Chapter 5

DNA and Genes

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Summary of Terms

- **Codon** A sequence of three nucleotides in an mRNA molecule that either stands for an amino acid or ends translation.
- **Deoxyribonucleic acid (DNA)** The cell's genetic material: a double-stranded molecule, consisting of sugar–phosphate backbones attached by pairs of matched nitrogenous bases, in the form of a double helix.
- **Diploid** Describes a cell that has two of each kind of chromosome.
- **DNA replication** The process through which a DNA molecule is copied in order for cells to divide and reproduce.
- **Gene** A section of DNA that contains the instructions for building a protein.
- **Genetic mutation** A change in the nucleotide sequence of an organism's DNA.
- **Genotype** The genetic makeup of an organism.
- **Haploid** Describes a cell that has one of each kind of chromosome.
- **Messenger RNA (mRNA)** An RNA molecule made during transcription that carries genetic information from DNA to the ribosomes.
- **Phenotype** The traits of an organism.
- **Ribonucleic acid (RNA)** A single-stranded molecule consisting of a sugar–phosphate backbone attached to a series of nitrogenous bases.
- **Transcription** The first step in building a protein, in which a molecule of RNA is assembled from information contained in DNA.
- **Transfer RNA (tRNA)** An RNA molecule that transfers an amino acid to a growing protein during translation.
- **Translation** The assembly of a protein based on information contained in an mRNA molecule.

Detailed Chapter Summary

A *gene* is a section of DNA that contains the instructions for building a protein. Remember that proteins are important in living organisms because they provide both structure and functionality. For example, enzymes are proteins, and enzymes help determine the chemical reactions that can occur in cells. An organism's genes make up its *genotype*, and an organism's traits make up its *phenotype*.

Genes are contained in structures called chromosomes. A *chromosome* consists of a single molecule of DNA wrapped around proteins called histones. Diploid cells have two of each type of chromosome. Haploid cells, such as sperm and eggs, have one of each type of chromosome. Humans have 23 pairs of chromosomes, including 22 pairs of autosomes and 1 pair of sex chromosomes. The sex chromosomes determine biological sex.

DNA has the structure of a double helix, that is, a spiraling ladder. DNA consists of two strands. Each strand has a backbone made of alternating molecules of deoxyribose sugar and phosphate (the "side" of the ladder) with a series of protruding nitrogenous bases (each representing one half of a "rung" of the ladder). Four nitrogenous bases are used in DNA -- adenine, cytosine, guanine, and thymine -- or A, C, G, T for short. Within the DNA molecule, the nitrogenous bases always bind with specific partners -- A always pairs with T, and G always pairs with C.

DNA replication describes the process through which a molecule of DNA is copied in preparation for cell division. During DNA replication, the two strands of DNA are separated and each strand is used as a template to build a new strand. This is possible because of the specific base-pairing rules in DNA (A always pairs with T, and G always pairs with C). Because of how DNA replication occurs, each new DNA molecule consists of one old strand and one new strand.

The other nucleic acid important to life, aside from DNA, is RNA. *RNA* is a single-stranded nucleic acid with a backbone consisting of alternating molecules of ribose sugar and phosphate. Like DNA, RNA uses four different nitrogenous bases. These nitrogenous bases are similar to the bases found in DNA except that RNA uses uracil (U) in place of thymine. Thus, the nitrogenous bases found in RNA are A, C, G, and U.

The process of building a protein from a section of DNA takes place in two steps, *transcription* and *translation*. Transcription takes place in the cell nucleus. During transcription, DNA is used to build a molecule of RNA. The two strands of DNA are separated, and one strand is used to build the RNA molecule. This process relies on the usual base pairing rules. Thus, where DNA has A, C, G, T respectively, the RNA transcript will have U, G, C, A respectively. A processing phase converts the RNA transcript to a mature messenger RNA, or *mRNA*, molecule. During the processing phase, a cap and tail are added to the molecule, introns are removed from the sequence, and exons are left in the sequence.

Transcription is followed by the process of translation, which occurs at ribosomes in the cell cytoplasm. During translation, a *codon* of three nucleotides in the mRNA molecule provides instructions on the assembly of the protein. These instructions include signaling the start of translation, specifying the addition of a single specific amino acid, and signaling the end of translation. The *genetic code* describes the specific instruction provided by each three-nucleotide codon. Transfer RNA, or *tRNA*, molecules assist in translation. Each tRNA molecule carries a three-nucleotide sequence called an *anticodon* as well as a specific amino acid. During translation, the appropriate anticodon binds to the codon in the mRNA molecule via base-pairing, and the associated amino acid is added to the growing protein. Translation ends when a stop codon is reached.

A *genetic mutation* occurs when the sequence of nucleotides in an organism's DNA is changed. The effects of genetic mutations on organisms vary widely—a mutation can have no effect at all or it can be fatal. Genetic mutations are also the original source of all genetic diversity. Some specific types of genetic mutations include point mutations, nonsense mutations, and frameshift mutations. A point mutation occurs when one nucleotide is substituted for another. A nonsense mutation creates a stop codon in the middle of a gene. A frameshift mutation occurs when the insertion or deletion of nucleotides results in a shifted reading frame during translation.