

The Viruses

CATALOGUE, CHARACTERIZATION
AND CLASSIFICATION

HEINZ FRAENKEL-CONRAT

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HEINZ FRAENKEL-CONRAT

*Department of Molecular Biology and Virus Laboratories
University of California
Berkeley, California*

PLENUM PRESS • NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

Fraenkel-Conrat, Heinz, 1910-

The viruses: catalogue, characterization, and classification.

Includes bibliographies and index.

1. Viruses. I. Title. [DNLM: 1. Viruses. QW 160 F799va]

QR360:F715 1985

576'.64

84-26649

ISBN 0-306-41766-9

©1985 Plenum Press, New York
A Division of Plenum Publishing Corporation
233 Spring Street, New York, N.Y. 10013

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Printed in the United States of America

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AND CLASSIFICATION

THE VIRUSES

Series Editors

HEINZ FRAENKEL-CONRAT, *University of California*
Berkeley, California

ROBERT R. WAGNER, *University of Virginia School of Medicine*
Charlottesville, Virginia

THE VIRUSES: Catalogue, Characterization, and Classification
Heinz Fraenkel-Conrat

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Preface

During the past two decades, virus taxonomy has advanced to the point where most viruses can be classified as belonging to families, genera, or groups of related viruses. Virus classification is primarily based on chemical and physical similarities, such as the size and shape of the virion, the nature of the genomic nucleic acid, the number and function of component proteins, the presence of lipids and of additional structural features, such as envelopes, and serological interrelationships. The families, genera, or groups of viruses that have been defined on the basis of such criteria by the International Committee on Taxonomy of Viruses (ICTV) will be described in some detail in this catalogue and illustrated by electron micrographs. In my present attempt to list most if not all well established and studied viruses in alphabetical order, I have largely confined myself to identifying them only in such taxonomic terms, generally without quoting specific data reported for individual viruses. If the latter data do not at times agree closely with those given for the taxon or group, it is difficult to decide to what extent this is attributable to misclassification due to insufficient data and errors in the analytical procedures and descriptions, or to what extent this is an expression of Nature's freedom of choice and abhorrence of restrictive classifications.

The classification of the animal viruses, including protozoa, that is dealt with in Section I of this book uses families (presently 19, named with the ending -viridae), subfamilies for three of these (ending in -virinae), and genera; species have in most cases not yet been officially identified. The taxonomic significance of terms such as *strains*, *mutants*, and (*sero*)*types* is not clearly established. Only those of the latter that have been studied in detail are listed.

Most plant viruses are only classified in terms of groups, with many viruses remaining uncertain in terms of classification or identification as separate viruses, rather than strains. The plant viruses, including those of protophyta, are dealt with in Section II. However, it must be noted that

the separate listing of plant and animal viruses is frequently arbitrary, since many plant viruses replicate in their insect (or other) vector. Those that are pathogenic in their plant host will be listed as plant viruses.

Family names have been coined and officially adopted for many of the bacterial and blue-green algal viruses, but no further classification has been generally accepted. Most of these viruses are identified only by letters or numbers, or by the host from which they were isolated, the same "names," i.e., identifying letters and/or numbers, frequently recurring in unrelated phages. Also many phage isolates with different "names" may actually be identical. Thus, it is questionable whether an attempt to list the phages in alphabetical order is worthwhile. Section III covers mostly bacteriophages that have been studied and used repeatedly and in more than one laboratory. To the extent possible, these are identified in terms of their family status, recognizing that that classification scheme is less advanced than that of the animal viruses.

The (deoxy) nucleotide and amino acid sequences of very many virus components have been and continue to be currently established. Thus the references to known sequences in this catalogue are incomplete. Such sequences are now known, at least in part, for most of the important viruses.

