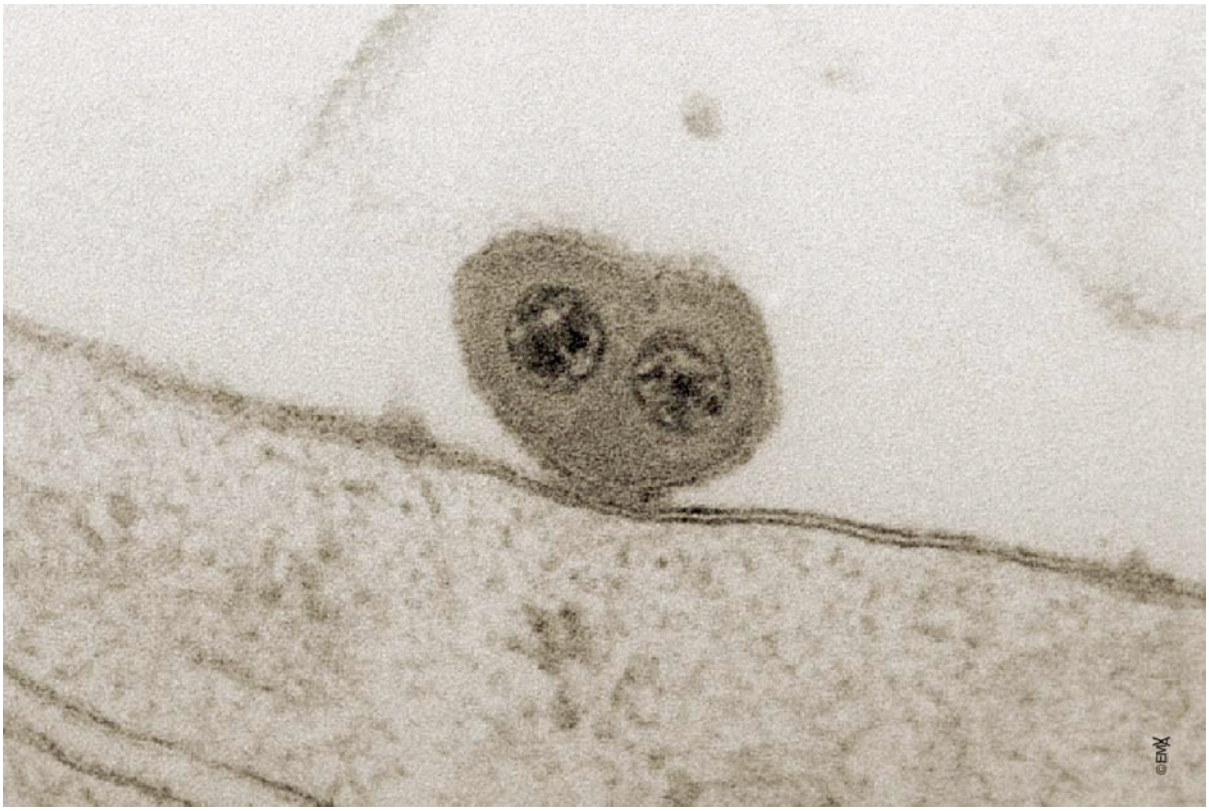
F A M I L Y A L B U M

OF VIRUSES



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Dear reader

with this script we like to make viruses visible for your eyes. Under normal circumstances you just get in contact with these small and tiny creatures when they are hidden in fluids, cells or bodies. Sometimes you don't even think about them. But they are there; often; and with a hidden beauty....

Viruses (from the latin "virus", meaning "poison") straddle the definition of life. They lie somewhere between supra molecular complexes and very simple biological entities. Viruses contain some of the structures and exhibit some of the activities that are common to organic life, but they are missing many of the others. In general, viruses are entirely composed of a single strand of genetic information encased within a protein capsule. Viruses lack most of the internal structure and machinery which characterize "life", including the biosynthetic machinery that is necessary for reproduction. In order for a virus to replicate it must infect a suitable host cell.

Viruses exist in two distinct states. When not in contact with a host cell, the virus remains entirely dormant. During this time there are no internal biological activities occuring with the virus and in essence the virus is no more than a static organic particle. In this simple, clearly non-living state viruses are referred to as "virions". Virions can remain in this dormant state for extended periods of time, waiting patiently to come into contact with the appropriated host. When the virion comes into contact with the appropriated host, it becomes active and is then reffered to as a virus. It now displays properties typified by living organisms, such as reacting to its environment and directing its effords toward self-replication.

We tried to include in this accumulation all important viruses, which are pathogene for vertebrates, but it is not yet completed. The introduced viruses are sorted in RNA and DNA viruses followed by the families in alphabetic order.

There are plenty of other viruses from plant, algae, fungi, bacteria and mycoplasma from which we show you just some examples under "special viruses".

With the method of electron microscopy it's possible to unveil the secret world of viruses. If you like to know more about the electron microscopy please have a look at www.em-va.unizh.ch

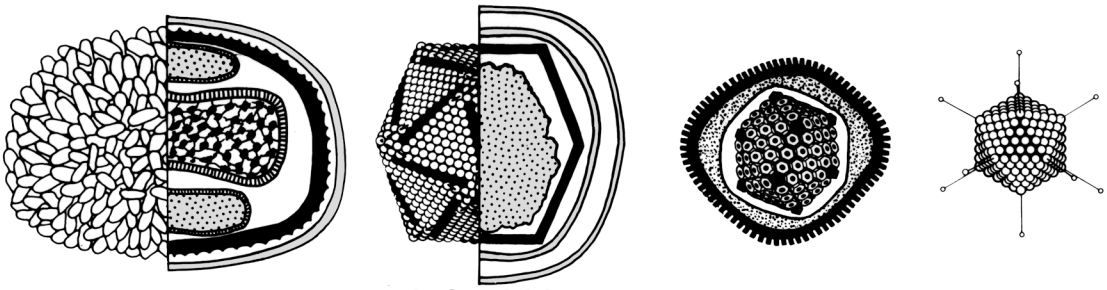
Now please enjoy the collected pictures and get a closer look.....

If you like to know more about viruses we recommend following webpages:
http://www.virology.net/Big_Virology/BVHomePage.html
http://www.ncbi.nlm.nih.gov/ICTVdb/Images/index.htm
or the reference book *Fields Virology*, Fourth Edition by Bernard N. Fields, et al.
Lippincott Williams & Wilkins, Philadelphia / PA, U.S.A.: ISBN: 0-7817-1832-5

Introduced Virus Families

Families	Strang form	Polarität	Segmente	Structure	Hülle	Size nm Approx.
DNA Viruses						
Adenoviridae	ds			I	-	70- 90
African Swine Fever	ds			Kompl.	+	200-250
Circoviridae	ss			I	-	17- 22
Hepadnaviridae	ds(RT)			I	+	40- 48
Herpesviridae	ds			I	+	150-200
Iridoviridae	ds			I	-/+	125-300
Papillomaviridae	ds			I	-	45- 55
Parvoviridae	ss/ds			I	-	18- 22
Poxviridae	ds			Kompl.	+	120x300
RNA Viruses						
Arenaviridae	ss	-	2	H	+	50-300
Arteriviridae	ss	+		I	+	60
Astroviridae	ss	+		I	-	28- 30
Birnaviridae	ds		2	I	-	60
Bunyaviridae	ss	-	3	H	+	90-120
Caliciviridae	ss	+		I	-	35- 40
Coronaviridae	ss	+		H	+	60-160
Filoviridae	ss	-		H	+	80
Flaviviridae	ss	+		H	+	40- 60
Orthomyxoviridae	ss	-	7-8	H	+	80-120
Paramyxoviridae	ss	-		H	+	120-150
Picornaviridae	ss	+		I	-	25- 30
Reoviridae	ds	+/-	10-12	I	-	60- 80
Retroviridae	Dimer	+		I	+	80-120
Rhabdoviridae	ss	-		H	+	70x180
Togaviridae	ss	+		I	+	50- 70
Specials						
Mimivirus	ds	+/-		I	-	400
Ampullaviridae	ds	+/-		Kompl.		230x 75
T4-like Bacteriophages	ds	+/-	circulär	Kompl.		50-110x400

DNA VIRUSES



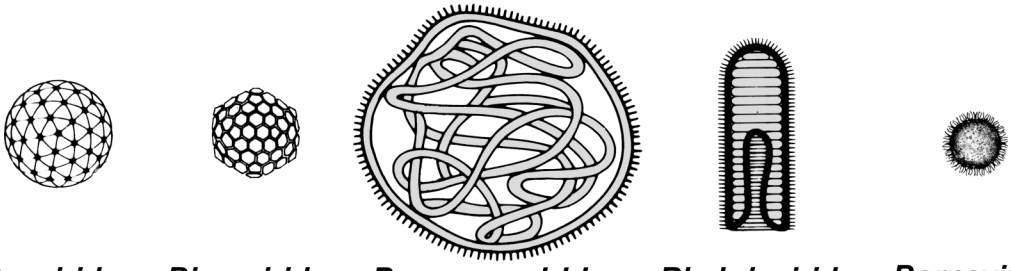
Poxviridae *Asfarviridae* *Herpesviridae* *Adenoviridae*

Papovaviridae *Parvoviridae* *Circoviridae*

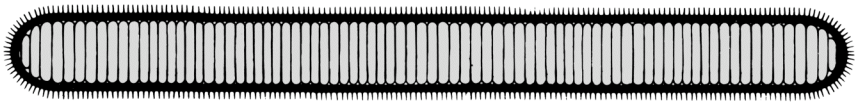
REVERSE-TRANSCRIBING VIRUSES

Hepadnaviridae *Retroviridae*

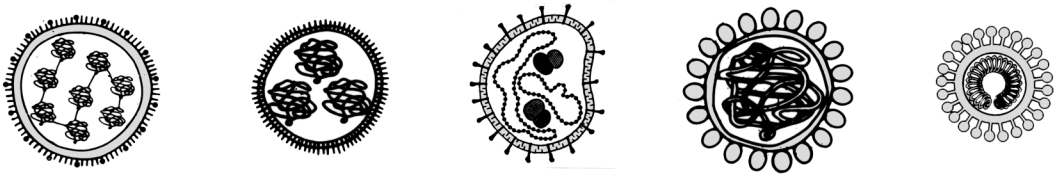
RNA VIRUSES



Reoviridae *Birnaviridae* *Paramyxoviridae* *Rhabdoviridae* *Bornaviridae*



Filoviridae

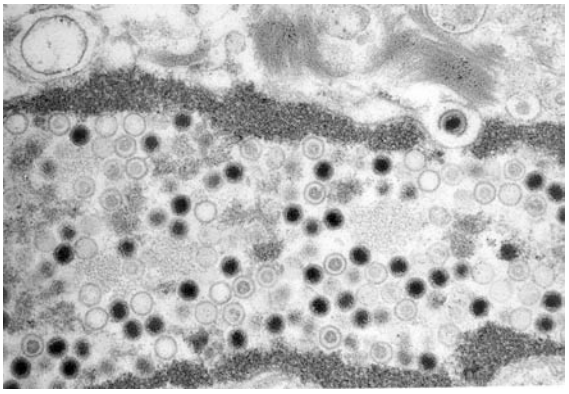


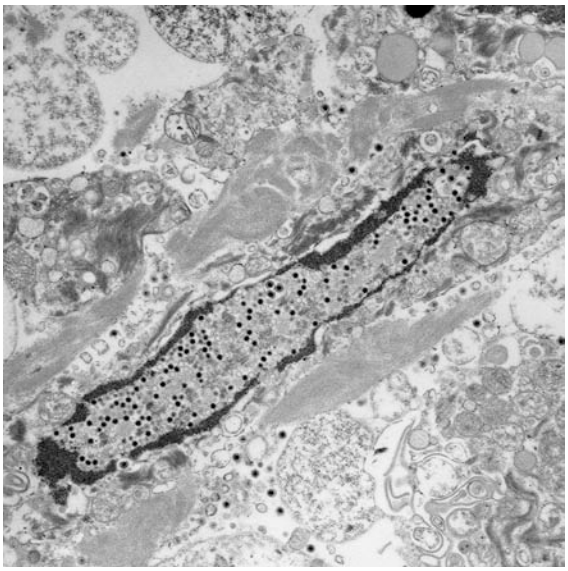
Orthomyxoviridae *Bunyaviridae* *Arenaviridae* *(Coronavirus)* *(Torovirus)*
Coronaviridae

Arteriviridae *Picornaviridae* *Caliciviridae* *Astroviridae* *Togaviridae* *Flaviviridae*

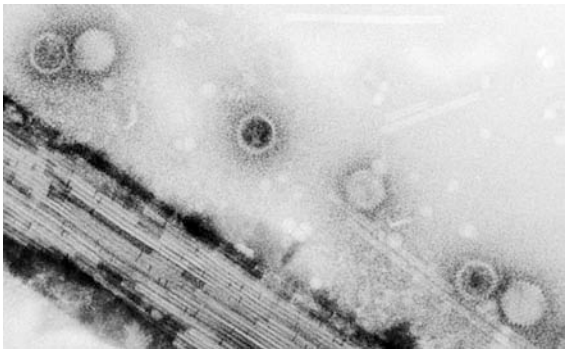
DNA VIRUSES

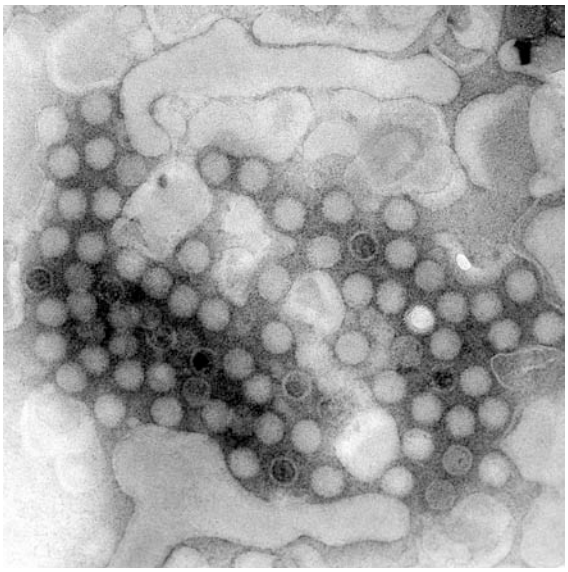
ADENOVIRIDAE





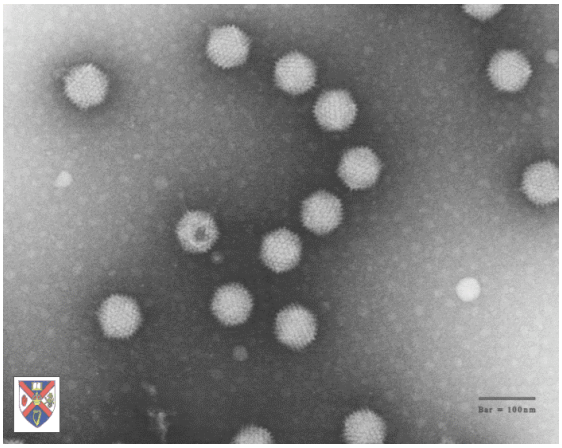
Adenoviruses
All the pictures on this page are made by the electron-microscopy department / University of Zurich, Mrs. E. Schraner.
For more details about electron-microscopy please visit http://www.em-va.unizh.ch



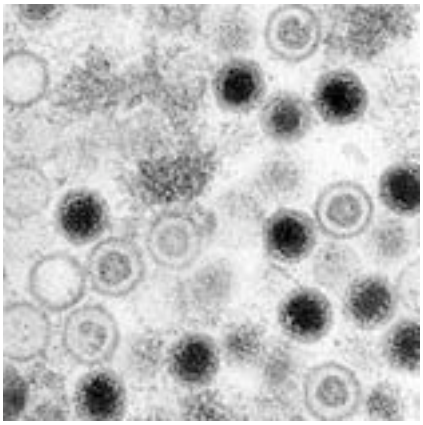


DNA VIRUSES

ADENOVIRIDAE

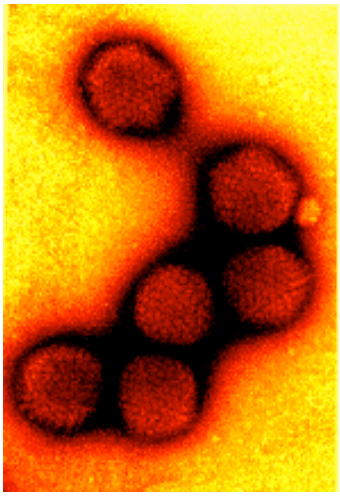


Animal Adenovirus

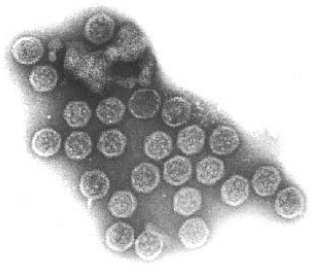


Ultrathin section of a cell nucleus with adenoviruses in different stages. The diameter of an adenovirus is 70 – 90nm / Electron Microscopy – University of Zurich

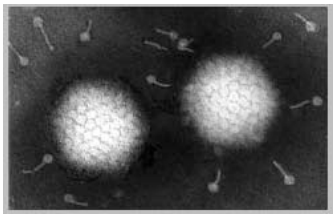
Adenoviruses
Adenoviruses are non-enveloped icosahedral particles. The capsid is built from 252 capsomers (*T*=25), of which 240 are hexavalent and 12 (situated at the apices) are pentavalent



electron micrographs

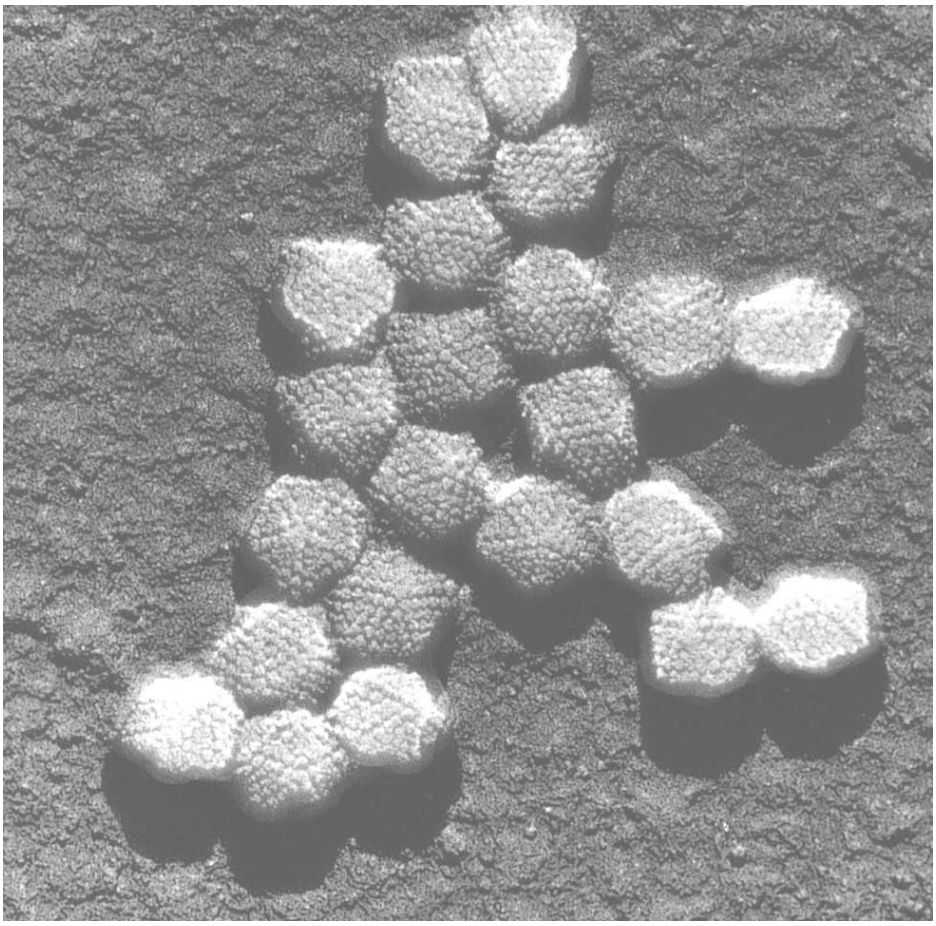


Two adenoviruses: the penton fibres consist of a slender shaft with a globular head. They are involved in the process of attachement of the virus particle to the host cell.

