KINDLING 5
ADVANCES IN BEHAVIORAL BIOLOGY

Editorial Board

Jan Bures
Institute of Physiology, Prague, Czech Republic

Irwin Kopin
National Institute of Mental Health, Bethesda, Maryland

Bruce McEwen
Rockefeller University, New York, New York

James McGaugh
University of California, Irvine, California

Karl Pribram
Stanford University School of Medicine, Stanford, California

Jay Rosenblatt
Rutgers University, Newark, New Jersey

Lawrence Weiskrantz
University of Oxford, Oxford, England

Recent Volumes in This Series

Volume 36 NOVEL APPROACHES TO THE TREATMENT OF ALZHEIMER'S DISEASE
Edited by Edwin M. Meyer, James W. Simpkins, and Jyunji Yamamoto

Volume 37 KINDLING 4
Edited by John A. Wada

Volume 38A BASIC, CLINICAL AND THERAPEUTIC ASPECTS OF ALZHEIMER'S AND PARKINSON'S DISEASES
Volume 1
Edited by Toshiharu Nagatsu, Abraham Fisher, and Mitsuo Yoshida

Volume 38B BASIC, CLINICAL AND THERAPEUTIC ASPECTS OF ALZHEIMER'S AND PARKINSON'S DISEASES
Volume 2
Edited by Toshiharu Nagatsu, Abraham Fisher, and Mitsuo Yoshida

Volume 39 THE BASAL GANGLIA III
Edited by Giorgio Bernardi, Malcolm B. Carpenter, Gaetano Di Chiara, Micaela Morelli, and Paolo Stanzione

Volume 40 TREATMENT OF DEMENTIAS: A New Generation of Progress
Edited by Edwin M. Meyer, James W. Simpkins, Jyunji Yamamoto, and Fulton T. Crews

Volume 41 THE BASAL GANGLIA IV: New Ideas and Data on Structure and Function
Edited by Gérard Percheron, John S. McKenzie, and Jean Féger

Volume 42 CALLOSAL AGENESIS: A Natural Split Brain?
Edited by Maryse Lassonde and Malcolm A. Jeeves

Volume 43 NEUROTRANSMITTERS IN THE HUMAN BRAIN
Edited by David J. Tracey, George Paxinos, and Jonathan Stone

Volume 44 ALZHEIMER'S AND PARKINSON'S DISEASES: Recent Developments
Edited by Israel Hanin, Mitsuo Yoshida, and Abraham Fisher

Volume 45 EPILEPSY AND THE CORPUS CALLOSUM 2
Edited by Alexander G. Reeves and David W. Roberts

Volume 46 BIOLOGY AND PHYSIOLOGY OF THE BLOOD–BRAIN BARRIER: Transport, Cellular Interactions, and Brain Pathologies
Edited by Pierre-Olivier Couraud and Daniel Scherman

Volume 47 THE BASAL GANGLIA V
Edited by Chihito Ohye, Minoru Kimura, and John S. McKenzie

Volume 48 KINDLING 5
Edited by Michael E. Corcoran and Solomon L. Moshé

A Continuation Order Plan is available for this series. A continuation order will bring delivery of each new volume immediately upon publication. Volumes are billed only upon actual shipment. For further information please contact the publisher.
Proceedings of the Fifth International Conference on Kindling, held June 27–30, 1996, in Victoria, British Columbia, Canada

DOI 10.1007/978-1-4615-5375-5

Softcover reprint of the hardcover 1st edition 1998

10 9 8 7 6 5 4 3 2 1

All rights reserved

No part of this book may be reproduced, stored in retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the Publisher
To Juhn A. Wada, the Thunderbird of Kindling
PREFACE

