HOW TO SUCCEED IN ORGANIC CHEMISTRY

JOHN E. GORDON, Ph.D.

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JOHN E. GORDON, Ph.D.

Department of Chemistry
Kent State University

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Acknowledgments

In a very real sense this is a book by students, for students. I listened, reacted, and organized, but the material itself originated in student response to organic chemistry and was repeatedly plowed back into successive courses, where many generations of students made their contributions in turn. Irene Brownstone, the series editor, helped improve not only the language and organization, but the logic and the science as well.

To the Reader

Today's textbooks are better than ever, but they leave out one thing—they don't tell you *what to do* to learn organic chemistry successfully. Neither do the study guides that accompany the textbooks. This guide tells you what to do and how to do it.

You can use this book as a supplement to your organic course; as a guide for independent study; or as a self-instructional review for achievement tests (GRE, MCAT). Whatever your purpose, look first at Unit 1, where you will find practical and detailed plans for using this book and learning organic chemistry.

Several hundred students have already contributed to the improvement of this guide by commenting on their experience with it. If you would like to make suggestions for its future development, please address them to:

Editor, Self-Teaching Guides
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New York, NY 10016

To the Instructor

Using this guide as a textbook supplement in the organic class can help you in several ways. By taking over repetition of worked-out examples and answering many questions not answered by the text, it should free some class time for other purposes. This guide provides a concrete and individualized self-study method that you can recommend to students who need more help than you can provide during office hours. It will be especially helpful in pulling the poorly prepared student through the first part of the course. By improving students' notational skills, it makes them better able to concentrate on content. Unit 1 gives students a detailed, practical plan for learning organic chemistry. The Cross-Reference Chart on pages xii to xv keys this guide to whatever textbook you are using in your organic chemistry course.

Suggestions for further improvements in this guide are welcome. Please write to:

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Cross-Reference Chart

To locate the units of this guide that you may want to consult in studying the various chapters of the following textbooks, consult the chart on pages xiv and xv.

Allinger, N. J., et al., *Organic Chemistry*, 2nd ed., Worth Publishers, New York, 1976.

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Streitwieser, A., Jr., and C. H. Heathcock, *Introduction to Organic Chemistry*, Macmillan, New York, 1976.

Ternay, A. L., Jr., *Contemporary Organic Chemistry*, W. B. Saunders, Philadelphia, 1976.

Zimmerman, H., and I. Zimmerman, *Elements of Organic Chemistry*, Glencoe, Encino, Calif., 1977.

Zlatkis, A., E. Breitmaier, and G. Jung, *A Concise Introduction to Organic Chemistry*, McGraw-Hill, New York, 1973.

UNITS OF THIS SUPPLEMENT FOR USE

Text \ Chapter	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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Unit numbers in italic type indicate major treatment of the topic in question.

WITH THE VARIOUS TEXTBOOK CHAPTERS

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UNIT ONE
Introduction

WHY IS THIS BOOK NECESSARY?

Your regular textbook and your instructor's lectures are composed of (a) a large body of experimental facts, qualitative and quantitative, (b) a network of theory that forms the basis for understanding and interrelating the facts, and (c) a notational system capable of communicating this material. The textbook (if it is well written) and the lectures (if your instructor is worth his/her salt) will give you a thoroughly explained, balanced, cohesive, and rational account of organic chemistry. This generally leads to *understanding* most individual topics of the subject, but it does not necessarily lead to success in the course. Why do many students feel that they "understand the material" but cannot answer questions and solve problems? Mainly because, although hearing lectures and reading books are reasonable ways to learn theoretical concepts, concepts are only *one third* of the subject. The other two parts—organic chemical facts and organic chemical notation—*are poorly learned by the traditional approach of lectures and reading alone.* This book teaches you how to get these facts and notation under control and how to analyze, solve, and respond to all the standard types of organic chemistry problems.

This book also aims to fill another set of gaps in the lecture/reading approach. Because time is short, your lecturer can hit only the high points, leaving out many of the small steps in the development of each topic that he/she thinks (or hopes) you can make by yourselves However, some students attending any lecture fail to make one of these steps somewhere along the way and are still puzzling over that step when the lecturer is winding up the argument. Even in the most thoughtfully developed textbooks, some students invariably find that a link in the chain of understanding is missing because the author thought it was too basic to include. This guide provides many of the small helps, hints, and gap fillers that speed learning.

Our remarks above apply equally well to strong students. A sizable number of A students in general chemistry run into difficulty in repeating their performance in the organic course. Even if you encounter no real difficulties in learning organic chemistry, you will do it faster and more easily using an efficient method of organizing and learning the factual material.

WHAT ARE THE OBJECTIVES OF THE ORGANIC COURSE AND THIS GUIDE?

At the end of the organic chemistry course you should be able to:

1. Given the structural formula or name of any of a large assortment of organic compounds, predict (a) the detailed three-dimensional *structure* of the molecule; (b) the *reaction products* arising from treatment with a variety of reagents; (c) the way in which bonds are made and broken to bring about product formation in these reactions (that is, the *reaction mechanism*); and (d) the effect of structural variations on *reactivity* (rate or position of equilibrium) in these reactions.

