

Index

1-D silica nanomaterials *see* one-dimensional silica nanomaterials

a

all-solid model (SSS) 63–65
 alumina (Al_2O_3) 303, 304
 amorphous calcium phosphates 476
 amorphous silica nanoparticles, synthesis 223–225
 anisotropic hydroxyapatite nanocrystals 407–440
 anisotropic nanosilica 221–238
 antibody-conjugated silica nanoparticles 124
 antimony ions, toxicity 167
 apatite-based bioceramics 267–269
 apatite evolution, model 466
 aragonite–biopolymer coordination 22
 asymmetric nanosilica 55–78
 – applications 74, 75, 78
 – characterization 72–74
 – synthesis 61, 62, 68–70
 asymmetric silica nanocoil 59
 asymmetric silica nanomaterials 68–70
 – catalytic growth 68, 69
 atomistic molecular dynamics (MD) 318
 atomistic Monte Carlo (MC) method 318
 Au–ZrO₂–DNA–hemoglobin biosensor 272, 273
 auto-ignition *see* combustion synthesis

b

bacterial synthesis
 – barium titanate 10, 11
 – ferromagnetic Co₃O₄ nanocrystals 9, 10
 – metal oxide nanomaterials 8, 9
 barium titanate (BT)
 – peptide nanorings 18, 19
 – room-temperature synthesis 10, 11
 BET equation 370

bioactive glasses
 – antimicrobial effects 212, 213
 – applications in dentistry 210–213
 – applications in tissue engineering 213–215
 – conventional 208, 209
 – dentin remineralization 211
 – gas-phase synthesis method 207, 208
 – liquid-phase synthesis method 204–206
 – nanometric 209, 210
 – silicate nanoscale *see* nanoscale bioactive silicate glasses
 bioceramics
 – apatite-based 267–269
 – nanostructured zirconia-based 263–267
 – nanostructured zirconia coatings 269, 270
 biocompatibility, porous silicon particles 377–382
 biodegradation, porous silicon particles 377–382
 biofunctionalization
 – applications 144–153
 – gold nanoparticles 110
 – internal *see* internal biofunctionalization
 – silica nanoparticles 112–146
 – spherical silica nanomaterials 109–156
 – surface 123–132
 biofunctionalized thiol-organosilica nanoparticles 127
 biolabeling, doped zirconia nanostructures 270, 271
 biomaterials
 – effects of nanosized particles 461, 462
 – natural calcium phosphate nanoparticles 449, 450

- biomedical engineering, use of nano-calcium phosphate 469–482
 - biomimetic construction, using hydroxyapatite nanoparticles 463–467
 - biomimetic peptides, non-natural metal oxide synthesis 47, 48
 - biomimetic synthesis
 - biomineralization 4–6, 8–20
 - cobalt hydroxide 26–28
 - hydroxyapatite nanocrystal 418–420
 - iron oxide 11
 - magnetite 11
 - manganese oxide 26–28
 - mediated mineralization 21–48
 - metal oxide nanomaterials 3–54
 - silica nanoparticles 31–45
 - using echinoderms as inspiration 24–28
 - biomineralization
 - calcium phosphate nanoparticles 449–482
 - components of 5, 6
 - optimization 6, 7
 - pathological 453
 - principles 472
 - biomineralized tissues, mechanical properties 455–457
 - biominerals, demineralization 458, 459
 - biopolymers, functionalized 46
 - biosensors
 - 1-D nanostructures 101–103
 - Au–ZrO₂–DNA–hemoglobin structure 272, 273
 - nanowire 102
 - zirconia nanomaterials 272, 273
 - block copolymers, ZnO nanoparticles 6
 - block copolypeptides 32, 33
 - templates for controlled silica formation 32, 33
 - bone
 - biomechanical properties 458
 - calcium phosphate nanoparticles 451, 452
 - mechanical properties 455, 456, 458
 - bone calcification, function of protein 455
 - bone cements, based on calcium phosphate 473
 - bone defects
 - treatment with calcium phosphates ceramics 471
 - treatment with nanostructured composites 469–473
 - bone regeneration, viral and nonviral vectors 470
 - bone-related cells, role of nano-calcium phosphate 473–476
 - bone repair, role of nano-calcium phosphate 469–473
 - bone replacement, synthetic hydroxyapatite nanocrystals 410
 - bone structure 407–409
 - bone tissue engineering 210
 - brachytherapy 382
 - BT *see* barium titanate
 - butterfly wings, templates for ZnO nanoparticles 19, 20
- C**
- cadmium ions, toxicity 166
 - cage nanosensors, monolithic 176
 - calcifications, ectopic 453
 - calcium phosphates
 - biological formation 454, 455
 - biological mineralization 449
 - cements 473
 - ceramics 471
 - crystallized 473–476
 - hollow nanospheres 479, 480
 - nanoparticles *see* nano-calcium phosphates
 - pathological biomineralization 453
 - treatment of bone defects 471, 473
 - calibration graphs 183–185
 - cancer imaging 397
 - cancer therapy *see* porous silicon particles
 - capillary radius, porous silicon particles 371
 - caries, lesion formation 459
 - Carnahan–Starling equation of state 322
 - catalyst host, silica nanomaterials 76
 - catalytic synthesis
 - growth models 64
 - symmetric nanosilica 63–65
 - CCMV *see* cowpea chlorotic mottle virus
 - Cd(ii) ion-sensor, optical 173–175
 - cell membranes
 - penetration by nanoparticles 317, 318
 - simplified representation 326
 - *see also* nanoparticle–membrane interaction
 - cell surface display (CSD) 5
 - proteins 6
 - cellular targeting strategy, 1-D NS-based nanostructures 94–101
 - cellular uptake
 - effect of microparticle size 393–396
 - porous silicon particles 391–397

