Nucleic Acids

DNA & RNA

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STRUCTURE OF DNA

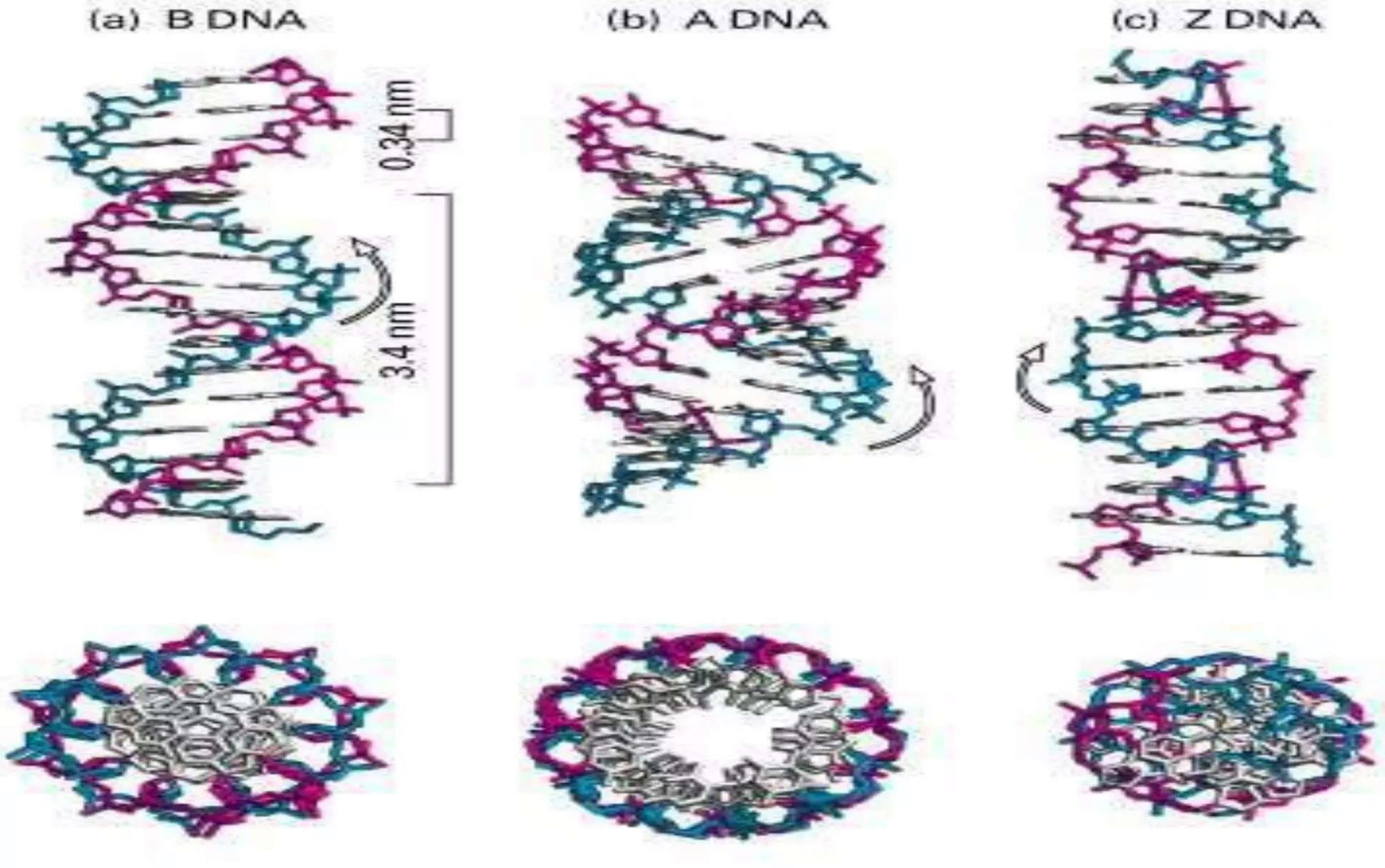
- DNA is a polymer of **deoxyribonucleotides.**
- The monomeric units held together by 3’5’-phosphodiester bonds as back bone.
- DNA is very **flexible molecule** and has the ability to exist in various forms based on environmental conditions, a features known as **structure polymorphism**.

