

Prologue

Some historians of science are inclined to classify fields and their impact with a broad brush — we are told that chemistry was the science of the 19th century, physics the science of the 20th, and that biology is the science of the 21st century. Other historians, such as the renowned Thomas Kuhn, discussed the concept of a paradigm shift and defined a separation for the impact of concepts and tools. As a practicing scientist I, in fact, see a simpler picture with less of a chasm in the progress of science. Biology without concepts and tools from physics, chemistry, and now engineering, would be severely limited. Tools are as important as concepts and, at the end, the two amalgamate to change the way we observe and the way we think.

We may recall the impact on biology of tools such as X-ray diffraction, electron microscopy, and NMR. Related and equally significant is the central role of concepts, such as chemical bonding, dynamics of transition states, and molecular recognition, in elucidating mechanisms of biological activity. From biology, the tools of RNAi, PCR, site-directed mutagenesis, and gene knockout are opening up new avenues of chemical syntheses and physical studies. Similarly, concepts of complementarity, self-assembly, and collective interactions (coherence) of molecular machines are introducing to physics and chemistry challenges and opportunities in the realm of emergence and complexity.

This volume brings about the confluence of concepts and tools and that of different disciplines to address significant problems of our time in physical biology and adjacent disciplines. Specifically, the book is structured to provide a broad perspective on the current state-of-the-art methods and concepts at the heart of chemical and biological behavior, covering the topics of visualization; theory and computation for complexity; macromolecular function, protein folding and misfolding; molecular recognition; and

systems integration from cells to consciousness. The scope of tools is wide-ranging, spanning imaging, crystallography, microfluidics, single-molecule spectroscopy, and synthetic probe targeting, either molecular or by metallic particles. The perspectives are made by world leaders of physics, chemistry, and biology, and they define potential new frontiers at the interface of these disciplines, including physical, systems, and synthetic biology.

The book, which is the product of the 2007 Welch Conference on Chemical Research, is not a proceeding of reports and references. The articles are overviews, rather than reviews. They provide a panoramic view across areas of progress made, from revolutionary tools for the determination of extended structures to perspectives on 21st century biology and medicine. It was pleasing to welcome an audience of nearly a thousand people, surely reflecting the excitement about the contributions and the contributors. Personally, I wish to thank all the contributors who accepted our invitation and made this volume possible. Out of the twenty scientists invited to the conference, only John Walker was unable to travel at the time of the gathering in Houston on October 22, 2007. Two colleagues, Susan Lindquist of MIT and Julie Theriot of Stanford University, were invited but could not participate.

The Houston event would not have been possible without the generous support of The Welch Foundation and its leaders. The contribution to the organization made by the president of the foundation, Mr. Norbert Dittrich, and his staff, especially Ms. Carla Atmar, is greatly appreciated. Over the years, the Welch conferences have benefited from the wisdom of members of the Scientific Advisory Board, chaired formerly by the late Norman Hackerman and now by James L. Kinsey. As a member, I have enjoyed and benefited from the wide-ranging and stimulating discussions, which in one way or another have influenced the outcome of this endeavor. During this event we celebrated the achievements of two distinguished colleagues, Noel Hush and William Miller, who both received the 2007 Welch Award for their contributions to theoretical chemistry — their addresses are happily included in this volume.



(From left)

Norbert Dittich,
Ahmed H. Zewail
and James L. Kinsey.

The timely completion of this book demanded careful orchestration among all contributors while the editor was in Pasadena or on travel. Essential to this coordination was the support of my assistants at Caltech, De Ann Lewis and Maggie Sabanpan. De Ann's special effort from the realization of the conference to the completion of the book is highly valued. Ms. Sook Cheng Lim at World Scientific made a long trip from Singapore to Pasadena and the quality of the printed volume reflects her diligence and dedication to this project. Last but not least, I wish to thank Dr. K. K. Phua for his special care and enthusiasm for a prompt publication.

Ahmed H. Zewail
Pasadena, California
December 15, 2007