Microbial Genetics

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Microbial Genetics علم وراثة الأحياء المجهرية

Microbial Genetics: Is a subject area within microbiology and genetic engineering. It studies the genetics of microorganism. This involves the study of genotype of microbial species and the expression system in the form phenotype. It also involve the study of genetic processes taking place in these microorganism i.e. recombination, mutation etc. The science of genetics defines and analyzes heredity of the vast array of structural and physiologic functions that form the properties of organisms. Gene, a segment of deoxyribonucleic acid (DNA) that encodes in its nucleotide sequence information for a specific physiologic property.(structural and physiologic properties of an organism . **Yeast cells** (which are eukaryotic) are frequently investigated because they can be maintained and analyzed in the haploid state. Many yeast contain an additional **genetic element**, an independently replicating 2-µm circle containing about 6.3 kbp of DNA. Such small circles of DNA, termed **plasmids** or **episomes**, are frequently associated with prokaryotes.

The Prokaryotic 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 . A few bacteria (e.g, ***Brucella melitensis*, and *Vibrio cholerae***) have genomes consisting **of two circular DNA molecules**.
- Many bacteria contain **additional genes** on **plasmids** that range in size from several to 100 kbp. In contrast to eukaryotic genomes, **98% of bacterial genomes are coding sequences. Covalently closed DNA circles (bacterial chromosomes and plasmids**), which contain genetic information necessary for their own replication, are called **replicons** or **episomes**.
- Because prokaryotes do not contain a **nucleus**, a membrane does not separate bacterial genes from cytoplasm as in eukaryotes. Some **bacterial species** are efficient at causing disease in higher organisms because they possess specific **genes for pathogenic determinants.** These genes are often clustered together in the DNA and are referred to as **Pathogenicity islands**.
- **Pathogenicity islands**. **gene segments** can be quite large (**up to 200 kbp**) and encode a collection of **virulence genes**. **Pathogenicity islands (1)** have a different G + C content from the rest of the genome; **(2)** are closely linked on the chromosome to tRNA genes; **(3)** are flanked by direct repeats; and **(4)** contain diverse genes important for pathogenesis, including antibiotic resistance, adhesins, invasins, and exotoxins, as well as genes that can be involved in genetic mobilization.
- **Genes essential for bacterial** growth (often referred to as "**housekeeping genes")** can be carried on the **chromosome** or may be found on **plasmids** that carry genes associated with **specialized functions** . **Many plasmids** also encode genetic sequences that mediate their transfer from one organism to another (e.g, those involved with **sex pili**) as well as others associated with genetic acquisition or rearrangement of DNA (e.g, **transposase**).
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Plasmids

- **Plasmids** were identified as **small genetic elements** carrying genes and capable of independent replication in **bacteria and yeasts**. The introduction of a **DNA restriction** fragment into a plasmid allows the DNA fragment to be amplified many times. Amplification of specific regions of DNA also can be achieved with bacterial enzymes using **polymerase chain reaction** (**PCR**) or other enzyme-based method of **nucleic acid amplification**
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- **Antibiotic resistance** :
- The most widely studied plasmid-borne characteristic is that of drug resistance. Many bacteria can become resistant to antibiotics by acquisition of a plasmid, although plasmid-borne resistance to some drugs such as **nalidixic acid** and **rifampicin** does not seem to occur. (In those cases, resistance usually occurs by mutation of the gene that codes for the target protein).
- The antibiotic resistance genes themselves are many and varied, ranging from plasmid-encoded **beta lactamases**, which destroy **penicillins** to membrane proteins which reduce the intracellular accumulation of tetracycline.

- **Colicins and bacteriocins:**
- Another property conferred by some plasmids that has been widely studied is the ability to produce a protein, which has an antimicrobial action, usually against only closely related organisms.
- One group of such proteins, produced by strains of *E. coli*, are capable of killing other *E. coli* strains, and are hence referred to as **colicins**, and the strains that produce them are **colicinogenic**.
- The **colicin gene** is carried on a plasmid (known as a Col plasmid), together with a second gene that confers immunity to the action of the colicin, thus protecting the cell against the lethal effects of its own product.

- **Virulence determinants:**
- In some bacterial species toxin genes are carried on plasmids rather than phages. For example, some strains of *E. coli* are capable of causing a disease that resembles cholera (although milder). These strains produce a toxin known as LT (labile toxin – to distinguish it from a different, heat-

stable, toxin known as ST). The LT toxin is closely related to the cholera toxin, but whereas the gene in V.

