Lecture 14
Discipline: Bioorganic Chemistry
Lecturer: Associate Professor, Dr. Gulnaz Seitimova

Title: Deoxyribonucleic acids (DNA). DNA organization levels. Physiological role. Nucleotides and DNA nucleosides, their structure, chemical properties. Pyrimidine and purine bases of nucleosides and nucleotides, their tautomeric transformations.

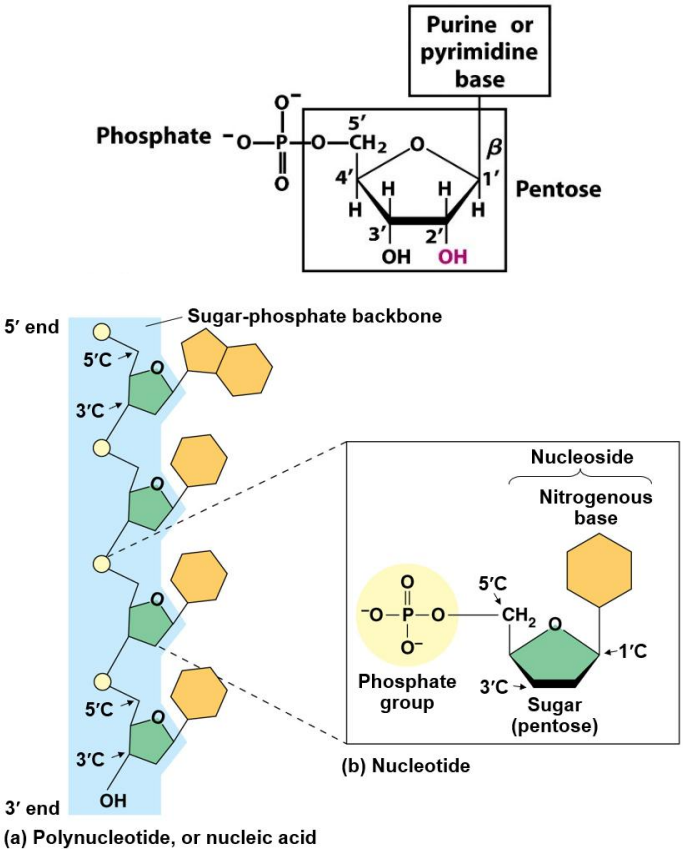
Objective: To explain the structural principles of DNA, the hierarchy of its organization levels, the physiological role of genetic material, and the chemical structure and tautomerism of nucleosides, nucleotides, and their purine and pyrimidine bases.

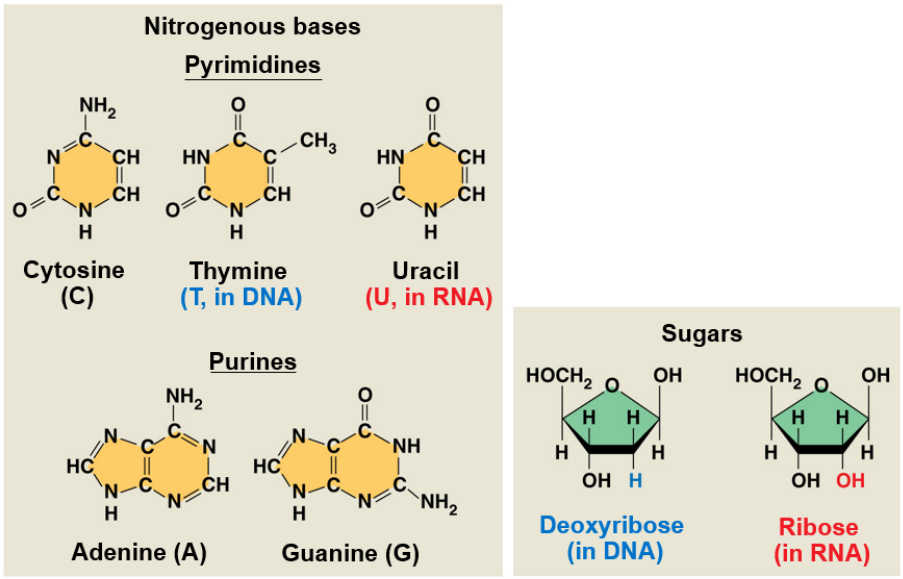
Main Questions: DNA: definition, composition, and structural features. Primary, secondary, tertiary, and quaternary organization levels of DNA. Physiological role of DNA in heredity, replication, and protein synthesis. Structure and chemical properties of nucleotides and nucleosides. Purine and pyrimidine bases: structural characteristics and tautomeric forms. Significance of tautomerism in mutagenesis and replication fidelity.

Key Notes and Theses

DNA Composition and General Structure

- DNA is a biopolymer composed of repeating deoxyribonucleotide units.
- Each nucleotide contains three components: deoxyribose, phosphate residue, and nitrogenous base (purine or pyrimidine).
- Purine bases: adenine (A) and guanine (G).
- Pyrimidine bases: cytosine (C) and thymine (T).





(c) Nucleoside components

Levels of DNA Organization

Primary structure: linear sequence of nucleotides connected by 3'→5' phosphodiester bonds.

Secondary structure: canonical double helix (B-form) stabilized by Watson–Crick base pairing (A–T, G–C) and π–π stacking interactions.

Tertiary structure: DNA supercoiling and packaging (nucleosomes, chromatin fibers).

Quaternary structure: chromosome-level organization in eukaryotic cells.

Physiological Role of DNA

- Repository of genetic information.
- Ensures faithful transmission of hereditary traits during cell division.
- Serves as a template for replication and for transcription in protein synthesis.
- Plays a key role in cell differentiation, biological development, and genome stability.

Nucleosides and Nucleotides: Structure and Chemical Properties

- A nucleoside = nitrogenous base + deoxyribose linked by an N-glycosidic bond.
- A nucleotide = nucleoside + phosphate group(s).
- Nucleotides can exist as mono-, di-, and triphosphates, exhibiting acidic properties due to ionizable phosphate groups.
- Chemical properties include hydrolysis, phosphorylation, and participation in enzymatic reactions involving polymerases and kinases.

Purine and Pyrimidine Bases

- Purines consist of a bicyclic (imidazole + pyrimidine) ring system; pyrimidines contain a single 6-membered ring.
- Bases engage in hydrogen bonding and π-electron interactions critical for helix stability.

Tautomeric Transformations

- Purine and pyrimidine bases undergo keto-enol (for pyrimidines) and amino-imino (for purines) tautomerism.
- Rare tautomeric forms can mispair during replication, leading to point mutations.
- Tautomeric equilibrium is influenced by pH, solvent, and temperature.

Questions for Knowledge Assessment

1. What are the structural differences between nucleosides and nucleotides?
2. What are the key features of the primary and secondary structures of DNA?
3. How do Watson–Crick base pairs stabilize the double helix?
4. What biological processes rely on DNA as a template?
5. How does tautomerism contribute to spontaneous mutations?
6. Describe the structural differences between purine and pyrimidine bases.
7. What roles do phosphodiester bonds play in DNA structure?

Recommended Literature

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