

## Volume 36: Alcohols

Preface .....	V
Volume Editor's Preface .....	VII
Table of Contents .....	XI
<b>Introduction</b>	
J. Clayden .....	1
<b>36.1 Product Class 1: Alkanols</b>	
<b>36.1.1 Synthesis by Oxidation</b>	
M. J. Porter .....	17
<b>36.1.2 Synthesis by Reduction</b>	
L. R. Cox .....	55
<b>36.1.3 Synthesis by Substitution</b>	
A. F. Parsons .....	177
<b>36.1.4 Synthesis by Addition to Alkynes and Alkenes</b>	
A. T. Russell .....	191
<b>36.1.5 Synthesis by Carbonylation Reactions</b>	
G. Ilyashenko, T. Schütz, and A. Whiting .....	245
<b>36.1.6 Synthesis by Addition of Organometallics to Carbon Dioxide, Carboxylic Acids, and Derivatives</b>	
C. Grosjean and A. Whiting .....	255
<b>36.1.7 Synthesis by Addition of Organometallics to Aldehydes and Ketones</b>	
C. G. Frost and J. Le Nôtre .....	271
<b>36.1.8 Synthesis by Resolution and Inversion Methods</b>	
J. Eames .....	341
<b>36.1.9 Synthesis from Other Alcohols by Modification</b>	
J. Eames .....	423
<b>36.2 Product Class 2: Cycloalkanols</b>	
P. J. H. Scott and P. G. Steel .....	459
<b>36.3 Product Class 3: Propargylic Alcohols</b>	
P. Forgione and L. D. Fader .....	531
<b>36.4 Product Class 4: Benzylic Alcohols</b>	
M. J. Porter .....	573
<b>36.5 Product Class 5: Allylic Alcohols</b>	
D. M. Hodgson and P. G. Humphreys .....	583

<b>36.6</b>	<b>Product Class 6: Homoallylic Alcohols</b>	667
	M. V. Perkins .....	
<b>36.7</b>	<b>Product Class 7: 1,n-Diols (<math>n &gt; 1</math>)</b>	757
	C. Nativi and S. Roelens .....	
<b>36.8</b>	<b>Product Class 8: Polyols, Including Carbohydrates</b>	799
	R. C. D. Brown .....	
<b>36.9</b>	<b>Product Class 9: <math>\beta</math>-Hydroxy Carbonyl Compounds</b>	847
	R. Mahrwald and B. Schetter .....	
<b>36.10</b>	<b>Product Class 10: n-Heteroatom-Functionalized Alcohols (<math>n \geq 2</math>; Heteroatom <math>\neq</math> Halogen)</b>	971
	M. J. Bingham and M. F. Greaney .....	
<b>36.11</b>	<b>Product Class 11: Alcohols and Diols by Deprotection</b>	1031
	M. G. Moloney and M. Yaqoob .....	
<b>36.12</b>	<b>Product Class 12: Metal Alcoholates</b>	1107
	J. V. Morey and A. E. H. Wheatley .....	
	<b>Keyword Index</b> .....	1167
	<b>Author Index</b> .....	1225
	<b>Abbreviations</b> .....	1295

## Table of Contents

<b>Introduction</b>	J. Clayden
<hr/>	
<b>Introduction</b>	1
<hr/>	
<b>36.1 Product Class 1: Alkanols</b>	
<hr/>	
<b>36.1.1 Synthesis by Oxidation</b>	M. J. Porter
<hr/>	
<b>36.1.1.1 Synthesis by Oxidation</b>	17
<b>36.1.1.1.1 Method 1: Oxidation of Alkanes</b>	17
<b>36.1.1.1.1.1 Variation 1: Oxidation with Molecular Oxygen</b>	17
<b>36.1.1.1.1.2 Variation 2: Oxidation with Ozone</b>	19
<b>36.1.1.1.1.3 Variation 3: Oxidation with Dioxiranes</b>	21
<b>36.1.1.1.1.4 Variation 4: Oxidation with Oxaziridines</b>	24
<b>36.1.1.1.1.5 Variation 5: Oxidation with Peroxy Acids</b>	25
<b>36.1.1.1.1.6 Variation 6: Oxidation with Fluorine</b>	26
<b>36.1.1.1.1.7 Variation 7: Oxidation with Metal Porphyrins</b>	27
<b>36.1.1.1.1.8 Variation 8: Oxidation with Ruthenium Compounds</b>	29
<b>36.1.1.1.1.9 Variation 9: Oxidation with Chromium Compounds</b>	30
<b>36.1.1.1.1.10 Variation 10: Oxidation with Methyltrioxorhenium(VII)</b>	32
<b>36.1.1.1.1.11 Variation 11: Biocatalytic Oxidation</b>	33
<b>36.1.1.1.2 Method 2: Oxidation of Organosilicon Compounds</b>	35
<b>36.1.1.1.2.1 Variation 1: Oxidation of Trichlorosilanes</b>	35
<b>36.1.1.1.2.2 Variation 2: Oxidation of Alkoxy silanes with Hydrogen Peroxide</b>	36
<b>36.1.1.1.2.3 Variation 3: Oxidation of Alkoxy silanes with Peroxy Acids</b>	37
<b>36.1.1.1.2.4 Variation 4: Oxidation of Alkoxy silanes with Molecular Oxygen</b>	38
<b>36.1.1.1.2.5 Variation 5: Oxidation of Dimethyl(phenyl)silanes</b>	38
<b>36.1.1.1.3 Method 3: Oxidation of Organoboron Compounds</b>	40
<b>36.1.1.1.3.1 Variation 1: Oxidation with Basic Hydrogen Peroxide</b>	40
<b>36.1.1.1.3.2 Variation 2: Oxidation with Sodium Perborate and Sodium Percarbonate</b>	41
<b>36.1.1.1.3.3 Variation 3: Oxidation with Trimethylamine N-Oxide</b>	42
<b>36.1.1.1.4 Method 4: Oxidation of Organomercury Compounds</b>	43
<b>36.1.1.1.5 Method 5: Oxidation of Organolithium, Organomagnesium, Organozinc, and Organocupper Compounds</b>	45
<b>36.1.1.1.5.1 Variation 1: Oxidation with Molecular Oxygen</b>	45
<b>36.1.1.1.5.2 Variation 2: Oxidation with Alkyl Hydroperoxides</b>	46
<b>36.1.1.1.5.3 Variation 3: Oxidation with Bis(trimethylsilyl) Peroxide</b>	47
<b>36.1.1.1.5.4 Variation 4: Oxidation with Oxaziridines</b>	48

<b>36.1.2</b>	<b>Synthesis by Reduction</b>	
	L. R. Cox	
<hr/>		
<b>36.1.2</b>	<b>Synthesis by Reduction</b>	55
<b>36.1.2.1</b>	Synthesis of Primary Aliphatic Alkanols	55
<b>36.1.2.1.1</b>	Method 1: Reduction of Carboxylic Acids	55
<b>36.1.2.1.1.1</b>	Variation 1: Using Metal Aluminum Hydrides and Alkoxyaluminum Hydrides	55
<b>36.1.2.1.1.2</b>	Variation 2: Using Metal Borohydrides and Related Compounds	57
<b>36.1.2.1.1.3</b>	Variation 3: Using Boranes and Related Compounds	59
<b>36.1.2.1.1.4</b>	Variation 4: Using Alane and Related Compounds	62
<b>36.1.2.1.1.5</b>	Variation 5: Using Samarium(II) Iodide	63
<b>36.1.2.1.1.6</b>	Variation 6: Transition-Metal-Catalyzed Reduction	63
<b>36.1.2.1.1.7</b>	Variation 7: Electrochemical Reduction	64
<b>36.1.2.1.1.8</b>	Variation 8: Enzymatic Reduction	64
<b>36.1.2.1.1.9</b>	Variation 9: By In Situ Derivatization	64
<b>36.1.2.1.2</b>	Method 2: Reduction of Esters	66
<b>36.1.2.1.2.1</b>	Variation 1: Using Metal Aluminum Hydrides and Related Systems	66
<b>36.1.2.1.2.2</b>	Variation 2: Using Metal Borohydrides and Related Systems	67
<b>36.1.2.1.2.3</b>	Variation 3: Using Boranes	70
<b>36.1.2.1.2.4</b>	Variation 4: Using Alane and Other Neutral Organoaluminum Reagents	71
<b>36.1.2.1.2.5</b>	Variation 5: Using Silanes and Siloxanes	72
<b>36.1.2.1.2.6</b>	Variation 6: Using Dissolving Metal Conditions	75
<b>36.1.2.1.2.7</b>	Variation 7: Using Samarium(II) Iodide	75
<b>36.1.2.1.2.8</b>	Variation 8: Transition-Metal-Catalyzed Hydrogenation	75
<b>36.1.2.1.2.9</b>	Variation 9: Electrochemical Reduction	75
<b>36.1.2.1.3</b>	Method 3: Reduction of Amides	76
<b>36.1.2.1.3.1</b>	Variation 1: Using Aluminum Hydrides and Borohydride Reducing Agents	76
<b>36.1.2.1.3.2</b>	Variation 2: Using Boranes	78
<b>36.1.2.1.3.3</b>	Variation 3: Using Dissolving Metals	78
<b>36.1.2.1.3.4</b>	Variation 4: Using Samarium(II) Iodide	78
<b>36.1.2.1.3.5</b>	Variation 5: Electrochemical Reduction	79
<b>36.1.2.1.3.6</b>	Variation 6: Transition-Metal-Catalyzed Hydrogenation	79
<b>36.1.2.1.4</b>	Method 4: Reduction of Acid Halides and Acid Anhydrides	79
<b>36.1.2.1.4.1</b>	Variation 1: Using Aluminum Hydride and Alkoxyaluminum Hydride Reducing Agents	79
<b>36.1.2.1.4.2</b>	Variation 2: Using Borohydride Reducing Agents	80
<b>36.1.2.1.4.3</b>	Variation 3: Using Boranes or Alane and Related Reagents	84
<b>36.1.2.1.4.4</b>	Variations 4: Miscellaneous Reductions	84
<b>36.1.2.1.5</b>	Method 5: Reduction of Thioesters	85
<b>36.1.2.1.5.1</b>	Variation 1: Using Aluminum Hydrides	85
<b>36.1.2.1.5.2</b>	Variation 2: Using Borohydrides	85
<b>36.1.2.1.5.3</b>	Variation 3: Using Neutral Organoaluminum Reagents	86
<b>36.1.2.1.5.4</b>	Variation 4: Using Heterogeneous Nickel Catalysts	86
<b>36.1.2.1.6</b>	Method 6: Reduction of Nitriles	87
<b>36.1.2.1.6.1</b>	Variation 1: Reactions Proceeding via the Intermediate Aldehyde	87
<b>36.1.2.1.6.2</b>	Variation 2: Reactions Proceeding via the Intermediate Carboxylic Acid or Ester	88