The number of citations that would be required to support the description of each virus would at least triple the size of this book. The use of a single "key" reference for each virus appears arbitrary and not always helpful. I therefore reference mainly the virus families and groups and, whenever possible, quote review chapters and occasionally recent papers to assist the reader in further searches. Also helpful are *Classification and Nomenclature of Viruses*, the Fourth Report of the International Committee on Taxonomy of Viruses (R. E. F. Matthews, Intervirology 17:1-3, 1982), *Virology Abstracts* (Cambridge Scientific Abstracts), the cumulative indexes of *Virology*, the *Journal of Virology*, and the *Journal of General Virology*, the recent textbook *Virology* (H. Fraenkel-Conrat and P. C. Kimball, Prentice-Hall, Englewood Cliffs, New Jersey, 1982), and the monograph *Plant Virology*, Second Edition (R. E. F. Matthews, Academic Press, New York, 1981). Most plant viruses are described in detail in the CMI/AAB *Description of Plant Viruses* series of pamphlets, edited by A. F. Murant and B. D. Harrison. Obviously, other volumes of this series (*The Viruses*), as they appear, will represent the most up-to-date source of information on each virus family or group. Currently available or in preparation are books on the herpesviruses (four volumes), the Reoviridae, the parvoviruses, the adenoviruses, etc.

Most virus families or groups of characteristic shapes are illustrated by electron micrographs. I am greatly indebted to Dr. R. C. Williams for Figures 1-12, 14-17, 19-25, 32, 34-36, and 42. Figure 13 was kindly supplied by Dr. D. W. Verwoerd, Figure 18, by Dr. E. M. J. Jaspars, Figure 40 by Dr. M. Salas, and the others by Dr. H.-W. Ackermann.

Contents

Section I.	Animal Viruses, Including Protozoal Viruses	1
	References	95
Section II.	Plant Viruses, Including Protophytal Viruses	107
	References	163
Section III.	Phages of Prokaryotes (Bacteria and Cyanobacteria) ..	171
	References	219
	Figures	223

SECTION I

Animal Viruses, Including
Protozoal Viruses

Virus	Group or subgroup	Genus	Subfamily or family
Abadina (transmitted by <i>Culicoides</i>)	Palyam	orbivirus	Reoviridae
Abelson's murine leukemia ⁽¹⁾ ; see oncoviruses			
Abras	probably Patois	bunyavirus	Bunyaviridae
<i>Abraxas grossularia</i>	type 8	cypovirus	Reoviridae
Abu Hammad	Dera Ghazi Khan	nairovirus	Bunyaviridae
Abu Mina	Dera Ghazi Khan	nairovirus	Bunyaviridae
Acado (mosquito transmitted)	Corriparta	orbivirus	Reoviridae
Acara	Capim	bunyavirus	Bunyaviridae
Acelaphine herpes h1: see malignant cattarrhal fever of wildebeest			
Acelaphine herpes h2: see hartebeest herpes virus			
<i>Acheta</i>		probably densovirus	Parvoviridae
<i>Acrobasis zelleri</i> (<i>Lepidoptera</i>)		B	Entomopoxvirinae
<i>Actias selene</i>	type 4	cypovirus	Reoviridae
Acute bee paralysis: see bee acute paralysis			
Acute hemorrhagic conjunctivitis (EV serotype 70; also 69, 71)		enterovirus	Picornaviridae
Acute infectious lymphocytosis (see EVU-16) ⁽²⁾			
Acute laryngotracheobronchitis	type 2	parainfluenza	Paramyxoviridae
Adenoassociated ⁽³⁾ : synonym for dependovirus			Parvoviridae

