DNA and RNA molecules for life

eCLIL project

LICEO SCIENTIFICO «NICCOLO' COPERNICO» – PAVIA

LICEO SCIENTIFICO «GALILEO GALILEI» - VOGHERA

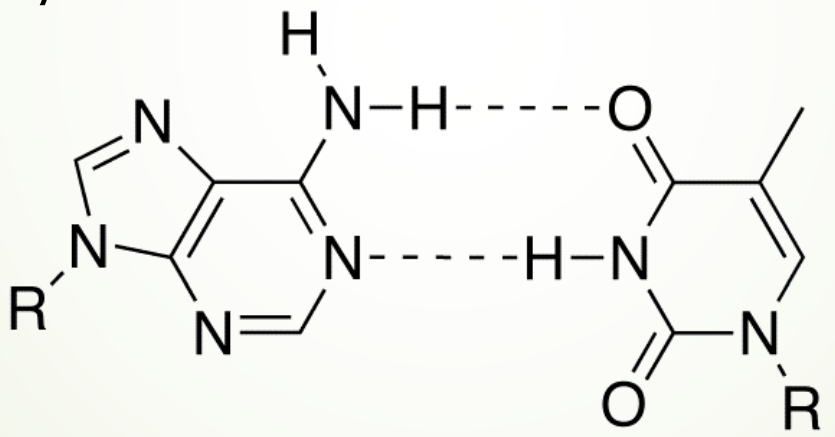
The Nucleotides

- They are composed by: phosphate group, monosaccharide sugar called deoxyribose and a nitrogen containing nucleobase

- The nucleobase can be: cytosine (C), guanine (G), adenine (A) or thymine (T)

Complementary Base Pairs: Adenine and Thymine

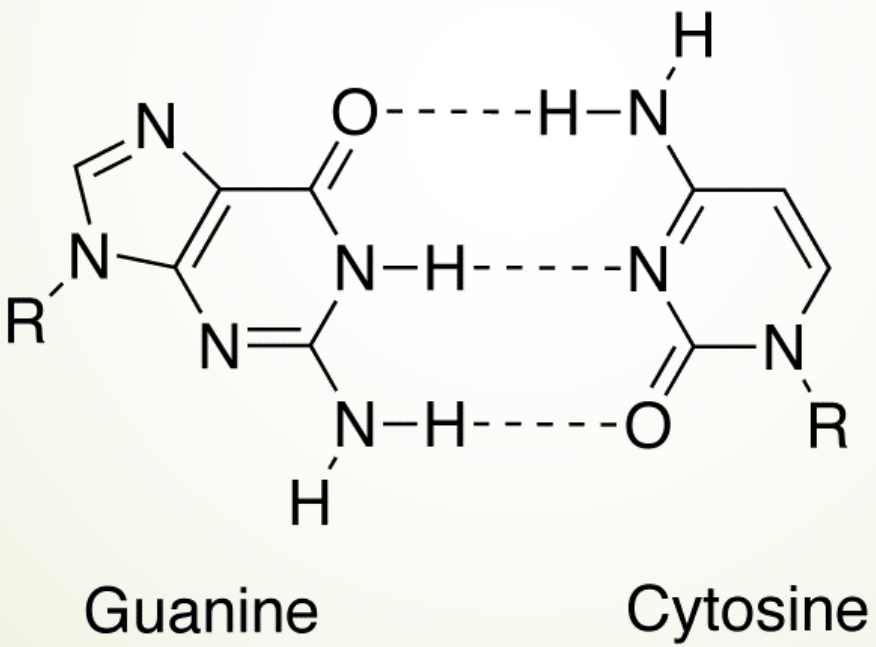
DNA contains *complementary base pairs* in which adenine is always linked by two hydrogen bonds to thymine (A-T)



Adenine Thymine

Complementary Base Pairs: Guanine and Cytosine

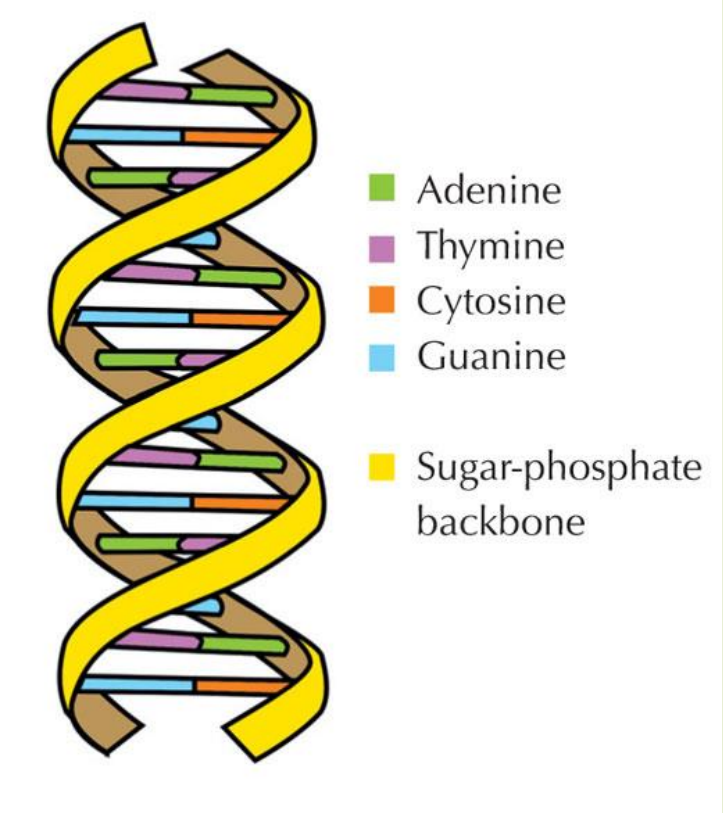
DNA contains *complementary base pairs* in which guanine is always linked by three hydrogen bonds to cytosine (G-C)



