THE IMMUNE RESPONSE TO INFECTION
THE IMMUNE RESPONSE TO INFECTION

EDITED BY

STEFAN H. E. KAUFMANN
Max Planck Institute for Infection Biology
Berlin, Germany

BARRY T. ROUSE
College of Veterinary Medicine, University of Tennessee
Knoxville, Tennessee

DAVID L. SACKS
Laboratory of Parasitic Diseases, National Institutes of Health
Bethesda, Maryland

WASHINGTON, D.C.
Macrophage in the process of engulfing *Mycobacterium tuberculosis* organisms.

Left (red): *Helicobacter pylori*; right (blue): *Neisseria gonorrhoeae* attached to epithelial cells.

All three photos courtesy of Volker Brinkmann and Stefan H.E. Kaufmann (Max Planck Institute for Infection Biology, Berlin, Germany).
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Contributors</strong></td>
<td>ix</td>
</tr>
<tr>
<td></td>
<td><strong>Preface</strong></td>
<td>xv</td>
</tr>
<tr>
<td></td>
<td><strong>The Immune Response to Infection:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Introduction</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>STEFAN H. E. KAUFMANN, BARRY ROUSE, AND DAVID SACKS</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SECTION I</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>HOST DEFENSE: GENERAL</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>1 Invertebrate Innate Immune Defenses</strong></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>LAURE EL CHAMY, CHARLES HETRU, AND JULES HOFFMANN</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>2 The Ontogeny of the Cells of the Innate and the Adaptive Immune System</strong></td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>FRITZ MELCHERS</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>3 The Evolutionary Origins of the Adaptive Immune System of Jawed Vertebrates</strong></td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>JIM KAUFMAN</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>4 Host Defense (Antimicrobial) Peptides and Proteins</strong></td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>LAURENCE MADERA, SHUHUA MA, AND ROBERT E. W. HANCOCK</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>5 Reactive Oxygen and Reactive Nitrogen Intermediates in the Immune System</strong></td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>CHRISTIAN BOGDAN</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>6 Complement in Infections</strong></td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>WILHLM J. SCHWAEBLE, YOUSSIF MOHAMMED ALI, NICHOLAS J. LYNCH, AND RUSSELL WALLIS</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>7 Immune Defense at Mucosal Surfaces</strong></td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>MARIAN R. NEUTRA AND JEAN-PIERRE KRAEHENBUHL</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>8 Regulation of Antimicrobial Immunity</strong></td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>YASMINE BELKAID, SHARVAN SEHRAWAT, AND BARRY T. ROUSE</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>9 Memory and Infection</strong></td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>DAVID MASOPUST AND MARK K. SLIFKA</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SECTION II</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>THE PATHOGENS</strong></td>
<td>131</td>
</tr>
<tr>
<td></td>
<td><strong>10 Overview of Viral Pathogens</strong></td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>JONATHAN W. YEWDELL AND JACK R. BENNINK</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>11 Overview of Parasitic Pathogens</strong></td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>RICK L. TARLETON AND EDWARD J. PEARCE</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>12 Overview of Bacterial Pathogens</strong></td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>PHILIPPE J. SANSONETTI AND ANDREA PUHAR</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>13 Overview of Fungal Pathogens</strong></td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>AXEL A. BRAKHAGE AND PETER F. ZIPFEL</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>14 Prionoses and the Immune System</strong></td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>JÜRGEN A. RICHT AND ALAN YOUNG</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SECTION III</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>INNATE IMMUNITY TO MICROBIAL INFECTIONS</strong></td>
<td>183</td>
</tr>
<tr>
<td></td>
<td><strong>15 Innate Immunity to Viruses</strong></td>
<td>185</td>
</tr>
<tr>
<td></td>
<td>AKIKO IWASAKI</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>16 Natural Killer Cell Response against Viruses</strong></td>
<td>197</td>
</tr>
<tr>
<td></td>
<td>JOSEPH C. SUN AND LEWIS L. LANIER</td>
<td></td>
</tr>
</tbody>
</table>
CONTENTS

SECTION IV  
ACQUIRED IMMUNITY TO MICROBIAL INFECTIONS / 237

19 Acquired Immunity against Bacteria / 209  THOMAS ARESCHOU, ANNETTE PLUDEMANN, AND SIAMON GORDON

20 Immune Responses to Persistent Viruses / 255  E. JOHN WHERRY AND PAUL KLEENERMAN

21 Acquired Immunity: Acute Bacterial Infections / 269  DENNIS W. METZGER

22 Acquired Immunity: Chronic Bacterial Infections / 279  ANDREA M. COOPER AND RICHARD ROBINSON

23 Acquired Immunity: Fungal Infections / 289  LUIGINA ROMANI

24 Acquired Immunity to Intracellular Protozoa / 301  PHILLIP SCOTT AND ELEANOR M. RILEY

25 Acquired Immunity to Helminths / 313  DAVID ARTIS AND RICK M. MAIZELES

SECTION V  
PATHOLOGY AND PATHOGENESIS / 325

26 Pathology and Pathogenesis of Bacterial Infections / 327  WARWICK J. BRITTON AND BERNADETTE S. SAUNDERS

27 Helicobacter pylori: the Role of the Immune Response in Pathogenesis / 337  KAREN ROBINSON AND JOHN C. ATHERTON

28 Pathogenesis of Helminth Infections / 347  THOMAS A. WYNN AND JUDITH E. ALLEN

29 Pathology and Pathogenesis of Malaria / 361  CHANAKI AMARATUNGA, TATIANA M. LOPERA-MESA, JEANETTE G. TSE, NEIDA K. MITA-MENDOZA, AND RICK M. FAIRHURST

