BIOCHEMISTRY

Man, a Bundle of Enzymes

Enzymes, thousands upon thousands of them, control the series of chemical reactions within the biological system of man, allowing him to live and breathe.

By RUBY YOSHIOKA

➤ LIFE MAY BE SAID to be a series of chemical reactions controlled by enzymes.

We laugh, cry, eat and sleep, get sick and then get well. All of these actions are possible because of the chemistry within our bodies. Whenever we move, breathe, act or think, we set a continuous series of chemical reactions into motion.

Most of these processes are extremely complex and are the subject of continuous research by biochemists and other scientists.

In order for the body to function properly, that is, complete the chemical reactions that let us play or work, certain chemicals and chemical compounds are essential. Oxygen, of course, is necessary, carbon, nitrogen, vitamins, amino acids, salts and certain metals, including even a tiny bit of the Space-Age metal molybdenum—all of these materials enter into the various reactions that allow the body to act as a complete well-organized machine.

Enzymes Most Important

Among all these necessary compounds, the most important are the chemical structures known as enzymes. Without enzymes, synthesized within the body cells, no chemical reactions would take place in the body, and there would be no life.

Every single chemical reaction within the body is dependent on some enzyme activity. There are thousands upon thousands of enzymes in our bodies, in the mouth, stomach. intestines and in all the cells that make up the tissues, to take care of the thousands of chemical processes. We are just a bundle of enzymes and owe our lives, good or bad, to these busy chemicals.

Not only does man depend upon enzymes for existence, but all biological systems—plant, animal and even the tiniest bacteria—exist because of enzyme activity.

What makes the enzymes so important? They are catalytic agents. They speed up chemical reactions within the biological cell, but are not themselves used up in the process. They allow chemical reactions within the body that would not ordinarily occur without their presence, or would take place very slowly. Without the catalytic action of enzymes, and only a tiny amount is necessary, we could not even make use of the oxygen which we breathe.

Enzyme activity of yeast and bacteria has been used by man for thousands of years, in making wines, breads and cheeses. But the nature of the action was not under serious scientific investigation until early in the 19th century. Substances that produced chemical reactions in biological media, such as starch digesting enzymes in malt, pepsin in gastric juice and salivary enzymes, were called "ferments."

Pasteur showed that the fermenting of wine was caused by microorganisms and grouped ferments into two groups. Those caused by chemicals were called "organized ferments" and those resulting from living organisms, "unorganized ferments."

The word "enzyme" was later introduced by Kuhne, derived from the Greek meaning "in yeast." The substance on which an enzyme acts is known as the substrate. In 1897 Buchner successfully extracted a system called zymase from yeast. This substance could convert sugar into alcohol and carbon dioxide, just as the live yeast did, showing that the enzymatic actions apparently due to the microorganisms themselves were actually chemical reactions within the cells.

In 1926 James Sumner succeeded in crystallizing urease, the first enzyme to be crystallized, and proved what most scientists were beginning to believe, that enzymes were proteins.

It is now recognized that enzymes are large molecules of protein containing one to several small catalytic centers. The function of the intricate molecular structure around the catalytic site, or whether the structure is even essential to the catalytic action, is not yet known.

Enzymes have characteristics typical of proteins, being water soluble, and sensitive to heat and acid. If the temperature becomes too high, they break down and become inactivated. If the temperature becomes too low, their activity slows down or ceases.

They also act only within a limited range of pH, usually close to neutrality, although a few, such as trypsin, found in gastric juice, operate in a highly acidic medium. Also, the more enzymes present, the greater the activity.

Specificity of Action

One of the most significant properties of enzymes is their specificity. They will catalyze only certain reactions and not others.

Certain enzymes act only on fats and are known as lipases. Amylases act only on carbohydrates and those that act on proteins are called proteases.

Not only are enzymes choosy about the chemical groups they will catalyze, but they will catalyze only certain types of reactions. Some catalyze only a single reaction, others a certain molecular group provided certain chemicals are present or absent in the substrate, and a third type acts only on specific linkages in the molecular chain. Still others act only on the left (levo-) form and not on the right (dextro-) form of a compound, or have stereochemical specificity.

Some enzymes are also tissue specific.

National Institutes of Health

ENZYME RESEARCH—How an enzyme reacts in kidney tissues is being observed and recorded by an investigator at the National Institute of Arthritis and Metabolic Diseases, Bethesda, Md. By studying the role of enzymes, biochemists learn more about the complex reactions controlling metabolism in health and disease.

That is, they will act only on reactions in the tissues in which they were synthesized. Thus, the enzymes in heart muscle catalyze reactions only on heart muscle and not those in the muscle of the leg, although the type of reactions catalyzed is the same.

Related to Diseases

Because of this quality of tissue specificity, enzymes are helpful in the diagnosis of disease and chemical imbalance within the body. When body tissue is damaged by disease, the enzymes of these tissues are released into the blood stream. By analyzing the enzymes, using electrophoretic techniques, the organ that has been damaged can be identified.

In what part of the tiny cells are these thousands of enzymes produced? It is now believed that they are synthesized in the cell chromosomes, and that one particular gene determines the formation of a specific enzyme. The gene is the small chemical unit responsible for the structure and function of an organism.

This hypothesis would help explain some enzymatic defects, such as are found in some diseases. If an enzyme for a necessary chemical step in the metabolic function of the body is missing, it usually means illness or even death.