Double Helix of DNA

The DNA structure is a **double helix** that:

- consists of two strands of nucleotides that form a double helix structure like a spiral staircase.
- has hydrogen bonds between the bases A–T and G–C
- has bases along one strand that complement the bases along the other.



DNA MODEL

YOU WILL NEED:

- ***144 plastic clothespin (4 different colours, length 7 cm)***
- ***36 plastic straws (length 20 cm, to be cut in 4, 5 cm pieces)***
- ***Drawstring (length 11M, TO DIVIDE IN 12 PIECES OF 45CM EACH AND 2 PIECES OF 280CM)***
- ***72 RECTANGULAR CARDBOARDS (4,5 X 2CM)***
- ***12 plasticised sheets of paper***

Preparation

Take one of the 280cm long pieces of drawstring and make a slot at one end of it. Insert a coloured clothespin and push it until it is stuck in the slot; now insert a 4,5 cm long piece of straw and then another clothespin. Keep on doing this until you have 36 clothespin and 36 pieces of straw in the drawstring. You now have the nitrogenous bases sequence of the first filament.

The same procedure has to be followed for the other 280cm long drawstring but while inserting the clothespins you have to pay attention at their colours: this sequence has to be complementary to the one of the first filament (adenine has to match with thymine and cytosine with guanine).

Conclude by matching the two filament's complementary bases/clothespins using the rectangular cardboards (that simulate the nitrogen bonding between the nitrogenous bases).

RNA

Ribonucleic acid (RNA) is a polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes. RNA and DNA are nucleic acids, and, along with proteins and carbohydrates, constitute the three major macromolecules essential for all known forms of life.

Some RNA molecules play an active role within cells by catalyzing biological reactions, controlling gene expression, or sensing and communicating responses to cellular signals. One of these active processes is protein synthesis, a universal function wherein mRNA molecules direct the assembly of proteins on ribosomes.

CONSTITUENT PARTS

NUCLEOTIDE

Nucleotides are organic molecules that serve as monomers (repetitive units) of the nucleic acids (both DNA and RNA)

The RNA is composed of three parts:

1. A nucleobase (purine or prymidine)
2. A five-carbon sugar (ribose)
3. At least one phosphate group

In RNA we have 4 bases:

Purines:

- Adenine [A]
- Guanine [G]

Pirymidines:

- Uracil [U]
- Cytosine [C]

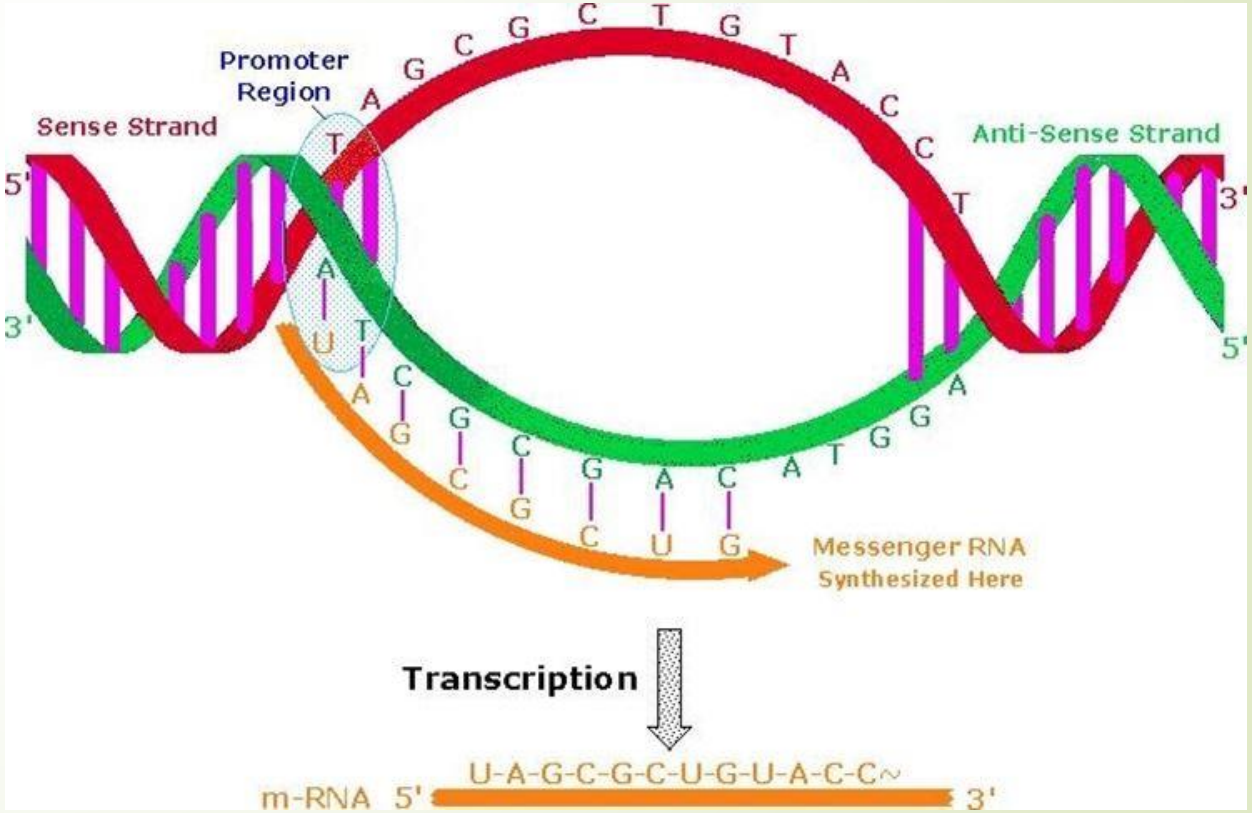
The Base pairs are:

