

**NEUROLOGY AND
NEUROBIOLOGY
VOLUME 24**

Alan R. Liss, Inc., New York

EXCITATORY AMINO ACID TRANSMISSION

Proceedings of a Satellite Symposium to the 30th Congress
of the International Union of Physiological Sciences
Held in Banff, Alberta, Canada, July 20-23, 1986

Editors

T. Philip Hicks

Department of Medical Physiology
The University of Calgary
Calgary, Alberta, Canada

David Lodge

Department of Physiology
Royal Veterinary College
London, U.K.

Hugh McLennan

Department of Physiology
University of British Columbia
Vancouver, British Columbia, Canada

ALAN R. LISS, INC., NEW YORK

Address all Inquiries to the Publisher
Alan R. Liss, Inc., 41 East 11th Street, New York, NY 10003

Copyright © 1987 Alan R. Liss, Inc.

Printed in the United States of America

Under the conditions stated below the owner of copyright for this book hereby grants permission to users to make photocopy reproductions of any part or all of its contents for personal or internal organizational use, or for personal or internal use of specific clients. This consent is given on the condition that the copier pay the stated per-copy fee through the Copyright Clearance Center, Incorporated, 27 Congress Street, Salem, MA 01970, as listed in the most current issue of "Permissions to Photocopy" (Publisher's Fee List, distributed by CCC, Inc.), for copying beyond that permitted by sections 107 or 108 of the US Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale.

Second Printing, October 1987

Library of Congress Cataloging-in-Publication Data

Excitatory amino acid transmission.

(Neurology and neurobiology ; 24)

Satellite symposium of the 30th Congress of the International Union of Physiological Sciences, held in Vancouver, July 1986.

Includes index.

I. Neurotransmitters—Congresses. 2. Amino acids—Congresses. I. Hicks, T. Philip. II. Lodge, David, Ph.D. III. McLennan, Hugh, 1927–. IV. International Congress of Physiological Sciences (30th : 1986 : Vancouver, B.C.) V. Series: Neurological and neurobiology ; v. 24. [DNLM: 1. Amino Acids—pharmacodynamics—congresses. 2. Synaptic Receptors—drug effects—congresses. W1 NE337B v.24 / QU 60 E96 1986] QP364.7.E979 1986 599'.01'88 86-27866
ISBN 0-8451-2726-8

EXCITATORY AMINO ACID TRANSMISSION

Neurology and Neurobiology

EDITORS

Victoria Chan-Palay
University Hospital, Zurich

Sanford L. Palay
The Harvard Medical School

ADVISORY BOARD

Albert J. Aguayo
McGill University

Günter Baumgartner
University Hospital, Zurich

Masao Ito
Tokyo University

Gösta Jonsson
Karolinska Institute

Bruce McEwen
Rockefeller University

William D. Willis, Jr.
The University of Texas, Galveston

1 • Cytochemical Methods in Neuroanatomy,
Victoria Chan-Palay and Sanford L. Palay,
Editors

**2 • Basic Mechanisms of Neuronal
Hyperexcitability,** Herbert H. Jasper and Nico
M. van Gelder, *Editors*

**3 • Anorexia Nervosa: Recent Developments
in Research,** Padraig L. Darby, Paul E.
Garfinkel, David M. Garner, and Donald V.
Coscina, *Editors*

**4 • Clinical and Biological Aspects of
Peripheral Nerve Diseases,** Leontino Battistin,
George A. Hashim, and Abel Lajtha, *Editors*

5 • The Physiology of Excitable Cells, Alan
D. Grinnell and William J. Moody, Jr., *Editors*

**6 • Developing and Regenerating Vertebrate
Nervous Systems,** Penelope W. Coates, Roger
R. Markwald, and Alexander D. Kenny,
Editors

**7 • Glutamine, Glutamate, and GABA in the
Central Nervous System,** Leif Hertz, Elling
Kvamme, Edith G. McGeer, and Arne
Schousboe, *Editors*

8 • Catecholamines, Earl Usdin, Arvid
Carlsson, Annica Dahlström, and Jörgen
Engel, *Editors*. Published in three volumes:
Part A: Basic and Peripheral Mechanisms;
Part B: Neuropharmacology and Central
Nervous System—Theoretical Aspects; Part C:
Neuropharmacology and Central Nervous
System—Therapeutic Aspects

