



FRACTALIZATION IN BIOLOGY

Vicsek, T. (ed.) (2001) *Fluctuations and scaling in biology*. Oxford University Press, Oxford, UK. x + 246 pp, figs, tables, index. Hardback: Price £50.00. ISBN 0-19-850789-5. Paperback: Price £24.95. ISBN 0-19-850790-9.

This book is a collection of contributions by seven authors in the field of mathematical biology. Its usefulness lies primarily in the exposure of some current, advanced topics, rather than a systematic coverage of the field. In this multi-author book, tighter editorial control would have eliminated a number of grammatical errors and mis-spellings.

Many biological systems are governed by fluctuations and, thus, techniques of statistical physics seem to provide a suitable mechanism for helping to understand them. There are six chapters in the book, spanning topics such as fluctuations, fractal geometry and stochastic scaling, self-organized criticality, patterns and correlations, fluctuation-driven transport and collective motion.

In spite of being named the *Basic concepts*, the first chapter provides essentially an executive summary of the rest of the book. An introductory chapter dealing with the concepts that underpin the rest of the book would have broadened the readership.

This book proposes several models of reality and examines their correctness. Selection of models is influenced by realization that the system under investigation consists of many similar interacting units. Many parameters are involved, and determination of the most significant ones is rarely possible.

Critical state is normally reached by changing one of the control parameters. Reaching the critical state without any parameter modification relates to the important concept of self-organized criticality. Applying this technique to the evolution model, through the mutation and selection processes, it turns out that the evolution/extinction rate is not constant, but displays fluctuations. These can be linked to major extinction events in the past. One may then hypothesize that there is no need for external events, such as meteorite collisions, to explain the intermittent nature of the extinctions.

A large part of the book deals with bacterial colonies. Topics such as proliferation, motility and chemotaxis are examined in detail. In systematic studies aimed at determining the influence of environmental factors, different morphology diagrams were obtained. Applying statistical measures, it was found that the boundary of the colony is best represented by a self-affine curve with long-range correlations. The independence of the Hurst exponent on the bacterial colony yields strong support for the 'universality'

feature, implying that the macroscopic patterns are not influenced by many microscopic features.

It is known that growing bacteria on nutrient-poor agar substrates leads to complex branching, with tip-splitting patterns. Many of the characteristic forms can be explained in terms of diffusion-limited processes, reflecting the fact that bacterial growth depends on locally available nutrients. One of the first models reproducing the fractal characteristics is the classic Diffusion Limited Aggregation (DLA). Other models are developed modelling motile and non-motile bacteria, by taking into account the microscopic 'rules' and macroscopic morphology.

The complex nature of DNA is addressed from the standpoint of statistical physics. It is demonstrated that the idea of the long-range correlations is appropriate for characterizing the highly heterogeneous nature of DNA. The location of coding and non-coding parts in the genome is still not well established. Application of the Detrended Fluctuation Analysis (DFA) facilitates the differentiation between these parts.

Next, the dimensional analysis of the brain's electrical activity is examined. It is disconcerting that this section uses words in place of Greek letters and disregards subscripts. Following a brief description of linear and non-linear methods for the analysis of the EEG, the section concentrates on the correlation, D_2 , and point-correlation, PD_2 , dimensions. It is argued that the accuracy of the latter algorithm is superior, especially for finite data samples, and several clinical applications are considered.

Many different mechanisms of biological motion exist and these are based on the individual motor proteins. These motors move in discrete steps and usually convert chemical energy into mechanical energy. The dynamical protein network lies at the basis of intracellular transport. The structure of linear and rotary motor families is examined in great detail. Fluctuation-driven transport serves as a basis for modelling biological systems. Mechanical properties of muscle contraction are derived from biochemical parameters, and an analytical formula for the force-velocity is obtained. It appears that rather simple assumptions suffice to describe the complex process of muscle contraction.

The last chapter deals with collective motion, from the universality standpoint, whereby the same pattern may develop in completely different environments. The collective features of organisms are studied using the self-propelled models in one, two and three dimensions. The book ends by investigating the social aspect of self-organization and examines the dynamics of pedestrians. Some of the empirical findings, such as trail formation, can be realistically modelled.

Overall, a book such as this is valuable for researchers, as it brings together physicists, mathematicians and biologists in an attempt to quantify some of the most complex real-life situations.

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HOW ARE COMMUNITIES BUILT FROM SPECIES POOLS?