- Adenine-Uracil [AU]
- Guanine-Cytosine [GC)

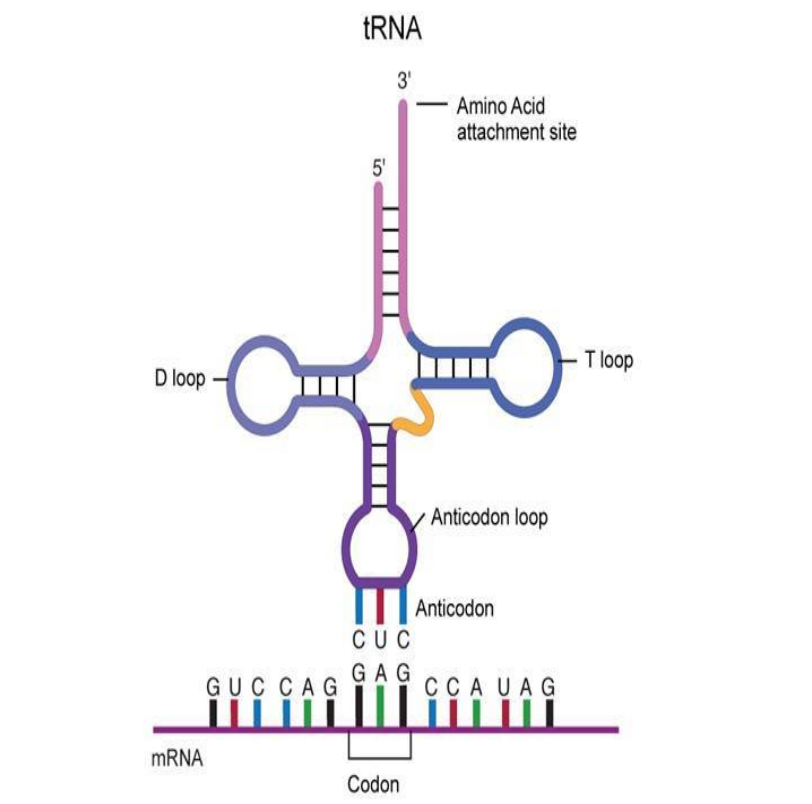
THE THREE TYPES OF RNA

The Messenger RNA (mRNA)

Messenger RNA is a single copy in complementary strand of a stretch of DNA and "transcribes" the instructions for the proper sequence in which amino acids must join together to form a protein. Each group of 3 nucleotides in sequence on the mRNA is said codon and carries the information necessary to the synthesis of a particular amino acid.



The Transfer RNA (tRNA)

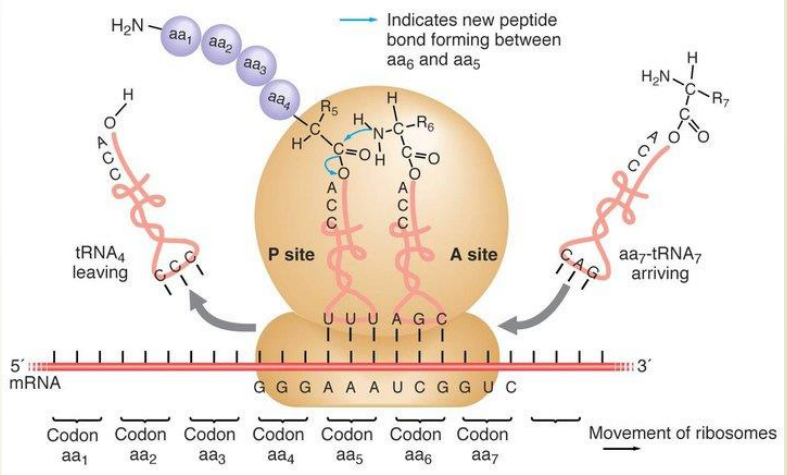


The transfer RNA (tRNA) recognizes the mRNA information and intervenes in the synthesis of amino acids. In some stretches of RNA transport, the bases pair up for complementarity. This results in an alternation of stretches of paired and "eyelets" in uncoupled bases which give the molecule a particular shape of a "clover". One end of the tRNA binds to a specific amino acid; on the opposite side, a particular sequence of 3 nucleobases (anticodon) is to appear in a codon of m-RNA.

