

THE NUCLEIC ACIDS

HISTORIC RESUME

Friedrich Miescher in 1869

- Isolated what he called **nuclein** from the nuclei of pus cells
- Nuclein was shown to have acidic properties, hence it became called **nucleic acid**



NUCLEIC ACID

- Nucleic acid are polymers that consist of nucleotide residues.
- Located in nuclei of cell
- Hereditary determinants of living organisms
- Elemental composition – carbon, hydrogen, oxygen, nitrogen and phosphorus

TYPES OF NUCLEIC ACID

- Deoxyribonucleic acid (DNA)
- Ribonucleic acid (RNA)

The distribution of nucleic acids in the eukaryotic cell

- DNA is found in the nucleus
with small amounts in mitochondria and chloroplasts
- RNA is found throughout the cell

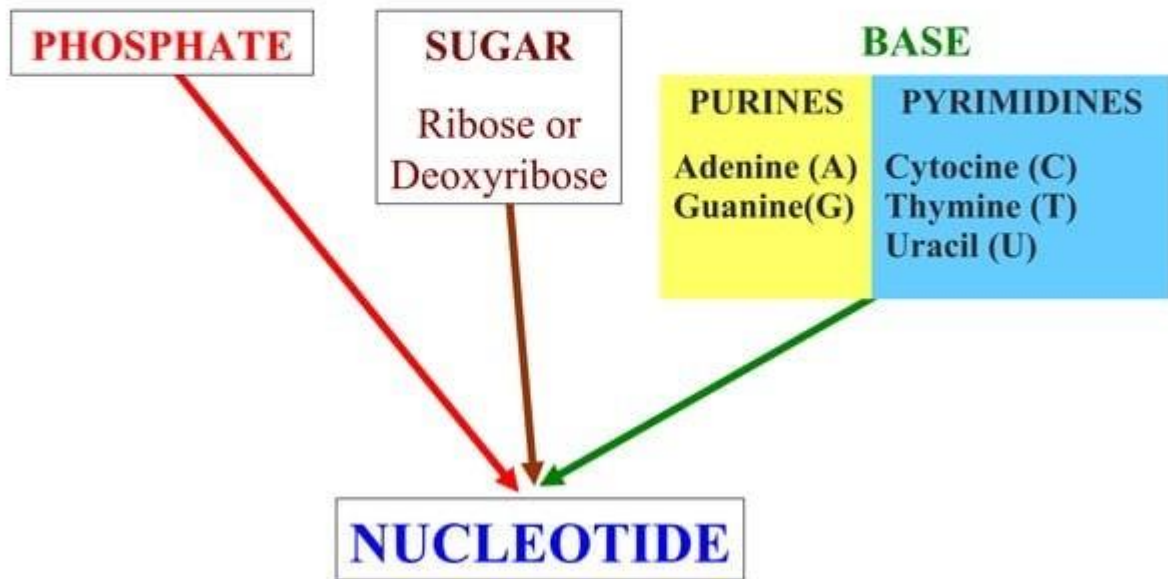
NUCLEIC ACID STRUCTURE

- Nucleic acids are **polynucleotides**
- Their building blocks are **nucleotides**

NUCLEOTIDES

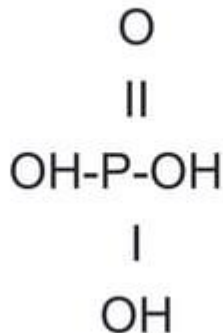
- Energy rich compounds that drive metabolic process in cell
- Serve as chemical signals, key links in cellular systems that respond to hormones and other extracellular stimuli
- Structural component of no of enzyme cofactor and metabolic intermediate
- Each nucleotide is formed by 3 units – PHOSPHATE, SUGAR, NITROGENOUS BASE

NUCLEOTIDE STRUCTURE



Phosphoric acid

- Molecular formula H_3PO_4
- Contains 3 monovalent hydroxyl group and a divalent oxygen atom
- All linked to pentavalent phosphorous atom