Weiher, E. & Keddy, P. (eds) (2001) *Ecological assembly rules: perspectives, advances, retreats*. Cambridge University Press, Cambridge, UK. xii + 418 pp, figs, tables, index. Paperback: Price £24.95. ISBN 0-521-65533-1. Hardback (1999): Price £75.00. ISBN 0-521-65235-9.

Community ecology has a long history of interest in identifying the mechanisms restricting local community membership to subsets of the pool of potential colonists. Attempting to answer the question 'How are communities built from species pools?' should involve patterns of species distributions at large (macro) scales, and indeed that is the direction taken by the contributions in the symposium volume on assembly rules edited by E. Weiher and P. Keddy (W & K). Although certain ecological factors, such as habitat requirements and species interactions, may be manipulated to provide insights about candidate assembly rules for the communities involved, it has been argued that experimental data alone may not address the extent to which certain small-scale mechanisms are influential at larger scales. In fact, the tool of choice among several contributions in W & K for assessing the likelihood of the tested assembly rules, involves 'null models'. Null models constitute a body of statistical methods, mainly based on Monte Carlo approaches, to assess whether patterns found in data are consistent with the expected results of a particular ecological mechanism of interest (e.g. interspecific competition). In this search, null models should be tailored to include the effects of all factors except the mechanism of interest. If the null model is rejected, it provides support for the mechanism being tested.

In their introduction, the editors state that the term 'assembly rules' should be used to signify the problem of how species are assembled from regional pools into communities. It is an interesting historical account to note how the terms 'null models' and 'assembly rules' are used interchangeably. However, although null models may be used as a tool in the search for assembly rules, they can be also applied when searching for patterns in other types of ecological problems (e.g. animal behaviour, population dynamics

or phylogeny). We believe that this distinction is important and that other research tools, such as manipulative experiments, can be useful complementary tools when searching for assembly rules organizing communities (see D. Kelt and J. Brown for some discussion — Chapter 3). A large portion of the long-standing controversy regarding assembly rules is related to the statistical issues involving null models, and perhaps some harmony could be achieved if assembly rules were to be seen as ideas of how communities are built from regional species pools and null models as recipes to deal with and test these ideas.

W & K includes a collection of 14 papers that are not as diverse in taxa studied as in the ways that assembly rules were investigated. A positive side of the book is that most contributors provide some historic and polemic accounts about their specific interests, organizing their chapters in a more educational fashion than standard papers in scientific journals. It also provides a wide range of problems where assembly rules have been applied, including issues related to conservation biology. However, most contributions fail in providing details on the specific methodological approaches that would allow readers to use the protocols involved. Also, given the style of writing used by most contributors, it is hard to distinguish whether some statements are personal opinions or accepted ecological facts. Ideally one should read J. Bastow Wilson's contribution (Chapter 5) first, as it may provide the reader with some general guidance for the remainder of the book. His chapter is helpful as it places the different types of data involved in community analysis (e.g. richness, species distribution, species-level traits) into different types of assembly rules (e.g. limiting similarity, species saturation, guild proportionality). The first three chapters provide a provocative debate on the issues related to guild assembly rules for mammals, and also on the ecological and statistical merits involving assembly rules and null models in general. The editors' contribution (Chapter 9) provides good coverage of how species-level traits may be used in determining sources of constraints in local community membership. Mark Lomolino's (Chapter 10) contribution is an important account of the influences of immigration and extinction across ecological and spatial scales in determining community composition.

Two foci of discussions seemed relevant while reading the book. The first one is whether assembly rules should or should not involve environmentally mediated patterns as a way of accounting for ecological restrictions to local membership. Bastow Wilson (Chapter 5) argues that assembly rules should only account for patterns driven by species interactions whereas the editors (Chapters 1 and 9) consider that assembly rules should account for patterns that are mediated either through the environment or species interactions. The second focus, which is also relevant to the previous one, is how to control for species habitat requirements

in null models when assessing the importance of interspecific competition in determining local community membership (see Chapters 1, 3 and 5). In this case, evidence for non-random patterns in species distributions does not necessarily imply the role of competition, but could be equally related to other factors, such as differences in environmental requirements of the species.

Although the book is not concisely written or well organized (in particular the introductory chapter), we believe that *Ecological Assembly Rules* has a space on the Community Ecology section of any ecologist's bookshelf and will provide a source of papers, ideas, and challenges that should be useful.

