Nucleic Acids

2.cl.

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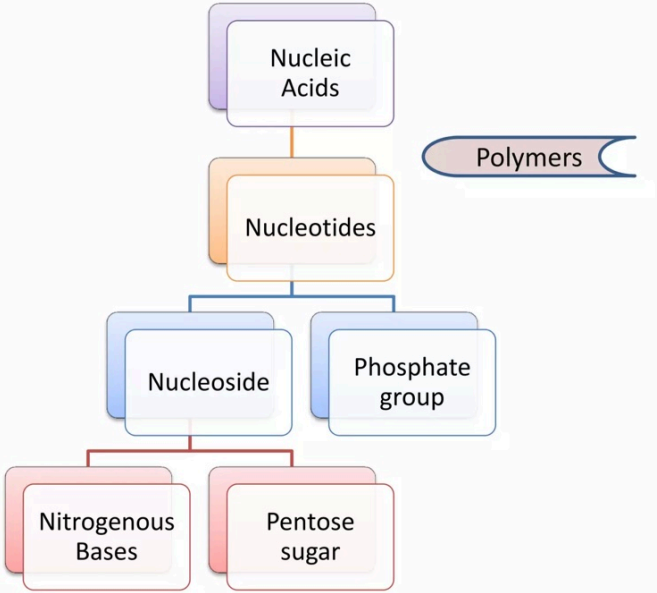
Definition

- Nucleic acids are the biopolymers, or large biomolecules, essential to all known forms of life. The term nucleic acid is the overall name for DNA and RNA.
- They are composed of nucleotides, which are the monomers made of three components: a 5-carbon sugar, a phosphate group and a nitrogenous base.
- If the sugar is a compound ribose, the polymer is RNA (ribonucleic acid); if the sugar is derived from ribose as deoxyribose, the polymer is DNA (deoxyribonucleic acid).

History

- Nuclein were discovered by Friedrich Miescher in 1869.
- In the early 1880s Albrecht Kossel further purified the substance and discovered its highly acidic properties. He later also identified the nucleobases.
- In 1889 Richard Altmann creates the term nucleic acid.
- In 1938 Astbury and Bell published the first X-ray diffraction pattern of DNA.
- In 1953 Watson and Crick determined the structure of DNA.

Structural Composition



Nitrogenous bases

- A nitrogenous base, or nitrogen-containing base, is an organic molecule with a nitrogen atom that has the chemical properties of a base.
- The main biological function of a nitrogenous base is to bond nucleic acids together.
- Nitrogenous bases are typically classified as the derivatives of two parent compounds, **pyrimidine** and **purine**.

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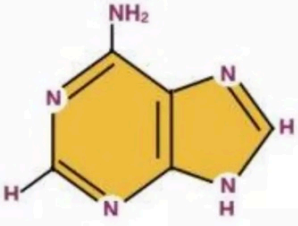
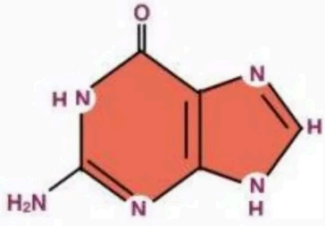
Purines

- Purine is a heterocyclic aromatic organic compound that consists of a two rings in their structure. It is water-soluble.



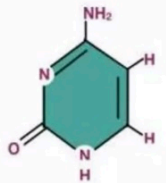
Adenine A

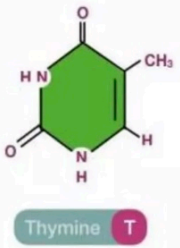


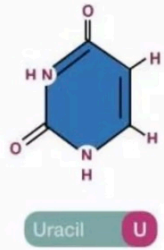
Guanine G

Pyrimidine

- Pyrimidine is an aromatic heterocyclic single ring organic compound similar to pyridine.
- it has the nitrogen atoms at positions 1 and 3 in the ring.

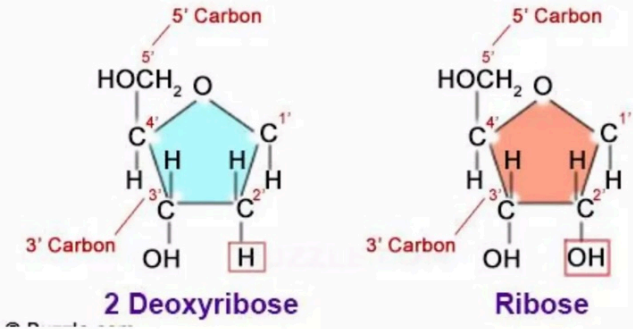




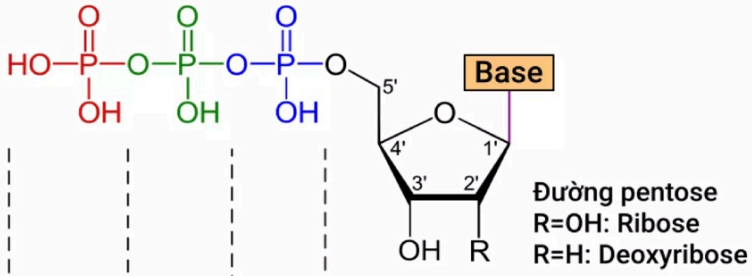


Pentose Sugar

- A **pentose sugar** is a monosaccharide with 5 carbon atoms. It can be Ribose (RNA) or deoxyribose (DNA).