**9 • Development of Visual Pathways in
Mammals,** Jonathan Stone, Bogdan Dreher,
and David H. Rapaport, *Editors*

**10 • Monoamine Innervation of Cerebral
Cortex,** Laurent Descarries, Tomás R. Reader,
and Herbert H. Jasper, *Editors*

11 • The Neurobiology of Zinc,
C.J. Frederickson, G.A. Howell, and
E.J. Kasarskis, *Editors*. Published in two
volumes: *Part A: Physiochemistry, Anatomy,*
and Techniques; Part B: Deficiency, Toxicity,
and Pathology

**12 • Modulation of Sensorimotor Activity
During Alterations in Behavioral States,**
Richard Bandler, *Editor*

**13 • Behavioral Pharmacology: The
Current Status,** Lewis S. Seiden and
Robert L. Balster, *Editors*

**14 • Development, Organization, and
Processing in Somatosensory Pathways,**
Mark Rowe and William D. Willis, Jr., *Editors*

15 • Metal Ions in Neurology and Psychiatry,
Sabit Gabay, Joseph Harris, and Beng T. Ho,

**16 • Neurohistochemistry: Modern Methods
and Applications,** Pertti Panula, Heikki
Päivärinta, and Seppo Soinila, *Editors*

**17 • Two Hemispheres—One Brain:
Functions of the Corpus Callosum,** Franco
Leporé, Maurice Ptito, and Herbert H. Jasper,
Editors

18 • Senile Dementia of the Alzheimer Type,
J. Thomas Hutton and Alexander D. Kenny,
Editors

**19 • Quantitative Receptor Autoradio-
graphy,** Carl A. Boast, Elaine W. Snowhill,
and C. Anthony Altar, *Editors*

20 • Ion Channels in Neural Membranes,
J. Murdoch Ritchie, Richard D. Keynes, and
Liana Bolis, *Editors*

**21 • PET and NMR: New Perspectives
in Neuroimaging and in Clinical
Neurochemistry,** Leontino Battistin and Franz
Gerstenbrand, *Editors*

**22 • New Concepts in Cerebellar
Neurobiology,** James King, *Editor*

**23 • The Vertebrate Neuromuscular
Junction,** Miriam M. Salpeter, *Editor*

24 • Excitatory Amino Acid Transmission, T.
Philip Hicks, David Lodge, and Hugh
McLennan, *Editors*

Contributors

Marianne Aarslew, Institute of Neuropathology, University of Copenhagen, DK-2100 Copenhagen, Denmark [265]

Caryl L. Amrick, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [213,261]

Julia A. Aram, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [83]

Timothy J. Ashwood, Department of Neurophysiology, University of Southampton, Southampton SO9 3TU, U.K. [333]

Philip M. Beart, Clinical Pharmacology and Therapeutics Unit, Austin Hospital, University of Melbourne, Heidelberg, Victoria 3084, Australia [361]

Debra A. Bennett, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [213,261]

Patrick S. Bernard, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [261]

T.V.P. Bliss, Division of Neurophysiology and Neuropharmacology, National Institute for Medical Research, London NW7 1AA, U.K. [337]

Carl A. Boast, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [249,261]

Helen M. Bowker, Department of Neurology, Institute of Psychiatry, London SE5 8AF, U.K. [165]

A. Braunwalder, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [91]

L. Brodin, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

J.T. Buchanan, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

N.R. Burton, Department of Physiology, St. George's Medical School, London University, London SW17 0RE, U.K. [147]

Steven Butcher, Department of Pharmacology, University of Edinburgh, Edinburgh, U.K. [139]

The number in brackets is the opening page number of the contributor's article.

xiv / Contributors

Astrid G. Chapman, Department of Neurology, Institute of Psychiatry, London SE5 8AF, U.K. [165]

Macdonald J. Christie, Clinical Pharmacology and Therapeutics Unit, Austin Hospital, University of Melbourne, Heidelberg, Victoria 3084, Australia [361]

Dorothy C.M. Chu, Neuroscience Program, University of Michigan, Ann Arbor, MI 48104 [127]

John Church, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [43,83,115]

Elizabeth J. Coan, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [317,353]

Graham L. Collingridge, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [317,345,349,353]

