

Index

- (+)-3-carene 492, 763, 769
1-butanol 101, 185–90, 196, 609,
 1143
1-butanol pathway 186–7, 196
1-deoxyxylulose-5-phosphate
 reductoisomerase 1079
1-hexanol 186–7, 190
1-octanol 187, 190, 847
1-propanol 101, 187–9, 587, 609
2-arylpropionic acids 95
2-dehydro-3-deoxygalactarate
 (DDG) aldolase 456
2-keto-acid decarboxylase 187
2-keto-acid pathway 188
2-methyl-1-butanol 187, 189,
 1145
2-phenylethanol 187
3-deoxy-D-arabino-heptulosonate-
 7-phosphate synthase 349,
 351
3-hydroxy-3-methylglutaryl-CoA
 synthase 191
3-hydroxypropanal 798, 1022,
 1024
3-hydroxypropanoic acid 1024
3-methyl-1-butanol 187, 189–90,
 194, 197, 1146
3-methylcatechol 332, 338–9
4-aza-D,L-L-leucine 189–90
4-thiazolidinones 504
5-cyanopentan-amide 355
5-hydroxymethylfurfural 342,
 1128–9, 1136, 1147
5-methylpyrazine-2-carboxylic acid
 358–9
6-amino penicillanic acid 574–5
7-amino desacetoxy
 cephalosporanic acid 574
7-ethoxy-4-(trifluoromethyl)coumarin
 675
7-methoxyresorufin 675
1,2-propanediol 400–1, 1141
1,3-dichloroprop-1-ene degradation
 pathway 327
1,3-propanediol 209, 223, 306,
 1022, 1024–5, 1107, 1109
 fermentation process 1022
1,3-propanediol dehydrogenases
 1024
1,5-diaminopentane 1050
2,5-formylfuroic acid 343
2,5-furandicarboxylic acid 342

ABC-transporter 326
ABE (acetone, butanol, ethanol)
 pathway 185
ABE production 1085
ABTS 540–1, 548, 699, 702, 708
Acetivibrio cellulolyticus 251
Acetobacter pasteurianus 899, 904
acetogenesis 209, 262–3, 1086
acetohydroxy acid
 isomeroreductase 186, 394
acetohydroxy acid synthase 186,
 189, 394, 398–9, 910, 912–13
acetolactate synthase 186, 912
acetone 185, 260, 452–3, 481–2,
 485–7, 586–9, 595, 618, 742,
 751, 754, 792, 794, 1085,
 1090

- acetyl-CoA acetyltransferase 191
 acetylxylan esterases 249
 acidic protease 453
 acidogenesis 262
 Actinobacteria 165
Actinoplanes philippinensis 828
 activated amino acid 873
 active pharmaceutical
 intermediates 562
 activity yield 522, 537, 539–40,
 542–4, 547–8, 558
 acyl-ACP reductase 191–2
 acyl-CoA oxidase 192
 acyl-CoA reductase 191, 196
 acyltransferase 87, 93, 191
 acyltransferase/wax-esterase 191
 ADP-ribose pyrophosphatase 191
Aerobacter cloaceae 828
 agar 82, 935, 959–60, 1007
 age-related macular degeneration
 163, 1042
 agricultural wastes 217, 380
 agro waste 380–1
Agrobacterium 295, 608–9, 819,
 821, 823–5, 828, 830–1,
 837–9, 846, 850
Agrobacterium radiobacter 608–9,
 824, 830, 838–9
Agrobacterium rhizogenes 828
Agrobacterium sp. 821, 831, 837
Agrobacterium tumefaciens 823,
 825, 850
 alanine dehydrogenase 878
 alarm pheromone 163–4
 Alcalase-CLEA 451–2, 480
Alcaligenes faecalis 574
 alcohol dehydrogenases 48, 91,
 184, 186–7, 253–4, 257, 259,
 400, 648, 650, 889, 895,
 915–19, 921, 922, 1024,
 1029
 alcohol oxidase 803
 alcohols 184–90, 196–7, 262–3,
 265–6, 374–5, 400–1,
 418–20, 433–4, 586–7,
 589–90, 603–4, 887–90, 892,
 894–6, 906–16
 non-fermentative 187, 189
 aldehyde decarbonylase 191–2
 aldol addition 450–1, 456–7, 461,
 784, 791, 800, 803
 aldol reactions 451–5, 784, 790
 asymmetric 453–4
 aldolases 456, 783–92, 794, 796,
 798, 800, 802, 804–12
 2-deoxyribose-5-phosphate
 aldolase 787
 class I 785, 788, 805
 class II 785–6, 788, 809
 D-tagatose-1,6-bisphosphate
 aldolase 787
 DHA-utilizing 789–90, 806,
 809–11
 DHAP-dependent 786, 788, 791,
 809
 donor specificities 786
 L-rhamnulose-1-phosphate
 aldolase 787
 pyridoxal-phosphate-dependent
 786
 pyruvate-dependent 786
 stereocomplementary 786–7,
 811
 aldose-1-epimerase 385–6
 algae 161, 182, 195, 354, 1007–20,
 1028–32, 1034–52, 1066–8,
 1071–2, 1074–6, 1079–80,
 1082–5, 1087, 1089–90, 1128
 biomass feedstock 1012–13
 diversity 1009–10
 genetic manipulation 195, 1067
 metabolic engineering 182, 190,
 1008, 1019, 1044
 structural components 1011
 algae biomass 1009, 1011,
 1013–15, 1051
 conversion 1015, 1051
 utilization 1009

- algae consortia 1011
- algae cultivation 1018, 1020
- algae growth 1011, 1019
 - autotrophic 1011
 - heterotrophic 1011
 - mixotrophic 1011
- algae production 1014, 1034, 1066
- algal biochemistry 1067
- algal biomass 1011, 1015, 1017, 1019, 1021, 1023, 1025, 1027, 1052, 1082, 1085
 - secondary fuels 1082
- algal biorefinery 1008, 1065–8, 1070, 1072, 1074, 1076, 1078, 1080, 1082, 1084, 1086, 1088, 1090–2
 - associated products 1091
 - operations 1091
- algal biorefinery concept 1008
- algal cells 305, 1019, 1073, 1087
 - photobioreactor system 1073
- alginate 354
- alkaline phosphatase 142, 597
- alkaline protease 144, 453, 460, 502–4, 507
- alkaliphilic bacteria 959
- alkene biosynthesis 193
- allergenicity of enzymes 975
- alpha-acetolactate synthase 97
- Amano lipase M 475, 507
- American Society for Testing Materials 1018
- AMFEP list of enzymes 964
- amino acid dehydrogenases 912
- amino acid precursors 187
- amino acid racemase 396, 834, 839
- amino acids 84, 98–9, 359–61, 374–5, 380–1, 383–4, 390–3, 396, 817–19, 822–3, 827–52, 863–9, 871, 874–81, 1048–9
 - D-phenylglycine 817, 827–8, 830, 836–7
 - non-canonical 817
- amino sugars 387–8
- amorphadiene 168, 171, 194, 671
- amorphadiene synthase 671
- amoxicillin 359, 574, 576, 827–8
- AMP-activated kinase 940
- ampicillin 574, 576, 827–8
- amylases 298–9, 950–1, 953, 963, 991–6, 998, 1031
- amyloglucosidase 299, 543, 545, 1085
- amylolytic activity 994
- amylolytic enzymes 991, 994–5
- amylopectin 985, 988–9, 991, 993, 995, 1001, 1031
 - structure 985, 988–9
- amylopullulanases 992–3, 996
- amylose 985–6, 988–9, 991, 995, 1001, 1031
 - structure 985–6, 988–9
- anaerobiosis 1072, 1074
- ancestral mutation method 137–8
- anethole 497
- anserine 864, 867
- anti-aging activity 931
- anti-cancer compounds 787
- anti-hyperglycemic drug 800
- antibiotics 121, 123, 206, 226–7, 231, 334, 506, 573–7, 672, 713, 817, 819, 827–8, 864, 874
- anticancer prodrugs 666, 669
- anticancer properties 931, 933
- anticapsin 876
- antifungal properties 932
- antimalarial drugs 640
- antimicrobial agents 217, 226, 232
- antimicrobial peptides 227
- antiproliferative agent 674
- antivirals 787
- Aphanothece halophytica* 285
- AquaFuels 1091
- Arabidopsis thaliana* 167, 172, 480, 488, 633, 685, 1039

- arabinose 88, 99, 249, 255, 376–7, 380–1, 383–4, 798, 803, 1030, 1138
Arabinose 380, 383–4
Araliaceae plants 173
 Archaea 165, 283–7, 298, 301, 303, 308
 archaeol lipids 307
Archis hypogaea 819
 arcylamide 355, 358
 arginine-aspartate dipeptides 878
 arginine catabolic pathway 327
 aromatic chemicals 338, 348
 artemisinic acid 62, 169, 171–2, 193
 Artemisinin 161
Arthrobacter aurescens 822, 837–8, 845, 847
Arthrosira platensis 1039
 aryl-alcohol oxidase 250
 aspartame 842, 868, 878, 880
Aspergillus niger 135, 570–1, 587, 748, 1104–5, 1107, 1111–12
Aspergillus oryzae 459, 467, 474, 570–1, 704, 963, 992
Aspergillus usamii 453
 astaxanthin 162–3, 170, 1028, 1038–9, 1045
 Astaxanthin 163, 1038
 astemizole 674–5
 asymmetric amination 99
 asymmetric dynamic kinetic resolution 496
 asymmetric reduction of alkenes 632–5
 homogeneous metal catalysts 632
 asymmetric synthesis 509, 613–14, 848, 887, 889, 897–8, 900
 atorvastatin calcium 96
 ATP synthase 49, 1069
 avermectin 100
Azotobacter vinelandii 216
 B-factor iterative test 96, 140
Bacillus amyloliquefaciens 588, 992, 995
Bacillus cereus 993
Bacillus fermentation process 964
Bacillus halodurans 304
Bacillus kaustophilus 845
Bacillus licheniformis 135, 139, 299, 451, 453, 460, 503–4, 588, 602, 609, 992, 995
Bacillus macerans 999
Bacillus megaterium 1025
Bacillus stearothermophilus 822–3, 847, 992
Bacillus subtilis 40, 49, 51, 55, 97, 133, 135, 140, 146, 185, 188, 194, 227, 326, 376, 502, 635, 641, 878, 964
 bacilycin 876
 bacitracin 876
 bacteriophages 83
 bacteriorhodopsin 284–5, 295–8 applications 284, 286, 295–6, 298
 bacteriovorus organisms 333
 Baeyer–Villiger monooxygenases 848
 barophiles 242
 bio-1,3-propane diol 1152
 bio-based chemicals 1012, 1127–8, 1130, 1132, 1134, 1136, 1138, 1140, 1142, 1144, 1146, 1148, 1150, 1152, 1154–6
 bio-based economy 373–4
 bio oil 1086–7
 bio-PET 1151
 Bio Shield 334
 bioalcohols 240
 biobased 181–2, 184, 186, 188, 190, 192, 194, 196, 198, 233
 biobased chemicals 233
 biobutanol 240–1, 253

