Nucleic acids: composition, structure, properties and functions of DNA and RNA

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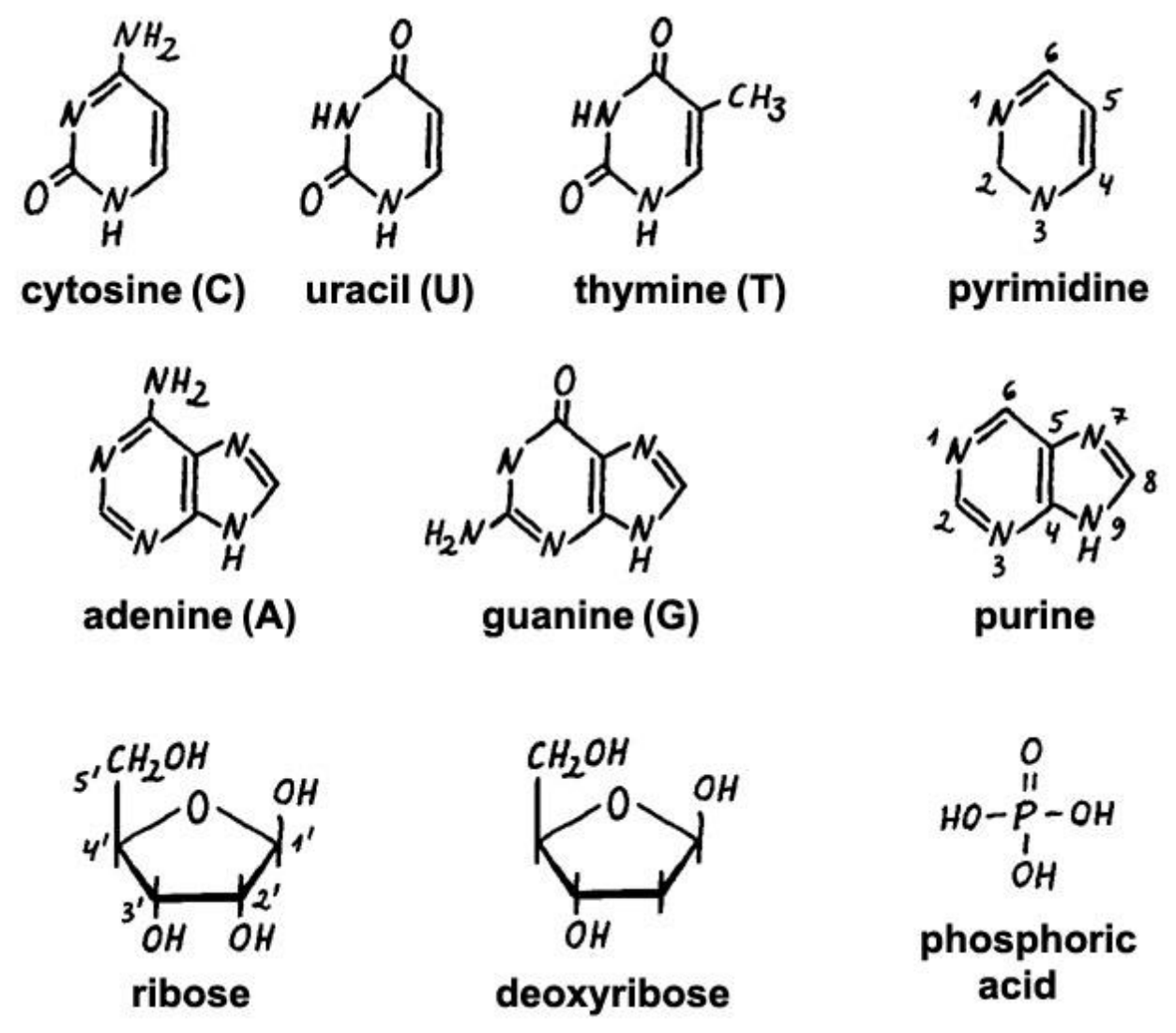
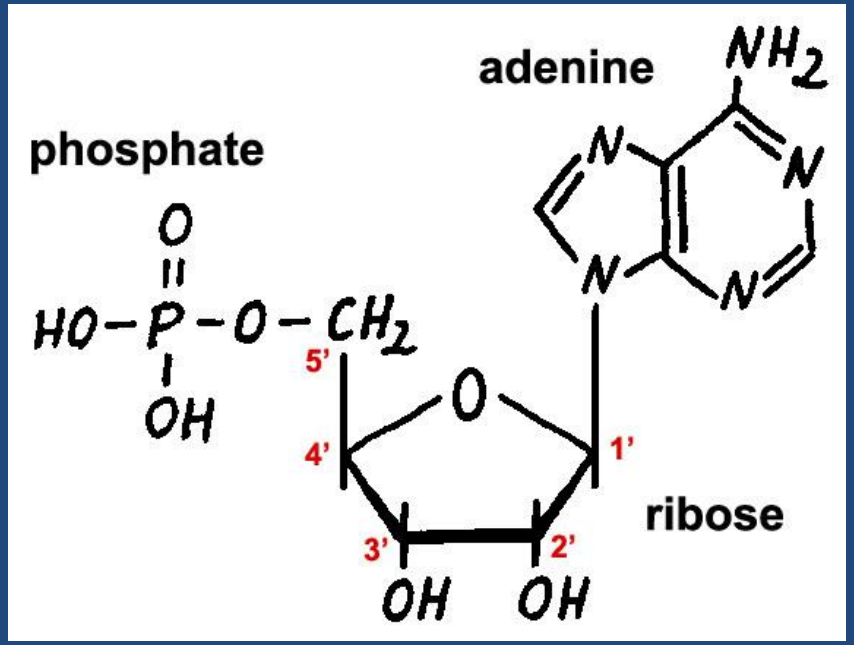
Nucleic acids are polymers of nucleotides

Each nucleotide is composed of a nitrogenous base, a pentose and at least one phosphate group. The latter makes nucleic acids acids.