Virus	Group or subgroup	Genus	Subfamily or family
ADENOVIRIDAE⁽⁴⁾. A very uniform family of icosahedral nonenveloped virions of about 80 nm diameter composed of 252 capsomers, buoyant density in CsCl 1.34 g/cm³. The 12 vertex capsomers (pentons) carry strain-characteristic glycoprotein fibers (10–30-nm long) with knobs at the ends; the rest is made up of hexons. The genome is linear double-stranded DNA of 20–25 × 10⁶ daltons in the mammalian and 28–30 × 10⁶ daltons in the avian viruses. At least ten proteins of 5–120 × 10³ daltons make up the virion. Each adenovirus has a narrow host range. Several are oncogenic in newborn nonhosts. Serological relations among the many different adenoviruses usually called "types" are very limited. Two genera have been defined (MASTADENOVIRUS and AVIADENOVIRUS; subgroups A–D or I–IV), and species names for those found in various animals have been proposed with hl–h34 for the (sero)types of the human virus species. Similar differentiation of serotypes are used for the animal adenoviruses (27 simian, ten bovine, eight avian, four porcine, two canine, and one ovine and opossum in 1979). Adenoviruses generally cause only light upper respiratory diseases (Figure 1).			
<i>Adoxophyes orana</i> ⁽⁵⁾	nuclear polyhedrosis virus (A)		Baculoviridae
<i>Aedes</i>			Togaviridae
<i>Aedes aegypti</i>		probably denguevirus	Parvoviridae
<i>Aedes aegypti</i> (Diptera)		C	Entomopoxvirinae
<i>Aedes cantans</i>		probably chikungundovirus	Iridoviridae
<i>Aedes iridescent</i> : see mosquito iridescent virus			
Aerocystis agent: see swim bladder inflammation agent of carp			
African green monkey cytomegalo (AGM-CMV)	cercopithecine	(h5) cytomegalovirus	Betaherpesvirinae
African green monkey EBV-like (AGM-EBV)	cercopithecine	(h14) lymphocryptovirus	Gammaparvovirinae

African horse sickness (vector <i>Culicoides</i> spp.)	9 serotype	orbivirus	Reoviridae
African swine fever ⁽⁶⁾	possibly genus of Iridoviridae (only five proteins)		
AG 80-24	probably Anopheles A	bunyavirus	Bunyaviridae
<i>Agrophylla lutenta</i>	type 10	cypovirus	Reoviridae
<i>Agrotis segetum</i>	type 9	cypovirus	Reoviridae
Aguacate		phlebovirus	Bunyaviridae
AIDS (acquired immune deficiency syndrome): see Human T-cell leukemia virus			
Aino	Simbu	bunyavirus	Bunyaviridae
Akabane	Simbu (RNA: 31 S, 26 S, 13 S)	bunyavirus	Bunyaviridae
AKR: see oncovirus			
AKv (mouse): see oncovirus			
Alajeula	probably Gamboa	bunyavirus	Bunyaviridae
Alastrim	identical to variola minor	orthopoxvirus	Chordopoxvirinae
Aleuquer		phlebovirus	Bunyaviridae
Aleutian disease of mink ⁽⁷⁾	(nontypical proteins), (causes immune- complex disease)		possibly Parvoviridae

Virus	Group or subgroup	Genus	Subfamily or family
Alfuy (mosquito-borne)		flavivirus	Togaviridae
Allerton: see bovine ulcerative mammillitis			
Alpha: genus of Togaviridae ⁽⁸⁾ (type species: Sindbis virus)			
Alphaherpesvirinae ⁽⁹⁾ : subfamily of Herpesviridae; rapidly growing, highly cytolytic			
Amapari	Tacaribe complex		Arenaviridae
Amphibian cytoplasmic		ranavirus	Iridoviridae
<i>Amsacta moorei</i> (Lepidoptera)	type species	B	Entomopoxvirinae
<i>ana</i> 1 (<i>Anas domestica</i> , duck)		aviadenovirus	Adenoviridae
Ananindena	Guama	bunyavirus	Bunyaviridae
Anatid herpes, hl: see duck plaque herpesvirus			
Anhanga		phlebovirus	Bunyaviridae
Anhembí	Bunyamwera	bunyavirus	Bunyaviridae
<i>Anomala cuprea</i> (Coleoptera)		A	Entomopoxvirinae
Anopheles A	type species of subgroup	bunyavirus	Bunyaviridae
Anopheles B	type species of subgroup	bunyavirus	Bunyaviridae
<i>ans</i> 1 (<i>Anser domesticus</i> , goose)		aviadenovirus	Adenoviridae
<i>Antheraea eucalypti</i>	Nudaurelia β group		

