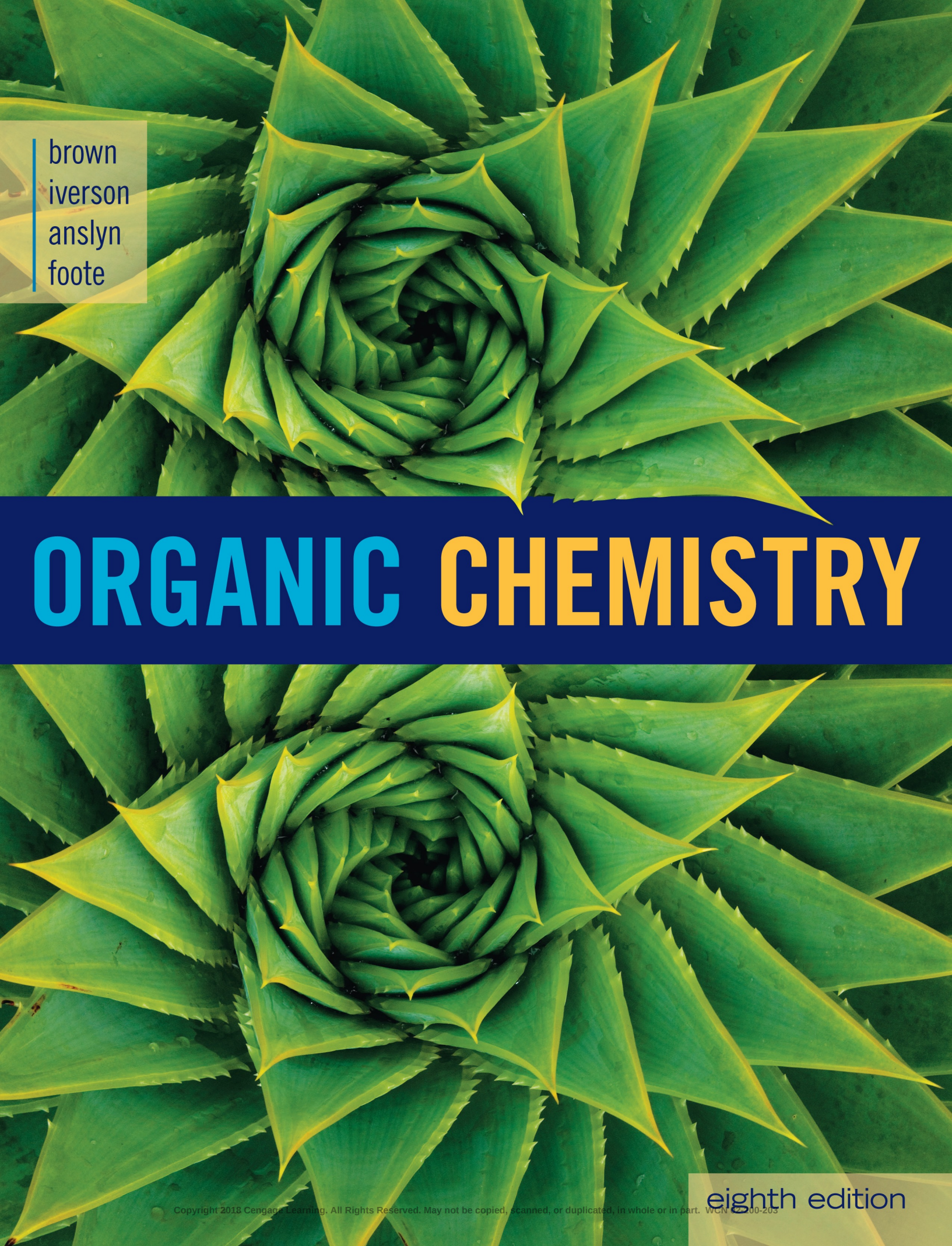
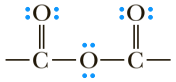
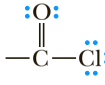
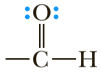
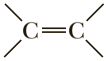
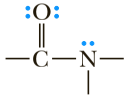
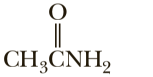
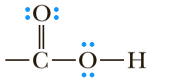
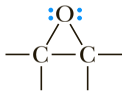
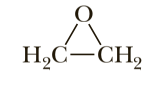
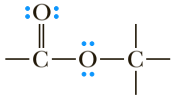
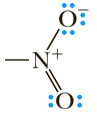
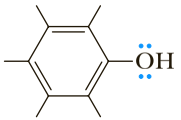
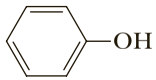


