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Guest editorial

The release of man-made chemicals and their subsequent behavior in the environment has been a subject of serious concern for several decades. The names of compounds such as PCB's, DDT, and pentachlorophenol do not remind one of the potentially useful applications for which these compounds were synthesized, but instead evokes the notion of detrimental chemicals that pollute the environment. The widespread distribution and the toxic properties of xenobiotics may disturb ecosystems and threatens groundwater and drinking water quality. The persistence of synthetic compounds in the environment must be attributed to one key factor: the lack of biodegradation.

Poor biodegradation of xenobiotics also has a profound influence on the feasibility of biological treatment processes. Local contamination of soil, groundwater, and wastewater is in principle very well amenable to biological cleanup, a cost effective technology if rapid degradation can be achieved. However, degradation is often very slow, and a main problem is the lack of organisms that can carry out the necessary biotransformation reactions.

The above practical problems make it extremely important to understand the scientific basis of recalcitrance and degradability. In general, rapid biodegradation requires three conditions to be fulfilled. First, the environmental conditions must be suitable for the type of organisms that carry out the degradation process. Depending on the biochemistry of the compounds present, this may be anaerobic or aerobic, low or high pH, etc. A second requirement is that the pollutant comes into contact with the organisms or suitable extracellular enzymes. This seems trivial, but in practice it can be the most difficult step, as is evident from experience with the treatment of contaminated soils. Third, the compounds must be intrisically degradable, i.e. microorganisms that produce biocatalysts that carry out the degradative ractions, should exist, and must be present or added. The first two conditions can often be met by chosing a suitable process technology. The last prerequisite is the area of the microbiologist. With many synthetic compounds, it is this third condition of intrinsic biodegradability that is critical. It is also this aspect that distinguishes many synthetic compounds from most natural compounds.

Industrial synthesis of the type of xenobiotic organic compounds that now are often recognized as causing pollution problems started about 100 years ago, when synthetic dyes appeared on the market. Organic synthesis is carried out in organic solvents, and these solvents are another group of bulk chemicals that are widely used and cause contamination of wastes and the environment. Later, building blocks for polymer synthesis, agrochemicals, plasticizers, detergents, synthetic oils and many more came on the market. Some of these compounds are degraded rapidly, others appeared to be very resistant. Many routes for chemical synthesis are accompanied by the formation of side products, which are usually disposed of as wastes.

The problem of intrinsic recalcitrance to biodegradation must in the first place be regarded as a problem of enzyme specificity and activity. Many degradative processes that could rapidly proceed from a thermodynamic point of view, do not occur in practice. Rapid degradation requires microorganisms that produce a set of catabolic enzymes to derive energy and carbon (or nitrogen, sulfur) for the synthesis of cellular material. Usually, synthetic compounds are transformed via a series of enzyme catalyzed reactions to compounds that are normal intermediates of cellular metabolism and on which growth of many organisms is possible. Since enzymes tend to be specific for a certain structure or a closely related group of structures, it is in priciple unlikely that a microorganism will produce all the enzymes necessary for the mineralization of synthetic compounds that did not occur on earth in significant concentrations when enzyme specificity developed during the course of evolution. Thus, one can expect that microorganisms have to recruite catabolic pathways for the degradation of synthetic compounds, either by combining different genes from organisms that produce enzymes that can catalyze certain catabolic steps, or by modifying the specificity of catabolic enzymes. The study of the genetics and biochemistry of catabolic pathways is therefore of great importance. From a scientific point of view, it contributes to our understanding of how molecular and microbial evolution proceed in response to a new environmental stress. Studying the genetics of catabolic pathways often gives a clue about recent evolutionary events. From an applied point of view, this type of research provides insight in the intrinsic possibilities and limitations of biological detoxification processes. Furthermore, the development of more dedicated adaptation strategies and the design and genetic construction of catabolic pathways for compounds that are recalcitrant at this moment are based on a detailed understanding of the genetics and biochemsitry of existing pathways. These principles are worked out in detail in the articles that follow.

It is the purpose of this *Special Issue of Biodegradation* to provide an up-to-date overview of the current knowledge on the genetic and biochemical aspects of the degradation of a number of representative and important compounds, including compounds relevant for cometabolic conversion reactions. The compounds covered include aliphatic and aromatic hydrocarbons, nitrogen-, halogen-, and phosphorus-containing chemicals, and PCB's. The reviews illustrate that an analysis of the genetics of a pathway can lead to important conclusions about mechanistic aspects of catabolic steps and the evolution of pathways. The last 3 papers illustrate the importance of genetic exchange and the construction of organisms with novel catabolic properties.

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Guest Editor