- cements, calcium phosphate-based 473
 ceramics, bioactive apatite-based
 267–269
 cerium oxide (CeO₂)
 – nanoparticle synthesis 301
 – water treatment 300–302
 chemical coupling, surface
 biofunctionalization 125
 chemical reactivity, size-dependency 7
 chemical vapor deposition (CVD) 88–90
 – catalyst preparation 85, 86
 classification
 – fluorescent silica nanoparticles 134
 – silica nanoparticles 112
 clathrin-mediated endocytosis 95
 coarse-grained MD, nanoparticle–cell
 membrane interactions 319
 coating
 – nano-hydroxyapatite 468, 469
 – non-zirconia bioceramics 269, 270
 cobalt hydroxide
 – biomimetic synthesis 26–28
 – nanoflakes 27
 cobalt oxide (Co₃O₄) nanocrystals
 – ionic liquid-assisted synthesis 20, 21
 – magnetization 10
 – protein-functionalized 9, 10
 – *see also* ferromagnetic Co₃O₄ nanocrystals
 combinatorial PD, peptide–substrate
 interaction 5
 combustion synthesis, zirconia nanoparticles
 253, 254
 composites, hydroxyapatite–collagen 467,
 468
 constrained biomineralization, using
 biotemplates 8–21
 copolypeptides
 – block segments as templates for
 controlled silica formation 32
 – silica morphology at different synthesis
 conditions 32
 coprecipitationself-assembly method,
 hydroxyapatite–collagen composites 467,
 468
 cowpea chlorotic mottle virus (CCMV) 4,
 16
 critical radius, dissolution of nano-calcium
 phosphates 460
 crystal growth, models 464, 465
 CSD *see* cell surface display
 CVD *see* chemical vapor deposition
 cytophilicity, nanophase versus conventional
 hydroxyapatite 474–476
- d**
 deformation models, hydroxyapatite
 nanocrystals in bone 456, 457
 degradation, organic pollutants 288, 289
 deleterious effects, metal ions 166–168
 demineralization
 – biominerals 458, 459
 – caries lesion formation 459
 dendrimers
 – as silica template 41–43
 – chemical structure 41
 density functional theory, Thompson–
 Ginzburg–Matsen–Balazs (TGMB)
 321–325
 dental implants, nanostructured zirconia-
 based bioceramics 267
 dentin remineralization, bioactive glasses
 211
 dentistry, bioactive glasses 210–213
 desorption mechanism, porous silicon
 particles 372
 diatomic cell walls, scanning electron
 microscopy 29
 diatoms, mediated mineralization 28–48
 dissipative particle dynamic (DPD)
 simulations 333–337
 – background and theoretical formalism
 332, 333
 – nanoparticle–cell membrane interactions
 332, 333
 – trends 345, 346
 dissipative particle dynamics (DPD)
 319–321
 DNA-conjugated silica nanoparticles,
 synthesis 125
 DNA detection 146, 147
 DNA hybridization analysis 146
 dopants, effect on toxicity of silica
 nanomaterials 236, 237
 doped zirconia nanostructures, for
 biolabeling 270, 271
 doping method, preparation of fluorescent
 silica nanoparticles 139–142
 dot–blot analysis, surface properties of
 nanoparticles 127, 128
 DPD *see* dissipative particle dynamics
 drug delivery 386, 387
 – fluorescent silica nanoparticles 151, 152
 – hydroxyapatite 440, 441
 – multi-stage 387–391
 – nanoshuttle 388
 – porous silicon particles 377–382
 – silica nanomaterial vehicles 73–76

- synthetic hydroxyapatite nanocrystals 410, 411
 - drug loading, porous silicon particles 383–386
 - dynamic templating model, silica condensation 35
- e**
- E. coli detection, magnetic glyco-nanoparticle based system 295
 - echinoderms
 - nanoengineered nanobricks 25
 - nanoscale architectures of mineralized organisms 23–28
 - ectopic calcifications 453
 - EELS *see* electron energy loss spectroscopy
 - EFM *see* electrostatic force microscopy
 - electron energy loss spectroscopy (EELS), porous silicon particles 374–377
 - electron microscopy, porous silicon particles 373–377
 - electrostatic force microscopy (EFM) 19
 - ellipsometric measurement, scheme 366
 - emulsion process
 - effect of ageing 429
 - effect of metal ion concentration 429, 430
 - hydroxyapatite nanocrystals 425–430
 - reverse micelles 426, 427
 - reverse microemulsion 427–429
 - surfactants 425, 426
 - enamel repair
 - hydroxyapatite nanoparticles 477
 - roles of nano-calcium phosphate 476–478
 - secondary caries 477
 - encapsulated compounds, calcium phosphate nanospheres 479, 480
 - endocytosis, clathrin-mediated 95
 - endothelial cells, porous silicon hemispherical microparticles 393
 - engulfing
 - small particle with a homogeneous membrane 337–342
 - small particle with a membrane raft 342–345
 - enzymatic peptide nanoassembly, Ga₂O₃ nanoparticles 17
 - epoxy-organosilica nanoparticles 117–119
 - doping with fluorescent dye 140
 - surface biofunctionalization 132, 133
 - transmission electron microscopy 121
- f**
- ferritin, mineralization 14, 15
 - ferroelectric BT nanoparticles, synthesis using peptide nanorings 18, 19
 - ferromagnetic Co₃O₄ nanocrystals
 - protein-functionalized 9, 10
 - synthesis 9, 10
 - FFT, iron oxide 12
 - fibers, nanoscale bioactive silicate glasses 204–208
 - field-emission scanning electron microscopy, silica nanoparticles 34
 - field-theoretical modeling, nanoparticle–cell membrane interactions 321–331
 - FITC *see* fluorescein isothiocyanate
 - FITC-conjugated mesoporous silicon particles, MRI enhancement 397
 - flame spray synthesis
 - scheme 205
 - *see also* gas-phase synthesis method
 - Flory–Huggins interaction parameters 327
 - flow cytometry analysis
 - fluorescent-tuned epoxy-organosilica nanoparticles 143
 - fluorescent-tuned silica nanoparticles 136, 137
 - multifluorescent nanoparticles 136, 137
 - silica nanoparticles surface-modified with proteins 129, 133
 - surface properties of nanoparticles 127–129, 132, 133
 - flow reaction formation, nanowires 86, 87
 - fluorescein isothiocyanate (FITC) 394
 - fluorescence intensity
 - rhodamine red-containing silica nanoparticles 139
 - TEOS nanoparticles 137–139
 - fluorescence microscopy
 - surface properties of nanoparticles 129, 130
 - TEOS nanoparticles 137
 - thiolorganosilica nanoparticles 141
 - fluorescence-resonance energy transfer (FRET), TEOS nanoparticles 137
 - fluorescent dye doping, epoxy-organosilica nanoparticles 140
 - fluorescent nanoparticles 133
 - fluorescent silica nanoparticles
 - classification 134
 - DNA detection 146, 147
 - DNA hybridization analysis 146
 - drug delivery 151, 152

