

Index

- AD *see* Always Defect
- age-at-birth distribution, 487
see also birth kernel
- aggregation, 216–217
see also clustering
- Allee effect, 317, 484, 500–502, 504, 512
- allelopathy, 12, 14, 17, 50
- altruism, 171, 334, 342, 361, 366, 368
- Always Cooperate, 146
- Always Defect, 137, 145–147, 208, 251, 323–332, 463–466
- anisotropy, 69, 294, 296–297, 313, 498
- Anti-Tit For Tat, 146
- artificial ecologies, 205, 361, 364, 366, 370–371, 376, 380, 386, 418
see also cellular automaton models
- assessment of fit, 87–88
- autocatalysis, 119, 134
- auto-correlation, 255, 266, 427, 429, 436, 444, 448
see also correlation density; covariance function; doublet density; pair density
- bacteria, 154, 243–249, 295, 313, 315, 457
- Bessel density, distribution, kernel, 306, 310, 317, 397, 409, 489, 493, 509, 511
- Bessel function, 409
- bimatrix games, 474–475, 477
- birth–death–movement process
 continuous space, 256–258, 263, 391, 418–425, 486–487, 495–496, 503–504
 lattice, 365–366, 370
- birth distribution, 487, 488, 492
see also birth kernel; reproduction kernel
- birth kernel, 486, 488–490, 493, 496, 498, 502, 508, 510
see also birth distribution; reproduction kernel
- Bully, 144, 146
- c_0 , 300, 308, 316, 490–500, 502
see also wave speed
- CA *see* cellular automaton models
- carousel model, 10, 55–61, 64
- catalytic support, 153–154, 160, 165–167, 171–172, 174, 178–179
- Cayley tree, 346, 347
- cellular automaton models
 colicin bacteria, 243–244
 and diffusion, 122, 155–157
 dwarf shrub community, 104–109
 forest fires, 109–114
 forest gaps, 237–238
 game theory, 138–148
 general specification, 155
 grassland communities, 43–46
 host–parasite, 271–274, 283–284, 288
 metabolic replication, 118–123
 plant reproduction strategies, 229
 predator–prey, 212–213, 184–186
see also artificial ecologies;
 birth–death–movement process,
 lattice; grid-based models; lattice
 logistic model; lattice models
- chaos, 220–221
- chemical spatial systems, 154
- Chicken game, 136, 139, 144
see also Hawk–Dove game
- clumping *see* clustering
- clustering, 49–50, 76–77, 165–168, 228–236, 247–248, 342–343, 350–353, 382, 386, 396, 400–405
see also foci; hot-spots
- clusters, 163–169
see also scroll rings; spiral waves;
 self-replicating spots
- cluster sizes, 234–236
see also aggregation
- coexistence
 and community size, 126–127
 and diffusion, 124–126
 game theory, 139, 141, 146
 grasses, 39, 40–41
 macromolecular replicators, 116, 119, 121, 123–129
 and metabolic coupling, 119

- molecular replicators, *116, 119, 121, 128–129*
- and neighborhood size, *117, 126–127, 131*
- and parasites, *131, 166–169*
- primitive genomes, *116*
- species, *71, 107, 342, 424*
- and surface metabolism, *133*
- colicin bacteria, *206, 243–249, 358*
- comparison methods in diffusion equations, *471–475*
- competition
 - altruists versus non-altruists, *334*
 - birth–death–movement process
 - representation, *256–258, 261–263, 366, 388–411, 421, 424*
 - clonally versus sexually reproducing plants, *227, 228, 341, 361*
 - coefficients, *28, 31–32*
 - colicin versus non-colicin bacteria, *243–245, 248, 358*
 - in coral reefs, *182*
 - in dwarf shrub community, *104–106*
 - among genes, *210–211*
 - in grassland communities, *28–47, 50*
 - influence of self-generated pattern, *260–261, 265–269, 287, 386*
 - measurement, *30, 31, 33*
 - neighborhood structure, *12–25, 263–269, 334, 385–386, 448, 450*
 - in replicator molecules, *129, 178*
 - scale, *396, 405, 409*
 - within species modulated by other species, *149*
 - and species turnover, *57*
 - as source of spatial separation, *50, 77*
 - transitivity of, *36, 39, 41, 42*
 - wavelike takeover, *316, 478, 501*
- competition kernels, *257, 391, 392, 411*
- competitive hierarchy, *36–37, 39, 42, 46*
- conditional intensity, *75*
- contact process, *344, 352, 358, 505*
 - see also* lattice logistic model
- continuous movement, *489, 499–500*
- convolution, *394, 395, 399, 420*
