

Instructor's Answer Key

Chapter 4: Enzymes and Energy

Answers to Test Your Understanding of Concepts and Principles

1. The specific tertiary structure of an enzyme is critically important in its catalytic action, because this function depends upon interaction of the substrate with active sites on the enzyme. The relationship between structure and function in enzyme action is easily understood by reference to the lock-and-key model, in which the substrate is seen to fit into a pocket in the enzyme that has a specific shape. Since the tertiary structure of proteins is largely stabilized by weak hydrogen bonds, treatments that break these weak bonds can alter the shape of the enzyme. Thus, changes in pH and temperature affect the catalytic ability of enzymes. [Note: This question is also answered in the Student Study Guide.]
2. As long as the concentration of enzymes is not a factor, the rate of an enzyme-catalyzed reaction as measured by the production of products varies directly with the substrate concentration. At a given level of enzyme concentration, the rate of the catalyzed reaction will increase as the substrate concentration increases, up to a maximum. At this maximum rate the enzymes are saturated with substrate since additional increases in substrate no longer increase the rate of reaction. If the substrate concentration is not rate limiting, then the rate of the enzymatic reaction will vary directly with enzyme concentration.
3. As the final product of a metabolic pathway accumulates, it can inhibit (by means of allosteric interaction) enzymes that catalyze early steps in the pathway. In this way, the increase in concentration of end product becomes self-limiting as it works to inhibit its own synthesis. This is similar to the negative feedback inhibition that helps to prevent excessive changes in various values of the internal environment.
4. According to the second law, a more organized state of matter has more free energy than a less organized state. Therefore, to produce the more organized, higher free energy state represented by ATP from the lower energy state represented by ADP and P_i , energy must be added. When ATP is converted into ADP and P_i , the energy difference that was used to make ATP must be liberated. This follows from the first law, which states that energy can be neither created nor destroyed.
5. NAD and FAD can become reduced when other molecules become oxidized and donate electrons to them. The reduced NAD and FAD can then carry these electrons to another cellular location and, in different reactions, donate the electrons to molecules that then become reduced. The oxidized NAD and FAD can then repeat these steps, become reduced in one reaction and subsequently oxidized in another reaction. In this way electrons are passed from one molecule to another in a series of coupled oxidation-reduction reactions.

6. Inborn errors of metabolism occur when a gene for the synthesis of a particular protein is defective and so an important metabolic pathway becomes disrupted. In phenylketonuria, the enzyme needed to convert phenylalanine to tyrosine is defective. Phenylalanine is not metabolized properly. Consequently, the accumulation of phenylalanine can cause mental retardation and decreased life span. In albinism, the enzyme that catalyzes the conversion of DOPA to melanin is defective and the albino condition occurs.
7. NAD and FAD are important molecules in hydrogen transfers. NAD is derived from niacin and FAD from riboflavin. Individuals must have niacin and riboflavin in their diet for the production of the coenzymes NAD and FAD.

Answers to Test Your Ability to Analyze and Apply Your Knowledge

1. Metabolic pathways in the cell involve many thousands of different types of enzyme-catalyzed reactions that are all linked together by intricate webs of interrelationships. Like workers on an assembly line the enzymes contribute a small part in the formation of the final product. The product of one enzyme reaction becomes the substrate for the next enzyme reaction, and so on. Since metabolic pathways are usually branched, one intermediate at a branch point can serve as substrate for two different enzymes and result in the formation of two different products. In this way, the branch point is an intersection like those of railway tracks with the enzymes involved acting as switches. The regulation of these intersections is often controlled by end-product inhibition, a form of negative feedback that would favor one enzyme-catalyzed pathway over another.
2. The enzyme LDH is normally a cytoplasmic enzyme but can be released from various diseased tissues, including heart muscle, liver, kidneys, and bone, as cell plasma membranes are disrupted. However, since LDH catalyzes the conversion of lactic acid to pyruvic acid and H_2 , only serum lactic acid would be digested and all other components of blood would remain unaffected.
3. Plant metabolic pathways and animal (human) metabolic pathways are very different. Plants are autotrophic using energy from the sun in a series of endergonic reactions to convert carbon dioxide and water to glucose (photosynthesis). Animals undergo cellular respiration, combusting the digested and absorbed glucose in a series of exergonic reactions to produce carbon dioxide and water, and to release energy. Since plants and animals are essentially metabolic opposites enzyme tablets derived from a plant should have little or no effectiveness as a digestive enzyme in humans. Other factors such as pH and temperature optima, coenzyme and cofactor requirements, and so on in plant enzymes versus animal enzymes would contribute to my concerns.