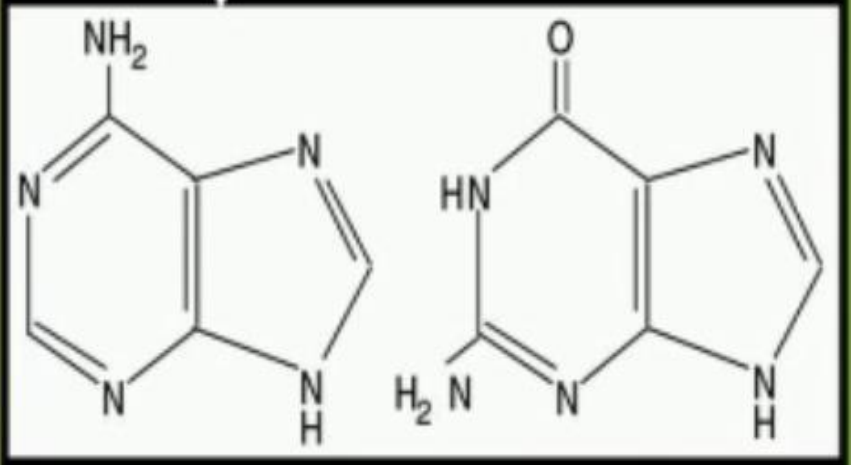
Uracil

Thymine — DNA

Bases in Nucleotides

Pure As Gold

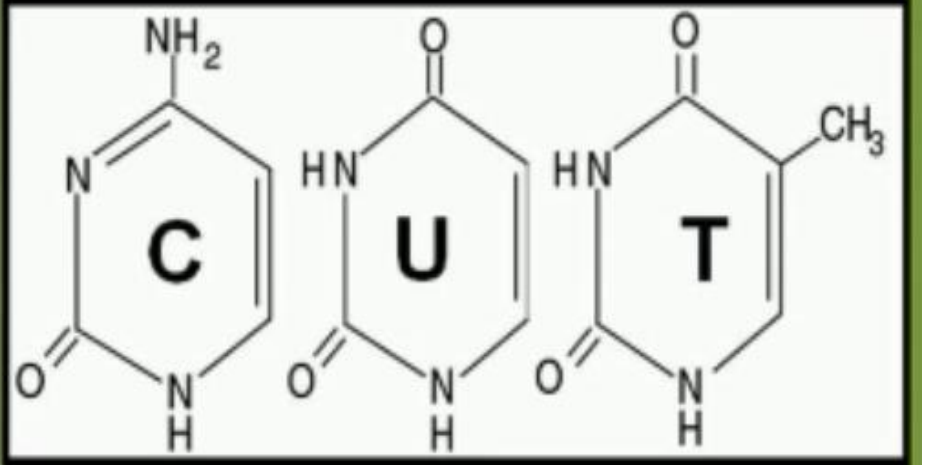
Purines



Adenine Guanine

DNA DNA
RNA RNA

Pyrimidines



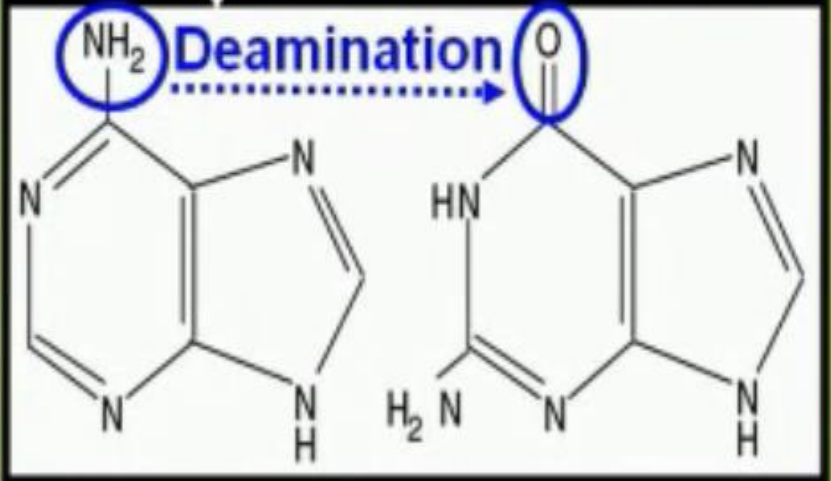
Cytosine Uracil Thymine

DNA DNA
RNA RNA

Bases in Nucleotides

Pure As Gold

Purines

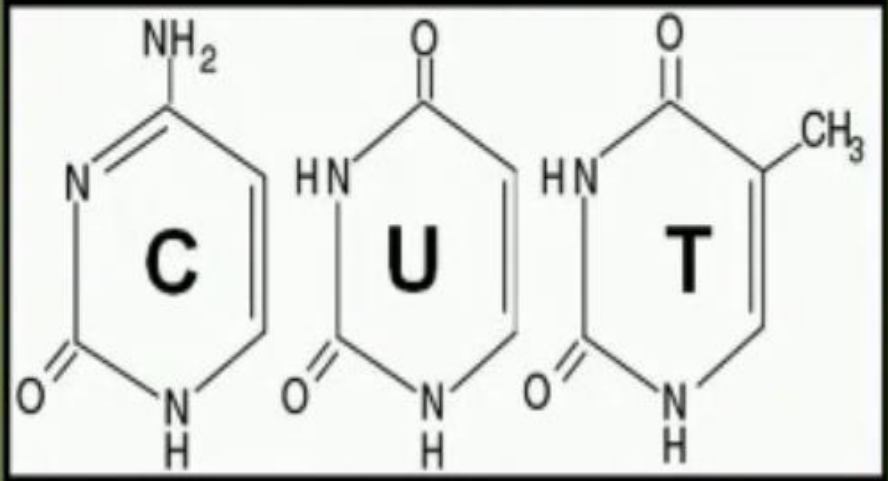


Adenine Guanine

DNA
RNA

DNA
RNA

Pyrimidines



Cytosine Uracil Thymine

DNA
RNA

RNA

DNA

Bases in Nucleotides

Pure As Gold

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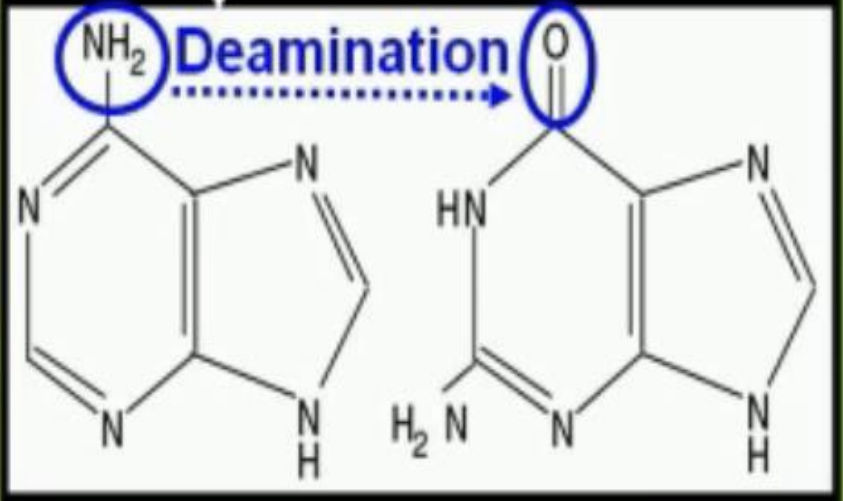
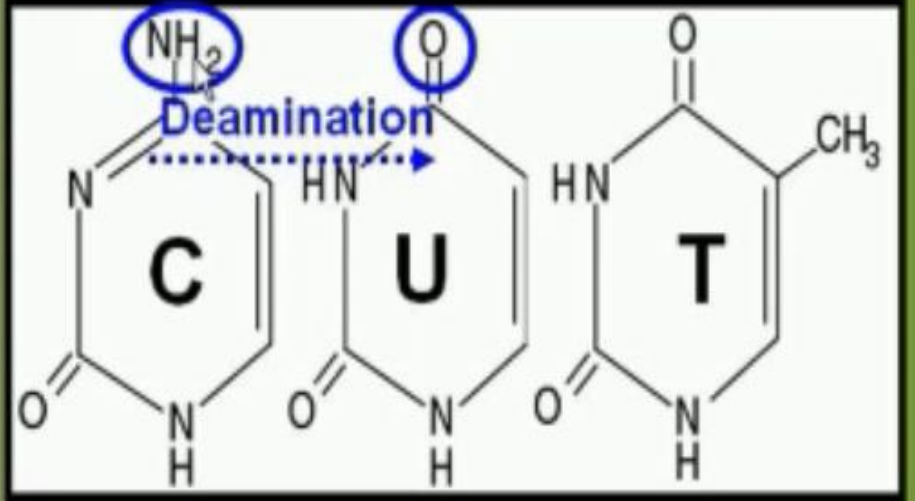


