ogy, but the random assumptions inherent in statistical mechanics seem incompatible with the self-organizing properties of biological clocks, for example, which Goodwin seeks to understand.

Many more speakers settle for comforting analogies. Gmitro and Scriven, trying to cope with morphogenesis, give models and concrete examples of pattern arising from uniformity which would have delighted D'Arcy Thompson. Arbib, trying to understand what self-replication entails, describes the theory of self-replicating automata and its implications for biology. A posthumous work of Von Neumann published in 1966 apparently transformed the theory from empty talk to decent mathematics, but his idea of an automaton is difficult to visualize and his idea of self-replication even more so. Yet this analogy holds promise. Iberall seeks to understand an organism's function by reducing it to a bundle of oscillations, as Huxley reduced it to a bundle of adaptations. Iberall's analogy becomes an all-too-comforting substitute for understanding, a tool for replacing a disturbingly immediate reality by something comfortably distant and artificial: witness the following (which he follows by even more incredible wordplay): "Mother, in the mother-child relation, teaches the child various patterns that are fairly adequate to provide the range of needs that will saturate the physiological oscillators over time."

Pattee wishes to reduce biology to physics. He is appalled by the contrast between machines which, be they solar systems or computers, are fated to break down and organisms, whose hereditary mechanisms permit the preservation and perfection of wonderfully delicate organization. How can biologists take evolution for granted when they cannot create life? This question underlies Pattee's subtle worries: he will only be satisfied by showing Maxwell's demon (Schrödinger's equation personified) how to arrange molecules into an organism which will reproduce itself accurately enough for selection to preserve and perfect it. The question seems curiously academic: Pattee is sure no man could "create life."

Several participants reject Pattee's goal outright. Living things are organized for their roles in life: why not capitalize on this and explore the harmonies of biology, the hierarchies of the universe? Bohm and Lieber feel we should change our idea of what constitutes a scientific explanation. Bohm asserts that to understand the function of living things we must refer to some goal outside the field of function (a computer makes no sense unless we know that someone built it to do calculations), and he feels uneasy about the role of natural selection as a mechanism which judges function. Moreover, like Aristotle and Eddington, he wants to know why the universe obeys the laws it does. Marjorie Grene, a philosopher, out-Bohms Bohm, speaking out against a "one-level nature of Democritean atomism" and the supposedly objective pose where "Science becomes computation-for-the-sake-of-prediction-for-the-sake-of-computation-for-the-sake-of-prediction . . . , 'understanding' merely a subjective addendum, and 'truth' a dirty word, dropped in weak moments like words with one less letter, but decently avoided, for the most part, in polite society." Bohm and Grene plump for a mathematics of order and hierarchy for the universe, and Bastin tries to supply some of it.

All this sounds suspiciously like a conflict between teleologists and mechanists. This becomes evident in a curious discussion of group selection, where Bohm, Grene, and Waddington insist that birds sometimes limit their reproduction because the good of their group requires it, while Maynard Smith vainly points out that this hypothesis lacks a mechanism because group selection rarely overcomes selection within groups. Here lies all the strange tension of biology: an Aristotelian philosophy emphasizing perfection and harmony which restores perspective but risks replacing explanation by wordplay, opposed to a mechanist philosophy which is by nature far more honest, but which risks losing all perspective in a welter of necessary detail.

Most biologists invoke natural selection to reconcile this conflict, but this does not satisfy Bohm and Grene. Unfortunately, Maynard Smith's discussion of natural selection does not dispel their doubts. The remark that selection favors the most reproductive genotype doesn't say much by itself: one cannot explain the growing complexity of ecosystems or of some of their occupants, or even make very many interesting predictions, unless one states what makes one genotype more reproductive than another, and this is just what Maynard Smith fails to do. If a (sufficiently simple) population depends on a specific nutrient source (like bacteria in a chemostat), then the most fit genotypes are those that require the least food to maintain their numbers: the "survival of the fittest" then becomes a *predictive* statement. If we ask what morphological changes would reduce food requirements, we rapidly wander into problems we cannot solve: how are we to *describe* the population's options, let alone compare their merit?

The conference has nothing to say about the problems of description: a curious silence, in view of Elsasser's assertion that one cannot measure and describe an organism accurately enough to predict its development. The theorist's central problem is to find meaningful, compelling caricatures: descriptions which capture interesting aspects of biological phenomena, in terms of which one can make interesting predictions. It may be easy enough to show that the complexity of life grows if we can describe what we are talking about in a sufficiently simple yet interesting way. At another level, molecular biologists are acutely embarrassed by the need to decide what is wanted of a "physical representation of development."

In sum, this book gave me a lot to think about. It has two or three articles, especially Bohm's first paper, and Kerner's, which I found quite beautiful. Even the abominable papers, of which there were a number, are abominable in interesting ways and forced me to think about what biology should be. This may be a very personal reaction, however: I doubt if this book will have a very great influence, and doubt if it deserves to. It is simply an unvarnished record of the reactions of intelligent people to the oldest problems in science.

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Reproduction in Wild Animals

Cycles Génitaux Saisonniers de Mammifères Sauvages. Entretiens de Chizé, 1967. R. CANIVENC, Ed. Masson, Paris, 1968. viii + 168 pp., illus. Paper, 46 F. Série Physiologique, No. 1.

