BIOCHEMISTRY

UNIT 4 NOTES

NUCLEIC ACID METABOLISM

- PURINE & PYRIMIDINE
- CATABOLISM OF PURINE NUCLEOTIDES
- STRUCTURE OF DNA & RNA
- TRANSCRIPTION & TRANSLATION

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NUCLEIC ACID

- Nucleic acid are naturally occurring primary information carrying biomolecules which forms the genetic material.
- Nucleic acid is made from nucleotides.
- Nucleotides are the monomers or building blocks of nucleic acid.
- Nucleic acid is the polymer of nucleotides or it is also known as Polynucleotides.

- Since, it is found in the nucleus (nuclei) of the cell and acidic in nature, hence it is known as Nucleic Acid.

Types of Nucleic Acid

① DNA (Deoxyribonucleic Acid)
② RNA (Ribonucleic Acid)

NUCLEOTIDES

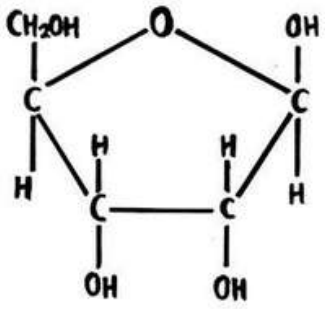
- Nucleotides are the monomeric unit of nucleic acid.
- A nucleotide is composed of 3 units.

① A Pentose Sugar
② Phosphoric Acid
③ A Nitrogenous Base

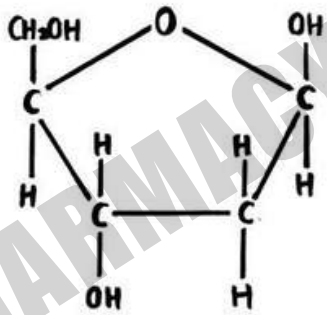
PENTOSE SUGAR

- It is a component of nucleotide.
- It named pentose because it contains 5 carbons.
- Pentose sugar is nothing but a monosaccharide with 5 carbon atoms.
- It is of two types.

① Ribose
② Deoxyribose



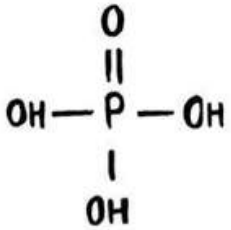
RIBOSE



DEOXYRIBOSE

PHOSPHORIC ACID

- It is also a component of nucleotide.
- Molecular formula = H_3PO_4
- It contains three hydroxyl group and one oxygen atom linked with a phosphorus atom.

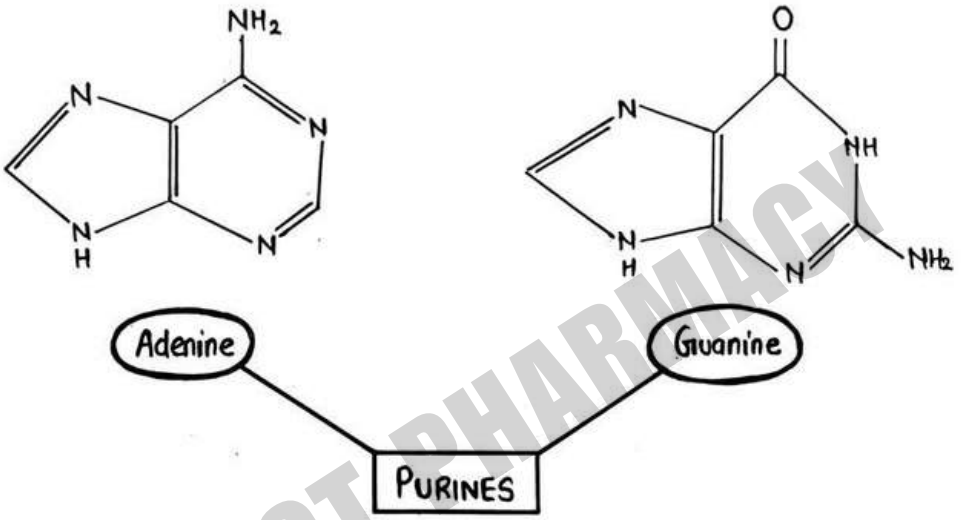


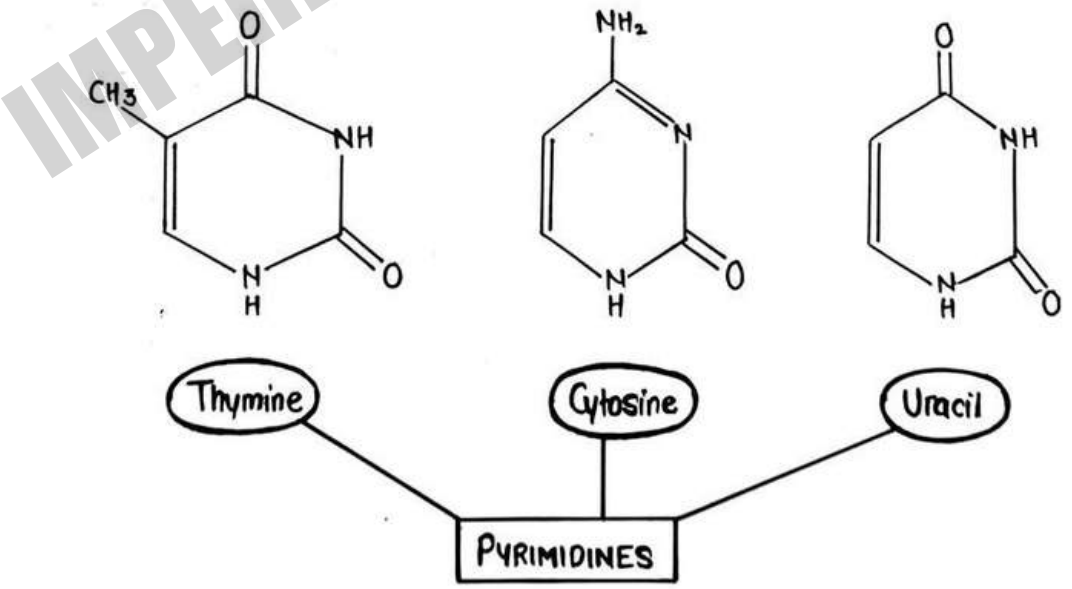
NITROGENOUS BASE

- Nitrogenous base is the component of nucleotide containing nitrogen.
- There are two types of nitrogenous base :

