mately must be attacked neurophysiologically.

Students of honey bee learning who have followed the micromaelstrom occasioned by Wenner's experiments on the role of odors in recruitment of foragers should be aware of J. L. Gould's recent work (*6*), which elegantly settles the matter.

Learning in Crustacea is reviewed by F. B. Krasne, who brings a noticeably biological and evolutionary perspective to his subject. Rather than simply catalog experiments showing that Crustacea can learn, Krasne raises questions concerning "the relationships among what an animal can learn, the organization of its nervous system, and the demands for learning made on it in life." A discussion of ecological constraints on learning is followed by a discussion of the kinds of learning shown by Crustacea. The latter discussion is particularly useful in that it breaks free of the traditional learning categories and considers types of learning representing solutions to general problems of adaptation. Plastic aspects of navigation, social behavior, and food selection provide axes along which one can make biologically meaningful comparisons between species. Krasne gives a particularly thorough treatment of the neural circuit mediating tactilely evoked tail-flip responses in the crayfish. This circuit has recently yielded insights into the way presynaptic inhibition can be used to protect afferent terminals from habituation during tail movement. The tail-flip circuit displays several forms of synaptic plasticity and is one of the most thoroughly and insightfully analyzed "simple systems" in all the invertebrates.

The octopus has been characterized as the closest thing to man outside the Vertebrata. The chapter on the cephalopods by G. D. Sanders supports this contention by being the longest and presenting an excellent summary of the massive and diverse body of information available, primarily on *Octopus vulgaris*. The experiments had their impetus both from formal learning theory (reversal learning, delayed reinforcement) and from ethological considerations of the types of adaptive challenges normally encountered (tactile discrimination, taste by touch). It will be interesting to see if taste aversion learning similar to that found in rats, slugs, and people also occurs in octopuses. The octopus work is now leading to detailed cellular analysis of the vertical lobe system, which has been found to be centrally involved in processes of learning and memory storage. This effort may prove to be a severe test of the ability to analyze function in a neural network on the basis of extensive behavioral and fine-structural information with only sparse underpinnings from direct neurophysiological recording.

It is interesting to consider why out of the more than a million species available the two that receive the most extensive treatment in these volumes, *Apis mellifera* and *Octopus vulgaris*, have been so attractive to researchers. The studies that have been done on these two animals have several features in common. In both cases visual discriminations have been involved and the visual stimuli have been used as signals for the presence of food. The learning shown by both creatures has been rapid and reliable. Certainly part of the explanation lies in the ease with which we, as visual animals, think of questions to ask other primarily visual animals. Moreover, the learning demonstrated in these species has direct relevance to their ecology. Particularly with the bee, ecological and ethological considerations have provided a wellspring of ideas for experiments to delineate the limits of learning ability. Food-related learning, whether concerned with location or safety, is a very general phenomenon that can be found in every major group of invertebrates, and the work that has been done on these two animals provides the most extensive and sophisticated sets of data within which to test general questions of the evolution of learning.

The demands for clean, rapid learning and few, large neurons are most likely to be met simultaneously among the gastropod mollusks. In this group more than any other, one is prone to have a tidy neural circuit analyzed at the cellular level that requires behavioral experiments to determine its reflex function and plastic capabilities. The more complex behavior modes seen in gastropods contain numerous suggestions of plastic components. A. O. D. Willows provides a thorough and informative summary of learning in this group. The identification of categories of learning that both have clear foundation in the animal's ethology and can be as rigorously analyzed as the habituation of gill withdrawal in *Aplysia* will be greatly aided by his treatment.

It should be clear that these volumes contain a large amount of useful information. The theoretical underpinning is incomplete, but the facts are there as grist for the reader's mill. Basic insights into the evolution of learning are yet to be generated, and the volumes are a progress report on the road to such insights. More detailed work, behavioral, anatomical, and physiological, is required on the most favorable organisms. This must be followed by sufficiently detailed work on closely related species that evolutionary trends are revealed.

The problem of making comparisons of learning ability is highlighted by the following passage from a recent review (*7*) of Leon Kamin's *The Science and Politics of I.Q.*

> Intelligence is a biological adaptation whose most distinctive characteristic is plasticity. Intelligence manifests itself in the ability to devise effective responses to new and unforeseen environmental challenges and to make creative use of relevant past experience. Criteria for assessing and comparing intelligent behavior must therefore necessarily vary from one culture or subculture to another. In seeking to devise "culture-free" tests of intelligence psychometricians are pursuing a chimera.

The parallels and problems are clear. Their resolution is one of the most interesting current themes in neurobiology.

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Evolutionary Genetics

Molecular Population Genetics and Evolution. MASATOSHI NEI. North-Holland, Amsterdam, and Elsevier, New York, 1975. xiv, 288 pp., illus. $34. Frontiers of Biology, vol. 40.

The past ten years have witnessed an almost revolutionary change in population genetics. The doldrums of the previous academic period of this subject terminated, not with its death, but rather with its entrance into a second romantic phase. This revolution, or at least revitalization, can be attributed to the application of the techniques of biochemistry and molecular biology to problems of evolutionary genetics. These made it possible to estimate both the amount of genetic diversity in natural populations and the rates of gene evolution. Most fortunately for the persistence of population genetics, the empirical estimates of these fundamental parameters were far different from the values that had been expected on the basis of the existing theory.

The author of this book, Masatoshi Nei, has been a leader of one of the two major factions of this "revolutionary" movement. He has made significant contributions both to theoretical population genetics and to the analysis and interpretation of molecular data. To a great extent, *Molecular Population Genetics and Evolution* is a chronicle of his work and that of his colleagues in arms. It is also an up-to-date, albeit somewhat biased, introduction to the subject and to contemporary evolutionary genetics at large.

