Intercellular and intracellular communication

General Editor: Professor B. Cinader

Interlocking ligand–receptor systems constitute an intercellular language in which molecules, e.g. factors and hormones, serve as words and convey signals – messages – through combination with membrane molecules, i.e. receptors. These signals can give rise to the production of other factors which can combine with receptors and thus form the sentences of the intercellular language. In the immune system, macromolecules of the *external* world cause distortions of the *internal* communication. The resulting change in the balance of molecular communication constitutes the immune response.

The analogy between verbal and molecular communication is supported by the existence of superfamilies of molecules, designed with a common two-chain structure and involved in recognition of different ligands. Members of these families show homologies in a variety of cell types among cells of different animals, from invertebrates to vertebrates.

Cell communication involves sequential molecular interactions between receptors and ligands, which are either cell-bound or are secreted by one cell and taken up by surface structures (receptors) of another cell. A succession of these interactions at the membranes of cells and organelles coordinate cell metabolism within the same and between different organs.

Receptors can be activated at a distance, or by receptor–ligand interaction between membranes of different cell types, i.e. via adhesion molecules which guide the structural development of organs, as exemplified by neural cell adhesion and embryological development under the influence of 'master' cells. Recognition and, thus, receptor–ligand interaction directs homing of cells in development, differentiation and cell migration.

Receptor–ligand communication plays various roles in the initiation of, and resistance to, infectious disease. Antigen recognition by B and T cells is one aspect of this process, the ability of a particular parasite to attach to a cell receptor is an example of another. In short, the interaction of the cellular milieu with external molecular changes occurs through receptors of the lymphoid system and through receptors of other cells, which control the ability of parasites to attach to special membrane sites, e.g. malarial merozoites to the N-terminal sugar N-acetyl glucosamine.

Interaction between ligand and receptor activates cells for a limited time. This limitation is achieved by endocytosis of receptor, or by dissociation of the complex in which the receptor is contained, resulting in decreased affinity for ligand.

Malfunction of a single step in cell communication results in disease and contributes to neoplastic transformation. Proliferation of neoplastic cells and spread of metastases may be promoted by the disappearance or blockage of receptors through which growth and metastatic spread are controlled.

The analysis of molecular language represents a major stream in biology in the twentieth century. This book is a part of a series in which we shall examine intercellular communication within and between organs, comparative as well as evolutionary aspects of this communication, and, finally, its effect on initiation and progression of disease.

Intercellular and intracellular communication

1 Hormones, receptors and cellular interactions in plants
Ed. C. M. Chadwick and D. R. Garrod

2 Receptors in tumour biology
Ed. C. M. Chadwick

Hormones, receptors and cellular interactions in plants

EDITORS:

C. M. CHADWICK

Department of Biological Sciences, University of Pittsburgh

D. R. GARROD

Senior Lecturer, Cancer Research Campaign Medical Oncology Unit
University of Southampton

The right of the University of Cambridge to print and sell all manner of books was granted by Henry VIII in 1534. The University has printed and published continuously since 1584.

CAMBRIDGE UNIVERSITY PRESS

Cambridge

London New York New Rochelle

Melbourne Sydney

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

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/9780521117647

First published 1986
This digitally printed version 2009

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

Library of Congress Cataloguing in Publication data

Main entry under title:
Hormones, receptors, and cellular interactions in plants
(Intercellular and intracellular communication; 1)

Includes bibliographical references and index.
1. Plant hormones. 2. Hormone receptors.
3. Cell interaction. I. Chadwick, C. M. (Christopher
Michael) II. Garrod, D. R.
QK731.H65 1986 581.19′27 85–7853

ISBN 978-0-521-30426-9 hardback
ISBN 978-0-521-11764-7 paperback

Cambridge University Press
978-0-521-11764-7 - Hormones, Receptors and Cellular Interactions in Plants
Edited by C. M. Chadwick and D. R. Garrod
Frontmatter
More information

CONTENTS

Cambridge University Press
978-0-521-11764-7 - Hormones, Receptors and Cellular Interactions in Plants
Edited by C. M. Chadwick and D. R. Garrod
Frontmatter
More information

CONTRIBUTORS

Clinton E. Ballou *Department of Biochemistry, University of California, Berkeley, California 94720, USA*

Eric G. Brown *Department of Biochemistry, University College of Swansea, Singleton Park, Swansea, SA2 8PP, UK*

C. M. Chadwick *Department of Biological Sciences, University of Pittsburgh, Pittsburgh, PA 15260, USA*

Adrienne E. Clarke *Plant Cell Biology Research Centre, School of Botany, University of Melbourne, Parkville, Victoria 3052, Australia*

Frank B. Dazzo *Department of Microbiology, Michigan State University, East Lansing, Michigan 48824, USA*

H. G. Dickinson *Department of Botany, Plant Science Laboratories, The University of Reading, Reading, UK*

J. E. Ellison *Cancer Research Campaign Medical Oncology Unit, Centre Block, Southampton General Hospital, Southampton SO9 4XY, UK*

L. C. Fowke *Department of Biology, University of Saskatchewan, Saskatoon, Sask., Canada, S7N 0WO*

D. R. Garrod *Cancer Research Campaign Medical Oncology Unit, Centre Block, Southampton General Hospital, Southampton SO9 4XY, UK*