<b>36.1.2.1.7</b>	Method 7:	Reduction of Aldehydes .....	88
<b>36.1.2.1.7.1</b>	Variation 1:	Using Metal Borohydrides .....	88
<b>36.1.2.1.7.2</b>	Variation 2:	Using Aluminum Hydrides and Related Reagents .....	92
<b>36.1.2.1.7.3</b>	Variation 3:	Using Borane, Alane, and Related Systems .....	93
<b>36.1.2.1.7.4</b>	Variation 4:	Using Organosilanes and Related Systems .....	95
<b>36.1.2.1.7.5</b>	Variation 5:	Using Organostannanes and Organostibines .....	99
<b>36.1.2.1.7.6</b>	Variation 6:	Using Alkali Metal and Alkaline Earth Metal Hydrides and Related Systems .....	101
<b>36.1.2.1.7.7</b>	Variation 7:	Using Meerwein–Ponndorf–Verley-Type Reactions .....	102
<b>36.1.2.1.7.8</b>	Variation 8:	Transition-Metal-Catalyzed Reduction: Hydrogenation and Transfer Hydrogenation .....	106
<b>36.1.2.1.7.9</b>	Variation 9:	Using Single-Electron-Transfer Reduction Strategies .....	108
<b>36.1.2.1.7.10</b>	Variations 10:	Miscellaneous Strategies .....	110
<b>36.1.2.1.8</b>	Method 8:	Reductive Ring Opening of Cyclic Ethers .....	111
<b>36.1.2.1.8.1</b>	Variation 1:	Using Borohydrides and Aluminum Hydrides .....	111
<b>36.1.2.1.8.2</b>	Variation 2:	Using Boranes and Neutral Aluminum Hydride Reagents .....	112
<b>36.1.2.1.8.3</b>	Variation 3:	Using Silanes .....	114
<b>36.1.2.1.8.4</b>	Variation 4:	Transition-Metal-Catalyzed Hydrogenolysis of Cyclic Ethers .....	114
<b>36.1.2.1.8.5</b>	Variation 5:	Using Single-Electron-Transfer Agents .....	115
<b>36.1.2.1.9</b>	Method 9:	Reduction of Peroxides and Related Systems .....	118
<b>36.1.2.1.9.1</b>	Variation 1:	Reduction of Hydroperoxides and Peroxides .....	118
<b>36.1.2.1.9.2</b>	Variation 2:	Reduction of Ozonides .....	118
<b>36.1.2.1.9.3</b>	Variation 3:	Reduction of Hydroxylamines .....	119
<b>36.1.2.2</b>		Synthesis of Secondary Aliphatic Alkanols .....	119
<b>36.1.2.2.1</b>	Method 1:	Reduction of Ketones .....	119
<b>36.1.2.2.1.1</b>	Variation 1:	Using Metal Aluminum Hydrides and Related Systems .....	119
<b>36.1.2.2.1.2</b>	Variation 2:	Using Borohydride Reducing Agents and Related Systems .....	120
<b>36.1.2.2.1.3</b>	Variation 3:	Using Boranes and Related Systems .....	121
<b>36.1.2.2.1.4</b>	Variation 4:	Using Silanes and Related Systems .....	122
<b>36.1.2.2.1.5</b>	Variation 5:	Using Stannanes and Related Systems .....	123
<b>36.1.2.2.1.6</b>	Variation 6:	Using Alkali Metal and Alkaline Earth Metal Hydrides and Related Systems .....	124
<b>36.1.2.2.1.7</b>	Variation 7:	Using Meerwein–Ponndorf–Verley-Type Reactions .....	125
<b>36.1.2.2.1.8</b>	Variation 8:	Transition-Metal-Catalyzed Hydrogenation and Transfer Hydrogenation .....	127
<b>36.1.2.2.1.9</b>	Variation 9:	Using Single-Electron-Transfer Methods .....	128
<b>36.1.2.2.1.10</b>	Variation 10:	Electrochemical Reduction .....	131
<b>36.1.2.2.1.11</b>	Variations 11:	Miscellaneous Procedures .....	132
<b>36.1.2.2.2</b>	Method 2:	Enantioselective Reduction of Ketones .....	132
<b>36.1.2.2.2.1</b>	Variation 1:	Asymmetric Transition-Metal-Catalyzed Hydrogenation and Transfer Hydrogenation .....	132
<b>36.1.2.2.2.2</b>	Variation 2:	Biocatalytic Reduction Methods .....	134
<b>36.1.2.2.3</b>	Method 3:	Reductive Ring Opening of Cyclic Ethers .....	137
<b>36.1.2.2.3.1</b>	Variation 1:	Using Metal Aluminum Hydrides .....	137
<b>36.1.2.2.3.2</b>	Variation 2:	Using Metal Borohydrides and Related Reagents .....	138
<b>36.1.2.2.3.3</b>	Variation 3:	Using Boranes, Alanes, and Related Reagents .....	140
<b>36.1.2.2.3.4</b>	Variation 4:	Transition-Metal-Catalyzed Hydrogenolysis of Cyclic Ethers .....	142

<b>36.1.2.2.3.5</b>	Variation 5: Using Single-Electron-Transfer Methods .....	143
<b>36.1.2.2.3.6</b>	Variation 6: Lewis Acid Mediated Silane Reduction of Cyclic Ethers .....	144
<b>36.1.2.2.3.7</b>	Variation 7: Nucleophile-Assisted Ring Opening Followed by Radical Reduction .....	144
<b>36.1.2.2.4</b>	Method 4: Reduction of Hydroperoxides, Peroxides, and Related Systems .....	145
<b>36.1.2.3</b>	Synthesis of Acyclic Secondary Alkanols Possessing a Stereogenic Center Containing No Heteroatoms .....	148
<b>36.1.2.3.1</b>	Method 1: Diastereoselective Reduction of Ketones Possessing an $\alpha$ -Stereogenic Center .....	149
<b>36.1.2.3.2</b>	Method 2: Diastereoselective Reduction of Ketones Possessing a $\beta$ -Stereogenic Center .....	151
<b>36.1.2.3.3</b>	Method 3: Diastereoselective Reduction of Ketones Possessing $\alpha$ - and $\beta$ -Stereogenic Centers .....	152
<b>36.1.2.4</b>	Synthesis of Tertiary Aliphatic Alkanols .....	153
<b>36.1.2.4.1</b>	Method 1: Reductive Ring Opening of Cyclic Ethers .....	153
<b>36.1.2.4.2</b>	Method 2: Reduction of Hydroperoxides and Peroxides .....	155
<b>36.1.3</b>	<b>Synthesis by Substitution</b>	
	A. F. Parsons	
<b>36.1.3</b>	<b>Synthesis by Substitution</b> .....	177
<b>36.1.3.1</b>	Method 1: Substitution of Halides .....	177
<b>36.1.3.1.1</b>	Variation 1: In Primary Haloalkanes .....	177
<b>36.1.3.1.2</b>	Variation 2: In Secondary Haloalkanes .....	178
<b>36.1.3.1.3</b>	Variation 3: In Tertiary Haloalkanes .....	179
<b>36.1.3.2</b>	Method 2: Substitution of Sulfonate Anions .....	180
<b>36.1.3.2.1</b>	Variation 1: In Methanesulfonates .....	180
<b>36.1.3.2.2</b>	Variation 2: In Trifluoromethanesulfonates .....	182
<b>36.1.3.2.3</b>	Variation 3: In 4-Toluenesulfonates .....	182
<b>36.1.3.3</b>	Method 3: Substitution of Oxygen Functionalities .....	183
<b>36.1.3.3.1</b>	Variation 1: In Ethers .....	183
<b>36.1.3.3.2</b>	Variation 2: In Acetals .....	183
<b>36.1.3.3.3</b>	Variation 3: In Esters .....	184
<b>36.1.3.4</b>	Method 4: Ring Opening of Epoxides with Carbon Nucleophiles .....	184
<b>36.1.3.4.1</b>	Variation 1: Using Cyanide Anion .....	184
<b>36.1.3.4.2</b>	Variation 2: Using Organolithium Reagents .....	185
<b>36.1.3.4.3</b>	Variation 3: Using Grignard Reagents .....	186
<b>36.1.3.4.4</b>	Variation 4: Using Organocuppper Reagents .....	186
<b>36.1.3.4.5</b>	Variation 5: Using Enolate Ions .....	187
<b>36.1.4</b>	<b>Synthesis by Addition to Alkynes and Alkenes</b>	
	A. T. Russell	
<b>36.1.4</b>	<b>Synthesis by Addition to Alkynes and Alkenes</b> .....	191
<b>36.1.4.1</b>	Method 1: Oxymercuration Followed by Reduction .....	191
<b>36.1.4.1.1</b>	Variation 1: Using Mercury(II) Acetate–Sodium Borohydride .....	195

---

<b>36.1.4.1.2</b>	Variation 2: Using Mercury(II) Acetate–Sodium Trithiocarbonate .....	201
<b>36.1.4.1.3</b>	Variation 3: Using Mercury(II) Acetate–Sodium Amalgam .....	202
<b>36.1.4.1.4</b>	Variation 4: Using Mercury(II) Trifluoroacetate–Sodium Borohydride .....	204
<b>36.1.4.1.5</b>	Variation 5: Using Mercury(II) Salts–Sodium Borohydride .....	205
<b>36.1.4.2</b>	Method 2: Acid-Catalyzed Addition of Water .....	206
<b>36.1.4.2.1</b>	Variation 1: Photoprotonation-Initiated Hydration of Alkenes .....	213
<b>36.1.4.3</b>	Method 3: Cobalt- or Manganese-Catalyzed Hydration of Alkenes .....	215
<b>36.1.4.3.1</b>	Variation 1: Using Bis(dipivaloylmethanato)manganese(II), Phenylsilane, and Oxygen .....	219
<b>36.1.4.4</b>	Method 4: Synthesis by Ozonolysis–Reduction .....	221
<b>36.1.4.4.1</b>	Variation 1: Using Ozone and Then a Borohydride or Borane Reductant ..	223
<b>36.1.4.4.2</b>	Variation 2: Using Ozone and Then an Aluminum Hydride Reductant ..	231
<b>36.1.4.5</b>	Method 5: Synthesis by Alkylative Hydroxylation .....	232
<b>36.1.4.5.1</b>	Variation 1: Carboalumination Catalyzed by Bis(cyclopenta-dienyl)zirconium(IV) Complexes with In Situ Oxygenation .....	232
<b>36.1.4.5.2</b>	Variation 2: Ethylmagnesiation Catalyzed by Dichlorobis(cyclopenta-dienyl)zirconium(IV) followed by In Situ Oxygenation .....	235
<b>36.1.4.5.3</b>	Variation 3: Radical Cyclization with In Situ Oxygenation .....	236
<b>36.1.4.6</b>	Method 6: Synthesis by Reductive Hydration of Alkynes .....	237

---

**36.1.5      Synthesis by Carbonylation Reactions**

G. Ilyashenko, T. Schütz, and A. Whiting

---

<b>36.1.5</b>	<b>Synthesis by Carbonylation Reactions</b> .....	245
<b>36.1.5.1</b>	Method 1: Synthesis by Carbonylation of Boranes .....	245
<b>36.1.5.1.1</b>	Variation 1: By Treatment with Carbon Monoxide .....	245
<b>36.1.5.1.2</b>	Variation 2: By Treatment with Carbon Monoxide in the Presence of Hydrides .....	247
<b>36.1.5.2</b>	Method 2: Synthesis by Carbonylation of Alkyl Halides .....	250
<b>36.1.5.2.1</b>	Variation 1: By Radical Carbonylation .....	250
<b>36.1.5.2.2</b>	Variation 2: Using Tricarbonylcobalt Complexes and Carbon Monoxide/Hydrogen .....	252
<b>36.1.5.3</b>	Method 3: Synthesis by Homologation of Alcohols Using Carbon Monoxide/Hydrogen .....	252

---

**36.1.6      Synthesis by Addition of Organometallics to Carbon Dioxide, Carboxylic Acids, and Derivatives**

C. Grosjean and A. Whiting

---

<b>36.1.6</b>	<b>Synthesis by Addition of Organometallics to Carbon Dioxide, Carboxylic Acids, and Derivatives</b> .....	255
<b>36.1.6.1</b>	Method 1: Addition to Carbon Dioxide .....	255
<b>36.1.6.2</b>	Method 2: Addition to Acyl Chlorides .....	256
<b>36.1.6.2.1</b>	Variation 1: Addition of Organocupper Compounds .....	256
<b>36.1.6.2.2</b>	Variation 2: Addition of Organoiron Compounds .....	256
<b>36.1.6.2.3</b>	Variation 3: Addition of Organomanganese Compounds .....	257
<b>36.1.6.2.4</b>	Variation 4: Addition of Organozirconocene Compounds .....	257

---

<b>36.1.6.2.5</b>	Variation 5:	Addition of Organolanthanum Compounds .....	258
<b>36.1.6.2.6</b>	Variation 6:	Addition of Organomagnesium Compounds .....	258
<b>36.1.6.2.7</b>	Variation 7:	Addition of Organolithium Compounds .....	259
<b>36.1.6.3</b>	Method 3:	Addition to Carboxylic Acids .....	260
<b>36.1.6.3.1</b>	Variation 1:	Addition of Organomagnesium Compounds .....	261
<b>36.1.6.3.2</b>	Variation 2:	Addition of Organolithium Compounds .....	261
<b>36.1.6.4</b>	Method 4:	Addition to Carboxylic Anhydrides .....	262
<b>36.1.6.5</b>	Method 5:	Addition to Carboxylic Acid Esters .....	263
<b>36.1.6.5.1</b>	Variation 1:	Addition of Organoaluminum Compounds .....	263
<b>36.1.6.5.2</b>	Variation 2:	Addition of Organocerium Compounds .....	264
<b>36.1.6.5.3</b>	Variation 3:	Addition of Organomagnesium Compounds .....	265
<b>36.1.6.5.4</b>	Variation 4:	Addition of Organolithium Compounds .....	267
<b>36.1.6.6</b>	Method 6:	Decarboxylation .....	268