- gene delivery 152, 153
 - imaging 148–151
 - microbe detection 147, 148
 - multiplexed assays 148
 - photodynamic therapy 153
 - preparation 134–144
 - protein detection 147
 - fluorescent thiorganosilica nanoparticles, microscopy 141
 - fluorescent-tuned silica nanoparticles 136, 137
 - epoxy-organosilica nanoparticles 143
 - formation, silica tube 39
 - free energy
 - Carnahan–Starling equation of state 322
 - membranes 333–337, 340
 - self-assembled lipids 335
 - Frenkel–Hill–Halsey equation, porous silicon particles 372
 - functional materials
 - biopolymers 46
 - cobalt oxide (Co₃O₄) nanocrystals 9, 10
 - gold nanoparticles on surfaces 110
 - one-dimensional silica 93–100
 - organosilica nanoparticles 115–117
 - protein-functionalized 9, 10
 - fusion proteins, silica nanomaterial formation 36
- g**
- β-Ga₂O₃ nanoparticles 17
 - gas-phase synthesis
 - preparation of bioactive glasses 207, 208
 - zirconia nanoparticles 256–258
 - zirconia nanorods 262
 - gastrointestinal tract, invasion of silica nanomaterials 228, 229
 - gene delivery, fluorescent silica nanoparticles 152, 153
 - glasses
 - bioactive *see* bioactive glasses
 - silicate *see* nanoscale bioactive silicate glasses
 - glyco-nanoparticle (MGNP)-based system, E. coli detection 295
 - gold nanoparticles, surface biofunctionalization 110
 - goldcoated silicon nanomaterials 92
 - gravimetry, porous silicon particles 365
 - growth models, catalytic synthesis of nanosilica 63–65

h

- hard tissues, calcium phosphate nanoparticles 451–453
- Hg(II) ion-sensor
 - optical 170–172
 - scheme 171
- high-order monolithic *see* HOM
- hole zones, bone calcification 455
- hollow calcium phosphate nanospheres, ultrasonic treatment 479, 480
- hollow silica nanoparticles, synthesis 68
- hollow silica structures, formation 44
- hollow zirconia nanotubes, syntheses 261
- HOM-DZ sink, cage for Pb(II) ions 175–178
- HOM-PR sink, cage for Sb(III) ions 172, 173
- HOM-TMPYP sink, cage for Cd(II) ions 173–175
- HOM-TPPS sink, cage for Hg(II) ions 170–172
- hybrid nanoparticle–lipid micellar structures, thermodynamics 321–325
- hydrolysis, peptide nanoring as templates 16–20
- hydrothermal methods
 - hydroxyapatite nanocrystals 420, 421
 - zirconia nanoparticles 249–251
- hydroxyapatite
 - crystal structure 409
 - in drug/protein delivery 440, 441
- hydroxyapatite coatings
 - nanoscale 440
 - nanostructured 468, 469
- hydroxyapatite–collagen composites 467, 468
 - applications 479
- hydroxyapatite nanocrystal synthesis
 - biomimetic 418–420
 - emulsion process 425–430
 - hydrothermal method 420, 421
 - mechanochemical powder 421–423
 - microwave-assisted 424, 425
 - other processes 430, 431
 - sol–gel process 415–418
 - solid-state reactions 424
 - wet chemical precipitation 412–415
- hydroxyapatite nanocrystals
 - biological characterization 434, 435
 - characterization 431–435
 - composition and phase analysis 431–433
 - in vitro evaluation methods 434
 - in vivo animal testing 435

- morphology 433, 434
- particle size 433, 434
- phase analysis 431–433
- size and morphology 433, 434
- spherical and anisotropic 407–440
- strength of bone 455, 456
- toxicology 435
- hydroxyapatite nanoparticles
 - adsorption on enamel surface 477, 478
 - biomimetic construction 463–467
 - enamel repair 477
 - mesenchymal stem cells 474–476
- hydroxyapatite phosphate, dissolution 460, 461
- hydroxyapatite scaffolds, in tissue engineering 439

i

- imaging
 - cancer 397
 - fluorescent silica nanoparticles 148–151
 - magnetic resonance 397
- immobilization strategies, optical sensing 170
- implants, nanoscale hydroxyapatite coatings 440
- imposition method, fluorescent silica nanoparticles 135–139
- inorganic anions, adsorption by TiO₂ nanoparticles 288, 289
- inorganic silica nanoparticles 113, 114
 - physical adsorption 124
 - schematic structure 114
 - surface biofunctionalization 123–126
 - transmission electron microscopy 117
- internal biofunctionalization 133–144
 - with drugs 142–144
- intracellular targeted delivery, silica 1-D silica nanomaterials 94
- invasion pathways into living systems
 - silica nanomaterials 225–230
 - via gastrointestinal tract 228, 229
 - via respiratory tract 225–228
 - via skin contact 229, 230
- ion-sensing procedures, one-step and simple 180–183
- ionic liquid-assisted synthesis, Co₃O₄ nanocrystals 20, 21
- iron oxide nanoparticles
 - medical applications 110
 - surface biofunctionalization 110
- iron oxides
 - biomimetic synthesis 11
 - FFT 12

