

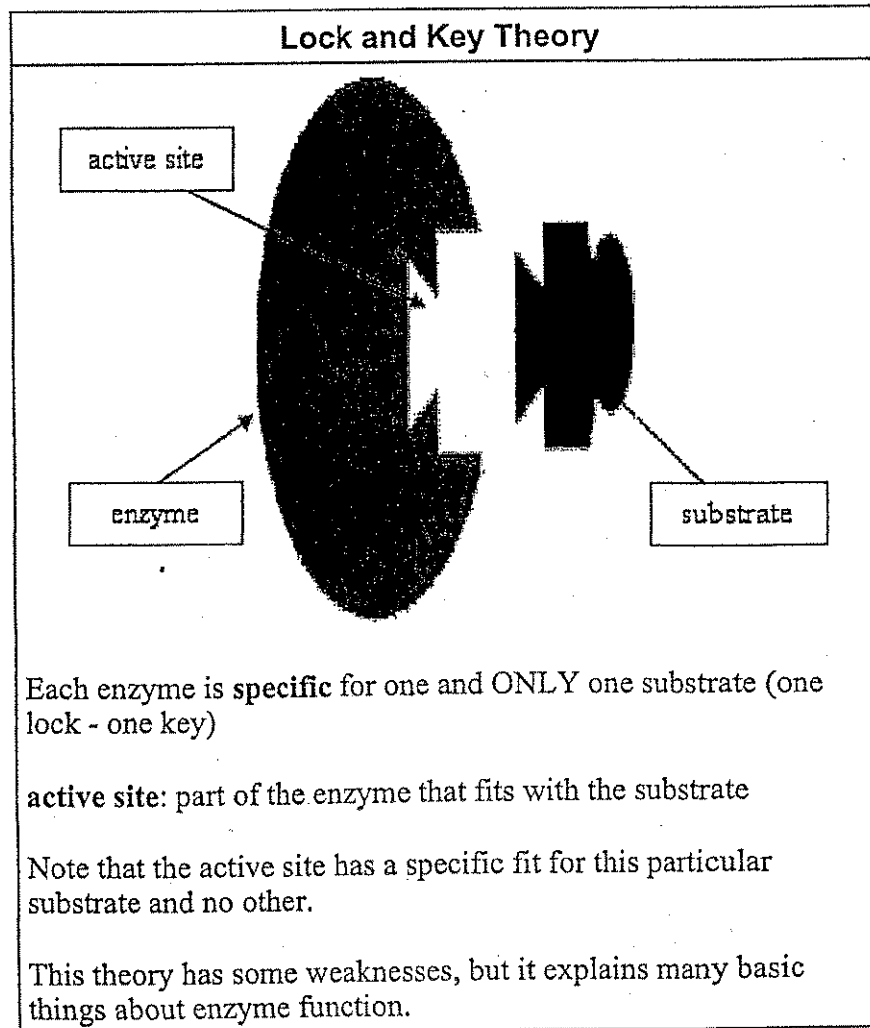
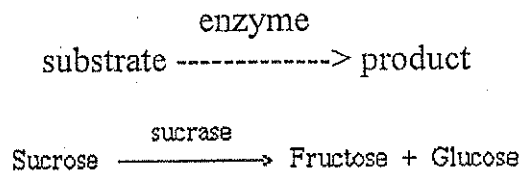
catalyst: inorganic or organic substance which speeds up the rate of a chemical reaction without entering the reaction itself.

enzymes: organic catalysts made of protein.

- most enzyme names end in -ase
- enzymes lower the energy needed to start a chemical rx. (activation energy speeding the reaction)

How do enzymes work?

substrate: molecules upon which an enzyme acts. The enzyme is shaped so that lock up with a specific substrate molecule.

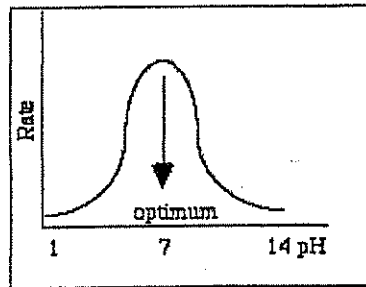


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Since the enzyme may unhook from the substrate, it may be reused many times.

