pH and Enzyme Activity

Enzymes also typically have maximum activity within a relatively narrow range of pH. The optimal pH for normal cell enzyme functions is almost neutral, about 7.3 to 7.4. Changes in pH can cause changes in protein structure and shape. For example, adding acid or base can interfere with the side-chain interactions and thus change the shape of a protein. Most enzymes become *inactivated,* or no longer work, because of denaturation when the pH changes. When milk sours (because lactic acid has formed), it curdles, and curds of the protein casein form. Yogurt is made by growing acid-producing bacteria in milk, which causes the casein to denature, giving yogurt its consistency.

The digestion of dietary protein by enzymes begins in the stomach. When food is swallowed, the stomach lining produces HCl and *pre-enzymes,* inactive forms of protein-digesting enzymes. These pre-enzymes travel from the stomach lining into the stomach before they become activated by the stomach's low pH of 1.5 to 2.0. This process is important because it prevents the active form of the enzymes from digesting the stomach lining. A layer of mucus protects the lining of the stomach from the enzymes it contains. Once activated, the enzymes catalyze the breakdown of the proteins in food into shorter polypeptide segments. *Pepsin* is a stomach enzyme found in adults. The partially digested protein in food travels into the small intestine, where the pH is 7 to 8. Under these conditions, the enzyme *trypsin* becomes active. It catalyzes the hydrolysis of the polypeptide segments into amino acids, which are absorbed through the intestinal wall and enter the bloodstream. The body uses these newly acquired amino acids to make other amino acids and new protein molecules. **Figure 15** shows how the protein in raw fish looks before and after it is soaked in acidic lime juice. Because the acidic lime juice denatures protein in the fish, the acid-treated fish looks very different.

FIGURE 15 The fish treated with lime has turned white because the acidic lime juice denatures the protein in raw fish.

SECTION REVIEW

1. Which elements do amino acids and proteins have in common with carbohydrates and lipids?
2. What is the difference between an amino acid and a protein?
3. Explain the difference between fibrous proteins and globular proteins.
4. Why are only small amounts of enzymes found in the body?

Critical Thinking

5. **RELATING IDEAS** Explain how the ball-like structure of globular proteins allows them to be water soluble.
6. **INFERRING CONCLUSIONS** If an essential amino acid is in short supply in the diet, it can become a limiting reactant in building any protein that contains the amino acid. Explain why, under these conditions, the only way that the cell could make that protein would be to degrade one of its proteins that contain the limiting amino acid.