Nucleoside & Nucleotide

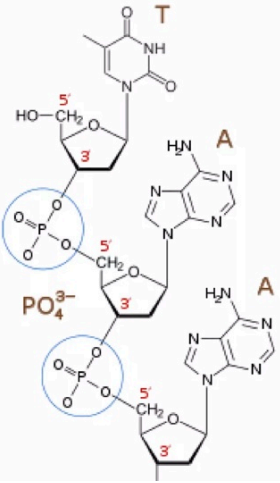


Polynucleotide

- A polynucleotide molecule is a biopolymer composed of 13 or more nucleotide monomers covalently bonded in a chain. DNA (deoxyribonucleic acid) and RNA (ribonucleic acid) are examples of polynucleotides with distinct biological function.
- The nucleotides can be held together by phosphodiester linkage to form polymer.

Phosphodiester bond

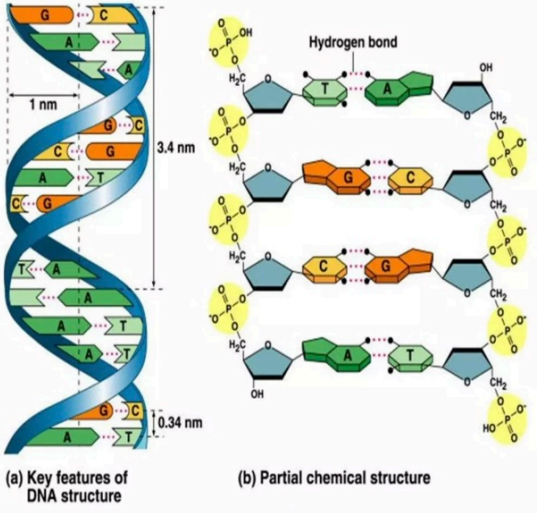
- A phosphodiester bond occurs when exactly two of the hydroxyl groups in phosphoric acid react with hydroxyl groups on other molecules to form two ester bonds.
- Phosphodiester bonds are central to all life on Earth as they make up the backbone of the strands of nucleic acid. In DNA and RNA, the phosphodiester bond is the linkage between the 3' carbon atom of one sugar molecule and the 5' carbon atom of another, deoxyribose in DNA and ribose in RNA.



Types of Nucleic acids

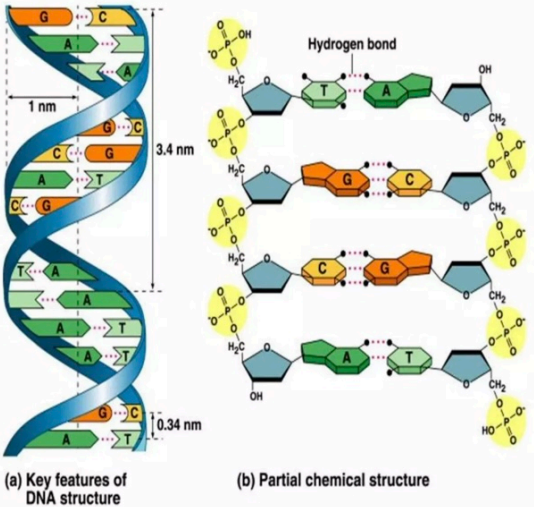
Feature	DNA	RNA
Function	Holds genetic information	Transcribes and regulates the genetic information
Strandedness	Double stranded	Single stranded
Nucleotides	A, T, C and G	A, U, C and G
Sugar	Deoxyribose	Ribose
Size	Large polymers	Variable in size but smaller than potential length of DNA polymers
Stability	Stable	Unstable
Location in the cell	Nucleus (a very small amount in mitochondria)	Moves from nucleus (specifically the nucleolus) to cytoplasm/ribosomes

Composition of DNA



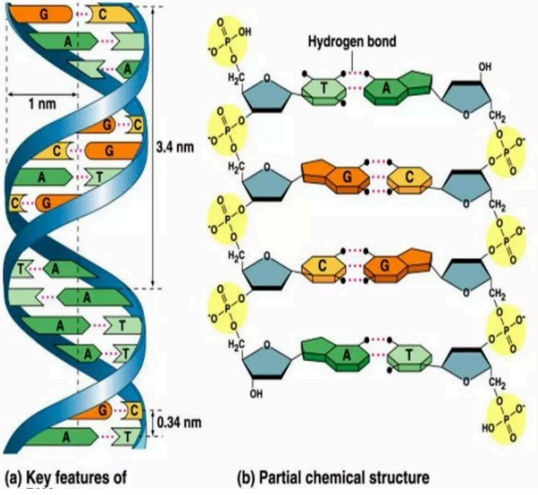
- Deoxyribonucleic acid is a molecule composed of two polynucleotide chains that coil around each other to form a double helix carrying genetic instructions for the development, functioning, growth and reproduction of all known organisms and many viruses.