The last Kindling Conference was organized by Dr. Juhn Wada and held at the University of British Columbia, Vancouver, B.C., in 1989. In the intervening years, research on kindling has proceeded at an explosive pace and significant advances have been made in our understanding of the molecular biological, anatomical, and physiological substrates of kindling, as well as in our appreciation of the age-dependent effects and complex behavioral consequences of kindling, its sensitivity to drugs, and its relevance to the clinical epilepsies. In order to review these developments and to provide researchers with an opportunity to interact face to face and discuss the issues that preoccupy us all, we organized the Fifth International Conference on Kindling, in Victoria, B.C., in the summer of 1996. Most of the stalwarts in kindling research were invited, as were a number of investigators whose research on kindling has become prominent in the past few years. We continue to miss the late Graham Goddard, the discoverer of kindling, and were saddened by the recent death of Eric Lothman, a prolific researcher and clinician who would have been a prominent participant. We were deeply disturbed to learn of the death of Frank Morrell, one of the earliest kindlers and an eminent neurologist, who died several months after our conference. We also regret that several of our colleagues were unable to attend the conference: Robert Ackermann, Tallie Baram, Robert De Lorenzo, Lewis Haberly, Gregory Holmes, Gildas Le Gal La Salle, Frank Morrell and Leyla de Toledo Morrell, Robert Post, Mitsumoto Sato, and Thomas Sutula.

The organization of Kindling 5 was slightly different from the past kindling conferences, in that the talks were loosely organized into themes, with each session being followed by a general discussion. In keeping with past conferences, however, we have attempted to capture the gist of the discussions that followed the presentations. The discussions are often more revealing than the formal presentations, and if nothing else they convey some of the informality of the dialogue among a group of researchers who know each other well.

Kindling 5 was dedicated to the keynote speaker, Dr. Juhn Wada, who is Professor Emeritus of Psychiatry and Neurological Sciences at the University of British Columbia. Everybody knows Dr. Wada. He is one of the preeminent epileptologists in the world, having contributed insightful and important research and clinical practice for over 40 years. He is the originator of the carotid amytal test for cerebral dominance, and he performed research with various “animal models” that anticipated aspects of kindling. In 1972 he turned his attention to kindling and became one of its most ardent boosters and one of the most prolific researchers in the field. He also was the driving force behind the first four International Conferences on Kindling, and it is fair to say that the prominence of kindling is in no small measure attributable to his influence.
Dr. Wada has been the recipient of many honours and awards. He was one of the organizers of and President of the Canadian League Against Epilepsy. He was President of the American Epilepsy Society, and he used his office to promote the recruiting of basic scientists as members of AES. In recognition of his many contributions to humanity, in 1992 he was made an Officer of the Order of Canada, entitling him to append the initials “O.C.” after his name. In 1995 the Japanese Government awarded him the Order of the Sacred Treasure, Gold and Silver Star, in recognition of his exemplary efforts to promote and expand relations between Canada and Japan in the medical field.

We want to thank the following sponsors for very generously providing the financial support that has made Kindling 5 possible:

- Parke Davis (Warner-Lambert Co.)
- CIBA-GENEVA
- Hoechst Marion Roussel, Inc.
- Bloorview Epilepsy Research Program (University of Toronto)
- Abbott Laboratories
- Wyeth-Ayerst Laboratories
- McNeil Pharmaceutical Corp.
- Wallace Laboratories

We also thank a number of people whose outstanding efforts enabled the conference to run smoothly. Several graduate students from the Department of Psychology, University of Victoria, assisted in the technical aspects of the conference: Lisa Armitage had the responsibility of transcribing discussions unexpectedly thrust on her at the last possible instant before the conference began, and she responded heroically by keeping an online record of the gist of the discussions. She also did much of the transcribing to hard copy after the conference. Darren Hannesson was responsible for the taping of the discussions and kept notes on who said what and when. This responsibility too came at the last minute. Paul Mohapel did a first rate job as the projector guy, handling the task without any major glitches, and even found time to ask a few pertinent questions. The organization of the molecular details of the conference was handled by several people from Conference Management, Division of Continuing Studies, University of Victoria: Mary O’Rourke quarterbacked the whole operation from the outset. We could not have done it without her, and she has our eternal gratitude. Nieves Forcada-Ausio helped with many of the organizational details, as did Sarah D’Aeth, who also was present for the entire conference and cracked the whip regarding adjourning for meals, submitting manuscripts, and regulating the air conditioning. Charlene Quinn and Victoria Emery provided critical background support. They all made the conference a reality. Finally, we thank all the kindlers, without whom there would not have been a Fifth International Conference on Kindling.

