ics, meteorology, or ecology of fire. After the Second World War the scientific investigation of fire entered the laboratory with Big Bucks for military research into the physics of mass fire and fire as a weapon. Many of Pyne's interpretations are, of course, arguable, as interesting hypotheses should be. Altogether, considering the strengths of this book, fire as a cultural force in history will probably not evaporate into any nirvana of worn-out enthusiasms.

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An Arena of Applied Science

JPL and the American Space Program. A History of the Jet Propulsion Laboratory. CLAYTON R. KOPPES. Yale University Press, New Haven, Conn., 1982, xiv, 300 pp., illus., + plates. $19.95. Yale Planetary Exploration Series.

JPL and the American Space Program chronicles and describes "the major technological developments in which the Jet Propulsion Laboratory has been involved," as well as the "scientific implications" of those developments. Beyond that, it provides, through discussions of JPL's changing relationship with the California Institute of Technology, the military, and the National Aeronautics and Space Administration, a thoughtful analysis of many aspects of the vastly expanded post-war partnership between scientists, their traditional university homes, and the federal government.

The advent of modern, university-operated, "big science" institutions is most often traced to the experiences and the relationships established between scientists and government during the Second World War. The wartime development of radar and atomic weapons clearly demonstrated the practical importance of the knowledge and the skills of academically oriented scientists and engineers. Those projects also revealed that decisively important branches of science, with their associated technologies (for example nuclear reactors and particle accelerators), required vast resources and new organizations and management structures for their effective pursuit.

Rocketry did not play as significant a role in the Allied victory as did radar or the atomic bomb. Nevertheless, as potential delivery vehicles for weapons (nuclear and otherwise), and as a means of obtaining access to the upper reaches of the atmosphere, rockets were recognized as having a considerable and perhaps essential role to play in maintaining American preeminence in strategically important areas of science and technology. They also had important economic implications for the United States aircraft industry.

At the end of the Second World War the Jet Propulsion Laboratory was in a unique position. The outgrowth of the Army-funded rocket project of Caltech's Guggenheim Aeronautical Laboratory, "the seedbed of American rocketry," JPL possessed expertise and facilities suited to further development of rockets and associated guidance, control, and communications technologies. During the 1950's several momentous events—not the least being the development of deliverable thermonuclear weapons and the 1957 launch of Sputnik—profoundly altered the nature and the activities of the laboratory. It is the forces, the events, and the reactions that have molded and continue to mold the evolution of JPL that form the subject of this book. Koppes treats clearly and in detail the development at JPL of the Corporal and Sergeant tactical nuclear weapons systems, JPL's entrance into the space age, its transfer to NASA, and its major role in the design, management, and operation of most of the unmanned lunar and planetary probes that have been launched or are planned by the United States. This is, therefore, an important book.

Koppes strives to provide a coherent structure to his account by presenting it "in relation to certain military and scientific policies of the national security state." The phrase "national security state" is taken from Daniel Yergin (*Shattered Peace: The Origins of the Cold War and the National Security State*, 1977). It is meant, by Koppes, to summarize what he sees as the most significant post-war changes in the nature and function of the federal government. His attempt to place the subject matter of his book in a broad context is laudable. However, the many goals of the book and the limited use made by Koppes of the staggering amounts of available primary source materials related to these wide-ranging concerns make for some serious weaknesses. For example, the extremely brief descriptions of the scientific significance of the planetary missions with which JPL has been involved suffer from the shallow documentary base on which they are constructed. This contrasts markedly with the excellent and well-documented accounts of the disputes over management practices and fees that have plagued relations between NASA, JPL, and Caltech.

There are problems with some accounts more central to the book's main concerns. The discussion in chapter 6 of the early JPL-managed Explorer satellites relies disproportionately on JPL publications and on the undocumented account given in *Countdown for Decision*, written in 1960 by Major General John B. Medaris (the retiring chief of the Army Ballistic Missile Agency and a leading advocate of a continuing Army role in rocketry and space). And, possibly as a result, the account of the Medaris-directed "reentry test vehicle" program understates the differences between the "Jupiter C" launch vehicle used to test Jupiter IRBM nose cones and the launch vehicle that eventually launched America's first artificial satellite; it treats only briefly the relationship between James van Allen, the Army Ballistic Missile Agency, and JPL, a relationship that led to the inclusion of cosmic-ray detectors aboard the early Explorers; and it gives a misleading account of the Explorer 4 satellite and Project Argus. (Project Argus, a classified project meant to determine whether the detonation of atomic weapons hundreds of miles above the earth would create magnetically trapped bands of radiation of military significance, had nothing to do with the International Geophysical Year or with the measurement of radiation "trapped in the atmosphere"; nor was it a simple follow-on to the radiation measurements made by Explorers 1 and 3, as one might conclude from Koppes's account.) The involvement of JPL and van Allen with Project Argus is an interesting story, but it is far more complex than is indicated in the published accounts Koppes has relied upon.

And later, when Koppes analyzes President Kennedy's 1961 decision to send astronauts to the moon (p. 115), he implies that direct military considerations played an important role (that is, in addition to more general national security concerns). "An aggressive man-in-space program emerged ineluctably as a key component of this [Kennedy's] military buildup, for reasons not only of prestige but of direct military capability." As far as is revealed in the notes, that statement is based on speeches and articles prepared several years after the fact. It is not very convincing as presented.

In his preface and in a note on sources, Koppes comments on the sparsity of historical scholarship on modern science and scientific institutions. *JPL and the*

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,