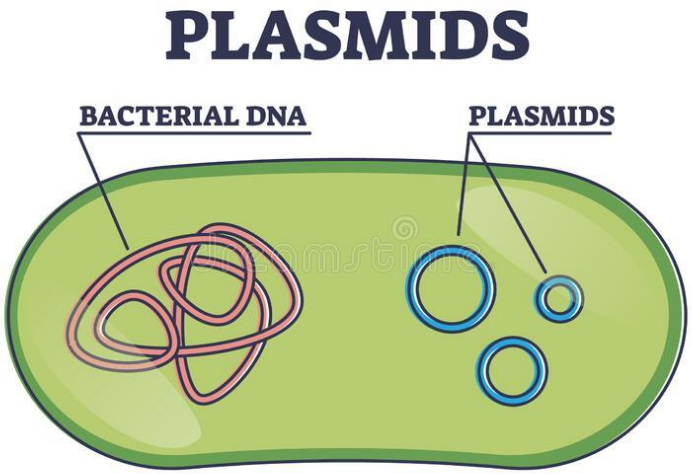
Plasmids

Microbiology VI

Plasmids

- The term plasmid was first introduced by the American molecular biologist **Joshua Lederberg** in 1952 to refer to "any extra-chromosomal hereditary determinant.".
- Like other organisms, bacteria use double-stranded DNA as their genetic material.
- However, bacteria organize their DNA differently than more complex organisms.
- In addition to the chromosome, bacteria often contain plasmids that are **extra – chromosomal hereditary** material.



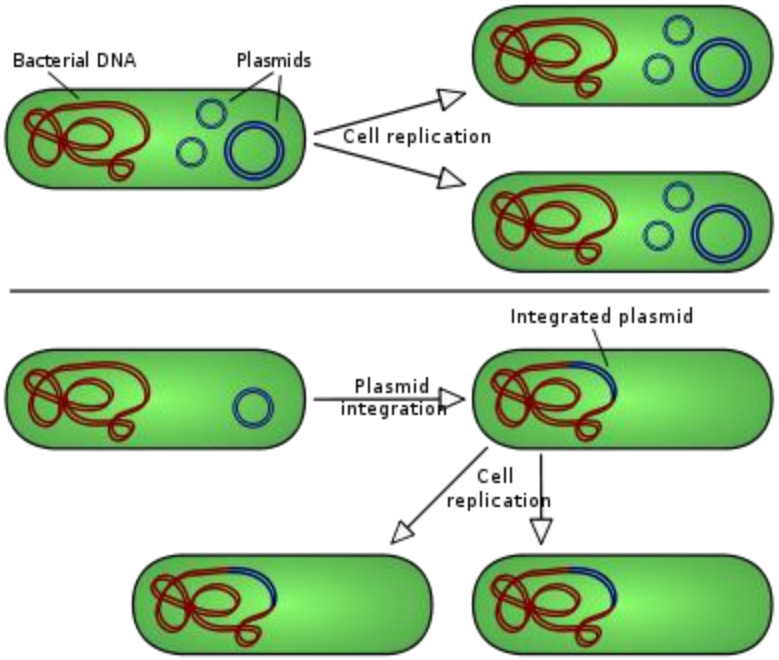
Properties of plasmids:

- **Plasmids:** are small double-stranded DNA molecules, usually circular that can exist independently of host chromosomes and are present in many bacteria
- They are also present in some yeasts and other fungi.

- They have their own **replication origins** and are autonomously replicating and stably inherited.

- Plasmids can be integrated into the chromosomal DNA.

- **Episomes**: are plasmids that are integrated into the chromosomal DNA.



- Plasmids are considered as replicons.
- **Replicon** is a DNA molecule or sequence that has a replication origin and is capable of being replicated.
- Plasmids and bacterial chromosomes are separate replicons.
- Plasmids have relatively few genes, generally less than 30.
- Their genetic information is not essential to the host, and bacteria that lack them usually function normally.

Classification of Plasmids

Plasmids may be classified in a number of ways.

- Types of plasmids based on **function**:
  - Fertility Plasmids
  - Resistance Plasmids
  - Col Plasmids
  - Degradative plasmids
  - Virulence plasmids

1. **Fertility Plasmids (F plasmid):** Carry the fertility genes (tra-genes) for conjugation, the transfer of genetic information between two cells.

2. **Resistance Plasmids (R plasmid):** Contain genes that can build resistance to antibiotics or poisons.

3. **Col Plasmids:** Contain genes that encode for the antibacterial polypeptides called **bacteriocins**, a protein that kills other strains of bacteria.

   Ex. The col proteins of *E. coli.*

4. **Degradative plasmids:** which enable the digestion of unusual substances.

   Ex. toluene and salicylic acid.

