Preface

When the publisher of this book asked me to contribute to a new series of leading-edge books in the area of biotechnology, I was honoured to accept the task and as a result of an intense e-mail exchange we agreed that a multi-contributor book was the best choice for a work on marine enzymes for biocatalysis. Indeed, for such a new topic a multi-contributor book is the key to have direct expert views at hand. However, this could be seen as an obstacle to producing a tool of wide assistance to diverse users: individual entrepreneurs, looking to expand their investment (e.g. biocatalyst production from marine waste material); pharmaceutical companies (e.g. biocatalytic improvement of synthetic steps); and researchers in the private and public sector, in relation to their different needs about how in-depth the analysis of the topic should be. In addition, graduate students pursuing careers in chemistry, pharmaceutical or biology sciences, were also seen as potential readers of this book.

At the end of this preparatory work I am proud to have had the opportunity to work with all the contributors of this collective effort. I feel certain that not only specialists within academic and industrial circles interested in new enzymes for biocatalysis, but also a less-specialized audience will find this book useful.

The marine ecosystem is the largest habitat on Earth, representing 70% of the surface of our planet. Oceans include the greatest extremes of temperature, light and pressure and habitats can range from tropical waters to ocean trenches at impressive pressure, several kilometers below sea level. These diverse marine environments still remain largely unexplored, understudied and underexploited in comparison with terrestrial ecosystems and organisms. Marine organisms are sources of natural bioactive substances with potential therapeutic activity, and as a consequence they should also be valued as a source of enzymes offering new and surprising catalytic activities to be applied in biocatalysis. The uniqueness of marine biocatalysts characterizes biocatalytic processes taking advantage of habitat-related properties such as salt tolerance, hyperthermostability, barophilicity, cold adaptivity, etc. Evolved

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properties such as substrate specificity, affinity, etc., are linked to the metabolic functions of the enzymes and to ecological assets related to the natural source. But novelty brought out by marine enzymes is more pervasive; new properties can in fact be discovered at the molecular level of catalysis, especially concerning close stereochemical details of reaction.

In the 'Introduction' section of this book, a general examination of the nature and level of interest in marine biological diversity, of the fundamentals of biocatalysis, of the stability of marine biocatalysts and of their applications to the biosynthesis of fine chemicals, are analysed in single dedicated chapters. The 'Sources' section provides traditional and modern strategies to get access to marine enzymes. Analysis of applicative examples of marine enzymes from a chemical and stereochemical viewpoint of catalysis better reveals the full potential of marine bioprospecting and this aspect is covered in the last section of the book 'Bioprocesses and biocatalytic characteristics'.

Professor Claire Armstrong and co-workers from the Department of Economics and Management, University of Tromsø, Norway, in the opening chapter have outlined a brief history of marine bioprospecting, illustrating the activity in the field today with regard to marine enzymes and pharmaceuticals. The discussion of topics of interest is held in the light of an ecosystem service and valuation framework, also for the analysis of public investment in bioprospecting activities. In Chapter 2 *Peter Lau and Stephan Grosse* from the National Research Council, Montreal, Canada, have been able to convey the fun before the fundamentals of biocatalysis showing the importance of this approach in our industrialized world striving for sustainability for the provision of goods and services to mankind. In addition, the tutorial flavour in presenting the basic parameters defining a biocatalytic reaction, cannot be neglected. A molecular approach for considering marine biocatalyst stability, especially regarding psychrophilic enzymes, is handled in Chapter 3 by *Professor Sambasiva Rao* and *Krishna Kanth Pulicherla* from the Department of Biotechnology, Acharya Nagarjuna University, Nagarjunanagar, India, and a general focus on marine enzymes applied to biosynthesis of fine chemicals is illustrated in Chapter 4 by *Jennifer Littlechild* and *Halina Novak* from the College of Life and Environmental Sciences in Exeter. The enzymes discussed include haloperoxidases, dehalogenases, alcohol dehydrogenases, L-aminoacylases, proteases, esterases and lipases.

In the body of the four chapters of the section 'Sources of marine enzymes', *Alan Dobson* and colleagues from the Marine Biotechnology Centre of Environmental Research Institute at University College in

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Cork, Ireland, start by explaining the challenges in accessing, exploring, and exploiting the potential reservoir of the marine environment. They remark that the major obstacle to date has been the limited capacity to culture marine microbes and details about genomic and metagenomic technologies that are now offering promising new strategies for marine biodiscovery. In the subsequent chapter *Professor Joydeep Mukherjee* and co-workers from the School of Environmental Studies, Jadavpur University, India, has focused on the attempts made to translate novel marine enzymatic activities into commercial bioprocesses. *Professor Satya P. Singh* and colleagues from the Department of Biosciences, Saurashtra University, India, in the two final chapters of this part analyse the population dynamics, diversity, phylogeny and biocatalytic potential of the entire microbial community of the saline ecosystems in the first chapter, and the rapidly increasing interest in the extremophilic actinomycetes, the studies on their diversity, enzymatic profiling, physiology and adaptive features, in the second. The actinomycetes are traditionally explored from soil for their valuable secondary metabolites. However, the actinomycetes from the aquatic ecosystems have been explored only in the limited sense and in recent years, novel examples from the various marine habitats have been isolated. These marine actinomycetes produce different types of new enzymes.

