Preface

This book originates from my doctoral thesis. One of the first problems of my work was to describe the spread of an infectious disease by a diffusion process and to statistically estimate the involved model parameters. At that time, I did not expect such a seemingly straightforward task to surface so many diverse open problems to fill an entire book. As a mathematician by training, I knew about stochastic calculus, but I did not anticipate the troubles of deriving diffusion approximations and inferring their parameters from real data.

When delving into the diffusion approximation literature, I noticed that there were several, at first sight, contradicting approaches, some of them formulated in generality, others being carried out for particular problems. Their appropriateness, differences and conformities, however, were unclear as well as their extension to more complex, e.g. multidimensional, processes. Furthermore, parameter estimation for diffusions is a challenging problem, in particular if the application of interest involves multi-dimensional processes, few observation times, latent variables and considerable measurement error. Under these circumstances, probably the only applicable technique is a popular Bayesian approach which is used in a number of scientific papers. I was astonished that I could not find any textbook which comprehensively explained it. Moreover, the method has a well-known but hard-to-grasp convergence problem, which has not been detailed in any book or review so far. Since I am convinced that these are subjects of wide-spread interest and importance, I dedicated to them the major chapter in each of the first two parts of this book. The third part finally addresses the initial project which triggered the theoretical questions: to estimate a diffusion model for the spread of diseases.

In contrast to existing literature, this book treats modelling and inference for diffusions under one umbrella. It thus covers both steps that necessarily arise in a real application. Importance is attached to presenting the methods both comprehensibly and mathematically well-founded. As such, the book addresses both theoreticians, like mathematicians and statisticians, as well as practitioners, like bioinformaticians and biologists. The reader is required to have basic knowledge about deterministic differential equations, probability theory and statistics. An introduction to stochastic calculus, in particular to diffusions, is provided in this book.

Everybody who supported me during the writing of my thesis "Bayesian Inference for Diffusion Processes with Applications in Life Sciences", submitted in 2010 at Ludwig-Maximilians-Universität Munich under my maiden name Christiane Dargatz, also supported the making of this book. My sincere gratitude is due to my supervisors Ludwig Fahrmeir and Gareth Roberts. They enriched my work through their advice, ideas and encouragement. I deeply appreciate the careful proof-reading and helpful comments by Michael Höhle. Katrin Schneider and Lothar Schermelleh deserve my thanks for having initiated the collaboration on the FRAP project and having collected all the data. I thank my former and present colleagues at Ludwig-Maximilians-Universität Munich and Helmholtz Centre Munich for their interest and helpful discussions. Furthermore, I thank Niels Thomas and Alice Blanck from Springer for the friendly and constructive cooperation. My family has been a constant source of support, which I greatly acknowledge. My heartfelt gratitude is due to my husband Florian, who caringly accompanied me and my work all chapters long.

Munich, Germany Christiane Fuchs