

Contributors vii

Preface xv

VOLUME 1

SECTION I:

General Virology

- 1** Virology: From Contagium Fluidum to Virome 1
Lynn W. Enquist and Vincent R. Racaniello
- 2** Principles of Virology 21
Richard C. Condit
- 3** Principles of Virus Structure 52
Stephen C. Harrison
- 4** Virus Entry and Uncoating 87
Ari Helenius
- 5** Viral Replication Strategies 105
Sean Whelan
- 6** Virus Assembly 127
Eric Hunter
- 7** Viruses, Cell Transformation, and Cancer 153
Daniel DiMaio and Hung Fan
- 8** Innate Responses to Viral Infections 189
Akiko Iwasaki and Ruslan Medzhitov
- 9** Adaptive Immune Response to Viral Infections 214
Thomas J. Braciale, Young S. Hahn, and Dennis R. Burton
- 10** Pathogenesis of Viral Infection 254
Mark T. Heise and Herbert W. Virgin
- 11** Virus Evolution 286
Edward C. Holmes
- 12** Epidemiology 314
Neal Nathanson and William J. Moss

13 Antiviral Agents 338

Donald M. Coen and Douglas D. Richman

14 Immunization Against Viral Diseases 374

Barney S. Graham, James E. Crowe, Jr., and Julie E. Ledgerwood

15 Diagnostic Virology 414

Gregory A. Storch and David Wang

SECTION II:

Specific Virus Families 453

Picornaviridae

16 *Picornaviridae*: The Viruses and Their Replication 453

Vincent R. Racaniello

17 Enteroviruses: Polioviruses, Coxsackieviruses, Echoviruses, and Newer Enteroviruses 490

Mark A. Pallansch, M. Steven Oberste, and J. Lindsay Whitton

18 Rhinoviruses 531

James E. Gern and Ann C. Palmenberg

19 Hepatitis A Virus 550

F. Blaine Hollinger and Annette Martin

Caliciviridae

20 *Caliciviridae*: The Noroviruses 582

Kim Y. Green

Astroviridae

21 Astroviruses 609

Ernesto Méndez and Carlos F. Arias

Togaviridae

22 *Togaviridae* 629

Richard J. Kuhn

23 Alphaviruses 651

Diane E. Griffin

- 24 Rubella Virus** 687
Tom C. Hobman

Flaviviridae

- 25 Flaviviridae** 712
Brett D. Lindenbach, Catherine L. Murray, Heinz-Jürgen Thiel, and Charles M. Rice

- 26 Flaviviruses** 747
Theodore C. Pierson and Michael S. Diamond

- 27 Hepatitis C Virus** 795
Stuart C. Ray, Justin R. Bailey, and David L. Thomas

Coronaviridae

- 28 Coronaviridae** 825
Paul S. Masters and Stanley Perlman

Arteriviridae

- 29 Arteriviruses** 859
Eric J. Snijder and Marjolein Kikkert

Order Mononegavirales

- 30 Mononegavirales** 880
Robert A. Lamb

Rhabdoviridae

- 31 Rhabdoviridae** 885
Douglas S. Lyles, Ivan V. Kuzmin, and Charles E. Rupprecht

Filoviridae

- 32 Filoviridae: Marburg and Ebola Viruses** 923
Heinz Feldmann, Anthony Sanchez, and Thomas W. Geisbert

Paramyxoviridae

- 33 Paramyxoviridae** 957
Robert A. Lamb and Griffith D. Parks

- 34 Parainfluenza Viruses** 996
Ruth A. Karron and Peter L. Collins

- 35 Mumps Virus** 1024
Steven A. Rubin, Christian J. Sauder, and Kathryn M. Carbone

- 36 Measles Virus** 1042
Diane E. Griffin

- 37 Henipaviruses** 1070
Lin-Fa Wang, John S. Mackenzie, and Christopher C. Broder

- 38 Respiratory Syncytial Virus and Metapneumovirus** 1086
Peter L. Collins and Ruth A. Karron

Bornaviridae

- 39 Bornaviridae** 1124
Christiane Herden, Thomas Briesse, W. Ian Lipkin, and Jürgen A. Richt

Orthomyxoviridae

- 40 Orthomyxoviridae** 1151
Megan L. Shaw and Peter Palese

- 41 Orthomyxoviruses** 1186
Peter F. Wright, Gabriele Neumann, and Yoshihiro Kawaoka

