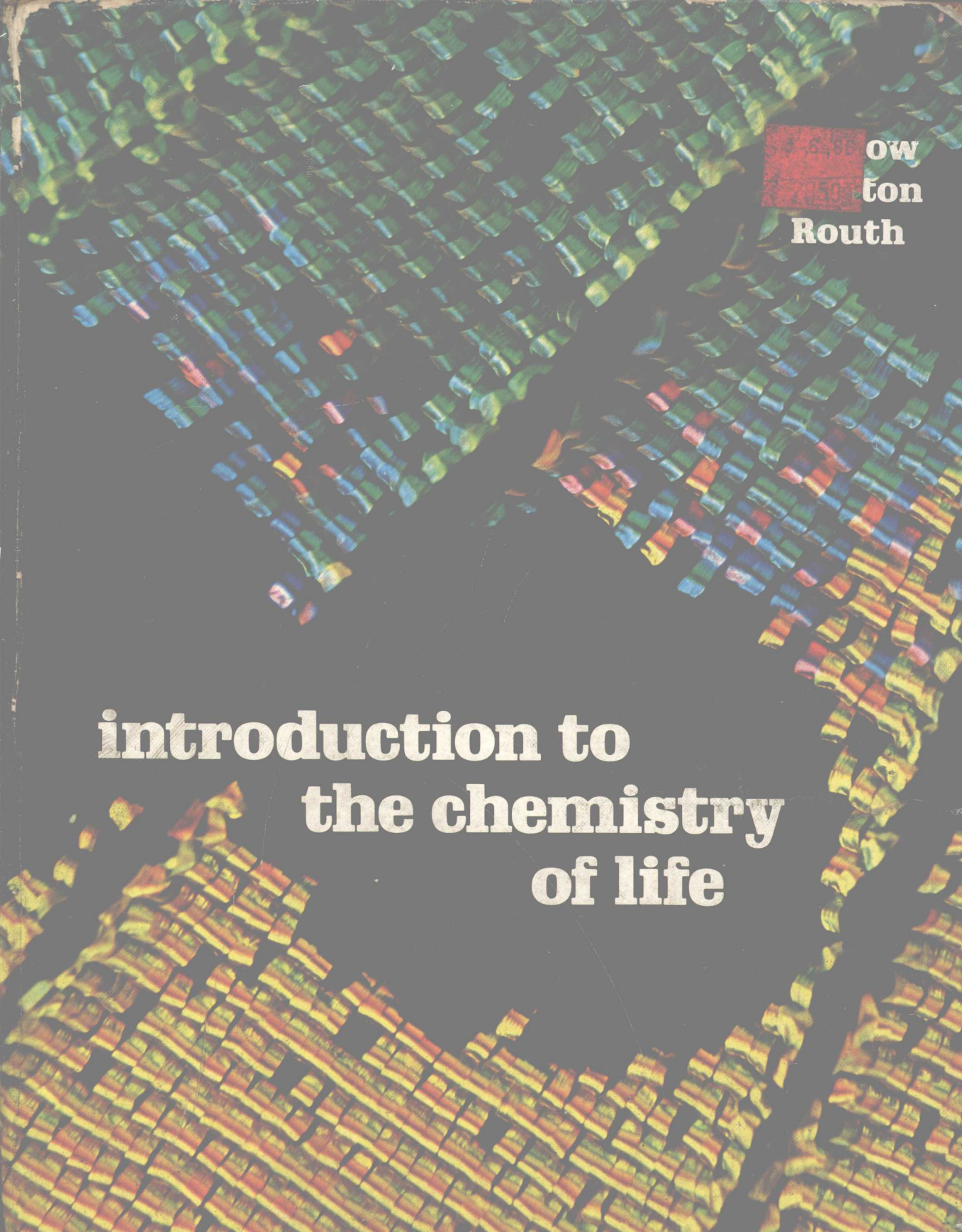

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introduction to the chemistry of life

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Preface

Introduction to the Chemistry of Life is a completely new textbook for a one-year survey course. It provides a foundation in the molecular concepts needed to understand many of the life processes of the human body, as well as some of the basic techniques of general chemistry, organic chemistry, and biochemistry.