- **Plasmids in plant-associated bacteria**
- A different type of pathogenicity is seen with the plant pathogen Agrobacterium tumefaciens, which causes a **tumour-like** growth known as a crown gall in some plants. Again, it is only strains that carry a particular type of plasmid (known as a Ti plasmid, for Tumour Inducing) that are pathogenic; in this case however, pathogenicity is associated with the transfer of a specific part of the plasmid DNA itself into the plant cells. This phenomenon has additional importance because of its application to the genetic manipulation of plant cells .

- **Metabolic activities**
- Plasmids are capable of **expanding** the host cell's range of metabolic activities in a variety of other ways. For example, a plasmid that carries genes for the fermentation of lactose.

- **Molecular properties of plasmids**
- **Bacterial plasmids** in general exist within the cell as circular DNA molecules with a very compact conformation, due to supercoiling of the DNA.
- In many cases, they are quite small molecules, just a few kilobases in length, but in some organisms, notably members of the genus ***Pseudomonas***, plasmids up to several **hundred kilobases** are common.
- In *E. coli* as consisting of **two types**. The **first group**, of which **ColE1** is the prototype, are relatively small (usually less than **10 kb**), and are present in **multiple copies** within the cell. Their replication is **not linked** to the processes of chromosomal **replication and cell division** (hence the high copy number).
- The **second group of plasmids**, exemplified by the **F plasmid**, are larger (typically greater than **30 kb**; F itself is about 100 kb) and are present in only **one or two copies per cell**.. It follows therefore that plasmids of this type **cannot be amplified**.
- ColE1, for example, is **6.4 kb in** size. If there are 30 copies per cell, this represents about 4 per cent of the total DNA of the cell.
- The **F plasmid** on the other hand (c. 100 kb), if it were to be present at a similar copy number, would add nearly 70 per cent to the total DNA content which would inevitably make the cell grow much more slowly

and any cells that had lost the plasmid would have a marked selective advantage. But the information required to establish conjugation in E. coli is quite extensive. With the F plasmid, for example about 30 kb (out of 100 kb) consists of genes required for plasmid transfer.

- **Plasmid replication and control**

Many plasmids are **replicated as double stranded circular molecules.** The overall picture with such plasmids is basically similar to that of the chromosome, I n that replication starts at a **fixed point** known as **oriV** (the vegetative origin, to distinguish it from the point at which conjugative transfer is initiated**, oriT**), and proceeds from this point, either in **one direction or in both directions simultaneously until the whole circle is copied**. However there are some aspects of replication that differ from that of the chromosome, especially for the **multicopy plasmids**. Two examples that have been studied intensively are **ColE1 and R100**.

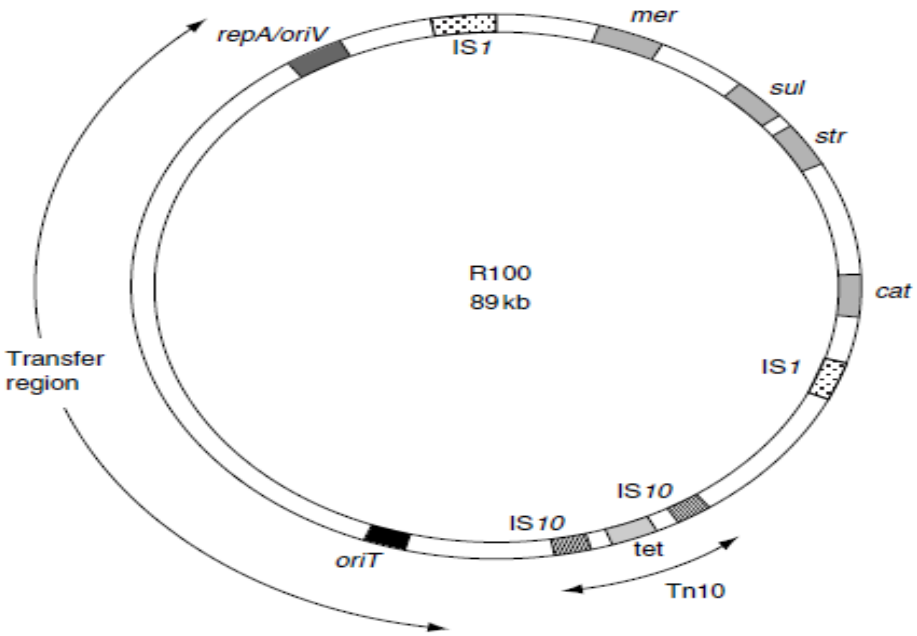

Figure 1. Genetic map of the conjugative E. coli plasmid R100. Resistance genes: cat, chloramphenicol (chloramphenicol acetyltransferase); mer, mercuric ions; str, streptomycin; sul, sulphonamides; tet, tetracycline. Other sites: oriT, origin of conjugative transfer; rep A/oriV, replication functions and origin of replication. IS1, IS10 are insertion sequences, Tn10 is a transposon