Bunyaviridae

- 42 Bunyaviridae** 1244
Richard M. Elliott and Connie S. Schmaljohn

VOLUME 2

Arenaviridae

- 43 Arenaviridae** 1283
Michael J. Buchmeier, Juan-Carlos de la Torre, and Clarence J. Peters

Reoviridae

- 44 Orthoreoviruses** 1304
Terence S. Dermody, John S. L. Parker, and Barbara Sherry

- 45 Rotaviruses** 1347
Mary K. Estes and Harry B. Greenberg

- 46 Orbiviruses** 1402
Polly Roy

Retroviridae

- 47** *Retroviridae* 1424
Stephen P. Goff

- 48** Human T-Cell Leukemia Virus Types 1 and 2 1474
Masahiro Fujii and Masao Matsuoka

- 49** Human Immunodeficiency Viruses: Replication 1502
Eric O. Freed and Malcolm A. Martin

- 50** HIV-1: Pathogenesis, Clinical Manifestations, and Treatment 1561
Daniel R. Kuritzkes and Richard A. Koup

- 51** Nonhuman Lentiviruses 1584
David T. Evans, John H. Elder, and Ronald C. Desrosiers

- 52** Foamy Viruses 1613
Axel Rethwilm and Dirk Lindemann

Polyomaviridae

- 53** Polyomaviruses 1633
James A. DeCaprio, Michael J. Imperiale, and Eugene O. Major

Papillomaviridae

- 54** Papillomaviruses 1662
Peter M. Howley, John T. Schiller and Douglas R. Lowy

Adenoviridae

- 55** *Adenoviridae* 1704
Arnold J. Berk

- 56** Adenoviruses 1732
William S.M. Wold and Michael G. Ison

Parvoviridae

- 57** *Parvoviridae* 1768
Kenneth I. Berns and Colin R. Parrish

Circoviridae

- 58** *Circoviridae* 1792
Xiang-Jin Meng

Herpesviridae

- 59** *Herpesviridae* 1802
Philip E. Pellett and Bernard Roizman

- 60** Herpes Simplex Viruses 1823
Bernard Roizman, David M. Knipe and Richard J. Whitley

- 61** Epstein-Barr Virus 1898
Richard M. Longnecker, Elliott Kieff and Jeffrey I. Cohen

- 62** Cytomegaloviruses 1960
Edward S. Mocarski, Jr, Thomas Shenk, Paul D. Griffiths, and Robert F. Pass

- 63** Varicella-Zoster Virus 2015
Ann M. Arvin and Don Gilden

- 64** Human Herpesviruses 6 and 7 2058
Koichi Yamanishi, Yasuko Mori, and Philip E. Pellett

- 65** Kaposi's A. Sarcoma-Associated Herpesvirus 2080
Blossom A. Damania and Ethel Cesarman

Poxviridae

- 66** *Poxviridae* 2129
Bernard Moss

- 67** Poxviruses 2160
Inger K. Damon

Hepadnaviridae

- 68** Hepadnaviruses 2185
Christoph Seeger, Fabien Zoulim, and William S. Mason

Genus Deltavirus

- 69** Hepatitis D (Delta) Virus 2222
John M. Taylor, Robert H. Purcell, and Patrizia Farci

Hepeviridae

- 70** Hepatitis E Virus 2242
Suzanne U. Emerson and Robert H. Purcell

Other Virus Groups

- 71** Mimivirus, Other Viruses Infecting Phagocytic Protists, and Their Virophages 2259
Philippe Colson and Didier Raoult

