tionist approach has produced useful information about tissues and molecules. Characteristics of the oxygen transport system (heart mass, blood oxygen capacity) often are correlated with individual variation in locomotor performance. Those physiological characteristics are themselves the products of many variables, and a one-to-one correspondence of physiological and genetic variation like that shown by the studies of Watt, Koehn, and Powers is unlikely. However, this is not an insurmountable problem—knowing the exact mechanism by which genetic variation affects performance would be most satisfactory, but knowing that physiological variation is heritable is adequate. A chapter by Stevan J. Arnold addresses the methods of demonstrating genetic correlations for physiological characters. Arnold's own work on the evolution of behavioral variation of garter snakes gives reason to hope that it will be possible to demonstrate the heritability of physiological characteristics, although we will probably never know exactly the genetic variation involved.

Progress in the upward direction—that is, demonstrating that variation in physiology and performance affects fitness—will require ingenuity. Work so far has focused on locomotor performance and survival—for example, on attempts to show that the individuals of a species that can run fastest or farthest are the ones that live longest. However, the exact roles that speed and endurance play in fitness are unknown. Consequently, no mechanistic hypotheses can be formulated, and this approach relies on large samples to reveal correlations. A positive correlation of the speed of juveniles with survival to adulthood would tell us that it's good to be fast, but not *why*. Many plausible hypotheses that would be of little interest with respect to evolution could explain the correlation: Perhaps the fastest individuals were most successful at avoiding a species of predator that was abundant in the years of the study, or perhaps they were best able to catch the prey that was most abundant, or perhaps an entirely different character that is correlated with speed was the critical factor. Correlational studies must be followed by tests of hypotheses.

Some recently initiated studies begin with a hypothesis to be tested, and this approach is probably the most efficient way to demonstrate mechanistic links between physiology and fitness. The key step in the process is identifying specific activities of organisms that are likely to affect fitness. The selection of questions and methods draws on field studies of behavior and ecology, and the activities studied—foraging, prey capture success, territorial defense, or vocalization—are normal behaviors of the organisms. For example, individual variation in mating tactics is often associated with variation in mating success. One can hypothesize that individual variation in physiological characters such as the ability to accumulate or mobilize energy stores might constrain an individual's choice of reproductive tactics, and thus directly affect its fitness via an effect on mating success. Such studies are preeminently field studies, and manipulation of resources such as food, territories, or shelters is usually a component of testing these hypotheses.

This approach is less laborious than a search for correlations because well-focused hypotheses can usually be tested with smaller sample sizes than are required for descriptive studies. In some cases correlational studies are likely to remain a necessary first step in generating hypotheses, but many hypotheses can be based on the enormous quantity of information that is already available. Employing this fine-grained approach to the selection of promising experimental situations and devising the appropriate tests require the broad, detailed, and mechanistic understanding of organisms that has traditionally been the strength of ecological physiology. The new directions proposed in this volume are being explored most successfully by studies that build on traditional strengths.

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Early Behavioral Plasticity

Perinatal Development. A Psychological Perspective. NORMAN A. KRASNEGOR, ELLIOTT M. BLASS, MYRON A. HOFER, and WILLIAM P. SMOTHERMAN, Eds. Academic Press, Orlando, FL, 1987. xiv, 448 pp., illus. $55; paper, $24.95. Behavioral Biology.