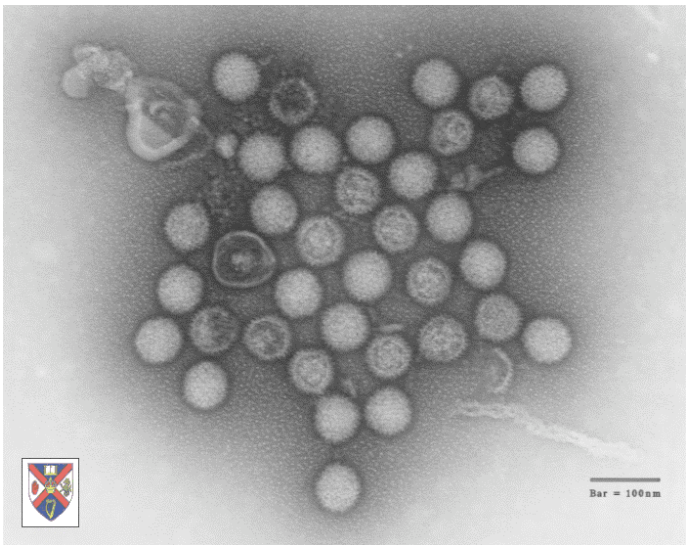


DNA VIRUSES

ADENOVIRIDAE



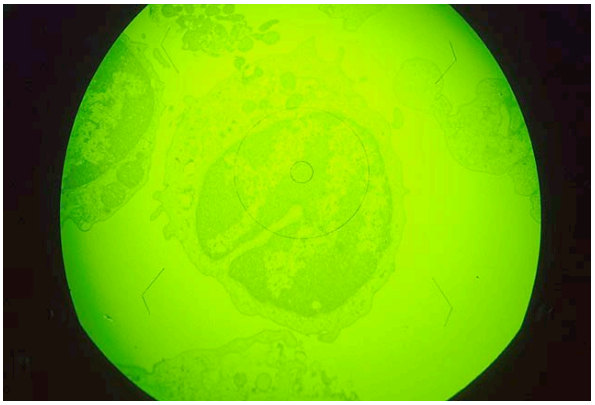
Avian Adenovirus
The sample was freeze-dried and shadowed with Pt/C.



Egg Drop Syndrome Virus

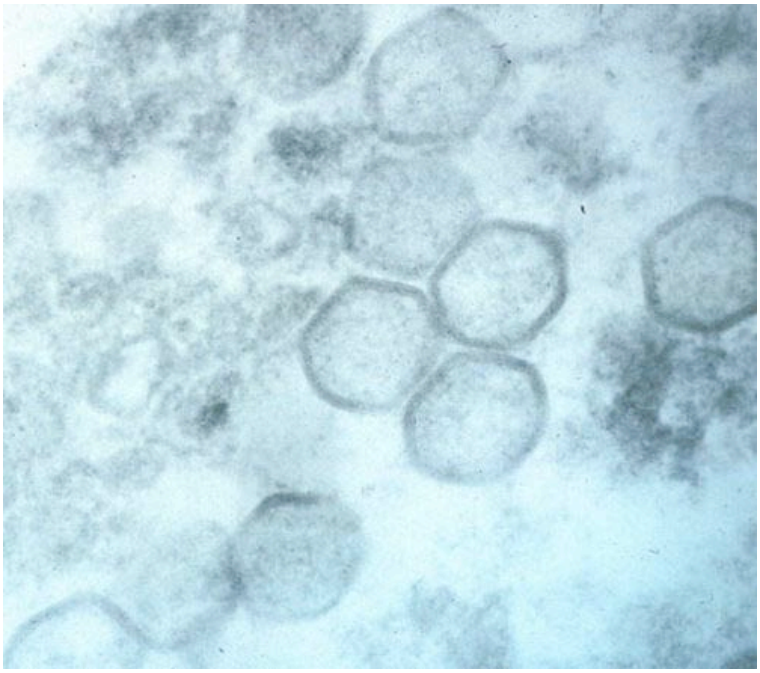
DNA VIRUSES

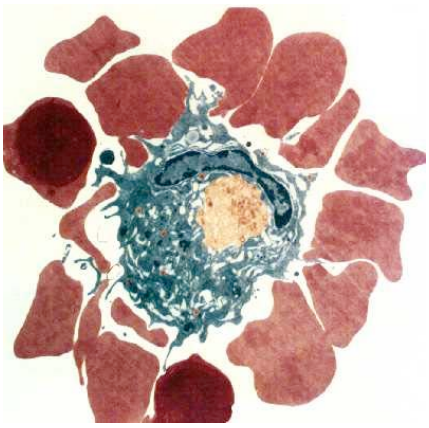
AFRICAN SWINE FEVER



Macrophage cell in early stages of infection with African swine fever virus

Electron-microscope image of hexagonal shaped **ASF Virus**



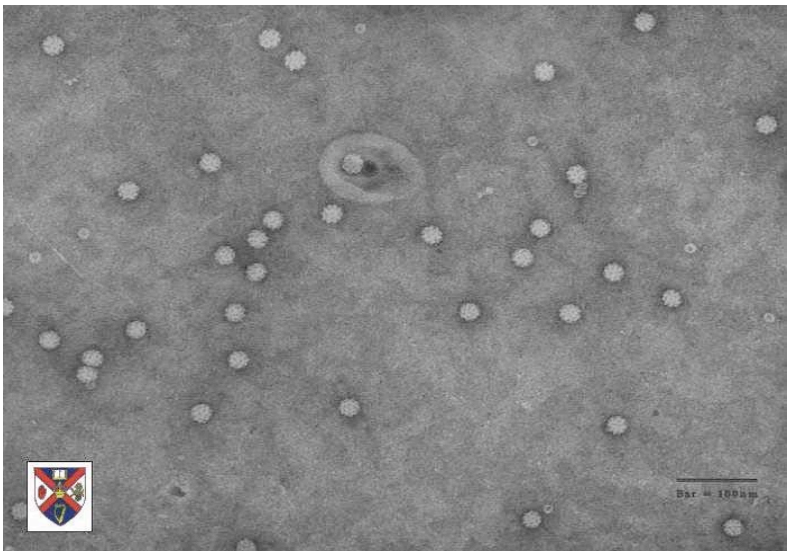


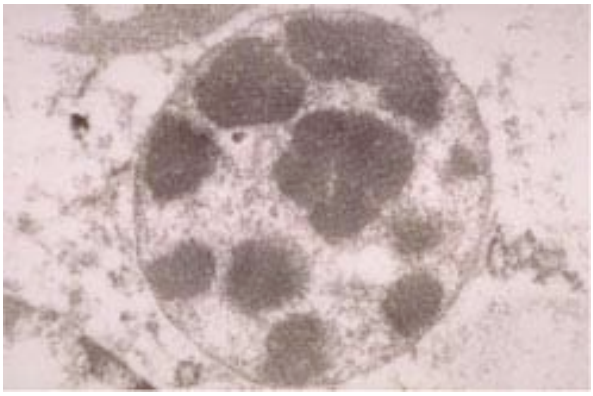
African swine fever virus (yellow) is within the macrophage (blue).
Surrounding the macrophage are red blood cells that have been attracted to the cell and have adhered to it, creating a camouflaging layer.

DNA VIRUSES

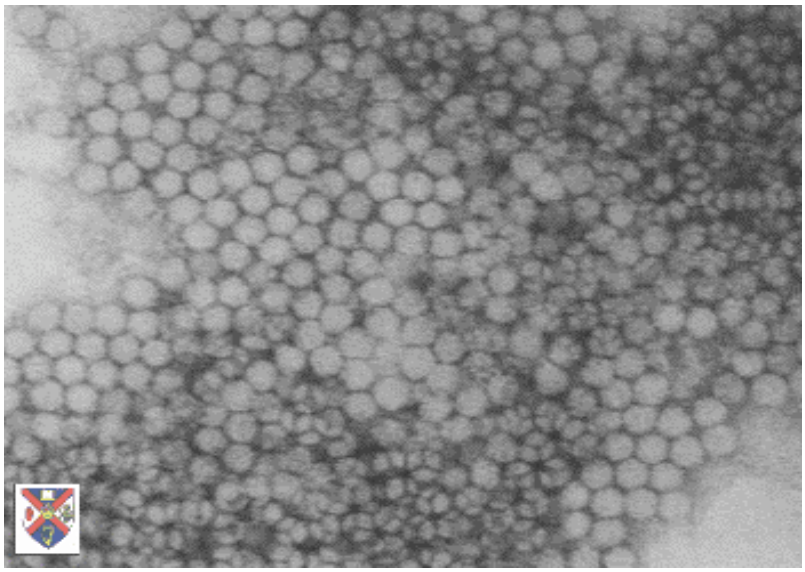
CIRCOVIRIDAE

Chicken Anaemia Virus (Gyrovirus)





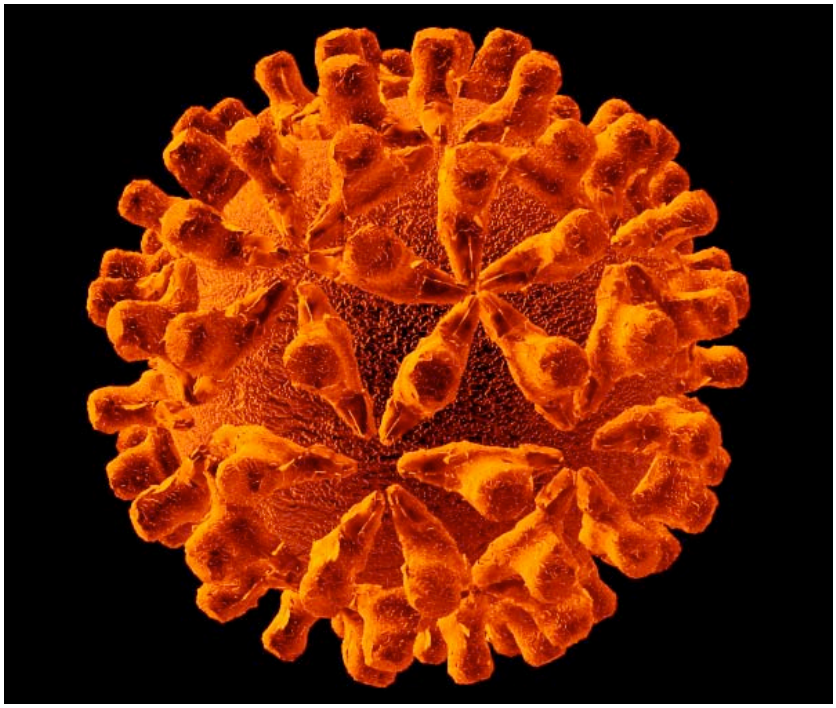
EM Picture of a pigeon bursa infected by Circovirus



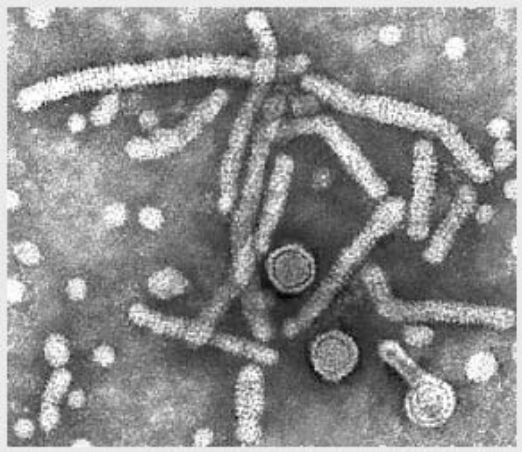
Porcines Circovirus

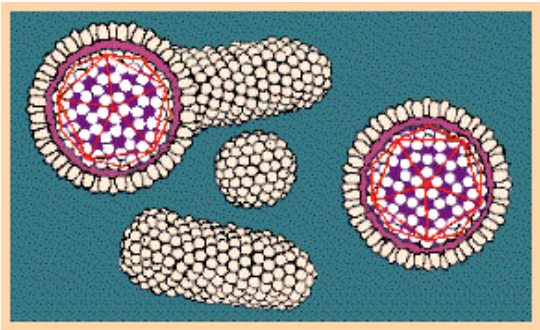
DNA VIRUSES

HEPADNAVIRIDAE



Hepatitis B Viruses



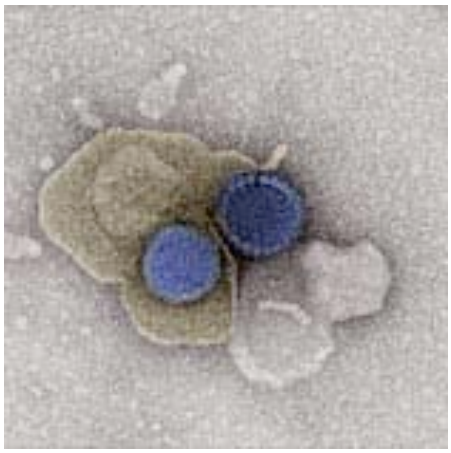


Hepatitis B virus cartoon
A diagrammatic representation of the hepatitis B virion and the surface antigen components

Hepatitis A virus is a Picornavirus
Hepatitis C virus is a Flavivirus
Hepatitis D virus is a Deltavirus
Hepatitis E virus is a Calicivirus (prov.)

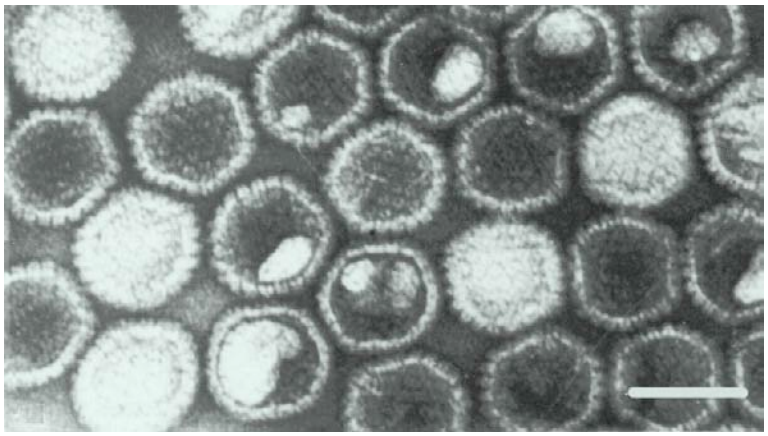
DNA VIRUSES

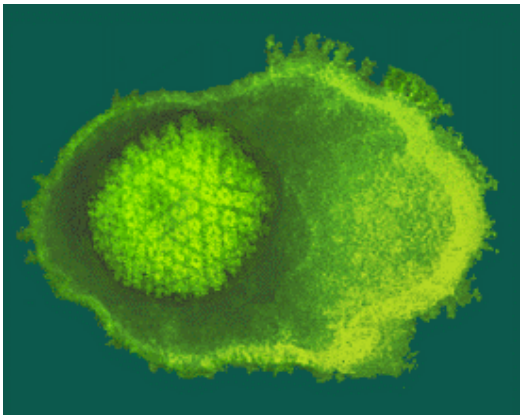
HERPESVIRIDAE



Bovines Herpesvirus Type 1
Shown in negative strain
Electron Microscopy / University of Zurich

Human Herpesvirus 3
the bar represents 100 nm
Naked capsides are seen.



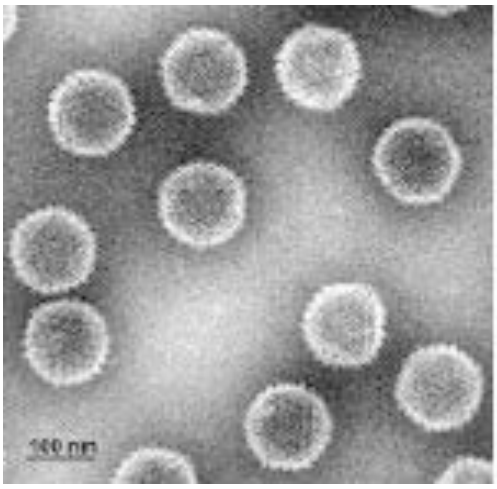


Herpesviruses have an envelope surrounding an icosahedral capsic, approximately 100 nm diameter, which contains the dsDNA genome.

When the envelope breaks and collapses away from the capsid, negatively stained virions have a typical “fried-egg” appearance.

DNA VIRUSES

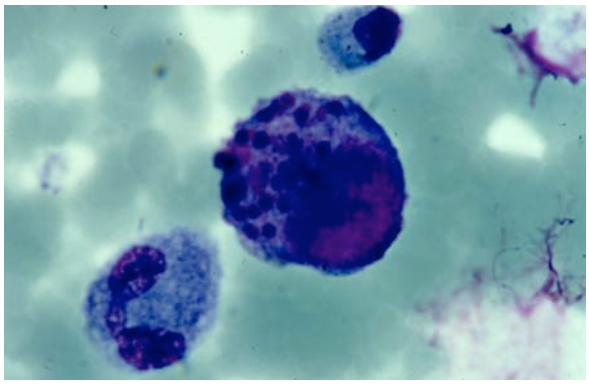
HERPESVIRIDAE

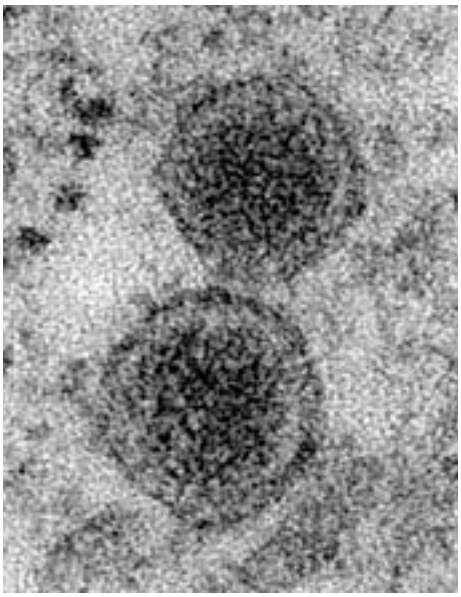


Equines Herpesvirus 1
Deenveloped EHV-1 nucleocapsids after residual tegument has been removed during centrifugation

Herpesviruses are structured in three subfamilies: Alphaherpesvirinade, Betaherpesvirinade, Gammaherpesvirinade and until now 48 unclassified viruses

Cytomegalovirus
Belongs to the Betaherpesvirinade

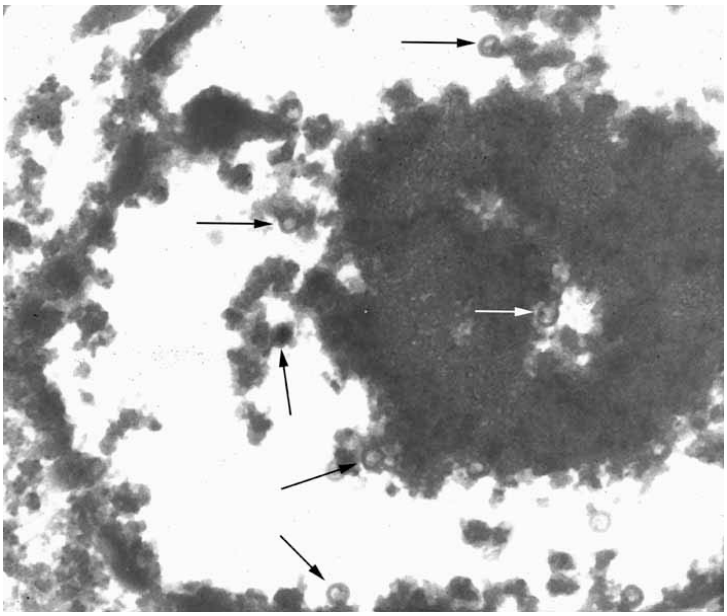




Green Turtle Herpesvirus
An alphaherpesvirus has been incriminated recently in the etiology of green turtle fibropapilloma (GTFP).