J.H. Connick, Department of Physiology, St. George's Medical School, London University, London SW17 0RE, U.K. [147,177]

Antonio Contestabile, Institute of Comparative Anatomy, University of Bologna, I-40126 Bologna, Italy [269]

Fiorenzo Conti, Departments of Anatomy and Physiology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514; present address: Istituto di Fisiologia Umana, Facoltà di Medicina e Chirurgia, Università di Ancona, 60131 Ancona, Italy [169,173]

Carl W. Cotman, Department of Psychobiology, University of California, Irvine, CA 92717 [325,341]

Vincenzo Crunelli, Department of Pharmacology, St. George's Medical School, London SW17 0RE, U.K. [301]

Michel Cuénod, Brain Research Institute, University of Zürich, CH-8029 Zürich, Switzerland [153]

Kenneth Curry, Department of Physiology, University of British Columbia, Vancouver, B.C. V6T 1W5, Canada [35]

N. Dale, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

Robert A. Davidoff, Veterans Administration Medical Center and Department of Neurology, University of Miami School of Medicine, Miami, FL 33101 [185]

J. Davies, Department of Pharmacology, The School of Pharmacy, University of London, London WC1N 1AX, U.K. [277]

Stephen N. Davies, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [43,83,115]

Nils Henrik Diemer, Institute of Neuropathology, University of Copenhagen, DK-2100 Copenhagen, Denmark [241,245,265]

Kim Quang Do, Brain Research Institute, University of Zürich, CH-8029 Zürich, Switzerland [153]

Jacques Durand, Unité de Recherches Neurobiologiques, INSERM (U6), F-13009 Marseille, France [285]

Ingemar Engberg, Institute of Physiology, University of Aarhus, DK-8000 Aarhus, Denmark [285]

M.L. Errington, Division of Neurophysiology and Neuropharmacology, National Institute for Medical Research, London NW7 1AA, U.K. [337]

R.H. Evans, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [19]

G.E. Fagg, Biology Research Laboratories, CIBA-GEIGY AG, 4002 Basel, Switzerland [107]

Gertrude Falk, Biophysics Unit, Department of Physiology, University College London, London WC1E 6BT, U.K. [47]

J.M.H. ffrench-Mullen, Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD 21205 [91]

John A. Flatman, Institute of Physiology, University of Aarhus, DK-8000 Aarhus, Denmark [285, 397]

Frode Fonnum, Division for Environmental Toxicology, Norwegian Defence Research Establishment, N-2007 Kjeller, Norway [269]

Ian D. Forsythe, Laboratory of Developmental Neurobiology, NICHD, NIH, Bethesda, MD 20892 [27]

Alan C. Foster, Merck Sharp and Dohme Research Laboratories, Neuroscience Research Centre, Harlow, Essex CM20 2QR, U.K. [107]

J.E. Franck, Department of Neurological Surgery, University of Washington, Seattle, WA 98195 [253]

Robin J.M. Franklin, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [43]

M. Galvan, Department of Physiology, Physiologisches Institut Universität München, D-8000 München 2, Federal Republic of Germany [71]

Robert L. Gannon, Department of Pharmacology and Toxicology, University of Texas Medical Branch, Galveston, TX 77550 [357]

Susan C. Gerhardt, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [249]

Simon J. Gibbons, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [369]

William R. Gray, Department of Biology, University of Utah, Salt Lake City, UT 84132 [51]

J. Timothy Greenamyre, Department of Neurology and Internal Medicine, University of Michigan, Ann Arbor, MI 48104 [233]

S. Grillner, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

Sarah Grimwood, Merck Sharp and Dohme Research Laboratories, Neuroscience Research Centre, Harlow, Essex CM20 2QR, U.K. [107]

Mary F. Gullak, Department of Neuroscience, Central Research Division, Pfizer, Inc., Groton, CT 06340 [55]

John C. Hackman, Veterans Administration Medical Center and Department of Neurology, University of Miami School of Medicine, Miami, FL 33101 [185]

Koichiro Hagihara, Department of Neurophysiology, Institute of Higher Nervous Activity, Osaka University Medical School, Osaka 530, Japan [409]

Anders Hamberger, Department of Neurobiology, University of Göteborg, 400 33 Göteborg, Sweden [139]

