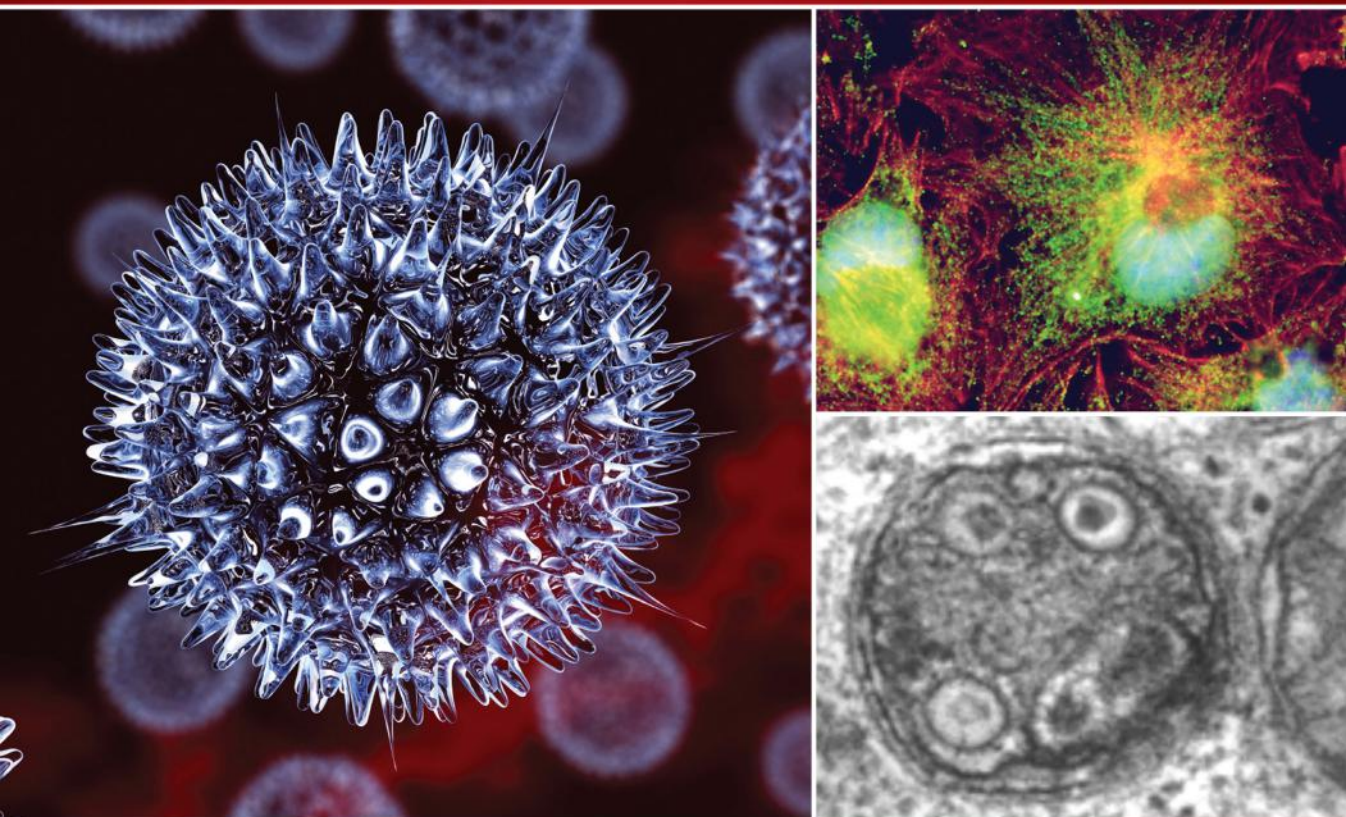


AUTOPHAGY, INFECTION, AND THE IMMUNE RESPONSE

Edited by William T. Jackson and Michele S. Swanson



WILEY Blackwell

AUTOPHAGY, INFECTION, AND THE IMMUNE RESPONSE



AUTOPHAGY, INFECTION, AND THE IMMUNE RESPONSE

EDITED BY

William T. Jackson and Michele S. Swanson

WILEY Blackwell



This edition first published 2015. © 2015 by John Wiley & Sons, Inc. All rights reserved

Published by John Wiley & Sons, Inc., Hoboken, New Jersey
Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Autophagy, infection, and the immune response / edited by William T. Jackson and Michele Swanson.
p. ; cm.

