MICROBIAL GENETICS
Introduction

• **Genetics:** is the science concerned with the cell characteristics, and how they are passed from one generation to the next.
**Gene:** it is the unit of heredity.

- It is a segment of DNA that carries, in its nucleotide sequence, information for specific biochemical or physiologic property.

**Phenotype:** All the heritable physical characters of the organism (Eye colour in humans, resistance to antibiotic in bacteria ...... etc.)

**Genotype:** It means the information in the DNA that control the phenotype.
Compartments of microbial genetics curriculum

- Basic Genetics
- Genetic variation and gene rearrangements.
- Advanced genetics
Basic genetics
Molecules of Genetics

• The main molecules of genetics are called **nucleic acids**.

• All the genetic information are stored as a sequence of bases through nucleic acids mainly in **DNA** and in **RNA** in some RNA viruses.
DNA (Deoxyribonucleic acid) serves as organism’s genetic material. It is divided into functional units (genes). Most of DNA is double stranded. The two strands held together by hydrogen bonds between A and T or G and C. It consists of non-identical, complementary base sequences.
The basic structure of DNA molecules is the **Nucleotide**.
**Sugar:** It is a cyclic form of 2-deoxyribose sugar that forms the backbone of the DNA.
3. Nitrogenous Bases

cyclic structure of purine and pyrimidine rings.

There are two major purines, adenine (A) and guanine (G),

• Three major pyrimidines, cytosine (C), uracil (U), and thymine (T).
Sugar backbone bones are linked to each other by phosphodiester bonds, i.e., a single phosphate connected by ester linkage to two sugars; DNA consists of alternating units of phosphate and 2 deoxy ribose.
phosphate connects two sugars: bonding the 3' carbon of one sugar and the 5' carbon of the next sugar.

DNA is only polymerized 5' to 3' and as antiparallel

i.e. one strand in the direction 5' to 3' and the other strand polymerized in the opposite direction.
Prokaryotic DNA molecules are double helix and circular. This circular double stranded DNA molecules are twisted and compacted through a process called super coiling "super helicity" this is done naturally by topoisomerase enzymes.
RNA (Ribonucleic acid)

Structurally similar to DNA except:
- Most of RNAs are single stranded.
- Sugar is ribose instead of deoxyribose.
- Uracil base instead of thymine base.
Functionally different from DNA

- Some of RNAs are used as messenger molecules (mRNA) to transfer information from DNA to protein.
- Some of RNA as a part of ribosomes (rRNA).
- Some are adaptor molecules (tRNA).
- Few RNA only acts as a genetic material like DNA (the viruses).
**GENOME**
It is the total genetic information in an organism.

**Prokaryotic genome (Bacterial):**

consist of a **single copy (Haploid) circular** DNA molecule.

Range from 580-4600 Kbp

Many bacteria contain extra chromosomal DNA materials as apart of genome called **plasmid** and **transposons**.
Eukaryotic genome (e.g. Some fungi):

- carried on two or more **linear chromosomes** separated from the cytoplasm by nuclear membrane.
- **Diploid eukaryotic** cells contain two homologues copies of each chromosome.
- Eukaryotic cells contain **mitochondria and chloroplast**.
- Some eukaryotes like yeasts contains plasmids.
- Eukaryotic genes unlike prokaryotes are interrupted by **introns**.
Viral genome :-

- Unlike others, may be of DNA or RNA.
- Capable of survival but no growth in absence of a host cell.
- Replication of viral genomes depends on the metabolic energy and the synthetic machinery of the host cell.
- Most viral genomes range in size from 40-300 Kbp.
DNA Functions in microbiology

I- Replication

II- Gene expression (protein synthesis)

A. Transcription

B. Translation

C. post-translational processes
The original DNA model by Watson and Crick.

X-ray diffraction photo of a DNA molecule,
DNA Replication

Semi conservative which means that one DNA molecule gives two DNA molecules each one consists of one strand from the original DNA and the other strand is newly formed one.
Replication starts at a fixed point called origin of replication (ori C) and terminated at fixed point called (Ter) point.
Steps of replication
1. The two old strands of DNA are separated by **helicase** enzyme to form the replication fork.
2. Replication of one strand template in 5' to 3' direction can proceed in a continuous fashion starting by addition of short segment of small RNA at the starting point called **primer**.
On this primer, DNA polymerase enzyme start to synthesize the new strand in a continuous manner from 5' to 3'; this is called the leading strand.
3. Replication of the other template strand can only proceed discontinuously. This strand is called the **lagging strand**, many primers (RNA primers) are used to synthesize the lagging new strand as fragments called **Okazaki fragments**.
4. Then all the RNA Primers are removed by DNA polymerase 1 and the gaps are sealed by DNA ligase to make a continuous DNA strand.
5. After formation of the two strands of DNA the old one and the new one, DNA gyrase Enzyme (Topoisomerase II) make twist and super helicity of each DNA molecules.
Enzymes of replication:

- Helicase enzyme
- RNA polymerase
- DNA polymerase
- DNA ligase
- DNA gyrase (topoisomerase II)
GENE EXPRESSION
(PROTEIN SYNTHESIS)
The mechanism by which the sequence of nucleotides in a gene determines the sequence of amino acids in a protein occurs in the following steps:

1. Transcription
2. Translation
3. Post–translational modification
Transcription :-

- the process by which a ssRNA is formed by RNA-polymerase using DNA as a template, this RNA is called mRNA.

- mRNA has a nucleotide sequence complementary to the template strand in the DNA.
The sequence of events occurs as follows
Each gene along the DNA is bounded by promoter and termination sites

1- **Promoter recognition**
(area at DNA recognized by RNA polymerase before the gene to be transcribed on which RNA – polymerase becomes attached).
2- **Chain initiation** in which recognition protein called **sigma factor** (σ) attaches to RNA polymerase to put it at the correct site of the first nucleotide to be transcribed.
3- Chain elongation in which RNA polymerase synthesizes the whole length of mRNA by polymerizing the complementary bases in the 5'-3' direction (note: RNA polymerase does not need primer to start unlike DNA polymerase).
Chain elongation

σ dissociates

5'

Growing RNA transcript
4- **Chain termination**, RNA polymerase continues until a transcription termination signal or terminator where the polymerase and newly synthesized RNA dissociate from the DNA to end the transcription.