**36.1.7      Synthesis by Addition of Organometallics to Aldehydes and Ketones**

C. G. Frost and J. Le Nôtre

---

<b>36.1.7</b>	<b>Synthesis by Addition of Organometallics to Aldehydes and Ketones</b>	....	271
<b>36.1.7.1</b>	Method 1:	Addition of Organolithium and Organomagnesium Reagents .....	271
<b>36.1.7.1.1</b>	Variation 1:	Direct Addition of Alkyl- and Arylmagnesium Halides .....	271
<b>36.1.7.1.2</b>	Variation 2:	Direct Addition of Alkyl- and Aryllithiums .....	273
<b>36.1.7.1.3</b>	Variation 3:	Direct Addition of Alkenyl- and Alkynylmagnesium Halides ..	275
<b>36.1.7.1.4</b>	Variation 4:	Direct Addition of Alkenyl- and Alkynyllithiums .....	276
<b>36.1.7.1.5</b>	Variation 5:	Direct Addition Using Barbier Conditions .....	277
<b>36.1.7.1.6</b>	Variation 6:	Direct Addition Using Unusual Reaction Conditions .....	278
<b>36.1.7.1.7</b>	Variation 7:	Direct Addition Using Additives .....	280
<b>36.1.7.1.8</b>	Variation 8:	Additions via Transmetalation .....	286
<b>36.1.7.1.9</b>	Variation 9:	Diastereoselective Additions to Acyclic Carbonyl Derivatives ..	288
<b>36.1.7.1.10</b>	Variation 10:	Diastereoselective Additions to Cyclic Carbonyl Derivatives ..	298
<b>36.1.7.1.11</b>	Variation 11:	Enantioselective Additions of Grignard Reagents .....	299
<b>36.1.7.1.12</b>	Variation 12:	Enantioselective Additions of Organolithium Derivatives .....	301
<b>36.1.7.1.13</b>	Variation 13:	Enantioselective Additions of Lithium/Magnesium Binary Reagents .....	303
<b>36.1.7.2</b>	Method 2:	Addition of Organozinc Reagents .....	304
<b>36.1.7.2.1</b>	Variation 1:	Direct Addition of Alkyl- and Arylzinc Reagents .....	304
<b>36.1.7.2.2</b>	Variation 2:	Direct Addition of Allyl- and Propargylzinc Reagents .....	305
<b>36.1.7.2.3</b>	Variation 3:	Addition via Transmetalation .....	306
<b>36.1.7.2.4</b>	Variation 4:	Diastereoselective Additions of Organozinc Reagents .....	307
<b>36.1.7.2.5</b>	Variation 5:	Catalytic, Enantioselective Additions of Organozinc Reagents ..	308
<b>36.1.7.3</b>	Method 3:	Addition of Organoboron, Organotin, Organosilicon, and Organoindium Reagents .....	320
<b>36.1.7.3.1</b>	Variation 1:	Additions via Transmetalation to Rhodium .....	320
<b>36.1.7.3.2</b>	Variation 2:	Enantioselective Additions via Transmetalation to Rhodium ..	323
<b>36.1.7.3.3</b>	Variation 3:	Additions via Transmetalation to Palladium .....	325
<b>36.1.7.3.4</b>	Variation 4:	Addition of Allylic Boron Reagents .....	325
<b>36.1.7.3.5</b>	Variation 5:	Lewis Acid Catalyzed Addition of Allylic Silane and Stannane Reagents .....	326
<b>36.1.7.3.6</b>	Variation 6:	Addition of Allylic Indium Reagents .....	327

<b>36.1.7.4</b>	Method 4: Addition of Other Organometallics .....	328
<b>36.1.7.4.1</b>	Variation 1: Catalytic Addition of In Situ Generated Organochromium Species .....	328
<b>36.1.7.4.2</b>	Variation 2: Addition of Allylic Manganese Reagents in Water .....	329
<b>36.1.7.4.3</b>	Variation 3: Addition of Organocadmium Reagents .....	329
<b>36.1.7.4.4</b>	Variation 4: Direct Addition of Organocupper Reagents .....	329
<b>36.1.7.4.5</b>	Variation 5: Enantioselective Addition of Organotitanium Reagents .....	330
<b>36.1.7.4.6</b>	Variation 6: Enantioselective Addition of Organoaluminum Reagents .....	331
<b>36.1.8</b>	<b>Synthesis by Resolution and Inversion Methods</b>	
	J. Eames	
<b>36.1.8</b>	<b>Synthesis by Resolution and Inversion Methods</b> .....	341
<b>36.1.8.1</b>	Method 1: Resolution of 1-Phenylethanol by Enantioselective Oxidation .....	342
<b>36.1.8.1.1</b>	Variation 1: Using a (Bicyclo[2.2.1]heptadiene)dichloropalladium(II)/(-)-Sparteine Complex .....	342
<b>36.1.8.1.2</b>	Variation 2: Using a (-)-Sparteine-Palladium(II) Complex .....	343
<b>36.1.8.1.3</b>	Variation 3: Using a [(4,5-Dihydrooxazolyl)ferrocenyl]phosphine-Ruthenium Complex .....	343
<b>36.1.8.1.4</b>	Variation 4: Using a Manganese(III)-salen Complex .....	344
<b>36.1.8.1.5</b>	Variation 5: Using Baker's Yeast .....	344
<b>36.1.8.2</b>	Method 2: Resolution of 1-Phenylethanol by Enantioselective Reduction .....	345
<b>36.1.8.2.1</b>	Variation 1: Using <i>Bacillus subtilis</i> , <i>Aspergillus niger</i> , and Horseradish Peroxidase .....	345
<b>36.1.8.2.2</b>	Variation 2: Using a Chiral Diphosphine .....	346
<b>36.1.8.3</b>	Method 3: Synthesis of ( <i>R</i> )- and ( <i>S</i> )-1-Phenylethanol via Enzymatic Ester Formation .....	347
<b>36.1.8.3.1</b>	Variation 1: Using Lipase QL .....	347
<b>36.1.8.3.2</b>	Variation 2: Using Porcine Pancreatic Lipase .....	348
<b>36.1.8.3.3</b>	Variation 3: Using Amano P Lipase .....	348
<b>36.1.8.3.4</b>	Variation 4: Using <i>Candida antarctica</i> Lipase .....	349
<b>36.1.8.3.5</b>	Variation 5: Using <i>Candida antarctica</i> Lipase B .....	349
<b>36.1.8.4</b>	Method 4: Synthesis of ( <i>R</i> )- and ( <i>S</i> )-1-Phenylethanol Using Acyl-Transfer Processes .....	351
<b>36.1.8.4.1</b>	Variation 1: Using an Asymmetric Mitsunobu Reaction .....	351
<b>36.1.8.4.2</b>	Variation 2: Using an Oxazolidinone as a Benzoyl- or Phosphoryl-Transfer Reagent .....	352
<b>36.1.8.4.3</b>	Variation 3: Using a Phosphabicyclooctane Acyl-Transfer Catalyst .....	353
<b>36.1.8.4.4</b>	Variation 4: Using a Chiral Pyridinium Acyl-Transfer Reagent .....	354
<b>36.1.8.4.5</b>	Variation 5: Using a Chiral 2,3-Dihydroimidazo[1,2- <i>a</i> ]pyridine .....	356
<b>36.1.8.4.6</b>	Variation 6: Using a Planar-Chiral 4-(Dimethylamino)pyridine Complex .....	356
<b>36.1.8.4.7</b>	Variation 7: Using a Chiral Atropisomeric 4-(Dimethylamino)pyridine Equivalent .....	358
<b>36.1.8.4.8</b>	Variation 8: Using a Ferrocene-Based Chiral 4-(Dimethylamino)pyridine ..	358
<b>36.1.8.4.9</b>	Variation 9: Using an Octapeptide Derived from a Split-and-Pool Library ..	359
<b>36.1.8.5</b>	Method 5: Synthesis of ( <i>R</i> )- and ( <i>S</i> )-1-Phenylethanol by Deracemization ..	360
<b>36.1.8.5.1</b>	Variation 1: Using a Combination of <i>Pseudomonas fluorescens</i> Lipase and a Rhodium Catalyst .....	360

<b>36.1.8.5.2</b>	Variation 2: Using a Combination of Novozym 435 and a Ruthenium Complex .....	360
<b>36.1.8.6</b>	Method 6: Synthesis of ( <i>R</i> )- and ( <i>S</i> )-1-Phenylethanol Using a Sequential Enzyme Resolution/Mitsunobu Inversion Process .....	362
<b>36.1.8.7</b>	Method 7: Resolution of 1-Phenylethanol via Inclusion Complexation ..	363
<b>36.1.8.8</b>	Method 8: Resolution of Hexan-2-ol .....	363
<b>36.1.8.8.1</b>	Variation 1: Using Lipozyme .....	363
<b>36.1.8.8.2</b>	Variation 2: Via an Inclusion Complex .....	364
<b>36.1.8.9</b>	Method 9: Resolution of 2-Methylhexan-1-ol Using <i>Pseudomonas cepacia</i> Lipase .....	364
<b>36.1.8.10</b>	Method 10: Resolution of 2-Ethylhexan-1-ol .....	365
<b>36.1.8.11</b>	Method 11: Synthesis of ( <i>R</i> )- and ( <i>S</i> )-Octan-2-ol .....	365
<b>36.1.8.11.1</b>	Variation 1: By Sulfenylation Followed by Stereospecific <i>S<sub>N</sub>2</i> Inversion ..	365
<b>36.1.8.11.2</b>	Variation 2: By Isourea Ether Formation Followed by Stereospecific <i>S<sub>N</sub>2</i> Inversion Using Acetic Acid .....	366
<b>36.1.8.11.3</b>	Variation 3: By Isourea Ether Formation Followed by Stereospecific <i>S<sub>N</sub>2</i> Inversion Using Formic Acid .....	367
<b>36.1.8.12</b>	Method 12: Resolution of 1-(4-Methoxyphenyl)ethanol .....	367
<b>36.1.8.13</b>	Method 13: Resolution of 2,2,2-Trifluoro-1-(1-naphthyl)ethanol .....	368
<b>36.1.8.14</b>	Method 14: Resolution of 2-Phenylpropan-1-ol .....	369
<b>36.1.8.15</b>	Method 15: Resolution of 1-Phenylpropan-1-ol .....	370
<b>36.1.8.16</b>	Method 16: Resolution of 1-Phenylbutan-1-ol .....	371
<b>36.1.8.17</b>	Method 17: Resolution of 1-(2-Thienyl)butan-1-ol .....	371
<b>36.1.8.18</b>	Method 18: Resolution of 6,10,14-Trimethylpentadecan-2-ol .....	373
<b>36.1.8.19</b>	Method 19: Resolution of 2,2-Dimethylcyclopantan-1-ol .....	374
<b>36.1.8.20</b>	Method 20: Resolution of <i>trans</i> -2-Phenylcyclohexanol .....	374
<b>36.1.8.20.1</b>	Variation 1: Using a Polymer-Supported Diamine .....	374
<b>36.1.8.20.2</b>	Variation 2: Using 2,2'-Bis(diphenylphosphino)-1,1'-binaphthyl .....	375
<b>36.1.8.21</b>	Method 21: Resolution of 2-(4-Methoxyphenyl)cyclohexanol .....	375
<b>36.1.8.22</b>	Method 22: Resolution of <i>trans</i> -2-(1-Methyl-1-phenylethyl)cyclohexanol ..	376
<b>36.1.8.23</b>	Method 23: Synthesis of (1 <i>R</i> ,2 <i>S</i> ,5 <i>R</i> )-Menthol .....	377
<b>36.1.8.24</b>	Method 24: Synthesis of (3 <i>B</i> ,5 <i>A</i> )-Cholestan-3-ol .....	378
<b>36.1.8.25</b>	Method 25: Resolution of 2-Chloro-1-phenylethanol .....	379
<b>36.1.8.26</b>	Method 26: Resolution of 1-Phenoxypropan-2-ol .....	379
<b>36.1.8.27</b>	Method 27: Resolution of (2,2-Dimethyl-1,3-dioxolan-4-yl)methanol ..	380
<b>36.1.8.28</b>	Method 28: Resolution of 5-(Hydroxymethyl)oxazolidin-2-one .....	380
<b>36.1.8.29</b>	Method 29: Resolution of Ethyl Hydroxy(phenyl)acetate .....	381
<b>36.1.8.30</b>	Method 30: Synthesis of (S)-Pantolactone .....	382
<b>36.1.8.31</b>	Method 31: Resolution of <i>cis</i> -2-(Benzoyloxy)cyclohexanol .....	382
<b>36.1.8.32</b>	Method 32: Resolution of <i>cis</i> -2-[4-(Dimethylamino)benzoyloxy]cyclohexanol .....	383
<b>36.1.8.33</b>	Method 33: Resolution of <i>cis</i> -2-(Dimethylcarbamoyloxy)cyclohexanol ..	384
<b>36.1.8.34</b>	Method 34: Resolution of Methyl 2-Hydroxy-3-(4-methoxyphenyl)-3-[(2-nitrophenyl)sulfanyl]propanoate .....	385
<b>36.1.8.35</b>	Method 35: Resolution of <i>trans</i> -Indane-1,2-diol .....	385
<b>36.1.8.36</b>	Method 36: Resolution of 1-Phenylethane-1,2-diol .....	386
<b>36.1.8.37</b>	Method 37: Resolution of 2,2-Dimethyl-1,3-diphenylpropane-1,3-diol ..	387
<b>36.1.8.38</b>	Method 38: Resolution of Pentane-2,4-diol Using <i>Candida antarctica</i> Lipase	388