Includes bibliographical references and index.

ISBN 978-1-118-67764-3 (cloth)

I. Jackson, William T., 1971- , editor. II. Swanson, Michele, editor.

[DNLM: 1. Autophagy-immunology. 2. Immune System Processes. 3. Immunity, Innate.

4. Virus Physiological Processes. QU 375]

QR181.7

616.07'9-dc23

2014029016

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

CONTENTS

Contributors	xiii
Preface	xvii
Acknowledgments	xix
1 AUTOPHAGY AND IMMUNITY	1
<i>Xu Liu and Daniel J. Klionsky</i>	
1.1 Introduction	1
1.2 Autophagy	2
1.2.1 Types of autophagy	2
1.2.2 Morphology	3
1.2.3 Molecular machinery	3
1.2.4 Physiological roles	5
1.3 Autophagy and immunity	6
1.3.1 Xenophagy: autophagic clearance of intracellular microorganisms	6
1.3.2 Autophagy and cryptides	9
1.3.3 Autophagy and pattern recognition receptors (PRRs)	9
1.3.4 Autophagy and MHC antigen presentation	10
1.3.5 Autophagy regulation by immune signaling molecules	11
1.3.6 Autophagy, inflammation, and autoimmunity	11
1.4 Conclusion	12
References	12
2 TECHNIQUES FOR STUDYING AUTOPHAGY	19
<i>Isei Tanida and Masato Koike</i>	
2.1 Introduction	19
2.2 Reagents and tools for studying autophagy	21
2.2.1 Reagents to monitor the lysosomal flux of LC3-II	21
2.2.2 Reagents that induce autophagy	21
2.2.3 Reagents and recombinant tools that inhibit autophagy	22
2.3 Detection of LC3-I AND LC3-II by immunoblotting	22
2.4 Immunofluorescent analyses of endogenous LC3	23
2.5 Monitoring autophagy using fluorescent protein-tagged LC3	23
2.6 Morphological analyses of autophagosomes and autolysosomes by TEM	24
2.6.1 Reagents or stock solutions	26
2.6.2 Resin embedding of cell pellets or microbes	26

2.6.3	Resin flat embedding of cells grown on glass or plastic coverslips	27
2.7	Techniques for immunoelectron microscopy	28
	References	29
3	ROLE OF AUTOPHAGY IN DNA VIRUS INFECTIONS <i>IN VIVO</i>	33
	<i>Xiaonan Dong and Beth Levine</i>	
3.1	Introduction	33
3.2	<i>In vivo</i> interplay between autophagy and DNA viruses in plants and invertebrates	34
3.3	<i>In vivo</i> interplay between autophagy and DNA viruses in vertebrates	35
3.3.1	Autophagy is an essential antiviral mechanism that protects against HSV-1 <i>in vivo</i>	35
3.3.2	The autophagy-HBV interplay <i>in vivo</i> : a balance between viral exploitation and tumor suppression	40
3.3.3	Autophagy may suppress γ -herpesvirus persistent infection	42
3.4	Conclusion	43
	Acknowledgments	44
	References	44
4	STUDYING RNA VIRUSES AND AUTOPHAGY <i>IN VIVO</i>	49
	<i>Mehrdad Alirezaei and J. Lindsay Whitton</i>	
4.1	Introduction	49
4.2	<i>In vivo</i> interactions between autophagy and RNA viruses in plants and invertebrates	50
4.2.1	Plants	50
4.2.2	Invertebrates	50
4.3	<i>In vivo</i> Interactions between autophagy and RNA viruses in vertebrates	51
4.3.1	Togaviridae	51
4.3.2	<i>Caliciviridae</i>	51
4.3.3	Orthomyxoviridae	53
4.3.4	Flaviviridae	53
4.3.5	Picornaviridae	54
4.4	Conclusion	62
	Acknowledgments	63
	References	63
5	AUTOPHAGY AND PICORNAVIRUS INFECTION	67
	<i>Tom Wileman, Zhigang Zhou, Matthew Whelband, Eleanor Cottam, Stephen Berryman, Terry Jackson and Rebecca Roberts</i>	
5.1	Introduction	67
5.2	Selective autophagy involves autophagy receptors with LC3-interacting domains	69
5.3	Autophagy is activated during virus infection	69
5.4	Picornaviruses and autophagy	69
5.4.1	Poliovirus	70
5.4.2	Coxsackievirus	72

