bibliography from standard journals.

Sornette goes on to verify his theory—that stock market crashes are manifestations of a phase transition—against historic financial data. In these three penultimate chapters, which, sadly, are dull in comparison with the earlier six, he has incorporated dreary time-series plots with opaque fits. The text in these chapters is plagued with inconsistent notations and mind-numbing displays of tables filled with irrelevant data, which suggest that the author perhaps rehashed previous papers to meet the publisher's deadline. These three chapters break the spell that Sornette initially had cast upon readers in the first six chapters, which are wonderful to read. Just one chapter instead of three might have better carried the message across to readers.

In his final chapter, Sornette widens the scope of his analysis to include global economic data. By looking at the past 10 or more years, he observes the onset of a phase transition and predicts that around 2050 the world economy is likely to shift into another regime. The evidence he provides may not be convincing to some readers, but his prediction is precise and bold.

Sornette provides many clues as to why stock markets crash. However, the many references to the renormalization group, network theory, and complex fractal dimensions appear as anecdotal analogies. Most physicists are unlikely to be impressed by the quality of the fits to the data. The models seem to contain many parameters, and little is said about the goodness of the fits. Sornette insists on the universality of the values taken by some of the parameters, such as the critical exponent and scaling ratio. However, he offers little evidence for this phenomenon, nor any kind of physical interpretation. In essence, the evidence is intriguing but not yet too convincing.

In the end, readers may be ambivalent about Sornette's book. On one hand, they may feel dissatisfied that this book only summarizes a work still in progress; on the other, they may be gratified by the prospect that there is more to discover. Although Sornette's book contains a couple of weak chapters, it nevertheless provides a captivating account of recent developments in econophysics. I thoroughly enjoyed the book, which substantially widened my horizons. Perhaps *Why Stock Markets Crash* will inspire more physicists to also extend the scope of their investigations to new realms and become, like Sornette, founding members of new branches of physics.

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Essential Mathematical Biology

Nicholas F. Britton
Springer-Verlag, New York, 2003. $34.95 (335 pp.).
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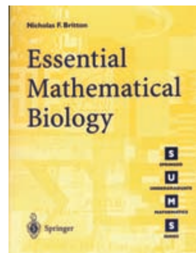
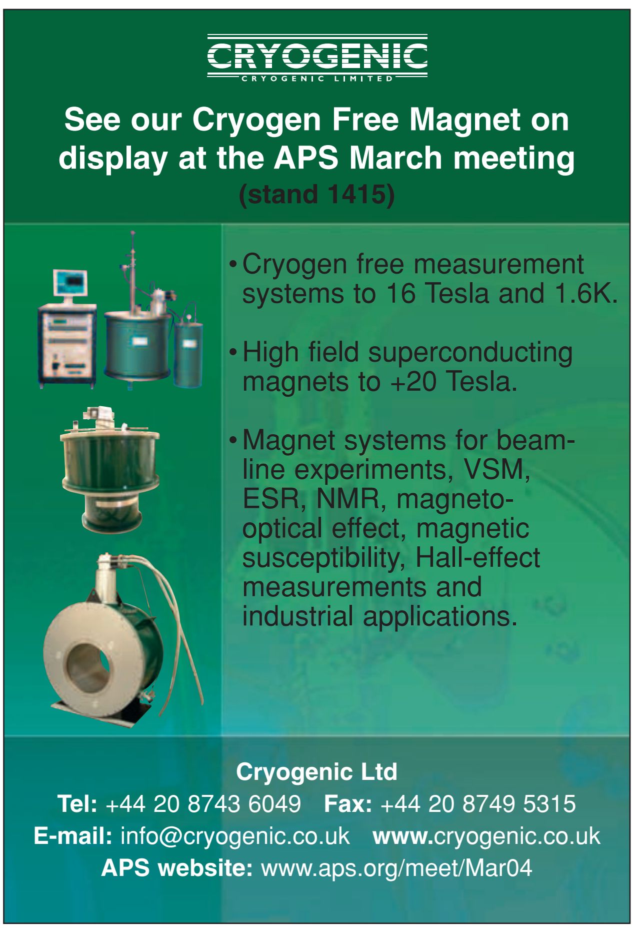
Those of us in mathematical biology like to imagine our field on the verge of achieving critical opalescence, in which the distinct characteristics of mathematicians, biologists, and even physicists are dissolved into a glittering new unity. More precise measurement techniques in molecular biology, evolutionary biology, and ecology are pushing strategic modelers like me