72	Plant Viruses	2289
	W. Allen Miller and Steven A. Whitham	
73	Insect Viruses	2326
	Paul D. Friesen	
74	Viruses and Prions of Yeasts, Fungi, and Unicellular Eukaryotes	2355
	Reed B. Wickner	
75	Bacteriophages	2384
	Roger W. Hendrix	
76	Prions	2418
	Stanley B. Prusiner	
77	Other Virus Groups	2459
	Philippe Colson and Didier Raoult	
78	Phagocytic Protists and Their Viriophages	2529
	Ruth A. A. and Peter J. Doolittle	
79	Miniviruses, Other Viruses Infecting	2569
	Philippe Colson and Didier Raoult	
80	Parainfluenza Viruses	2599
	Suzanne U. Emerson and Robert H. Purcell	
81	Paramyxoviruses	2629
	Robert G. Anderson and Robert A. Lamb	
82	Hepatitis E Virus	2659
	Suzanne U. Emerson and Robert H. Purcell	
83	Hepatitis D (Delta) Virus	2729
	John M. Taylor, Robert H. Purcell, and Robert A. Lamb	
84	Filoviridae	2759
	John M. Taylor, Robert H. Purcell, and Robert A. Lamb	
85	Rhabdoviridae	2819
	Christoph Seeger, Fabian Zoonen, and William S. Mason	
86	Hepadnaviridae	2889
	Christoph Seeger, Fabian Zoonen, and William S. Mason	
87	Poxviridae	2959
	Inger K. Damon	
88	Reoviridae	3029
	Robert G. Anderson and Robert A. Lamb	
89	Rotaviridae	3099
	Robert G. Anderson and Robert A. Lamb	
90	Coronaviridae	3169
	Koichi Yamamoto, Yasuko Mori, and Philip C. Follis	
91	Human Herpesviruses 6 and 7	3209
	Edward S. Mocarski, Jr. Thomas Shank, Paul D. Galloway, and Robert A. Lamb	
92	Varicella-Zoster Virus	3239
	Ann M. Arvin and Don Glidden	
93	Cytomegalovirus	3269
	Philip C. Follis, David S. Hirsch, and Robert A. Lamb	
94	Epstein-Barr Virus	3309
	Robert M. Anderson, Elton Kieff, and Robert A. Lamb	
95	Kaposi's A-Sarcoma-Associated Herpesvirus	3380
	Blossom A. Derman and Ethel Cesarman	
96	Arteriviridae	3419
	Blossom A. Derman and Ethel Cesarman	
97	Arteriviruses	3459
	Blossom A. Derman and Ethel Cesarman	
98	Order Mononegavirales	3509
	John A. Melnick	
99	Mononegavirales	3519
	John A. Melnick	

