

## Index

- AIC (Aikake Information Criterion) 131–132
- AIDS  
 evolution of drug resistance in HIV 182  
 viral dynamics 208
- Alabama beach mouse (*Peromyscus polionotus ammobates*)  
 298, 299
- algebra, two prey diet choice problem 3–5, 18
- Allee effects 290
- Anderson's theory of vitality 314–316
- Anisopteromalus calandrea* (parasitoid) 137
- Anopheles* spp. (mosquitoes), vector of malaria 188–193,  
 194, 207
- Aphytis lingnanensis* (parasitoid) 134, 150, 151
- arithmetic mean (arithmetic average) 31–35
- Asobara tabida* (parasitoid) 137
- asymptotic expansion 113–114, 129
- asymptotic normal theory 127
- asymptotic size 25–27
- Atlantic cod (*Gadus morhua*) stocks 216–217
- Atlantic salmon (*Salmo salar*), egg size and parent–offspring  
 conflict 8–10, 18
- backward equations 268–272, 276–279, 284
- backward iteration 155, 166
- Bayes, Thomas 125–127
- Bayes's Theorem 82, 83–84
- Bayesian methods 91–95  
 fishery stock assessment analysis 100–101  
 statistical analysis 125–127, 128–129  
 updating of *t*-distribution parameter 130
- behavior and population dynamics combined 155–159, 160,  
 166–167
- Bernoulli, Daniel 73–74, 88–92
- Bernoulli trials 88–92
- beta density 94–95, 123–124, 125  
 conjugate prior for the binomial parameter 128–129
- beta function 127
- Beverton, Ray 29, 30, 73
- Beverton Holt stock–recruitment relationship 212, 213–215,  
 239–241
- BIC (Bayesian Information Criterion) 131–132
- bifurcations 40–48, 74–76
- binomial coefficient 88–92
- binomial distribution 88–95  
 Poisson limit of the binomial 100
- biodemography of survival 311–314, 319–320
- bioeconomics and overfishing 218–224, 241–242
- bioinformatics 168–169
- blue noise 283
- box model (Freedman) for appropriate probability model  
 101, 102
- Brownian motion 77–78, 251–254, 260–264, 282
- BSE (mad-cow disease) 208
- calculus  
 egg size in Atlantic salmon (*Salmo salar*) 8–10, 18  
 extraordinary sex ratios 10–12, 18  
 stochastic calculi 282, 318–319
- Callosobruchus chinensis* (bruchid beetle) 137
- catastrophe theory 45–48, 74–76
- catastrophic changes in population size 294–296, 318
- Cauchy distribution 120–121
- chaos theory and complexity 40–43, 74
- Chapman–Kolmogorov equation (Master Equation) 270, 272
- chi-square distribution 115–116
- cholera 208
- coefficient of variation 87–88
- conditional probability 81–84, 85–86
- confidence intervals 93, 94
- conjugate priors 112, 128–129
- contagion and virulence 176–178, 182, 183
- continuous random variables 84–85, 86–88

- CPUE (Catch Per Unit Effort) 217–218, 229–231, 240–241
- Creutzfeldt–Jacob disease (CJD) 208
- cusp bifurcation 45–48, 74–76
- cusp catastrophe 45–48, 74–76
- Darwinian fitness *see* fitness measures
- Darwinian gradualism, challenges to 309–311
- data sampling and appropriate probability model 101, 102
- Dawson's integral 307–309
- delay differential equations 164
- delay differential models, host–parasitoid dynamics 164
- deterministic chaos 40–43, 74
- differential equations
- bifurcations 40–48, 74–76
  - classification of steady states 48–58, 74–76
  - diffusion and exponential growth 64–69, 78
  - diffusion and logistic growth 69–73, 79
  - diffusion as a random walk 58–64, 77–78
  - discrete logistic map 38–43, 74
  - individual growth 23–29, 30, 73
  - life history invariants 29, 30, 73
  - linear and nonlinear diffusion 79
  - logistic equation 36–38, 74
  - measures of fitness in fluctuating environments 31–36
  - population growth in fluctuating environments 31–36, 73–74
  - predation and random search 20–23, 24
  - two-dimensional 48–58
- diffusion
- and exponential growth 64–69, 78
  - and logistic growth 69–73, 79
  - as a random walk 58–64, 77–78
  - in a bounded region 62–64, 78
  - in an unbounded region 60–62, 78
  - linear and nonlinear 79
  - model of the process 58–64, 77–78
  - reaction-diffusion equations 79
  - see also* stochastic population dynamics; stochastic population theory (ecological applications)
- diffusion approximation 318–319
- diffusion equation definition 59–60, 77–78