Aotine h1, 2, 3: see herpes aotusviruses				
Aotine h4: see owl monkey cytomegalovirus				
<i>Apanteles melanoscelus</i> (wasp)	probably (double-stranded circular DNA of $2-25 \times 10^6$ daltons) (D)			Baculoviridae
Apeu		C	bunyavirus	Bunyaviridae
Aphid viruses ¹⁰ (<i>Rhopalosiphum padi</i>)	27 nm diameter (162 S), buoyant density CsCl 1.37 g/cm ³ , ss RNA (31 S)			possibly Nodaviridae
<i>Aphodius tasmaniae</i> (Coleoptera)		A		Entomopoxvirinae
Aphtho ⁽¹¹⁾ : genus of Picornaviridae (type species: foot and mouth disease virus, aphthovirus D)				
Apoe			flavivirus	Togaviridae
<i>Aporophylla lutulenta</i>	type species of type 10		cypovirus	Reoviridae
Arbo: obsolete term for many arthropod-borne toga etc. viruses				
ARENNAVIRIDAE ⁽¹²⁾ : Enveloped pleomorphic though predominantly round virions of 100–200 nm diameter and 325–580 S, 1.2 g/cm ³ density in sucrose, consisting of a core containing ribosome-like particles (arena = sand) and a lipid bilayer envelope with surface projections. Two viral minus-stranded RNAs of about 1.1 and 2.7×10^6 daltons and smaller ribosomal etc. RNAs are present. The nucleocapsid protein is about 63×10^6 daltons, about two glycoproteins are somewhat smaller. The host range of each arenavirus is narrow. Members of the family show more or less close serological relationships. The type species is lymphocytic choriomeningitis virus (LMC), others the Lassa and Mozambique viruses and the American Tacaribe complex with many members. Several are pathogenic to man and young rodents, and LMC generally persistent. Transmission is vertical and horizontal, often venereal (Figure 2).				

Virus	Group or subgroup	Genus	Subfamily or family
Argentina: Strain of vesicular stomatitis virus, closely related to coccal virus			
Arkansas bee ⁽¹³⁾	(41×10^3 dalton protein, yet probably nodavirus)		Nodaviridae
Arumowot		phlebovirus	Bunyaviridae
Asia-1		aphthovirus	Picornaviridae
Astro ⁽¹⁴⁾	unclassified 28 nm isometric particles consisting of two proteins of 33×10^3 daltons, and 2.8×10^6 dalton RNA carrying 3' terminal poly(A)		
Ateline herpes 1: see spider monkey cytomegalovirus			
Ateline herpes 2, 3: see herpes ateles virus			
ATS-124: see oncovirus			
Aura (related to western equine encephalitis virus)		alphavirus	Togaviridae
Aus MK 6357 (transmitted by mosquitoes)		orbivirus	Reoviridae
Australian antigen: circulating hepatitis B virus protein aggregate			
<i>Autographa californica</i> ⁽¹⁵⁾ (wide host range pesticide)	nuclear polyhedrosis virus (A)		Baculoviridae
Avalon	Sakhalin	nairovirus	Bunyaviridae
Aviadenoviruses: genus of Adenoviridae (of fowl, goose, duck, pheasant)			
Avian adenoviruses: see aviadenoviruses			

Avian C-type: see oncovirus

Avian dependoviruses: *see* adenoassociated viruses

Avian encephalomyelitis

probably cardiovirus
Picornaviridae

Picornaviridae

Avian erythroblastosis: *see* oncovirus

Avian herpes: see Marek's disease

Avian herpes, h1 herpesviruses: Anatid (duck), ciconid (stork), columbid (pigeon), gruid (crane), meleagrid (turkey), perdid (quail), phalacrocoracid (cormorant), psittacid (parrot), strigid (owl); all as far as known Alphaherpesvirinae.

Avian infectious bronchitis (IBV)⁽¹¹⁶⁾

Coronaviridae

Arian influenza A

orthomyxovirus

Orthomyxoviridae

Avian leukemia: see oncovirus

Avian leukosis: see oncovirus

Avian myeloblastosis (AMV) and myeloblastosis-associated: see oncovirus

Avian myelocytomatosis (MC 29): see oncovirus

Avian osteopetrosis: see oncovirus

Avian reticuloendotheliosis: *see* oncovirus

Avian sarcoma⁽¹⁷⁾: see oncovirus

Avipox⁽¹⁸⁾: subgroup of Chordopoxvirinae (type species: fowlpox virus)

B (monkey herpes) (h1)

simplexvirus

Alphaherpesvirinae

B 19 (pathogenic in children)

parvovirus

Parvoviridae