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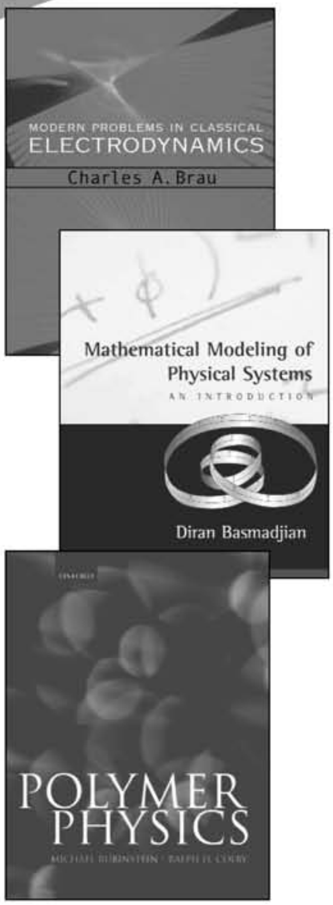

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(who ask, "Could this mechanism produce that phenomenon in principle?") to become predictive modelers (who ask, "Are these measured rate constants and interactions consistent with those experimental results?"). Biologists who collaborate closely with quantitative modelers may overcome the sting of Ernest Rutherford's remark that all of science is either physics or stamp collecting. Physicists, conversely, are realizing that it is biologists who now collect the most interesting stamps, as evidenced by the increasing number of physics journals that focus on biological questions.

As the field develops, it is a pleasure and challenge to share the wide spectrum of problems and approaches with eager undergraduates from various backgrounds. Several textbooks are available, now including *Essential Mathematical Biology* by Nicholas Britton. The author, director of the University of Bath's Centre for Mathematical Biology, exemplifies interdisciplinary approaches by bringing powerful applied mathematics to bear on such problems as the implications of habitat loss, coordination of social-insect colonies, and evolution of sex in plants, the fascination of which should not be underestimated.

The biological topics covered in Britton's new book are reasonably broad; they include models of competition and predation, diseases, evolution, motion, reaction kinetics, pattern formation, and tumor growth. The mathematical topics include the classics of mathematical biology: difference and differential equations, first-order partial differential equations for age-structured populations, and reaction–diffusion systems. The discussion of mathematical methods is supplemented by appendixes outlining the fundamental techniques.

I was disappointed that the author made this textbook so traditional and did not attempt to bring the new spirit of mathematical biology to life. The topics and the approach rarely capitalize on what we have learned in recent decades. *Mathematical Models in Biology*, by Leah Edelstein-Keshet (Random House, 1988) covers much of the same ground and often does a better job of motivating questions and explaining the mathematics. James D. Murray's *Mathematical Biology* (Springer-Verlag, 2003), a two-volume update of a 1989 text, also covers much of the same ground, although in a mathematically—and physically—heftier form.

I appreciate Britton's including basic models of evolutionary and game theory, strangely neglected in other books, but wish he had discussed the stochastic models that play a fundamental role in helping scientists interpret the recent flood of genetic-sequence data. The sections on metapopulations—populations viewed as unions of smaller units—introduce an important and neglected topic, but the author makes no connection with work on the genetic structure of populations. The chapter on tumor modeling is a welcome addition (although more in-depth material on this topic is included in Murray's book), but the generic models Britton considers give little sense of what makes different types of tumors behave differently.

Of course, difficult choices had to be made to keep the book in a compact and reasonably priced package. Undergraduate students unfamiliar with the complexity of modern biology could easily be overwhelmed by detailed models; they benefit most from understanding general principles. Nonetheless, any text must carefully motivate questions, and I often found that Britton's book fell short. For example, the bistable equation, which describes signal propagation in an excitable medium, is introduced with the mathematician's beloved "let f satisfy $f'(0) < 0$, $f'(1) < 0$, $f(u) < 0$ for u in $(0, a)$, $f(u) > 0$ for u in $(a, 1)$," but the equation's half-page coverage gives no idea under what circumstances such a function might arise. The section on delay-differential equations, which play a particularly important role in biological modeling, describes a generic system with a developmental delay and concludes, "More generally, the effect of delay is often to destabilize steady states." It does not, however, mention physiological examples or look at the period of the resulting oscillations.

More frustrating than the sketchy motivations was the publisher's failure to include a full bibliography of papers mentioned in the text and its decision to provide only a very sketchy index that omits authors of cited papers and major topics such as the bistable equation.

In short, *Essential Mathematical Biology* would serve well as a template for an advanced undergraduate or beginning graduate course in mathematical biology, but would require supplementation to bring the biology up to date, add exercises, clarify the motivations, and tie together different threads. A more advanced research physicist with a growing interest in biological philately might better taste the excitement of the field by having lunch with some biologists.

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