

Let's Talk about the Organic Chemistry Course

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Discussions of the appropriate content of the chemistry curriculum never seem to include discussion of the organic chemistry course. With very few exceptions, organic chemistry textbooks are very similar.¹ The sequence and emphasis have been essentially unchanged for 30 years. Spectroscopy and a few new reactions and mechanisms have been inserted, pushing other topics later and later in the course. The result is a course that is a poor match for current work in organic chemistry.

In the 1940's and 1950's, organic chemists made major advances in the study of mechanisms. Free radical mechanisms had been discovered in the 1930's; solvolysis reactions were used to generate carbocations not obtainable under usual reaction conditions; isotopic labeling and kinetics measurements contributed to understanding of mechanisms. In 1959, a textbook² appeared that for the first time made theory fundamental to the course. That book not only swept the market at the time, but so dominated the market for years afterward that most people teaching chemistry studied from one edition of that text and started teaching from another. The result has been that nearly everyone assumes that the topics chosen for emphasis by those authors will necessarily be covered, and that the sequence of topics in the course is inevitable.

After 30 years, isn't it again time to take a fresh look at the selection and arrangement of material? It is a lot of work to start from scratch, to abandon one's tried-and-true lecture notes, to omit or postpone topics "everyone expects" in order to leave room for more emphasis on topics of current importance, but the result might be a course that is not only more relevant but also more stimulating for students.

A really thoroughgoing reworking of the organic chemistry course, starting without preconceived ideas about topics that *must* be covered, might lead to a course that is substantially different, both in content and sequence of topics, from the "traditional" one. The discussion below makes some suggestions for such a reworking; it is not intended to prescribe a particular course, but to stimulate thought and discussion.

In recent years, so many new reactions, and improved conditions for carrying out old reactions, have been developed, that students cannot possibly be expected to learn them all. We should select a reasonable number of reactions that are widely applicable. We should then use these reactions to teach students to work with increasingly complicated compounds and systems. If a reaction cannot be found

repeatedly in the recent literature, it should not be included in the course unless it is of fundamental importance in biosynthetic mechanisms, major manufacturing methods, or whatever else is relevant for the students likely to be enrolled.

The same criterion should apply to coverage of mechanisms: does this mechanism help students understand an important reaction? We should avoid "mechanism-for-the-sake-of-mechanism" and focus on the use of mechanisms as a way to understand, predict, and modify reactions. We should emphasize the pattern of electron pair flow and stress the importance of identifying the electron pair donor and the electron pair acceptor.

Why should we teach the S_N1 reaction of halides? What purpose does it serve in a beginning course? There are very few examples of useful yields of substitution product at a tertiary carbon, and most of those are reactions of alcohols. Most discussions of "S_N1 reactions" are in fact discussions of conditions for carbocation formation and are oversimplified. Students focus on substitution and have difficulty understanding that the major product is the alkene. Omitting this confusing discussion from the chapter on alkyl halides would still leave the useful discussion of carbocations in the chapter on alcohols.

Since most of the course deals with ionic reactions, it makes no sense to start the discussion of mechanisms with radical reactions. On the other hand, it is important that students learn that pure bromine or chlorine can react destructively with hydrocarbons, just as they should know that other kinds of radical reactions can be troublesome (unwanted reactions with oxygen, polymerization of styrene) or useful. Sometime in the course there should be a discussion of various reactions that occur by radical mechanisms, but this could well be postponed until students have developed a good feel for ionic reactions.

In view of the importance of the carbonyl group in organic synthesis and in biological mechanisms, carbonyl compounds should be covered fairly early in the course, preferably no later than one-third of the way through the year, to permit repeated drill and review. Problems involving enols and acetals should be included early to familiarize students with these groups before they must use them later.

Reactions of various types of carbanions are very extensively used in modern organic synthesis and are analogous to important biosynthetic mechanisms. However, except for some organometallic compounds, these reactions are usually treated rather briefly, late in the course. We should increase the emphasis on carbanions.

If carbonyl compounds are to be covered early, some topics traditionally covered early must be postponed. We can decrease the emphasis on alkyl halides. Most of the theoretical concepts could be better presented in relation to the far more widely useful alcohols. At one time, many textbooks postponed aromatic substitution reactions until after dis-

¹ No specific texts will be identified in the discussion, since the argument applies to so many of them. Over the years, an occasional text has appeared that differed from the standard pattern in some way. The author applauds the presence and quality of such books but would like to encourage more widespread discussion and experimentation.

² Morrison, R. T.; Boyd, R. N. *Organic Chemistry*; Allyn and Bacon: Boston, 1959.

cussion of the important functional groups. Returning to that arrangement would allow earlier coverage of the various functional groups.

The course should include more emphasis on stereochemistry. It is not enough to discuss stereochemistry only at the start of the year and in the discussion of carbohydrates. We should repeatedly discuss both the stereochemistry of reactions and the effect of crowding on the relative rates of reaction at two groups.

Students should be asked to work extensively with realistic examples, including cyclic compounds and compounds containing more than one functional group. These compounds need to appear in relatively easy problems as well as in the more difficult problems so that students become accustomed to recognizing and working with functional groups in various types of structures.

When possible, we should put the discussion into the

broad context by including discussion of environmental and economic concerns. This might include such ideas as the importance of byproducts, separation and disposal problems, and the difference between laboratory methods and manufacturing methods. Often we talk only about the major or desired product of a reaction, without making students aware of these other concerns.

These are fairly sweeping suggestions, and people are likely to disagree with them. Wonderful! Let's disagree, argue, justify our ideas, look closely at what students are learning (as opposed to what we think we are teaching). Let's discuss and experiment. Let's have imaginative authors, and manuscript reviewers who accept what an author is trying to do, rather than expecting every book to fit the same mold. Throughout, let's keep in mind the question of what we want students to be capable of doing at the end of the course, and the limits of time available.