

Introduction to General, Organic, and Biochemistry

SEVENTH EDITION

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PERIODIC TABLE OF THE ELEMENTS

ABOUT THE AUTHORS

FREDERICK A. BETTELHEIM is a Distinguished University Research Professor at Adelphi University, and a Visiting Scientist at the National Eve Institute NIH. He has coauthored every edition of Introduction to General, Organic & Biochemistry and several laboratory manuals, including Laboratory Experiments for General, Organic & Biochemistry and Experiments for Introduction to Organic Chemistry. He is the author of Experimental Physical Chemistry and coauthor of numerous monographs and research articles. Professor Bettelheim received his Ph.D. from the University of California, Davis, and his areas of specialization have included the biochemistry of proteins and carbohydrates and the physical chemistry of polymers. He was Fulbright Professor at the Weizman Institute, Israel, and Visiting Professor at the University of Uppsala. Sweden, at Technion, Israel, and at the University of Florida, He was keynote lecturer at the 16th International Conference on Chemical Education, August 2000, in Budapest, Hungary, where his lecture topic was "Modern Trends in Teaching Chemistry to Nurses and Other Health-Related Professionals."

WILLIAM H. BROWN, a new coauthor for the sixth edition of Introduction to General, Organic and Biochemistry, is Professor of Chemistry at Beloit College, where he has twice been named Teacher of the Year. He is also the author of two best-selling undergraduate texts, Introduction to Organic Chemistry, sixth edition, and Organic Chemistry, third edition. His regular teaching responsibilities include organic chemistry, advanced organic chemistry, and special topics in pharmacology and drug synthesis. He was the leader of a team revising the organic chemistry material appearing in the upcoming Encyclopaedia Britannica CD-ROM. Professor Brown 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.

JERRY ARCH (d. 1997) was the coauthor of *Introduction* to General, Organic & Biochemistry for its first five editions. He was the sole author of the best-selling Advanced Organic Chemistry text, now in its fifth edition, which has been translated into many languages, including Russian and Japanese. He was a member of the Physical Organic Chemistry Commission of the International Union of Pure and Applied Chemistry, and as such was instrumental in the development of several nomenclature systems. Professor March received his Ph.D. at Pennsylvania State University and was Professor of Chemistry at Adelphi University, specializing in organic chemistry.

PREFACE

To see the world in a grain of sand And heaven in a wild flower Hold infinity in the palm of your hand And eternity in an hour.

> WILLIAM BLAKE, Auguries of Innocence



ERCEIVING ORDER in the nature of the world is an ontological—not just pedagogical—need. It is our primary aim to convey the relationship among facts, thereby presenting a totality of the scientific edifice built over the centuries. In this process we marvel at the unity of laws that govern everything in the ever-exploding dimensions: from photons to protons, from hydrogen to water, from carbon to DNA, from genome to intelligence, from our planet to the galaxy and to the known universe. Unity in all diversity.

In writing the preface of the seventh edition of our textbook, we cannot help but ponder the paradigm shift that has occurred during the last 25 years. From the seventies slogan of "Better living through chemistry" to today's epitaph of "Life by chemistry," one is able to discern the change in focus. Chemistry not only helps to provide the amenities of good life but also lies at the heart of our concept and is the preoccupation of life itself. This shift in emphasis demands that our textbook, which is designed primarily for the education of future practitioners of health sciences, should attempt to provide both the basics and the scope of the horizon within which chemistry touches our life.

The increasing use of our textbook made this new edition possible, and we wish to thank our colleagues who adopted the previous editions for their courses. Testimony from colleagues and students indicates that we managed to convey our enthusiasm for the subject to students, who find this book great help in studying difficult concepts.

In the new edition, we strive further to present an easily readable and understandable text. At the same time, we emphasize the inclusion of new relevant concepts and examples in this fast-growing discipline, especially in the Biochemistry part. We maintain an integrated view of chemistry. From the very beginning in the General Chemistry part, we include organic compounds and biochemical substances to illustrate the principles. The progress is an ascension from the simple to the complex. We urge our colleagues to advance to the chapters of biochemistry as fast as possible, because there lies most of the material that is relevant to the future professions of our students.

Dealing with such a giant field in one course—and possibly the only course in which students get an exposure to chemistry—makes the selection of the material an overarching enterprise. Even though we tried to keep the book to a manageable size and proportion, we inevitably included more topics than could possibly be covered in a two-semester course. Our aim was to provide a variety of material, from which the instructor can select the topics he or she deems most important. We organized the sections so that each can stand independently; consequently, leaving out sections or even entire chapters will not cause fundamental cracks in the total edifice. We have increased the number of topics covered and provided 25 percent more new problems, many of them challenging and thought-provoking.

