

The background of the book cover is a dark, textured blue-grey. It is decorated with several white line drawings of molecular structures. On the left side, a large, prominent drawing of a DNA double helix runs vertically. Scattered across the top and right portions of the cover are several smaller, more complex molecular structures, including branched chains and ring systems. The title 'Giant Molecules' is printed in a large, white, serif font, centered in the upper right area.

Giant Molecules

Essential Materials for Everyday
Living and Problem Solving

Second Edition

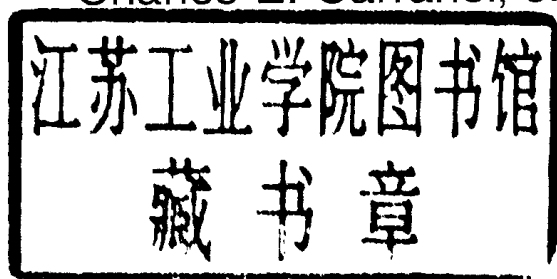
CHARLES E. CARRAHER Jr.

GIANT MOLECULES

Essential Materials for Everyday Living and Problem Solving

SECOND EDITION

Charles E. Carraher, Jr.



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GIANT MOLECULES

Second Edition

PREFACE

Today, a scientific and technological revolution is occurring, and at its center are giant molecules. This revolution is occurring in medicine, communication, building, transportation, and so on. Understanding the principles behind this revolution is within the grasp of each of us, and it is presented in this book.

Giant molecules form the basis for life (human genome, proteins, nucleic acids), what we eat (complex carbohydrates, starches), where we live (wood, concrete), and the society in which we live (tires, plants, paint, clothing, biomaterials, paper, etc.). This text introduces you to the world of giant molecules, the world of plastics, fibers, adhesives, elastomers, paints, and so on, and also provides you with an understanding of why different giant molecules perform in the way they do. Giant molecules lend themselves to a pictorial presentation of the basic principles that govern their properties. This pictorial approach is employed in this text to convey basic principles and to show why different giant molecules behave in a particular manner; we use visual aids such as drawings, pictures, figures, structures, and so on. This text allows us to understand why some giant molecules are suitable for long-term memory present in the human genome while others are strong, allowing their use in bullet-resistant vests, others are flexible and used in automotive dashboards and rubber bands, others are good adhesives used to form space age composites, others are strong and flexible forming the cloths we wear, and so on.

This text is written so that those without any previous science training will be able to understand the world of giant molecules. Thus, the book begins with essential general basics, moving rapidly to material that forms the basics that enables the presentation of general precepts and fundamentals that apply to all materials and especially giant molecules. The initial two steps are accomplished in the first two chapters, and the remainder of the book considers materials concepts, fundamentals, and application. These basics are covered in a broad-brush manner but emphasize the fundamentals that are critical to the success of dealing with and understanding the basics of materials composed of giant molecules.

The book is arranged so that the earlier chapters introduce background information needed for later chapters. Basic concepts are interwoven and dispersed with illustrations that reinforce these basic concepts in practical and applied terms introduced throughout the text. The material is presented in an integrated, clear, and concise manner that combines basics/fundamentals with brief/illustrative applications.

Each chapter has a

- Glossary
- Bibliography
- Questions and answers section

A grouping of appropriate electronic sites is included.

This book is written for two different audiences. The first audience is the technician that wants to know about plastics, paints, textiles, rubbers, adhesives, fabrics and fibers, and composites. The second audience is those students required to include a basic science course in their college/university curriculum. This book can act as the basis of that course and as an alternative to a one-semester course in geology, chemistry, physics, and biology. Furthermore, it may have use in pre-college (high school) trade schools and as an alternative advanced elective to fulfill a science requirement in high school.

CHARLES E. CARRAHER, JR.

The Society of Plastics Engineers is dedicated to the promotion of scientific and engineering knowledge of plastics and to the initiation and continuation of educational programs for the plastics industry. Publications, both books and periodicals, are major means of promoting this technical knowledge and of providing educational materials.