DNA VIRUSES

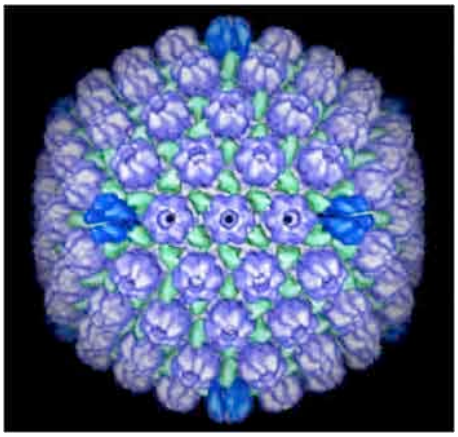
HERPESVIRIDAE

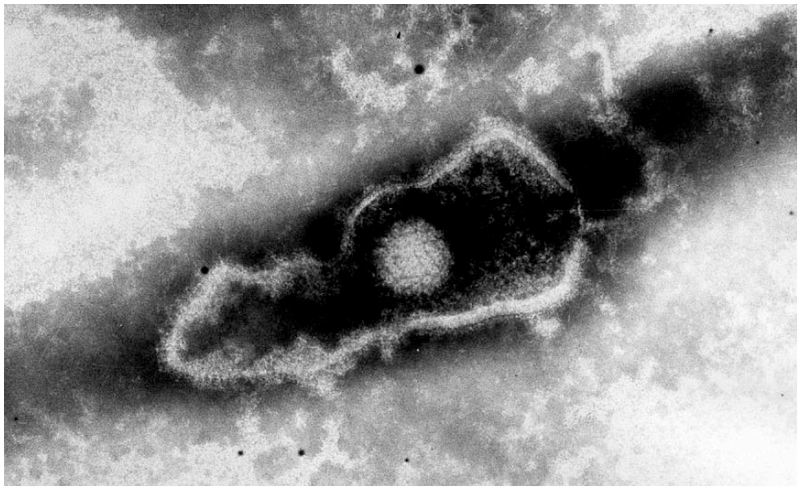


Endotheliotropic Herpesvirus

Electron micrography of Asian elephant cardiac endothelial cell infected with herpesvirus. The arrows point to individual viroids inside the nucleus prior to emerging from the cell to infect additional cells. (photo courtesy of Laura Richman)

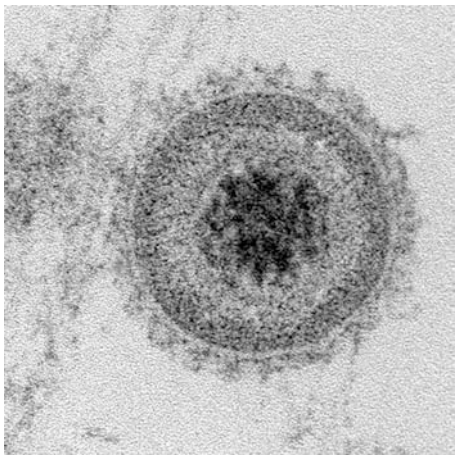
Herpes Simplex Virus 1 capsid: A T=16 icosahedral structure composed of the major capsid protein arranged in hexons (blue) and pentons (darker blue), and two minor capsid proteins forming triplexes (green).

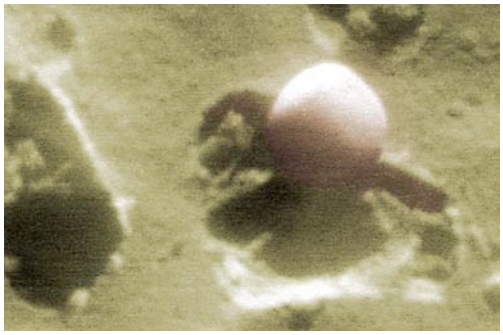


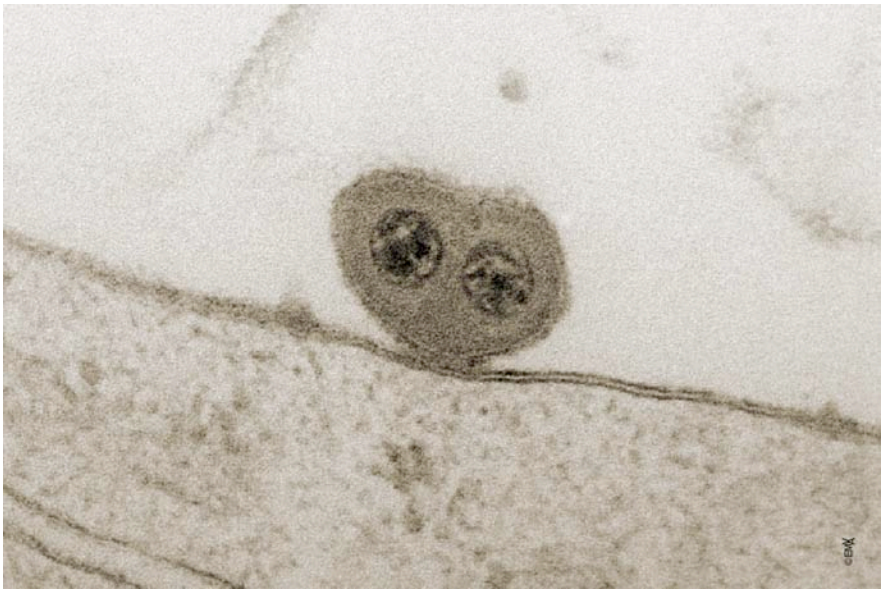


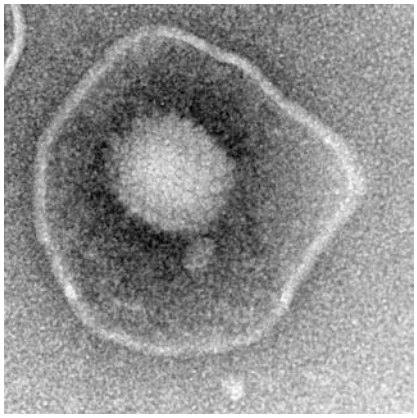
DNA VIRUSES

HERPESVIRIDAE







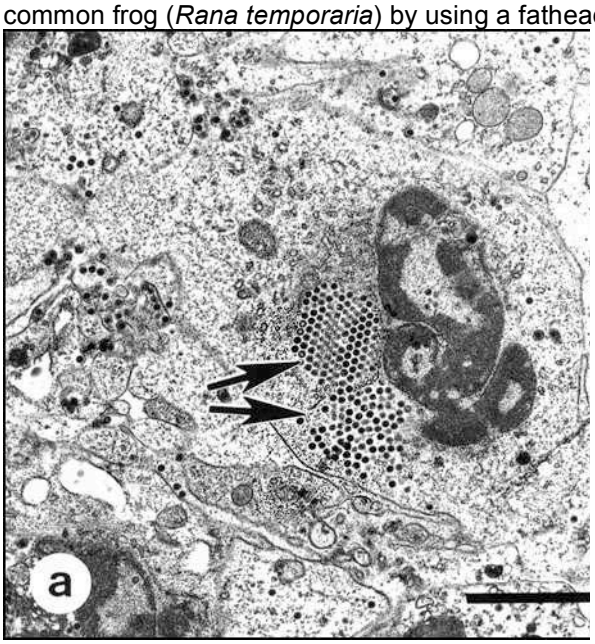


Herpesviruses
© for all four pictures by electron-microscopy department / University of Zurich

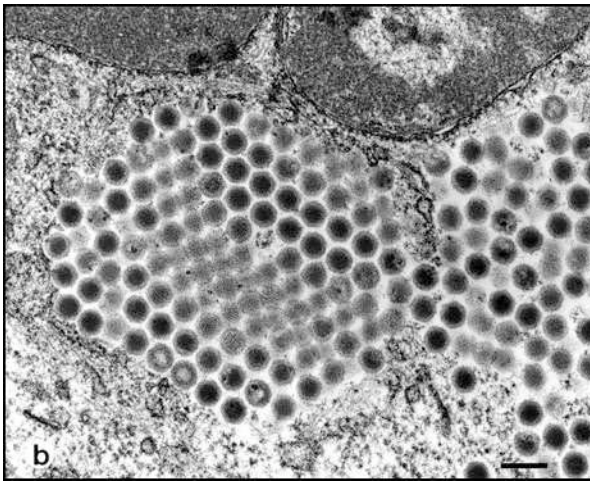
DNA VIRUSES

IRIDOVIRIDAE

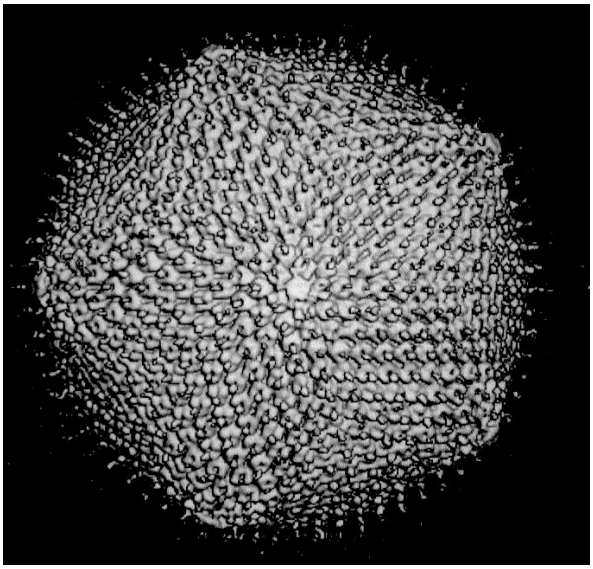
Transmission electron micrographs of **iridovirus** cultured from the liver of a naturally diseased common frog (*Rana temporaria*) by using a fathead minnow epithelial cell line.



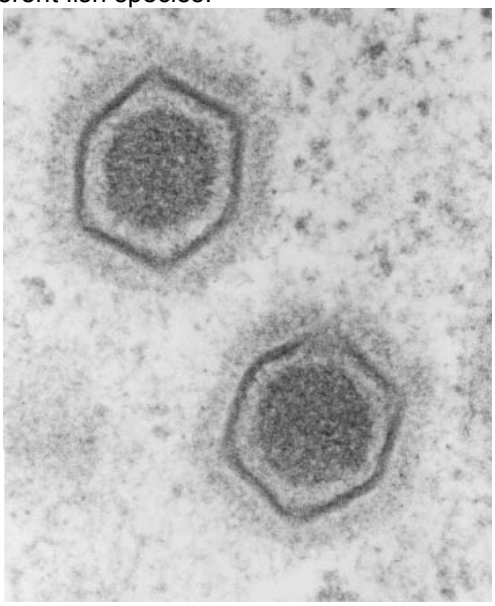
Picture a: Virus-infected cell. Large isocahedral viruses are conspicuous within the cytoplasm (arrows). Bar = 2 µm.



Picture b: Paracrystalline array of iridovirus. Bar = 200 µm.



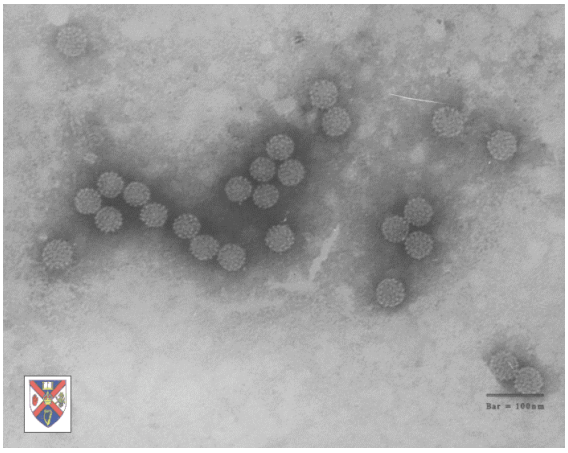
Lymphocystivirus
Is responsible for lymphocystis, a contagious infectious disease which affects the skin of different fish species.



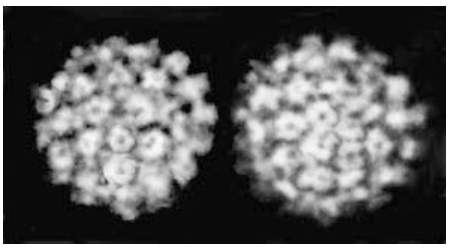
DNA VIRUSES

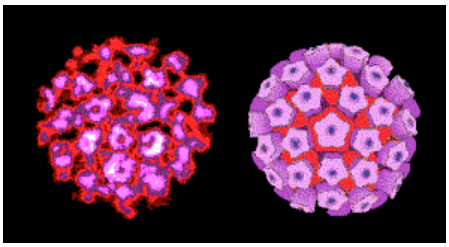
PAPILLOMAVIRIDAE

Animal Papillomavirus
papillomavirus particles are approximately 55 nm in diameter



Rabbit, infected with the Shope papillomavirus





The capsid is composed of 72 morphological units, or capsomers, arranged on the surface of a *T*=7 icosahedron. The capsomers located at each of the 12 vertices, are pentavalent (i.e. is surrounded by five adjacent capsomers), and the other 60 capsomers are hexavalent (each adjacent to six capsomers).

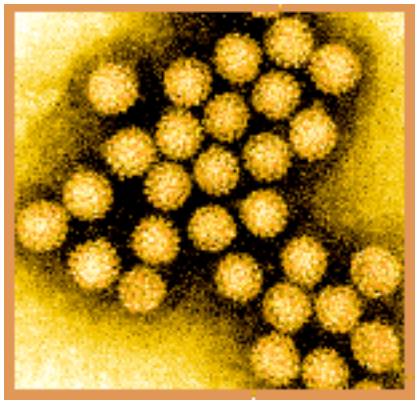
A model of the papillomavirus capsid is shown beside a coumputer colorized EM image.

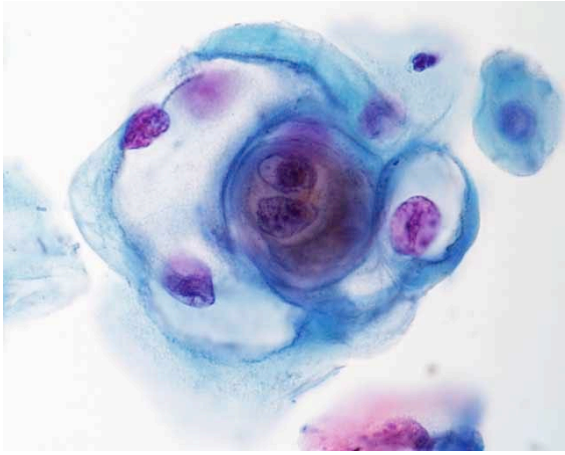
DNA VIRUSES

PAPILLOMAVIRIDAE

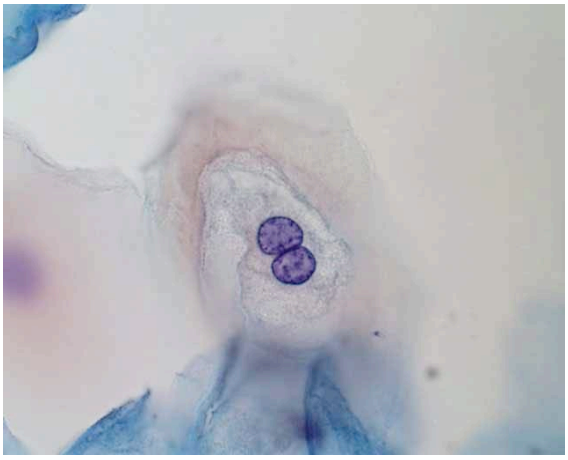
Multiple Human Papillomavirus

Many types of papillomavirus cause benign skin tumours (warts) in their natural hosts. These warts often regress sponteanously, but some warts, (caused by specific types of papillomavirus, particullary types 16 and 18) regularly become malignant if they persist for a sufficiently long time





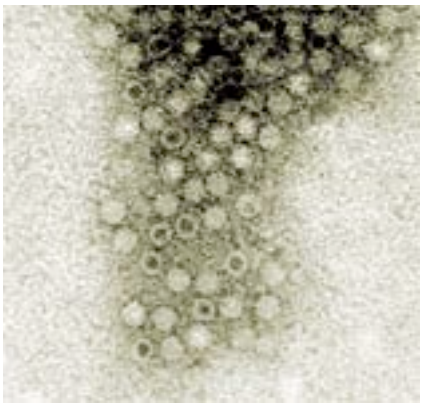
This cell is positive for human papillomavirus (HPV), indicated by the clear area just outside the nucleus. At first glance, the cell below looks like it's positive for HPV, but it's not. The cloudy area surrounding the nucleus is comprised mainly of glycogen. In an HPV-infected cell, the virus destroys glycogen.



Bovine Papilloma Virus

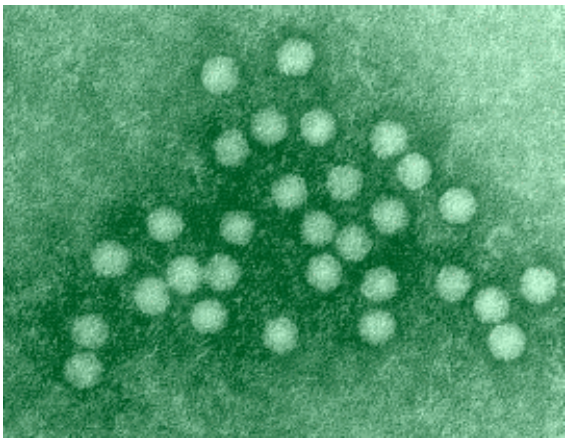
DNA VIRUSES

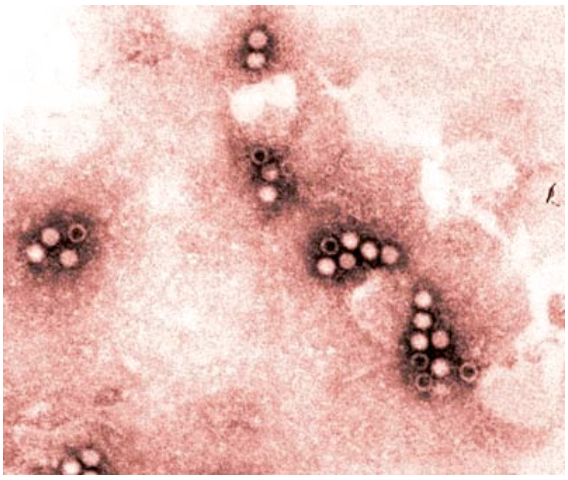
PARVOVIRIDAE



Porcines Parvovirus (PPV)
Electron Microscopy University of Zurich

Parvoviruses are the smallest known DNA-containing viruses. The capsids have icosahedral symmetry and are approximately 25nm in diametre.



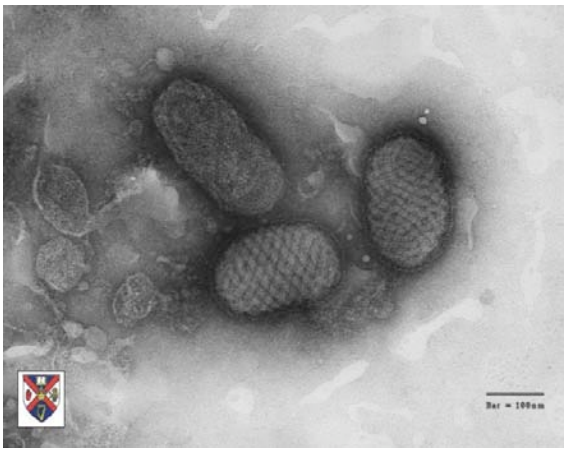


Human Parvovirus B19
A negatively stained preparation of parvovirus as seen by transmission electron microscopy.