30 Pathology and Pathogenesis of Virus Infections / 383  CARMEN BACA JONES AND MATTHIAS VON HERRATH

SECTION VI  
EVASION AND SUPPRESSION OF THE ANTIMICROBIAL HOST RESPONSE / 391

31 Viral Immune Evasion / 393  LILA FARRINGTON, GABRIELA O’NEILL, AND ANN B. HILL

32 Growing Old and Immunity to Viruses / 403  JANKO NIKOLICH-ZUGICH AND MARCIA A. BLACKMAN

33 Growing Old and Immunity to Bacteria / 413  JOANNE TURNER

34 Bacterial Strategies for Survival in the Host / 425  ANNA D. TISCHLER AND JOHN D. MCKINNEY

35 Suppression of Immune Responses to Protozoan Parasites / 441  DAVID L. SACKS

36 Immune Evasion by Parasites / 453  JOHN M. MANSFIELD AND MARTIN OLIVIER

SECTION VII  
GENETICS OF THE ANTIMICROBIAL HOST RESPONSE / 471

37 Genetics of Antibacterial Host Defenses / 473  STEVEN M. HOLLAND

38 Immunogenetics of Host Response to Parasites in Humans / 483  JENEFER M. BLACKWELL

39 Immunogenetics of Virus Pathogenesis / 491  SEAN WILTSHE, DAVID I. WATKINS, EMIL SKAMENE, AND SILVIA M. VIDAL
SECTION VIII __________________________
AUTOIMMUNITY AND CANCER  /  509

40 Viruses, Autoimmunity, and Cancer / 511
MEGHANN TEAGUE GETTS,
LIES BOGAERT, W. MARTIN KAST, AND
STEPHEN D. MILLER

41 The Role of Bacterial and Parasitic Infections in Chronic Inflammatory Disorders and Autoimmunity / 521
STEFAN EHLERS AND GRAHAM A. W. ROOK

42 Theileria-Induced Leukocyte Transformation: an Example of Oncogene Addiction? / 537
MARIE CHAUSSEPIED AND
GORDON LANGSLEY

SECTION IX __________________________
IMMUNE INTERVENTION / 547

43 Systems Vaccinology: Using Functional Signatures To Design Successful Vaccines / 549
TROY D. QUERE AND BALI PULENDAR

44 Meeting the Challenge of Vaccine Design To Control HIV and Other Difficult Viruses / 559
BARNEY S. GRAHAM AND
CHRISTOPHER WALKER

45 Immune Intervention Strategies against Tuberculosis / 571
PETER ANDERSEN AND STEFAN H. E. KAUFMANN

46 Immune Intervention in Malaria / 587
CAROLE A. LONG AND FIDEL P. ZAVALA

47 Targeting Components in Vector Saliva / 599
MARY ANN McDOWELL AND SHADEN KAMHAWI

SECTION X __________________________
THE MAJOR KILLERS (CLINICS,
EPIDEMIOLOGY, AND IMMUNE PARAMETERS) / 609

48 AIDS Vaccines: the Unfolding Story / 611
STEPHEN NORLEY

49 Tuberculosis / 623
GERHARD WALZL, PAUL VAN HELDEN, AND
PHILIP R. BOTHA

50 Malaria: Clinical and Epidemiological Aspects / 633
ANDREA A. BERRY, MYAING M. NYUNT, AND
CHRISTOPHER V. FLOWE

51 The Epidemiology and Immunology of Influenza Viruses / 643
RAFAEL A. MEDINA, IRENE RAMOS, AND
ANA FERNANDEZ-SESMA

Index / 653
Contributors

YOUSSIF MOHAMMED ALI
Department of Infection, Immunity and Inflammation,
University of Leicester, MSB, University Road,
Leicester LE1 9HN, United Kingdom

JUDITH E. ALLEN
Institutes of Evolution, Immunology and Infection Research,
University of Edinburgh, Edinburgh EH9 3JT, UK

CHANAKI AMARATUNGA
Laboratory of Malaria and Vector Research, National Institute
of Allergy and Infectious Diseases, Rockville, MD 20852

PETER ANDERSEN
Department of Infectious Disease Immunology, Statens Serum
Institut, Copenhagen, Denmark

THOMAS ARESCHOUG
Department of Laboratory Medicine, Division of Medical
Microbiology, Lund University, Sölvegatan 23,
22362 Lund, Sweden

DAVID ARTIS
Department of Pathobiology, School of Veterinary
Medicine, University of Pennsylvania, Philadelphia,
PA 19104-4539

JOHN C. ATHERTON
Nottingham Digestive Diseases Centre Biomedical
Research Unit, University Hospital, Nottingham,
NG7 2UH, United Kingdom

CARMEN BACA JONES
Center for Type 1 Diabetes Research, La Jolla Institute
for Allergy and Immunology, 9420 Athena Circle,
La Jolla, CA 92037

YASMINE BELKAID
Mucosal Immunology Unit, Laboratory of Parasitic Diseases,
Division of Intramural Research, National Institute of Health,
4 Center Drive B1-28, Bethesda, MD 20892

ANDREA A. BERRY
Center for Vaccine Development, University of Maryland
School of Medicine, Baltimore, MD 21201

MARCIA A. BLACKMAN
The Trudeau Institute, Saranac Lake, NY 12983

JENEFER M. BLACKWELL
Telethon Institute for Child Health Research, Centre for
Child Health Research, University of Western Australia,
Subiaco, Western Australia, Australia

LIES BOGAERT
Departments of Molecular Microbiology & Immunology and
Obstetrics & Gynecology, Norris Comprehensive Cancer
Center, University of Southern California, Los Angeles,
CA 90033. Department of Surgery and Anesthesiology of
Domestic Animals, Faculty of Veterinary Medicine,
University of Ghent, Merelbeke, B-9820, Belgium

CHRISTIAN BOGDAN
Microbiology Institute Clinical Microbiology,
Immunology and Hygiene, Friedrich Alexander University
Erlangen, Nuremberg, and University Clinic of Erlangen,
Wasserturmstraße 3/5, D-91054 Erlangen, Germany

PHILIP R. BOTHA
Division of Infectious Diseases, Department of Medicine
Tygerberg Academic Hospital, Faculty of Health Sciences,
University of Stellenbosch, P.O. Box 19063, Tygerberg,
7505, South Africa

