BOOK REVIEWS

Stress, the Aging Brain, and the Mechanisms of Neuron Death. Robert M. Sapolsky. 1992. MIT Press, Cambridge MA. 429 p. $55.00 hardcover.

This monograph considers in great detail evidence in support of the premise that elevations in circulating concentrations of the adrenal steroid hormones called glucocorticoids (cortisol in humans, subhuman primates, and some other animals; corticosterone in rats, mice, and some other animals), repeated naturally or by experimental means throughout the life span of an animal, can result in neuronal cell death, and can produce deficits in function that occur in the aging brain. Since the normal, physiologically regulated method by which glucocorticoids become elevated is in response to stressful encounters, stress is implicated as the initiator of subsequent pathology.

With regard to mechanics, the book is subdivided into three parts, each containing from three to six chapters, for a total of 14 chapters. Part I explores the adrenocortical axis and the mechanisms by which its functions are regulated. This includes the processes activated in response to stress to elevate glucocorticoids, and the importance of the hippocampus in the feedback regulation which terminates glucocorticoid secretion. The chapter which presents an introduction to this axis is now required reading for students in my endocrinology class, and can be used by undergraduate and graduate students alike as a clear example of neuroendocrine structural and functional regulation. The last chapter of this part of the book introduces evidence to support the idea of glucocorticoids as neurotoxic molecules, especially to a given population of cells in the hippocampus. The idea that such cell death will result in progressive disruption of adrenal axis function, causing prolonged secretion of glucocorticoids, is supported in this chapter.

Part II describes processes, both programmed and unprogrammed, by which neurons die. The initial chapter provides studies supporting the damaging effects of gluccorticoids on hippocampal neurons. This is followed by a chapter describing mechanisms involved in programmed cell death, a process which is considered eminently normal by developmental biologists. Succeeding chapters examine abnormal necrotic injury to neurons and processes whereby the delivery of insufficient supplies of energy may cause much of the damage under these conditions. The last chapter of this part of the book returns to the effects of glucocorticoids on neurons, with the primary message that the glucocorticoids are not in and of themselves directly damaging to neurons, but that they compromise the ability of specific neurons in the hippocampus to survive various neurological insults, likely by disruption of energy supply. Such interaction could ultimately result in disruption of adrenal axis feedback control, further neurological damage, and development of age-related neurological diseases.

Part III of the book considers whether Parts I and II should generate significant concern in those who read them! The concept of development of individual differences in stress response is considered (animals handled early in life secrete less glucocorticoid in response to stress than those left unhandled). Recommendations are made for the discontinuation of adrenal steroid "therapy" in the wake of neurological damage, by virtue of the possible detrimental effects of such treatment. The question of whether any of the detrimental effects of glucocorticoids, largely revealed in lab rats, are relevant to human neurological conditions is considered in the final chapter of the book.

Those who have heard Robert Sapolsky deliver a lecture will recognize the clear concise style of this book; there will be no question as to the identity of the author. The book can be best described as "user-friendly" throughout. For example, each of the 14 chapters ends with a summary of the major points made in the chapter and, from the second chapter on, each succeeding one begins with a "Summary of the Book So Far." This integrates the details of material presented to that point, and prepares the reader for the next segment of information. Sapolsky provides the reader with "warnings" about chapters which may digress from the main focus of the book, and which can be omitted from a read-through without major disruption of the train of thought. The book contains a cross-referenced index of four pages, and a reference section which runs for more than 80 pages.