① PURINES (Adenine, Guanine)

② PYRIMIDINES (Urasil, Thymine and Cytosine)





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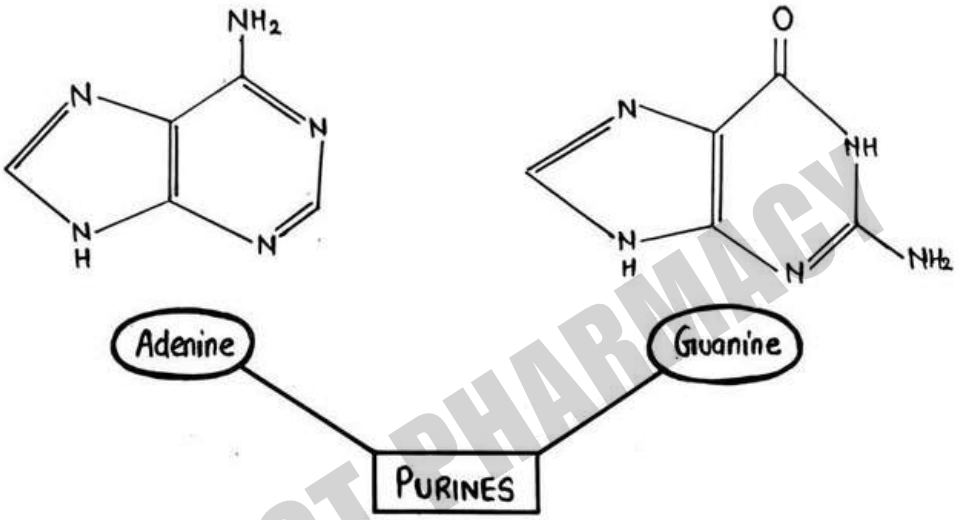

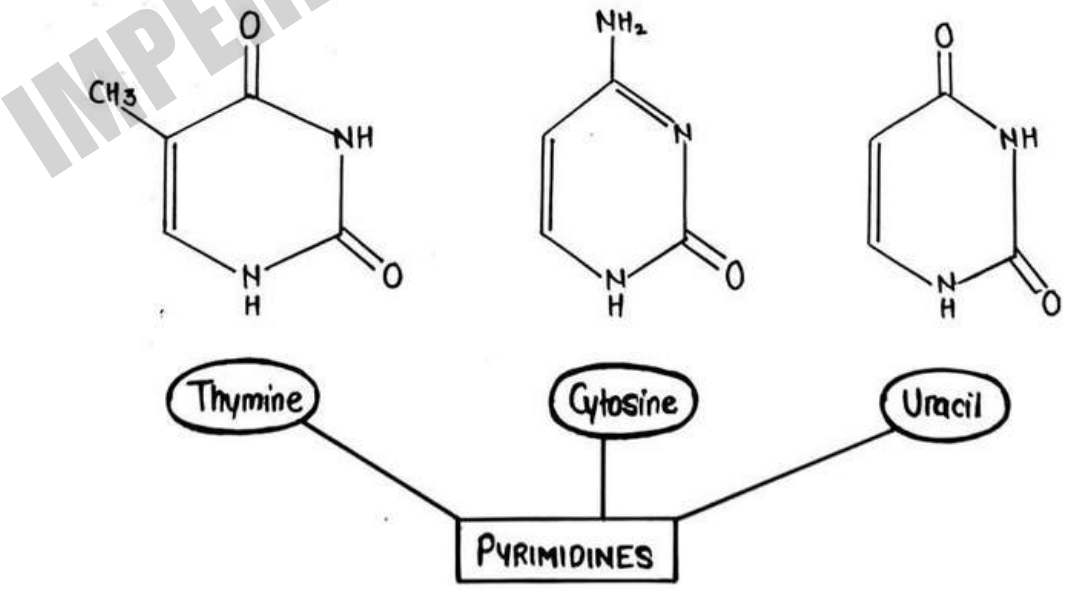

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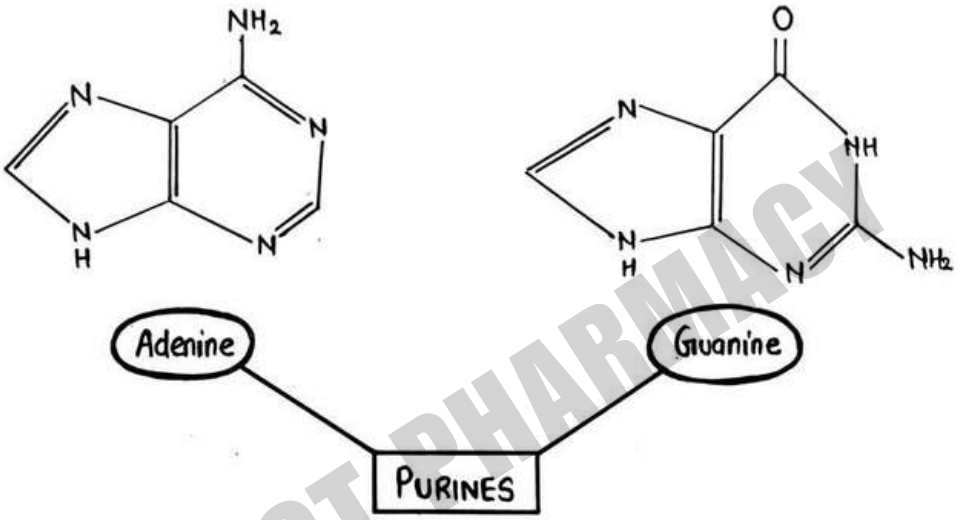

