Contents

1

Role and Significance of Restorative Dental Materials, 1

Scope of Materials Covered in Restorative Dentistry, 1A Systems Approach to Restorative Materials, 2Application of Various Sciences, 2Future Developments in Biomaterials, 2

2

The Oral Environment, 5

Enamel, 5 The Mineral, 8 Dentin, 9 Physical and Mechanical Properties, 12 The Dentin-Enamel Junction, 15 Oral Biofilms and Restorative Dental Materials, 17

3

Materials-Centered Treatment Design, 23

Evidence-Based Dentistry, 23 Patient Evidence, 23 Scientific Evidence, 23 Planning for Dental Treatment, 24

4

Fundamentals of Materials Science, 29

Mechanical Properties, 29 Force, 29 Stress, 30 Stress-Strain Curves, 31 Viscoelasticity, 39 Dynamic Mechanical Properties, 42 Surface Mechanical Properties, 43 The Colloidal State, 45 Diffusion Through Membranes and Osmotic Pressure, 46 Adsorption, Absorption, and Sorption, 46 Surface Tension and Wetting, 47 Adhesion, 48 Optical Properties, 50 Color, 50 Measurement of Color, 50 Surface Finish and Thickness, 52

Opacity, Translucency, Transparency, and Opalescence, 53 Index of Refraction, 53 Optical Constants, 53 Thermal Properties, 56 Temperature, 56 Transition Temperatures, 56 Heat of Fusion, 57 Thermal Conductivity, 58 Specific Heat, 58 Thermal Diffusivity, 59 Coefficient of Thermal Expansion, 59 Electrical Properties, 60 Electrical Conductivity and Resistivity, 60 Dielectric Constant, 61 Electromotive Force, 61 Galvanism, 62 Electrochemical Corrosion, 63 Zeta-Potential, 63 Other Properties, 63 Tarnish and Discoloration, 63 Water Sorption, 64 Setting Time, 64 Shelf Life, 65 Summary, 65

5

Testing of Dental Materials and Biomechanics, 69

Compressive Strength, 69 Flexure, 69 Flexural Strength, 69 Permanent Bending, 71 Diametral Tensile Strength, 71 Shear Strength, 71 Torsion, 72 Fatigue Strength, 73 Fracture Toughness, 73 Fractographic Analysis, 73 Tear Strength and Tear Energy, 75 Hardness, 75 Brinell Hardness Test, 76 Knoop Hardness Test, 76 Vickers Hardness Test, 76 Rockwell Hardness Test, 76 Barcol Hardness Test, 77 Shore A Hardness Test, 77 Nanoindentation, 77 Wear, 78

Setting Time, 79 Measurement, 79 Dynamic Mechanical Analysis, 79 Rheology, 80 Differential Scanning Calorimetry, 80 Spectrometric Techniques, 80 Pycnometry, 81 Bond Strength Test Methods, 81 Macroshear Bond Strength Tests, 82 Macrotensile Bond Strength Tests, 83 Microtensile Bond Strength Tests, 83 Microshear Bond Strength Tests, 83 Push-Out Tests, 83 Methods for Measuring Shrinkage and Stress During the Cure of Resin Composites, 83 Mercury Dilatometer, 83 Bonded Disk, 84 AcuVol, 84 Managing Accurate Resin Curing Test, 84 Cavity Configuration Factor (C-Factor), 84 Stress Analysis and Design of Dental Structures, 85 Polymerization Stress Test, 86 Tensilometer, 86 Tensometer, 87 Crack Analysis, 87 Specifications for Restorative Materials, 87 American Dental Association Specifications, 88 American Dental Association Acceptance Program, 88 Index of Federal Specifications and Standards, 88