- Dirac, Paul 61–62, 78
- Dirac delta function 61–62, 78
- discounting (bioeconomics) 221–224, 241–242
- discrete logistic map 38–43, 74
- discrete random variables 84–85, 86–88
- disease *see* population biology of disease
- disease transmission models 171–173
- distribution function 84–85
- domains of attraction 49–50, 51
- escape from 285–287, 317, 319
- Drosophila subobscura* (fruit fly) 134–137
- ecological applications of stochastic differential equations 283–284
- see also* stochastic population theory (ecological applications)
- ecological aspects of disease models 207
- ecosystem-based fisheries management 244–246
- Ecosystem Advisory Panel Report 244–246
- egg size in Atlantic salmon, parent–offspring conflict 8–10, 18
- eigenvalues 53–58, 71–73
- eigenvectors 53–58, 71–73
- Einstein, Albert 251, 282–283
- Eldredge, Niles 309–311
- error distribution, normal (Gaussian) distribution 114–116
- errors in variables 130
- escape from a domain of attraction 285–287, 317, 319
- ESS (Evolutionarily Stable Strategy) 11–12, 18–19, 182–184
- ESY (Ecologically Sustainable Yield) 238
- Euler–Lotka equation of population demography 311–314, 319–320
- events 81–84, 85
- evolutionary theory
- biodemography 311–314, 319–320
  - escape from a domain of attraction 285–287, 317, 319
  - punctuated equilibrium 309–311, 319
  - transitions between adaptive peaks 302–311
- exercises, importance of 4–5
- expectation 86–88
- experiments 81–82
- exponential distribution function 85–86
- extinction times 130
- connecting models and data 319
  - density independent diffusion approximation 292, 297–301
  - escape from a domain of attraction 285–287, 317
  - general density dependent case 301–302
  - MacArthur–Wilson theory of 287–293, 317–318
  - role of a ceiling on population size 293–296, 318
- extraordinary sex ratios 10–12, 18
- Feller, William 268–269
- Feynman, Richard 282
- Feynman–Kac formula 276–278, 282
- financial engineering 320–322
- fish stock assessment 94–95
- Fisher, R. A. 10–12, 18, 69–73, 125–127
- Fisher equation 69–73, 79

- fisheries
- as an agent of selection 244
  - ecosystem-based approach to management 244–246
  - fishery system 210–212, 238
  - optimal age at maturity 27–28
  - relative size at maturity 29, 30, 73
  - salmon life histories 227, 242–243
  - sustainability issues 210
- fisheries models
- age structure 224–227, 239–241
  - Atlantic cod (*Gadus morhua*) stocks 216–217
  - Bayesian methods in stock assessment and management 241–242
  - behavior of fishermen 239
  - Beverton Holt stock–recruitment relationship 212, 213–215, 239–241
  - bioeconomics and overfishing 218–224, 241–242
  - Catch Per Unit Effort (CPUE) 217–218, 229–231, 240–241
  - discounting (bioeconomics) 218, 221–224, 241–242
  - Ecologically Sustainable Yield (ESY) 238
  - hake (*Merluccius capensis* and *M. paradoxus*) 229–231
  - marine reserves model 231–236, 243–244
  - Maximum Net Productivity (MNP) 216, 218
  - Maximum Sustainable Yield (MSY) 216, 218, 241
  - open and closed populations 214–215
  - Optimal Sustainable Population size (OSP) 217–218
  - process uncertainty and observation error 228–231, 238, 243
  - Ricker stock–recruitment relationship 212, 213, 239–241
  - risk analysis in decision making 236–237, 246–247
  - salmon fisheries management 227–228, 242–243
  - Schaefer model and its extensions 215–218, 220–221
  - stochastic models 228–231, 233–236
  - stock–recruitment relationships 212–215, 239–241
  - targets, thresholds and reference points 241
  - use for management 238
  - yield per recruit 225–227
- fishery science
- Ricker map 39–40
  - Ricker recruitment function 74
- fitness measures
- energy acquisition 3–5
  - number of grand offspring 11–12
  - per capita growth rate 31–36
- fluctuation and dissipation 282–283
- focus (steady state) 54–55, 71–73
- foraging in patchy environments 2–8, 18
- marginal value theorem (plane geometry) 5–8, 18
  - two prey diet choice problem 3–5, 18
- forward equations 272–276, 278, 284