5.4.3	Human enterovirus 71	73
5.4.4	Encephalomyocarditis virus	73
5.4.5	Foot-and-mouth disease virus	74
5.4.6	Human rhinoviruses	75
5.5	Caution in interpretation of induction of LC3 puncta and double-membraned vesicles in the context of autophagy	75
5.5.1	LC3 puncta	75
5.6	Conclusions and future research	77
	References	78
6	FLAVIVIRUSES AND AUTOPHAGY	81
	<i>Tristan X. Jordan and Glenn Randall</i>	
6.1	Introduction	81
6.1.1	Autophagy	81
6.2	Flaviviruses	83
6.3	Dengue virus	83
6.3.1	Autophagosomes as a platform for replication?	85
6.3.2	Modulation of lipid metabolism	86
6.3.3	Potential role for the autophagy-related proteins USP10 and USP13 in DENV virion maturation	87
6.3.4	Cytoprotective autophagy	88
6.3.5	The role of autophagy in an ADE model of monocyte infection	89
6.3.6	Autophagy in DENV infections in mice	89
6.4	Other Flaviviruses	90
6.4.1	Japanese encephalitis virus	90
6.4.2	Modoc virus	90
6.4.3	West Nile virus	90
6.5	Concluding remarks	92
	Acknowledgments	92
	References	93
7	AUTOPHAGY: A HOME REMODELER FOR HEPATITIS C VIRUS	101
	<i>Marine L.B. Hillaire, Elodie Décembre, and Marlène Dreux</i>	
7.1	Introduction	101
7.1.1	Autophagy	101
7.1.2	Hepatitis C virus (HCV) disease, genome and replication	103
7.2	HCV induces a proviral autophagy	111
7.3	How does HCV trigger autophagy vesicle accumulation?	111
7.4	Dynamic membrane remodeling by autophagy	113
7.5	Interlinkage of autophagy with the innate immune response	114
7.6	Autophagy and cell death	115
7.7	Removal of aberrant deposits and organelles by autophagy: implications for liver injury associated with chronic hepatitis C	116
7.7.1	Autophagy and lipid metabolism	116
7.7.2	Mitophagy and HCV persistence	117
7.8	Conclusions and future directions	118
	Acknowledgments	119
	References	119

8	MODULATING AUTOPHAGY TO CURE HUMAN IMMUNODEFICIENCY VIRUS TYPE-1	127
	<i>Stephen A. Spector and Grant R. Campbell</i>	
8.1	Introduction	127
8.2	HIV subverts autophagy to promote its own replication	129
8.3	HIV infection inhibits autophagy during permissive infection while induction of autophagy leads to inhibition of HIV	130
8.4	HIV-induced autophagy in bystander CD4 ⁺ T cells results in cell death	130
8.5	Modulation of autophagy as a mechanism for HIV-associated neurocognitive impairment	132
8.6	How can autophagy be exploited to control and eradicate HIV?	134
	Acknowledgments	137
	References	138
9	AUTOPHAGY IN THE INFECTED CELL: INSIGHTS FROM PATHOGENIC BACTERIA	143
	<i>Andrea Sirianni and Serge Mostowy</i>	
9.1	Introduction	143
9.2	Autophagy–bacteria interactions	143
9.2.1	<i>Salmonella typhimurium</i>	144
9.2.2	<i>Mycobacterium tuberculosis</i>	145
9.2.3	<i>Legionella pneumophila</i>	146
9.2.4	<i>Listeria monocytogenes</i>	147
9.2.5	<i>Shigella flexneri</i>	149
9.2.6	<i>Mycobacterium marinum</i>	150
9.3	Conclusions	151
	Acknowledgments	151
	References	152
10	Rab PROTEINS IN AUTOPHAGY: STREPTOCOCCUS MODEL	159
	<i>Takashi Nozawa and Ichiro Nakagawa</i>	
10.1	Introduction	159
10.2	Rab GTPase	160
10.3	Rab GTPases in starvation-induced autophagy	160
10.4	Rab localization in autophagy during <i>Streptococcus</i> infection	161
10.5	Involvement of Rab7 in the initial formation of GcAV	163
10.6	Requirement of Rab23 for GcAV formation	163
10.7	Facilitation by Rab9A of GcAV enlargement and lysosomal fusion	164
10.8	Conclusion and perspective	165
	References	167
11	HELICOBACTER PYLORI INFECTION CONTROL BY AUTOPHAGY	171
	<i>Laura K. Greenfield, Frances Dang, and Nicola L. Jones</i>	
11.1	<i>Helicobacter pylori</i>	171
11.2	<i>H. pylori</i> and evasion of host immune responses	176
11.3	Autophagy	178
11.4	Acute <i>H. pylori</i> infection: induction of autophagy in gastric epithelial cells	180

