proach when they were found to be unattainable.

Cusumano recognizes that the Japanese approach to software development was facilitated by the structure of the domestic computer industry. Fewer competitors and a focus on mainframes rather than minicomputers and PCs (at least historically) meant that software was developed primarily for large computers with relatively stable architectures and applications. For those needs an emphasis on process refinement was appropriate. The U.S. market, with its rapid technological change and a preference for standardized software packages for small computers, is less suited to such a degree of control and conformity (which is probably also anathema to the average U.S. programmer).

Unfortunately, the lessons of Cusumano's detailed research are obscured by a tendency to core-dump all he has learned about a company into the book. As a consequence the reader must wrestle with succeeding sets of acronyms and charts of process flows. Moreover, Cusumano ultimately falls between two stools by including too much detail to make for exciting reading by the layperson, and too little detail for real learning by software engineers.

However, the more important drawback to the book is its failure to prove the superiority of the Japanese approach to software development. The detailed evidence presented on performance refers only to the Japanese marketplace. If the Japanese are so good at software development why do they not sell software outside Japan? Lacking a convincing argument on this point, the book becomes mainly descriptive. It does not, for example, compare the introduction of the factory approach to software development with its introduction in another industry (management of contracting, for example, seems to be analogous to software and is another area in which the Japanese claim to be superior to the United States), and so cannot elucidate broadly applicable lessons. Nor can the reader compare and contrast the two countries' management styles, for the book's description of the U.S. style of software development is limited to four companies and 25 pages. I believe there is basically a trade-off between the two approaches to software development—between a combination of productivity and program reliability on the one hand and product sophistication on the other. The Japanese approach may indeed be efficient at generating customized application programs in vertical markets, such as automated banking machines, traffic control, or reservations systems. It has been less effective in developing new standard programs, whether for operating systems or general business application. This has been the strength of U.S. software development. That more tightly managed development processes sacrifice innovation for efficiency is no surprise; whether the sacrifice is economically justified has yet to be determined.

Nevertheless, it is easy to criticize a book for what it is not. Cusumano has written a fine, detailed historical account of how the Japanese manage software development. It is possible that, as the ratio of hardware costs to software costs decreases, a relatively inelegant program, cheap to write but requiring more processing time and memory than a carefully crafted program, becomes economically desirable. If it does, then the Japanese approach to the management of software development may indeed pose, as Cusumano implies, an effective challenge to the current U.S. dominance of the software industry.

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Acoustic Strategies

Acoustic Behavior of Insects. An Evolutionary Perspective. WINSTON J. BAILEY. Chapman and Hall (Routledge, Chapman and Hall), New York, 1991. xvi, 225 pp., illus. $87.50.

Insects are the most successful of terrestrial beings, and in their lives we can find counterparts to our own. The ways in which they have adapted to life on earth can be viewed as models for the "Johnny-come-latelys" of evolution, including human beings. One is reminded that some renowned commentators on human social behavior—Alfred Kinsey, R. D. Alexander, and E. O. Wilson—were entomologists first (even the young Freud had a brief obsession with the brains of insects and crayfish before moving on). Behavioral biologists are rightly fascinated by the signals contained within the songs of birds, the croaking of frogs, and the howlings of monkeys, but it should not surprise us that crickets were chirping long before these animals and for the same "reasons." For all these animals, the "songs" are signals for survival.

Bailey's little book is about the role that acoustic signals play in the lives of insects. It is unusual in that it attempts to bring together two major themes of behavioral biology—evolution and mechanism—in the analysis of acoustic communication. Among recent books on the subject, the evolutionary theme is represented by Thornhill and Alcock's *The Evolution of Insect Mating Systems* (Harvard University Press, 1983) and the mechanist point of view by Ewing's *Arthropod Bioacoustics* (Cornell University Press, 1990) and Huber *et al.*'s *Cricket Behavior and Neurobiology* (Cornell University Press, 1988). None of these, nor a half-dozen other books on insect communication behavior, really provide a synthesis of the two disparate viewpoints of sociobiology and neuroethology. It is to Bailey's credit that he makes this attempt, and that is the value of this slim volume.