- Conway's Game of Life, *139*
- corrected correlation density, *430–431*
- corrected pair density *see* corrected
 - correlation density
- correlation corrections, *340, 449–451, 514–515*
- correlation density
 - advantages, *429–430*
 - auto-correlation, *255, 266, 427, 429, 436, 444, 448*
 - corrected, *430–431*
 - cross-correlation, *255, 427, 429, 444, 448*
 - definition, *254, 428*
 - dynamics, *260, 265, 432–438, 452–455*
 - examples, *254, 427, 428*
 - as expression of pattern, *255*
 - further reduction of, *451–452*
 - higher order, *428*
 - as measure of local environment, *426–427*
 - measurement, *428*
 - and relaxation projections, *417, 430–431, 451–452*
 - see also* conditional intensity; covariance function; doublet density; moment methods; pair-approximation methods; pair density; spatial moments
- coupled map lattice, *197, 210–211*
- covariance function
 - average, *394*
 - definition, *393–394*
 - dynamics, *396, 408*
 - measure of local crowding, *394*
 - quasi-equilibrium, *398–400*
 - see also* conditional intensity; correlation density; doublet density; moment methods; pair-approximation methods; pair density; spatial moments
- critical transmissibility, *275–278, 281–283, 286–288*
- cross-correlation, *255, 429, 444*
 - see also* correlation density; covariance function; doublet density; pair density
- data analysis, *65–88, 209–226*
 - Bayesian methods, *85–86*
 - correlation density, measurement of, *428*
 - correlation structures, *69, 88*
 - data configurations, *66, 70*
 - descriptive methods, *66–70*
 - fluctuation diagram, *216–217*

- Gibbs sampler, 86
 image restoration, 85
 Markov random fields, 77–79, 84–86
 maximum likelihood estimation, 81–83, 84–87
 method of moments, 83
 model adequacy, 87–88, 94–95, 111
 model fitting, 80–88
 pseudo-likelihood estimation, 87
 simulation methods, 84
 spatial scales, determining, 213–216
 spectral methods, 84
 stochastic models, 70–80
 time series analysis, 67–68, 70, 213–225
 trend, 67, 69–70
 variogram, 72
 Whittle's method, 84
- degrees of freedom, 413–417, 425–426, 451–452
- delta function
 Dirac, 253, 255, 407, 416–419, 422–423, 460
 generalized, 422–423, 433, 438
- demographic stochasticity, 93, 199–200, 258, 269, 342, 358, 381, 385–386, 482, 485
- deterministic approximation, 259, 264, 267, 268
- deterministic dynamics, embedded, 71, 170, 209, 219–224, 226
- deterministic models, 170, 187, 340, 404, 500–503
- diffusion, 122, 155–157, 459–463
see also reaction–diffusion models, systems
- diffusion operator, 156, 174, 462
- direct interaction scale, 484
- dispersal kernel, 257, 302, 306, 310–312, 391–392, 397, 410, 421, 425, 509
see also displacement distribution; movement kernel
- dispersal scale, 312, 396, 405, 409, 483–484, 496–497, 507–511
- displacement distribution, 317, 487, 489, 491–493, 496, 501, 509
see also dispersal kernel; movement kernel
- displacibility, 32
- disturbance, 18, 45, 57–58, 236–237, 242, 400, 462
 fire, 18, 109–114
 and resources, 18
see also perturbation
- doublet density, 205–206, 231–232, 345–347, 351, 429
see also correlation density; pair density
- doubly stochastic Poisson process, 76
- dwarf shrub community dynamics, 104–108, 109
- dynamic simulation in plant pathology, 302
 EPIMUL, 302–303, 305, 309
 PODESS, 303, 309–312
- dynamic sufficiency, 413, 415, 417
see also degrees of freedom; relaxation projections
- ecological signal, 2, 205, 256, 269, 412
- embedding dimension, 218, 219, 221, 222
- epidemics
 first-order, 293–298, 300–303, 310–313
 integral equation models, 304–306
 on a lattice structure, 250, 271–288, 349
 plant, 292–315, 317
 rabies, 91, 97–104, 114, 316–317, 510–511
 second-order, 293, 298, 301, 304–306, 308, 312–315
 zero-order, 293–300, 302, 309, 312–313, 315; *see also* foci
see also foci; hot-spots
- EPIMUL spatio-temporal simulation model, 302–303, 305, 309
- equilibrium density, 31, 234, 247, 263, 265, 267–268, 501
- ergodicity, 60–63, 64, 273, 352, 394, 396