AXEL A. BRAKHAGE
Leibniz Institute for Natural Product Research and
Infection Biology, Hans Knoell Institute (HKI),
Friedrich Schiller University Jena, Department Molecular and
Applied Microbiology and Department of Infection Biology,
Beutenbergstrasse 11a, 07745 Jena, Germany

MICHAEL A. BREHM
Department of Pathology, University of Massachusetts
Medical School, Worcester, MA 01655

WARWICK J. BRITTON
Centenary Institute, Locked Bag No 6, Newtown, 2042;
and Discipline of Medicine, Sydney Medical School,
University of Sydney (D06), Sydney, 2006, NSW, Australia
LAURENCE MADERA
Department of Microbiology and Immunology, Centre for Microbial Diseases & Immunity Research, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada

RICK M. MAIZELS
Centre for Immunity, Infection and Evolution, and Institute of Immunology and Infection Research, University of Edinburgh, Edinburgh EH9 3JT, United Kingdom

JOHN M. MANSFIELD
Department of Bacteriology, Microbial Sciences Building, 1550 Linden Drive, University of Wisconsin-Madison, Madison, WI 53716

DAVID MASOPUST
Department of Microbiology, Center for Immunology, University of Minnesota, 2-182 Medical Biosciences Building, 2101 6th St. SE, Minneapolis, MN 55455

MARY ANN McDOWELL
The Eck Institute for Global Health and Infectious Diseases, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556

JOHN D. McKinney
Global Heath Institute, Swiss Federal Institute of Technology (EPFL), CH-1015 Lausanne, Switzerland

RAFAEL A. MEDINA
Department of Microbiology and the Emerging Pathogens Institute, Mount Sinai School of Medicine, New York, NY 10029

FRITZ MELCHERS
Max Planck Institute for Infection Biology, Senior Research Group on Lymphocyte Development, Charitéplatz 1, D 10117, Berlin, Germany

DENNIS W. METZGER
Center for Immunology and Microbial Disease, Albany Medical College, Albany, New York 12208

STEPHEN D. MILLER
Department of Microbiology-Immunology and Interdepartmental Immunobiology Center, Feinberg School of Medicine, Northwestern University, Chicago, IL 60611

NEIDA K. MITA-MENDOZA
Laboratory of Malaria and Vector Research, National Institute of Allergy and Infectious Diseases, Rockville, MD 20852

MARIAN R. NEUTRA
Department of Pediatrics, Harvard Medical School, and GI Cell Biology Laboratory, Children's Hospital, Boston, MA 02115

JANKO NIKOLICH-ZUGIC
Department of Immunobiology and the Arizona Center on Aging, University of Arizona College of Medicine, Tucson, AZ 85718

STEPHEN NORLEY
Robert Koch Institute, 13353 Berlin, Germany

MYAING M. NYUNT
Department of International Health, Global Disease Epidemiology and Control Program, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205

MARTIN OLIVIER
Department of Microbiology and Immunology, Duff Medical Building, 3775 University, McGill University, Montréal, Québec, Canada.

GABRIELA O'NEILL
Dept. of Molecular Microbiology and Immunology, Oregon Health and Science University, Portland, OR 97239

EDWARD J. PEARCE
Trudeau Institute Inc., 154 Algonquin Avenue, Saranac Lake, NY 12983

CHRISTOPHER V. PLOWE
Center for Vaccine Development, Howard Hughes Medical Institute and University of Maryland School of Medicine, Baltimore, MD 21201

ANNETTE PLÜDDEMANN
Department of Primary Health Care, University of Oxford Old Road Campus, Oxford, OX3 7LF, UK

ANDREA PUHAR
Emory Vaccine Center, Emory University, 954 Gatewood Road, Atlanta, GA 30329

TROY D. QUEREC
Emory Vaccine Center, Emory University, 954 Gatewood Road, Atlanta, GA 30329

IRENE RAMOS
Department of Microbiology and the Emerging Pathogens Institute, Mount Sinai School of Medicine, New York, NY 10029

JÜRGEN A. RICHT
Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University, K224B Mosier Hall, Manhattan, KS 66506-5601

ELEANOR M. RILEY
Department of Infectious and Tropical Diseases, London School of Tropical Medicine and Hygiene, London, UK

RICHARD ROBINSON
Trudeau Institute, Inc., 154 Algonquin Ave., Saranac Lake, NY

KAREN ROBINSON
Centre for Biomolecular Sciences, University of Nottingham, Nottingham, NG7 2RD, United Kingdom

LUIGINA ROMANI
Microbiology Section, Department of Experimental Medicine and Biochemical Sciences, University of Perugia, Via del Giochetto, 06122 Perugia, Italy

GRAHAM A. W. ROOK
Centre for International and Medical Microbiology (CIMM), Windeyer Institute for Medical Sciences, University College London (UCL), 46 Cleveland Street, GB - London W1T 4JF, United Kingdom
JEANETTE G. TSE
Laboratory of Malaria and Vector Research, National Institute of Allergy and Infectious Diseases, Rockville, MD 20852

JOANNE TURNER
Center for Microbial Interface Biology, and Department of Internal Medicine, Division of Infectious Diseases, The Ohio State University, 460 West 12th Ave., Columbus, OH 43210

PAUL VAN HELDEN
DST/NRF Centre of Excellence for Biomedical TB Research, Division of Molecular Biology and Human Genetics, Department of Biomedical Sciences, Faculty of Health Sciences, University of Stellenbosch, P.O. Box 19063, Tygerberg, 7505, South Africa

SILVIA VIDAL
Department of Human Genetics, The McGill Life Sciences Complex, Bellini Pavilion, Room 356, 3649 Promenade Sir William Osler, Montreal, QC H3G 0B1, Canada

MATTHIAS VON HERRATH
Center for Type 1 Diabetes Research, La Jolla Institute for Allergy and Immunology, 9420 Athena Circle, La Jolla, CA 92037