To do all this in one book is very ambitious given the extensive literature in insect bioacoustics and neuroethology. Nonetheless, Bailey provides a brief and readable introduction to the diverse mechanisms by which insects produce sounds, the multitude of kinds of "ears" that have evolved to hear them, and a glimpse at the way acoustic signals are detected, localized, and "recognized" by the nervous system. Like nearly all animals that hear, insects "use" acoustic signals to mediate behaviors relating to mating and territorial rights among members of the same species. Insects must also detect the presence of predators, some of which give themselves away by the sounds that they make. For a look at reproductive behavior, Bailey draws his examples from the orthopteroid insects (grasshoppers, crickets, katydids) as well as from his own work on cicadas. As an example of how insects detect acoustically active predators, Bailey recounts the story of insectivorous bats—which use ultrasonic biosonar signals to detect and localize flying insects—and the moths that evade the bats by hearing them and flying away.

A certain amount of detail is missing from Bailey's brief chapters that would deepen the reader's understanding of the bioacoustics and neurobiology that underlie insect bioacoustics, but a mechanistic account is not his major objective. The subtitle of his book is "An Evolutionary Perspective," and, taking a strict selectionist perspective, he tackles some big questions of behavioral ecology, such as the advantages of singing in a chorus, a behavior observed in cicadas, katydids, and tree crickets, among insects—but also seen in frogs and birds. He discusses the role of natural and sexual selection in the evolution of mating calls in insects and the "conflicts of interest" that confront male and female in sending and receiving these acoustic signals.

Bailey ends his book with a thought-provoking chapter on the evolution of social signals. Because this subject is as controversial as it is important in sociobiology, his musings will not find universal agreement. But I welcome this book because it represents an attempt at a synthesis that is sorely needed in behavioral biology, where evolutionary biologists tend to ignore questions about physiological mechanisms and dismiss their investigators as "watchmakers" and where neuroethologists, taking comfort in their "hard" data, tend to dismiss their sociobiological colleagues as philosophers. This is a book that should be read by advanced undergraduates and graduate students in neuroethology and biobehavioral science programs. I can also recommend it for anyone who has ever wondered, upon hearing crickets or katydids sing on a hot summer's night, how or why they do it. My main reservation about the book is actually a hope that the publisher will read this and bring it out as an affordable paperback.

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The Mathematics of Infection

Infectious Diseases of Humans. Dynamics and Control. ROY M. ANDERSON and ROBERT M. MAY. Oxford University Press, New York, 1991. viii, 757 pp., illus. $115.

Even as we near the end of a triumphant century for science, infectious diseases remain a threat to humans everywhere. Many such diseases have had a long association with humans and are thoroughly understood in biomedical terms, with effective vaccines at hand; some, like AIDS, are of relatively recent experience. Studies of infectious disease fall loosely into three categories: laboratory, field, and mathematical. Communication between these areas is improving but remains generally poor. Laboratory work focuses on the machinery of the parasite, with the golden prize being a vaccine or some other effective prophylactic. Fieldwork is an often urgent blend of epidemiological study and health-care delivery. Mathematical work ranges from the study of simple, general models to detailed statistical analysis of particular data sets. For those afflicted by disease (and there are millions, predominantly children, every year) the overriding concern is an integration of existing knowledge that allows effective use of scarce resources in the field. On the other hand, planners with longer time horizons can anticipate the development of new knowledge as well as improvements in infrastructure and political support.