Adenine Guanine

DNA DNA
RNA RNA

Pyrimidines



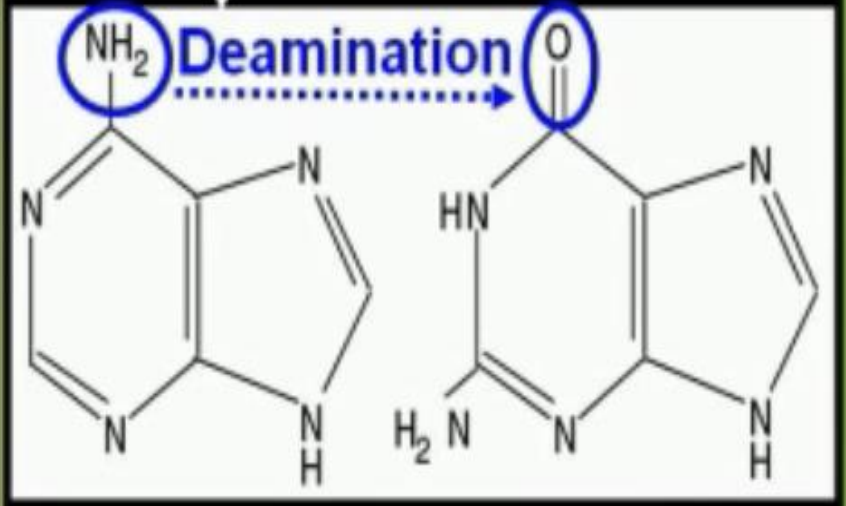
Cytosine Uracil Thymine

DNA DNA
RNA RNA

Bases in Nucleotides

Pure As Gold

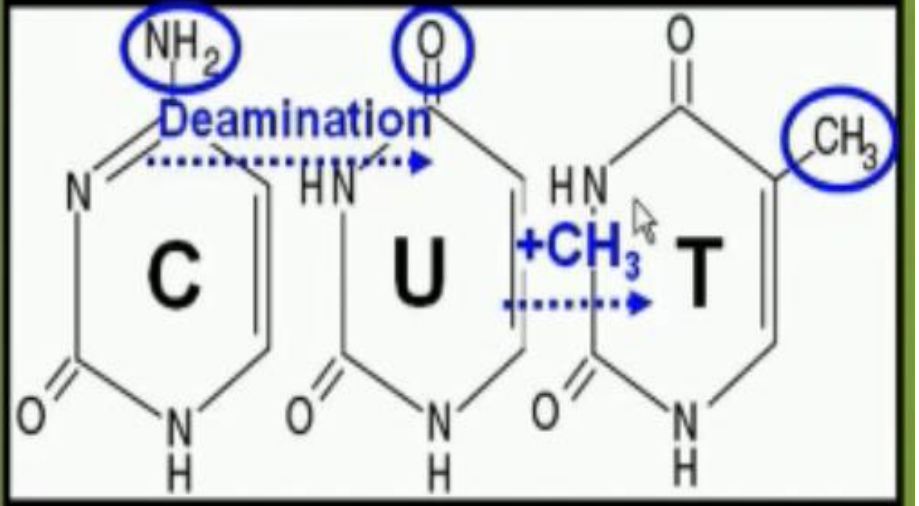
Purines



Adenine Guanine

DNA RNA DNA RNA

Pyrimidines



Cytosine Uracil Thymine

DNA RNA RNA DNA

Bases in Nucleotides

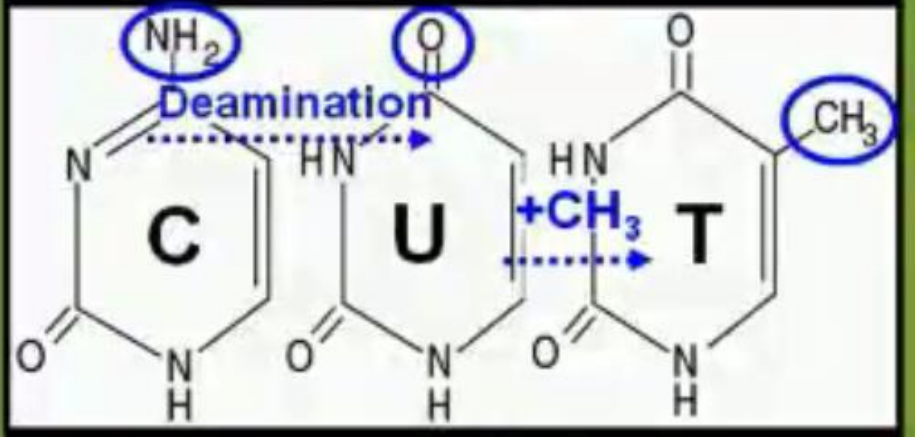
Pure As Gold

Purines

Adenine Guanine

DNA RNA DNA RNA

Pyrimidines

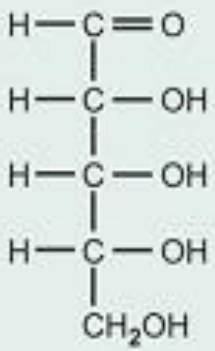


Cytosine Uracil Thymine

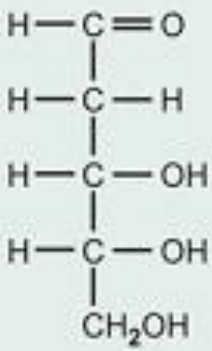
DNA RNA RNA DNA

PENTOSE SUGAR

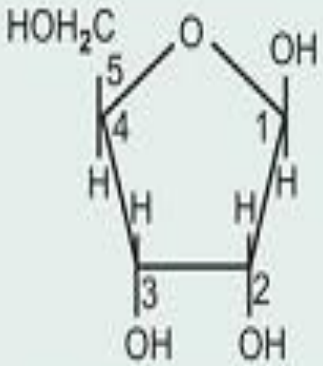
- D-ribose and D-2-deoxyribose are the only sugars so far found in the nucleic acids.
- D- ribose is present in RNA while D-2-deoxyribose is present in DNA.
- Pentoses are present in nucleosides in ring structure of B – form.



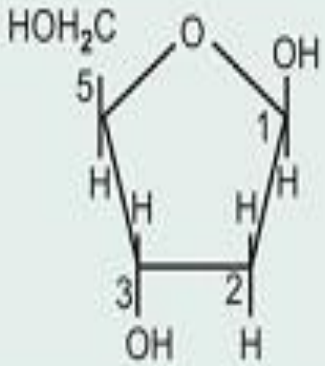
D-Ribose



D-2-deoxyribose



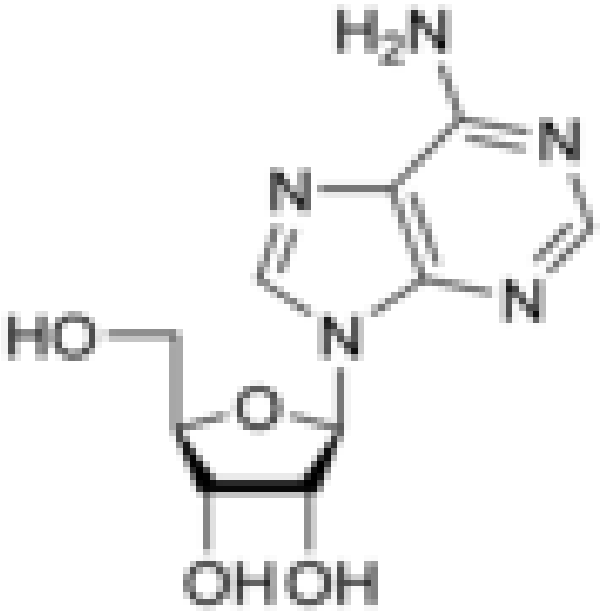
β-D-Ribofuranose



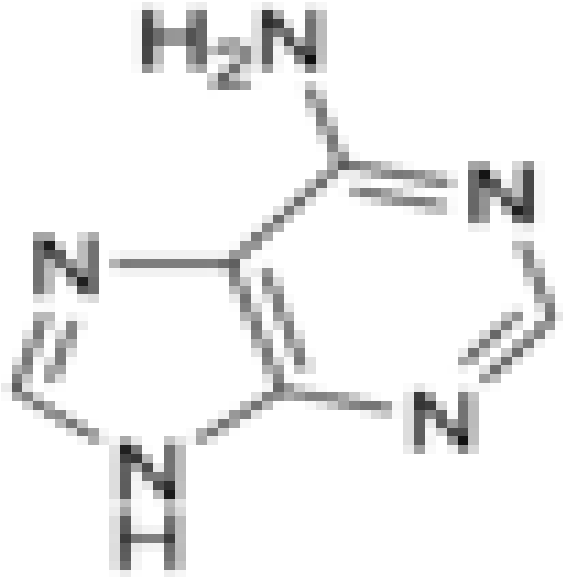
β-D-2-deoxyribofuranose

Nucleoside	Base		Sugar
• Adenosine	Adenine	+	Ribose
• Deoxyadenosine	Adenine	+	deoxyribose
• Guanosine	Guanine	+	Ribose
• Deoxyguanosine	Guanine	+	deoxyribose
• Uridine	Uracil	+	Ribose
• Cytidine	Cytosine	+	Ribose
• Deoxycytidine	Cytosine	+	deoxyribose
• Thymidine	Thymine	+	deoxyribose