This 2nd Edition of *Giant Molecules* contains enough easily read basic science to permit the nonscientist to understand the structure and use of all polymers. The Society of Plastics Engineers, through its Technical Volumes Committee, has long sponsored books on various aspects of plastics and polymers. The final manuscripts are reviewed by the Committee to ensure accuracy of technical content. Members of this Committee are selected for outstanding technical competence and include prominent engineers, scientists, and educators.

In addition, the Society publishes *Plastics Engineering Magazine*, *Polymer Engineering and Science*, *Journal of Vinyl and Additive Technology*, *Polymer Composites*, proceedings of its Annual Technical Conference and other selected publications. Additional information can be obtained from the Society of Plastics Engineers, 14 Fairfield Drive, Brookfield, CT, 06804 - www.4spe.org.

Executive Director & CEO
Society of Plastics Engineers

MICHAEL R. CAPPELLETTI

CONTENTS

Preface

xv

1 The Building Blocks of Our World

1

- 1.1 Introduction / 2
- 1.2 Setting the Stage / 2
- 1.3 Basic Laws / 3
- 1.4 Matter/Energy / 5
- 1.5 Symbols for the Elements / 7
- 1.6 Elements / 7
- 1.7 Atoms / 8
- 1.8 Classical Atomic Structure / 8
- 1.9 Modern Atomic Structure / 10
- 1.10 Periodicity / 11
- 1.11 Molecular Structure / 14
- 1.12 Chemical Equations / 17
- 1.13 Chemical Bonding / 20
- 1.14 Intermolecular Forces / 24
- 1.15 Units of Measurement / 25
- Glossary / 26
- Review Questions / 28
- Bibliography / 29
- Answers to Review Questions / 30

2 Small Organic Molecules

31

- 2.1 Introduction / 31
- 2.2 Early Developments in Organic Chemistry / 32
- 2.3 Alkanes / 32
- 2.4 Unsaturated Hydrocarbons (Alkenes) / 35
- 2.5 Aliphatic Compounds / 39
- 2.6 Unsaturated Compounds / 42
- 2.7 Benzene and Its Derivatives (Aromatic Compounds) / 43

2.8	Heterocyclic Compounds /	44
2.9	Polymeric Structure /	46
2.10	Structures /	47
	Glossary /	50
	Review Questions /	53
	Bibliography /	54
	Answers to Review Questions /	54

3 Introduction to the Science of Giant Molecules

57

3.1	A Brief History of Chemical Science and Technology /	58
3.2	Polymerization /	64
3.3	Importance of Giant Molecules /	68
3.4	Polymer Properties /	69
	A. Memory /	69
	B. Solubility and Flexibility /	70
	C. Cross-Links /	73
3.5	A Few Definitions of Polymers (Macromolecules) /	73
3.6	Polymer Structure /	75
3.7	Molecular Weights of Polymers /	78
3.8	Polymeric Transitions /	80
3.9	Testing of Polymers /	80
3.10	Chemical Names of Polymers /	81
3.11	Trade Names of Polymers /	82
3.12	Importance of Descriptive Nomenclature /	82
3.13	Marketplace /	82
	Glossary /	86
	Review Questions /	91
	Bibliography /	92
	Answers to Review Questions /	92

4 Relationships Between the Properties and Structure of Giant Molecules

95

4.1	General /	96
4.2	Elastomers /	97
4.3	Fibers /	98
4.4	Plastics /	98
4.5	Adhesives /	99
4.6	Coatings /	99
4.7	Polyblends and Composites /	100
4.8	Crystalline–Amorphous Structures /	101
	A. Chain Flexibility /	107
	B. Intermolecular Forces /	108
	C. Structural Regularity /	108
	D. Steric Effects /	109

4.9	Summary / 109
	Glossary / 110
	Review Questions / 110
	Bibliography / 111
	Answers to Review Questions / 111

5 Physical and Chemical Testing of Polymers **113**

5.1	Testing Organizations / 114
5.2	Evaluation of Test Data / 117
5.3	Stress/Strain Relationships / 117
5.4	Heat Deflection Test / 120
5.5	Coefficient of Linear Expansion / 121
5.6	Compressive Strength / 121
5.7	Flexural Strength / 121
5.8	Impact Test / 123
5.9	Tensile Strength / 123
5.10	Hardness Test / 124
5.11	Glass Transition Temperature and Melting Point / 126
5.12	Density (Specific Gravity) / 126
5.13	Resistance to Chemicals / 128
5.14	Water Absorption / 129
	Glossary / 129
	Review Questions / 130
	Bibliography / 130
	Answers to Review Questions / 132