Formation of nucleotides



Example of a nucleotide: adenosine monophosphate (AMP)

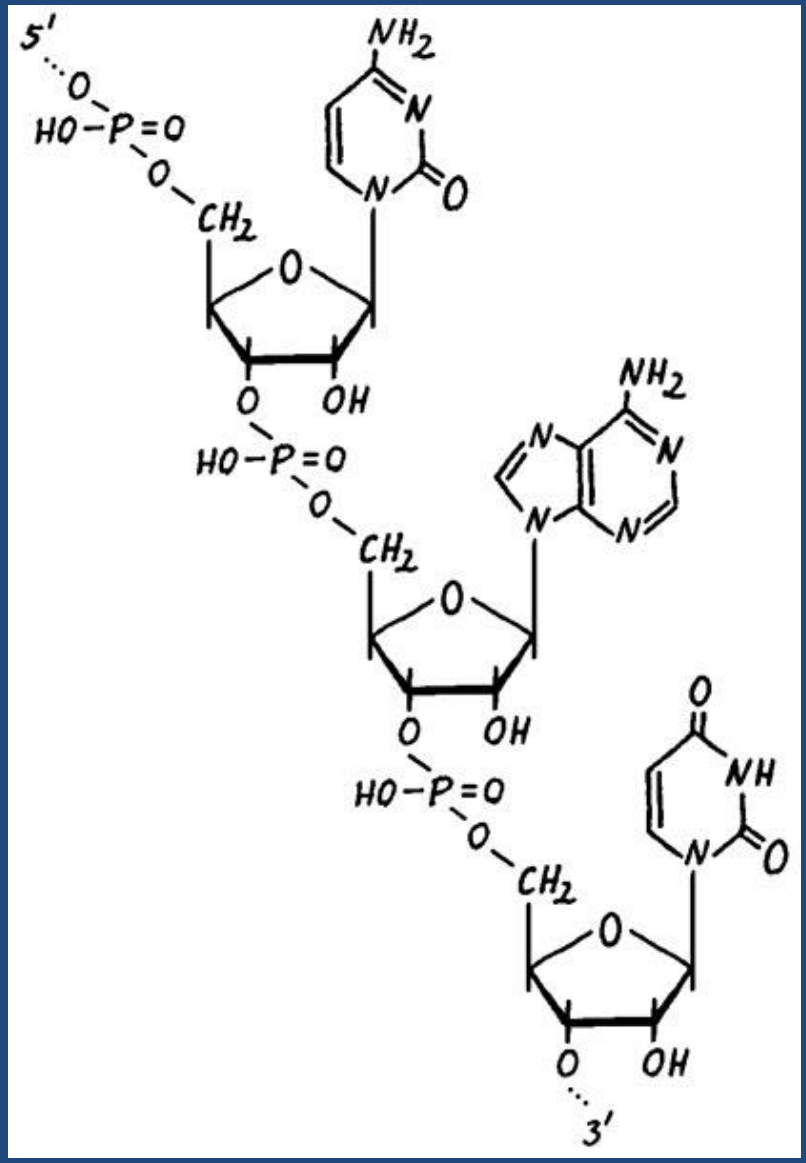
The polynucleotide chain

Nucleotides bind together to form a polynucleotide chain. The phosphate at the 5’ atom of a pentose reacts with the 3’ hydroxyl group of another pentose. The result is a covalent bond called phosphodiester bond.

The two ends are designated as 5’ and 3’, respectively.

Because of the phosphates, DNA and RNA are acids (bases are too weak to make a difference).

