Microbial genetics

Chromosomes are cellular structures made up of genes that carry hereditary information. A gene is not just a segment of DNA, a gene is a specific sequence of nucleotides that codes for a functional product, usually a protein. All the genetic information in a cell is the genome.

Most prokaryotic genes are carried on the bacterial chromosome. And with few exceptions, bacterial genes are haploid. Genome sequence data from more than 340 microbial genomes demonstrate that most prokaryotic genomes (>90%) consist of a single circular DNA molecule containing from 580 kbp to more than 5220 kbp of DNA .

Usually bacteria have only one chromosome (while yeast have 7 , humans 46), but some bacteria (e.g, *Brucella melitensis*, and *Vibrio cholerae*) have genomes consisting of two circular DNA molecules. DNA in chromosomes is in the form of one, long double helix associated with many of proteins that regulate the activity of genes. In prokaryotes, DNA of bacteria is circular and it is not found within a nuclear membrane.

In a prokaryotic cell, the nucleoid (meaning nucleus-like) is an irregularly shaped area that contains all or most of the genetic material; unlike the nucleus of a eukaryotic cell, it is not encased in a nuclear membrane.

Prokaryotic organisms often have circular, double-stranded DNA in their genomes. Approximately 60% of the nucleoid is made up of DNA, with trace amounts of RNA and protein.

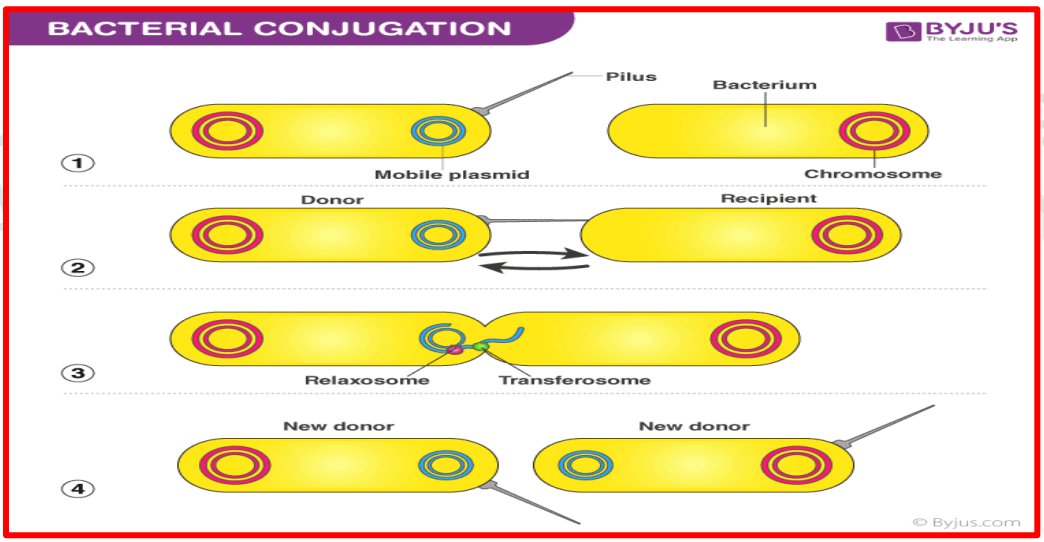
Additional genes are found in many bacteria on plasmids that vary in size from a few to 100 kbp. 98% of bacterial genomes are coding sequences, as opposed to eukaryotic genomes. Replicons, also known as episomes, are covalently closed DNA circles that store genetic information required for their own replication. These circles include bacterial chromosomes and plasmids.