<b>36.1.8.39</b>	Method 39:	Resolution of Hexane-2,5-diol .....	389
<b>36.1.8.40</b>	Method 40:	Resolution of 1,1'-Binaphthalene-2,2'-diol .....	389
<b>36.1.8.41</b>	Method 41:	Resolution of <i>trans</i> -Cyclohexane-1,2-diol .....	391
<b>36.1.8.41.1</b>	Variation 1:	Using a Double-Inversion Method .....	391
<b>36.1.8.41.2</b>	Variation 2:	By Kinetic Resolution .....	391
<b>36.1.8.42</b>	Method 42:	Resolution of Pentane-1,2-diol .....	392
<b>36.1.8.43</b>	Method 43:	Resolution of Hexane-1,2-diol .....	393
<b>36.1.8.44</b>	Method 44:	Resolution of <i>trans</i> -2-Azidocyclohexanol .....	393
<b>36.1.8.45</b>	Method 45:	Resolution of 2-Aminopropan-1-ol .....	394
<b>36.1.8.46</b>	Method 46:	Resolution of <i>trans</i> -2-[Methyl(phenyl)amino]cyclohexanol .....	395
<b>36.1.8.47</b>	Method 47:	Resolution of <i>trans</i> -2-Pyrrolidin-1-ylcyclohexanol .....	396
<b>36.1.8.48</b>	Method 48:	Resolution of <i>trans</i> -2-(1 <i>H</i> -Pyrazol-1-yl)cyclohexanol .....	397
<b>36.1.8.49</b>	Method 49:	Resolution of 2-( <i>tert</i> -Butylamino)-1-(2,2-dimethyl-4 <i>H</i> -1,3-benzodioxin-6-yl)ethanol .....	398
<b>36.1.8.50</b>	Method 50:	Resolution of <i>cis</i> -4-(Dimethylamino)-N-(2-hydroxycyclohexyl)benzamide .....	399
<b>36.1.8.51</b>	Method 51:	Resolution of <i>trans</i> -N-(2-Hydroxycyclohexyl)acetamide .....	401
<b>36.1.8.51.1</b>	Variation 1:	Using an Octapeptide .....	401
<b>36.1.8.51.2</b>	Variation 2:	Using a Tripeptide .....	401
<b>36.1.8.52</b>	Method 52:	Resolution of 2-[( <i>tert</i> -Butoxycarbonyl)amino]-3-(hydroxymethyl)bicyclo[2.2.1]heptane .....	402
<b>36.1.8.53</b>	Method 53:	Resolution of Cyclohex-2-en-1-ol .....	402
<b>36.1.8.53.1</b>	Variation 1:	Using a Palladium-Catalyzed Deracemization Reaction .....	402
<b>36.1.8.53.2</b>	Variation 2:	Using a Chiral Dianiline/Ruthenium Mediated Enantioselective Hydrogenation .....	404
<b>36.1.8.53.3</b>	Variation 3:	Using an Ephedrine/Ruthenium Mediated Enantioselective Hydrogenation .....	405
<b>36.1.8.54</b>	Method 54:	Resolution of ( <i>Z</i> )-Pent-3-en-2-ol .....	405
<b>36.1.8.55</b>	Method 55:	Resolution of 4-Phenylbut-3-en-2-ol .....	406
<b>36.1.8.55.1</b>	Variation 1:	Using <i>Candida antarctica</i> Lipase .....	406
<b>36.1.8.55.2</b>	Variation 2:	Using a Planar-Chiral 4-(Dimethylamino)pyridine Equivalent Complex .....	407
<b>36.1.8.55.3</b>	Variation 3:	By Enantioselective Oxidation .....	408
<b>36.1.8.56</b>	Method 56:	Resolution of 4-Phenylbut-3-yn-2-ol and 3-Phenylbut-3-en-2-ol .....	409
<b>36.1.8.56.1</b>	Variation 1:	Using <i>Pseudomonas</i> AK .....	409
<b>36.1.8.56.2</b>	Variation 2:	Using an Asymmetric Katsuki-Jacobsen Epoxidation Reaction .....	409
<b>36.1.8.57</b>	Method 57:	Resolution of 3-(Ethoxycarbonyl)but-3-en-2-ol .....	410
<b>36.1.8.58</b>	Method 58:	Resolution of ( <i>E</i> )-1-(Trimethylsilyl)oct-1-en-3-ol .....	410
<b>36.1.8.59</b>	Method 59:	Resolution of ( <i>Z</i> )-3-(Trimethylsilyl)oct-3-en-2-ol .....	411
<b>36.1.8.60</b>	Method 60:	Resolution of ( <i>E</i> )-1-Cyclohexylbut-2-en-1-ol .....	411
<b>36.1.8.61</b>	Method 61:	Resolution of 2-Methylpent-1-en-3-ol .....	412
<b>36.1.8.62</b>	Method 62:	Resolution of 1-(2-Thienyl)pentan-1-ol .....	412
<b>36.1.8.63</b>	Method 63:	Resolution of Pent-4-ene-2,3-diol .....	413
<b>36.1.8.64</b>	Method 64:	Resolution of 2-Phenylcyclohex-2-en-1-ol .....	413
<b>36.1.8.65</b>	Method 65:	Resolution of Oct-1-yn-3-ol .....	414
<b>36.1.8.66</b>	Method 66:	Resolution of ( <i>Z</i> )-Undeca-1,5-dien-3-ol .....	414
<b>36.1.8.67</b>	Method 67:	Synthesis of 1-Deuteroocot-2-yn-1-ol .....	415

<b>36.1.8.68</b>	Method 68: Resolution of 1-(2-Bromophenyl)-1-phenylprop-2-yn-1-ol .....	415
<b>36.1.9</b>	<b>Synthesis from Other Alcohols by Modification</b>	
	J. Eames	
<hr/>		
<b>36.1.9</b>	<b>Synthesis from Other Alcohols by Modification</b> .....	423
<b>36.1.9.1</b>	Method 1: C-Alkylation of Alcohols by Oxidation Followed by Addition ..	423
<b>36.1.9.2</b>	Method 2: Isomerization of Allylic Alcohols .....	428
<b>36.1.9.3</b>	Method 3: Asymmetric C-Alkylation of Alcohols by Deprotonation/ Addition .....	430
<b>36.1.9.4</b>	Method 4: [1,2]-Acyl and -Allyl Transfer .....	433
<b>36.1.9.5</b>	Method 5: Propargylation and Rearrangement of Allylic Alcohols .....	435
<b>36.1.9.6</b>	Method 6: Dehydrodimerization of Alcohols .....	436
<b>36.1.9.7</b>	Method 7: Hydroxylation of Allylic Alcohols .....	438
<b>36.1.9.8</b>	Method 8: Reaction of Allylic Alcohols with Singlet Oxygen .....	439
<b>36.1.9.9</b>	Method 9: Dihydroxylation of Allylic Alcohols .....	440
<b>36.1.9.10</b>	Method 10: Epoxidation of Allylic Alcohols .....	441
<b>36.1.9.10.1</b>	Variation 1: Stereoselective Epoxidation of Allylic Alcohols .....	442
<b>36.1.9.11</b>	Method 11: [2 + 2] Cycloadditions of Allylic Alcohols .....	443
<b>36.1.9.12</b>	Method 12: Alkylation of the C=C Bond of Allylic Alcohols .....	444
<b>36.1.9.13</b>	Method 13: Cyclopropanation of Allylic Alcohols .....	445
<b>36.1.9.14</b>	Method 14: Reduction of Allylic Alcohols .....	446
<b>36.1.9.14.1</b>	Variation 1: Stereoselective Reduction of Allylic Alcohols .....	446
<b>36.1.9.15</b>	Method 15: Palladium-Catalyzed Vinylic Arylation of Allylic Alcohols .....	447
<b>36.1.9.16</b>	Method 16: Palladium-Catalyzed C-Alkylation of Allylic Alcohols .....	448
<b>36.1.9.17</b>	Method 17: Functionalization of $\alpha$ -Hydroxy Carbonyl Compounds .....	448
<b>36.1.9.18</b>	Method 18: C-Alkylation of Allylic Alcohols by Boration .....	451
<hr/>		
<b>36.2</b>	<b>Product Class 2: Cycloalkanols</b>	
	P. J. H. Scott and P. G. Steel	
<hr/>		
<b>36.2</b>	<b>Product Class 2: Cycloalkanols</b> .....	459
<b>36.2.1</b>	<b>Product Subclass 1: Cyclopropanols</b> .....	459
<b>36.2.1.1</b>	Synthesis of Product Subclass 1 .....	459
<b>36.2.1.1.1</b>	Method 1: Cyclopropanation of Enol Derivatives .....	460
<b>36.2.1.1.1.1</b>	Variation 1: Of Zinc Enolates .....	461
<b>36.2.1.1.1.2</b>	Variation 2: Of Samarium Enolates .....	462
<b>36.2.1.1.2</b>	Method 2: Cyclopropanation of Enol Ether Derivatives .....	463
<b>36.2.1.1.3</b>	Method 3: Cyclopropanation of Alkenes with Alkoxycarbenes or Acyloxycarbenoids .....	465
<b>36.2.1.1.3.1</b>	Variation 1: With Carbenes Derived from Chloromethyl Ethers .....	465
<b>36.2.1.1.3.2</b>	Variation 2: With Alkoxylated Fischer Carbene Complexes .....	466
<b>36.2.1.1.3.3</b>	Variation 3: With Zinc Carbenoids from Other Esters .....	467
<b>36.2.1.1.4</b>	Method 4: Cyclopropanation of Esters and Acyl Sulfonamides (Kulinkovich Reaction) .....	468
<b>36.2.1.1.4.1</b>	Variation 1: Titanium(IV)-Mediated Cyclopropanation of Esters .....	468
<b>36.2.1.1.4.2</b>	Variation 2: Kulinkovich Reactions with Substituted Alkenes .....	471