11.5	Chronic <i>H. pylori</i> infection: suppression of autophagy in gastric epithelial cells	184
11.6	<i>H. pylori</i> induction of autophagy in immune cells	185
11.7	Host genetics affecting autophagic clearance of <i>H. pylori</i>	185
11.8	<i>H. pylori</i> disrupted autophagy and gastric cancer	186
11.9	<i>H. pylori</i> therapy: is autophagy a contender?	187
11.10	Concluding remarks	188
	Acknowledgments	189
	References	189

12 INTERACTIONS BETWEEN SALMONELLA AND THE AUTOPHAGY SYSTEM **201**

Teresa L.M. Thurston and David W. Holden

12.1	Introduction	201
12.2	<i>Salmonella</i> 's life within the host	201
12.3	<i>Salmonella</i> 's survival in a harsh intracellular habitat	202
12.4	Models for studying <i>Salmonella</i> infection	203
12.5	Mechanisms of <i>Salmonella</i> autophagy	204
	12.5.1 <i>Salmonella</i> is targeted for antibacterial autophagy	204
	12.5.2 Antibacterial autophagy induction	205
	12.5.3 Eat-me signals for antibacterial autophagy	206
	12.5.4 Autophagy receptors provide cargo specificity	208
12.6	Autophagy of <i>Salmonella in vivo</i>	209
12.7	Bacterial countermeasures	210
	12.7.1 Could <i>Salmonella</i> counteract autophagy?	210
	12.7.2 Potential autophagy avoidance mechanisms	210
	12.7.3 SseL deubiquitinates autophagy-targeted protein aggregates	210
	12.7.4 Does <i>Salmonella</i> inhibit selective antibacterial autophagy?	211
12.8	Perspectives	211
	References	213

13 HOST FACTORS THAT RECRUIT AUTOPHAGY AS DEFENSE AGAINST TOXOPLASMA GONDII **219**

Carlos S. Subauste

13.1	Introduction	219
13.2	CD40, autophagy and lysosomal degradation of <i>T. gondii</i>	220
13.3	Events downstream of CD40 involved in the stimulation of autophagy	222
13.4	Relevance of autophagy during <i>in vivo</i> infection with <i>T. gondii</i>	224
13.5	IFN- γ and ATG5 in <i>T. gondii</i> infection	224
13.6	<i>T. gondii</i> manipulates host cell signaling to inhibit targeting by LC3 ⁺ structures and to maintain the nonfusogenic nature of the parasitophorous vacuole	227
13.7	Autophagy machinery within <i>T. gondii</i>	228
13.8	Conclusion	229
	Acknowledgments	229
	References	229