The biological processes involved in the development of the nervous system are the subjects of increasingly active and productive research. One of the major themes in the analysis of nervous system development has been the role played by early experience in modulating or regulating the developmental program. Indeed, the spectacular influence of sensory input on the anatomy and function of sensory systems and the sharp temporal dependency (sensitive periods) characteristic of such phenomena are themselves major research areas. The striking success of these research endeavors (and the high degree of biological responsiveness they have revealed) has occurred over roughly the same period in which significant societal attempts have been made to maximize intellectual development by a variety of educational interventions. There have been some attempts to seek illuminating relationships between these very different levels of environmental, or experiential, modifications of brain development. To date, however, the findings of developmental neuroscience have not had substantial impact on the solution of educational problems, and the difficult work of early educational intervention is not serving as a guide to the formulation of more biological developmental research. In view of the vast gulf separating these worlds of discourse, this is not surprising. (A number of review volumes have appeared within the last couple of years which describe the situation well: *Developmental Neuropsychobiology*, edited by Greenough and Juraska; *The Brain, Cognition, and Education*, edited by Friedman, Klivington, and Peterson; *The Effectiveness of Early Intervention for At-Risk and Handicapped Children*, edited by Guralnick and Bennett.)

The book reviewed here, *Perinatal Development*, edited by Krasnegor, Blass, Hofer, and Smotherman, makes the case that productive interaction is occurring across the biological-behavioral barrier in developmental research. The work presented in the book focuses on the perinatal period, and this facilitates a rigorous biological perspective and at the same time emphasizes that behavioral plasticity is a suitable and profitable object of study.

The substance of the book is composed of 19 chapters divided into four segments concerned with comparative perinatal learning, neural substrates of behavioral plasticity, parent-infant interactions, and social and emotional development. A pleasing continuity is achieved in the problems and analytic methods that are presented in these diverse categories.

An initial goal is to establish definitively that the perinatal organism is not only behaviorally rich but capable of exhibiting a variety of learning phenomena. Some of the evidence that this is so is summarized by Alberts, who emphasizes the substantial conceptual shift in this regard that has taken place since the '60s. His chapter provides a working framework—that of the ontogenetic adaptiveness of the learning that occurs during the perinatal period—for interpreting much of the behavioral work.

Sensory systems have, of course, been the neural locus where much of our knowledge of developmental plasticity has been gained. The olfactory system plays a prominent role in early behavioral patterns of mammals, and a chapter by Shepherd, Pedersen, and Greer presents a detailed picture of the

anatomy of this system in the rat. Plasticity of the olfactory behavior of rat pups, along with an analysis of its cellular-metabolic basis, is described by the Shepherd group and presented in more detail in a chapter by Leon and co-workers. Striking and specific changes in the 2-deoxyglucose uptake in olfactory structures, particularly in the olfactory glomeruli, are produced by early odorant experience. More general anatomical studies of the results of early environmental manipulations are discussed by Greenough in terms of neuronal and synaptic survival and development.

The early plasticity of the olfactory system is but one of many neurobiologic mechanisms mediating the establishment of appropriate maternal-infant relationships. The possibility of breaking down and analyzing the complex web of these relationships is discussed convincingly by Hofer. Specific sensory modalities can be shown to have specific mediating effects, and different brain neurochemical systems may be differentially involved in certain sorts of maternal behavior. Numan focuses on the medial preoptic area in analyzing maternal behavior, whereas Pedersen and Prange emphasize oxytocin as an activator of such behavior. Rosenblatt shows that hormonal states characteristic of the end of pregnancy (high estrogen and declining progesterone levels) provide a sufficient condition to initiate maternal activity in the rat but that maintenance of this activity requires appropriate behavioral (nonhormonal) interactions between mother and pups.

A combination of genetic behavioral predisposition in primate infants with the experiential environment provided by maternal and group characteristics is analyzed in a chapter by Suomi. Genetically highly reactive infants may exhibit their behavioral predisposition only under certain conditions of stress. What is impressive is that the genetic and situational components of behavior are becoming susceptible to experimental analysis and modifications under conditions of controlled breeding and rearing in a primate model. How strong is the genetic factor? What hormonal and neural systems are involved in differential tendencies toward pathological behavior? What environmental conditions maximally elicit or prevent such behavior?