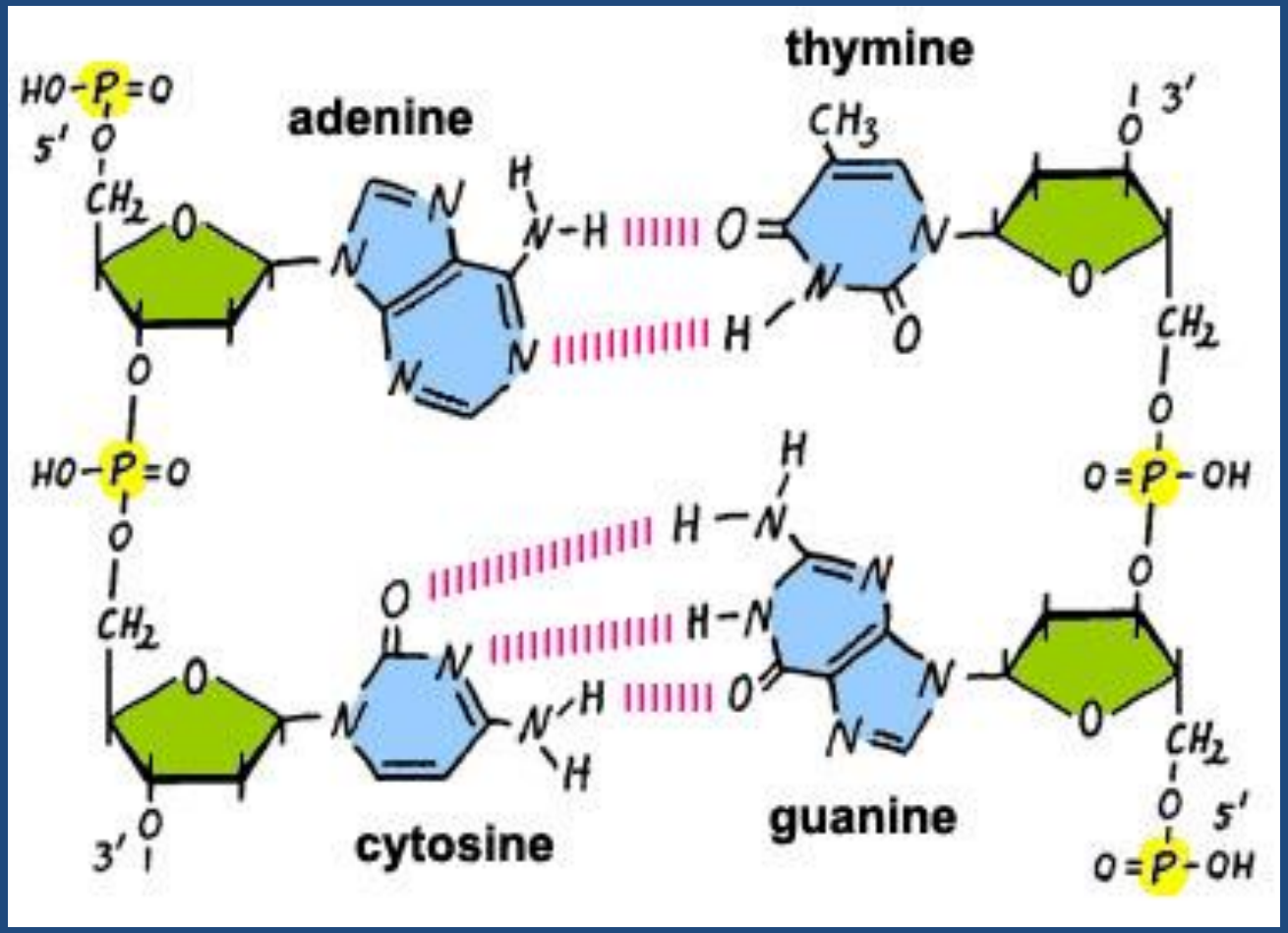
The alternating pentoses and phosphates form a uniform backbone, from which nitrogenous bases protrude.



Part of RNA polynucleotide chain

The complementarity rule

Each base can only bond with one other, A with T and C with G. This is called the complementary base pairing rule.



Complementary binding

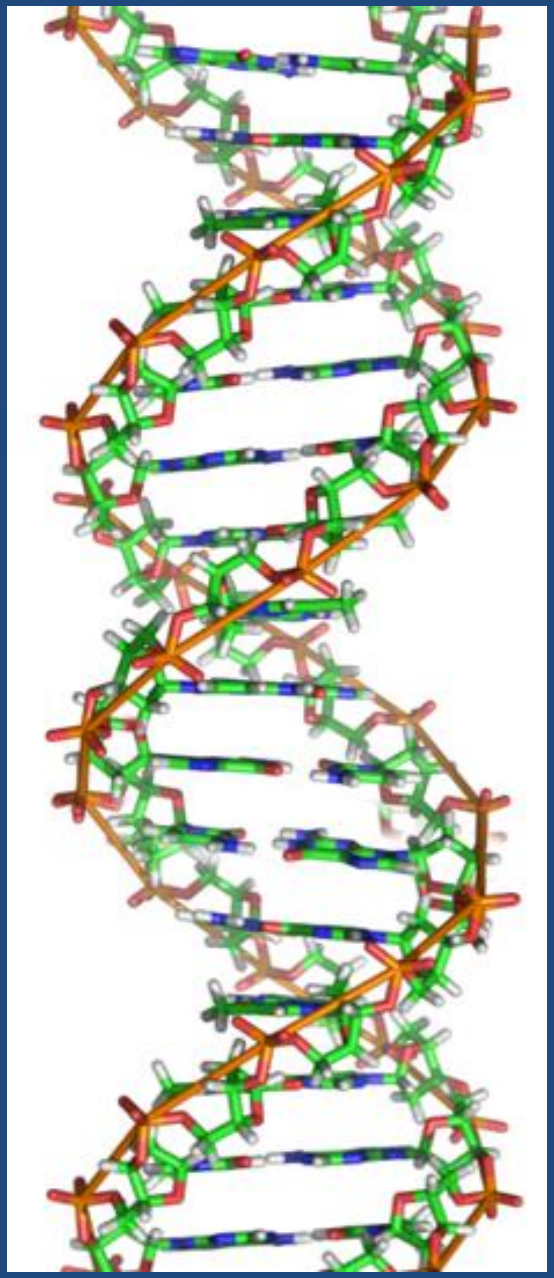
The double helix of DNA

It has a diameter of 2 nm.

