Arrow Pushing in Organic Chemistry

An Easy Approach to Understanding Reaction Mechanisms

Daniel E. Levy

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Dedicated to the memory of Henry Rapoport (1918–2002)
Professor of Chemistry, Emeritus
University of California — Berkeley
A true teacher and mentor

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Preface

Organic chemistry is a general requirement for most students pursuing degrees in the fields of biology, physiology, medicine, chemical engineering, biochemistry, and chemistry. Consequently, many of the students studying organic chemistry initially do so out of obligations to required curriculum rather than out of genuine interest in the subject. This is, in fact, expected as almost all college students find themselves enrolling in classes in which they either have no interest or cannot foresee application of the subject to their future vocation. Alternatively, there are students who are intrigued with the potential application of organic chemistry to fields including pharmaceuticals, polymers, pesticides, food science, and energy. However, whichever group represents the individual students, there is always a common subset of each that tenuously approaches the study of organic chemistry due to rumors or preconceived notions that the subject is extremely difficult and requires extensive memorization. Having personally studied organic chemistry, and tutored many students in the subject, I assure you that this is not the case.

When first presented with organic chemistry course material, one can easily be caught up in the size of the book, the encyclopedic presentation of reactions, and the self-questioning of how one can ever decipher the subject. These students frequently compile endless sets of flash cards listing specific chemical reactions and their associated names. Like many of my classmates, I began to approach the subject in this manner. However, this strategy did not work for me as I quickly realized that memorization of reactions did not provide any deductive or predictive insight into the progression of starting materials to products and by what mechanisms the transformations occurred. In fact, the fundamental fault in the "memorization strategy" is that in order to be effective, the student must not only memorize all chemical reactions and associated reaction names, but also all associated reaction mechanisms and potential competing processes. It was not until I abandoned the memorization strategy that I began to do well in organic chemistry and develop a true appreciation for the subject and how the science benefits society.

The presumption that introductory organic chemistry entails very little memorization is valid and simplifies the subject provided the student adheres to the philosophy that the study

of organic chemistry can be reduced to the study of interactions between organic acids and bases. From this perspective, organic chemistry students can learn to determine the most acidic proton in a given molecule, determine the most reactive site (for nucleophilic attack), determine the best reactants (nucleophiles and electrophiles), and how to predict reaction products. In learning to predict these components of organic reactions, the beginning organic chemist will be able to deduce reasonable routes from starting materials to products using the basic mechanistic types involved in introductory organic chemistry. Furthermore, through an understanding of how electrons move, extrapolations from ionic or heterolytic mechanisms can be used to explain free radical and electrocyclic processes. Finally, by utilizing the principles discussed in this book, the student will gain a better understanding of how to approach the more advanced reaction types discussed as the introductory organic chemistry course progresses.

The goal of this book is not to present a comprehensive treatment of organic chemistry. Furthermore, this book is not intended to be a replacement for organic chemistry texts or to serve as a stand-alone presentation of the subject. This book is intended to supplement organic chemistry textbooks by presenting a simplified strategy to the study of the subject in the absence of extensive lists of organic reactions. Through application of the principles presented herein, it is my hope that this book, when used as intended, will aid the beginning student in approaching organic chemistry as I did—with little memorization and much understanding.

DANIEL E. LEVY, PH.D.

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About the Author

Daniel E. Levy received his Bachelor of Science in 1987 from the University of California at Berkeley where, under the direction of Professor Henry Rapoport, he studied the preparation of 4-amino-4-deoxy sugars and novel analogs of pilocarpine. Following his undergraduate studies, Dr. Levy pursued his Ph.D. at the Massachusetts Institute of Technology. Under the direction of Professor Satoru Masamune, he studied sugar modifications of amphotericin B, the total synthesis of calyculin A and the use of chiral isoxazolidines as chiral auxiliaries. In 1992, Dr. Levy completed his Ph.D. and has since worked on various projects involving the design and synthesis of novel organic compounds. These compounds include glycomimetic inhibitors of fucosyl transferases and cell adhesion molecules, peptidomimetic matrix metalloproteinase inhibitors, carbocyclic AMP analogs as inhibitors of type V adenylyl cyclase, heterocyclic ADP receptor antagonists, and inhibitors of calmodulin-dependent kinase. Dr. Levy is currently the director of synthetic chemistry at Intradigm Corporation in Palo Alto, California.

Arrow Pushing in Organic Chemistry is Dr. Levy's third book. In 1995, Dr. Levy co-authored a book entitled *The Chemistry of C-Glycosides* (1995, Elsevier Sciences). Collaborating with Dr. Péter Fügedi, Dr. Levy developed and presented short courses entitled "Modern Synthetic Carbohydrate Chemistry" and "The Organic Chemistry of Sugars," which were offered by the American Chemical Society Continuing Education Department. With Dr. Fügedi, Dr. Levy co-edited his second book entitled *The Organic Chemistry of Sugars* (2005, CRC Press).