Some Important Organic Functional Groups

	Functional Group*	Example	IUPAC Name
Acid anhydride			Ethanoic anhydride (Acetic anhydride)
Acid chloride			Ethanoyl chloride (Acetyl chloride)
Alcohol		CH_3CH_2OH	Ethanol (Ethyl alcohol)
Aldehyde			Ethanal (Acetaldehyde)
Alkane	------	CH_3CH_3	Ethane
Alkene		$CH_2{=}CH_2$	Ethene (Ethylene)
Alkyne	$-C{\equiv}C-$	$HC{\equiv}CH$	Ethyne (Acetylene)
Amide			Ethanamide (Acetamide)
Amine, primary		$CH_3CH_2NH_2$	Ethylamine
Amine, secondary		$(CH_3CH_2)_2NH$	Diethylamine
Amine, tertiary		$(CH_3CH_2)_3N$	Triethylamine

	Functional Group*	Example	IUPAC Name
Carboxylic acid			Ethanoic acid (Acetic acid)
Disulfide	$-S-S-$	CH_3SSCH_3	Dimethyl disulfide
Epoxide			Oxirane (Ethylene oxide)
Ester			Methyl ethanoate (Methyl acetate)
Ether	$-O-$	CH_3OCH_3	Dimethyl ether
Haloalkane	$-X:$ X = F, Cl, Br, I	CH_3CH_2Cl	Chloroethane (Ethyl chloride)
Ketone			Propanone (Acetone)
Nitrile	$-C{\equiv}N:$	$CH_3-C{\equiv}N$	Ethanenitrile (Acetonitrile)
Nitro		CH_3NO_2	Nitromethane
Phenol			Phenol
Sulfide	$-S-$	CH_3SCH_3	Dimethyl sulfide
Thiol	$-S-H$	CH_3CH_2SH	Ethanethiol (Ethyl mercaptan)

* Where bonds to an atom are not specified, the atom is assumed to be bonded to one or more carbon or hydrogen atoms in the rest of the molecule.

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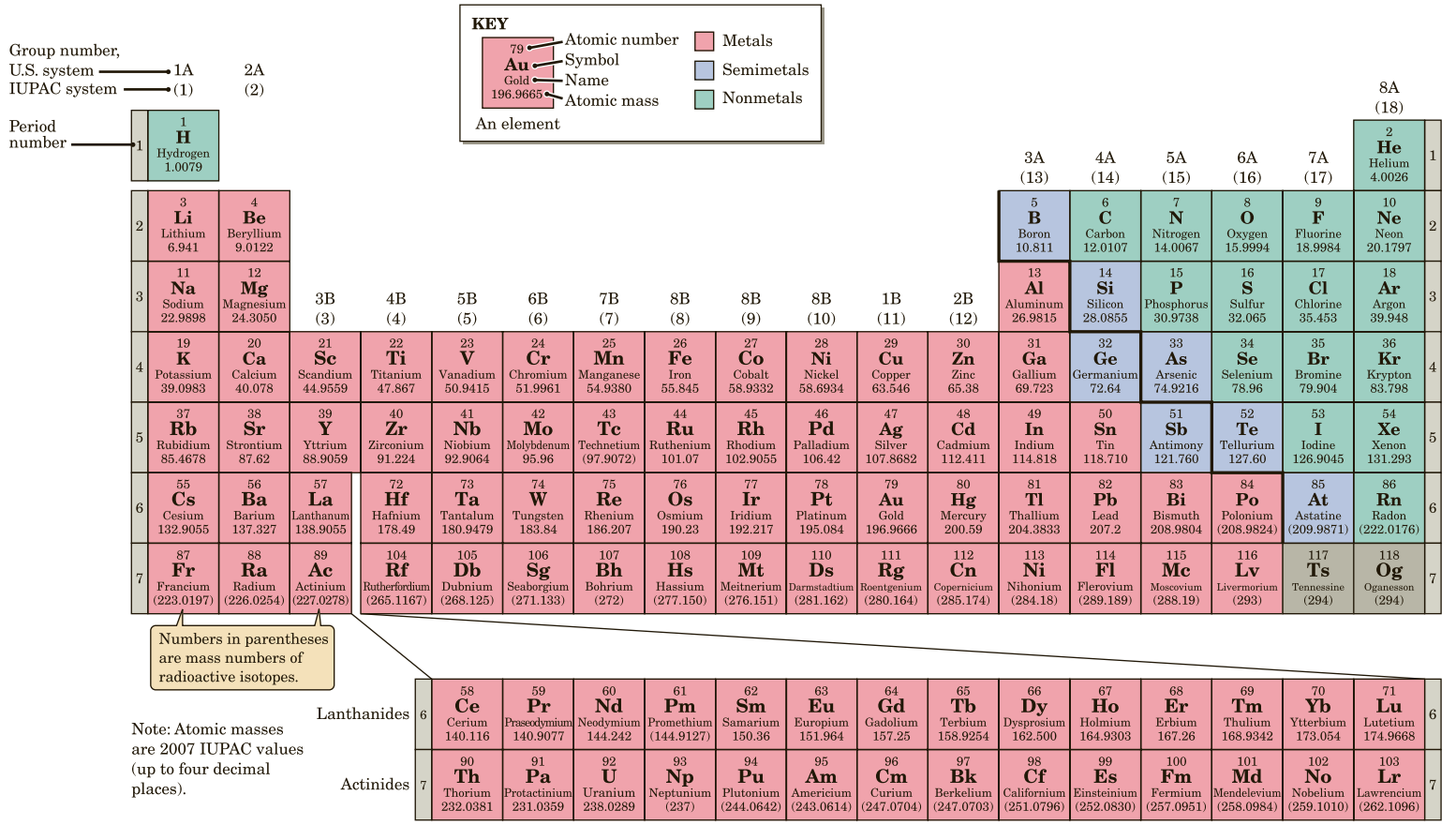
Periodic Table of the Elements