Conformations of DNA double helix

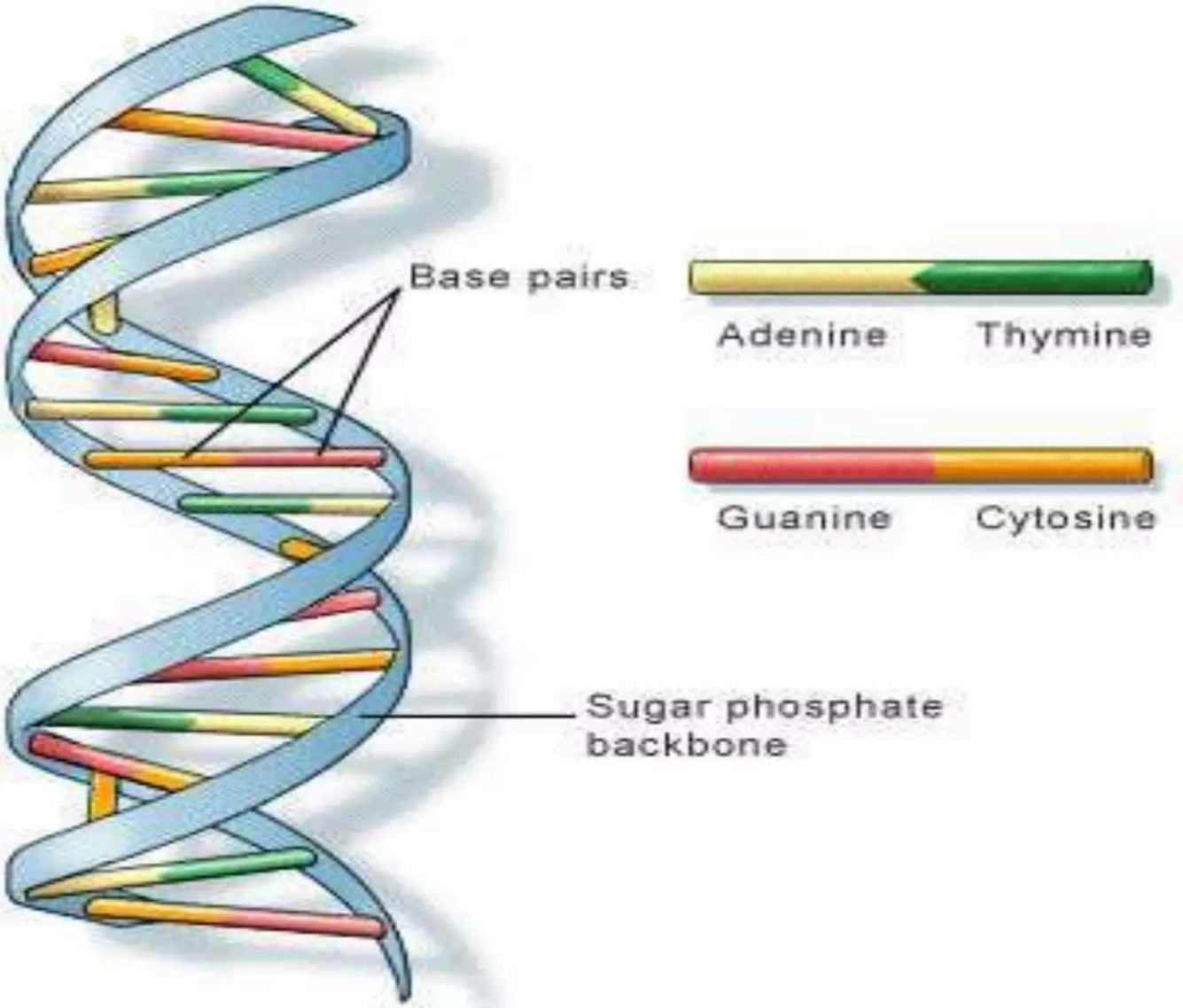
- The double helical structure of DNA exists in 6 forms A, B, C, D, E and Z form.
- Among these **B, A & Z** forms are important.
- **B-form** is most predominant form under physiological conditions.
- **A-from** is **right-handed helix**. It contains **11 base pairs.**
- A-form DNA is tilted from the central axis.

- **Z-form** is a **left –handed helix** and contains **12 base pairs per turn.**
- The **polynucleotide strands of DNA** move in a **zig-zag fashion** called as Z-DNA.
- DNA also exists in certain **unusual structures**.
- These structure are important for **molecular recognition of DNA by proteins & enzymes.**

TYPES OF DNA



Structure of DNA



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CHARGAFF'S RULE

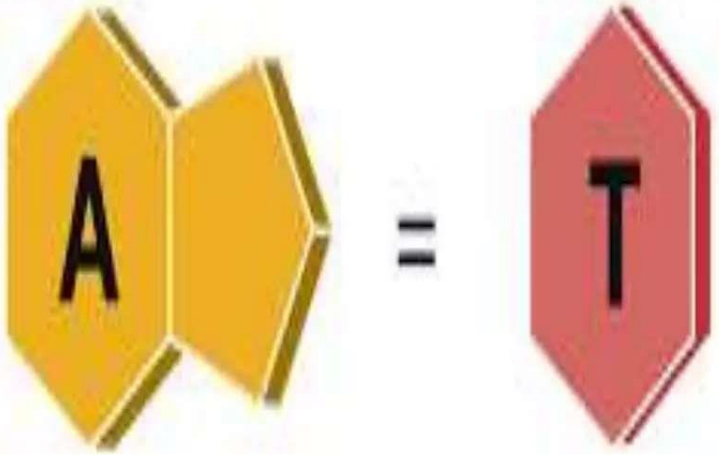
- DNA has equal numbers of **adenine & thymine** residues

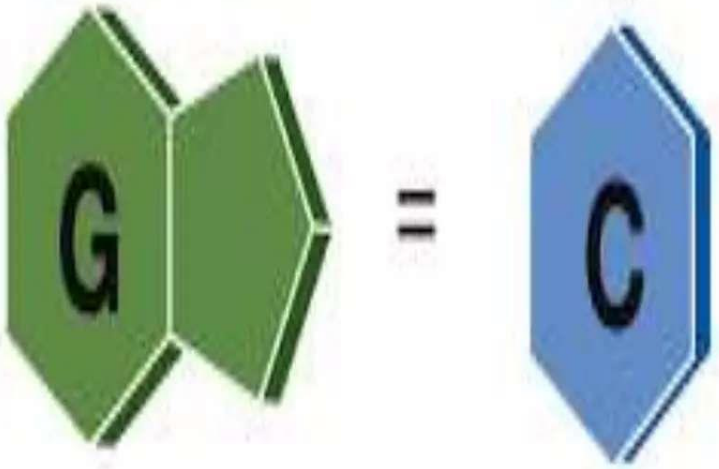
  (A=T) and equal number of **guanine & cytosine** residues (G=C).

- This is called as ***Chargaff's rule of molar equivalence of between purines & pyramidines in DNA structure.***

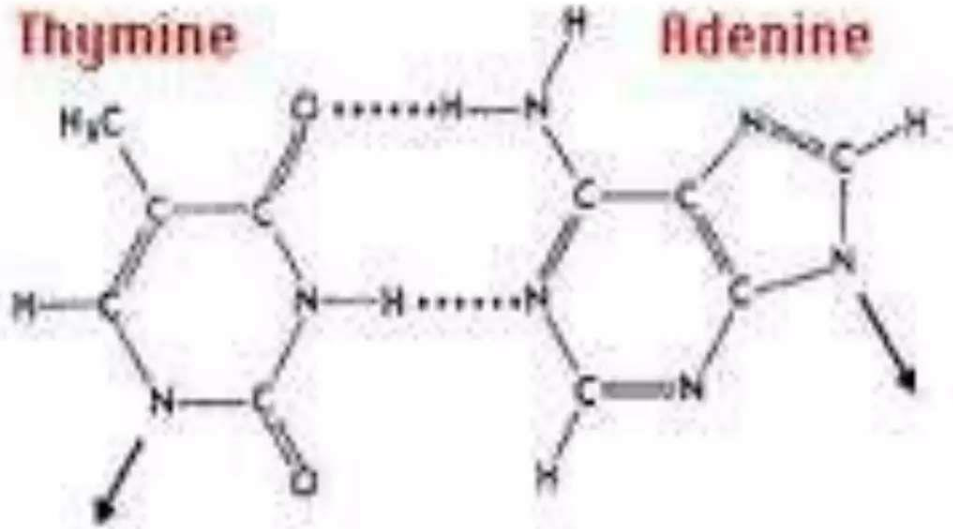
- **RNAs** which are usually single stranded, **do not obey Chargaff's rule.**