see also stationarity
- ESS, 144, 172, 250, 319, 321–322, 323, 324, 327, 333
- evolution
 cooperation, 463–466, 474–475
 diffusion, 479–480
 games, 135–150, 318, 335, 463–466, 474–475
 prebiotic, 116–134, 153–169, 171–188
 transmissibility, 282–287
 evolutionarily stable strategies *see* ESS

- evolutionary game theory *see* evolution
- external heterogeneity, externally generated
spatial patterns, 52–54, 448–449,
497–500
- fat-tailed kernels, 311, 317, 496, 501
- Fick's law, 460–461
- fit, assessment of, 87–88
- Floquet multiplier, 190, 192–193
- fluctuation corrections, 449–451, 514–516
- fluctuation diagram, 196, 216–217, 225
- foci, 300, 305, 307, 311–315, 317
lattice, 362, 385
plant disease, 292–315, 317
phytopathology, 315, 488
and wave front, 340
see also epidemics, zero-order; hot-spots;
wave speed
- focus *see* foci
- foraging, by plants, 15–16, 25
- forest dynamics
fires, 109–111, 113–114
gaps, 236–243
herbivory, and oaks, 34
oaks, spread of after ice age, 315–316
regeneration waves, 341
- forest gaps, 236–243
- fungal diseases of plants *see* epidemics
- Game of Life, 139
- game theory, 135–156, 474–475, 463–466,
318–335
- gene competition, 210–211
- genets, 16, 24–25
- grassland communities, 38–47, 48–64
carousel models, 56–58, 59–60, 61
cellular automaton model, 42–46
competition, 28–47
competition coefficients determined from
traits, 40–41
ergodicity, 60–61, 62–63, 64
grazing, 36–37, 46, 53
guild proportionality, 58, 59–60, 61
herbivory, 32–34
invasion, 30, 31, 34–36, 37, 42
measuring competition, 29–38
mosaic cycle, 55–56, 59, 60–61
mutual invasion, 34–36, 42
neighbor effects, 32–38
patch dynamics, 1, 19, 28–29
space preemption, 58–59, 60, 61
spatial interaction outcomes, 42–46
spatial-temporal patterns, 48–54
transition matrices, 38–42
transitivity, 36, 39, 41–42
see also carousel model; ergodicity;
guild proportionality; mosaic cycle;
plant interactions; space preemption
- grazing
and competition, 36–37, 46, 53
dwarf shrub community, 109
and grassland patterns, 53
- grid-based models
bacterial competition, 243–247
descriptors, 96–97
dwarf shrub community, 104–109
and ecological systems, 95–96, 114–115
forest fires, 109–114
forest gaps, 236–243
games, 135–150
gene competition, 210–211
host–parasite, 272–277
and mathematics, 97, 114–115
pair approximations, 227–247, 341–357,
374–377
versus partial differential equations,
153–169
prebiotic evolution, 120–134
predator–prey, 184–187, 212–213
procedures, 96
rabies, 97–104
rules and algorithms, 94–96, 114–115
seeds versus clonal growth, 228–236
see also cellular automaton models;
lattice models
- Grim, 145
- guerilla species, 37
- guild proportionality, 58, 59–61
- Hamilton rule, 327–328, 334
- Hawk–Dove game, 136, 144
see also Chicken game
- herbivory, 32–34
- host–parasite models
critical transmissibility, 275, 277–278,
282–284, 297

- dynamics, 272–277
 - and mean-field assumptions, 277, 285
 - modeling, 271–276
 - pair approximation, 301
 - PATCH model, 279–282, 287, 289–291
 - scale, 274
 - spatial dynamics, 273–274, 275
- hot-spots, 509
 - see also* foci
- hypercycles, 92–93, 117, 156–163, 171–182
 - and parasites, 116, 154–155, 160–161, 171–172, 178–180
 - scroll rings, 162–163
 - spirals, 159–162, 174, 178–179
 - spots, 174, 179
- indirect interaction scale, 484
- individual-based model components, 18–19, 487–489, 499–500, 509–512
- individual-based models, 1–3
 - birth–death–movement process, 418, 425
 - and cellular automaton models, 151–152
 - continuous space, 253, 391–394, 418–424
 - discrete-entity simulations, 184–187
 - for fat-tailed kernels, 311
 - and lattice models, 342
 - limitations, 2, 5, 412–413, 515
 - predator–prey models, 184–187, 196, 199–200
 - and reaction–diffusion models, 152, 457
 - spatial structure, 3
 - see also* artificial ecologies; cellular automaton models
- insect diseases in plants, 292, 295, 308, 312, 313, 315, 316
- insects, 292, 295, 308, 313, 315
- integral equations, 486–497, 507–511