CHRISTOPHER WALKER
Nationwide Children’s Hospital and the Departments of Pediatrics, Pathology, and Molecular Virology and Medical Genetics, The Ohio State University, Columbus, OH 43205

RUSSELL WALLIS
Department of Infection, Immunity and Inflammation, University of Leicester, MSB, University Road, Leicester LE1 9HN, United Kingdom

GERHARD WALzl
DST/NRF Centre of Excellence for Biomedical TB Research, Division of Molecular Biology and Human Genetics, Department of Biomedical Sciences, Faculty of Health Sciences, University of Stellenbosch, P.O. Box 19063, Tygerberg, 7505, South Africa

SEAN WILTSHIRE
Department of Human Genetics, The McGill Life Sciences Complex, Bellini Pavilion, Room 356, 3649 Promenade Sir William Osler, Montreal, QC H3G 0B1, Canada
CONTRIBUTORS  ■  xiii

THOMAS A. WYNN
Immunopathogenesis Section, National Institute of Allergy
and Infectious Disease, National Institutes of Health,
Bethesda, MD 20892-8003

JONATHAN W. YEWDELL
Laboratory of Viral Diseases, National Institute of Allergy and
Infectious Diseases, Bethesda, MD 20892-3209

ALAN YOUNG
Department of Veterinary Science, South Dakota State
University, Box 2175, ARW168F, Brookings, SD 57007

FIDEL P. ZAVALA
Department of Molecular Microbiology and Immunity,
Bloomberg School of Public Health, Malaria Research
Institute, Johns Hopkins University, 615 N. Wolfe St.,
Baltimore, MD 21283

PETER F. ZIPFEL
Leibniz Institute for Natural Product Research and
Infection Biology, Hans Knoell Institute (HKI),
Friedrich Schiller University Jena, Department Molecular and
Applied Microbiology and Department of Infection Biology,
Beutenbergstrasse 11a, 07745 Jena, Germany
“Excellent textbooks and review volumes on immunology, virology, parasitology, medical microbiology, and infectious diseases abound. So what gap is this book aimed to fill?”

This question was posed in the preface of the ASM Press book *Immunology of Infectious Diseases* (edited by Stefan H. E. Kaufmann, Alan Sher, and Rafi Ahmed), published in 2002. The explanation provided then still holds true today. Microbiology and immunology, despite their common roots, have matured as distinct disciplines, and infectious diseases are too often viewed from the perspective of either the microbe or the host. A more holistic approach was provided by that book and a second one published by ASM Press in 2004, *The Innate Immune Response to Infection* (edited by Stefan H. E. Kaufmann, Ruslan Medzhitov, and Siamon Gordon).

These books now urgently need updating because the knowledge base in immunology, as well as with all types of infectious agents, has expanded dramatically. The present volume, *The Immune Response to Infection*, covers all aspects of innate and adaptive immune mechanisms and describes how they interact with pathogens of different types, resulting in either success or failure to control infection and clinical disease. This volume also emphasizes how our understanding of mechanistic events is leading the design and production of more effective prophylactic and therapeutic control measures for infectious agents.

Most of the chapters here consider host-pathogen interactions in the context of the broad divisions of the microbial world—either viruses, bacteria, or parasites—and do not confine their discussion to any individual pathogen. The exceptions are for the agents of the “big three” infectious diseases—HIV/AIDS, tuberculosis, and malaria—which account for almost one-third of human deaths from infections, as well as influenza, which is the focus of much media and public attention. We have also included chapters that consider the detrimental sequelae of infection that are an indirect result of the infectious process, such as chronic inflammation, cancer, and autoimmunity. Finally, all of the chapters emphasize the special attributes that make pathogens difficult to control, and they appraise the prospects of current and future prophylactic and therapeutic vaccines.

We hope that this book, which comprises the rich variety of aspects of infection and immunity, helps to further promote the important relationship between immunology and medical microbiology. We express our deep appreciation to the editorial staff of ASM Press, in particular, Greg Payne and Ellie Tupper. We also want to thank our associates Mary Louise Grossman and Lisa Washington for their secretarial help and for their wonderful dedication. Most of all, we thank our colleagues for sacrificing so much of their valuable time to generously share their outstanding expertise with us and with the readers of this book.