A few words on the complexity of marine environments should be added here. This complexity ranges from symbiotic relationships to biology and chemistry of defence mechanisms and from chemoecology of marine invasions up to the strategies found in prokaryotes to adapt to extreme environments. The interdisciplinary study of this complexity, promoted in this book, will enable researchers to find an arsenal of enzymes and pathways greatly demanded in biotechnological applications.

The third section of the book includes examples of bioprocesses focusing on biocatalytic characteristics. Generally speaking, there is a large technological interest in hydrolytic enzymes in the processing of organic material for exploitation as food or animal feed. Marine enzymes are recognized as advantageous in the hydrolysis of organic waste coming from seafood farming. Interesting examples are found in the chapters by *Professor T. Ojima* (Chapter 13) and *Professors K. Konno* and *Y. Tian* (Chapter 9) from Hokkaido University, Japan, concerning common squid and scallops that are important marine resources in their country, especially in Hokkaido. Proteolytic and carbohydrate active enzymes are of interest in the waste materials from the processing of these foods. Marine bioprocesses based on carbohydrate active enzymes are well known as described not only in the chapters above but also when

discussing how marine organisms cope with osmotic stress, in Chapter 17 by *Professor M.S. da Costa* and colleagues from the University of Coimbra, Portugal, and when focusing on polysaccharide degrading enzymes from marine bacteria in Chapter 16 by *Professor Mirjam Czjzek* and *Gurvan Michel* from the Station Biologique de Roscoff, CNRS.

The importance of other classes of enzymes is detailed in Chapter 10 by *Professor D. Zhu* and co-workers from the Institute of Industrial Biotechnology of Chinese Academy of Sciences, intended to summarize recent advances in the asymmetric synthesis including hydroperoxylation, hydroxylation, epoxidation, reduction, reductive amination, hydrolysis of epoxides and esters, and transglycosylation. All these reactions are very important in biocatalysis for stereochemical output of reaction, thus a similar importance is fulfilled by Chapter 14 by *Professor Notomista* and colleagues from the University of Naples about obligate hydrocarbonoclastic bacteria that are a particularly rich source of enzymes for these type of reactions of industrial interest. As these marine hydrocarbonoclastic bacteria are relatively recent discoveries, and have a novel physiology, they might be expected to have enzyme repertoires that are so far unprospected and potentially interesting for the biocatalysed synthesis or modification of fine chemicals and added value compounds.

More specialized processes are described in the remaining chapters. Chapter 11 by *Professors Chandrasekaran* and *Beena* from the University of Science and Technology in Cochin, India, details tannase, a type of catalyst generally derived from terrestrial sources. Novel biocatalytic features of a marine tannase produced by *Aspergillus awamori* isolated from sea water are described in comparison with terrestrial tannases. Tannins, compounds widespread in edible fruits and vegetables, possess hydrolysable ester bonds. They are nutritionally undesirable as they form complexes with protein, starch and digestive enzymes leading to a reduction in the nutritional value of food. Tannases are acyl hydrolase involved in biodegradation of tannins and have important applications in various industries, particularly in food and pharmaceutical sectors.

Chapter 12 by *Professor Yamada* from Kagoshima University, Japan, reports on a series of imidazole-related compounds, such as carnosine, anserine, homocarnosine, etc., widely distributed in different tissues of terrestrial and aquatic vertebrates. The focus is on six kinds of vertebrate enzymes catalysing the biosynthesis and degradation of these dipeptides discussing possible biocatalytic applications of enzymes acting on imidazole-related dipeptides.

Ligninolytic enzymes from marine derived fungi are described in Chapter 15 by *Professors Sette* and *Bonugii-Santos* from São Paulo State

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University, Brazil. One of the most important current applications of these ligninolytic biocatalysts is in the environmental remediation domain to degrade or neutralize pollutants or to decolorize dyes via bio-based processes. Taking into account that much environmental pollution occurs in saline conditions, the use of marine-derived fungal enzymes can be considered strategic, since these micro-organisms are adapted to the marine ecosystem.