Eric W. Harris, Pharmacology Department, Pennwalt Pharmaceuticals, Rochester, NY 14623 [341]

xvi / Contributors

Yoshio Hata, Department of Neurophysiology, Institute of Higher Nervous Activity, Osaka University Medical School, Osaka 530, Japan [409]

P. Max Headley, Department of Physiology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [309]

Paul Herrling, Wander Research Institute, CH-3001 Bern, Switzerland [153]

Caroline E. Herron, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [317,345,349]

G.C. Heywood, Department of Surgery, St. George's Medical School, London University, London SW17 0RE, U.K. [177]

T. Philip Hicks, Department of Medical Physiology, Faculty of Medicine, The University of Calgary, Calgary, Alberta T2N 4N1, Canada [xxiii,373,401]

R. Hill, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

Alice M. Holohean, Veterans Administration Medical Center and Department of Neurology, University of Miami School of Medicine, Miami, FL 33101 [185]

Anthony L. Horne, MRC Neuropharmacology Research Group, Department of Pharmacology, The School of Pharmacy, University of London, London WC1N 1AX, U.K. [99]

Martin D. Hynes, III, Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, IN 46285 [123]

Hunter Jackson, Department of Anatomy, University of Utah School of Medicine, Salt Lake City, UT 84132 [51]

Ingemar Jacobson, Department of Neurobiology, University of Göteborg, 400 33 Göteborg, Sweden [139]

Patricia Janak, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [249]

F. Fryd Johansen, Institute of Neuropathology, University of Copenhagen, DK-2100 Copenhagen, Denmark [241,245]

Kenneth M. Johnson, Department of Pharmacology and Toxicology, University of Texas Medical Branch, Galveston, TX 77550 [119]

Martin W. Jones, Department of Anatomy, University of Bristol Medical School, Bristol BS8 1TD, U.K. [369]

Susan M. Jones, Department of Pharmacology and Toxicology, University of Texas Medical Branch, Galveston, TX 77550 [119]

M. Balslev Jørgensen, Institute of Neuropathology, University of Copenhagen, DK-2100 Copenhagen, Denmark [241,245]

Yoshihiro Kaneko, Neurobiology Laboratory, Motor Disorders Clinical Research Foundation, Fukushima 960, Japan [67]

John S. Kelly, Department of Pharmacology, University of Edinburgh, Edinburgh EH8 9JZ, U.K. [301]

John A. Kemp, Merck Sharp and Dohme Research Laboratories, Neuroscience Research Centre, Harlow, Essex CM20 2QR, U.K. [107]

Ian C. Kilpatrick, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [181,369]

Thomas Klockgether, Max-Planck-Institute for Experimental Medicine, D-3400 Göttingen, Federal Republic of Germany [257,365]

Wouter Koek, Department of Pharmacology, University of Michigan Medical School, Ann Arbor, MI 48109-0010 [205]

John D.C. Lambert, Institute of Physiology, University of Aarhus, DK-8000 Aarhus, Denmark [285]

J. David Leander, Central Nervous System Research, Eli Lilly and Company, Indianapolis, IN 46285 [123, 197]

John Lehmann, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79,91,161]

Robert B. Leonard, Department of Physiology and Biophysics and Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550 [357]

Nathalie Leresche, Département de Neurosciences de la Vision, Université Pierre et Marie Curie, Paris Cedex 05, France [301]

Robin A.J. Lester, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [317,345,349]

Jeffrey M. Liebman, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [261]

David Lodge, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [xxiii,43,83,115]

Patricia Loo, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [91]

M.A. Lynch, Division of Neurophysiology and Neuropharmacology, National Institute for Medical Research, London NW7 1AA, U.K. [337]

John F. MacDonald, Department of Pharmacology and Playfair Neuroscience Unit, Toronto Western Hospital, University of Toronto, Toronto, Ontario M5T 2S8, Canada [59]

David S.K. Magnuson, Department of Physiology, University of British Columbia, Vancouver, B.C. V6T 1W5, Canada [35]

William F. Maragos, Neuroscience Program, University of Michigan, Ann Arbor, MI 48104 [127,233]

David Martin, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [83]

Louis L. Martin, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [413]

Hideaki Masui, Research and New Product Planning Division, Yoshitomi Pharmaceutical Industries, Ltd., Osaka 541, Japan [389]