We discuss topics that are accessible to a first-year college student and can be of later use in relating chemical principles to everyday life. Particular care has been taken to include concepts and applications that will prepare *allied health science* students for their future careers. Students who plan to enter fields such as physical education, home economics, agriculture, and the social sciences should also benefit from this approach to chemistry through its impact on human biology.

Expecting the student audience to contain diverse backgrounds and interests, we do not anticipate any particular level of technical preparation. Students with a very limited background in high school chemistry should expect to spend a longer time studying, especially in Chapters 2 to 6, than those coming directly from high school with a strong chemistry background. Our presentation is designed to help each student develop the motivation and enthusiasm that will lead to mastery of chemical skills.

It is quite difficult for a single textbook to meet the needs and interests of every student. An author tends to include what he or she feels the student *should* know and to aim at the highly literate, self-motivated, and extremely capable reader. Unfortunately, such pupils are truly rare. The typical college student needs some help in learning chemistry. The one-year survey course thus poses some very specific challenges, which we attempt to meet with this textbook.

Alternative Chapter Sequences

The most common two-semester sequence using this text might cover Chapters 1 through 12 in the first term and the remainder of the text in the second term. There are several alternative paths through the material. A first-term course that includes only general chemistry might begin with Chapters 1 to 6, then skip to Chapters 10 to 14; the second-term could then include the organic and biochemistry of Chapters 7 to 9 and 15 to 28.

It is possible to use this text in a one-semester or two-quarter course through the judicious elimination of topics that are inessential to a particular student group. The following fifteen chapters might be considered *most essential* to a short course for health science students: 1, 4, 5, 7, 9, 12, 13, 17, 18, 19, 20, 22, 23, 24 and 25. The result would be a course with approximately half of the material in the full text, but with all of the truly important topics for a class studying the chemical background of human physiology. Necessary bridging is minimal and could be carried out in lecture.

A Readable Presentation of Chemistry

Some students are excellent readers; others are not. Any college student should be able to understand a clear, direct presentation. Highly technical discussions, such as we often find in scientific journals, present serious difficulties for some readers. Since our primary objective is to help the student master chemical concepts, we have kept the textual language as coherent and understandable as possible.

As the student progresses from the relatively simple discussions of general and organic chemistry to some of the difficult areas of metabolism, the technical level of the text must inevitably rise. We have tried to avoid "quantum jumps" in reading level and to keep the entire book within the grasp of an average college student.

A Flexible Approach to Chemical Arithmetic

Many students can handle all of the mathematics used in general chemistry, including the calculation of empirical formulas and fractional pH values. Others are prepared to add, subtract, multiply, and divide but are fearful if asked to do much more. In fact, some students settle on biology-related career programs because of an aversion to math!

This text has been organized to allow the instructor to emphasize calculations or to avoid them, depending on the needs and skills of the class. Where calculations are presented, we emphasize the use of *conversion factors* (the dimensional-analysis or unit-factor method) rather than the solution of algebraic equations. Appendix B contains a review of some frequently used mathematical tools, such as the calculation of per cent.

Attention to Mastery of Specific Skills Related to Human Biochemistry

We hope that the student will not only learn some fundamentals of chemistry but will also understand the applications of these principles to a clinical situation. There is a tendency in the allied health field to hope that the student will memorize and retain a tremendous range of information. At the same time, we expect understanding and application of the skills and concepts in diverse situations. Not even our best students can approach this ideal. Choices must be made. There must be an appropriate balance between the learning of concepts and the ability to apply them. Instead of touching superficially on a large number of topics, we have chosen to emphasize mastery of a small but important selection of skills.

In addition, we have tried to emphasize the interrelationships between general and organic chemistry. Some texts begin with the theories, models, and calculations of general inorganic chemistry, followed by a short course in organic nomenclature and reactions. Finally, the student reaches the third "subject," human biochemistry, which may be the only part of the course that will seem relevant and interesting. By that point, the student's enthusiasm and motivation may be weakened, if not entirely evaporated.

We have taken a different approach. The concepts of general chemistry are equally applicable to inorganic and organic compounds, as we have shown by our choice of examples in Chapters 1 to 6. Ionic and covalent compounds work in harmony in the human body. Both types are certainly necessary for life; both types should be well understood.