- forward iteration 155, 166
- Fourier coefficients 65, 66–69, 78
- Fourier series 65, 66–69, 78
- Frank, F. C. 56–58, 76–77
- frequency dependent model for disease transmission 172, 173
- frequentist approach to statistical analysis 125–127
- fruit flies, lifestyles 134
- gambler's ruin
- in a biased game 257–260
  - in a fair game 253, 254–257
  - rare events happen quickly 309
- gamma density 103–104, 105–107
- conjugate prior for the Poisson process 112, 128–129
  - in the negative binomial distribution 106, 107–112
- gamma function 104–105, 127
- Gaussian (normal) distribution 112–116
- Gaussian white noise 261–264
- Generalized Function 61–62, 78
- Generalized Linear Model 80–81
- genetic models
- diffusion processes in population genetics 284
  - spread of an advantageous allele 69–73, 79
- genomics 168–169
- geometric mean (geometric average) 32–35
- Gompertz mortality model 319–320
- Gould, Stephen J. 309–311
- growth equations, individual 23–29, 30, 73
- hake (*Merluccius capensis* and *M. paradoxus*) 229–231
- Halticoptera rosae* (parasitoid) 134
- Hamilton, W. D. 10–12, 18, 312
- helminth worm parasites 193–201, 208
- accounting for free-living stages 199
  - ecological setting for host–parasite dynamics 199–201
  - underlying host–worm model 194–198
- hepatitis C virus spread 169–170
- HIV *see* AIDS
- Hopf bifurcation 76
- host–parasite interactions *see* helminth worm parasites
- host–parasitoid dynamics *see* parasitoids
- hypothesis testing 113–114
- immune system *see* optimal immune response
- independent increments 282
- Individual-Based Models (IBMs) 166
- see also* forward iteration
- individual growth equations 23–29, 30, 73
- invasion biology 69–73, 79
- unbeatable (ESS) level of virulence 182–184

- island biogeography, MacArthur–Wilson theory 287–293, 317–318
- isocline analysis 56–58, 71–73
- iteration, forward and backward 155, 166
- Ito calculus 253–254, 282, 318–319
- Jensen's inequality 33–34
- Kac, Mark 276–278, 282
- Kermack–McKendrick epidemic theorem 174–175, 177
- Kimura, M. 306–307
- Kolmogorov backward equation 268–272
- Kolmogorov forward equation 272–276
- law of total probability 83–84
- least squares 116–119
- Leptopilina heterotoma* (parasitoid) 134
- Levin's patch model 74–76
- life history invariants 29, 30, 73
- life tables 311–312, 319–320
- Lighthill, M. J. (Sir James) 61–62, 78
- likelihood 91–95, 116, 127
- likelihood ratio 131–132
- linear regression 116–118
- linear superposition of solutions 52–58
- log-likelihood 91–95, 116
- log-normal distribution 121–122
- logistic equation 36–38, 74
- Lotka–Volterra competition equations 48–49, 56–58
- Lotka–Volterra mutualistic interaction equations 48–49, 77
- Lotka–Volterra predator–prey equations 48–49, 57–58
- Lotka's renewal equation for population growth 311–312, 319–320
- Lucilia cuprina* (Australian sheep–blowfly) 149–150
- MacArthur–Wilson theory of extinction time 287–293, 317–318
- macroparasites 168–169
- malaria
  - annual death rate 188–189
  - caused by parasitic *Plasmodium* spp. 189–190, 207
  - cycle of infection 189–190
  - history of study and fight against 188–189
  - mosquito vectors (*Anopheles* spp.) 188–193, 194, 207
  - standard vector model 190–193, 194, 207
  - vector-based disease 188–193, 194, 207
- marginal value theorem 5–8, 18, 178, 182, 183
- marine reserves (marine protected areas) model 231–236, 243–244
- Markov process 260–261
- mass action model for disease transmission 169–170, 172, 173
- Master Equation *see* Chapman–Kolmogorov equation
- mathematics, pure and applied 15
- mean 86–88
- mean-variance power laws 127–128
- metapopulation ecology 317–318
- microparasites 168–169
- MLE (maximum likelihood estimate) 91–95
- MNP (Maximum Net Productivity) 36, 37, 216, 218
- model selection, via likelihood ratio, AIC and BIC 130–132
- model testing, methods 129
- moments 86–88
- mortality
  - Gompertz mortality model 319–320
  - see also* predation and random search
- mortality plateaus 320
- MSY (Maximum Sustainable Yield) 216, 218, 241