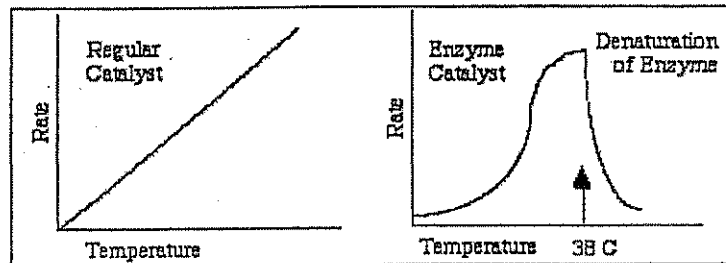
Factors Influencing Enzyme Activity

pH: the optimum (best) in most living things is close to 7 (neutral). High or low usually slow enzyme activity



Temperature: strongly influences enzyme activity

- optimum (best) temperature for maximum enzyme function is usually about 37°C
- reactions proceed slowly below optimal temperatures
- above 45°C, most enzymes are **denatured** (change in their shape so the enzyme site no longer fits with the substrate and the enzyme can't function)

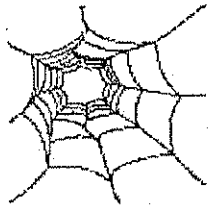


Concentrations of Enzyme and Substrate

When there is a fixed amount of enzyme and an excess of substrate molecules the reaction will increase to a point and then level off.

This leveling off occurs because all of the enzyme is used up and the excess substrate has nothing to combine with.

If more enzyme is available than substrate, a similar reaction rate increase and level-off will occur. The excess enzyme will eventually run out of substrate molecules to react



This unit is an explanatory page, referenced by several units dealing with the action of enzymes. As such it has a slightly different format than most units on this website - for example it does not lead directly on to the "next topic" in a sequence.

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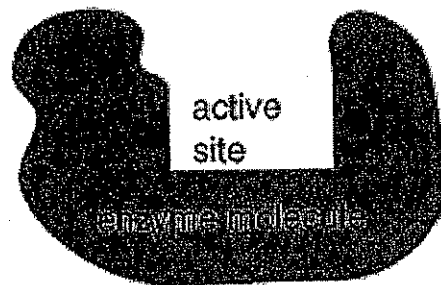
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How enzymes work

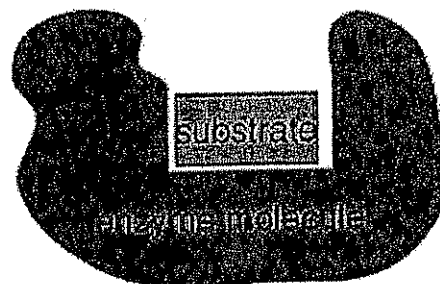
Essential points about enzymes :

- all enzymes are **proteins**
- each enzyme has a **specific catalytic action**
- their **normal activity** depends on their environment
- **abnormal conditions** cause reduced activity

1 Enzymes are globular proteins - their molecules are round in shape. They have an area - usually thought of as a pocket-shaped gap in the molecule - which is called the **active site**. Some enzymes are found inside cells (intracellular enzymes), and some - especially digestive enzymes - are released so they have their effects outside the cell (extracellular enzymes). *The accompanying diagrams are intended to illustrate a generalised account of the action of digestive enzymes.*