The book treats both the theoretical and the empirical aspects of population genetics. The relevant mathematical theory is presented in sufficient detail to give those not familiar with it a good notion of the major points and general flavor of this approach. As the author states, in most cases an effort has been made to minimize the difficulty of the mathematics presented, and it is possible to get a fair amount out of the book even if the two primarily theoretical chapters are avoided. However, the theoretical and empirical aspects of population genetics are so intertwined that a deep understanding of the subject requires at least some knowledge of its mathematical foundations. The book includes a lucid presentation of the logic behind the use of molecular data for population genetic studies and a good summary of the relevant aspects of molecular biology. Extensive consideration is given to the use of protein data for the analysis of gene differences among populations, a subject to which Nei has made a major contribution. In addition to the book's primary concern with microevolutionary phenomena, there is substantial consideration of speciation, evolution beyond the species level, and the evolution of genetic systems. Finally, and most significant, there is an extensive and up-to-date bibliography of the field.

I believe that this monograph can serve both as a reference for evolutionary biologists and as an introduction to this subject for advanced students. A word of caution is warranted, however. Currently "molecular population genetics" is in the midst of a controversy. Most of the protein polymorphism and molecular evolutionary rate data can be explained theoretically by two quite opposing hypotheses: (i) natural selection, and (ii) random genetic drift of selectively neutral and near-neutral alleles. Nei is firmly in the neutralist camp. This is most apparent in the book's concluding section on adaptive and nonadaptive evolution, a neutralist position statement which, I believe, will go a long way toward clearing up many of the misunderstandings of this hypothesis. Nei's bias is also reflected to a certain extent in the choice of material used, but most predominantly in its interpretation. He does, however, present the major selectionist arguments, acknowledges the action of selection when the evidence for it is unambiguous, and concedes the difficulty of distinguishing between these hypotheses with existing theory and data.

In no way do I believe that the biases detract from the significance or utility of the book. I just hope that the high price the publishers are charging will not preclude its reaching the large audience it deserves.

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The Biology of Cancer

Carcinogenesis as a Biological Problem. I. BERENBLUM. North-Holland, Amsterdam, and Elsevier, New York, 1974. xxviii, 376 pp., illus. $34.75. Frontiers of Biology, vol. 34.

Developmental Aspects of Carcinogenesis and Immunity. Proceedings of a symposium, Manhattan, Kans., June 1973. THOMAS J. KING, Ed. Academic Press, New York, 1974. xvi, 218 pp., illus. $8.95.

The seemingly obvious but complex relationship between neoplastic growth and normal cell differentiation has drawn biologists, and especially developmental biologists, ever closer to the cancer problem. These two books, one a monograph by a single author and the other the proceedings of a symposium, are attempts to integrate and put into perspective the new information that has resulted.

The first book takes the more comprehensive approach and treats neoplasia as a general biological problem; the second deals with the broad subjects of tumorigenesis and immunity but deals with them as a developmental problem.

The carcinogenic (chemical agent) approach and the oncogenic (viral agent) approach to cancer research have given it the character of a two-lane highway, both lanes traversing the same ground but often in opposite directions. Thus in *Carcinogenesis as a Biological Problem* Berenblum has chosen to treat the two approaches separately, for each giving a historical account of its origins, followed by a summary of contemporary studies, theories, and clinical implications.

Experimentation with chemical carcinogenesis "began" in 1918 as a result of the general observation that carcinomas arose in the presence of coal tar. It was not until 1933, however, when Cook *et al.* synthesized the first pure carcinogenic agent, that research models became applicable to clinical situations and cancer research was brought to the fore.

Speculation about viral origins of cancer, on the other hand, arose from theories of bacteriology that, as early as 1903, postulated the presence of microorganisms smaller than bacteria. Though researchers on viral oncogenesis were limited to light microscopy until after World War II, Rous's experiments with cell-free filtrates in 1900 gave strong impetus to the viral theory of tumor origin. One important difference between chemical and viral theories of oncogenesis is that the viral theory attempts to explain the process of cancer, whereas the chemical theory would explain only the onset of the disease. Perhaps the complexity of the disease justifies both approaches.

The major considerations of the book are contemporary studies of most known carcinogens, chemical and viral. The treatments of the many agents, influencing factors, and theories are necessarily brief, but the brevity is offset by extensive lists of references following each chapter. It must be mentioned at this point that unfortunately few of the references postdate 1970. Nevertheless, in this field where knowledge grows almost hourly, the monograph provides a thorough background up to the last few years' work.

The purpose of the 32nd symposium of the Society for Developmental Biology, of which *Developmental Aspects of Carcinogenesis and Immunity* is the proceedings, was "to bring into central focus recent advances in carcinogenesis and immunity and emphasize their relationship to fundamental processes of developmental biology."

Reflecting the divisions of the symposium, the book is divided into five sections, each presenting at least two reports. In the first section evidence for the multipotentiality of the tumorous state is presented by Pierce (benign cells within malignant tumors) and by Meins (tumor reversal in crown gall).

The second section considers cell proliferation, differentiation, and neoplasia. Included is a detailed report by Pitot which discusses neoplasia as a function of altered messenger RNA template stability. Temin and Kang complement this report in a later section with their evidence for RNA-directed DNA polymerase activity in normal cell differentiation.

In another section of the book, virus-mediated transformation in vitro is dealt with broadly by Rapp, and the curious failure of other viruses to cause proliferative transformation in vivo is discussed by Todaro. (However, one must bear in mind that although in vitro transformation may possess several similarities to tumorigen-