- multinomial distribution 95
- mutualism 48–49, 77
- Nasionia vitripennis* (parasitoid) 144
- negative binomial distribution (first form) 102–103
- negative binomial distribution (second form) 103–104, 106, 107–112
  - comparison with Poisson distribution 106, 109, 110, 111
- negative binomial model of disease transmission 172–173
- Neyman, Jerzy 125–127
- Nicholson–Bailey model (population dynamics) 135–137
  - effects of host refuges 137, 142–145
  - effects of multiple attacks 143–145
  - instability 135–140
  - stabilization 137, 141–145, 164
  - variation in attack rate 137, 141–143
- no-flux boundary conditions 62–64
- noise
  - blue 283
  - Gaussian white 261–264
  - red 283
- non-informative priors 128–129
- non-invadable sex ratio 10–12, 18–19
- non-negative measurements 121–122
- normal (Gaussian) distribution 112–116
- normal probability density function 112–113
- observation error and process uncertainty 228–231, 238, 243
- open and closed population models 214–215
- optical activity, and spontaneous asymmetric synthesis 56–58, 76–77
- optimal age at maturity 27–28
- optimal foraging theory 317–318

- optimal immune response 201–205, 208  
   T-cell phenotypes in multiple infections 201–203  
   trade-off with reproduction 203–205
- optimal virulence level 176–178, 182, 183
- Ornstein–Uhlenbeck process 264–268, 282–283
- oscillations 54–55  
   relaxation oscillations 46, 47–48, 74–76
- OSP (Optimal Sustainable Population size) 217–218
- parasite burden  
   costs to an organism 203–205  
   optimal response to 203–205
- parasites *see* helminth worm parasites
- parasitic wasps, sex ratio bias 10–12, 18
- parasitoids  
   behavior and population dynamics combined 155–159, 160, 166–167  
   classification of life histories 133, 135  
   delay differential models for host–parasitoid dynamics 164  
   egg limitation on reproductive effort 159–164  
   evolution of host choice 150–155, 165  
   Nicholson–Bailey model 135–137  
   Nicholson–Bailey model instability 135–140  
   Nicholson–Bailey model stabilization 137, 141–145, 164  
   overlapping generations in continuous time 145–150  
   pheromone marking of hosts 165  
   reproductive success factors 159–164  
   spatial aspects of host interaction 164  
   time limitation on reproductive effort 159–164  
   typical species 133, 134  
   wide range of topics for investigation 165
- parent–offspring conflict, egg size in Atlantic salmon 8–10, 18
- patch leaving 123–124, 125, 165
- path integrals 282
- per capita growth rate 36–38, 74  
   as a measure of fitness 31–36  
   spatial variation 31–32  
   temporal variation 32–36
- persistence time  
   density independent diffusion approximation 292, 297–301, 299  
   general density dependent case 301, 301–302  
   *see also* extinction times
- pest outbreak, relaxation oscillations 46, 47–48, 74–76
- phase plane 49–50, 51, 56–58, 76
- pheromone marking by parasitoids 165
- plane geometry, marginal value theorem 5–8, 18
- plankton bloom, relaxation oscillations 46, 47–48, 74–76
- Plasmodium* spp., cause of malaria 189–190, 207
- Poisson distribution 95–100  
   comparison with negative binomial distribution 106, 109, 110, 111
- Poisson increment 279–281
- Poisson limit of the binomial 100
- Poisson process, gamma density conjugate prior 112
- population biology of disease  
   basic reproductive rate of a disease ( $R_0$ ) 171  
   cholera 208  
   complexity of models 169  
   contagiousness (infectiousness) 176–178, 182, 183  
   cultural and behavioral effects 207  
   demographic processes added to models 179–181  
   ecological aspects of disease models 207  
   evolution of virulence 178, 182–188, 206  
   force of infection 169–170  
   frequency dependent model for transmission 172, 173  
   general literature 205–206  
   helminth worms 193–201, 208  
   hepatitis C virus spread 169–170  
   Kermack–McKendrick epidemic theorem 174–175, 177  
   macroparasites 168–169  
   malaria 188–193, 194, 207  
   mass action model for transmission 169–170, 172, 173  