Audience

As with the previous editions, we developed this book for nonchemistry majors, mainly those entering health sciences and related fields, such as nursing, medical technology, physical therapy, and nutrition. Students in

environmental studies can also benefit from it. In its entirety, the seventh edition can be used for a one-year (two-semester or three-quarter) course in chemistry, or parts of the book can be used for a one-term chemistry course.

We assume that the students using this book have little or no background in chemistry. Therefore, we introduce the basic concepts slowly at the beginning and increase the tempo and the level of sophistication as we go on. We progress from the basic tenets of general chemistry to organic and finally to biochemistry. We consider this progress as an ascent in terms of both practical importance and sophistication. Throughout the text, we integrate the three parts by keeping a unified view of chemistry. We do not consider the general chemistry sections to be the exclusive domain of inorganic compounds, so we frequently use organic and biological substances to illustrate general principles.

While teaching the chemistry of the human body is our ultimate goal, we try to show that each subsection of chemistry is important in its own right, besides being required for future understanding.

Chemical Connections (Medical and Other Applications of Chemical Principles)

The Chemical Connections features contain applications of the principles discussed in the text. Comments from users of the earlier editions indicate that these boxes have been especially well received and provide a much-requested relevance to the text. In the seventh edition, we have updated some of these features and added a number of new ones.

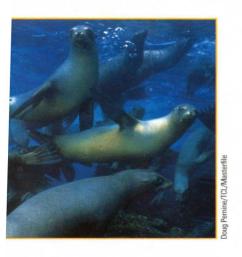
The majority of Chemical Connections boxes deal with health-related applications. Ones new to this edition focus on topics such as COX-2 inhibitors and their use in chemoprevention, amyloid structures in prion diseases including systematic amyloidosis and Alzheimer's disease, proteomics, zymogen and hypertension, botulinum toxin (Botox), phamacogenomics, "antisense drugs," four modes of combating AIDS, fusion inhibitors, iron–sulfur cluster assemblies, lipomics, structures of photosystems I and II, prenylation of Ras protein, potential anticancer vaccines, and glycomics.

The presence of these features allows for a considerable degree of flexibility. If an instructor wants to assign only the main text, the Chemical Connections do not interrupt continuity, and the essential material will be covered. However, because they enhance the core material, most instructors will probably wish to assign at least some of the Chemical Connections. In our experience, students are eager to read the relevant Chemical Connections, even without assignments, and they do so with discrimination. From such a large number of boxes, an instructor can judiciously select those that best fit the particular needs of the course. To enhance the material in the Chemical Connections, we provide problems at the end of each chapter covering all of the boxes.

Metabolism: Color Code

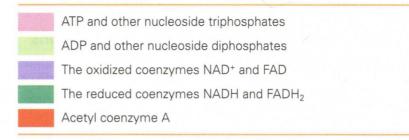
The biological functions of chemical compounds are explained in each of the biochemistry chapters and in many of the organic chapters. Throughout the book, emphasis is placed in chemistry rather than physiology. In the past, we have received much positive feedback regarding the way in which we have organized the topic of metabolism (Chapters 26, 27, and 28). We have maintained this organization in the current edition.





First we introduce the common metabolic pathway through which all food will be utilized (the citric acid cycle and oxidative phosphorylation). Only then do we discuss the specific pathways leading to the common pathway. We find this organization to be a useful pedagogic device, and it enables us to sum the caloric value of each type of food because its utilization through the common pathway has already been learned. Finally, we separate the catabolic pathways from the anabolic pathways by treating them in different chapters, emphasizing the different ways in which the body breaks down and builds up different molecules.

The topic of metabolism is a difficult one for most students, and we have tried to explain it as clearly as possible. As in the previous edition, we enhance the clarity of presentation by the use of a color code for the most important biological compounds discussed in Chapters 26, 27, and 28. Each type of compound is screened in a specific color, which remains the same throughout the three chapters. These colors are as follows:



In figures showing metabolic pathways, we display the numbers of the various steps in yellow.

In addition to this major use of a color code, other figures in various parts of the book are color coded so that the same color is used for the same entity throughout. For example, in all Chapter 22 figures that show enzyme—substrate interactions, enzymes are always shown in blue and substrates in orange.

