

Cell and molecular Biology/ Theory

Introduction to molecular Biology

- Nucleic acid structures

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THE UNIVERSITY *of* DUHOK



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VETERINARY MEDICINE

Learning objectives

- Understand the science of molecular Biology
- Understand the structure and function of nucleic acids
- Understand the concept of complementarity in nucleic acids

Molecular Biology

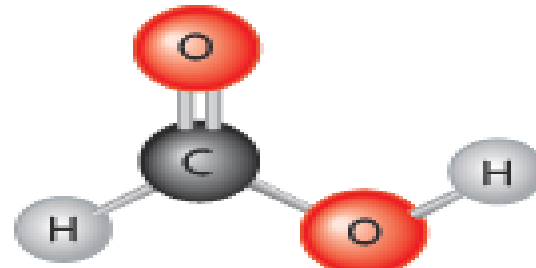
- **Molecular Biology** is the study of the structure of macromolecules as well as studying biochemical and molecular processes within cells, especially the processes of DNA replication, RNA transcription, and protein translation.
- **Organisms are composed of matter**, which is anything that takes up space and has mass. Matter exists in many forms. Rocks, metals, oils, gases, and living organisms.

- **Elements and Compounds**

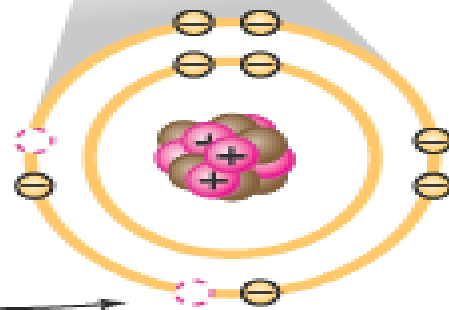
Matter is made up of elements.

- **An element** is a substance that cannot be broken down to other substances by chemical reactions. Chemists recognize 92 elements occurring in nature; gold, copper, carbon, and oxygen are examples.
- **A compound** is a substance consisting of two or more different elements combined in a fixed ratio. Table salt, for example, is sodium chloride (NaCl), a compound composed of the elements sodium (Na) and chlorine (Cl) in a 1:1 ratio

Formic acid

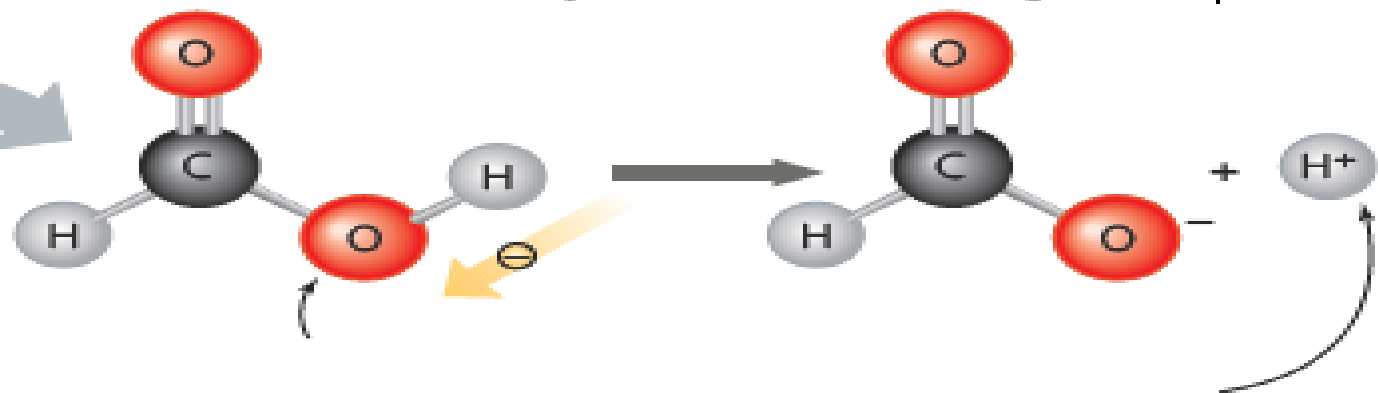


Oxygen atom



Oxygen has space for 2 more electrons, so it can form 2 bonds.

A **compound's properties** depend on its atoms and how they are bonded together.

