DNA is replicated by a process known as semi-conservative replication. The enzyme responsible for this process is a replicase, more specifically it is called DNA dependent DNA polymerase. (A polymerase puts together polymers or macromolecules). The DNA polymer is made off of an existing DNA template. The manufactured double stranded and helical DNA consists of an old (parent) strand and a new (daughter) strand. This explains the use of the term semi-conservative. The bases always pair in a specific way. Cytosine will pair with guanine and adenine will pair with thymine. This specific pairing pattern produces a DNA strand that is said to be complementary. The arrangement of triplet sequences of bases on the DNA will ultimately determine the order and placement of amino acids in proteins produced. Therefore, in protein synthesis, the nucleic acid which serves as the stored genetic code for making proteins is DNA.

Messenger RNA (mRNA) is manufactured off of one of the DNA strands (master or sense strand) in a complementary fashion in protein synthesis. This process is called transcription and the enzyme responsible for producing the mRNA is called RNA polymerase. We say that mRNA contains the codon sequences.

Transfer RNA (tRNA) transports required amino acids to recognizable codons. Transfer RNA contains the anticodon sequences which match up with the mRNA codons. Building the protein at ribosomes by adding appropriate amino acids carried by tRNA to the mRNA is called translation.

Ribosomal RNA (rRNA) is a structural building material used in the formation of ribosomes.

The *genotype* (genome) is defined as the complete array of genes possessed by a cell. This is the normal complement of genes. Bacteria have between 2000 and 3000 genes. All of the genes in the genome may not be expressed at a given time.

Note that bacterial cells are generally haploid and not diploid. In haploid cells, a single gene can determine a genetic trait, whereas in diploid cells two genes co-expressed will determine a trait. Therefore, in haploid prokaryotic cells, any mutation in the cell’s DNA will be expressed. In diploid eukaryotic cells, a mutant gene will be paired with its non-mutant gene and gene expression may be masked (hidden) or delayed.

The *phenotype* of an organism would represent those genes that are being expressed at a given time. Environmental factors play a role as to which genes may be turned on or turned off and therefore expressed. This process of altering gene expression is known as phenotypic modification. Here are some examples of environmental factors that can produce phenotypic changes.

1. Media - Milk in media can induce capsule production. Low nutrient content in media can induce sporogenesis.
2. Temperature - *Serratia marcescens* grown at 25 degrees C. will produce a red pigment. This organism grown at 37 degrees C. will grow without pigment.
3. Age (aging cells will change cell environment) - Young cells are small and yield the most reliable Gram stains. Older cells are larger and have granules and perhaps spores. Older Gram positive cells may revert to Gram negative.
4. Biochemical or physiological alterations-Inducible enzymes are produced when increased concentrations of substrate are present. Repressible enzymes are not manufactured in the presence of increased concentrations of reaction products.

Genotypic modifications or changes-these are called mutations. The cell that houses a mutation is called a mutant. The positioning of the nitrogenous bases in DNA in triplets produces sequences that ultimately build proteins. Four possible nitrogenous bases are used to build each triplet. How many different triplet sequences can be made from the four different bases? The answer is 64 different "3 letter words" can be made from a "4 letter alphabet". The 64 code words can create 64 different codons in the form of mRNA in the transcription process. The 64 different code words only code for 20 different amino acids. Since more than one 3 letter code word codes for the same amino acid, the code is said to be redundant (degenerate). For example, you will notice that there are 6 different codons for the amino acid leucine. However, any single 3 letter code word, will code for just 1 amino acid. See figure in Ch. 8 that illustrates the 64 different codons that have been made from the 64 different codes. Three of the codons are stop sequences. AUG is both a start codon and the sequence for the amino acid methionine. Discuss different types of mutations.

1. Substitution of a base (point mutation)-a single base at one point is replaced with a different base. This can create an incorrect triplet sequence that places the wrong amino acid into the protein chain. This mutation with the substitute amino acid is called a missense mutation. The effect can be dramatic. For example, the hemoglobin found in Sickle Cell Anemia is altered in this fashion. If the substitution results in one of the stop sequences in the middle of the growing protein chain, this can prevent the synthesis of a functional protein. The production of this nonsense codon results in a nonsense mutation.

2. Insertion or deletion of a base (frameshift mutation)-adding or deleting a base will shift amino acids into different triplets. The potential for changing every triplet sequence from the mutation and beyond exists. This creates many missense producing codons and the greatly increased chances for a completely nonfunctional protein created as a result of a nonsense mutation.

Causing Mutations

1. Spontaneous Mutations-typographical error made during replication. Approximately one in every billion base pairs is copied incorrectly without any added chemical or physical presence. There are on average 900 base pairs per protein. Since young cells have an increased rate of replication, mutation rates in general are increased.

2. Chemical Mutagens
   a. Base (nucleoside) analog-chemicals that are structurally similar to normal bases found in nucleic acids. These are wrongly incorporated into DNA during replication where the normal bases should have been. Examples include 2-aminopurine and 5-bromouracil. Antiviral and antitumor drugs are sometimes base analogs and work to damage nucleic acids in this fashion.
   b. Benzopyrene found in coal tar and cigarette smoke can cause frameshifts.
   c. Aflatoxin produced by the mold Aspergillus flavus grows on peanuts and grain can also cause frameshifts. This toxin is associated with liver cancer.
   d. Acridine dyes can cause frameshift mutations.
   e. Carcinogens-chemicals that are associated with causing cancer. 90% of the chemical mutagens are considered to be carcinogenic.

3. Physical Mutagens
   a. Radiation-from X-rays, gamma rays, ultra violet (U.V.) light.