Features

Chemical Connections are a series of 150 in-depth and intriguing essays that describe applications of chemical concepts presented in the text. Examples include "Timed-Release Medications" (Chapter 7), "The Solubility of Drugs in Body Fluids" (Chapter 16), and "AGE and Aging" (Chapter 21).

Worked examples and corresponding problems are included throughout each chapter to help students develop sound problem-solving skills. Each of the 160 examples includes a detailed solution and is accompanied by a similar problem for students to try on their own.



CD-ROM icons in the text refer to **Interactive General, Organic and Biochemistry CD-ROM, version 2.0,** which accompanies this book. Students are encouraged to use the CD for additional help or information whenever they see this icon.

Margin notes offer additional bits of information, such as historical notes, and reminders, which complement nearby text.

Molecular models, including ball-and-stick models, space-filling models, and electron density maps, appear throughout the text and serve as appropriate aids to visualizing molecular properties and interactions.

A dynamic art program enhances the book's clarity and makes the text visually exciting. A number of new annotated art and macro/micro art pieces have been added. Many new photographs have been added to the book as well, illustrating reactions, chemical procedures, and applications.

Margin definitions of many new terms reinforce key terminology.

Key Reactions, which appear at the ends of many organic chapters, are an annotated list of new reactions introduced in that chapter (Chapters 10–18), along with an example of the reaction and the section in which it is introduced. These lists help students to summarize the organic reactions they have learned.

End-of-chapter problems are paired to give students two tries at solving a particular problem type. Problem numbers that appear in color indicate difficult problems; ones marked with this tetrahedral icon are application-type problems. Problems are broken up by section topics, followed by an additional set of unclassified problems. Problems based on the Chemical Connections help to reinforce the applications of the chemical principles.

>

Chapter Summaries are section-by-section synopses of the key terms and concepts introduced in each chapter.

The Glossary at the end of the book gives a definition of each new term along with the number of the section in which it is introduced.

Answers to all in-text and odd-numbered end-of-chapter problems are provided at the end of the book. Detailed, worked-out solutions to these same problems are provided in the *Student Solutions Manual*.

Style

Feedback from colleagues and students alike indicates that one of the book's major assets is its style, which addresses students directly using simple and clear phrasing. In the seventh edition, we continue to make special efforts to provide clear and concise writing. Our hope is that this style will facilitate the understanding and absorption of difficult concepts.

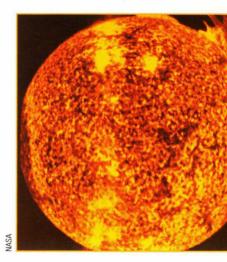
Problems

Approximately 25 percent of the problems in this edition are new. The number of more challenging, thought-provoking questions has also been increased. The end-of-chapter problems are grouped and given subheads in order of topic coverage. Problem numbers in color specify more challenging ideas; those marked with a tetrahedral icon are application-type problems; and a group of problems are based on the Chemical Connections boxes. In the last group, called "Additional Problems," problems are not arranged in any specific order.

The answers to all in-text and odd-numbered end-of-chapter problems appear at the end of the book. Complete worked-out solutions to all in-text and end-of-chapter problems are supplied in the *Instructor's Manual*.

Ancillaries

The following ancillaries are available to qualified adopters. Please contact your local Thomson • Brooks/Cole sales representative for details.



- Interactive General, Organic and Biochemistry CD-ROM, version 2.0, is an unparalleled multimedia presentation of GOB topics. Created by William Vining of the University of Massachusetts and Susan Young of Hartwick College, it features extensive use of videos and animations to create a strong link between observable macroscopic properties and molecular-scale chemical interpretations. It is supported by an interactive database of three-dimensional molecular models.
- Student Study Guide, by William Scovell of Bowling Green State University, includes reviews of chapter objectives, important terms and comparisons, focused reviews of concepts, and self-tests.
- Student Solutions Manual, by Mark Erickson of Hartwick College, William Brown of Beloit College, and Rodney Boyer of Hope College. contains complete worked-out solutions to all in-text and odd-numbered end-of-chapter problems.
- Instructor's Manual, by Mark Erickson of Hartwick College, William Brown of Beloit College, and Rodney Boyer of Hope College, contains worked-out solutions to all in-text and even-numbered end-of-chapter problems.