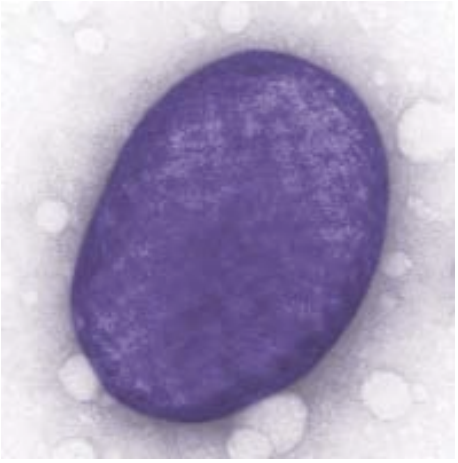
DNA VIRUSES

POXVIRIDAE

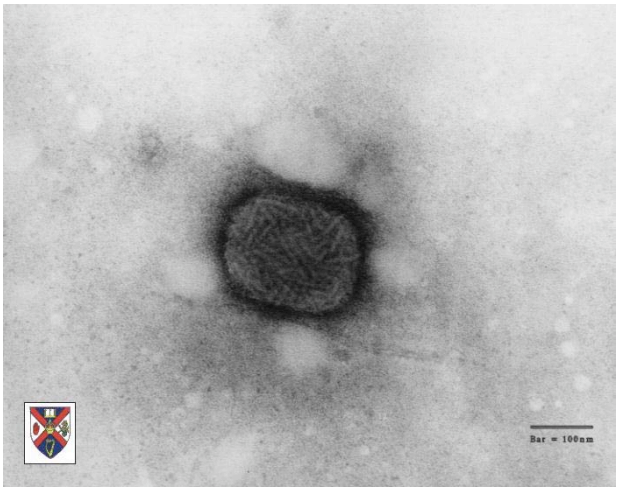
Poxviruses are the largest and most complex viruses known
Oval or “brick-shaped” particles 200-400nm long can be visualized by the best light microscopes. The external surface is ridged in parallel rows, sometimes arranged helically.



an Animal Parapoxvirus

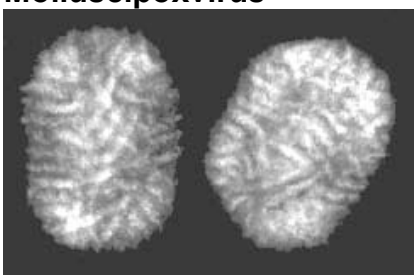


Parapoxvirus is responsible for contagious ecthyma (Orf or “sore mouth”) in sheep and goats. This can lead to a loss of condition as animals will often refuse to feed. It is extremely contagious and the virus can be passed on to humans working with infected animals



an Animal Orthopoxvirus

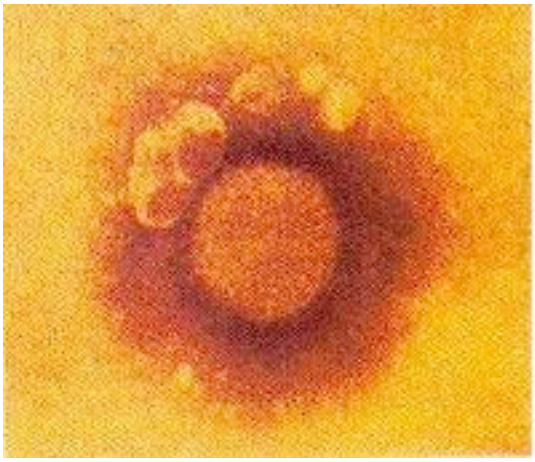
Molluscipoxvirus

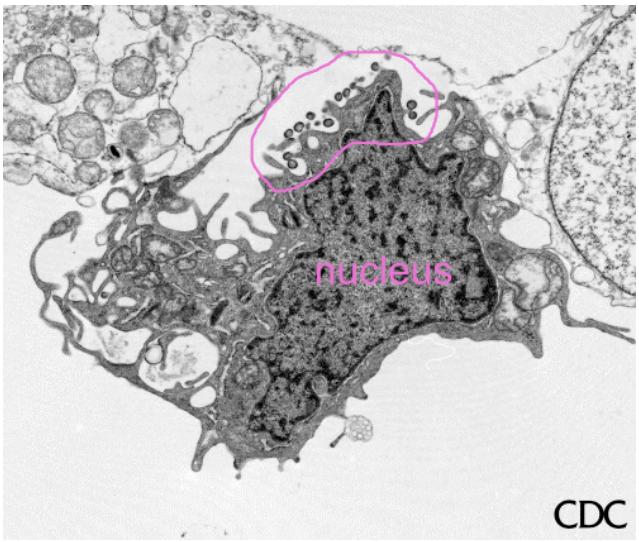


RNA VIRUSES

ARENAVIRIDAE

an Arenavirus





Culture cell infected with an arenavirus. Image shows extracellular virus particles budding from the surface. Magnification approx. 12,000 times.

Lassa Virus; electron micrograph
The virus, a member of the virus family Arenaviridae, is a single-stranded RNA virus and is zoonotic or animal-borne. The host of Lassa Virus is a rodent.

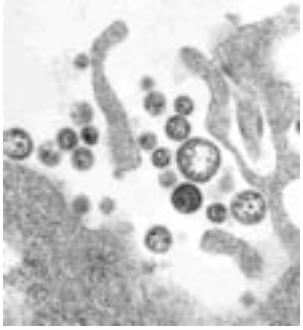
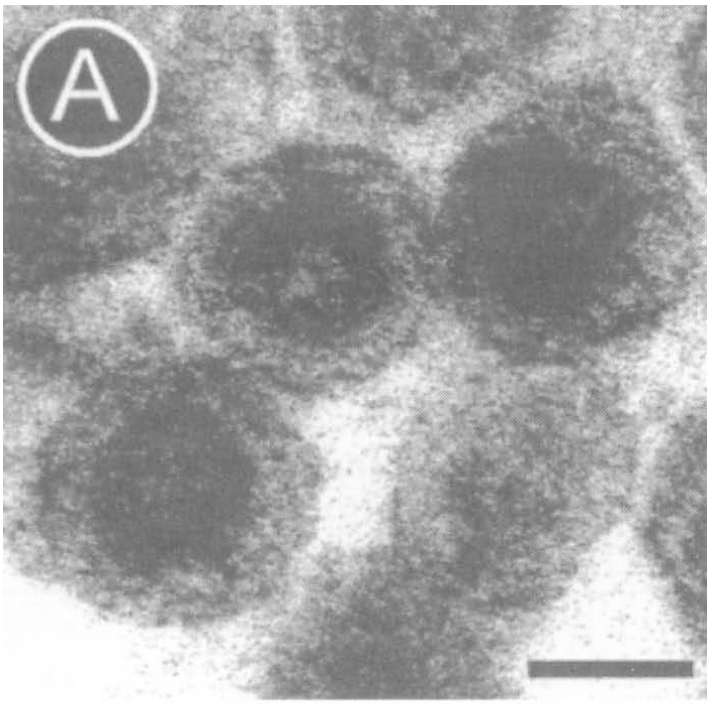
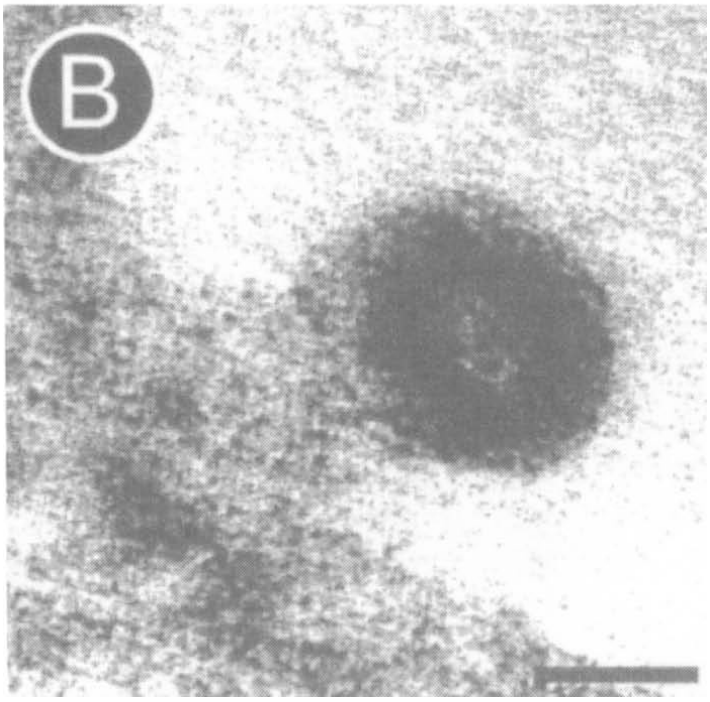


Image courtesy Cynthia Goldsmith, M. Bowen on http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/

RNA VIRUSES

ARTERIVIRIDAE

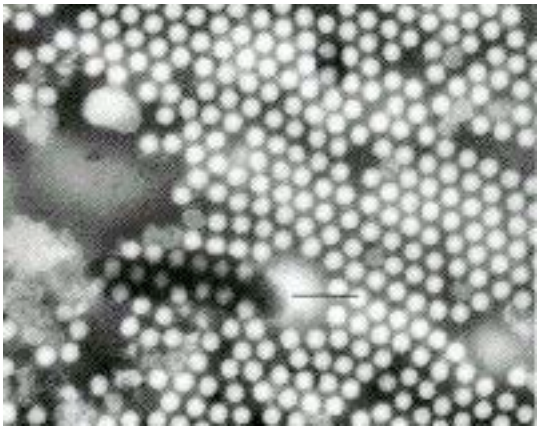




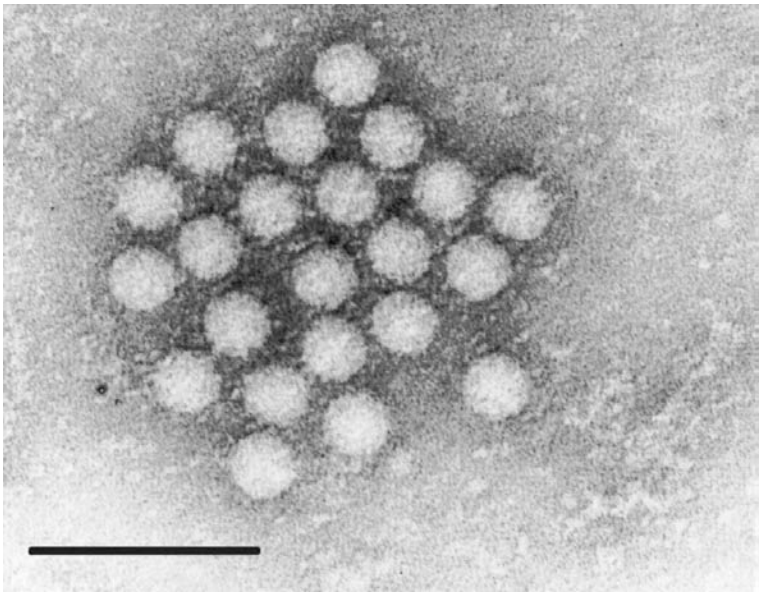
PRRSV (A) and EAV (B)
Picture source: Fields Virology, 4th edition, Volume 1, p. 1207.

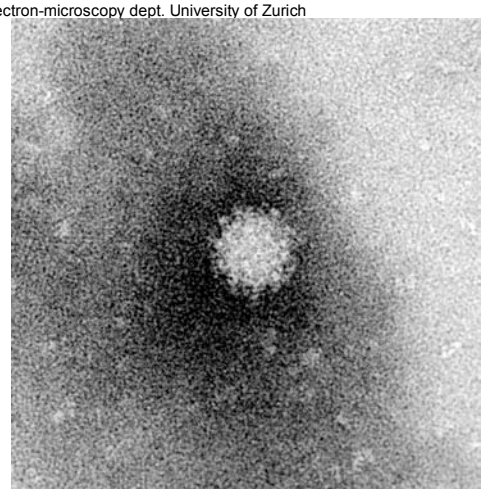
RNA VIRUSES

ASTROVIRIDAE



Human Astrovirus
the bar represents 100 nm

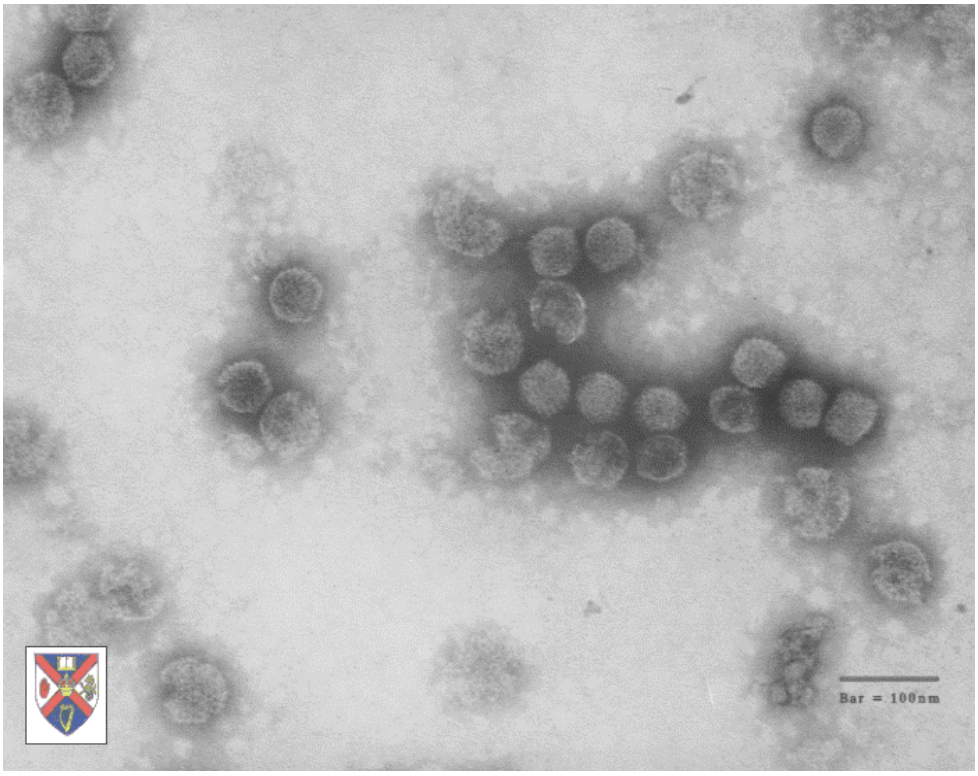




Animal Astrovirus
Astroviruses are small (28nm) non-enveloped positive strand viruses associated mainly with diarrhoea in the young of various animal species including man. In birds these viruses may cause a variety of other conditions from hepatitis in the duckling to immune suppression in the turkey.

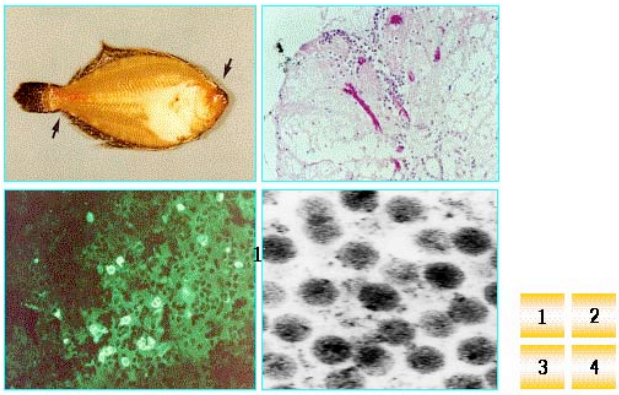
RNA VIRUSES

BIRNAVIRIDAE



Birnavirus
the bar represents 100 nm

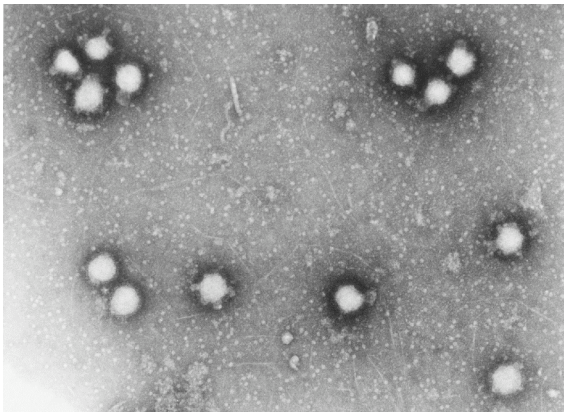
Birnaviral disease



1. Hemorrage of the head and accumuration of ascites
2. Hisotologically, necrosis of the brain
3. Rapid diagnosis using FAT
4. Birnavirus particles

RNA VIRUSES

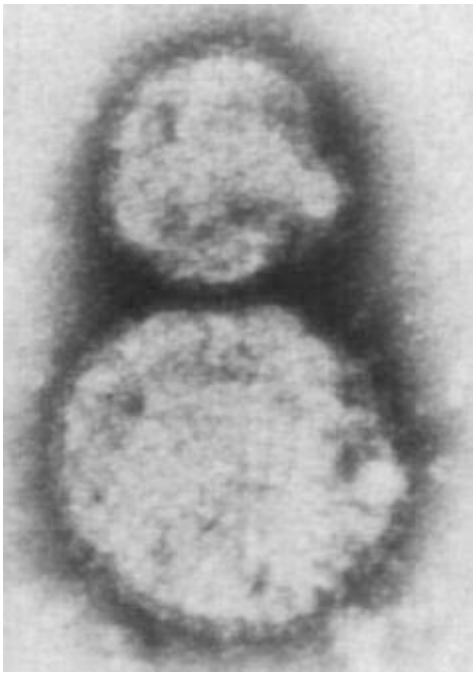
BUNYAVIRIDAE



Bunyaviridae are grouped into 5 genera:

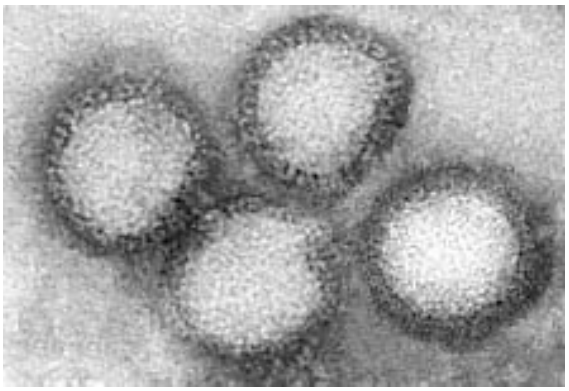
- Bunyavirus
- Phlebovirus
- Nairovirus
- Hantavirus
- Tospovirus

Bunyavirus



Viruses in the taxonomic family Bunyaviridae have multicomponent, largely negative-sense RNA genomes (ambisense), encapsidated in spherical / pleomorphic enveloped particles containing helical nucleocapsids. Particles have a sedimentation coefficient of 350-500 Svedbergs, a buoyant density in CsCl of 1.2 g per cc, and are sensitive to lipid solvents and detergents.

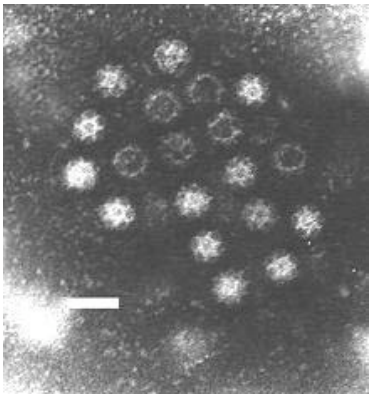
Hantavirus



Rift Valley Fever Virus
(Phlebovirus)

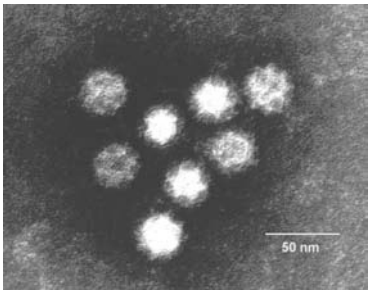
RNA VIRUSES

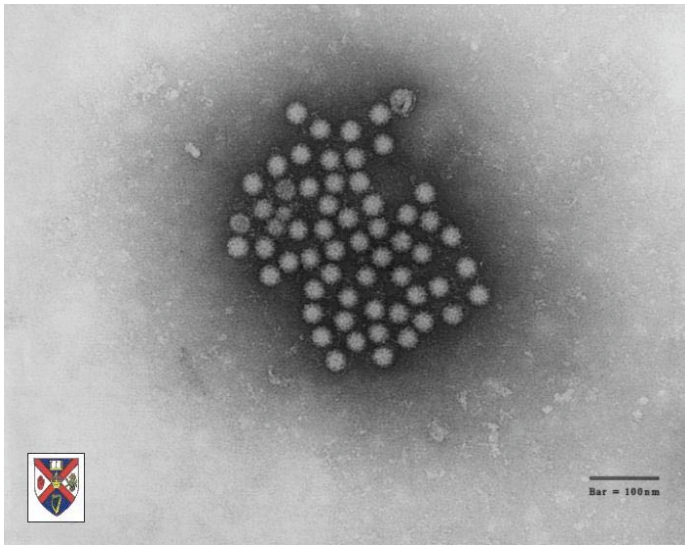
CALICIVIRIDAE



Note the 'Star of David' image exhibited by individual virus particles. This is distinct from the star-like images exhibited by astrovirus particles. Bar = 50 nanometers.