STEFAN H. E. KAUFMANN,
BARRY T. ROUSE, AND
DAVID L. SACKS
Index

AAV. See Adeno-associated virus
AAV: See Adeno-associated virus vectors
ABC. See ATP-binding cascade
Acanthochelona aitauae, 527
N-Acetylglucosamine, 9
Acinetobacter lwoffi, 571–572
Acute infection
Acute phase reactants, 403
Active tuberculosis disease, 627
Activation-induced cytidine deaminase
Acrocephalus anundinaceus
Immunogenetics, 486t
induction of, 274
Acute infection and, 239–240, 272, 571–572
to intracellular protozoa, 301–308
Mycobacterium leprae, 285–286
Mycobacterium tuberculosis, 284–285
Mycobacterium ulcerans
Mycobacterium ulcerans
Acquired immunity
acute bacterial infections, 269–276
acute infection and, 274–276
antibacterial, 274–276
in gastrointestinal tract, 314–317
Helicobacter pylori, 342–344
to helminths, 313–321
immunogenetics, 486t
induction of, 274
innate immunity and, 239–240, 272, 571–572
to intracellular protozoa, 301–308
Mycobacterium leprae, 285–286
Mycobacterium tuberculosis, 284–285
Mycobacterium ulcerans, 285
TB and, 572–573
against viral infection, 239–251
Acquired immunodeficiency syndrome (AIDS), 1, 134, 580
animal models for, 611
clinical trials, 616
DNA vaccines, 614
generic vaccines, 613–614
reasons for optimism, 617–618
recombinant viral vectors, 614
replicating vectors, 617
subunit vaccines, 613
therapeutic vaccines, 616–617
vaccines, 611–618
Acrocephalus annundinaceus, 50
Activation-induced cytidine deaminase
(AID), 30, 124
Active tuberculosis disease, 627
diagnostic markers for, 628
ACTs. See Artemisinin-based combination therapies
Acute infection
acquired immunity, 274–276
immune responses following, 256–258
Acute phase reactants, 403
Acute rheumatic fever (ARF), 524
Acute viruses, immunity to, 404–409
Adaptive immune system
immunogenetics, 486t
ontogeny of cells of, 21–33
parasitic infections and, 231–232
viral immunity and, 404
ADCC. See Antibody-dependent cellular cytotoxicity
ADCI. See Antibody-dependent cellular inhibition
Adeno-associated virus (AAV), 239
Adeno-associated virus vectors (AAVV), 615
Adenovirus, 577–578
vectors, 614
Adhesion defects, 477–479
Adjuvants
pathogens as, 515
for protein subunit vaccines, 576–577
synthetic, 552
Against viral infection, 239–251
Aging
animal models of, 419
bacterial immunity and, 413–419
CD8 T-cell memory and, 405–406
CMV and, 408–409
De Novo infections and, 406
EBV and, 407–408
HCV and, 409
HIV and, 409, 421
HSV and, 409
human studies of, 420t
innate immunity and, 413
peripheral memory T-cells and, 406
respiratory infections and, 405
viral immunity and, 403–410
VZV and, 407
Agnathans, 17
AHR. See Allergic airway hypersensitivity response
AID. See Activation-induced cytidine deaminase
AIDS. See Acquired immunodeficiency syndrome
AIDS-associated retrovirus (ARV), 493
AIM2, 190
AIM2-ASC inflammasome, 191
AKT, 541t
Alkaline phosphatase (ApC), 431
Allergic airway hypersensitivity response (AHR), 385
Allergic response, 384t
Alternative activated macrophages, 317–318
Alternative complement pathway, 88
deficiencies, 90
Alum, 552–553
ALVAC, 565, 566
AMA1, 592
Amblyomma americanum, 604
Amblyomma mexicanum, 50
Amphimedon queenslandica, 16
Amphioxus, 44
AMPs. See Antimicrobial peptides
Ancient antiviral defense mechanisms, 191
Ancyllostoma duodenale, 146
Anemia, Plasmodium vivax and, 372
Annelids, 16
Anopheles gambiae
Anophelines gambiae, 15, 638
ANT3, 644
Anthrax, 3
Antibacterial-acquired immunity, 274–276
Antibacterial host defenses, 473–476
Antibacterial-acquired immunity, 274–276
barrier defects, 473
cutaneous defenses, 473–474
immune defects, 474–477
pulmonary defenses, 474–477
Antibiotics, 529
Antibodies
mucosal, 529
usefulness of, 250–251
viral infection control by, 249–250
Antibody-dependent cellular cytotoxicity (ADCC), 104, 250, 272
Antibody-dependent cellular inhibition (ADCI), 592
Antibody-dependent enhancement of infection, 384t
Antibody-mediated immune effector mechanisms, 307–308
Antibody-mediated immunity, 592
Antibody-mediated protection, 269–270
Antibody responses
importance of, 247
kinetics, 247–248
Antibody-secreting cells (ASC), 125–126, 247
Entries followed by an f indicate a figure; those followed by a t indicate a table.
INDEX