14	MYCOBACTERIUM TUBERCULOSIS AND THE AUTOPHAGIC PATHWAY	233
	<i>Gabriela María Recalde and María Isabel Colombo</i>	
14.1	<i>Mycobacterium tuberculosis</i> , a pathogen that resides in a self-tailored compartment to avoid killing by the host cell	233
14.2	The ESX-1 secretion system	235
14.3	<i>Mycobacterium marinum</i> , a close relative that escapes and forms actin tails in the cytoplasm	235
14.4	Mycobacterium actively modulates autophagy	236
14.5	Mycobacterium tuberculosis, a pathogen also able to escape toward the cytoplasm	239
14.6	Concluding remarks	240
	References	241
15	AUTOPHAGY ENHANCES THE EFFICACY OF BCG VACCINE	245
	<i>Arshad Khan, Christopher R. Singh, Emily Soudani, Pearl Bakhru, Sankaralingam Saikolappan, Jeffrey D. Cirillo, N. Tony Eissa, Subramanian Dhandayuthapani and Chinnaswamy Jagannath</i>	
15.1	Introduction	246
15.2	Induction of autophagy through mTOR enhances antigen presentation via the MHC-II pathway in macrophages and dendritic cells	247
15.2.1	Rapamycin-induced autophagy enhances antigen presentation in APCs	248
15.2.2	Rapamycin and Torin1-induced autophagy enhances both antigen presentation and IL-1 β secretion from BCG infected APCs	248
15.3	Intracellular mechanisms of autophagic routing of particulate BCG vaccine and secreted Ag85B into autophagosomes and enhanced MHC-II mediated antigen presentation	251
15.3.1	Overexpression of secreted Ag85B in BCG vaccine leads to aggresome formation in the cytosol of APCs	251
15.3.2	Overexpressed Ag85B from BCG vaccine forms aggresomes, which enhance antigen presentation through autophagy	251
15.3.3	Discussion: <i>in vitro</i> studies on autophagy and antigen presentation	253
15.4	Rapamycin activation of dendritic cells enhances efficacy of DC-BCG vaccine	255
15.4.1	Discussion	256
15.5	Rapamycin coadministration with BCG vaccine in mice enhances CD4 and CD8 T cell mediated protection against tuberculosis	256
15.5.1	Discussion	262
15.6	Conclusions	262
	Acknowledgments	263
	References	263

16	AUTOPHAGY'S CONTRIBUTION TO INNATE AND ADAPTIVE IMMUNITY: AN OVERVIEW	267
	<i>Christina Bell, Michel Desjardins, Pierre Thibault and Kerstin Radtke</i>	
16.1	Autophagy: different routes to the same goal?	267
16.2	Xenophagy: it is a dog-eat-dog world	269
16.3	Autophagy and Toll-like receptors: a mutual turn-on	269
16.4	Autophagy and antigen presentation: a cry for help to clear pathogenic invaders	270
16.5	Autophagy and inflammasomes: Mutual regulation for an effective immune response	273
16.6	Cross-talk between autophagy and cytokines	273
	Acknowledgments	275
	References	275
17	AUTOPHAGY IN IMMUNE RESPONSES TO VIRUSES	279
	<i>Christophe Viret and Mathias Faure</i>	
17.1	Innate immunity against viruses	279
17.2	Autophagy in antiviral innate immunity	281
17.2.1	Virus sensing for autophagy induction	281
17.2.2	Role of autophagy in xenophagy of viruses	282
17.2.3	Role of autophagy in antiviral innate immunity signaling	283
17.3	Autophagy manipulation by viruses to resist innate immunity	285
17.3.1	Autophagy manipulation by viruses to prevent IFN-I synthesis	285
17.3.2	Viruses subvert autophagy to interfere with inflammatory responses	286
17.3.3	Autophagy and cell death during virus infection	287
17.4	Autophagy in antiviral adaptive immunity	287
17.4.1	Promotion of adaptive immune responses to viral infection by autophagy	287
17.4.2	MHC class II-restricted presentation of viral epitopes	288
17.4.3	MHC class I-restricted presentation of viral epitopes	290
17.4.4	Autophagy and cross-presentation	292
17.5	Autophagy manipulation by viruses to escape adaptive immunity	294
17.5.1	MHC class II antigen presentation pathway	294
17.5.2	MHC class I antigen presentation pathway	295
17.5.3	Autophagy and antigen-presenting cell function	295
17.6	Concluding remarks	296
	Acknowledgments	296
	References	297
18	PROCESSING AND MHC PRESENTATION OF ANTIGENS AFTER AUTOPHAGY-ASSISTED ENDOCYTOSIS, EXOCYTOSIS, AND CYTOPLASM DEGRADATION	303
	<i>Christian Münz</i>	
18.1	Introduction	303
18.2	Substrate recognition by macroautophagy	305

18.3	Antigen processing for MHC class II presentation by macroautophagy	307
18.4	A role of macroautophagy in MHC class I antigen presentation	308
18.5	Antigen release by autophagy-assisted exocytosis	309
18.6	Autophagy-assisted phagocytosis	310
18.7	Conclusions and outlook	312
	Acknowledgments	312
	References	312
	Index	317

CONTRIBUTORS

Mehrdad Alirezaei Department of Immunology and Microbial Science, The Scripps Research Institute, La Jolla, California, USA

