

Table of Contents

Introduction

J. S. Siegel and Y. Tobe

	Introduction	1
45.1	Product Class 1: Cyclopropenium Salts, Cyclopropenones and Heteroatom Analogues, and Cyclopropenyl Radicals and Anions P. Merino	
45.1	Product Class 1: Cyclopropenium Salts, Cyclopropenones and Heteroatom Analogues, and Cyclopropenyl Radicals and Anions	11
45.1.1	Product Subclass 1: Cyclopropenium Salts	12
45.1.1.1	Synthesis of Product Subclass 1	12
45.1.1.1.1	Method 1: Synthesis from Cyclopropenes	12
45.1.1.1.1.1	Variation 1: Hydride Abstraction	12
45.1.1.1.1.2	Variation 2: Protonation	13
45.1.1.1.1.3	Variation 3: Halide Abstraction	14
45.1.1.1.2	Method 2: Synthesis from Halocyclopropanes	17
45.1.1.1.3	Method 3: Synthesis from Cyclopropenones or Their Heteroatom Analogues	17
45.1.1.1.3.1	Variation 1: O-Alkylation and Related Processes	17
45.1.1.1.3.2	Variation 2: Protonation	18
45.1.1.1.3.3	Variation 3: Formation of Dications	19
45.1.1.1.4	Method 4: Transformations of Other Cyclopropenium Salts	20
45.1.1.1.4.1	Variation 1: Friedel–Crafts-Type Reactions	20
45.1.1.1.4.2	Variation 2: Substitution	21
45.1.1.2	Applications of Product Subclass 1 in Organic Synthesis	24
45.1.1.2.1	Method 1: Synthesis of Cyclopropenes	24
45.1.1.2.2	Method 2: Synthesis of Cyclic Compounds	26
45.1.1.2.3	Method 3: Synthesis of Acyclic Compounds	28
45.1.2	Product Subclass 2: Cyclopropenones and Their Heteroatom Analogues ...	31
45.1.2.1	Synthesis of Product Subclass 2	31
45.1.2.1.1	Method 1: Synthesis from Cyclopropenium Salts	31
45.1.2.2	Applications of Product Subclass 2 in Organic Synthesis	35
45.1.2.2.1	Method 1: Synthesis of Heterocyclic Systems	35
45.1.2.2.1.1	Variation 1: Nitrogen Heterocycles	35
45.1.2.2.1.2	Variation 2: Oxygen Heterocycles	40
45.1.2.2.2	Method 2: Synthesis of Carbocycles	42
45.1.3	Product Subclass 3: Cyclopropenyl Radicals	44
45.1.3.1	Synthesis of Product Subclass 3	44

45.1.4	Product Subclass 4: Cyclopropenyl Anions	44
45.1.4.1	Synthesis of Product Subclass 4	44
45.2	Product Class 2: Cyclobutadienes, Cyclobutenediones, and Squaric Acids S. J. Collier and S. K. Singh	
45.2	Product Class 2: Cyclobutadienes, Cyclobutenediones, and Squaric Acids ..	49
45.2.1	Product Subclass 1: Cyclobutadienes	49
45.2.1.1	Synthesis of Product Subclass 1	57
45.2.1.1.1	Method 1: Synthesis by Cycloreversion	57
45.2.1.1.2	Method 2: Synthesis by Decomposition of Cyclopropenyl Diazomethanes ..	60
45.2.1.1.3	Method 3: Synthesis from Metal–Cyclobutadiene Complexes	62
45.2.1.1.3.1	Variation 1: Using Iron Complexes	62
45.2.1.1.3.2	Variation 2: Using Other Metal Complexes	65
45.2.1.1.4	Method 4: Other Methods	66
45.2.2	Product Subclass 2: Cyclobutenediones	68
45.2.2.1	Synthesis of Product Subclass 2	69
45.2.2.1.1	Method 1: Synthesis from Alkynes	69
45.2.2.1.1.1	Variation 1: By Cycloaddition Reactions	69
45.2.2.1.1.2	Variation 2: Using Transition-Metal Complexes	71
45.2.2.1.2	Method 2: Synthesis from Alkenes	73
45.2.2.1.3	Method 3: Synthesis from Other Cyclobutenediones	75
45.2.2.1.3.1	Variation 1: Friedel–Crafts Reaction of Halocyclobutenediones	75
45.2.2.1.3.2	Variation 2: Reaction of Squaric Acid Derivatives and Carbon Nucleophiles ..	77
45.2.2.1.3.3	Variation 3: Transition-Metal-Catalyzed Cross-Coupling Reactions	80
45.2.2.1.4	Method 4: Other Methods	82
45.2.3	Product Subclass 3: Squaric Acids and Derivatives	83
45.2.3.1	Synthesis of Product Subclass 3	86
45.2.3.1.1	Method 1: Synthesis of Squaric Acids from Polyhalocyclobutenes and Related Reactions	86
45.2.3.1.2	Method 2: Synthesis of Squarate Esters from Squaric Acids	88
45.2.3.1.3	Method 3: Synthesis via Transesterification and Related Reactions	90
45.2.3.1.4	Method 4: Other Methods	91
45.2.4	Product Subclass 4: Sulfur Analogues of Squaric Acid and Related Compounds	91
45.2.4.1	Synthesis of Product Subclass 4	95
45.2.4.1.1	Method 1: Synthesis from Squarate Esters and Sulfur Nucleophiles, and Related Reactions	95
45.2.4.1.2	Method 2: Synthesis by Alkylation of Thiosquarate Anions	98
45.2.4.1.3	Method 3: Other Methods	99

