

Index

A

Abalone, 142, 171
Abiotic, 55, 58, 59, 66
ACC. *See* Amorphous calcium carbonate
Acid-insoluble matrix (AIM), 171, 180, 185
Acid-soluble matrix (ASM), 171, 179, 181, 182, 185, 187
Actin-like protein, 19
Additive, 53, 142, 145, 150, 170–185
Adsorption, 54, 58, 65, 66
Adult spine, 209–212
Adult tooth, 212–217
AIM. *See* Acid-insoluble matrix
Amino acids, 173–175, 183, 184, 192, 332, 337, 339, 341, 343, 347, 367–369, 372, 377, 379
Amorphous calcium carbonate (ACC), 143, 149–150, 164, 170, 175, 176, 178, 179, 184, 185, 208–209, 212, 215–218, 227, 326
Amorphous calcium phosphate, 150, 188
Antagonistic, 53
Antibodies, 369–379
Aragonite, 143–150, 154–163, 170, 171, 174–176, 178–181, 184, 185, 370, 372, 380, 386, 388
Aragonite crystal, 335, 337, 339, 340, 342–347
Archea, 88
Arthrobacter, 54, 58, 63
ASM. *See* Acid-soluble matrix
Atmospheric oxygen level, 255
Aurantimonas, 54, 60, 62, 64
Autotrophy, 52, 57
Axial filament, 267

B

Bacillus, 55, 56, 60, 62–64, 66
Bacillus subtilis, 131, 133
Bacteria, 49–67, 88
Bacterial calcium carbonate precipitation, 114
 active vs. passive, 116, 117
 in calcium homeostasis, 128
 in eutrophic conditions, 120, 121
 evolution and meaning, 132
 genetic control, 131
 heterogeneous nucleation, 133
 implications and applications, 114
 metabolic pathways involved, 123, 124
 role of bacterial surfaces, 119, 133
 role of EPS, 134
 role of pH, 119, 120
 role of protons, 129, 130
Bacterial calcium metabolism, 127
 calcium metabolism and precipitation, 130, 131
 calcium regulation, 128
 role of Ca^{2+} , 127
Bacterial S-layer, 88
Basal lamina, 234
Bioavailability, 52
Bio-crystallisation, 276
Biofilm, 87, 90
Biogenic, 63, 64, 66
Biogeochemical cycles, 49
Biologically controlled mineralization, 83, 227
Biologically induced mineralization, 81, 226
Biomedicine, 275
Biomineral, 142–171, 173–175, 177–180, 184