Sugar

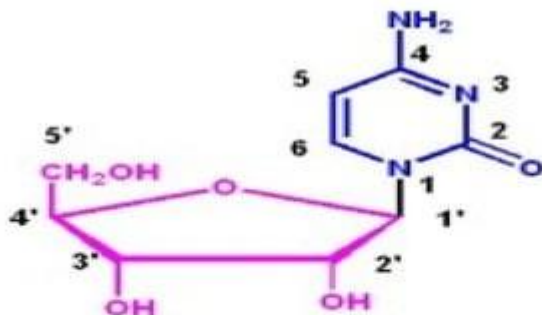
- 5 carbon keto sugar or pentose
- One possess d2 deoxyribose and other contain d ribose
- Both sugar are present in furanose form and beta configuration
- Pentose sugar form esters with phosphoric acid and is called phosphodiester bond

Nitrogenous base

- 2 types of nitrogenous base
- PURIN AND PYRIMIDINES DERIVATIVES
- This base is linked to sugar moiety by same carbon used in sugar-sugar bond
- PURINS are – ADENINE AND GUANINE
- PYRIMIDINE DERIVATIVES are – URACIL, THYMINE AND CYTOSINE

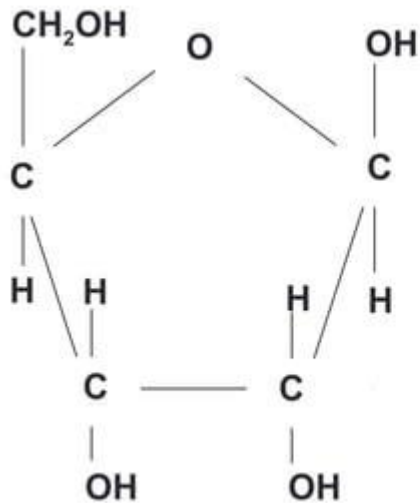
NUCLEOSIDES

- When ribose or 2-deoxyribose is combined with purine or pyrimidine base Nucleoside is formed

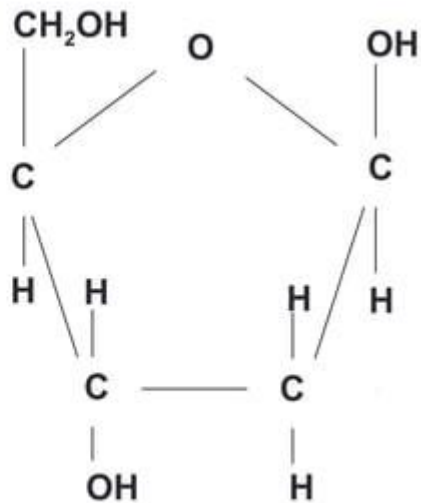


A nucleoside:
 **β -glycosidic bond between D-ribose and
cytosine nitrogenous base**

RIBOSE

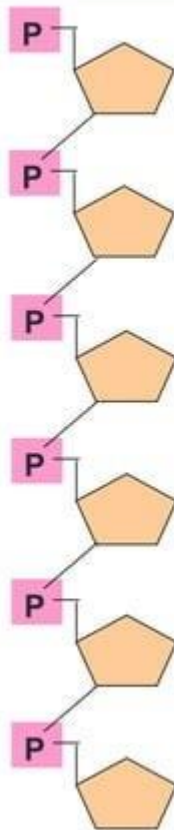


DEOXYRIBOSE



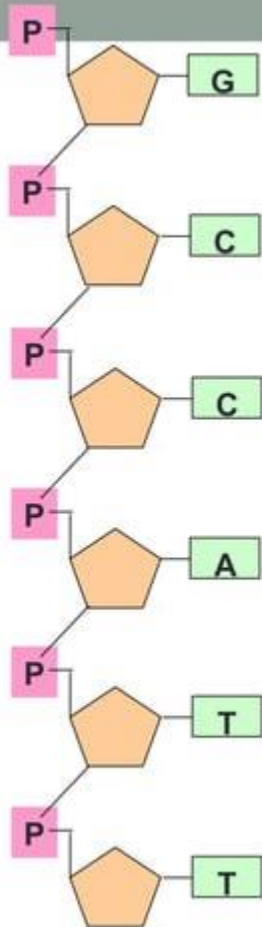
THE SUGAR-PHOSPHATE BACKBONE

- The nucleotides are all orientated in the same direction
- The phosphate group joins the 3rd Carbon of one sugar to the 5th Carbon of the next in line.