Mark L. Mayer, Laboratory of Developmental Neurobiology, NICHD, NIH, Bethesda, MD 20892 [27]

xviii / Contributors

Susannah McGuirk, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [345]

Hugh McLennan, Department of Physiology, University of British Columbia, Vancouver, B.C. V6T 1W5, Canada [xxiii,1,35]

Stephen McPherson, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79,91]

Brian S. Meldrum, Department of Neurology, Institute of Psychiatry, London SE5 8AF, U.K. [189,257,273]

E. Edward Mena, Department of Neuroscience, Central Research Division, Pfizer, Inc., Groton, CT 06340 [55]

R.S. Metherate, Department of Microsurgical Research, Royal Victoria Hospital, Montreal, Quebec H3A 1A1, Canada [401]

K.N. Mewett, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [19]

Zeke Miljkovic, Department of Pharmacology and Playfair Neuroscience Unit, Toronto Western Hospital, University of Toronto, Toronto, Ontario M5T 2S8, Canada [59]

Daniel T. Monaghan, Department of Psychobiology, University of California, Irvine, CA 92717 [325]

L.E. Moore, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

Lyn S. Mozley, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [181,369]

Deborah E. Murphy, Neuroscience/Cardiovascular Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [63]

Claire F. Newland, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [353]

Lina S. Nicolopoulos, Department of Physiology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [309]

Elsebet Ø. Nielsen, Department of Chemistry BC, Royal Danish School of Pharmacy, DK-2100 Copenhagen, Denmark [265]

Jun-Ichiro Oka, Departments of Toxicology and Pharmacology, Faculty of Pharmaceutical Sciences, University of Tokyo, Tokyo 113, Japan [401]

John W. Olney, Department of Psychiatry, Washington University School of Medicine, St. Louis, MO 63110 [217]

H.J. Olverman, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [19]

Paul Ornstein, Chemical Research, Department of Pharmacology, Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, IN 46285 [123,197,205]

Celestine T. O'Shaughnessy, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [83]

Ole P. Ottersen, Anatomical Institute, University of Oslo, 0162 Oslo 1, Norway [131]

Martin J. Pagnozzi, Department of Neuroscience, Central Research Division, Pfizer, Inc., Groton, CT 06340 [55]

Thomas N. Parks, Department of Anatomy, University of Utah School of Medicine, Salt Lake City, UT 84132 [51]

Chris G. Parsons, Department of Physiology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [309]

Gary Pastor, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [261]

Ragnhild Paulsen, Division for Environmental Toxicology, Norwegian Defence Research Establishment, N-2007 Kjeller, Norway [269]

Martin J. Peet, Department of Physiology, University of British Columbia, Vancouver, B.C. V6T 1W5, Canada [35]

John B. Penney, Jr., Department of Neurology and Neuroscience Program, University of Michigan, Ann Arbor, MI 48104 [127, 233]

Peter Petrusz, Department of Anatomy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514 [169, 173]

Mario Pirchio, Dipartimento di Fisiologia e Biochimica, Università di Pisa, 56100 Pisa, Italy [301]

P.C. Pook, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [19]

J.E. Quinlan, Department of Pharmacology, The School of Pharmacy, University of London, London WC1N 1AX, U.K. [277]

Aldo Rustioni, Departments of Anatomy and Physiology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514 [169, 173]

Hiromichi Sato, Department of Neurophysiology, Institute of Higher Nervous Activity, Osaka University Medical School, Osaka 530, Japan [389, 409]

P.A. Schwartzkroin, Departments of Neurological Surgery and Physiology and Biophysics, University of Washington, Seattle, WA 98195 [253]

Michael Schwarz, Max-Planck-Institute for Experimental Medicine, D-3400 Göttingen, Federal Republic of Germany [257, 365]

M.J. Sheardown, Department of Pharmacology, The School of Pharmacy, University of London, London WC1N 1AX, U.K. [277]

Richard A. Shiells, Biophysics Unit, Department of Physiology, University College London, London WC1E 6BT, U.K. [47]

Michael A. Simmonds, MRC Neuropharmacology Research Group, Department of Pharmacology, The School of Pharmacy, University of London, London WC1N 1AX, U.K. [99]

N.T. Slater, Department of Physiology, Northwestern University Medical School, Chicago, IL 60611 [71]