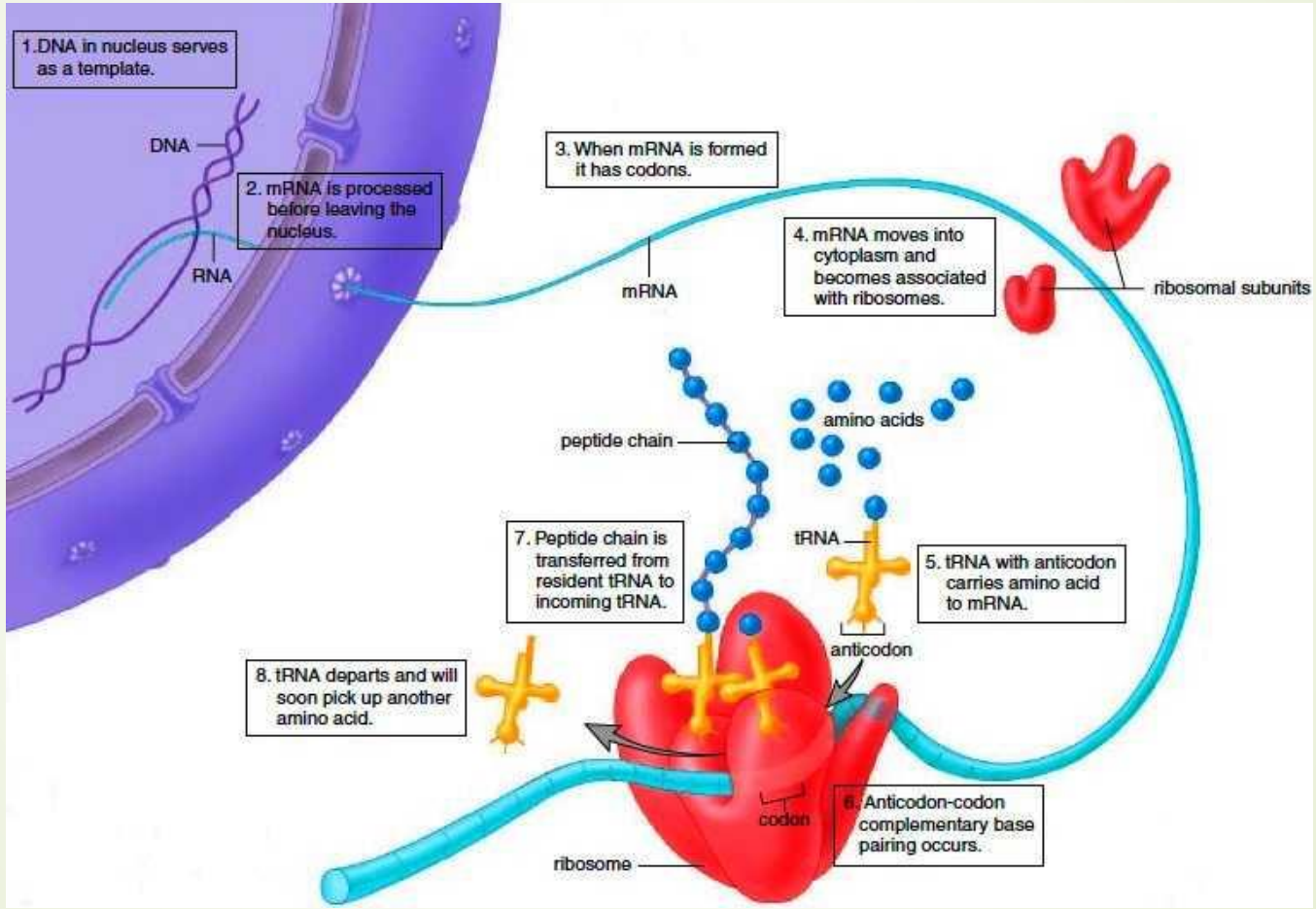
The Ribosomial RNA (rRNA)

The ribosomal RNA binds to certain proteins to form ribosomes, or organelles composed of two different subunits of dimensions on which protein synthesis takes place. Ribosomal RNA is the most abundant type of RNA present in the cell. rRNA not encode proteins directly, but it is the essential part (about two thirds) of the ribosomes, catalytic machines performing assembling of proteins, present in all living cells.