 - and epidemic spread, 304–306
 - input variables, 306, 308
 - methods, 514
 - as rapid-stirring limits, 514
 - and reaction–diffusion models, 504–507
- integral kernel *see* birth distribution; birth kernel; competition kernels; dispersal kernel; displacement distribution
- integro-difference models, 317
- intensity, 75
- interacting particle systems, 271, 342, 388, 515
 - see also* lattice models
- interaction kernels, 420–421, 425, 434, 436–437
- interaction neighborhood, 24–25, 46–47
- invasibility
 - calculating, 247
 - competitive hierarchy, 46
 - criteria, 319, 333
 - and evolutionary stability, 321–323
 - games, 139
 - and invasiveness, 31–32, 35, 36
 - pair-approximation analysis, 250
 - see also* invasiveness
- invasion conditions, 246–247, 363, 381–385, 386
- invasion of neighboring space, 30, 31, 34–37, 42
- invasion waves
 - and Allee effects, 317, 484–485, 501, 512
 - circular, 494
 - dispersive, 293; *see also* kernels, fat-tailed
 - independent spread, 485–500
 - linear models, 485–500, 504, 507–509
 - nonlinear models, 504
 - pushed, 501
 - rabies, 99–101, 510–511
 - in reaction–diffusion models, 321–322, 331–332, 315–316, 475–478, 504–507
 - run for your life theorem, 493–498, 503
 - shape theorems, 503
 - spatial inhomogeneity, 497–499
 - spherical, 494
 - temporal inhomogeneity, 497–499
 - see also* traveling wave front; wave speed; wavelike spatial spread
- invasiveness
 - competitive hierarchy, 37, 39, 42, 46
 - and invasibility, 31–32, 35, 46
 - see also* invasibility
- isopath map, 296–297, 299–301, 304, 305, 314
- isotropy,
 - correlation structure by assumption, 255, 344, 394, 407

- deviations from, 312, 497
- observed, 300
- use of, 255, 265, 345, 407, 427–428, 451
- see also* anisotropy; rotational symmetry
- Iterated Prisoner's Dilemma game, 136–137, 145–150, 250–251, 323–335, 463–466
- Kermack–McKendrick equation, 312, 359
- kernel-based models
 - continuous-time, 252–270, 317, 388–411, 482–512
 - discrete-time, 293, 317
- kernels
 - birth, 486, 488–490, 493, 496, 498, 502, 508, 510; *see also* birth distribution; reproduction kernel
 - competition, 257, 391–392, 410, 411
 - discrete-time, 293, 317
 - dispersal, 257, 302, 306, 310–312, 391, 392, 397, 421, 425, 509; *see also* displacement distribution; movement kernel
 - displacement, 317; *see also* displacement distribution
 - fat-tailed, 311, 317
 - interaction, 420, 421, 425, 434, 436, 437
 - marginal, 493
 - movement, 420, 438
 - normalized, 307
 - reproduction, 508, 509
 - spatial, 392, 395
- Kirkwood superposition approximation, 442
- Kronecker symbol, 254, 260, 420, 422, 431, 436,
- kurtosis, 492, 500
- Laplace transform, 419, 488–489, 490, 493, 499, 508, 512
- lattice logistic model, 344–349, 355
- see also* contact process
- lattice models
 - artificial societies, 150
 - birth–death–movement process, 365–366, 370
 - complexity, 2
 - coupled map lattice, 197, 210–211
 - invasion dynamics, 382–385
 - limitations, 361, 362–363
 - logistic models, 344–349, 355
 - and moment methods, 404–406
 - and pair approximations, 344–358
 - pair-dynamics models, 359–387
 - random lattices, 362, 373–374, 380
 - square lattices, 376–377
 - superimposed lattices, 149
 - triangular lattices, 374–376, 380
 - see also* artificial ecologies; cellular automaton models; grid-based models
- learning strategies, 149
- life-history parameters, 398
- life-history traits in plants, 31, 37, 40–41, 228–234, 379
- linear conjecture, 502, 503
- linearized stability analysis, 145, 466–471
- local configuration dynamics, 279–282, 452
- local extinction, 160–162, 169, 175–177, 180–181
- local mean field, 335
- see also* rapid-stirring limit
- local stability analysis *see* linearized stability analysis
- locally infinite systems, 512
- logistic growth, 359, 363, 381, 383, 391, 465
- see also* spatial logistic model
- Lotka–Volterra models
 - competition, 39, 389, 400
 - and moment approximation, 256, 258, 434–435
