record industry's decline is caused by today's music being "crummy").

The absence of biographies for the contributors is strange. It would have helped to learn that Daphne Keller — contributor of perhaps the most clearly articulated essay, describing the US legal system's adjustment (or lack of it) to the digitization of culture — is a product lawyer at Google. It would have been useful to know that Ken Jordan, who writes about digitally induced synaesthesia and co-authors an overview of networked collaborative art with Spooky, is both a founder of the entertainment website www.sonicnet.com and an editor of *Multimedia: From Wagner to Virtual Reality* (W. W. Norton, 2001). Readers might have liked to learn that many contributors are musicians — not just Eno, Roumain and Williams, but also Vijay Iyer, Pauline Oliveros and Robin Rimbaud (known as Scanner), among others.

The book's index is especially haphazard. For instance, multiple references to rap group De La Soul and to drum-and-bass act 4 Hero go unindexed, whereas single-instance nods to soundtrack composer Jack Nitzsche and rock band Rush make the cut. The Boulez interview cites Max Mathews, the computer-science legend and namesake of the popular Max/MSP music software program, but he is not in the index because a translator mistakenly rendered his surname as "Mathieu".

The 45-track CD that accompanies *Sound Unbound* illustrates and parallels the book's central argument, locating a historical foundation for today's innovations. Explanatory material beyond the song listings would have been appreciated, however. Segues make unforeseen associations, such as when an Erik Satie orchestration blends into a Steve Reich woodwind piece, suggesting a distant precursor to contemporary minimalist composition. The set is heavy on excerpts from avant-garde stalwarts, serving as a primer both on early pioneer composers (Edgard Varèse, Pierre Schaeffer) and on modern figures from the laptop era (Ryoji Ikeda, Carsten Nicolai). Evident in much of the music is how producers such as Spooky and Bill Laswell filter existing material through their own record collections and musical equipment; on several tracks, DJs take archival spoken-word recordings of Marcel Duchamp, Jean Cocteau, Antonin Artaud and others and set them against a groovy back beat.

DJs may have come a long way from the halcyon era of night-hawk broadcasters to the brave new world of mash-up-happy culture vultures, but one thing has remained — successful DJs need to know their audience. Perhaps the audience for MIT's publications expects just a little more rigour, a little more structure and a little more editorial rhythm. ■

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# Exemplary epidemiology

**Modeling Infectious Diseases in Humans and Animals**
by Matt J. Keeling and Pejman Rohani
Princeton University Press: 2007. 366 pp. $65, £38.95

**Mark Woolhouse**

Infections produce further infections. The implications of this simple observation have long intrigued theoreticians and confounded empiricists. It implies nonlinear dynamics, to use the mathematical jargon, and this makes it difficult to be intuitive about what will happen next, especially if the intention is to intervene. Expert opinion is often not up to the task; we also need the insights provided by mathematical models. These are being widely used to help understand the epidemiology of infectious diseases and to design control programmes. Models can support, add to and sometimes even overturn prevailing wisdom — think of malaria, AIDS, measles or foot-and-mouth disease.

In 1991, Roy Anderson and Robert May published the hugely influential *Infectious Diseases of Humans* (Oxford University Press). The subject has since advanced significantly, and *Modeling Infectious Diseases in Humans and Animals* meets the need for a new synthesis. Authors Matt Keeling and Pejman Rohani are mathematicians by training who have made important and original contributions to epidemiology, so they are well qualified to deliver an authoritative, comprehensive and up-to-date review.

Their book contains a guide to different models and provides worked examples of the insights that models offer, and of specific applications to real-world problems. They cover an impressive range of mathematical approaches, from two-line coupled differential equations through event-based stochastic models to spatially explicit microsimulations, and many others. Their examples cover an equally wide range of infectious diseases, from measles in school children to sexually transmitted infections in koalas. In every case, there is a thoughtful description of the rationale for the model, the assumptions behind it, the types of question it can be used to address, how to implement it (helpfully supported by a website providing access to computer code), and what the model tells us.

With all of this to hand, is the reader fully equipped to become a modeller of infectious disease? Not quite. Modelling is more than a technical exercise. It also requires that the practitioner makes critical judgements at different stages of the process, notably design, parameterization, validation and prediction.

Model design is the first and most important step. Success depends on how well we pose the questions we want to answer, and how effectively we identify the essential biology and translate it into mathematical equations or computer code. Keeling and Rohani manage this effortlessly, but it is a difficult art to instil in others except by example. There are plenty of examples in their book that repay close attention: particularly the sections on seasonality and contact tracing.

The second step, and an active area in the field, is model parameterization. It is not a major theme of *Modeling Infectious Diseases*. It was once acceptable to run a projection through some data points and declare the model good enough. This is no longer the case. More powerful computers and software have increased the availability of sophisticated estimation techniques, often using bayesian methodologies.

The third step is validation — the extent to which we should believe, and sometimes act on, the output of a model. Keeling and Rohani take a mathematician's view of this. Their book is punctuated by concise summaries of the insights drawn from the models, presented as robust conclusions. These are helpful in communicating key results but empiricists will often, rightly, demand something more. Ideally, this should include testing model predictions against independent data.

Prediction is a difficult task that we routinely undertake, for example, when making a decision about implementing disease-control measures. Such decisions must always involve some kind of model, even if it is only a mental one. Mathematical models have two huge advantages. First, they are transparent — the inputs, assumptions and logic are available for inspection, criticism and change in a way that is rarely the case for expert opinion. Second, models can be used to explore, *in silico*, the expected impacts of many more different control options than could ever be trialled in practice. Often, models will be the best evidence we have for our decisions.

Keeling and Rohani advocate, as strongly as I do, the use of mathematical models to help design disease-control programmes and they devote the final chapter to this topic. They recognize that modelling is a partnership between modellers and empiricists, including experts in the disease system of interest, providers of epidemiological data and those responsible for disease control. For that reason, I hope that the readership of *Modeling Infectious Diseases* will extend beyond existing and new devotees of this challenging and exciting discipline. Most medics, vets and health workers will never write a mathematical model themselves, but it is increasingly important that they are familiar with the work of those that do. ■

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