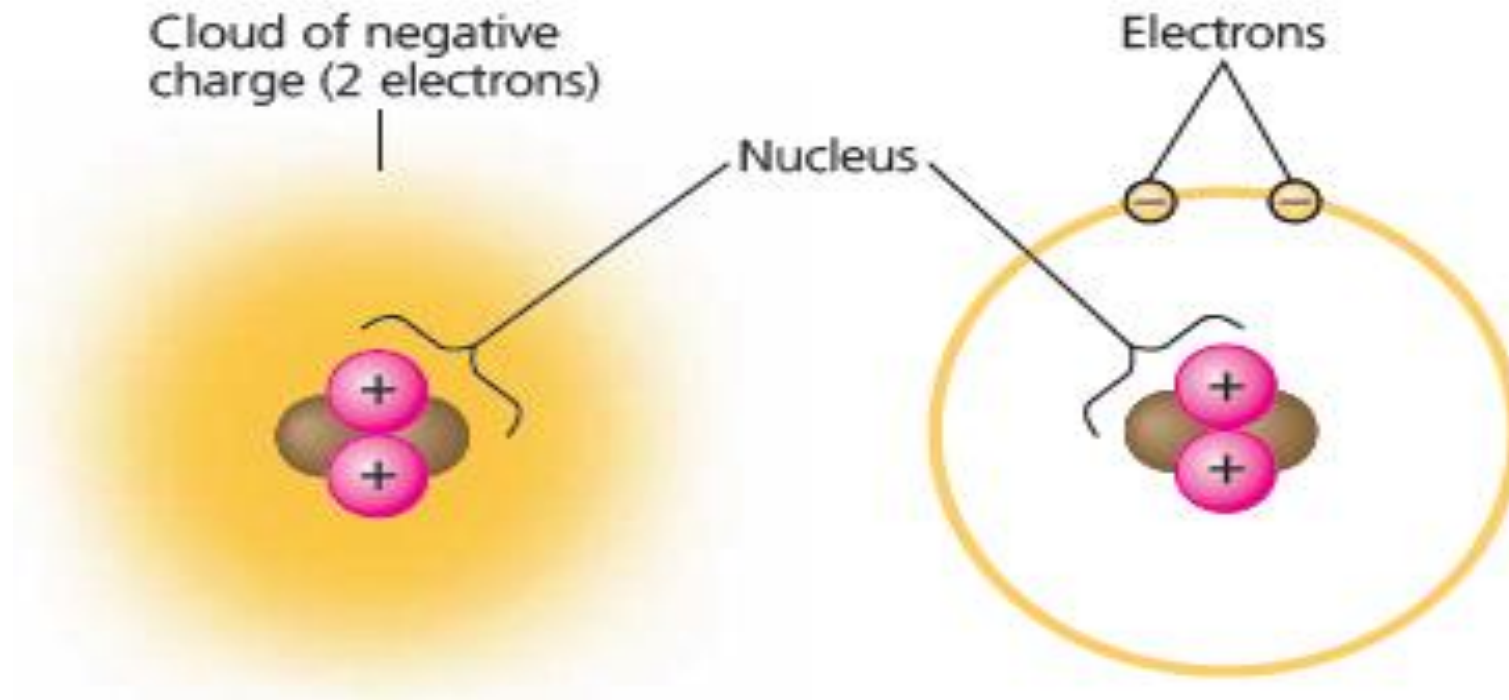


The elements of life

Table 2.1 Elements in the Human Body		
Element	Symbol	Percentage of Body Mass (including water)
Oxygen	O	65.0%
Carbon	C	18.5%
Hydrogen	H	9.5%
Nitrogen	N	3.3%
Calcium	Ca	1.5%
Phosphorus	P	1.0%
Potassium	K	0.4%
Sulfur	S	0.3%
Sodium	Na	0.2%
Chlorine	Cl	0.2%
Magnesium	Mg	0.1%

Trace elements (less than 0.01% of mass): Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)

- **A molecule** is a chemical structure consisting of two or more units called atoms,
- **The atoms** that make up a molecule are joined together by **covalent bonds** in which pairs of electrons are shared between pairs of atoms.