Complement-like opsonins, 14–15
Complement receptor 1 (CR1), 30, 89, 228, 364, 371, 464
Complement regulator acquiring surface proteins (CRASPs), 169
IL-1. See Interleukin 1
IL-1B. See Interleukin 1B
IL-1R. See Interleukin 1 receptor
IL-1 receptor-associated kinase (IRAK), 9, 74, 249
IL-2. See Interleukin 2
IL-4. See Interleukin 4
IL-5. See Interleukin 5
IL-6. See Interleukin 6
IL-7. See Interleukin 7
IL-8. See Interleukin 8
IL-9. See Interleukin 9
IL-10. See Interleukin 10
IL-12. See Interleukin 12
IL-13. See Interleukin 13
IL-15. See Interleukin 15
IL-17. See Interleukin 17
IL-23. See Interleukin 23
IL-27. See Interleukin 27
IL-33. See Interleukin 33
IL-IR/TLR. See Interleukin IR/Toll-like receptor
IMD pathway, 7
Drosophila, 11–12
FNDC4 and, 9
Immune adaptation, bacterial survival and, 430–433
Immune cells, differentiation of, 75
Immune complex formation, 384t
Immune complex-mediated pathology, 330
Immune defects, 474–477
adhesion, 477–479
neutrophil granule formation, 476
neutrophil oxidative metabolism, 476
Immune effectors, Drosophila, 8
Immune evasion, 435–465
cellular activation and, 459–460
HIV, 560–561
Leishmania, 461–465
T-cell, 398–399
Immune modulation, mechanisms of, 461
Immune reconstitution disease (IRD), 626
Immune regulated catalase (IRC), 13
Immune stromal keratitis (ISK), 384–385
Immune subversion, bacterial survival and, 434–435
Immune suppression
bacterial survival and, 435–437
Chagas' disease and, 446
of dendritic cells, 441–443
IL-10 and, 443–446
leishmaniasis and, 445–446
protozoa and, 441–449
regulatory T-cells and, 443–446
Immunity. See specific types
Immunogenetics
acquired immunity, 486t
innate immunity, 486t
nonimmune related, 486t
of parasite host response, 483–488
of virus pathogenesis, 491–506
Immunoglobulin-like repeat proteins, 14
Immunoglobulin superfamily (IgSF), 16
Immunology, birth of, 3
Immunomodulation, 59–60
BPI, 64–65
cathelicidins, 61–62
defensins, 59–60
fungal infections, 297
iNOS, 79
mechanisms of, 62–63
ROI, 74
Immunoreceptor tyrosine-based activation motif (ITIM), 14, 32, 272, 329
Immunoreceptor tyrosine-based inhibitory motif (ITIM), 46, 329, 492
Immunoreceptor tyrosine-based microorganism exposure and, 528–529
IMT. See Isoniazid monotherapy
Indoleamine 2,3-dioxygenase, 289
Inducible regulatory cells, 110–112
Infected red blood cells (iRBCs), 306
Infections. See specific types
Infiltrating leukocytes, 340
Inflammasomes, 200
activation of, 190
NLRP3-ASC, 190–191
Inflammation
in extracellular bacterial infection, 328
in malaria, 365
Inflammatory bowel disease (IBD), 476
Influenza, 404–405, 643–651, 650f
circulation of, 644f
effects of, 650
innate immunity, 649–650
1918 pandemic, 645–646
1957 pandemic, 646
1977 pandemic, 646
1997 pandemic, 646
pathogenicity of, 645f
susceptibility loci, 504f
2009 pandemic, 648f
vaccines, 649
Influenza A virus (IAV), 239
Inhibitor of apoptosis proteins (IAPs), 395
Innate B lymphocytes, 211
Innate cellular responses, 229–230
Innate cytokines, 395–396
Innate immune system
adaptive immune system linking with, 32
in annelids, 16
bacterial pathogens and, 209–222
comparative analysis of, 15–16
complement system and, 221–222
Drosophila, 7–13
fungal pathogens and, 167
general aspects of, 209–212
humoral, 211–222, 226–227
invertebrate, 7–17
modulation of, 213
in mollusks, 16
ontogeny of cells of, 21–33
origin of, 16–17
parasitic infections and, 225–232
viruses and, 185–194
Innate immunity, 485–486
acquired immunity and, 239–240, 272,
74, 286, 307, 321, 456
immunogenetics, 486f
influenza, 649–650
malaria, 639
Innate recognition receptors, in bacterial infection, 214–215
iNOS, 303, 331, 351, 431
antimicrobial activity, 77–78
cellular localization of, 76
Influenza (IL-1f), 228, 282, 284–285, 286, 307, 321, 456
Interferon-mediated immunity, 495–502
effectors, 497
signaling, 497–498
viral escape, 498
Interferon receptors, 201
Interferons (IFNs), 385, 400
amplification of, 191
antiviral effectors induced by, 193
induction, 192
NK cells, 201–202
type 1, 191–194
Interferon stimulated response element (ISRE), 193
Interleukin 1 (IL-1), 89, 306, 337
Borreia burgdorferi and, 435
Interleukin 1B (IL-1B), 58
Interleukin 1 receptor (IL-1R), 8
Interleukin 2 (IL-2), 122
Interleukin 4 (IL-4), 284, 315, 317
Interleukin 5 (IL-5), 229, 315, 320
Interleukin 6 (IL-6), 60, 61, 306
Interleukin 7 (IL-7), 33, 122
receptors, 259
Interleukin 8 (IL-8), 427
Interleukin 9 (IL-9), 315
Interleukin 10 (IL-10), 109, 149–150,
206, 241, 283, 303, 307, 415,
446, 447, 448
production of, 434f
subsets of, 444f
suppression of immune responses by,
443–446
Interleukin 12 (IL-12), 201, 228–229, 283,
302, 441, 447
type 1, 202
Interleukin 13 (IL-13), 314, 315, 317
Interleukin 15 (IL-15), 122, 202
Interleukin 17 (IL-17), 301, 474
Interleukin 23 (IL-23), 283
Interleukin 27 (IL-27), 447
Interleukin 33 (IL-33), 316
Interleukin IR/Toll-like receptor
(IL-IR/TLR), 7
Intestinal epithelial cells (IECs), 315
Intracellular bacteria
pathology of, 330–334
rapidly growing, 331
Intracellular control mechanisms, 23
Intracellular protozoa
acquired immunity to, 301–308
of phagocytic cells, 302–304
T-cell dependent control of, 302–303
Intraepithelial lymphocytes, 98
Invertebrate innate immune defenses, 7–17
IPS-1, 200
IRAK. See IL-1 receptor-associated kinase
IRAK-1, 462
rapid inactivation of, 463f
IRAK-4, 475–476
iRBCs. See Infected red blood cells
IRG. See Immune regulated catalase
IRD. See Immune reconstitution disease
IRF3, 192, 200, 495
IRF7, 192
IRP9, 202
Iris, from oxides ricinus, 604
Irritable bowel syndrome (IBS), 529
ISG. See IFN-stimulated genes
ISG15, 194
ISK. See Immune stromal keratitis
Isoniazid monotherapy (IMT), 625
ISRE. See IFN-stimulus response elements;
Interferon-stimulated response element
IsSMase. See Sphingomyelinase-like enzyme
ITAM. See Immune receptor tyrosine-based inhibitory motif
ITIM. See Immune receptor tyrosine-based inhibitory motif
Ixodes ricinus, 604
B-cell inhibitory protein from, 604
iris from, 604
Ixodes scapularis, 603–604
PGE₂, 603
Salp15 from, 603
Salp25 from, 603
sirolastatin from, 603

JAK. See Janus kinase
JAK1, 396, 496f, 497
Theileria and, 541t
JAK2, 462f
JAK/STAT pathway, 527
JAK1, 396, 497
LMP-1, 217, 526
JAK2, 462
JAK1, 396, 497
JAK-driven T-cell responses, 529
JAK/STAT pathway, 210
JAK2, 462
JAK1, 396, 497
JAK1, 396, 496f, 497
JAK-driven T-cell responses, 529
JAK/STAT pathway, 210

Kakpo's sarcoma (KS), 516
Kakpo's sarcoma herpesvirus (KSHV), 395, 407–408, 516, 519
Killed bacterial vaccines, 575
Killer cell lectin-like receptor G1 (KLRE1), 122, 206, 246, 406
Killer cell lectin-like receptor G1 (KLRE1), 122, 206, 246, 406
killer cell lectin-like receptor G1 (KLRE1), 122, 206, 246, 406
KIR3DS1, 502
KIR3DL1, 199
KIR2DL1, 397
KIR3DL1, 199
KIR3DL1, 199
KIR3DL1, 199
KIR3DS1, 502
Kircher, Athanasius, 1
Klebsiella pneumoniae, 60, 161, 222, 329
KLRG1. See Killer cell lectin-like recep-
tor G1
Koch, Robert, 3
KS. See Kakpo's sarcoma
KSHV. See Kakpo's sarcoma herpesvirus
Kupffer cells, 328
Kuru, 173