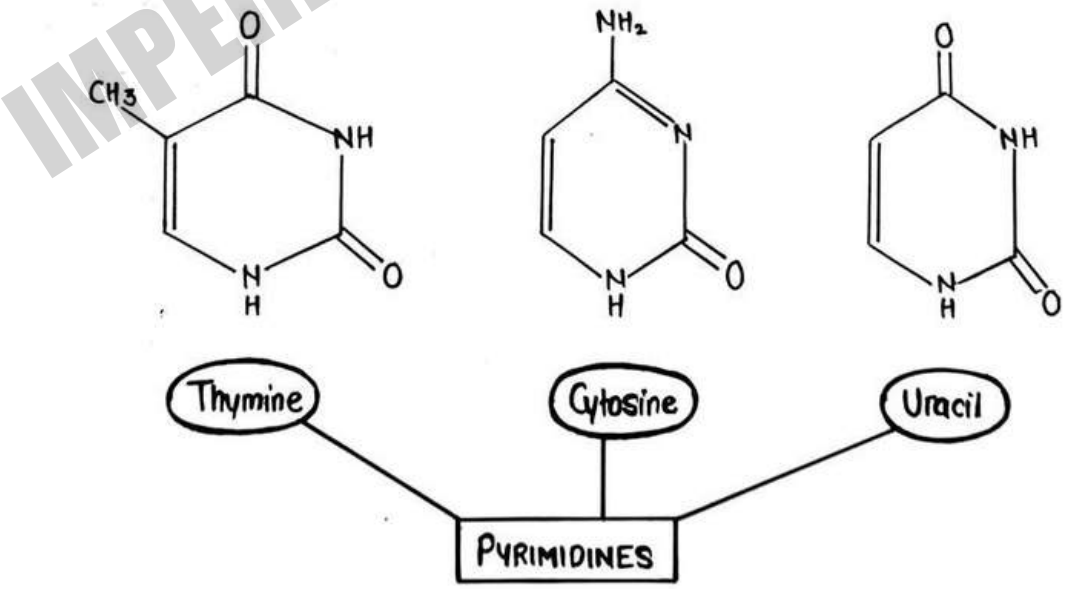

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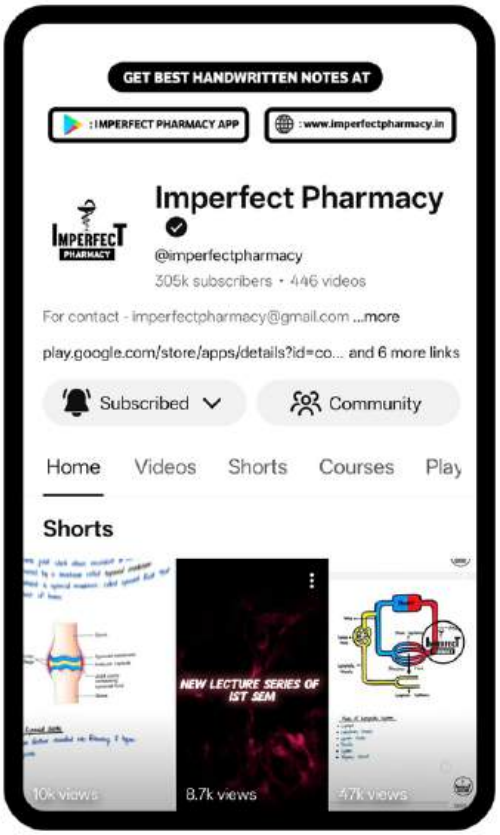