ADDING IN THE BASES

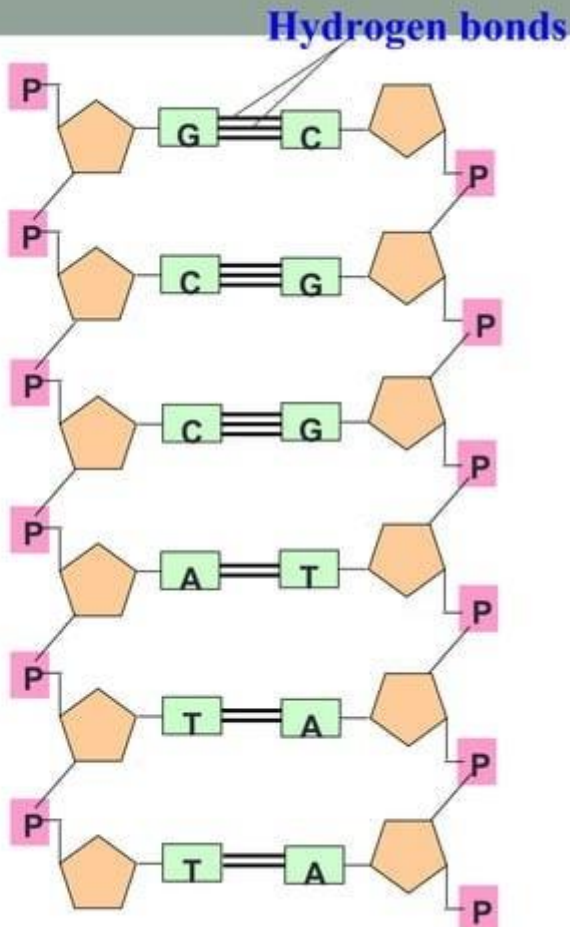
- The bases are attached to the 1st Carbon
- Their order is important
It determines the genetic information of the molecule



DEOXY RIBONUCLEIC ACID

- Every living organism contain **DNA**
- **MATERIAL OF INHERITENCE**
- Discovered in 1960
- By **FRANKILIN, WATSON AND CRICK**
- Through series of experiments and concluded that DNA is the genetic material present in nucleus of cell
- Human DNA contains 3 million deoxyribonucleotide residues and contain 25000 genes
- Genes are stretch of DNA that carries codes of protein production

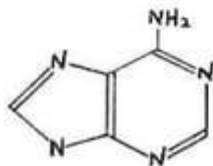
**DNA IS MADE OF
TWO STRANDS OF
POLYNUCLEOTIDE**



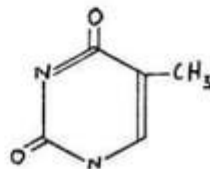
DNA IS MADE OF TWO STRANDS OF POLYNUCLEOTIDE

- The sister strands of the DNA molecule run in opposite directions (**antiparallel**)
- They are joined by the bases
- Each base is paired with a specific partner:
 - A** is always paired with **T**
 - G** is always paired with **C**
 - ie,,,, each Purine is paired with Pyrimidine
- Thus the sister strands are **complementary** but not identical
- The bases are joined by **hydrogen bonds**