- InfoTrac® College Edition Every new copy of General, Organic and Biochemistry, seventh edition, comes packaged with four months of free access to InfoTrac College Edition. This online resource features a comprehensive database of reliable, full-length articles (not abstracts) from thousands of top academic journals and popular sources—updated daily and spanning 22 years! Just some of the journals available 24 hours a day, seven days a week: American Scientist, Science, Science News, Science Weekly, and thousands more.
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 - Multimedia Manager for Organic Chemistry: A Microsoft® PowerPoint® **Link Tool** is a digital library and presentation tool that is available on one convenient multiplatform CD-ROM. Thanks to its easy-to-use interface, you can readily take advantage of Brooks/Cole's presentations, which consist of art and tables from the text, as well as more than 700 PowerPoint presentation lecture slides especially created for this book by William E. Brown. The presentations are available in a variety of e-formats that are easily exported into presentation software or used on Webbased course support materials. You can even customize your own presentation by importing your personal lecture slides or any other material you choose. The result is an interactive and fluid lecture that truly engages your students.
 - ExamView® Computerized Testing allows you to enhance your range of assessment and tutorial activities—and save yourself time in the process. You can create, deliver, and customize tests and study guides (both print and online) in minutes with this user-friendly assessment and tutorial system. **ExamView** offers both a *Quick Test Wizard* and an Online Test Wizard that guide you step-by-step through the process of creating tests. Using ExamView's complete word processing capabilities, you can enter an unlimited number of new questions or edit existing



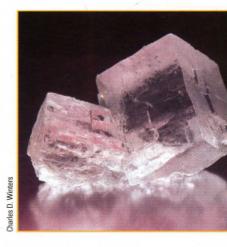
questions. And **ExamView** is the only test generator that offers a "what-you-see-is-what-you-get" feature that allows you to see the test you are creating on the screen exactly as it will print! You can explore **Exam-View** online at http://www.examview.com/product_info/tour.htm.

- **Printed Test Bank**, contains approximately 50 multiple-choice questions per chapter for each of the 31 chapters in this text.
- WebTutor™ Advantage on WebCT and Blackboard Students have
 access to study tools that correspond chapter by chapter with the book,
 while professors can use WebTutor Advantage to provide virtual office
 hours, post syllabi, track student progress on the practice quizzes, and
 more. Visit http://webtutor.thomsonlearning.com for more information and to try WebTutor Advantage.
- Overhead Transparencies The 150 full-color overhead transparencies include figures and tables taken directly from the text.
- Brooks/Cole Chemistry Book Companion Web Site at http://www.brookscole.com/chemistry includes a rich array of teaching and learning tools for students and instructors. It includes online quizzes, tutorials, and more.
- Laboratory Experiments for General, Organic & Biochemistry, fifth edition, by Frederick A. Bettelheim and Joseph M. Landesberg, includes 52 experiments that illustrate important concepts and principles in general, organic, and biochemistry. Three new experiments are featured: (1) fermentation of a carbohydrate: ethanol from sucrose; (2) isolation of DNA from onions; and (3) neurotransmission: an example of enzyme specificity. In addition, many experiments have been revised. All experiments have new pre- and post-lab questions. The large number of experiments allows sufficient flexibility for the instructor.
- Instructor's Manual to Accompany Laboratory Experiments will help instructors in grading the answers to questions and in assessing the range of experimental results obtained by students. The *Instructor's Manual* also contains reminders for professors to pass on to students and details on how to handle disposal of waste chemicals.

Acknowledgments

The publication of a book such as this one requires the efforts of many more people than merely the authors. We would like to thank the following professors who offered many valuable suggestions for this new edition:

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REVISION SUMMARY

General Chemistry

In **Chapter 2, Atoms,** we introduce four of the five methods we use throughout the text to represent molecules: we show water as a molecular formula, a structural formula, a ball-and-stick model, and a space-filling model. We introduce electron density maps, a fifth form of representation, in Chapter 3. To draw the correlation between electron configuration and the Periodic Table, we have added a miniature version of the Periodic Table as a new graphic to show the locations of groups of elements as they are discussed. Figure 2.12 shows that the pairing of electron spins is a consequence of the alignment of the magnetic poles of spinning electrons. We have revised the discussion of electron configuration and the Periodic Table in Section 2.7 to focus on the underlying organization by s, p, d, and f blocks.

The material in **Chapter 3**, **Chemical Bonds**, has been reorganized to group the discussion of ionic compounds first, followed the discussion of molecular compounds. The major revision in **Chapter 4**, **Chemical Reactions**, is the deletion of the discussion and significance of the terms *exergonic* and *endergonic*. We now discuss the energetics of chemical reactions only in terms of how exothermic and endothermic they are.

