

Contents

1 AMINO ACIDS	1
1.1 The glutamic acid group	1
1.1.1 Glutamic acid and glutamine	1
1.1.2 Proline	4
1.1.3 Arginine	4
1.2 The aspartic acid group	6
1.2.1 Aspartic acid and asparagine	6
1.2.2 Threonine	7
1.2.3 Methionine	8
1.2.4 Lysine	9
1.2.5 Isoleucine	11
1.3 The alanine, valine, and leucine group	13
1.3.1 Alanine	13
1.3.2 Valine	14
1.3.3 Leucine	14
1.4 The serine, glycine, cysteine, and selenocysteine group	15
1.4.1 Serine	15
1.4.2 Glycine	16
1.4.3 Cysteine	17
1.4.4 Selenocysteine	19
1.5 The aromatic and heterocyclic amino acids group	20
1.5.1 Phenylalanine and tyrosine	20
1.5.2 Tryptophan	27
1.5.3 Histidine	28
1.6 Modified proteinogenic amino acids	30
1.6.1 Cystine	31
1.6.2 Hydroxyproline	31
1.6.3 Hydroxylysine	32
1.6.4 Methylhistidine	32
1.6.5 Phosphoserine	33
1.7 Non-protein amino acids	33
1.7.1 3-Amino acids and 4-amino acids	34
1.7.1.1 β -Alanine	34
1.7.1.2 γ -Aminobutanoic acid	35
1.7.2 <i>N</i> -Substituted amino acids	35
1.7.2.1 Sarcosine, <i>N,N</i> -dimethylglycine, and glycine betaine	35
1.7.2.2 Carnitine	38
1.7.3 Alicyclic amino acids	39
1.7.3.1 Aminocyclopropane-1-carboxylic acid	39
1.7.3.2 Hypoglycin and related compounds	40
1.7.3.3 Cyclopentenylglycine	42
1.7.4 Hydroxyamino acids	43
1.7.4.1 Dihydroxyphenylalanine	43
1.7.5 Sulfur-containing amino acids	43

1.7.5.1 <i>S</i> -Alk(en)ylcysteines and their sulfoxides	43
1.7.5.2 <i>S</i> -Methylmethionine	46
1.7.5.3 Homomethionine	46
1.7.5.4 Taurine	47
1.7.6 Heterocyclic amino acids and related amino compounds	49
1.7.6.1 Creatine and phosphocreatine	49
1.7.6.2 Pípecolic acid	49
1.7.6.3 Substituted glycines	50
1.7.6.4 Substituted alanines	51
1.7.6.5 Substituted aminobutanoic acids	54
1.8 Transformation products of amino acids	58
1.8.1 Amines	58
1.8.1.1 Catecholamines	59
1.8.1.2 Polyamines	60
1.8.2 Aldehydes, alcohols, and esters	62
1.8.2.1 Aldehydes	62
1.8.2.2 Alcohols	63
1.8.3 Other compounds	65
References	66
2 PEPTIDES	72
2.1 γ -Glutamylpeptides	72
2.1.1 Glutathione	72
2.1.2 Other γ -glutamylpeptides	74
2.2 Histidine dipeptides	77
- 2.2.1 Carnosine and anserine	77
References	77
3 LIPIDS	79
3.1 Fatty acids	79
3.1.1 Saturated fatty acids	80
3.1.1.1 <i>Claisen condensation</i>	84
3.1.2 Medium-chain saturated fatty acids	85
3.1.3 Long-chain saturated and unsaturated fatty acids	85
3.1.3.1 Long-chain saturated fatty acids	86
3.1.3.2 Long-chain monounsaturated fatty acids	86
3.1.3.3 Long-chain polyunsaturated fatty acids	89
3.1.4 Less common fatty acids	91
3.1.4.1 Geometrical and positional isomers of unsaturated fatty acids ..	91
3.1.4.2 Acetylenic fatty acids	93
3.1.4.3 Branched-chain fatty acids	94
3.1.4.4 Alicyclic fatty acids	97
3.1.4.5 Epoxy fatty acids	99
3.1.4.6 Hydroxy and oxo fatty acids	100