100	Human Immunodeficiency Viruses	3580
	Bar O. Freed and Malcolm A. Martin	
101	Human T-Cell Leukemia Virus Types 1 and 2	3601
	Bar O. Freed and Malcolm A. Martin	
102	Human T-Cell Leukemia Virus Type 3	3621
	Bar O. Freed and Malcolm A. Martin	
103	Human T-Cell Leukemia Virus Type 4	3641
	Bar O. Freed and Malcolm A. Martin	
104	Human T-Cell Leukemia Virus Type 5	3661
	Bar O. Freed and Malcolm A. Martin	
105	Human T-Cell Leukemia Virus Type 6	3681
	Bar O. Freed and Malcolm A. Martin	
106	Human T-Cell Leukemia Virus Type 7	3701
	Bar O. Freed and Malcolm A. Martin	
107	Human T-Cell Leukemia Virus Type 8	3721
	Bar O. Freed and Malcolm A. Martin	
108	Human T-Cell Leukemia Virus Type 9	3741
	Bar O. Freed and Malcolm A. Martin	
109	Human T-Cell Leukemia Virus Type 10	3761
	Bar O. Freed and Malcolm A. Martin	
110	Human T-Cell Leukemia Virus Type 11	3781
	Bar O. Freed and Malcolm A. Martin	
111	Human T-Cell Leukemia Virus Type 12	3801
	Bar O. Freed and Malcolm A. Martin	
112	Human T-Cell Leukemia Virus Type 13	3821
	Bar O. Freed and Malcolm A. Martin	
113	Human T-Cell Leukemia Virus Type 14	3841
	Bar O. Freed and Malcolm A. Martin	
114	Human T-Cell Leukemia Virus Type 15	3861
	Bar O. Freed and Malcolm A. Martin	
115	Human T-Cell Leukemia Virus Type 16	3881
	Bar O. Freed and Malcolm A. Martin	
116	Human T-Cell Leukemia Virus Type 17	3901
	Bar O. Freed and Malcolm A. Martin	
117	Human T-Cell Leukemia Virus Type 18	3921
	Bar O. Freed and Malcolm A. Martin	
118	Human T-Cell Leukemia Virus Type 19	3941
	Bar O. Freed and Malcolm A. Martin	
119	Human T-Cell Leukemia Virus Type 20	3961
	Bar O. Freed and Malcolm A. Martin	
120	Human T-Cell Leukemia Virus Type 21	3981
	Bar O. Freed and Malcolm A. Martin	
121	Human T-Cell Leukemia Virus Type 22	4001
	Bar O. Freed and Malcolm A. Martin	
122	Human T-Cell Leukemia Virus Type 23	4021
	Bar O. Freed and Malcolm A. Martin	
123	Human T-Cell Leukemia Virus Type 24	4041
	Bar O. Freed and Malcolm A. Martin	
124	Human T-Cell Leukemia Virus Type 25	4061
	Bar O. Freed and Malcolm A. Martin	
125	Human T-Cell Leukemia Virus Type 26	4081
	Bar O. Freed and Malcolm A. Martin	
126	Human T-Cell Leukemia Virus Type 27	4101
	Bar O. Freed and Malcolm A. Martin	
127	Human T-Cell Leukemia Virus Type 28	4121
	Bar O. Freed and Malcolm A. Martin	
128	Human T-Cell Leukemia Virus Type 29	4141
	Bar O. Freed and Malcolm A. Martin	
129	Human T-Cell Leukemia Virus Type 30	4161
	Bar O. Freed and Malcolm A. Martin	
130	Human T-Cell Leukemia Virus Type 31	4181
	Bar O. Freed and Malcolm A. Martin	
131	Human T-Cell Leukemia Virus Type 32	4201
	Bar O. Freed and Malcolm A. Martin	
132	Human T-Cell Leukemia Virus Type 33	4221
	Bar O. Freed and Malcolm A. Martin	
133	Human T-Cell Leukemia Virus Type 34	4241
	Bar O. Freed and Malcolm A. Martin	
134	Human T-Cell Leukemia Virus Type 35	4261
	Bar O. Freed and Malcolm A. Martin	
135	Human T-Cell Leukemia Virus Type 36	4281
	Bar O. Freed and Malcolm A. Martin	
136	Human T-Cell Leukemia Virus Type 37	4301
	Bar O. Freed and Malcolm A. Martin	
137	Human T-Cell Leukemia Virus Type 38	4321
	Bar O. Freed and Malcolm A. Martin	
138	Human T-Cell Leukemia Virus Type 39	4341
	Bar O. Freed and Malcolm A. Martin	
139	Human T-Cell Leukemia Virus Type 40	4361
	Bar O. Freed and Malcolm A. Martin	
140	Human T-Cell Leukemia Virus Type 41	4381
	Bar O. Freed and Malcolm A. Martin	
141	Human T-Cell Leukemia Virus Type 42	4401
	Bar O. Freed and Malcolm A. Martin	
142	Human T-Cell Leukemia Virus Type 43	4421
	Bar O. Freed and Malcolm A. Martin	
143	Human T-Cell Leukemia Virus Type 44	4441
	Bar O. Freed and Malcolm A. Martin	
144	Human T-Cell Leukemia Virus Type 45	4461
	Bar O. Freed and Malcolm A. Martin	
145	Human T-Cell Leukemia Virus Type 46	4481
	Bar O. Freed and Malcolm A. Martin	
146	Human T-Cell Leukemia Virus Type 47	4501
	Bar O. Freed and Malcolm A. Martin	
147	Human T-Cell Leukemia Virus Type 48	4521
	Bar O. Freed and Malcolm A. Martin	
148	Human T-Cell Leukemia Virus Type 49	4541
	Bar O. Freed and Malcolm A. Martin	
149	Human T-Cell Leukemia Virus Type 50	4561
	Bar O. Freed and Malcolm A. Martin	