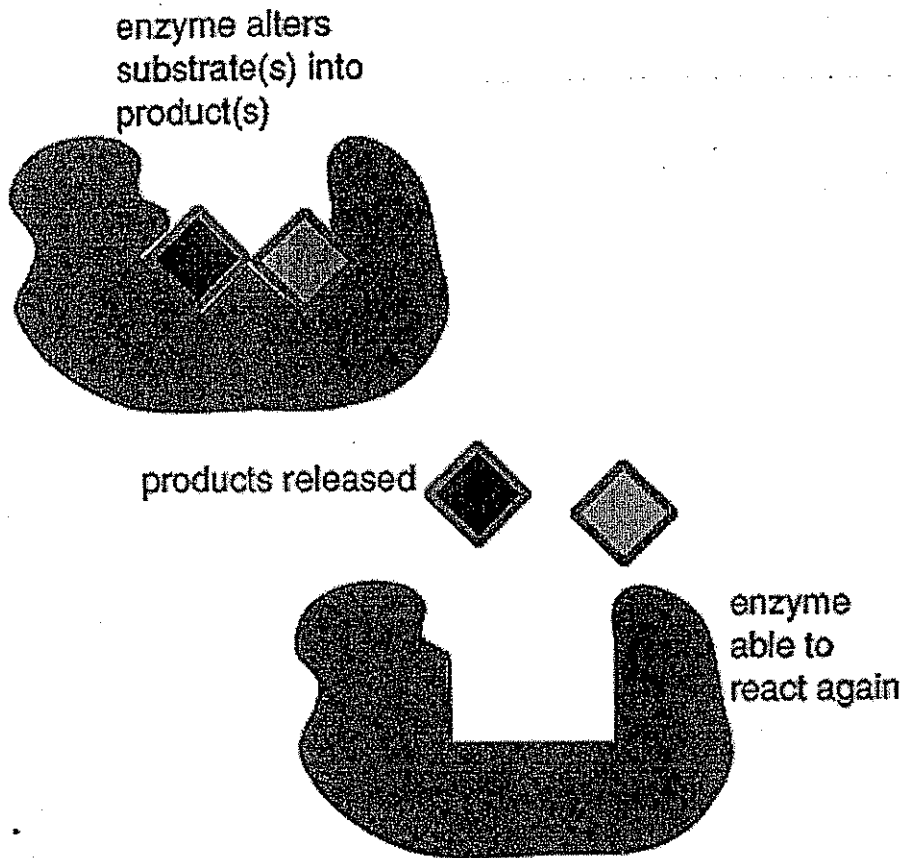


2 (Only) the substrate (or substrates) fits/fit into the active site. There are several types of enzyme which contribute to different types of biochemical reaction - *see below*. It is not widely appreciated (even by some teachers!) that water is also a reactant in the digestion (enzyme-controlled breakdown) of most biological molecules.



The enzyme speeds up the process of conversion of substrates (reactants) into products - usually so much that the reaction does not take place in the absence of enzyme.

Although the enzyme obviously joins with the substrate for a short while, the enzyme and substrate split apart afterwards, releasing the enzyme. Thus the enzyme is not used up in the process (unlike the substrate(s)), so it can continue to react if more substrate is provided.



3 Within the normal range, changes in temperature, pH, and concentrations of substrate and enzyme affect the rate of reaction in accordance with predictable interactions between enzyme and substrate molecules.



- The effects of temperature may be explained on the basis of kinetic theory - increased temperature increases the speed of molecular movement and thus the chances of molecular collisions, so within a narrow range (often 0-45 °C), the rate of reaction is proportional to the temperature. It is often said that an enzyme's rate of reaction doubles for every 10° C rise in temperature. In this respect, the biochemistry of enzymes is similar to chemistry as studied elsewhere. However, the interaction between this positive effect of increased temperature and the negative effect described below results in a different situation, so that enzymes may be said to have an **optimum temperature** for their action.

- Changes in the pH probably affect the attraction between the substrate and enzyme, and thus the efficiency of the conversion process. Often, there is an optimum pH - near to pH 7 (neutral) in

intracellular enzymes, and either in the acidic range (perhaps pH 1- 6) or in the alkaline range (pH 8-14) for different digestive enzymes.

- Some enzymes work better if other substances are also present. Some enzymes (pepsin - from the stomach) work better if acid is present (see above), and some, e.g. lipases are more effective if emulsifying agents are present because they break up the substrate into smaller droplets.

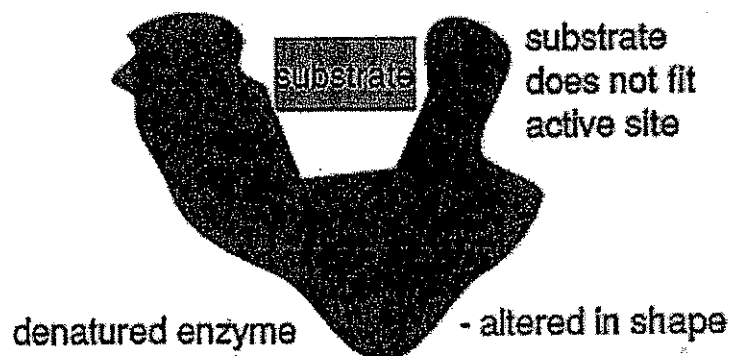
4 Above normal temperatures (say 60 °C), heat alters irreversibly the enzyme molecule. This denaturation is due to molecular vibrations (caused by heat) which change the shape of the protein, altering the folding and internal cross-linkages in its polypeptide chains. These changes - especially in the region of the active site - mean that the enzyme is inactivated, even when returned to normal temperature.