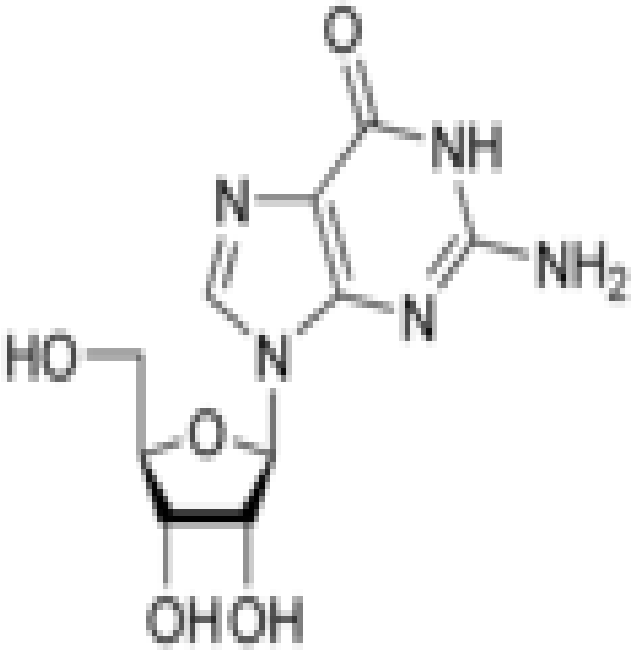
ADENOSINE



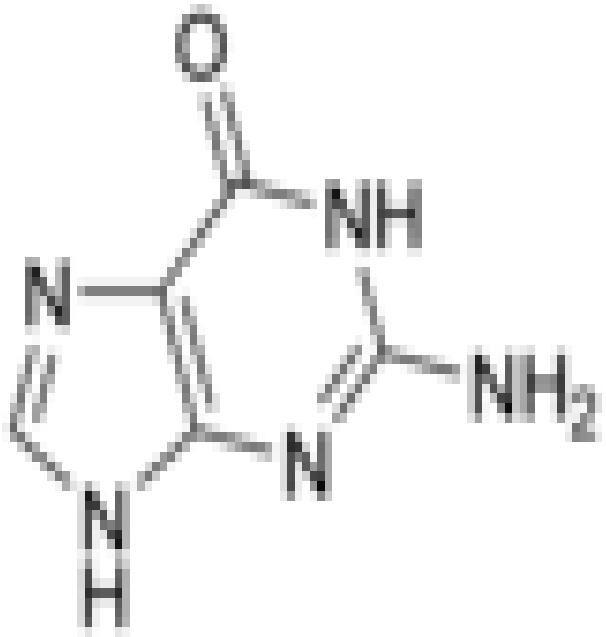
ADENINE



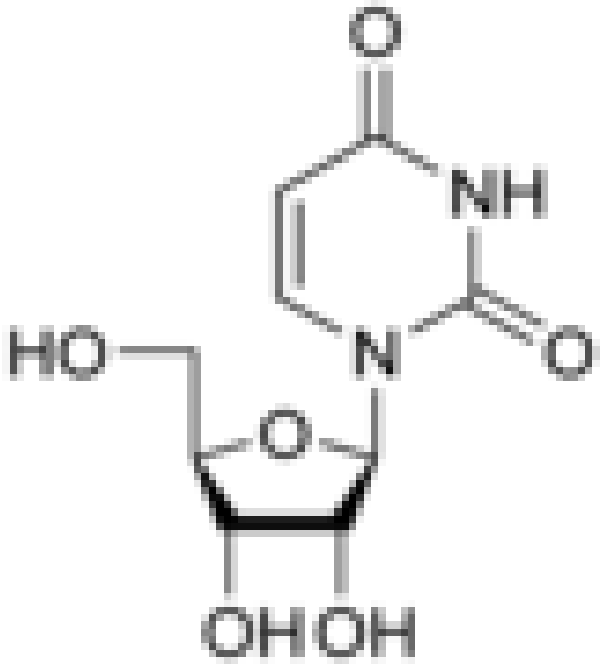
GUANOSINE



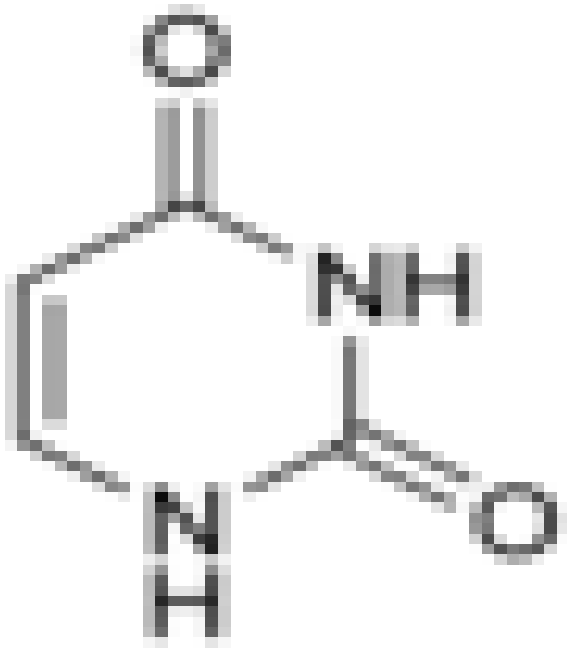
GUANINE



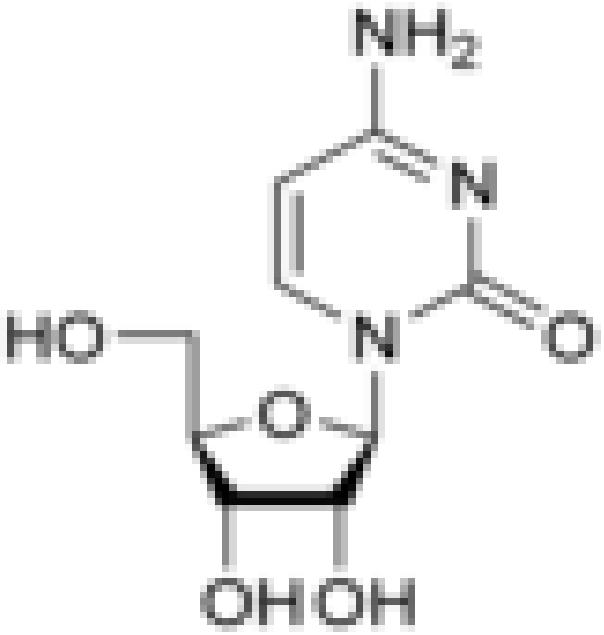
URIDINE



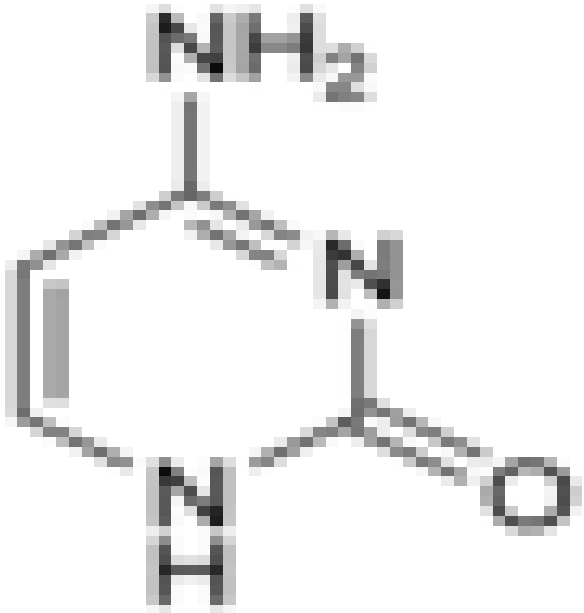
URACIL



CYTADINE



CYTOSINE

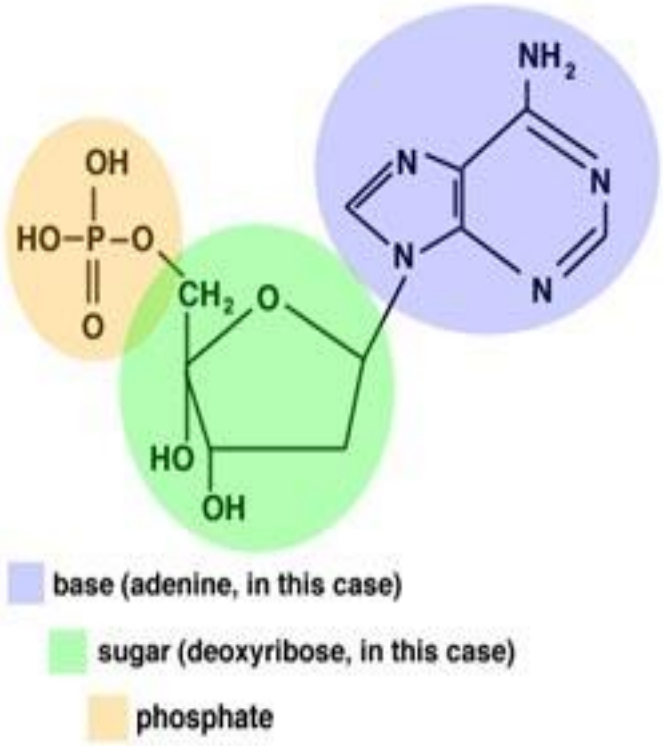


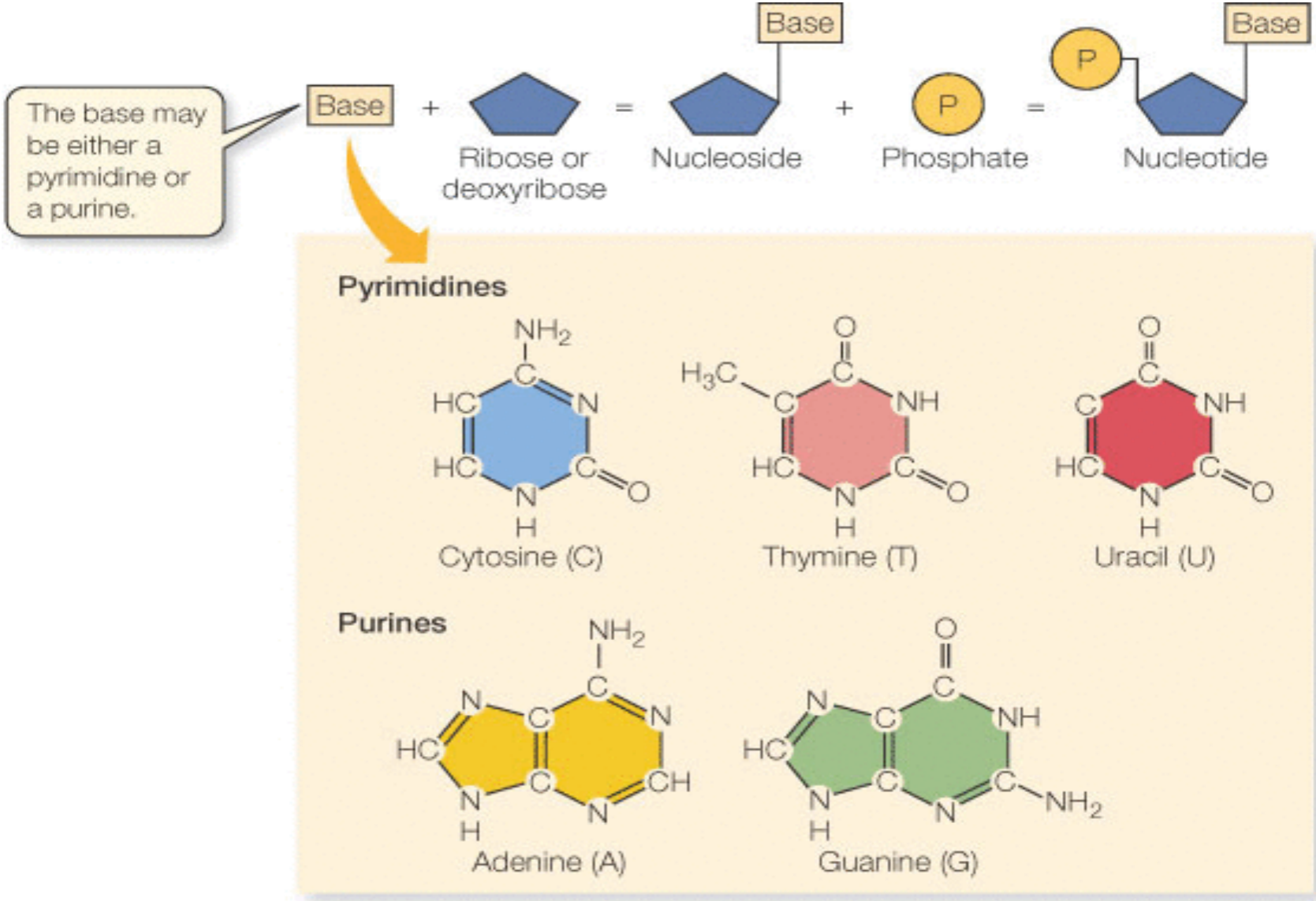
NUCLEOTIDES

NUCLEOTIDES

- A nucleotide is the monomer structural unit of nucleotide chains that form the nucleic acids.
- The building block of