Pearl Bakhru Department of Pathology and Laboratory Medicine, University of Texas Health Sciences Center, Houston, Texas, USA

Christina Bell Proteomics and Mass Spectrometry Research Unit, Institute for Research in Immunology and Cancer, Département de Pathologie et Biologie Cellulaire, Université de Montréal, Montreal, Quebec, Canada

Stephen Berryman The Pirbright Institute, Woking, Surrey, UK

Grant R. Campbell Department of Pediatrics, Division of Infectious Diseases, University of California, San Diego, La Jolla, California, USA

Jeffrey D. Cirillo Department of Microbial Pathogenesis and Immunology, Texas A&M University Health Sciences Center—College of Medicine, College Station, Texas, USA

María Isabel Colombo Laboratorio de Biología Celular y Molecular, Instituto de Histología y Embriología (IHEM)-CONICET, Facultad de Ciencias Médicas, Universidad Nacional de Cuyo, Mendoza, Argentina

Eleanor Cottam The Pirbright Institute, Woking, Surrey, UK

Frances Dang Departments of Paediatrics and Physiology, University of Toronto, Cell Biology Program, Research Institute, The Hospital for Sick Children, Toronto, Ontario, Canada

Elodie Décembre CIRI, Université de Lyon, Lyon, France; Inserm, Lyon, France; Ecole Normale Supérieure de Lyon, Lyon, France; Université Claude Bernard Lyon 1, Lyon, France; CNRS, Lyon, France; LabEx Ecofect, Université de Lyon, Lyon, France

Michel Desjardins Department of Pathology and Cell Biology, Université de Montreal, Montreal, Quebec, Canada

Subramanian Dhandayuthapani Center of Excellence for Infectious Diseases, Department of Biomedical Sciences, Paul L. Foster School of Medicine, Texas Tech Health Sciences Center, El Paso, Texas, USA

Xiaonan Dong Center for Autophagy Research and Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas, USA

Marlène Dreux CIRI, Université de Lyon, Lyon, France; Inserm, Lyon, France; Ecole Normale Supérieure de Lyon, Lyon, France; Université Claude Bernard Lyon 1, Lyon, France; CNRS, Lyon, France; LabEx Ecofect, Université de Lyon, Lyon, France

- N. Tony Eissa** Department of Medicine, Baylor College of Medicine, Houston, Texas, USA
- Mathias Faure** International Center for Infectiology Research (CIRI), CNRS, Université Claude Bernard Lyon 1, Université de Lyon, Ecole Normale Supérieure de Lyon, Lyon, France
- Laura K. Greenfield** Departments of Paediatrics and Physiology, University of Toronto, Cell Biology Program, Research Institute, The Hospital for Sick Children, Toronto, Ontario, Canada
- Marine L.B. Hillaire** CIRI, Université de Lyon, Lyon, France; Inserm, Lyon, France; Ecole Normale Supérieure de Lyon, Lyon, France; Université Claude Bernard Lyon 1, Lyon, France; CNRS, Lyon, France; LabEx Ecofect, Université de Lyon, Lyon, France
- David W. Holden** MRC Centre for Molecular Bacteriology and Infection, Section of Microbiology Imperial College London, London, UK
- Terry Jackson** The Pirbright Institute, Woking, Surrey, UK
- Chinnaswamy Jagannath** Department of Pathology and Laboratory Medicine, University of Texas Health Sciences Center, Houston, Texas, USA
- Nicola L. Jones** Departments of Paediatrics and Physiology, University of Toronto, Cell Biology Program, Research Institute, The Hospital for Sick Children, Toronto, Ontario, Canada
- Tristan X. Jordan** Department of Microbiology, The University of Chicago, Chicago, Illinois, USA
- Arshad Khan** Department of Pathology and Laboratory Medicine, University of Texas Health Sciences Center, Houston, Texas, USA
- Daniel J. Klionsky** Life Sciences Institute and Department of Molecular, Cellular and Developmental Biology, University of Michigan, Ann Arbor, Michigan, USA
- Masato Koike** Department of Cell Biology and Neuroscience, Juntendo University School of Medicine, Tokyo, Japan
- Beth Levine** Center for Autophagy Research, Department of Microbiology, Department of Internal Medicine and Howard Hughes Medical Institute, University of Texas Southwestern Medical Center, Dallas, Texas, USA
- Xu Liu** Life Sciences Institute and Department of Molecular, Cellular and Developmental Biology, University of Michigan, Ann Arbor, Michigan, USA
- Serge Mostowy** Section of Microbiology, MRC Centre for Molecular Bacteriology and Infection, Imperial College London, London, UK
- Christian Münz** Viral Immunobiology, Institute of Experimental Immunology, University of Zürich, Zürich, Switzerland
- Ichiro Nakagawa** Department of Microbiology, Kyoto University Graduate School of Medicine, Kyoto, Japan
- Takashi Nozawa** Department of Microbiology, Kyoto University Graduate School of Medicine, Kyoto, Japan
- Kerstin Radtke** Département de Pathologie et Biologie Cellulaire, Université de Montréal, Montreal, Quebec, Canada
- Glenn Randall** Department of Microbiology, The University of Chicago, Chicago, Illinois, USA