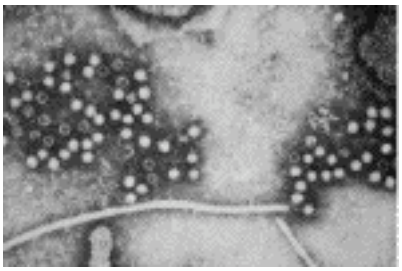
Caliciviruses



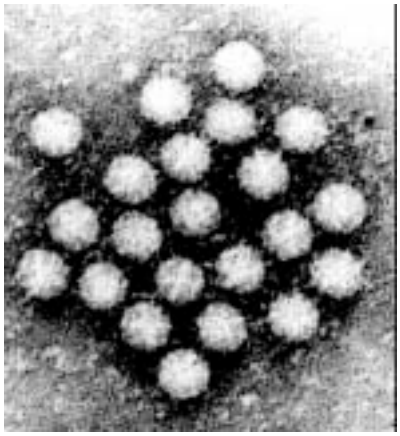


Bovine Calicivirus

Hepatitis E Virus
Based on similar physicochemical and biologic properties, HEV has been provisionally classified in the Caliciviridae family; however, the organization of the HEV genome is substantially different from that of other caliciviruses and HEV may eventually be classified in a separate family.

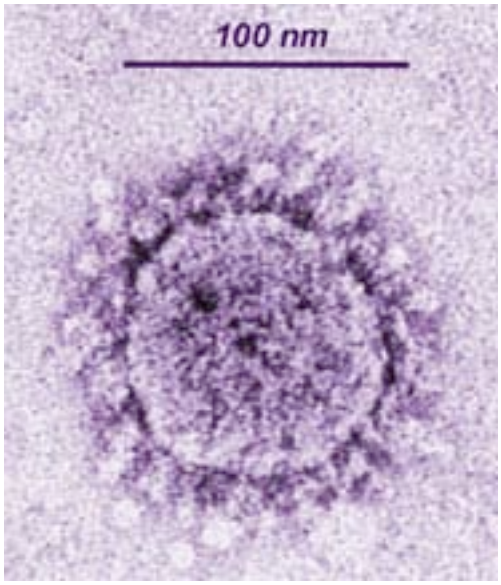


Norwalk Virus

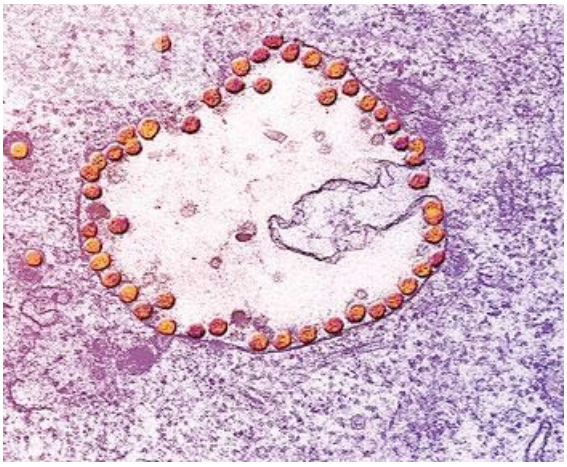


RNA VIRUSES

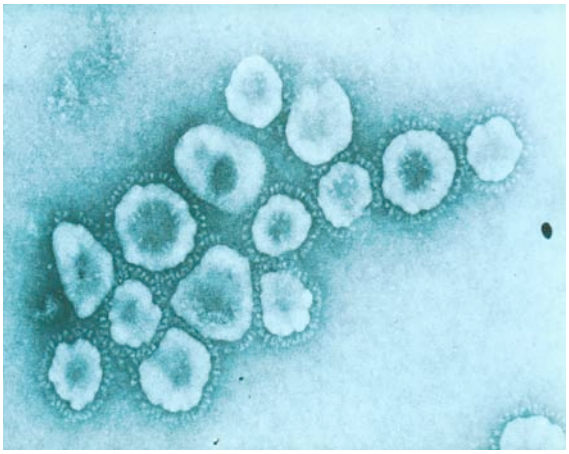
CORONAVIRIDAE

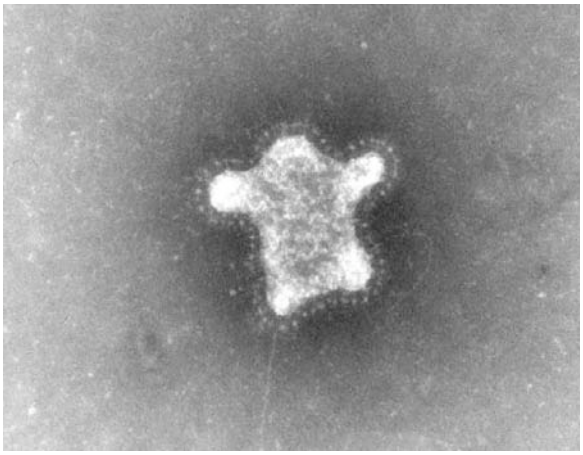


One of the well known representatives of the big corona virus family is the virus which cause the **Severe Acute Respiratory Syndrom**, better known as SARS. This virus is a fatal lung disease and is a type of coronavirus. The disease is caused by the inhalation of virus particles, which are carried in tiny water droplets in the air. In 2002 SARS appeared in China and has spread throughout the world since.



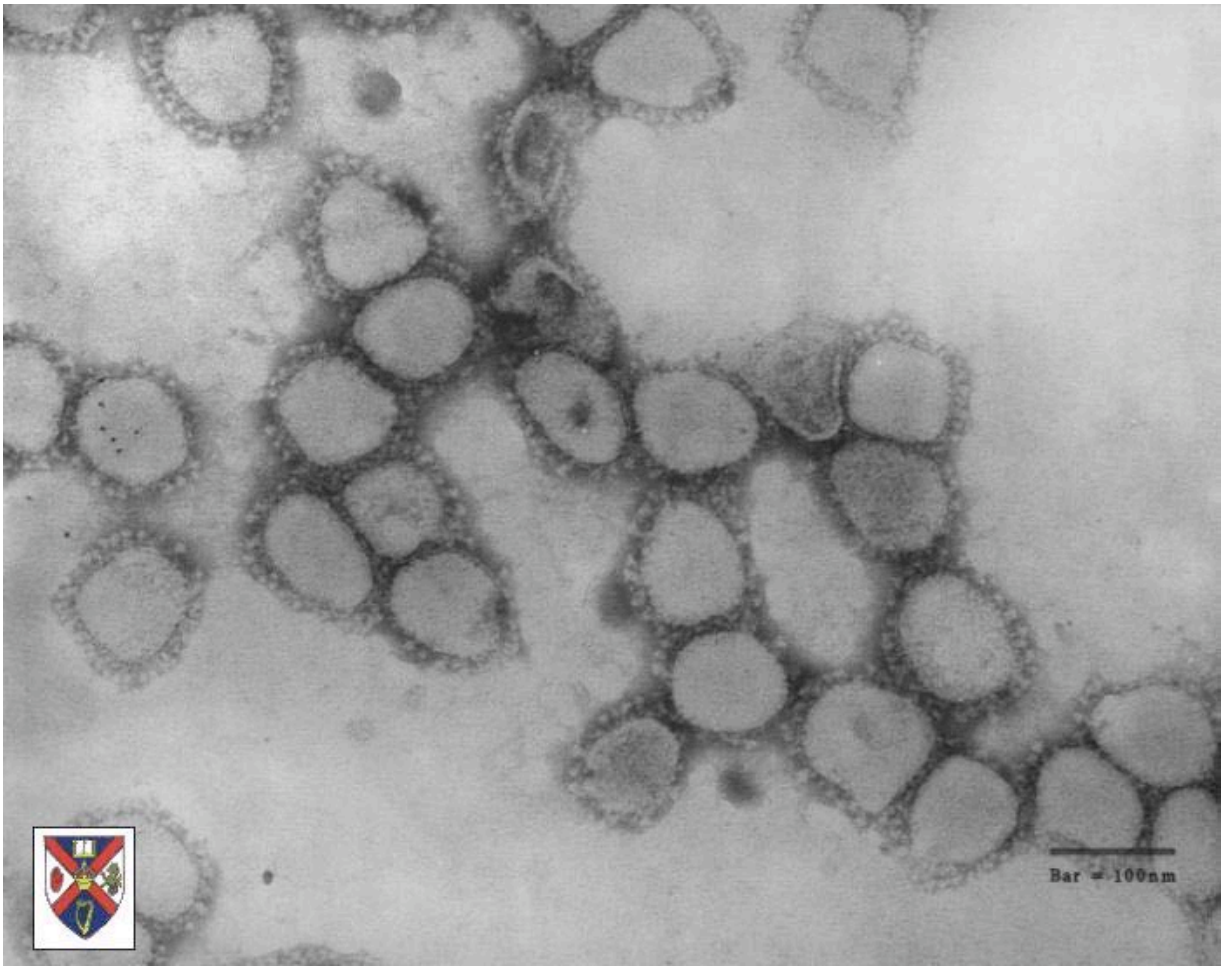
SARS
Severe Acute Respiratory Syndrom Virus



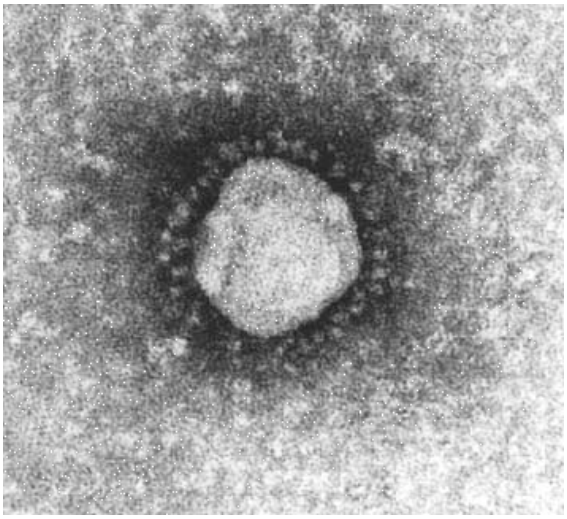


RNA VIRUSES

CORONAVIRIDAE



Bovine coronavirus

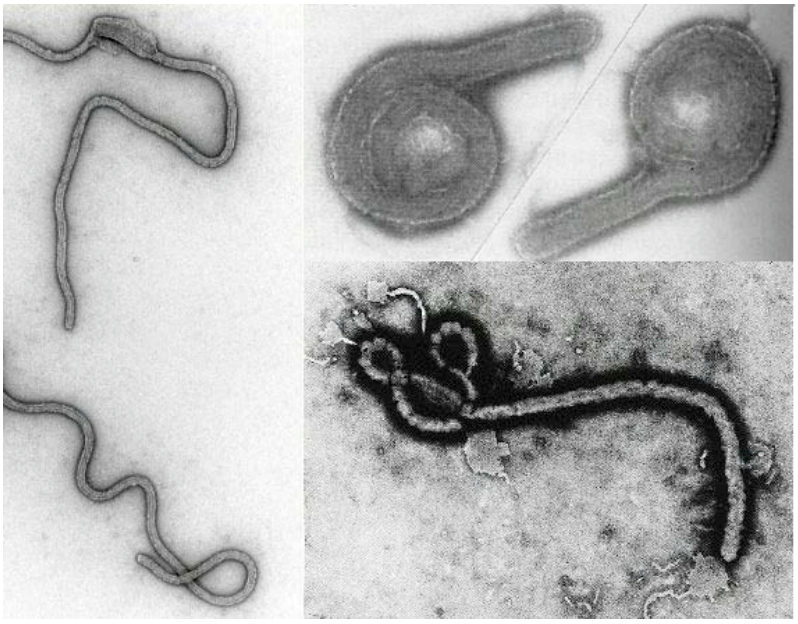


A view of a negatively-stained electron micrograph of a coronavirus particle

RNA VIRUSES

FILOVIRIDAE

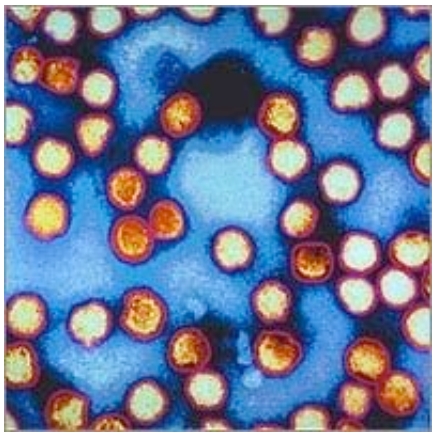
Negative stain image of an isolate of **Marburg virus**, showing filamentous particles as well as the characteristic "Shepherd's Crook".



Electron micrographs of virus particles: Negative stains of **Ebola virus**.

RNA VIRUSES

FLAVIVIRIDAE



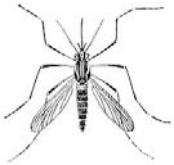
Tick-borne Encephalitis Virus FSME

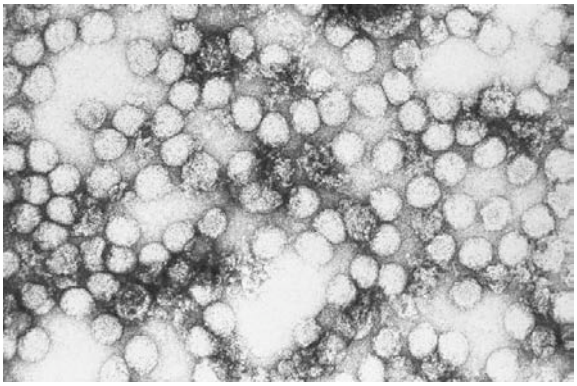
The disease first appears as a mild influenza-like fever accompanied by leuko- and thrombocytopenia that clears up within a few days. About 30% of patients go on to develop more severe symptoms with meningitis and meningoencephalitis. Belongs to the Flavivirus.

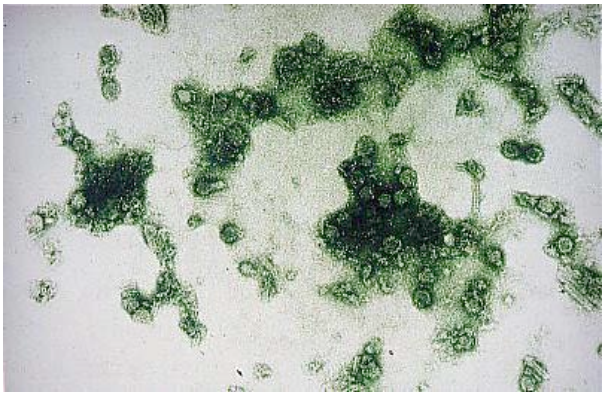
Yellow Fever Virus

Flavivirus

An electron micrograph of Yellow Fever Virus virions. Virions are spheroidal, uniform in shape and are 40-60nm in diameter. The name "Yellow Fever" is due to the ensuing jaundice that affects some patients. The vector is the Aedes aegypti or Haemagogus spp. mosquito.







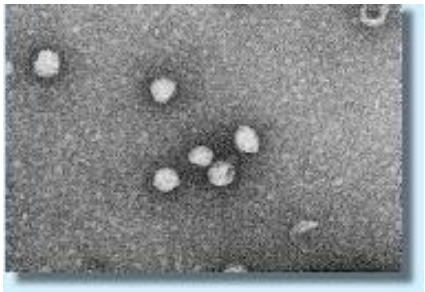
Dengue Virus

Flavivirus

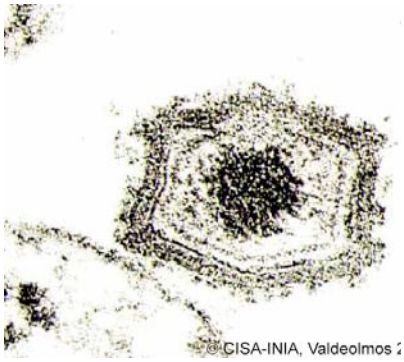
Dengue and dengue hemorrhagic fever (DHF) are caused by one of four closely related, but antigenically distinct, virus serotypes (DEN-1, DEN-2, DEN-3, and DEN-4), of the genus *Flavivirus*. Infection with one of these serotypes does not provide cross-protective immunity, so persons living in a dengue-endemic area can have four dengue infections during their lifetimes.

RNA VIRUSES

FLAVIVIRIDAE

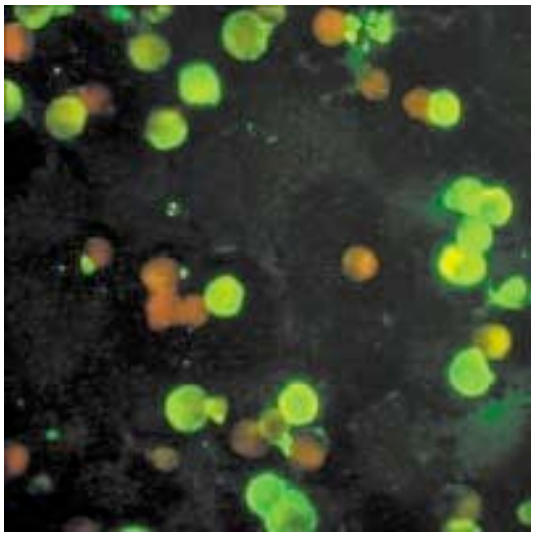


Classical Swine Fever or Hog Cholera Virus
Pestivirus



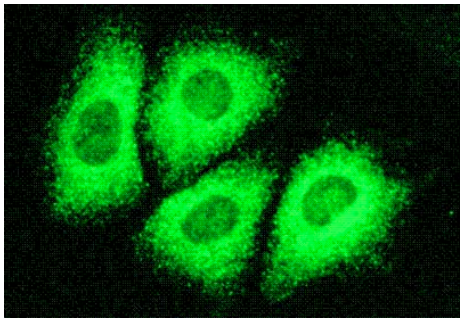
Bovine Viral Diarrhea Virus / BVDV
Pestivirus

BVDV causes a number of serious diseases in cattle resulting in large annual losses to the cattle industry. The virus can pass across the placental membrane of infected cows to the unborn calf, causing abortion or early deads. However calves that survive the infection remain carriers and can pass on the virus to other members of the herd. The virus can spread quickly unless action is taken to isolate the infected animals.