6 Thermoplastics **133**

6.1	Introduction / 134
6.2	Polyethylenes—History / 136
6.3	High-Density Polyethylene / 138
6.4	Low-Density Polyethylene / 143
6.5	Ultrahigh-Molecular-Weight Polyethylene / 145
6.6	Linear Low-Density Polyethylene / 145
6.7	Cross-Linked Polyethylene / 146
6.8	Other Copolymers of Ethylene / 147
6.9	Polypropylene / 147
6.10	Other Polyolefins / 151
6.11	Polystyrene / 151
6.12	Styrene Copolymers / 153
6.13	Poly(Vinyl Chloride) and Copolymers / 156
6.14	Fluorocarbon Polymers / 157
6.15	Acrylic Polymers / 160
6.16	Poly(Vinyl Acetate) / 161

6.17	Poly(Vinyl Ethers) /	162
6.18	Cellulosics /	162
6.19	Plastics Processing /	163
	A. Introduction /	163
	B. Casting /	165
	C. Blow Molding /	166
	D. Injection Molding /	166
	E. Laminating /	167
	F. Compression Molding /	170
	G. Rotational Molding /	171
	H. Calendering /	171
	I. Extrusion /	174
	J. Thermoforming /	175
	K. Reinforced Plastics /	175
	L. Conclusion /	175
	Glossary /	176
	Review Questions /	177
	Bibliography /	178
	Answers to Review Questions /	180

7 Engineering Plastics

183

7.1	Introduction /	183
7.2	Nylons /	184
7.3	Polyesters /	187
7.4	Polycarbonates /	191
7.5	Polyacetals/Polyethers /	192
7.6	Poly(Phenylene Oxide) /	194
7.7	Poly(Phenylene Sulfide) /	194
7.8	Poly(Aryl Sulfones) /	195
7.9	Polyimides /	197
7.10	Poly(Ether Ether Ketone) and Polyketones /	199
7.11	Polysiloxanes /	200
7.12	Other Engineering Thermoplastics /	203
	Glossary /	204
	Review Questions /	206
	Bibliography /	207
	Answers to Review Questions /	208

8 Thermosets

209

8.1	Introduction /	209
8.2	Phenolic Resins /	210
8.3	Urea Resins /	214
8.4	Melamine Resins /	215

8.5	Alkyds–Polyester Resins /	216
8.6	Epoxy Resins /	218
8.7	Silicones /	219
8.8	Polyurethanes /	221
8.9	Plastic Composites /	222
	Glossary /	223
	Review Questions /	225
	Bibliography /	226
	Answers to Review Questions /	227

9 Fibers

229

9.1	Introduction /	229
9.2	Production Techniques /	232
9.3	Nylons /	235
9.4	Polyesters /	240
9.5	Acrylic Fibers /	241
9.6	Glass Fibers /	242
9.7	Polyolefins /	243
9.8	Polyurethanes /	244
9.9	Other Fibers /	244
	Glossary /	247
	Review Questions /	249
	Bibliography /	249
	Answers to Review Questions /	250

10 Rubbers (Elastomers)

251

10.1	Early History /	251
10.2	General Properties of Elastomers /	254
10.3	Structure of Natural Rubber (NR) /	254
10.4	Harvesting Natural Rubber /	257
10.5	Styrene–Butadiene Rubber (SBR) /	258
10.6	Polymers from 1,4-Dienes /	259
10.7	Polyisobutylene /	262
10.8	Heat-Softened Elastomers /	262
10.9	Other Synthetic Elastomers /	263
10.10	Processing of Elastomers /	265
10.11	Tires /	267
10.12	The Bounce /	270
	Glossary /	270
	Review Questions /	273
	Bibliography /	273
	Answers to Review Questions /	274