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

Mechanics of Gene transfer between bacterial cells

Conjugation

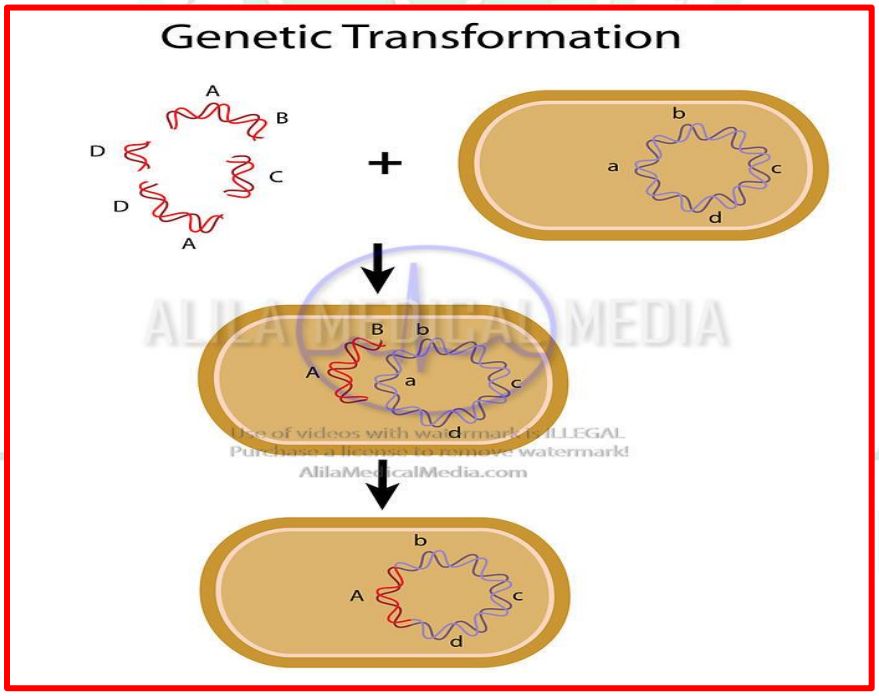
Conjugation is the process by which a **donor** bacterium transfers a copy of a plasmid to a **recipient** bacterium, through a **pilus**. The process requires cell-to-cell contact. The donor cell (**F+**) has a **conjugative plasmid**, an extrachromosomal piece of dsDNA that codes for the proteins necessary to make a threadlike filament known as a pilus. The pilus is used to bind to the recipient (**F-**) cell, bringing it in close proximity to the donor cell. It is believed that a channel is then opened between the two cells, allowing for a ssDNA copy of the plasmid to enter the recipient cells. Both cells then make the complementary copy to the ssDNA, resulting in two F+ cells capable of conjugation.



Transformation

The process of **transformation** also allows a bacterial cell to acquire new genes, but it does not require cell-to-cell contact. In this process the new genes are acquired directly from the environment. Typically the process requires a donor cell that at some point lysed and released **naked DNA** to the environment. The recipient cell is one that is capable of taking up the DNA from the environment and incorporating it into its own genome, where the cell is described as being **competent**.

The process typically occurs at the end of exponential phase of growth or beginning of the stationary phase, in the presence of high cell density and limited nutrients.



Transduction

Transduction involves the use of a virus, a bacteriophage, to act as a conduit for shuttling bacteria genes from one cell to another, thus negating the necessity for cell-to-cell contact. There are two different types of transduction: **generalized transduction** and **specialized transduction**.

Generalized transduction

In generalized transduction, a bacterial host cell is infected with either a virulent or a temperate bacteriophage engaging in the **lytic cycle** of replication. After the first three steps of replication (absorption, penetration, and synthesis), the virus enters into the assembly stage, during which fully formed virions are made. During this stage, random pieces of bacterial DNA are mistakenly packaged into a phage head, resulting in the production of a **transducing particle**. While these particles are not capable of infecting a cell in the conventional sense, they can bind to a new bacterial host cell and inject their DNA inside. If the DNA (from the first bacterial host cell) is incorporated into the recipient's chromosome, the genes can be expressed.

Specialized transduction

Specialized transduction can only occur with temperate bacteriophage, since it involves the **lysogenic cycle** of replication. The bacteriophage randomly attaches to a bacterial host cell, injecting viral DNA inside. The DNA integrates into the chromosome of the host cell, forming a prophage. At some point induction occurs, where the prophage is excised from the bacterial chromosome. In specialized transduction, the excision is incorrectly performed and a portion of bacterial genes immediately adjacent to the viral genes are excised too. Since this DNA is used as

the template for the synthesis stage, all copies will be a hybrid of viral and bacterial DNA, and all resulting virions will contain both viral and bacterial DNA.

Once the cell is lysed, the virions are released to infect other bacterial host cells. Each virion will attach to the host cell and inject in the DNA hybrid, which could be incorporated into the host chromosome, if a prophage is formed. At this point the second bacterial host cell can contain its own DNA, DNA from the previous bacterial host cell, and viral DNA.