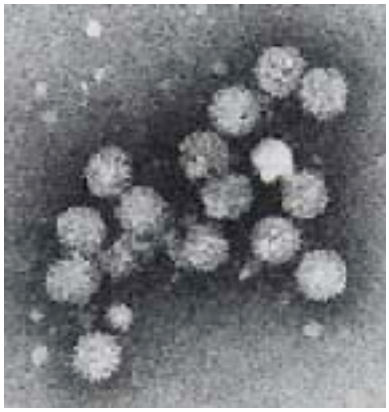
RNA VIRUSES

FLAVIVIRIDAE



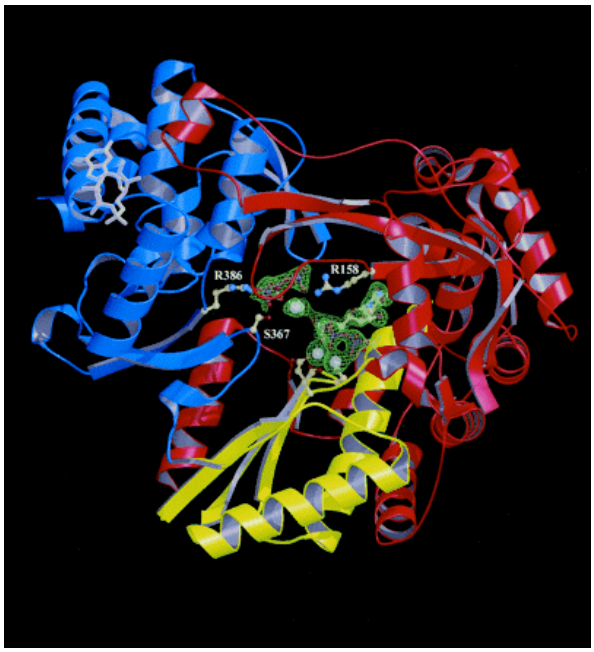
New cell culture model for **Hepatitis C virus**. Immunfluorescence staining of NS5A in human HuH-7 cells containing a subgenomic hepatitis C virus replicon. (Photo by K. Barth und M. Frese)

Hepatitis C Virus



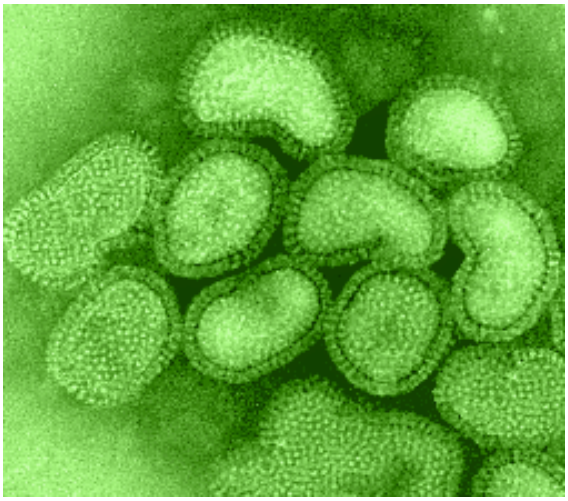
Structure of the hepatitis C virus RNA polymerase in complex with nucleotides.

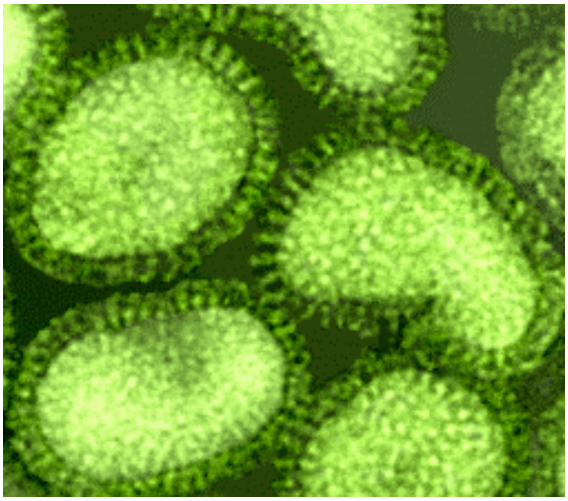
Cover photograph of Journal of Virology, April 2002 / Volume 76, Issue 7 (Copyright © 2002, American Society for Microbiology. All Rights Reserved.). With friendly permission of ASM to publish in our manual “Family Album of Viruses”. *(See related article in Jon p. 3482.)*



RNA VIRUSES

ORTHOMYXOVIRIDAE

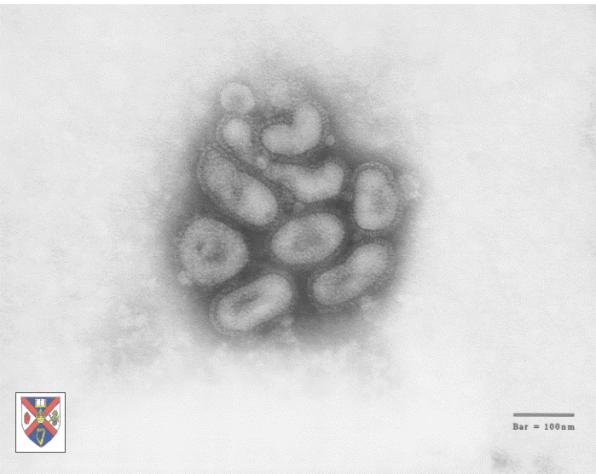


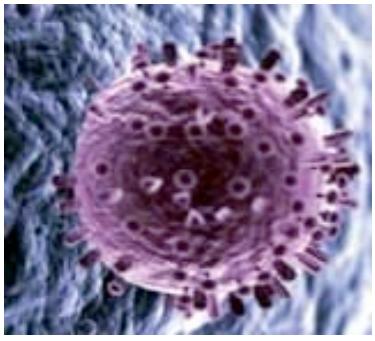


human influenza viruses

Virions are usually roughly spherical and about 200nm in diameter. The envelope contains rigid "spikes" of **haemagglutinin** and **neuraminidase** which form a characteristic halo of projections around negatively stained virus particles.

animal influenza virus



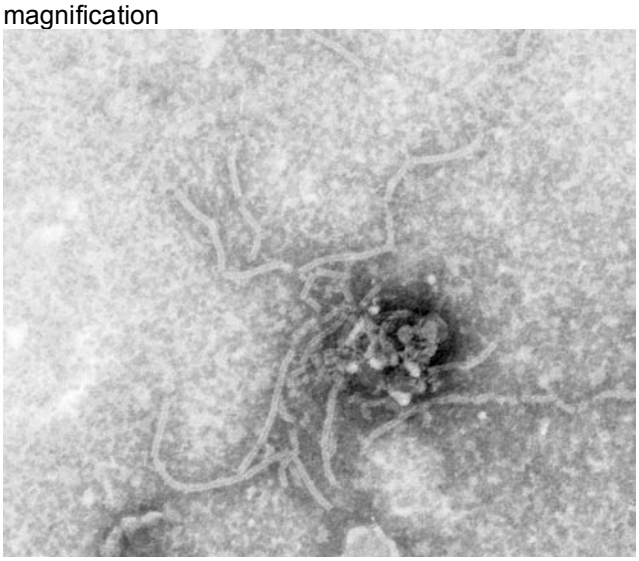


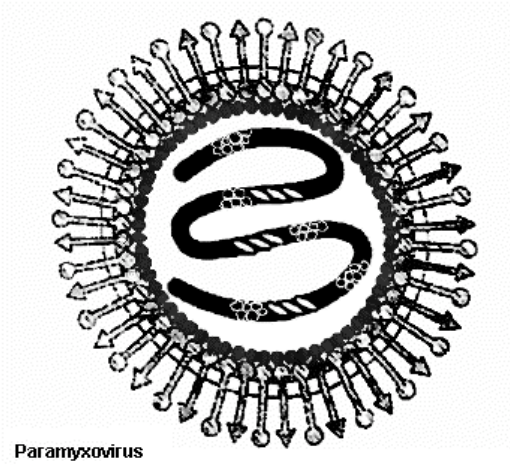
This illustration shows the influenza virus penetrating the wall of a human cell

RNA VIRUSES

PARAMYXOVIRIDAE

Paramyxovirus ribonucleoprotein at 30,000 x magnification





Paramyxovirus
Diagram of virion section (taken from ICTV guidelines)

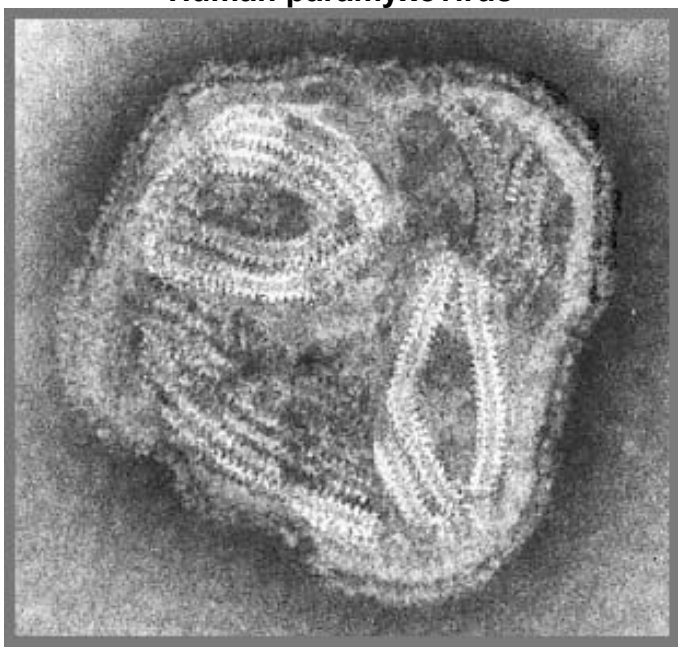
The Paramyxovirus-Family has two subfamilies:

Paramyxovirinae (paramyxoviruses, rubulaviruses, morbilliviruses) and

Pneumovirinae (pneumoviruses)

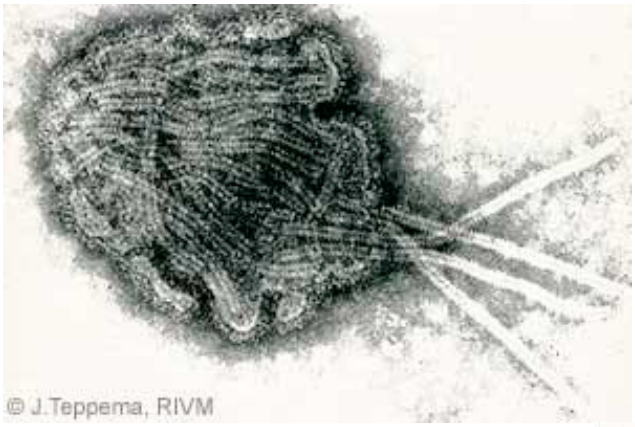
They cause diseases for example:
Parainfluenza, Newcastle Disease, Rinderpest, Bovine Respiratory Syncytal Virus BRSV, Measle, Mumps

Human paramyxovirus



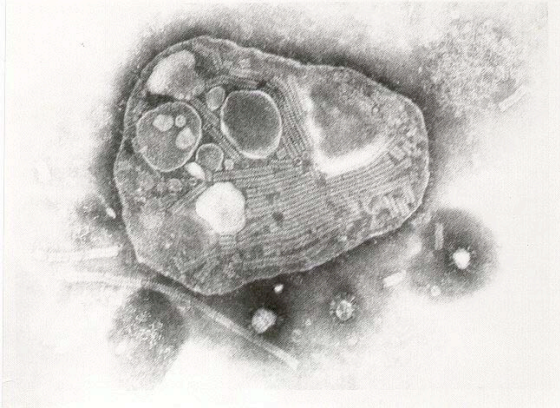
RNA VIRUSES

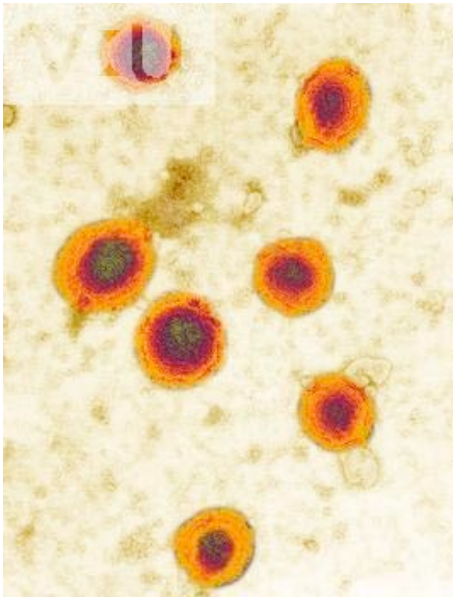
PARAMYXOVIRIDAE



Morbillivirus

Rinderpest Virus (Morbillivirus)

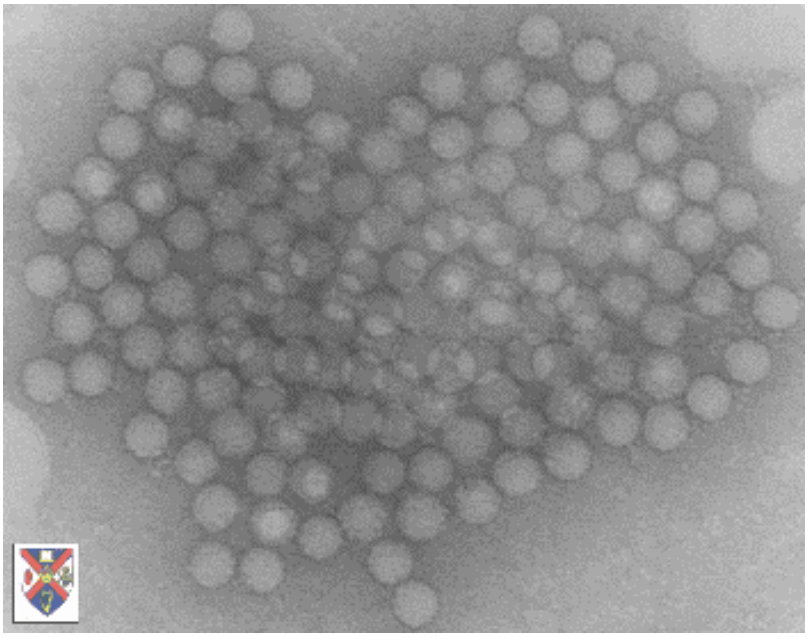




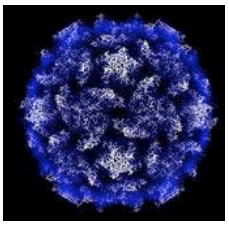
Mumps Virus (Rubulavirus)

RNA VIRUSES

PICORNAVIRIDAE



animal picorna-virus



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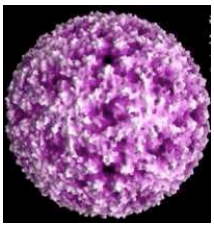

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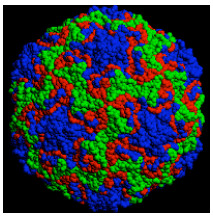

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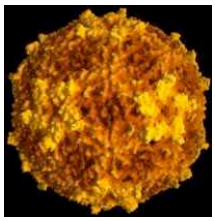

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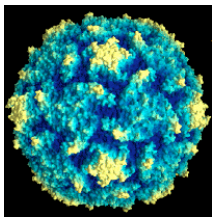

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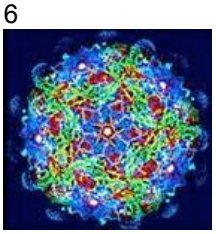
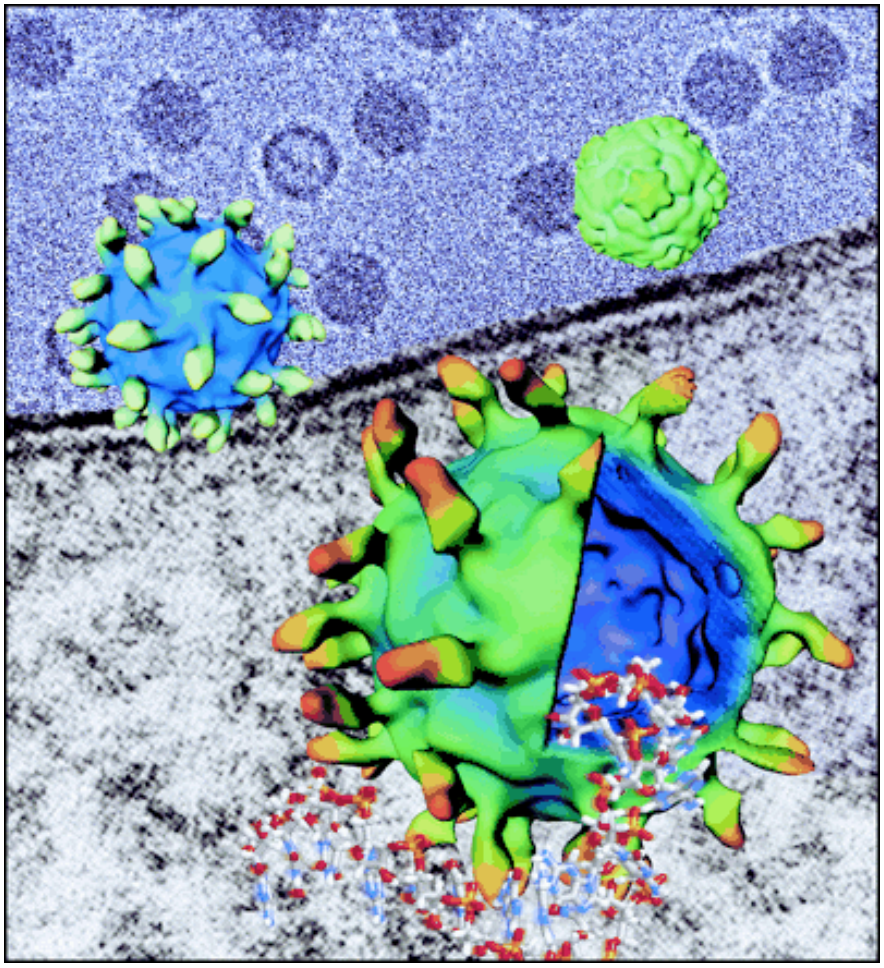


1. Human Poliovirus
2. Molecular surface of Foot and Mouth Disease Virus, radially depth cued as solved by X-ray crystallography
3. Rhinovirus 14, color coded by protein as solved by X-ray crystallography
4. Molecular surface of Mengovirus, radially depth cued as solved by X-ray crystallography
5. Molecular surface of Poliovirus Type 1
6. Foot and Mouth Disease Virus

RNA VIRUSES

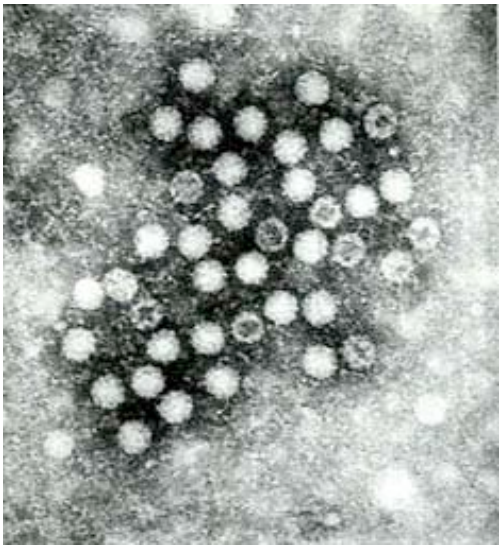
PICORNAVIRIDAE



Human rhinovirus 3, a picornavirus (genus: rhinovirus) that causes the common cold in humans, infects cells by first attaching to intercellular adhesion molecule 1 on the cell surface. Binding of the receptor leads to conformational changes in the viral capsid, resulting in viral genome release. Comparative structural analysis of three virus uncoating intermediates by cryo-electron microscopy reveals that the receptor molecule serves as a mediator, seizing the "breathing" capsid in an open expanded state so that the viral genome can exit from the cage. *(See related article on p. 6101.)*
Cover photograph of Journal of Virology, June 2003 / Volume 77, Issue 11 (). With friendly permission of ASM to publish in our manual “Family Album of Viruses”.