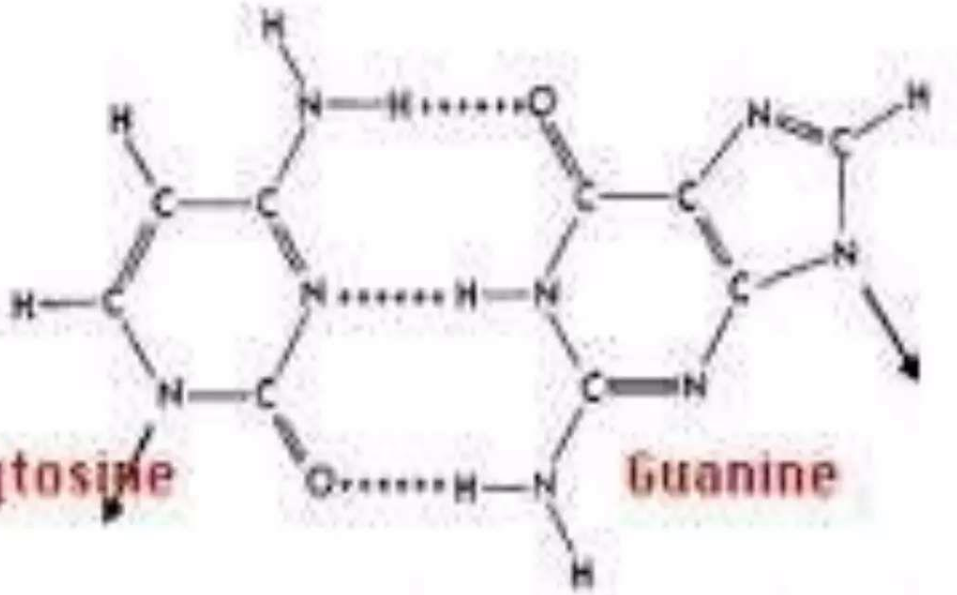
Chargaff's Rule of Base Pairing



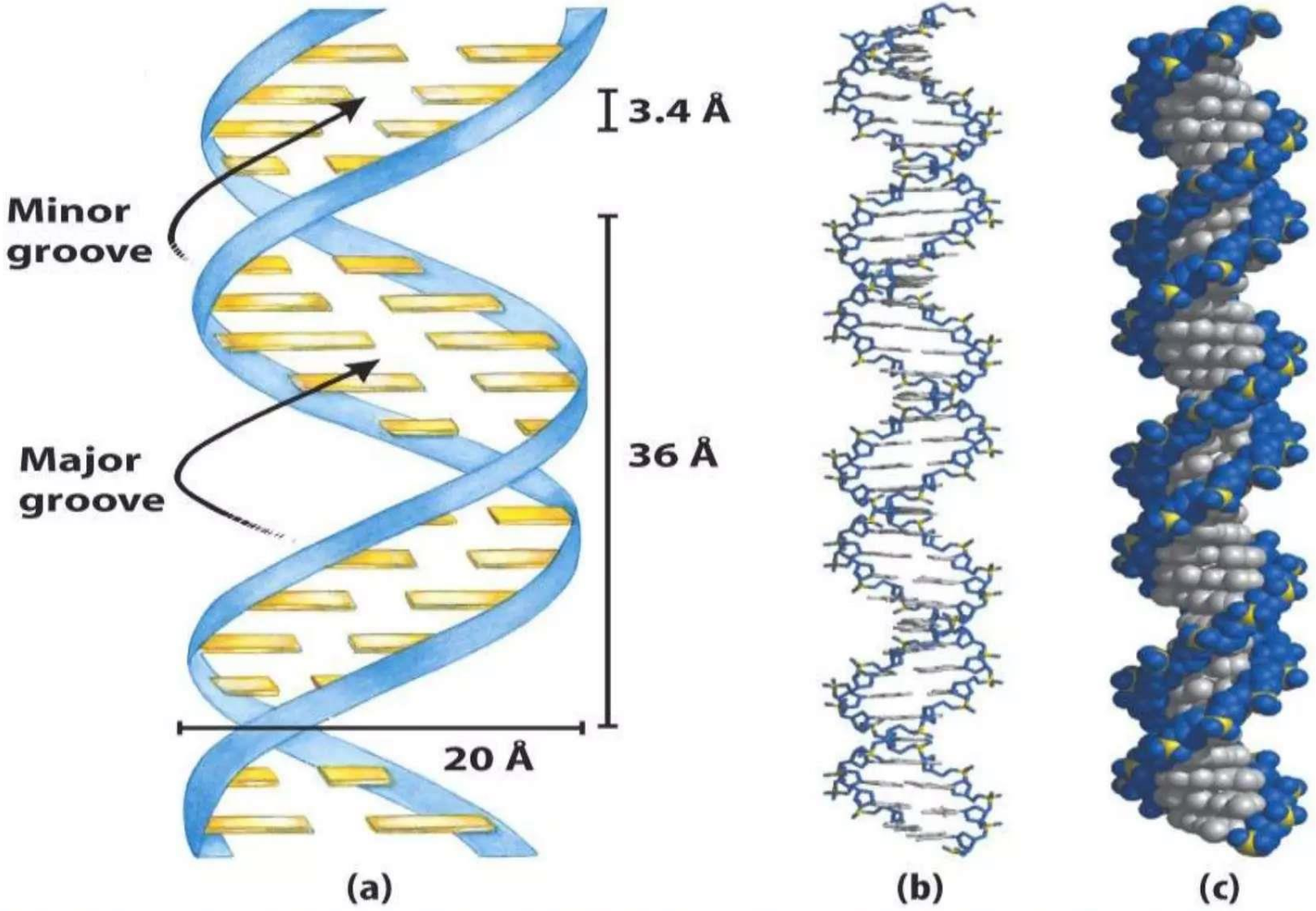


Purines = Pyrimidines





DNA DOUBLE HELIX



DNA double helix

- Double helical structure was proposed by **Watson & Crick in 1953.**
- The DNA is a **right handed double helix.**
- It consists of **two polydeoxyribonucleotide chains** twisted around each other on a common axis of symmetry.
- The chains are **paired in an antiparallel manner**, the 5'-end of one strand is paired with the 3'-end of the other strand.

