University of Mosul
Lecture No.: 1
College of Veterinary Medicine
Date:
Unit of Scientific Affairs
Website:

Lecture title: Nucleotides

Lecturer Affiliation: University of Mosul / College of Veterinary Medicine / Department of Physiology, Biochemistry and Pharmacology

Occurrence: Nucleotides are present in all type of cells.

Biochemical Importance

1. Nucleotides are high energy compounds.
2. Nucleotides are required for formation of certain co-enzymes.
3. Some nucleotides act as a 'second messenger' because many hormones exert their action through nucleotides.
4. Certain nucleotides act as a carrier or donor of activated sugars, sulfates and nitrogenous compounds.
5. Few nucleotides are involved in signal transduction.
6. Some nucleotides are involved in regulation of metabolic pathways.
7. Nucleotides act as alarmones (regulate cell metabolism and alarms cell when there is disturbance).
8. Synthetic analogs of nucleosides and nitrogenous bases are anticancer and antiviral agents.
9. Some nitrogenous bases are CNS stimulants.
10. Some bases act as anti-oxidants.

11. Some nucleotide analogs are mutagens.
12. Nucleotides are building blocks of nucleic acids (DNA and RNA).
13. Cyclic nucleotide (cAMP) is involved in the regeneration of nervous tissues that are injured.
14. Some nucleotides are involved in regulation of ion channel activity.

Chemical nature of nucleotides

1. Nitrogen bases.
2. Sugar (Ribose or deoxyribose).
3. Phosphate.

Nitrogenous bases: Nucleotides contain two types of nitrogenous bases. They are purine bases and pyrimidine bases.

Purine bases:

- Purine contains heterocyclic ring system. The carbon (C) and nitrogen (N) atoms of purine ring are numbered in anticlockwise direction.

- The purines present in nucleotides are adenine and guanine. The structures of adenine and guanine along with their systematic names are shown in fig.1.

- Other purine bases are xanthine, hypoxanthine and uric acid,

the structures of these bases are shown in fig.1.

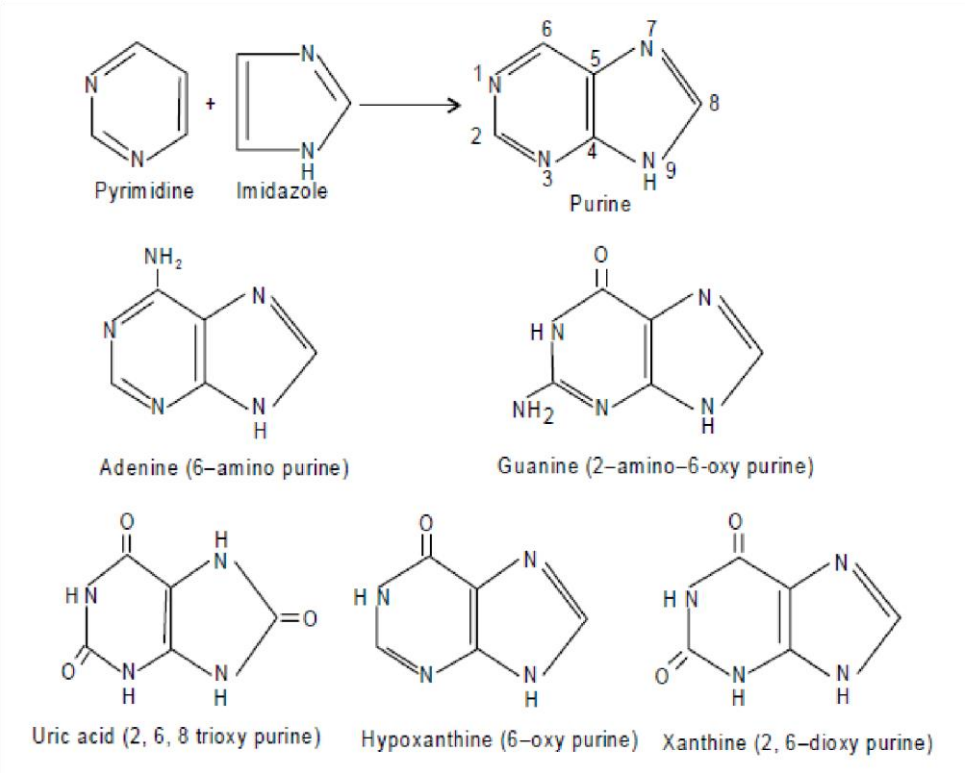


Fig. 1. Structure of purines

Properties of purine bases

1. Purine bases absorb light in UV region at 260 nm. This property is used for detection and quantitation of purine nucleotides.
2. Purine bases are capable of forming hydrogen bonds.