It would be wrong to say that an enzyme is KILLED by heat, since it is only a molecule, not an organism.

However, misconceptions of this sort are easily spread (see the BASC enzymes booklet!)

The higher the temperature to which the enzyme is subjected and the longer the heating is continued, the greater the proportion of damaged enzyme molecules and the result is that the conversion process becomes less and less efficient.



Below normal temperatures, enzymes become less and less active, due to reductions in speed of molecular movement, but this is reversible, so enzymes work effectively when returned to normal temperature.

Enzymes are sometimes adversely affected by other chemical substances which combine with them, either at their active site or by altering the overall shape of their molecule. Many drugs and poisons have their effect in this way.

Click [here](#) for more information about enzymes.

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What Are Enzymes?

Enzymes are a delicate lifelike substance found in all living cells, whether animal or vegetable. Enzymes are energized protein molecules necessary for life.

They catalyze and regulate nearly all biochemical reactions that occur within the human body. Enzymes turn the food we eat into energy and unlock this energy for use in the body. They can not be seen with even the most powerful microscope, but their presence and strength can be determined by improved blood and immune system functions. There are three types of enzymes. Our bodies naturally produce two types, **digestive** and **metabolic enzymes** as they are needed, while **food enzymes can only be consumed orally.**

METABOLIC ENZYMES:

speed up the chemical reaction within the cells for detoxification and energy production. They enable us to see, hear, feel, move and think. Every organ, every tissue, and all 100 trillion cells in our body depend upon the reaction of metabolic enzymes and their energy factor. Metabolic enzymes are produced by the liver, pancreas, gallbladder and other organs. **In short, metabolic enzymes are the energy enzymes**

DIGESTIVE ENZYMES:

are secreted along the digestive tract to break food down into nutrients and waste. This allows nutrients to be absorbed into the blood stream and the waste to be discarded. **Human digestive enzymes include ptyalin, pepsin, trypsin, lipase, protease, and amylase.** The body does not make cellulase, an enzyme necessary for proper digestion of fiber, so it must be introduced through the raw foods we eat. **Without proper amounts of these enzymes our body cannot remove all the waste and will become toxic**

METABOLIC ENZYMES:

are introduced to the body through the raw foods we eat and through consumption of supplemental enzyme fortifiers. Raw foods naturally contain enzymes providing a source of digestive enzymes when ingested. However, raw food manifests only enough enzymes to digest that particular food, not enough to be stored in the body for later use. **The cooking and processing of food destroys all of its enzymes.** Since most of the foods we eat are cooked or processed in some way and since the raw foods we do eat contain only enough enzymes to process that particular food, our bodies must produce the majority of the digestive enzymes we require. **For these reasons it is recommended that we supplement our diet with enzymes.**

What do Enzymes Do?

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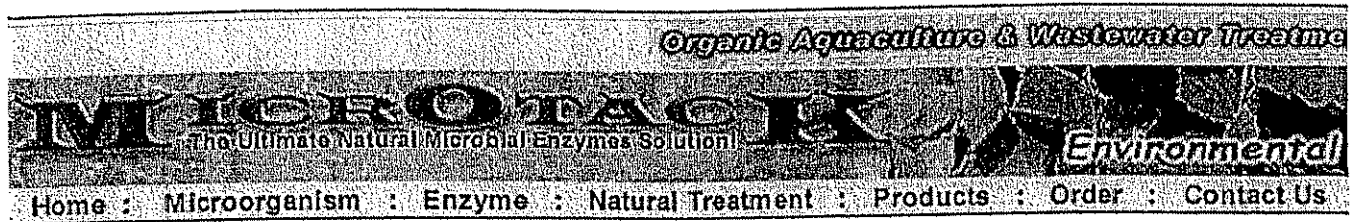
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How Are Enzymes Named?

One researcher reports treating grain, sorghum or barley with the enzyme "gumase" while another reports the same with the enzyme "beta-glucanase". When methodologies are examined, it is discovered that both of these preparations are the same product. Unfortunately, this apparent contradiction in terms happens often. Enzymes have been named by several methods and this fact has been known to cause confusion in their classification. For example, common or "trivial" names of enzymes, generally contain a prefix representing the name of the substance or substrate upon which they act or affect, followed by the suffix "ase". The "ase" simply denotes or identifies that the substance is an enzyme. Examples of this system of nomenclature includes the enzyme that catalyzes the conversion of proteins into their component amino acids, the name of this enzyme is "protease" or "proteinase".