- One strand runs in the **5 ' to 3 ' direction** while the other runs in **3' to 5 ' direction.**
- The width (or diameter) of a double helix is **20**Å **(2nm).**
- Each turn of helix is **34**Å **(3.4nm)** with 10 pairs of nucleotides, each pair placed at a distance of about **3.4** Å.
- The **hydrophilic deoxyribose-phosphate backbone** of each chain is on the **outside of the molecule**, whereas the **hydrophobic bases are stacked inside.**

- The **polynucleotide chains** are not identical but **complementary** to each other due to base pairing.
- The two strands are held together by **hydrogen bonds** between a **purine & pyrimidine.(**A = T, G = C)
- The spatial relationship between the two strands in the helix creates a major (wide) groove and a minor (narrow) groove.

- These grooves provide access for the **binding of regulatory proteins** to their specific recognition sequences along the DNA chain.
- DNA helix proves Chargaff's rule.
- The genetic information resides on **template strand** or **sense strand.**
- The opposite strand is **antisense strand**.

COMPLEMENTARY STRANDS

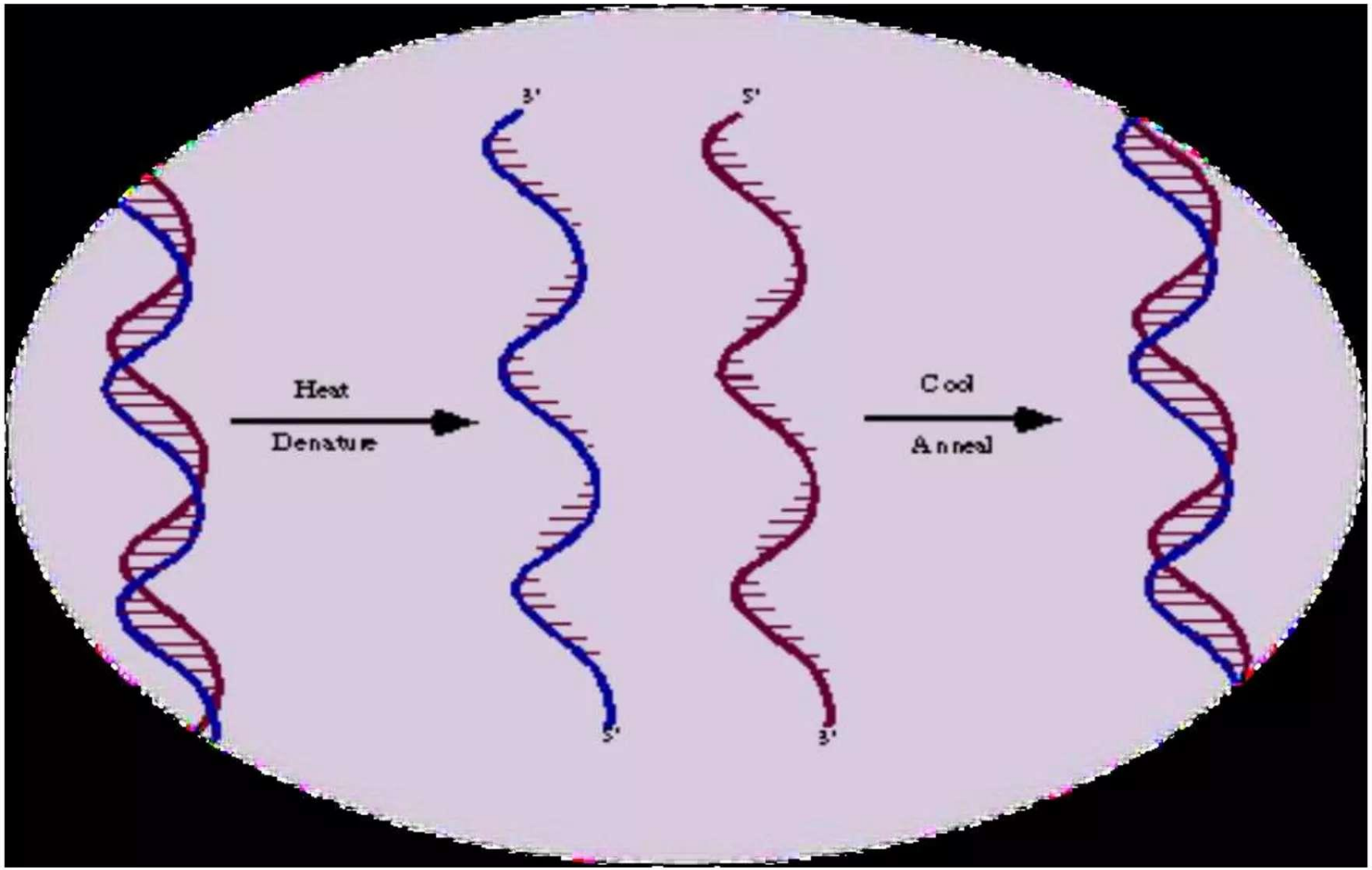
- The two strands of DNA are not identical but **two strands are complementary to each other.**
- **Adenine** pairs with **thymine** through **two hydrogen bonds.**
- **Guanine** pairs with **cytosine** through **three hydrogen bonds.**

- **G-C base pairs** are **more stable** than A-T base pairs.
- Complementary base sequence accounts for chargaff's rule.
- It also accounts for each **DNA strand** acting as a **template for the synthesis** of its complementary strand **during DNA replication.**

DENATURATION OF DNA

- The two strands of DNA are held together by hydrogen bonds
- Disruption of hydrogen bonds (by change in pH or increase in temperature) results in separation of strands
- The phenomenon of **loss of helical structure of DNA** is known as DENATURATION.
- **Phosphodiester bonds** are not broken by denaturation.
- It is measured by absorbance at 260nm.