D.A.S. Smith, Department of Physiology, St. George's Medical School, London University, London SW17 0RE, U.K. [147, 177]

Lawrence D. Snell, Department of Pharmacology and Toxicology, University of Texas Medical Branch, Galveston, TX 77550 [119]

xx / Contributors

Karl-Heinz Sontag, Max-Planck-Institute for Experimental Medicine, D-3400 Göttingen, Federal Republic of Germany [257,365]

Douglas J. Steel, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79,91]

A. Stelzer, Department of Physiology, Physiologisches Institut Universität München, D-8000 München 2, Federal Republic of Germany [71]

T.W. Stone, Department of Physiology, St. George's Medical School, London University, London SW17 0RE, U.K. [147,177]

Jon Storm-Mathisen, Anatomical Institute, University of Oslo, 0162 Oslo 1, Norway [131]

Peter Streit, Brain Research Institute, University of Zürich, CH-8029 Zürich, Switzerland [153]

Naonori Sugai, Department of Anatomy, Fukushima Medical College, Fukushima 960, Japan [67]

Roger J. Summers, Department of Pharmacology, University of Melbourne, Parkville, Victoria 3052, Australia [361]

Hiroshi Takeuchi, Department of Physiology, Gifu University School of Medicine, Gifu 500, Japan [75]

István Tarnawa, Institute for Drug Research, H-1325 Budapest, Hungary [397]

C.A. Taylor, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79]

G. ten Bruggencate, Department of Physiology, Physiologisches Institut Universität München, D-8000 München 2, Federal Republic of Germany [71]

Alex M. Thomson, Department of Physiology, University College, Cardiff CF1 1XL, U.K. [381,405]

Cindy Tsai, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79,161]

Tadaharu Tsumoto, Department of Neurophysiology, Institute of Higher Nervous Activity, Osaka University Medical School, Osaka 530, Japan [389, 409]

Lechoslaw Turski, Max-Planck-Institute for Experimental Medicine, D-3400 Göttingen, Federal Republic of Germany [257,273,365]

Waldemar A. Turski, Department of Pharmacology, Medical School, PL 20-090 Lublin, Poland [273]

Mark Urnes, Department of Anatomy, University of Utah School of Medicine, Salt Lake City, UT 84132 [51]

Susan L. Van Eyck, Departments of Anatomy and Physiology and Curriculum in Neurobiology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514 [173]

Jose L. Vega, Veterans Administration Medical Center and Department of Neurology, University of Miami School of Medicine, Miami, FL 33101 [185]

Luigi Villani, Institute of Comparative Anatomy, University of Bologna, I-40126 Bologna, Italy [269]

P. Wallen, Department of Physiology III, Karolinska Institutet, S-114 33 Stockholm, Sweden [293]

Kazuko Watanabe, Department of Physiology, Gifu University School of Medicine, Gifu 500, Japan [75]

Jeffrey C. Watkins, Department of Pharmacology, University of Bristol Medical School, Bristol BS8 1TD, U.K. [19, 273]

Richard J. Weinberg, Departments of Anatomy and Physiology and Curriculum in Neurobiology, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514 [173]

David C. West, Department of Physiology, University College, Cardiff CF1 1XL, U.K. [309, 405]

Gary L. Westbrook, Laboratory of Developmental Neurobiology, NICHD, NIH, Bethesda, MD 20892 [27]

Eva Westerberg, Laboratory for Experimental Brain Research, University of Lund, Lund Hospital, S-221 85 Lund, Sweden [225]

Howard V. Wheal, Department of Neurophysiology, University of Southampton, Southampton SO9 3TU, U.K. [333]

Tadeusz Wieloch, Laboratory for Experimental Brain Research, University of Lund, Lund Hospital, S-221 85 Lund, Sweden [225]

Leif Wiklund, Laboratoire de Physiologie Nerveuse, CNRS, 91190 Gif-sur-Yvette, France [309]

Michael Williams, Neuroscience/ Cardiovascular Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [63, 91]

E.H.F. Wong, Merck Sharp and Dohme Research Laboratories, Neuroscience Research Centre, Harlow, Essex CM20 2QR, U.K. [107]

Paul L. Wood, Neuroscience Research, Research Department, Pharmaceuticals Division, CIBA-GEIGY Corporation, Summit, NJ 07901 [79, 91, 413]

