a marvellously thorough range of aspects of disease, from comparison of different vaccination policies to the coevolution of host and parasite populations.

Differential equations in biology do have their problems, however. Their air of apparent precision (mimicking the genuine precision of, say, the law of gravity, $\ddot{x} = -gx$) can mislead the unwary. For instance, it is a common and reasonable simplification to represent the rate at which infected individuals recover as being proportional to the number of infected individuals: in its simplest form, $Y = -\mu Y$. Unfortunately, this form carries the implicit assumption that the duration of the infectious period has a specific distribution, the exponential, which is a poor approximation in most cases. Although this unwanted precise assumption generally has little effect on the dynamics of the model, it can make a difference to the stability or otherwise of the endemic state.

Sorting out robust conclusions from those that are sensitive to unreliable modelling detail is a delicate task for the mathematician. Regrettably, biologists often use this overprecision as an excuse to dismiss the mathematical approach to disease dynamics (or, equally undesirably, they swallow specific differential equations uncritically). May and Anderson are, of course, well aware of such problems, and are full of insights into the general qualitative truths that lie behind specific details. A nice example is their summary of the timescales of dynamics in terms of those of the disease itself (its 'generation gap', D) and the human population (its mean lifetime, L). They describe the initial epidemic outbreak, the regrowth of susceptibles that follows, and the later coupling of infected and susceptible individuals in endemic oscillations, as being on timescales of D, L and their geometric mean $\sqrt{DL}$, respectively.

Even Anderson and May can get caught up in the obfuscations of the differential-equation approach, as in their basic consideration of equilibrium in chapter 4. Here they establish a number of simple and appealing results, relating basic epidemic and population parameters, as approximations in specific cases, when slight modifications can be shown to hold more generally by simply considering the logically possible flows between disease states.

At a deeper level, many such simple relationships become poor approximations when one gets into the complexities of population heterogeneity. Some of these complexities may require models framed in terms of individuals; a basic imprecision of differential equations is their treatment of population as a continuous mass, which makes it difficult to use them to model spatial or social contact structures. Corresponding data studies at the individual and local level will also be required. Recent improvements in computer technology have helped here by providing better databases, and by opening up new possibilities for the use of computer-intensive methods in the analysis of data.

This is a masterly survey of a wide range of aspects of the dynamics of human diseases. It is difficult to see how such width could have been achieved other than by using simple differential-equation models. But these models rarely provide the last word; when one considers the details of populations, it is often unclear what level of accuracy has been achieved. The book should therefore be seen as setting a rich agenda for further research rather than as a final solution. □

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Taming the oceans of the world

Donald S. McLusky

Dynamics of Marine Ecosystems: Biological–Physical Interactions in the Oceans. By K. H. Mann and J. R. N. Lazier. *Blackwell Scientific: 1991. Pp. 466. £24.95, $46.95 (pbk).*

WHEN A. G. Tansley introduced the term "ecosystem" in 1935, he stressed the interaction between living and nonliving components. Over the years, biologists have come to use the word mainly for studies of the energy transfers within food webs. These studies have been useful for coordinating research and as models for explaining ecological principles. At the same time, physical techniques have become more sophisticated and scientists can now study processes in the world's seas using satellite imagery and other ways of collecting data quickly and directly.

Mann and Lazier claim that the time has come to rejoin these two branches of study, with marine ecology emerging as an integrated discipline concerned with the physics, chemistry and biology of the sea. The relevance of this new marine ecology has probably never been greater: the physical processes underlying large-scale biological phenomena such as production at upwellings of fronts are now better understood; measurements of biological and physical parameters can be made at truly comparable levels; the need to understand the influence of marine ecological processes on world climate is urgent; and a study of fundamental ecological processes is important in ocean management.

The book is imaginatively divided into three sections on the basis of scale. The first is concerned with processes on a scale of less than 1 km. The authors admit that grappling with the physics of turbulent flow is hard labour for many biologists but claim that it is essential for understanding contemporary marine ecology. From this beginning, the reader approaches the vertical structure of the ocean. Here the authors acknowledge that the long-term understanding based on Sverdrup's observations has been confirmed by modern technology. From a combined physical and biological understanding, four general patterns of primary production in the oceans can now be recognized.

In the second section, the authors discuss processes on a scale of 1–1,000 km, and include detailed accounts of coastal upwelling based on studies of the Canary, Peru, California and Benguela currents, and studies of fronts in coastal waters. The authors freely confess that the latter field is new and that there is so far no consensus among researchers.

The third section covers processes on a scale of thousands of kilometres, including the circulation of the ocean basins, and the biological consequences of variability in ocean circulation, including events from the North Sea and the Pacific. In the final chapter, the authors look at the oceans and global climate change. They point out the crucial role of the oceans in carbon dioxide balance — the oceans and their sediments contain almost all the carbon dioxide ever issued into the atmosphere. They also consider the many complications in assessing the role of phytoplankton in pumping carbon into the interior of the oceans and, after summarizing the many alternatives, wisely conclude that it is, as yet, impossible to be certain what the overall effects will be on the oceans or the atmosphere.

The book is well written and the authors' approach works well. They give a clear plan in the first chapter of their aim to unite varied disciplines, and each chapter is complemented by a simple summary, as well as 'boxes' to provide supplementary reading or formulae. I am sure that the book will be adopted as a standard text for many marine science courses. More importantly, it highlights enough unanswered questions to motivate a new generation of researchers. □

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