Sapolsky has made a solid case for the glucocorticoids as mediators of neuronal cell death, particularly in experimental rodents, and particularly in the hippocampus. His extension of this case to subhuman primates has some base in experimental support, but that to humans is less solid. Such attempts at extension have lead to controversy, as have reports that *deficiency* of glucocorticoids can also lead to neuronal death, in areas of the hippocampus different from those damaged by glucocorticoid excess. Sapolsky has not dodged these results which run counter to his own, but has included them in counterpoint to the findings in his lab and labs of others whose work supports his (e.g., Landfield, McEwen, Meany). There are certainly findings in other systems that the same endocrine molecule can have opposite effects on different cells, or even on the same cells, without construing one finding as correct and the opposite as incorrect. The opposite effects are simply considered as opposite ends of the same question. Undoubtedly, continued investigation will result in progress from the two ends of the glucocorticoid question to an integrative middle. In the interim, the monograph by Robert Sapolsky provides a good summary of work being done at one of the ends, with acknowledgement of that taking place at the other. Sapolsky ends his preface with the comment, "...this book now contains all I know as of January 10, 1992," and this statement has the ring of truth with regard to the presented information. Data collected since then, and that yet to be collected, will help us all to know, as his last chapter asks, "Is This Relevant to the Human?"

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The Sexual Brain. Simon LeVay. 1993. The MIT Press, Cambridge, MA. 168 p. $22.50 cloth.

Most people are intrigued by sexual behavior, but the area of sex research is in its infancy, especially as it relates to disciplines outside the social sciences and humanities. Simon LeVay in *The Sexual Brain* crosses this barrier in sex research by exploring the biological bases for human sexual behavior. This book is a review of the current literature on brain functions as they relate to sexual behavior and gender behavior. However, this is more than a literature review, LeVay attempts to integrate the information currently available on how anatomical structures, physiological mechanisms, hormonal systems, genetic influences, and neurochemical and neuroelectrical activity may influence a complex human behavior: human sexuality.

Although biological processes tend to intimidate most readers, especially those drawn to literature on the social sciences or the humanities, LeVay has successfully written about some of the most complex biological mechanisms in a way that is easy to follow both for the lay reader and the hard scientist. *The Sexual Brain* begins by giving the reader an overview of the biological and physiological systems that have been studied in relation to human sexual behavior. This overview includes a review of evolutionary theory, genetics, sexual differentiation, the organization of the human brain, the biological mechanisms of sex, and hypothalamic functioning and other neural mechanisms. LeVay then continues by reviewing some of the behaviors related to sexual behavior and sex differentiated behaviors and traits. Research on courtship behaviors and maternal behaviors in both humans and other non-human species are explored, as well as behaviors that are gender specific that lie outside of the realm of sexual behaviors. LeVay has also included chapters on his current area of research, sexual orientation and gender identity.

Of specific interest is the chapter on human sexual orientation. For a long time a debate has been brewing on the causes of sexual orientation. Is sexual orientation a function of nature or of nurture? Most of the past research on sexual orientation focused on the environmental causes of orientation. However, very recently there has been a flurry of research on biological mechanisms that may influence people's orientation. LeVay quite extensively and quite thoroughly reviews the evidence supporting the theory that orientation may be, at least in part, genetically or biologically determined. This review includes his own work on the differences between heterosexuals and homosexuals in hypothalamic functioning.

LeVay also believes that all of human sexuality and sexual behavior is rooted in anatomical brain structure and neurophysiology. It is in this belief that this book is founded. LeVay conveys the biological and evolutionary theory behind the behavior. Whereas most literature in the area of the hard sciences is notoriously dry, LeVay writes with unusual palatability and lightness. He provides a smattering of information about topics such as neuroendocrinology, genetics, molecular biology, brain anatomy and function, and cognitive and behavioral psychology without a large amount of inane details. This book is for all types of readers from the scientist to the lay reader. *The Sexual Brain* comes highly recommended to anyone interested in the mechanisms behind the complexities of human sexuality.

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In the Wake of Chaos: Unpredictable Order in Dynamical Systems. Stephen H. Kellert. 1993. The University of Chicago Press, Chicago, IL. 176 p. $19.95 hardcover.