Pyrimidine bases

- Pyrimidine is a heterocylic compound. The structure of pyrimidine ring along with numbering of atoms is shown in

  Fig.2

- The C and N atoms are numbered in clockwise direction.
- The pyrimidine bases present in nucleotides are cytosine, uracil and thymine. The structures of these pyrimidines along with their systematic names are shown in Fig.2

Properties of pyrimidine bases

1. Pyrimidine bases also absorb UV light at 260 nm. This property is used to detect and estimate pyrimidine nucleotides.
2. They are capable of forming hydrogen bonds.

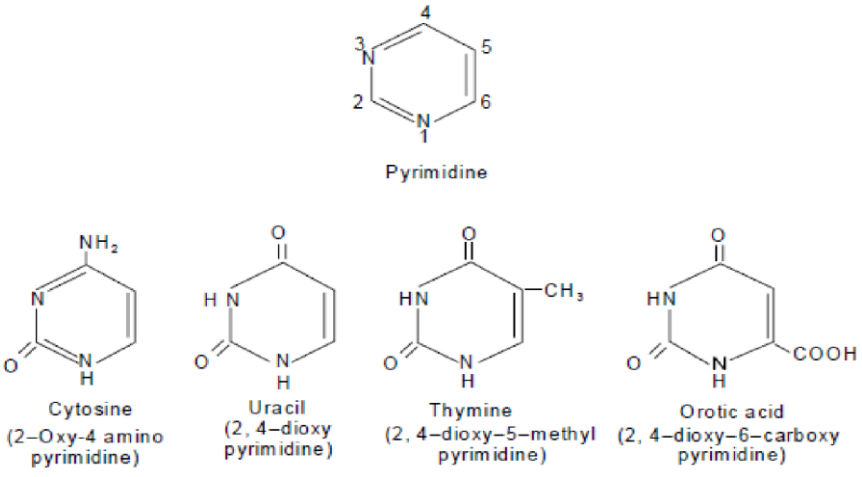


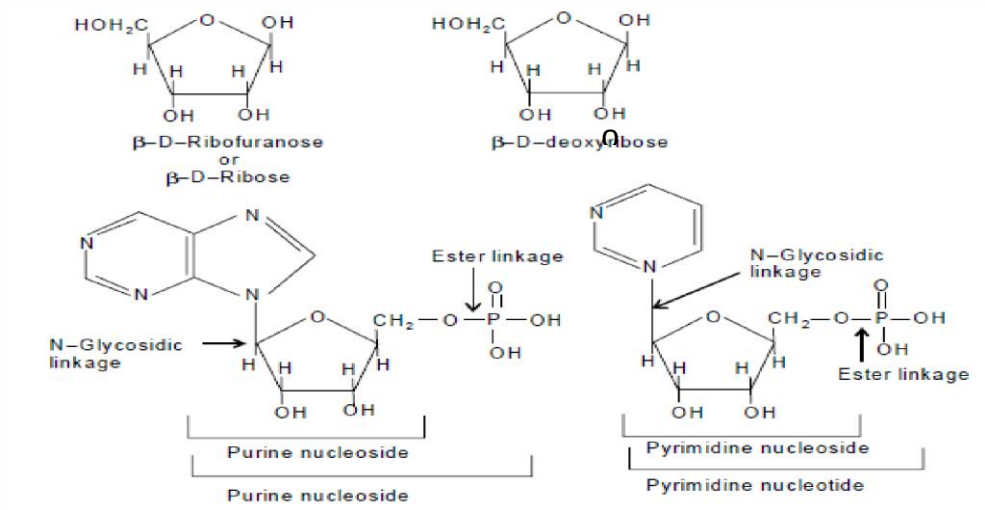
Fig. 2. Structure of pyrimidine

Sugars

Two types of pentose sugars are found in nucleotides. They are ribose and deoxyribose. Nucleotides are named according to the type of sugar present. If the sugar is deoxyribose then nucleotide is named as deoxyribonucleotide. Similarly, if the sugar is ribose then nucleotide is named as ribonucleotide.

Nucleosides: A nucleoside is composed of purine and pyrimidine base and sugar. Nitrogenous bases bonded to sugar molecule by Nglycosidic bond. (fig.3).