DENATURATION OF DNA



MELTING TEMPERATURE (TM)

- It is defined as **the temperature at which half of the helical structure of DNA is lost.**
- G-C base pairs are more stable than A-T base pair.
- **Tm is greater for DNAs with high content of G-C base pair.**
- **Formamide destabilizes** hydrogen bonds of base pairs.
- This is used in rDNA technology.
- **RENATURATION (REANNEALING):**
- It is a process in which **the separated complementary DNA strands can form a double helix.**

ORGANIZATION OF DNA IN CELL

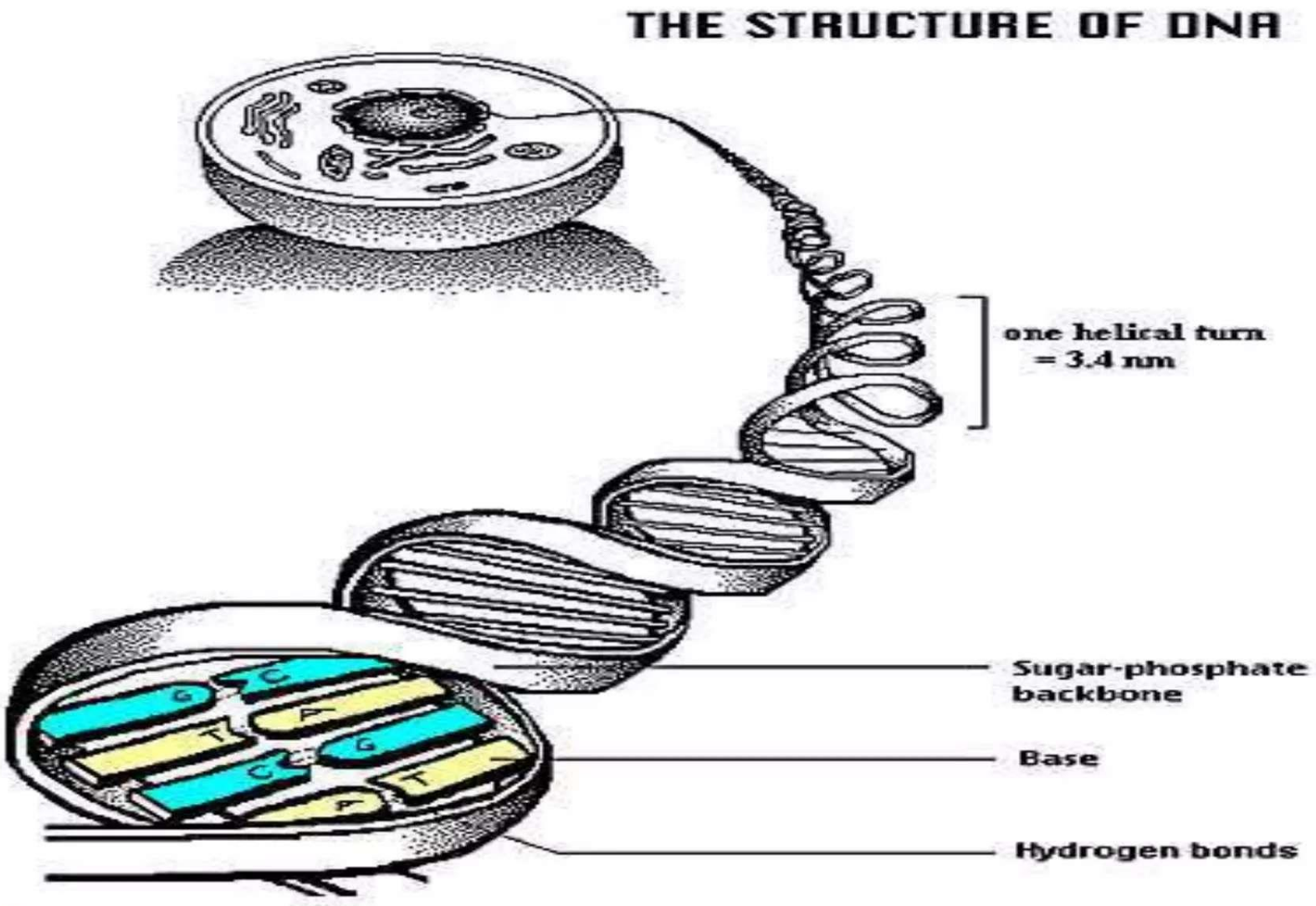
PROKARYOTIC DNA:

- The DNA is organized as a **single chromosome** in the form of double stranded circle.
- Packed in the form of **nucleoids**.

