Microbial Genetics

Definitions:

- **Molecular biology** is the study of **biology** at a **molecular** level. It concerns with the interactions between the various systems of a cell, including the interrelationship of DNA, RNA and protein synthesis and learning how these interactions are regulated.

-**Molecular genetics** is the field of **biology** which studies the structure and function of **genes** at a **molecular** level.

-The science of **genetics** defines constancy and change in the vast array of physiological functions that form the properties of organisms.

-**Gene** is the unit of heredity**,** a segment of DNA that carries in its nucleotide sequence information for a specific biochemical or physiological property.

-**Genome** is the genetic information of the cell. Genome is composed of chromosomes containing genes.

-**Plasmids** were identified as small genetic elements capable of independent replication in bacteria and yeasts.

-**Genetic engineering** is technology that has been responsible for tremendous advances in the field of medicine.

-**Phenotype** is the collective structural and physiological properties of a cell or an organism. Ex. eye color in a human or resistance to an antibiotic in a bacterium.

-The chemical basis for variation in phenotype is change in **genotype,** or alteration in the sequence of DNA within a gene or in the organization of genes.

Organization of Genes

The Structure of DNA & RNA

-Genetic information is stored as a sequence of bases in **deoxyribonucleic acid (DNA),** some RNA viruses [eg, influenza], genetic information is stored as a sequence of bases in **ribonucleic acid (RNA).**

-Most DNA molecules are **double-stranded, with complementary bases** (A-T; G-C) paired by hydrogen bonding in the center of the molecule.

-The orientation of the two DNA strands is described as **antiparallel**; one strand is chemically oriented in a 5' to 3' direction, while its complementary strand runs 3' to 5'. The complementarity of the bases enables one strand **(template strand)** to provide the information for copying or expression of information in the other strand (**coding strand**).

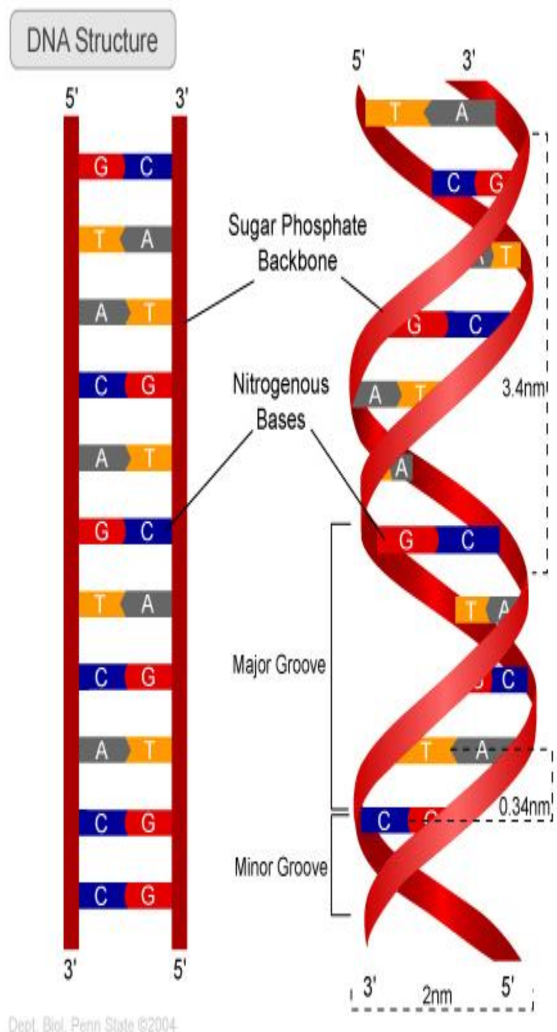
-The **base pairs** are stacked within the center of the DNA double helix and they determine its genetic information. Each helical turn of the helix has one **major groove and one minor groove.**

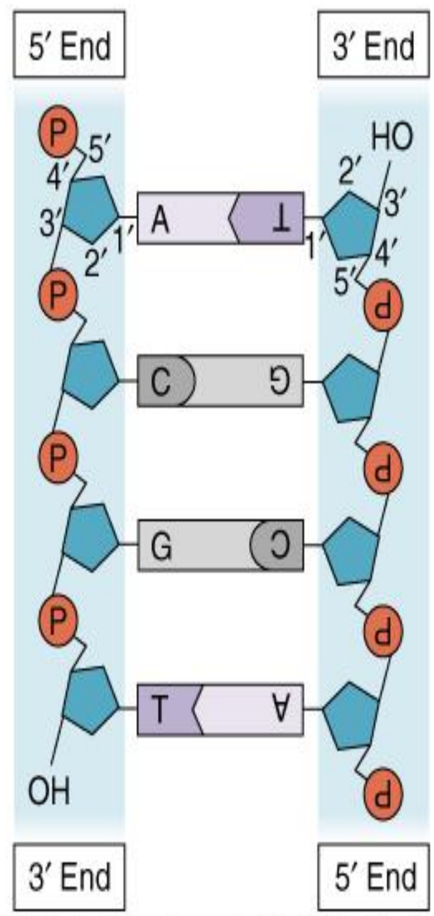
-A small virus may contain a single DNA molecule of 5 kbp, whereas the single DNA molecule that forms the *Escherichia coli* chromosome is 4639 kbp. The total length of the *E coli* chromosome is roughly 1 mm. Since the overall dimensions of the bacterial cell are roughly 1000-fold smaller than this length, it is evident that a substantial amount of folding, or **supercoiling.**

