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Microbial Genetics

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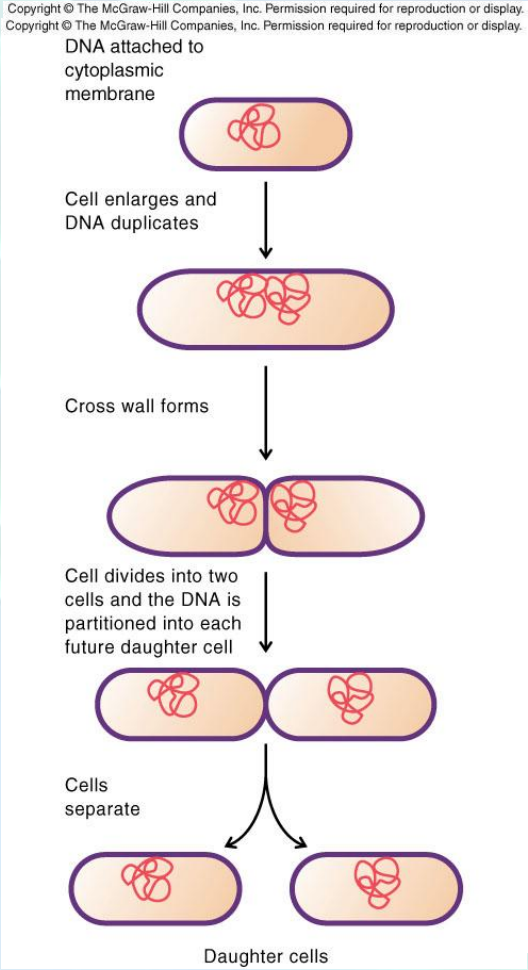
Microbial Genetics: Basics

- On a basic level, nucleic acids, stored in the form of genetic code (DNA) macromolecules, are the specific elements that are passed on from generation to generation
- Fundamentally speaking, there are two ways that genetic information can flow:
  - Externally
  - Internally

- **External -** Transference between bacterial generations occurs when DNA replicates and, through the process known as binary fission, is distributed to two identical daughter cells
- **Internal -** Transference within the bacterial cell is the end-product of proteins needed for cell growth and metabolism. Because DNA and protein have different chemical components, DNA must first be transcribed into mRNA before it can be converted into a protein.

Principles of Bacterial Growth

- Prokaryotic cells divide by binary fission
  - One cell divides into two
    - Two into four etc.
  - Cell growth is exponential
    - Doubling of population with each cell division
    - Exponential growth has important health consequences
  - Generation time
    - Time it takes for population to double
    - a.k.a. doubling time
    - Varies among species



DNA and RNA Structure: Characteristics

- Both DNA and RNA belong to a class of macromolecules called nucleic acids
- In DNA, the sugar is deoxyribose whereas in RNA the sugar is ribose. The primary difference between the sugars is that ribose has a hydroxyl group (OH) and deoxyribose does not. This results in making deoxyribose more stable than ribose.
- The nitrogenous bases within the nucleotide are: adenine (A), guanine (G), cytosine (C), thymine (T), and uracil (U).

Components of a Nitrogenous Base

- Both adenine and guanine are purines
- Adenine and guanine are both found in DNA and RNA
- Cytosine, thymine and uracil are pyridines
- While cytosine is found in both DNA and RNA, thymine is only found in DNA and uracil is only found in RNA
- Nucleotides are formed when a phosphate attaches to the 5' carbon of the sugar and one of the nitrogenous bases attaches to the 1' carbon of the sugar

- In the majority of cases, RNA is comprised of one strand of nucleic acids joined by phosphodiester bonds.
- A DNA molecule is comprised of two strands of nucleotides twisted together to form a double helix.
- The sugar-phosphate backbone is found on the outside of this helix and the bases are found branching towards the middle.
- Hydrogen bonds join the nitrogenous bases and hold the two strands together.

Microbial Genetics: Related Terms

- **Complementation --** important for the storage and delivery of genetic information, is a state that occurs because the two strands of DNA are complementary to one another on account of what is referred to as base pairing.
- **Anti-parallel Strands --** another characteristic state, occurs on account of the two strands of DNA being anti-parallel (running in opposite directions) to one another.

- **Chromosome --** In short, a chromosome is a combination of varying quantities of genes and protein. To understanding genetics, you must first understand that a gene is a sequence of nucleotides found in DNA containing hereditary codes.
- **Protein --** Macromolecules that fulfill a range of functions within the cell. They provide support, storage, delivery, protection, and contribute catalytic enzymes.

Proteins are structured in the following manner:

- Proteins are made up of repetitious units called amino acids.
- Amino acids consist of a carbon atom bonded to hydrogen, a carboxyl group, and an R side chain.
- All in all, there exist twenty different amino acids within proteins. The R side chain is the component that both differentiates amino acids from one another, as well as, and determines the manner in which amino acids will interact with one another.
- Amino acids are linked together by peptide bonds which, in turn, result in forming polypeptide chains.
- The sequential order of amino acids (within the polypeptide chain) is known as the protein's 'primary structure'. Proteins consist of at least one or more polypeptide chains brandished together.

- In an effort to study specific genes of microorganisms and ascertain their functions and contributions to carrying on the legacy in question, the science of microbial genetics is employed.
- A major goal of microbial genetics is to connect genes to their *in vivo* (reproduction conducted outside of the uterus) functions.
- As a whole, microbial genetics addresses the following areas:
- The functions of genes within their proper context in a genome.
- Gene regulation, protein synthesis, and protein function in most microorganisms.
- Genetic exchanges, as they occur in nature.

Microbial Genetics: Varied Approaches

- **Selection versus screening**--To identify those specific genes that play a role in particular process, the selection process entails killing off unwanted agents so that only the desirable ones can grow. In contrast, the screening process is considered to be a more tedious undertaking whereby each clone is closely examined in an effort to detect a pre-selected characteristic

- **Mutagenesis--**Often, the process of mutagenesis (the creation or formation of a mutation) can be used as a powerful genetic tool. Under such conditions, a specified gene function is eradicated in order to study other functions. The method by which microbiologists perform the mutagenization of cells include: transposons, irradiation (e.g. with UV), and chemicals. Note: Mutations may also be performed via mistakes in error-prone replication and repair of DNA.

- **Complementation --** The process by which microbiologists are able to identify the gene whose mutagenesis resulted in a physiological deficiency. The complementation approach introduces a 'corrected' replica of the gene into the mutant cells in an effort to restore performance via complementing the defective copy of the gene.
- The two tools commonly used to produce 'complementation' (or simply a good quality copy of the gene) are the processes known as conjugation (gene transfer from a donor to a recipient by direct physical contact) and transformation (uptake and incorporation of foreign --donated-DNA)

- **Recombination --** The technique in which a defective copy of a gene is actually replaced with a 'healthy' copy. In order to recombine genes microbiologists employ the following procedures:
- **Transduction** -- transference of DNA fragments of between cells tainted with viruses. The DNA fragments are selected based upon their ability to potentially recombine with the bacterial chromosome
- **Transformation --** via which DNA fragments comprised of 'suicide plasmids' (cells which cannot be maintained stably within cells due an absence of a specialized replicated quality) are utilized. Such fragments are selected based upon the likelihood that they may recombine with the bacterial chromosome