11	Paints, Coatings, Sealants, and Adhesives	275
11.1	History of Paints / 276	
11.2	Paint / 276	
11.3	Paint Resins / 278	
11.4	Water-Based Paints / 279	
11.5	Pigments / 280	
11.6	Application Techniques for Coatings / 280	
11.7	End Uses for Coatings / 281	
11.8	Solvent Selection / 282	
11.9	Sealants / 282	
11.10	History of Adhesives / 283	
11.11	Adhesion / 284	
11.12	Types of Adhesives / 284	
11.13	Resinous Adhesives / 285	
	Glossary / 286	
	Review Questions / 289	
	Bibliography / 290	
	Answers to Review Questions / 291	
12	Composites	293
12.1	Introduction / 293	
12.2	General / 294	
12.3	Theory / 294	
12.4	Fiber-Reinforced Composites / 295	
	A. Fibers / 295	
	B. Matrixes (Resins) / 297	
12.5	Particle-Reinforced Composites—Large-Particle Composites / 297	
12.6	Applications / 298	
12.7	Processing—Fiber-Reinforced Composites / 300	
12.8	Processing—Structural Composites / 301	
12.9	Processing—Laminates / 302	
12.10	Nanocomposites / 302	
	Glossary / 303	
	Review Questions / 303	
	Bibliography / 304	
	Answers to Review Questions / 304	
13	Nature's Giant Molecules: The Plant Kingdom	307
13.1	Introduction / 307	
13.2	Simple Carbohydrates (Small Molecules) / 308	
13.3	Cellulose / 311	
13.4	Cotton / 315	

13.5	Paper /	315
13.6	Starch /	317
13.7	Other Carbohydrate Polymers /	318
13.8	Lignin /	319
13.9	Bitumens /	320
13.10	Other Natural Products from Plants /	321
13.11	Photosynthesis /	322
	Glossary /	323
	Review Questions /	325
	Bibliography /	325
	Answers to Review Questions /	326

14 Nature's Giant Molecules: The Animal Kingdom **329**

14.1	Introduction /	329
14.2	Amino Acids /	330
14.3	Proteins /	334
14.4	Protein Structure /	334
14.5	Enzymes /	343
14.6	Wool /	343
14.7	Silk /	344
14.8	Nucleic Acids /	345
14.9	The Genetic Code /	352
14.10	Genetic Engineering /	355
14.11	DNA Profiling /	356
14.12	Melanins /	357
	Glossary /	359
	Review Questions /	361
	Bibliography /	362
	Answers to Review Questions /	362

15 Derivatives of Natural Polymers **365**

15.1	Introduction /	365
15.2	Derivatives of Cellulose /	366
15.3	Derivatives of Starch /	371
15.4	Leather /	371
15.5	Regenerated Protein /	372
15.6	Natural Rubber /	372
15.7	Derivatives of Natural Rubber /	373
15.8	Modified Wool /	373
15.9	Japanese Lacquer /	374
15.10	Natural Polymers Through Biotechnology /	374

15.11 Other Products Based on Natural Polymers /	374
Glossary /	375
Review Questions /	376
Bibliography /	377
Answers to Review Questions /	377

16 Inorganic Polymers **379**

16.1 Introduction /	380
16.2 Portland Cement /	380
16.3 Other Cements /	381
16.4 Silicates /	381
16.5 Silicon Dioxide (Amorphous)—Glass /	385
16.6 Silicon Dioxide (Crystalline)—Quartz /	388
16.7 Asbestos /	388
16.8 Polymeric Carbon—Diamond /	389
16.9 Polymeric Carbon—Graphite /	391
16.10 Polymeric Carbon—Nanotubes /	392
16.11 Ceramics /	396
16.12 High-Temperature Superconductors /	397
16.13 Viscoelastic Behavior /	398
Glossary /	400
Review Questions /	402
Bibliography /	402
Answers to Review Questions /	403

17 Specialty Polymers **405**

17.1 Water-Soluble Polymers /	406
17.2 Oil-Soluble Polymers /	407
17.3 Polymeric Foams /	407
17.4 Polymer Cement /	407
17.5 Xerography /	408
17.6 Piezoelectric Materials /	409
17.7 Conductive and Semiconductive Materials /	409
17.8 Silicon Chips /	411
17.9 Ion-Exchange Resins and Anchored Catalysts /	411
17.10 Photoactive Materials /	413
17.11 Controlled-Release Polymers /	414
17.12 Dendrites /	414
17.13 Ionomers /	416
17.14 Liquid Crystals /	417
17.15 Recycling Codes /	419