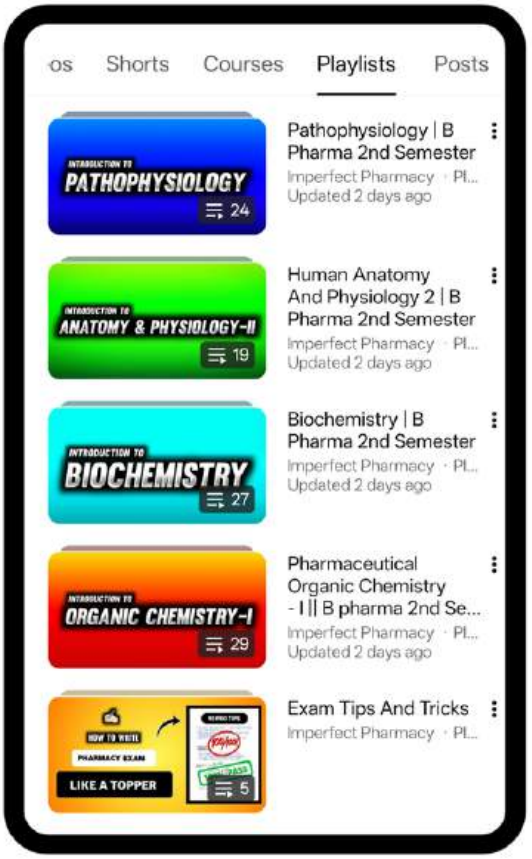

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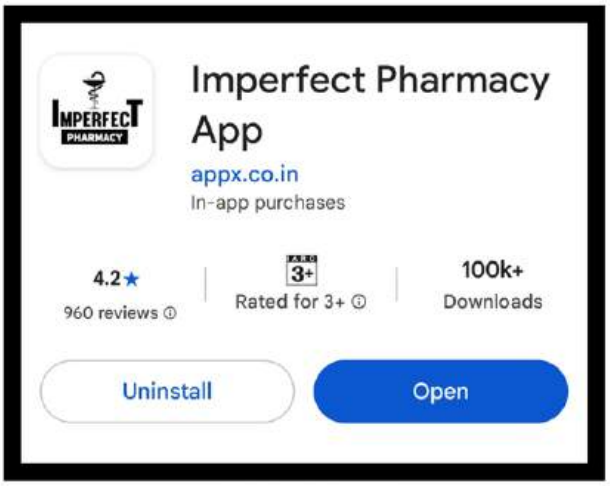
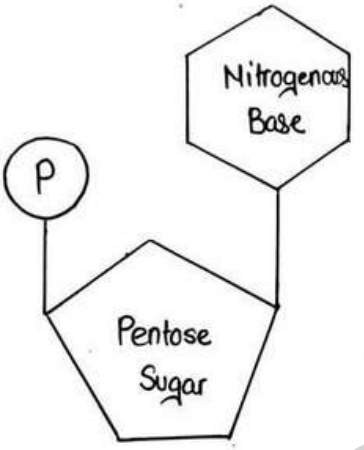
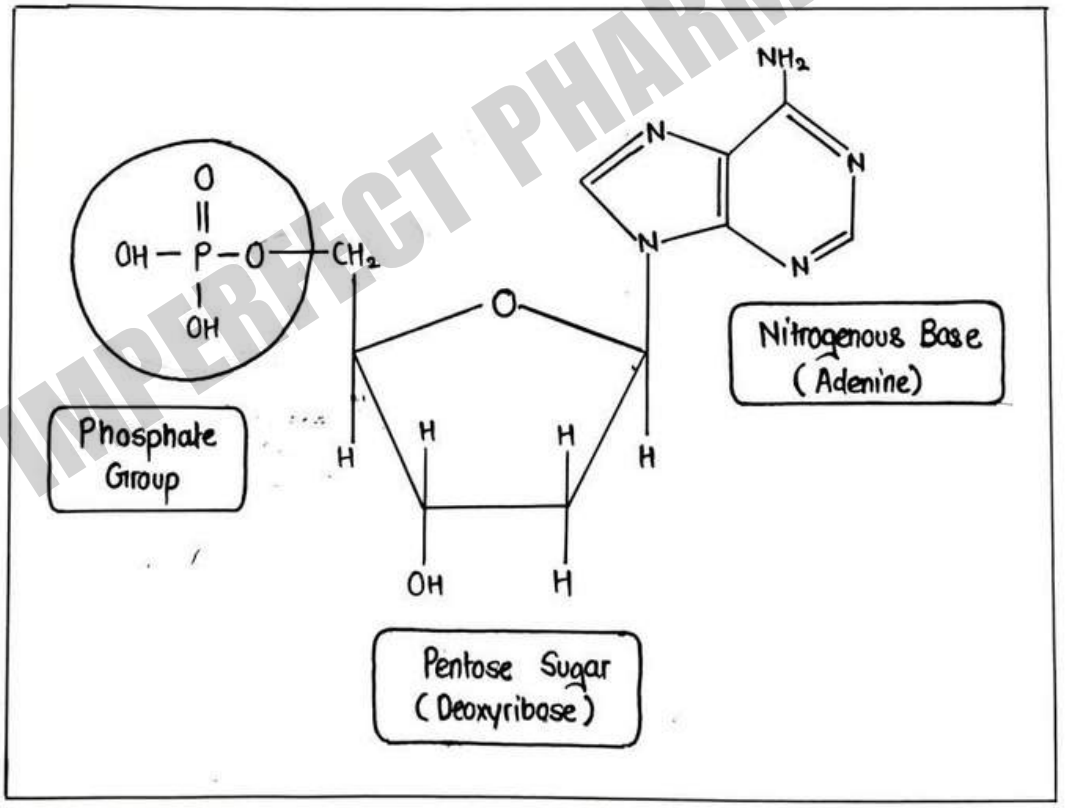


Stoucture of Nucleotide

A nucleotide is made from combination of Pentose sugar, Nitrogenous base and phosphoric acid.



GENERAL STRUCTURE

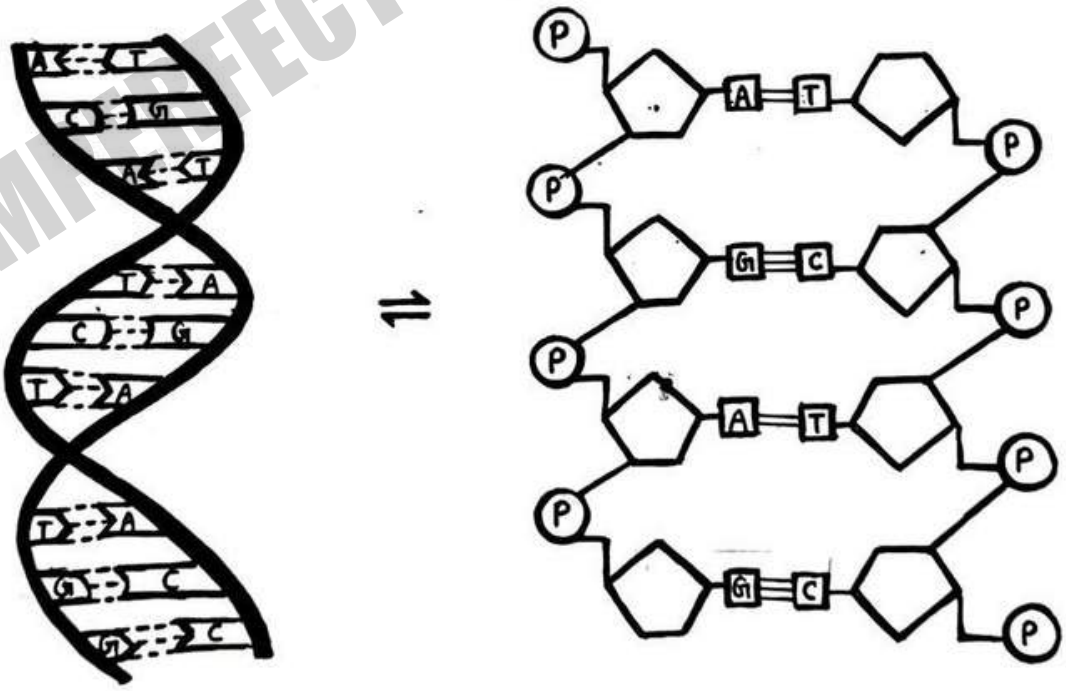


NUCLEOTIDE

NOTE : Pentose Sugar + Nitrogenous Base + Phosphate Group = Nucleotide.
Pentose Sugar + Nitrogenous Base = Nucleoside.
Or, we can say Nucleotide = Nucleoside + Phosphate Group.