- Biocatalysis 73–4, 76, 78, 80, 82–4, 86, 323–4, 583, 585, 595–7, 603, 605–7, 631–2, 648–50, 1101
 biocatalysts 34–8, 58–9, 62, 267–70, 449–50, 458–60, 521–2, 527, 554, 583–5, 632–4, 654–5, 663–6, 668–70, 684–8
 cost contribution 554
 industrial applications 606, 634, 733
 physical separation 556
 robust 245, 268, 554, 556, 561
 specific activity 56, 527, 574
 biochemicals 212, 1066
 biodegradable 64, 303, 305, 346, 889, 893, 986–7, 1000–1, 1023, 1027, 1103–5, 1111, 1141–2, 1144, 1150–3
 biodegradable packaging material 986, 1000–1
 biodegradable plastics 64, 303, 346, 987, 1000
 biodegradable polymers 387, 1001, 1027, 1104–5, 1142, 1144
 biodegradations 336
 halogenated hydrocarbons 336
 polycyclic aromatic hydrocarbons 336
 toluene 336
 biodiesel 223, 240–1, 265–70, 305–6, 389–90, 417–45, 563, 566, 1010, 1012–20, 1026, 1028, 1047, 1086–7, 1089
 biodiesel production 223, 265–70, 305, 390, 417–38, 440, 442, 444, 563, 566, 1010, 1012, 1016–20, 1026, 1028
 enzymatic 266–7, 417, 419, 422–3, 425–7, 429–31, 433, 435, 437–8, 441, 444
 glycerol recovery 442
 immobilized enzymes 429, 431, 438, 445
 liquid formulated enzymes 429–31, 434
 oil pretreatment 417, 425
 raw materials 267, 419, 563
 Tsinghua group 444–5
 biodiesel standards 418
 biodiesel synthesis 419, 426–8, 430, 435, 1086–7, 1089
 bioelectricity 218, 222
 bioenergy 212, 1014, 1020, 1128, 1130
 bioethanol 216–17, 223, 240–1, 253–5, 257, 265, 419–20, 1002, 1012–13, 1015–16, 1029–32, 1084–5, 1087, 1128, 1151–2
 biofuel production 182–3, 240, 245, 247, 252–3, 255, 257, 259, 261, 263, 268–70, 1008, 1015, 1017, 1127–8
 biofuels 35–6, 181–2, 186, 196–8, 218, 239–42, 269–70, 444, 1008, 1012–15, 1017, 1019, 1029, 1052, 1081–2
 production 97, 101, 182, 184–5, 188, 190–1, 196, 240–2, 269–70, 1008, 1012–15, 1017, 1019, 1029, 1066
 biogas production 212, 219, 232, 262–3
 two-stage process 263
 biogas reactors 209
 biogases 240
 bioinformatical methodologies 52
 bioinformatics 116, 127, 244
 biological safety 964
 biomass 97, 182–3, 240, 242, 244–7, 380–5, 1011–15, 1017–19, 1023–5, 1030–2, 1065–6, 1085, 1127–8, 1130, 1132–3
 biomass-derived chemicals 349

- biomethane 1012
 biomonomers 1152–4
 biophotolysis 263, 1072, 1075
 bioplastics 1001, 1023, 1150–3
 market size 1150
 biopolymers 95, 707, 1128, 1132,
 1150–3
 industrial applications 1152
 bioprocess development 54–5, 58
 bioreactor equipment 59
 biorefineries 1034, 1128, 1130
 biorefinery approach 232
 biorefinery carbohydrates 1135
 biorefinery concept 223, 232,
 1008, 1015, 1047, 1051,
 1127, 1130
 bioremediation 244, 309, 324–5,
 331, 336, 616, 685, 711, 1012
 biosensors 38, 669, 676–80, 688,
 699, 712
 cytochrome c 677
 glucose oxidase 677
 biosurfactants 344–5, 1025, 1028
 Biot number 531
 biotransformation 34–7, 39, 41–2,
 44, 46–8, 53, 55, 58–60, 331–
 2, 337–9, 342, 401, 647–9,
 652, 654–5
 biphasic aqueous-organic cultures
 351
 biphasic systems 594, 604–5, 611,
 614, 642, 651
 interfacial inactivation 594
 bisabolane 194, 1029
 bisabolene 170, 174, 194, 1029
Blakeslea trispora 1028
 boceprevir 86, 89–90
 botryococcenes 1080
Botryococcus braunii 1011, 1017,
 1080
 branched-chain keto acid
 decarboxylase 897
Brevibacillus agri 822, 846
 brewing industries 994, 1002
 British Soap and Detergent
 Industry Association 973
 brown algae 354, 1011, 1041
 bufuralol 676
 bulk chemicals 35–6, 64, 84, 232,
 554, 563, 1101, 1127, 1142
 butanol 101, 185–90, 221, 223–4,
 253, 255, 260, 266, 268–9,
 435–6, 1021, 1029, 1084–5,
 1089–90, 1143–4
 butyryl-CoA dehydrogenase 186

C. tyrobutyricum 1139
 cadaverine 378, 383, 397, 403,
 1146, 1154
 cadaverine permease 397
 calcium channel blockers 483
 Callera Trans L 417, 429, 432–5,
 439–41
Candida albicans 932
Candida antarctica 428, 451, 493,
 565, 589, 595, 602, 604, 609,
 732, 743–4, 769, 772, 1028
Candida antarctica lipase B 589,
 604, 609, 743, 769, 772
Candida cylindracea lipase 755
Candida rugosa lipase 593, 1109
Candida tenuis 401
Candida tropicalis 217
Candida utilis 904
 canola oil 425
 canthaxanthin 307, 1039
 carbamoylglycines 846–7
 carbon fixation 183, 195, 1052
 carbon-fixing bacteria 182
 carbon footprint 951, 978, 980,
 1153
 carbon–carbon bond formation
 451
 carboxymethyl cellulose 539
 cardiovascular diseases 931, 939,
 1035–6, 1039

- carnosine 864, 866–7
 carotenes 165–6, 1041
 carotenogenesis 290
 carotenoids 101, 163, 165–8, 170,
 295, 307, 391, 402–3, 639,
 1012, 1028, 1034, 1038–9,
 1041–2, 1047
 functional diversity 166
 structural diversity 165–6
 carrageenan 560, 1007, 1011
 castor oil 1153
 catalytic triad 451, 732, 824,
 1103–4, 1117
 caustic refining 425
 caustic wash 439, 443
 cell factories 352, 374, 1044
 cellobiohydrolase I 136, 140
 cellobiohydrolase II 133, 137
 cellobiohydrolases 1139
 cellobiose 104, 248, 259, 306,
 376–7, 380–2, 1138
 cellulases 132, 247–8, 299, 382,
 539, 601, 605, 950, 953, 963,
 966, 1030, 1139
 cellulolytic enzymes 248, 251, 605,
 1030, 1138
 cellulolytic hosts 254
 cellulose 97, 217, 245–52, 257,
 259–62, 380–2, 539–40,
 570–1, 601, 605, 1030,
 1083–4, 1132–3, 1138–40,
 1153
 crystalline 246, 248, 259–61,
 1030, 1138
 cellulosic biomass 85, 97, 183, 605
 cellulosic ethanol 246, 254, 269,
 1019
 cellulosic feedstocks 183
 cellulosomes 250–2, 259, 1030
 cephadroxil 359, 574
 cephalexin 574, 576
 cephalosporin G 574
 cephalosporins 121, 359
 chaperone buffering 122, 124,
 126–7, 130
 chaperones 126–9, 149, 291
 chemical 149
 chemical industries 46, 62, 64, 91,
 96, 632, 1130
 chemo-enzymatic epoxidation
 723, 734, 736, 749, 753, 774
 advantages 736
 mechanism 734
 chiral amines 355
 chiral primary amines 889
 chitin 300, 375, 387–8, 1000
 chitosan 387, 523, 539, 543, 569,
 1001
Chlamydomonas perigranulata
 1031
Chlamydomonas reinhardtii 1008,
 1031–2, 1036, 1039, 1044,
 1072
Chlorella sp. 1084, 1089
Chlorella vulgaris 1011, 1034,
 1041, 1083
Chlorococcus sp. 1031
 chlorophyll-type pigments 1069
 chlorophylls 1034, 1038
 cholera toxin 1046
 cholesterol-lowering
 pharmaceuticals 787
Chromohalobacter salexigens 294,
 299
 cinchona alkaloids 479
 citral 640, 643–4, 649, 652
 citramalate pathway 101
 citramalate synthase 101, 186, 189
 citronellal 640, 1137
 Claisen condensation 193
Clarkia breweri 164
 climate change 181, 220
Clostridium acetobutylicum 61, 380
Clostridium butyricum 209,
 1022–23
Clostridium cellulolyticum 251

- Clostridium cellulovorans* 251, 382
Clostridium josui 251
Clostridium pasteurianum 1022
Clostridium spp. 1085
Clostridium thermobutyricum 224
Clostridium thermocellum 214, 251–2
 co-cultivation process 214
 co-infected patients 666
 CO_2 emissions 242, 338, 1065
 cobalamin production 357
Coccinella septempunctata 164
 cocoa butter 563
 codon context 52
 codon usage 52, 1150
 cofactor 35–9, 41–3, 45–9, 58–9, 62, 326–8, 340–1, 394–5, 401, 634–6, 641–3, 645–6, 650–5, 895–7, 918–23
 availability 35, 37, 41, 48, 59, 655
 pools 49, 896
 preference 37–9, 645
 regeneration 35–6, 42–3, 47–8, 58–9, 62, 92, 328, 646, 650–1, 655, 893, 895, 907, 912, 919–23
 cofactor metabolism 326–7
 cofactor regeneration 35–6, 42–3, 47–8, 58–9, 62, 92, 328, 646, 650–1, 655, 893, 895, 907, 912, 919–23
 enzyme-coupled approach 920, 922
 in situ coproduct recycling 923
 substrate-coupled approach 920, 922
 cohesin module 251
 cold shock protein CspB 143
 combinatorial active-site saturation test 90
 commodity plastics 1102, 1134
 compounded annual growth rate 1128
 computational approaches 92, 131–2
 consensus method 136–41
 consolidated bioprocessing 240, 251, 260–1, 270, 1045
 organisms 260
 consumer safety 973
 continuous flow reactor 492
 cooking oil 441, 444
Corynebacterium glutamicum 44, 188, 293, 373–4, 403, 534, 842, 879, 1138, 1154
Corynebacterium sepedonicum 828
 cosmetic esters 563–4
 cosmetics 55, 163, 227, 288, 458, 713, 842, 986, 997–8, 1000, 1010, 1021, 1027, 1141
 cross-linked enzymes 451, 458, 523, 569, 571, 742, 957, 1001
 cross-linked enzyme aggregates 451
 crotonase 186, 595
 cultivation conditions 55, 57, 267, 1008, 1017
Cupriavidus basilensis 328
Curcuma zedoaria 173–4
Curvularia sp. 671
 cyanobacteria 195–6, 285, 631–2, 634, 636, 638, 640, 642–6, 648, 650, 652, 654, 1068, 1071–2, 1074–6
 cyanobacterial genus 1076
Cyanothece 1076
Gloeothecace 1076
 cyanobacterial strains 642, 1074
 cyanocobalamin 356
 cyanophycin 878–9, 881, 1048
 biotechnological production 879
 platform chemical 1048
 cyanophycin synthetase 879
 cyanophycinase 878–9
 cyclic metabolic switch 1075–6
 cyclodextrins 991, 998–9
 applications 998–9
 production 998–9
 cyclomaltodextrin 999