3.1.4.7 Lipoic acid	101
3.2 Plant wax components	102
3.2.1 Cuticular wax	102
3.2.2 Cutin	104
3.3 Triacylglycerols, glycerophospholipids, and glyceroglycolipids	105
3.3.1 Triacylglycerols	106
3.3.2 Glycerophospholipids	108
3.3.2.1 Phosphatides	110
3.3.2.1.1 Ethanolamine and choline	114
3.3.2.2 Lysophosphatides	115
3.3.2.3 Plasmalogens	116
3.3.3 Glyceroglycolipids	117
3.4 Lipid peroxidation	119
References	123
4 SACCHARIDES	128
4.1 Monosaccharides	128
4.1.1 Sugar phosphates and sugar nucleotides	128
4.1.2 D-Galactose, uronic acids, pentoses, and L-rhamnose (UDP-glucose interconversion pathway)	132
4.1.3 L-Galactose, L-gulose, and L-fucose (GDP-mannose interconversion pathway)	135
4.1.4 Aminosugars	136
4.1.4.1 Acetylmuramic acid	138
4.1.4.2 Acetylneuraminic acid	138
4.1.5 Sugar alcohols	140
4.1.5.1 Glucitol	140
4.1.5.2 Mannitol	141
4.1.6 Cyclitols	141
4.1.6.1 Inositols	142
4.1.6.2 Phytic acid	143
4.2 Oligosaccharides	144
4.2.1 Glucooligosaccharides	145
4.2.2.1 Trehalose	145
4.2.2 Fructooligosaccharides	146
4.2.2.1 Saccharose	146
4.2.3 Galactooligosaccharides	147
4.2.3.1 Lactose	147
4.2.3.2 Raffinose and higher α -galactooligosaccharides	148
4.2.3.3 Fagopyritols	149
4.3 Polysaccharides	150
4.3.1 Reserve polysaccharides	151
4.3.1.1 Starch and glycogen	151
4.3.1.2 Fructans	154

4.3.2 Plant cell wall polysaccharides	155
4.3.2.1 Cellulose and callose	155
4.3.2.2 Pectin	156
4.3.3 Chitin	159
4.3.4 Glycosaminoglycans	159
4.4 Transformation products of sugars	162
4.4.1 Lactic acid fermentation	163
4.4.1.1 Homolactic acid fermentation	163
4.4.1.2 Heterolactic acid fermentation	165
4.4.1.3 Formation of acetoin, biacetyl, and butane-2,3-diol	165
4.4.2 Alcoholic fermentation	168
4.4.3 Acetic acid fermentation	168
4.4.4 Propionic acid fermentation	169
References	170
5 VITAMINS	173
5.1 Fat - soluble vitamins	173
5.1.1 Vitamin A	173
5.1.2 Vitamin D	178
5.1.3 Terpenoid quinones	181
5.1.3.1 Vitamin E	181
5.1.3.2 Ubiquinones	184
5.1.3.3 Plastoquinones	184
5.1.3.4 Vitamin K	185
5.2. Water - soluble vitamins	189
5.2.1 Thiamine	189
5.2.1.1 Pyrimidine part of thiamine	189
5.2.1.2 Thiazole part of thiamine	190
5.2.1.3 Phosphate esters of thiamine	191
5.2.2 Riboflavin	193
5.2.2.1 Cofactors of riboflavin	196
5.2.3 Nicotinic acid and nicotinamide	196
5.2.3.1 Nicotinamide adenine dinucleotides	198
5.2.3.2 Other nicotinic acid derivatives	200
5.2.3.2.1 <i>N</i> -glucosylnicotinic acid	200
5.2.3.2.2 Trigonelline	201
5.2.4 Pantothenic acid	201
5.2.4.1 Coenzyme A and ACP	203
5.2.5 Vitamin B ₆	204
5.2.5.1 Structurally related compounds	206
5.2.6 Biotin	206
5.2.7 Folic acid	208
5.2.7.1 7,8-Dihydrofolic acid	209
5.2.7.2 Coenzyme forms of folic acid	210

5.2.8 Cobalamins	210
5.2.9 Vitamin C	220
5.2.9.1 Ascorbic acid	222
5.2.9.1.1 Biosynthesis in animals	222
5.2.9.1.2 Biosynthesis in plants	223
5.2.9.2 Ascorbic acid analogues	225
5.2.9.3 Transformation products of ascorbic acid	226
References	228
6 TERPENOIDS	231
6.1 Isopentenyl diphosphate and dimethylallyl diphosphate	231
6.2 Geranyl diphosphate and higher terpenyl diphosphates	234
6.3 Monoterpenoids	236
6.3.1 Monoterpenic hydrocarbons	237
6.3.1.1 <i>Wagner-Meerwein rearrangement</i>	242
6.3.2 Monoterpenic alcohols and other monoterpenoids	242
6.3.3 Irregular monoterpenoids	252
6.3.4 Iridoids	252
6.4 Sesquiterpenoids	257
6.4.1 Sesquiterpenic hydrocarbons	258
6.4.2 Sesquiterpenic alcohols and other sesquiterpenoids	265
6.4.2.1 <i>Diels-Alder reaction</i>	270
6.5 Diterpenoids	271
6.5.1 Diterpenic hydrocarbons	271
6.5.2 Alcohols and other diterpenoids	272
6.6 Triterpenoids and steroids	277
6.6.1 Squalene and 2,3-epoxysqualene	277
6.6.2 Triterpenoids	279
6.6.2.1 Cucurbitacins	282
6.6.2.2 Degraded triterpenoids	284
6.6.2.2.1 Limonoids	285
6.6.2.2.2 Quassinoids	286
6.6.3 Steroids	287
6.6.3.1 Animal sterols	287
6.6.3.2 Plant sterols	291
6.6.3.3 Fungus sterols	292
6.6.4 Saponins	294
6.6.4.1 Triterpenoid saponins	295
6.6.4.2 Steroidal saponins	298
6.7 Tetraterpenoids and higher terpenoids	299
6.7.1 Tetraterpenoids	300
6.7.1.1 Degraded tetraterpenoids	300
6.7.1.1.1 C ₁₃ compounds	300
6.7.1.1.2 C ₁₁ compounds	305