- pH-dependent structures 13
- TEM 12
- water treatment 293–295

j

- joint replacements, nanostructured zirconia-based bioceramics 265, 266

k

- K₂SO₄–PAA biomimetic assembly 23

l

- lanthanide-doped zirconia nanomaterials, biomedical applications 270, 271
- laser ablation, nanowires 87, 88
- lead ions, toxicity 167, 168
- lipid bilayer
 - hybrid structures 321–325
 - *see also* membrane
- lipid bilayer–nanoparticle interactions 347
- simulation results 325–331
- liquid-phase synthesis method, bioactive glasses 204–206
- living systems, invasion pathways of silica nanomaterials 225–230

m

- Mag-Dye·MSNs 397
- magnesium oxide (MgO), water treatment 302, 303
- magnetic nanoparticles, applications 67
- magnetic properties
 - bifunctional Fe₃O₄@Ag 295
 - metal oxide nanoparticles 6
- magnetic resonance imaging (MRI)-enhancement 397
- magnetite (Fe₃O₄), biomimetic synthesis 11
- magnetite-like iron oxide, pH dependency of structure 12, 13
- magnetosomes, transmission electron microscopy images 12
- manganese oxides
 - biomimetic synthesis 25–28
 - nanoflakes 27
 - polymer-templated synthesis 26
 - water treatment 295–300
- margination, effect of microparticle shape 392, 393
- MC *see* Monte Carlo method
- MD *see* molecular dynamics
- mechanochemical powder synthesis, hydroxyapatite nanocrystals 421–423
- mediated mineralization, biogenic organisms 21–48

- membrane free energy
 - parameters from numerical model 333–337
 - *see also* free energy
- membrane–nanoparticle interaction, phase diagram 328
- membrane wrapping around particle, cross-sectional images 338
- membranes, engulfing a small particle 337–345
- mercury ions, toxicity 167
- mesenchymal stem cells 474–476
- mesoporous silica monoliths
 - cage-like 163–195
 - calibration of nanosensors 182–184
 - ion-sensing procedures 180–182
 - metal ion sensing techniques 168
 - metal ion toxicity 166, 167
 - optical nanosensor designs 169–179, 185–194
 - optical nanosensor schemes 164, 165
- mesoporous silicon microparticles
 - hemispherical 364
 - production 363–365
- mesoporous silicon nanoparticles
 - drug delivery 387
 - internalized by human cells 395
- mesoscale modeling *see* nanoparticle–membrane interactions
- metal-ion complexes, stability constant 185
- metal ion-sensing systems 168, 169
 - monolithic cage nanosensors 176
 - rapid time-response 187–189
 - reversibility 190, 191
- metal ions
 - emulsion process 429, 430
 - optical sensing assays of 178–180
 - properties in biological systems 5
 - toxicity and deleterious effects 166–168
- metal oxide nanomaterials
 - alumina 303
 - bacterial synthesis 8, 9
 - biomimetic synthesis 7, 8
 - cerium oxide 300, 301
 - for water treatment 287–304
 - future processing perspectives 48, 49
 - iron oxides 293, 294
 - magnesium oxide 302
 - magnetic properties 6
 - manganese oxides 294–299
 - titanium dioxide 288–292
- metal oxide structures, in organisms 21–48
- metal oxide synthesis
 - biomimetic 24–28, 47, 48
 - using viral templates 15, 16
 - within a protein cage 14–16
- metal oxides
 - biomineralization 6
 - hydrolysis using peptide nanorings as templates 16–20
 - in nature 4–7
 - non-natural 14
- metals, components of biomineralization 5
- micelles, reverse 426, 427
- microbe detection, fluorescent silica nanoparticles 147, 148
- microemulsion
 - hollow silica structures 44
 - reverse 427–429
 - silica nanoparticles 224
- microorganisms, TiO₂ nanoparticles 289, 290
- microparticle production 363
- microparticle shape, effect on margination 392, 393
- microparticle size, effect on cellular uptake 393–396
- microwave-assisted synthesis, hydroxyapatite nanocrystal 424, 425
- microwave sintering, nanopowders 436–438
- mineral–protein composites 456, 457
- mineralization
 - biological *see* biomineralization
 - constrained biological 8–21
 - mediated 21–48
 - non-natural metal oxide 14
- mineralized organisms, nanoscale architectures 23
- models
 - all-solid synthesis 63–65
 - apatite evolution 466
 - crystal growth 464, 465
 - mesoscale *see* nanoparticle–membrane interaction
 - nanosilica synthesis 59–70
 - solid–liquid–solid synthesis 63–65
 - vapor–liquid–solid growth 63–65
 - vapor–solid–solid synthesis 63–65
- molecular dynamics (MD), atomistic 318
- monolithic nanosensors
 - metal ion-sensing assays 176
 - stability 189, 190
 - *see also* HOM
- Monte Carlo (MC) method, nanoparticle–cell membrane interactions 318
- mother-of-pearl, aragonite–biopolymer coordination 22

