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GENERAL MICROBIOLOGY
MCB 202

1. Discuss microbial variation and hereditary in bacteria
2. Explain microbial recombination

1. Microbial variation and hereditary in bacteria

MICROBIAL HEREDITARY IN BACTERIA

Hereditary, also called biological inheritance, is the passing on of traits from parents to their offspring. Offspring acquire genetic information of their parents either through asexual or sexual reproduction.

There are many different species of bacteria on Earth, and they mostly reproduce by binary fission (the production of two identical daughter cells from one mother cell). Therefore, each replication cycle doubles the number of cells in a bacterial population. The bacterial chromosome is a long circle of deoxyribonucleic acid (DNA) that is attached to the membrane of the cell. During replication, the chromosome is copied, and the two copies are divided into the two daughter cells. Transfer of genetic information from the mother cell to offspring is called ‘vertical transmission’.
Beneficial mutations that develop in one bacterial cell can also be passed to related bacteria of different lineages through the process of ‘horizontal transmission’.There are three main forms of horizontal transmission used to spread genes between members of the same or different species: conjugation (bacteria-to-bacteria transfer), transduction (viral-mediated transfer), and transformation (free DNA transfer). These forms of genetic transfer can move plasmid , bacteriophage, or genomic DNA sequences. A plasmid is a small circle of DNA separate from the chromosome; a bacteriophage is a virus that

reproduces in bacteria by injecting its DNA; and the genome is the total DNA of the bacterial organism.

After transfer, the DNA molecules can exist in two forms, either as DNA molecules separate from the bacterial chromosome (an episome), or can become part of the bacterial chromosome.
CONJUGATION: is the transfer of DNA by direct cell-to-cell contact,depending on the presence of conjugative plasmid.
TRANSDUCTION: is a process mediated by viruses. It is a frequent mode of horizontal gene transfer in nature and it is known that huge number of genes are moved by marine viruses from one host cell to another. Viruses inject their DNA into a recipient cell, these viruses are called bacteriophages or phases. After injecting their DNA, new bacteriophage particles are produced which may kill the host cell (lytic growth) or may not kill the host (temperate growth) instead inherited by daughter host cells (transduction). Transduction may be 'generalised' or 'specialised'.
TRANSFORMATION: also called DNA transformation. A few species of bacteria have evolved systems that transport free DNA from the outside of the bacterial cell into the cytoplasm. These bacteria are called naturally competent for DNA transformation. In some bacteria, the process of DNA transformation is induced in the laboratory either physically or chemically by making cell passively permeable to DNA. Transformation can therefore be defined as the uptake of DNA (either a plasmid or a fragment of linear DNA) by a cell, from the surrounding and maintenance of the DNA in the recipient in a "heritable form".

MICROBIAL VARIATION IN BACTERIA
Variation refers to change in an organism relative to its parent or former state. The diversity or form and function among microorganisms is unparalleled among other groups of organisms. Microorganisms exhibit an enormous capacity to evolve new potentialities. Variation is " hereditary" or "environmental" depending on whether the change results from interplay of gene and environment or from the introduction of new genes. Since hereditary is the transfer of genes, hereditary variation is transmissible to the progeny.

Environmental variation doesn't alter the genes and it is therefore considered non transmissible.
Most bacterial cells contain a single chromosome, and therefore each gene is present in only one copy (with occasional exceptions). Thus, bacteria are haploid due to which genetic changes have an immediate effect on the phenotype or properties of the bacteria cell, this is a highly desirable characteristic for isolation of mutants in the laboratory. The short generation time and ability to produce large numbers of progeny make it possible to isolate virtually any kind of mutation. In nature, these properties mean that evolution is rapid.
Hereditary variation can occur by recombination of genes from haploid nuclei to form a diploid heterozygote in bacteria. Recombinant types, somewhat limited by linkage, are partially restored by crossing-over. If the bacteria possesses a haploid stage, variation may occur upon segregation. Recombinant types are; transformation, conjugation and transduction. Also, occasionally a spontaneous genetic change occurs in one of the daughter cells produced after asexual reproduction. This change (mutation) is heritable and passed on to the progeny of the variant cell with characteristics different from the original parents.

2. MICROBIAL RECOMBINATION

Recombination is a process by which pieces of DNA are broken and recombined to produce new combinations of alleles, thus creating genetic diversity that reflects differences in DNA sequence of different organisms.
Microbial recombination is a type of genetic recombination that involves the transfer of DNA from one microbe (usually a donor bacteria) to another called the "reciepient". This process helps to generate genetic variation in different bacteria required for adaption to changes in environment. Bacteria which are microbes are the most diversified group of organisms on earth and they are very important to maintain balance in the environment. They belong to a group called prokaryotes and its genetic organisation is different from that of eukaryotes. Although they do not undergo meiosis or sexual

reproduction (they mostly produce by binary fission), they are enormously diversed. The essence of sex is genetic recombination (mostly occur in higher animals), and bacteria achieve this via three (3) mechanisms:

1) Conjugation
2) Transformation
3) Transduction

These mechanisms involve different processes but in all cases two DNA are brought together and there must be a form of "sexual union". The essence is to transfer gene from one individual to another and it plays an essential role in the evolution of new variants in nature.

CONJUGATION: also called "bacterial conjugation" is the transfer of DNA by direct cell-to-cell contact or through a bridge like connection, between two bacteria. In order to perform conjugation, the donor must have a mobilizable genetic element (plasmid or transposon). Most conjugate plasmid have system ensuring the recipient cell does not already contain a similar element.

Mechanism of conjugation;

1. Donor cell produce pilus.
2. Pilus attaches to recipient cell thus connecting the two bacterial cells.
3. The mobile plasmid which is single strand DNA is then transferred to recipient cell.
4. Both recircularize their plasmids, synthesize the second strands and reproduce pilus. Both cells are now viable donor.

TRANSFORMATION: is the uptake of DNA, either a plasmid or fragment of linear DNA by a cell from the surroundings and maintenance of the DNA in the recipient in a heritable form. Bacteria transformation may be referred to as stable genetic change brought about by taking up naked DNA without associated cells or protein.

Competency is complex phenomenon and it depends on several conditions. A few specie can spontaneously take up DNA fragment

from their surrounding through a process called NATURAL TRANSFORMATION. majority of bacterial species can take up DNA from the surrounding only after laboratory procedures (their cell walls and membranes are made permeable to DNA) in a process called ARTIFICIAL TRANSFORMATION.

TRANSDUCTION: is the transfer of bacterial or archeal genes by viruses. It doesn't involve direct contact, instead viruses known as bacteriophages help in the transfer of DNA from one cell to another. When a bacteriophage injects its DNA into a recipient bacterial cell, it begins to produce new copy of itself via replication which could kill the host cell (lytic growth). Some bacteriophage do not kill the host cell in the process (temperate phage), but instead can be inherited by daughter host cells. Therefore acquisition of a so -called temperate prophage by a recipient cell is a form of transduction. Many bacteriophage also have the ability to transfer chromosomal or plasmid genes between bacterial cell.
In GENERALIZED TRANSDUCTION, any gene can be transferred from a donor cell to a recipient cell. Bacteriophage that are involved packages bacterial genes into their capsid instead of their own DNA. Whereas some bacteriophage can pickup a subset of chromosomal genes and transfer them to other bacteria, this process is called SPECIALISED TRANSDUCTION.