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PLANT EVOLUTION: FROM THE DEPTHS

Willis, K.J. & McElwain, J.C. (eds) (2002) *The evolution of plants*. Oxford University Press, Oxford, UK. x + 378 pp, figs, tables, line diagrams, half-tones, glossary, index. Paperback: Price £22.95. ISBN 0-19-850065-3.

These are exciting times in evolutionary science. Awakened by the technological wizardry that has revealed more nucleotide sequences than fit in a virtual encyclopaedia and overshadowed by the creationist fungus, whose mycelium is thriving among the roots of the new science of complexity to bring out old debates, the recently published book by Willis and McElwain is a breath of fresh air. There is no doubt about it, this is an important work. Without being blinded by new methodologies, the ideas expressed shine out for their reforming characteristics.

Writing a book on plant evolution is a challenging task. You just have to glance at the repertoires concerned to see the general lack of daring on the part of authors. This is perhaps understandable because of the enormous task represented by the need to select sources, for which one needs a unifying criterion difficult to establish in a field of growing specialization. Then there is the expectation that a satisfactory model in *tempo* and *modo* including the whole taxonomic scope, needs to be established – and what do you do with the algae, cyanobacteria, fungi and many unicellular eukaryotes that have traditionally been the subject of botanical study? Finally, our discoveries in recent years concerning horizontal gene transfer and developmental control of gene expression exceed the assimilation capacity of even the best-informed evolutionary biologist, while there is the growing suspicion among researchers that the well-loved adaptationist protocol is about to collapse. Yet, evolution is a historical process and,

whether we like it or not, it is less subject to experimentation and prediction than it is to serious questioning in the search for coherent interpretation.

Straightforward and fluent, but without vehemence, Willis and McElwain take up the challenge. In masterly fashion, they correlate the processes of migration, genetic drift, selection, stasis, speciation, extinction, changes in ecological dominance, leaf physiology, plate tectonics, greenhouse effect, and variations in the levels of atmospheric CO₂. Sowing the seeds of critical analysis in the minds of the reader from the outset, *The evolution of plants* is a 10-round contest. It starts with a chapter on the methods used to study the evolutionary record, followed by six chapters on the principal landmarks of plant evolution (earliest forms, colonization of land, first forests, emergence of spermatophytes, origin of angiosperms, and patterns in the Cenozoic), a chapter on the mass extinction of animals compared with the persistence of plant populations, another on the potential of ancient DNA and the biomolecular record as sources of evolutionary information, and, finally, by a chapter in defence of the authors' model ('Evolutionary theories and the plant fossil record'). Cryptogamists may bemoan the small number of cladograms referring to photosynthetic eukaryote groups and their successive series of endosymbioses. The main compromise, however, concerns the evolution of embryophytes from the fossil record perspective, while the book occasionally takes on a strong palaeobiogeographic flavour. Not to be missed is the companion website, www.oup.com/uk/plantevol, which contains Biome Maps in full colour, and provides additional support for both the student and the lecturer.

The main argument is that plant macroevolutionary patterns do not coincide with their animal counterparts. Willis and McElwain note that, although biological interactions (adaptation, competition and co-evolution) have been the controlling influence on a good part of species diversity, they do not seem to be responsible for the principal speciation episodes recorded in the fossil record. It is fascinating to realise that the periods of pulsation tectonics coincide with changes in the fossil record of land plants: terrestrialization during middle Ordovician to early Silurian times (460–430 Ma), rapid expansion of lycopsids, sphenopsids, progymnosperms, and the first seed plants during the Middle Devonian–early Carboniferous pulse (375–350 Ma), gymnosperm radiation in the Carboniferous–Permian transition (300–260 Ma), increases of antophyte relatives (Pentoxylales, Czekanowskiales, Gnetales) in the mid Jurassic (170–160 Ma), and unequivocal appearance and major radiation of flowering plants during the Aptian–Campanian superplume (120–80 Ma).

In the always difficult steps from the observation of patterns to the establishment of processes, Willis and McElwain start from a hierarchical scheme of causality, suggesting that at the very top are tectonic pulses associated with the atmospheric content of CO₂ and a global extrinsic abiotic stress

from which plants cannot escape. When the reader finally puts *The evolution of plants* down, they may be tempted to think that, if for nothing else, the book has served as an excuse to present a tremendously good idea. And there's nothing wrong with that since we scientists live in a world of data and we are more accustomed to browsing papers anxiously than carefully reading a book in search of good ideas. Read

this book slowly, for it contains a wealth of details. And good ideas.

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