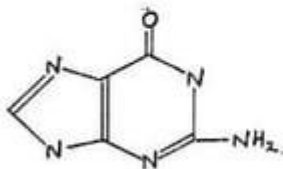
Purines & Pyrimidines



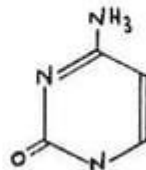
Adenine



Thymine

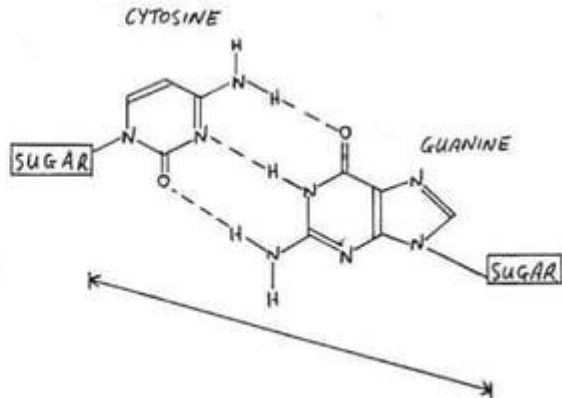
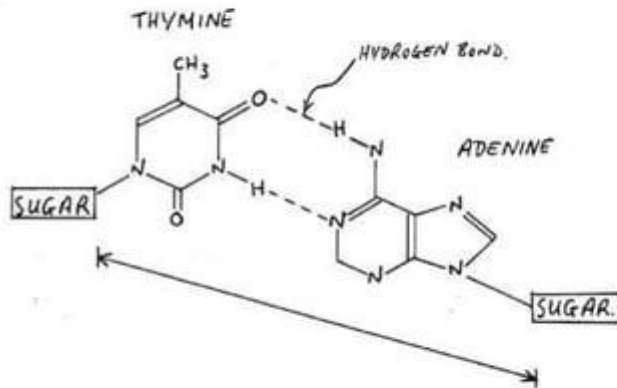


Guanine



Cytosine

Watson & Crick Base pairing



The Double Helix (1953)



STRUCTURE OF DNA

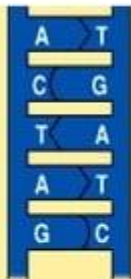
- Structure of DNA can be understood in terms of 3 levels of structure
1. **PRIMARY STRUCTURE** ; refers to the sequence of its nucleotide residue
 2. **SECONDARY STRUCTURE**; it pertains to the helix formed by two DNA strands
 3. **TERTIARY STRUCTURE**: refers to the 3 dimensional shape. Arises from supercoiling where double helix is being twisted into compact shape

DNA REPLICATION

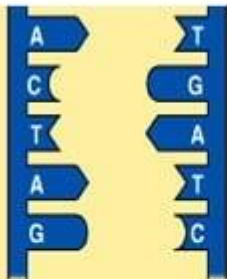
- DNA carries all information necessary for making protein required by living organisms
- To pass information stored in DNA to new generation of cell DNA replication must take place
- This information is carried in primary structure of dna
- To pass the information stored in DNA to a new generation of cells, DNA replication must take place
- When DNA is replicated, each strand of the doublehelix serves as a template for the manufacture of a new strand of DNA
- In each of the daughter *DNA* strands, one strand from the parent DNA is present

Contd...

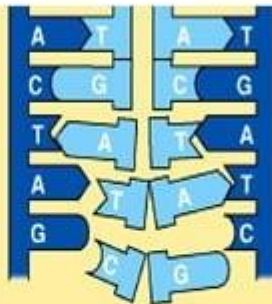
- This is called semiconservative replication
- The production of new DNA is carried out by enzymes called **DNA** polymerases
- DNA polymerase catalyzes ***the addition of deoxyribonucleotide residues*** to a growing DNA strand



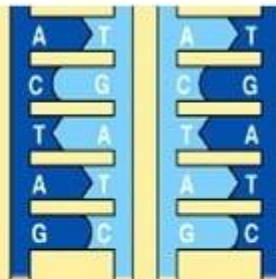
The parent molecule has two complementary strands of DNA. Each base is paired by hydrogen bonding with its specific partner, A with T and G with C.



(b) The first step in replication is separation of the two DNA strands.



(c) Each parental strand now serves as a template that determines the order of nucleotides along a new complementary strand.



(d) The nucleotides are connected to form the sugar-phosphate backbones of the new strands. Each "daughter" DNA molecule consists of one parental strand and one new strand.

