ALLOSTASIS, HOMEOSTASIS, AND THE COSTS OF PHYSIOLOGICAL ADAPTATION

The concept of homeostasis, the maintenance of the internal physiological environment of an organism within tolerable limits, is well established in medicine and physiology. In contrast, allostasis is a relatively new idea. Allostasis explains how regulatory events maintain organismic viability, or not, in diverse contexts with varying setpoints of bodily needs and competing motivations. Allostasis accounts for wide variation in function, adaptation, and cephalic involvement in systemic physiological regulation. It provides a conceptual framework for both the protective and the damaging effects that occur in overall regulation of physiological and behavioral systems. This book, the first edited volume to focus on allostasis, orients the reader by addressing basic physiological regulatory systems and examining bodily regulation under duress. It integrates the basic concepts of physiological homeostasis with disorders such as depression, stress, anxiety, and addiction and will therefore appeal to graduate students, medical students, and researchers working in related areas.

Jay Schulkin is a research professor in the Department of Physiology and Biophysics at Georgetown University, the Director of Research of the American College of Obstetricians and Gynecologists, and a research associate at the Clinical Neuroendocrinology Branch of the National Institute of Mental Health. He is the author of several books for Cambridge University Press, including *Calcium Hunger* (2001), *The Neuroendocrine Regulation of Behavior* (1999), and *Sodium Hunger* (1991).

Allostasis, Homeostasis, and the Costs of Physiological Adaptation

Edited by

JAY SCHULKIN
Georgetown University

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9781107406582

First published 2004
First paperback edition 2012

A catalogue record for this publication is available from the British Library

Library of Congress Cataloguing in Publication Data
Allostasis, homeostasis and the costs of physiological adaptation / edited by Jay Schulkin.
p. cm.
Includes bibliographical references and index.
ISBN 0-521-81141-4
1. Allostasis. 2. Homeostasis. 3. Adaptation (Physiology) I. Schulkin, Jay.
QP82.A36A457 2004
612′.022 – dc22 2003062975

ISBN 978-0-521-81141-5 Hardback
ISBN 978-1-107-40658-2 Paperback

Dedicated to Mary Dallman, Ralph Norgren, and Larry Swanson

Contents

Preface

The fun part of science includes the discoveries that we make, the people who we meet and befriend, and our exploration of the larger world. The practice of science ought to cut across narrow boundaries of self-enclosure. I have enjoyed working with both old friends and colleagues and new ones in the context of putting together this book.

Two concepts essential for research in which I have been involved are homeostatic and allostatic regulation. The first is well known, the second is not. There are many books on homeostasis. This is the first edited book on allostasis, which is the volume's primary focus. It became clear that something more than traditional homeostasis would be needed to account for the diverse forms of adaptation to changing circumstances that animals exhibit. Many investigators have noted this fact. Allostasis does not have a univocal meaning for the authors in this book. Two defining features of allostasis are its emphasis on (1) adaptive changes and diverse range of physiological and behavioral options that emerged with central nervous system involvement in peripheral physiological regulation and (2) the breakdown of regulatory systems when pushed beyond adaptation.

The authors in this volume, in one way or another, have been thinking for some time about behavioral and physiological regulatory systems. The topics are diverse but not exhaustive of the literature on regulatory physiology and systems neuroscience. It is hoped that these essays will invite others to revisit the topic toward the goal of understanding the mechanisms that underlie physiological and behavioral adaptation in the regulation of the internal milieu.

I apologize in advance to those who may not have been mentioned but who have contributed to the field. This book is but a small-scale searchlight on the field of regulatory physiology and behavioral neuroscience.

I was first introduced to the concept of allostasis because Peter Sterling and I were in the same department at the University of Pennsylvania. I was

giving a departmental talk as a new professor, and in those days my rate of speech far exceeded that necessary for the content I needed to explain. I did not know Peter Sterling then, but it got back me to me that Peter was dismayed by my lecture. I went up to him to talk, and eventually we became friends. This has been an important relationship for both of us.

I took his allostasis paper with me to Italy in 1987 and spent much time critiquing it. It was only after I came to Washington and the National Institute of Mental Health in 1992 that I started to integrate the concept into my scientific research. This continued with my long-term collaboration with Bruce McEwen.

I want to thank my family and friends.

Contributors

Ziad Boulos
New York State Psychiatric Institute and Department of Psychiatry
Columbia University
New York, New York

David S. Goldstein
Clinical Neurocardiology Section
National Institute of Neurological Disorders and Stroke
Bethesda, Maryland

George F. Koob
Department of Neuropharmacology
The Scripps Research Institute
La Jolla, California

Bruce S. McEwen
Harold and Margaret Milliken Hatch Laboratory of Neuroendocrinology
The Rockefeller University
New York, New York

Michel Le Moal
Psychobiologie des Comportements Adaptatifs
Institut National de la Sante et de la Recherche Medicale
Bordeaux, France

Michael L. Power
Smithsonian National Zoological Park
Washington, D.C.

Jeffrey B. Rosen
Department of Psychology
University of Delaware
Newark, Delaware

Alan M. Rosenwasser
Department of Psychology
University of Maine
Orono, Maine

Carol D. Ryff
Department of Psychology
University of Wisconsin
Madison, Wisconsin

Jay Schulkin
Department of Physiology and Biophysics
Georgetown University
Washington, D.C., and
Clinical Neuroendocrinology Branch
National Institute of Mental Health
Bethesda, Maryland

Teresa Seeman
Department of Genetics
University of California, Los Angeles
Los Angeles, California

Burton Singer
Office of Population Research
Woodrow Wilson School of International Affairs
Princeton University
Princeton, New Jersey

Peter Sterling
Department of Neuroscience
University of Pennsylvania
Philadelphia, Pennsylvania

John C. Wingfield
Department of Zoology
University of Washington
Seattle, Washington