Laboratory of genetics and physiology 2 (LGP2), 189
La Crosse virus, 622
Lactobacillus, chronic inflammatory disorders and, 527t
Lactobacillus reuteri, 530
Lactoferrin, 64, 65
LAD1. See Leukocyte adhesion deficiency, type 1
LAD2. See Leukocyte adhesion deficiency, type 2
LAD3. See Leukocyte adhesion deficiency, type 3
LAM. See Lipocarabinomannan
Lamellocytes, 14
Lamina propria, 30
LAMP 1, 217, 526
LAMP 2, 526
Lassa fever, 139
Latent membrane proteins (LMP), 31–32
Latent persistent viruses, 407–409
Latent tuberculosis infection, 625
L-chain loci, 31
LCMV. See Lymphocytic choriomeningitis virus
Lectin-like receptors, 216
Lectin pathway, 87
deficiencies, 90
hemirnths and, 351–352
recognition molecules, 87
specific serine proteases, 87–88
structure of, 87
Leeuwenhoek, Antonius van, 2
Legionella in animal models of aging, 419:
human studies of, 420
Legionella pneumophila, 155, 213, 218, 219,
414, 418, 431
Leishmania
downstream regulatory events, 464
DTH and, 601–602
GLWS, 487t
immune evasion by, 461–465
protective immune response, 601–602
Leishmania braziliensis, 445
Leishmania donovani, 78, 113, 147, 149,
226, 227, 228, 301, 304
DC and, 442t
Leishmania major, 282, 284
DC and, 442t
Leishmania mexicana, 464
Leishmania
is cutaneous, 599
immunological suppression and, 445–446
sand flies, 600
visceral, 485
LEKT1. See Lymphopoietic Kazal-type trypsin inhibitor
Leprosy, pathology of, 333–334
Leucine rich repeats (LRRs), 8, 44, 219, 495
Leukocyte adhesion deficiency, type 1
(LAD1), 477–478
Leukocyte adhesion deficiency, type 2
(LAD2), 478
Leukocyte adhesion deficiency, type 3
(LAD3), 478
Leukocytes, innate, 210
Leukotrienes, 604
LGP2. See Laboratory of genetics and physiology 2
Lipid A, 157
Lipids, 212
Lipocarabinomannan (LAM), 212, 435, 579
Lipopolysaccharide (LPS), 226, 302
Lipopolysaccharides (LPSs), 15, 157, 212,
350, 419, 425, 552, 600
Lipopolysaccharides (LPSs), 212
Lipoteichoic acid (LTA), 212
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579
Lipoarabinomannan (LAM), 212, 435, 579

Toxocara canis, 229
Toxoplasma, 144, 147, 301, 304
Toxoplasma gondii, 105, 228, 231, 487
tPA. See Type tissue plasminogen activator
TyrK, 428
Tri 1 cells, induction of, 110–111
TRAF, 16
TRAF2, 10
TRAF3, 186
TRAF6, 186
TRAIL, 203, 205
Transcription controls, 25
Transforming growth factor beta (TGF-β), 109, 110, 317
Transmissible mink encephalopathy (TME), 173
Transmissible spongiform encephalopathies (TSEs), 173
Transmission disequilibrium test (TDT), 484
TRAP. See Thrombospinoid-related adhesive protein
Trefoil factor 3 (TFF3), 319
Treg, 109–110, 149, 344
Th17 and, 529–530
Th1, 529–532
Treponema pallidum, 155, 427–428
Trachyscyllium, 48, 50
Trichinella, 229
Trichinella spiralis, 320
chronic inflammatory disorders and, 527
Trichostrogylos pallidus, 147
Trichurus muris, 229, 352
Trichurus suis, chronic inflammatory disorders and, 527
Trichurus trichiura, 146, 229
GLWS, 4876
TRIF, 231, 563
TRIM5α, 194
TRIM genes, 48
Trypanolytic factor, 227
Trypanosoma, 484
Trypanosoma brucei, 226–227
Trypanosoma cruzi, 525–526
DC and, 442
Trypanosoma antigentic variation, 454–455
Trypanosoma lysis factor (TLF1), 227
Trypanosoma virulence, 463–461
TSEs. See Transmissible spongiform encephalopathies
TSLF. See Thymic stromal lymphoprotein
TSS. See Toxic shock syndrome
TST. See Tuberculosis skin test
Tuberculosis (TB), 1, 414, 418, 483
acquired immunity and, 572–573
active, 627
in animal models of aging, 419;
attenuated parasite vaccines, 589–590
biomarkers, 628–630
clinical trials, 580–581
drug-resistant, 624
DTH and, 531–537
epidemiology of, 623–624
extensively drug resistant, 627–628
future vaccination strategies, 579–580
HIV-associated, 623–624
human studies of, 420;
immune intervention strategies against, 571–582
latent, 625
memory and, 573
mortality, 623
pathogenesis of, 625–626
pathology of, 332–333
postexposure vaccination, 578–579
progression of, 624
spread of, 624
stopping, 627–628
strategies against, 574–575
subdominant epitopes, 579
suppression, 573
vaccine candidates, 577;
vaccine construct design, 588–589
Tumor necrosis factor (TNF), 74, 89, 174, 201, 209, 394, 456, 628, 634–635
Tumor necrosis factor-receptor (TNFR), 7
Tumor necrosis factor-receptor 1 (TNFRI), 11
Tumor necrosis factor-receptor 2 (TNFR2), 44
Tyk2, 46
Tyk2 deficiency, 480
Type 3 secretion system (T3SS), 158
Type O blood group antigen, 371
Tyrosine kinase 2 (TYK2), 202
UBEL, 194
UL16, 398
UL18, 397
ULBP, 398
UNCO93B, 186
Uncomplicated malaria, 362, 635
UniProt, 60
uPA. See Urokinase plasminogen activator
UPEC. See Uropathogenic Escherichia coli
Urinary tract infection (UTI), 413, 414;
in animal models of aging, 420;
human studies of, 420;
Urokinase plasminogen activator (uPA), 169
Uropathogenic Escherichia coli (UPEC), 433–434
UTI. See Urinary tract infection
V-Ab immune complex formation. See Virus-antibody immune complex formation
Vaccine(s)
AIDS, 611–618
attenuated parasite, 589–590
candidates for TB, 577;
cellular immunity and, 564
chips, 554
development of, for HIV, 562–565
development of, for RSV, 567
DNA, 578, 614
empiricism and, 567
erythrocystic-stage malaria, 590–593
evolution of, 568
effective signatures and, 555
fungal infections, 296–297
future, strategies for TB, 579–580
generic, 613–614
humoral immunity and, 565–566
influenza, 649
killed bacterial, 575
live attenuated virus, 612;
malaria, 590–594, 639–640
mucosal, 105
multiantigenic subunit, 589
Vaccine(s) (continued)