17.16 Smart Materials / 420	
Glossary / 420	
Review Questions / 421	
Bibliography / 422	
Answers to Review Questions / 422	

18 Additives and Starting Materials **425**

18.1 Introduction / 426	
18.2 Fillers / 426	
18.3 Reinforcements / 430	
18.4 Coupling Agents / 431	
18.5 Antioxidants / 432	
18.6 Heat Stabilizers / 433	
18.7 Ultraviolet Stabilizers / 433	
18.8 Flame Retardants / 434	
18.9 Plasticizers / 434	
18.10 Impact Modifiers / 436	
18.11 Colorants / 436	
18.12 Catalysts and Curing Agents / 436	
18.13 Foaming Agents / 437	
18.14 Biocides / 437	
18.15 Lubricants and Processing Aids / 437	
18.16 Antistats / 438	
18.17 Starting Materials / 438	
Glossary / 441	
Review Questions / 443	
Bibliography / 443	
Answers to Review Questions / 444	

19 The Future of Giant Molecules **445**

19.1 The Age of Giant Molecules / 445	
19.2 Recycling Giant Molecules / 447	
19.3 Emerging Areas / 448	
19.4 New Products / 449	
Bibliography / 452	

Appendix 1. Studying Giant Molecules **455**

Appendix 2. Electronic Web Sites **459**

Index **463**

THE BUILDING BLOCKS OF OUR WORLD

- 1.1 Introduction
- 1.2 Setting the Stage
- 1.3 Basic Laws
- 1.4 Matter/Energy
- 1.5 Symbols for the Elements
- 1.6 Elements
- 1.7 Atoms
- 1.8 Classical Atomic Structure
- 1.9 Modern Atomic Structure
- 1.10 Periodicity
- 1.11 Molecular Structure
- 1.12 Chemical Equations
- 1.13 Chemical Bonding
- 1.14 Intermolecular Forces
- 1.15 Units of Measurement
- Glossary
- Review Questions
- Bibliography
- Answers to Review Questions

1.1 INTRODUCTION

Science in the broadest sense is our search to understand what is about us. The quest is marked by observation, testing, inquiring, gathering data, explaining, questioning, predicting, and so on. Four major sciences have evolved, yet today's areas of inquiry generally require contributions from more than one. Thus subdisciplines such as biochemistry have developed, and geophysical combinations and other areas of study have also developed: chemical engineering, geography/geology, medical biology, patient law, medical technology, medical physics, and so on. In general terms the four major areas of science can be briefly described as follows:

Biology or Biological Sciences: Study of living systems.

Chemistry: Study of the chemical and physical properties and changes of matter.

Geology: Study of the earth.

Physics: Study of the fundamental components and regularities of nature and how they fit together to form our world.

Mathematics is the queen of science dealing with quantities, magnitudes, and forms and their relationship to one another and to our world.

Engineering deals with design and construction of bridges, highways, computers, biomedical devices, industrial robots, roads, and so on. Giant molecules are used in these endeavors. The design and construction of plants that process prepolymer starting materials as well as this effort of engineering the polymers themselves, along with the machinery used in polymer processing, are also part of the assignment.

This chapter presents a brief overview of some of the science that is essential for an appreciation of the science of giant molecules.

We will be concerned with matter—that is, anything that has mass and occupies space. The term mass is used to describe a quantity of matter. However, in most cases, we will refer to weight instead of mass. Weight, unlike mass, varies with the force of gravity. For example, an astronaut in orbit may be weightless but his or her mass is the same as it was on the earth's surface.

1.2 SETTING THE STAGE

Polymers exist as essential materials for sophisticated objects such as computers and the space shuttle and as simple materials such as rubber bands and plastic spoons. They may be solids capable of stopping a bullet, or they may be liquids such as silicon oils offering a wide variety of flow characteristics.

We not only run across polymers in our everyday lives, but also have questions involving them. When mixing an epoxy adhesive (glue) it gets warm. Why? The dentist stuck a “blue light” into my mouth when I was having a cavity filled. What was happening? When I looked at the filaments in my rug I noticed they