Macromolecules of the cell

- A macromolecule is an organic molecule of >1000 molecular weight
 - monomer units linked via covalent bonds to form polymer (macromolecule)
- Combination of different monomer units builds a range of macromolecules
 - Sugars \rightarrow Polysaccharides
 - Amino acids \rightarrow Proteins
 - Nucleotides \rightarrow Nucleic acids
 - Fatty acid \rightarrow lipid

Macromolecules have biological importance such as:

- Information carrying capacity – DNA
- Biological catalysts – proteins

SUBUNIT



sugar

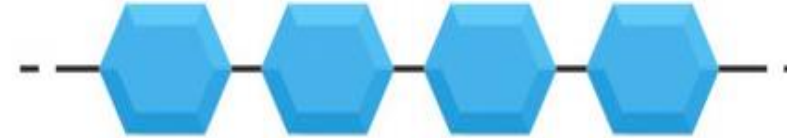


amino acid

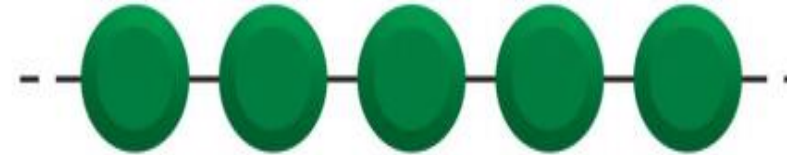


nucleotide

MACROMOLECULE



polysaccharide



protein



nucleic acid

Proteins

- Polymers composed of amino acid building blocks (monomers)
- **Major functions**
 - Catalytic (increase the rate of a chemical reaction without changing themselves - enzymes)
 - Structural
 - Transport (transmembrane)
 - Movement
 - Regulation
 - Storage
 - Signalling
 - Receptors
- Protein size ranges from 51 amino acids to more than 5,000

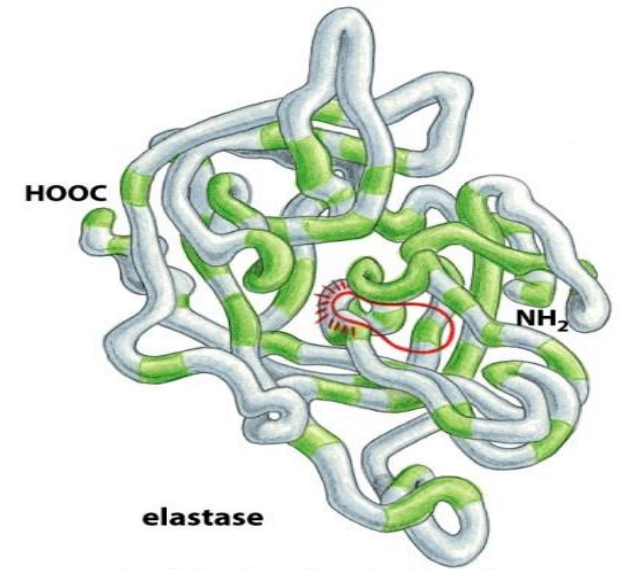


Figure 4-18 Essential Cell Biology 3/e (© Garland Science 2010)

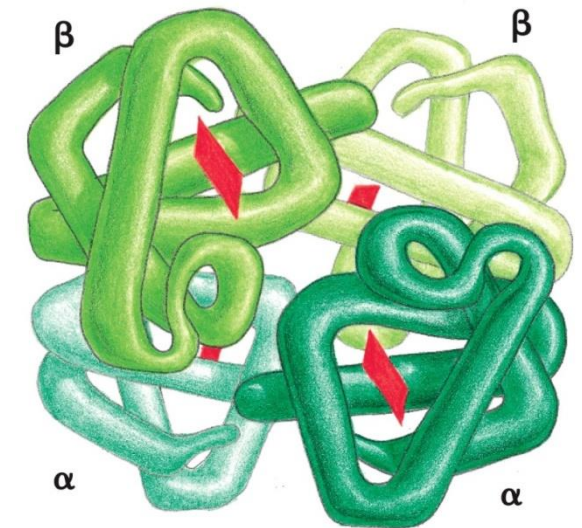
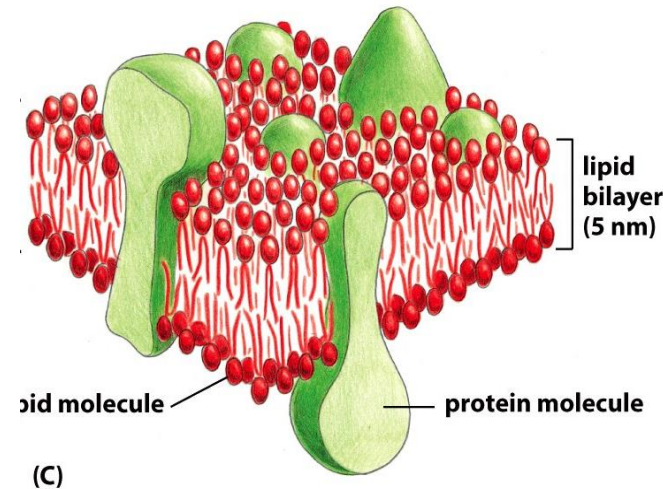