This volume is the record of the first of a series of annual conferences held at the Centre for Biological Studies of Wild Animals at Chizé (Deux-Sèvres), France. The meetings attempt to unite field and laboratory studies of wild animals, and, in this case, the disciplines of endocrinology and ethology. The papers summarize the authors' previous work or research in progress—they are not meant to review a field, or to replace detailed research results

published elsewhere. Instead, they serve as introductions to the authors' work and as springboards for discussion.

The papers fall fairly clearly into two groups. Four deal with the elusive inferences possible from tropical field studies. P. Charles-Dominique records probable seasonal breeding in *Perodicticus potto* in Gabon; *Arctocebus* (the golden potto) in the same area may give birth at any time of year. Arlette Petter discusses Madagascar lemurs. She concludes that, although the months of mating and birth differ in each genus, nearly all the young are weaned during the wet season when there is abundant food. G. Dubost attempts to relate birth peaks in the chevrotain, *Hyemoschus aquaticus*, and Elizabeth Pagès the birth peaks of pangolins, to the complex twice-yearly rains and fruiting times of the Gabon jungle. All these papers have in common the difficulty of obtaining data on the animals themselves, either their birth seasons or their ecology.

The other groups of papers deal with reproductive physiology in European mammals. P. Delost speaks from a lifetime's work on rodent reproduction, particularly on the quiescent period when the reproductive tract may partially regress. The degree and time of regression differs between species, between populations in different regions of France, and even within a population from year to year, as does the length of gestation. Mme. L. Martinet discusses the growth rate and longevity of *Microtus arvalis*: voles born in the spring grow rapidly and reproduce and die in the same summer, whereas those born in the fall grow slowly and overwinter before reproducing. Canivenc *et al.* deal with delayed implantation in mustelids, particularly the European badger, which mates during a postpartum oestrus, then keeps the blastocyst free about 300 days before implantation—its total pregnancy therefore lasts very nearly one year! M. Herlant treats the role of the hypothalamus in delayed ovulation in *Myotis* bats, and A. Peyre the peculiar cysts which form in the ovotestis of the mole and the desman (*Galemys pyrenaicus*).

The discussions are fun—revealing, perhaps even dangerously revealing, of personal quirks. They are, at times, factually misleading, as when Canivenc remarks that lemurs in Madagascar (at 13 to 25 degrees below the equator!) are little exposed to changes in day length, or when Grassé says that female primates of low dominance status may be slow to be impregnated (a view not confirmed by any primate study). However, such discussions are not published to convey information, but to give the flavor and excitement of a meeting of specialists.

In summary, this book, like too many symposia, has some new and important information among much, particularly in discussions, that is thin or even professionally useless. As a book it is perhaps most interesting for enabling non-French readers, who may know few of the participants, so quickly to pick up the feel of research in France.

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A Topic in Virology

Interferon. J. VILČEK. Springer-Verlag, New York, 1969. iv + 142 pp. $10.50. Virology Monographs, vol. 6.

This review of interferon is comprehensive, but not encyclopedic. If it attempted to be the latter, it would represent duplication of effort in a very popular area of literary endeavor.

What should one expect in a work of this type? To be useful, it must be timely; it must be fairly complete; and finally, from a work by a single author one expects readability and balance of judgment, qualities so rarely found in multiauthored compendia.

This book discusses literature published up to 1968. It is at most one year out of date, which is acceptable in a review of this size. It includes the important recent developments, such as the discovery of the double-stranded RNA inducers by the Merck group. It reflects the uncertainty of knowledge regarding the mechanism of action of interferon, about which we thought we knew more in 1966 than we do now. The author still diagrams the Marcus-Salb model in great detail, although there is scant positive evidence to support it. He does not mention the work by H. Levy and his co-workers at the National Institutes of Health showing that synthetic double-stranded RNA inhibits tumor growth in the animal. But this finding is so recent and unevaluated that perhaps it is just as well it has escaped review at this time. One actually does not know whether this effect has anything to do with interferon.

The coverage of the major subjects in the field of interferon is fairly complete. These include the assay, induction and synthesis, purification, and mechanism of action of interferon. There is relatively little on the effect of interferon in man or its prospects as an antiviral agent. These matters are so speculative, however, that the author may have been wise not to spend too much time on them.

On the whole, the mass of data is reviewed in a brief, precise, usually impartial, and yet interesting way. The language flows easily, and the book is at times even entertaining, which is remarkable for literature of this type. The bibliography is in alphabetic order by authors, and full references are given. This is useful for those who wish to have a handy compilation of the literature. There is no subject index, which may be construed as a deficiency. Nor is there an author index, so the innumerable experts in the field will not be able to look up the number of times they have been quoted.

I find this to be a useful book at this particular time for graduate students, teachers, and researchers in virology.

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Phylogeny of Some Insects

Evolutionary Trends in Heteroptera. Part 1, Eggs, Architecture of the Shell, Gross Embryology and Eclosion. R. H. COBBEN. Centre for Agricultural Publications and Documentation, Wageningen, The Netherlands, 1968. viii + 476 pp., illus. Dfl. 55. Laboratorium voor Entomologie, Wageningen, Mededeling No. 151. Also published as Agricultural Research Reports, No. 707.

Starting as an intensive investigation of eggs and their development and observations on the egg-laying habits of the shore bugs (Saldidae), the study on which this book is based expanded to include about 350 species "representing almost all families of Heteroptera." The results are presented in a 240-page, family-by-family description of details of the enclosing egg layers and some gross morphology of certain species in each family.

The effort to "trace separately the evolution of each egg-character" (pp. 250–349) of necessity continues the