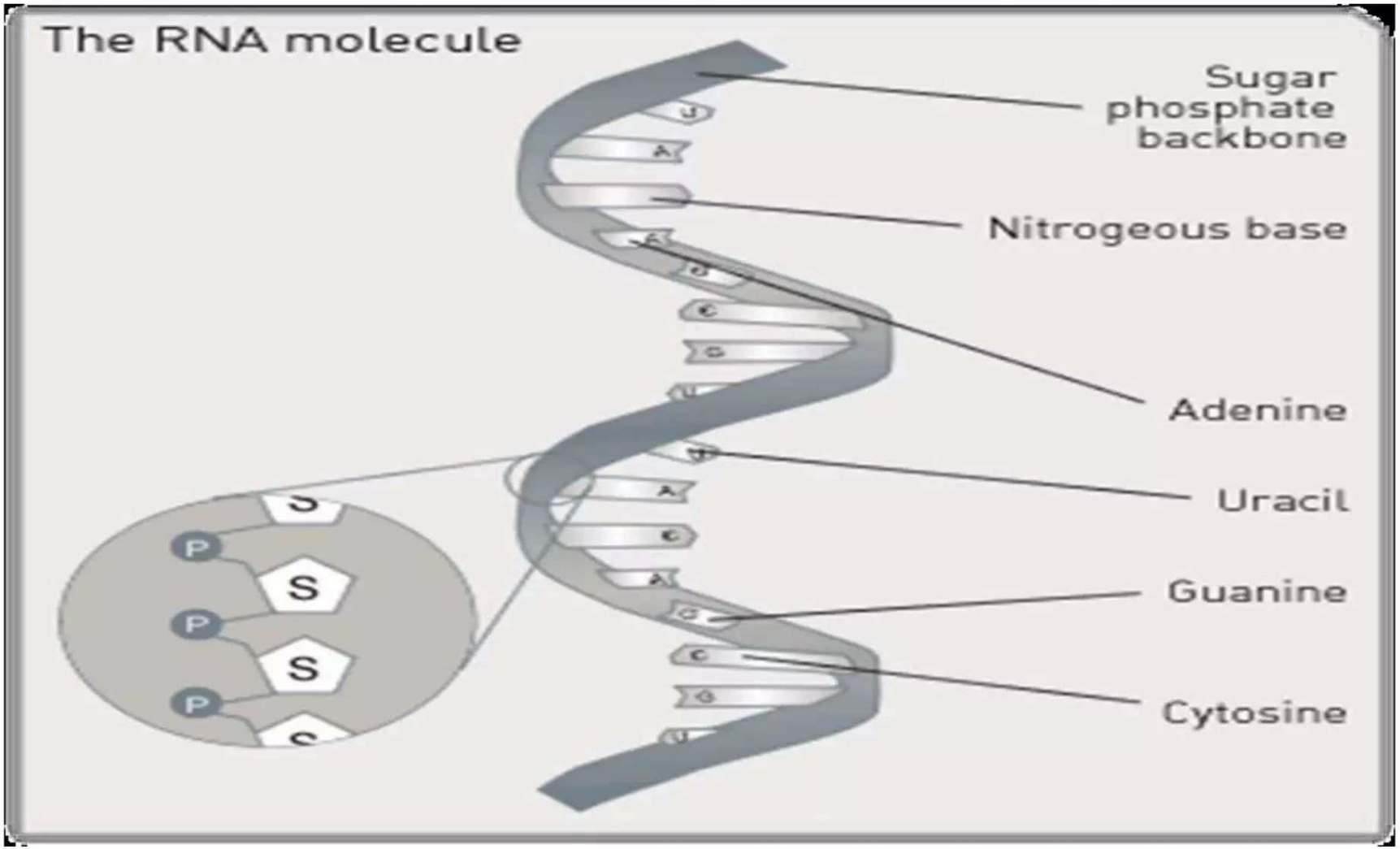
EUKARYOTIC DNA:

- DNA is associated with **various proteins to form chromatin** which then organized into **compact structures chromosomes.**

Organization of DNA in cell



STRUCTURE OF RNA



Structure of RNA

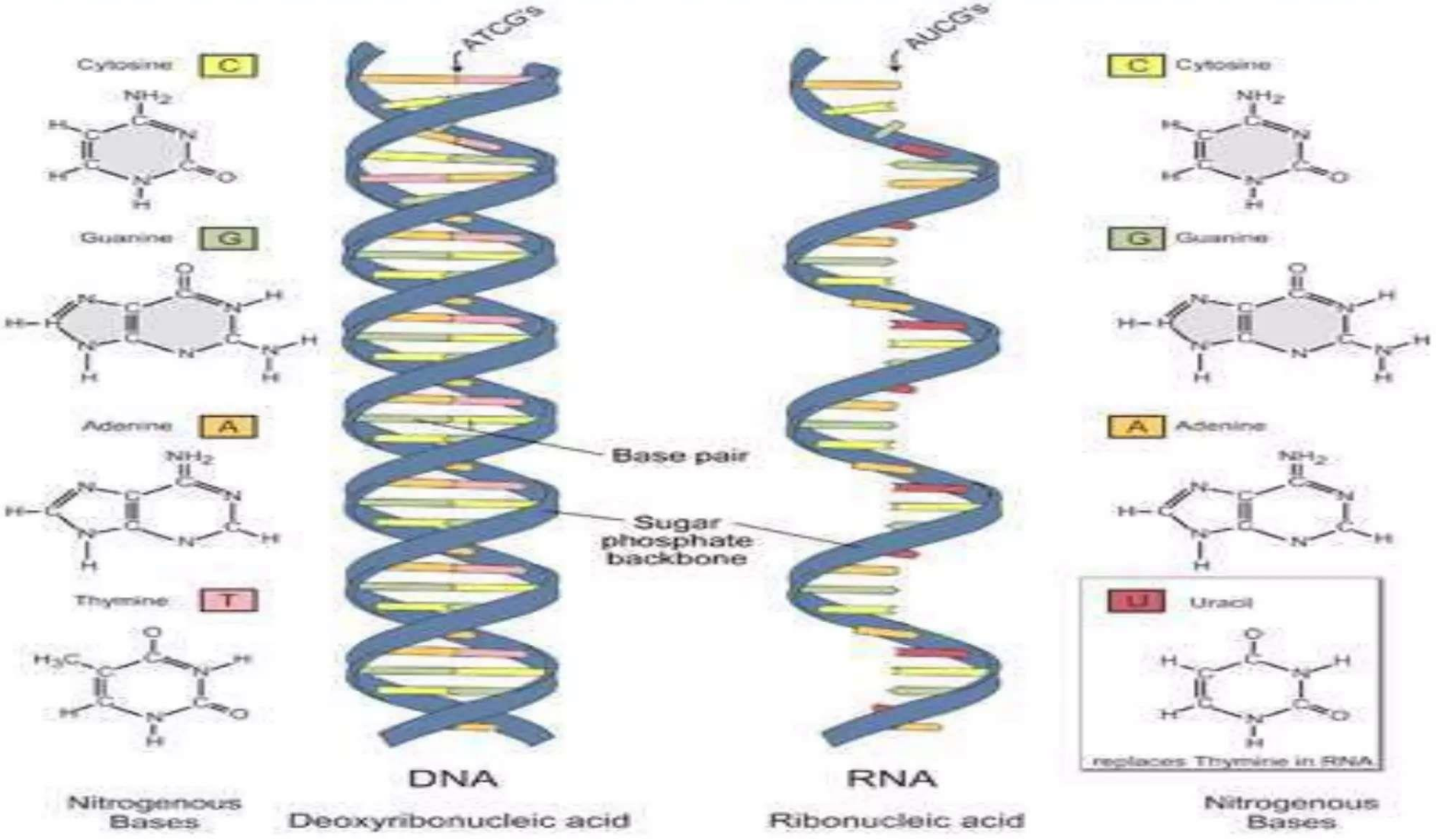
- RNA is a **polyribonucleotide**
- It is **single stranded polynucleotide**. Phosphodiester bond links the nucleotides.
- Formed between 3-OH group of one pentose sugar & 5-OH group of another pentose sugar of ribonucleotide.
- Nucleotides found in RNA are : - AMP, GMP, CMP, UMP
- **Thymine base absent** in RNA. Minor methylated thymine & dihydrouracil also present.