6

Biocompatibility and Tissue Reaction to Biomaterials, 91

Measuring Biocompatibility, 91
In Vitro Tests, 92
Animal Tests, 94
Usage Tests, 94
Correlation Among In Vitro, Animal, and Usage Tests, 95
Using In Vitro, Animal, and Usage Tests
Together, 96
Standards That Regulate the Measurement of Biocompatibility, 97
Biocompatibility of Dental Materials, 98
Reactions of Pulp, 98
Reaction of Other Oral Soft Tissues to Restorative Materials, 105
Summary, 108

7

General Classes of Biomaterials, 113

Metals and Alloys, Chemical and Atomic Structure of Metals, Atomic Structure, Physical Properties of Metals, Polymers, Basic Nature of Polymers, Ceramics, Composites,

8

Preventive and Intermediary Materials, 123

Pit and Fissure Sealants, 123 Light-Cured Sealants, 123 Air Inhibition of Polymerization, 123 Properties of Sealants, 123 Clinical Studies, 125 Application of Sealants, 125 Glass Ionomers as Sealants, 126 Flowable Composites as Sealants, 126 Glass Ionomers to Prevent the Progression of Caries, 127 Composition and Reaction, 127 Properties, 127 Resin-Modified Glass Ionomers, 128 Composition and Reaction, 129 Properties, 129 Manipulation, 130 Resin-Modified Glass Ionomers as Cavity Liners, 130 Calcium Hydroxide Cavity Liners, 130 Mineral Trioxide Aggregate, 131 Fluoride Varnishes, 131 Remineralization, 131

9

Restorative Materials: Resin Composites and Polymers, 135

Multipurpose Resin Composites, 136 Composition, 136 Polymerization Reactions, 144 Packaging of Composites, 147 Properties of Composites, 147 Physical Properties, 147 Mechanical Properties, 151 Clinical Properties, 152 Composites for Special Applications, 153 Microfilled Composites, 153 Bulk Fill Composites, 154

X

Syringeable Composites, 154 Laboratory Composites, 155 Core Build-Up Composites, 155 Provisional Composites, 155 Glass Ionomers, 156 Components and Setting Reaction of Conventional Glass Ionomer, 156 Cermets, 157 Components and Setting Reactions of Resin-Modified Glass Ionomers, 158 Tri-Cure Glass Ionomer System, 159 Nanoionomer, 160 Packaging of Glass Ionomers, 161 Clinical Applications of Glass Ionomers, 161 Properties of Glass Ionomers, 161 Compomers, 163 Composition and Setting Reaction, 163 Properties, 164 Manipulation, 164 Light-Curing Units, 164 Quartz-Tungsten-Halogen Light-Curing Units, 164 Blue Light-Emitting Diodes, 164 Prosthetic Applications of Polymers, 165 Physical Form and Composition, 165 Athletic Mouth Protectors, 166

10

Restorative Materials: Metals, 171

Metals for Direct Placement: Amalgam, 171 Composition and Morphology, 171 Amalgamation Processes: Admixed Alloys, 172 Physical and Mechanical Properties, 174 Bonding of Amalgam, 177 Dental Casting Alloys, 178 Types and Composition, 178 Metallic Elements Used in Dental Alloys, 180 Noble Alloys, 184 Base-Metal Alloys, 190 Wrought Alloys, 200 Microstructure, 200 Composition, 200 Properties, 201 Wrought Stainless Steel Alloys, 201 Wrought Nickel-Titanium Alloy, 203 Wrought Beta-Titanium Alloy, 204

11

Restorative Materials: Ceramics, 209

Classification of Dental Ceramics, 209 Classification by Application, 209 Classification by Fabrication Method, 209 Classification by Crystalline Phase, 209 General Applications of Ceramics in Prosthetic Dentistry, 210