 - multi-patch, 193–196
 - predator–prey, 187, 359
 - spatial analogues, 263, 421, 449
 - spatial dynamics, 187–190, 199
 - two-patch, 187–193, 197
 - see also* predator–prey models;
- Lyapunov exponents, 174, 218, 219, 220–221
- Lyapunov function, 188
- Markov process, 68, 77, 229, 286, 350, 391, 421–422, 486
- Markov random fields, 77–79, 84–86
 - clique, 78
 - hard-core process, 78

- homogeneous pairwise-interaction process, 78
- master equation, 421, 422
- maximum likelihood estimation, 81–84, 87
- mean crowding, 231
- mean density
 - comparison of models, 256–267, 445–446
 - correlation corrections, 449–451
 - definition, 254, 393, 426, 428
 - dynamics, 258, 394–395, 406–407, 433–434
 - fluctuation corrections, 449–451
 - see also* intensity; singlet density
- mean-field approximation
 - assumptions, 4, 231
 - as basis of ecological ideas, 18, 270, 412
 - colicin bacteria, 245–246, 248, 358
 - correlation corrections to, 450–451
 - epidemics, 354–355
 - and evolution rate, prediction of, 207, 287
 - fluctuation corrections to, 450–451
 - host–parasite, 277, 285, 287
 - lattice logistic model, 348, 380
 - local mean field, 335
 - Lotka–Volterra model, 261–262
 - mutant parasite, 285
 - and pair-dynamics models, 387
 - and parasites, 160
 - plants reproducing by seeds and growth, 231, 236
 - and predator–prey modeling, 183
 - selective pressure, 285
 - shortcomings, 1–4, 90–91, 148, 160, 207, 231, 252, 275, 343, 350, 358, 412, 424
 - and transmission rate, 275
- metabolic replication, 119–123, 124
- method of moments, 82
 - see also* moment methods; pair-approximation methods
- model adequacy, 87–88, 94–95, 111
- model fitting, 80–88
- moment methods, 83
 - accuracy, 259, 261–262, 264, 267, 398–399, 402–404, 442–447, 503
 - closures, 371–379, 363, 389–390, 396, 438–447, 503
 - competition model, spatial, 250–261, 400–403
 - correlation corrections, 450–451
 - equations, 258, 260, 261, 263, 265, 394, 396, 406–411, 432–438, 452–455
 - fluctuation corrections, 450–451
 - and lattice models, 388–389, 392, 404–406
 - logistic model, spatial, 261–269, 391–400
 - and pair approximations, 252, 254–255, 258, 260, 265, 404–405, 424–431, 434–449, 451–455
 - and reaction–diffusion models, 252, 269, 359–360, 404–405, 515
 - and relaxation projections, 440
 - spatial moments, definition, 254–255, 392–394, 426–432
 - waves, 503–504
 - see also* corrected correlation density; correlation density; pair-approximation methods
- Moore neighborhood, 120, 128–129, 155, 243
- mosaic cycle, 55–56, 59, 60–61
- movement kernel, 420, 438
 - see also* dispersal kernel; displacement distribution
- neighbor effect *see* neighborhood
- neighborhood
 - and cooperation, 149–150
 - Markov random field, 77–78
 - Moore, 120, 128–129, 155, 243
 - nearest-neighbor disturbances, 75
 - neighbor effects, 3, 12–14, 18–19, 21, 23, 32–34, 229, 238, 257, 379
 - plants, 4–26
 - refuge, 33–34
 - size, 20, 119, 123–129, 263, 265, 267, 362, 398, 503
 - spatial structures, 23–25, 50
 - von Neumann, 43, 135, 155, 235, 243, 272, 462
 - see also* patch dynamics, in plant communities; plant interactions
- nematodes, 292, 295–296, 313, 315
- von Neumann neighborhood, 43, 135, 155, 235, 243, 272, 462

- Neyman–Scott Poisson cluster process, 74, 77
 non-isotropy *see* anisotropy; isotropy
- oak trees *see* forest dynamics
 origin of life, 116, 133, 152, 153–154, 157
see also prebiotic evolution
 overdispersion, 49, 75, 76, 444
- pair-approximation methods
 accuracy, 234, 237, 240–243, 250,
 348–349, 355, 357, 379–383
 approximation step *see* closure
 basic contact process *see* contact process
 birth–death–movement process,
 365–368, 370–371, 380–382
 closure, 232, 346–347, 351–353, 363,
 371–379
 cluster sizes, 234–236
 colicin bacteria, 243–247
 contact process, 344–349
 definitions, 228–232, 343–346, 350,
 355–356, 364, 371
 epidemics, 250, 349–355, 357–358
 equations, 230–232, 238–239, 345–348,
 351–352, 354, 360, 364, 367,