2. Show sufficient facility with the *notation* of organic chemistry to communicate this knowledge (understand and answer questions, look things up).

3. Design reaction paths by which a great variety of moderately complex organic compounds can be prepared from simple, readily available compounds (*synthetic* capability).

4. Deduce the structural formula of an unknown organic compound from spectroscopic or chemical data.

5. Predict very roughly the *physical* and *physiological* properties of an organic compound given its structural formula.

6. Demonstrate some knowledge of the *sources* of and *uses* for organic compounds in the practical world.

I have arranged the goals roughly according to my own opinion of their decreasing importance for chemistry majors. For preprofessional students, 5 and 6 may be more important than 3 and 4. The order of these goals is not perfectly arbitrary because the highly interwoven and cumulative nature of organic chemistry requires that basic facts of structure and reactivity be learned before later material can make any sense.

This guide focuses on goals 1 to 4, in the following way:

(a) It gives you an effective organizational network of visual and verbal cues which, if practiced as directed, guarantees efficient learning and recall of the large body of facts on which goal 1 is based. And it develops the rules and analogies from this body of facts to allow you to predict information about new compounds in new situations.

(b) It will help you achieve complete notational competence.

(c) It develops detailed analyses and solution techniques for each of the common problem types.

Goals 5 and 6 are better covered in textbooks and laboratory work and will not be discussed here. Specific objectives are stated at the beginning of each unit.

HOW IS LEARNING ORGANIC CHEMISTRY LIKE LEARNING A SECOND LANGUAGE?

Many people have observed the similarity of processes and problems between learning organic chemistry and learning a second language. Some similarities are: (a) the new notation that is required for communicating chemical ideas is like a new language; (b) a large volume of new information must be stored in readily accessible form; (c) the study methods that are successful in second-language learning also work in the study of organic chemistry. Actually, the analogy holds to a surprising extent through a detailed technical analysis of the two subjects. Two points are especially important to us:

1. A limited number of "basic sentence patterns" of a language are general frameworks that we use to generate an unlimited number of meaningful, specific constructions. In language learning it has proved to be more important to master and be able to manipulate easily the forms and patterns within a limited vocabulary than it is to acquire a large vocabulary. Similarly, a limited number of "allowed reactions" and simple rules of analogy generate the unlimited number of chemical transformations actually observed to occur in nature. Much of this guide's method is based on:

- Thorough learning of the basic patterns of organic chemical behavior and extensive drill on turning these rapidly into large numbers of specific equations, mechanisms, structures, and so on.
- Developing rules that, like grammatical rules, summarize large areas of experience and can be rapidly applied to new situations.
- Adapting study techniques that have proved effective in second-language learning.

2. All learning depends upon motivation, perception, and exercise. The language learner's most important task is to internalize the basic patterns and to acquire a new system of language habits so that he/she can react automatically to the structural signals of the second language. This can be accomplished only by drill. Theoretical study of a language does not improve your ability to speak. All this applies equally well to organic chemistry learning. Structure recognition and structure drawing must be automatic and accurate. The eye must learn to assemble all cues and size up just what has gone on in a given reaction—quickly, as a matter of habit. Obviously, achieving this proficiency will also require drill. The exercises in this guide are designed to give you this essential practice.

WHAT ARE THE MOST COMMON STUDENT DIFFICULTIES AND HOW CAN YOU AVOID THEM?

Most students perform at a fraction of their potential in organic chemistry because they are troubled by one or more of the following problems:

1. Lack of organization.
2. Notational problems.
3. Too little drill.
4. Falling behind.
5. Poor problem analysis.
6. Difficulties in seeing and manipulating three-dimensional objects in two dimensions.
7. Poor study habits.

Let's discuss these one by one.

1. *Lack of organization.* This can affect every aspect of your work, from allocation of time and the preparation of factual material to be learned, to the acquisition of notational skill and the analysis and solution of problems. The basic set of organic chemical facts consists of perhaps 150 characteristic reactions. To internalize this list in readily usable form, you must have help from the logical relationships within the material, from an underlying theory with predictive power, or from mnemonic or other devices. We will develop a fourfold organization that very much simplifies acquisition, recall, and use. Thus the approximately 150 reactions can be classified in four different ways (don't worry now about what each means—we take that up later):

(a) By mechanism; the approximately 150 reactions occur by means of only nine basic mechanisms (standard sequences of bond-breaking/bond-making steps).
(b) By functional group.
(c) By change in oxidation or alkylation state.
(d) By visual charting of structural relationships.

In recalling most organic chemical facts you have these four classifiers to use as cues—it is rare when all four cues fail.

In Units 14 to 19, where we discuss material that constitutes the bulk of the "memory work" of organic chemistry, we lay out specific instructions for organizing the material to be learned.

2. *Notational problems.* Difficulty in keeping up with the lecturer while taking notes, failure to finish exams, loss of points due to illegible exam answers, inability to manipulate three-dimensional structures on paper—these are the common symptoms of inadequacy in using organic chemical notation. Instructors often lack patience with students who, after several weeks or months, insist that they "know the material" but cannot demon-