DNA

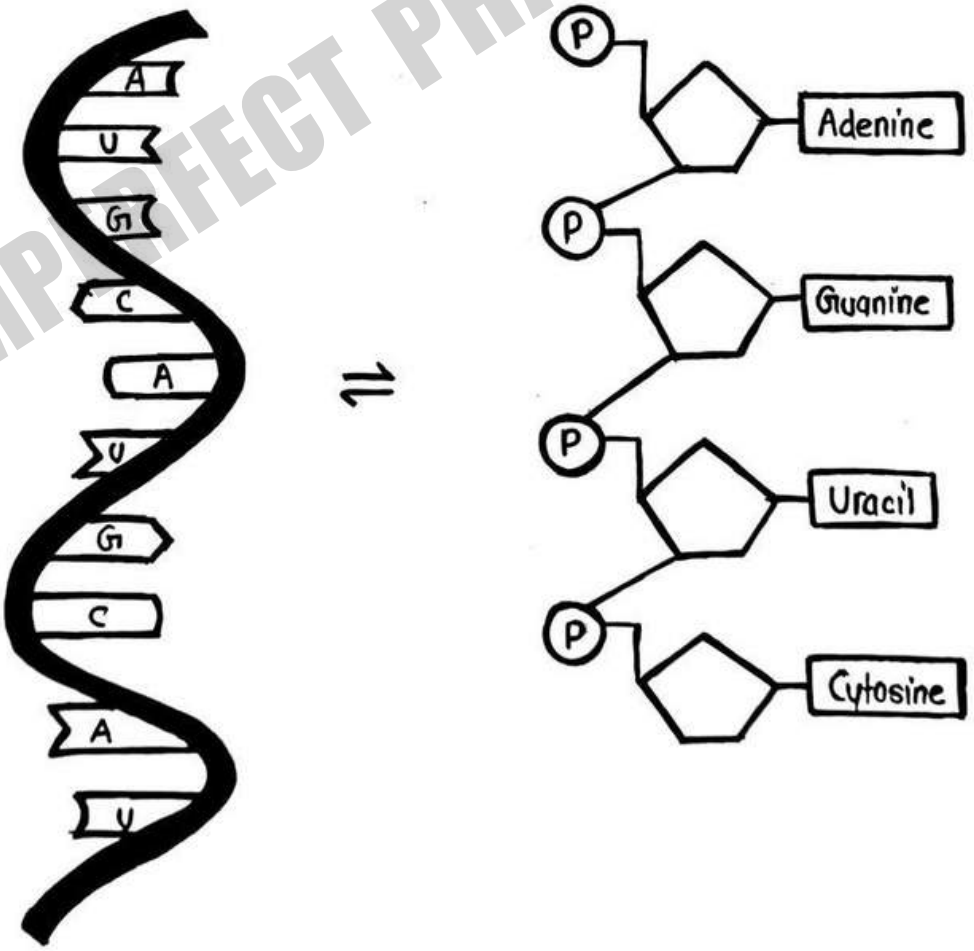
- The word DNA stands for Deoxyribonucleic Acid.
- It contains deoxyribose sugar.
- Nitrogenous Bases in DNA are : Adenine, Guanine, Cytosine, Thymine
- They are usually double stranded.
- It acts as genetic material & carries genetic information.



RNA

- RNA stands for Ribonucleic Acid.
- It contains ribose sugar.
- Nitrogenous Bases in RNA are : Adenine, Guanine, Cytosine, Uracil
- RNA is mainly responsible for protein synthesis.
- There are generally single stranded.
- There are mainly three types of RNA involved in protein synthesis

① mRNA (messenger RNA)
② tRNA (transfer RNA)
③ rRNA (ribosomal RNA)



DNA REPLICATION

- It is the process in which DNA makes multiple copies of itself.
- It is a biological polymerisation, that proceeds in the sequence of initiation, elongation & termination.
- It is an enzyme catalysed reaction.
- DNA Polymerase is the main enzyme in the replication process.

Models Of DNA Replication

There are basically 3 models of DNA replication:

① Conservative Model
② Dispersive Model
③ Semiconservative Model

Steps of DNA Replication

There are mainly 3 steps involved in the process of DNA replication:

① Initiation
② Elongation
③ Termination

INITIATION

- DNA replication demands a high degree of accuracy because even a minute mistake would result in mutations. Thus, replication cannot initiate randomly at any point in DNA.
- To begin the process of replication there is a particular region called origin of replication, this is the point where the replication originates.

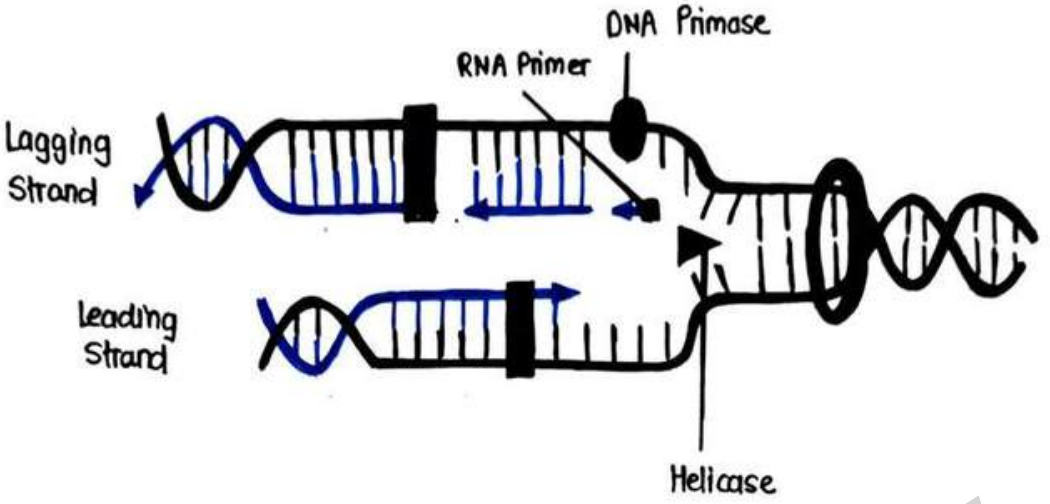
- Replication begins with the spotting of this origin followed by the unwinding of two DNA strands.
- Unzipping of DNA strands in their entire length is not feasible. due to high energy input. Hence, first, a replication fork is created catalysed by helicase enzyme that unzips the DNA strands.