Organic Chemistry

Eighth Edition

William H. Brown
Beloit College, Emeritus

Brent L. Iverson
University of Texas, Austin

Eric V. Anslyn
University of Texas, Austin

Christopher S. Foote
University of California, Los Angeles

Chapter 29 was originally contributed by
Bruce M. Novak
University of Texas at Dallas

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William H. Brown, Brent L. Iverson, Eric V. Anslyn, Christopher S. Foote

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Dedication

This Eighth Edition is dedicated to the memory of our dear friend and colleague, Christopher Foote. Chris's insights, encouragement, and dedication to this project can never be replaced. His kind and nurturing spirit lives on in all who are lucky enough to have known him.

About the Authors

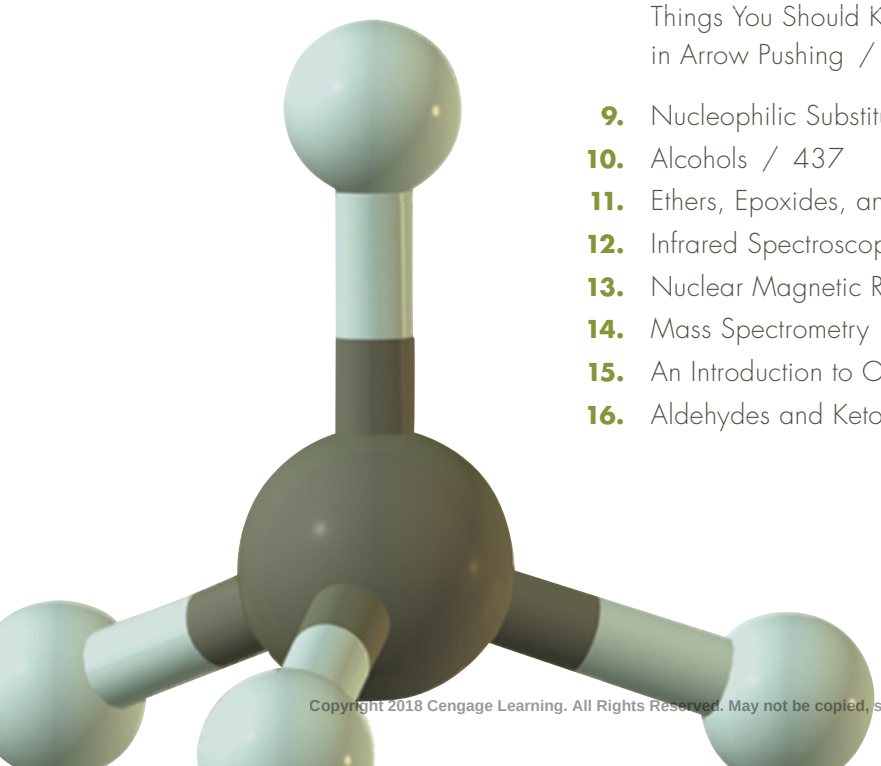
William H. Brown is an Emeritus Professor of Chemistry at Beloit College, where he has twice been named Teacher of the Year. His teaching responsibilities included organic chemistry, advanced organic chemistry, and special topics in phar-macology and drug synthesis. He received his Ph.D. from Columbia University under the direction of Gilbert Stork and did postdoctoral work at the California Institute of Technology and the University of Arizona.

