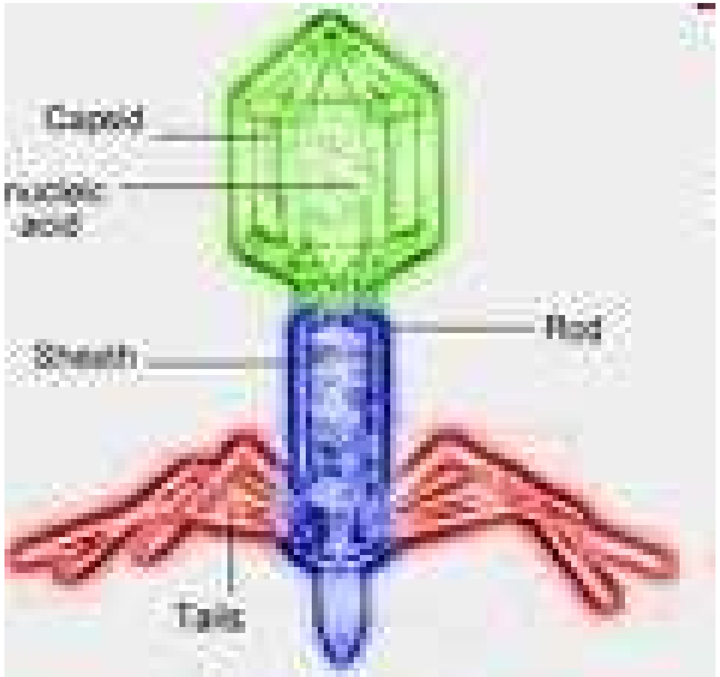
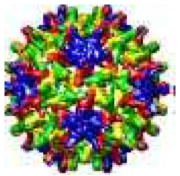
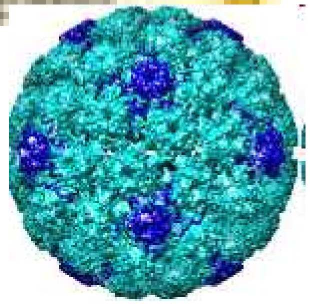
CHAPITRE V
NOTIONS DE VIROLOGIE