Figure 4-20 Essential Cell Biology 3/e (© Garland Science 2010)

Genome (blueprint)

- **Deoxyribo**nucleic acid (DNA) is double helix structure that contains the structural blueprint for all genetic instructions.

Two types of nucleic acids

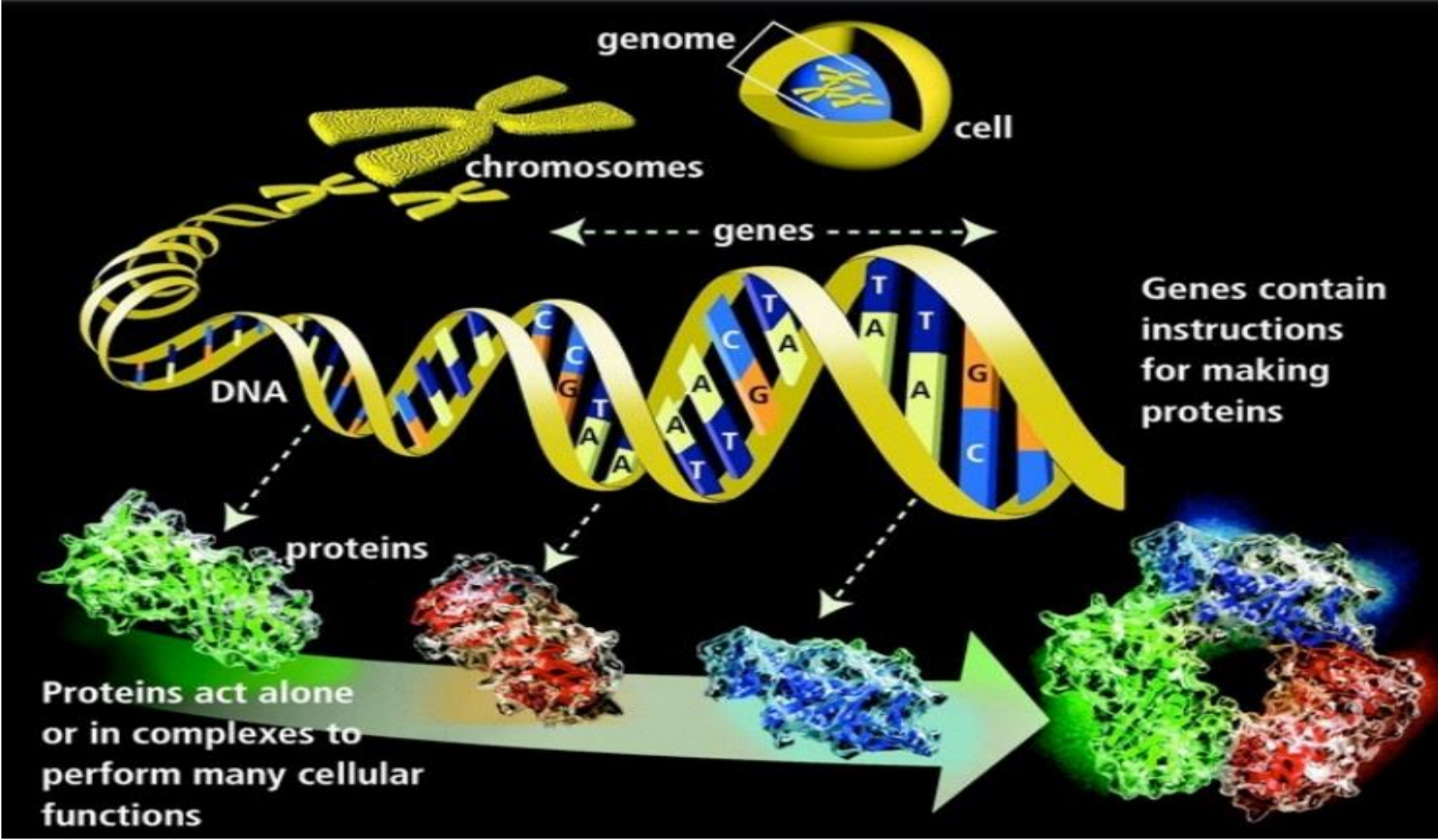
DNA: **deoxyribo**nucleic acid

RNA: **ribo**nucleic acid

The genomes of all multicellular animals, consists of two distinct parts:

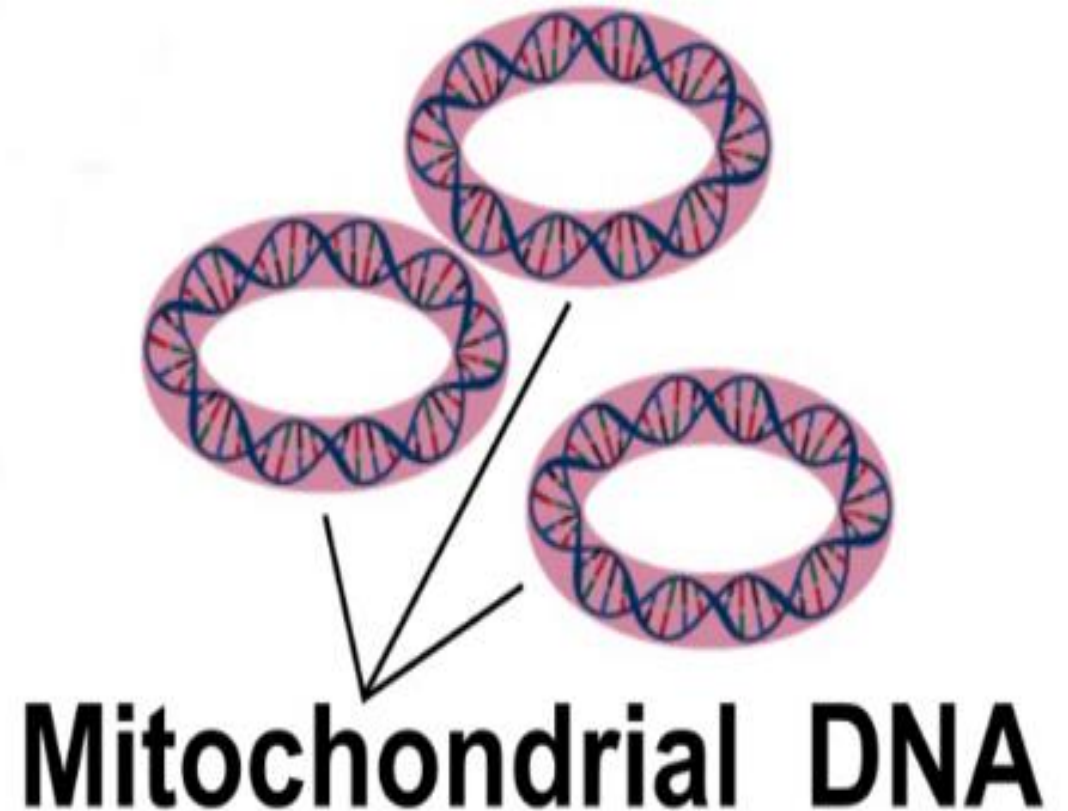
1- The nuclear genome

- Found in the nucleus of the cell
- 3,3 billion bases arranged in linear chromosomes
- Two copies of each chromosome present
- Maternally and paternally inherited
- Contains approximately 20,000 - 30,000 genes
- 93% of the genome contains non-coding DNA