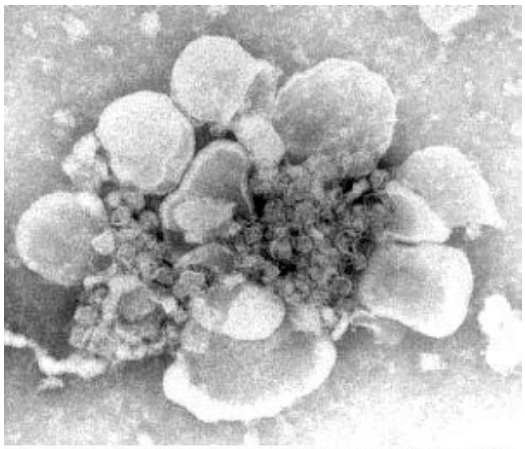
RNA VIRUSES

PICORNAVIRIDAE

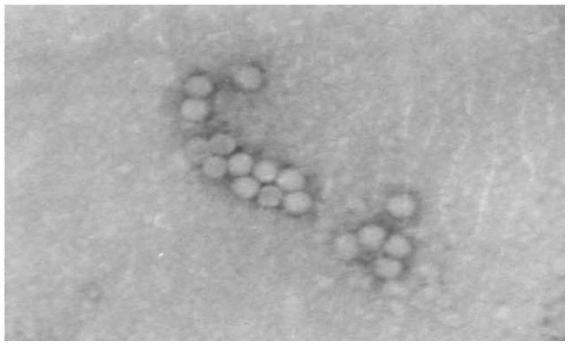


Hepatitis A Virus (Genus: Hepatitis A Virus)

Poliovirus (Enterovirus)



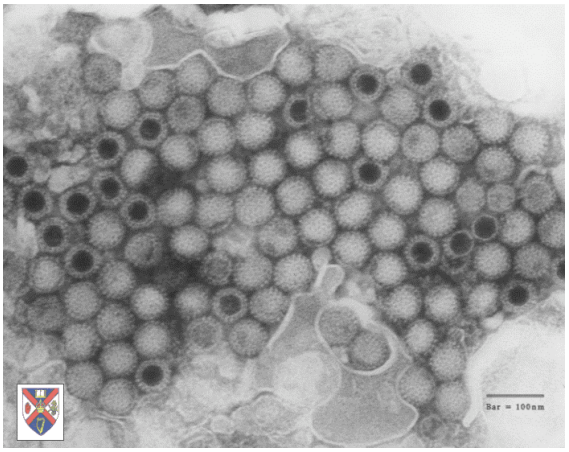
Electron micrograph of a poliovirus replication rosette
© D. Egger & K. Bienz, University of Basel



Swine Vesicular Disease Virus
SVDV (Enterovirus) Crystalline array of SVDV from electron microscopy

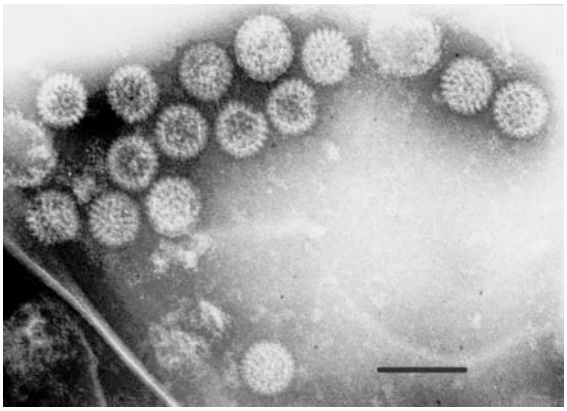
RNA VIRUSES

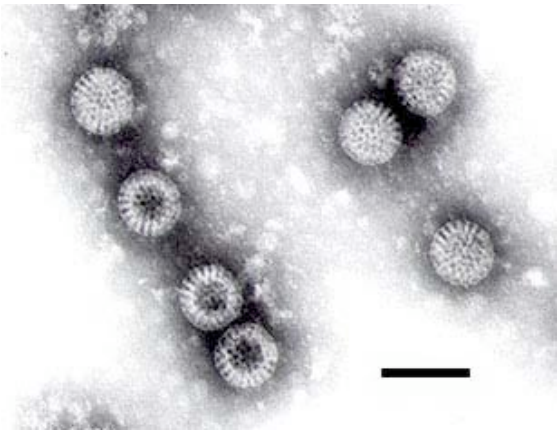
REOVIRIDAE



An Animal Orthoreovirus

Bovine Rotavirus

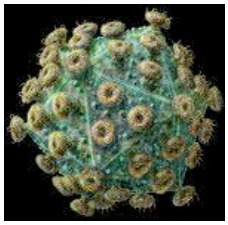




Note the wheel-like appearance of some of the rotavirus particles. The observance of such particles gave the virus its name ('rota' being the Latin word meaning wheel). Bar = 100 nanometers

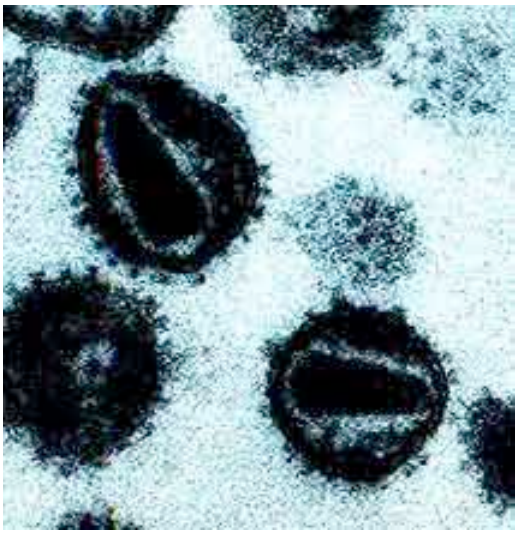
RNA VIRUSES

RETROVIRIDAE

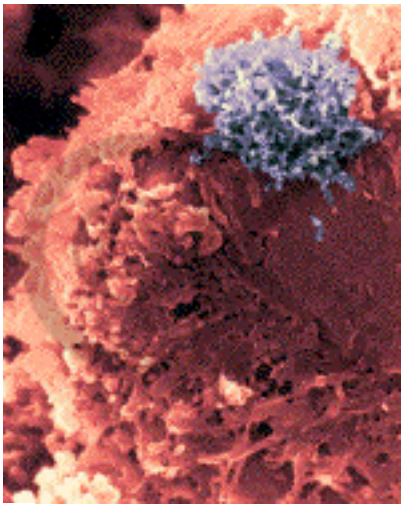


Human Immunodeficiency Virus / HIV

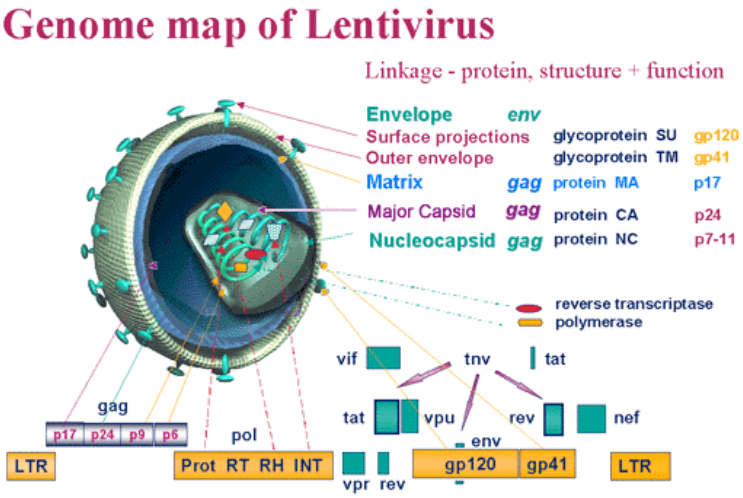
This computer generated art quality graphics of HIV was done by Russell Kightley of Canberra, Australia.



HIV Virus

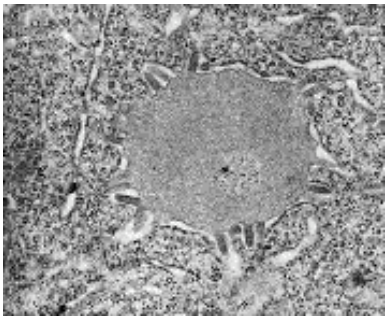


Viral particle seen by Scanning electron microscopy (SEM) at a magnification of 26,400x of human T-lymphotropic virus attacking a T-lymphocyte . This image is from Dennis Kunkel

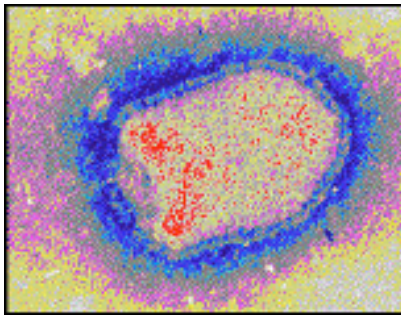


RNA VIRUSES

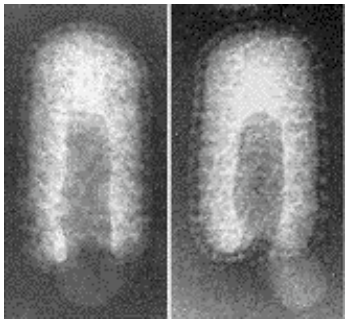
RHABDOVIRIDAE



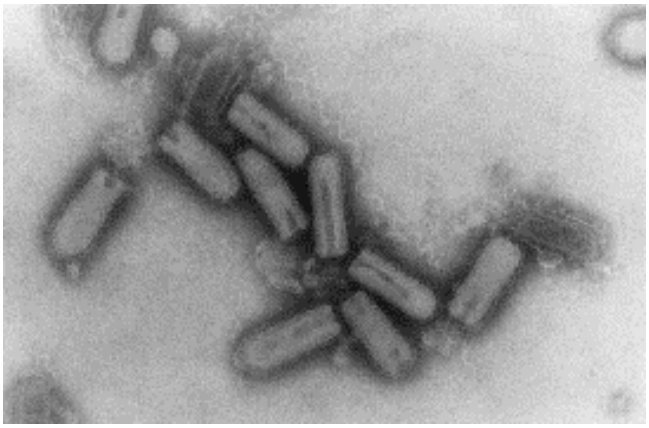
Rabies Virus (Lyssavirus)



With electron microscopy, rabies virion shows a 75 nm mean diameter, and a length varying between 130 and 300 nm (mean: 180 nm); spike-like projections (9 nm long) can be seen on the viral envelope.

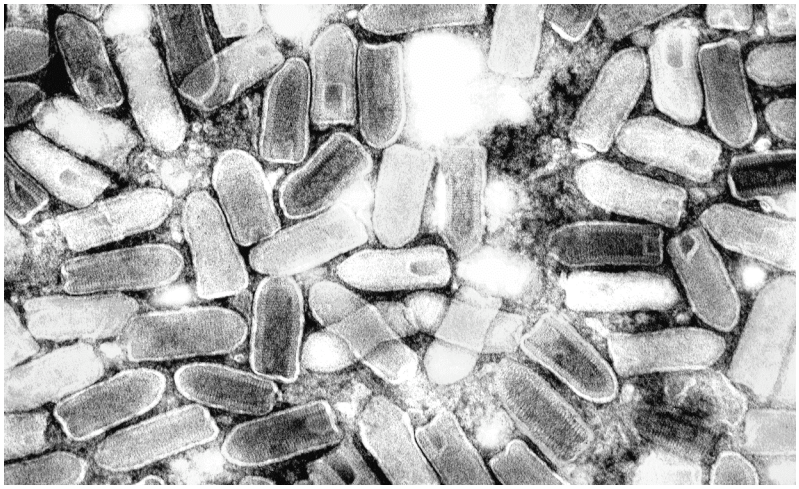


Bullet-shaped rabies virions with glycoprotein-studded envelopes. The "spikes" cover the entire envelope surface, including the quasiplanar ends of the viruses.



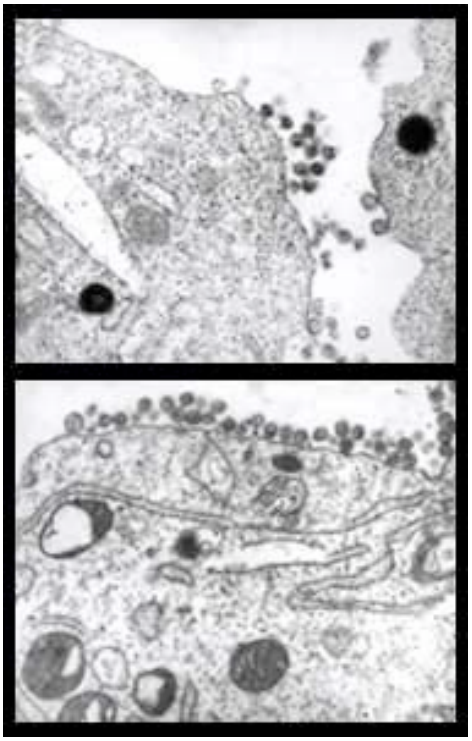
Vesicular stomatitis virus (Vesiculovirus)

Vesicular stomatitis virus, VSV-I type 1, purified from an infected cell culture. This is an important pathogenic virus of cattle, causing fever and vesicles in the mouth and on the feet. Negatively stained virions: note that they are clearly "bullet shaped" just like rabies virus. Magnification approximately x40,000.

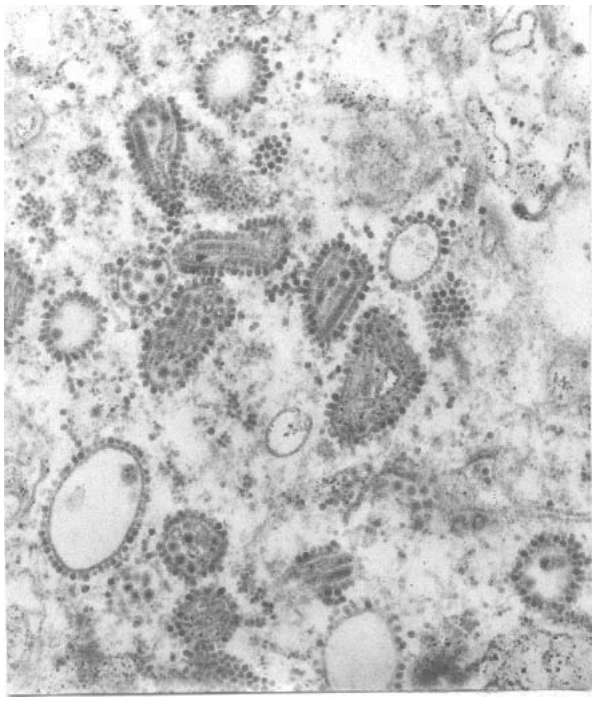


RNA VIRUSES

TOGAVIRIDAE



Sneaky viruses: antibodies usually help fight invaders but the **Ross River Virus** (alphavirus) small black dots) multiblies more when antibodies are present (below) than when they are absent (above)



Electron micrograph of a **Semliki Forest virus** (alphavirus) infected cell showing virus particles and intermediate stages in viral replication.(above)

Rubella Virus (Rubivirus)
It is roughly spherical with a diameter of 60-70 nm. It has an icosahedral (20-faced) nucleocapsid, which contains the single-stranded RNA genome.

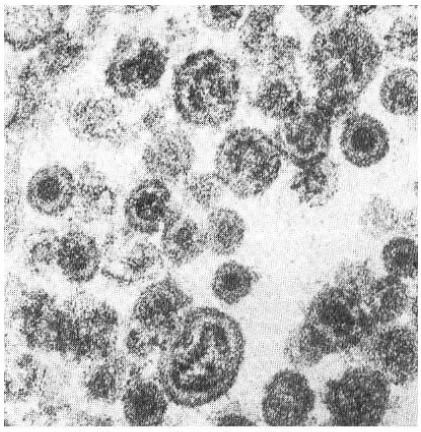


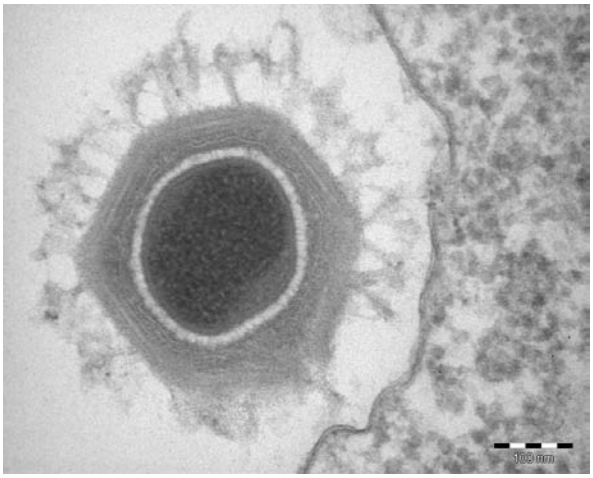
Figure 1. Rubella Virus

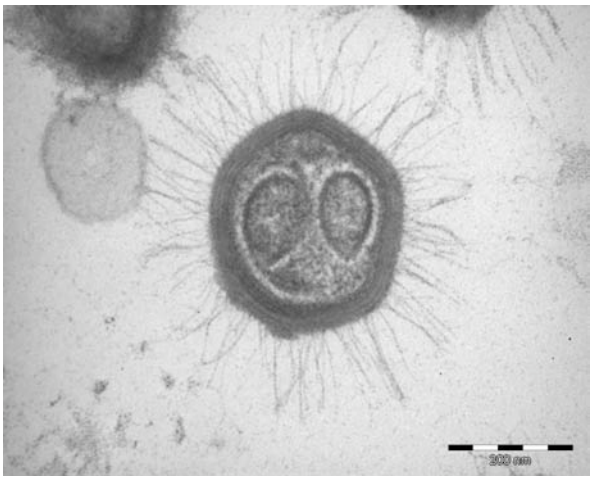
Rubella virus is an acute infection in children and adults, also known as German Measels (Röteln). It is characterized by fever and a lightly spotted rash.

SPECIAL VIRUSES

MIMIVIRUS

A new, big virus.





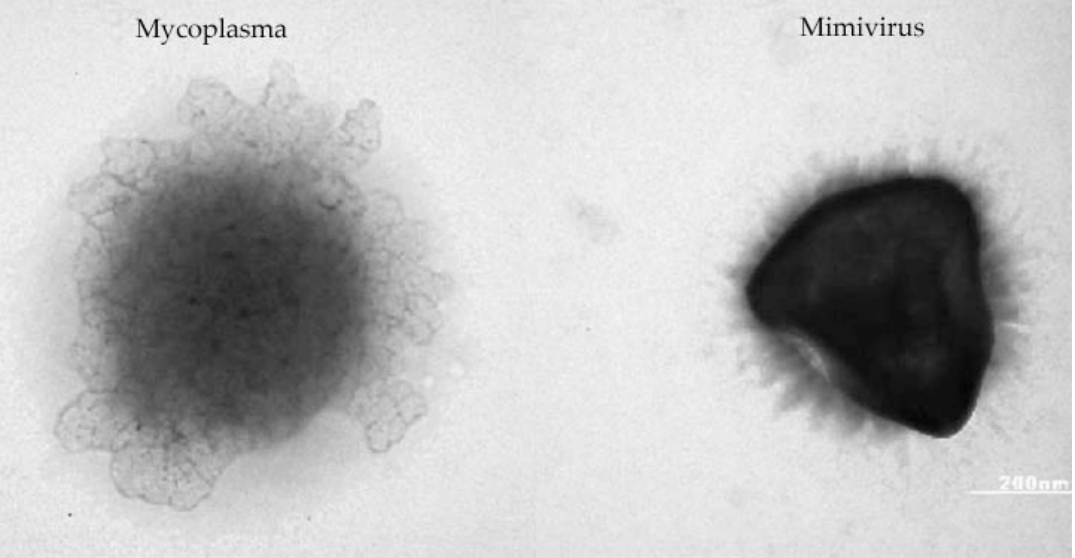
Mimivirus particle infecting an ameoba

The surprise in the mimivirus genome, was not only its record 1.2-Mb size, but the nature of its gene content itself. The detailed analysis of mimivirus genome analysis brings about three different lines of evidence [3].

1)mimivirus is a "regular" nucleocytoplasmic large DNA virus (NCLDV): it contains all the core genes that have been identified as strictly or most often conserved in previously described pox-, irido-, asfar- and phycodna- viruses.

2)Yet, an analysis of the most similar homologs of mimivirus genes, as well as its pattern of loss of facultative NCLDV "core genes" does not suggest an affinity with one of the established NCLDV families. Mimivirus appears to be the first representative of the mimiviridae, a proposed new NCLDV group.