Brent L. Iverson received his B.S. from Stanford University and his Ph.D. from the California Institute of Technology. He is a University Distinguished Teaching Professor and the Dean of the School of Undergraduate Studies at the University of Texas at Austin as well as a respected researcher. Brent's research spans the interface of organic chemistry and molecular biology. His group has developed several patented technologies, including an FDA-approved treatment for late-stage anthrax.

Eric V. Anslyn received his B.S. from California State University, Northridge, and his Ph.D. from the California Institute of Technology. He is the Norman Hackerman Professor and a University Distinguished Teaching Professor at the University of Texas at Austin. Eric's research focuses on the physical and bioorganic chemistry of synthetic and natural receptors and catalysts.

Christopher S. Foote received his B.S. from Yale University and his Ph.D. from Harvard University. His scholarly credits include Sloan Fellow; Guggenheim Fellow; ACS Baekland Award; ACS Cope Scholar; Southern California Section ACS Tolman Medal; President, American Society for Photobiology; and Senior Editor, Accounts of Chemical Research. He was a Professor of Chemistry at UCLA.

Contents in Brief



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Preface

Learning Through Understanding

The best way to master organic chemistry is to develop an intuitive understanding of basic principles, then understand how to apply those principles to new and increasingly complex situations.

The learning of organic chemistry is analogous to putting together a complex jigsaw puzzle and at least two distinct approaches can be imagined. The first approach, reflecting the way many students unfortunately approach their first organic chemistry class, is to memorize each new piece of the puzzle individually, with no context, and then try to blindly guess where it is to be placed by trial-and-error. We can all agree that a much better approach to finishing a jigsaw puzzle (as well as learning organic chemistry) is to keep the overall picture of the completed puzzle in mind and then evaluate each new piece being considered in the context of where it might fit into the emerging image. This book has been written in alignment with the far more effective second approach to learning by providing a strong foundation of basic concepts at the beginning, then constantly referring to a "big picture" understanding as each new concept and functional group is presented in context. To accomplish this, the eighth edition builds upon two key innovations from previous editions that teach students *how* to learn two of the most important elements of organic chemistry, namely mechanisms and synthesis.

- **Mechanisms** We present a revolutionary paradigm for learning organic chemistry mechanisms. Students are introduced to a small set of individual mechanism elements, and importantly, *when* each of these mechanism elements is to be used. The four most important of these elements are *"Make a bond between a nucleophile and an electrophile," "Break a bond to create stable molecules or ions," "Add a proton," or "Take a proton away."* Reaction mechanisms throughout the book are written in stepwise fashion and described as logical combinations of the individual mechanism elements. This new approach not only simplifies the learning of mechanisms for students but also makes it easier for them to recognize similarities and differences between related reactions. Most important, this approach makes the *prediction* of reaction mechanisms a straightforward, multiple-choice situation in which the correct mechanism element for a given step of each new reaction mechanism is systematically chosen from a small menu of choices.
- **Synthesis** We present another important innovation in organic chemistry learning that we refer to as the Organic Chemistry Reaction Roadmap. It is a graphical

representation of the different organic reactions taught in the context of the important functional groups. The functional groups of an organic chemistry roadmap are analogous to cities on a real roadmap, and the reactions are like the roads between those cities. Arrows are used to represent known routes between functional groups, and the reagents required to bring about each reaction are written next to the corresponding arrow. Multistep synthesis questions are often very challenging for organic chemistry students even though synthesis is at the core of organic chemistry as a discipline. The power of the organic chemistry reaction roadmap is that it helps students visualize the reactions that are appropriate to interconvert key functional groups in multistep synthesis problems. The construction and use of organic chemistry reaction roadmaps are introduced in the end-of-chapter problems beginning in Chapter 6 and presented in complete form inside the back cover of this book, which students can tear out and use.

What's New for the Eighth Edition?