- cyclophosphamide 666, 668
 CYP-based gene-directed enzyme prodrug therapy 669
 cancer treatment 669
 CYP enzymes 663–80, 683–8
 adverse drug reaction 684
 bacterial 664–5, 670, 672–3,
 676–7, 679, 685–8
 detoxification 670, 683, 688
 directed evolution 670, 674–5,
 683
 engineering 670, 674, 686
 immobilized 672, 675, 678, 685
 mammalian 664–5, 670, 673,
 675–7, 679, 686–8
 metabolism 663–4, 666–7, 670,
 673–4, 678, 685, 687–8
 CYP induction 666
 CYP inhibition 667
 CYP isozymes 664
 CYP-mediated toxicity 669
 CYP nanobiochips 673
 CYP polymorphism 668, 676
 CYP single nucleotide polymorphism 665
 cysteine-type hydrolases 872
 cytochrome b_5 665
 cytochrome b6/f 1069
 cytochrome P450 46, 122, 126,
 143, 192, 663–8, 670–88
 cytochrome P450 BM3 122, 126
 cytochrome P450 reductase 665
 Cytochromes P450 165–6, 669–70
 D-(+)-biotin 804
 D-amino acids 396, 827–30,
 832–41, 864
 production 395–6, 827–30, 833,
 835, 837–9, 841
 D-aminoacylase 467–9, 474–5,
 480, 503, 506
 D-carbamoylases 822–4
 catalytic triad 824
 nitrilase superfamily 824
 D-fagomine 787, 803–4
 D-fructose-1,6-bisphosphate aldolase 784, 787, 802
 D-fructose-6-phosphate aldolase 790
 biological function 791
 D-hydantoinase 360, 821, 831–5,
 837, 840–2, 849
 D-lactate dehydrogenase 377, 387,
 398
 D-mannitol 401
 D-p-hydroxyphenyl glycine 359
 Damköhler number 532–4
 de novo biosynthesis 943
 debranching enzymes 992, 995
 deep eutectic solvents 584–5,
 606–9, 852
 commercially available 607
 defensins 1045
 degumming 417, 423–7, 434, 441
 enzymatic 417, 423–7, 441
 dehydrogenases 38–9, 41–2, 48–9,
 91–2, 326, 333, 342, 645, 648,
 650, 889, 895, 912, 915–19,
 921
Deinococcus radiodurans 845, 997
 deoxyribose-phosphate aldolase 98
 deoxyxylulose phosphate synthase 1079
 desaturase 170, 172, 402, 1036
 designer bugs 851
 designer cells 48
 detergent enzymes 950–2, 963–4,
 966–7, 969, 972–4, 976,
 978, 980
 amylases 950, 963
 confectioning 967
 downstream processing 966
 global market 951, 953
 lipases 950, 963
 major players 953

- production organisms 963–4
 proteases 950, 952, 963–4, 968,
 972–6, 980
 safety 964, 974
 detergent formulation 957, 970
 detergent proteases 949–50,
 952, 954, 956, 958–60, 962,
 964, 966–8, 970–2, 974–6,
 978–80, 982
 environmental risk 975
 dextrin 543, 992
 dextrinization 989
DHA kinase 802–3
DHAP-dependent aldolases 786,
 788, 791
 limitations 788
Diacronema vlkianum 1034, 1041
Diaeretiella rapae 164
 dialysis membrane reactor 225
 diatoms 1009–10
 dicarboxylic acids 389, 748, 1105,
 1109
Dictyostelium discoideum 820
 dielectric constants 591
 Diels–Alder-like transformations
 456
 diesel fuels 190, 195
 dietetic beer 994
 diffusion limitations 531, 535, 538,
 543–4, 559, 740
 diffusion-reaction model 527
 dihydrofolate reductase 147
 dihydropyrimidinase 819, 821
 dihydrouracil 819–21, 848, 850
 dihydroxy-acid dehydratase 186
 dihydroxyacetone 783–4, 786–90,
 792, 794, 796, 798, 800, 802,
 804, 806, 808–10, 812, 1024,
 1026
 prochiral building block 790
 diols 887–90, 892, 894–6, 898,
 900, 902, 904, 906, 908, 910,
 912, 914–23, 1105, 1109–11,
 1119
- dipeptidase activity 877
 dipeptide antibiotic 876
 dipeptides 863–8, 871–4, 876–81
 dipeptides
 biotechnological production 879
 chemical synthesis 867, 879
 extraction from natural sources
 867
 nutritional relevance 864
 directed evolution 73–106, 116,
 122, 124, 126, 128–9, 132,
 143, 148–50, 670, 674–5,
 683, 844, 954, 962
 applications 76, 83–4, 91, 95,
 101, 104–5, 116
 combinatorial strategy 128–9,
 150
 pathway engineering 100
 screening of mutant proteins 82
 directed evolution strategies 74–5,
 83–5
 oxidoreductases 85
 diterpenes 163–5, 1136
 DNA assembler method 102
 DNA shuffling 76–7, 79, 81, 86–7,
 93, 95, 97–8, 100–1, 131,
 144–5, 147, 676
 DNA technology 268, 373, 951
 dockerin module 251
 docosapentaenoic acid 1028
 dolichols 167–8
 doramectin 100
 downstream processing 43, 53,
 59–60, 266, 304, 345–6, 351,
 358, 584, 868, 893, 895, 960,
 966, 970
Drosophila melanogaster 192
 drug-eluting stents 933, 944
Dunaliella bardawil 290
Dunaliella salina 285, 306, 1011,
 1039, 1041
 dynamic kinetic resolution 361,
 496, 818, 849, 895

- (E)-alpha-bisabolene synthase 191
 E-numbers 989
 echinacea 667
 ectoine 284, 287, 291–5, 304–5,
 308
 biomedical applications 292
 cosmetic benefits 292
 production 284, 287, 290–1,
 293–5, 304
 transgenic systems 293
Ectothiorhodospira halochloris 291
 edible vaccines 1046
 effective diffusion coefficient 528,
 531
 effective microorganisms 216
 effectiveness factor 523, 527–39,
 541–2, 544–5, 547–9
 Ehrlich pathway 187, 400
 electron transport chain 328,
 1068–9
 elongase 402, 1036
 emollient esters 563–5
Empedobacter brevis 873
 enantiomeric excess 89, 340, 479,
 492, 499, 594, 641, 830, 850,
 897, 899, 904
 endoglucanase 87, 97
 endoglucanases 248, 251, 1138
 energy crops 217, 1066
 energy efficiency ratio 1019
 engineering biology 61, 63
 enoate reductases 461, 632–3
 enoyl-CoA hydratase 191
Enterobacter cloacae 254, 635
Enterobacter sp. 1022
 environmental pollution 64, 709,
 1000
 enzymatic promiscuity 450, 477,
 500–1, 503, 505, 507–8,
 511–12
 industrial applications 450, 511
 multistep organic processes
 500–1, 503, 505, 507
 enzyme cascade 789, 798–9, 802,
 900, 921–3
 process design 900
 enzyme cascade reactions 789,
 798–9, 802
 enzyme cascades 887–8, 890,
 892–6, 898, 900, 902, 904,
 906, 908, 910–12, 914, 916,
 918, 920–2
 cyclic cascade 894
 linear cascade 894
 novel recycling cascade 894
 orthogonal cascade 894
 parallel cascade 894
 enzyme engineering 105, 115, 119,
 124–5, 127–8, 130, 150, 188,
 198, 562, 893, 900, 902, 951,
 954
 function-stability 124
 rational design 150
 sustainable 128, 130, 1137
 trade-offs 124
 enzyme evolution 115–18, 120,
 122–4, 126, 128, 130, 132,
 134, 136, 138, 140, 142, 144,
 146, 150
 enzyme fitness 116, 118–20, 123,
 142, 149
 enzyme membrane reactor 556
 Enzyme REACH consortium 967
 enzyme toolboxes 892–3, 896, 900
 multi-step synthetic approaches
 893
 oxidoreductases 893, 896
 product diversity 892
 smart combination 896
 transaminases 893
 enzymes 42–6, 50–6, 73–104,
 245–54, 426–34, 553–63,
 663–81, 683–8, 704–14,
 817–25, 892–901, 949–53,
 966–76, 978–80, 991–7
 enzymatic cell lysate activity 147