In the 1950's, **Watson & Crick** built the first model of DNA:-

- Two strands coiled called a **double helix**.
- Sides made of a pentose sugar Deoxyribose bonded to phosphate (PO_4) groups by **phosphodiester bonds**.
- Center made of nitrogen bases bonded together by weak hydrogen bonds.
- 5' end-means P comes off 5' carbon of deoxyribose sugar
  3'means P comes of 3' end of deoxyribose sugar
- The length of a DNA molecule is usually expressed in thousands of base pairs, or kilobase pairs (kbp).

- Made up of subunits called nucleotides which made of: phosphate group, 5-carbon sugar and nitrogenous base: double ring purines Adenine (A) Guanine (G and single ring pyrimidines Thymine (T) Cytosine (C)
  Purine only pair with Pyrimidine
  Three hydrogen bonds required to bond Guanine & Cytosine
  Two hydrogen bonds are required to bond Adenine & Thymine





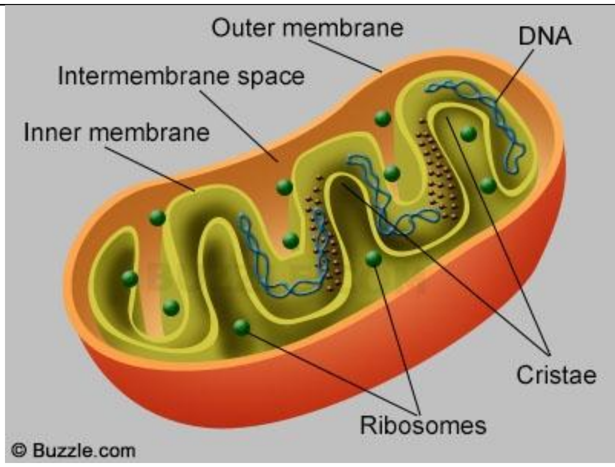
Ribonucleic acid (RNA) most frequently occurs in **single-stranded form**. The base **uracil** (U) serves in RNA the hybridization function that thymine (T) serves in DNA, so the complementary bases that determine the structure of RNA are A-U and C-G. **RNA Functions**: three major RNAs:-

mRNA (messenger RNA): DNA transcript.

tRNA (transfer RNA): transfer amino acid during protein synthesis.

rRNA (ribosomal RNA): make up ribosomes.

Eukaryotic Genome	**Prokaryotic Genome**
genome is carried on two or more **linear chromosomes** separated from the cytoplasm within the membrane of the nucleus	genome consist of a **single circular DNA molecule. Membranes do not separate** bacterial genes from cytoplasm
Diploid eukaryotic cells contain two **homologues** of each chromosome	bacterial genes are **haploid**
Mutations, or genetic changes, frequently cannot be detected in diploid cells because the contribution of one gene copy compensates for changes in the function of its homologue.	The effects of mutations can be most readily discerned in **haploid** cells, which carry only a single copy of most genes.
A gene that does not achieve phenotypic expression in the presence of its homologue is **recessive**, whereas a gene that overrides the effect of its homologue is **dominant**.	absent
Eukaryotic cells contain **mitochondria** and, in some cases, chloroplasts. Within each of these organelles is a circular molecule of DNA	absent

	
absent	**Many bacteria** contain additional genes on **plasmids**
absent	**Some bacterial species** can invade higher organisms because they possess specific genes for pathogenic determinants. These genes are referred to as **pathogenicity islands.**
absent	**Transposons** are genetic elements that contain several kbp of DNA

The Viral Genome

1-Viruses are capable of survival, **but not growth**, in the absence of a cell host. Replication of the viral genome depends upon the metabolic energy and the macromolecular synthetic machinery of the host.

2- successful propagation of the virus requires **(1) a stable form** that allows the virus to survive in the absence of its host, **(2) a mechanism** for invasion of a host cell, **(3) genetic information** required for replication of the viral components within the cell, and **(4) additional information** that may be required for packaging the viral components and liberating the resulting virus from the host cell.

3-Distinctions are frequently made between viruses associated with eukaryotes and viruses associated with prokaryotes, the latter being termed **bacteriophage.**

4-The nucleic acid molecule of bacteriophages is surrounded by a protein coat. Some phages also contain lipid. Many phages contain **double-stranded DNA**; others contain **double-stranded RNA**, **single-stranded RNA**, or **single stranded-DNA**.

