# Protein

**Proteins** can be considered in two ways:

- ·as components of certain foods
- ·as a source of amino acids for body protein synthesis

A protein molecule is like a string of beads.  Each bead represents one of about 20 or more **amino acids**.  Stringing the beads in various orders, or forming shorter or longer strings, creates (synthesizes) protein molecules that have different properties and functions.

Protein digestion is the opposite of protein synthesis: the string is broken at multiple points by digestive enzymes.  Individual beads (amino acids) and small groups of beads (dipeptides and tripeptides) are released for absorption.  After absorption, individual amino acids become available for synthesis into protein in all tissues, where they are reassembled into chains of various lengths and arrangements, becoming the protein molecules the body uses.

## ***Protein Functions***

Proteins perform many essential functions.  Specialized proteins have developed that carry out each function.  Some examples:

- ·Structural proteins form the primary components of muscle, tendons, skin, arteries, and veins, and provide a matrix into which minerals are deposited in bone.
- ·**Enzyme** proteins carry out chemical reactions in cells, or digest foods in the intestine.
- ·Antibody proteins, as discussed in Module 1, react with specific antigens.
- ·**Hormone** proteins circulate in the bloodstream and influence the activity of cells throughout the body.
- ·Transport proteins carry various substances through the body; hemoglobin, for example, carries oxygen from the lungs to tissue cells.

Proteins are also a source of energy, but to a lesser extent than fats and carbohydrates.

## ***Amino Acids***

As shown in Figure 1, amino acids are members of a group of chemical compounds that contain:

- ·at least one amino group (—$NH_2$)
- ·a carboxyl group (—COOH)

In addition to being building blocks for proteins, amino acids perform many functions, including

·neurotransmitters precursors
·nucleotide synthesis
·cell water regulation
·vitamin activation
·bile synthesis

Only 20 of the amino acids are synthesized into proteins.

Fig. 1. Drawing of general amino acid molecule.

The body readily synthesizes some amino acids as needed. These **nonessential amino acids** are not required in the diet, but *are* essential to good health. Amino acids the body cannot synthesize are called **dietary essential amino acids**. Because only insignificant amounts of dietary essential amino acids are synthesized in the body, they must be supplied by proteins in the diet. The ability of a protein to supply the dietary essential amino acids is referred to as the protein's quality. Conditionally essential amino acids are those that may be required in the diet during times of rapid growth, tissue restoration, or disease state.

Table 1 lists dietary essential, conditionally essential, and nonessential amino acids.

### *Protein Synthesis*

Figure 2 shows how a cell combines amino acid molecules to synthesize a protein. The hookup occurs between the carboxyl group of one amino acid and the amino group of the other, forming a peptide linkage. A water molecule is split out in the reaction. The resulting molecule is called a **dipeptide**.

Fig. 2. Drawing showing joining of amino acids through peptide linkages.

As Figure 2 shows, the reaction can continue after a dipeptide is formed. A third amino acid molecule can be added, and another water molecule split out. This forms a chain of three amino acids, called a **tripeptide**. As the chain grows by adding more amino acids, it is called a **polypeptide**. When the chain becomes longer than about 20 amino acids, it is called a protein.

An average protein has about 400 amino acids in the chain. There are many possible combinations of the 20 important amino acids, and an extremely large number of possible proteins.

When proteins are formed, genes in the cell's nucleus control the order in which amino acids are added to the chain. The order of the amino acids and the length of the chain determine the protein molecule's properties and functions.

### *Protein Digestion*

Enzymes released into the digestive tract digest proteins. The process is the reverse of the protein synthesis shown in Figure 2, in which the amino acids are linked together. The enzymes split the peptide linkages between amino acids. They also split a water molecule, $H_2O$ or HOH into two parts: a H–, to replace on the newly freed amino group; and an –OH, to replace on the carboxyl group.

During digestion:

- proteins are broken down almost completely, forming amino acids, dipeptides, and tripeptides
- the amino acids are absorbed from the digestive tract by enterocytes and passed directly into the blood
- dipeptides and tripeptides are also absorbed directly by the enterocytes, and are broken down into their amino acid components before being passed into the blood