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Biocatalysts

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When a century ago researchers started to work with enzymes, microorganisms, or cell extracts as biocatalysts (i.e., biochemical catalysts) they never imagined that this field will become one of the most exciting and innovative research subjects in the last years.

Biocatalysts were originally described as natural substances (i.e., enzymes) that initiate or modify the rate of a chemical reaction in a live body. Nowadays, this term is far broader because the use of protein engineering techniques to assist in the creation of enzymes for unusual intermediates in synthetic chemistry, as well as the advance of molecular biology, high-throughput tools, and bioinformatics that help to overcome new complex issues. Science progresses quickly in areas related to the development of novel biocatalytic methods, including biocatalytic retro synthesis, modular biocatalysts, bioinformatics, molecular biology, nanoscale methodologies, protein engineering, molecular design, and advanced X-ray techniques. Biocatalysts play a prominent role in the quest for new solutions to existing problems such as new vaccines for chronic diseases, decrease of environmental pollution, new environmentally friendly fuels, stronger and biodegradable materials, and purification of contaminated water.

The remarkable chemical characteristics that possess the enzymes derived from plants, microorganisms or animal tissues are relevant for their biocatalytic activities. For example, biocatalysts are chemo-, regio-, enantio-, and diastero-selective [1] and they are used in the synthesis of enantiopure drugs by immobilized lipase-catalysis [2], in the transformation of nucleoside derivatives into anti-cancer drugs [3], or in the asymmetric reduction of substituted acetophenones [4] to produce large amounts of enantiopure alcohols for the agrochemical and pharmaceutical industries. On the other hand, the vast amount of data stored on protein databases can be used in the development of biocatalysts that are compatible with extreme reaction conditions such as extreme temperatures, high ionic concentrations, or sudden changes in pH. We must take into consideration not only the existing biocatalysts but also new enzymes or bacteria living in extreme environments (i.e., extremophiles), which present unique characteristics (e.g., resistance to very high or low temperatures, high salinity, high alkalinity, high acidity, and to high levels of ionizing radiation) and could be used in the development of new compounds or procedures. For example, the thermo alkaliphilic catalase isolated from the bacteria *Thermusbrockianus* is capable of breaking down the hydrogen peroxide into oxygen and water and it is stable at high temperatures (30-94 °C) and pH (6-10). This catalase will be able to remove hydrogen peroxide from textile bleaching industrial processes, or could be used to obtain oxygen. These reasons, and the statement that biocatalysts are environmentally friendly, explain why this research area is so dynamic.

Dedicated efforts, from both academic and industrial realms, have been paramount in the development of novel biocatalysts (e.g., isolated enzymes or engineered whole cells – an entire group of genetically modified cells) with important uses in the food industry [5], DNA replication and cloning, diagnostic tests and biosensors [6], nanomaterial production, breakdown of nerve agents (e.g., organophosphates) [7], desulfurization of fossil fuels [8], and intermediate compounds that are used in the development of active molecules [9]. An important goal is to reduce the time and to optimize the synthetic process or isolation of enzymes. The fabrication of enzymes obtained by using modern biotechnologic techniques will be less expensive than other design synthesis approaches.

As scientists we try to emulate and understand the surrounding nature, and we are always amazed by the intrinsic beauty of each biological process. We want to learn from Mother Nature how to produce biocatalysts that can benefit the humanity. Our investigations, based on the synergy between science and life, will achieve this dream in the near future.

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