Michael E. Corcoran and Solomon Moshé
CONTENTS

1. Genetic Predisposition and Kindling Susceptibility in Primates ............. . 1
   Juhn A. Wada

General Discussion 1 ....................................................... 13

DEVELOPMENTAL PATTERNS

2. Idiosyncrasies of Limbic Kindling in Developing Rats ......................... 15
   Kurt Z. Haas, Ellen F. Sperber, Barbara Benenati, Patric K. Stanton, and
   Solomon L. Moshe

3. Long-Term Effects of Kindling on Learning and Memory in the Developing
   Brain ............................................................................. 27
   Matthew Sarkisian, Pushpa Tandon, and Gregory L. Holmes

4. Short Interval Electrical Amygdala Kindling in Infant Rats: The Paradigm and
   Its Application to the Study of Age-Specific Convulsants .................... 35
   Tallie Z. Baram, Edouard Hirsch, and Linda Schultz

5. Ontogeny of Temporal Lobe Epilepsy in Amygdala-Kindled Kittens:
   Phenomenology, Treatment Alternatives, and Basic Mechanisms of
   Sleep-Waking State Seizure Activity ...................................... 45
   Margaret N. Shouse, James Langer, Paul Farber, Michael Bier, Orly Alcalde,
   and Ronald Szymusiak

General Discussion 2 ......................................................... 61

ELECTROPHYSIOLOGICAL MECHANISMS

6. Lasting Prolongation of NMDA Channel Openings after Kindling ............. 65
   Istvan Mody and David N. Lieberman

7. Long-Lasting Changes in the Pharmacology and Electrophysiology of Amino
   Acid Receptors in Amygdala Kindled Neurons .................................. 75
   Patricia Shinnick-Gallagher, N. Bradley Keele, and Volker Neugebauer
8. Role of the Dentate Gyrus in the Spread of Seizures within the Hippocampal-Parahippocampal Circuit ........................................... 89
   Janet L. Stringer and Enhui Pan

9. Quenching: Persistent Alterations in Seizure and Afterdischarge Threshold following Low-Frequency Stimulation ........................................... 101
   Susan R. B. Weiss, Xiu-Li Li, E. Christian Noguera, Terri Heynen, He Li,
   Jeffrey B. Rosen, and Robert M. Post

10. Kindling-like Effects of Electroconvulsive Shock Seizures ................. 121

General Discussion 3 ............................................... 131

MORPHOLOGICAL AND ANATOMICAL MECHANISMS

11. The Role of Rhinencephalic Networks in Early Stage Kindling ............. 133
    James L. Burchfiel, Craig D. Applegate, Gary M. Samoriski, and
    Jay Nierenberg

12. The Role of Rhinencephalic Networks in the Late Stages of Kindling ....... 151
    Craig D. Applegate, James L. Burchfiel, Russell J. Ferland, and
    Jay Nierenberg

13. The Perirhinal Cortex and Kindled Motor Seizures .......................... 167
    Dan C. McIntyre and Mary Ellen Kelly

14. Comparison of Synapse Remodeling following Hippocampal Kindling and
    Long-Term Potentiation ........................................... 179
    Yuri Geinisman, Frank Morrell, Leyla deToledo-Morrell, Inna S. Persina, and
    Eddy A. Van der Zee

    Ronald J. Racine, Beth Adams, Philip Osehobo, Norton W. Milgram, and
    Margaret Fahnestock

16. Dissociations between Kindling and Mossy Fiber Sprouting ................ 211
    Michael E. Corcoran, Lisa L. Armitage, Darren K. Hannesson,
    Elaine M. Jenkins, and Paul Mohapel