What does mathematical work contribute to the ultimate objective of eliminating, or controlling, infectious disease? The answer depends on the distance between the mathematics and the facts. For most infectious diseases of humans, the facts consist of serial observations, what are called event-histories, recording the health of individuals in populations at risk. These event-histories are detailed, microlevel data, and they vary greatly in quality and completeness between diseases and countries. Closest to the data are statistical analyses that deal with the exploration of causal linkages (via probabilistic models) and with forecasting at different levels of aggregation (from community to country). At a greater remove are large-scale simulation models that attempt to mimic, in essential (but computationally tractable) detail, the course of an infectious disease over time in a population. Farthest from the facts are simple, "strategic" mathematical models, often inspired by theoretical population ecology and genetics, that attempt to elucidate the basic dynamic processes that determine the pattern of disease in space and time. Such strategic models are the subject expounded by Roy Anderson and Robert May in this large and important book.

The central goals of the mathematics that Anderson and May describe are qualitative insights of two kinds. First, if a common dynamic underlies all infectious disease processes, such processes can usefully be analyzed with a common set of qualitative and quantitative concepts and tools. They will also share qualitative static and dynamic properties. Second, any particular infectious disease is distinguished by a wealth of special biological, ecological, sociological, and other characteristics. As a way of coping sensibly with such detail, the mathematical modeler seeks to identify those features that are truly significant in determining the statics and dynamics of the particular disease.

The core of this book effectively synthesizes the burgeoning mathematical literature in a way that focuses on the basic insights obtainable from the theory. The book focuses on deterministic models; stochastic models are mentioned only occasionally. The authors make a pedagogically useful, if biologically loose, distinction between macroparasites (most flukes and worms) and microparasites (everything else). In this book, macroparasites are those for which it is important to keep track of individual parasite loads and infected individuals must be treated as a heterogeneous group. The first half-dozen chapters on microparasites bring together the work of many people in the last two decades; key concepts are identified (such as basic reproductive rate, thresholds, and herd immunity), many otherwise tedious formulas are compactly derived, and the important consequences of the key mathematical ideas are crisply explained. A valuable effort is made to illustrate the mathematical conclusions by reference to the specific details of particular infectious diseases. A later set of chapters does the same job for macroparasites. This material is likely to become the standard reference for mathematical modelers in this field, and should also be most useful to people entering the field and as a textbook in courses.

Standing somewhat apart from this core is approximately a third of the book, dealing with sexually transmitted diseases, various aspects of heterogeneity, and features peculiar to developing countries. There is an interesting discussion of sexually transmitted diseases, including AIDS, focusing on the need for certain kinds of data and on the special modeling strategies that appear fruitful. This work is still in its early stages; however, modeling has had an important early role in the scientific discourse surrounding AIDS.

The material on genetic and spatial heterogeneity and on developing countries makes a start on some important issues, but is not as well developed. This is a reflection of the literature, which has largely focused on the simplest genetic, spatial, and demographic assumptions. Many assumptions that underlie the models in this book are most appropriate to developed countries. For many diseases, especially childhood diseases, the pattern of prevalence is very different in developed and developing countries. Several diseases that are no longer a concern in developed countries have become serious problems in developing countries. The book makes a start, but a very sketchy one, at identifying critical assumptions that may need to be modified.

Another aspect of infectious disease in developing countries that is not addressed here is the widespread occurrence of multiple disease in the same individual. It is very likely that there is a strong historicity to the health status of children who are exposed to multiple parasitic infections. Data analysis and even simple probabilistic modeling are very difficult in such cases. These problems pose an important challenge for mathematical modelers.

The authors repeatedly stress the importance of keeping the theory in close touch with the facts, and they have pulled together an impressive amount of data that illustrate the value of their mathematical models. This is an important contribution, the beginning of a critical evaluation of the successes and failures of mathematical models as tools for qualitative understanding and as policy inputs. Nevertheless, any reader will be struck by the absence of a systematic methodology for model estimation and testing. This is a long-standing problem in mathematical biology and a weakness in this kind of theory: many parameters are difficult to define operationally and even more difficult to estimate.

One reason for this is that dynamic mod-