- global market 73, 951, 953
 industrial applications 76, 104,
 298, 354, 450, 605–6, 621,
 651, 676, 705, 707, 709, 711,
 713, 906
 promiscuous 450–1, 453, 455–7,
 459, 461, 463, 465, 467,
 469–71, 473, 475, 477, 493,
 508–9, 511
 recombinant 34, 37, 42–3, 48, 52,
 55–6, 62, 80, 194, 261, 327,
 361, 651, 704, 963–4
 soluble expression level 121, 142
 thermoacidophilic 265
 thermoalkalophilic 265
 epichlorohydrin 726
 epistasis 120, 123–4
 stability-mediated 123–4
 epistatic interactions 138
 epoxidation of alkenes 490, 731,
 735, 754–5
 epoxidation of cyclic alkenes 764
 epoxides 492, 511, 671, 723,
 725–6, 734, 736–7, 741,
 754, 761, 763, 768, 772,
 889, 892
 epoxidized fatty compounds 725,
 772
 application 725, 772
 epoxy resins 726
 epoxystearic acid 737
 error-prone PCR 131, 145, 961
Erwinia chrysanthemi 254
Erwinia rhamontici 572
Escherichia coli 133, 135, 167,
 185, 293, 374, 467, 474,
 488, 651–2, 703, 705,
 790–1, 819, 821
 esomeprazole 86, 90
 esterases 95–6, 249, 301, 427,
 489, 509, 562, 732, 734,
 1103, 1120
 ethanol 183–5, 212–13, 216–18,
 230–2, 246–7, 253–61,
 265–6, 400, 420, 587–9,
 1002, 1023, 1029–33,
 1084–5, 1133–6
 ethanol production 102, 184, 191,
 216–18, 231, 246–7, 253–9,
 261, 327, 400, 1014, 1019,
 1031–2, 1138
 ethylene oxide 726, 1022
 eukaryotic algae 182, 190, 195
 Eupergit C 541, 544
 European biodiesel standard 1018
 European commission 978
 evolutionary dynamics of enzymes
 118
 evolutionary trajectory 124–6
 exoglucanases 248, 259, 382
 exopolysaccharides 287, 301, 303
 applications 301, 303
 experimental approaches 92, 128,
 130, 141
 extremophiles 43–4, 239–40,
 242–8, 250, 252, 254, 256,
 258, 260, 262, 264, 266, 268,
 270, 991
 extremophilic microbes 284
 extremozymes 243, 245, 298
- FAeSTER process 444
Fagopyrum esculentum 803
 family shuffling 77, 86, 89, 132,
 145, 962
 farnesane 194, 1029
 farnesene 163–4, 194, 1029
 farnesol 194
 farnesyl diphosphate synthase 191
 fat replacer 987
 fatty acid biosynthesis 191–2,
 196, 934, 942
 fatty acid decarboxylase 191
 fatty acid metabolite pool 190
 fatty acid methyl esters 190, 418,
 563, 734–5, 744, 746, 774,
 1016, 1090

- fatty acid pathways 196
 fatty acids 190, 192–3, 196, 257,
 262–3, 421–2, 563–4, 731–2,
 734–5, 737–8, 740–3, 749,
 1015–17, 1034–7, 1087–9
 fed-batch 56–8, 223, 226, 304–5,
 343, 357, 394, 398, 401, 436,
 746, 905, 938, 963, 966
 fed-batch strategy 357, 938
 feedstocks 182–3, 185, 195,
 197–8, 217, 261–2, 267, 419,
 427, 1012, 1029, 1031, 1033,
 1128–9, 1132–3
 renewable 183, 1129
 [FeFe]-hydrogenase 1072
 fermentable sugars 242, 245–7,
 249, 994, 1086
 fermentation 183–6, 205–6,
 211–14, 217, 221–33, 253,
 258–61, 263–4, 286–8,
 326–7, 963–6, 1002,
 1029–33, 1085–6, 1137–9
 fermentation pathways 221, 253,
 327
 fermented foods 228, 286
 jeotgal 286
 nam pla 286
 pla-ra 286
 ferredoxin 172, 222, 1043, 1069
 ferredoxin:NADP⁺ oxidoreductase
 1069
 ferulic acid decarboxylase 473
 feruloyl esterase 135, 139, 249,
 587
 Fick's law 527
 fine chemicals sector 84
Flavobacterium sp. 840, 845
 flavonoids 710–11, 1149–50
 fluorescence activated cell-sorting
 97
 fluoro-analog selection 349
 fluorous solvents 584–5, 611,
 614–15, 621
 flux coupling analysis 41
 food 34–6, 55, 205–6, 209, 240–2,
 287–9, 668–9, 680, 706–7,
 985–9, 996–9, 1001–2,
 1035–7, 1042–3, 1142–4
 food fermentation 205–6
 food lipids 563
 food supplements 1036, 1042
 formate conversion 197
 formate dehydrogenase 398, 401,
 636, 646, 653, 920–1
 fossil energy balance 1019
 fossil fuels 181, 218, 220, 240–2,
 263, 712, 1019, 1065
 free fatty acids 190, 418, 509, 734,
 737, 749, 775, 1016, 1103
 freedom to operate 553
 fructokinase 379–80
 fructose 375–80, 401, 567,
 571–3, 784, 787, 789–92,
 798, 802–3, 806, 808,
 994, 996–7, 1129, 1136
 fructosyl amino acid oxidase 38
 fucoxanthin 1041–2
 functional foods 1035
 functional ingredients 1035
 fungal fermentation process 966
 furan-2,5-dicarboxylic acid 1129
 furaneol 803–4
 furans 997, 1129, 1135–6
 furfural 343, 381, 1129,
 1135–6
Fusarium oxysporum 217
 galactokinase 385–6
 gas vesicles 307–8
 gene-deletion mutants 40
 gene expression 35, 50–3, 62–3,
 382, 944, 1045–6
 control 50–1, 53
 heterologous 35, 50–2, 62, 382,
 1045–6
 gene libraries 51, 55, 57

- vector-based 51
- gene overexpression 43, 52
- gene shuffling methodologies 962
- Genencor process 1024
- genetic diversity 130
 - experimental approaches 130
- genetic fusion 149
- genome engineering 104
 - gene-cluster evolution 104
 - shuffling 104
 - trackable multiplex
 - recombineering 104
- Geobacillus thermodenitrificans* 244
- germacrene A hydroxylase 172
- germacrene D 164, 174
- GHG avoidance 1013
- GHG emissions 419, 1023, 1065, 1147
- global warming 239, 1155
- glucoamylases 567, 993–5
- glucocorticoid receptors 125
- glucokinases 379
- gluconeogenesis 385, 784, 933
- glucosamine 388
- glucose 56–9, 212–14, 221–5, 248–9, 325–6, 328, 332–3, 350–2, 375–6, 378–86, 393–8, 567–8, 570–3, 993–8, 1002
- glucose homeostasis 933
- glucose isomerase 567, 996
- glucose-release systems 57
- glutamic acid 44–5, 391, 832, 836, 842, 1049–50, 1133, 1144
 - platform chemical 1049
- gluten 707, 986–8, 994
- glyceraldehyde 3-phosphate dehydrogenase 387, 398
- glyceride polymers 441
- glycerol 223–4, 266–8, 305–6, 378, 389–90, 430–2, 436–9, 441–4, 587–9, 607–9, 938, 1020–6, 1028–9, 1088–9, 1107–8
 - crude 223–4, 389–90, 1020–1, 1023, 1028
 - microbial conversion 223
 - platform chemical 1021, 1024
 - re-utilization 1020
 - valorization 1020, 1026
- glycerol dehydratase 1024
- glycogen phosphorylase 800
- glycolaldehyde 784, 792, 794
 - self- and cross aldolization 794
- glycolysis 53, 184, 195, 224, 254, 326, 379, 389, 395, 784, 1023
- glycosidase inhibitors 787, 801
- Glycyrrhiza* 162, 172
- glyoxal oxidase 250
- glyoxylate cycle 399
- greases 419, 421
- green algae 195, 1009, 1039, 1068, 1072, 1074–5, 1080
- Green Chemistry 94, 1101, 1127
- Green Chemistry Challenge Award 94
- green fluorescent protein 1045
- green solvents 596, 607, 614
- greenhouse gas 241–2, 262, 418, 1130, 1151
- greenhouse gas (GHG) emissions 262
- greenhouse gas emissions 418, 1130, 1151
- guluronic acid 1032
- Haematococcus pluvialis* 163, 291, 1034
- haloalkane dehalogenases 615–16, 618, 621
- molecular dynamics simulations 618, 620–1
- protein-solvent interactions 621
- steady-state kinetic measurements 618

- substrates 615–16
- time-resolved fluorescence spectroscopy 618
- haloarchaeal enzymes 298
- Halobacteriaceae* 285, 288, 295–6, 298, 307, 309
- Halobacterium salinarum* 286, 295, 297, 306–7
- Halococcus thailandensis* 286
- Halofex mediterranei* 287
- halohydrin dehalogenase 87, 96, 511
- Halomonas boliviensis* 294, 304
- Halomonas elongata* 284, 287, 291, 301, 306
- Halomonas meridiana* 299
- Halomonas salina* 294
- halophiles 242, 283–7, 298, 301, 305–9
 - as heterologous expression vectors 306
- halophilic Archaea 284, 287, 303
- halophilic enzymes 284, 298–9
 - amylases 298–9
 - amyloglucosidases 298–9
 - case studies 299
 - nucleases 298
 - proteases 298
- halophilic microorganism 283
 - industrial applications 283
 - physiological diversity 283
- Halorhabdus utahensis* 299, 601
- halorhodopsin 295, 297
- Halorubrum sodomense* 299
- Halorubrum tebenquichense* 307
- Halothermothrix orenii* 299
- Hantzsch dihydropyridine synthesis 483
- heat shock proteins 292
- Helianthus tuberosus* 685
- heme monooxygenases 663–4
- hemicellulose 214, 217, 240, 245–50, 253, 259–60, 262, 299, 306, 380–1, 383, 697, 1128, 1132–3, 1138–40
- hemicellulose hydrolysis 240, 248
- hen egg white lysozyme 478
- Henry-reaction 800–1
- hepatic gluconeogenesis 933
- HERA project 952, 974–5
- herb medicine 943
- herbal/dietary supplements 663, 665, 667
- heterocysts 1075
- heterologous metabolic pathways 100
- heterologous pathway engineering 185
- HFCS synthesis 567
- high-cell-density fermentations 352
- high fructose corn syrups 994
- high throughput methods 75
- high throughput screening 97
- high-value chemicals 373–4, 376, 378, 380, 382, 384, 386, 388, 390, 392, 394, 396, 398, 400, 402
- high-value products 206, 1007, 1014, 1034–5, 1037, 1039, 1041, 1043, 1045, 1047, 1049, 1051, 1128
- histone deacetylases 940
- HMBPP reductase 1079
- HMG-CoA reductase 169, 1078
- holoenzyme libraries 91
- holographic image storage 296
- homoethanol pathway 253
- host bacteria 55–6
 - Gram-negative 55
- host organism 34, 36–7, 39, 41–5, 47, 49–52, 54, 58, 352–3
 - choice 37, 41, 43, 45, 47, 49, 51, 54
- human IgG antibody 1046
- human risk assessment 973