James H. Woods, Departments of Pharmacology and Psychology, University of Michigan Medical School, Ann Arbor, MI 48109-0010 [205]

Anne B. Young, Department of Neurology and Neuroscience Program, University of Michigan, Ann Arbor, MI 48104 [127, 233]

Sophie Zeman, Department of Physiology, Royal Veterinary College, London NW1 0TU, U.K. [83]

Dexing X. Zhang, Veterans Administration Medical Center and Department of Neurology, University of Miami School of Medicine, Miami, FL 33101 [185]

Dennis M. Zimmerman, Chemical Research, Lilly Research Laboratories, Eli Lilly and Company, Indianapolis, IN 46285 [123, 197]

Preface

Within the past decade (and most noticeably in the past five years), a considerable upsurge of interest has taken place in the roles of excitatory amino acids as synaptic transmitters. This has been due in large part to the introduction of receptor-specific and less selective antagonists of amino acid receptors. Electrophysiological and neuropharmacological studies using these new substances have allowed the establishment and characterization of several distinct subclasses of receptors, and in consequence the whole field of excitatory amino acid transmission is progressing at an unprecedented pace.

It is due in part to these rapid advances that the idea evolved of holding a scientific meeting devoted to this subject as a satellite symposium to the 30th Congress of the International Union of Physiological Sciences, in Vancouver, July 1986. The enthusiastic response from over one hundred scientists was ample proof that such a meeting was not only overdue but also of sufficient interest and benefit to attract participants from twelve countries throughout Europe, North America, Australia, and Asia. The meeting was held at the Rimrock Inn, Sulphur Mountain, in the scenic and natural environment of Banff National Park, on July 20–23, 1986.

The book therefore presents a topical “state of the art” survey of most aspects of excitatory amino acid transmission; as a satellite of the IUPS Congress, the meeting emphasized the physiological aspects of the field, which were complemented by important contributions from anatomical, biochemical, behavioural, immunocytochemical, pharmacological, and clinical applications. We hope sincerely that its impact will be felt by facilitating further developments in this burgeoning field of research not only in the basic physiological and allied sciences, but also in the clinical domain. A final word of thanks is due to the contributors and the publisher, who have facilitated the editors’ goal of publication of the proceedings within five months of the meeting.

**T. Philip Hicks
David Lodge
Hugh McLennan**

Acknowledgments

The Satellite Symposium was supported financially by generous contributions from the following bodies: The Alberta Heritage Foundation for Medical Research, Eli Lilly and Company, CIBA-GEIGY, Nova Pharmaceuticals, Monsanto Corporation, Carl Zeiss Canada Ltd., Narco Scientific Ltd., Fine Science Tools Ltd., Digital Equipment Canada Ltd., and Fisher Scientific.

Contents

Contributors	xiii
Preface	
<i>T. Philip Hicks, David Lodge, and Hugh McLennan</i>	xxiii
Acknowledgments	xxv

I. OVERVIEW

Setting the Scene: The Excitatory Amino Acids—30 Years On <i>Hugh McLennan</i>	1
---	---

II. RECEPTORS: CLASSIFICATION AND ACTIVATION

Recent Advances in the Pharmacology of Excitatory Amino Acids <i>J.C. Watkins, R.H. Evans, K.N. Mewett, H.J. Olverman, and P.C. Pook</i>	19
NMDA Receptor Function: Clues From Biophysical Experiments <i>Mark L. Mayer, Gary L. Westbrook, and Ian D. Forsythe</i>	27
Conformational Requirements for Activation of Burst Firing of Rat CA-1 Hippocampal Pyramidal Neurons <i>Martin J. Peet, Kenneth Curry, David S.K. Magnuson, and Hugh McLennan</i>	35
Role of Calcium in Neuronal Responses to Excitatory Amino Acid Analogues <i>Stephen N. Davies, Robin J.M. Franklin, John Church, and David Lodge</i>	43
Specialized Glutamate Receptors for Retinal Rod Signals <i>G. Falk and R.A. Shiells</i>	47
Effects of Spider Venoms on Transmission Mediated by Non-N-Methyl-D- Aspartate Receptors in the Avian Cochlear Nucleus <i>Hunter Jackson, Mark Urnes, William R. Gray, and Thomas N. Parks</i> . . .	51