ELONGATION

- As the strands are separated, the polymerase enzymes start synthesizing the complementary sequence in each of the strands.
- The parental strands will act as a template for newly synthesising daughter strands.
- It is to be noted that elongation is unidirectional i.e. DNA is always polymerised only in the 5' to 3' direction.
- In one strand it is continuous, called continuous replication while in other strand it is discontinuous, called discontinuous replication.
- They occur as fragments called Okazaki fragments.
- The enzyme called DNA ligase joined them later.

TERMINATION

- Termination of replication occurs in different ways in different organisms.
- An enzyme, called exonuclease removes all the RNA primers from original strand after the formation of continuous & discontinuous strands.



DNA REPLICATION

ENZYMES INVOLVED IN DNA REPLICATION

DNA Replication is a highly enzyme dependent process. There are so many enzymes involved in DNA Replication as follows :

① DNA Polymerase

- It helps in polymerisation, catalyses & regularises the whole process of DNA replication with support of other enzymes.
- DNA polymerase is of three types :

(i) DNA Polymerase I
(ii) DNA Polymerase II
(iii) DNA Polymerase III

② Helicase

Helicase is the enzyme that unzips the DNA strands by breaking the hydrogen bonds between them.

③ Ligase

Ligase is the enzyme which joins the okazaki fragments together of discontinuous DNA strands.

④ Primase

The enzyme helps in the synthesis of RNA primer.

⑤ Endonucleases

These produce a single stranded or double stranded cut in a DNA molecule.

TRANSCRIPTION

- Transcription is a process in which RNA (Ribonucleic Acid) is synthesized from DNA.
- It is the first step of Gene expression in which genetic information stored in DNA expressed through RNA.
- It is simply known as RNA Synthesis.
- Only specific part of DNA is responsible for RNA Synthesis known as Structural Gene.
- RNA synthesis is mediated by **RNA Polymerase**.
- The ~~template~~ ~~respo~~ strand at which RNA synthesis takes place is known as **Template (Transcripted) Strand**.
- The strand other than Template is known as Coding (Non-Transcripted) Strand.

Stages of Transcription

Transcription involves 3 different stages :

1. Initiation
2. Elongation
3. Termination

Initiation

- RNA Polymerase, an enzyme responsible for RNA Synthesis. binds to a specific region of DNA called **Promoter**.
- This marks the starting point for Transcription.
- The process involves unwinding of DNA.

Elongation

- The RNA polymerase moves along DNA template, unwinding the double helix and synthesizing a complementary RNA strand.
- As it moves, it continues to unwind the DNA ahead and rewind it behind, forming an RNA strand that is complementary to DNA template.

Termination

Eventually, transcription reaches a termination sequence in the DNA, which signals the ~~DNA~~ RNA Polymerase to release the newly synthesized RNA strand & detach from DNA Template. in the presence of Rho factor.

TRANSLATION

- Translation is defined as process by which genetic information encoded in mRNA is decoded to produce a specific sequence of amino acids, which then folds into functional protein.
- The process occurs in ribosomes of cells & involves interactions between mRNA, tRNA & ribosomal proteins.

Stages of Translation

Translation involves 3 stages :

① Initiation
② Elongation
③ Termination

Initiation

- The mRNA binds to the ribosome and the process begins with the start codon (AUG) being recognized by initiator tRNA (carrying methionine).

Elongation

- Amino Acids are added one by one to the growing polypeptide chain.
- This occurs as the ribosome moves along the mRNA molecule, reading each codon (a triplet of nucleotides) & matching it with corresponding anticodon of incoming tRNA molecule.

Termination

- The process continues until a stop codon (UAA, UAG, UGA) is encountered on the mRNA.
- This signals the ribosome to release the newly synthesized polypeptide chain, which then folds into its functional 3 dimensional unit.

Biosynthesis Of Purine Nucleotides

There are mainly two methods of biosynthesis of Purines :

① De Novo Pathway
② Salvage Pathway

De Novo Pathway

- In denovo pathway purine nucleotides are synthesized not free purine bases
- Ribose - 5 - Phosphate used as precursor in de novo pathway :