- Biomineralization, 78, 115, 141–193, 199–219,
 226, 239, 331–347
 in the early Cambrian, 132
 terms and processes, 115
 Biomineralization-related genes, 240
 Bio-seed, 81, 85, 90, 98, 101
 Bio-silica, 83
 Biosintering, 272
 Birnessite, 84
 Bivalve, 355, 357, 358, 360, 361, 366, 368,
 370, 372, 383
 Black smokers, 104
 Body plan, 252
 Bone, 142, 143, 150–153, 164–166, 168, 186,
 188, 191
 Brittlestar, 146–148, 153
 Burgess Shale, 257
 Byssus, 356
- C**
- Cadmium, 240
 Calcarea, 253
 Calcification-associated peptide, 321
 Calcite
 distorsion, 381
 lattice, 381
 twinning, 381, 382
 Calcium, 203–204
 Calcium-bearing minerals, 227
 Calcium-binding ability, 323
 Calcium carbonate, 316, 332, 333, 335,
 338–341, 343, 344, 346, 347
 amorphous, 357
 aragonite, 143–150, 154–163, 170, 171,
 174–176, 178–181, 184, 185
 calcite, 143–150, 161, 163, 164, 170, 171,
 173–178, 180, 181, 183–185
 vaterite, 143, 144, 148–149, 157, 158,
 161–163, 170, 171, 173–176,
 179–182, 184, 185
 Calcium carbonate crystals, 119
 formation, 120
 polimorphs, 119
 Calcium phosphate
 hydroxyapatite (HA), 150, 151, 153, 166,
 167, 188
 octacalcium phosphate, 150, 151
 Calprismin, 354, 372–376, 378–380, 384–386
 Carbon fixation, 54
 Carp otolith, 142–159
 asteriscus, 154, 157–159, 170, 179, 182, 185
 sagitta, 154, 156–159
 lapillus, 154–156, 158, 159, 179, 181, 185
 Caspartin
 localization, 374
 in vitro, 374, 376, 382
 Cathepsin L, 269
 Cation diffusion facilitators, 9
 Challenger expedition, 79
 Chemical mineralization, 83
 Chengjiang, 257
Cherax quadricarinatus, 320
 Chitin, 334–336, 342, 345–347, 368, 386, 388
 Chitin-binding ability, 323
 Chitin-binding domain, 320
 Choiidae, 260
C_{mag}, 14
 Coccolith, 98
 Coccolithophores, 98
 Coercivity, 16
 Collagen, 151–153, 164, 165, 175–178, 185,
 186, 188–192, 256
 Comitalia, 266
 Compartmentalization, 62
 Composite, 160, 164, 187–191
 Coprecipitation, 13
 Co-rich crusts, 78
 Crab, 144, 163–164
Crateromorpha meyeri, 269
 Crayfish, 319
 Crustaceans, 316
 Crystal growth, 333, 338, 340, 341, 344–347
 Crystalline calcium carbonate, 227
 Crystal morphologies, 18
 Crystal orientation, 161, 162, 187
 Crystal polymorph, 326
 Cuticle, 316
 Cyanobacteria, 123, 129, 133, 134
- D**
- Demospongiae, 253
 Depositing bacteria, 92
Desulfovibrio magneticus, 6
 Diactins, 259
Diagoniella sp, 260
 Discoidin family member, 235
 DUF protein, 273
- E**
- Easy axis, 16
 Ecdysteroid, 317
 Echinoderms, 199–219, 228
 ECM molecule, 234

- Ecotoxicology, 239
 Ecto-mesoderm signaling, 235
 Ediacaran, 253
 EDTA. *See* Ethylenediaminetetraacetic acid
 Efflux, 61, 63
 Electron acceptor, 51, 55, 65
 Electronics, 275
 Electrophoresis, 368–374
 Element, 142, 143, 146–148, 166, 170
 ELISA, 369, 370, 372, 378
 Embryo development, 231
 Embryonic spicules, 206–208, 210, 217, 229
 Emulsion, 384, 385, 388
 Enamel, 153, 166–169
 Endolithobiontic microbes, 105
 Endoskeleton, 199–219
 Enzymatically controlled mineralization, 83
Erythrobacter, 60, 62, 64
 Ethylenediaminetetraacetic acid (EDTA), 162, 170, 171, 173
 Exopolysaccharides (EPS), 51
 Extrapallial
 fluid, 384
 space, 354
- F**
- Face-selective adhesion, 18
 Fan mussel, 353–389
 Feo, 12
 Ferric, 10
 Ferric uptake regulator (FUR), 12
 Ferrihydrite, 13
 Ferrite, 16
 Ferritin, 29–44
 Ferritin evolution, 39–41
 Ferromanganese, 53
ferrooxidans, 104
 Ferrous, 10
 Fiber, 164, 166–168, 189–193
 Fibril, 151, 152, 154–159, 163–168, 188–192
 Foraminifera, 13
 Framework, 176, 188
 Framework proteins, 336–339, 344, 345
 Functional material, 142, 188, 191, 192
- G**
- GAP 65, 320
 Gastrolith, 318
 Gastrolith disk, 318
 Gastrolith matrix protein (GAMP), 319
 Gene regulatory network, 234
 Gene repertoire of PMCs, 242
 Giant basal spicules, 265
 Goethite, 13
 Greigite, 4
 Growth kinetics, 14
 Growth regulator, 17
- H**
- Halomonas*, 57
Halomonas eurihalina, 120, 122
 Hematite, 13
 Heteroepitaxy, 386, 388
 Heterotrophy, 54, 55, 57
 Hexactinellida, 253
 Hierarchical assembly, 165–169, 187
 Homeobox genes, 253
 HtrA-like proteases, 9
 Hunan, 257
 Hydrothermal vent, 50, 56, 64, 78, 102
 20-Hydroxyecdysone, 320
 Hyperthermia treatment, 20
Hyphomicrobium, 57, 58
- I**
- IM. *See* Insoluble matrix
 Immunogold, 374–376, 378
 Increased CO₂ levels, 242
 Induction, 14
 Inflammatory events, 231
 Inorganic mineral, 142, 143
 In situ, 55, 56, 58, 59
 Insoluble matrix (IM), 170
 Integrin receptor, 237
 In vitro crystallization tests, 243
 In vitro mineralization, 171, 177–179, 185
 Iron biominerals, 40–44
 Iron concentrations, 6
 Iron uptake, 10
 Ivory, 142, 153
- L**
- Lake Chagytai, 255
 Larval skeleton morphology, 233
 Larval transcriptome, 242
 Lattice, 143, 146, 150, 153, 159, 174, 175, 190
 Lattice parameter, 15
 Leptothrix, 57, 59–62, 64, 66
 Lower Cambrian, 257

