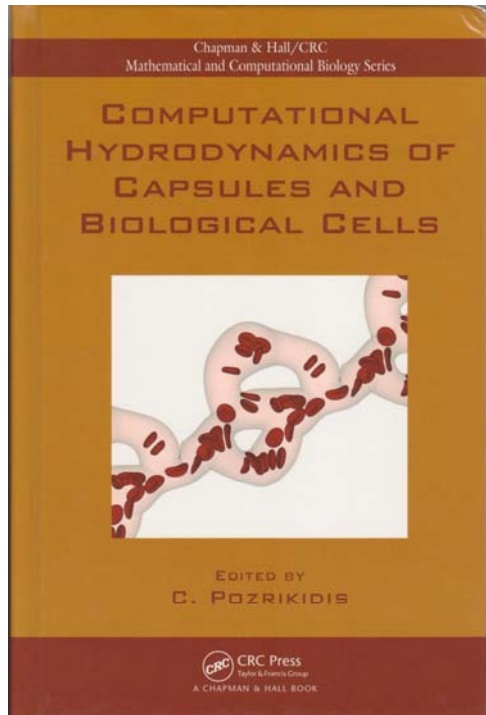


CONSTANTINE POZRIKIDIS (EDITOR) COMPUTATIONAL HYDRODYNAMICS OF CAPSULES AND BIOLOGICAL CELLS



CRC Press
ISBN-13: 978-1-4398-2005-6
Hardcover
311 pages
1st Edition (2010)

Spanning biological, mathematical, computational, and engineering sciences, computational biofluidynamics addresses a diverse family of problems involving fluid flow inside and around living organisms, organs, tissue, biological cells, and other biological materials. **Computational Hydrodynamics of Capsules and Biological Cells** provides a comprehensive, rigorous, and current introduction to the fundamental concepts, mathematical formulation, alternative approaches, and predictions of this evolving field.

In the first several chapters on boundary-element, boundary-integral, and immersed-boundary methods, the book covers the flow-induced deformation of idealized two-dimensional red blood cells in Stokes flow, capsules with spherical unstressed shapes based on direct and variational formulations, and cellular flow in domains with complex geometry. It also presents simulations of microscopic hemodynamics and hemorheology as well as results on the deformation of capsules and cells in dilute and dense suspensions. The book then describes a discrete membrane model where a surface network of viscoelastic links emulates the spectrin network of the cytoskeleton, before presenting a novel two-dimensional model of red and white blood cell motion. The final chapter discusses the numerical simulation of platelet motion near a wall representing injured tissue. This volume provides a roadmap to the current state of the art in computational cellular mechanics and biofluidynamics.

It also indicates areas for further work on mathematical formulation and numerical implementation and identifies physiological problems that need to be addressed in future research. MATLAB[®] code and other data are available at <http://dehesa.freeshell.org/CC2>.

Table of Contents

	Preface	xi
	About the Editor	xv
Chapter 1	Flow-Induced Deformation of Two-Dimensional Biconcave Capsules	1
	<i>C. Pozrikidis</i>	
	1.1. Introduction	1
	1.2. Mathematical framework	4
	1.3. Numerical method	9
	1.4. Cell shapes and dimensionless numbers	13
	1.5. Capsule deformation in infinite shear flow	15
	1.6. Capsule motion near a wall	25
	1.7. Discussion	30

Chapter 2	Flow-Induced Deformation of Artificial Capsules	35
	<i>D. Barthès-Biesel, J. Walter, A.-V. Salsac</i>	
	2.1. Introduction	35
	2.2. Membrane mechanics	38
	2.3. Capsule dynamics in flow	43
	2.4. B-spline projection	46
	2.5. Coupling finite elements and boundary integrals	52
	2.6. Capsule deformation in linear shear flow	57
	2.7. Discussion	65
Chapter 3	A High-resolution Fast Boundary-integral Method for Multiple Interacting Blood Cells	71
	<i>Jonathan B. Freund, Hong Zhao</i>	
	3.1. Introduction	72
	3.2. Mathematical framework	77
	3.3. Fast summation in boundary-integral computations	83
	3.4. Membrane mechanics	87
	3.5. Numerical fidelity	90
	3.6. Simulations	96
	3.7. Summary and outlook	104
Chapter 4	Simulating Microscopic Hemodynamics and Hemorheology with the Immersed-Boundary Lattice-Boltzmann Method	113
	<i>J. Zhang, P. C. Johnson, A. S. Popel</i>	
	4.1. Introduction	114
	4.2. The lattice-Boltzmann method	116
	4.3. The immersed-boundary method	121
	4.4. Fluid property updating	123
	4.5. Models of RBC mechanics and aggregation	124
	4.6. Single cells and groups of cells	126
	4.7. Cell suspension flow in microvessels	134
	4.8. Summary and discussion	142
Chapter 5	Front-Tracking Methods for Capsules, Vesicles, and Blood Cells	149
	<i>Prosenjit Bagchi</i>	
	5.1. Introduction	149
	5.2. Numerical method	153
	5.3. Capsule deformation in simple shear flow	157
	5.4. Capsule interception	164
	5.5. Capsule motion near a wall	167
	5.6. Suspension flow in a channel	168
	5.7. Rolling on an adhesive substrate	170
	5.8. Summary	173
Chapter 6	Dissipative Particle Dynamics Modeling of Red Blood Cells	183
	<i>D. A. Fedosov, B. Caswell, G. E. Karniadaki</i>	
	6.1. Introduction	184
	6.2. Mathematical framework	185
	6.3. Membrane mechanical properties	190
	6.4. Membrane-solvent interfacial conditions	196
	6.5. Numerical and physical scaling	197
	6.6. Membrane mechanics	198
	6.7. Membrane rheology from twisting torque cytometry	202
	6.8. Cell deformation in shear flow	204
	6.9. Tube flow	209
	6.10. Summary	212

Chapter 7	Simulation of Red Blood Cell Motion in Microvessels and Bifurcations	219
	<i>T. W. Secomb</i>	
	7.1. Introduction	219
	7.2. Axisymmetric models for single-file RBC motion	222
	7.3. Two-dimensional models for RBC motion	225
	7.4. Tank-treading in simple shear flow	229
	7.5. Channel flow	231
	7.6. Motion through diverging bifurcations	232
	7.7. Motion of multiple cells	235
	7.8. Discussion	239
Chapter 8	Multiscale Modeling of Transport and Receptor-Mediated Adhesion of Platelets in the Bloodstream	245
	<i>N. A. Mody, M. R. King</i>	
	8.1. Introduction	246
	8.2. Mathematical framework	253
	8.3. Motion of an oblate spheroid near a wall in shear flow	258
	8.4. Brownian motion	266
	8.5. Shape and wall effects on hydrodynamic collision	274
	8.6. Transient aggregation of two platelets near a wall	283
	8.7. Conclusions and future directions	294
	Index	309