  nucleic acid



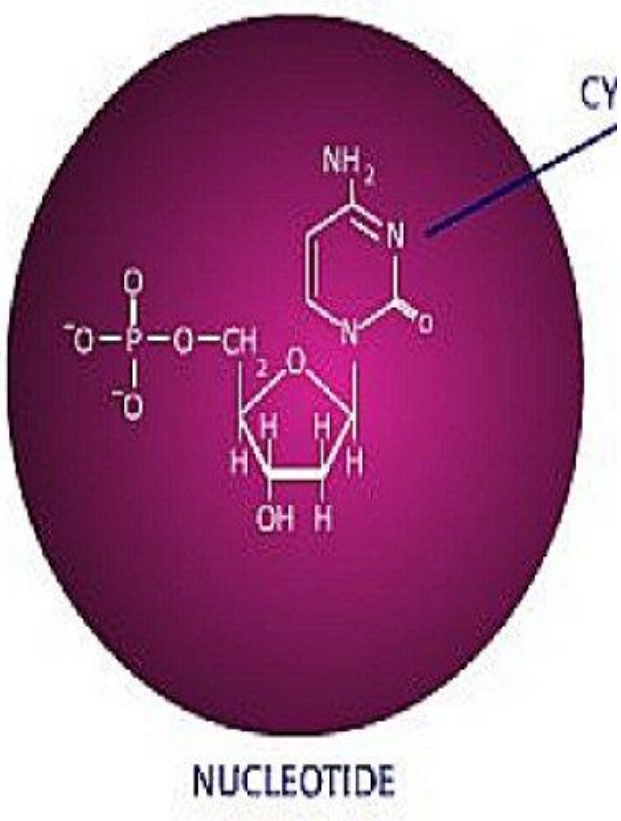

The base may be either a pyrimidine or a purine.
Base
+
Ribose or deoxyribose
=
Base
Nucleoside
+
P
Phosphate
=
P
Base
Nucleotide
Pyrimidines
Cytosine (C)
Thymine (T)
Uracil (U)
Purines
Adenine (A)
Guanine (G)

CONTENTS

- Each nucleotide contains

three items:

- A nitrogenous base
- A pentose sugar
- And phosphate group



Nucleotide Structure

All nucleotides are composed of:

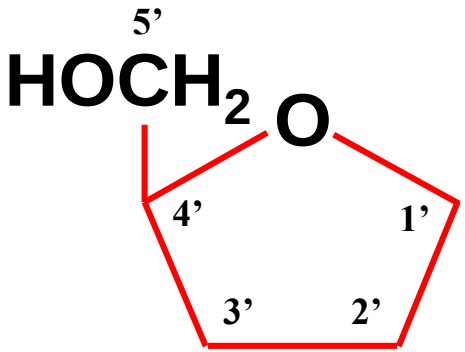
5-carbon sugar : D-ribose (RNA)
D-deoxyribose (DNA)

Base Purine
Pyrimidine

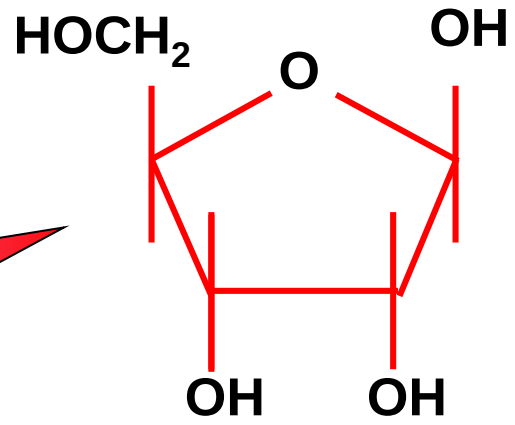
Phosphate group A nucleotide **WITHOUT** a phosphate group is a **NUCLEOSIDE**

Nucleotide Structure - 1
Sugars

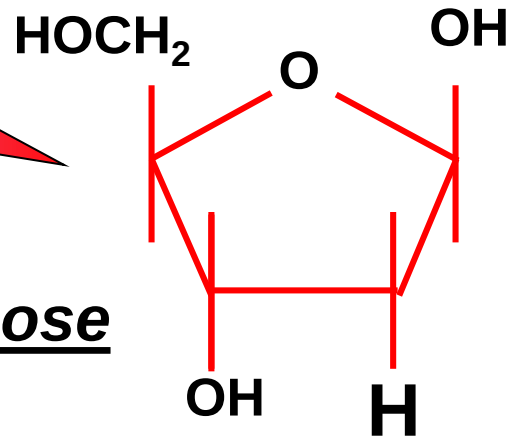
Generic Ribose Structure



Ribose



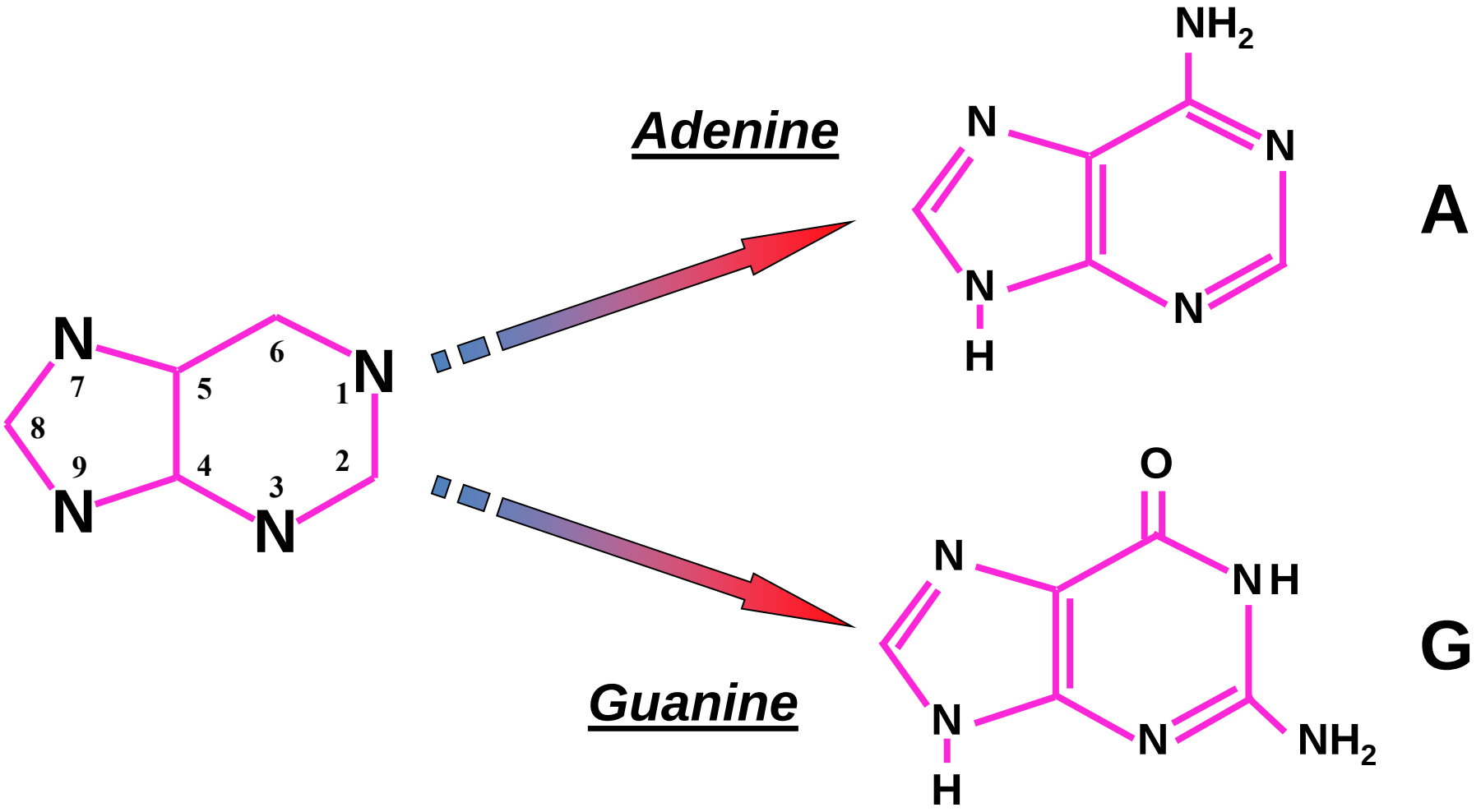
Deoxyribose



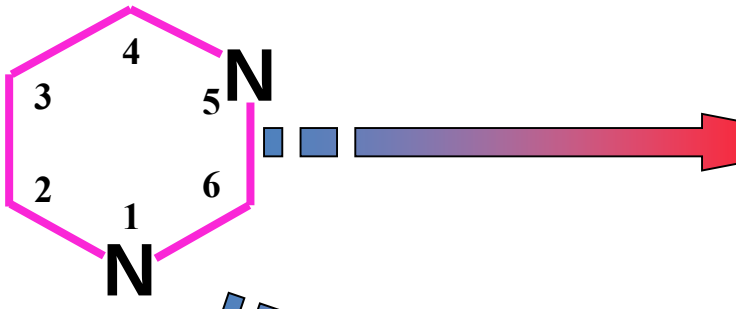
N.B. Carbons are given numberings as a prime