- **Due to single–stranded nature**, there is no specific relation between purines & pyramidine content.
- It will **not obey** the chargaff's rule.

- ALKALI HYDROLYSIS:
- Alkali can hydrolyse RNA to 2'3'-cyclic diesters.
- This is due to presence of OH group at 2'position.

- Orcinol colour reaction:
- RNAs can be identified by orcinol colour reaction due to presence of ribose.

Structures of DNA & RNA



Types of RNA

- Three major types:
- Messenger RNA:5-10%
- Transfer RNA:10-20%
- Ribosomal RNA:50-80%

- RNAs are synthesized from DNA
- Involved in protein synthesis.

Messenger RNA (*mRNA*):

- It **carries genetic information** from DNA **for protein synthesis**.
- Precursor form is **heterogeneous nuclear RNA**(hnRNA)

- ***Structure: It contains***
- **Cap:** is an inverted **7-methyl GTP attached to 5'end.**
- **5'UTR:** (5'untranslated region) is **at the 5'end.**
- **Coding region** contains **3 types of codons**:

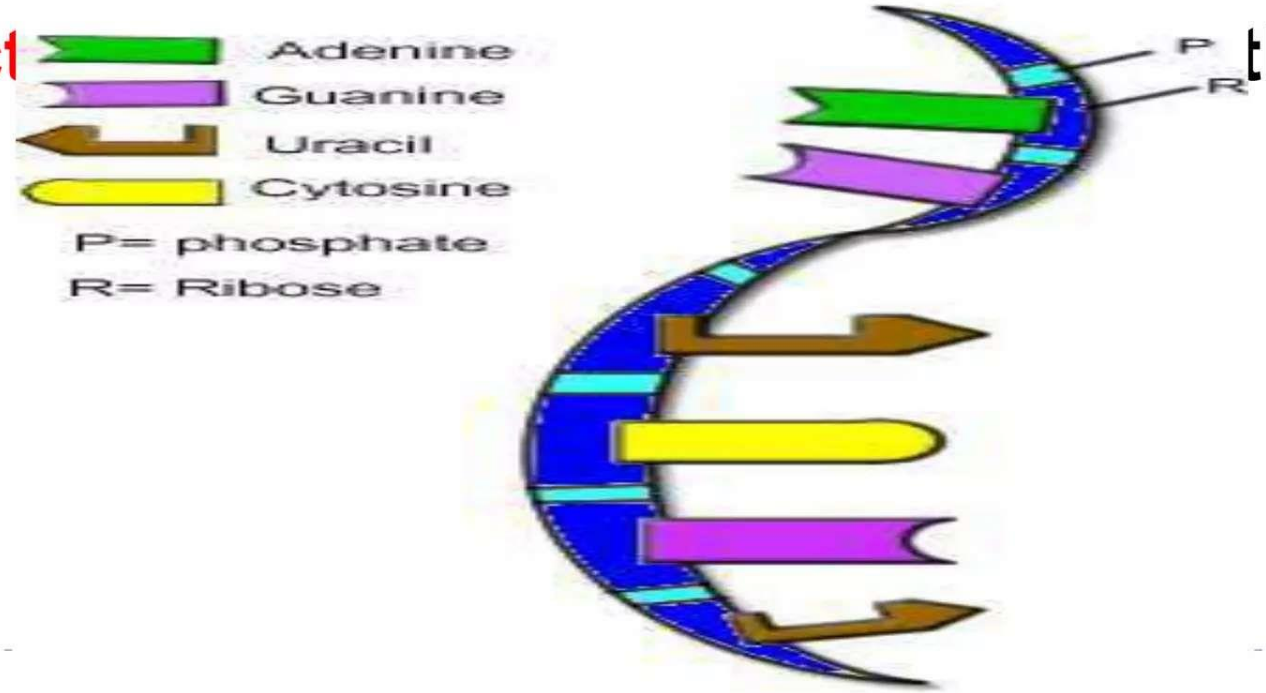
1. **Initiating codon**-is always for AUG for methionine.
2. **Specific codon**-for different amino acids
3. **Terminating codons**-which are UGA, UAA & UAG.

- **3'UTR** (3'untranslated region) at **3' end**.
- **Polyadenylate tail (poly A tail):** Consists of **200-300**

adenylate residues at the 3' end.

- mRNA accounts for 5 to 10% of total RNA.