M

- Macromolecule, 142, 143, 149, 150, 153, 171, 175, 176, 183, 188
 polyanionic, 369
 polydispersity, 369
- MagA, 12
- Maghemite, 13, 15
- Magnesian calcite, 225, 228
- Magnesium, 143, 149, 175–178, 186
- Magnetic fields, 5
- Magnetic remanence, 16
- Magnetic resonance imaging (MRI), 20, 21
- Magnetic saturation moment, 15
- Magnetite, 15
- Magnetite biomineralization pathway, 9
- Magnetite formation, 13
- Magnetite/goethite, 78
- Magnetobacterium bavaricum*, 7
- Magnetoreception, 3
- Magnetosome chain, 19
- Magnetosome island (MAI), 7
- Magnetosomes, 5, 9
- Magnetospirillum*
M. gryphiswaldense, 6
M. magneticum, 6
M. magnetotacticum, 6
- Magnetotactic bacteria (MTB), 3, 5
- Magnetotaxis, 6
- MAI. *See* Magnetosome island
- MamB, 13
- MamJ, 19
- MamK, 19
- MamM, 13
- Manganese, 49–67
- Manganese deposition, 92
- Mangroves, 23, 57
- Mantle, 354, 357, 359, 360, 366, 376, 377, 379, 382, 385, 386, 388, 389
- Marine Ore, 81
- Marinoan, 253
- Matrix
 amino acid, 368, 369, 372
 biochemistry, 367–369, 373, 375, 382
 calcium-binding, 379, 380
 conchiolin, 367, 368
 electrophoresis, 368–374
 insoluble, 367, 368, 373, 375, 386
 interprismatic, 368
 intracrystalline, 364, 367, 368, 373, 381
 intraprismatic, 363, 364, 368, 369, 374
 serology, 369–372
 sheath, 363, 364
 soluble, 368–371, 373, 375, 377, 379, 380
- Matrix proteins, 332, 337–342, 344, 347
- MC-1, 7
- MCOs. *See* Multicopper oxidases
- Membrane, 145, 178, 189
- Mesocrystal, 383–385, 388
- Metallochaperones, 62
- Metalloenzymes, 51, 63
- Metallogenium*, 57, 58
- Metals, 240
- Micronodule, 91
- Microorganisms, 85
- MIH. *See* Molt-inhibiting hormone
- Mineral bridge, 160–162
- Mineral deposition, 90
- Mineralization, 78
- MMP. *See* Multicellular magnetotactic prokaryote
- Mms6, 15
- Mn(II)-oxidizing bacteria, 94
- Molecular biomineralization, 104
- Molecular evolution, 325
- Molecule, 169, 170, 175–178, 183, 184, 190–192
- Mollusc shell, 143, 144, 159–160
- Molting, 316
- Molting hormone, 317
- Molt-inhibiting hormone (MIH), 317
- Monorhaphis chuni*, 264
- Morphogenetic assays, 237
- Morpholinos injection, 239
- Morphology, 145, 146, 154, 156, 158, 160–163, 170, 171, 176, 179, 184
- MRI. *See* Magnetic resonance imaging
- mRNA microinjection, 239
- MTB. *See* Magnetotactic bacteria
- Mucin, 377, 378
- Mucoperlin, 354, 372, 375, 377, 378, 386, 388
- Multicellular magnetotactic prokaryote (MMP), 7
- Multicopper oxidases (MCOs), 56
- N**
- Nacre, 144, 153, 158, 160–163, 171, 178, 180
 elemental composition, 367
 mineralogy
 row-stack, 365, 366, 386, 388
 structure
 tablet, 364–367, 375, 378, 386, 388
 ultrastructure, 382
- Nacrein, 337–340, 342, 343