45.3	Product Class 3: Cyclopentadienyl Anions, Cyclopentadienones, and Heteroatom Analogues P. Merino	
45.3	Product Class 3: Cyclopentadienyl Anions, Cyclopentadienones, and Heteroatom Analogues	109
45.3.1	Product Subclass 1: Cyclopentadienyl Anions	110
45.3.1.1	Synthesis of Product Subclass 1	110
45.3.1.1.1	Method 1: Direct Deprotonation	110
45.3.1.1.1.1	Variation 1: Using Alkylolithium Reagents	110
45.3.1.1.1.2	Variation 2: Using Metal Hydrides	113
45.3.1.1.1.3	Variation 3: Using Elemental Alkaline Metals	115
45.3.1.1.1.4	Variation 4: Using Alkali Metal Amides	116
45.3.1.1.2	Method 2: Metal Exchange	117
45.3.1.1.3	Method 3: Synthesis from Pentafulvenes	118
45.3.1.1.4	Method 4: Synthesis from Spirocyclopentadienes	122
45.3.1.2	Applications of Product Subclass 1 in Organic Synthesis	123
45.3.1.2.1	Method 1: Synthesis of Metallocenes and Metal Complexes	123
45.3.1.2.2	Method 2: Synthesis of Functionalized Cyclopentadienides	123
45.3.1.2.3	Method 3: Synthesis of Substituted Cyclopentadienes and Indenes	125
45.3.1.2.3.1	Variation 1: Alkylation Reactions	125
45.3.1.2.3.2	Variation 2: Nucleophilic Addition to Carbonyl Compounds	126
45.3.2	Product Subclass 2: Cyclopentadienones and Heteroatom Analogues	129
45.3.2.1	Synthesis of Product Subclass 2	129
45.3.2.1.1	Method 1: Synthesis from Dicarbonyl Compounds	129
45.3.2.1.2	Method 2: Synthesis from Alkynes	133
45.3.2.1.2.1	Variation 1: Insertion of Carbon Monoxide	133
45.3.2.1.2.2	Variation 2: Reaction with Cyclopropanones	135
45.3.2.1.2.3	Variation 3: Reaction with Isocyanates or Isothiocyanates	137
45.3.2.1.3	Method 3: Synthesis from 1,3-Diene-1,4-diyldilithium Compounds	138
45.3.2.1.4	Method 4: Synthesis from Cyclopentenones and Related Compounds	140
45.3.2.1.5	Method 5: Ring-Contraction Methods	141
45.3.2.2	Applications of Product Subclass 2 in Organic Synthesis	143
45.3.2.2.1	Method 1: Formation of Metal Complexes	143
45.3.2.2.2	Method 2: Synthesis of Functionalized Cyclopentadienes	143
45.3.2.2.3	Method 3: Synthesis of Fused Systems	145
45.3.2.2.3.1	Variation 1: Polyaromatic Compounds	145
45.3.2.2.3.2	Variation 2: Polycyclic Compounds	147

45.4	Product Class 4: Benzene and Alkylbenzenes E. Zysman-Colman	
45.4	Product Class 4: Benzene and Alkylbenzenes	157
45.4.1	Product Subclass 1: Benzene	157
45.4.1.1	Synthesis of Product Subclass 1	157
45.4.1.1.1	Method 1: Thermal Aromatization of Acetylene	157
45.4.1.1.1.1	Variation 1: Metal-Catalyzed Aromatization of Acetylene	157
45.4.1.1.2	Method 2: Metal-Catalyzed Aromatization of Alkanes	158
45.4.1.1.2.1	Variation 1: Metal-Catalyzed Aromatization of Alcohols	158
45.4.1.1.3	Method 3: Metal-Catalyzed Aromatization of Cycloalkanes	158
45.4.1.1.3.1	Variation 1: Aromatization of Cycloalkenes Using Sonication	158
45.4.2	Product Subclass 2: Monoalkylbenzenes	159
45.4.2.1	Synthesis of Product Subclass 2	159
45.4.2.1.1	Method 1: Friedel–Crafts Alkylation of Arenes	159
45.4.2.1.1.1	Variation 1: Lewis Acid Catalyzed Friedel–Crafts Alkylation of Arenes with Alkyl Halides	159
45.4.2.1.1.2	Variation 2: Brønsted Acid or Base Catalyzed Friedel–Crafts Alkylation of Arenes with Alkyl Halides	161
45.4.2.1.1.3	Variation 3: Photochemical Friedel–Crafts Alkylation of Arenes with Alkyl Halides	161
45.4.2.1.1.4	Variation 4: Friedel–Crafts Alkylation of Arenes with Alcohols	162
45.4.2.1.1.5	Variation 5: Friedel–Crafts Alkylation of Arenes with Alkenes	165
45.4.2.1.1.6	Variation 6: Via Tandem Lewis Acid Catalyzed Halogenation and Friedel–Crafts Alkylation of Alkenes	166
45.4.2.1.1.7	Variation 7: Friedel–Crafts Alkylation of Arenes with Epoxides	166
45.4.2.1.1.8	Variation 8: Friedel–Crafts Alkylation of Arenes with Aldehydes	168
45.4.2.1.1.9	Variation 9: Friedel–Crafts Alkylation of Arenes with Alkyl Methanesulfonates or Trifluoromethanesulfonates	170
45.4.2.1.1.10	Variation 10: Lewis Acid Catalyzed Friedel–Crafts Alkylation of Arenes with γ -Alkenyl Silyl Ethers	172
45.4.2.1.1.11	Variation 11: Lewis Acid Catalyzed Friedel–Crafts Alkylation of Arenes with Allylic Acetates	172
45.4.2.1.2	Method 2: Alkylation of Arenes via Cross Coupling of Arenes to Benzyl Ethers	173
45.4.2.1.3	Method 3: Alkylarenes via a Tandem Alkylation–Hydride Reduction Sequence	173
45.4.2.1.3.1	Variation 1: Via Palladium-Catalyzed C–H Activation of Arenes and Coupling with Alkylstannanes	174
45.4.2.1.4	Method 4: Alkylation of Arenes via Suzuki Reaction of Alkylboranes and Related Alkylboron Reagents with Aryl Halides	175
45.4.2.1.4.1	Variation 1: Via Nickel-Catalyzed Cross Coupling	177
45.4.2.1.4.2	Variation 2: Via Organocuprate Coupling to Aryl Trifluoromethanesulfonates	177
45.4.2.1.4.3	Variation 3: Via Kumada-Type Cross Coupling	178