6.7.1.1.3 C ₁₀ compounds	306
6.7.1.1.4 C ₉ compounds	307
6.7.2 Higher terpenoids	307
References	308
7 PHENOLIC COMPOUNDS	314
7.1 Phenolic acids	315
7.1.1 Cinnamic acids	315
7.1.2 Benzoic acids and simple benzenoid compounds	316
7.2 Aldehydes and alcohols	319
7.3 Substituted alkenylbenzenes	321
7.4 Esters	325
7.4.1 Volatile esters	325
7.4.2 Nonvolatile esters	325
7.4.2.1 Chlorogenic acids	325
7.4.2.2 Rosmarinic acid and other caffeic acid derivatives	327
7.4.2.3 Sinapic acid esters	331
7.5 Cinnamic acid amides	331
7.6 Lignans and lignin	332
7.6.1 Lignans	333
7.6.2 Lignin	337
7.7 Tannins	339
7.7.1 Hydrolyzable tannins	339
7.8 Coumarins	340
7.8.1 Coumarin and its derivatives	343
7.8.2 Furanocoumarins	346
7.8.3 Isocoumarins	348
7.8.3.1 <i>Biosynthesis of aromatic polyketides</i>	349
7.8.3.1.1 <i>Dieckmann condensation</i>	351
7.9 Stilbenes	351
7.10 Styrylpyrones	353
7.11 Gingerols	356
7.12 Isoflavonoids	357
7.12.1 Isoflavones	357
7.12.2 Pterocarpans	360
7.13 Flavonolignans	361
7.14 Miscelaneous compounds	362
7.14.1. Phloroglucinols	363
7.14.2 Phthalides	366
References	367
8 NATURAL PIGMENTS	373
8.1 Tetrapyrroles	373
8.1.1 Porphyrins	374

8.1.1.1 Hemes	377
8.1.1.2 Chlorophylls	377
8.2 Melanins	380
8.2.1 Eumelanins	380
8.2.2 Pheomelanins	381
8.2.3 Allomelanins	382
8.3 Betalains	385
8.4 Quinones	388
8.4.1 Benzoquinones	389
8.4.2 Naphthoquinones	390
8.4.3 Anthraquinones	391
8.5 Xanthoncs	396
8.6 Flavonoids	397
8.6.1 Chalcones and flavanones	400
8.6.1.1 Quinochalcons	402
8.6.2 Flavones, flavanonols, flavonols, leucoanthocyanidins, (epi)catechins, and anthocyanidins	403
8.6.3 Aurones	403
8.6.4 Condensed tannins	406
8.6.5 Miscellaneous flavonoids	409
8.7 Isochromenes	411
8.8 Curcuminoids	412
8.9 Carotenoids	415
8.9.1 Carotenes	415
8.9.2 Xanthophylls	417
8.9.3 Apocarotenoids	423
8.10 Iridoids	424
8.11 Miscellaneous terpenoids	426
References	428
9 ALKALOIDS AND TOXIC GLYCOSIDES	432
9.1 Alkaloids	432
9.1.1 Pyridine, piperidine, and pyrrolidine alkaloids	433
9.1.1.1 Nicotine	433
9.1.2 Piperine	435
9.1.3 Pyrrolizidine alkaloids	437
9.1.3.1 Necines	439
9.1.3.1.1 Mannich reaction	441
9.1.3.2 Necic acids and their esters	441
9.1.3.2.1 Acyloin condensation	443
9.1.3.2.2 Michael addition	443
9.1.4 Quinolizidine alkaloids	444
9.1.5 Quinoline alkaloids	445
9.1.5.1 Quinine	445

9.1.6 Capsaicinoids	448
9.1.7 Purine alkaloids	449
9.1.8 Steroidal glycoalkaloids	453
9.2 Cyanogens	455
9.2.1 Cyanogenic glycosides	456
9.2.2 Pseudocyanogenic glycosides	461
9.2.3 Cyanolipids	462
9.3. Glucosinolates	462
9.3.1 Glucosinolate decomposition products	466
References	470
INDEX	473