5. **Virulence plasmids:** which turn the bacterium into a pathogen.

   Ex. Ti plasmid in *Agrobacterium tumefaciens*

- Types of plasmids by their ability to **transfer** to other bacteria:
  - Conjugative plasmids
  - Non-conjugative plasmids

1. Conjugative plasmids:

Contain transfer genes necessary for non-sexual transfer of genetic material, which perform the complex process of conjugation, the transfer of plasmids to another bacterium.

Ex. **F** and **F' plasmids**.

2. Non-conjugative plasmids:

These plasmids are incapable of initiating conjugation hence they can only be transferred with the assistance of conjugative plasmids.

3. Intermediate classes of plasmids:

- Are also called mobilizable plasmids, and carry only a subset of the genes required for transfer.

- They can parasitize a conjugative plasmid, transferring at high frequency only in its presence.

- Plasmids are now being used to manipulate DNA and may possibly be a tool for curing many diseases.

- Plasmids can also be classified based on copy number:
  - Stringent plasmid
  - Relaxed plasmid

Stringent plasmid:

- It replicates only along with the main bacterial chromosome.
- It is present as a single copy, or at most several copies per cell.

Relaxed plasmid:

- It replicates within a cell independently of the chromosomal DNA replication.
- Thus multiple copies of plasmids are present

Plasmids can also be classified into **incompatibility** groups:

- Compatible type
- Incompatible type

- **Compatible type**: A microbe can harbour different types of plasmids, but different plasmids can only exist in a single bacterial cell if they are **compatible**.
- If two plasmids are not compatible, one or the other will be rapidly lost from the cell.

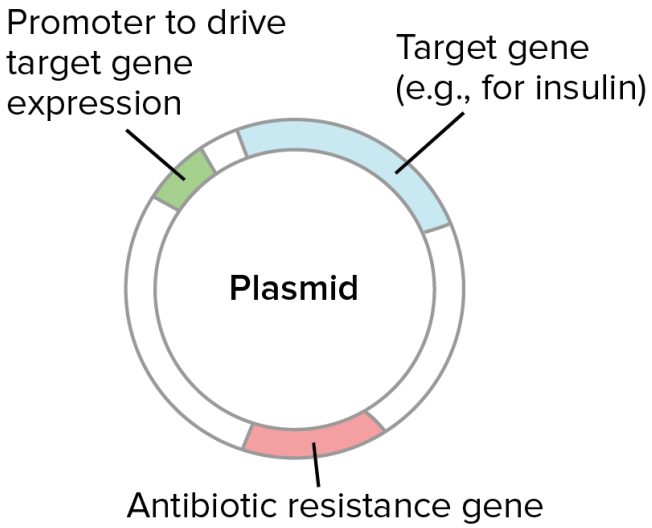
- Different plasmids may therefore be assigned to different incompatibility groups depending on whether they can **coexist** together.

- **Incompatible plasmids** normally share the same replication or partition mechanisms and can thus not be kept together in a single cell.

Application of plasmids as vectors

- Artificially constructed plasmids may be used as vectors in genetic engineering.
- These plasmids serve as important tools in genetics and biotechnology labs, where they are commonly used to clone and amplify (make many copies of) or express particular genes.
- A wide variety of plasmids are commercially available for such uses.
- The gene to be replicated is normally inserted into a plasmid that typically contains a number of features for their use.
- These include a gene that confers resistance to particular antibiotics (ampicillin is most frequently used for bacterial strains), an origin of replication to allow the bacterial cells to replicate the plasmid DNA, and a suitable site for cloning.

Artificially constructed plasmid – used as vectors in genetic engineering



Applications of plasmids

1. **Medical uses:**

   Plasmid contains some genes advantages to the bacterial host by genetic engineering.

- **Plasmids can code for antibiotics**:

  Some bacteria become immune to antibiotics because they have plasmids that make them immune. They can also give their plasmids to other bacteria through transformation.

- Ex. Plasmids for Antibiotic Resistance:
  - Kanamyicin resistance
  - Chloramphenicol resistance
  - B-galactosidase resistance
  - Gentamycin resistance

- **Production of antibiotics**:
  - Ampicillin
  - Tetracycline
  - Kanamycine
  - Bleomycin
  - Hygromycin B
  - Chloramphenicol

- Degradation of complex organic compounds.
- Production of insulin
- Production of colchicines.

2. Agricultural uses:

- Herbicide resistant plants
- Pesticide resistant plants
- Virus resistant plants
- Stress resistant plants
- Improvement of crops quality

3. Transgenic animals.
4. Production of industrial & GMO foods.
5. DNA technology in bioconservation.
6. Recombinant DNA technology.
7. Cloning vectors.

Application of Plasmids