45.4.2.1.4.4	Variation 4:	Via Negishi-Type Cross-Coupling Reactions	180
45.4.2.1.4.5	Variation 5:	Via Stille-Type Cross-Coupling Reactions	181
45.4.2.1.4.6	Variation 6:	Via Hiyama-Type Cross-Coupling Reactions	182
45.4.2.1.5	Method 5:	Alkylation of Benzenes through an S_NAr Mechanism	183
45.4.2.1.6	Method 6:	Alkylation of Benzyl Bromides Using Organocuprates in the Presence of Trialkylboranes	183
45.4.2.1.7	Method 7:	Reduction of Alkyl Aryl Ketones Using Hydrazine and a Base under Wolff–Kishner Conditions	184
45.4.2.1.7.1	Variation 1:	Microwave Heating under Classic Wolff–Kishner Conditions	185
45.4.2.1.7.2	Variation 2:	Wolff–Kishner Reduction of <i>N</i> -(<i>tert</i> -Butyldimethylsilyl)hydrazones	185
45.4.2.1.7.3	Variation 3:	Using Tosylhydrazones and Alkylboranes	187
45.4.2.1.7.4	Variation 4:	Reduction Using Zinc–Hydrochloric Acid under Clemmensen Conditions	187
45.4.2.1.7.5	Variation 5:	Using Phenylphosphines	187
45.4.2.1.7.6	Variation 6:	Using Trialkyl Phosphites	188
45.4.2.1.7.7	Variation 7:	Using Organosilanes	188
45.4.2.1.7.8	Variation 8:	Using Metal Aluminum or Boron Hydrides and a Second Co-reductant	189
45.4.2.1.7.9	Variation 9:	Using Selenium under an Atmosphere of Carbon Monoxide	192
45.4.2.1.7.10	Variation 10:	Using Hydrogen Gas in the Presence of a Metal Catalyst	192
45.4.2.1.7.11	Variation 11:	Using Water or Alcohols as Hydrogen Sources for Reduction in the Presence of a Metal Catalyst	193
45.4.2.1.7.12	Variation 12:	Via Tandem Thioketal Formation and Metal Reduction	194
45.4.2.1.7.13	Variation 13:	Using Palladium/Carbon as a Catalyst	195
45.4.3	Product Subclass 3: Polyalkylbenzenes		195
45.4.3.1	Synthesis of Product Subclass 3		195
45.4.3.1.1	Method 1:	Polyalkylbenzenes via a Directed Carbopalladation Reaction	195
45.4.3.1.2	Method 2:	[2 + 2 + 2] Transition-Metal-Catalyzed Cyclotrimerization of Alkynes	195
45.4.3.1.3	Method 3:	Nickel-Catalyzed Synthesis of Polyalkylated Phenols	198
45.4.3.1.4	Method 4:	[4 + 2] Cyclization of Alkynes with Enynes	198
45.4.3.1.5	Method 5:	Tandem Sonogashira–[4 + 2] Benzannulation Protocol of Alkynes with Vinyl Bromides	203
45.4.3.1.6	Method 6:	Alkene Metathesis	203
45.5	Product Class 5: Styrenes, Stilbenes, and Other Alk-1-enylbenzenes		
	D. A. Alonso and C. Nájera		
45.5	Product Class 5: Styrenes, Stilbenes, and Other Alk-1-enylbenzenes		209
45.5.1	Synthesis of Product Class 5		209
45.5.1.1	Alkenation of Aldehydes		209
45.5.1.1.1	Method 1:	Wittig-Type Reactions	210
45.5.1.1.1.1	Variation 1:	The Wittig Reaction	210
45.5.1.1.1.2	Variation 2:	The Horner–Wittig Reaction	212

45.5.1.1.1.3	Variation 3:	The Horner–Wadsworth–Emmons Reaction	214
45.5.1.1.2	Method 2:	The Peterson Reaction	215
45.5.1.1.3	Method 3:	The Julia Reaction	216
45.5.1.1.4	Method 4:	The Perkin Reaction	217
45.5.1.1.5	Method 5:	The Modified Julia Reaction	218
45.5.1.1.6	Method 6:	The McMurry Reaction	220
45.5.1.2		Elimination Reactions	221
45.5.1.2.1	Method 1:	Elimination of Alcohols	221
45.5.1.2.2	Method 2:	Elimination of Alkyl Halides	222
45.5.1.2.3	Method 3:	Elimination of 1,2-Dibromides	223
45.5.1.3		Reduction of Alkynes	224
45.5.1.3.1	Method 1:	Partial Catalytic Hydrogenation of Alkynes	224
45.5.1.4		Alkene Cross-Metathesis Reactions	226
45.5.1.4.1	Method 1:	Using Molybdenum and Ruthenium Carbene Complexes	226
45.5.1.5		Palladium-Catalyzed Cross-Coupling Reactions	227
45.5.1.5.1	Method 1:	The Mizoroki–Heck Reaction	227
45.5.1.5.1.1	Variation 1:	Aryl Halides as Electrophiles	228
45.5.1.5.1.2	Variation 2:	Arenediazonium Salts as Electrophiles	232
45.5.1.5.1.3	Variation 3:	Decarbonylative Heck Reaction	234
45.5.1.5.1.4	Variation 4:	Desulfonylative Heck Reaction	236
45.5.1.5.2	Method 2:	The Suzuki–Miyaura Reaction	237
45.5.1.5.3	Method 3:	The Hiyama Reaction	239
45.5.1.5.4	Method 4:	The Kosugi–Migita–Stille Reaction	240
45.5.1.5.5	Method 5:	The Negishi Reaction	242
45.5.1.5.6	Method 6:	The Kumada–Tamao–Corriu Reaction	243
45.5.1.5.7	Method 7:	Organoindium Cross-Coupling Reactions	244
45.6		Product Class 6: Annulated Benzenes (1<i>H</i>-Cyclopropabenzenes, 1,2-Dihydrocyclobutabenzenes, Indanes, and Indenes)	
		P. Merino	
45.6		Product Class 6: Annulated Benzenes (1<i>H</i>-Cyclopropabenzenes, 1,2-Dihydrocyclobutabenzenes, Indanes, and Indenes)	253
45.6.1		Product Subclass 1: 1<i>H</i>-Cyclopropabenzenes	253
45.6.1.1		Synthesis of Product Subclass 1	253
45.6.1.1.1	Method 1:	Photolysis of 3 <i>H</i> -Pyrazoles	253
45.6.1.1.2	Method 2:	Aromatization Reactions	254
45.6.1.1.3	Method 3:	Synthesis from Other Cyclopropabenzenes	255
45.6.1.1.4	Method 4:	Direct Formation of the Cyclopropane Ring	257
45.6.1.1.5	Method 5:	Synthesis of Silicon, Germanium, and Boron Analogues of Cyclopropabenzene	258
45.6.1.2		Applications of Product Subclass 1 in Organic Synthesis	259
45.6.1.2.1	Method 1:	Synthesis of Carbon-Containing Aromatic Compounds	259