Another example is the enzyme that accelerates the breakdown of the two components of starch into sugars. The components of starch are known as "amylose" and "amylo-pectin", thus, the enzyme helping to break them down is called "amylase". Confusion may exist, however, when older names of enzymes are used. Included in these older terms are ficin, pepsin, bromelin and trypsin, which are older trivial names of individual types of protease preparations, the enzymes that accelerate digestion of proteins. There are also many sub-classes of enzymes. Amylases are a prime example; subclasses of amylase include: alpha-amylase, beta-amylase, and gluco-amylase, to name a few. All these enzymes do is accelerate the digestion of starch and are broadly classified as amylases, but their actions are all slightly different in nature.

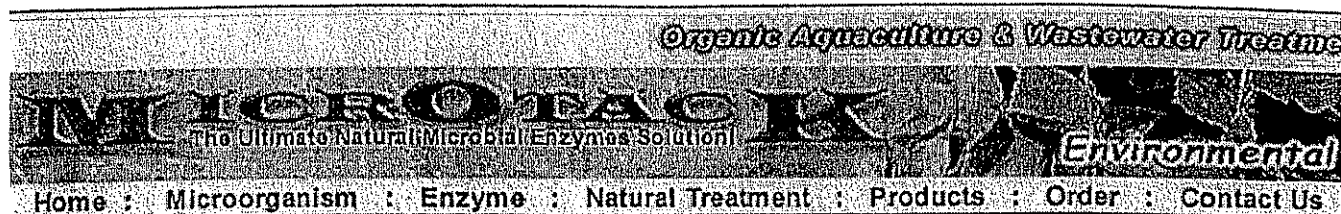
To help sort this out, the International Union of Biochemistry in 1961 proposed a system for enzymes' classification and naming which is finding acceptance mainly in this discussion. One example of this system, however, is the term: "alpha 1, 4-glucan glucanohydrolase" which is a name for alpha-amylase.

All these systems of nomenclature may become confusing to someone who has use for only a few types of enzymes or uses them for industrial or agricultural purposes. Therefore, the use of the more widely known terms such as "amylase" and "protease" are more or less universally in these fields. It should be remembered, however, that there are many types of enzymes that fit into these broad categories that may be more or less suitable for specific agriculturally related application. The final selection for a specific application should be made only after consulting a knowledgeable individual well-versed in the technical aspects of the particular enzyme requirements and applicable characteristics.

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**Sub Contents ;**[How Do Enzymes Function?](#)[How Are Enzymes Named?](#)[Where Do Enzymes Come From?](#)[How Are Enzymes Produced?](#)[Activity and Stability of](#)[Enzymes?](#)[\[Enzyme Main Menu \]](#)**How Do Enzymes Function?**

Enzymes are "biological catalysts." "Biological" means the substance in question is produced or is derived from some living organism. "Catalyst" denotes a substance that has the ability to increase the rate of a chemical reaction, and is not changed or destroyed by the chemical reaction that it accelerates.

Generally speaking, catalysts are specific in nature as to the type of reaction they can catalyze. Enzymes, as a subclass of catalysts, are very specific in nature. Each enzyme can act to catalyze only very select chemical reactions and only with very select substances. An enzyme has been described as a "key" which can "unlock" complex compounds. An enzyme, as the key, must have a certain structure or multi-dimensional shape that matches a specific section of the "substrate" (a substrate is the compound or substance which undergoes the change). Once these two components come together, certain chemical bonds within the substrate molecule change much as a lock is released, and just like the key in this illustration, the enzyme is free to execute its duty once again.