   microparasites 168–169  
   negative binomial model of transmission 172–173  
   optimal immune response 201–205, 208  
   optimal virulence level for a disease organism 176–178, 182, 183  
   power model for transmission 172  
   prion disease kinetics 208  
   relationship between virulence and contagion 176–178, 182, 183  
   relevance of 168–169  
   role of genomics and bioinformatics 168–169  
   SI model 169–171  
   SIR model of epidemics 173–178, 179–181, 206, 207  
   SIRS model of endemic diseases 178–181, 206, 207  
   spatial aspects of disease transmission 209  
   standard vector model for malaria 190–193, 194  
   stochastic epidemics 209  
   transmission between infected and susceptible individuals 171–173  
   transmission models 171–173  
   vector-based diseases 188–193, 194, 207  
   virulence (infectiousness) 176–178, 182, 183
- population demography, Euler–Lotka equation 311–314, 319–320
- population dynamics and behavior combined 155–159, 160, 166–167

- population dynamics models  
 advanced models 145–150  
 delay differential models 164  
 overlapping generations in continuous time 145–150  
*see also* Nicholson–Bailey model
- population genetics *see* genetic models
- population growth  
 deterministic chaos 40–43, 74  
 in fluctuating environments 31–36, 73–74  
 rate of 36–38, 74
- population oscillations, relaxation oscillations 46, 47–48, 74–76
- population size  
 catastrophic changes in 294–296, 318  
 ceiling 293–296, 318  
 MacArthur–Wilson theory of extinction time 287–293, 317–318
- power model for disease transmission 172
- predation and random search 20–23, 24
- predator–prey interactions 48–49, 57–58
- prion disease kinetics 208
- priors *see* conjugate priors; non-informative priors
- probability density function 84–85
- probability distributions  
 binomial distribution 88–95  
 chi-square distribution 115–116  
 log-normal distribution 121–122  
 multinomial distribution 95  
 negative binomial distribution (first form) 102–103  
 negative binomial distribution (second form) 103–104, 106, 107–112  
 normal (Gaussian) distribution 112–116, 115  
 Poisson distribution 95–100, 106, 109, 110, 111  
*t*-distribution 80–81, 119–121, 130
- probability model, connection between data sample and data source 101, 102
- probability theory 81–88  
 Bayes's Theorem 82, 83–84  
 coefficient of variation 87–88  
 conditional probability 81–84, 85–86  
 continuous random variables 84–85, 86–88  
 discrete random variables 84–85, 86–88  
 distribution function 84–85  
 events 81–84, 82, 85  
 expectation 86–88  
 experiments 81–82  
 exponential distribution function 85–86  
 law of total probability 82, 83–84  
 mean 86–88  
 moments 86–88  
 probability density function 84–85  
 random variables 84–85  
 sample space 81–82  
 standard deviation 87–88  
 variance 86–88
- process uncertainty and observation error 228–231, 238, 243
- punctuated equilibrium 309–311, 319
- random search and predation 20–23, 24
- random search with depletion 100–101
- random variables 84–85
- reaction-diffusion equations 79
- red noise 283
- reflecting boundary conditions 62–64
- relative size at maturity 29, 30, 73
- relaxation oscillations 46, 47–48, 74–76
- renewal processes 18
- resistance, evolution of 182, 206
- Rhagoletis basiola* (rose hip fly) 134
- Rhagoletis completa* (walnut husk fly) 134
- Ricker map 39–40
- Ricker recruitment function 74
- Ricker stock–recruitment relationship 212, 213, 239–241
- saddle point 49–50, 51, 54, 56–58, 71–73
- salmon fisheries management 227–228, 242–243
- salmon life histories 227, 242–243  
*see also* Atlantic salmon
- sample space 81–82
- Schaefer model and its extensions 215–218, 220–221
- Seber's delta method 35–36
- separation of variables 62–64, 78
- sex ratio bias 10–12, 18
- SI* model of disease spread in a population 169–171
- SIR* model of epidemics 173–178, 179–181, 206, 207
- SIRS* model of endemic diseases 178–181, 206, 207
- spatial aspects of disease transmission 209