In **Chapter 5, Gases, Liquids, and Solids,** we have rearranged the presentation of intermolecular forces of attraction to be in order of increasing energy—namely, London dispersion forces, dipole—dipole interactions, and hydrogen bonding. We have deleted Graham's law of diffusion, and added a Chemical Connections box on supercritical CO₂.

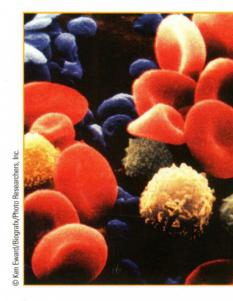
Chapter 8, Acids and Bases, now introduces the use of curved arrows to show the flow of electrons in organic reactions. Specifically, we use them here to show the flow of electrons in proton-transfer reactions. We have dropped the discussion of normality and equivalents from the discussion of the stoichiometry of acid—base reactions. The major revision in this chapter is an expansion of the discussion of acid—base buffers and the Henderson-Hasselbalch equation.

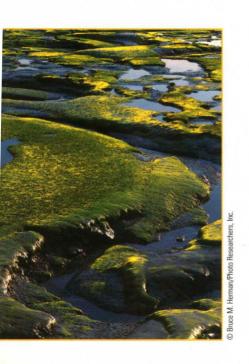
Chapter 9, Nuclear Chemistry, has new information on the creation of superheavy elements.

Organic Chemistry

Chapter 10, Organic Chemistry, is little changed except for an added Chemical Connections box on combinatorial chemistry.

In Chapter 11, Alkanes and Cycloalkanes, we introduce the concept of line-angle formulas and continue using these formulas throughout the organic chapters (Chapters 11–18). They are easier to draw than the usual condensed structural formulas as well as easier to visualize. In previous editions, line-angle formulas were used only to represent cycloalkane and aromatic rings. A new Section 11.9B describes the halogenation of alkanes. The following section treats chlorofluorocarbons (the Freons) and their replacements, plus haloalkane solvents. A new Chemical Connections box describes the environmental impact of Freons. Section 12.5, covering the terpenes, has been shortened considerably. A new Chemical Connections box in Chapter 12, Alkenes, treats ethylene, a plant growth regulator.





The positions of Chapters 13 and 14 have been reversed from the sixth edition. Chapter 13, Benzene and Its Derivatives, now follows immediately after the treatment of alkenes and alkynes. We have expanded the discussion of phenols to include phenols and antioxidants. In this subsection, we treat auto-oxidation of unsaturated fatty acid hydrocarbon chains as a radical-chain mechanism leading to hydroperoxidation. We also discuss how substituted phenols such as BHT and BHA act as antioxidants. Chapter 14, Alcohols, Ethers, and Thiols, has been reorganized so that the material now discusses alcohols first (Sections 14.2 and 14.3), then ethers (Section 14.4), and finally thiols (Section 14.5).

In **Chapter 15, Chirality: The Handedness of Molecules,** the introduction of the concept of a stereocenter in Section 15.2 is done much more slowly and carefully using 2-butanol as a prototype. Section 15.4, which treats molecules with two or more stereocenters, has been shortened to concentrate on recognizing a stereocenter by the placement of four different groups on a carbon. The relationship in cyclic compounds between cis-trans isomers and enantiomers has been reduced to a minimum.

In **Chapter 16, Amines,** a new Section 16.7, "Epinephrine: A Prototype for the Development of New Bronchodilators," traces the development of new asthma medications such as albuterol (Proventil) from epinephrine as a lead drug. To **Chapter 17, Aldehydes and Ketones,** we have added a discussion of $NaBH_4$ as a carbonyl-reducing agent with emphasis on it as a hydride transfer reagent. We then make the parallel to NADH as a carbonyl-reducing agent and as a hydride transfer agent.

To Chapter 18, Carboxylic Acids, Anhydrides, Esters, and Amides, we have added a brief discussion of the preparation of amides by treating a carboxylic acid with an amine (which gives a salt) and then heating this salt to eliminate water. A more useful preparation of amides is the treatment of an amine with an anhydride. We have added two new Chemical Connections: "Pyrethrins—Natural Insecticides of Plant Origin," and "Ultraviolet Sunscreens and Sunblocks."

Biochemistry

The most significant revision in **Chapter 19, Carbohydrates**, is a new Chemical Connections box on high-fructose corn syrup.