45.6.1.2.2	Method 2: Synthesis of Heterocyclic Compounds	261
45.6.2	Product Subclass 2: 1,2-Dihydrocyclobutabenzenes	263
45.6.2.1	Synthesis of Product Subclass 2	263
45.6.2.1.1	Method 1: Synthesis from Cycloproparenes	263
45.6.2.1.2	Method 2: Synthesis from 2 <i>H</i> -Pyran-2-ones	264
45.6.2.1.3	Method 3: Photochemical Reactions	265
45.6.2.1.4	Method 4: Synthesis from Benzyne Derivatives	267
45.6.2.1.5	Method 5: Other Annulation Reactions	270
45.6.2.1.6	Method 6: Synthesis from Metallocyclopentadienes	278
45.6.2.2	Applications of Product Subclass 2 in Organic Synthesis	280
45.6.2.2.1	Method 1: Synthesis of Aromatic Compounds	280
45.6.2.2.1.1	Variation 1: Synthesis of Substituted Benzenes	280
45.6.2.2.1.2	Variation 2: Synthesis of Condensed Systems	280
45.6.2.2.2	Method 2: Synthesis of Heterocyclic Compounds	285
45.6.2.2.3	Method 3: Synthesis of Steroid Derivatives	287
45.6.3	Product Subclass 3: Indanes	289
45.6.3.1	Synthesis of Product Subclass 3	289
45.6.3.1.1	Method 1: Friedel–Crafts Cyclization	289
45.6.3.1.2	Method 2: Nazarov Cyclizations	291
45.6.3.1.3	Method 3: Metal-Mediated Cyclization Reactions	292
45.6.3.1.3.1	Variation 1: Palladium-Catalyzed Cyclization (Heck Reaction)	292
45.6.3.1.3.2	Variation 2: Rhodium-Catalyzed Cyclization	296
45.6.3.1.4	Method 4: Electrochemical Cyclization	299
45.6.3.1.5	Method 5: Ring-Contraction Reactions	300
45.6.3.1.6	Method 6: Multicomponent Reactions	302
45.6.3.1.7	Method 7: Cycloaddition Reactions	304
45.6.3.2	Applications of Product Subclass 3 in Organic Synthesis	305
45.6.3.2.1	Method 1: Indanes as Ligands in Organometallic Complexes	305
45.6.3.2.2	Method 2: Synthesis of Heterocyclic Systems	306
45.6.4	Product Subclass 4: Indenes	307
45.6.4.1	Synthesis of Product Subclass 4	307
45.6.4.1.1	Method 1: Friedel–Crafts Annulations	307
45.6.4.1.2	Method 2: Metal-Catalyzed Annulation Reactions	311
45.6.4.1.2.1	Variation 1: Palladium-Catalyzed Annulation	311
45.6.4.1.2.2	Variation 2: Nickel-Catalyzed Annulation	314
45.6.4.1.2.3	Variation 3: Ruthenium-Catalyzed Annulation	315
45.6.4.1.2.4	Variation 4: Rhodium-Catalyzed Annulation	316
45.6.4.1.2.5	Variation 5: Rhenium-Catalyzed Annulation	318
45.6.4.1.2.6	Variation 6: Cobalt-Catalyzed Annulation	318
45.6.4.1.2.7	Variation 7: Gold-Catalyzed Annulation	319
45.6.4.1.2.8	Variation 8: Platinum-Catalyzed Annulation	320
45.6.4.2	Applications of Product Subclass 4 in Organic Synthesis	320

45.6.4.2.1	Method 1:	Synthesis of Fused Indanes and Related Compounds	320
45.6.4.2.2	Method 2:	Synthesis of Heterocyclic Systems	321
45.7	Product Class 7: Cycloheptatrienylium (Tropylium) Salts, Tropones, Tropones, and Heteroatom Analogues		
	K. Abou-Hadeed and H.-J. Hansen		
45.7	Product Class 7: Cycloheptatrienylium (Tropylium) Salts, Tropones, Tropones, and Heteroatom Analogues		
			329
45.7.1	Product Subclass 1: Cycloheptatrienylium (Tropylium) Salts		
			330
45.7.1.1	Synthesis of Product Subclass 1		
			330
45.7.1.1.1	Method 1:	Ring Enlargement of Benzene Derivatives	330
45.7.1.1.2	Method 2:	Aryl-Substituted Tropylium Ions by Arylation of the Parent Ion	332
45.7.1.1.3	Method 3:	Oxidation of Cycloheptatrienes with Nitrosyl Tetrafluoroborate	333
45.7.1.1.4	Method 4:	Tropylium Salts by Alkylation of Tropones and Trophiones	334
45.7.1.1.5	Method 5:	Formation of Silatropylium Ions	335
45.7.1.1.6	Method 6:	Formation of Azatropylium (Azepinium) Ions	336
45.7.2	Product Subclass 2: Tropones		
			337
45.7.2.1	Synthesis of Product Subclass 2		
			337
45.7.2.1.1	Syntheses by [6 + 1] Combinations		
			337
45.7.2.1.1.1	Method 1:	Synthesis from Phenols by Dihalocarbene Addition	337
45.7.2.1.1.1.1	Variation 1:	Reduction of (Dihalomethyl)cyclohexadienones with Polymer-Bound Dibutyltin Hydride	339
45.7.2.1.1.2	Method 2:	Annulated Tropones by Intramolecular Oxidative Coupling of Phenols	341
45.7.2.1.1.3	Method 3:	2,3-Dichloro-5,6-dicyanobenzo-1,4-quinone Oxidation of Spirocyclic Naphthalen-2-ones	342
45.7.2.1.1.4	Method 4:	Synthesis from Dihalocarbene Adducts of Cyclohexadienes	342
45.7.2.1.1.4.1	Variation 1:	Chlorocarbene Addition to Silyl Enol Ethers	343
45.7.2.1.1.5	Method 5:	Tropones via Halotropylium Ions as Reactive Intermediates	344
45.7.2.1.1.6	Method 6:	Tropones from [4 + 2] Cycloaddition of Benzo-1,2-quinones and Arylalkynes	346
45.7.2.1.2	Syntheses by [5 + 2] Combinations		
			347
45.7.2.1.2.1	Method 1:	<i>cine</i> Substitution of <i>exo</i> -7-Chlorobicyclo[3.2.0]hept-2-en-6-one	348
45.7.2.1.2.2	Method 2:	Light-Induced Synthesis of 3- and 4-Alkyltropones	349
45.7.2.1.3	Syntheses by [4 + 3] Combinations		
			350
45.7.2.1.3.1	Method 1:	Rearrangement of 8-Oxabicyclo[3.2.1]oct-6-en-3-ones with Trimethylsilyl Trifluoromethanesulfonate and Triethylamine	350
45.7.2.1.3.1.1	Variation 1:	Cycloaddition of Furans and 1,1,3,3-Tetrachloro-2-oxidopropenylium Cation	351
45.7.2.1.3.1.2	Variation 2:	2,7-Dichlorotropones from [3 + 4] Cycloaddition of Buta-1,3-dienes and 1,1,3,3-Tetrachloro-2-oxidopropenylium Cation	353