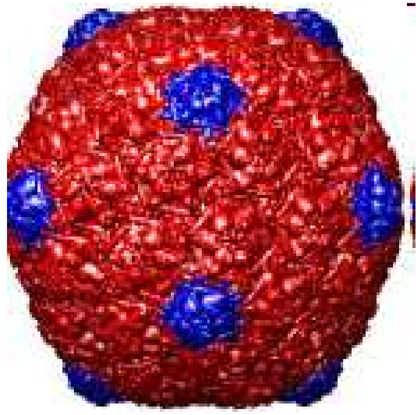




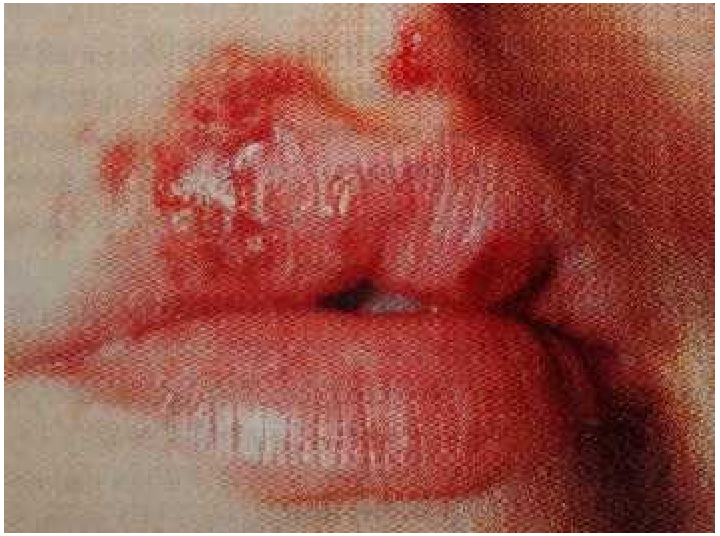
Hepatitis B Virus,

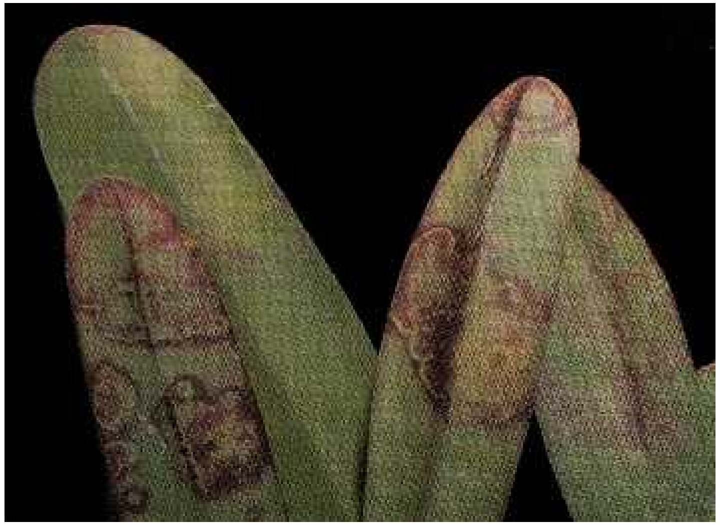


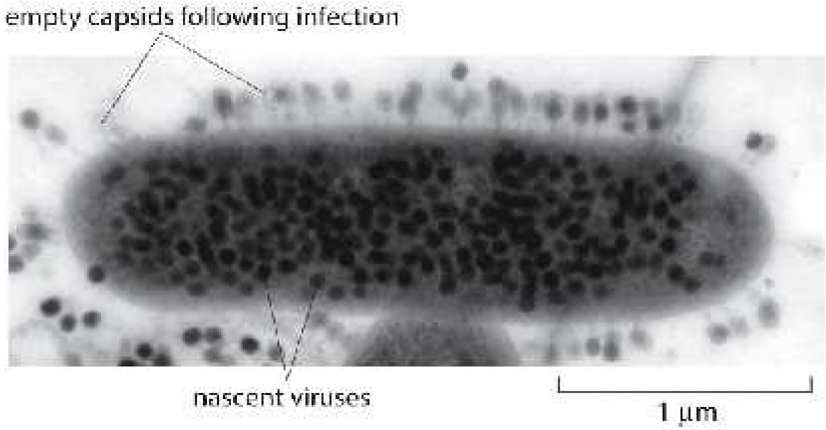
Human Papillomavirus 16 L1



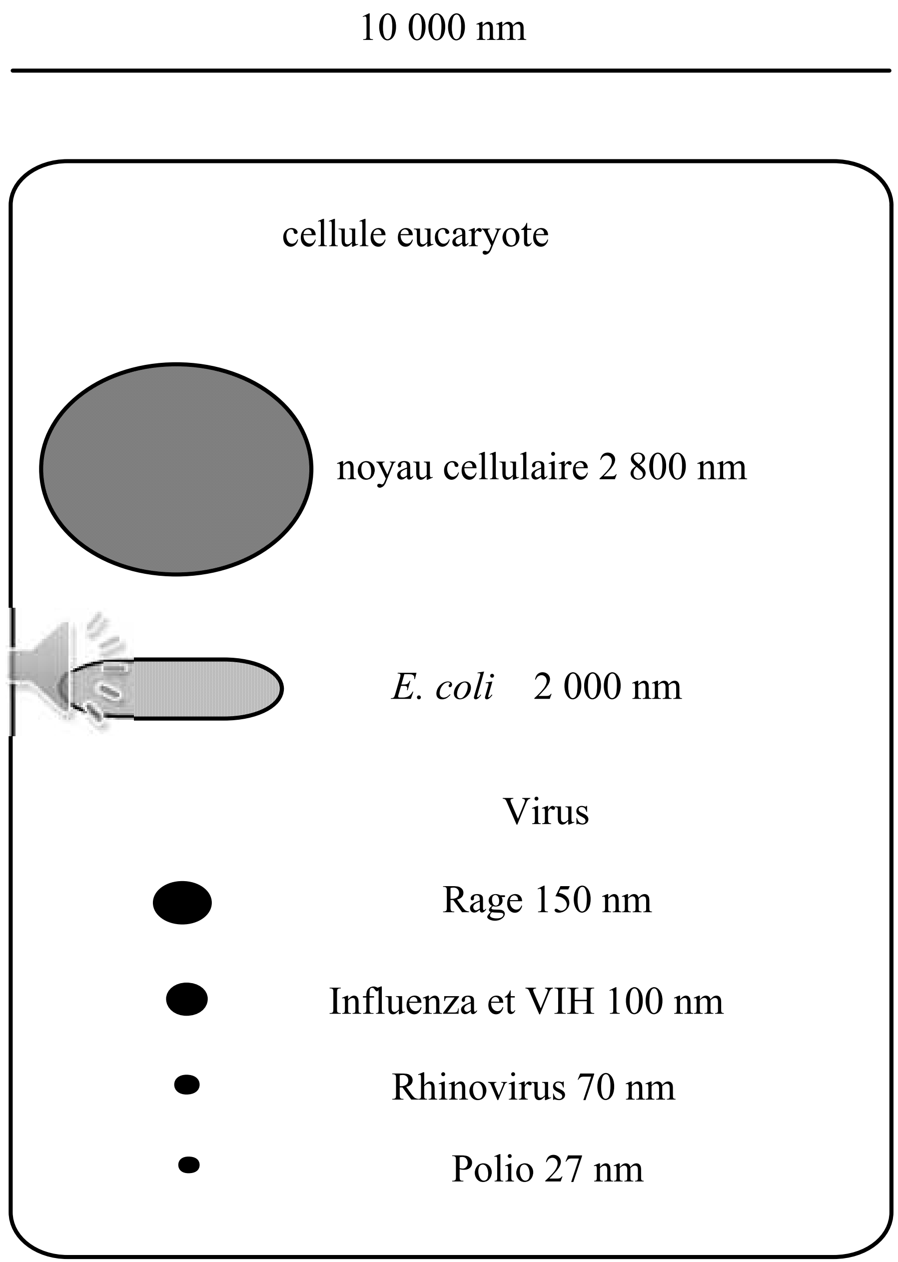
Bacteriophage HK97 HeadII






empty capsids following infection
nascent viruses
1 µm

TAILLE DES VIRUS



1 nm = 10^{-9} m

General properties of viruses

- Replicate independently of the chromosome of cells, but dependent on cells
- Infect animals (and people), plants, and bacteria (**bacteriophage**)
- Extracellular forms (**virions**) are metabolically inert
- Contain either DNA or RNA
- Range in size from about 28 nm to about 200 nm in diameter
- Important tools for microbial geneticists and genetic engineers

STRUCTURE DES VIRUS

Tous les virions, qu'ils soient entourés d'une enveloppe ou non, sont construits autour d'une nucléocapside centrale.