In **Chapter 20, Lipids,** new topics include a description of potassium ion channels and the mode of transportation of K⁺. The discussion of steroids in Section 20.9 has been reorganized and expanded. Detailed discussions on the structure, transport, and concentrations of the different lipoproteins have been added. The functions of steroidal and nonsteroidal anti-inflammatory agents are discussed, including the COX-2 inhibitors and their use in chemoprevention.

In **Chapter 21, Proteins**, we present an expanded Chemical Connections on protein conformation-dependent diseases that summarizes amyloid structures in prion-related diseases such as mad cow disease, Creutzfeld-Jacob disease, systematic amyloidosis, and Alzheimer's disease. New discussions focus on the quaternary structures of hemoglobin, collagen, and integral membrane proteins. A new Chemical Connections highlights the new discipline of proteomics and its function.

The discussion of enzymes now includes details of the chemistry of active sites in **Chapter 22**, **Enzymes**. In 65 percent of enzyme-catalyzed reactions, the active site operates with acid—base reactions. A new Chemical Connections, "Zymogen and Hypertension," describes the specificity of different ACE inhibitors.

New features in **Chapter 23**, **Chemical Communications: Neurotransmistters and Hormones**, are the updating of the list of drugs affecting neurotransmission, inclusion of the role of the phosphatidylinositol phosphates as secondary messengers, and the recognition of neurosteroids synthesized in the brain. New Chemical Connections describe the use of the botulinum toxin (Botox) in the cosmetics industry and the neurodegenerative role played by beta amyloid versus tau protein in Alzheimer's disease.

The ever-increasing developments in molecular biology necessitated rewriting of **Chapter 24**, **Nucleotides**, **Nucleic Acids**, **and Heredity**. It now inludes a new section on quaternary and higher structures of DNA leading to the superstructures of chromosomes. The section on DNA replication now includes material on the opening up of superstructures and the components of replisomes. A new section describes the different mechanisms of DNA repair. A new Chemical Connections feature deals with phamacogenomics' ability to tailor medication to an individual's predisposition.

Chapter 25, Gene Expression and Protein Synthesis, underwent major reorganization and expansion. We now concentrate on gene expression and protein synthesis as they operate in eukaryotes. Gene regulation has been expanded to cover different entries on the transcriptional, translational, and post-translational levels. New Chemical Connections cover antisense drugs, four modes of combating AIDS including the new "fusion inhibitors," and the role of the tumor suppression protein p53 in aging.

Chapter 26, Bioenergetics: How the Body Converts Food to Energy, has a new Chemical Connections on iron-sulfur cluster assemblies.

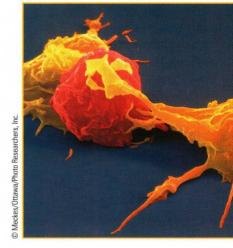
The only new feature in **Chapter 27**, **Specific Catabolic Pathways: Carbohydrate**, **Lipid**, **and Protein Metabolism**, is a Chemical Connections on lipomics, the collective lipid components of a cell.

In Chapter 28, Biosynthetic Pathways, there is extended coverage of photosynthesis, including the newly discovered structures of photosystems I and II. Stepwise synthesis of cholesterol up to the C10 and C15 units are detailed. A new Chemical Connections features prenylation of the Ras protein and its effect on signal transduction.

Chapter 29, Nutrition, has been reorganized to present separate sections on carbohydrates in diet and their digestion and similarly on fats and proteins. References to the latest Dietary Reference Intakes are included as well as discussion of current fad diets such as the Atkins diet and raw food diet.

Chapter 30, Immunochemistry, has been expanded to include a new section on how to recognize "self," which includes coverage of autoimmune diseases and their treatment. The existing sections were subdivided to facilitate the comprehension of difficult concepts. A new subsection was written to explain how the body acquires the diversity to react to different antigens. Among the Chemical Connections is a new feature on potential anticancer vaccines and on glycomics (a distant cousin of genomics and proteomics).

In **Chapter 31, Body Fluids,** we moved the Chemical Connections "Breathing and Dalton's Law" here from Chapter 5 to provide a better survey of gas transports in the blood.