<b>36.2.1.1.4.3</b>	Variation 3:	Intramolecular Kulinkovich Reactions .....	471
<b>36.2.1.1.5</b>	Method 5:	Cyclopropanation of Acid Chlorides .....	472
<b>36.2.1.1.5.1</b>	Variation 1:	With Chloromethylolithium .....	473
<b>36.2.1.1.5.2</b>	Variation 2:	With Samarium(II) Iodide/Diiodomethane .....	473
<b>36.2.1.1.6</b>	Method 6:	Intramolecular Reactions of $\beta$ -Functionalized Carbonyl Compounds .....	474
<b>36.2.1.1.6.1</b>	Variation 1:	Cyclopropanation of Lithium Enolates with Acylsilanes .....	474
<b>36.2.1.1.6.2</b>	Variation 2:	Reactions with $\beta$ -Bromo Esters via $\beta$ -Bromo Ketones .....	475
<b>36.2.1.1.6.3</b>	Variation 3:	Reactions with $\beta$ -Stannylated Compounds .....	476
<b>36.2.1.1.7</b>	Method 7:	Chromium(II) Chloride Catalyzed Reductive Cyclization of $\alpha,\beta$ -Unsaturated Carbonyl Compounds with Aldehydes .....	476
<b>36.2.1.1.8</b>	Method 8:	Addition of 1,1-Bimetallic Reagents to $\alpha$ -Substituted Ketones .....	478
<b>36.2.1.1.9</b>	Method 9:	Reactions of $\alpha$ -Substituted Epoxides and Ketones .....	479
<b>36.2.1.1.9.1</b>	Variation 1:	Reactions of $\alpha$ -Halo Epoxides with Grignard Reagents .....	479
<b>36.2.1.1.9.2</b>	Variation 2:	Treatment of $\alpha$ -Halo Epoxides with Samarium(II) Iodide .....	479
<b>36.2.1.1.10</b>	Method 10:	Synthesis from 1,3-Dihalo Ketones .....	480
<b>36.2.1.1.11</b>	Method 11:	Ring Contractions .....	480
<b>36.2.1.1.11.1</b>	Variation 1:	Of Cyclobutane-1,2-diones .....	480
<b>36.2.1.1.11.2</b>	Variation 2:	Of 1,2-Bis(trimethylsiloxy)cyclobutenes .....	481
<b>36.2.2</b>	<b>Product Subclass 2: Cyclobutanols</b>	.....	481
<b>36.2.2.1</b>	Synthesis of Product Subclass 2 .....	481	
<b>36.2.2.1.1</b>	Method 1:	[2+2]-Cycloaddition Reactions .....	482
<b>36.2.2.1.1.1</b>	Variation 1:	[2+2] Photoadditions between Enol Ethers and Alkenes .....	482
<b>36.2.2.1.1.2</b>	Variation 2:	[2+2] Cycloadditions of Allenes with Enol Ethers .....	483
<b>36.2.2.1.1.3</b>	Variation 3:	[2+2]-Cycloaddition Reactions of $\alpha,\beta$ -Unsaturated Carbonyl Compounds with Enol Ethers .....	483
<b>36.2.2.1.2</b>	Method 2:	Norrish-Yang Photocyclization of Aryl Ketones .....	484
<b>36.2.2.1.3</b>	Method 3:	Intramolecular Nucleophilic Addition Reactions .....	486
<b>36.2.2.1.3.1</b>	Variation 1:	Intramolecular Nucleophilic Additions to Ketones .....	486
<b>36.2.2.1.3.2</b>	Variation 2:	Intramolecular Cyclization of Hydroxy Vinylcyclopropanes .....	487
<b>36.2.2.1.4</b>	Method 4:	Intramolecular Ring Opening of Epoxides .....	487
<b>36.2.2.1.4.1</b>	Variation 1:	Nucleophilic Additions to Epoxides .....	487
<b>36.2.2.1.5</b>	Method 5:	Ketyl Radical Cyclization Reactions .....	489
<b>36.2.2.1.5.1</b>	Variation 1:	Samarium(II)-Mediated Ketyl Alkene Cyclizations .....	489
<b>36.2.2.1.5.2</b>	Variation 2:	Pinacol Reactions of 1,4-Diketones .....	489
<b>36.2.2.1.6</b>	Method 6:	Ring Expansion .....	491
<b>36.2.2.1.6.1</b>	Variation 1:	Rearrangement of Oxaspiropentanes .....	491
<b>36.2.2.1.7</b>	Method 7:	Ring Contraction .....	491
<b>36.2.2.1.7.1</b>	Variation 1:	Zirconium-Mediated Ring Contractions of 4-Vinylfuranosides .....	491
<b>36.2.3</b>	<b>Product Subclass 3: Larger-Ring Cycloalkanols</b>	.....	492
<b>36.2.3.1</b>	Synthesis of Product Subclass 3 .....	492	
<b>36.2.3.1.1</b>	Method 1:	Cycloadditions of 1-Alkoxylated Dienes .....	493
<b>36.2.3.1.2</b>	Method 2:	Cycloaddition Reactions of Enol Ethers .....	494
<b>36.2.3.1.3</b>	Method 3:	[3+2]-Cycloaddition Reactions of Allylsilanes .....	495
<b>36.2.3.1.4</b>	Method 4:	Intramolecular Nucleophilic Additions to Aldehydes, Ketones, and Acetals .....	496

---

<b>36.2.3.1.4.1</b>	Variation 1:	Intramolecular Additions of Organometallic Reagents .....	496
<b>36.2.3.1.4.2</b>	Variation 2:	Intramolecular Aldol Reactions .....	497
<b>36.2.3.1.4.3</b>	Variation 3:	Intramolecular Morita–Baylis–Hillman Reactions .....	500
<b>36.2.3.1.4.4</b>	Variation 4:	Intramolecular Carbonyl-Ene Reactions of Unsaturated Aldehydes and Ketones .....	501
<b>36.2.3.1.4.5</b>	Variation 5:	Intramolecular Metallo-Ene Reactions of Aldehydes and Ketones Containing Allylmetal Groups .....	504
<b>36.2.3.1.5.1</b>	Method 5:	Intramolecular Radical Addition Reactions .....	506
<b>36.2.3.1.5.1</b>	Variation 1:	Intramolecular Radical Additions to Aldehydes and Ketones ..	506
<b>36.2.3.1.5.2</b>	Variation 2:	Intramolecular Alkyne–Aldehyde (Ynal) Cyclizations .....	508
<b>36.2.3.1.6</b>	Method 6:	Ketyl Radical Cyclization Reactions .....	509
<b>36.2.3.1.6.1</b>	Variation 1:	Intramolecular Ketyl Radical Cyclizations .....	509
<b>36.2.3.1.6.2</b>	Variation 2:	Intramolecular Pinacol Reactions .....	510
<b>36.2.3.1.6.3</b>	Variation 3:	Cyclization of Epoxide-Derived Radicals .....	512
<b>36.2.3.1.7</b>	Method 7:	Intramolecular Epoxide-Opening Reactions .....	513
<b>36.2.3.1.7.1</b>	Variation 1:	With Enolates and Equivalent Compounds .....	513
<b>36.2.3.1.7.2</b>	Variation 2:	Cyclization of Epoxyalkenes .....	515
<b>36.2.3.1.7.3</b>	Variation 3:	Cyclization of Allylmetal Epoxides .....	516
<b>36.2.3.1.7.4</b>	Variation 4:	Ring Opening of Epoxides with Organometallic Reagents ..	517
<b>36.2.3.1.8</b>	Method 8:	Hydroboration and Carbonylation of Trienes .....	519

### **36.3 Product Class 3: Propargylic Alcohols**

P. Forgione and L. D. Fader

---

<b>36.3</b>	<b>Product Class 3: Propargylic Alcohols</b> .....	531
<b>36.3.1</b>	Synthesis of Product Class 3 .....	532
<b>36.3.1.1</b>	Method 1: Reduction of Alkynals .....	532
<b>36.3.1.1.1</b>	Variation 1: Meerwein–Ponndorf–Verley Reduction .....	532
<b>36.3.1.1.2</b>	Variation 2: Hydride-Type Reduction of Alkynals .....	534
<b>36.3.1.2</b>	Method 2: Reduction of Alkynones .....	534
<b>36.3.1.2.1</b>	Variation 1: Asymmetric Transfer Hydrogenation .....	535
<b>36.3.1.2.2</b>	Variation 2: Catalytic Asymmetric Reduction with Chiral Oxazaborolidines	537
<b>36.3.1.2.3</b>	Variation 3: Stoichiometric Asymmetric Reduction with Chiral Boranes ..	540
<b>36.3.1.2.4</b>	Variation 4: Stoichiometric Asymmetric Reduction with Chiral Aluminum Hydrides .....	543
<b>36.3.1.2.5</b>	Variation 5: Achiral Reductants and Substrate-Controlled Diastereoselective Reduction .....	544
<b>36.3.1.3</b>	Method 3: Addition of Carbon Groups to Alkynals .....	545
<b>36.3.1.3.1</b>	Variation 1: Grignard Additions .....	545
<b>36.3.1.3.2</b>	Variation 2: Lithium Additions .....	546
<b>36.3.1.3.3</b>	Variation 3: Aldol Additions .....	546
<b>36.3.1.3.4</b>	Variation 4: Zinc Additions .....	547
<b>36.3.1.3.5</b>	Variation 5: Miscellaneous Additions .....	548
<b>36.3.1.4</b>	Method 4: Addition of Carbon Groups to Alkynes .....	549
<b>36.3.1.4.1</b>	Variation 1: Using Organozinc Reagents .....	549
<b>36.3.1.5</b>	Method 5: Alkyne Additions to Aldehydes .....	550
<b>36.3.1.5.1</b>	Variation 1: Using Lithium Reagents .....	550

---

<b>36.3.1.5.2</b>	Variation 2: Using Zinc Reagents .....	553
<b>36.3.1.5.3</b>	Variation 3: Using Zinc–Titanium Reagents .....	556
<b>36.3.1.5.4</b>	Variation 4: Using Silver–Zirconium Reagents .....	557
<b>36.3.1.5.5</b>	Variation 5: Using Silicon Reagents .....	557
<b>36.3.1.5.6</b>	Variation 6: Using Indium Reagents .....	558
<b>36.3.1.5.7</b>	Variation 7: Non-Transition-Metal Methods .....	559
<b>36.3.1.6</b>	Method 6: Alkyne Additions to Ketones .....	559
<b>36.3.1.6.1</b>	Variation 1: Using Magnesium Reagents .....	559
<b>36.3.1.6.2</b>	Variation 2: Using Copper–Zinc Reagents .....	560
<b>36.3.1.6.3</b>	Variation 3: Using Zinc Reagents .....	560
<b>36.3.1.6.4</b>	Variation 4: Using Rhodium Reagents .....	561
<b>36.3.1.6.5</b>	Variation 5: Nonmetallic Methods .....	562
<b>36.3.1.7</b>	Method 7: Synthesis by Rearrangements .....	563
<b>36.3.1.8</b>	Method 8: Synthesis from Other Propargylic Alcohols .....	564
<b>36.3.1.8.1</b>	Variation 1: By Displacement of Halides .....	564
<b>36.3.1.8.2</b>	Variation 2: By Coupling of a Terminal Alkyne .....	565
<b>36.3.1.9</b>	Methods 9: Miscellaneous Methods .....	565

---

**36.4 Product Class 4: Benzylic Alcohols**

M. J. Porter

---

<b>36.4</b>	<b>Product Class 4: Benzylic Alcohols</b> .....	573
<b>36.4.1</b>	Synthesis of Product Class 4 .....	573
<b>36.4.1.1</b>	Method 1: Oxidation of Benzylic C–H Groups .....	573
<b>36.4.1.1.1</b>	Variation 1: Oxidation with 2,3-Dichloro-5,6-Dicyanobenzo-1,4-quinone ..	573
<b>36.4.1.1.2</b>	Variation 2: Oxidation with Trimethylamine N-Oxide .....	574
<b>36.4.1.1.3</b>	Variation 3: Enantioselective Hydroxylation with Vaulted Metalloporphyrin Catalysts .....	575
<b>36.4.1.1.4</b>	Variation 4: Enantioselective Hydroxylation with a Ruthenium–Porphyrin Catalyst .....	576
<b>36.4.1.1.5</b>	Variation 5: Enantioselective Hydroxylation with Manganese–salen Catalysts .....	576
<b>36.4.1.2</b>	Method 2: Wittig Rearrangement .....	578
<b>36.4.1.2.1</b>	Variation 1: [1,2]-Wittig Rearrangement of Benzyl Ethers .....	578
<b>36.4.1.2.2</b>	Variation 2: Enantioselective [1,2]-Wittig Rearrangement .....	580
<b>36.4.1.2.3</b>	Variation 3: Anion Translocation/[1,2]-Wittig Rearrangement .....	580
<b>36.4.1.2.4</b>	Variation 4: <i>ortho</i> -[2,3]-Wittig Rearrangement .....	581

---

**36.5 Product Class 5: Allylic Alcohols**

D. M. Hodgson and P. G. Humphreys

---

<b>36.5</b>	<b>Product Class 5: Allylic Alcohols</b> .....	583
<b>36.5.1</b>	Synthesis of Product Class 5 .....	585
<b>36.5.1.1</b>	Method 1: Oxidation with Selenium Reagents .....	585
<b>36.5.1.1.1</b>	Variation 1: With Less Than a Stoichiometric Amount of Selenium Dioxide ..	586
<b>36.5.1.1.2</b>	Variation 2: With a Catalytic Amount of Selenium Dioxide .....	587