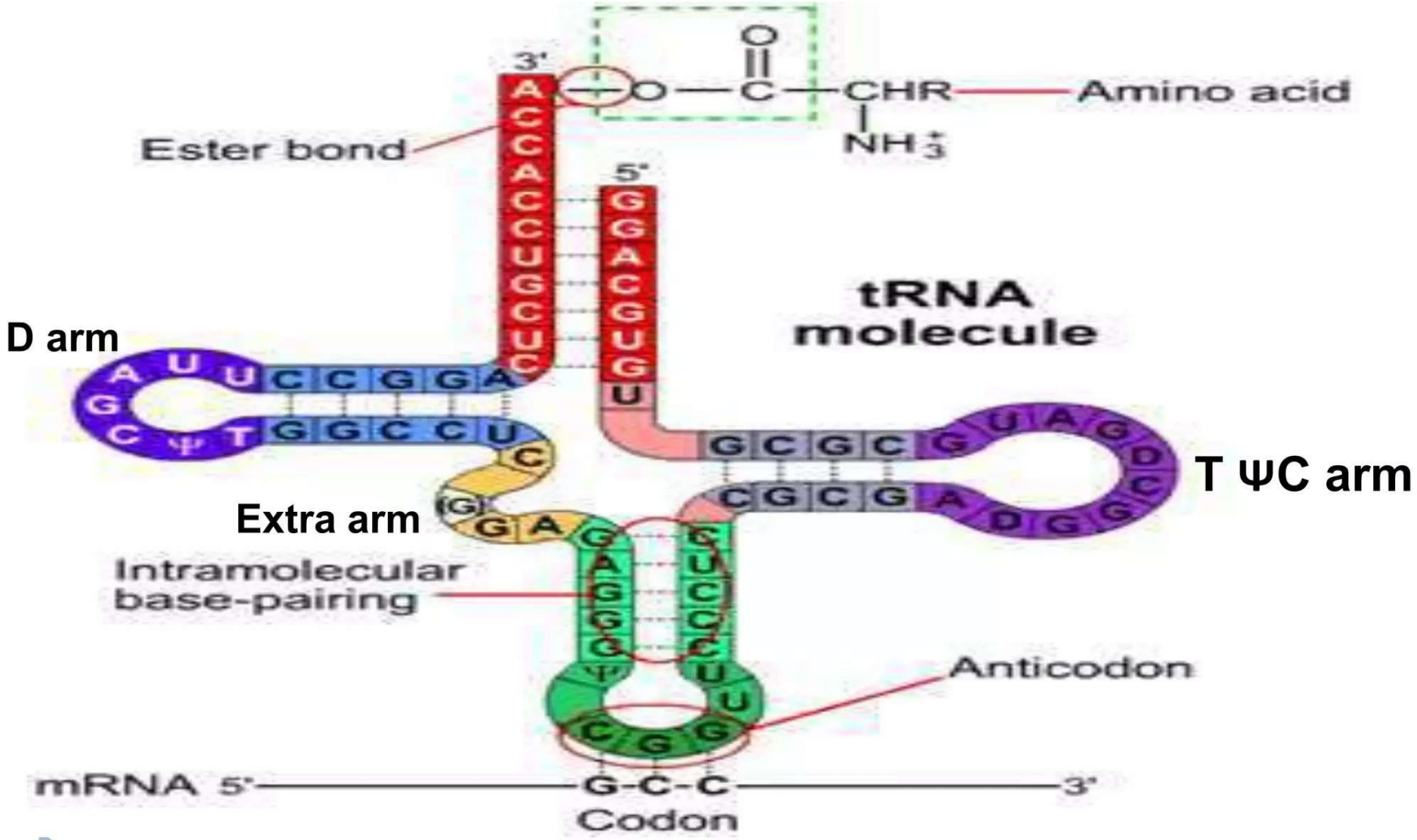
- **Funct** **thesis**



Transfer RNA (tRNA)

- Transfer RNA (soluble RNA) contains 71-80 nucleotides.
- Molecular weight-25,000.
- At least 20 species of tRNAs, corresponding to 20 Amino acids.
- Required **for protein biosynthesis**.
- It contains many unusual bases & nucleosides.
- Unusual bases present in t RNA are ***thymine, dihydrouracil, hypoxanthine,1-methyladenine & 2-N dimethyl guanine***

Structure of tRNA



- Pseudouridine is an unusual nucleoside found in t-RNA.

- ***Structure:***

- Clover leaf structure & it has five arms.
- ***CCA arm: Cytosine-Cytosine-Adenine (CCA-arm) present at*** 3'end. It is an acceptor arm for the attachment of amino acids to form amino acyl tRNA.
- ***D arm:*** *contains* ***dihydrouracil.***
- **T¥C arm**: (thymidine-pseudouridine-cytosine arm)
  - contains **pseudouridine.**

- **Anticodon arm**: contains of sequence of three bases that are **complementary to codon mRNA**.

- tRNA is also *called* ***adapter tRNA*** because *it carries specific amino acids on its 3' end along with anticodon at its anticodon arm.*

- **Extra arm:** also called **variable arm**.

- Based on length of extra arm-tRNA is classified into

- Class-1 tRNA: Contain short arm (3-5 base pairs)
- Class-2t RNA: Contain long arm (13-20base pairs)

- tRNA accounts for 15-30% of total cellular RNAs.
- tRNA is smaller in size.
- tRNA is synthesized as precursor tRNA.
- Mature form is formed by post transcriptional modifications.

FUNCTIONS:

- tRNA is required for **protein synthesis.**
- It is required for the **transfer of specific amino acids** to the site of protein synthesis.
- Also required for incorporation of **specific amino acids to the growing polypeptide chain.**

Ribosomal RNA

- r-RNA is found in **ribosomes.**
- Eukaryotic ribosomes are factories of protein synthesis.
- Composed of two major nucleoprotein complexes**-60s subunit & 40s subunit**
- 60s subunit contains- **28s rRNA, 5s rRNA & 5.8s rRNA**
- 40s subunit contains- **18s rRNA**

- Main function is protein biosynthesis.

Cellular RNA & their functions

Type of RNA	abbreviation	functions
Messenger RNA	mRNA	Transfers genetic information to synthe
Heterogeneous nuclear RNA	hnRNA	Precursor for mRNA & other RNAs
Transfer RNA	tRNA	Transfers amino acid to mRNA for protein biosynthesis.
Ribosomal RNA	rRNA	Provides structural frame work for ribosomes.
Small nuclear RNA	snRNA	Involved in mRNA processing
Small nucleolar RNA	snoRNA	Involved in processing of rRNA molecules.
Small cytoplasmic RNA	scRNA	Selection of proteins for export.
Transfer messenger RNA	tmRNA	Present in bacteria. adds short peptide tags to proteins to facilitate degradation of incorrectly synthesized proteins.