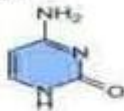
RNA

- Ribonucleic acid (RNA), like DNA, is a long, unbranched macromolecule consisting of nucleotides joined by 3' → 5' phosphodiester bonds
- The number of ribonucleotides in RNA ranges from as few as 75 to many thousands

STRUCTURE OF RNA

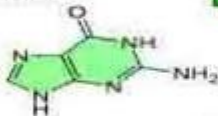
- RNA structure is similar to DNA
 - both are sugar-phosphate polymers and both have
 - nitrogen-containing bases attached
 - but there are 3 differences between them
-
- 1) RNA contains a different monosaccharide residue
 - 2) RNA contains the bases A, G, C, and **U** instead of A, G, C, and **T**
 - 3) RNA exists as a single strand instead of a double strand

Cytosine



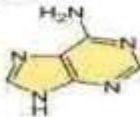
C

Guanine



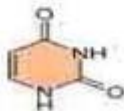
G

Adenine



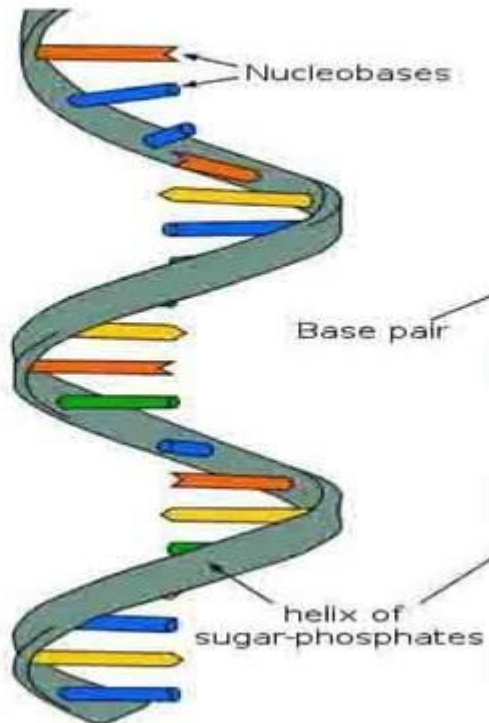
A

Uracil



U

Nucleobases
of RNA



TYPES OF RNA AND FUNCTIONS

Type	Abbreviation	Function(s)
Messenger RNA	mRNA	Transfers genetic information from genes to ribosomes to synthesize proteins.
Heterogeneous nuclear RNA	hnRNA	Serves as precursor for mRNA and other RNAs
Transfer RNA	tRNA	Transfers amino acid to mRNA for protein synthesis.
Ribosomal RNA	rRNA	Provides structural framework for ribosomes
Small nuclear RNA	snRNA	Involved in mRNA processing
Small nucleolar RNA	snoRNA	Plays a key role in processing of rRNA molecules
Small cytoplasmic RNA	scRNA	Involved in selection of proteins for export.
Transfer messenger RNA	tmRNA	Mostly present in Bacteria. Adds short peptide tags to proteins to facilitate the degradation of incorrectly synthesized proteins.

NUCLEIC ACID AND PROTEIN SYNTHESIS

- The following three processes are involved in duplication, transfer, and use of genetic information
- **1) Replication:** The process by which a replica, or identical copy, of DNA is made when a cell divides
- **2) Transcription:** The process by which the genetic messages contained in DNA are read and copied
- **3) Translation:** The process by which the genetic messages carried by RNA are decoded and used to build proteins