- new construct design, 588–589
- postexposure, 578–579
- preexposure, 575–576
- prion, 178–179
- protein subunit, 576–577
- purified recombinant protein, 612
- recombinant vector, 612, 614
- RSV, 567
- salivary, 604, 605
- signaling networks, 552–554
- specialized tissue and, 566–567
- subunit, 613
- therapeutic, 616–617
- traditional, 611–612
- transmission-blocking, 593–594
- virus-like particle, 612
- whole cell, 593
- whole inactivated virus, 612
- Vaccinia, 125–126
- Vaccinia virus (VV), 239
- Vaccinology, 549–555
- systems, 554
- Vacuolating cytotoxin (VacA), 340
- T-cell function and, 436–437
- VAR2CSA, 368, 369, 593
- var genes, 365–366
- Variable lymphocytes receptor (VLR), 17, 44
- Variable region-containing chitin-binding protein (VCBP), 46
- Variant antigenic type (VAT), 454
- Variant surface glycoprotein (VSG), 145, 454, 456–456, 460
- specific T cells, 456–457
- Varicella zoster virus (VZV), 125–126, 199, 239
- aging and, 407
- VariVax, 407
- Varro, Marcus Terentius, 1
- VAT. See Variant antigenic type
- V-ATPase, 431
- VCBP. See Variable region-containing chitin-binding protein
- VDAC1, 644
- VD), 27
- VDR. See Vitamin D receptor
- Vectors. See specific vectors
- Vector saliva
  - immunological memory and, 604
  - neutrophils and, 602
  - polymorphism, 604
  - targeting components in, 599–606
- Vesicular stomatitis virus (VSV), 186, 497, 602

V genes, 45
- Vibrio cholerae, 101, 162
- Viperine, 194
- vir gene, 373
- Viral immune evasion, 393–400
  - of apoptosis, 399–400
  - of CD8+ T cells, 400
  - evolutionary considerations, 399–400
  - IFN, 399
- Viral immunity
  - adaptive, 404
  - age and, 403–410
  - innate, 403–404
  - LCMV, 407
- Viral infection. See also Persistent viruses
  - acquired immunity against, 239–251
  - antigen presentation and, 242–243
  - complement system in, 93
  - control of, by antibodies, 249–250
  - heterologous immunity in, 251
  - pathology of, 383–388
- Viral pathogens. See also Persistent viruses
  - acquired immunity against, 239–251
  - antigen presentation and, 242–243
  - complement system in, 93
  - control of, by antibodies, 249–250
  - heterologous immunity in, 251
- Viral vectors, 577–578
- Virulence factors, 159–161
  - interactions between, 340
  - transmission, 159
- Virus-antibody (V-Ab) immune complex formation, 385
- Virus entry, genetic control of, 492–495
- Virus-induced autoimmunity, 387–388
- Virus-induced immunopathology, 384–385
- Virus-induced tissue damage, 383
- Virus-like particle vaccines, 612
- Virus pathogenesis
  - immunogenetics of, 491–506
  - mouse genetics, 492
  - susceptibility loci, 504
- Virus-specific T-cell epitopes, 242
  - activation of, 244–245
- Visceral leishmaniasis (VL), 485, 599
- Vitamin D3, 61
- Vitamin D receptor (VDR), 332
- Vivax malaria
  - genetic resistance to, 375
  - pathogenesis of, 371
  - reticulocytes and, 371–372
  - severe, 374
- VL. See Visceral leishmaniasis
- VLR. See Variable lymphocytes receptor
- von Behring, Emil, 3
- VSG. See Variant surface glycoprotein
- VSV. See Vesicular stomatitis virus
- V to J rearrangements, 28
- VV. See Vaccinia virus
- VZV. See Vesicular stomatitis virus
- Warren, Robin, 337
- Warts, hypogammaglobulinemia, infections, and myelokathexis (WHIM), 475
- West Nile virus (WNV), 239, 406–407, 493, 602
  - susceptibility loci, 504
- WHIM. See Warts, hypogammaglobulinemia, infections, and myelokathexis
- Whole cell vaccines, 593
- Whole inactivated virus vaccines, 612
- Wnt-signaling pathway, 23
- Wright, Almroth, 4
- Wuchereria bancrofti, 146
- Xenophagy, 191
- Xenopus laevis, 50
- Xenopus tropicalis, 48, 50
- X-linked severe congenital neutropenia (XLN), 475
- X. See X-linked severe congenital neutropenia
- Yellow fever virus (YFV), 553
  - susceptibility loci, 504
- Yersinia enterocolitica, 159, 161
- Yersinia pestis, 271, 273, 280, 435
- Yersinia pseudotuberculosis, 330
- YFV. See Yellow fever virus
- YM-1, 318
- ZAP-70, 32