Chaos theory is often described, at least in popular expositions, as a "new science" or a "revolution" in science. To what extent this is true is the subject of considerable debate in the scientific and academic communities. (Some have argued, for instance, that chaos theory is simply a corollary of a much bigger and more important revolution, namely, the computer revolution.) On the one hand, the increased exploration of nonlinear dynamical systems has no doubt increased our understanding of Nature. On the other hand, as the author of the book under review points out, "chaos theory does not introduce any fundamental revisions in our laws of nature as quantum mechanics or relativity did." Moreover, it is clearly the case that chaos theory has been subjected to a not inconsiderable amount of "hype" and overglamorization. In this thought-provoking little book the author makes the case that "chaos theory is rich with philosophical interest."

The book is made up of five chapters each devoted to separate, but related, topics. The first chapter is a very respectable introduction to the subject of chaos theory itself. The author defines chaos theory as "the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems." (A minor quibble here: Chaos theory is concerned with *bounded* solutions. The author mentions this in a footnote, but I would have liked to have seen it included in the definition.) A central feature of chaos theory is that solutions of simple deterministic nonlinear dynamical systems can, and often do, exhibit "sensitive dependence on initial conditions." When solutions that start out close together diverge rapidly from each other it is for all practical purposes impossible to predict the evolution of the system from a particular state. Thus, chaotic systems are often described as deterministic systems that give rise to "random" behavior. Moreover, since in chaotic systems the solutions remain bounded, the "stretching" that results from nearby points diverging from each other must be accompanied by a "folding" that brings together far away points. This "stretching and folding" gives rise to complicated limit sets called "strange attractors." The hope is that chaos theory will lead scientists to a greater understanding of some types of apparently complex phenomena, such as turbulence.

Sensitive dependence on initial conditions imposes severe limitations on predicting the future evolution of any individual state in a chaotic dynamical system. In any

physical system it is, of course, impossible to achieve an exact knowledge of the initial conditions; and, since chaotic systems don't admit closed form solutions, this limitation is not only derived from imperfect measuring devices—mere round-off error will doom us, if nothing else does. Since chaotic systems are "deterministic" one might argue that prediction is theoretically possible, and that the limitations imposed are merely practical. The second chapter explores several different ways in which something can be "impossible." The author contends that chaos theory blurs the distinction between the theoretically and the practically possible, and that chaos theory imposes a "distinctive" type of limitation on predictions. Mathematically a dynamical system is "deterministic" if, for given initial data, solutions exist and are unique. However, if it is impossible to make useful predictions about the future states of a system, then does it make sense, philosophically, to refer to that system as deterministic? The third chapter discusses some of the possible meanings of determinism and their relationship to predictability.

In the fourth chapter the author discusses the effect chaos theory has had on the way science tries to understand Nature. Specifically, the author treats "the object, the method, and the character of understanding provided by chaos theory." One aspect of the character of understanding provided by chaos theory is that since certain types of quantitative predictions are impossible, qualitative understanding plays an important role in chaos theory (and, indeed, in the theory of nonlinear dynamical systems, generally).

The final chapter of the book addresses what the author refers to as "the nontreatment of chaos." There can be little doubt that many of the mathematical and experimental precursors of chaos theory existed long before chaos theory became a subject of widespread interest. The usual explanations revolve around the nonexistence of digital computers and the difficulty of studying nonlinear dynamical systems without the aforementioned digital computers. The author contends that these explanations (and others, for example, academia's preference for the linear over the nonlinear) do not tell the whole story, and that social and cultural factors are highly important in explaining this relative neglect of chaos theory. Unfortunately, I must confess that I found the section entitled "A Role for Social Interests" to be somewhat less than convincing. For example, after reading approximately 150 pages of what I thought were very cogent and well-expressed arguments, I found the author's argument in favor of a connection between the nontreatment of chaos theory and the "domination" of women to be somewhat of a stretch.

Nonetheless, I expect that this book will be of interest to anyone who is interested in chaos theory or in the philosophy of science. In particular, I think it would be especially appropriate reading material for any course in the philosophy of science.