DNA



Replication

Transcription

RNA



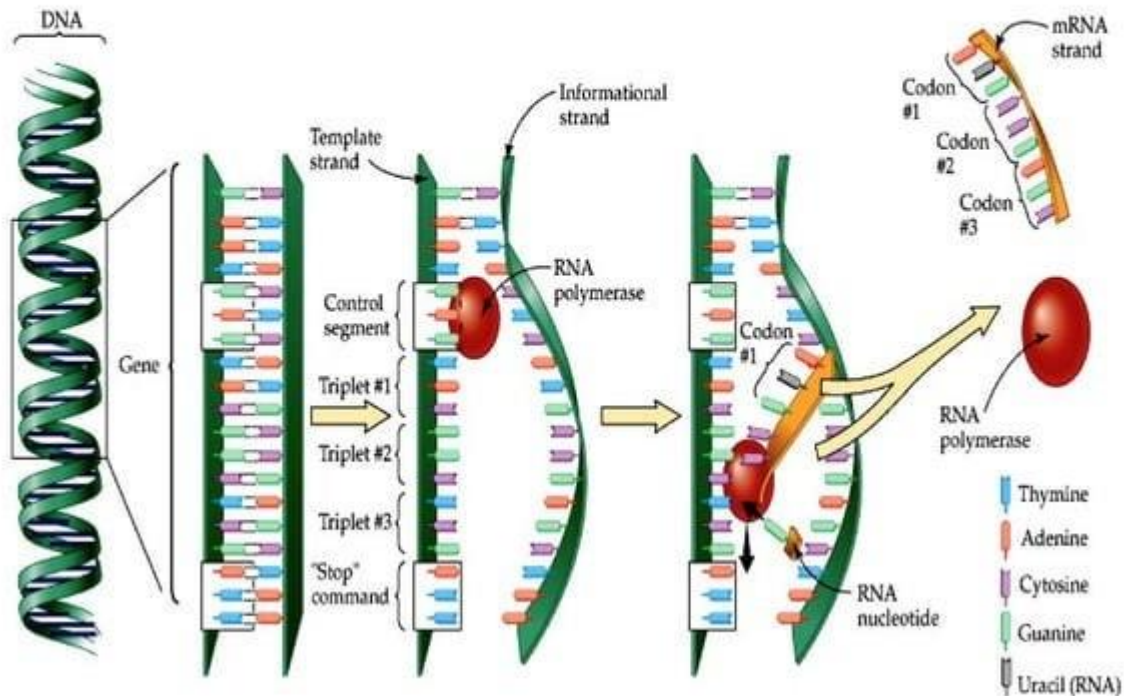
Translation

protein



TRANSCRIPTION

- The first step in using the information stored in DNA to produce proteins is transcription - using DNA as a template to make RNA
- Controlled by interactions of promoter and enhancers
- Several different types of rnas are produced including mRNA, tRNA and rRNA
- TRANSCRIPTION INVOLVES 4 STEPS
 - **INITIATION**
 - **ELONGATION**
 - **TERMINATION**
 - **PROCESSING**



Translation: Protein Synthesis

- The synthesis of proteins occur at ribosomes, which are outside the nucleus and within the cytoplasm of cells
- The mRNA connects with the ribosome, and the amino acids attached to *transfer RNA* are delivered one by one
- **Protein synthesis, or translation, takes place in *three* steps:**
 - **1. Initiation** - a ribosome, mRNA, and tRNA come Together to form a complex
 - **2. Elongation** - amino acids are joined to the growing polypeptide chain
 - **3. Termination** - the protein has been synthesized and the ribosome-mRNA-tRNA complex dissociates

GENETIC CODE

- The ribonucleotide sequence in a mRNA chain is like a coded sentence that specifies the order in which amino acid residues should be joined to form a protein
- Each word, or **codon** in the mRNA sentence is a series of **three** ribonucleotides that code for specific amino acid
- For example, the series uracil-uracil-guanine (UUG) on an mRNA chain is a codon directing incorporation of the amino acid leucine into a growing protein chain

CONTROL OF GENE EXPRESSION

- The DNA of each living thing contains thousands of genes
- These genes are not continually **expressed** (*read to make proteins*), because the production of unneeded proteins would be an inefficient use of resources
- Control of gene expression prevents the manufacture of unwanted/unneeded proteins

GENE REGULATION

- Label for the cellular process that control the rate and manner of gene expression
- Mechanisms of gene regulation include;
 - 1. regulating the rate of transcription
 - 2. regulating the processing of RNA molecules
 - 3. regulating the stability of mrna molecule
 - 4. regulating the rate of translation

MUTATION

- Any permanent change in the primary structure of (sequence of nucleotide residues in) DNA is called **mutation**
- Mutations might involve the switching of one base pair for another or the addition or deletion of base pairs
- Errors in replication and exposure to mutagens (mutation causing agents, including x rays, UV radiation, nuclear radiation, and chemicals) are the common causes of mutations
- When the mutations are in the sex cells (sperm or ovarian cells), the mutation can be inherited - **genetic diseases**

RECOMBINANT DNA

- **Recombinant DNA** contains two or more DNA segments not found together in nature
- made by cutting a gene out of one organism and recombining it into the genetic machinery of another organism
- The protein encoded by the inserted gene is then synthesized by the target organism
- Insulin has been made this way

THANK YOU