American Space Program is a welcome contribution to that scholarship; but it also reminds those of us interested in contributing to this area just how difficult such writing can be. Most of all, it demonstrates how necessary it is to be careful and critical in the use of the immense amounts of as yet undigested source material.

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Kinetic Theory of Patterns

Models of Biological Pattern Formation. HANS MEINHARDT. Academic Press, New York, 1982. xii, 230 pp., illus. $37.

There are not many fields in which it remains proper to speculate about the explanations of phenomena as widely as 13th-century scientists did about the rainbow. Biological development is, however, such a field. To explain how a seemingly uniform system develops into disparate parts one might consider, for instance, geometrical fitting of parts, equilibrium phase separations, electrical fields, imbalances of mechanical stresses, and instabilities in chemical kinetic processes. All these theoretical strategies have been used. None has yet suffered clear defeat or attained secure victory in the test against experiment.

Kinetic theory has dealt mainly with the interplay of an autocatalytic and slowly diffusing activator with a rapidly diffusing inhibitor, which was hypothesized over 30 years ago by Turing to be "the chemical basis of morphogenesis." More recent elaborations, retaining this concept, have replaced Turing's linear equations with more complex nonlinear ones. These are more realistic, especially in that they allow patterns of chemical substances to settle into steady states rather than growing forever in exponential fashion.

Among these models, that of Gierer and Meinhardt, first published about a decade ago, has accounted with notable success for *Hydra* regeneration and response to grafting and for effects of damage in early insect embryogenesis. Meinhardt's book is principally a detailed account of the correlation of this model with a wide variety of experimental phenomena. His continual stress on putting theory and experiment together is especially welcome in a field in which the theoreticians seem often to communicate only with each other and in which the theories are unproved.

Despite its title, the book is not an overview. It deals only with kinetic modeling and even in that realm is more about *a* model than about models. The Gierer-Meinhardt equations have special features closely related to the form of the dominant nonlinear term (activator concentration squared divided by inhibitor concentration). Predicted patterns are highly sensitive to destruction of inhibitor, which fits well with some features of *Hydra* and insects. But Meinhardt sometimes seems to imply that nonlinearity must always be expected to have this form and thereby runs into unnecessary difficulties. For example, he has trouble persuading his model to generate two-dimensional hexagonal arrays, and in three places in the book he tries to find a way out of the difficulty. None of them is necessary. The Prigogine and Lefever "Brusselator" model has a different kind of nonlinearity (activator squared *times* inhibitor) and generates hexagonal arrays very easily. Meinhardt refers to this model once, and briefly. It could be the subject of another book in the format of his. I have elsewhere characterized the Gierer-Meinhardt model as "headstrong" and the Brusselator as "adaptable" because of the tendency of the former to stabilize activator peaks and the latter to let peaks appear, disappear, and move around. Meinhardt gives no such comparison.

Meinhardt compares his model's account of insect development with those of five other models, lettered A through E. The reader would hardly get the message from this account that Kauffman's model (E) is in the same category as Meinhardt's, that is, reaction-diffusion with short-range activation and long-range inhibition.

Meinhardt covers polarity (*Fucus* egg, *Echinus* embryo), periodicity in two dimensions, size regulation, *Hydra* grafting, insect embryogenesis, limb regeneration, switching on and off of genes, and stripes, segmentation, and leaf venation, and he includes FORTRAN programs to enable the reader to play the game himself or herself. According to the reader's background the various treatments may appear admirably brief or over-compressed. Chapter 9, for instance, describes a concept of "cooperation of compartments" not previously familiar to me, and I am having some difficulty grasping it.

I have indicated a few deficiencies in the book; and I feel that I must categorically contradict one statement (p. 39), that "in most biological cases, pattern formation does not involve symmetry breaking." But I do not want these negative remarks to obscure the main strength of the book. It is still rare in this field for anyone to build a strong bridge between experiment and theory. Meinhardt pursues this objective relentlessly and in detail. He discusses very clearly, for example, how to determine whether a true inhibitor is present, or only a depletion effect that kinetically mimics an inhibitor, and, even more important, how to determine which is the activated end and which the inhibited in any system. Meinhardt has written a thoroughly scientific work that a developmental biologist, whether of theoretical or experimental bias, should not ignore.

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Desert Ecology

Ecology of Desert Organisms. GIDEON LOUW and MARY SEELY. Longman, New York, 1982. vi, 194 pp., illus. Paper, $17.50.

Kyzl-kum. Alashan. Kara-kum. Taklamakan. Romantic names for remote regions in interior Asia. These and other deserts constitute the last of Earth's terrestrial frontiers: even in central Asia with its vast hordes of humanity the deserts still represent immense uninhabited regions. Human life in deserts is by no means easy—limited resources and the harsh climate impose a certain discipline and respect for nature. Moreover, since population density is of necessity very low and living is so difficult, life in deserts assumes a certain tranquil and almost mystical quality. Religions arise there. Stories and movies are often set against this intriguingly austere background. Deserts can capture even the confirmed urbanite's imagination.

Books on desert ecology, both scientific and popular, abound. The present modest volume is much better than most. It details, fairly accurately, many of the mechanisms by which plants and animals cope with challenging desert conditions, especially high temperatures and water shortages but also unpredictable resource availabilities. As a bonus, the evolutionary basis of various behavioral and physiological adaptations is also considered. The authors have derived much of their own experience with desert organisms in the extremely arid Namib desert of southwestern Africa and provide a wealth of information on this little-known system. Other desert regions get more than passing mention, however, and the book is rather well balanced overall. There is a lot of basic ecology here. For such a small volume, it does a very creditable job.

The book concludes with a most distressing chapter on man in the desert. Applied ecology seldom mixes well with basic ecology, and the book ends on a particularly disconcerting note: as the human population burgeons, more and more people are seeking the warm climates and serenity offered by deserts, with the inevitable resulting destruction of these once-beautiful but fragile habitats; Phoenix, Arizona, is proposed (tongue in cheek, one supposes) as a "monument to behavioral thermoregulation."

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