---

<b>36.5.1.1.3</b>	Variation 3: Oxidation of Chiral Allylic Selenides .....	587
<b>36.5.1.2</b>	Method 2: Dihydroxylation .....	588
<b>36.5.1.2.1</b>	Variation 1: Asymmetric Dihydroxylation .....	588
<b>36.5.1.2.2</b>	Variation 2: Directed Dihydroxylation .....	589
<b>36.5.1.2.3</b>	Variation 3: Enzymatic Dihydroxylation .....	590
<b>36.5.1.3</b>	Method 3: Allylic Substitution .....	590
<b>36.5.1.3.1</b>	Variation 1: Substitution of Allylic Halides .....	591
<b>36.5.1.3.2</b>	Variation 2: Asymmetric Iridium-Catalyzed Substitutions of Allylic Carbonates .....	591
<b>36.5.1.4</b>	Method 4: Elimination of $\beta$ -Hydroxy Selenides .....	592
<b>36.5.1.5</b>	Method 5: Additions of Metalated Selenoxides .....	593
<b>36.5.1.6</b>	Method 6: Additions to $\alpha$ -Epoxy Hydrazones .....	594
<b>36.5.1.7</b>	Method 7: Elimination Reactions of Iodo Ketals .....	595
<b>36.5.1.8</b>	Method 8: Elimination of Allylic Cyclic Carbonates .....	596
<b>36.5.1.8.1</b>	Variation 1: With Organocuprates .....	596
<b>36.5.1.8.2</b>	Variation 2: Palladium-Catalyzed Eliminations .....	597
<b>36.5.1.9</b>	Method 9: Reduction of $\alpha$ -Halo Epoxides .....	598
<b>36.5.1.9.1</b>	Variation 1: With Transition Metals .....	598
<b>36.5.1.9.2</b>	Variation 2: With Organometallics .....	599
<b>36.5.1.10</b>	Method 10: Reduction of 2,3-Epoxy Alcohols .....	599
<b>36.5.1.10.1</b>	Variation 1: Reduction of Unactivated Epoxy Alcohols .....	600
<b>36.5.1.10.2</b>	Variation 2: Reduction of Sulfonylated Epoxy Alcohols .....	600
<b>36.5.1.11</b>	Method 11: Elimination of $\alpha$ -Epoxystannanes .....	602
<b>36.5.1.12</b>	Method 12: Reduction of Propargylic Alcohols to <i>E</i> -Alk-2-enols .....	602
<b>36.5.1.13</b>	Method 13: Reduction of Propargylic Alcohols to <i>Z</i> -Alk-2-enols .....	604
<b>36.5.1.14</b>	Method 14: 1,2-Reduction of $\alpha,\beta$ -Unsaturated Carbonyl Compounds Using Boron Reagents .....	605
<b>36.5.1.14.1</b>	Variation 1: Using Nonenantioselective Boron Reagents .....	606
<b>36.5.1.14.2</b>	Variation 2: Using Chiral Boron Reagents .....	607
<b>36.5.1.15</b>	Method 15: 1,2-Reduction of $\alpha,\beta$ -Unsaturated Carbonyl Compounds Using Aluminum Hydride Reagents .....	608
<b>36.5.1.15.1</b>	Variation 1: Using Nonenantioselective Aluminum Hydride Reagents .....	608
<b>36.5.1.15.2</b>	Variation 2: Using Chiral Aluminum Reagents .....	609
<b>36.5.1.16</b>	Method 16: 1,2-Reduction of $\alpha,\beta$ -Unsaturated Carbonyl Compounds Using Ruthenium Catalysts .....	610
<b>36.5.1.16.1</b>	Variation 1: Using Nonenantioselective Ruthenium Catalysts .....	611
<b>36.5.1.16.2</b>	Variation 2: Using Chiral Ruthenium Catalysts .....	612
<b>36.5.1.17</b>	Method 17: 1,2-Reduction of $\alpha,\beta$ -Unsaturated Carbonyl Compounds Using Other Reagents .....	614
<b>36.5.1.18</b>	Method 18: Additions of Organometallic Reagents to $\alpha,\beta$ -Unsaturated Carbonyl Compounds .....	615
<b>36.5.1.18.1</b>	Variation 1: Addition of Organozinc Reagents .....	615
<b>36.5.1.18.2</b>	Variation 2: Addition of Organolithium Reagents .....	619
<b>36.5.1.18.3</b>	Variation 3: Addition of Grignard Reagents .....	620
<b>36.5.1.18.4</b>	Variation 4: Addition of Other Organometallic Reagents .....	620
<b>36.5.1.19</b>	Method 19: Alkenylation of Carbonyl Compounds .....	622
<b>36.5.1.19.1</b>	Variation 1: Using Organozinc Reagents .....	622
<b>36.5.1.19.2</b>	Variation 2: Using Organolithium Reagents .....	626

<b>36.5.1.19.3</b>	Variation 3: Using Grignard Reagents .....	627
<b>36.5.1.19.4</b>	Variation 4: Using Organochromium Reagents .....	628
<b>36.5.1.19.5</b>	Variation 5: Using Organotitanium Reagents .....	630
<b>36.5.1.20</b>	Method 20: Transition-Metal-Catalyzed Alkenylation of Carbonyl Compounds .....	631
<b>36.5.1.20.1</b>	Variation 1: Achiral Catalytic Alkenylations of Carbonyl Compounds .....	631
<b>36.5.1.20.2</b>	Variation 2: Asymmetric Nickel-Catalyzed Alkenylation of Carbonyl Compounds .....	634
<b>36.5.1.20.3</b>	Variation 3: Asymmetric Copper-Catalyzed Alkenylations of Carbonyl Compounds .....	636
<b>36.5.1.21</b>	Method 21: Addition of Organolithium Reagents to Epoxides .....	637
<b>36.5.1.22</b>	Method 22: Addition of Organometallic Reagents to Vinyl Epoxides .....	639
<b>36.5.1.23</b>	Method 23: Epoxide Homologations .....	640
<b>36.5.1.24</b>	Method 24: Rearrangement of Epoxides Using Lithium Amides .....	640
<b>36.5.1.24.1</b>	Variation 1: Using Achiral Lithium Amides .....	641
<b>36.5.1.24.2</b>	Variation 2: Using Stoichiometric Chiral Lithium Amides .....	642
<b>36.5.1.24.3</b>	Variation 3: Using Catalytic Chiral Lithium Amides .....	643
<b>36.5.1.25</b>	Method 25: Rearrangement of Epoxides Using Other Reagents .....	645
<b>36.5.1.26</b>	Method 26: Reduction of Epoxides with Samarium(II) Iodide .....	647
<b>36.5.1.27</b>	Method 27: Rearrangement of Sulfoxides .....	648
<b>36.5.1.28</b>	Method 28: Allylic Rearrangements .....	649
<b>36.5.1.28.1</b>	Variation 1: Acid-Mediated Rearrangements .....	650
<b>36.5.1.28.2</b>	Variation 2: Rhenium-Catalyzed Rearrangements .....	650
<b>36.5.1.29</b>	Method 29: Enzymatic Resolution of Allylic Alcohols .....	652
<b>36.5.1.30</b>	Method 30: Nonenzymatic Resolution of Allylic Alcohols .....	653
<b>36.5.1.30.1</b>	Variation 1: Sharpless Asymmetric Epoxidation .....	653
<b>36.5.1.30.2</b>	Variation 2: Other Methods of Nonenzymatic Resolution .....	655

## **36.6 Product Class 6: Homoallylic Alcohols**

M. V. Perkins

<b>36.6</b>	<b>Product Class 6: Homoallylic Alcohols .....</b>	667
<b>36.6.1</b>	Synthesis of Product Class 6 .....	667
<b>36.6.1.1</b>	Synthesis by Allylation of Carbonyl Compounds .....	667
<b>36.6.1.1.1</b>	Method 1: Synthesis Using Organoboron Reagents .....	668
<b>36.6.1.1.1.1</b>	Variation 1: With Allyl Groups Containing Stereocenters at C1 .....	670
<b>36.6.1.1.1.2</b>	Variation 2: With Chiral Ligands on Boron .....	672
<b>36.6.1.1.1.3</b>	Variation 3: Reactions of Achiral Allylboron Reagents with Chiral Aldehydes .....	681
<b>36.6.1.1.1.4</b>	Variation 4: Reactions of Chiral Allylboron Reagents with Chiral Aldehydes (Double Stereodifferentiation) .....	685
<b>36.6.1.1.2</b>	Method 2: Synthesis Using Organotin Reagents .....	688
<b>36.6.1.1.2.1</b>	Variation 1: With Allyl Groups Containing Stereocenters at C1 or C4 .....	690
<b>36.6.1.1.2.2</b>	Variation 2: In Reactions Using Chiral Lewis Acids .....	695
<b>36.6.1.1.2.3</b>	Variation 3: In Reactions with Chiral Aldehydes .....	697
<b>36.6.1.1.2.4</b>	Variation 4: Reactions of Chiral Allyltin Reagents with Chiral Aldehydes (Double Stereodifferentiation) .....	700
<b>36.6.1.1.3</b>	Method 3: Synthesis Using Organosilicon Reagents .....	702

---

<b>36.6.1.1.3.1</b>	Variation 1: With Chiral Allyl Groups or Chiral Lewis Acids .....	703
<b>36.6.1.1.3.2</b>	Variation 2: In Reactions with Chiral Aldehydes .....	705
<b>36.6.1.1.4</b>	Method 4: Synthesis Using Organochromium Reagents .....	710
<b>36.6.1.1.4.1</b>	Variation 1: With Chiral Allyl Groups .....	714
<b>36.6.1.1.4.2</b>	Variation 2: In Reactions with Chiral Aldehydes .....	718
<b>36.6.1.1.5</b>	Method 5: Synthesis Using Other Organometallic Reagents .....	722
<b>36.6.1.1.5.1</b>	Variation 1: Using Titanium Reagents .....	722
<b>36.6.1.1.5.2</b>	Variation 2: Using Indium Reagents .....	724
<b>36.6.1.1.5.3</b>	Variation 3: Using Zinc Reagents .....	726
<b>36.6.1.1.5.4</b>	Variation 4: Using Zirconium Reagents .....	727
<b>36.6.1.2</b>	Synthesis by [2,3]-Wittig Rearrangement .....	728
<b>36.6.1.2.1</b>	Method 1: Rearrangement of $\alpha$ -Allyloxy Enolates .....	730
<b>36.6.1.2.1.1</b>	Variation 1: Using $\alpha$ -Allyloxylated Ketones .....	730
<b>36.6.1.2.1.2</b>	Variation 2: Using $\alpha$ -Allyloxylated Carboxylic Acids and Esters .....	735
<b>36.6.1.2.1.3</b>	Variation 3: Using $\alpha$ -Allyloxylated Carboxamides .....	740
<b>36.6.1.2.1.4</b>	Variation 4: Using [(Allyloxy)methyl]-4,5-Dihydrooxazoles and [(Allyloxy)methyl]-5,6-Dihydro-1,3-oxazines .....	741
<b>36.6.1.2.2</b>	Method 2: Rearrangement of Allyl Lithiomethyl Ethers .....	744
<b>36.6.1.2.2.1</b>	Variation 1: Using (Tributylstannyl)methyl Ethers .....	744
<b>36.6.1.2.2.2</b>	Variation 2: Using (Trimethylstannyl)methyl Ethers .....	750

---

## **36.7 Product Class 7: 1,n-Diols (n > 1)**

C. Nativi and S. Roelens

---

<b>36.7</b>	<b>Product Class 7: 1,n-Diols (n &gt; 1)</b> .....	757
<b>36.7.1</b>	<b>Product Subclass 1: 1,2-Diols</b> .....	757
<b>36.7.1.1</b>	Synthesis of Product Subclass 1 .....	757
<b>36.7.1.1.1</b>	Method 1: Dihydroxylation of Alkenes .....	757
<b>36.7.1.1.1.1</b>	Variation 1: Upjohn Dihydroxylation .....	758
<b>36.7.1.1.1.2</b>	Variation 2: Using Reusable Osmium(VIII) Oxide on Ion Exchanger .....	759
<b>36.7.1.1.1.3</b>	Variation 3: Using Osmium(VIII) Oxide Encapsulated in a Polyurea Matrix ..	760
<b>36.7.1.1.2</b>	Method 2: Sharpless Dihydroxylation .....	761
<b>36.7.1.1.2.1</b>	Variation 1: Using Standard Conditions .....	762
<b>36.7.1.1.2.2</b>	Variation 2: Using Ionic Liquids .....	762
<b>36.7.1.1.3</b>	Method 3: Rhodium-Catalyzed Enantioselective Diboration of Alkenes ..	763
<b>36.7.1.1.4</b>	Method 4: Pinacol Couplings .....	763
<b>36.7.1.1.4.1</b>	Variation 1: Using Samarium(II) Iodide .....	764
<b>36.7.1.1.4.2</b>	Variation 2: In Aqueous Media .....	765
<b>36.7.1.1.5</b>	Method 5: The Aldol Reaction .....	765
<b>36.7.1.1.5.1</b>	Variation 1: Direct Aldol Reactions Using Chiral Organometallic Catalysts	766
<b>36.7.1.1.5.2</b>	Variation 2: Direct Aldol Reactions Catalyzed by Proline .....	767
<b>36.7.1.1.6</b>	Method 6: Ozonation of Alkenylstannanes .....	768
<b>36.7.1.1.7</b>	Method 7: Epoxide Ring Opening .....	769
<b>36.7.1.1.7.1</b>	Variation 1: Hydrolytic Kinetic Resolution of Terminal Epoxides .....	769
<b>36.7.1.1.7.2</b>	Variation 2: Ring Opening of 2,3-Epoxy Alcohols .....	769
<b>36.7.1.1.7.3</b>	Variation 3: Catalyzed by Epoxide Hydrolase .....	770