Nucleotide Structure - 2

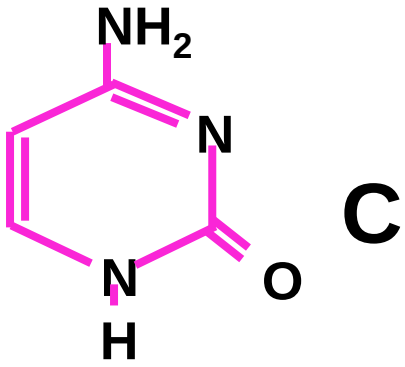
Bases - Purines



Nucleotide Structure - 3Bases - Pyrimidine

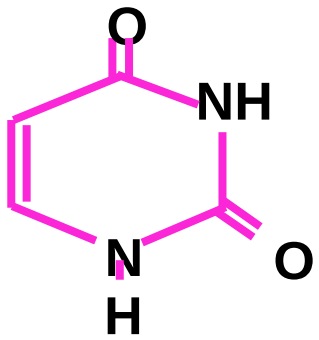


Cytosine



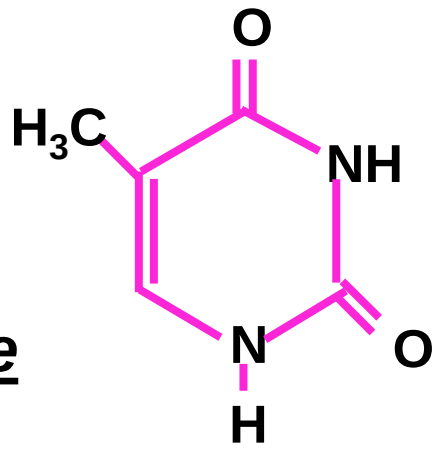
C

Uracil



U

Thymine



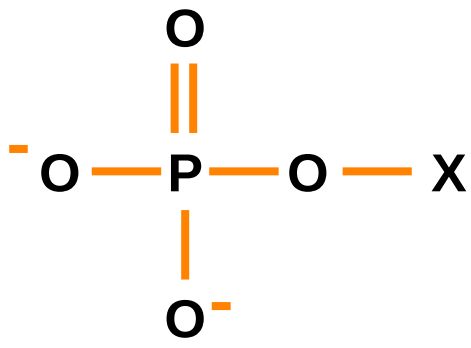
T

Nucleotide Structure - 4
Phosphate Groups

Phosphate groups are what makes a nucleoside a nucleotide

Phosphate groups are **essential** for nucleotide polymerization

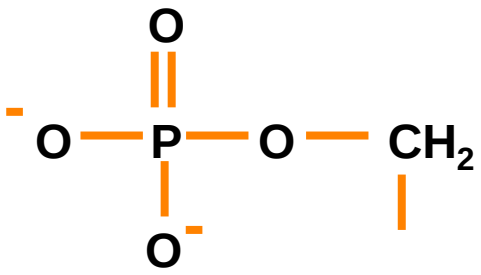
Basic structure:



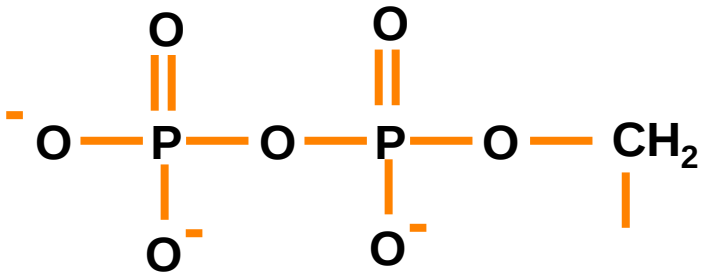
Nucleotide Structure - 4Phosphate Groups

