BOOKS: MICROBIOLOGY

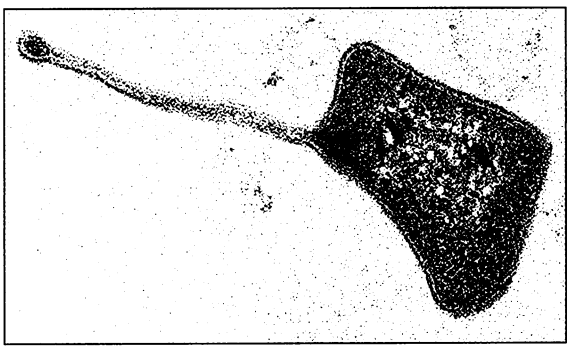
Fascinations of the Third Domain

W. Ford Doolittle

In the late 1960s, Carl Woese and his students decided to put microbial taxonomy on a sound and uniform phylogenetic footing, through the painstaking accumulation of information derived from the sequence of an RNA component of the ribosome—namely small subunit (SSU) rRNA. A decade later, on the basis of a simple comparative analysis of such information, they announced that prokaryotes were of two fundamentally and surprisingly distinct sorts, Eubacteria and Archaebacteria (renamed Bacteria and Archaea in 1989). As prokaryotes, both groups were known to lack the enclosed nucleus, endomembrane system, cytoskeleton, and energy-yielding organelles of eukaryotes. But, this shared structural simplicity aside, there proved to be many fundamental differences between them. Indeed, the 1980s and 1990s saw the trumpeting of one astounding archaeal feature after another. Some aspects highlighted the "extremophily" (obligatory growth at very high temperatures, high salt, or low oxygen) then thought to be a defining feature of archaea, some (transcription, translation and replication machinery) showed a puzzlingly greater similarity to eukaryotes than to bacteria, and some (lipids, some enzyme cofactors) were just unique.

The Surprising Archaea
Discovering Another Domain of Life
by John L. Howland
Oxford University Press, New York, 2000. 214 pp. $29.95, £ 19.95. ISBN 0-19-511183-4

In *The Surprising Archaea*, John Howland gives a succinct account of the development and excitement of the field. He explains its fundamental evolutionary premises particularly well. First, there is the belief that archaea are so very different from bacteria because the two groups diverged when life was quite new and still ill-formed; that is, the root of the SSU rRNA tree corresponds to some single last common ancestral cell, older than the oldest cellular fossils (3.5 billion years). Second, some features of archaea, extreme thermophily in particular, are primitive—unchanged from the ancestral condition. Third, archaea were principal partners in forming the chimeras we know as eukaryotes; they contributed the basic information-processing machinery.



Close to the common ancestor? *Archaeoglobus lithotrophicus*, from marine hydrothermal vents, combines many of the properties of thermophiles and methanogens.

Howland, a biology professor at Bowdoin College, is not an archaeal insider. Perhaps this is why he says little about the people involved in the discovery and acceptance of the archaea, and that is a pity. The older I get, the more I understand that—although there are indeed facts about nature and we can indeed discover them—the personalities of scientists and the politics of their interactions have enormous impact on the importance we attribute to different facts and on the broadest conceptual frameworks within which we interpret them. Archaebacteriology would not have unfolded as it did, and our feelings about the importance of the group would have been much different, without Woese, Otto Kandler, Wolfram Zillig, Norm Pace, Mitch Sogin, Gary Olsen, and the several others making up what Lynn Margulis once called "Woese's army."

In fact, had the field developed differently, we might not now hold to the three tenets mentioned above. SSU rRNA is very good at telling us what organisms belong to what major groups, but less reliable when it comes to relationships between groups. Many genes tell different stories than SSU rRNA, and we do not actually know whether rRNA trees track the history of any large fraction of the genes in modern prokaryotic genomes. Although it is appealingly romantic to assume that life started hot, arguments based on the phylogenetic distribution of hyperthermophiles are not compelling. Nor do we have any way of proving that the root of the tree corresponds to some single ancestral cell that lived 3.5 billion years ago. (Indeed Woese, unlike many of the troops, never thought there was such a cell.)

In his concluding chapters Howland does discuss some of the winds of revisionism now beginning to blow, but still his is a very whiggish account. I'm sure the story will be told very differently ten years from now. I am also unsure what audience the book was intended for. There is too much biochemical detail to make it suitable for nonscientists, not enough detail to make it appropriate as a text for students, and far too few figures and diagrams for anybody. All that said, if you want a quick and easy explanation why those of us who were turned on to archaea in the 1970s remain tuned in today, this is the best you will find.

The author is in the Department of Biochemistry and Molecular Biology, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4H7. E-mail: ford@is.dal.ca

BOOKS: AGRICULTURE

Another World Food Scare?

John H. Sanders

Journalist Richard Manning's call for a new Green Revolution is a good airport book of the nonfiction variety. The characteristics of such a book are that it combines light reading with very pessimistic conclusions.