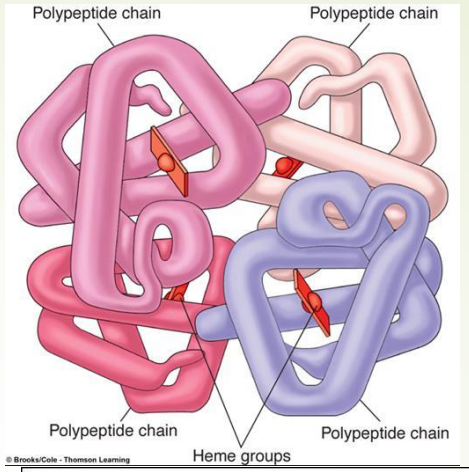
The rRNA function is to provide a mechanism for decoding mRNA into amino acids (the center of the small subunit of the ribosome) and interact with the tRNA during protein synthesis, providing the activity of the peptidyltransferase, which occurs in the major subunit. The correctness of the translation is due to the work of both subunits.

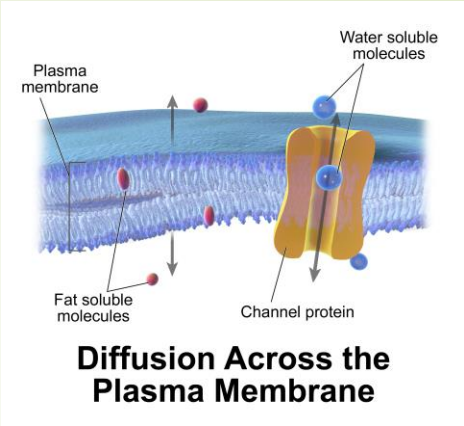


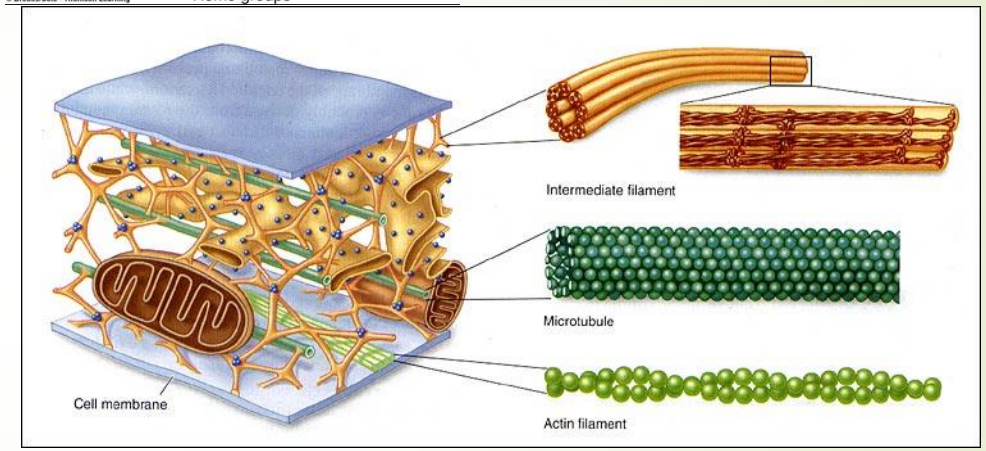
SYNTHESIS OF PROTEINS

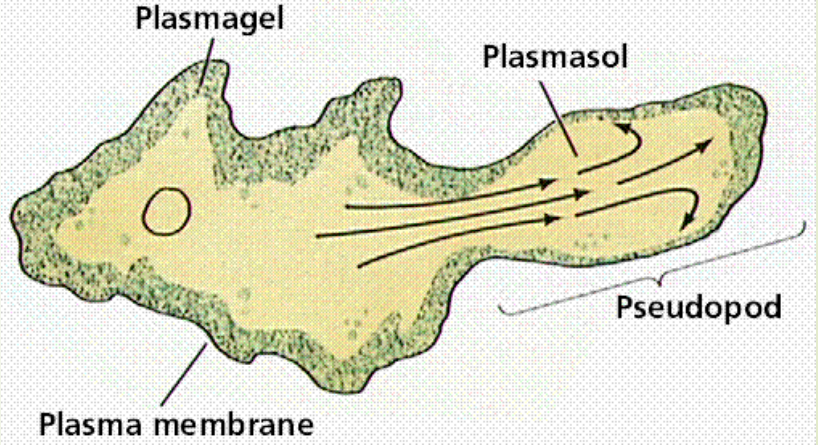


Proteins are the working molecules of the cell. They catalyze an extraordinary range of chemical reactions, provide structural rigidity, control the permeability of membranes, regulate the concentrations of needed metabolites, recognize and bind other biomolecules, cause motion, and control the functioning of genes. These incredibly diverse tasks are performed by molecules synthesized from only 20 different amino acids.

