## **Contents**

1	Introduction			1
	1.1		ific Frontiers at the Interface of Mathematics and Life Sciences adra V. Antoniouk and Roderick V. N. Melnik	3
		1.1.1	Developing the Language of Science and	
			Its Interdisciplinary Character	3
		1.1.2	Challenges at the Interface: Mathematics and Life Sciences	5
		1.1.3	What This Book Is About	10
		1.1.4	Concluding Remarks	14
2	Ma	themati	ical and Statistical Modeling of Biological Systems	17
	2.1	Ensem	able Modeling of Biological Systems	19
		David	Swigon	
		2.1.1	Introduction	19
		2.1.2	Background	21
		2.1.3	Ensemble Model	25
		2.1.4	Computational Techniques	27
		2.1.5	Application to Viral Infection Dynamics	30
		2.1.6	Ensemble Models in Biology	34
		2.1.7	Conclusions	36
3	Pro	Probabilistic Models for Nonlinear Processes and Biological Dynamics		
	3.1	Nonlii	near Lévy and Nonlinear Feller Processes:	
		an An	alytic Introduction	45
		Vassil	i N. Kolokoltsov	
		3.1.1	Introduction	45
		3.1.2	Dual Propagators	49
		3.1.3	Perturbation Theory for Weak Propagators	52
		3.1.4	T-Products	54
		3.1.5	Nonlinear Propagators	57
		3.1.6	Linearized Evolution Around a Path of a Nonlinear Semigroup	60
		317	Sensitivity Analysis for Nonlinear Propagators	64



		3.1.8	Back to Nonlinear Markov Semigroups	66
		3.1.9	Concluding Remarks	68
4	New	v Result	s in Mathematical Epidemiology and Modeling Dynamics	
	of I	nfectiou	is Diseases	71
	4.1		l Solutions of Epidemic Equation	73
		4.1.1	Introduction	73
		4.1.2	Epidemic Models	75
		4.1.3	Formal Solutions	76
		4.1.4	Separation of Variables	79
		4.1.5	Solvability of General Equations	80
		4.1.6	Concluding Remarks	84
5	Mat	themati	cal Analysis of PDE-based Models and Applications	
		Cell Biol		87
	5.1	ototic Analysis of the Dirichlet Spectral Problems  n Perforated Domains with Rapidly Varying Thickness fferent Limit Dimensions	89	
		5.1.1	Introduction	89
		5.1.2	Description of a Thin Perforated Domain with Quickly	0,
			Oscillating Thickness and Statement of the Problem	90
		5.1.3	Equivalent Problem	92
		5.1.4	The Homogenized Theorem	94
		5.1.5	Asymptotic Expansions for the Eigenvalues and	
			Eigenfunctions	100
		5.1.6	Conclusions	107
6	Axi	omatic	Modeling in Life Sciences with Case Studies	
	for	Virus-i	mmune System and Oncolytic Virus Dynamics	111
	6.1		natic Modeling in Life Sciences	113
		6.1.1	Introduction	113
		6.1.2	Boosting Immunity by Anti-viral Drug Therapy:	
			Timing, Efficacy and Success	115
		6.1.3	Predictive Modeling of Oncolytic Virus Dynamics	123
		6.1.4	Conclusions	138

7	The	ory, Ap	oplications, and Control of Nonlinear PDEs in Life Sciences	145
	7.1		ne Semilinear Parabolic Equation of Normal Type	147
		7.1.1	Introduction	147
		7.1.2	Semilinear Parabolic Equation of Normal Type	148
		7.1.3	The Structure of NPE Dynamics	153
		7.1.4	Stabilization of Solution for NPE by Start Control	158
		7.1.5	Concluding Remarks	159
	7.2		me Classes of Nonlinear Equations with $L^1$ -Data	161
		7.2.1	Nonlinear Elliptic Second-order Equations with $L^1$ -data	162
		7.2.2	Nonlinear Fourth-order Equations with Strengthened	
			Coercivity and L <sup>1</sup> -Data	178
		7.2.3	Concluding Remarks	185
8	Ma	themati	ical Models of Pattern Formation and Their Applications	
	in E	)evelop	mental Biology	189
	8.1	Reacti	on-Diffusion Models of Pattern Formation	
	in Developmental Biology		elopmental Biology	191
		Anna l	Marciniak-Czochra	
		8.1.1	Introduction	191
		8.1.2	Mechanisms of Developmental Pattern Formation	193
		8.1.3	Motivating Application: Pattern Control in <i>Hydra</i>	
		8.1.4	Diffusive Morphogens and Turing Patterns	197
		8.1.5	Receptor-based Models	200
		8.1.6	Multistability	206
		8.1.7	Discussion	207
9	Mo	deling t	the Dynamics of Genetic Mechanism, Pattern Formation,	
	and	the Ge	enetics of "Geometry"	213
	9.1	Mode	ling the Positioning of Trichomes on the Leaves of Plants	215
		Robert	t S. Anderssen, Maureen P. Edwards and Sergiy Pereverzyev Jr.	
		9.1.1	Introduction	215
		9.1.2	Activator-inhibitor Reaction-diffusion Modeling	
			of the Trichome Positioning	
		9.1.3	Hexagonal Recursion	221
		9.1.4	Conclusions	225

10	Statistical Modeling in Life Sciences and Direct Measurements			
	10.1 Error Estimation for Direct Measurements in May-June 1986 of <sup>131</sup> I Radioactivity in Thyroid Gland of Children and Adolescents and Their Registration in Risk Analysis			
	10.1.1 Introduction	231		
	10.1.2 Materials and Methods			
	10.1.3 Conclusion and Discussion	239		
	10.1.4 Appendix. Approximation of Conditional Expectations	240		
11	Design and Development of Experiments for Life Science Applications	245		
	11.1 Physiological Effects of Static Magnetic Field Exposure in an in vivo			
	Acute Visceral Pain Model in Mice	247		
	János F. László			
	11.1.1 Introduction	247		
	11.1.2 Methods			
	11.1.3 Results			
	11.1.4 Discussion	266		
	11.1.5 Conclusions	269		
12	Mathematical Biomedicine and Modeling Avascular Tumor Growth	277		
	12.1 Continuum Models of Avascular Tumor Growth	279		
	Helen M. Byrne			
	12.1.1 Introduction	279		
	12.1.2 Diffusion-limited Models of Avascular Tumor Growth	281		
	12.1.3 Tumor Invasion	289		
	12.1.4 Multiphase Models of Avascular Tumor Growth	295		
	12.1.5 Conclusions	303		
Ind	PX	313		