General Discussion 4 ............................................... 225

SYNAPTIC PHARMACOLOGY AND NEUROCHEMISTRY OF KINDLING

17. Regional Specific Changes in Glutamate and GABA Receptors, PKC Isozymes,
    and Ionic Channels in Kindling Epileptogenesis of the Hippocampus of
    the Rat ............................................................ 229
    Fernando H. Lopes da Silva, Guido C. Faas, Willem Kamphuis,
    Miriam Titulaer, Martin Vreugdenhil, and Wytse J. Wadman
18. Kindling: A Pathologic Activity-Driven Structural and Functional Plasticity in Mature Brain ................................................. 245
Devin K. Binder and James O. McNamara

19. Activities of Protein Kinase C in the Kindling Model of Epilepsy ...................... 255
Kazufumi Akiyama

20. Kindling Induces Long-Term Changes in Gene Expression ........................... 267
Ann C. Rice and Robert J. DeLorenzo

Donald P. Cain

22. Neurotrophins and Kindling Epileptogenesis ........................................ 299
Olle Lindvall, Zaal Kokaia, Eskil Elmér, Istvan Ferencz, Johan Bengzon, and Merab Kokaia

23. Somatostatin- and Neuropeptide Y-Mediated Neurotransmission in Kindling Epileptogenesis ............................................... 313
Annamaria Vezzani, Charles Piwko, Marco Gobbi, Christoph Schwarzer, Gunther Sperk, and Daniel Hoyer

BEHAVIORAL EFFECTS OF KINDLING

24. Amygdala Kindling and Rodent Anxiety .................................................. 327
Robert Adamec

25. Long-Term Amygdala Kindling and Defensive Behavior in Rats ..................... 349
John P. J. Pinel, Lisa E. Kalynchuk, and Dallas Treit

26. The Neurobehavioral Consequences of Kindling ....................................... 361
Theresa D. Hernandez, Lisa A. Warner, and Sylvia Montañez

27. Kindling and Spatial Cognition .................................................................. 377
Michael E. Corcoran, Lisa L. Armitage, Trevor H. Gilbert, Darren K. Hannesson, and Paul Mohapel

28. Long-Lasting Behavioral and Electrophysiological Effects Induced by Partial Hippocampal Kindling ......................................... 395
L. Stan Leung, B. Shen, R. Sutherland, C. Wu, K. Wu, and D. Zhao

DRUGS AND KINDLING

29. Protective Effects of Brain-Derived Neurotrophic Factor in Hippocampal Kindling ................................................................... 409
Sophie Reibel, Yves Larmet, Josette Carnahan, Bich-Thuy Lê, Christian Marescaux, and Antoine Depaulis
30. Perforant Path Kindling, NMDA Antagonism, and Late Paired Pulse Depression 421
   Mary E. Gilbert

31. Pharmacology of Glutamate Receptor Antagonists in the Kindling Model 435
   Wolfgang Löscher

32. Interactions between Convulsants at Low-Dose and Phenobarbital in the
   Hippocampal Slice Preparation 451
   Larry G. Stark, R. M. Joy, W. F. Walby, and T. E. Albertson

General Discussion 5 465

CLINICAL IMPLICATIONS OF KINDLING

33. The Syndrome of Mesial Temporal Lobe Epilepsy: A Role for Kindling 469
   Jerome Engel, Jr.

34. Contributions of Kindling to Clinical Epileptology 485
   Kiyoshi Morimoto, Hitoshi Sato, Mariko Osawa, and Mitsumoto Sato

35. Vagus Nerve Stimulation: Effects on Circadian Sleep Organization and Kindling
   Development in the Cat 495
   Augusto Fernández-Guardiola, Adrián Martínez-Cervantes,
   Alejandro Valdés-Cruz, Victor Magdaleno-Madrigal, and
   Rodrigo Fernández-Mas

36. Facilitation of Kindling and Long Term Potentiation by Hippocampal Lesions 501
   Claude G. Wasterlain, Andrey M. Mazarati, Yukiyoishi Shirasaka,
   Raman Sankar, and Kerry W. Thompson

Summary Discussion 509

Participants Photo 511

Index 513