- MRI *see* magnetic resonance imaging
- multifluorescent nanoparticles, flow cytometry analysis 136, 137
- multiplexed assays, fluorescent silica nanoparticles 148
- multisilicate nanoparticles 119–122
- multistage drug delivery system 387–391
- nanoshuttle 390
 - pH-responsive particles 389
- multiwalled carbon nanotubes (MWNTs), silica 66
- n**
- nacreous layers
- nanoengineered nanobricks 25
 - three-tier architecture 22, 23
- nanoassembly, enzymatic peptide 17
- nanobiotechnology 109
- nanobricks, nanoengineered 25
- nano-calcium phosphates 449–482
- applications 478–480
 - biomedical engineering 469–482
 - bone 451, 452
 - bone-related cells 473–476
 - bone repair 469–473
 - dissolution 460
 - enamel repair 476–478
 - hard tissues 451–453
 - stability 457–462
 - synthesis 462, 463
 - tooth 452, 453
 - transfection efficiency 470
- nanocoils, silica 58
- nanocomposites, TiO₂ 291–293
- nanocrystals, hydroxyapatite *see* nano-hydroxyapatite
- *see also* nanomaterials
- nanofibers, silica condensation 35
- nanofilms, TiO₂ 291
- nanoflakes
- cobalt hydroxide 27
 - manganese oxide 27
- nanogranular friction, hydroxyapatite nanoparticles of bone 456
- nano-hydroxyapatite 407–440
- coating 468, 469
 - high-strength 439
 - proliferation of mesenchymal stem cells 474–476
 - *see also* hydroxyapatite nanoparticles
- nano-hydroxyapatite–collagen composites 467, 468
- nanomaterials
- alumina (Al₂O₃) 303, 304
 - cerium oxide 300–302
 - formation 36
 - invasion pathways into living systems 225–230
 - invasion via respiratory tract 225–228
 - invasion via skin contact 229, 230
 - invasion via the gastrointestinal tract 228, 229
 - iron oxides 293–295
 - magnesium oxide 302, 303
 - manganese oxides 295–300
 - metal oxide *see* metal oxide nanomaterials
 - synthesis *see* synthesis
 - toxicity 230–233, 235, 236
 - zirconia 245–275
 - *see also* nano-hydroxyapatite
- nanometric bioactive glasses 209, 210
- nanoparticle–lipid bilayer interactions, simulation results 325–331
- nanoparticle–membrane interaction
- atomistic molecular dynamics 318
 - atomistic Monte Carlo method 318
 - biophysical factors 318–321, 318
 - coarse-grained MD 319
 - DPD *see* dissipative particle dynamic simulations
 - field-theoretical modeling 321–331
 - mesoscale modeling 317–349
 - nonselective 318–321
 - phase diagram 328
 - thermodynamic model 327–331
- nanoparticle-related products, safety 318
- nanoparticle/water/membrane system, thermodynamics 321–325
- nanoparticles
- amorphous silica 223–225
 - bifunctional Fe₃O₄@Ag 295
 - calcium phosphate 449–482
 - epoxy-organosilica 117–119, 132, 133
 - fluorescent-tuned epoxy-organosilica 143
 - inorganic silica 113, 114
 - multisilicate 119–122
 - organosilica 115–117, 126–133
 - ORMOSIL 126
 - penetration of cell membranes 317, 318
 - phase behavior near a lipid bilayer 320–331
 - silica *see* silica nanoparticles
 - surface-modified *see* surface-modified nanoparticles
 - surface properties 127, 128
 - synthesis *see* synthesis
 - thiol-organosilica *see* thiol-organosilica nanoparticles

- TiO₂ *see* TiO₂
- ZnO *see* ZnO nanoparticles
- nanopowders, microwave sintering 436–438
- nanorods
 - TiO₂ 290, 291
 - zirconia 259–263
- nanoscale architectures, mineralized organisms 23
- nanoscale bioactive silicate glasses
 - advantages 209
 - applications in dentistry 210–212
 - applications in tissue engineering 213
 - biomedical applications 203–216
 - fabrication 204–208
- nanoscale building blocks, for zno nanowires 24–26
- nanoscale ferroelectric properties, monitoring 19
- nanoscale hydroxyapatite coatings, for load-bearing implants 440
- nanosensors
 - analytical parameters 183–185
 - cage 176
 - cage for Cd(II) ions 173–175
 - cage for Hg(II) ions 170–172
 - cage for Pb(II) ions 175–178
 - cage for Sb(III) ions 172, 173
 - cage-like sinks 185–187
 - calibration graphs 183–185
 - metal ions 178–180
 - monolithic 189, 190
 - optical *see* optical nanosensors
 - optically selective 192–194
 - performance of 176
 - selectivity profiles 193, 194
 - sensing features 191
 - textural parameters 191
- nanoshuttle 388
- nanosilica 55–59
 - anisotropic and spherical 221–238
 - applications 72–78
 - applications (overview) 74, 75
 - asymmetric *see* asymmetric nanosilica
 - characterization 70–72
 - materials applications 76
 - medical applications 73–76
 - optical applications 76, 77
 - shapes 57
 - symmetric *see* symmetric nanosilica
 - *see also* silica nanomaterials; silica nanoparticles
- nanosilica synthesis 55–78
 - all-solid model 63–65
 - applications 72–78
 - catalytic growth 63, 64, 68–715
 - characterization 70, 71
 - methods (overview) 60–62
 - models 59–70
 - noncatalytic growth 65–67, 69–719
 - noncatalytic synthesis 64–68
 - solid–liquid–solid model 63–65
 - vapor–liquid–solid growth 63–65
 - vapor–solid–solid model 63–65
- nanosilica toxicity
 - effect of dopants 236, 237
 - effect of dose 237
 - effect of interaction time 237
 - effect of particle size 234, 235
 - effect of shape 235
 - effect of surface properties 236
 - gastrointestinal tract exposure 228, 229
 - respiratory tract exposure 225–228
 - skin contact 229, 230
 - summary 237, 238
- nanosize effects, in biomaterials 461, 462
- nanosprings
 - silica 84–90
 - silicon carbide 90, 91
- NanOss bone void filler, treatment of bone defects 471
- nanostructured coatings, hydroxyapatite 468, 469
- nanostructured glasses, bioactive 210
- nanostructured sensing systems, selectivity profiles 193, 194
- nanostructured zirconia
 - bioceramics 263–267
 - coatings on bioceramics 269, 270
 - in bioactive apatite-based ceramics 267–269
- nanostuctures (NS)
 - 1-D 94–101
 - cellular targeting strategy 94–101
 - doped zirconia 270, 271
 - silica helical 69, 70
 - silica metallized 91, 92
- nanotubes
 - silica 46
 - TiO₂ 290, 291
- nanovectors 386, 387
 - porous silicon particles 377–382
- nanowire biosensor 102
- nanowires
 - chemical vapor deposition 88–90
 - flow reactor synthesis 86, 87
 - in situ catalyst application 85
 - laser ablation 88–90