La nucléocapside est composée d'un acide nucléique, soit de l'ADN soit de l'ARN, maintenu dans une coque protéique appelée capside.

La capside protège le matériel génétique viral et favorise ainsi son transfert éventuel vers une cellule hôte.

Le filament d'acides nucléiques peut être de l'ADN ou de l'ARN. Il représente le génome viral.

Il peut être circulaire ou linéaire, bicaténaire (double brin) ou monocaténaire (simple brin).

Le génome sous forme d'ADN est généralement bicaténaire.

Le génome sous forme d'ARN est généralement monocaténaire et peut être à polarité positive (dans le même sens qu'un ARN messager) ou à polarité négative (complémentaire d'un ARN messager).

STRUCTURE DE LA CAPSIDE

Certaines capsides sont de forme <u>icosahédrique</u>. (Un icosahèdre est un polyèdre régulier avec 20 faces triangulaires équilatérales et 12 sommets).

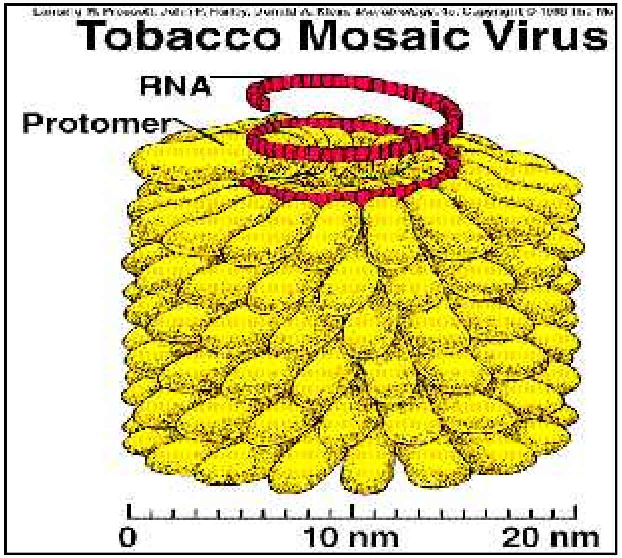
Certaines capsides sont <u>hélicoïdales</u> en forme de cylindre protéique creux; elles peuvent être rigides ou flexibles.