- Humicola brevis* 248–9
 Hunan River Biodiesel 444
 hydantoin racemase 360, 817,
 824–6, 834–5, 838–41, 844–6
 substrate specificities 825
 hydantoinase process 360–1,
 817–18, 820–2, 824, 826–8,
 830–2, 834, 836–42, 844,
 846–52
 D-amino acids 827, 834, 836–9,
 841
 hydantoinase 360–1, 817–22,
 824, 826–8, 830–44, 846–52
 L-amino acids 361, 818, 827,
 834, 838–40, 842, 847, 851
 L-carbamoylase 817, 833, 835,
 838, 846
 milestones 851
 patents 817, 852
 hydantoinases 819–22, 827,
 837–8, 848–9
 active site 821
 classification 822
 eukaryotic 820–1
 GXXDXHXH-sequence motif 821
 immobilized 837
 stereochemistry gate loops 821
 hydantoins 359–60, 819–21,
 824–5, 827–31, 836–8,
 840–1, 843–4, 846, 850–1
 hydrogen 221, 263, 489, 770, 1071
 hydrogen biosynthesis pathway
 1071
 hydrogen production 221–2, 232,
 263–4, 297, 306, 1009, 1086
 “dark” fermentation mechanism
 263
 hydrogenases 48
 hydrolases 87, 95–6, 508–9,
 583–4, 586, 588–90, 594–6,
 600, 602–6, 608, 610–12,
 620, 822, 991, 1102–3
 in non-conventional media
 583–4, 586, 588, 590, 592,
 594, 596, 598, 600, 602, 604,
 606, 608, 610, 612
 resolution processes 589
 α/β-hydrolase fold 510, 732,
 1103–4
 α/β-hydrolase fold enzymes 96
 hydrothermal treatment 988
 hydroxy acids 733, 1154
 hydroxyacetone 783, 792, 803
 hydroxyectoine 291–4, 305
 hydroxynitrile lyase 88, 479, 505
 hypoosmotic shock 294
 ibuprofen 674
 ice nucleation gene 306
 IEA Bioenergy report 1128
 ifosfamide 666, 669
 iminocyclitols 787, 799–801
 synthesis 799–801
 immobilization of enzymes 595
 strategies 595
 immobilization quality 536
 immobilization techniques 523
 adsorption 523
 covalent binding 523
 entrapment 523
 immobilized enzymes/biocatalysts
 428–34, 436–8, 443–5,
 521–3, 526–7, 536–48,
 672–3, 677–8, 736, 740–1,
 743–4, 769–71, 828–31,
 833, 852, 1025–7, 1102
 protein loading 527
 penicillin amidase 541
 stability 429, 433, 546, 736
 immobilized lipases 443, 463, 733
 immunosuppression activity 932
 inclusion bodies 51, 56, 130, 143,
 352
 inducer drug 666
 industrial biocatalysis 73–4, 76,
 78, 80, 82–6, 88–90, 92, 94,

- 96, 100, 115–16, 323–4, 583, 631–2, 654–5
 industrial biotechnology 55–6, 205–8, 210, 212, 214, 216, 218–26, 228, 230, 232–3, 324, 373–4, 391, 578, 1032
 industrial enzymology 244
 interfacial activation 732
 internal diffusion 531
 International Energy Agency, 2013 181
 intraparticle diffusion 544–5
 intratumoral prodrug activation 682
 intrinsic enzyme activity 531
 ionic liquids 458, 490, 584–5, 596–7, 599, 601, 603, 605–6, 747, 759, 762, 852, 1083, 1128, 1136
 coating agents 606
 IPP-DMAPP isomerase 1078
 isobutanol 187–9, 196–7, 400, 1029, 1143
 isobutanol pathway 188, 400
Isochrysis galbana 1034–5, 1041
 isopentenol 194
 isoprene 1076–7
 biosynthesis pathway 1077
 isoprene synthase 191, 197, 1077, 1148
 isoprenoid pathway 1029, 1079
 isoprenoid producing pathway 194
 isoprenoids 161–70, 172–4, 176, 193, 1015, 1076–9
 biosynthesis pathway 1078–9
 biosynthetic pathway 163, 165
 pathway engineering 161–4, 166, 168–70, 172, 174, 176
 physiological functions 163, 176
 isopropylmalate dehydratase 186
 isopropylmalate dehydrogenase 134, 186
 isopropylmalate synthase 186
 isosorbide 1147–8
 isothermal DNA assembly 102
 iterative saturation mutagenesis 80, 90, 99

Jatropha 419, 1012, 1017, 1019, 1132
Jatropha curcas 419
Jeotgalicoccus 193

 kairomone 164
 Kenaf 1153
 Kennedy pathway 1088
 keratinase 135, 139
 keto-enol tautomerism 824–5
 ketoacid decarboxylase 186, 400, 1029
 ketocarotenoids 1038–9
Klebsiella planticola 1026
Klebsiella pneumoniae 325, 1023
Kluyveromyces lactis 570, 646
Kluyveromyces marxianus 227
 Knoevenagel reaction 457–8, 460–1
 decarboxylative 460–1
 Kunitz trypsin inhibitor 307
 kyotorphin 866–7

 L-amino acid ligase 876, 881
 L-amino acids 361, 818, 827, 832–5, 838–40, 842–7, 851
 production 818, 827, 833, 835, 838–9, 842–5, 847, 851
 L-arabinose isomerase 88, 99
 L-arginine 384, 390–2
 L-carbamoylase 817, 832–5, 838, 841, 843–7
 L-carbamoylases 822–4

- peptidase family 823
L-citrulline 392
L-hydantoinase 360, 833–5, 838, 844–5, 847
 maltose-binding protein 844
L-isoleucine 188, 393
L-lactate dehydrogenase 256, 258, 378, 387
L-norvaline 188
L-ornithine carbamoyltransferase 396
L-threonine biosynthesis 188
 laccase 85, 91–2, 144, 250, 507, 540–1, 697–714, 803
 laccases 91–2, 697–714
 advantages 699
 biochemical properties 701
 mode of action 700
 redox mediators 701
 redox potentials 699, 702
 spectroscopic characteristics 700
Lactacin B production 227, 229
 lactate dehydrogenases 387, 912
 lactate production 41, 50, 255
 lactic acid 206, 211, 225, 227, 231, 256, 258–9, 375, 383, 386–7, 394, 398–400, 1135, 1138, 1141
 lactic acid production 398
 lactide/glycolide copolymers 1152
Lactobacillus brevis 49, 916, 918, 921, 1023
Lactobacillus delbrueckii 386
Lactobacillus plantarum 225, 227, 473
Lactobacillus reuteri 1022, 1024
Lactobacillus zeae 225
Lactococcus lactis 55, 227, 385–6, 400
Laetiporus sulphureus 249
 Lecitase Ultra process 423
 lecithins 1130
 Leopoldina report 1132
Leuconostoc pseudomesenteroides 401
 leukotriene B4 dehydrogenase 633
 levodione 639, 646
 levulinic acid 1129, 1133, 1135, 1139, 1145
 library creation methods 76, 83
 life cycle analysis 978, 1032
 life cycle assessment 419, 1013, 1050
 light-harvesting complexes 165
 lignin 217, 245–6, 249–50, 380–1, 697–700, 708–9, 1011, 1127–8, 1132, 1138–9, 1153
 phenolic compounds 381
 lignin hydrolysis 250
 lignin peroxidase 250, 698
 ligninolytic enzymes 697
 laccase 698
 lignin peroxidase 698
 lignocellulose 245–7, 249–52, 257, 260, 264–5, 380–2, 387, 709, 742, 754, 1002, 1029, 1084, 1138–9
 lignocellulose hydrolysates 381, 1002
 lignocellulosic biofuel production 1128
 lignocellulosic biomass 97, 217, 242, 245–6, 257, 265, 380, 382–3, 385
 lignocellulosic hydrolysates 342, 375, 381, 383
 lignocellulosic materials 206, 246, 1017, 1128
 lignocellulosic wastes 214, 233, 240
 lignocellulosics 380, 709, 1138
 pretreatment 1138
 limonene 672, 770, 1136–7
 linalool 161, 164, 174
 linear cascade 894–5
 linoleic acid epoxidation 742

- lipase 428–9, 457–9, 461–6, 470–1, 481–4, 489–94, 506–9, 561–6, 611–15, 723–74, 1089–90, 1102–5, 1107–13, 1115–17, 1119–21
 lipase ATP-transporter recognition domain 353
 lipase-catalysed reactions 590
 in organic media 590
 lipase catalyzed 465, 755
 epoxidation 755
 perhydrolysis 755
 lipase-catalyzed epoxidation 490–2, 723–74
 alkenes 491–3, 723–74
 fatty acids 734, 740–3, 749
 ionic liquids 747
 reaction conditions 738, 751–2, 756, 763
 various plant oils 749
 lipase-catalyzed perhydrolysis 489–90, 755
 dimethyl carbonate 755
 lipase PS 496, 506
 lipases 95–6, 268–9, 427–9, 434–5, 457–9, 481–2, 489–91, 561–3, 603–5, 725, 731–7, 747–8, 1103–4, 1110–11, 1119–21
Aspergillus niger 1104, 1111
Candida antarctica B-lipase 428
Candida antartica 1104, 1119
Candida cylindracea 470, 1104
Candida rugosa 268, 1104
 from extremophiles 268
 immobilized 428, 443, 458, 463, 490, 732–3, 1016, 1110
Mucor miehei 481
 porcine pancreatic 1104, 1110, 1119
 promiscuous 453–4, 459, 464, 470, 475, 481, 489, 493, 496, 509
Pseudomonas cepacia 1111
Pseudomonas fluorescens 268, 489, 1109
Rhizomucor miehei 733, 1104
Rhizopus delemar 1111
Rhizopus japonicus 1111
 stability 268, 443, 566, 605, 723, 769, 953, 1104
Yarrowia lipolytica 1104, 1110
 lipid trigger conditions 1017
 liquid protease products 969
 long-chain fatty acids 1103
 lung surfactant 292
 lutein 163, 165, 1039–41
 lyases 87, 89, 98, 784, 791
 lycopene 101, 166, 170, 402, 1040
 lycopene cyclases 101
Lycopersicon esculentum 641
Lysinibacillus sphaericus 394
 lysozyme 478, 1083
 macroalgae 1009, 1033, 1041
 macrophomate synthase 456
Macrotyloma uniflorum 819
 magnetic beads 525, 541
 Maillard reactions 994, 996
 malaria treatment 1047
 malonyl/methylmalonyl-CoA ligase (MatB) pathway 936
 maltodextrin 244
 maltodextrins 991, 995–6
 maltooligosaccharide 304, 993, 998–9
 manganese peroxidase 250
 mannuronic acid 354, 1032
 marine microalgae 419
Marinococcus halophilus 293
 mass transfer limitations 39, 340, 527–8, 531, 546, 557, 606–7
 mass transport resistances 541
 mating 79, 91, 934

