Microbial Genetics

The contributions of microbial genetics to the science world, as well as, the world at large, have been extensive and, in many respects, pivotal to furthering significant studies.

The fundamental molecular tools of every genetics laboratory (for example, polymerases, restriction enzymes and cloning vectors) have been derived from the genetic studies of microbes.

When attempting to understand the nature of microbial genetics, what we are looking to do is learn more about the inheritance of specific traits among those organisms which are undetectable by the naked eye.

In investigating characteristics which have been passed on from generation to generation, we need to also figure into the equation such activities as: morphology (adaptation), metabolism, antibiotic resistance, et al, for the reason that all of these interconnected activities are also attained via the organism's ancestral lineage.

A. 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, within a microorganism, there are two ways that genetic information can flow:

1. **External -** Transference between bacterial generations occurs when DNA replicates and, through the process known as binary fission, is distributed to two identical daughter cells.
2. **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.

B. DNA and RNA Structure: Characteristics

Both DNA and RNA belong to a class of macromolecules called nucleic acids.

- Nucleic acids are polynucleotides meaning they encompass a group of nucleotides.

- 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.
- In both RNA and DNA, the phosphate is linked to the 5' carbon of the sugar.
- The nitrogenous bases within the nucleotide are: adenine (A), guanine (G), cytosine (C), thymine (T), and uracil (U).

Further defined, the components of a nitrogenous base:

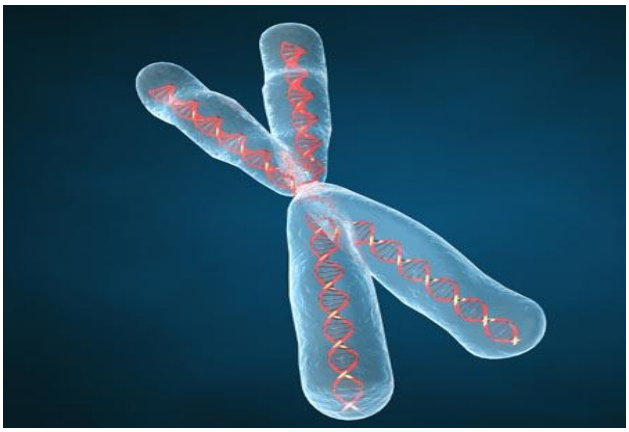
- Both adenine and guanine are purines
- Adenine and guanine are both found in DNA and RNA
- Cytosine, thymine and uracil are pyridines
- While cytosine is found in both DNA and RNA, thymine is only found in DNA and uracil is only found in RNA.
- Nucleotides are formed when a phosphate attaches to the 5' carbon of the sugar and one of the nitrogenous bases attaches to the 1' carbon of the sugar.
- Strands of both DNA and RNA consist of nucleotides joined by phosphodiester bonds. A phosphodiester bond exists between the phosphate of one nucleotide and the sugar 3' carbon of the next nucleotide. This then forms a backbone of alternating sugar and phosphate molecules known as the 'sugar-phosphate backbone'.
- 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.

C. 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.

To get a sense of how the process works--the following outlines the various approaches and tools involved in a manufactured and replicated laboratory study:

C. 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.

Yet, despite this legacy and the huge clinical significance of microbial genetics, the post-genomic potential of the field is only just beginning to be tapped.

Lesson 7 Assignment 1: Ingredients Please

Name three major components of a nucleotide.

Lesson 7 Assignment 2: Copy That

What are the two processes that are commonly used to produce a good quality copy of a gene?