CONTENTS

1. ENZYME KINETICS
1.1 Introduction .......................................................... 1
1.2 Michaelis-Menten theory and the pseudo-steady state hypothesis ........................................ 2
1.3 Enzyme-substrate-inhibitor system and an experimental example .......................................... 20
1.4 Allosteric enzymes and the Monod-Wyman-Changeux model ................................................. 32
References ............................................................................. 40

2. FACILITATED DIFFUSION
2.1 Physiological background and observed phenomena ................................................................. 42
2.2 Steady state model and governing equations .............................................................................. 46
2.3 Asymptotic solutions and comparison with experiment ............................................................. 53
2.4 Facilitated diffusion and the case of carbon monoxide ............................................................ 63
2.5 Biological interpretation of results and general principles for facilitated diffusion of a ligand by a macromolecular carrier ................................................................. 68
2.6 Model for muscle respiration: role of myoglobin .................................................................... 70
References ............................................................................. 82

3. REDUCTION OF DIMENSIONALITY IN DIFFUSION PROCESSES: ANTENNA RECEPTORS OF MOTHS
3.1 Introduction ....................................................................... 83
3.2 Reduction of dimensionality in diffusion processes ................................................................. 87
3.3 Mean times for diffusion ........................................................................................................... 90
3.4 Coupled three-dimensional and surface diffusion processes .................................................... 98
3.5 Application of dimensional reduction in diffusion to the sex-attractant receptors of the silk moth ................................................................................................................. 101
3.6 Collection efficiency of an isolated sensillum: Peclet number Pe < 1 ..................................... 107
3.7 Collection efficiency of an isolated sensillum: Peclet number Pe ≥ 1 ....................................... 111
3.8 Application to antennae filter and threshold experiments in bombykol olfaction ................... 118
References ............................................................................. 126

4. BIOLOGICAL OSCILLATORS I. HOMOGENEOUS TEMPORAL OSCILLATIONS
4.1 Introduction, Monod-Jacob model and practical examples ...................................................... 128
4.2 Lotka-Volterra system ............................................................................................................. 136
4.3 General principles for real biological oscillators ...................................................................... 141
4.4 Simple hypothetical model chemical reaction exhibiting ........................................................ 160
References ............................................................................. 165
4.5 Belousov-Zhabotinskii reaction and its model mechanism 159
4.6 Linear and global analysis of the model system 168
4.7 Model enzyme synthesis control system 178
4.8 Higher-order enzyme synthesis control systems, delay models, and some general results 184
4.9 Model oscillator with substrate inhibition 193

References 199

5. BIOLOGICAL OSCILLATORS II. SPATIAL STRUCTURE AND NONLINEAR WAVE PHENOMENA

5.1 Introduction 203
5.2 Kinematic waves: spatial structures without diffusion 212
5.3 Fisher equation and propagating wave solutions 217
5.4 Asymptotic wave form and stability of wave solutions of Fisher's equation 226
5.5 Travelling wave model for the Belousov-Zhabotinskii reaction 233
5.6 Travelling wavefront solutions for the Belousov-Zhabotinskii reaction and comparison with experiment 239
5.7 Reaction-diffusion travelling waves 244
5.8 Reaction-diffusion systems in finite domains: large time behaviour and spatial structures 252
5.9 Diffusive instability and spatial structures in reaction-diffusion systems in finite domains 264

References 272

MATHEMATICAL APPENDICES

A1. SINGULAR PERTURBATION THEORY: MATCHED EXPANSION PROCEDURES

A1.1 Introduction and basic definitions 275
A1.2 Simple illustrative examples and intuitive approach 279
A1.3 Matching technique and non-trivial example 292
A1.4 Asymptotic procedure for systems of first order differential equations 302
A1.5 Exponential asymptotic procedure 310

References 313

A2. BOUNDARY CONDITIONS AND FACILITATED DIFFUSION: MATHEMATICAL ANALYSIS 314

A3. LINEAR DIFFUSION EQUATION: SPECIAL SOLUTIONS

A3.1 Two-dimensional axially symmetric diffusion 327
A3.2 Three-dimensional radially symmetric diffusion in \( a \leq r \leq b \) 330
A3.3 Similarity solutions for a class of diffusion equations 332

A4. HOPF BIFURCATION THEOREM AND LIMIT CYCLES 336

A5. SOME MATHEMATICAL RESULTS FOR REACTION-DIFFUSION SYSTEMS

A5.1 Existence and uniqueness of bounded solutions for a class of reaction-diffusion equations 354
A5.2 Bounds for the speed of propagation of wave solutions of a model system for the Belousov-Zhabotinskii reaction 356
A5.3 General results for the Laplacian operator in bounded domains 359

INDEX 363