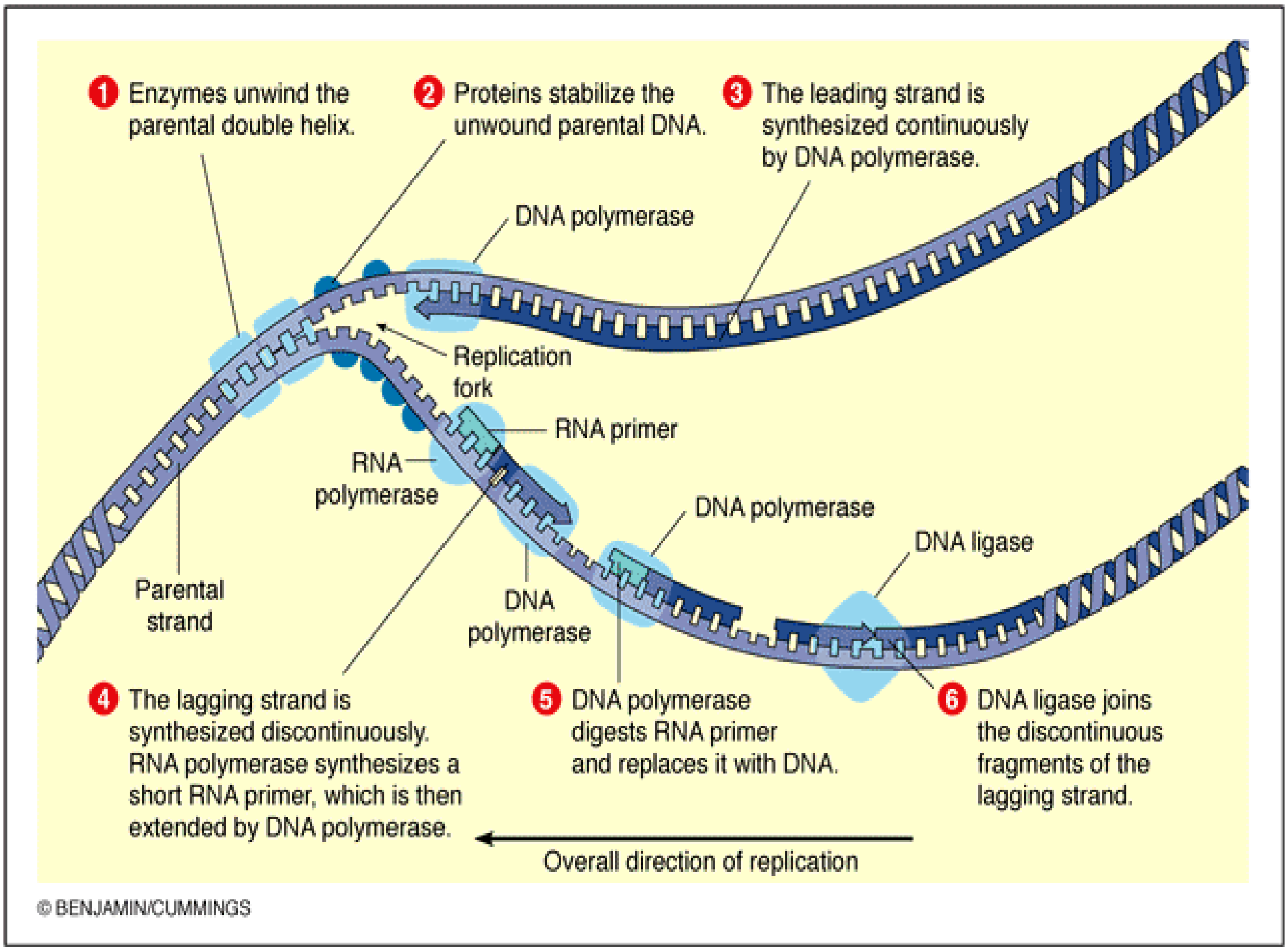
Replication

- DNA has to be copied **before a cell divides**
- DNA is copied during the **S or synthesis phase of interphase**

Semiconservative Model of Replication

- Idea presented by Watson & Crick

  The two strands of the parental molecule separate, and each acts as a template for a new complementary strand. New DNA consists of 1 parental (original) and 1 new strand of DNA.



Eukaryotic DNA	Bacterial DNA
replication of DNA begins at **several points** along the linear chromosome	replication of DNA begins at **one point** and moves in both directions
Telomeres specialized DNA sequences (carried on the ends of eukaryotic chromosomes) that seem to be associated with accurate replication of chromosome ends	absent
eukaryotes have evolved specialized machinery, called a **spindle** that pulls daughter chromosomes into separate nuclei newly formed by the process of **mitosis**	absent
more extensive division of nuclei by **meiosis** halves the chromosomal number of diploid cells to form haploid cells. Frequently, the haploid cells are **gametes**. Formation of gametes followed by their fusion to form diploid **zygotes** is the primary source of genetic variability via recombination in eukaryotes	The replication of circular double-stranded bacterial DNA begins at the *ori* locus and involves interactions with several proteins. The **origin** (*ori*) and **termination sites** (*ter*) for replication are located at opposite points on the circular DNA chromosome. The two daughter chromosomes are separated before cell division, so that each progeny gets one of the daughter DNAs
	Restriction enzymes provide bacteria with a mechanism to distinguish between their own DNA and DNA from other biologic sources. In this specificity of sequence recognition lies the selectivity of DNA fragment preparation that is the foundation of much genetic engineering