CHEMISTRY AND BIOLOGY

Essay #10: Enzymes

We saw from essays #6, 8, and 9 why enzymes are used, and how ultimate control of the cell's functioning is by enzyme "selection" in the nucleus. One purpose of this essay is to illustrate the importance and use of enzymes simply by the essay's connections in the chart. A second purpose is to briefly examine the regulatory properties of the enzymes themselves.

The molecules that an enzyme influences are called its *substrate*. Three things determine whether a substrate will be affected by a particular enzyme:

- The substrate must have a specific functional group (see essay #5), which can bond at a specific location on the enzyme, the *positioning site*.
- It must contain the specific functional group that the enzyme is designed to influence.
- The catalytic effect of an enzyme occurs at another localized spot on its surface, the *catalytic site*. The substrate molecule must be the correct size and shape so that, when it is bonded at the positioning site, the functional group to be catalyzed is at the catalytic site.

For example, chymotrypsin is an enzyme that catalyses the hydrolysis of peptide bonds at a particular amino acid, phenylalanine, which contains an aromatic ring. The ring bonds at the positioning site, which lines up the peptide bond at the catalytic site, as shown in Figure 22.

The nucleus responds to relatively large-scale changes that indicate different cellular processes should be occurring, and adjusts the availability of enzymes accordingly. But at the level of each cellular process, as it is occurring, there is continual "fine adjustment" of its rate in response to the short term needs of the cell.

Each cellular process (for example, glycolysis) is a series of reactions catalyzed by a system of enzymes, where the product of the action of one enzyme becomes the substrate for the next one. The first enzyme of this series is called a *regulatory enzyme*. It contains a special site that bonds with the end product of that process, inhibiting the enzyme's activity. This is called feedback inhibition. When the supply of the end product accumulates above the needed amount, the regulatory enzymes are inhibited and the process slows down.

Similarly, enzymes can be inhibited or stimulated by the presence of ATP, ADP, coenzymes, or other substrates, depending on their concentrations at the time.

Figure 23 illustrates the "automatic fine adjustment system" for glycolysis. If energy is being used up too fast by the cell, there will be an accumulation of ADP. Looking at Figure 23, we see that the ADP stimulates key reactions of glycolysis, producing the needed energy.

Coenzymes are molecules that act in coordination with many enzymes (often physically attached) to aid in the transfer of a molecule or atom from one substrate to another. Vitamins are usually used as important components of coenzymes. We have seen, in essay #8, two important coenzymes: NAD^+ and CoA. NAD^+ uses the vitamin niacin, and CoA uses the vitamin pantothenic acid.

This writing sample is an excerpt from the supplementary textbook *From Above the Web: A New Look at Physics and its Extensions*, first draft manuscript, copyright by the authors: Stephen Arthur, James Atkins, Mark Termes, and Lorne Whitehead. Funded by an OFY grant. Original idea and project proposal by Stephen Arthur. **See flowchart example with excerpt from the Introduction by Lorne Whitehead.** (Dr. Whitehead is Vice-President Academic and Provost of the University of British Columbia as of 2004. He is the founder of TIR Systems and holds a research chair in the UBC Department of Physics.)