- plasma-enhanced chemical vapor deposition 88, 89
- silica 84–90
- silicon *see* silicon nanowires
- silicon carbide *see* silicon carbide nanowires
- vapor–liquid–solid growth 84
- VLS synthesis 86, 87
- zirconia 259–263
- ZnO 20, 24–26
- nitrogen adsorption, porous silicon particles 368–373
- non-natural metal oxides, mineralization using ferritin 14
- nonaqueous sol–gel technique 255, 256
- noncatalytic synthesis, nanosilica 64–68
- nonviral vectors, bone regeneration 470
- NS *see* nanostructures

o

- one-dimensional silica nanomaterials 83–102
 - biological applications 101–103
 - cellular targeting 94–101
 - functionalization 90–93
 - in vitro toxicity 97–99
 - in vivo toxicity 99–101
 - metallized 91, 92
 - silica nanowires and nanosprings 84–89
 - toxicology studies 93–100
- optical nanomaterials, silica 76, 77
- optical nanosensors
 - assaying metal ions 178–180
 - based on mesoporous silica carriers 169–178
 - basic concept 164–166
 - HOM 191
 - HOM (DZ sink) 175–178
 - HOM (PR sink) 172, 173
 - HOM (TMPYP sink) 173–175
 - HOM (TPPS sink) 170–172
 - immobilization strategies 170
 - trace-level toxic ions 192–194
- organic pollutants, degradation by TiO₂ nanoparticles 288, 289
- organisms with genetically controlled metal oxide structures 21–48
- organosilica nanoparticles 114–123
 - functional 115–117
 - properties 111
 - surface biofunctionalization 126–133
 - tetraethoxysilicate 111
- ORMOSIL nanoparticles 114–117
 - surface biofunctionalization 126
- osteogenic cells, influence of the crystallinity of calcium phosphate 473–476
- osteoporosis, pathological biomineralization 453
- Ostim, injectable bone matrix 473

p

- ³²P-doped porous silicon particles 382
- PAA *see* poly(acrylic acid)
- Pb(II) ion-sensor, optical 175–178
- PD *see* phage display
- Pechini method 252–253
- PECVD *see* plasma-enhanced chemical vapor deposition
- peptide nanorings
 - ferroelectric BT nanoparticles 18, 19
 - templates for hydrolysis of metal oxides 16–20
- peptide–substrate interaction, combinatorial PD 5
- pH-dependent structures, iron oxides 12, 13
- pH-responsive particles, drug delivery 389
- phage display (PD) 5
- phagocytosis, porous silicon hemispherical microparticles 393
- phospholipid membranes, nanosized holes 318
- photocatalysts, titanium dioxide 288
- photodynamic therapy, fluorescent silica nanoparticles 153
- plasma-enhanced chemical vapor deposition (PECVD), nanowires 88–90
- pollutant ions, optical sensing 163
- poly(acrylic acid) (PAA)–K₂SO₄ biomimetic assembly 23
- poly-L-lysine, as silica template 38, 39
- polyamines
 - as silica template 39–41
 - chemical structure 44
- polymer templates
 - cobalt hydroxide nanoflakes 27, 28
 - manganese oxide 25, 26
- porosification
 - silica microparticles 363, 364
 - silicon wafer 361, 362
- porous silicon 359–362
- porous silicon particles
 - BET equation 370
 - biocompatibility 380
 - capillary radius 371
 - cellular uptake 391–397
 - characterization 365–377
 - delivery of therapeutics 377–382

- desorption mechanism 372
- dissolution kinetics 378
- drug loading 383–386
- effects of surface modification 396, 397
- electron energy loss spectroscopy 374–377
- for imaging and therapy of cancer 357–398
- Frenkel–Hill–Halsey equation 372
- gravimetry 366, 367
- hemispherical 393
- microfabrication 363–365
- nanovectors 377–382
- nitrogen adsorption 368–373
- phagocytosis by endothelial cells 393
- pore volume 371
- porosity 365
- scanning electron microscopy 373, 374
- scanning transmission electron microscopy 374–377
- spectroscopic ellipsometry 366, 367
- surface modification 379
- transmission electron microscopy 374–377
- uptake 391–397
- X-ray diffraction 367, 368
- precipitation techniques, synthesis of zirconia nanomaterials 251, 252
- protein cage
 - cryoelectron microscopy reconstruction 15
 - template for metal oxide synthesis 14, 15
- protein delivery
 - hydroxyapatite 440, 441
 - synthetic hydroxyapatite nanocrystals 410
- protein detection, fluorescent silica nanoparticles 147
- protein-functionalized ferromagnetic Co_3O_4 nanocrystals 9
- proteins, cell surface display 6

r

- R5 peptide, as silica template 33–38
- remineralization, dentin 211
- respiratory tract exposure, invasion of silica nanomaterials 225–228
- reverse micelles, emulsion process 426, 427
- reverse microemulsion 427–429
 - silica nanoparticles 224
- rhodamine red-containing silica nanoparticles 139

s

- Sb(III) ion-sensor, optical 172, 173
- scanning electron microscopy (SEM)
 - cell walls of diatom species 29
 - mesoporous silicon microparticles 364
 - porous silicon particles 373, 374
- scanning transmission electron microscopy (STEM), porous silicon particles 374–377
- sectioning, electron microscopy 373–377
- self-assembled lipids, free energy of a membrane 335
- self-consistent field theory 320–331
- SEM *see* scanning electron microscopy
- sensors
 - Cd(ii) ion 173–175
 - Hg(II) ion 170–172
 - optical *see* optical nanosensors
 - Pb(II) ion 175–178
 - Sb(III) ion 172, 173
 - silica nanomaterials 76
 - *see also* biosensors
- serum opsonization, uptake inhibition 397
- silaffin-1 a1, chemical structure 30
- silane nanoparticles, organically modified 114, 115
- silanization, surface biofunctionalization 124, 125
- silica
 - condensation into nanofibers 35
 - encapsulation of Au⁰ nanoparticles 42
 - mesoporous carriers 169–178
 - morphology (copolypeptides at different synthesis conditions) 32
 - silica helical nanostructures, synthesis 69, 70
 - silica monoliths, mesoporous cage-like 163–195
 - silica nanocoils 58
 - asymmetric 59
 - synthesis 69
 - silica nanomaterials
 - as a catalyst host 76
 - as drug delivery vehicles 73–76
 - as optical materials 76, 77
 - as sensors 76
 - asymmetric 68–70
 - formation 119
 - growth 68, 69
 - invasion pathways into living systems 225–230
 - one-dimensional *see* one-dimensional silica nanomaterials
 - shape 235
 - spherical 109–156