<b>36.7.1.1.7.4</b>	Variation 4: In Aqueous Media .....	770
<b>36.7.1.1.8</b>	Method 8: Alkylation of Oxazolidinone Derivatives .....	772
<b>36.7.1.1.9</b>	Method 9: Prévost–Woodward Dihydroxylation .....	773
<b>36.7.2</b>	<b>Product Subclass 2: 1,3-Diols</b> .....	774
<b>36.7.2.1</b>	Synthesis of Product Subclass 2 .....	775
<b>36.7.2.1.1</b>	Method 1: Reduction of $\beta$ -Hydroxy Ketones .....	775
<b>36.7.2.1.2</b>	Method 2: Reduction of $\beta$ -Dicarbonyls .....	776
<b>36.7.2.1.3</b>	Method 3: Ring Opening of Epoxy Alcohols .....	778
<b>36.7.2.1.3.1</b>	Variation 1: By Organometallics .....	778
<b>36.7.2.1.3.2</b>	Variation 2: By Rearrangement of 2,3-Epoxy Alcohols .....	779
<b>36.7.2.1.4</b>	Method 4: Allylation of $\beta$ -Hydroxy Aldehydes .....	779
<b>36.7.2.1.4.1</b>	Variation 1: Chelation-Controlled Addition of Organometallics .....	779
<b>36.7.2.1.4.2</b>	Variation 2: By an Aldol–Reduction Sequence .....	780
<b>36.7.2.1.5</b>	Method 5: Oxymercuration of Homoallylic Hemiacetals .....	781
<b>36.7.2.1.6</b>	Method 6: Ring Opening of $\beta$ -Hydroxy $\delta$ -Lactones .....	782
<b>36.7.3</b>	<b>Product Subclass 3: 1,4-Diols</b> .....	782
<b>36.7.3.1</b>	Synthesis of Product Subclass 3 .....	782
<b>36.7.3.1.1</b>	Method 1: Reduction of Unsaturated 1,4-Diketones .....	782
<b>36.7.3.1.1.1</b>	Variation 1: By Hydrogenation .....	782
<b>36.7.3.1.1.2</b>	Variation 2: By Hydroboration–Rearrangement of 1,2-Disubstituted Cyclobutenes .....	783
<b>36.7.3.1.1.3</b>	Variation 3: Hydroboration–Reduction of Allyl Ketones .....	784
<b>36.7.3.1.2</b>	Method 2: Aldol Reactions of Aldehydes with Hydroxyacetone .....	785
<b>36.7.3.1.3</b>	Method 3: Deprotection of Chiral Acetals Derived from Ene Acetals .....	785
<b>36.7.3.1.4</b>	Method 4: Michael Addition–Reduction of $\alpha,\beta$ -Unsaturated Enones .....	786
<b>36.7.4</b>	<b>Product Subclass 4: 1,5-Diols</b> .....	787
<b>36.7.4.1</b>	Synthesis of Product Subclass 4 .....	787
<b>36.7.4.1.1</b>	Method 1: Coupling of Vinylxiranes and Ketones .....	787
<b>36.7.4.1.2</b>	Method 2: Reaction of Lithium Dianions with Carboxy Compounds .....	787
<b>36.7.4.1.3</b>	Method 3: Pentenyl Dianion Synthons for Ene-1,5-Diol Synthesis .....	788
<b>36.7.4.1.4</b>	Method 4: Double Allylboration Reactions .....	788
<b>36.7.4.1.5</b>	Method 5: Reductive Decomplexation of $\pi$ -Allyltricarbonyliron Lactone Complexes .....	789
<b>36.7.4.1.6</b>	Method 6: Boron-Tethered Radical Cyclization .....	790
<b>36.7.5</b>	<b>Product Subclass 5: 1,6-Diols</b> .....	791
<b>36.7.5.1</b>	Synthesis of Product Subclass 5 .....	791
<b>36.7.5.1.1</b>	Method 1: Hex-3-ene-1,6-diols by Reduction of Organozinc Intermediates .....	791
<b>36.7.5.1.2</b>	Method 2: Hydride Reduction of Substituted 2,4-Diene-1,6-dials .....	792
<b>36.7.5.1.3</b>	Method 3: Titanium(IV) Chloride Mediated Addition of Octa-2,6-diene to Aldehydes .....	792
<b>36.7.5.1.4</b>	Method 4: Titanium(IV) Isopropoxide Mediated Coupling of Butylmagnesium Chloride with Aldehydes and Ketones .....	793

<b>36.7.6</b>	<b>Product Subclass 6: 1,7-Diols</b>	794
<b>36.7.6.1</b>	Synthesis of Product Subclass 6	794
<b>36.7.6.1.1</b>	Method 1: Reductive Decomplexation of $\pi$ -Allyltricarbonyliron Lactone Complexes	794
<b>36.7.6.1.2</b>	Method 2: Reaction of Organolithium Compounds with Epoxides	794
<b>36.8</b>	<b>Product Class 8: Polyols, Including Carbohydrates</b>	
	R. C. D. Brown	
<hr/>		
<b>36.8</b>	<b>Product Class 8: Polyols, Including Carbohydrates</b>	799
<b>36.8.1</b>	Synthesis of Product Class 8	799
<b>36.8.1.1</b>	Method 1: Synthesis from Organosilanes	800
<b>36.8.1.1.1</b>	Variation 1: From Aryldimethylsilanes	800
<b>36.8.1.1.2</b>	Variation 2: From Oxasilacycloalkanes	802
<b>36.8.1.1.3</b>	Variation 3: From Silacyclopentanes	804
<b>36.8.1.2</b>	Method 2: Synthesis from Alkylboranes	804
<b>36.8.1.3</b>	Method 3: Criegee Rearrangement of Bis(peroxosulfonates)	805
<b>36.8.1.4</b>	Method 4: Hydrolysis of Alkyl Halides	807
<b>36.8.1.5</b>	Method 5: Hydrolysis of Epoxides	808
<b>36.8.1.5.1</b>	Variation 1: Of Epoxy Alcohols	808
<b>36.8.1.5.2</b>	Variation 2: Of Bis(epoxides) and Tris(epoxides)	812
<b>36.8.1.6</b>	Method 6: Regioselective Reduction of Diepoxy Alcohols	814
<b>36.8.1.7</b>	Method 7: Stereoselective Reduction of $\beta$ -Hydroxy Ketones	814
<b>36.8.1.7.1</b>	Variation 1: <i>anti</i> -Selective Reduction of $\beta$ -Hydroxy Ketones by Tetramethylammonium Triacetoxyborohydride	815
<b>36.8.1.7.2</b>	Variation 2: <i>syn</i> -Selective Reduction of $\beta$ -Hydroxy Ketones by Diethyl(methoxy)borane and Sodium Borohydride	817
<b>36.8.1.8</b>	Method 8: Reduction of Endoperoxides	819
<b>36.8.1.9</b>	Method 9: Dihydroxylation of Hydroxyalkenes	821
<b>36.8.1.9.1</b>	Variation 1: Of Acyclic Allylic Alcohols by Osmium(VIII) Oxide	822
<b>36.8.1.9.2</b>	Variation 2: Of Other Acyclic Hydroxyalkenes by Osmium(VIII) Oxide	830
<b>36.8.1.9.3</b>	Variation 3: Of Cyclic Hydroxyalkenes by Osmium(VIII) Oxide	831
<b>36.8.1.10</b>	Method 10: Dihydroxylation of Dienes and Trienes by Osmium(VIII) Oxide	837
<b>36.9</b>	<b>Product Class 9: <math>\beta</math>-Hydroxy Carbonyl Compounds</b>	
	R. Mahrwald and B. Schetter	
<hr/>		
<b>36.9</b>	<b>Product Class 9: <math>\beta</math>-Hydroxy Carbonyl Compounds</b>	847
<b>36.9.1</b>	Synthesis of Product Class 9	847
<b>36.9.1.1</b>	Method 1: Additions of Aldehydes to Preformed Enolates	847
<b>36.9.1.1.1</b>	Variation 1: Additions to Lithium Enolates	849
<b>36.9.1.1.2</b>	Variation 2: Additions to Magnesium Enolates	855
<b>36.9.1.1.3</b>	Variation 3: Additions to Boron Enolates	860
<b>36.9.1.1.4</b>	Variation 4: Additions to Titanium Enolates	868
<b>36.9.1.2</b>	Method 2: Catalytic Aldol Additions of Silicon Enolates Using Lewis Acids	878
<b>36.9.1.2.1</b>	Variation 1: Using Silver Lewis Acids	879

<b>36.9.1.2.2</b>	Variation 2: Using Palladium Lewis Acids .....	880
<b>36.9.1.2.3</b>	Variation 3: Using Platinum Lewis Acids .....	881
<b>36.9.1.2.4</b>	Variation 4: Using Copper Lewis Acids .....	883
<b>36.9.1.2.5</b>	Variation 5: Using Tin Lewis Acids .....	887
<b>36.9.1.2.6</b>	Variation 6: Using Titanium Lewis Acids .....	893
<b>36.9.1.2.7</b>	Variation 7: Using Zirconium Lewis Acids .....	898
<b>36.9.1.2.8</b>	Variation 8: Using Boron Lewis Acids .....	901
<b>36.9.1.3</b>	Method 3: Direct Catalytic Aldol Reactions .....	907
<b>36.9.1.4</b>	Method 4: Amine-Catalyzed Aldol Additions .....	918
<b>36.9.1.5</b>	Method 5: Antibody-Catalyzed Aldol Additions .....	927
<b>36.9.1.6</b>	Method 6: Enzyme-Catalyzed Aldol Additions .....	928
<b>36.9.1.7</b>	Method 7: Lewis Base Catalyzed Aldol Additions .....	936
<b>36.9.1.8</b>	Method 8: Reactions of Aldehydes/Ketones with $\alpha$ -Halo Ketones (Reformatsky Reaction) .....	944
<b>36.9.1.9</b>	Method 9: Reactions of Dithianes with Epoxides .....	947
<b>36.9.1.10</b>	Method 10: Gold- and Rhodium-Catalyzed Aldol Additions .....	948
<b>36.9.1.11</b>	Method 11: Rearrangement of Epoxy Silyl Ethers .....	952
<b>36.9.1.12</b>	Method 12: Reduction of 4,5-Dihydroisoxazoles .....	953

---

**36.10 Product Class 10: n-Heteroatom-Functionalized Alcohols**

( $n \geq 2$ ; Heteroatom  $\neq$  Halogen)

M. J. Bingham and M. F. Greaney

---

<b>36.10</b>	<b>Product Class 10: n-Heteroatom-Functionalized Alcohols</b> ( $n \geq 2$ ; Heteroatom $\neq$ Halogen) .....	971
<b>36.10.1</b>	<b>Product Subclass 1: <math>\beta</math>-Heteroatom-Functionalized Alcohols</b> .....	971
<b>36.10.1.1</b>	Synthesis of Product Subclass 1 .....	971
<b>36.10.1.1.1</b>	Method 1: Epoxide Ring Opening with Oxygen Nucleophiles .....	971
<b>36.10.1.1.2</b>	Method 2: Epoxide Ring Opening with Sulfur, Selenium, or Tellurium Nucleophiles .....	979
<b>36.10.1.1.3</b>	Method 3: Epoxide Ring Opening with Nitrogen Nucleophiles .....	983
<b>36.10.1.1.4</b>	Method 4: Epoxide Ring Opening with Phosphorus Nucleophiles .....	989
<b>36.10.1.1.5</b>	Method 5: Thiirane Substitution Reactions .....	991
<b>36.10.1.1.6</b>	Method 6: Aziridine Substitution Reactions .....	992
<b>36.10.1.1.7</b>	Method 7: Nucleophilic Addition of Sulfur-, Selenium-, or Tellurium-Stabilized Carbanions to Carbonyl Groups .....	993
<b>36.10.1.1.8</b>	Method 8: Nucleophilic Addition of Boronic Acids to Imines (The Petasis Reaction) .....	995
<b>36.10.1.1.9</b>	Method 9: Addition of Phosphorus Ylides to Carbonyl Compounds .....	996
<b>36.10.1.1.10</b>	Method 10: Thiol–Alkene Co-oxidation .....	998
<b>36.10.1.1.11</b>	Method 11: Hydroxysulfenylation Using Electrophilic Sulfur .....	1000
<b>36.10.1.1.12</b>	Method 12: Hydroxyselenation Using Electrophilic Selenium .....	1003
<b>36.10.1.1.13</b>	Method 13: Hydroxytelluration Using Electrophilic Tellurium .....	1004
<b>36.10.1.1.14</b>	Method 14: Synthesis of $\beta$ -Amino Alcohols by Aminohydroxylation of Alkenes .....	1005