Thus, instead of providing a "mini-course" in each of the three vast fields of general, organic, and biochemistry, we begin with the simplest aspects of chemistry and gradually proceed to discuss the more complex molecules and reactions of metabolism. Such topics as nutrition, radiation therapy, breathing, and blood pressure are briefly discussed in early chapters. This reminds students that chemical and physical principles underlie many different aspects of life and health.

Of course, there is no way in which our particular selection of topics can possibly meet the needs of every class. Somewhat more material is included in this text than can be learned well during an academic year. If we have included topics that are not needed, then skip those sections. We may have omitted a few subjects that the instructor considers relevant; then by all means provide lectures on such material and bring your own ideas, interests, and enthusiasm directly into the course. A textbook is not a syllabus but a learning resource, to be adapted to the distinct needs of the class.

Study Aids Within Each Chapter

Each chapter section contains *learning goals,* the specific skills or objectives that the student should master. *Self-check questions* are provided right at the end of the chapter section, as an immediate way to verify progress before going on to the next section. Solved *examples* are provided for many techniques that require practice. The student is encouraged to work step by step through these carefully chosen problems. The learning goals, self-checks, and examples work together in each section to steer the student towards mastery of the essentials.

At the end of each chapter, the learning goals are again presented so that the student may use them as a checklist while reviewing for exams. There is a chapter *glossary* of technical terms, with reference to the page on which each term is used in context. A two-column set of *questions and problems* evaluates each learning goal. The left-hand column, with solutions in Appendix A, is for student use. The right-hand column contains equivalent questions, which may be assigned for homework since the answers are provided only in the *instructor's manual.* An unusually large number (1658) of questions are provided so that the instructor may make a judicious selection of those which best suit the needs of the class. Certain starred (*) questions go somewhat beyond the learning goals.

Most self-check and end-of-chapter questions involve situations related to health care and other aspects of modern life. It is important that questions serve not only to measure the student's progress but also to remind the student of the *relevance* of the chemistry that is being learned.

An Attractive Textbook to Motivate Students

We are trying to teach the "TV generation." Some students need some visual impact to focus their attention on what they are learning. A chemistry textbook can be rigorous and effective and also use two-color format, photographs, diagrams, and language in a way that motivates the student. We have attempted to do this.

The Most Important Learning Resource is the Instructor

We have tried to maximize the value of this text for your classes. Some students may learn the material well through self-study. Most, however,

enjoy the direct encouragement, insight, and teacher-transmitted enthusiasm that face-to-face instruction can provide. No matter how hard the authors worked to achieve a high level of readability, accuracy, and relevance in the presentation, the true testing ground of our efforts is in your classroom.

The authors welcome communication from instructors who use this text. Which aspects work well? Which chapters could stand some improvement in the next edition? What would you like to see added? deleted?

We have included more than 1000 relevant applications of chemistry to clinical or real-world situations, taken from various sources, such as the *Merck Index*. A few errors of fact or interpretation may have crept in. Please help us correct any such mistakes so that we may better serve your students.

ACKNOWLEDGMENTS

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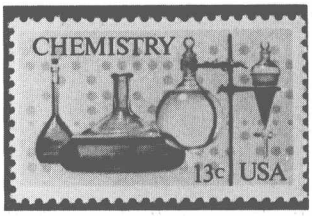
To the Student



Chemistry is the study of all substances, the "stuff" or matter that makes up your body, the earth, and all other objects you can feel or taste, smell or see. The chemist wants to know *what* is contained in a particular object and *how* it got there. With this knowledge, the chemist can then classify and name the smallest bits of matter and put them together in the test tubes and flasks of the laboratory to make products that are important in our daily lives.

You may be taking this course because you wish to learn more about the chemicals in our environment. Or you may be entering a career that applies chemistry to real-life problems, such as the health professions. As you read through this text, you will see that chemistry affects everyone each day. Knowledge of chemistry is needed to understand food, drugs, metals, plastics, and other materials, living and nonliving. While we introduce you to the scientific principles, we will frequently remind you that these principles are applied every day by real people and are not simply "nice ideas" dreamed up by teachers to make you study.

Whether or not you have previously taken and enjoyed a chemistry course, you *have* the capability to learn this one! Nothing in this text is beyond your grasp. However, you must expect to put in a good deal of hard work. You must plan to organize your study time. This part of *Introduction to the Chemistry of Life* is intended to get you started on the right foot.