Number of phosphate groups determines nomenclature

Monophosphate
e.g. AMP

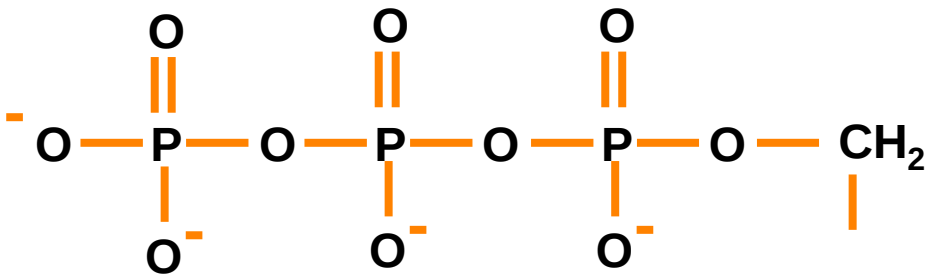


Diphosphate
e.g. ADP

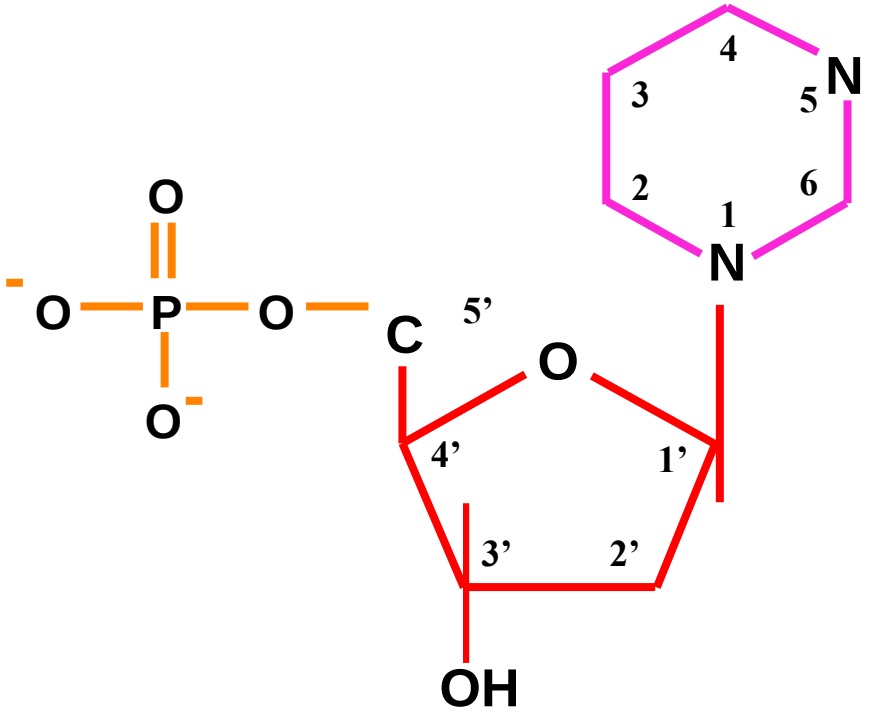


Nucleotide Structure - 4
Phosphate Groups

Triphosphate
e.g. ATP

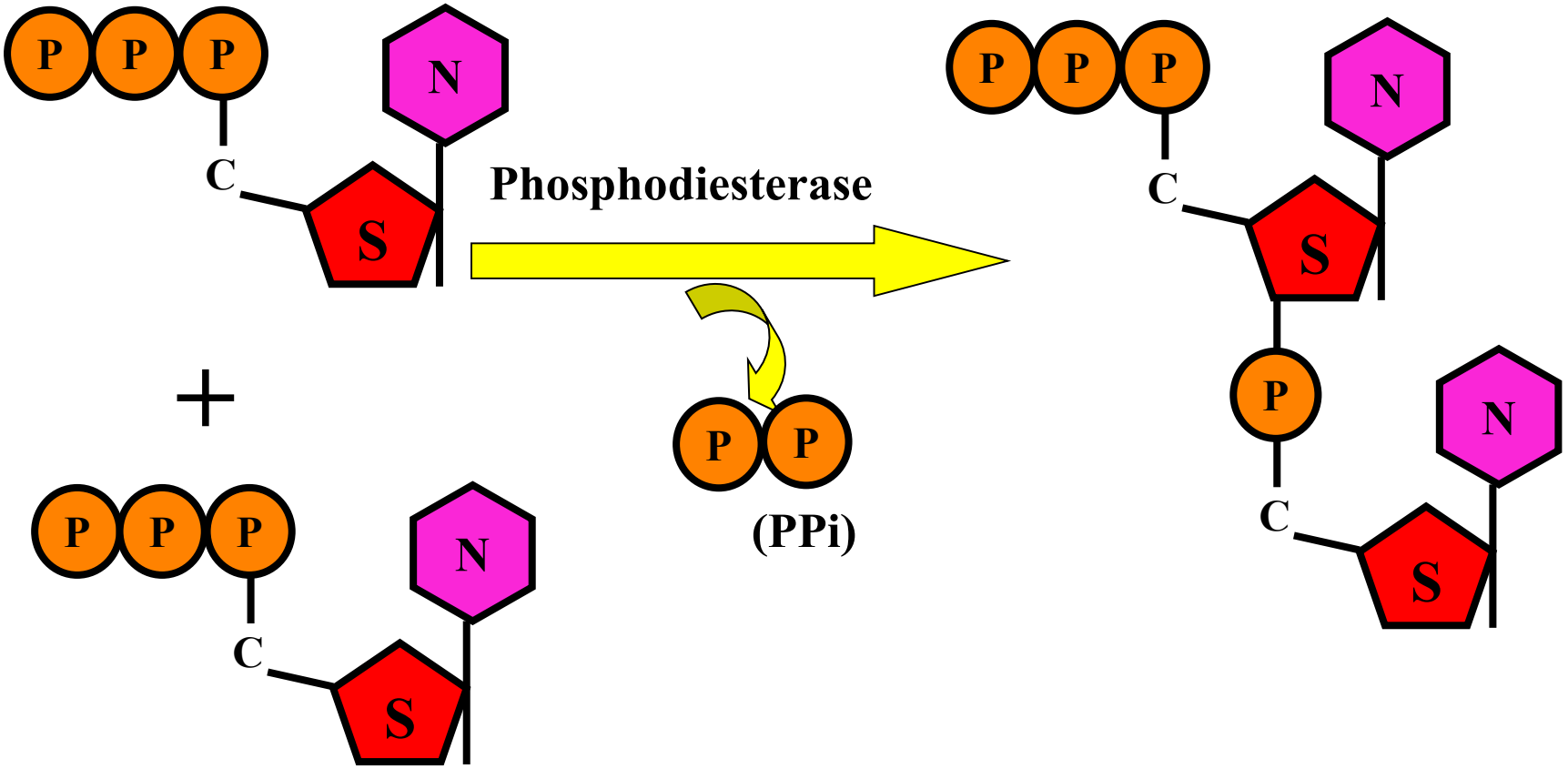


Nucleotide Structure - 4Base-Sugar-PO_4^{2-}

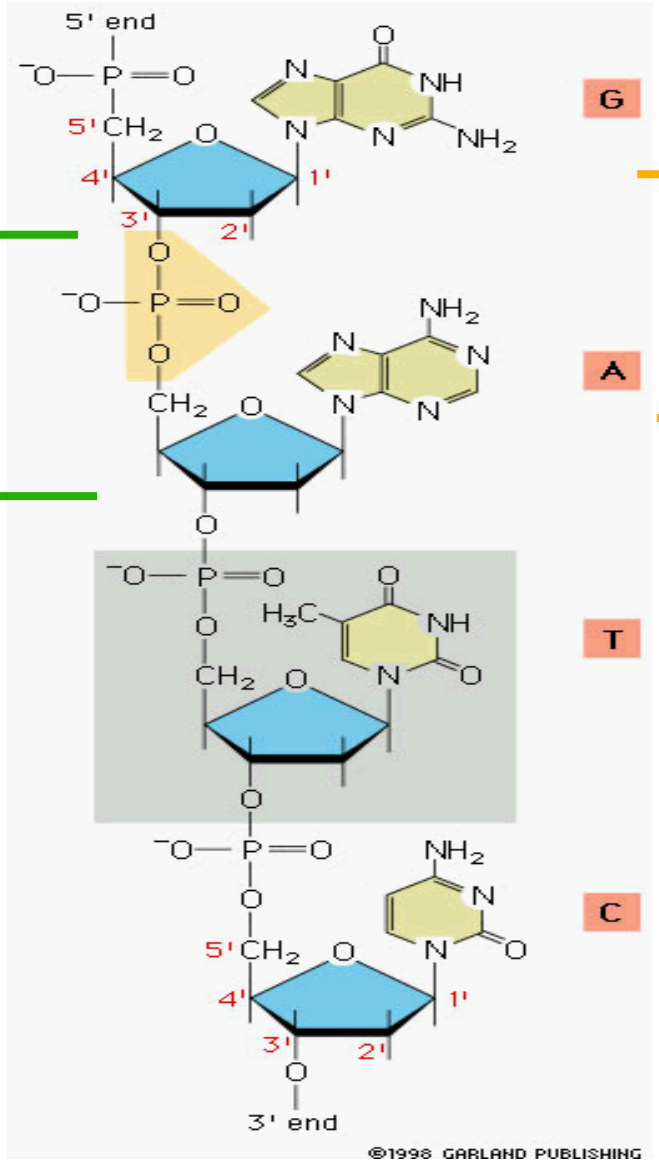


Monophosphate

Nucleic Acid Structure Polymerization



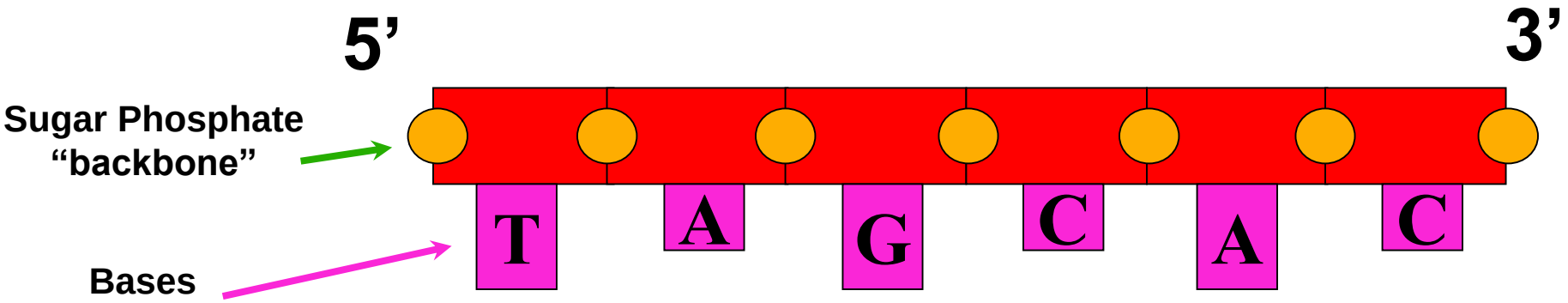
Nucleic Acid Structure Polymerization



Sugar Phosphate "backbone"

Nucleotide

Nucleic Acid Structure Polymerization



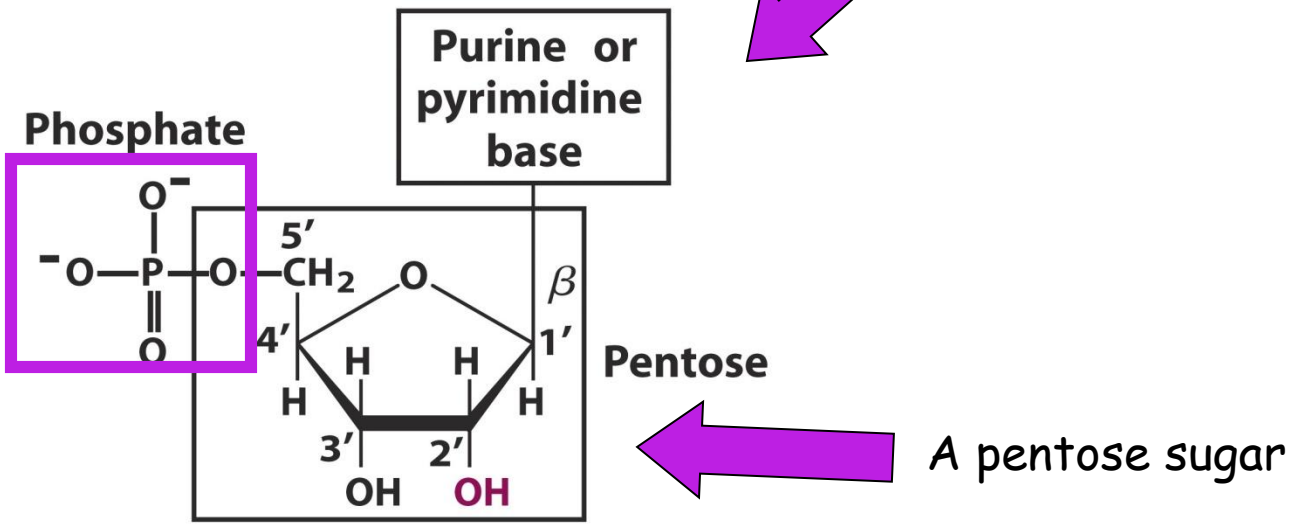
5’ TAGCAC 3’

Structure of nucleotides

Nucleotides have three characteristic components:

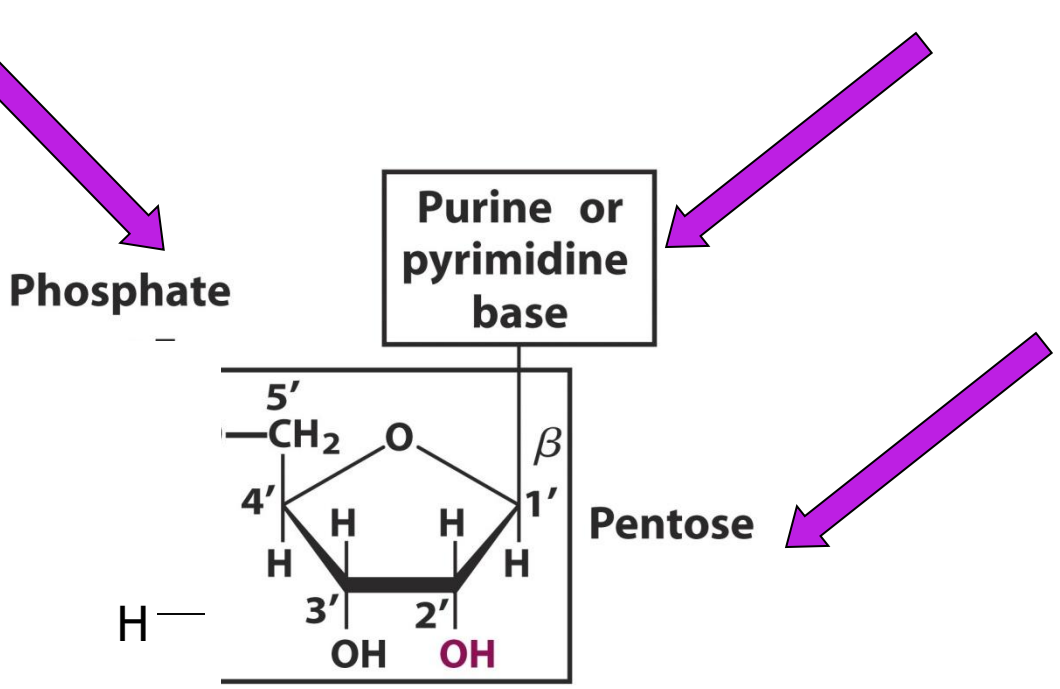
A phosphate group

A nitrogenous base (pyrimidines or purine)



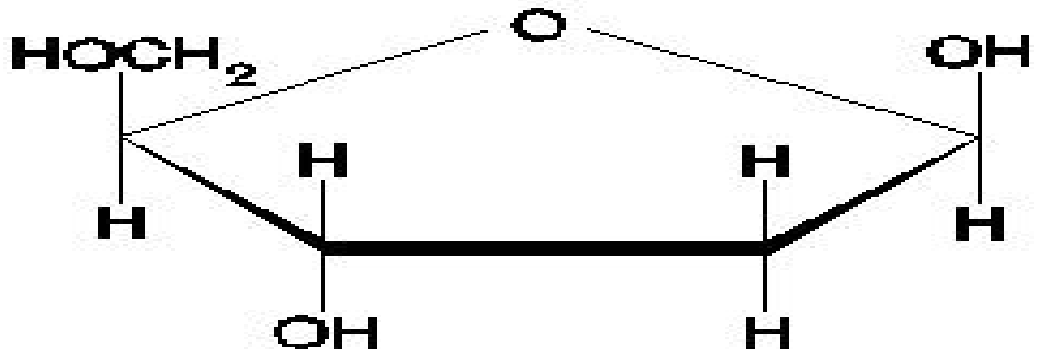
Structure of nucleosides

Remove the phosphate group, and you have a nucleoside.