Les <u>virus complexes</u> sont ceux dont la symétrie de capside n'est pas totalement icosahédrique ou hélicoïdale.

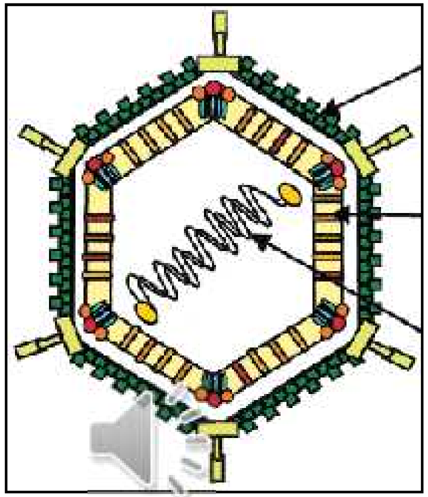
Certains virus possèdent une enveloppe lipidique (une couche extérieure membranaire entourant la nucléocapside).

Les virus enveloppés sont plutôt sphériques ou de forme variable même si leur nucléocapside est icosahédrale ou hélicoïdale.

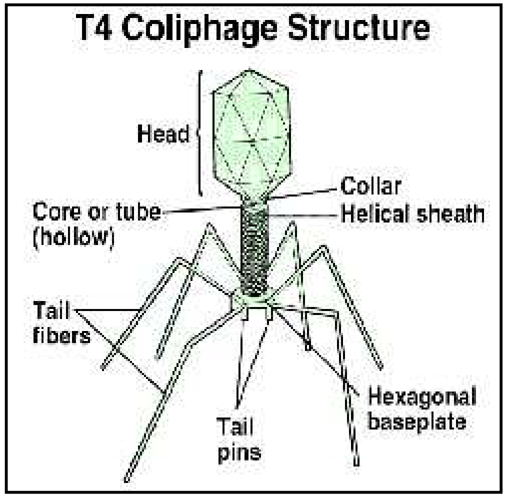
MORPHOLOGIE DES CAPSIDES



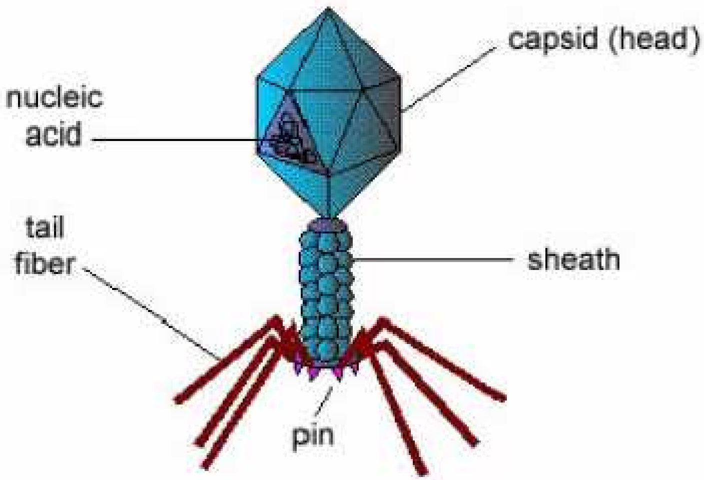
Hélicoïdale