Nucleotides: They are phosphorylated nucleosides. Thus, a nucleotide has three structural components. They are nitrogenous base, sugar and phosphate. Phosphate is attached to ribose by an ester linkage.



nucleotide

Fig. 3. Structures of ribose, deoxyribose; purine and pyrimidine nucleosides and their corresponding nucleotides

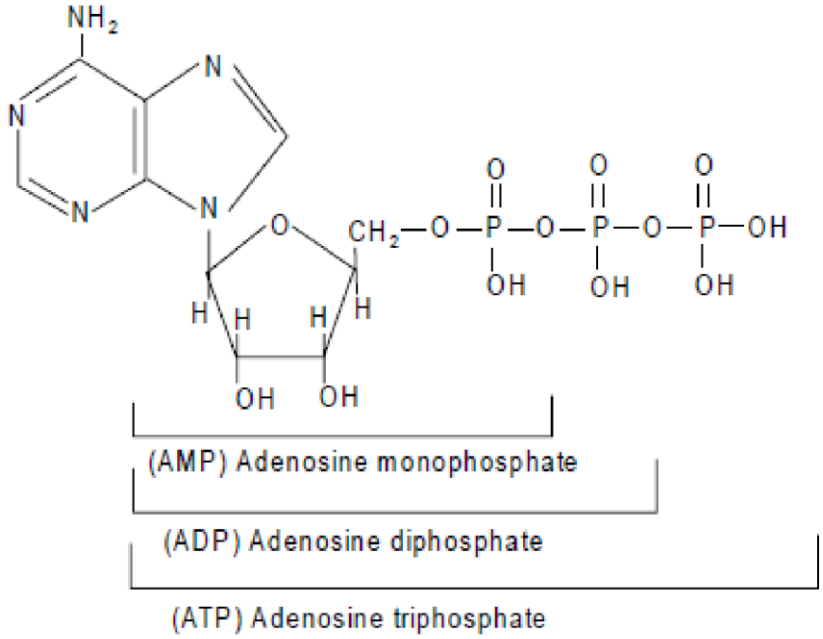


Fig. 4. AMP, ADP, and ATP structure

Dinucleotides

They consist of two nucleotides. They are joined together by phosphodiester linkage. 3'-OH of the first nucleotide is linked to 5'OH of second nucleotide by the phosphodiester bond.

Two co-enzymes, which are dinucleotides; NAD^+ ($NADP^+$) and FAD.

Oligonucleotides

They consist of 2-10 nucleotides. **Adenine nucleotides and their functions**

1. ATP is energy currency of cell.

2. Oxidative phosphorylation of respiratory chain requires ADP.

ADP is a high energy compound.

3. ATP, ADP and AMP are allosteric effectors of several enzymes.

4. Several hormones apply their action through cyclic AMP (cAMP).

5. Adenine nucleotides are constituents of FAD and NAD^+

($NADP^+$), and coenzyme A.

6. Oligoadenylate is mediator for interferon action.

7. ATP is required for protein biosynthesis.

Guanine nucleotides and their functions

1. GTP and GDP are high energy compounds.

2. GTP is required for protein biosynthesis.

3. Many hormones mediate their action though cyclic GMP (cGMP).

4. G-proteins, which requires GTP and GDP are involved in signal transduction of several biological processes like vision, taste, metabolic regulation, olfaction, and also in the development of cancer.

5. RNA is catalytic action require the presence of GMP.

6. GDP is carrier of activated sugars in the biosynthesis of mucopolysaccharides.

Uracil nucleotides

1. UTP and UDP are high energy compounds.

2. UDP is a carrier of activated sugars and amino sugars needed for the synthesis of glycogen, glycoportein, gangliosides… etc.

3. UDP-glucuronate serves as a donor of glucuronide in conjugation reactions.

Cytosine nucleotides

1. CTP and CDP are high energy compounds.

2. CDP-choline serves as a donor of choline in the biosynthesis of phospholipid.

Purine and pyrimidine analogs

Several synthetic analogs of purines and pyrimidines are used as anti-cancer agents, in the treatment of autoimmune diseases, certain types of hypersensitivity, AIDS…etc.

Purine analogs:

1. Mercaptopurine.

2. Thioguanine.

3. 2-Aminopurine.

4. Allopurinol.

5. Azathiopurine.

Pyrimidine analogs:

1. 5-Flurouracil (5-FU).