α - D - Ribose - 5 - Phosphate

ATP, AMP — PRPP Synthase

5 - Phosphoribosyl - α - Pyrophosphate

Glutamine + H_2O, Glutamate + PPi — PRPP Glutamyl Amidotransferase

5 - Phospho - β - D - Ribosylamine

Glycine + ATP, ADP + Pi — Phosphoribosyl Glycinamide Synthase

Glycinamide ribosyl - 5 - Phosphate

N^5, N^{10} - Methenyl THF, THF — Formyl transferase

Formylglycinamide ribosyl - 5 - Phosphate

Glutamine + ATP + H_2O, Glutamate + ADP + Pi — Synthase

Formylglycinamidine ribosyl - 5 - Phosphate

ATP, ADP — Synthase

5 - Aminoimidazole ribosyl - 5 - Phosphate

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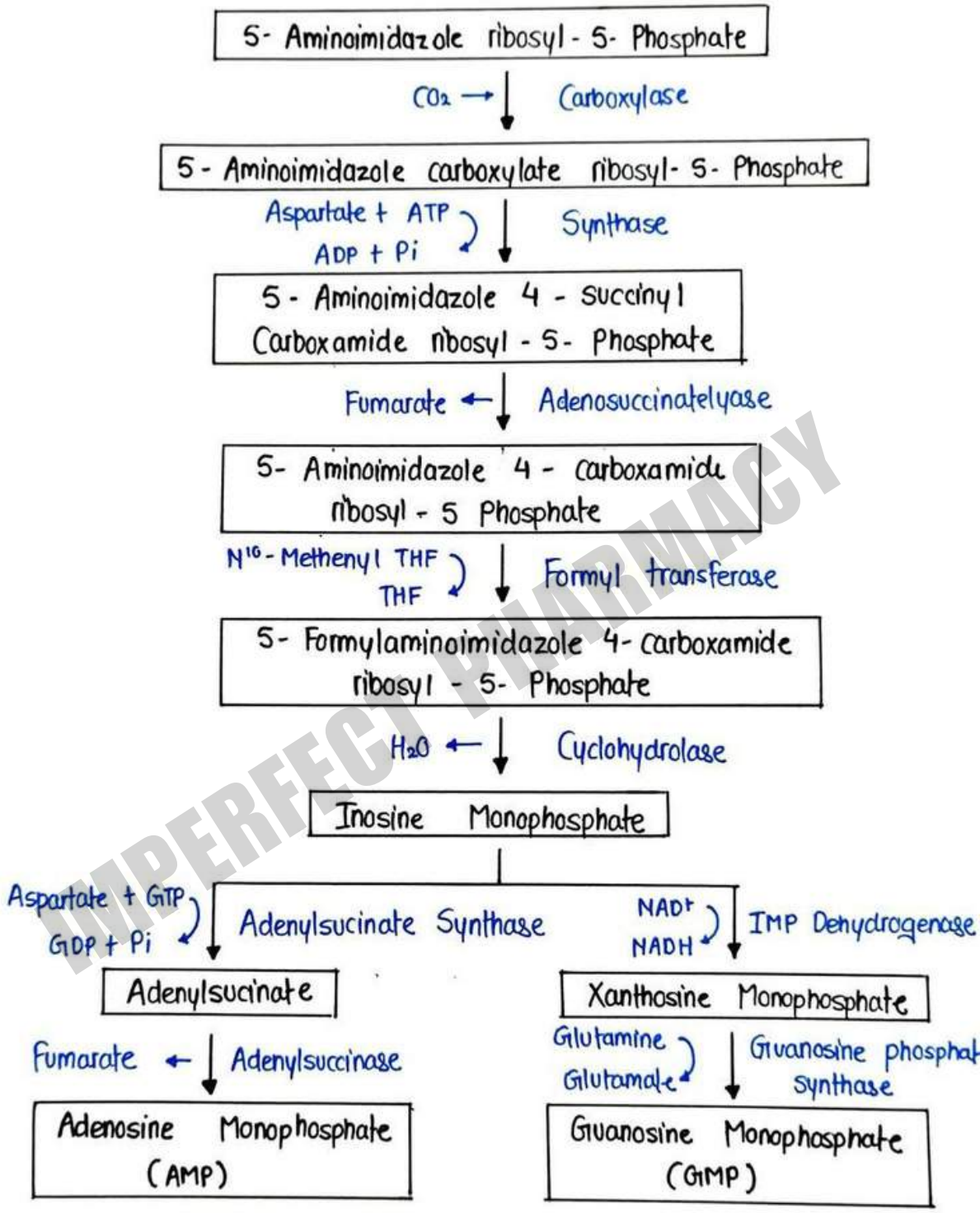
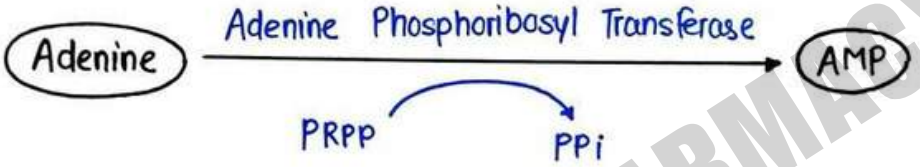
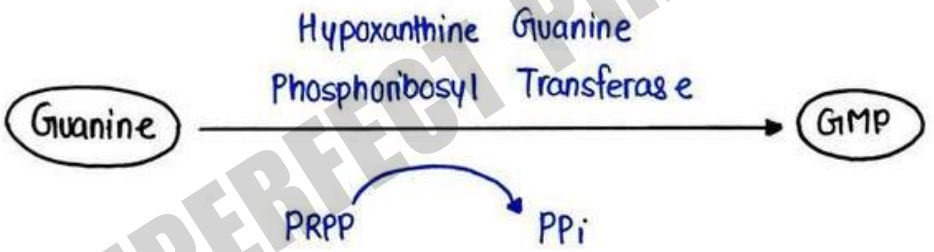
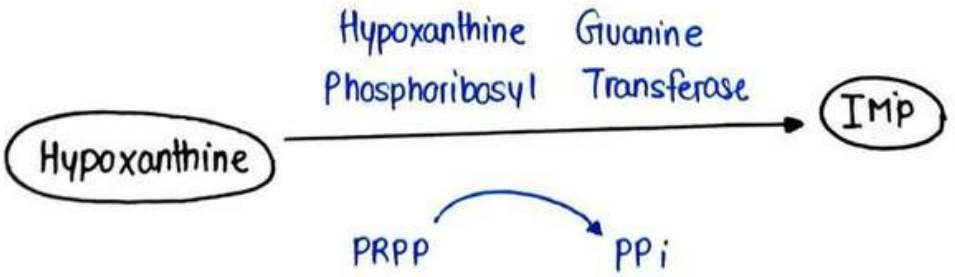


Salvage Pathway For Purines

- This pathway provides purine nucleotide for the tissues which are incapable of their biosynthesis by denovo pathway.
- example : human brain has low levels of PRPP amidotransferase & also RBCs cannot synthesize 5- phosphoribosylamine.
- Now these tissues mainly depends on salvage pathway for purine nucleotide synthesis.
- This is much simpler & required less energy.







Biosynthesis Of Pyrimidine Nucleotides

Biosynthesis of pyrimidine nucleotides occured by :

① De Novo Pathway
② Salvage Pathway

De Novo Pathway

- The pyrimidine nucleotides are :

① Cytidine Monophosphate
② Uridine Monophosphate.
③ Thymidine Monophosphate

- Unlike the synthesis of purine nucleotide, pyrimidine ring is made first & then attached to ribose phosphate., which is donated by PRPP.