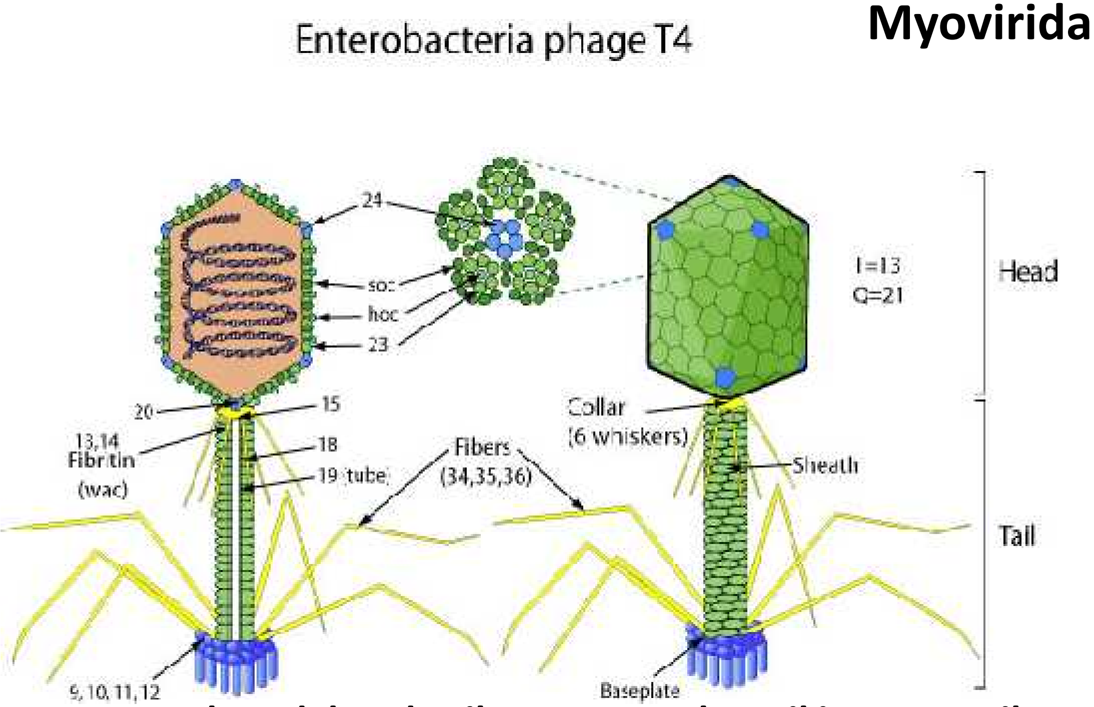
Icosahèdre

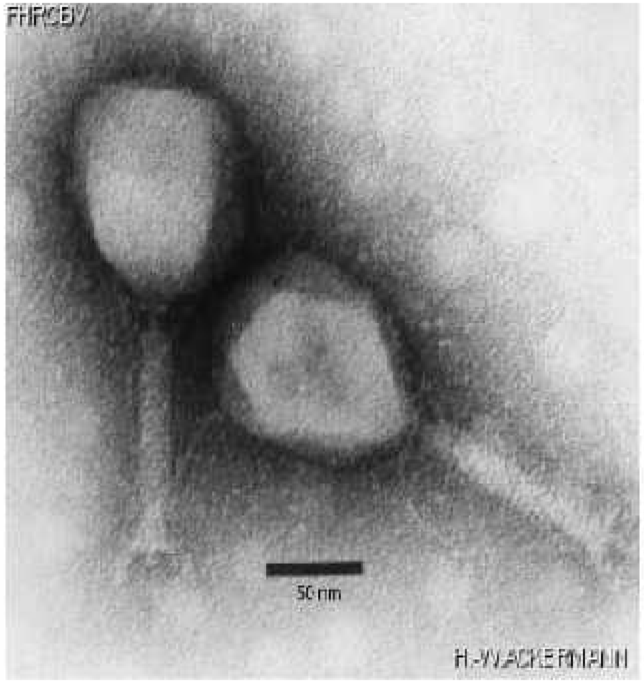


Complexe



Myoviridae





Non-enveloped, head-tail structure. The tail is contractile.

GENOME

Linear, dsDNA genome of about 33-244 kb, encoding for 40-415 proteins, the peduoviruses being the smallest ones. Some species have a linear, circularly permuted genome.

GENE EXPRESSION Genes are transcribed by operons.

REPLICATION CYTOPLASMIC

Adsorption: the phage attaches to the target cell through its tail fibers.

