

Understanding Bacteria and Enzymes

The adaptable nature of bacteria makes it possible to exploit particular strains for their beneficial qualities. The natural biodegradation of organic waste can be greatly enhanced by the introduction of naturally occurring, non genetically engineered, non pathogenic bacteria. Biodegrading "specialists" are scientifically selected for their exceptional enzyme production and long term stability. In the natural environment, both bacteria, and the enzymes they produce, play a significant part in biodegradation: Bacteria produce the enzymes essential for metabolizing the food source (organic waste) into energy necessary for further growth of the living organism. Enzymes facilitate the phase of metabolism in which complex compounds are broken into simpler ones (catabolism). This, in turn, speeds the process of converting the food source into an available energy supply for bacterial growth and reproduction (and continuous enzyme production).

A. BACTERIA

- 1. General Background** Although some bacteria may cause certain diseases, many more bacteria are not only harmless, but they actually are very beneficial. The positive influence of these numerous useful microscopic organisms in our biosphere is incalculable. For example, without bacteria, the soil would not be fertile (and all plants and animals ultimately are dependent upon soil fertility for life sustaining materials). Various species of bacteria are concerned in the decomposition of organic matter, fermentation, and the fixing of atmospheric nitrogen. Many of the common bacteria of air, soil and water are capable of digesting dead organic materials, proteins, carbohydrates, fats and grease, and cellulose breaking them down to simpler molecules and in utilizing these substances. This impressive ability of bacteria as a group to produce such a great diversity of biochemical changes and end results constitutes one of the outstanding facts of the natural world.
- 2. Rate of Multiplication** Given reasonable and suitable conditions for growth, the rate of asexual multiplication of bacteria is very rapid; it has been found that a cell divides every 20 to 30 minutes. So, assuming that conditions are conducive to a rate of one division every 30 minutes, a single individual cell will have produced 4 cells at the end of the first hour, 16 at the end of two hours, and about one million (1,000,000) at the end of fifteen (15) hours. Thus, when products containing millions of selected bacteria per milliliter are introduced under suitable conditions, the eventual bacterial growth is astronomical, and, by virtue of the presence of such great numbers of efficient, beneficial bacteria, the presence and growth of less productive and often harmful, naturally occurring bacteria are greatly reduced by competitive exclusion. Simply stated, the selected, introduced bacteria are more efficient and out compete the naturally occurring bacteria for the food source.
- 3. Conditions Affecting Growth of Bacteria**

- a. Food requirements.** Bacteria must obtain from their environment all nutrient materials necessary for their metabolic processes and cell reproduction. The food must be in solution and must pass into the cell.
- b. Temperature.** For every bacterium, there are certain cardinal points of temperature at which growth is most rapid. Although different bacterial species differ widely, the optimum growth temperature for most bacteria lies between 5° C and 55° C (41 ° F to 131 ° F). Growth may slow at temperatures below 5°C (41 ° F) and cell damage may occur at temperatures above 60° C (140° F). The ordinary cells (non spores) are damaged at temperatures of 60° to 80° C (122° F to 140° F); hence a single boiling of a fluid or even pasteurization (application of a heat of 63° C or 145° F) is sufficient to eliminate them. Bacterial spores, however, must be subjected to very prolonged heating at higher temperatures before they are distressed.
- c. pH.** Each bacterium has a pH range within which growth is possible. Growth will occur in environments that have pH values between 4.5 and 10; the optimum pH value differs greatly between species but an environment kept close to neutral (pH 7) will sustain most bacterial species.
- d. Moisture.** Bacteria require moisture. The importance of moisture for bacterial growth will be seen clearly if it is realized that bacteria have no mouth parts and all their food must be absorbed in a soluble form by the process of diffusion through the cell wall; without sufficient moisture, therefore, the inflow of food and the outflow of excreta becomes impossible.
- e. Oxygen.** Bacteria of various kinds exhibit wide differences in their relation to oxygen of the air. Some need oxygen for respiration and cannot grow unless it is provided. These are known as aerobes. Others grow only in the absence of free oxygen and are unable to use it in their respiration, they are called anaerobes. Still others can grow under either condition and are termed facultative.