CO_2 + Glutamine + ATP

2 ATP + H_2O → 2 ADP + P_i : Carbamoyl Phosphate Synthase II

Carbamoyl Phosphate

Aspartic Acid, P_i : Aspartate Transcarbomylase

Carbamoyl Aspartate

NAD^+ → $NADH$: Dihydroorotase

Orotate

PRPP → PP_i : Orotate Phosphoribosyl Transferase

Oritidine Monophosphate

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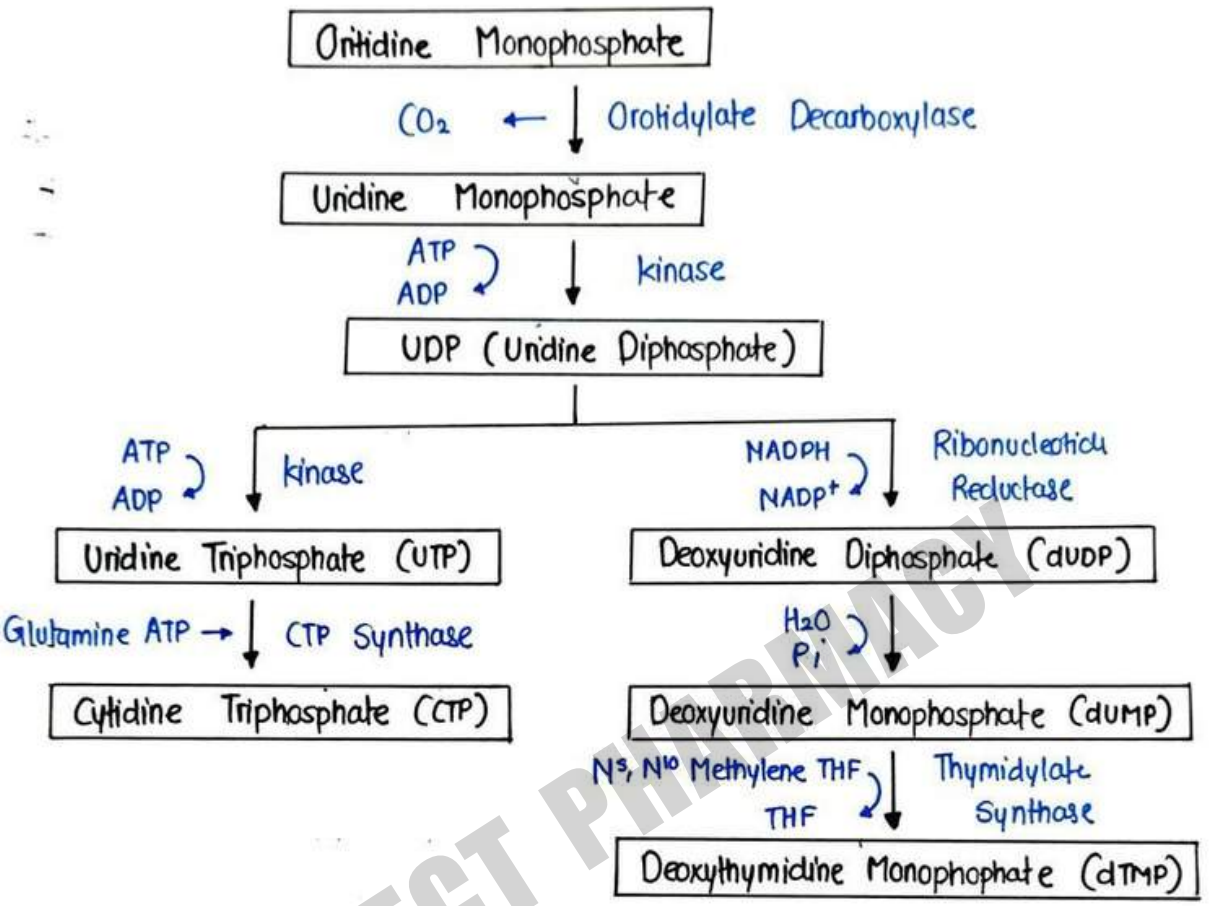
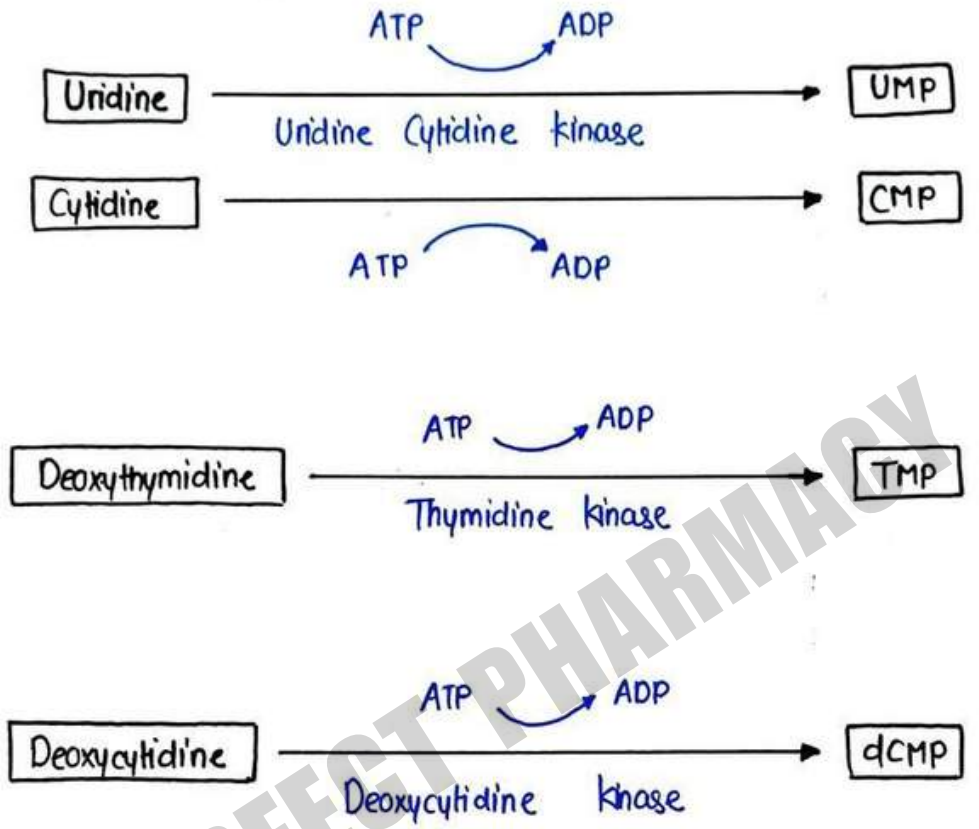


Salvage Pathway for Pyrimidines



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