HEALTH-RELATED TOPICS

| Vous | | Bile salts | Sect. 20.11 |
|---|-------------------|--|--------------|
| Key: | | Blood buffers | Sect. 8.11D |
| ChemConn = Chemical Connections Box n | number | Blood cleansing | Sect. 31.5 |
| Sect. = Section number Prob. = Problem number | | Blood clotting | ChemConn 31B |
| 110b. – 110blem number | | Blood pressure | Sect. 31.8 |
| Abundance of elements in the human body | ChemConn 2B | Blood pressure measurement | ChemConn 5D |
| Acid and base burns to the cornea | ChemConn 8B | Blood types | ChemConn 19D |
| Acidic polysaccharides in the body | Sect. 19.8 | Blue diaper syndrome | ChemConn 28C |
| Acidosis and alkalosis | ChemConn 8D | Botox | ChemConn 23C |
| Active sites | ChemConn 22C | Botulism | ChemConn 23C |
| AGE and aging | ChemConn 21B | Breath-alcohol screening | ChemConn 14B |
| AIDS | ChemConn 25C | Breathing and Boyle's Law | ChemConn 5B |
| Albuterol (Proventil) | Sect. 16.7 | Breathing and Dalton's Law | ChemConn 31C |
| Alkaloids | ChemConn 16B | Bronchodilators and asthma | Sect. 16.7 |
| Alzheimer's disease | ChemConn 23D | Brown fat and hibernation | ChemConn 26B |
| Amphetamines | ChemConn 16A | Buffers | Sect. 8.11 |
| Anabolic steroids | ChemConn 20G | | |
| Angiotensin | ChemConn 22F | Calcium, as a signaling agent | ChemConn 23A |
| Antacids | ChemConn 8C | Capsaicin | ChemConn 13F |
| Antibodies and cancer therapy | ChemConn 30A | Carbohydrates, as signals of virulence | |
| Anticancer drugs | ChemConn 24A | and malignancy | ChemConn 30E |
| Antidepressants Sect. 2 | 3.5F, Prob. 15.33 | Carcinogenic PAHs and smoking | Sect. 13.3B |
| Antigens | Sect. 30.3 | Carcinogens | ChemConn 25E |
| Antihistamines | Sect. 23.5G | β -Carotene | Prob. 12.60 |
| Anti-inflammatory drugs | ChemConn 20I | Cephalosporins | ChemConn 18B |
| Antioxidants | Sect. 13.5C | Chiral drugs | ChemConn 15A |
| Antisense drugs | ChemConn 25A | Chirality, in biomolecules | Sect. 15.6 |
| Apoptosis, programmed cell death | ChemConn 24E | Cholera | Sect. 23.5D |
| Artificial sweeteners | ChemConn 29C | Cis-trans isomerism, in vision | ChemConn 12C |
| Ascorbic acid (vitamin C) | ChemConn 19B | Cocaine | ChemConn 16B |
| Aspartame | Prob. 18.56 | Cocaine addiction | ChemConn 23E |
| Aspirin and other NSAIDs | ChemConn 18C | Cold compresses | ChemConn 1C |
| Asthma | Sect. 20.12 | Coniine | ChemConn 16B |
| Atherosclerosis, levels of LDL and HDL | Sect. 20.9E | Coral chemistry and broken bones | ChemConn 3A |
| Atomic energy | Sect. 9.8 | COX-2 inhibitor drugs | ChemConn 20I |
| Atropine | Prob. 16.50 | Creatine, performance enhancement | ChemConn 29D |
| Attention deficit disorder (ADD) | ChemConn 23F | Crenation | Sect. 6.8B |
| Autoimmune diseases | Sect. 30.7 | CT, MRI, ultrasound, and PET scans | ChemConn 9E |
| Autoxidation | Sect. 13.5C | Cystic fibrosis | ChemConn 27E |
| | | Cytochrome P-450, in detoxification | ChemConn 26C |
| B cells | Sect. 30.2C | Cytokines | Sect. 30.6 |
| Barbiturates | ChemConn 18E | | |
| Basal caloric requirement | Sect. 29.3 | DDT | ChemConn 13A |
| Basic excision repair (BER) of DNA | Sect. 24.7 | Diabetes | ChemConn 23G |
| Bends | ChemConn 6B | Dichloroacetic acid | Sect. 18.2D |
| BHT, an antioxidant in foods | Sect. 13.5C | Dietary Reference Intakes (DRI) | Sect. 29.2 |