- mauran 302
 nanofibers 302
 medium engineering 586, 608
Meiothermus ruber 997
 membrane reactors 733, 905
 mesophilic microorganisms 993
 mesophilic organisms 240, 253–4,
 268
 met-enkephalin 866
 metabolic burden 51–2, 102
 metabolic engineering 49–50,
 62–3, 181–2, 184, 190, 192,
 194–8, 374–5, 390–3, 397,
 401–3, 931–2, 934–6,
 938–40, 944
 metabolic flux 40, 102, 196,
 349–50, 1036
 metabolic pathway engineering
 1013, 1138
 metabolic pathways 45, 52–3, 85,
 100, 103, 182–3, 198, 210,
 221, 240, 270, 375, 1067,
 1072, 1078
 metabolic systems 182
 metabolically engineered
 production strains 34–7, 42,
 58–61
 definition 34–5, 59
 metabolism 35, 37–8, 41–2, 44–52,
 56, 58–9, 62–3, 219, 255–6,
 325–8, 663–4, 666–7, 673–5,
 677–8, 685–8
 metagenomic sequencing 213
 metagenomic technologies 244
 metagenomics 34, 228, 270
 metathetic ethenolysis 740
 methane production 210, 262
Methanococcus jannaschii 101,
 263, 819
 methanogenesis 209, 262–3
 methanogens 210, 222, 262–3,
 308
Methanosarcina mazei 209
 methicillin-resistant *S. aureus* 227
 methoxamine 888
 methoxymorpholinyl doxorubicin
 682
 methylerythritol phosphate (MEP)
 pathway 165, 1078
 methylmalonyl-CoA mutase
 (MutAB) pathway 936
 mevalonate (MVA) pathway 104,
 165, 169, 193, 671, 1078
 mevalonate diphosphate
 decarboxylase 191
 mevalonate kinase 191
 Michael addition 450, 461–73,
 500–3, 507
 4-oxalocrotonate tautomerase
 472
 microalgae 195, 267, 269, 1008–
 14, 1017–20, 1028, 1031,
 1034, 1036–8, 1041, 1044–6,
 1068, 1071, 1084, 1087
 cell factories 1044
 eukaryotic 195, 1008–9, 1012
 oil content 1012, 1017
 prokaryotic 1009
 transgenic 1044–5
 microalgal biofuels 1014, 1052
 co-production of HVPs 1014
Microbacterium liquefaciens 825,
 840
 microbial communities 207, 210,
 228–9, 262, 286
 microbial consortia 205, 207, 214–
 15, 218, 224, 230, 232–3
 biofuels 218
 butanol 224
 simultaneous production 224
 synthetic biology approach 230
 microbial feedstocks 182
 microbial fuel cells 218, 220
 mediator-less 220
 microbial oils 267
 microcellulosome 382
 synthetic 382
Micrococcus luteus 192

- microemulsion systems 540
 microfluidics 82–3, 105, 852
 microorganism fermentation 184
 microplate 57, 82
 microspheres 543
 miglitol 800
 miglustat 800
 minimization of metabolic adjustment 41
 minimization of metabolites balance 41
Miscanthus 1132
 mixed culture-based bioprocesses 207
 mixed culture fermentation 209, 211, 221, 228–9
 challenges 228
 interrelationships 229
 terminal-restriction fragment length polymorphism 229
 mixed culture technology 211
 mixed cultures 205–6, 208–14, 221–2, 226, 229–32, 264
 advantages 208–9
 communication 226
 complex substrates 208, 213, 221
 contamination 206, 211, 222, 230
 oxygen removal 212
 stability 210
 modeling software packages 40
 molasses 211, 213, 253, 302, 374, 376, 378–9, 1138
 monoamine oxidase 86, 89
 monoglycerides 439, 1016
 monooxygenases 46, 62, 89, 91, 355, 663–4, 732, 848, 934
 monoterpenes 163–5, 174, 1136–7
 montelukast sodium 86, 92
 multi-copper-containing oxidases 699
 multiple promiscuities 497
 mutagenesis 74, 76, 78–80, 83, 85–8, 90–3, 95–101, 131–6, 143–6, 674, 676, 807, 831, 934–8, 960–2
 mutant libraries 76, 80, 82–3, 92, 105, 807
 chemical mutagenesis 76
 mutants 40–2, 75, 81, 83, 91–3, 95, 97–8, 103, 189–90, 255–6, 349, 393–4, 683, 935–7, 1045
 mutational tolerance 126, 149
 mutations 74–7, 81, 92, 97–9, 116–17, 120–50, 259, 389, 935–6
 antagonistic interactions 123
 compensatory 121–2, 124–30, 148
 destabilizing 117, 121–6, 128, 137, 148–50
 neutral drift 126–7, 149
 permissive 121, 124–7, 130
Mycobacterium colombiense 473
Mycobacterium smegmatis 828
Mycobacterium tuberculosis 700
Mycobacterium vaccae 398, 401, 652, 654

 n-hexanol 101
N-L-alanyl-L-glutamine 868
 NAD(P)H-plastoquinone reductase 1071
Nannochloropsis gaditana 1008, 1036
 nanocomposites 1000–1
 nanofibres 1084
 nanosized optoelectronic devices 297
 naringinase 538
 National Renewable Energy Laboratory 1010, 1134
Natrialba aegyptia 305
Natrinema gari 286–7
Neochloris oleoabundans 1017
 neointimal hyperplasia 933

- neoteric solvents 584
 neoxanthin 165
Nephila clavipes 1155
 net energy ratio 1013, 1019
 neuraminic acids 387
 neuro-degenerative diseases 1039
 neuroactive dipeptide 866
 neuroprotective effects 866, 940
 [NiFe]-hydrogenase 1074
 nitril hydratase 358
 nitroalkenes 463, 633–4, 639–41,
 643–4
 non-conventional media 583–4,
 586, 588–90, 592, 594, 596,
 598, 600, 602, 604, 606, 608,
 610, 612, 620
 deep eutectic solvents 584
 fluorous solvents 584
 ionic liquids 584, 606
 organic solvents 584–7, 589–90,
 592, 605, 608, 620
 supercritical fluids 584, 610
 non-conventional reaction media
 620
 organic solvents 620
 non-nucleoside reverse
 transcriptase inhibitors 678
 non-pathogenic *Pseudomonas*
 323–4, 326, 328, 330–4, 336,
 338, 340, 342, 344, 346, 348,
 350, 352–6, 358, 360–1
 non-proteinogenic amino acids
 396
 non-ribosomal peptide synthetases
 89, 99, 874–5
 condensation domain 874
 thiolation domain 874
 non-steroidal anti-inflammatory
 drug 354
Nonomuraea flexuosa 249
 norephedrine 888–9, 910–12, 915
Nostoc sp. 172, 643, 654
 Nuclease P1 453
 nutraceutical applications 932
 nutraceuticals 84, 161–3, 1035,
 1042
 nutritional genomics 1035
 nutritional supplements 866–7,
 880
 obesity 931, 939, 941
 oleic acid epoxidation 740
 oligoesters 1105, 1109–10
 omega-3 fatty acids 1034, 1036–7
 health benefits 1036
 omics technologies 965
 organic co-solvent systems 594
 organic co-solvents 584, 588, 595,
 615–18, 620
 organic solvent 35, 43, 60, 92, 290,
 480, 589, 591, 593–5, 603,
 605–6, 613, 618, 621, 903
 organic solvent systems 589
 nearly anhydrous 589–90
 organic solvents 59–60, 326, 329,
 575–6, 584–93, 595–6,
 603–6, 608, 611, 614–15,
 620–1, 903, 906, 999, 1001
 ornithine cyclodeaminase 395
 ornithine decarboxylase 396
 osmophiles 242
 osmotic solutes 291
 oxidases 38, 250, 699
 oxidosqualene cyclase 488
 oxoglutarate dehydrogenase 391
 oxygenases 39, 47, 92
 oxygenic photosynthesis 1068–9
 P450 fatty acid decarbonylase 193
 P450 monooxygenase 46, 90
 P450 monooxygenases 46, 91
 P450 propane monooxygenases 91
 packed-bed reactors 436, 438, 444
 paclitaxel 162, 355, 847

- Pantoea agglomerans* 291
Pantoea ananatis 168
Pantoea dispersa 572
 paper industry 705, 708, 990, 1000
 pathways 36–8, 40–2, 44–6, 48–50, 52–4, 62–4, 100–5, 165–6, 182–92, 194, 220–1, 253–4, 256, 375–7, 1077–8
 efficiency 52–3, 102–3
 penicillin 133, 141, 231, 391, 474, 541, 574–7, 604
 penicillin G 133, 141, 474, 574–7, 604
 penicillin G acylase 133, 141, 474, 574–7
Penicillium chrysogenum 573
Penicillium citrinum 453
 pentose phosphate pathway 61, 328, 351, 383, 805
 peptidase family 823
 peptidases 864, 878
 percarboxylic acid 728, 730, 734–5
 perillic acid 1137
 peroxidase 91, 144, 250, 497, 698, 699, 907
 petrochemical alkenes 723
 petrochemical industry 309, 348, 1133, 1135–6
 petrochemical refineries 1128
 petrochemicals 35, 60, 64, 95, 670, 686–7, 1135
 petroleum-based fuels 1008
Petrotoga mobilis 299
 PHA synthase 347–8
Phaeodactylum tricornutum 1046
Phaesolus lunatus 819
 phage-assisted continuous evolution 83, 105
 phage infections 211
 pharmaceutical industry 64, 83–4, 89, 98, 305, 393–4, 398, 401, 583, 713, 842, 1000, 1037
 pharmaceutically active compounds 510, 888, 891
 pharmaceuticals 95, 227, 302, 339–40, 348, 373, 450, 458, 481, 590–1, 846–7, 1130, 1140, 1143–4, 1146
 phenacetin 673, 675
 phenobarbital 666
 phenolic acid decarboxylases 473
Lactobacillus plantarum 473
 phenylalanine aminomutase 88, 99
 phenylalanine/tyrosine ammonia lyase 349
 pheromones 787, 887
 phosphite dehydrogenases 92
 phosphodiesterases 940
 phosphoenolpyruvate carboxylase 392, 397, 400
 phospholipase A 423
 phospholipases 417, 422–4, 1111, 1131
 phospholipids 417, 422–7, 441, 1036, 1083, 1087–8, 1130
 phosphomevalonate kinase 191
 phosphotransferase system 378–9
 phosphotriesterase 118
 phospholipase A2 1131
Photobacterium lipolyticum 269
 photobioreactor 1020, 1073
 photochromic properties 296
 photofermentation 263
 photon conversion efficiency 1074
 photosynthesis 165, 195, 245, 1010, 1038, 1068–71, 1075, 1078, 1132
 mechanism 1068
 photosynthetic efficiency 195, 1007–8, 1051–2, 1066
 phycobilins 1012, 1038, 1043
 phycobiliprotein 1043–4
 phycocyanin 1039, 1043–4
 phylogenetic analysis 138