There are four new features in the eighth edition, each intended to enhance dramatically student engagement and learning. We are excited to introduce almost 100 videos, which are lessons from the authors in an audio/visual format that take students through the working of example problems and important graphics. In other words, most of the key lessons from the book. We also introduce three other new features designed to enhance student learning and test preparation: (1) "**Things You Should Know**," (2) **Margin bullets** emphasizing and reinforcing key foundational ideas that recur throughout the book, and (3) the most comprehensive **end-of-chapter "Study Guides"** of any text that recap the key ideas, lessons, homework problems, and reactions of each chapter.

- **Videos** The authors are particularly excited by the addition of almost 100 short videos in MindTap to accompany the eighth edition. These new audio/visual features are specifically intended to bring the material in the text to life. The videos provide students with an on-demand resource that covers much of the most difficult and important material. Icons in the margin of the text indicate to students when a video is available to better explain an example problem or key figure.
  - In the videos, Eric Anslyn and Brent Iverson, the two lead authors, discuss the material in an interactive fashion, reminiscent of the NPR program "Car Talk" with Click and Clack, the Tappet Brothers. While undoubtedly not quite as amusing as that classic program, the students should get a feeling for the love of organic chemistry shared by both authors, their strong bond of friendship, and of course most important—key ways to think about organic chemistry.
  - This feature is forward looking, because the authors presume that textbooks will become increasing interactive, having aspects to their structure that bring the authors and students closer and more connected, while also making the topics increasingly more interesting, live, and thereby easier to grasp. After all, experiencing a video explanation that includes dynamic graphics as well as verbal discussions and banter is substantially more engaging and informative than reading and examining graphics on the written page. We believe that this extensive collection of groundbreaking new videos will help propel the college textbook publishing industry into a future in which student learning is supported by a seamless combination of text, videos, and assigned problems.
- **Things You Should Know** There are important transitions between distinct topics in the sequence of the book that are good places to stop, reflect, and take

stock of what has been learned, while looking forward to the next set of chapters. At such transitions, we have now included five primers that we call "Things You Should Know." By pulling these key topics out from the chapters, we keep the flow of the chapters moving, while emphasizing topics that permeate several of the future chapters. If students read and fully digest these primers, they will be well prepared to approach the discipline of organic chemistry including all the material in subsequent chapters.

- For example, after Chapter 1 we have "Things You Should Know I, General Conclusions from Quantum Mechanics," which primarily recaps lessons and principles from quantum mechanics or other essential pieces of information that the students must use to understand molecular structure, properties, reactions and mechanisms. Such lessons include "Delocalization of charge over a larger area is stabilizing," and "Delocalization of π electron density over a larger area is stabilizing." Note that several of these lessons and principles cannot be fully explained unless students move on to advanced classes where the basis of these lessons are taught, yet we still need students to use them in introductory organic chemistry courses.
- As another example, after Chapter 5 we have a Things You Should Know section that contrasts the terminology "Brønsted/Lowry Acids/Bases," "Lewis Acids/Bases," and "Nucleophiles/Electrophiles." All of these terms can be used to describe similar kinds of chemical reactions, and understanding which is appropriate in a given scenario is often unclear to students. We give straightforward guidelines for when to use the different terms.
- As a third example, prior to Chapter 17 we summarize the common reaction types that are about to be explored in the next three chapters in a primer called "Things You Should Know V, Carboxylic Acid Derivative Reaction Mechanisms."

- **Margin Bullets** To emphasize that many of the fundamental lessons of organic chemistry continue to guide the discussions of topics in future chapters, we now place in the margins a series of bullet points derived from the first primer "Things You Should Know I, General Conclusions from Quantum Mechanics." The idea is to emphasize for students that the same fundamental principles are used to explain patterns of molecular structure, properties and reactivity throughout the text.
- **End-of-Chapter "Study Guides"** One of the largest structural changes to the book is a reimagining of the synopsis sections of the chapters into concise end-of-chapter "Study Guides." Instead of simply a recap of the material, it is now laid out in a fashion that takes the students through topics with simple bulleted lessons, explanations, and with graphic summaries all of the key reactions related to that specific topic. Representative end-of-chapter problems are listed for each section, directing students to questions that test the knowledge being summarized. These chapter summaries can be seen as "crib notes" that the students carry with them, continually refer to, and guide their study when preparing for exams. As an added bonus, there are two related appendices that students find particularly helpful: "Summary of Stereochemical Terms" and "Summary of the Rules of Nomenclature," both of which compile all the information students need to know about these important topics in a convenient, single location.

Other Important Features

Several important additional features of the book have been retained because they foster student learning.