BOOK REVIEWS

Microbial Evolution

Population Genetics of Bacteria. S. BAUMBERG, J. P. W. YOUNG, E. M. H. WELLINGTON, and J. R. SAUNDERS, Eds. Published for the Society for General Microbiology by Cambridge University Press, New York, 1995. xii, 348 pp., illus. $110 or £55. Symposia of the Society for General Microbiology, vol. 52. From a symposium, Leicester, U.K., Jan. 1995.

The bacteria display an amazing diversity of metabolic activities and life styles. Comprising two of the six kingdoms of living organisms, they define the limits of the biosphere, being found in the uppermost reaches of the Earth's atmosphere and in its deep subsurface and prospering at temperature as high as 250°C and at pH as low as 2, conditions under which most self-respecting proteins would denature and DNA double helixes fall apart. Although numerous books on bacterial genetics and on the population genetics of higher eukaryotes are published every year, volumes on bacterial population genetics and evolution have been few. The present collection of papers is only the third to appear in the last two decades, following *Evolution in the Microbial World* (M. J. Carlile and J. J. Skehel, Eds.; Cambridge Univ. Press, 1974) and *Microorganisms as Model Systems for Studying Evolution*, R. P. Mortlock, Ed.; Plenum, 1984). This might suggest that there is no interest in the field or that nothing has changed since the last volume was published in 1984. Neither conclusion is correct. A Gordon Conference devoted to the field has been meeting biennially since 1987, and almost all other conferences concerned with population genetics and evolution now include some speakers working with microbes. So what's new? A lot, it turns out from reading this book. The field has been growing healthily, and the chapters in this volume provide an excellent overview of it.

Perhaps the most significant conclusion that emerges from the book is that bacterial populations are clearly not the homogeneous entities that classical models of evolution in asexual populations would have us believe. Rather, natural populations of a variety of species have been shown to contain abundant levels of variation (Sharp *et al.*; Whittam) and to possess a wide range of population structures. The immense power of the *Escherichia coli* experimental system has allowed mechanisms for the generation of this variation to be analyzed in considerable detail. Thus, certain regions of the bacterial chromosome have been found to be highly mutable as a result of small chromosomal rearrangements (Saunders), and overall mutation rate can increase drastically under inclement conditions—the phenomenon now widely known as "adaptive mutation" (Foster). As the variability generated by these systems can significantly increase the ability of a cell and its descendants to survive, they can be thought of as adaptations to life in an inconstant and hostile environment.

Although it is true that bacteria reproduce primarily asexually, horizontal transfer of DNA, and therefore recombination, can occur by means of transformation, phage-mediated transduction, and conjugation. These processes can generate very different population structures, as is illustrated in several chapters in this book. At one end of the range, the naturally transformable *Neisseria gonorrhoeae* possesses a completely panmictic population structure—being apparently as promiscuous as its human host (Maiden and Feavers; Spratt *et al.*). At the other extreme, even the lowly *E. coli*, with a predominantly clonal population structure, shows patterns of sequence variation among strains that reveal a history of recombination (Milkman and McKane).

One issue that repeatedly surfaces in the book is, What constitutes a species in bacteria? Maynard Smith addresses this question head-on in the opening chapter—a particularly provocative and enlightening one—entitled "Do bacteria have population genetics?" He concludes that "no species concept could be devised [for bacteria] that would carry the heavy load of meanings and theoretical implications" that the concept has regarding higher organisms. Yet strains of *E. coli* are similar to each other and can be distinguished on the basis of DNA sequence divergence from strains of, say, *Salmonella*, which also can be grouped together. Clearly there are clusters of prokaryotic organisms, but what maintains them as units and how did they arise? We are perhaps closer to answering these questions and to identifying "speciation genes" in prokaryotes than in any other group of organisms. We now know a considerable amount about barriers to recombination in the Enterobacteriaceae, erected by the numbers and diversity of restriction-modification systems (Barcus and Murray), as well as by the mismatch repair enzymes (Radman, an invited speaker at the conference that gave rise to the book but unfortunately not a contributor to the book). On the other hand, the SOS system acts as a positive regulator of interspecific recombination, and so-called "promiscuity genes" that allow cross-species transmission across wide boundaries have been identified in R-plasmids (Wilkins).

One of the fascinating aspects of microbial evolution is the seeming ease and speed with which bacteria can evolve new functions. This is a second theme of the book—adaptive evolution. The rapid acquisition of antibiotic resistance, covered in two of the chapters (Bennett, Levin), is but one spectacular example. Meanwhile, in the laboratory, the short generation times of bacteria allow experiments to be carried out that can last as many as ten thousand generations (Lenski)—a time span approaching an era for many higher organisms! Evolutionary changes and the sequence in which they occur can thus be determined directly, without resort to the inferential procedures that are usually required in evolutionary biology.

Who should read this book? Although it contains little information that has not already been published, it provides an overview of the advances in microbial population biology over the last 11 years or so. It should therefore be useful for workers in the field. It should also be a valuable introduction for the vast majority of evolutionary biologists not working with microorganisms. They will not fail to be impressed by the power of microbial systems for the analysis of evolutionary changes and to be fascinated by the peculiarities of microbial populations.

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Island Reptiles

Anolis Lizards of the Caribbean. Ecology, Evolution, and Plate Tectonics. JONATHAN ROUGHGARDEN. Oxford University Press, New York, 1995. xiv, 200 pp., illus., + plates. $59.95 or £45; paper, $29.95 or £20. Oxford Series in Ecology and Evolution.

From the title one could be misled into thinking that this little book is a field guide for the identification of the most exuberant