These examples illustrate the combined behavioral and biological approach of this book. The focus is on the relatively brief perinatal period when the complexity of the interaction between environment and organism is amenable to control and analysis. Some of the work presented does venture into the world of subhuman primate development, and indeed of behavioral preference patterns in humans (Kagan, Reznick, and Snidman). Little effort is wasted throughout the book in spelling out parallels between the animal models and human development. The implicit relevance of the work presented and discussed emerges with greater force because of this restraint on the part of the authors. Certainly this book cannot and does not attempt to bridge the gap between molecular and cellular neuroscience on the one hand and the problems of optimizing the human educational process on the other. It does, however, embody an approach whereby neuroscience can illuminate the process of experiential modification of brain development and the behavior mediated thereby. Despite the perinatal focus of this book, it merits the attention of those concerned with the general problem of experiential modulation of behavioral capacity.

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Host-Microbe Interactions

Virulence Mechanisms of Bacterial Pathogens. JAMES A. ROTH, Ed. American Society for Microbiology, Washington, DC, 1988. xiv, 390 pp., illus. $75; to members, $55. From a symposium, Ames, IA, June 1987.

With the demonstration of an etiologic role for bacteria in anthrax by Robert Koch in 1876 and the acceptance of the formal criteria for separating pathogenic from nonpathogenic microorganisms, first proposed by Henle but now known as Koch's postulates, the examination of bacterial virulence began. These early investigators identified a number of pathogenic bacterial species and characterized several properties related to virulence. During these early years, the ability to confer a protective effect against a pathogenic strain of bacteria through the attenuation of the agent and the subsequent use of the altered strain as a vaccine was first described by Pasteur, without any knowledge of the host immune response. The experimental observations that documented the virulence of specific bacterial species were quickly followed by additional work describing the basic characteristics for a variety of microorganisms and numerous histopathologic descriptions of the damage caused during infection of a living host. Today, a broad variety of techniques that focus on both the suspect pathogen and the host response to infection are available. Many of these tools allow scientists to explore the mechanisms responsible for virulence at the cellular and molecular level. Indeed, our methods for defining host-microbe interactions have become so sophisticated that we often lose sight of the complex environment in which such interactions normally occur. As stated in the preface to this volume, "The biologic context must not be lost amidst the glamour of the new technologies."

This volume, from a symposium, attempts to integrate the knowledge of bacterial virulence gained through the use of modern molecular biologic and biochemical methods with a more traditional understanding of virulence at the functional level. It includes sections on adherence, colonization, and invasion, resistance to humoral defense mechanisms, resistance to cellular defense mechanisms, bacterial toxins, and strategies to overcome virulence. Each section contains an introductory overview and several chapters dealing with specific topics related to that functional area.

The first chapter, "Bacterial infection of mucosal surfaces: an overview of cellular and molecular mechanisms," by Lawrence Arp, is particularly well written and provides a theoretical basis for many of the interactions that lead to microbial attachment and penetration of these surfaces. Subjects covered include the physiochemistry of the glycocalyx, as well as fimbrial adhesins, mucosal receptors, and other factors that allow bacteria to adhere to the mucosal surface as the first step in invasion. In the same section the chapter dealing with colonization of the gut, by Rolf Freter, stands out as an excellent discussion of this complex ecosystem. Freter provides a great deal of data and a mathematical model that predicts bacterial population levels in a complex system, based on the ability to adhere. The use of this strategy is an important new technique for gaining a better understanding of microbe-host interactions in vivo.

The overviews of humoral and cellular defense mechanisms are, of necessity, descriptions of the various components of the host immune response. Some topics, such as antigenic shift, antigenic similarity, and iron uptake, are covered in several of the subsequent chapters in a somewhat repetitive manner. Not surprisingly, most of the chapters dealing with specific model systems include detailed discussions of various virulence mechanisms as they pertain to animal species other than humans. Although some of this information is applicable to human disease, much of it is not. Perhaps the greatest weakness of this volume is the absence within each section of any comparative information regarding various hosts or

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