- spatial aspects of host–parasitoid interaction 164
- spatial variation in per capita growth rate 31–32
- spiral point (steady state) 54–55, 71–73
- spontaneous asymmetric synthesis, and optical activity 56–58, 76–77
- stable node 49–50, 51, 54, 56–58, 71–73
- standard deviation 87–88
- statistical analysis  
 Bayesian approach 125–127, 128–129  
 frequentist approach 125–127
- steady states  
 classification 48–58, 71–73, 74–76  
 determination of stability 137–140

- stochastic calculi 282, 318–319
- stochastic differential equations 283
- stochastic dynamic programming 151–155, 158, 161–164, 165–166
- stochastic epidemics 209
- stochastic harvesting equation 278–279
- stochastic integrals 264–268
- stochastic models 228–231, 233–236
- stochastic population dynamics
- alternative to Brownian motion 279–281
  - backward equations 268–272, 276–279, 284
  - Brownian motion 251–254, 260–264, 282
  - Chapman–Kolmogorov equation (Master Equation) 270, 272
  - derivative of Brownian motion 261–264
  - Feynman–Kac formula 276–278, 282
  - forward equations 272–276, 278, 284
  - from deterministic to stochastic dynamics 248–251
  - gambler's ruin in a biased game 257–260
  - gambler's ruin in a fair game 253, 254–257
  - Gaussian white noise 261–264
  - general diffusion processes 268–272
  - independent increments 282
  - Kolmogorov backward equation 268–272
  - Kolmogorov forward equation 272–276
  - Markov process 260–261
  - nature of stochastic processes 248
  - Ornstein–Uhlenbeck process 264–268, 282–283
  - path integrals 282
  - Poisson increment 279–281
  - stochastic differential equations 283
  - stochastic harvesting equation 278–279
  - stochastic integrals 264–268, 283
  - thinking along sample paths (trajectories) 248–251, 282
  - transition density and covariance of Brownian motion 260–261
- stochastic population theory (ecological applications) 283–284
- Anderson's theory of vitality 314–316
  - biodemography of survival 311–314, 319–320
  - catastrophic changes to population size 294–296
  - connecting models and data 319
  - density independent diffusion approximation 292, 297–301
  - diffusion approximation 318–319
  - escape from a domain of attraction 285–287, 317
  - Euler–Lotka equation of population demography 311–314, 319–320
  - general density dependent case 301–302
  - life tables 311–312, 319–320
  - MacArthur–Wilson theory of extinction time 287–293
  - population genetics applications 284
  - punctuated equilibrium 309–311
  - role of a ceiling on population size 293–296
  - transitions between adaptive peaks 302–311
- stock–recruitment relationships 212–215, 239–241
- Stratonovich calculus 282, 318–319
- Student's *t*-random variable 119–120
- superparasitism 165
- survival
- Anderson's theory of vitality 314–316
  - biodemography of 311–314, 319–320
  - Euler–Lotka equation of population demography 311–314, 319–320
  - life tables 311–312, 319–320
- t*-distribution 80–81, 119–121, 130
- Taylor, L. R. 127–128
- temporal variation in per capita growth rate 32–36
- theoretical biology
- building intuition about biological systems 15–17
  - gaining mathematical skills 15–17
  - importance of writing skills 14–15, 19
  - interaction of mathematics and science 1–2
  - toolbox metaphor 12–15
- total least squares 118–119, 130
- traveling waves 69–73
- two prey diet choice problem 3–5, 18
- unbeatable (uninvadable) sex ratio 10–12, 18–19
- unstable node 49–50, 51, 54, 56–58
- variance 86–88
- vector-based diseases, malaria 188–193, 194, 207
- Verdi, Giuseppe 15–17
- virulence
- AIDS virus 182, 208
  - and contagion 176–178, 182, 183
  - coevolution with host response 184–188
  - drug resistance 182
  - evolution of 178, 182–188
  - leader–follower (Stackelberg) game 184–185
  - optimal level 178, 182, 183
  - timescale of evolution 182
  - unbeatable (ESS) level of virulence 182–184
- viruses
- spread of hepatitis C 169–170
  - viral dynamics and AIDS 182, 208
- von Bertalanffy, Ludwig 23–29, 30
- Wiener process 251
- writing and the creative process 14–15, 19