B. ENZYMES

- 1. Introduction** Bacteria exhibit great diversity in their physiological activities. The energy necessary for carrying on cell activity and the building materials needed for the formation of new cells during multiplication is secured in a variety of ways. The acquisition of energy and materials, in turn, is related in large measure to the different enzymes produced by various bacteria.
- 2. Examples of Enzyme Action** Many enzymes are discharged from the cells that produce them and, therefore, function outside the living cells ("extra cellular"). For example, the secretions of the digestive tract of animals contain many such extra cellular enzymes. All of the enzymes of the digestive tract act to convert the complex molecules of food into smaller, simpler molecules which are easier to take into the bacterial cell. The process of degradation is called hydrolysis. This degradation, which involves the conversion of solids into water soluble substances, and of large water soluble molecules into smaller ones, is the essence of the process of digestion.

C. SPORE FORMATION Some bacteria are able to form spores. Spores are formed usually when conditions become unsatisfactory for active metabolism and for cell reproduction. Bacterial spores are extremely stable, and resistant to heat, drying, light, disinfectants and other harmful agents than the original vegetative bacterial organism. Spores may survive for many years. When more suitable conditions present themselves, the spore germinates and again develops a cell similar to the one that originally formed the spore. This new cell, under favorable conditions of moisture, temperature, pH and food supply, begins active metabolism, reproduction, and enzyme production.

D. CONCLUSION Bacteria in nature actively compete for nutrients and the most successful species in a given habitat will be those capable of best utilizing the conditions that prevail. The introduced, specially selected, beneficial, problem solving bacteria dominate the system they are added to, and safely and economically resolve problems by eliminating the source of the problem (the organic waste is broken down, digested and metabolized). Odors are reduced by eliminating their source; and as a result, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (S/S), and Volatile Fatty Acids (VFA) are reduced; and the primary byproducts of this microbial degradation are water (H₂O) and carbon dioxide (CO₂).

----- BASIC DEFINITIONS
Aerobic Bacteria: Bacteria that require the presence of oxygen to live and function.
Anaerobic Bacteria: Bacteria that do not require the presence of oxygen to survive they are capable of living and

functioning in the absence of oxygen. **Bacteria:** Any of a group of diverse, ubiquitous, microscopic single celled microorganisms. **Biochemical Oxygen Demand I(BOD):** The amount of oxygen that is required/consumed by bacteria during the digestion of the organic waste in water. BOD is a relative measure of water quality since the higher the BOD, the greater the amount of organic waste in the water. Surcharges and fines are based on the BOD levels of the wastewater. **Biodegradation:** The digestion of organic substances by biological action, a process usually involving microbes, particularly bacteria. **Chemical Oxygen Demand (COD):** The amount of oxygen that is required/consumed during the digestion of organic waste by chemical means. COD is a relative measure of water quality since the higher the COD, the greater the amount of organic material in the water. **Chemotaxis:** The ability of an organism, in this case bacteria, to detect and move toward a particular chemical. Selected bacteria exhibit positive chemotaxis and move toward higher levels of biochemical food sources. This ability is particularly advantageous when the goal is the efficient digestion of organic materials. **Colony Forming Unit I(CFU):** The standard microbiological method used to count bacteria. The number of viable cells that give rise to a colony of bacteria on a suitable agar medium. **Enzyme: (a/k/a non living chemical catalyst):** Any of various complex organic substances originating from living microorganisms, and capable of producing certain chemical changes in organic substances by catalytic action. Enzymes are the chemical catalysts of living cells. **NOTE:** While bacteria metabolize a wide variety of organic material, enzymes are substrate specific. For example: Protease enzyme catabolizes ("breaks down") protein Amylase enzyme breaks down starch and carbohydrate Lipase enzyme breaks down fat and grease Xylanase enzyme breaks down plant material (xylan) Cellulase enzyme breaks down cellulose Urease enzyme breaks down urea **Facultative Bacteria:** Bacteria that are capable of living and functioning either in the presence of oxygen or absence of oxygen. **Microbial Degradation:** The beneficial activities selected of bacteria in carrying out biodegradation. **Motile:** Capable of motion. Selected bacteria are motile, enabling them to move about their immediate environment. **Spore:** The inactive/dormant, protected/resistant form that some bacteria can temporarily assume, when conditions are not satisfactory for active metabolism and cell reproduction. **Suspended Solids (SS):** Particles of organic waste suspended in water. The levels of SS are often used to indicate water quality. **Volatile Fatty Acids I(VFA):** Volatile Fatty Acids are the compounds primarily responsible for the "sour" or "rancid" odors emanating from decaying organic material. The presence of high levels of VFA's are indicative of inefficient microbial degradation of organic waste.

About the Author

Leo is the developer of [Earths Balance](http://earthsbalance.com), an Earth friendly company leveraging the science of probiotics and other natural remedies to benefit people, pets and planet. You can learn more by visiting <http://earthsbalance.com>

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