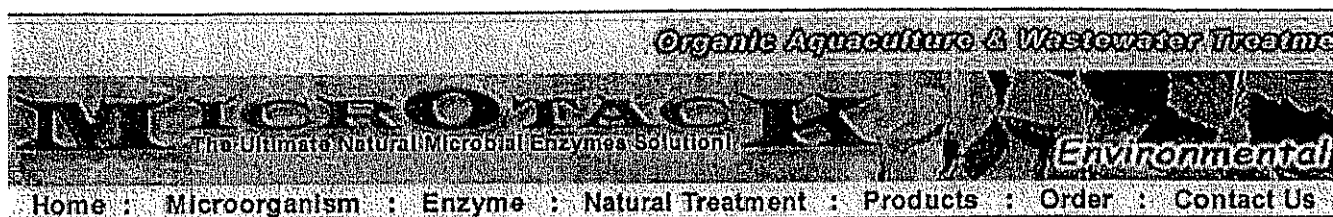
Many chemical reactions do proceed but at such a slow rate that their progress would seem to be imperceptible at normally encountered environmental temperature. Consider for example, the oxidation of glucose or other sugars to useable energy by animals and plants. For a living organism to derive heat and other energy from sugar, the sugar must be oxidized (combined with oxygen) or metabolically "burned".

However, in a living system, the oxidation of sugar must meet an additional condition; that oxidation of sugar must proceed essentially at normal body temperature. Obviously, sugar surrounded by sufficient oxygen would not oxidize very rapidly at this temperature. In conjunction with a series of enzymes created by the living organism, however, this reaction does proceed quite rapidly at temperatures up to 100°F (38°C). Therefore, enzymes allow the living organism to make use of the potential energy contained in sugar and other food substances.

Enzymes or biological catalysts allow reactions that are necessary to sustain life proceed relatively quickly at the normal environmental temperatures.

Enzymes often increase the rate of a chemical reaction between 10 and 20 million times what the speed of reaction would be when left uncatalyzed (at a given temperature).

Nutrients locked in certain organics are complex macromolecules, or in hard-to-digest matrices may be released or predigested by a high degree of heat or

**Sub Contents ;**[How Do Enzymes Function?](#)[How Are Enzymes Named?](#)[Where Do Enzymes Come From?](#)[How Are Enzymes Produced?](#)[Activity and Stability of Enzymes?](#)[\[Enzyme Main Menu \]](#)**What Affects the Activity and Stability of Enzymes?**

Waste processing levels usually dictate some variation in physical conditions under which the enzyme products must function. In order to utilize enzymes to their optimal potential in catalytic ability, we must be familiar with the basic principles that can affect the activity and stability of these enzymes. Enzymes, being biological compounds and being comprised of a high percentage of protein, are subject to many environmental effects. Although the following principles hold true for most biological enzymes produced for commercial agricultural use:

The pH of the environment has a profound affect on enzyme activity and stability. Activity optimal for pH's of various enzymes vary; however, the optimal pH's for the biological catalysts produced by most commercial strains of microorganisms lies between pH 4.0 and 7.5. This range is from moderately acidic to mildly alkaline in nature. These are the pH levels normally encountered. Figure 1, indicates a difference in activity levels that various enzymes exhibit at varying pH levels.

Another major affect of enzyme activity and stability is temperature. Since enzymes are biochemical catalysts, made up at least partially of protein, they are sensitive in varying degrees to heat. Raising temperatures of the environment generally multiplies the degree of activity by the enzyme. Once an optimum temperature has been reached, however, even higher temperatures cause rapid degradation of the enzyme with concurrent and irreversible loss in activity. Optimal temperatures generally range from 98 °F to 140 °F (37 °C to 60 °C) for most hydrolytic enzymes. High temperatures (over 150 °F, 66 °C) generally have detrimental effects on the enzymes. However, there is broad variation in resistance and sensitivity to heat among the enzymes' types. Bacterial enzymes such as those from *Bacillus subtilis* are less sensitive to heat than are the fungal enzymes of *A. oryzae*. Some amylase preparations prepared by the fermentation of *Bacillus* species can withstand even boiling for short periods and have optimal activities in the 158 °F - 176 °F (70 °C-80 °C) range. Our laboratory has determined that approximately 85% of the activity from *Bacillus subtilis/licheniformis* alpha-amylase survives high heat. *A. oryzae* amylases, however, showed a greater than 90% loss activity in high heat. When the enzyme-bearing, dried fermentation products of these two microorganisms are kept dry, they are much more resistant to environmental temperature stress than if they are moistened. In fact, very few stability problems are encountered with most enzymes in typical situations.

Basic Knowledge of Enzymes Applied

Making use of general knowledge about enzymes including how they act, under what conditions they perform, and how to preserve their activity is important in applying the technology of enzymes to organic waste digestion.