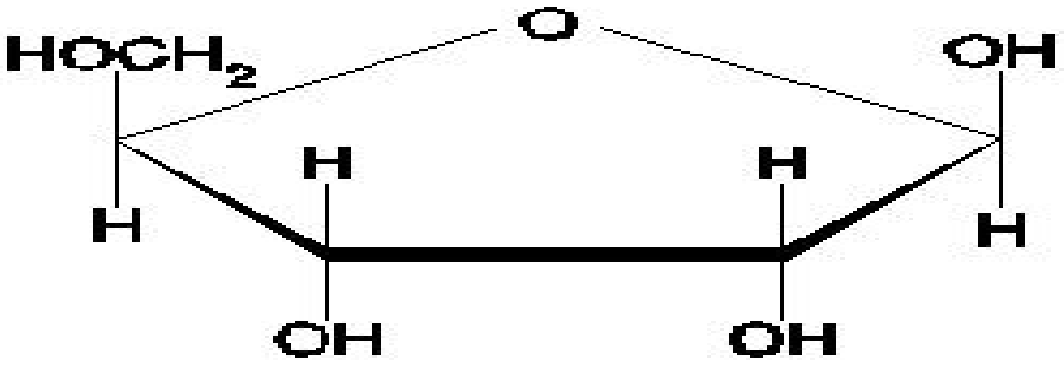


NUCLEOBASES

- Mostly nucleotides bases are:
- **PURINE BASES**:
- adenine (A)
- guanine (G).
- **PYRIMIDINE BASES:**
- thymine (T)
- cytosine (C)
- uracil (U).



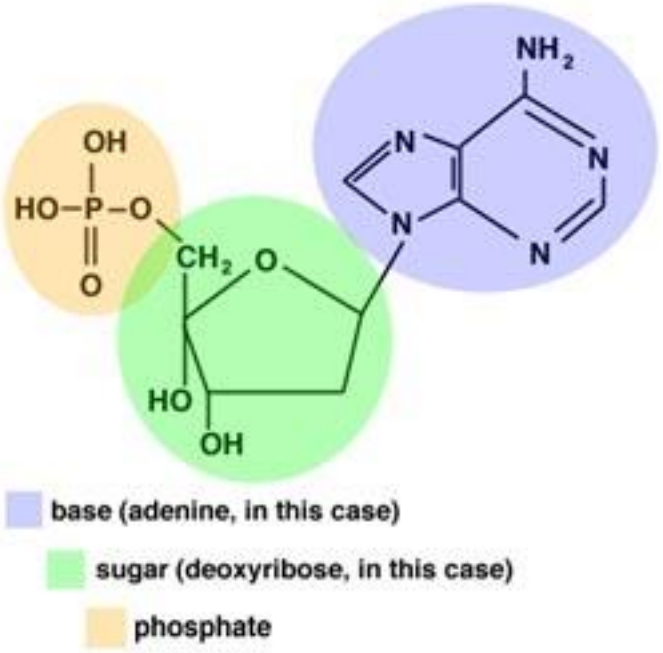
Deoxyribose

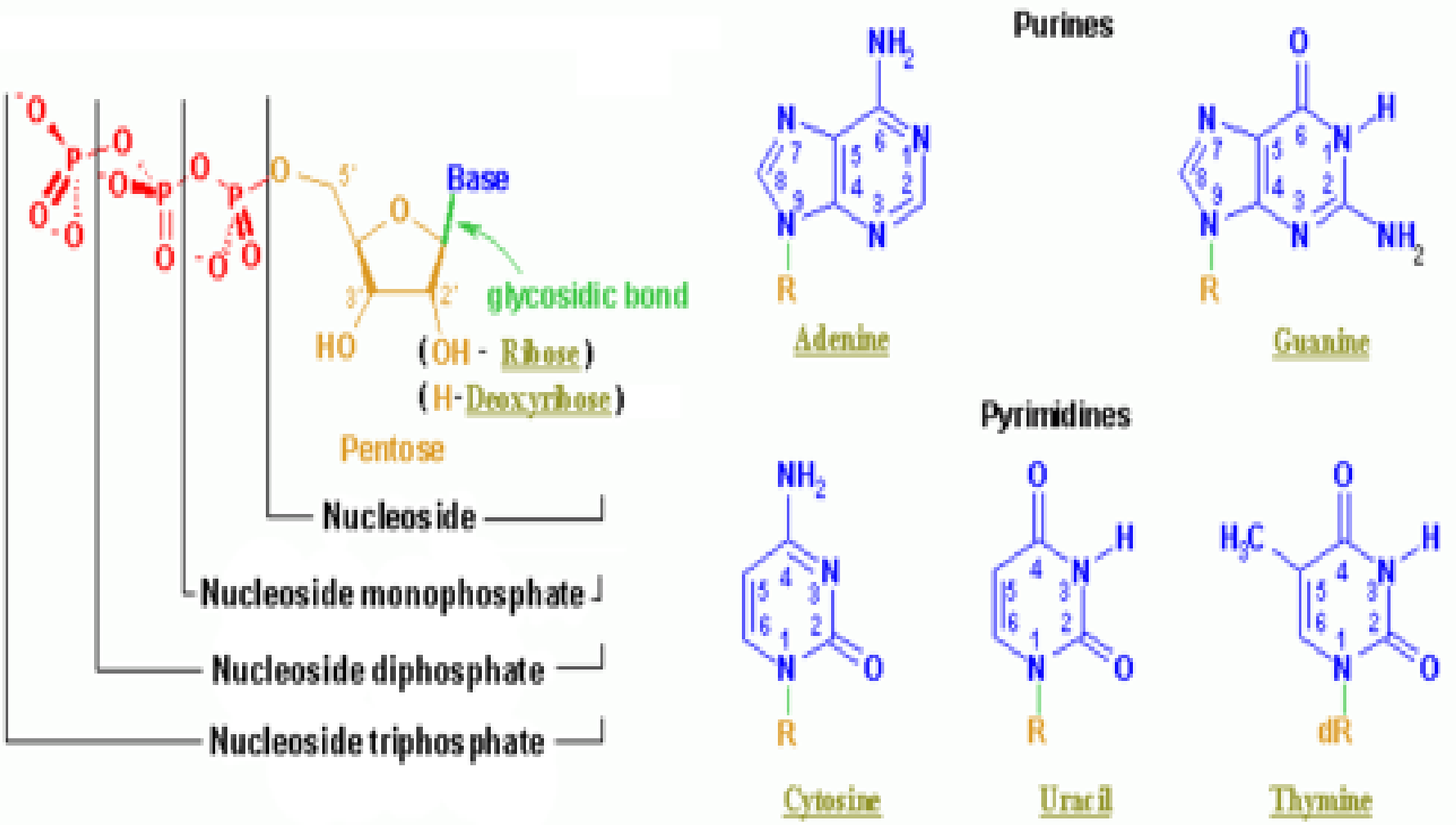


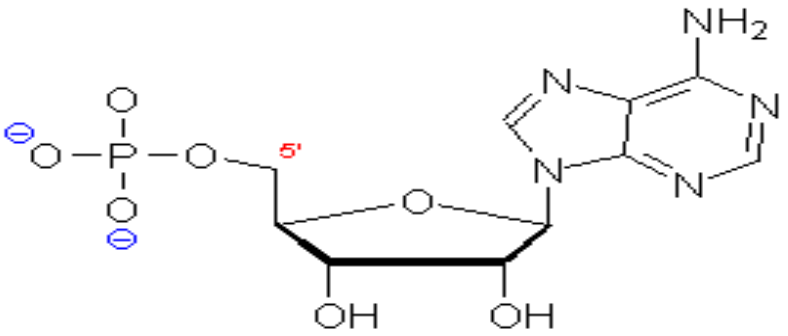
Ribose

PHOSPHATE GROUP

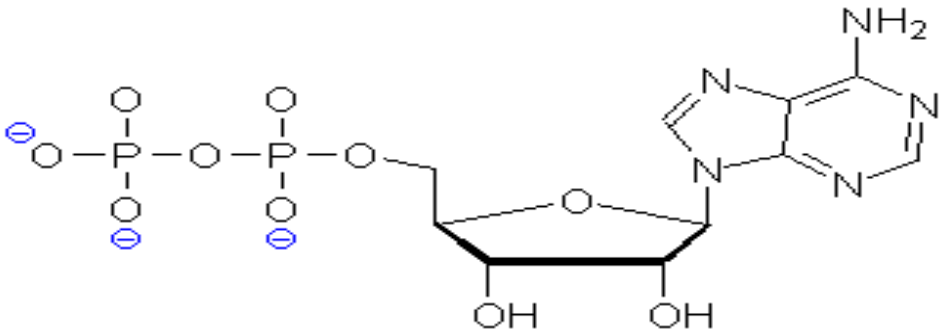
- Phosphate group is attached by an ester linkage to the OH of the 5'C of the pentose sugars.



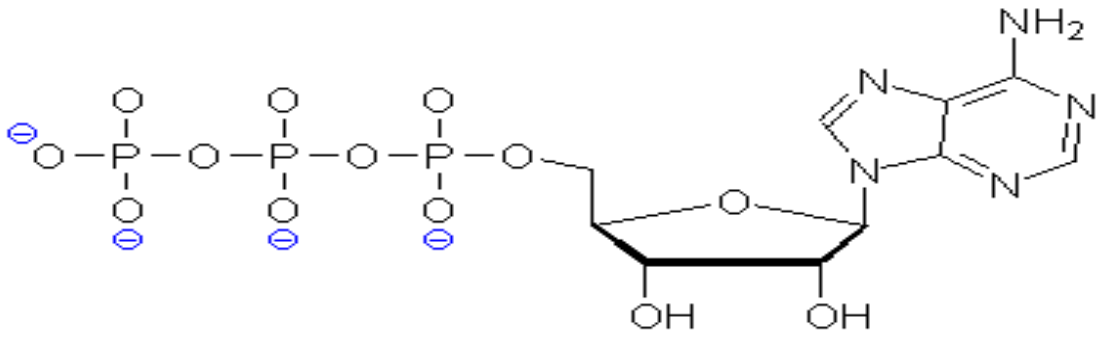

Base
glycosidic bond
(OH - Ribose)
(H-Deoxyribose)
Pentose
Nucleoside
Nucleoside monophosphate
Nucleoside diphosphate
Nucleoside triphosphate
Purines
Adenine
Guanine
Pyrimidines
Cytosine
Uracil
Thymine



Adenosine 5'-monophosphate
(AMP)