- Nacreous layer, 144, 145, 153, 159–160, 171, 172
- Nacreous organic matrix, 335–341
- Nanofiber, 191–193
- Nanostructure, 161, 163, 191
- Niutitang formation, 257
- Nodule formation, 92–94
- Nodules, 83
- Nucleation, 13, 15, 332, 333, 335, 337, 338, 340, 342–347
- O**
- OATZ. *See* Oxidic-anoxic transition zone
- Occluded proteins, 204–205, 207–210, 217, 218
- Oceanospirillum*, 55
- O-phosphatases, 51, 63
- Orchestia cavimana*, 321
- Orchestin, 321
- Organic matrix, 143, 144, 146, 160, 163, 171, 178, 188
- Organism, 143–164, 170, 171, 173
- Oriented assembly, 159, 160
- Oxidic-anoxic transition zone (OATZ), 6
- Oxidation, 49–67
- P**
- Paracentrotus lividus*, 233
- Pearl, 144, 149, 159–163, 171, 173, 178–180
 lackluster pearl, 149, 160–163
- Pearl quality, 339, 344
- Pedomicrobium*, 57, 58, 61, 62, 64
- Peptide, 184, 191–193
- Periostracum, 354, 360, 361, 384, 385
- pH, 149, 189
- Phosphoenolpyruvate (PEP), 326
- 3-phosphoglycerate (3PG), 326
- Phosphorylation, 323
- Photosensory, 146, 148
- Pinna nobilis*
 development, 357, 361
 geographic distribution, 358
 pearl, 356, 360, 365, 377
 physiology, 355, 357, 359, 378
 reproduction, 355, 357
 resource, 356
 taxonomy, 369, 370
- Pinnidae, 358, 366
- Pinnoidea, 357
- Plasmids, 55, 58, 61
- Pl-nectin*, 235
- PMC. *See* Primary mesenchyme cells
- Polymer, 160, 183, 184, 188
- Polymetallic crusts, 96
- Polymetallic nodules, 80, 83
- Polymorph, 144, 148, 161, 162, 170, 171, 176, 179, 180, 185
- Polysaccharide, 144, 149, 163, 170
- Porewater, 55
- Porifera, 252
- Postembryonic skeletal elements, 205–206
- Post-translational processing, 323
- Precambrian oceans, 254
- Primary mesenchyme cells (PMC), 201–205, 207, 217, 225
- Primmorph system, 261
- Prism
 competition, 383–386, 388
 crystallography, 381
 elemental composition, 367
 formation, 364, 366, 367, 379, 383, 385–387
 growth, 376, 383, 384, 386
 honeycomb, 362, 363, 384
 mineralogy, 367, 370, 372
 monocrystal, 363, 364, 383
 pyrolysis, 364
 regular, 355, 361, 363, 383
 simple, 355, 360, 361, 363, 364
 ultrastructure, 363–364, 382
- Procambarus clarkii*, 319
- Protein, 144, 146, 150, 151, 153, 154, 156, 162, 164, 170–173, 175, 176, 179–181, 184, 185, 187, 192
 acidic, 353–389
 calprismin, 354, 372, 374–376, 378–380, 384–386
 caspartin, 372–374, 376–382, 384–386
 fractionation, 368, 369
 mucoperlin, 372, 375, 377, 378, 386, 388
- Protein–mineral interactions, 243
- Protein nanocages, 29–44
- Proteobacteria, 57–60, 63, 64
- Proterozoic, 253, 255
- Protospongia tetranema*, 260
- Pseudomonas*, 54, 56, 58, 59, 61–64, 66
- Pseudomonas fluorescens*, 128
- Pteriomorpha, 357
- Pyrite, 104
- R**
- Radiotracer, 55, 56
- Rebers-Riddiford (R-R) consensus sequence, 322
- Reduction, 51–54, 56, 59, 64, 65