- toxicity 231–237
- use of fusion protein 36
- silica nanoparticles 112, 123
 - amorphous 223–225
 - antibody-conjugated *see* antibody-conjugated silica nanoparticles
 - applications 144–153
 - applications in medical diagnosis 146–148
 - biofunctionalization 122–144
 - biological synthesis 30, 31
 - biomimetic synthesis 31–45
 - classification 112
 - DNA-conjugated *see* DNA-conjugated silica nanoparticles
 - dot-blot analysis (ability to bind proteins) 128
 - effects of template modifications 43
 - field-emission scanning electron microscopy images 34
 - flow cytometry analysis 129, 133
 - fluorescent 134–144
 - induced toxicity *see* silica nanomaterials-induced toxicity
 - inorganic 113, 114, 123–126
 - internal biofunctionalization 133–144
 - internal biofunctionalization with drugs 142–144
 - medical diagnosis 146–148
 - medical therapy 151–153
 - organosilica *see* organosilica nanoparticles
 - reverse microemulsion synthesis method 224
 - rhodamine red-containing 139
 - size evaluation 120
 - surface biofunctionalization 110, 111, 123–133
 - surface-modified with proteins 129
 - toxicity 234, 235
- silica nanosprings
 - amorphous helical 69
 - chemical vapor deposition 84
 - synthesis 84–90
- silica nanostructures, metalized 1-D 91, 92
- silica nanotubes
 - formation from a functionalized biopolymer 46
 - synthesis 65
 - synthesis using multiwalled carbon nanotubes 66
- silica nanowires
 - chemical vapor deposition 84
 - synthesis 84–90
- silica particles
 - diameter and dispersity 40
 - formed in aqueous PEI solutions 40
 - sphere diameter distribution 37
- silica platelets, pLL-induced condensation of 38
- silica structures
 - hollow 44
 - one-dimensional *see* one-dimensional silica structures
- silica templates
 - dendrimers 41–43
 - poly-L-lysine 38, 39
 - polyamines 39–41
 - R5 peptide 33–38
- silica tubes, formation 39
- silicate glasses *see* nanoscale bioactive silicate glasses
- silicon
 - biocompatibility and biodegradation 377–382
 - microfabrication 363, 364
 - porous 359–362
- silicon-based nanowires *see* silicon nanowires
- silicon carbide nanosprings/nanowires, synthesis 90, 91
- silicon doping, pore size 361
- silicon microparticles
 - hemispherical mesoporous 364
 - mesoporous 363–365
 - porosification process 364
- silicon nanomaterials, goldcoated 92
- silicon nanowires, synthesis 83, 90
- silicon particles, porous 357–398
- silicon wafers
 - doping-dependent pore size 361
 - porosification 361, 362
- simulations
 - DPD *see* dissipative particle dynamic simulations
 - nanoparticle–lipid bilayer interactions 325–331, 347–1014
 - nanoparticle–membrane interactions 332–346
- size-dependency
 - chemical reactivity 7
 - physical properties 7
 - toxicity 234, 235
- skin contact, invasion of silica nanomaterials 229, 230
- small particles
 - homogeneous membrane 337–342
 - membrane raft 342–345

- sol-gel technique
 - bioactive glasses 205
 - hydroxyapatite nanocrystals 415-418
 - nonaqueous 255, 256
 - zirconia nanoparticles 254, 255
 - *see also* liquid-phase synthesis method
- solid-liquid-solid (SLS) model, nanosilica synthesis 63-65
- solvent-based synthesis
 - combustion 253, 254
 - hydrothermal 249-251
 - nonaqueous sol-gel technique 255, 256
 - Pechini method 252, 253
 - precipitation techniques 251, 252
 - sol-gel methods 254, 255
 - zirconia nanomaterials 248-256
- spectroscopic ellipsometry, porous silicon particles 366, 367
- spermidine, chemical structure 44
- spherical nanosilica 221-238
 - biofunctionalization 109-156
 - toxicity 221-238
- STEM *see* scanning transmission electron microscopy
- Stöber method 223, 224
- structuredirecting agents, biomineralization 6
- surface biofunctionalization
 - chemical coupling 125
 - epoxy-organosilica nanoparticles 132, 133
 - gold nanoparticles 110
 - inorganic silica nanoparticles 123-126
 - iron oxide nanoparticles 110
 - organosilica nanoparticles 126-133
 - ORMOSIL nanoparticles 126
 - physical adsorption 124
 - silanization 124, 125
 - silica nanoparticles 110, 111, 123-133
 - thiol-organosilica nanoparticles 126
- surface-modified nanoparticles
 - flow cytometry analysis 129, 133
 - fluorescence microscopy 130
 - porous silicon 379, 396, 397
- surfactants, emulsion process 425, 426
- symmetric nanosilica 59-70
 - application as drug delivery vehicles 73-76
 - applications (overview) 74, 75
 - catalytic synthesis 63-65
 - characterization 72-74
 - noncatalytic growth 65-68
 - synthesis methods (overview) 60-62
- synthesis 295
 - amorphous helical silica nanosprings 69
 - amorphous silica nanoparticles 223-225
 - antibody-conjugated silica nanoparticles 124
 - asymmetric nanosilica *see* asymmetric nanosilica
 - bacterial *see* bacterial synthesis
 - barium titanate 10, 11
 - biomimetic *see* biomimetic synthesis
 - catalytic *see* catalytic synthesis
 - cerium oxide nanoparticles 301
 - Co₃O₄ nanocrystals 9, 10
 - combustion 253, 254
 - CVD 85, 86
 - DNA-conjugated silica nanoparticles 125
 - ferroelectric BT nanoparticles 18, 19
 - flame spray 205
 - gas-phase *see* gas-phase synthesis
 - hollow silica nanoparticles 68
 - hollow zirconia nanotubes 261
 - hydrothermal 249-251
 - hydroxyapatite nanocrystals *see* hydroxyapatite nanocrystal synthesis
 - ionic liquid-assisted 20, 21
 - liquid-phase 204-206
 - mechanochemical powder 421-423
 - metal oxide *see* metal oxide synthesis
 - microwave-assisted 424, 425
 - mineralization using ferritin 14, 15
 - mineralization using viruses 15, 16
 - nano-calcium phosphates 462-469
 - nanoparticle 16
 - nanosilica *see* nanosilica synthesis
 - nanowires 86, 87, 89-1104
 - non-natural metal oxide 47, 48
 - noncatalytic 64-68
 - silica helical nanostructures 69, 70
 - silica nanocoils 69
 - silica nanosprings 84-90
 - silica nanotubes 65
 - silica nanowires 84-90
 - silicon carbide nanosprings 90, 91
 - silicon carbide nanowires 90
 - solvent-based *see* solvent-based synthesis
 - symmetric nanosilica *see* symmetric nanosilica
 - zirconia nanomaterials 245-263
 - zirconia nanorods and nanowires 259-263
- ZnO nanoparticles 6, 19, 20
- ZnO nanowires 25, 26
- synthesis templates *see* template-based synthesis methods
- synthetic hydroxyapatite nanocrystals, medical applications 410