- phylogenetic reconstruction
 approaches 125
- phytoene 101, 166, 170, 402, 1041
- phytoene desaturase 101, 170, 402
- phytoene synthase 166, 170, 402
- Pichia pastoris* 56, 98, 704
- Pichia stipidis* 213
- Piedmont Biofuels 433, 444
- pigments 285, 334, 710, 969,
 1008, 1028, 1035, 1038,
 1042–3, 1051, 1068–9, 1078
- pinocembrin 1149–50
 biosynthesis 1149
- Planococcus rifitoensis* 300
- plant defense 333, 1136
- plant oil-based unsaturated
 derivatives 723
- plant oils 345, 724–5, 733, 735,
 737, 743, 749–51, 772–4
 fatty acid composition 724
 world production 724
- Plasmodium falciparum* 1046–7
- plasticizers 747, 773, 1000, 1143,
 1146
- plastoquinone pool 1069
- platform chemicals 1035, 1127–9,
 1133–41, 1143, 1145, 1147–9
 marked size 1128
- poly(3-hydroxybutyrate) 1105
- poly(butylene succinate) 1104
- poly(ethylene glycols) 726
- poly(ethylene terephthalate) 1022,
 1104
- poly(hydroxycarboxylic acids)
 1105
- poly(lactic acid) 1104
- poly(trimethylene terephthalate)
 1022
- polyamides 396, 774, 1027,
 1120–1, 1144, 1147, 1154
- polybutylene succinate 1152
- polycarbonate 348, 1118–19,
 1147, 1152
- polycondensation 490, 496, 1104,
 1106, 1111, 1119–20
- polyester synthesis 430, 1104–7,
 1109, 1111, 1113, 1115,
 1117, 1154
- A-B type monomer 1105, 1109
- ring-opening polymerization
 1104–6, 1117
- polyesters 303, 306, 490, 496, 726,
 728, 1102, 1104–5, 1107,
 1110–11, 1143, 1145
 1147–8, 1151, 1154
- biodegradable 303, 1001,
 1104–5, 1151
- low-molecular-weight 1110
- Polyethylene 290, 307, 342, 589,
 592, 617, 968, 1001, 1023,
 1026, 1136, 1150–2
- Polyethylene terephthalate 342,
 1150
- Polyhydroxyalkanoate 326, 344,
 347, 402
- Polyhydroxyalkanoates 346, 374,
 391, 402, 1012, 1025, 1151,
 1153
- Polyketide synthases 934
- Polylactic acid 773, 1151–2
- Polymer synthesis 496, 1102–3
- Polymeric materials 1102
- Polymerizations 1102–3, 1107,
 1110–11, 1117, 1119
- Polymers 84–5, 248–9, 301–3,
 346, 387, 441, 592, 774,
 1000–1, 1025–7, 1101–6,
 1118–22, 1142–4, 1147,
 1150–3
- Benefits 1103, 1121, 1150
- Biocatalytic synthesis 1101–2,
 1104, 1106, 1108, 1110,
 1112, 1114, 1116, 1118,
 1120, 1122
- Biodegradable 64, 346, 387,
 1000–1, 1027, 1103–5, 1142,
 1144, 1150–1, 1153

- polyamides 774, 1027, 1120–1,
 1144
 polycarbonates 1119
 polyesters 726, 774, 1001, 1025,
 1102, 1104–5, 1143, 1147
 polymethylmethacrylate, polyvinyl
 alcohol 541
 polypeptides 878, 1104, 1120
 polyphosphate kinase 877
 polyunsaturated fatty acids 1017,
 1019, 1035–6, 1088–9
 polyvinylacetate divinylbenzene
 541
 porcine pancreatic lipase 589, 601,
 1104–5, 1109–11, 1114, 1119
 post-PKS modification 938
 post-PKS processing 939
 powder detergents 562, 950, 959,
 968, 971
 prenyl transferases 165, 1080
 Prileschajew epoxidation 728,
 735, 775
 reaction mechanism 728, 735
 prions 959
 process control 53, 58, 289, 965,
 1013
 Process Intensification 1148–9
 prodrugs 666–9, 680–1, 683
 promiscuous biocatalysts 449–50,
 452, 454, 456, 458, 460, 462,
 464, 466, 468, 470, 472, 474,
 476, 478
 aldol addition 451, 457
 Biginelli reaction 485, 487
 Hantzsch-type reaction 483–4
 Henry reaction 480, 506
 Mannich reaction 481–2
 Markovnikov addition 473–5,
 477, 508
 Michael addition 461–2, 466–73,
 501–2, 507
 Ugi reaction 484
 propane monooxygenase 122, 126
 propionic acid 224–6, 232, 375,
 587, 842, 1027, 1141
 propionyl-CoA carboxylase (PCC)
 pathway 936
 propylene oxide 726, 990
 Pros tide 143
Protaminobacter rubrum 572–3
 protease type XIV 483
 proteases 143, 256, 286, 296, 298,
 300, 453–4, 589, 595, 863–4,
 949–54, 956–64, 966–80,
 982, 1120
 analysis 976–8
 bacteriolytic activity 959
 performance 454, 951, 957–61,
 980
 substrate specificity 953, 961,
 1120
 protein engineering 34, 37–9, 74,
 78, 87, 115–16, 128, 137, 586,
 806, 808, 810–11, 951, 954,
 962
 protein folding 118–19, 121, 137
 protein hydrolysates 1047–8
 protein misfolding 51
 protein sequence activity
 relationships 92
 protein stability 116–17, 119–28,
 131, 143, 243, 664, 679, 687
 kinetic 117–19, 121, 127
 thermodynamic 117, 119, 127,
 143
 threshold model 119, 122–3
 protein waste 1047
 proteins 116–20, 127–8, 132,
 138–43, 147–9, 261–2,
 328–30, 352–3, 863, 878,
 972, 986–7, 994, 1011,
 1046–7
 proteolytic activity 959–60, 973,
 976
 metagenomic screening 960
 mining of genome data 960
 proteolytic enzymes 847, 949–50,
 974, 1120
 proteorhodopsin 297

- Proteus mirabilis* JV 254
 protonmotive properties 296
 protoplast fusion 934
Pseudoalteromonas undina 1031
Pseudomonads 323–9, 331–6,
 340–1, 352–5
Pseudomonas aeruginosa 323, 588,
 595, 611, 732, 1109, 1114
Pseudomonas aeruginosa lipase
 1109
Pseudomonas cepacia lipase 1109,
 1111
Pseudomonas chlorophasis 828
Pseudomonas fluorescens 268, 489,
 510, 608, 898, 1104, 1109,
 1115
Pseudomonas mesoacidophila 572
Pseudomonas putida 39, 43, 46,
 172, 185, 323, 395, 639, 672,
 823, 898, 997, 1025, 1154
Pseudomonas syringae 323
Pseudomonas striata 828
Pseudomonas stutzeri lipase 465
Pseudomonas syringae 306, 323
Pueraria montana 197, 1079
 pullulan 993
 pullulanase 991–3, 995
 puromycin 681
 putrescine 383–4, 388, 390,
 396–7, 1138, 1144, 1154
 pyoverdines 334–6
 pyrimidine derivatives 466, 503,
 507
Pyrococcus furiosus 244, 996
Pyrococcus woesei 299, 992
 pyrodextrins 986, 989
 pyruvate carboxylase 387, 392–4,
 397–8, 400
 pyruvate decarboxylase 184,
 253–4, 256, 400, 510, 904
 pyruvate decarboxylases 897, 912
 pyruvate-ferredoxin oxidoreductase
 1071
 pyruvate formate-lyase 139
 pyruvate kinase 260, 802–3
 pyruvate removal 911–12
 quinaldine 4-oxidase 39
 (R)-carvone reduction 647,
 652–53
Ralstonia eutropha 303, 402, 1046
Ralstonia sp. 919
 ramipril 846
 random mutagenesis 101, 131,
 189, 357, 670, 831, 961, 1045
 techniques 130–1
 rapamune 932
 rapamycin 931–9, 941, 944
 biosynthesis 931–2, 934–5,
 937–9, 941
 rapamycin analogs 933, 938, 944
 rare sugars 798
 rational protein design 734
 REACH chemical law 952
 reactive metabolites 674
 reactive oxygen substances 1038
 recombinant DNA technology 268,
 373, 951
 recombinant proteins 352–3,
 1044, 1046
 recombinant whole-cell biocatalysts
 34–5, 53, 62
 definition 34–5
 recombination approaches 132
 recombination libraries 132
 structure-guided 132
 redox cofactor balancing 328
 reductive hydrogenation 888
 reductive pyrimidine degradation
 pathway 819–20, 823
 Reichstein synthesis 998
 renewable building blocks 1153

- microbial production 1153
 renewable energy generation 1065
 renewable energy sources 183
 renewable epoxy plasticizers 747
 renewable feedstock 35, 37, 58–9,
 774, 1051
 renewable substrates 338
 respiratory allergies 950
 response surface methodology
 742, 747, 750
 restenosis 933, 944
 resveratrol 53, 931–2, 934, 936,
 938–44
 biosynthesis 931–2, 934, 936,
 938–44
 health benefits 939
 mechanism of action 939
 retinal 285, 295, 297
 retro-aldol activity 456
 retro-aldol reaction 784, 799
 retro-aldolase 810
 de novo design 810
 retro-Strecker racemization
 mechanism 496
 Reynolds number 535
 rhamnolipid synthesis 345–6
 recombinant 345–6
 rhamnolipids 344–6, 538, 1025,
 1028
 rhamnosyltransferase I 345
Rhizomucor miehei 249, 465, 586,
 733, 1104
Rhizomucor miehei lipase 465
Rhizopus oryzae 459, 608–9, 612,
 1138
Rhizopus peka 227
Rhodobacter sphaeroides 222
Rhodococcus rhodochorus 685
Rhodococcus rhodochrous J1 358
Rhodotorula glutinis 1028
 ribulose kinase 384
 ribulose-5-phosphate 4-epimerase
 384
 rice starch 987
 specific applications 987
 rifampicin 666
 ring-opening polymerization
 1104–6, 1112, 1117, 1119–20
 enzyme-catalyzed 1105–6, 1117
 mechanism 1117, 1119
 Rubisco 196
 RubisCO enzyme 1070
Ruminococcus flavefaciens 251
- (*S*)-2-chloropropionic acid 355
 (*S*)-benzoin 900
 saccharification 217, 247, 260,
 996, 1029–32, 1084–5
Saccharomyces 44, 62, 79–80, 91,
 168, 185, 253, 326, 485, 510,
 570–1, 900, 905, 994, 1002
Saccharomyces bayanus 1031
Saccharomyces cerevisiae 40, 56,
 62, 79–80, 92, 101–2, 144,
 168, 171, 185, 188, 193–4,
 217, 227, 253, 326, 485, 510,
 604, 704, 905, 1002, 1024,
 1030, 1039
Saccharomyces kluyveri 820
Saccharomyces lactis 570–1
Salinibacter ruber 285
 saturation mutagenesis 79–80, 83,
 86, 88, 90, 95, 99–100, 122,
 131, 135, 140, 144–6, 489,
 807, 831
 scaffoldin 251–2
 SCHEMA algorithm 132
 screening 53–5, 57–8, 82–3, 91,
 97–8, 104–5, 130–1, 141–5,
 147–8, 188–9, 349, 810,
 907–9, 936–7, 959–62
 seaweeds 1007, 1011
 Sec-pathways 403
 semisynthetic cephalosporins 359
 semisynthetic penicillins 359
 Sepharose 538, 541

