Preface

The relationship of molecular chirality and biology is intriguing. Our curiosity prompts the question as to why diverse natural biological molecules are overwhelmingly dissymmetric. Is it so that nature uses the dissymmetry of biological molecules to create specificity in the interaction with other molecules? Does the myriad network of interaction aim to control the functionality of a bewildering variety of molecular machines with ease, fidelity, and efficiency? If so, how? Whatever the answer is, eventually the orientation-dependent interaction between molecules in the confined state in biological systems is responsible for the manifestation of many fascinating properties.

Enzymes exhibit remarkable capacities for discrimination as they carry out life processes. Despite the amazing variety of the structure and function of the enzymes, it is expected that unifying principles exist in their structural organization. Evolution must have developed, retained, and continued to further develop these minimal features for the better efficacy of a reaction. Active site structures of enzymes are nanosized spaces. Their confined geometries are designed by evolution to recognize and capture the specific substrates, place them in favored geometry, and finally drive forward the formation of the product to continue life processes. It is tempting to look into the active site structure and the discrimination therein to understand how nature utilizes the chiral structures of molecules in carrying out vital biological reactions much more efficiently than the corresponding synthetic processes. The conserved features of the organization of the active site structure of enzymes indicate that a network of electromagnetic interactions controls the remarkable fidelity of the reaction. The pattern of interaction is an outcome of the intricate interplay of electrostatic (such as charge–charge, charge–dipolar, polar–polar, induction type, and hydrogen bonding, to name a few), hydrophobic, or van der Waals interactions. The network of interaction depends on the orientation-dependent arrangement of the active site residues around the reactants, and confinement of the reactants is important here. The evolutionary processes develop the structure of the active site and network of interaction in order to perform reactions with improved speed, accuracy,

and efficiency. With this perception in view, this book aims to provide the author's perspective about the influence of chirality in driving reactions within enzymatic cavities of nanodimension.

Chirality embraces numerous biological, biomimetic, and nonbiological systems, and the topic touches an extremely broad area of phenomena. Tremendous advances are being made in chirality-related fields using principles of physics, chemistry, biology, and mathematics. Often, chirality shows its manifestation in seemingly disparate phenomena. This book is not intended to provide a compendium of the wide variety of manifestations of chiralities in different systems, and no attempt is made to be exhaustive in this respect. Enzymes being the workhorses of the cells, their workings are of high significance and study in this field is greatly advancing. A vast body of literature exists about the chiral specificity of different enzymes. Since research on the stereoselectivity in enzymatic reactions is continuously growing, an anthology of stereoselectivity in enzymatic reactions is beyond the scope of this book. Consequently, if the reader is interested in learning about a specific class of enzyme, its structure, or biochemistry related to stereoselectivity, he or she is advised to look elsewhere for that information. On the other hand, readers will gain from this book a clear view of how the interactions between the active site residues and the substrate molecules influence reactions.

The author has written a brief review on the related topic in the *International Reviews in Physical Chemistry*, and his curiosity with the subject grew into this book. It was apparent during the time of writing the review, and still now, that there is a dearth of books that concentrate exclusively on the interaction of chiral molecules within the active site structure. This book evolved to fill this gap. It is intended primarily for graduate students, teachers, and researchers in the fields of chemistry, biology, medicine, pharmacy, and related interdisciplinary academia such as nanobiology and nanochemistry. One needs only basic ideas of intermolecular interaction as applicable to biophysical chemistry to make use of this book. The theoretical developments have been described at a simple, unsophisticated level throughout. As the subject is in a state of constant evolution and a comprehensive understanding is yet to be achieved in many arenas, constructive suggestions are most welcome.

It is our hope that the views presented in this book shall be further developed to design custom-made novel biocatalysts with better efficiency. Often a trial-and-error method is employed to develop synthetic enzymes, and the process is time consuming and expensive. A combination of crystallographic studies with electronic structure based computational analysis as described in this book may lead to future elucidation of new drugs that can target biological active sites with better efficacy.