<b>36.10.2</b>	<b>Product Subclass 2: <math>\gamma</math>-Heteroatom-Functionalized Alcohols</b>	1009
<b>36.10.2.1</b>	Synthesis of Product Subclass 2	1009
<b>36.10.2.1.1</b>	Method 1: Epoxide Ring Opening with Heteroatom-Stabilized Carbanions	1010
<b>36.10.2.1.2</b>	Method 2: Nucleophilic Ring Opening of Oxetanes	1013
<b>36.10.2.1.3</b>	Method 3: Reduction of Cyano Esters or Ketones	1015
<b>36.10.2.1.4</b>	Method 4: Synthesis from $\alpha,\beta$ -Unsaturated Carbonyl Compounds	1016
<b>36.10.2.1.5</b>	Method 5: Hydroboration of Allylic Substrates	1018
<b>36.10.2.1.5.1</b>	Variation 1: Addition to Allylic Alcohols	1020
<b>36.10.3</b>	<b>Product Subclass 3: <math>\delta</math>-Heteroatom-Functionalized Alcohols</b>	1021
<b>36.10.3.1</b>	Synthesis of Product Subclass 3	1021
<b>36.10.3.1.1</b>	Method 1: Nucleophilic Ring Opening of Oxetanes with Phosphorus-Stabilized Carbanions	1021
<b>36.10.3.1.2</b>	Method 2: Synthesis from $\alpha,\beta$ -Unsaturated Carbonyl Compounds	1022
<b>36.11</b>	<b>Product Class 11: Alcohols and Diols by Deprotection</b>	
	M. G. Moloney and M. Yaqoob	
<hr/>		
<b>36.11</b>	<b>Product Class 11: Alcohols and Diols by Deprotection</b>	1031
<b>36.11.1</b>	Synthesis of Product Class 11	1035
<b>36.11.1.1</b>	Method 1: Alcohols by Cleavage of Stannoxanes	1035
<b>36.11.1.1.1</b>	Variation 1: Reaction with Electrophiles	1035
<b>36.11.1.1.2</b>	Variation 2: Reaction by Radical Formation	1038
<b>36.11.1.2</b>	Method 2: Alcohols by Cleavage of Siloxanes	1040
<b>36.11.1.2.1</b>	Variation 1: Acidic Hydrolysis	1044
<b>36.11.1.2.2</b>	Variation 2: Basic Hydrolysis	1047
<b>36.11.1.2.3</b>	Variation 3: Fluoride Hydrolysis	1048
<b>36.11.1.2.4</b>	Variation 4: Lewis Acid Mediated Hydrolysis	1051
<b>36.11.1.2.5</b>	Variation 5: Photolytic Cleavage	1051
<b>36.11.1.3</b>	Method 3: Alcohols by Cleavage of Carbonates and Carbamates	1052
<b>36.11.1.3.1</b>	Variation 1: Acidic Hydrolysis	1053
<b>36.11.1.3.2</b>	Variation 2: Basic Hydrolysis	1053
<b>36.11.1.3.3</b>	Variation 3: Reductive Cleavage	1055
<b>36.11.1.3.4</b>	Variation 4: Cleavage by Metal Catalysis	1056
<b>36.11.1.3.5</b>	Variation 5: Hydrogenolysis	1058
<b>36.11.1.4</b>	Method 4: Alcohols by Cleavage of Esters	1058
<b>36.11.1.4.1</b>	Variation 1: Acidic Hydrolysis	1059
<b>36.11.1.4.2</b>	Variation 2: Basic Hydrolysis	1060
<b>36.11.1.4.3</b>	Variation 3: Reductive Cleavage	1063
<b>36.11.1.4.4</b>	Variation 4: Nucleophilic Cleavage	1064
<b>36.11.1.4.5</b>	Variation 5: Enzymatic Hydrolysis	1066
<b>36.11.1.5</b>	Method 5: Alcohols by Cleavage of Acetals	1067
<b>36.11.1.5.1</b>	Variation 1: Acidic Hydrolysis	1067
<b>36.11.1.5.2</b>	Variation 2: Basic Hydrolysis	1069
<b>36.11.1.5.3</b>	Variation 3: Reductive Cleavage	1069
<b>36.11.1.5.4</b>	Variation 4: Nucleophilic Cleavage	1069

---

<b>36.11.1.5.5</b>	Variation 5: Cleavage by Lewis Acids .....	1070
<b>36.11.1.5.6</b>	Variation 6: Oxidative Cleavage .....	1072
<b>36.11.1.5.7</b>	Variation 7: Photolytic Cleavage .....	1073
<b>36.11.1.6</b>	Method 6: Alcohols by Cleavage of Ethers .....	1073
<b>36.11.1.6.1</b>	Variation 1: Acidic Hydrolysis .....	1073
<b>36.11.1.6.2</b>	Variation 2: Basic Hydrolysis .....	1078
<b>36.11.1.6.3</b>	Variation 3: Hydrogenolytic Cleavage .....	1079
<b>36.11.1.6.4</b>	Variation 4: Reductive Cleavage .....	1080
<b>36.11.1.6.5</b>	Variation 5: By Elimination .....	1082
<b>36.11.1.6.6</b>	Variation 6: Cleavage with Transition Metals .....	1083
<b>36.11.1.6.7</b>	Variation 7: By Oxidation .....	1084
<b>36.11.1.7</b>	Method 7: Alcohols by Cleavage of Sulfonates and Sulfenates .....	1085
<b>36.11.1.7.1</b>	Variation 1: Cleavage by Substitution with Iodide .....	1086
<b>36.11.1.7.2</b>	Variation 2: Cleavage by Reaction with Fluoride .....	1087
<b>36.11.1.7.3</b>	Variation 3: Reductive Cleavage .....	1087
<b>36.11.1.7.4</b>	Variation 4: Photolytic Cleavage .....	1090
<b>36.11.1.8</b>	Method 8: Diols by Cleavage of Cyclic Boronates .....	1093
<b>36.11.1.8.1</b>	Variation 1: Aqueous Hydrolysis .....	1093
<b>36.11.1.8.2</b>	Variation 2: Nucleophilic Cleavage .....	1093
<b>36.11.1.9</b>	Method 9: Diols by Cleavage of Cyclic Dioxytinanes .....	1094
<b>36.11.1.10</b>	Method 10: Diols by Cleavage of Cyclic Dioxsilanes .....	1095
<b>36.11.1.10.1</b>	Variation 1: Acidic Hydrolysis .....	1095
<b>36.11.1.10.2</b>	Variation 2: Fluoride-Mediated Cleavage .....	1095
<b>36.11.1.11</b>	Method 11: Diols by Cleavage of Cyclic Carbonates .....	1096
<b>36.11.1.11.1</b>	Variation 1: Basic Hydrolysis .....	1096
<b>36.11.1.12</b>	Method 12: Diols by Cleavage of Cyclic Acetals .....	1096
<b>36.11.1.12.1</b>	Variation 1: Acidic Hydrolysis .....	1097
<b>36.11.1.12.2</b>	Variation 2: Lewis Acid Hydrolysis .....	1100
<b>36.11.1.12.3</b>	Variation 3: Basic Hydrolysis .....	1101
<b>36.11.1.12.4</b>	Variation 4: Reductive Cleavage .....	1101
<b>36.11.1.12.5</b>	Variation 5: Oxidative Cleavage .....	1102

---

**36.12      Product Class 12: Metal Alcoholates**

J. V. Morey and A. E. H. Wheatley

---

<b>36.12</b>	<b>Product Class 12: Metal Alcoholates</b> .....	1107
<b>36.12.1</b>	<b>Product Subclass 1: Group 16 Metal Alcoholates</b> .....	1107
<b>36.12.1.1</b>	Synthesis of Product Subclass 1 .....	1107
<b>36.12.1.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1107
<b>36.12.1.1.2</b>	Method 2: Synthesis by Transmetalation .....	1108
<b>36.12.2</b>	<b>Product Subclass 2: Group 15 Metal Alcoholates</b> .....	1108
<b>36.12.2.1</b>	Synthesis of Product Subclass 2 .....	1108
<b>36.12.2.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1108
<b>36.12.2.1.2</b>	Method 2: Synthesis by Transmetalation .....	1110

<b>36.12.3</b>	<b>Product Subclass 3: Group 14 Alcoholates</b> .....	1110
<b>36.12.3.1</b>	Synthesis of Product Subclass 3 .....	1110
<b>36.12.3.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1110
<b>36.12.3.1.2</b>	Method 2: Synthesis by Nucleophilic Ring Opening .....	1114
<b>36.12.4</b>	<b>Product Subclass 4: Group 13 Metal Alcoholates</b> .....	1114
<b>36.12.4.1</b>	Synthesis of Product Subclass 4 .....	1114
<b>36.12.4.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1114
<b>36.12.5</b>	<b>Product Subclass 5: Chromium and Molybdenum Alcoholates</b> .....	1116
<b>36.12.5.1</b>	Synthesis of Product Subclass 5 .....	1116
<b>36.12.5.1.1</b>	Method 1: Synthesis by Transmetalation of an Alcoholate .....	1116
<b>36.12.6</b>	<b>Product Subclass 6: Vanadium Alcoholates</b> .....	1118
<b>36.12.6.1</b>	Synthesis of Product Subclass 6 .....	1118
<b>36.12.6.1.1</b>	Method 1: Synthesis by Nucleophilic Addition .....	1118
<b>36.12.7</b>	<b>Product Subclass 7: Titanium and Zirconium Alcoholates</b> .....	1119
<b>36.12.7.1</b>	Synthesis of Product Subclass 7 .....	1119
<b>36.12.7.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1119
<b>36.12.7.1.2</b>	Method 2: Synthesis by Nucleophilic Addition .....	1120
<b>36.12.8</b>	<b>Product Subclass 8: Group 2 Metal Alcoholates</b> .....	1122
<b>36.12.8.1</b>	Synthesis of Product Subclass 8 .....	1122
<b>36.12.8.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1122
<b>36.12.8.1.2</b>	Method 2: Synthesis by Metalation of an Alkanol Equivalent .....	1126
<b>36.12.8.1.3</b>	Method 3: Synthesis by Nucleophilic Addition .....	1127
<b>36.12.9</b>	<b>Product Subclass 9: Lithium Alcoholates</b> .....	1128
<b>36.12.9.1</b>	Synthesis of Product Subclass 9 .....	1128
<b>36.12.9.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol .....	1128
<b>36.12.9.1.2</b>	Method 2: Synthesis by Transmetalation .....	1129
<b>36.12.9.1.3</b>	Method 3: Rearrangement of a Carbolithiate .....	1129
<b>36.12.9.1.3.1</b>	Variation 1: Retro-Brook Rearrangements .....	1130
<b>36.12.9.1.3.2</b>	Variation 2: Phosphate-Based Carbanion Rearrangements .....	1131
<b>36.12.9.1.3.3</b>	Variation 3: [1,2]-Wittig Rearrangements .....	1132
<b>36.12.9.1.3.4</b>	Variation 4: [2,3]-Wittig Rearrangements .....	1135
<b>36.12.9.1.3.5</b>	Variation 5: [1,4]-Wittig Rearrangements .....	1143
<b>36.12.9.1.3.6</b>	Variation 6: Metalated Epoxide Rearrangements .....	1143
<b>36.12.9.1.4</b>	Method 4: Synthesis by Reductive Lithiation of C—O Bonds .....	1147
<b>36.12.9.1.4.1</b>	Variation 1: Reductive Lithiation of Acyclic Ethers .....	1147
<b>36.12.9.1.4.2</b>	Variation 2: Reductive Lithiation of Cyclic Ethers .....	1147
<b>36.12.9.1.5</b>	Method 5: Addition across Carbonyl Bonds .....	1150
<b>36.12.9.1.5.1</b>	Variation 1: Using Organolithium Reagents .....	1150
<b>36.12.9.1.5.2</b>	Variation 2: By Reductive Lithiation .....	1153

<b>36.12.10</b>	<b>Product Subclass 10: Higher Group 1 Metal Alcoholates</b>	1154
<b>36.12.10.1</b>	Synthesis of Product Subclass 10	1154
<b>36.12.10.1.1</b>	Method 1: Synthesis by Deprotonation of an Alkanol	1154
<b>36.12.10.1.2</b>	Method 2: Synthesis by Combination with Organolithium Substrates	1159
 <b>Keyword Index</b>		1167
 <b>Author Index</b>		1225
 <b>Abbreviations</b>		1295