 373–377, 384
 forest gaps, 236–243
 improved, 349–357
 invasion conditions, dynamics, 246–247,
 382–385
 lattice logistic model, 344–349; *see also*
 birth–death–movement process;
 contact process
 pair-edge approximation, 248–250, 452,
 503
 predator–prey, 358
 Prisoner’s Dilemma, 250–251
 and reaction–diffusion models, 359–360
 relation to moment methods, 252, 343,
 346, 372, 405
 seed versus clonal representation,
 228–234
 socially influenced mortality, 355–357
 waves, 503
see also moment methods
- pair density
 closure, continuous space, 434–444
 closure, lattice, 363, 372, 377, 386–387
 corrected, 430
 definition, continuous space, 427–429
 definition, lattice, 364–365
 dynamics, continuous space, 260, 339,
 434–435, 447, 452–455
 example, 472
 as expression of spatial pattern, 360,
 427–430, 434
 simplified characterization, 451
see also correlation density; doublet
 density
- pair-edge approximation, 248–250, 452, 503
- pandemics *see* epidemics, second-order
- parasite–host *see* host–parasite models
- parasites, metabolic 116, 119, 129–133,
 154, 160–162, 165–170, 171–172,
 178–181
see also hypercycles
- partial differential equations *see*
 reaction–diffusion equations
- patch dynamics, in plant communities, 19,
 28–29, 48–53
- PATCH model *see* host–parasite models
- patchiness index, 231
- pattern dynamics, 421, 423–425
- Pavlov strategy, 145, 146, 147, 149
- PCA *see* cellular automaton models
- PDE *see* reaction–diffusion equations
- perimeter polynomials, 235, 236
- perturbation, 482
see also disturbance
- phalanx species, 37
- plant interactions
 clonal growth, 15
 competition, measurement of, 29–38
 competition coefficients determined from
 traits, 40–41
 competition mechanisms, 12–18
 foraging, 15
 life-history traits in plants, 31, 40–41,
 228–234, 379
 neighbor effects, 32–38
 neighborhood, 19–26
 patch dynamics, 19, 28–29
 positive neighbor effects, 13
 resources, 14–17
 roots, 17
 seed dispersal, 17

- size plasticity, 21, 23
see also dwarf shrub community dynamics; grassland communities; foci, phytopathology
- PODESS spatio-temporal simulation model, 303, 309–310
- Poincaré map, 192–193
- point processes, 72–75, 77–79, 338–339, 388–389, 391, 405–406, 418–425
see also Poisson processes
- Poisson processes, 10, 49, 70, 72–80, 82–83, 253, 310, 407, 450, 487
- polycyclic fungal diseases *see* foci
- prebiotic evolution, 116–134, 153–169, 171–182
see also hypercycles; parasites, metabolic; replicator macromolecules; surface metabolism
- predator–prey models
 demographic stochasticity, 93, 199–200, 258, 269, 342, 358, 381, 385–386, 482, 485
 differential equation models, 187–198
 embedding dimension, 218, 221–222
 individual-based, 184–188, 196, 199–200, 212–213
 lattice, 358
 Lyupanov exponents, 219, 220–221
 multi-patch, 199
 spatial Lotka–Volterra, 187–196
 spatial Rosenzweig–MacArthur, 185–186, 196–199
 spatial scales, 183–184, 213, 216, 221
 statistical stabilization, 200
 time series, 214–215, 219, 221
see also host–parasite models; Lotka–Volterra models
- principal components analysis, 223
- Prisoner’s Dilemma, 135–150, 250–251, 323–335, 463–466
- probabilistic cellular automaton models *see* cellular automaton models
- pseudo-likelihood estimation, 87
- quasi-monotone systems, 473–475
- rabies, 91, 97–104, 114, 316–317, 510–511
- ramets, 24, 29
- random drift, 342
see also demographic stochasticity
- random lattices
 foci, 362
 invasion dynamics, 385
 and pair approximation, 373–374, 378, 380–382
 simulation, 380–381
- rapid-stirring limit, 514
see also local mean field
- reaction–diffusion equations
 catalytic networks *see* hypercycles
 versus cellular automaton models, 91, 118, 151–153, 155–157, 169–170
 clusters *see* spots
 comparison methods, 471–475
 cut-offs, 159, 161–163, 165–167, 169, 177, 515
 derivation, 156, 459–566
 evolution of diffusion, 479–481
 and fluctuation corrections, 515
 games, 318–335, 463–466, 474–475
 Hamilton rule, 327–328, 334