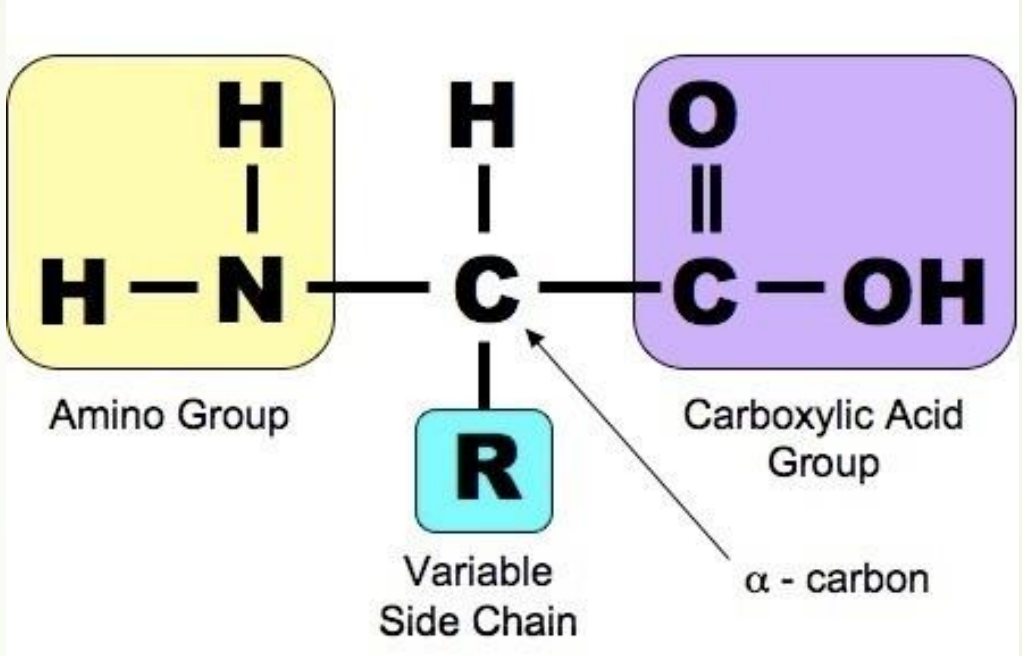








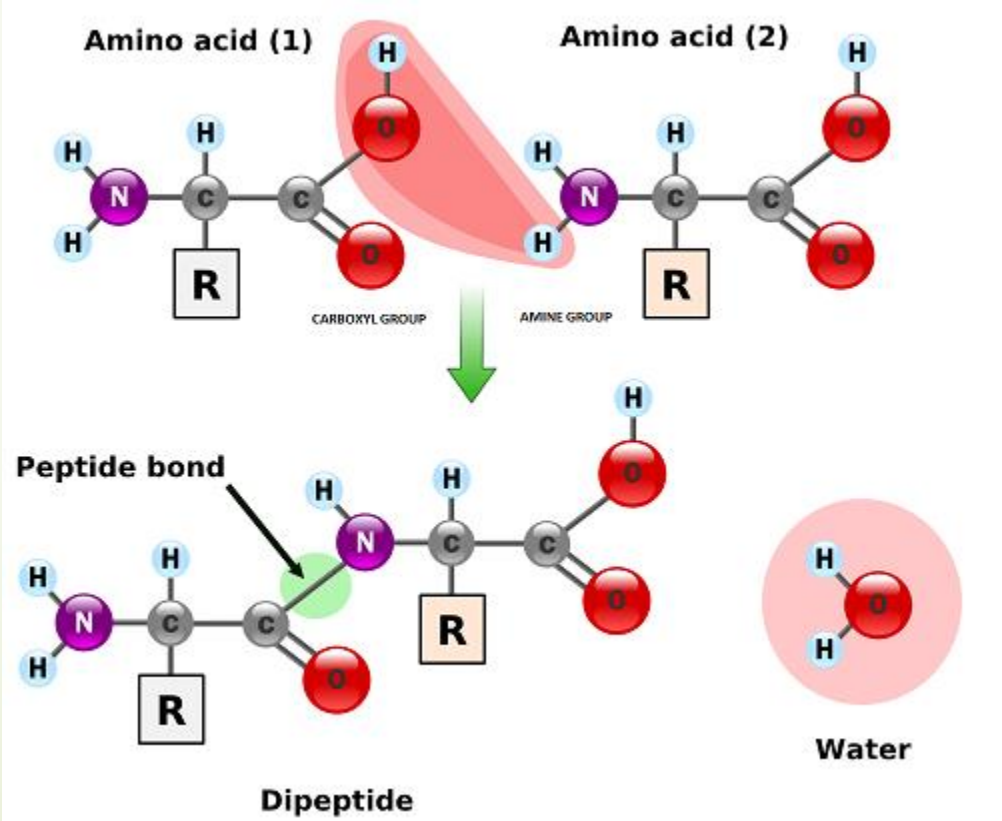
The monomers that make up proteins are called amino acids because, with an exception (proline), each contains an amino group ($-NH_2$) and an acidic carboxyl group (-COOH)