45.7.2.1.3.2	Method 2:	3-Aminotropones from an <i>N</i> - <i>tert</i> -Butoxycarbonyl-Protected Furan-2-amine	354
45.7.2.1.3.3	Method 3:	Cyclopropanation of Buta-1,3-diene with Ethyl 3-Diazopyruvate	355
45.7.2.1.3.4	Method 4:	Cyclopropanation of Buta-1,3-dienes with Vinylcarbenes Followed by Cope Rearrangement	356
45.7.2.1.3.5	Method 5:	[4 + 2] Cycloadditions with 4,8-Dioxaspiro[2.5]oct-1-ene	359
45.7.2.1.3.6	Method 6:	Reaction of Functionalized Buta-1,3-dienes and Tetrachlorocyclopropene	361
45.7.2.1.4		Heteroanalogues of Tropones	361
45.7.2.1.4.1	Method 1:	Oxidation of a 3 <i>H</i> -Azepine	362
45.7.3		Product Subclass 3: Tropolones	363
45.7.3.1		Synthesis of Product Subclass 3	364
45.7.3.1.1		Syntheses by [6 + 1] Combinations	364
45.7.3.1.1.1	Method 1:	Rearrangement of 7-Halobicyclo[4.1.0]heptanediones	364
45.7.3.1.1.2	Method 2:	Photooxygenation of Ethyl 4,5-Dioxymethylenecyclohepta-2,4,6-trienecarboxylate	366
45.7.3.1.1.3	Method 3:	β -Tropolones from <i>o</i> -Quinones and Triphenylbismuthonium 2-Oxoalkalides	367
45.7.3.1.1.4	Method 4:	β -Tropolones from <i>o</i> -Quinones and 2-Methylquinolines	368
45.7.3.1.2		Syntheses by [5 + 2] Combinations	369
45.7.3.1.2.1	Method 1:	Base-Catalyzed Rearrangement of 7,7-Dichloro-4-isopropylidenebicyclo[3.2.0]hept-2-en-6-ones	369
45.7.3.1.2.2	Method 2:	Best Route to γ -Tropolone	370
45.7.3.1.2.3	Method 3:	Pyrylium 3-Oxides as a New Tool for α -Tropolone Synthesis	371
45.7.3.1.3		Syntheses by [4 + 3] Combinations	372
45.7.3.1.3.1	Method 1:	Cyclopropanation of 2-Methoxy-Substituted Buta-1,3-diene Ketals	372
45.7.3.1.3.1.1	Variation 1:	β -Tropolone Methyl Ethers from Cyclopropanation of 3-Methoxy-Substituted Buta-1,3-diene Ketals	373
45.7.3.1.3.2	Method 2:	[3 + 4] Cycloaddition of a Methoxy-2-oxidopropenylum Cation with Furans	374
45.7.3.1.3.3	Method 3:	α -Tropolones by Hydroxylation of 8-Oxabicyclo[3.2.1]oct-6-en-3-ones	375
45.7.3.1.3.4	Method 4:	β -Tropolone Formation on Basic Cleavage of 2,2-Dimethoxy-8-oxabicyclo[3.2.1]oct-6-en-3-ones	376
45.7.3.1.4		Heteroanalogues of Tropolones	377
45.8		Product Class 8: Cyclooctatetraenes T. Nishinaga	
45.8		Product Class 8: Cyclooctatetraenes	383
45.8.1		Synthesis of Product Subclass 8	384

45.8.1.1	Method 1:	Cyclization of Octatetraenes	384
45.8.1.2	Method 2:	Copper-Mediated Cyclotetramerization of Ethenes	384
45.8.1.3	Method 3:	Metal-Mediated Cyclodimerization of Butadienes	385
45.8.1.3.1	Variation 1:	Copper-Mediated Homocoupling	385
45.8.1.3.2	Variation 2:	Copper-Mediated Cross Coupling	387
45.8.1.3.3	Variation 3:	Nickel-Mediated Homocoupling	388
45.8.1.3.4	Variation 4:	Nickel-Mediated Cross Coupling	388
45.8.1.4	Method 4:	Reduction of Cyclooctadienes and Cyclooctatrienes Followed by Oxidation of the Resultant Dianion	389
45.8.1.5	Method 5:	Dehydrohalogenation of Annulated Cyclooctatrienes and Cyclooctadienes	390
45.8.1.6	Method 6:	Removal of Acidic Protons	391
45.8.1.7	Method 7:	Decarbonylation and Decarboxylation	391
45.8.1.8	Method 8:	Wittig Reaction	393
45.8.1.9	Method 9:	Extrusion of Oxygen	393
45.8.1.10	Method 10:	Extrusion of Sulfur Dioxide	393
45.8.1.11	Method 11:	Nickel-Catalyzed Cyclotetramerization of Alkynes	394
45.8.1.12	Method 12:	Isomerization of Cyclooctatetraene Valence Isomers	396
45.8.1.12.1	Variation 1:	Isomerization of Bicyclo[4.2.0]octatrienes	396
45.8.1.12.2	Variation 2:	Isomerization of Tricyclo[4.2.0.0 ^{2,5}]octa-3,7-dienes	398
45.8.1.12.3	Variation 3:	Isomerization of Semibullvalenes	398
45.8.1.12.4	Variation 4:	Isomerization of Cubanes	399
45.8.1.12.5	Variation 5:	Photolysis of Barrelene	399
45.8.1.13	Method 13:	Base-Catalyzed Rearrangement of Cycloocta-1,5-diyne	399
45.8.1.14	Method 14:	Ring Expansion by Carbene Rearrangement	400
45.8.1.15	Method 15:	Synthesis with Retention of the Cyclooctatetraene Ring by Halogenation of Cyclooctatetraene	400
45.8.1.16	Method 16:	Synthesis with Retention of the Cyclooctatetraene Ring by Functionalization of Bromocyclooctatetraene	401
45.8.1.16.1	Variation 1:	Metalation Reactions	401
45.8.1.16.2	Variation 2:	Dehydrobromination Reactions	402
45.8.1.16.3	Variation 3:	Cross-Coupling Reactions	403
45.9	Product Class 9: Nine-Membered and Higher Annulenes and Related Ions		
	T. Nishinaga		
45.9	Product Class 9: Nine-Membered and Higher Annulenes and Related Ions		
45.9.1	Product Subclass 1: Annulenes and Related Ions		
45.9.1.1	Synthesis of Product Subclass 1		
45.9.1.1.1	Method 1:	Halogenation Followed by Dehydrohalogenation	407
45.9.1.1.2	Method 2:	Corey–Winter Alkene Synthesis	408
45.9.1.1.3	Method 3:	Wittig Reaction	409
45.9.1.1.4	Method 4:	McMurry Coupling	409
45.9.1.1.5	Method 5:	Reductive Elimination of Chlorine	410
45.9.1.1.6	Method 6:	Hydrogenation of Dehydroannulenes	410
45.9.1.1.7	Method 7:	Valence Isomerization	412