Metal-Ceramic Crowns and Fixed Dental Prostheses, 210 All-Ceramic Crowns, Inlays, Onlays, and Veneers, 211 Mechanical and Thermal Properties of Dental Ceramics, 211 Toughening Mechanisms, 211 Test Methods, 212 Comparative Data, 213 Optical Properties of Dental Ceramics, 214 All-Ceramic Restorations, 215 Sintered All-Ceramic Materials, 215 Heat-Pressed All-Ceramic Materials, 216 Machinable All-Ceramic Materials, 217 Metal-Ceramic Restorations, 219 Requirements for a Metal-Ceramic System, 220 Metal-Ceramic Bonding, 221 Ceramics for Metal-Ceramic Restorations, 222 Effect of Design on Metal-Ceramic Restorations, 224 Failure and Repair of Metal-Ceramic Restorations, 225

12

Replicating Materials: Impression and Casting, 229

Purpose of Impression Materials, 229 Desirable Qualities, 229 Types of Impression Materials, 231 Alginate Hydrocolloids, 231 Elastomeric Impression Materials, 237 Occlusal Registration Materials, 250 Impression Trays, 250 Die, Cast, and Model Materials, 250 Desirable Qualities of a Cast or Die Material, 250 Dental Plaster and Stone, 251 Epoxy Die Materials, 251 Comparison of Impression and Die Materials, 251 Gypsum Products, 252 Chemical and Physical Nature of Gypsum Products, 252 Properties, 255 Manipulation, 260 Casting Investments, 260 Properties Required of an Investment, 261 Composition, 261 Calcium Sulfate-Bonded Investments, 262 Effect of Temperature on Investment, 262 Thermal and Hygroscopic Casting Investment, 265 Brazing Investment, 268 Investment for All-Ceramic Restorations, 268 CONTENTS

13

Materials for Adhesion and Luting, 273

Principles of Adhesion, 273 Adhesive Systems, 275 Bonding to Other Substrates, 280 Repair of Composite, Ceramic, and Ceramic-Metal Restorations, 282 Classification and Characteristics of Luting Agents, 282 Classification, 282 Biocompatibility, 283 Interfacial Sealing and Anticariogenic Activity, 283 Adhesion, 283 Mechanical Properties, 283 Handling Properties and Radiopacity, 283 Viscosity and Film Thickness, 284 Solubility, 284 Esthetics, 284 Acid-Base Cements, 284 Zinc Oxide-Eugenol and Noneugenol Cements, 284 Glass Ionomer, 285 Resin-Modified Glass Ionomer, 287 Calcium Aluminate/Glass Ionomer Cement, 289 Resin-Based Cements, 289 Resin Cements, 289 Self-Adhesive Resin Cements, 290 **Resin Cements for Provisional** Restorations, 292

14

Digital Imaging and Processing for Restorations, 295

Dental CAD/CAM Systems, 295 Digital Impressions, 296 Design Software, 297 Processing Devices, 298 Clinical Outcomes, 298

15

Dental and Orofacial Implants, 301

Classification, 301 Endosseous Implant, 301 Osseointegration and Biointegration, 301 Factors Affecting the Endosteal Implant, 304 Geometry, 304 Magnitude of the Force, 304 Duration of the Force, 304 Type of Force, 305 Implant Diameter, 305 Implant Length, 305 Surfaces and Biocompatibility, 305 Ion Release, 306 Surfaces, 306 Surface Alterations, 306 Surface Coatings, 308 Implant Materials and Processing, 308 Challenges and the Future, 309

16

Tissue Engineering, 313 Autograft, 313 Allograft, 313 Xenograft, 313 Alloplasts, 314 Strategies for Tissue Engineering, 314 Injection of Cells, 314 Guided Tissue Regeneration, 315 Cell Induction, 315 Cells Within Scaffold Matrices, 317 Stem Cells, 318 Biomaterials and Scaffolds, 320 Biological Materials, 320 Ceramic and Glass Materials, 320 Polymeric Materials, 321 Cell Culture Methods, 322 Tissue-Engineered Dental Tissues, 322

Appendix A: Conversion of Units, 327

Index, 331

xii