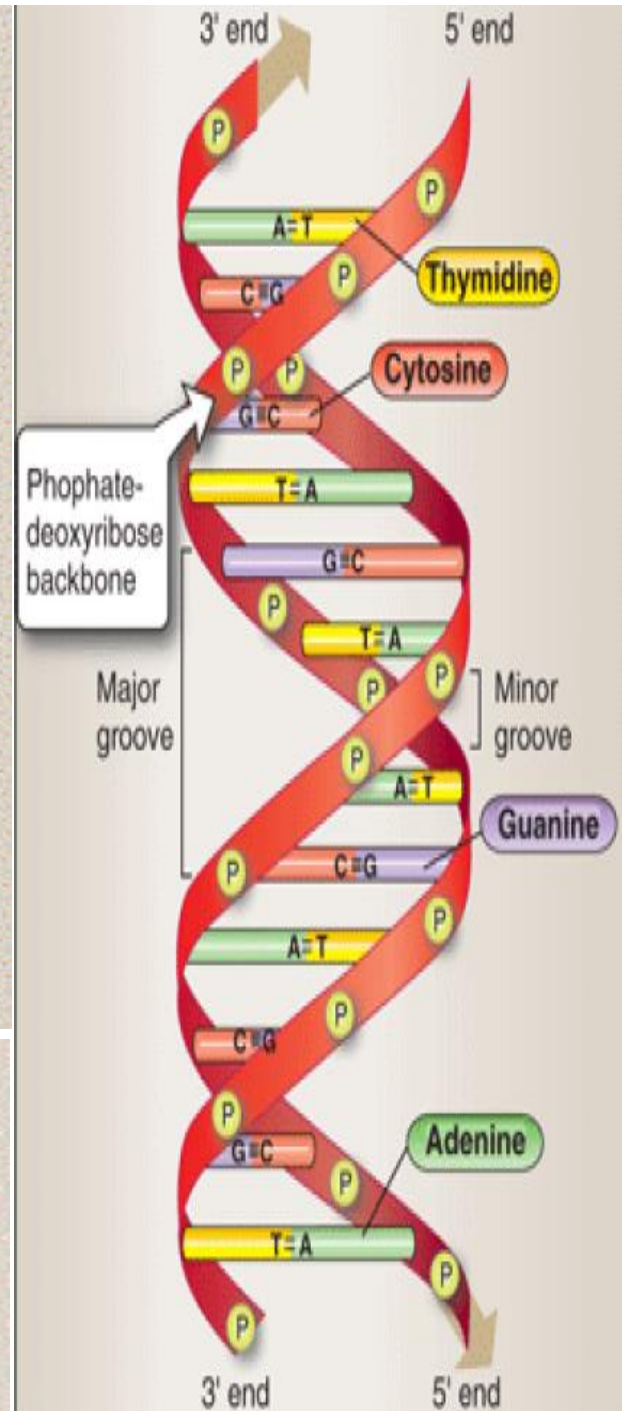
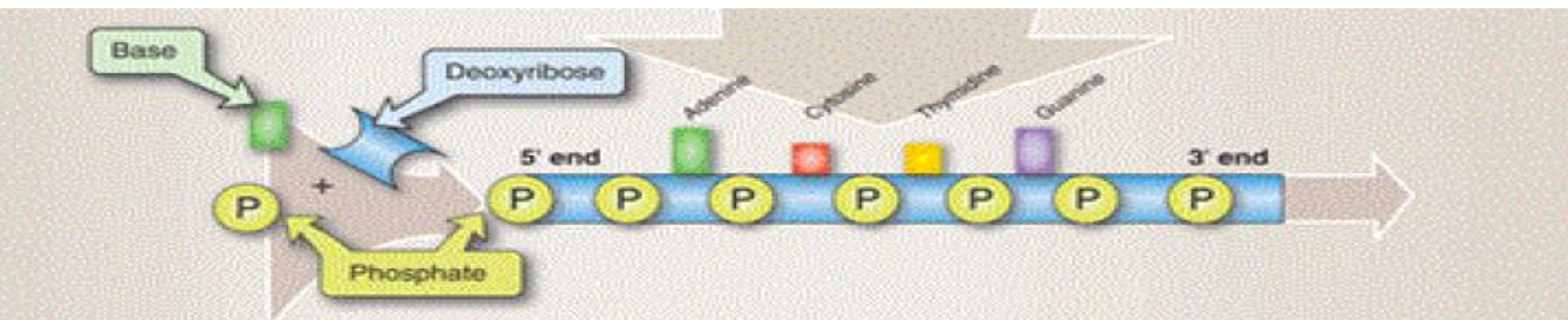