45.9.1.1.8	Method 8:	Reductive Methylation of Octalene Dianion	414
45.9.1.1.9	Method 9:	Prototropic Rearrangement	414
45.9.1.1.10	Method 10:	Substitution of Annulene Rings	415
45.9.2	Product Subclass 2: Methano[n]annulenes and Related Ions		416
45.9.2.1	Synthesis of Product Subclass 2		416
45.9.2.1.1	Method 1:	Electrocyclization Followed by Dehydrohalogenation	416
45.9.2.1.2	Method 2:	Dehydrogenation of Dihydro- or Tetrahydro[n]annulenes and Tetrahydropyrenes	416
45.9.2.1.3	Method 3:	Dihydropyrenes by Elimination of Dimethyl Sulfide	417
45.9.2.1.4	Method 4:	Dehydration of Allylic Alcohols	418
45.9.2.1.5	Method 5:	Elimination of Methanol	418
45.9.2.1.6	Method 6:	Dehydrohalogenation	418
45.9.2.1.7	Method 7:	Sulfur Elimination	419
45.9.2.1.8	Method 8:	McMurry Coupling	419
45.9.2.1.9	Method 9:	Diels–Alder Reactions of Cyclopropabenzene	420
45.9.2.1.10	Method 10:	Cycloaddition of Acetylene Followed by C–C Bond Cleavage	420
45.9.2.1.11	Method 11:	Reductive Addition to Dienones	421
45.9.2.1.12	Method 12:	Electrophilic Substitution of Annulene Rings	421
45.9.2.1.13	Method 13:	Substitution via Organometallic Species	422
45.9.2.1.14	Method 14:	Decarbonylation of Dialdehydes	423
45.9.2.1.15	Method 15:	Functionalization of Annulenes via Annulynes	423
45.9.2.1.16	Method 16:	Functionalization of Annulenes via Homocoupling	424
45.9.2.1.17	Method 17:	Functionalization via Cross Coupling	424
45.10	Product Class 10: Fulvenes		
	S. Ito and N. Morita		
45.10	Product Class 10: Fulvenes		429
45.10.1	Product Subclass 1: Triafulvenes		430
45.10.1.1	Synthesis of Product Subclass 1		430
45.10.1.1.1	Method 1:	Synthesis from Cyclopropenones	430
45.10.1.1.1.1	Variation 1:	Condensation Reactions with Active Methylene Compounds Initiated by Acetic Anhydride	430
45.10.1.1.1.2	Variation 2:	Wittig and Peterson Alkenation Reactions	431
45.10.1.1.1.3	Variation 3:	Condensation Reactions with Ketenes	432
45.10.1.1.1.4	Variation 4:	Reaction of Cyclopropenethione with Tetracyanoethene Oxide	432
45.10.1.1.2	Method 2:	Synthesis from Cyclopropenylium Salts	433
45.10.1.1.2.1	Variation 1:	Proton Abstraction from Substituted Cyclopropenylium Salts	433
45.10.1.1.2.2	Variation 2:	Reaction of Heterosubstituted Cyclopropenylium Salts with Active Methylene Compounds	434
45.10.1.1.3	Method 3:	Synthesis from Substituted Methylenecyclopropanes by Elimination	435
45.10.1.1.4	Method 4:	Carbene Reactions of Cyclopropenylienes	436
45.10.1.1.5	Method 5:	Synthesis of Benzotriafulvenes by Peterson Alkenation	437