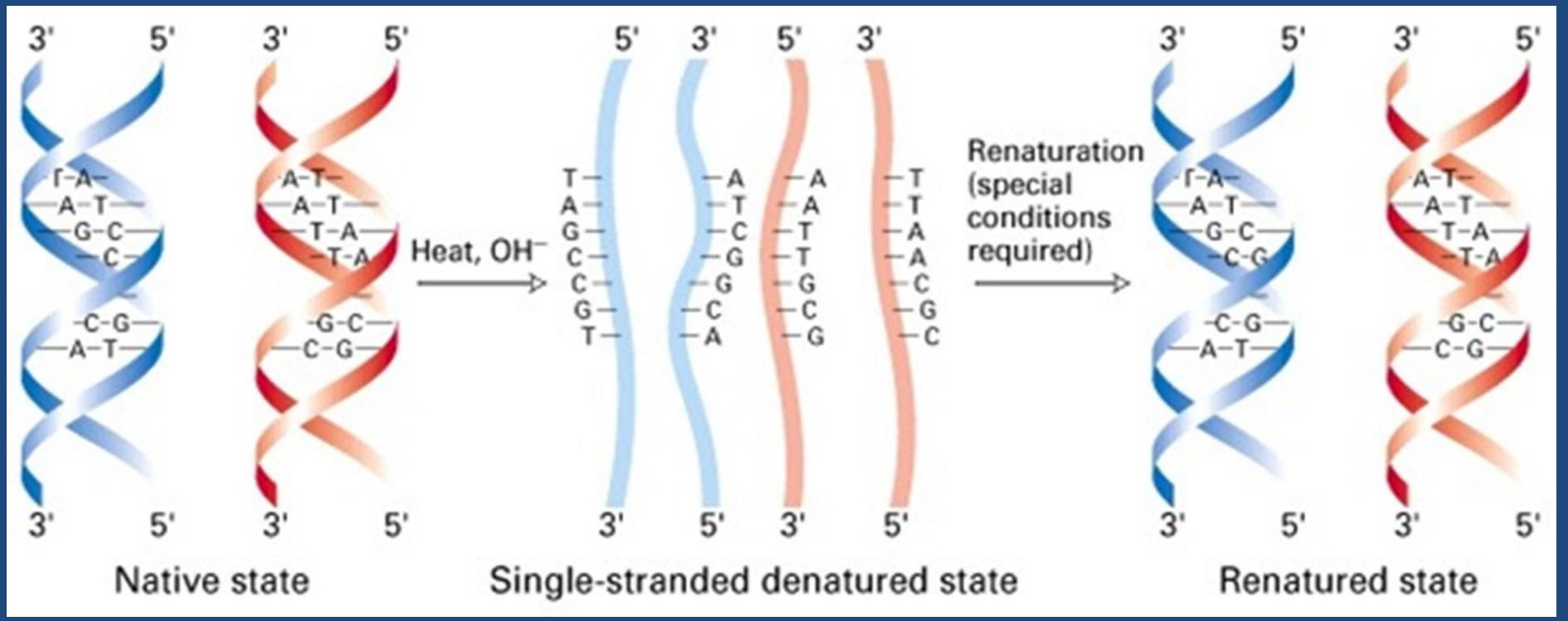
Two complementary strands of DNA come together thanks to hydrogen bonding between the nitrogenous bases that allows DNA to make the famous double-helix.

A DNA molecule consists of two strands that wind around each other like a twisted ladder.

(Richard Wheeler, Wikimedia)

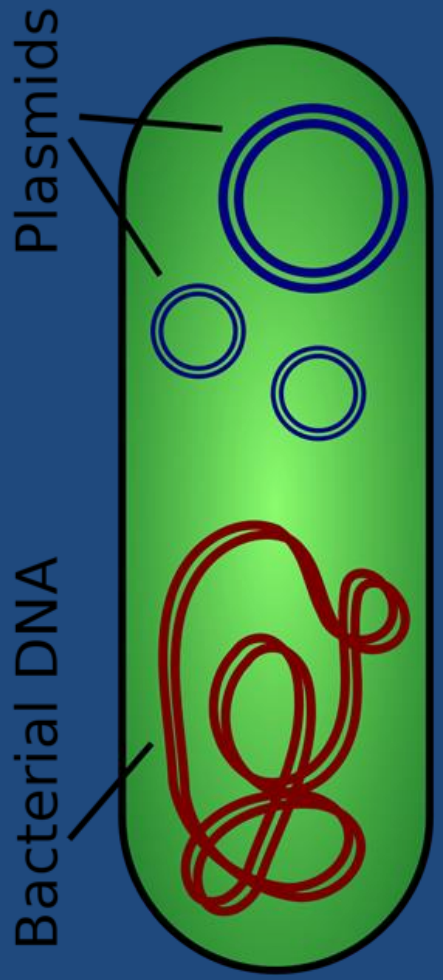


Denaturation and renaturation of DNA



Denaturation is a process in which biomolecules lose their spatial structure, which is present in their native state, by application of some external stress or compounds. In many cases, denaturation is reversible (molecules can regain their native state when the denaturing influence is removed). This process is called renaturation.