STUDYING CHEMISTRY

You already have your own style of learning and your own way of coping with courses and examinations. It is important that you learn how to study chemistry effectively so that this course will be a satisfaction rather than a nightmare.

The most important fact is that **chemistry must be learned actively.** You will not learn much chemistry by simply *listening* to the teacher or only *reading* the textbook. Listening and reading are very important skills. However, they are passive skills; they don't leave very much in your brain!

While you listen to a lecture and while you study a chapter, you should be thinking, challenging, and restating in your own words what is being said. Always have pencil and paper at hand, so you can take notes on what is important. You should also jot down any questions you have so you can get the answers later.

If a new word is presented, write it down, and be sure you know what it means. Try to relate what you are learning now to what you studied last week and a month ago. Try to get an overall picture of what this course is

trying to accomplish so that you will understand how each learning goal fits in.

ORGANIZATION OF THIS BOOK

Each of the 28 chapters of this textbook treats a particular theme or topic. Each chapter is divided, to make your studying easier, into several numbered sections, such as Section 23.1, 23.2, 23.3. Each section generally discusses one chemical concept, process, or method.

Your course may not cover every section of every chapter. Don't feel you are being shortchanged. Chemistry is such a vast subject, you can only learn so much of it in one course. If you wish to increase your understanding of chemistry after this course, there are many excellent resources for you to use.

LEARNING GOALS

At the beginning of each section you will find one or more *learning goals*. A learning goal tells you what you should be *able to do* when you finish the section. This can be a tremendous help in studying because you can plan your work to achieve these goals. Naturally, these goals describe almost exactly what kinds of questions you must expect on homework, quizzes, and examinations. If you can "do" the learning goal, you should be able to answer the test question on that same topic.

For example, the first learning goal in this textbook is

> *LEARNING GOAL 1A: Given the name of any of 25 elements important to the human body, write the symbol; or, given the symbol, write the name.*

You thus know, at the beginning of Chapter 1, that you must memorize some names and some symbols. Some of them you probably already know, such as H for hydrogen. Some may be unfamiliar. Your learning task is very clear.

The learning goals in this text are those that the authors felt to be most appropriate for all students. However, your instructor may feel that some other objectives are more important in your particular course. Be alert to any changes, additions, or deletions that your teacher may announce.

SELF-CHECK EXERCISES

At the end of each section, you will find a series of questions called a *self-check*. Think of this as a mini-quiz that acts like a gate in a fence. If you do well on the self-check (compare your answers with those in Appendix A), then pass through the "fence" into the next section. If you have difficulty, go back over the part you have just studied and review the material that you have not yet learned.

Do each self-check with pencil and paper as if you were taking a classroom quiz. Do *not* refer back and forth between the questions and the an-

swers. If a calculation is involved, do all the work before you look at the answer. If you "cheat" here, you injure your own chances of really knowing whether or not you have reached the learning goal. The self-check questions and learning goals are matched very carefully.

MEMORIZATION

Many students (and quite a few teachers) think of "learning chemistry" as involving a lot of memory work. In one sense they are right. Chemistry has a *language* of its own.

If you learn a foreign language, you must repeat certain words to yourself until they are part of your memory. That is how you build a vocabulary so that you can say what you mean in that language. If you cannot find the words to express yourself, you cannot communicate.

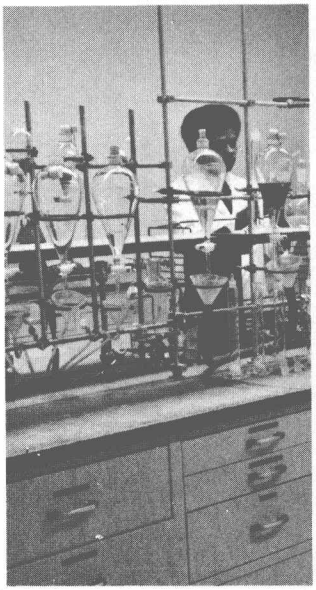
However, language is more than a list of memorized words. You must also be able to put those words together to make sentences; the word order must make sense or, again, you will not be able to get your ideas across. You cannot memorize how to form sentences and how to choose the proper words from your list to express each idea. You must *understand* how the language functions. This understanding comes not from memory work but from practice with many different kinds of sentences and situations.