 Hutson–Vickers model, 329–331, 333
 hypercycles, 157–159, 173–174
 and integral equation models, 504–507
 invasion waves, 315–316, 322–323, 327–329, 331–332, 475–478, 491, 497–498, 501–503, 504, 508
 linearized stability, 466–471
 literature on, 458–459
 numerical methods, 156, 174, 459
 prebiotic evolution, 116–118, 153–154, 171–174
 predator–prey models, 187–201, 502–503
 Prisoner’s Dilemma, 149, 321–335, 463–466
 as rapid-stirring limits, 514
 scroll rings, waves, 162–163
 spatial population expansion *see* invasion waves
 spirals, spiral patterns, spiral waves, 161–162, 174–175, 178–179
 spots, 163–169, 174–175, 179–180
 Turing instability, 323, 466–471
 waves *see* invasion waves; scroll rings; spiral waves

- reaction–diffusion models, systems
 116–134, 151–170, 171–182, 187–201,
 309, 315–316, 318
see also cellular automaton models;
 reaction–diffusion equations
- relaxation projections, 414–415, 417
 alternative methods, 451–452
 and correlation densities, 425
 and moment closure, 440
 as simplification, 414–415, 425
 and spatial scale, 426
see also degrees of freedom; dynamic
 sufficiency
- repeated games *see* Iterated Prisoner's
 Dilemma game
- replication–diffusion equations *see*
 reaction–diffusion equations
- replication–diffusion models *see*
 reaction–diffusion models, systems
- replicator macromolecules
 “advantage of the rare” effect, 126, 130
 as cellular automata, 119–123
 characteristics, 118–119
 clusters, 163–169
 coexistence, 116, 123–129
 community size, 126–127, 129–132
 and hypercycle theory, 116–117,
 153–154, 171–172
 and parasites, 116, 129–133, 163–169
 persistence, 126–128
 surface metabolism, 120–121, 133–134
see also hypercycles; parasites,
 metabolic; reaction–diffusion
 equations; surface metabolism
- reproduction kernel, 508–509
see also birth distribution, birth kernel
- resistance to parasites, 116–118, 129–133,
 160–163, 165–168, 171–172, 178–182
see also evolution, transmissibility
- Retaliator, 144
- Rock–Scissors–Paper game, 144
- Rosenzweig–MacArthur models, 185–186,
 196–198
see also Lotka–Volterra models;
 predator–prey models
- rotational symmetry, 375, 485, 492
see also isotropy
- run for your life theorem, 493–498, 503
- sandpile avalanches, 113–114
- scale
 competition, 396, 405, 409
 direct interaction scale, 484
 dispersal, 312, 396, 405, 409, 483–484,
 496–497, 507–511
 indirect interaction scale, 484
 sexual scale, 483–484
 spatial heterogeneity, 425–426, 497–498
 spatial scales, 496–497
- scroll rings, 155–156, 160–163
see also self-replicating spots; spiral waves
- second moment, 206, 254–256, 260–265,
 389, 396, 429, 439
see also correlation density; covariance
 function; doublet density
- second-order models, 389–391, 394, 396,
 403, 405, 407–408, 439–440
- selective pressure, 282, 284–287
- self-organized criticality, 113–114
- self-replicating entities *see* replicator
 macromolecules
- self-replicating spots, 172, 174, 177
 resistance to parasites, 178–180
see also clusters; scroll rings; spiral waves
- self-structuring patterns and evolution, 118,
 128, 181–182
see also scroll rings; self-replicating
 spots; spiral waves
- sexual scale, 483–484
- shape theorems, 503
- SI model *see* host–parasite models
- singlet density, 205–206
 definition, 345, 426, 428
 dynamics, 231, 251, 345, 347, 350–351,
 363, 380, 385, 426, 428, 443
see also mean density
- singular value decomposition, 225–226
- SIR model, 349–355, 357–358
- Snowdrift game, 136, 144
see also Hawk–Dove game
- solidarity game, 150
- space preemption, 58–61
- spatial competition experiments, 29–40,
 46–47
- spatial competition models, 361
 colicin bacteria, 243–250
 genes, 210–213

- grassland plants, 43–46
- Lotka–Volterra, 257–261, 400–403, 420–421, 446
- plant reproductive strategies, 228–237
- spatial density function, 418
- spatial evolutionary game theory *see* evolution
- spatial heterogeneity, inhomogeneity, 52–54, 448–449, 497–500
- spatial hypercycle model *see* hypercycles