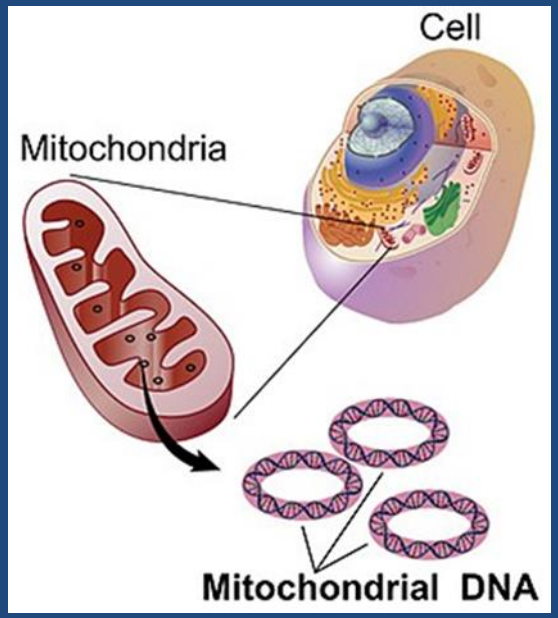
Linear vs circular DNA

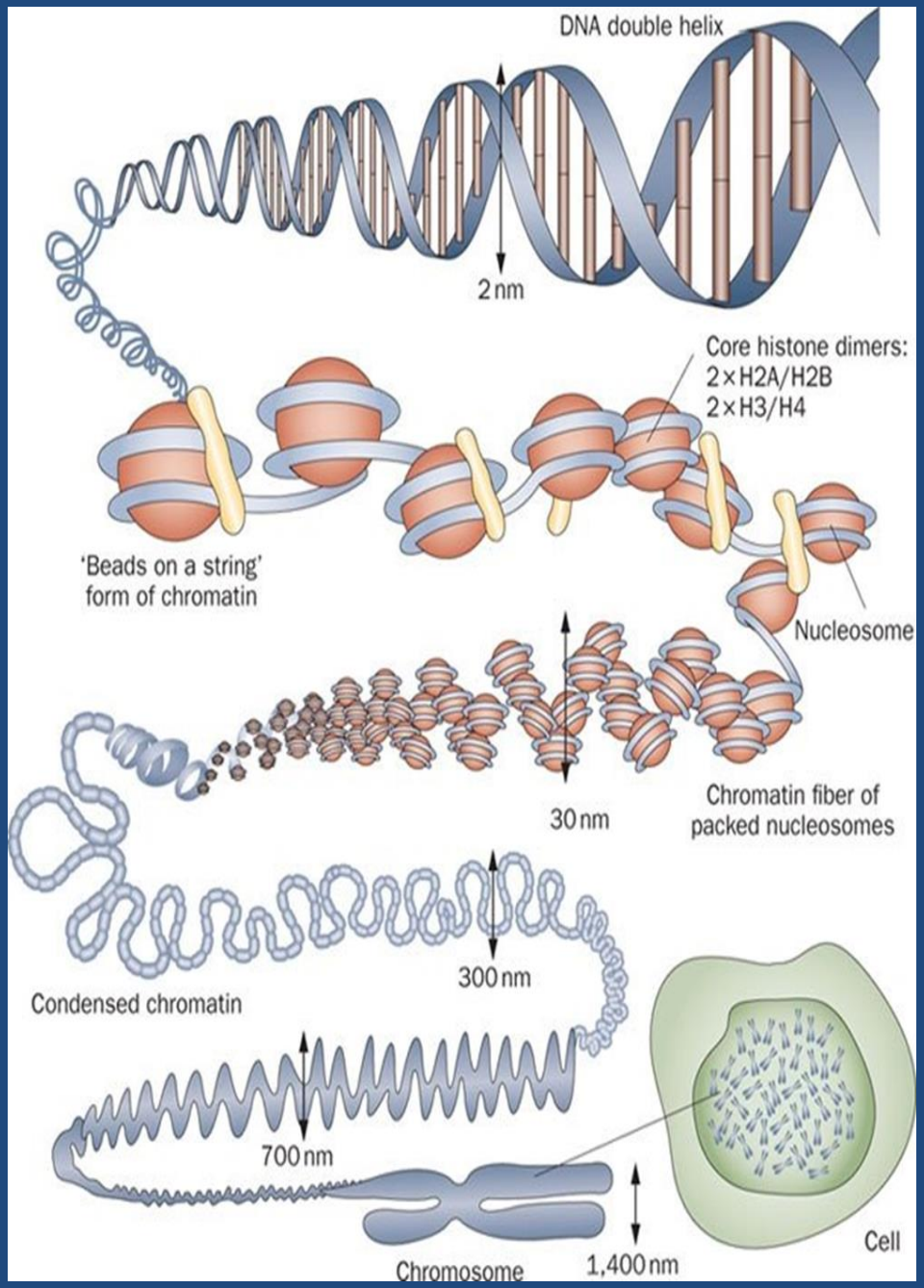


In prokaryotes, the genome is primarily a ring DNA molecule, sometimes called a bacterial chromosome or bacterial DNA.
In addition to the chromosome, the bacterial cell may have plasmids – much smaller, also ring DNA molecules.

In eukaryotes, nuclear DNA is linear. Like prokaryotic DNA, it is packed with proteins. This is how chromatin fibers are formed.

Mitochondria and chloroplasts of eukaryotic cells contain ring DNA molecules.





Types of RNA

There are three major types of RNA:

- Ribosomal RNA (rRNA)
- Transfer RNA (tRNA)
- Messenger RNA (mRNA)