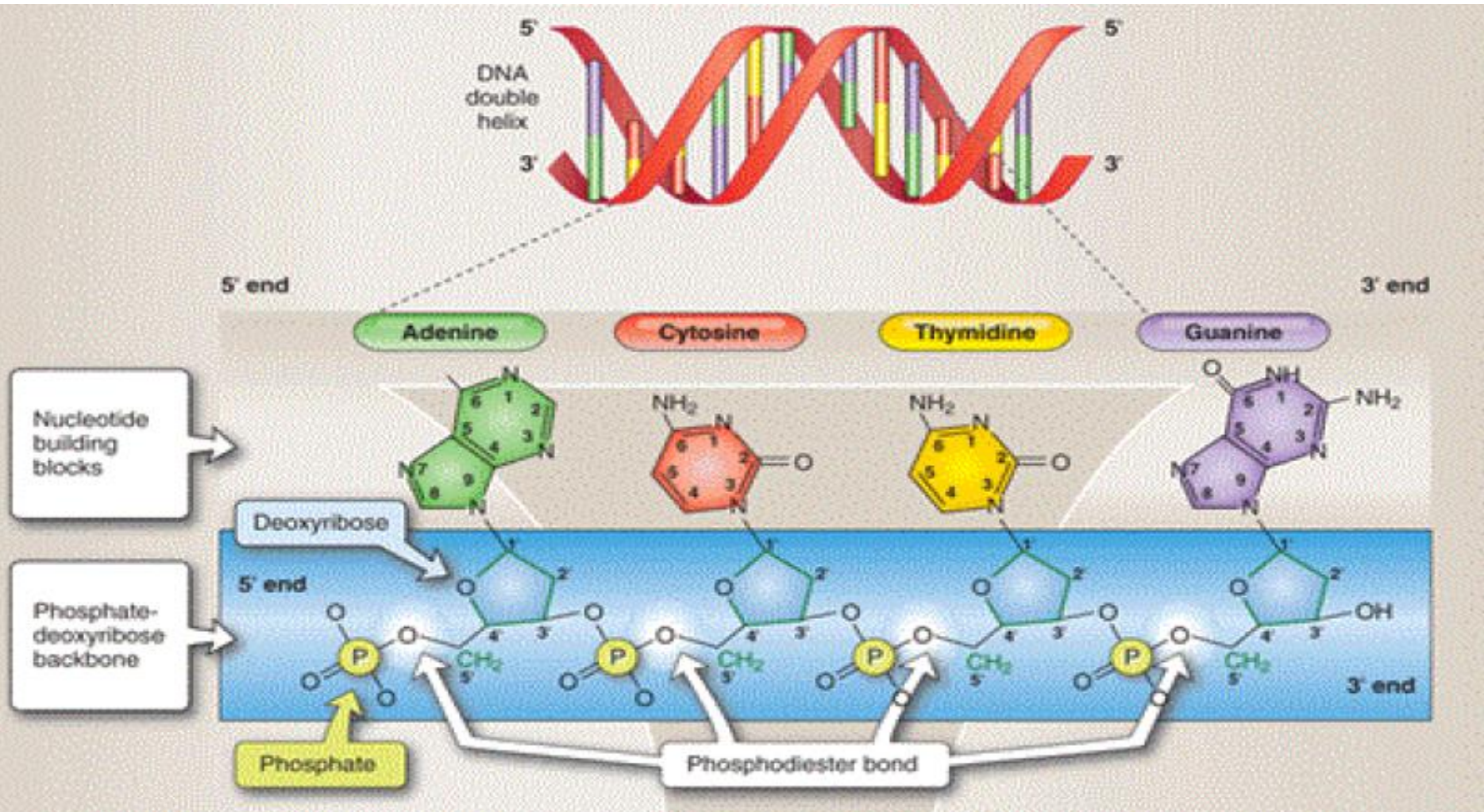
2- The mitochondrial genome