Chemistry works in exactly the same way. You must learn—memorize—a number of terms in each chapter. These terms are given in **boldface** type where they are first discussed and are seen again at the end of the chapter in the glossary. Certain important symbols must also be planted in your memory.

However, that's just the chemical language. To explain what is happening in a chemical process, you must go beyond simple memorization to understand what general principles are being applied.

In the case of a calculation, you should rely on a good deal of practice instead of on memorizing the example. Setting up and solving a problem involving math comes from experience with different kinds of problems.

Some students have very good memories for scientific "facts"; others hate to memorize. Each student must strike a balance between memory work and answering practice questions so that he or she will have both the vocabulary of chemistry and the ability to use it properly.



A modern analytical chemistry laboratory, that of the Food and Drug Administration pesticide division. Photograph by Donald D. Dechert.

CHAPTER SUMMARIES

At the end of each chapter, the learning goals are brought together in a checklist so that you can make sure you are ready for a test on that chapter. The glossary contains a simple definition of each new term. Both the learning goals checklist and the glossary contain page references so that you can go back and clarify any doubtful points.

END-OF-CHAPTER QUESTIONS

At the end of each chapter, there are two columns of questions and problems. The questions in the *left*-hand column (color numbers) are an-

swered in the back of this textbook. The right-hand column (black) contains questions generally similar to those in the other column and will probably be used in homework assignments since no answers to these questions are given in this book.

Always write out your own answer completely before you refer to the "book" solution or consult another student.

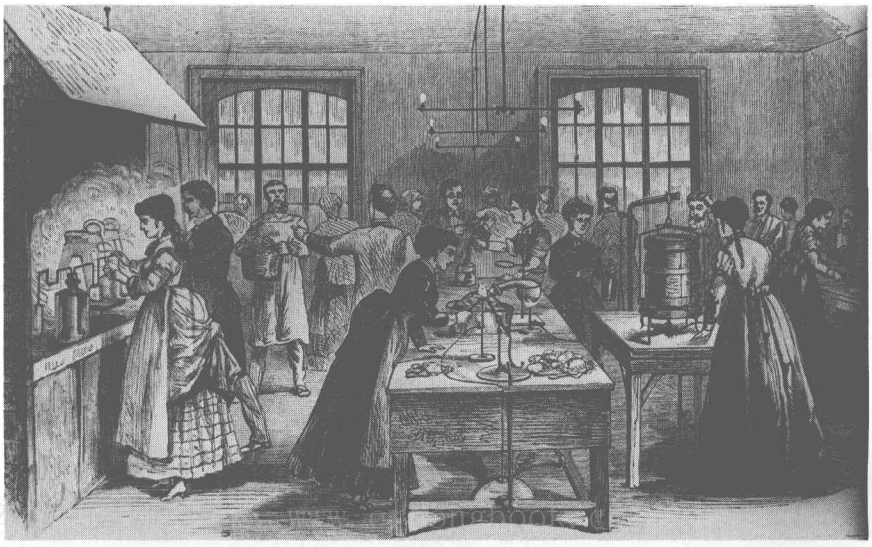
Most of the end-of-chapter questions are arranged by section and test your performance on the learning goals of that section. Some questions, marked with stars (*), may go a bit beyond the listed goals.

SOME STUDY HINTS

No two students are exactly alike. What works well for your neighbor may not work for you. However, many students have found that the following methods help them complete the course successfully.

1) Outline what your instructor says in class. Do not attempt to copy down every word. Instead, try to take notes on the *main* points. These notes will help you study for exams. In addition, writing something down several times is an excellent way to place it in your memory.
2) Take notes while you study the textbook. Many students write *in* their book; a well-marked book is a sign of a student who knows how to study.
3) Don't try to study chemistry while watching television, talking with friends, or doing a job. Most students learn most effectively if they concentrate in a quiet, comfortable place.
4) Work through every *example* given in the text. Practice makes perfect.
5) When doing calculations (chemical arithmetic), use the simple methods presented in the text or by your instructor. Learn the conversion-factor method (Chapter 2), and use it. Don't panic!
6) Use common sense to check *all* answers.

A typical U.S. college chemistry laboratory of 1869, at the Massachusetts Institute of Technology.



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