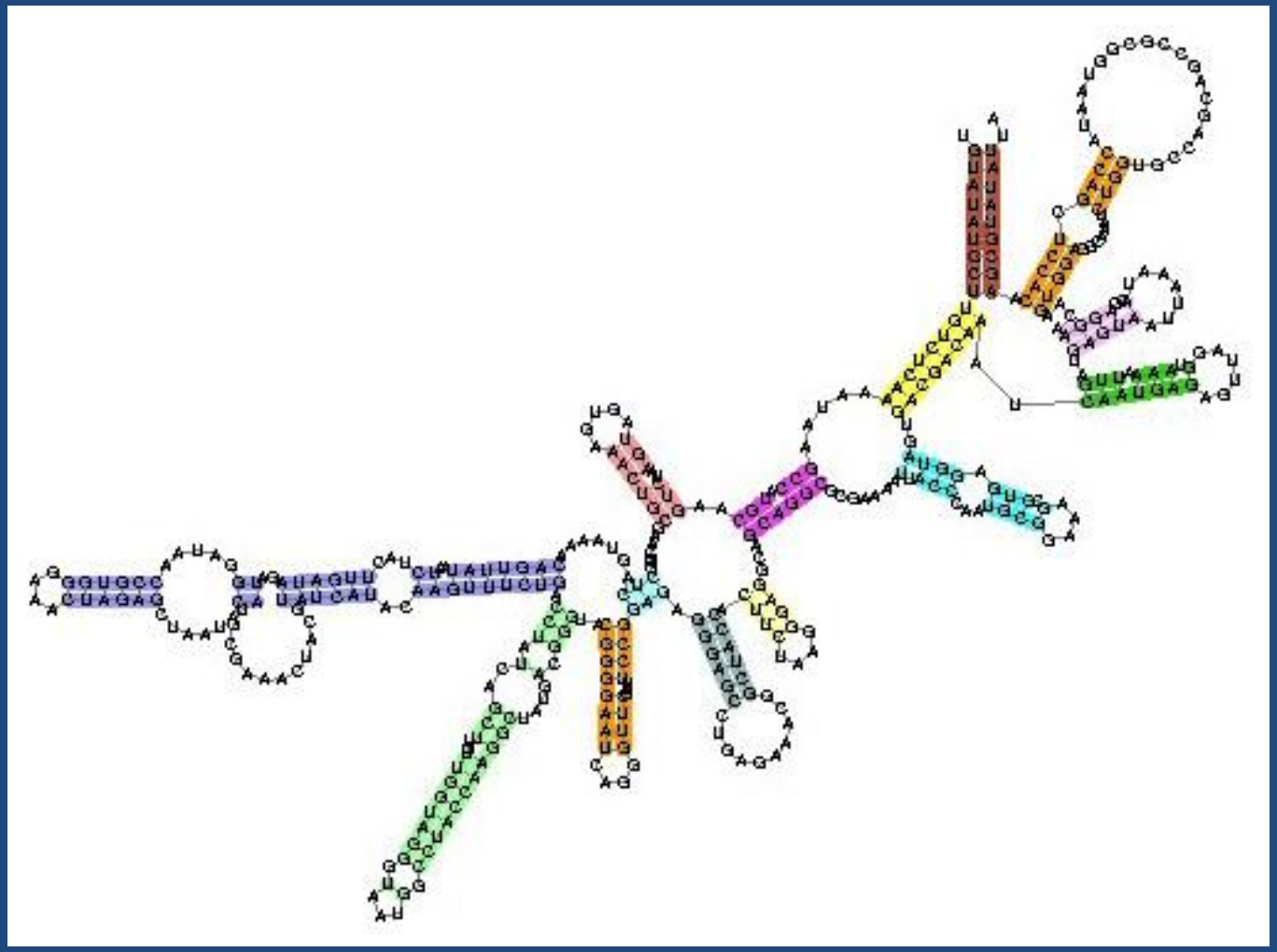
They all participate in protein synthesis.

RNA viruses have another type of RNA:

- Genomic RNA, with the functions reserved in cells for DNA, and often double-stranded like it.

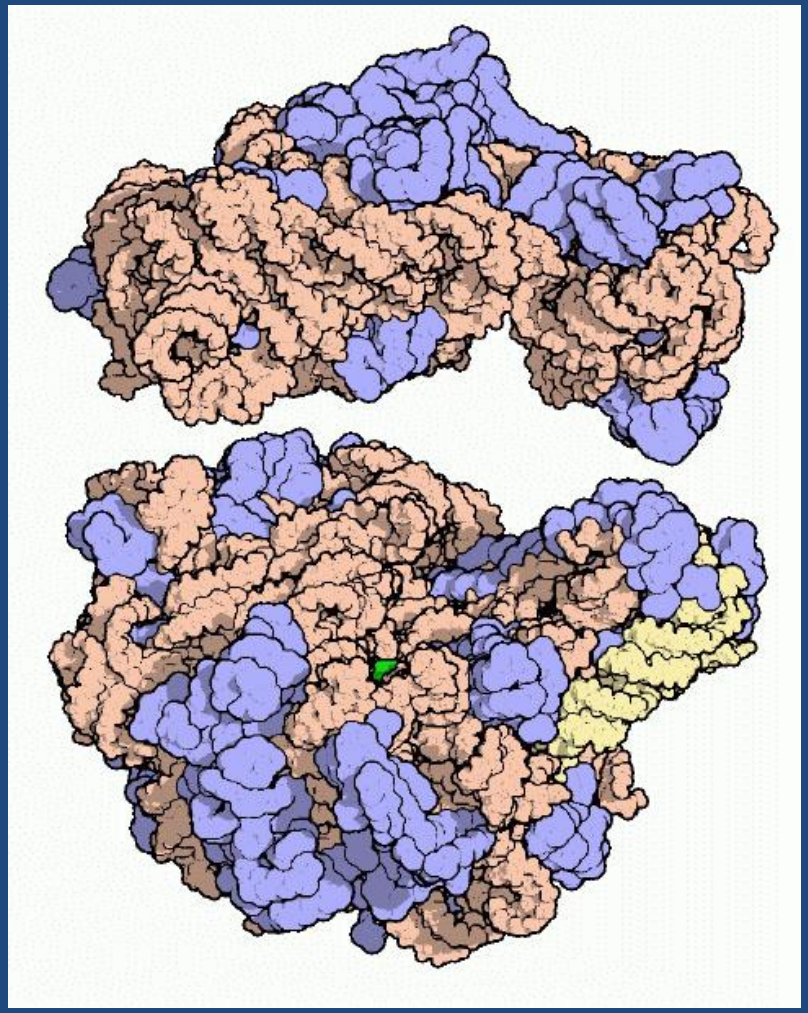
Ribosomal RNA (rRNA)

together with ribosomal proteins builds ribosomes



Secondary structure of the 5’ domain of small subunit rRNA (Rfam / Wikimedia)