45.10.2	Product Subclass 2: Triafulvalenes	438
45.10.2.1	Synthesis of Product Subclass 2	438
45.10.2.1.1	Method 1: Synthesis of Dibenzotriafulvalenes by Carbene Dimerization ..	438
45.10.2.1.2	Method 2: Synthesis of Naphthotriafulvalenes by Peterson Alkenation ...	439
45.10.3	Product Subclass 3: Pentatriafulvalenes	439
45.10.3.1	Synthesis of Product Subclass 3	440
45.10.3.1.1	Method 1: Synthesis from Cyclopropenones	440
45.10.3.1.1.1	Variation 1: Condensation Reactions with Cyclopentadiene Derivatives Initiated by Acetic Anhydride	440
45.10.3.1.1.2	Variation 2: Condensation Reactions with Substituted Cyclopentadienes ..	441
45.10.3.1.2	Method 2: Synthesis from Cyclopropenylum Salts	441
45.10.3.1.2.1	Variation 1: Proton Abstraction from Substituted Cyclopropenylum Salts ..	441
45.10.3.1.2.2	Variation 2: Condensation Reactions of Heterosubstituted Cyclopropenylum Salts	442
45.10.3.1.3	Method 3: Condensation Reactions of Dichlorocyclopropene Derivatives ..	444
45.10.3.1.4	Method 4: Synthesis of Benzopentatriafulvalenes by Peterson Alkenation ..	444
45.10.4	Product Subclass 4: Heptatriafulvalenes	445
45.10.4.1	Synthesis of Product Subclass 4	445
45.10.4.1.1	Method 1: Synthesis of Benzoheptatriafulvalenes by Peterson Alkenation ..	445
45.10.5	Product Subclass 5: Pentafulvalenes	445
45.10.5.1	Synthesis of Product Subclass 5	446
45.10.5.1.1	Method 1: Reactions of Cyclopentadienes with Aldehydes or Ketones	446
45.10.5.1.1.1	Variation 1: Condensation Reactions Initiated by Strong Bases	446
45.10.5.1.1.2	Variation 2: Condensation Reactions Initiated by Secondary Amines	447
45.10.5.1.1.3	Variation 3: Condensation Reactions of Cyclopentadienide Ions with Ketones	448
45.10.5.1.2	Method 2: Reactions of Sodium Cyclopentadienide with 1-Haloalkyl Acetates	449
45.10.5.1.3	Method 3: Reactions of Cyclopentadienes with Carboxylic Acid Derivatives	450
45.10.5.1.3.1	Variation 1: Reaction with a Vilsmeier Reagent	450
45.10.5.1.3.2	Variation 2: Condensation Reactions with O-Alkylated Amides	450
45.10.5.1.3.3	Variation 3: Condensation Reactions with S-Alkylated Thioamides	451
45.10.5.1.3.4	Variation 4: Condensation Reactions with Iminium Salts	452
45.10.5.1.4	Method 4: Reactions of Cyclopentadienes with Triheteromethyl Cations ..	453
45.10.5.1.4.1	Variation 1: Condensation Reactions with O-Alkylated Urea Derivatives ...	453
45.10.5.1.4.2	Variation 2: Condensation Reactions with S-Methylated Thiourea Derivatives	453
45.10.5.1.5	Method 5: Metal-Catalyzed Cyclization Reactions	454
45.10.5.1.5.1	Variation 1: Trimerization of Alkynes	454
45.10.5.1.5.2	Variation 2: Cyclization Reactions of Alkynes and Vinyl Halides	454
45.10.6	Product Subclass 6: Pentafulvalenes	455
45.10.6.1	Synthesis of Product Subclass 6	455
45.10.6.1.1	Method 1: Oxidative Coupling of Cyclopentadienides	455

45.10.6.1.2	Method 2:	Synthesis from Cyclopentadienones	456
45.10.6.1.2.1	Variation 1:	Condensation Reactions with Cyclopentadienides	457
45.10.6.1.2.2	Variation 2:	Peterson Alkenation	458
45.10.6.1.3	Method 3:	Reductive Coupling of 5,5-Dihalocyclopentadienes	458
45.10.7	Product Subclass 7: Heptapentafulvalenes		459
45.10.7.1	Synthesis of Product Subclass 7		459
45.10.7.1.1	Method 1:	Reactions of Cyclopentadienides with Tropylium Salts	459
45.10.7.1.1.1	Variation 1:	Coupling of Cyclopentadienides with Tropylium Salts	460
45.10.7.1.1.2	Variation 2:	Reactions of Cyclopentadienides with Acetoxytropylium Salts	460
45.10.7.1.2	Method 2:	Reactions of Cyclopentadienes with Tropones	461
45.10.7.1.3	Method 3:	Synthesis from Cycloheptatrienylpentafulvenes by Hydrogen Migration	462
45.10.8	Product Subclass 8: Heptafulvenes		462
45.10.8.1	Synthesis of Product Subclass 8		463
45.10.8.1.1	Method 1:	Synthesis from Tropones	463
45.10.8.1.1.1	Variation 1:	Condensation Reactions with Active Methylene Compounds Initiated by Acetic Anhydride	463
45.10.8.1.1.2	Variation 2:	Reaction with Grignard Reagents	464
45.10.8.1.1.3	Variation 3:	Condensation Reactions with Ketenes	465
45.10.8.1.1.4	Variation 4:	Reaction of Cycloheptatrienethiones with Tetracyanoethene	466
45.10.8.1.2	Method 2:	Synthesis from Tropylium Salts	466
45.10.8.1.2.1	Variation 1:	Proton Abstraction from Alkyl-Substituted Tropylium Salts	466
45.10.8.1.2.2	Variation 2:	Condensation Reactions with Active Methylene Compounds	468
45.10.8.1.2.3	Variation 3:	Reactions with Bromomalononitrile	469
45.10.8.1.3	Method 3:	Synthesis from Heterosubstituted Tropylium Salts	469
45.10.8.1.3.1	Variation 1:	Reaction of an Alkoxytropylium Salt with an Active Methylene Compound	469
45.10.8.1.3.2	Variation 2:	Reaction of an Acetoxytropylium Salt with a Lithium Reagent	470
45.10.8.1.4	Method 4:	Enolization of Acylcycloheptatrienes	470
45.10.8.1.5	Method 5:	Synthesis by Hofmann Elimination	471
45.10.8.1.6	Method 6:	Synthesis from Heptafulvenone	472
45.10.8.1.6.1	Variation 1:	Reactions of Heptafulvenone with Carbonyl Compounds	472
45.10.8.1.6.2	Variation 2:	Reactions of Heptafulvenone with Thioketones	473
45.10.9	Product Subclass 9: Heptafulvalenes		473
45.10.9.1	Synthesis of Product Subclass 9		474
45.10.9.1.1	Method 1:	Dimerization of Cycloheptatrienylenes	474
45.10.9.1.1.1	Variation 1:	Heptafulvalenes from the Sodium Salts of Tropone Tosylhydrazones	474
45.10.9.1.1.2	Variation 2:	Dehydrochlorination of Chlorocycloheptatrienes	475
45.10.9.1.1.3	Variation 3:	Rearrangement of Phenylcarbenes	475
45.10.9.1.2	Method 2:	Reductive Coupling of 7,7-Dichlorocycloheptatrienes	476
45.10.9.1.3	Method 3:	Reactions of Heptafulvenone with Tropone Derivatives	477

