Summary

12–1 DNA

To understand genetics, biologists had to learn the chemical makeup of the gene. Scientists discovered that genes are made of DNA. **Scientists also found that DNA stores and transmits the genetic information from one generation of an organism to the next.** Scientists began studying DNA structure to find out how it carries information, decides traits, and replicates itself.

- DNA is a long molecule made up of units called **nucleotides.** Each nucleotide is made up of a 5-carbon sugar, a phosphate group, and a nitrogen-containing base.
- There are four kinds of bases: adenine (A), guanine (G), cytosine (C), and thymine (T).

Watson and Crick made a three-dimensional model of DNA. Their model was a double helix, in which two strands were wound around each other. A double helix is like a twisted ladder. Sugar and phosphates make up the sides of the ladder. Hydrogen bonds between the bases hold the strands together. Bonds form only between certain base pairs: between adenine and thymine, and between guanine and cytosine. This is called **base pairing.**

12–2 Chromosomes and DNA Replication

Most prokaryotes have one large DNA molecule in their cytoplasm. Eukaryotes have DNA in chromosomes in their nuclei. Before a cell divides, it copies its DNA in a process called **replication. During DNA replication,**

- **the DNA molecule separates into two strands. Each strand of the DNA molecule serves as a model for the new strand.**
- Following the rules of base pairing, new bases are added to each strand. For example, if the base on the original strand is adenine, thymine is added to the newly forming strand. Likewise, cytosine is always added to guanine.
- The end result is two identical strands.

12–3 RNA and Protein Synthesis

For a gene to work, the genetic instructions in the DNA molecule must be decoded. The first step is to copy the DNA sequence into RNA. RNA is a molecule which contains instructions for making proteins. RNA is similar to DNA, except for three differences:

- The sugar in RNA is ribose instead of deoxyribose.
- RNA is single-stranded.
- RNA has uracil in place of thymine.

Most RNA molecules are involved in making proteins. **There are three main kinds of RNA:**

- **Messenger RNA** has the instructions for joining amino acids to make a protein.
- Proteins are assembled on ribosomes. Ribosomes are made up of proteins and **ribosomal RNA.**
- **Transfer RNA** carries each amino acid to the ribosome according to the coded message in messenger RNA.

RNA is copied from DNA in a process called **transcription**. **During transcription:**

- **The enzyme RNA polymerase binds to DNA and separates the two DNA strands.**
- **RNA polymerase builds a strand of RNA using one strand of DNA as the template.**
- The DNA is transcribed into RNA following base-pairing rules except that uracil binds to adenine.

The directions for making proteins are in the order of the four nitrogenous bases. This code is read three letters at a time. Each **codon,** or group of three nucleotides, stands for an amino acid. Some amino acids are specified by more than one codon. One codon is a start signal for translation. Three codons signal the end of a protein.

Translation is the process in which the cell uses information from messenger RNA to make proteins. Translation takes place on ribosomes.

- Before translation can begin, messenger RNA is transcribed from DNA.
- The messenger RNA moves into the cytoplasm and attaches to a ribosome.
- As each codon of the messenger RNA moves through the ribosome, the proper amino acid is brought into the ribosome by transfer RNA. The ribosome joins together each amino acid. In this way, the protein chain grows.
- When the ribosome reaches a stop codon, it releases the newly formed polypeptide and the process of translation is complete.

12–4 Mutations

Mutations are mistakes made when cells copy their own DNA. **Mutations are changes in the genetic material of a cell.**

- Gene mutations are changes in a single gene. A **point mutation** occurs at a single point in the DNA sequence of a gene. When a point mutation causes one base to replace another, only one amino acid is affected. If a nucleotide is added or removed, it causes a **frameshift mutation.** All the groupings of codons are changed. This can cause the gene to make a completely different protein.
- In a chromosome mutation, there is a change in the number or the structure of chromosomes. There are four kinds of chromosomal mutations: *deletions*, *duplications*, *inversions*, and *translocations*.

12–5 Gene Regulation

Genes can be turned on and off as different proteins are needed. In prokaryotes, some genes are turned on and off by a chromosome section called an operon. An **operon** is a group of genes that work, or operate, together. In bacteria, one operon controls whether the organism can use the sugar lactose as food. It is called the *lac* operon. **The *lac* genes are turned off by repressors and turned on by the presence of lactose.** Operators and promoters are DNA sequences in the operon that control when genes are turned on and off.

- When the cell needs a certain protein, RNA polymerase attaches to the promoter and makes a messenger RNA that is translated into the needed protein.
- When the cell no longer needs the protein, it makes another protein called the repressor. The repressor attaches to the operator. This blocks the promoter so RNA polymerase cannot attach to it. This turns the genes of the operon off.

Most eukaryotic genes are controlled individually and have regulatory sequences that are much more complex than those of the *lac* operon. In eukaryotes, genes are regulated by enhancer sequences located before the point at which transcription begins. Some proteins can bind directly to these DNA sequences. Ways in which these proteins affect transcription include:

- increasing the transcription of certain genes
- attracting RNA polymerase
- blocking access to genes