

Joon Park
R. S. Lakes

BIOMATERIALS

An Introduction

Third Edition

 Springer

CONTENTS

Preface	v
----------------------	---

1: Introduction

1.1. Definition of Biomaterials	2
1.2. Performance of Biomaterials	8
1.3. Brief Historical Background	9
Problems	12
Symbols/Definitions	12
Bibliography	13

2: The Structure of Solids

2.1. Atomic Bonding	18
2.2. Crystal Structure	19
2.3. Imperfections in Crystalline Structures	26
2.4. Long-Chain Molecular Compounds (Polymers)	28
2.5. Supercooled and Network Solids	32
2.6. Composite Material Structure	34
Problems	37
Symbols/Definitions	38
Bibliography	39

3: Characterization of Materials — I

3.1. Mechanical Properties	42
3.2. Thermal Properties	63
3.3. Phase Diagrams	67
3.4. Strengthening by Heat Treatments	71
3.5. Surface Properties and Adhesion	72
Problems	75
Symbols/Definitions	78
Bibliography	80

4: Characterization of Materials — II: Electrical, Optical, X-Ray Absorption, Acoustic, Ultrasonic, etc.

4.1.	Electrical Properties.....	84
4.2.	Optical Properties	87
4.3.	X-Ray Absorption.....	90
4.4.	Acoustic and Ultrasonic Properties.....	91
4.5.	Density and Porosity.....	93
4.6.	Diffusion Properties.....	94
	Problems	95
	Symbols/Definitions	96
	Bibliography	97

5: Metallic Implant Materials

5.1.	Stainless Steels	100
5.2.	Co-Based Alloys.....	103
5.3.	Ti and Ti-Based Alloys.....	107
5.4.	Dental Metals.....	113
5.5.	Other Metals	117
5.6.	Corrosion of Metallic Implants.....	120
	Problems	130
	Symbols/Definitions	135
	Bibliography	136

6: Ceramic Implant Materials

6.1.	Structure–Property Relationship of Ceramics	140
6.2.	Aluminum Oxides (Alumina).....	142
6.3.	Zirconium Oxides (Zirconia).....	143
6.4.	Calcium Phosphate	152
6.5.	Glass-Ceramics	155
6.6.	Other Ceramics	158
6.7.	Carbons.....	159
6.8.	Deterioration of Ceramics	162
	Problems	166
	Definitions	169
	Bibliography	170

7: Polymeric Implant Materials

7.1.	Polymerization and Properties	174
7.2.	Effect of Structural Modification and Temperature on Properties.....	178
7.3.	Polymeric Implant Materials	180
7.4.	High-Strength Thermoplastics.....	192
7.5.	Deterioration of Polymers	194
	Problems	198
	Definitions	204
	Bibliography	205

8: Composites as Biomaterials

8.1.	Structure	208
8.2.	Mechanics of Composites.....	209
8.3.	Applications of Composite Biomaterials	213
8.4.	Biocompatibility of Composite Biomaterials	221
	Problems	221
	Symbols/Definitions	222
	Bibliography	223

9: Structure–Property Relationships of Biological Materials

9.1.	Proteins	226
9.2.	Polysaccharides	230
9.3.	Structure–Property Relationship of Tissues	232
	Problems	255
	Symbols / Definitions	259
	Bibliography	261

10: Tissue Response to Implants

10.1.	Normal Wound-Healing Process	266
10.2.	Body Response to Implants	273
10.3.	Blood Compatibility	279
10.4.	Carcinogenicity.....	284
	Problems	286
	Definitions	287
	Bibliography	288

**11: Soft Tissue Replacement — I: Sutures, Skin,
and Maxillofacial Implants**

11.1.	Sutures, Surgical Tapes, and Adhesives	292
11.2.	Percutaneous and Skin Implants	302
11.3.	Maxillofacial and Other Soft-Tissue Augmentation.....	307
	Problems	325
	Definitions	326
	Bibliography	327

12: Soft Tissue Replacement — II: Blood Interfacing Implants

12.1.	Blood Substitutes and Access Catheters	333
12.2.	Cardiovascular Grafts and Stents.....	333
12.3.	Blood Vessel Implants.....	336
12.4.	Heart Valve Implants.....	343
12.5.	Heart and Lung Assist Devices.....	347
12.6.	Artificial Organs	351
	Problems	361
	Definitions	363
	Bibliography	364

13: Hard Tissue Replacement — I: Long Bone Repair

13.1. Wires, Pins, and Screws	371
13.2. Fracture Plates	377
13.3. Intramedullary Devices.....	383
13.4. Acceleration of Bone Healing	386
Problems	389
Definitions	391
Bibliography	392

14: Hard Tissue Replacement — II: Joints and Teeth

14.1. Joint Replacements	397
14.2. Spinal Implants	425
14.3. Dental Restorations and Implants	435
14.4. Interface Problems in Orthopedic and Dental Implants.....	443
Problems	450
Definitions	452
Bibliography	454

15: Transplants

15.1. Overview	460
15.2. Immunological Considerations.....	462
15.3. Blood Transfusions.....	466
15.4. Individual Organs	467
15.5. Regeneration.....	474
15.6. Ethical Considerations.....	476
Problems.....	476
Definitions	480
Bibliography	480

16: Tissue Engineering Materials and Regeneration

16.1. Overview	486
16.2. Substrate Scaffold Materials.....	489
16.3. Sterilization of Scaffolds	505
16.4. Regeneration Stimulated Electrically	505
16.5. Cellular Aspects, Viability, Stem Cells	506
16.6. Bladder Regeneration	507
16.7. Cartilage Regeneration	507
16.8. Skin Regeneration.....	507
16.9. Bone Regeneration	508
16.10. Regeneration in the Cardiovascular System	508
16.11. Summary.....	509
Problems.....	509
Symbols/Definitions	511
Bibliography	512

CONTENTS

xi

Appendices

Appendix I:	Physical Constants and Conversions.....	517
Appendix II:	SI Units	518
Appendix III:	Common Prefixes	518
Appendix IV:	Properties of Selected Elements.....	519
Appendix V:	Properties of Selected Engineering Materials	520
 Name Index		 521
Subject Index		535