Sometimes a person is born with an enzyme missing. For example, lack of the phosphorylase enzyme in the skeletal muscle of one patient caused muscle weakness and cramps. Since there is no way in which to supply a missing enzyme into the tissue, there is no cure for such a disease.

Scientists are doing research to find how substances can be introduced into the body that may cause the synthesis of a missing enzyme.

Enzymes cannot always act alone to produce a reaction; some require the presence of certain metals, such as zinc or molybdenum, to perform their functions. These metals are known as activators.

Another group of enzyme helpers are coenzymes, compounds containing phosphates. These activators supply certain elements or compounds necessary for a particular enzyme activity or take away a product of enzyme action. Two such coenzymes are diphosphopyridine nucleotide (DPN), or coenzyme I, and triphosphopyridine nucleotide (TPN), or coenzyme II, important in the metabolism of our bodies because they take part in oxidation-reduction processes. It is now believed that most vitamins act as coenzymes.

Enzymes are inhibited as well as activated by chemicals. In the treatment of diseases with sulfanilamides, or sulfa drugs, the enzymes within the bacteria are inhibited by the drug, thus killing the bacteria.

Antibiotics act in the same way. Antibiotics are not effective against viral disease, however, because viruses do not have enzymes of their own which can be inactivated. Viruses live within the body cell and make use of the enzymes already present.

Since enzymes are important in all metabolic activities of the cells, scientists believe there must be a close interrelationship of the enzymes with hormones, but little is known in this field.

No enzyme has yet been synthesized in the laboratory. However, a partial laboratory synthesis of the enzyme ribonuclease that catalyzes ribonucleic acid (RNA) has been reported. RNA is the substance that carries the genetic code, allowing an organism to reproduce itself. Ribonuclease is the first enzyme whose structure and exact arrangement of the molecule have been determined.

Industrial Importance

Aside from their importance in body metabolism and disease, enzymes have wide use in industry, especially in food technology. Because of their rapid action at low temperature and the small concentration necessary, they have a great advantage commercially.

They are of major industrial importance in the tanning of hides and the production of beer. Enzymes for industrial purposes are obtained from plant, animal and bacterial sources, the last of the three being the most important because of availability. Some proteases and amylases, enzymes essential for digestive processes, are commercially available and are widely used in such products as meat tenderizers, preparation of syrups and in some pharmaceutical compounds.

Digestion of Foods

In the laboratory enzyme activity is most readily observed in the digestion of foods. The saliva contains ptyalin, a salivary amylase, which starts the breakdown of carbohydrates into sugars.

Results of enzymatic action on starches can be observed by chewing a piece of bread or other starchy food and then testing for starch. The action of invertase, which breaks down sucrose (sugar) into the simpler sugars, glucose and fructose can also be shown in the laboratory.

Enzymes convert the food we eat into smaller units—into forms usable by our body cells. The food we eat would be completely useless to us if the enzymes that reduce carbohydrates to simple sugars, proteins to small molecules of peptides, and fats into lipids and glycols were absent.

Extensive research is being carried on at the National Institutes of Health as well as at many other research establishments on the biochemistry of enzymes and their relation to diseases. Industrially, organizations such as the Wallerstein Company, Staten Island, N. Y., are active in the field of food technology.

The first Enzyme Center in the United States was recently established at Tufts University School of Medicine, Boston. The major purpose of this facility is to step up the production of enzymes and make them available for research.

Our life depends upon these molecular structures, the enzymes, but very little is yet known about their complex mechanisms or how they function, or how they are synthesized.

In 1800, it is said, the French Academy of Sciences offered a prize of one kilogram of gold for the best answer to the question,

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"What is the difference between ferments and the materials they are fermenting?" But the prize has not yet been claimed. When this is known, man may be a step closer to the answer to the greatest question of all, "What is life and what is the spark that sets it into motion?"

A start in the study of the complex system of enzyme activity for the young scientist is given in the THINGS of science unit on Enzymes. The experimental kit (No. 269) is available at 75¢ each from THINGS of science, 1719 N St., N.W., Washington, D. C. 20036.

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AVIATION

Portable Air Aid Beacon Ready for Marines

➤ A LAND beacon that can be moved about quickly to give navigation signals to aircraft has been designed for the U.S. Marine Corps for use in "brush fire" combat.

Developed by International Telephone and Telegraph Corporation Federal Laboratories in Nutley, N. J., the Tacan (tactical air navigation) beacon can be transported by helicopter, truck or even towed over the ground. It can be set up and operating within 15 minutes.

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Nature Note

➤ THE FINGERS of country boys are stained, these days, as though they were starting to turn Indian, beginning at the edges. Walnuts are ripe.

The black walnut tree is an American species, having its range throughout the eastern half of the country, reaching its best development in the Ohio River Basin where it may grow as tall as 150 feet.

Its thick-husked, hard-shelled, tasty nuts are very much in demand today, especially for use in such desserts as candy and cake. But the fruit of the tree is insignificant when compared to the hard, heavy, straight-grained durable wood that is valuable for cabinet-making, veneers, furniture, piano cases and many other things.

In pioneer days, a family that moved west was especially proud if it could claim a mahogany dresser or piece of furniture. Abraham Lincoln and many pioneer farmers split black walnut wood for fence rails and nothing else.

Today the walnut forests are diminishing, however, and walnut furniture carries the same distinction as mahogany.

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