- sequence-based predictions 132
 serine hydroxymethyltransferase 395, 498
 serine protease inhibitor 452
Serratia plymuthica 572
 serum paroxonases 147
 SESAM technology 961
 sesquiterpenes 163–5, 174, 176, 1136
 SFPR technology 649
Shewanella oneidensis 193
 shikimic acid pathway 936
 sialic acid 388–9, 457, 1044
 siderophores 334–5
 siderotyping 336
 silica aerogels 544
 Simplex optimization method 740
 simvastatin 87, 93–4, 145, 674
Sinorhizobium meliloti 823, 825, 850
 sitagliptin 86, 93–4
 site-directed mutagenesis 80, 86, 88, 91–2, 98, 131, 133–6, 145, 499, 674, 676, 846, 901, 961
 solvent tolerance 43, 255, 328–32, 336, 338, 341, 348, 795, 808, 811
 solventogenesis 224, 1086
Sphingobium yanoikuyaе 916
 spider silk 1154–5
Spirulina maxima 1011, 1041
Spirulina platensis 1032, 1044
Spirulina spp. 1018
Sporobolomyces ruberrimus 1028
 squalene hopene cyclases 488
 stability threshold 120–1, 124, 126, 128–9, 142, 149
 stabilizing mutations 117, 122, 124–8, 130–3, 136–42, 144, 148–50
 prediction 132, 137, 139–40, 150
 staggered extension process 77, 98, 144
 staling process 995
Staphylococcus aureus 101, 168
 staphyloxanthin 1038
 starch 257, 259, 304, 374, 376, 378, 542–3, 545–6, 567–8, 985–98, 1000–2, 1031, 1070–1, 1084, 1132–3
 saccharification 217, 996, 1031
 starch granules 986–92, 994
 starch liquefaction 993
 starch processing 985–6, 988, 990–4, 996, 998, 1000, 1002
 enzymatic degradation 986
 starch production 986, 1002, 1031
 starch retrogradation 993
 starch syrups 995–6, 1002
 starches 183, 985, 988–90, 1001–2
 stearodonic acid 1036
 stereoselective reductive amination 888
 sterols 612, 1034, 1132
 stigmasterol 492, 1132
 stilbene synthase 941
 Stokes–Einstein equation 529
 strain engineering 41, 43, 45, 47, 49, 51, 240, 653, 655
Streptomyces almqvistii 828
Streptomyces avermitilis 100
Streptomyces clavuligerus 171
Streptomyces griseolus 686
Streptomyces griseus 376, 483, 495
Streptomyces hygroscopicus 932, 934
Streptomyces mikataensis 828
Streptomyces murinus 997
Streptomyces sp. 168, 170, 672
 structural-based predictions 132
 StyA monooxygenase 340
 styrene epoxidation 341, 759
 submerged fermentation processes 206
 substrate-diffusion limitations 592
 subtilase superfamily 957
 Subtilisin Carlsberg 950
 Subtilisins 954

- succinic acid 382, 389–90, 397–8, 1027, 1108, 1129, 1135, 1142–3, 1154
 sugar-derived building blocks 1133
Sulfolobus shibatae 244
Sulfolobus solfataricus 244, 265, 994
 supercritical CO₂ 1031, 1083, 1136
 supercritical fluid 610
 supercritical fluids 584–5, 610–11, 613, 770, 904, 1018
 surfactants 292, 344, 558, 565, 572, 726, 773, 953, 968, 970–3, 977, 1021, 1027–8, 1147
 Sweetzyme 569, 997
 switchgrass 217, 261, 306, 1132
Synechococcus elongatus 185, 196
Synechocytis sp. 1079
 synthetic biology 105, 181–2, 230, 577, 896
 synthetic enzyme cascades 887–8, 890, 892–6, 898, 900, 902, 904, 906, 908, 910, 912, 914, 916, 918, 922
 1,2-amino alcohols 887, 895–6
 1,2-diols 887, 889, 895–6, 915, 919
 asymmetric synthesis 887, 900
 multi-chiral centres 888, 896
 synthetic metabolic pathways 183
 syntrophic lifestyles 207
 syringaldazine 540–1, 702

Tagetes patula 163
Talaromyces thermophiles 249
 tandem acylation/Michael addition 502
 Tat pathway 403
 taxifolin 1132
 taxol 162, 172, 510, 672, 847
 taxonomy 324–5
 TCA cycle 50, 328, 331, 391–2, 397, 399, 1023
 temsirolimus 932–3
 terephthalic acid 342, 348, 1022, 1129, 1147
 terpene cyclase 1137
 terpene synthases 163, 171, 193
 terpenes 161, 329, 639, 730, 733, 1136–7
 terpenoids 161, 193, 643, 1132
 testosterone 332, 675
Tetragenococcus halophilus 286
 tetrahydrochromene derivatives 502
 tetraterpenes 163, 1136
 ThDP-dependent enzymes 895–901, 903–4, 906
 acyloin condensations 897
 aldehyde-ketone cross-coupling 897
 benzaldehyde lyase 897
 benzoylformate decarboxylase 897
 carboligation reactions 897
 pyruvate decarboxylases 897
 therapeutic proteins 95, 1046–7
Thermoanaerobacter species 256
Thermoanaerobacterium *saccharolyticum* 214, 258
Thermoascus aurantiacus 249
 thermodynamic stability model 118
Thermomyces lanuginosus 249, 268, 471, 600
 thermophiles 243, 247, 249, 254–5, 263–4, 284, 996
 Thermophiles 247, 264
 thermophilic bacteria 222, 247, 249, 255, 261, 993
 thermophilic fungi 249
 thermophilic methanogens 262
 thermophilic organisms 240, 255
 thermophilic proteins 125

- thermoplastic starch 1000
 thermoreversible starch gels 991
 thermozymes 245
Thermus aquaticus 996
 Thiele modulus 528, 530–2, 544, 548
Thioalkalivibrio 309
 thiocyclitol 801
 thioesterase 190–2, 196, 876
 thraustochytrid strains 1028
 threonine aldolase 498
 threshold model 119, 122–3
 thylakoid membrane 1069–70, 1072
 TIGR approach 104
 TIM barrel 634, 791
 toluene dehydrogenase 339
 TOR signaling 941
Toxicodendron vernicifluum 697–8
 transaldolase 790–1, 805
 transaldolase B 790–1, 805
 transaminase 45, 86, 93, 394, 907, 910–11, 914–15
 Transbiodiesel 443
 transcriptome analysis 392
 transesterification 266, 268–9, 417–18, 420, 422, 428–9, 432–3, 437–44, 587–8, 600, 608–10, 612, 733, 1016, 1089–90
 chemical catalysts 420, 1016
 lipase-catalyzed 734, 1016, 1020, 1023
 transesterification process 266, 268, 422, 439
 chemical 266
 transgenic plants 670, 673, 685–7, 944
 translation rules 52
 transportation fuels 184, 1051, 1130
 transposon mutants 349
 trehalose 991, 997–8
 trehalose synthases 997
 trehalulose 572
 triacylglycerides 195, 749, 754, 1017, 1087
 triacylglycerol lipases 725, 731
 properties 725
 triacylglycerols 749, 1008, 1016, 1036–7, 1103
 tricarboxylic acid cycle 49, 53, 389
 tricarboxylic cycle 897
Trichoderma reesei 601, 704, 957, 966, 1045
 triglycerides 421, 428–9, 563, 732–3, 737, 773–4, 1016
 triolein 1103
 triose phosphate isomerase 802–3
 tripeptides 864–5, 878
 triterpenes 163, 1136
 truncated 3-hydroxy-3-methylglutaryl-CoA reductase 191
 TTC-based screening assay 908
 reductive amination 909
 two-phase reactions 871
 two-step cascade 910, 913–14
 tyrocidine 876
 tyrosine phenol lyase 87, 98, 349, 351
 UDP-galactose-epimerase 386
 UDP-glucose-1-P-uridylyltransferase 386
 uptake hydrogenase 1074
 urea hydrogen peroxide 736, 758, 763, 768, 770
 uronic acid 302
 UV-mutagenesis 937
 valine biosynthesis 188, 393
 valine catabolic pathway 936

- value-added compounds/products 34, 37, 53, 58, 100, 380, 390, 583, 1008
 vastatin drugs 98
 vegetable oil 417, 563, 774, 1090
Veillonella criceti 225
 verapamil 674–5
 vertebrate gastrointestinal system 865
Vibrio splendidus 1033
Vicia faba 819
 violaxanthin 165, 1041
 viral glycoproteins 800
 virginiamycin 231
 vitamin B12 306, 355–7, 1034
 molecular structure 356
 vitamins 84, 206, 213, 663, 1000, 1008, 1034
 in vivo lipid profiling 1018
 in vivo overlap extension 80, 91
 in vivo shuffling 79, 85, 91–2
- waste cooking oils 421
 wastewater 206, 214–16, 219–20, 223, 229, 232, 262, 264, 266–7, 705–8, 710, 713, 990, 1011, 1020
 wastewater treatment 206, 214–6, 223, 229, 232, 266, 705–6, 710, 713, 1020
 water-mimicking solvent 591
 white-rot fungi 246, 697–8, 700
 whole-cell biocatalysis 34, 37, 42, 47, 50–1, 58, 60, 62–3, 329, 337, 341, 373, 604
 whole-cell biocatalysts 34–7, 48, 53, 56, 59, 62, 268, 554, 652, 655, 1016
 wood degradation 697
 worker safety 973
 world food markets 241
- Xanthomonas campestris* 133, 383
 xanthophyll cycle 165
 xanthophylls 165, 290, 1038, 1041
 xenobiotics 336, 634, 663–4, 688, 711
 xerophiles 243
 xylan 191–2, 248–9, 255, 258, 1139
 xylanases 249, 251, 264, 299–300, 1030, 1139
 xylanolytic enzymes 1139
 xylene monooxygenase 42
 xylitol 401, 403, 1133, 1135, 1145
 xylose 101–3, 213, 249, 253, 255, 257–8, 263, 350, 376, 378, 380–3, 401, 996–7, 1136, 1138–9
 xylose isomerase 101–2, 378, 383, 996–7
 xylulokinase 378, 383, 401
- Yersinia pseudotuberculosis* 897
- zeaxanthin 165, 168, 639, 1039, 1041
Zebellella denitrificans 1025
 zerumbone 172–4
Zingiber zerumbet 170, 174
Zingiberaceae family 173–4
 zotarolimus 933
Zymomonas mobilis 213, 253, 327, 400, 488