View of rRNA in the ribosome

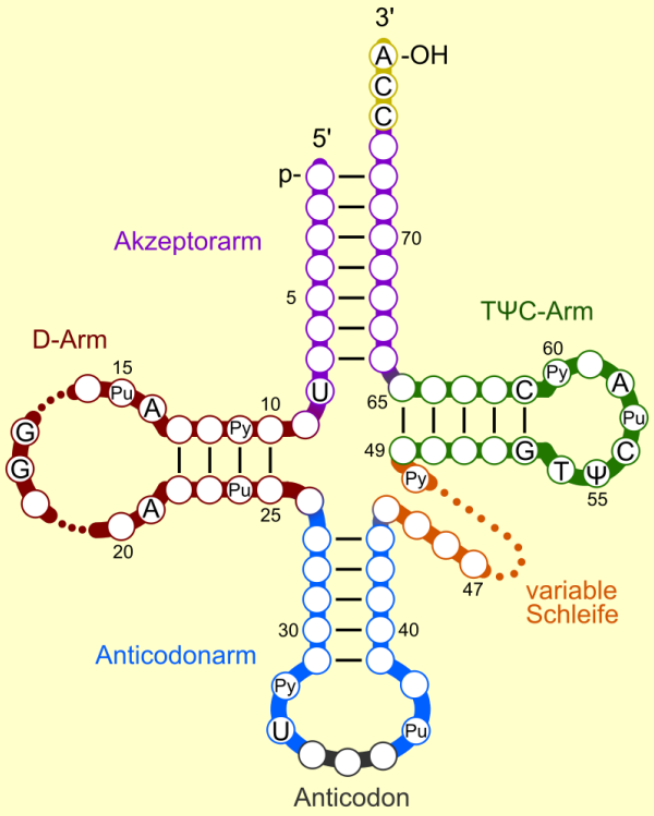


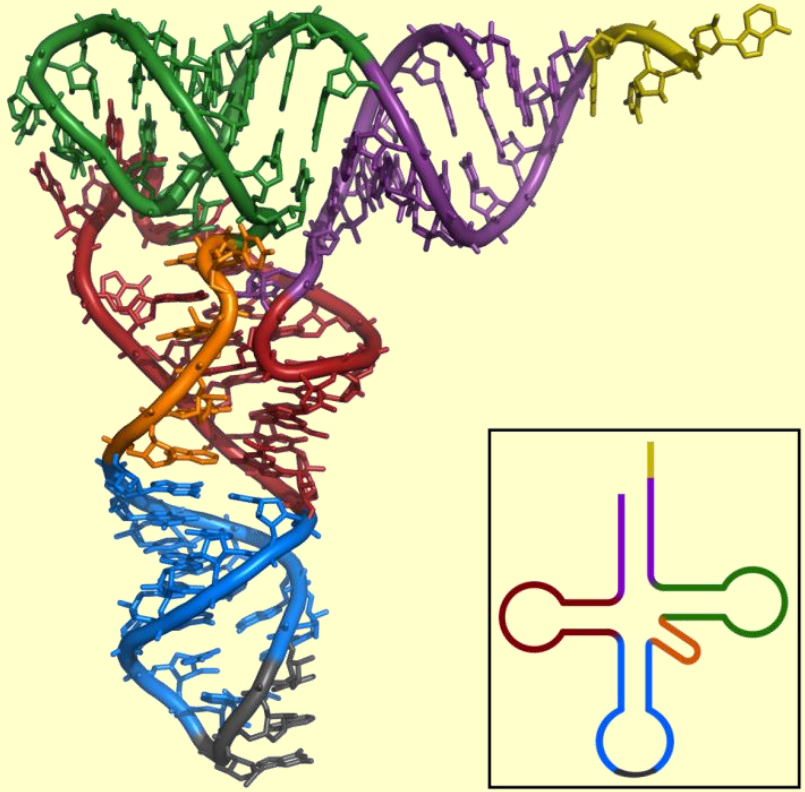
Proteins are shown in blue, rRNAs in orange and yellow

(David S. Goodsell, 2000, PDB ID: MoM_2000_10)

Transfer RNA (tRNA)