- spatial logistic model
- continuous, 261–269, 391–400, 445
 - lattice, 344–349, 355, 360, 370–371, 381, 383
- spatial moments, 253–256, 392–394
- see also* correlation density; moment methods
- spatial population expansion *see* invasion waves; wave form; wavelike spatial spread
- spatial scales, 213–218, 425–426, 496–497
- species traits and competition matrices, 40–41
- spectral methods, 66, 68, 84, 399–400
- spiral waves, 117–118, 128, 159–162, 174–175
- bounding conditions, 155
 - cellular automaton models, 160–161
 - and parasites, 160, 172, 178–179, 180
 - and partial differential equation models, 161–162, 174–177
 - and self-replication, 174–175
 - see also* clustering; scroll rings; self-replicating spots
- spots *see* self-replicating spots
- square lattices, 376–377
- see also* cellular automaton models; grid-based models; lattice models
- stability analysis, 195, 200–201, 330–331, 466–471
- stationarity, 394, 407
- see also* data analysis, trend; ergodicity
- statistical stabilization, 196, 198–200
- stochastic models and data analysis, 70–80, 84–86, 88
- surface metabolism, 133–134
- susceptible–infected *see* host–parasite models
- susceptible–infected–recovered model *see* SIR model
- temporal inhomogeneity, 497–499
- TFT *see* Tit For Tat
- third moments, 260, 377–379, 403–404
- see also* triplet densities
- time series analysis, 67–68, 70, 84, 213–225
- Tit For Tat, 137–138, 145–149, 208, 251, 323–332, 463–466, 471, 478, 481
- transition matrices, estimation from invasion experiments, 42
- transition rates, 370, 422–433
- birth–death–movement process in continuous space, 257, 263, 420–421
 - colicin bacteria model, 244
 - forest gaps model, 237–238
 - lattice birth–death–movement process, 344
 - plant reproduction model, 229
 - SIR model, 350
 - socially changed mortality model, 355
 - spatial logistic model, 344
 - spiral logistic model, 263, 391–392
- transition rules, 96
- dwarf shrub community model, 105
 - forest fire model, 110
 - games, 137–138, 140–142, 145–146
 - gene competition, 210
 - grassland competition model, 42–43
 - host–parasite model, 272–273
 - metabolic replication model, 119–121
 - PATCH model, 279–281, 289–291
 - predator–prey models, 184–185
 - predator–prey–resource models, 212–213
 - rabies model, 101
 - reaction–diffusion, 155–157
- transitive competition, 39
- traveling wave front
- games, 321–322, 329, 331, 333–334
 - plant diseases, 292–315
 - rabies, 99–102
 - in reaction–diffusion models, 475–478
 - and sexual interaction, 384
 - shape, 476, 495–476, 502–503
 - see also* foci; invasion waves; scroll rings; spiral waves; wave speed

- trend, 67, 69–70, 200, 258, 512
- triangular lattice models, 374–376, 380, 382, 383, 385
- triplet densities
- closure assumptions, 260, 346, 351, 372–379, 386–387, 439–444
 - definition, 231–232, 345, 429
 - effect on pair dynamics, 232, 251, 366, 369, 371, 431, 435, 436–438
 - examples, 383, 431, 443
 - see also* moment methods, closure; pair-approximation methods, closures
- Turing
- bifurcation, 466–470
 - instability, 323, 458, 470
 - pattern, 340
- two-patch models
- Lotka–Volterra, 187–193
 - Rosenzweig–MacArthur, 196–197
- underdispersion *see* clustering
- Vanderplank’s equation, 301, 311, 488
- viruses, 295, 299, 313
- wave form, 60
- waves
- fir forest regeneration, 341
 - heathlands, 60
 - see also* invasion waves; scroll rings; spiral waves; traveling wave front; wave speed
- wave speed, 481–493, 497–501, 505, 507–512
- Allee effect, 317, 501, 512
 - amplification effect, 507
 - concentrated reproduction, 493
 - continuous movement, 499–500
 - experimental results, 299, 303, 308
 - home ranges, 489
 - hot-spots, 509
 - quantitative applications, 315–317
 - see also* c_0
- wavelike spatial spread
- approximation formulas, 492, 493
 - in reaction–diffusion models, 487, 491
 - run for your life theorem, 493–498, 503
 - wave speed, 487, 490–491, 493–494
- Whittle’s method, 84