Composition of DNA



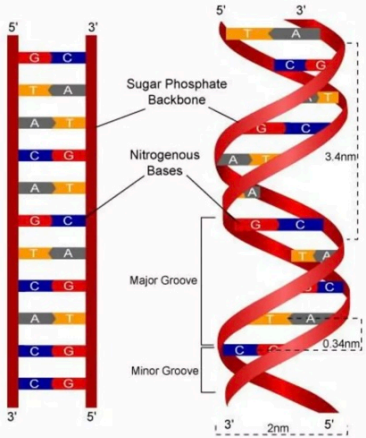
- DNA was first isolated by Friedrich Miescher in 1869. Its molecular structure was first identified by Francis Crick and James Watson at the Cavendish Laboratory within the University of Cambridge in 1953, whose model-building efforts were guided by X-ray diffraction data acquired by Raymond Gosling, who was a post-graduate student of Rosalind Franklin at King's College London.

Composition of DNA



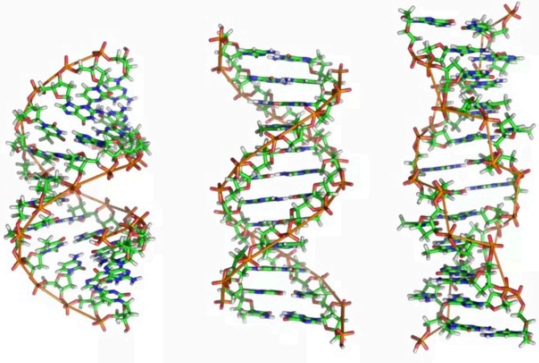
- In all species it is composed of two helical chains, bound to each other by hydrogen bonds. Both chains are coiled around the same axis, and have the same pitch of 34 angstroms (Å) (3.4 nanometres).
- The pair of chains has a radius of 10 angstroms (1.0 nanometre).
- According to another study, when measured in a different solution, the DNA chain measured 22 to 26 angstroms wide (2.2 to 2.6 nanometres), and one nucleotide unit measured 3.3 Å (0.33 nm) long.

Composition of DNA



- Twin helical strands form the DNA backbone.
- Another double helix may be found tracing the spaces, or grooves, between the strands. These voids are adjacent to the base pairs and may provide a binding site.
- As the strands are not symmetrically located with respect to each other, the grooves are unequally sized. One groove, the major groove, is 22 angstroms (Å) wide and the other, the minor groove, is 12 Å wide.

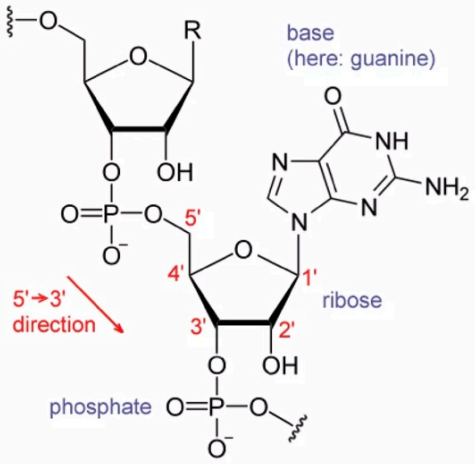
Conformation of DNA structure



From left to right, the structures of A, B and Z DNA

- DNA exists in many possible conformations that include A-DNA, B-DNA, and Z-DNA forms, although, only B-DNA and Z-DNA have been directly observed in functional organisms.
- The conformation that DNA adopts depends on the hydration level, DNA sequence, the amount and direction of supercoiling, chemical modifications of the bases, the type and concentration of metal ions, and the presence of polyamines in solution.

Composition of RNA



- Ribonucleic acid (RNA) is a polymeric molecule essential in various biological roles in coding, decoding, regulation and expression of genes.
- Each nucleotide in RNA contains a ribose sugar, with carbons numbered 1' through 5'. A base is attached to the 1' position, in general, adenine (A), cytosine (C), guanine (G), or uracil (U). Adenine and guanine are purines, cytosine and uracil are pyrimidines.

Types of RNA

- There are 4 types of RNA, each encoded by its own type of gene:
- mRNA - Messenger RNA: Encodes amino acid sequence of a polypeptide.
- tRNA - Transfer RNA: Brings amino acids to ribosomes during translation.
- rRNA - Ribosomal RNA: With ribosomal proteins, makes up the ribosomes, the organelles that translate the mRNA.
- snRNA - Small nuclear RNA: With proteins, forms complexes that are used in RNA processing in eukaryotes. (Not found in prokaryotes.)

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Thank You