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| | T | | | |
|---------------|---|----------------------------------|--|----------------------------|
| | Diets | Sect. 29.2 | Innate immunity | Sect. 30.1A |
| | 2,4-Dinitrophenol, as an uncoupling agent | ChemConn 26B | Insulin | Sect. 21.7 |
| | DNA fingerprinting | ChemConn 24C ChemConn 1A | Iodide ion and goiter | ChemConn 13C |
| | Drug dosage and body mass | ChemConn 1A | Ionic compounds in medicine Ionizing radiation | ChemConn 3B Sect. 9.4 |
| | Elements necessary for human life | ChemConn 2A | Iron–sulfur cluster assembly | ChemConn 26A |
| | Emulsions and emulsifying agents | ChemConn 6D | from-sulfur cruster assembly | Chemconn 26A |
| | Enzymes, in diagnosis | Sect. 22.7 | Jaundice | ChemConn 27G |
| | Enzymes, in therapy | Sect. 22.7 | baunuice | Chemconn 27G |
| | Ephedrine | Prob. 15.26 | Ketoacidosis, in diabetes | ChemConn 27C |
| | Epibatadine | Prob. 16.51 | Ketone bodies | Sect. 27.7 |
| - | Epinephrine | Sect. 16.7 | / 1200010 200100 | 2000.2111 |
| | Esters, as flavoring agents | Sect. 18.3 | Lactate accumulation | ChemConn 27A |
| | Ethers and anesthesia | ChemConn 14D | Laser in situ keratomileusis (LASIK) | ChemConn 21H |
| | Ethylene, a plant growth regulator | ChemConn 12A | Laser surgery and protein denaturation | ChemConn 21H |
| | Ethylene oxide, a chemical sterilant | ChemConn 14C | Lipid storage diseases | ChemConn 20F |
| | | | Lowering body temperature | ChemConn 7B |
| | Fluid mosaic model of membranes | Sect. 20.5 | Lycopene | Prob. 12.61 |
| | Free radicals ChemConn 9 | D, Section 13.5C | | |
| | Freons | ChemConn 11B | Mad cow disease | ChemConn 21E |
| | | | Menstrual cycle | Sect. 20.10BB |
| | Galactosemia | ChemConn 19A | Mobilization of leukocytes | ChemConn 30C |
| | Gallstones | Sect. 20.9A | Monoclonal antibodies | Sect. 30.4C |
| | Gene therapy | Sect. 25.8 | Morphine and enkephalins | Sect. 23.6 |
| | Genetic code | Sect. 25.4 | Mucins | Sect. 21.10 |
| | Genetic engineering | Sect. 25.8 | Multiple sclerosis | ChemConn 20E |
| | Glutathione | ChemConn 21A | | n 22A, Sect. 23.3E |
| | Gout | Sect. 6.6B | Mutagens | ChemConn 25E |
| | G-protein/cAMP cascade | Sect. 23.5C | Mutations and biochemical evolution | ChemConn 25E |
| | TT. /4 | 0 | Myasthenia gravis | ChemConn 30D |
| Heart enzymes | | Sect. 22.7 | N- | 0 |
| | Heavy metal poisoning ChemConn Helicobacter | 22E, Sect. 21.10 ChemConn 22B | Naproxen Nerve gases and antidotes | Sect. 15.3 |
| | Heme products, in bruises | Sect. 27.10 | Neurotransmitters | ChemConn 23B |
| | Hemodialysis | ChemConn 6F | Nicotine | Sect. 23.2 ChemConn 16B |
| | Hemolysis | Sect. 6.8B | | hemConn 3C, 23F |
| | Heparin | Sect. 19.8B | Nitroglycerin, an explosive and a drug | ChemConn 14A |
| | High fever | ChemConn 7A | 14100 grycerin, an explosive and a drug | Chemconn 14A |
| | High-fructose corn syrup | ChemConn 19E | Oncogenes | ChemConn 25F |
| | Hormones | Sect. 23.2 | Oral contraception | ChemConn 20H |
| | Human insulin | ChemConn 21C | Osmotic pressure | Sect. 6.8B |
| | Hyaluronic acid | Sect. 19.8 | Oxidative damage | ChemConn 26C |
| | Hyperbaric medicine | ChemConn 5C | Oxidizing antiseptics | ChemConn 4C |
| | Hypertension and its control | ChemConn 31E | | |
| | Hypoglycemic awareness | Sect. 21C | p53, a central tumor suppressor protein | ChemConn 25G |
| | Hypothermia and hyperthermia | ChemConn 1B | Parenteral nutrition | ChemConn 29A |
| | | | Parkinson's disease | ChemConn 23E |
| | Ibuprofen | Sect. 15.3 | Penicillins | ChemConn 18B |
| | Immune system | Sect. 30.1B | pH of some common materials | Sect. 8.8 |
| | Immunization | ChemConn 30B | Phenols, as antioxidants | Sect. 13.5C |
| | Immunoglobulin | Sect. 30.4 | Phenylcyclidine (PCP) | Sect. 23.4B |
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