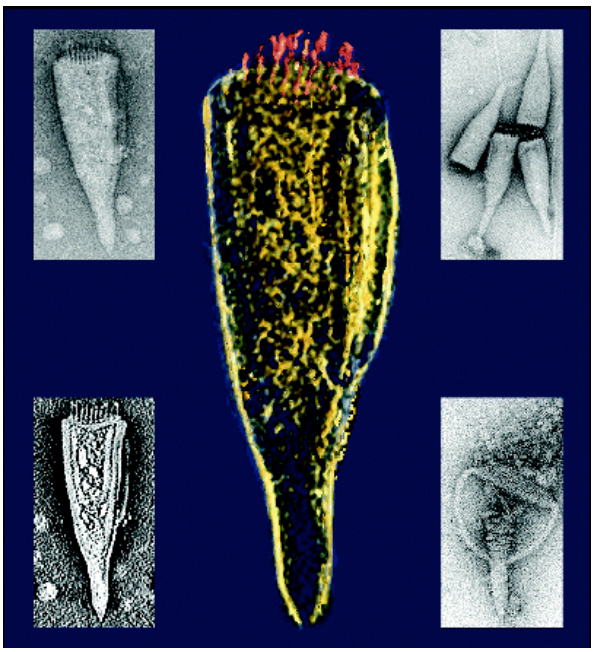
3)In addition to a normal complement of NCLDV gene homologs, mimivirus exhibits many genes encoding functions never encountered in any virus, including eight components central to protein translation: four aminoacyl tRNA synthetases (aaRS) together with four translation factors relevant to each of the initiation, elongation and termination steps. The enzymatic activity of mimivirus tyrRS has been experimentally verified.



SPECIAL VIRUSES

AMPULLAVIRIDAE

Ever and anon unknow viruses are found and have to be classified and disposed into existing or new viral families.



The center shows a false-color-coded visualization of the 3D structure of ***Acidianus* bottle-shaped virus** (ABV) obtained by electron tomography (approximate size, 230 by 75 nm). Other images, clockwise from top left, show a single, negative-stained ABV virion, digitally imaged by transmission electron microscopy; four ABV virions, attached to each other with the ring of filaments; a partly disrupted virus, displaying parts of its interior structural components; and a tomographic section through the 3D reconstruction of the virion.

Viral Diversity in Hot Springs of Pozzuoli, Italy, and Characterization of a Unique Archaeal Virus, *Acidianus* Bottle-Shaped Virus, from a New Family, the *Ampullaviridae*

Monika Häring,1,2 Reinhard Rachel,2 Xu Peng,3 Roger A. Garrett,3 and David Prangishvili1,2*

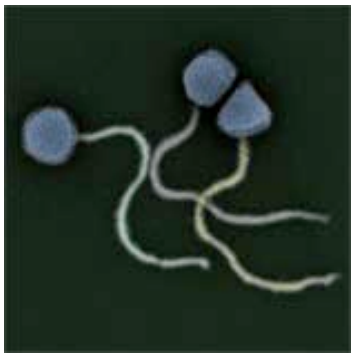
Molecular Biology of the Gene in Extremophiles Unit, Institut Pasteur, rue Dr. Roux 25, 75724 Paris Cedex 15, France,1 Department of Microbiology, Archaea Centre, University of Regensburg, Universitätsstrasse 31, D-93053 Regensburg, Germany,2 Danish Archaea Centre, Institute of Molecular Biology, Copenhagen University, Sølvgade 83H, DK-1307 Copenhagen K, Denmark3

Received 2 February 2005/ Accepted 20 April 2005

Virus-like particles with five different morphotypes were observed in an enriched environmental sample from a hot, acidic spring (87 to 93°C, pH 1.5) in Pozzuoli, Italy. The morphotypes included rigid rods, flexible filaments, and novel, exceptional forms. Particles of each type were isolated, and they were shown to represent viable virions of five novel viruses which infect members of the hyperthermophilic archaeal genus *Acidianus*. One of these, named the *Acidianus* bottle-shaped virus, ABV, exhibits a previously unreported morphotype. The bottle-shaped virion carries an envelope which encases a funnel-shaped core. The pointed end of the virion is likely to be involved in adsorption and channeling of viral DNA into host cells. The broad end exhibits 20 (± 2) thin filaments which appear to be inserted into a disk, or ring, and are interconnected at their bases. These filaments are apparently not involved in adsorption. ABV virions contain six proteins in the size range 15 to 80 kDa and a 23.9-kb linear, double-stranded DNA genome. Virus replication does not cause lysis of host cells. On the basis of its unique morphotype and structure, we propose to assign ABV to a new viral family, the *Ampullaviridae*.

SPECIAL VIRUSES

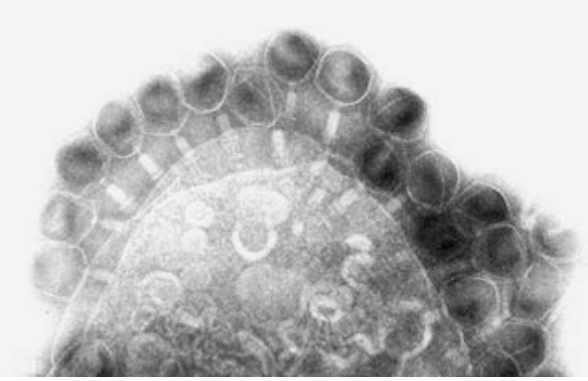
BACTERIOPHAGES

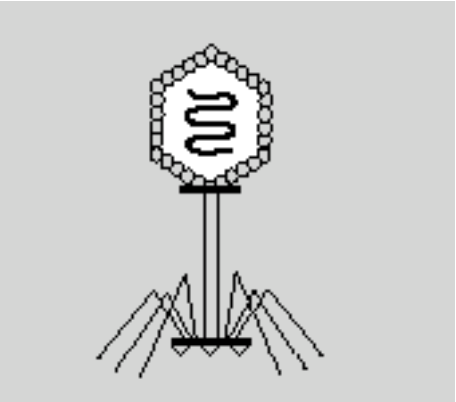


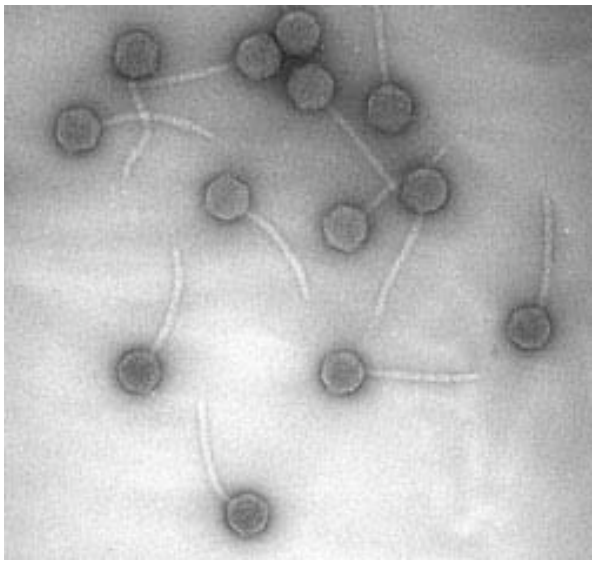
Bacteriophage (phage) are obligate intracellular parasites that multiply inside bacteria by making use of some or all of the host biosynthetic machinery (i.e., viruses that infect bacteria.).

There are many similarities between bacteriophages and animal cell viruses. Thus, bacteriophage can be viewed as model systems for animal cell viruses. In addition a knowledge of the life cycle of bacteriophage is necessary to understand one of the mechanisms by which bacterial genes can be transferred from one bacterium to another.

Bacteriophages: RC-1-Phages on Rhodobacter casulatus







Picture source:

Cover: http://www.em-va.unizh.ch/ Electron Microscopy / University of Zurich. Thank you Elisabeth Schraner!

Introduction: http://www.dform.com/projects/t4/virus.html, about viruses

Virus Overview: http://www.vetmed.ucdavis.edu/viruses/download.html, School of Veterinary Medicine, University of California, Davis, CA, with permission for our educational purposes

DNA Viruses:

Adenoviridae:
http://www.em-va.unizh.ch, Electron Microscopy / University of Zurich. Thank you Elisabeth Schraner
http://www.parent.qub.ac.uk , from Stewart McNulty at Veterinary Sciences, Queen's University, Belfast.
http://www.vetvir.unizh.ch , from the Electron Microscopy, University of Zurich (Ultrathin section of a cell nucleus)
http://www.virology.net/Big_Virology/BVDNAadeno.html, from Center for Cell Imaging at the Yale University School of Medicine.
http://www.bmc.uu.se/virology/welcome.html, from the Department of Virology, Biomedical Centre of Uppsala.
http://web.uct.ac.za/depts/mmi/stannard/adeno.html, from Linda Stannard, of the Department of Medical Microbiology, University of Cape Town
http://www.virology.net/Big_Virology/EM/Adeno-FD.jpg, From Milan Nermut from the UK's National Institute for Biological Standards and Control
http://wwwparent.qub.ac.uk/afs/vs/vsd3.gif, from Stewart McNulty at Veterinary Sciences, Queen's University, Belfast.

Baculoviridae:
We thank Dr. Hans Ackermann, Department of Microbiology, Medical Faculty, Laval University Quebec, Canada for the pictures from the Granulovirus (left), Nucleopolyhedrovirus (right).
http://www.virology.net/Big_Virology/BVDNAbaculo.html, from the Carstens' Lab at Queen's University, Canada.

Circoviridae:
http://www.ictvdb.iacr.ac.uk/WIntkey/Images/vsd12_c.jpg
http://www.oropharma.com/en/duiven/html/circovirus.html
http://www.qub.ac.uk/afs/vs/vsd9c.gif

Hepadnaviridae:
http://research.amnh.org/exhibitions/epidemic/hepb.html
http://web.uct.ac.za/depts/mmi/stannard/hepb.html, from Linda Stannard, of the Department of Medical Microbiology, University of Cape Town

Herpesviridae:
http://www.vetvir.unizh.ch/frame.html, from the Electron Microscopy, University of Zurich (Bovine Herpesvirus, Type2)
http://www.ncbi.nlm.nih.gov/ICTVdb/Images/Fenner/herpes2.htm, John Curtin School of Medical Research, Canberra, Dr. Frank Fenner
http://web.uct.ac.za/depts/mmi/stannard/herpes.html, fm Linda Stannard, Department of Medical Microbiology, University of Cape Town
http://www.virology.net/Big_Virology/Special/EHV1/EHVpage.html, Steven K. Vernon, WHRI, Wyeth-Ayerst Research, Radnor, Pa.
http://lbmi.org/pathologyimages, Cytomegalovirus
http://www.pbrc.hawaii.edu/rrl/project4/viral_etiology_of_green_turtle_f.htm
http://www.turtles.org/h0149041.jpg
http://www.bio.davidson.edu/courses/genomics/seq/elevirus/elephantvirus.html
http://info.med.yale.edu/labmed/casestudies/casestudy7/casestudy7_13.html
http://www.clinical-virology.org/gallery/cvn_em_01.html

Iridoviridae:
http://www.cdc.gov/ncidod/eid/vol5no6/images/daszak4b.jpg
http://www.cdc.gov/ncidod/eid/vol5no6/images/daszak5b.jpg
http://www.ucm.es/info/genetica/grupod/Cromovibac/iridovirus.jpg
http://www.sct.ub.es:801/Galeria/13T.gif

Papovaviridae:
http://wwwparent.qub.ac.uk/afs/vs/vsd15.gif
http://ww2.lafayette.edu/~hollidac/jacksforreal.html, Picture dated 5/4/04 by Mike Bellamy of Omaha, NB
http://web.uct.ac.za/depts/mmi/stannard/papillo.html, fm Linda Stannard, Department of Medical Microbiology, University of Cape Town
http://web.uct.ac.za/depts/mmi/stannard/papillo.html, fm Linda Stannard, Department of Medical Microbiology, University of Cape Town
http://web.uct.ac.za/depts/mmi/stannard/papillo.html, fm Linda Stannard, Department of Medical Microbiology, University of Cape Town
http://researchnews.osu.edu/archive/thinpreppics.htm, from Gerard Nuevo
http://www.bioreliance.com/investigate.html#BovinePapillomavirus

Parvoviridae:
http://www.vetvir.unizh.ch/frame.html, from the Electron Microscopy, University of Zurich (Porcines Parvovirus)
http://www.uct.ac.za/depts/mmi/stannard/parvo-c.gif

http://www.wadsworth.org/databank/hirez/gradyp2.gif

Poxviridae:
http://wwwparent.qub.ac.uk/afs/vs/vsd6e.html, From Stewart McNulty at Veterinary Sciences, Queen's University, Belfast
http://www.virology.net/Big_Virology/EM/mollusc3.gif
http://www.bioreliance.com/investigate.html#parapoxvirus
http://www.csiro.au/index.asp?type=mediaRelease&id=Prpox2

African Swine Fever:
http://www.ars.usda.gov/is/graphics/photos/piadc/k7335-17.jpg
http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAH/EMPRES/GEMP/resources/500/asf-pm-Asf118_jpg.jpg
http://www.iah.bbsrc.ac.uk/schools/factfiles/ASF.htm

RNA Viruses:

Arenaviridae:
http://www.virology.net/Big_Virology/BVRNAarena.html, reprinted from Scientific American
http://www.multiscope.com/ratzapper/arenavirus.htm
http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/lassaf.htm

Arteriviridae:
Fields Virology, 4th edition, Volume 1, p. 1207

Astroviridae:
http://www.virology.net/Big_Virology/BVRNAastro.html, by Dr Hans Ackermann, Department of Microbiology, Laval University, Quebec, Canada.
http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/00.005.htm, by Dr Hans Ackermann, Department of Microbiology, Laval University, Quebec, Canada.
http://www.em-va.unizh.ch, Electron Microscopy / University of Zurich. Thank you Elisabeth Schraner

Birnaviridae:
http://www.qub.ac.uk/afs/vs/vsd6c.html, Veterinary Sciences, Queen's University, Belfast.
http://www.lib.noaa.gov/korea/diseases/img_status/slide003.gif

Bunyaviridae:
http://www.ncbi.nlm.nih.gov/ICTVdb/WIntkey/Images/b6.gif
http://www.virology.net/Big_Virology/BVRNAbunya.html, from Ray Bauman's Hantavirus Tutoria
http://web.uct.ac.za/depts/mmi/stannard/emimages.html, from Linda Stannard, of the Department of Medical Microbiology, University of Cape Town

Caliciviridae:
http://www.epa.gov/nerlcwww/images.htm
http://www.ncbi.nlm.nih.gov/ICTVdb/WIntkey/Images/em_calic.gif
http://wwwparent.qub.ac.uk/afs/vs/vsd19.jpg
http://www.virology.net/Big_Virology/EM/em_norwa.GIF
http://www.virology.net/Big_Virology/BVRNAcalici.html

Coronaviridae:
http://www.virology.net/Big_Virology/BVRNAcorona.html
http://www.visualsunlimited.com/browse/vu203/vu203243.html
http://www.kuleuven.ac.be/rega/mvr/sarspic.htm
http://wwwparent.qub.ac.uk/afs/vs/vsd14.jpg
http://www.tulane.edu/~dmsander/WWW/335/Corona.gif

Filoviridae:
http://www.cdc.gov/ncidod/dvrd/spb/images/pathimag/Marburg-emb.jpg
http://www.ncbi.nlm.nih.gov/ICTVdb/WIntkey/Images/em_filov.jpg
please find important information about Marburg and Ebola on http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/marburg.htm

Flaviviridae:
http://www.vitanet.de/gesundheitsratgeber/infektionen/zeckenbisserkrankungen/erkennen/uebertragung/fsme/
http://bienen-netz.de/Wissen/seite-z.htm, tick
http://www.lib.uiowa.edu/hardin/md/cdc/2176.html
http://scarab.msu.montana.edu/historybug/yellow_fever.htm, mosquito and information about yellow fever
http://biology.beloit.edu/emgdis/2001pages/eradicate/denvirus.jpg
http://www.verbraucherministerium.de/forschungsreport/rep1-98/ima1_98/s07a.jpg, CSFever: Dr. F. Weiland, BFAV Tübingen

http://epitrop.cirad.fr/fr/epidemio/MaladiePrio/ppa.html
http://www.ukl.uni-freiburg.de/microbio/vir/haller/images/hepatitis-c.gif
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http://jvi.asm.org/content/vol76/issue7/cover.shtml with permission of American Society for Microbiolgoy

Orthomyxoviridae:
http://www.uct.ac.za/depts/mmi/stannard/flu3c.gif
http://www.uct.ac.za/depts/mmi/stannard/flucolo3.gif
http://wwwparent.qub.ac.uk/afs/vs/vsd10.gif
http://www.pbs.org/wnet/secrets/case_killerflu/clues.html

Paramyxoviridae:
http://www.vir.gla.ac.uk/staff/bhellad/Paramyxo_401_30k.jpg
http://www.ncbi.nlm.nih.gov/ICTVdb/WIntkey/Images/paramyx.gif
http://www.uct.ac.za/depts/mmi/stannard/para-4a.gif
http://www.monachus-guardian.org/mguard10/1001cont.htm
http://www.virology.net/Big_Virology/BVRNApara.html R. Kaushik, Dep. of Microbiology & Cell Biology, Indian Institiute of Science, Bangalore, India
http://www.visualsunlimited.com/browse/vu469/vu469349.html

Picornaviridae:
http://wwwparent.qub.ac.uk/afs/vs/vsd16.gif
http://www.virology.net/Big_Virology/EM/smplv4.JPG
http://www.virology.net/Big_Virology/EM/fmdv.jpg
http://www.virology.net/Big_Virology/EM/r14_ico.gif
http://www.virology.net/Big_Virology/EM/mengo.jpg
http://www.virology.net/Big_Virology/EM/polio1.gif
http://www.accessexcellence.org/WN/graphics/fmdvirus.jpg
http://jvi.asm.org/content/vol77/issue11/ with permission of American Society for Microbiolgoy
http://www.epidemic.org/theFacts/viruses/viralReplication.html
University of Basel
http://journals.iucr.org/d/issues/2002/06/02/gr2243/gr2243fig1.html

Reoviridae:
http://wwwparent.qub.ac.uk/afs/vs/vsd2.gif
http://www.ncbi.nlm.nih.gov/ICTVdb/Images/Cornelia/calver1.jpg
http://www.epa.gov/nerlcwww/graphics/rota.jpg

Retroviridae:
http://www.virology.net/Big_Virology/BVretro.html
http://www.virology.net/Big_Virology/BVretro.html, From the Department of Microbiology, University of Otaga, New Zealand.
http://www.denniskunkel.com/index.php?cPath=13&sort=1a&page=2
http://www.ncbi.nlm.nih.gov/ICTVdb/WIntkey/Images/gm_lenti.gif

Rhabdoviridae:
http://www.virology.net/Big_Virology/BVRNArhabdo.html, from Frederick A. Murphy, now at U.C. Davis
http://www.virology.net/Big_Virology/BVRNArhabdo.html
http://www.virology.net/Big_Virology/BVRNArhabdo.html, from ATV's Special Rabies page by Steven K. Vernon, of Wyeth-Ayerst Research
http://www.virology.net/Big_Virology/BVRNArhabdo.html
http://www.vetmed.ucdavis.edu/viruses/download.html Micrograph fm F. A. Murphy, School of Veterinary Medicine, University of California, Davis.

Togaviridae:
http://www.abc.net.au/science/news/img/rrv3.jpg, Pic: John Curtin School of Medical Research
http://www.tcd.ie/Microbiology/Webfigure.JPEG
http://www.choicehealthcare.co.uk/mmr_rubella.html
http://www.labnews.de/en/specials/rubella/abc/theabc.php
http://duke.usask.ca/~misra/virology/stud2004/wee2/homepage.html Link for EEEV and WEEV

Special Viruses:
Mimivirus:
http://giantvirus.org/gallery.html

Ampullaviridae:
http://jvi.asm.org/content/vol79/issue15/index.dtl with permission of American Society for Microbiolgoy

Bakteriophage:
http://www.em-va.unizh.ch/ Electron Microscopy / University of Zurich
http://pathmicro.med.sc.edu/mayer/phage.htm
http://www.infektionsbiologie.ch/seiten/lernwege/lernweg_viren/viren_kap1_02.htm
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