- Regeneration, 230
 Regulative proteins, 339–341
 Reverse-phase high-performance liquid chromatography, 173
Rhabdocalyptus dawsoni, 257
 RNAi, 320
 RubisCo, 60
- S**
- Scanning electron microscopy (SEM), 145, 147, 155–158, 162, 165, 172, 174–179, 181–187, 228
 Sclerocytes, 230, 267
 Seamounds, 97
 Sea urchin, 200, 201, 205–210, 212–216, 218, 225
 Sea urchin skeleton, 242
 Sediments, 50, 53, 55–57, 60, 64
 Self-assembly (self-assembled), 168, 185, 188–192
 SEM. *See* Scanning electron microscopy
 Sensor, 145–146, 159
 Sequestration, 64
 Serology
 ELISA, 369, 370
 serotaxonomy, 369, 370
 Shape anisotropy, 18
 Shell, 143–145, 149, 150, 158–163, 170, 171, 179, 180
 growth, 355, 358–360, 363, 382, 383
 layer, 355, 358, 359, 361, 373, 375
 microstructure, 360–361, 367, 370, 372, 381, 382
 pigment, 356, 358
 size, 356, 359
 spine, 359, 360, 362
 use, 376, 377
 Shell nacreous layer, 331–347
 Spheric nodules, 85
 Siderophores, 10
 Silica, 253
 Silicase, 271
 Silicatein, 83, 268
 Simulation, 170, 188, 193
 Single calcite crystal, 146, 175
 Single crystal silicon, 172, 185
 Single magnetic domain (SD), 16
 Skeleton, 256
 abnormalities, 241
 defects, 237
 deposition, 231
 S-layer, 92
 Smart material, 148
Solactiniella plumata, 257
 Soluble iron, 10
 Soluble matrices (SM), 170–173
 Soluble or insoluble matrix, 227
Sphaerotilus, 51, 57
 Spherical (structure), 146–148, 173, 176, 178, 179, 184
 Spherulite, 383–385
 Spicule formation, 200–204, 207
 Spicule matrix genes, 226
 Spicule-matrix proteins, 229, 242
 Spicules, 259, 261
 Spines, 228
 Spores, 55, 56, 60, 62, 66
 SRB. *See* Sulfate reducing bacteria
 Stauracts, 259
 Stem cells, 231
 Stereom, 228
 Structure-function relationship, 323
 Sturtian, 253
Suberites domuncula, 94, 261
 Sulfate reducing bacteria (SRB), 124, 125, 134
 Superparamagnetic, 16
 Supersaturation, 227
 Syncytial membrane, 233
 Syncytial network, 230
 Synergistic, 53
- T**
- Teeth, 228
 Temperature, 146, 149, 184, 185, 189
 Template, 149, 162, 177–185, 189, 191
Tethya lyncurium, 263
 Three-dimension, 148, 154, 156, 161, 162, 164, 188, 193
 Todorokite, 84
 Tooth (teeth), 153, 165–169
 Toxicity, 53–54, 65, 66
 Transmission electron microscopy (TEM) (HRTEM) (FETEM), 155, 157–160, 165, 167, 189, 190, 192, 228
Triticispongia diagonata, 260
 Twinning, 16
- U**
- Univin, 238
 UV-B radiation, 240

V

Vegetative cells, 55, 56

Vendian, 253

Vernadite, 84

WWater-soluble matrix (WSM), 171, 173, 179,
181, 182, 185, 187**X**

X-organ/sinus gland complex, 317

X-ray diffraction (XRD), 160, 161, 172, 176,
179, 181, 185, 187

X-rays, 241

Y

Y-organ, 317

Z

Zebrafish, 164–165