**Subject: Molecular Biology**

**Semester: 1 (U E F1)**

**Number of credits: 0.6**

**Subject Coefficient: 3**

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**CHAPTER 1: STRUCTURES OF NUCLEIC ACIDS**

1-1- Structure of Nucleic Acids

- Nucleotides: Structure and Properties

- The Primary Structure of Nucleic Acids

- The Three-Dimensional Structure of DNA:

- Characteristics of the Double Helix

- Intranuclear Compaction and Chromosomes

- The Different Types of RNA: Main Structural and Functional Characteristics.

1-2- Organization of Genes and Genomes

**CHAPTER 2: DNA REPLICATION**

1- DNA Replication in Prokaryotes

2- DNA Replication in Eukaryotes

**CHAPTER 3: MUTATIONS AND DNA REPAIR MECHANISMS**

1- Mutations

- Causes of Mutations

- Mutagenic Agents

- Different Types of Mutations

2- DNA Repair

- Main Repair Systems

**CHAPTER 4: GENE EXPRESSION**

1- TRANSCRIPTION

➢ Gene Structure (in Prokaryotes and Eukaryotic Genes)

➢ Transcription in Prokaryotes

➢ Transcription in Eukaryotes

2- TRANSLATION

➢ The Genetic Code

➢ Stages of Translation in Prokaryotes

➢ Stages of Translation in Eukaryotes

**CHAPTER 5: REGULATION OF GENE EXPRESSION**

1- Regulation of Gene Expression in Prokaryotes

❖ The Lactose Operon

❖ The Tryptophan Operon

2- Regulation of Gene Expression in Eukaryotes

❖ Post-Transcriptional Regulation

❖ Post-Translational Regulation

**CHAPTER 6: Techniques Used in Molecular Biology**

**CHAPTER 1: NUCLEIC ACID STRUCTURES**

1-1- History

1953: Discovery of the double helix (Watson and Crick).

Analysis of X-ray diffraction patterns using DNA crystals.

1953: A model of the genetic code (Gamow).

1956: RNA is discovered.

1958: Demonstration of the semi-conservative model of DNA replication (Meselson and Stahl).

1960: Discovery of messenger RNA (Monod).

1961->1966: Deciphering of the genetic code (Nirenberg and Matthaei) through in vitro protein synthesis from poly-U RNA.

Refining of the "central dogma" of molecular biology.

1965: The lactose operon (Jacob and Monod) Study of the activity of Beta-galactosidase Model

of the regulation of gene expression

**2- Characteristics of Nucleic Acids**

Nucleic acids are of two types: DNA and RNA. DNA, or deoxyribonucleic acid, carries genetic information.

RNAs either carry information so that it can be translated into proteins (messenger RNA), or they play a structural role (ribosomal RNA, transfer RNA, and other small RNAs).

DNA is located in the nucleus, but it is also found in the mitochondria.

RNAs are located in the nucleus and in the cytoplasm (also in the mitochondria). Indeed,

DNA is transcribed into RNA in the nucleus, which is itself translated into proteins in the cytoplasm for messenger RNA.

**3-Structure of Nucleic Acids:**

Nucleic acids are composed of phosphoric acids, pentoses, and nitrogenous bases:

Phosphoric acid is a triacid in which one acid function is dissociated, giving DNA a negative charge, and the other two can form phosphodiester bonds.

Pentoses are cyclic carbohydrates with 5 carbon atoms that exist in the form of β-D-ribofuran and in the "deoxy" form for DNA.

**The bases are of two types:**

**Pyrimidine bases:** cytosine, thymine (DNA), and uracil (RNA).

**Purine bases:** Guanine, adenine, and hypoxanthine (precursor of purine bases and present in tRNAs).

The association of a base and a pentose by an N-glycosidic bond is called a nucleoside.

The association of a nucleoside and phosphoric acid by a phosphodiester bond at the 5' end of the pentose is called a nucleotide.

**4- DNA structure:**

DNA is a double-stranded molecule consisting of two strands directed antiparallel and associated in type B double helices. It is composed of as many purine bases as pyrimidine bases; in fact, there are as many adenine as thymine, and as many guanine as cytosine.

The two strands are linked by hydrogen bonds present between all the bases of DNA: two hydrogen bonds between bases A and T, and three hydrogen bonds between bases G and C. The DNA double helix has a diameter of 20 Å, a pitch of 34 Å, which corresponds to 10 nucleotides.

The DNA double helix: The discovery of the structure of DNA revolutionized the study of biological phenomena by introducing the molecular dimension. Proposed by **Watson and Crick in 1953**, it was derived not only from the interpretation of X-ray diffraction images taken by Franklin, but also from the work of **Erwin Chargaff** (who had shown that for any DNA molecule, the number of adenine molecules is equal to the number of thymine molecules, and that the number of cytosine molecules is equal to the number of guanine molecules) and finally from electron microscopy analyses, which showed that the diameter of the DNA molecule is 20 Å, suggesting that this molecule contains two deoxyribose phosphate chains.

**Physicochemical Properties of DNA**

The hydrogen bonds and hydrophobic interactions that maintain the double helix structure are weak forces, and relatively small amounts of energy can separate the two strands, a process called denaturation.

1- Melting Temperature: If a DNA solution is heated to a certain temperature, the hydrogen bonds that hold the two paired strands together break. This is called DNA melting, characterized by the melting temperature (Tm).

The denaturation and renaturation of DNA strands in solution are critical reconstitutions for various normal biological functions (replication, transcription, etc.).

**Tm** is the temperature required to achieve **50%** separation of the two strands.

Factors influencing Tm

The melting temperature is influenced by several factors:

- C + G %: Tm increases with increasing CG %.

- DNA sequence size.

**- Ultraviolet light absorption:** The absorption properties of purines and pyrimidines in the UV **at 260 nm**, and proteins **at 280 nm**, make it possible to measure nucleic acids (C: concentration), and to estimate protein contamination during nucleic acid purification.

**Solubility:** DNA becomes an acid salt in aqueous media and is therefore soluble. It precipitates

in the presence of ethanol and a high salt concentration. This property allows for its purification.

**DNA shapes:**

Circular DNA is found in bacteria and some viruses. This DNA is often double-stranded. In eukaryotes, the wrapping of DNA around histone proteins and its organization contribute to the circularization of DNA in these organisms (DNA circularity can therefore be considered a universal fact and an essential attribute of active DNA).

**Topoisomers:** Two DNAs with exactly the same number of nucleotides and the same base sequence, but differing in the twisting number L (the number of turns one strand makes around the other strand) are called topoisomers.

- **The relaxed state**: the tension on the double helix is ​​minimal.

**- The supercoiled state**: the axis of the double helix can wrap around itself, forming a superhelix. Two forms of supercoiling are theoretically possible:

**• Positive supercoiling**: the twisting number has been increased

• **Negative supercoiling:** the twisting number has been decreased.