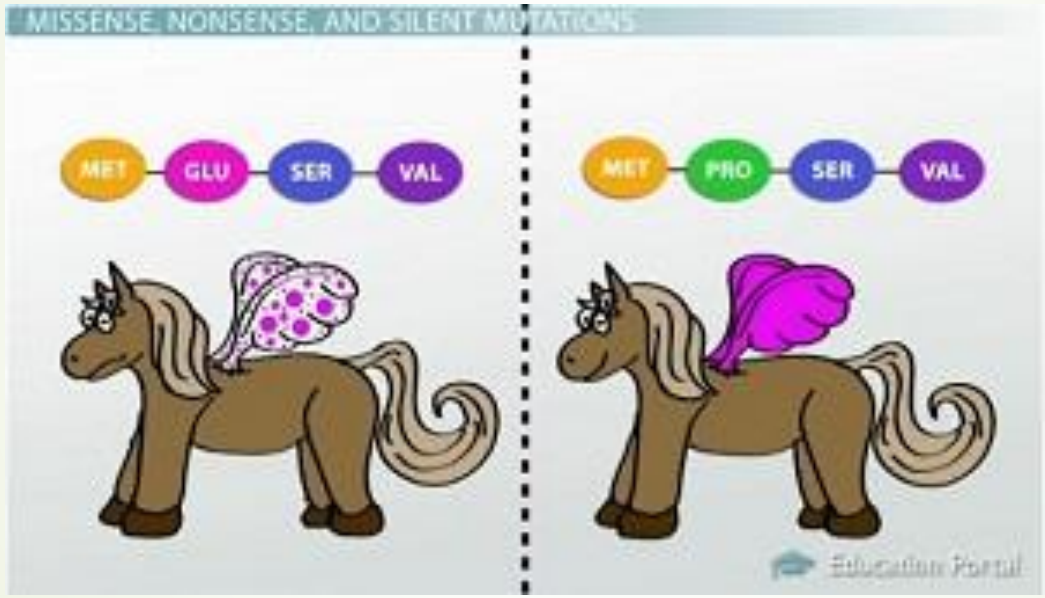
All amino acids are constructed according to a basic design: a central carbon atom called the α carbon is bonded to an amino group, to a carboxyl group, to a hydrogen atom, and to one variable group, called side chain or R group

PROTEINS ARE POLYMERS COMPOSED OF AMINO ACIDS CONNECTED BY PEPTIDE BONDS

The peptide bond, the chemical bond that connects two amino acid in a polymer, is formed between the amino group of one amino acid and the carboxyl group of an another. This reaction, which is called condensation, liberates a water molecule

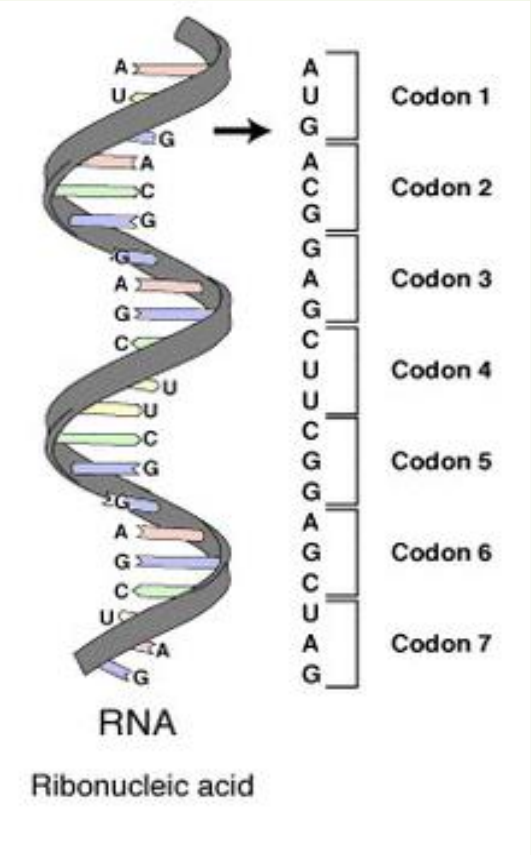


A genetic mutation can lead to the substitution of one amino acid for another at a defined place in the protein. If the substitution inserts an amino acid with a very different side chain the protein is often altered and it is rendered non functional.



mutant protein normal protein

Codon is a sequence of 3 nucleotides



A series of codons in part of a messenger RNA (mRNA) molecule. Each codon consists of three nucleotides, usually corresponding to a single amino acid. The nucleotides are abbreviated with the letters A, U, G and C. This is mRNA, which uses U (uracil). DNA uses T (thymine) instead. This mRNA molecule will instruct a ribosome to synthesize a protein according to this code.

	U	C	A	G	
U	UUU, UUC } Phe UUA, UUG } Leu	UCU, UCC, UCA, UCG } Ser	UAU, UAC } Tyr UAA Stop UAG Stop	UGU, UGC } Cys UGA Stop UGG Trp	U C A G
C	CUU, CUC, CUA, CUG } Leu	CCU, CCC, CCA, CCG } Pro	CAU, CAC } His CAA, CAG } Gln	CGU, CGC, CGA, CGG } Arg	U C A G
A	AUU, AUC, AUA } Ile AUG Met	ACU, ACC, ACA, ACG } Thr	AAU, AAC } Asn AAA, AAG } Lys	AGU, AGC } Ser AGA, AGG } Arg	U C A G
G	GUU, GUC, GUA, GUG } Val	GCU, GCC, GCA, GCG } Ala	GAU, GAC } Asp GAA, GAG } Glu	GGU, GGC, GGA, GGG } Gly	U C A G

When you know the sequence of bases you can build a protein using the table you have just seen.