Looking back, approximately once per decade there has been a scare over world food supplies (*1*). Consistent with this tradition, the introductory chapter of *Food's Frontier* tells us that significant improvements in yields for the principal food crops cannot be achieved in developing countries and that any further gains will be evolutionary rather than revolutionary. Combining this conclusion with continued rapid population growth, Manning returns to Malthus, the first modern food-scare writer, or at least to Paul Ehrlich, the most alarmist of these authors in the 1960s.

Food's Frontier
The Next Green Revolution
by Richard Manning
North Point (Farrar, Straus, and Giroux), New York, 2000. 233 pp. $24, C$38.95. ISBN 0-86547-593-8.

The author is in the Department of Agricultural Economics, Purdue University, 1145 Krannert Building, West Lafayette, IN 47907–1145, USA. E-mail: sanders@agecon.purdue.edu

In the rest of the book, Manning provides a series of vignettes from around the world on efforts to improve crop yields, increase crop diversity, and reduce natural pests and diseases. He interviews local scientists, provides country-specific contexts, and captures well the different national environments. He sets the search for new agricultural technologies against the background of the AIDS epidemic and inept government in Zimbabwe, the continuing wars in Uganda, and the pressing poverty of Ethiopia.

Several chapters focus on case studies drawn from the worldwide struggle of national agricultural scientists against plant diseases and insects in their countries' principal food crops. Throughout these accounts, Manning stresses the need for adapting technologies to region-specific agricultural constraints and market opportunities. The examples from India and China offer excellent defenses of the arguments for genetic engineering. And the discussion of genetics and bioengineering at Fudan University in Shanghai also highlights the potential benefits of the international ties among scientists through the Internet.

In the chapter on the basic staple in Chile, potatoes, the author takes aim at the excessive use and dangers of pesticides during the raising and storage of crops. Farmers are careless with insecticides and clearly spray too heavily and too frequently. Manning also mentions the expected conflicts with agricultural chemical companies as alternative methods of combating insect pests are adopted. He connects the search to lower pesticide costs and to reduce poisoning in developing countries with organic gardening led by innovations in breeding trichome-bearing potato varieties at Cornell. (Trichomes, tiny hairs on the leaves, act to trap insects mechanically and also secrete a chemical that alarms insect pests.)

Three important aspects of Manning's interpretation can be seen in different perspectives. First, as the author recognizes, the Green Revolution involved more than just the introduction of new varieties. When the effects on cereal yields from various inputs are carefully separated, around 40% of the gains can be attributed to the introduction of new varieties; the rest came from additional use of inorganic fertilizer and other agricultural chemicals, better water supplies, and improved cultural practices. As Manning points out, the yield effects from the Green Revolution have been concentrated on wheat, rice, and, more recently, maize. But this does not imply that disaster is imminent; varietal improvements and the other inputs still have the potential to increase yields of other cereals (such as sorghum, millet, teff), tubers, grain legumes, and oil seeds.

Second, to conclude that most agricultural technologies introduced into developing countries were not appropriate ignores the important roles of national political and economic systems in changing agricultural practices. Many of these technologies will become appropriate when governments stop distorting their economies by subsidizing food prices in various ways and develop policies that enable farmers to benefit from increasing crop productivity.

Third, despite the risk that selection will break down single-gene resistance techniques, this approach has been extremely valuable economically. In the United States, the T gene in barley has held up against stem rust for over 50 years; similarly, in wheat the Hope gene has kept stem rust in check for over 40 years and the LR-34 gene has limited leaf rust for more than 20 years (*2*). Multiple-gene resistance and other techniques are preferable when they are available, of course. Otherwise, we use what we have if it works, and we anticipate breakdowns. Agriculture is a system of constant change, so sustainability is a relative term.

Airport books are fun, so read *Food's Frontiers* and become upset that the developed countries are not doing more to move agriculture along in developing countries. But you can also get excited about Manning's reports on what scientists, national and international, are doing. The current need to accelerate the diffusion process, which Manning stresses in his conclusions, can be considered an opportunity rather than a crisis. We must focus on helping the developing countries improve incentives for farmers, on improving input and product markets, and on attacking the critical problem of governance.

References and Notes

1. Even in the late 1960s, with the widespread concern with the continuing drought in the Indian subcontinent, the prognosticators of gloom did not look back and note the regularity of food availability scares being introduced once a decade and then dismissed again [J. H. Sanders, R. C. Hoyt, *Am. J. Agric. Econ.* **52**,132 (1970)].
2. Contributions from J. Janick, H. Ohm, and R. Frederickson are gratefully acknowledged.

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BROWSINGS

CREDIT: ALEX S. MACLEAN/FROM *TAKING MEASURES ACROSS THE AMERICAN LANDSCAPE*

Taking Measures Across the American Landscape. *James Corner and Alex S. MacLean.* Yale University Press, New Haven, CT, 2000. Paper, 205 pp., $35, £22.50. ISBN 0-300-08696-2.

This award-winning book, first released in 1996, showcases MacLean's low-altitude aerial photographs of the human-built countryside in the United States. Some scenes are reinterpreted in collages by landscape architect Corner, who also contributes commentary on how people shape and are shaped by the land. These contour-farmed fields in Iowa reflect adjustments of agricultural practices to match more closely local circumstances.