- Gabriela María Recalde** Laboratorio de Biología Celular y Molecular, Instituto de Histología y Embriología (IHEM)-CONICET, Facultad de Ciencias Médicas, Universidad Nacional de Cuyo, Mendoza, Argentina
- Rebecca Roberts** Department of Infection and Immunity, Sheffield University, Sheffield, UK
- Sankaralingam Saikolappan** Center of Excellence for Infectious Diseases, Department of Biomedical Sciences, Paul L. Foster School of Medicine, Texas Tech Health Sciences Center, El Paso, Texas, USA
- Christopher R. Singh** Department of Pathology and Laboratory Medicine, University of Texas Health Sciences Center, Houston, Texas, USA
- Andrea Sirianni** Section of Microbiology, MRC Centre for Molecular Bacteriology and Infection, Imperial College London, London, UK
- Emily Soudani** Department of Pathology and Laboratory Medicine, University of Texas Health Sciences Center, Houston, Texas, USA
- Stephen A. Spector** Department of Pediatrics, Division of Infectious Diseases, University of California, San Diego, La Jolla and Rady Children's Hospital, San Diego, California, USA
- Carlos S. Subauste** Division of Infectious Diseases and HIV Medicine, Department of Medicine, Department of Ophthalmology and Visual Sciences, Department of Pathology, Case Western Reserve University School of Medicine, Cleveland, Ohio, USA
- Isei Tanida** Department of Biochemistry and Cell Biology, National Institute of Infectious Diseases, Tokyo, Japan
- Pierre Thibault** Proteomics and Mass Spectrometry, Research Unit, Institute for Research in Immunology and Cancer, Université de Montréal, Montreal, Quebec, Canada
- Teresa L. M. Thurston** MRC Centre for Molecular Bacteriology and Infection, Section of Microbiology, Imperial College London, London, UK
- Christophe Viret** International Center for Infectiology Research (CIRI), CNRS, Université Claude Bernard Lyon 1, Université de Lyon, Ecole Normale Supérieure de Lyon, Lyon, France
- Matthew Whelband** Norwich Medical School, University of East Anglia, Norwich, Norfolk, UK
- J. Lindsay Whitton** Department of Immunology and Microbial Science, The Scripps Research Institute, La Jolla, California, USA
- Tom Wileman** Norwich Medical School, University of East Anglia, Norwich, Norfolk, UK
- Zhigang Zhou** Norwich Medical School, University of East Anglia, Norwich, Norfolk, UK

PREFACE

Since the discovery nearly 20 years ago that pathogenic bacteria and viruses intimately associate with autophagosomal membranes, scientists have determined that autophagy is a critical component of innate and acquired immunity. Of course, as with all aspects of the host immune response, some pathogens have turned autophagy to their advantage. For this volume, experts in the fields of bacteriology, virology, mycology, parasitology, immunology, and cell biology describe the cellular mechanisms of autophagosome formation and maturation, its contribution to host defenses, and the mechanisms pathogenic microbes have acquired to overcome and subvert this formidable barrier to infection. In addition, specialists discuss current efforts to exploit knowledge of the autophagy pathway to improve vaccine design. Accordingly, this thorough examination of an extraordinary cellular battleground between host and pathogen can stimulate ongoing research to understand and to manipulate autophagy to improve human health.

William T. Jackson
Michele S. Swanson