M. A. Hall *Department of Botany and Microbiology, The University College of Wales, Aberystwyth, Dyfed, SY23 3DA, UK*

Mark A. Holden *Department of Botany, The University of Edinburgh, Edinburgh, EH9 3JH, UK*

Barbara J. Howlett *Plant Cell Biology Research Centre, School of Botany, University of Melbourne, Parkville, Victoria 3052, Australia*

K. R. Libbenga *Department of Plant Molecular Biology, Botanisch Laboratorium, Rijksuniversiteit Leiden, Leiden, The Netherlands*

P. C. G. v.d. Linde *Department of Plant Molecular Biology, Botanisch Laboratorium, Rijksuniversiteit Leiden, Leiden, The Netherlands*

A. C. Maan *Department of Plant Molecular Biology, Botanisch Laboratorium, Rijksuniversiteit Leiden, Leiden, The Netherlands*

Cambridge University Press
978-0-521-11764-7 - Hormones, Receptors and Cellular Interactions in Plants
Edited by C. M. Chadwick and D. R. Garrod
Frontmatter
More information

A. M. Mennes *Department of Plant Molecular Biology, Botanisch Laboratorium, Rijksuniversiteit Leiden, Leiden, The Netherlands*

Peter C. Newell *Department of Biochemistry, University of Oxford, South Parks Road, Oxford, OX1 3QU, UK*

Russell P. Newton *Department of Biochemistry, University College of Swansea, Singleton Park, Swansea, SA2 8PP, UK*

Michael Pierce *Department of Biochemistry, University of California, Berkeley, California 94720, USA*

Julie E. Ralton *Plant Cell Biology Research Centre, School of Botany, University of Melbourne, Parkville, Victoria 3052, Australia*

I. N. Roberts *Department of Botany, Plant Science Laboratories, The University of Reading, Reading, UK*

John L. Stoddart *Plant Biochemistry Department, University College of Wales, Welsh Plant Breeding Station, Aberystwyth, Dyfed, SY23 3EB, UK*

Michael M. Yeoman *Department of Botany, The University of Edinburgh, Edinburgh, EH9 3JH, UK*

PREFACE

The complementary binding of a ligand and receptor is the basic language of intercellular communication. Processes of this type are generally categorized under the heading 'cellular recognition' which includes the binding between a cell and (a) another cell (b) a bacterium or foreign particle or (c) a molecule. Such behaviour requires that a cell should anticipate its interaction with the environment by the provision of specific molecules (receptors) which can receive environmental stimuli. These stimuli are as diverse as, for example, the appearance of hormone molecules or contact with a bacterial food organism. The molecular components of the stimulus may be regarded as the ligand. The crucial aspect of ligand–receptor interaction is that the former fits into and binds to the latter in a chemically specific and exclusive manner.

The study of ligand–receptor interactions is well advanced in animal systems, especially in relation to hormones, growth factors, endocytosis and the immune system. By contrast, studies with plants have met with varied success. The aim of this book is to take a broad look at the current status of ligand–receptor interactions in a variety of higher and lower plant systems. It is hoped that this may provide a cross-fertilization of ideas and a stimulus to research in some of the more difficult areas.

One of the most crucial factors affecting the rate of progress of this type of research appears to be the location of the receptors. Plant cells are surrounded by a tough cell wall and this appears to be a barrier which must be penetrated in order to permit identification of receptors. It is probably fair to say that this has hampered research on plant hormone receptors. However, progress is now beginning to be made. The current status of some hormone receptors of higher plants is reviewed in Chapter 1 (auxins), Chapter 2 (ethylene) and Chapter 3 (gibberellin).

We have begun the book with discussion of the major unsolved problems of receptors for these hormones because they stress the difficulties of this type of research. Problems relating to the role of cyclic AMP in plants (Chapter 4) seem to fall into the same category and may be contrasted with the degree of sophistication reached in the study of cyclic AMP receptors in *Dictyostelium* (Chapter 5). Here, some receptors are readily accessible on the exposed plasma membrane, facilitating their study.

In many plant interactions receptors on the extreme outer surface are involved in the initial stages, and in some instances study of receptor mechanisms are well advanced. Examples of this type of interaction considered here are the mating of yeast (Chapter 8), pollen–stigma interactions (Chapter 9), host–pathogen interactions (Chapter 10) and the infection of root hairs by nitrogen-fixing bacteria (Chapter 11).

Adhesion in the cellular slime moulds (Chapter 6), of which *Dictyostelium discoideum* is the most studied example, represents a system in which interaction occurs directly between surface membranes of adjacent cells. The methods used to study adhesion have been applied with great effect to the cells of vertebrate animals and may be useful in plants. However, it must be said that even here the details of the molecular mechanism of cell–cell adhesion have not been elucidated.

One way to study the plasma membrane of plant cells is to remove the cell wall and isolate the living protoplast. The technology for doing this has been available for some time and is now giving rise to the studies of membrane-associated receptor mechanisms (Chapter 7). Finally, a paradox is that most living systems, probably all, possess carbohydrate-binding proteins known as lectins. These possess, *par excellence*, the properties demanded of receptors, yet in the vast majority of cases their functions are unknown. Many plants are particularly richly supplied with lectins. The intriguing problem of their function is discussed in Chapter 12.

The idea for this book was generated by the series editor Dr Cinader. We plunged into it as something of a challenge, having little detailed knowledge of the systems involved. We have learned much during the editorial process and hope that this volume will provide a similar stimulus to its readers.

C. M. Chadwick
D. R. Garrod
January 1985