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Ecology and Our Endangered Life-Support Systems. Eugene P. Odum. 1993. Sinauer Associates, Inc., Sunderland, MA. 301 p. $18.95 paper.

This second edition of a now classic ecology primer retains its message, structure, and readability but with addition of some new facts, examples, concepts, and issues; and, in an epilogue, it updates successes and failures in our stewardship of the earth. Although very slightly enlarged in both length and format, it still is a handy and concise ecology primer for use as an introduction to ecology for general courses and as a supplemental reader in environmental science courses.

The structuring of the book is unchanged. It opens with a prologue about the Apollo 13 moon flight, crippled by breakdown of its life-support systems, and this is used as an analogy to our crippled "spaceship earth." Although an apt comparison, the incident already may seem dated. Still, it sets the stage for Odum's goal: describing earth's vital processes in order to preserve them and thus ourselves. As before, the first three chapters give scope to the ecological problems facing us, and the last five provide details about the ecological processes implicated in these problems. An epilogue assesses the vast task facing us and the possible outcomes.

In Chapter One, Odum distinguishes between fabricated, domesticated, and natural areas; and he shows that although the fabricated areas are a small fraction of the total area, they represent a large fraction of energy consumption (energy intensity). In two briefly documented examples (New York Bight and Illinois River Basin), he details existing damage to these life-support systems. He also gives brief consideration to San Francisco Bay, Chesapeake Bay, and Lake Erie. It would have added greatly to this revision if he had inserted several examples from the southern, west central, and northwestern U.S. This would have brought his message closer to home for readers from these regions. Also, he might have very slightly expanded the Chesapeake Bay section because of its tremendous size, regional consequences, and recent, if limited, progress. These advantages would, I think, have outweighed the primer's further slight expansion. In Chapter Two he looks at systems, their levels of organization, and their interactive complexity. Then he offers the "emergent property principle" for understanding the product of such systems. Using ecological modeling he shows how smog production emerges as the outcome of the Los Angeles basin ecological system. Chapter Three is a brief formal presentation of modeling, emphasizing energetics, as applied to meadow and pond ecosystems.

The meat of the book is in Chapters Four through Eight which cover energetics, biogeochemical cycles and physical conditions, population ecology, development and evolution, and world ecosystems. Additions to these chapters now include ecotones, diversity, energetics, agroecology, succession, mutualism, evolution, ecological economics, waste reduction, ecosystem types, and global concerns (such as ozone holes and climate change). Thus, even for a primer, there has been addition of some important new concepts, emphases, or developments.

The epilogue represents an expanded discussion of world problems and predictions for the future. Necessarily,

with an update only every four years and with an explosion of very recent publications, it cannot stay abreast. Even so, it does provide an important update. As an example, Odum summarizes the findings in *Beyond Limits* (1992), a 20-year follow-up on the Club of Rome's *The Limits of Growth* (1972). This study reports that global resources (relative to demand) are worse than predicted; but it foresees a sustainable future if critical socio-economic and political changes occur, if there are targeted sharp reductions in population growth rates and urban-industrial development, and if cooperative and holistic (holoeconomic) approaches are developed. In acting on this program, worrisome gaps (in income, food, value, and education) will have to be addressed; current social traps will have to be turned into trade-offs; there must be shifts from quantitative to qualitative growth; priorities will have to be adjusted uniquely for each world region in terms of its income and population density; and, in dealing with unintended consequences of technological developments, we must develop counter-technologies and bear transition costs. These and other changes only will occur if there is an "about-face" in management of production systems: away from *more output* and toward *less* (and more efficient) *input*. Whether humanity, a parasite on the biosphere, can make this shift from a short-term to long-term survival system is still an open question. But, as Lee Mitchell noted in his review of Odum's first edition (Ohio J. Sci. 89: 196), "The bugler has hopefully not signaled our last warning." Perhaps not, but he is mounting the parapet.

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