- Found in the mitochondrial matrix
- Around 20,000 bases in a circular chain of DNA
- Multiple copies present in each mitochondri
- Maternally inherited
- Contains 37 genes that encode:
 - 13 proteins-coding genes
 - 22 tRNAs genes and 2 rRNAs genes
- 3% of the genome contains non-coding DNA

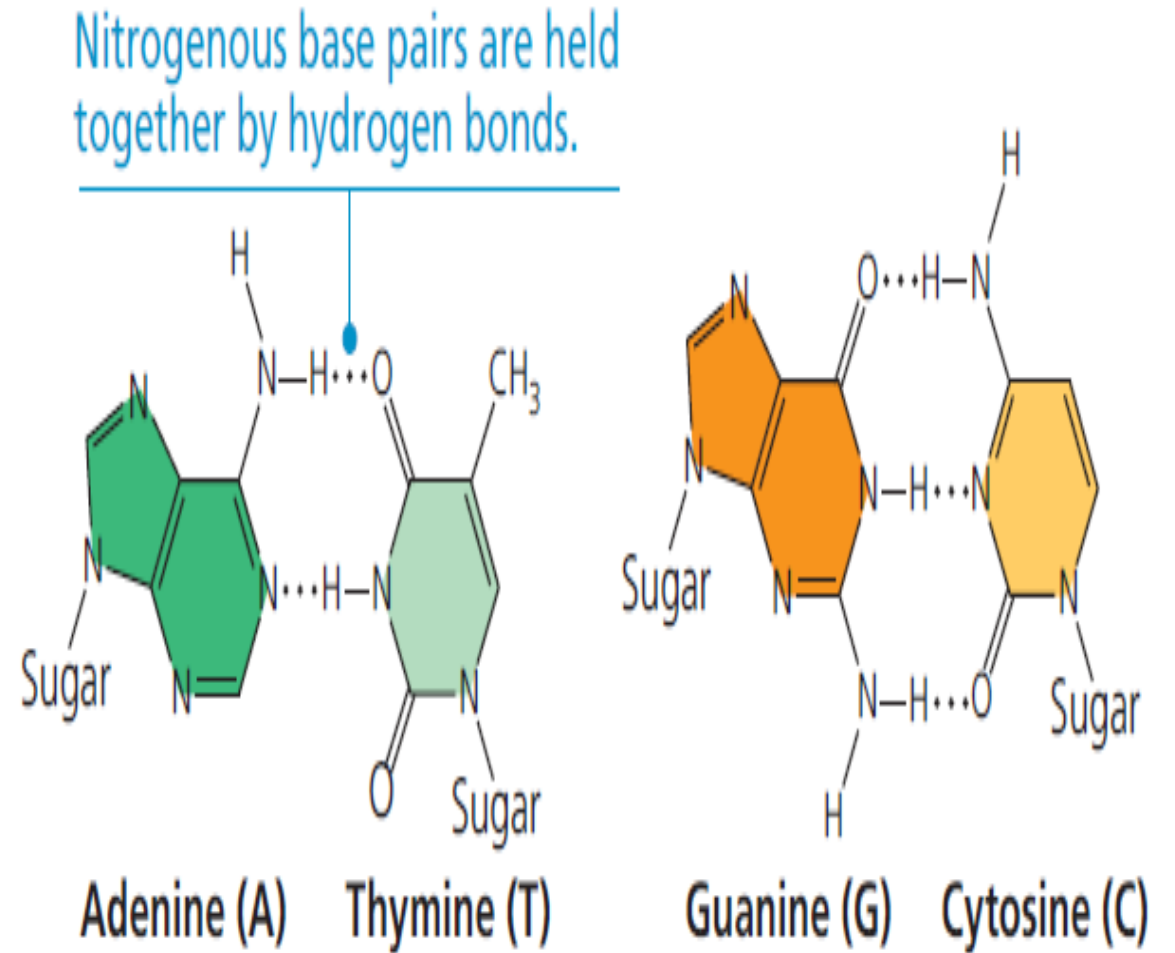


Structure of Nucleic acids

- **Both DNA and RNA** are polymers and composed of nucleotide monomers
- **Nucleotide**: it consists of pentose sugar, phosphate group and nitrogen-containing bases (purine or pyrimidine).
- **DNA Backbone**: it consists of sugars and phosphates
- **Bases** are attached to the sugars and project from the backbone chain
- **Nucleotide monomers** are linked by phosphodiester bond between the **sugar** and the **phosphate**.
- **In DNA** the pentose is deoxyribose, **in RNA** it is ribose



- Nitrogenous base pairs are held together by hydrogen bonds
- **In DNA the four different bases are:**
 - Purines: adenine (A) and guanine (G)
 - Pyrimidines: cytosine (C) and **thymine (T)**
- **In RNA the four bases are:**
 - Purines: adenine and guanine
 - Pyrimidines: cytosine and **uracil (U)**



Complementarity of nucleic acids (Watson-Crick Base Pairs)

- The two strands in the DNA duplex are opposite in chemical polarity, so strands can synthesize only in the 5' end to 3' end direction.
- The two strands are anti-parallel in nature; that is, one strand will have the 3' carbon of the sugar, whereas the other strand will have the 5' carbon
- Bases pair through hydrogen bonds: adenine (A) always pairs with thymine (T), guanine (G) always pairs with cytosine (C).
- for example: 5' AACGTGTT 3' is complementary to 3' TTGCACAA 5'