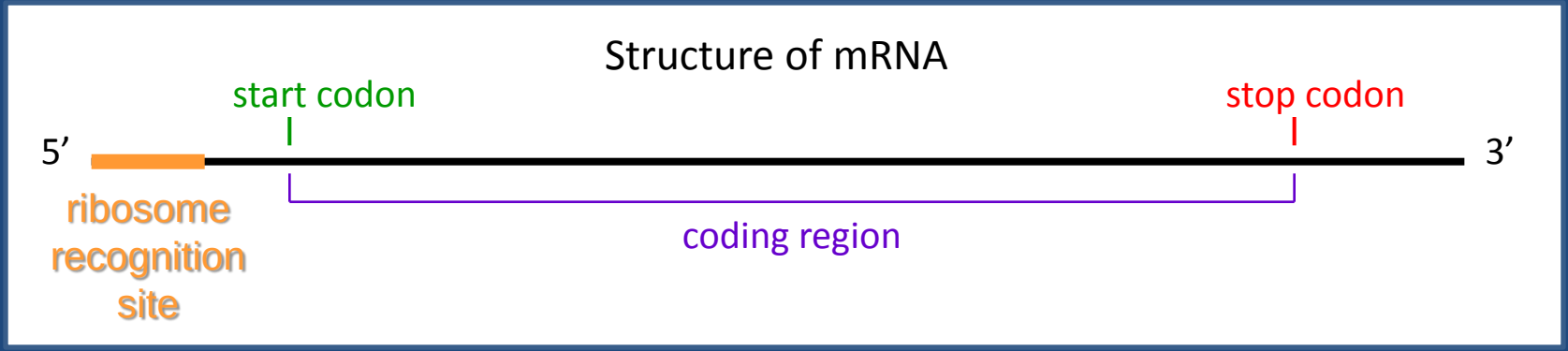
transfers amino acids for protein synthesis to ribosomes





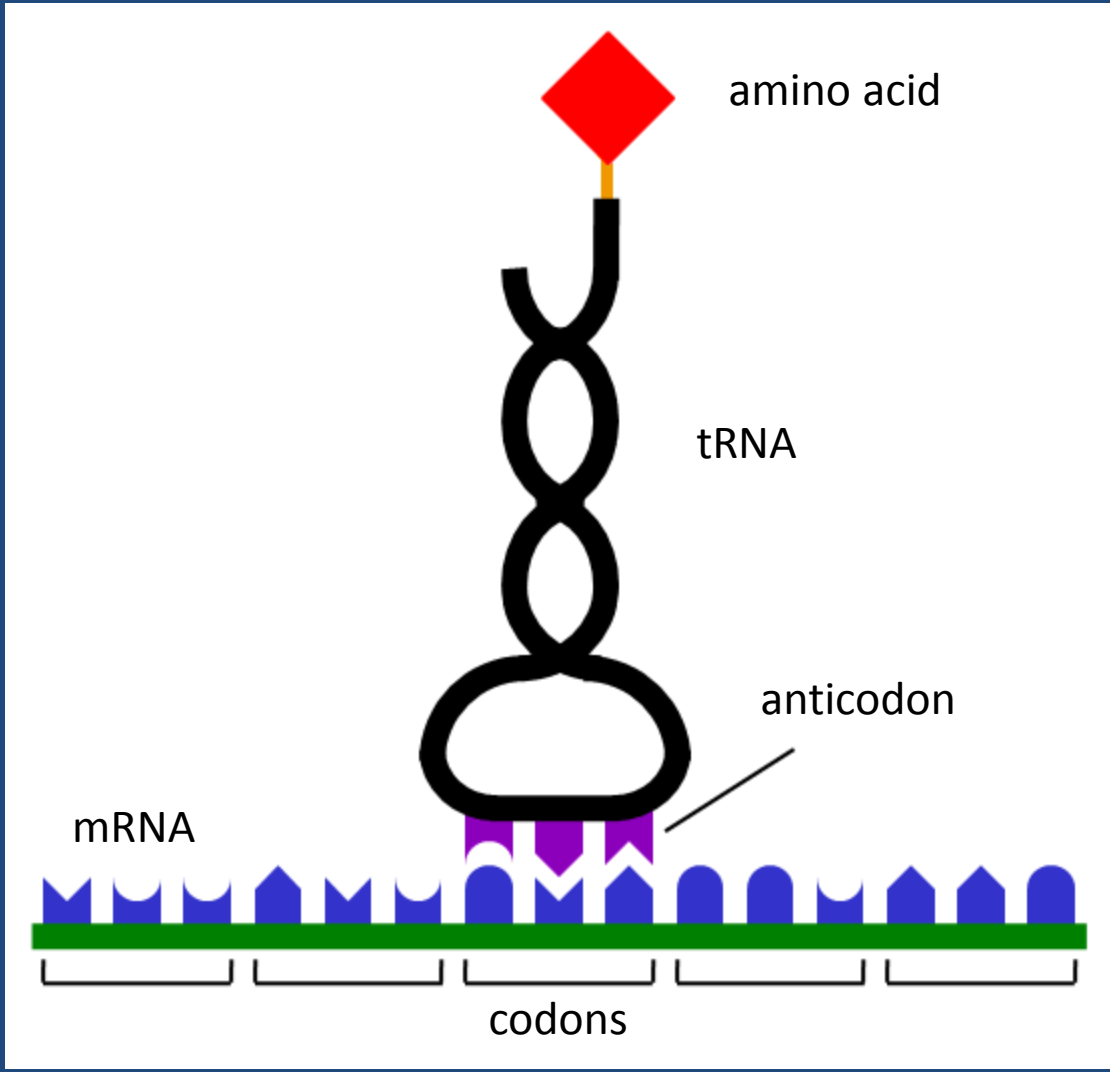
Secondary and tertiary structure of tRNA (Yikrazool, Wikimedia)

Messenger RNA (mRNA)



A single-stranded RNA molecule that corresponds to the genetic sequence of a gene and is read by the ribosome in the process of producing a protein.

Interaction between mRNA and tRNA



More about this in the next lectures...