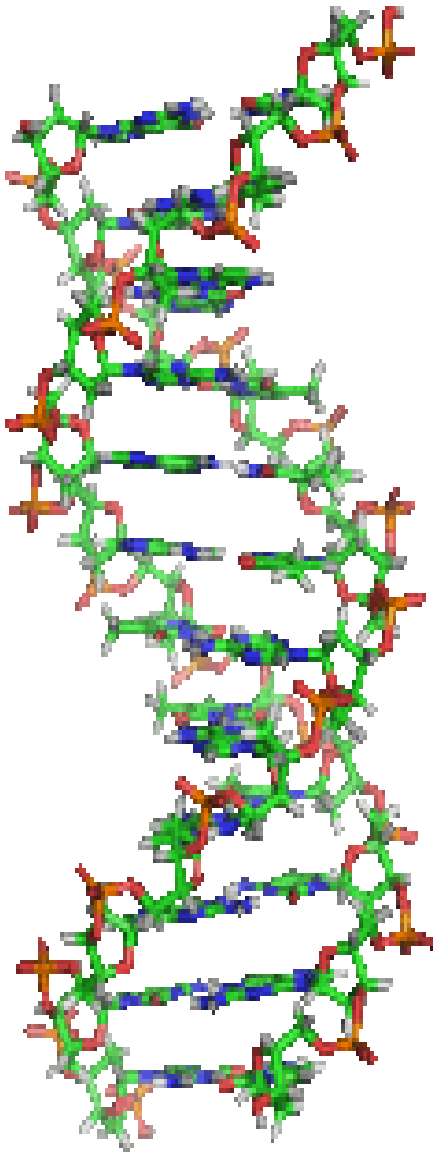


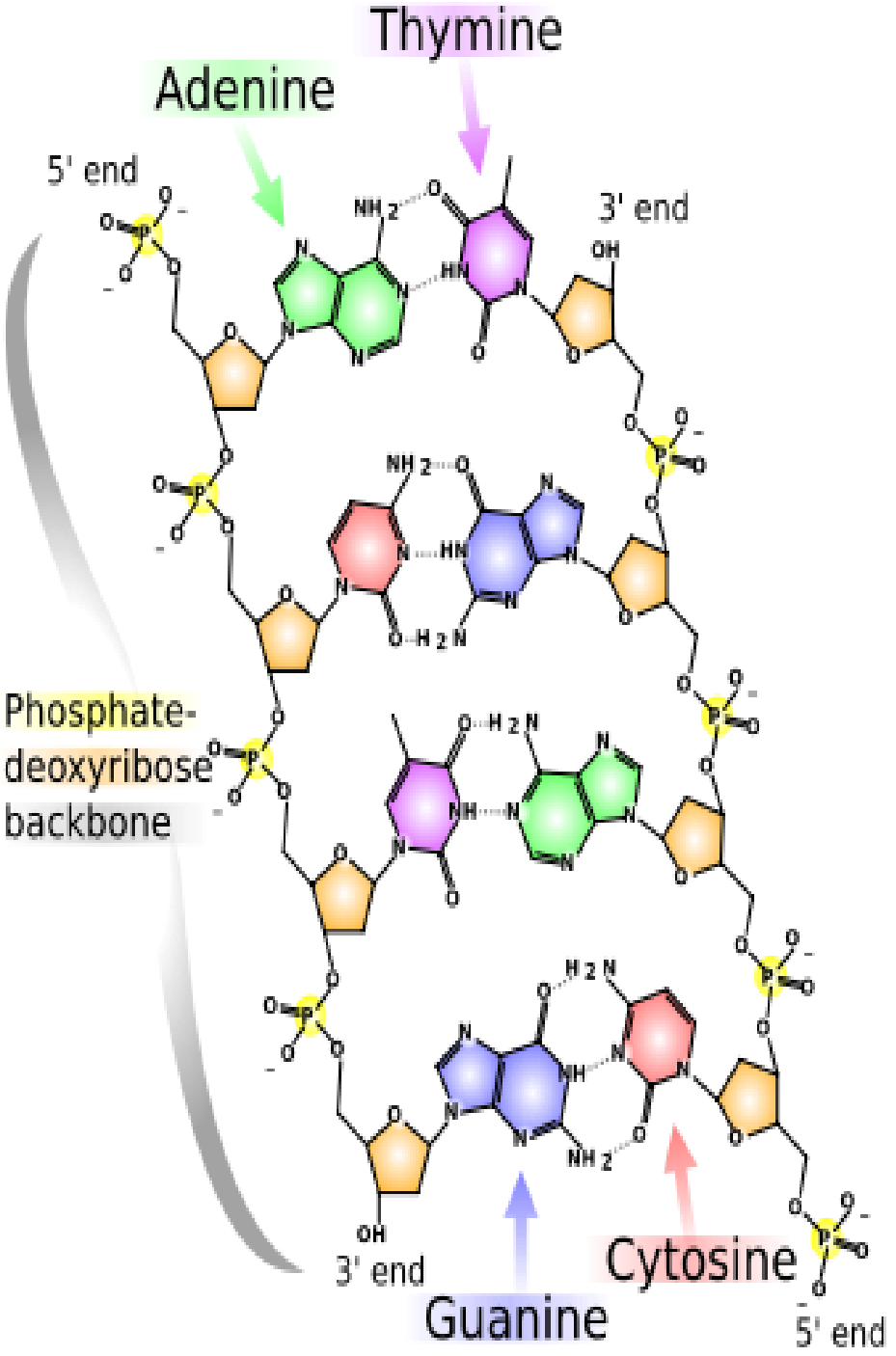
Adenosine 5'-diphosphate
(ADP)



Adenosine 5'-triphosphate
(ATP)

Neucleotide	Base	Sugar	Phosphoric acid
(a) Present in RNA			
• *Adenylic acid or Adenylate (AMP)*	Adenine	+ Ribose	+ Phosphoric acid
• *Guanylic acid or Guanylate (GMP)*	Guanine	+ Ribose	+ Phosphoric acid
• *Cytidylic acid or Cytidylate (CMP)*	Cytosine	+ Ribose	+ Phosphoric acid
• *Uridylic acid or Uridylate (UMP)*	Uracil	+ Ribose	+ Phosphoric acid
(b) Present in DNA			
• *Deoxy adenylic acid or deoxy Adenylate (dAMP)*	Adenine	+ Deoxyribose	+ Phosphoric acid
• *Deoxy guanylic acid or deoxy guanylate (d GMP)*	Guanine	+ Deoxyribose	+ Phosphoric acid
• *Deoxy cytidylic acid or deoxy cytidylate (d CMP)*	Cytosine	+ Deoxyribose	+ Phosphoric acid
• *Thymydylic acid or thymidylate (TMP)*	Thymine	+ Deoxyribose	+ Phosphoric acid




Thymine
Adenine
5' end
3' end
Phosphate-
deoxyribose
backbone
3' end
Cytosine
Guanine
5' end

FUNCTIONS

- Nucleotides are the single units that make up nucleic acids like RNA and DNA – literally the building blocks of life.
- Nucleotides code for proteins and enzymes.
- They determine the genetic structure of life.
- They also function to transport and transform cellular energy and regulate enzymes.
- Without nucleotides, we would not have a genetic code.
- Act as a second messenger important in many biological processes
- Intracellular source of energy - Adenosine triphosphate (ATP

DERIVATIVES

CLASSIFICATION OF NUCLEOTIDE

- **1. ADINOSINE NUCLEOTIDE**

  ATP

  ADP

  AMP

  cAMP.

CLASSIFICATION OF NUCLEOTIDES

- **2. GUANOSINE NUCLEOTIDE**.

  GTP

  GDP

  GMP

  cGMP

CLASSIFICATION OF NUCLEOTIDES

- **3. URIDINE NUCLEOTIDE.**

  UTP

  UDP

  UMP

CLASSIFICATION OF NUCLEOTIDES

- **4 . CYTIDINE NUCLEOTIDES**.

  CTP

  CDP

  CMP

  d-CMP

CLASSIFICATION OF NUCLEOTIDES

- **5. MISCELLANEOUS.**
- Active methionine
- Coenzymes
- NAD
- FAD
- NADP
- FMN
- CoA

BIOLOGICAL ACTION OF NUCLEOTIDES

AMP

- Enzyme activator
- Enzyme Inhibitor

BIOLOGICAL ACTION OF NUCLEOTIDES

ADP

- Act as oxidative phosphorylation
- Control cellular respiration
- Muscle contraction.
- Enzyme activator

- **ATP**

  . Supply free energy

  . Synthesis of phosphocreatine from creatine

  . Muscle contraction

  . Act as phosphate donor in phosphtransferase reaction

- **GTP**

.Citric acid cycle

.It is necessary for formation of 3 – 5 cAMP

. Protein synthesis

.rhodopsin synthesis

.gluconeogenesis

- **UTP**

  . Biosynthesis of pyrimidine

  .Conversion of glucose to gylactose

  . Detoxification of bilirubin

- **CTP**

.Biosynthesis of phospholipids

.An important precursor of bacterial cell wall

. Synthesis of salivary mucin

- **cAMP**

.Mediate the effects of different enzymes

.vasodilatation

.neurotransmitter

.dark light adaptation

.diagnosis of hyperthyroid and hypothyroid

. Differentiation of extra and intrahepatic obstruction

PHYSICAL PROPERTIES

- Soluble in water
- Solubility increase and depend upon phosphorylation of nucleotide.
- Nucleotide carry negative charge at their physiological pHs.
- Stable over wide range of pH
- At elevated temperature, protonation of purine base results.
- Strongly absorb UV lights

CLINICAL IMPORTANCE & BIOCHEMICAL ROLE:

- Allopurinol: Inhibits the biosynthesis of pyrine & xynthine oxidase. It is used in the treatment of hyperuricemia and gout.
- Cyatarabine: Used in chemotherapy of Ca.
- Vidrabine: Are used in the treatment of viral infection.
- Azathiopurine: It inhibits the biosynthesis of purine and used as an immunosuppressive agent during:

  organ transplant and grafting

- 5-Iodo-2-deoxyuridine: used in herpes simplex virus as in the treatment of herpetic keratitis.
- 5-fluorouracil: used as antiviral agent.
- Aminophylline and Theophylline: inhabit the cAMP catabolism this cAMP level increased in cell. Specially in the treatment of asthema.

ANY QUESTION

- CHATTERJEA BIOCHEMISTRY
- LIPPINCOTT BIOCHEMISTRY
- HARPERS BIOCHEMISTRY
- SATYANARAYANA BIOCHEMISTRY
- INTERNET

Thank you