CGA	**UCG**	**GAA**	**UUC**	**GGA**	**ACU**	**AUG**	**CGA**
Arg	**Ser**	**Glu**	**Phe**	**Gly**	**Thr**	**Met**	**Arg**

Exercise:

Insuline chain as 21 amynoacids

	U	C	A	G	
U	UUU, UUC: Phe UUA, UUG: Leu	UCU, UCC, UCA, UCG: Ser	UAU, UAC: Tyr UAA: Stop UAG: Stop	UGU, UGC: Cys UGA: Stop UGG: Trp	U C A G
C	CUU, CUC, CUA, CUG: Leu	CCU, CCC, CCA, CCG: Pro	CAU, CAC: His CAA, CAG: Gln	CGU, CGC, CGA, CGG: Arg	U C A G
A	AUU, AUC, AUA: Ile AUG: Met	ACU, ACC, ACA, ACG: Thr	AAU, AAC: Asn AAA, AAG: Lys	AGU, AGC: Ser AGA, AGG: Arg	U C A G
G	GUU, GUC, GUA, GUG: Val	GCU, GCC, GCA, GCG: Ala	GAU, GAC: Asp GAA, GAG: Glu	GGU, GGC, GGA, GGG: Gly	U C A G

Gly-Ile-Val-Glu-Gin-Cys-Cys-Thr-Ser-Ile-Cys-Ser-Leu-Tyr-Gin-Leu-Glu-Asn-Tyr-Cys-Asn

Find triplettes connected whit this amynoacids

DNA SEQUENCING

DNA sequencing is the process of determining the precise order of nucleotides in DNA.

DNA sequencing uses a restriction enzyme.

A restriction enzyme cuts DNA in a specific site known as restriction sites.
To cut DNA, all restriction enzymes make two incisions in the DNA double helix.
We have different restriction enzyme for different DNA sequence.

Exercise: you want to know who have stolen jam from fridge.

You have got:
- DNA sequence of an hair found into the fridge;
- Relatives' DNA sequences;
- restriction enzyme that separes CCGG bases in CC GG.

You have to divide relatives' DNA in CCGG sites and compare them with DNA of hair

SEQUENCE OF HAIR

TGCTAGCACCGGTATTGCCGGTGCTTAGCAACCGGATCTAGCATCCGGCAATCACGCACCGGGCTACTGCATTAGCCCGGCATGCATGCCGGAA

ACGATCGTGGCCATAACGGCCACGAATCGTTGGCCTAGATCGTAGGCCGTTAGTGCGTGGCCCGATGACGTAATCGGGCCGTACGTACGGCCTT

MUM'S DNA

TGACCGGTCATGCCCGGACGCTATGCCCGGGCGTGATAGCTCTACCGGTCCAATAGCTAGCTCGACCGGTACGGAGCTTAGCTAGGCTATGCGT

ACTGGCCAGTACGGGCCTGCGATACGGGCCCGCACTATCGAGATGGCCAGGTTATCGATCGAGCTGGCCATGCCTCGAATCGATCCGATACGCA

DAD'S DNA

ATGCTAGCACCGGTATTGCCGGTGCTTAGCAACCGGATCTAGCATCCGGCATTCACGCACCGGGCTACTGCATTAGCCCGGCATGCATGCCGGA

TACGATCGTGGCCATAACGGCCACGAATCGTTGGCCTAGATCGTAGGCCGTAAGTGCGTGGCCCGATGACGTAATCGGGCCGTACGTACGGCCT

GIRL'S DNA

TGACCGGTCATGCCCGGTACGGAGCTTAGCTAGCTATGCGCCGGTATTGCCGGTGCTAAGCATCCGGATCTAGCATCCGGTCCAATAGCTAGCT

ACTGGCCAGTACGGGCCATGCCTCGAATCGATCGATACGCGGCCATAACGGCCACGATTCGTAGGCCTAGATCGTAGGCCAGGTTATCGATCGA

SCIENCE LAB
DNA ESTRACTION

☺ CLASSWORK!!! ☺

MULTIPLE CHOICE

1) Chromosomes are:
- Condensed DNA
- Despiralized DNA
- RNA
- Aligned codons

2) Each nucleotide is formed by:
- Sugar, nitrogenous base and protein group
- Sugar, protein and phosphoric group to group
- Sugar, phosphate group, nitrogenous base
- Nitrogenous base, sugar and phosphate group

3) The complementarity of the bases is explained
- Thanks to ni hydrogen bonds
- Thanks to the number of disulphide bridges
- Thanks to the number of bonds in general
- Due to the chemical similarity

4) Which element is not present in a DNA molecule?
- oxygen
- sulphur
- nitrogen
- carbon

5) The transcript:
- Occurs in the nucleus
- Occurs in the cytoplasm
- It is semi-conservative
- Is conservative

6) The prokaryotic chromosomes are formed

- only repeated DNA
- both DNA sequence that DNA repeated
- unique DNA sequence or DNA repeated
- only DNA sequence

7) What is the name of the chromatids point of contact

- centromero
- origine Replication
- telomero
- esomero

8) Where are written the genetic traits

- RNA
- Pintail
- Fragments of DNA
- Nucleotides

HAVE YOU A NICE AFTERNOON!

Thank you very much for your attention.

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