150	Human T-Cell Leukemia Virus Type 51	4581
	Bar O. Freed and Malcolm A. Martin	
151	Human T-Cell Leukemia Virus Type 52	4601
	Bar O. Freed and Malcolm A. Martin	
152	Human T-Cell Leukemia Virus Type 53	4621
	Bar O. Freed and Malcolm A. Martin	
153	Human T-Cell Leukemia Virus Type 54	4641
	Bar O. Freed and Malcolm A. Martin	
154	Human T-Cell Leukemia Virus Type 55	4661
	Bar O. Freed and Malcolm A. Martin	
155	Human T-Cell Leukemia Virus Type 56	4681
	Bar O. Freed and Malcolm A. Martin	
156	Human T-Cell Leukemia Virus Type 57	4701
	Bar O. Freed and Malcolm A. Martin	
157	Human T-Cell Leukemia Virus Type 58	4721
	Bar O. Freed and Malcolm A. Martin	
158	Human T-Cell Leukemia Virus Type 59	4741
	Bar O. Freed and Malcolm A. Martin	
159	Human T-Cell Leukemia Virus Type 60	4761
	Bar O. Freed and Malcolm A. Martin	
160	Human T-Cell Leukemia Virus Type 61	4781
	Bar O. Freed and Malcolm A. Martin	
161	Human T-Cell Leukemia Virus Type 62	4801
	Bar O. Freed and Malcolm A. Martin	
162	Human T-Cell Leukemia Virus Type 63	4821
	Bar O. Freed and Malcolm A. Martin	
163	Human T-Cell Leukemia Virus Type 64	4841
	Bar O. Freed and Malcolm A. Martin	
164	Human T-Cell Leukemia Virus Type 65	4861
	Bar O. Freed and Malcolm A. Martin	
165	Human T-Cell Leukemia Virus Type 66	4881
	Bar O. Freed and Malcolm A. Martin	
166	Human T-Cell Leukemia Virus Type 67	4901
	Bar O. Freed and Malcolm A. Martin	
167	Human T-Cell Leukemia Virus Type 68	4921
	Bar O. Freed and Malcolm A. Martin	
168	Human T-Cell Leukemia Virus Type 69	4941
	Bar O. Freed and Malcolm A. Martin	
169	Human T-Cell Leukemia Virus Type 70	4961
	Bar O. Freed and Malcolm A. Martin	
170	Human T-Cell Leukemia Virus Type 71	4981
	Bar O. Freed and Malcolm A. Martin	
171	Human T-Cell Leukemia Virus Type 72	5001
	Bar O. Freed and Malcolm A. Martin	
172	Human T-Cell Leukemia Virus Type 73	5021
	Bar O. Freed and Malcolm A. Martin	
173	Human T-Cell Leukemia Virus Type 74	5041
	Bar O. Freed and Malcolm A. Martin	
174	Human T-Cell Leukemia Virus Type 75	5061
	Bar O. Freed and Malcolm A. Martin	
175	Human T-Cell Leukemia Virus Type 76	5081
	Bar O. Freed and Malcolm A. Martin	
176	Human T-Cell Leukemia Virus Type 77	5101
	Bar O. Freed and Malcolm A. Martin	
177	Human T-Cell Leukemia Virus Type 78	5121
	Bar O. Freed and Malcolm A. Martin	
178	Human T-Cell Leukemia Virus Type 79	5141
	Bar O. Freed and Malcolm A. Martin	
179	Human T-Cell Leukemia Virus Type 80	5161
	Bar O. Freed and Malcolm A. Martin	
180	Human T-Cell Leukemia Virus Type 81	5181
	Bar O. Freed and Malcolm A. Martin	
181	Human T-Cell Leukemia Virus Type 82	5201
	Bar O. Freed and Malcolm A. Martin	
182	Human T-Cell Leukemia Virus Type 83	5221
	Bar O. Freed and Malcolm A. Martin	
183	Human T-Cell Leukemia Virus Type 84	5241
	Bar O. Freed and Malcolm A. Martin	
184	Human T-Cell Leukemia Virus Type 85	5261
	Bar O. Freed and Malcolm A. Martin	
185	Human T-Cell Leukemia Virus Type 86	5281
	Bar O. Freed and Malcolm A. Martin	
186	Human T-Cell Leukemia Virus Type 87	5301
	Bar O. Freed and Malcolm A. Martin	
187	Human T-Cell Leukemia Virus Type 88	5321
	Bar O. Freed and Malcolm A. Martin	
188	Human T-Cell Leukemia Virus Type 89	5341
	Bar O. Freed and Malcolm A. Martin	
189	Human T-Cell Leukemia Virus Type 90	5361
	Bar O. Freed and Malcolm A. Martin	
190	Human T-Cell Leukemia Virus Type 91	5381
	Bar O. Freed and Malcolm A. Martin	
191	Human T-Cell Leukemia Virus Type 92	5401
	Bar O. Freed and Malcolm A. Martin	
192	Human T-Cell Leukemia Virus Type 93	5421
	Bar O. Freed and Malcolm A. Martin	
193	Human T-Cell Leukemia Virus Type 94	5441
	Bar O. Freed and Malcolm A. Martin	
194	Human T-Cell Leukemia Virus Type 95	5461
	Bar O. Freed and Malcolm A. Martin	
195	Human T-Cell Leukemia Virus Type 96	5481
	Bar O. Freed and Malcolm A. Martin	
196	Human T-Cell Leukemia Virus Type 97	5501
	Bar O. Freed and Malcolm A. Martin	
197	Human T-Cell Leukemia Virus Type 98	5521
	Bar O. Freed and Malcolm A. Martin	
198	Human T-Cell Leukemia Virus Type 99	5541
	Bar O. Freed and Malcolm A. Martin	
199	Human T-Cell Leukemia Virus Type 100	5561
	Bar O. Freed and Malcolm A. Martin	