t

- TEM *see* transmission electron microscopy
 - template-based synthesis methods
 - block copolypeptides 32, 33
 - butterfly wings 19, 20
 - dendrimers 41–43
 - ferritin 14, 15
 - metal oxides 14, 15
 - poly-L-lysine 38, 39
 - polyamines 39–41
 - protein cage 14, 15
 - R5 peptide 33–38
 - viruses 15, 16
 - zirconia nanorods and nanowires 260
 - ZnO nanoparticles 19, 20
 - tetraethoxysilicate (TEOS) nanoparticles
 - 111
 - fluorescence 137–139
 - photostability 137
 - textural parameters, optical HOM nanosensors 191
 - therapeutics delivery *see* drug delivery
 - thermodynamics
 - nanoparticle/membrane interaction 327–331
 - nanoparticle/water/membrane system 321–325
 - thiol functional groups, surface
 - biofunctionalization 110
 - thiol-organosilica nanoparticles 115–117
 - schematic structure 115
 - strategies for the conjugation of biomolecules 127
 - surface biofunctionalization 126
 - synthetic conditions 116
 - transmission electron microscopy 118
 - Thompson–Ginzburg–Matsen–Balazs (TGMB) self-consistent field/density functional theory 321–325
 - time-response, rapid 187–189
 - TiO₂
 - nanocomposites 291–293
 - nanofilms 291
 - nanoparticles 288–290
 - nanorods/nanotubes 290, 291
 - photocatalyst 288
 - water treatment 288–293
 - tissue engineering
 - bioactive glasses 213–215
 - hydroxyapatite scaffolds 439
 - titanium dioxide *see* TiO₂
 - tooth, calcium phosphate nanoparticles 452, 453
 - top-down methods, synthesis zirconia nanoparticles 258
 - toxic ions, optically selective nanosensors 192–194
 - toxicity
 - 1-D nanostructures in vitro 97–99
 - 1-D nanostructures in vivo 99–101
 - antimony ions 167
 - cadmium ions 167
 - effect of silica nanoparticle size 234, 235
 - lead ions 167, 168
 - mercury ions 167
 - metal ions 166–168
 - nanomaterials-induced 230–233
 - nanosilica *see* nanosilica toxicity; silica nanomaterials-induced toxicity
 - toxicology
 - 1-D silica nanomaterials 93–100
 - hydroxyapatite nanoparticles 435
 - transfection efficiency, nano-calcium phosphates 470
 - transmission electron microscopy (TEM)
 - epoxy-organosilica nanoparticles 121
 - inorganic silica nanoparticles 117
 - magnetosomes 12
 - porous silicon particles 374–377
 - thiol-organosilica nanoparticles 118
 - tubular ZnO nanowires, synthesis from templated butterfly wings 20
 - tumor microenvironment 391, 392
- u**
- ultrasonic treatment, hollow structures 479, 480
 - unbranched polyamines, morphology of silica nanoparticles 43
 - uptake
 - effect of microparticle size 393–396
 - effect of surface modification 396, 397
 - inhibition 397
 - oxidized porous silicon microparticles 397
 - porous silicon particles 391–397
- v**
- vapor–liquid–solid (VLS) model
 - nanosilica synthesis 63–65
 - nanowire synthesis 84, 86, 87
 - vapor–solid–solid (VSS) model, nanosilica synthesis 63–65
 - viral templates, metal oxide synthesis 15, 16
 - viral vectors, bone regeneration 470

w

- water treatment
 - alumina (Al_2O_3) 303, 304
 - cerium oxide 300–302
 - iron oxides 293–295
 - magnesium oxide 302, 303
 - manganese oxides 295–300
 - metal oxide nanomaterials 287–304
 - titanium oxide 288–293
- wet chemical precipitation, hydroxyapatite nanocrystal 412–415
- wuestite-like iron oxide, pH dependency of structure 12, 13

x

- X-ray diffraction, porous silicon particles 367, 368

z

- zirconia-based bioceramics
 - dental implants 267
 - nanostructured 263–267
- zirconia nanomaterials 245–275
 - applications in the life sciences 271–273
 - biomedical applications 263–273
 - biosensors 272, 273

- immobilization of enzymes and proteins 271, 272
 - stabilization 271
 - synthesis 246–263
- zirconia nanoparticles
 - combustion synthesis 253, 254
 - gas-phase synthesis 256–258
 - hydrothermal synthesis strategies 249–251
 - nonaqueous sol–gel technique 255, 256
 - Pechini method 252, 253
 - precipitation techniques 251, 252
 - sol–gel methods 254, 255
 - solvent-based synthesis 248–256
 - top-down methods for synthesis 258
 - zirconia nanorods, synthesis 259–263
 - zirconia nanostructures, doped 270, 271
 - zirconia nanowires, synthesis 259–263
- ZnO nanoparticles
 - shape 7
 - synthesis 6, 7, 19, 20
 - ZnO nanowires
 - 1-D lateral growth 24
 - growth on a 2-D surface 25
 - nanoscale building blocks 24–26
 - oriented growth 25, 26
 - tubular 20