45.11	Product Class 11: Dimethylenecyclobutenes and Quinodimethanes H. Sano and J. Nishimura	
45.11	Product Class 11: Dimethylenecyclobutenes and Quinodimethanes	483
45.11.1	Product Subclass 1: Dimethylenecyclobutenes	483
45.11.1.1	Synthesis of Product Subclass 1	484
45.11.1.1.1	Method 1: [3,3]-Sigmatropic Rearrangements and Electrocyclic Reactions	484
45.11.1.1.1.1	Variation 1: Thermolysis of Hexa-1,5-diyne	484
45.11.1.1.1.2	Variation 2: Thermolysis of Substituted Diallenes	485
45.11.1.1.1.3	Variation 3: Dimerization of Species Generated In Situ from Propenes, Propadienes, or Propynes	485
45.11.1.1.2	Method 2: Synthesis from Cyclobutenes	487
45.11.1.1.2.1	Variation 1: By the Formation of <i>exo</i> -Double Bonds via Hofmann Elimination	487
45.11.1.1.2.2	Variation 2: By Wittig Reaction	487
45.11.1.1.2.3	Variation 3: By Dehydrochlorination	488
45.11.1.1.2.4	Variation 4: By Substitution of Carbanionic Species Generated from 1,2-Dimethyl-3,4-dimethylenecyclobutene	488
45.11.2	Product Subclass 2: Quinodimethanes	489
45.11.2.1	Synthesis of Product Subclass 2	490
45.11.2.1.1	Method 1: <i>o</i> -Quinodimethanes by Thermal Reactions	490
45.11.2.1.1.1	Variation 1: Ring Opening of Benzannulated Cyclobutenes	490
45.11.2.1.1.2	Variation 2: Elimination of Sulfur Dioxide from Sulfoxes	493
45.11.2.1.1.3	Variation 3: Elimination of Sulfur Dioxide from Sultines	494
45.11.2.1.1.4	Variation 4: Elimination of Carbon Dioxide from 5,8-Dihydro-7 <i>H</i> -1,3-dioxolo[4,5- <i>g</i>][2]benzopyran-7-one	494
45.11.2.1.1.5	Variation 5: Elimination of Hydrogen Chloride from 1-Methyl-2-(trichloromethyl)benzenes	494
45.11.2.1.2	Method 2: <i>o</i> -Quinodimethanes by 1,4-Elimination Reactions of 1,2-Dialkylbenzenes Containing Leaving Groups Bonded to the Alkyl Substituents	495
45.11.2.1.2.1	Variation 1: Using Metals as Reducing Agents	495
45.11.2.1.2.2	Variation 2: Anion-Induced 1,4-Eliminations	496
45.11.2.1.2.3	Variation 3: Hofmann Elimination of <i>N,N,N</i> -Trimethyl(10-methyl-9-phenanthryl)methanaminium Chloride	498
45.11.2.1.2.4	Variation 4: Proton-Induced 1,4-Eliminations	499
45.11.2.1.3	Method 3: <i>o</i> -Quinodimethanes by Addition/Elimination Reactions	499
45.11.2.1.4	Method 4: <i>o</i> -Quinodimethanes by Photochemical Reactions	500
45.11.2.1.4.1	Variation 1: Photochemically Induced 1,5-Shifts	500
45.11.2.1.4.2	Variation 2: Photochemically Induced Eliminations	501
45.11.2.1.5	Method 5: <i>o</i> -Quinodimethanes by Cathodic Reduction and Anodic Oxidation of 1,2-Dialkylbenzenes	502
45.11.2.1.6	Method 6: <i>o</i> -Quinodimethanes by Palladium(0)/Samarium(II) Iodide Induced Intramolecular Cyclization	503

45.11.2.1.7	Method 7:	<i>p</i> -Quinodimethanes by Pyrolysis of 1,4-Dialkylbenzenes and Their Derivatives	503
45.11.2.1.8	Method 8:	<i>p</i> -Quinodimethanes by Methylenation of Naphtho-1,4-quinone or Anthra-9,10-quinone	504
45.12	Product Class 12: Radialenes		
	M. Iyoda		
45.12	Product Class 12: Radialenes		
45.12.1	Product Subclass 1: [3]Radialenes		
45.12.1.1	Synthesis of Product Subclass 1		
45.12.1.1.1	Method 1:	Synthesis by Substitution Reactions	508
45.12.1.1.1.1	Variation 1:	Aromatic Substitution Reactions	508
45.12.1.1.1.2	Variation 2:	Nucleophilic Substitution Reactions	512
45.12.1.1.2	Method 2:	Synthesis by Elimination Reactions	515
45.12.1.1.2.1	Variation 1:	E2 Elimination of Hydrogen Halides	515
45.12.1.1.2.2	Variation 2:	Elimination of Trimethylamine (Hofmann Elimination)	516
45.12.1.1.3	Method 3:	Synthesis by Addition Reactions	516
45.12.1.1.3.1	Variation 1:	Addition of Methylene-carbenes	516
45.12.1.1.3.2	Variation 2:	Addition and Oligomerization of Transition Metal Carbenoids	517
45.12.1.1.4	Method 4:	Synthesis by Cyclization Reactions	518
45.12.1.1.4.1	Variation 1:	Synthesis by Ring Closure with Transition Metals	519
45.12.2	Product Subclass 2: [4]Radialenes		
45.12.2.1	Synthesis of Product Subclass 2		
45.12.2.1.1	Method 1:	Synthesis by Elimination Reactions	519
45.12.2.1.1.1	Variation 1:	E2 Elimination of Hydrogen Halides and Pyrolysis of Hofmann Bases	520
45.12.2.1.1.2	Variation 2:	1,4-Dehalogenation, Reductive Dehydroxylation, and Retro-Diels–Alder Reaction	522
45.12.2.1.2	Method 2:	Synthesis by Dimerization Reactions	523
45.12.2.1.2.1	Variation 1:	Thermal and Photochemical Dimerization Reactions	524
45.12.2.1.2.2	Variation 2:	Transition-Metal-Mediated Dimerization and Oligomerization Reactions	527
45.12.3	Product Subclass 3: [5]Radialenes		
45.12.3.1	Synthesis of Product Subclass 3		
45.12.3.1.1	Method 1:	Transition-Metal-Mediated Oligomerization Reactions	536
45.12.3.1.2	Method 2:	Addition–Elimination Reactions of [5]Radialenones	537
45.12.4	Product Subclass 4: [6]Radialenes		
45.12.4.1	Synthesis of Product Subclass 4		
45.12.4.1.1	Method 1:	Synthesis by Reductive Elimination Reactions	539
45.12.4.1.2	Method 2:	Synthesis by Elimination or Isomerization Reactions at High Temperature	540
45.12.4.1.3	Method 3:	Transition-Metal-Mediated Oligomerization Reactions	541

45.12.5	Product Subclass 5: Expanded Radialenes	542
45.12.5.1	Synthesis of Product Subclass 5	542
	Keyword Index	i
	Author Index	xxxiii
	Abbreviations	lxi