Viral exolysin degrades cell wall locally

Ejection of the viral DNA into host cell cytoplasm by contraction of the tail sheath.

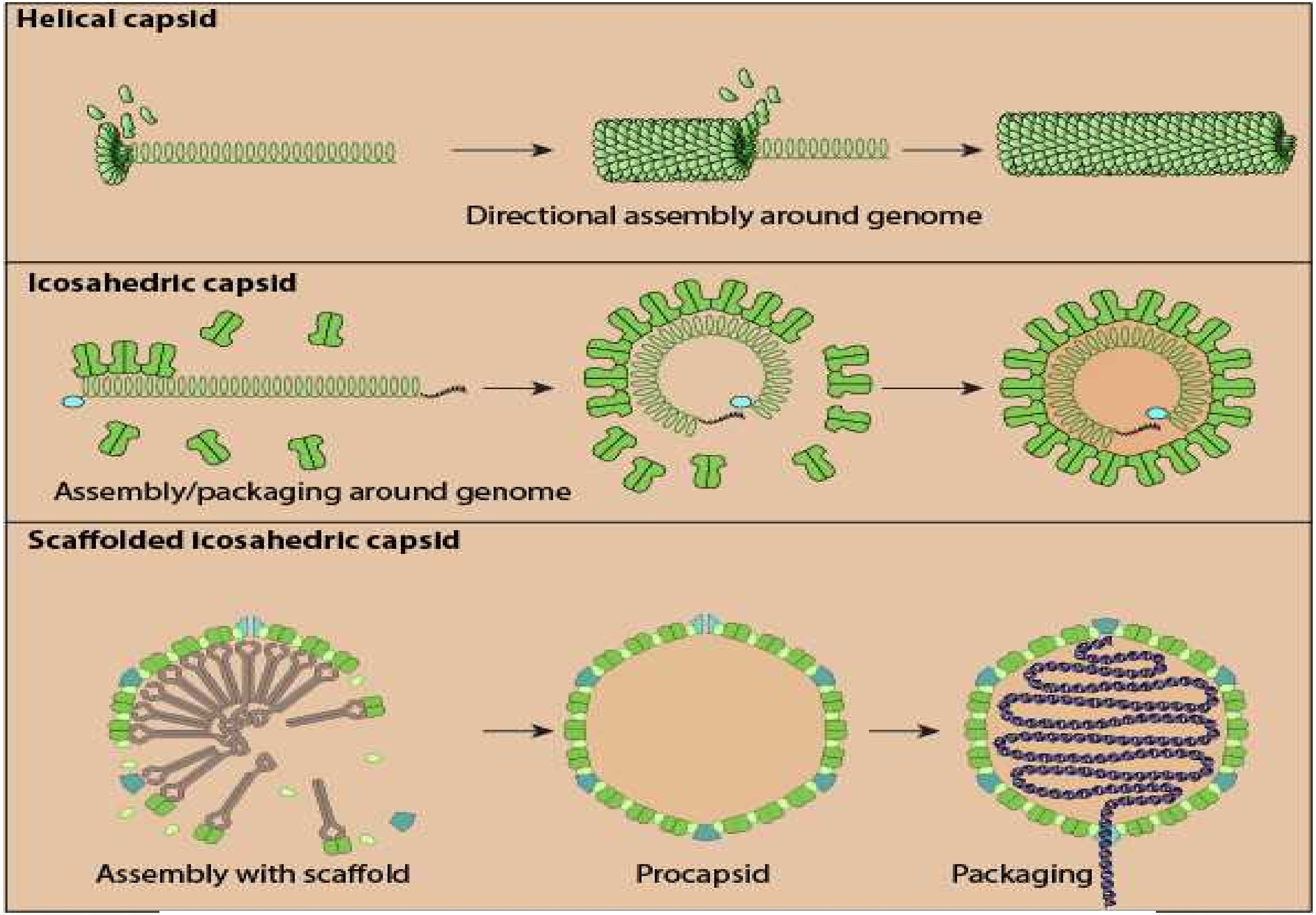
Transcription and translation of early genes.

Replication of genomic DNA. Transcription and translation of late genes.

Assembly of an empty procapsid and packaging of the genome.

Viral tail fibers assembly and viral tail assembly.

Mature virions are released from the cell by lysis.

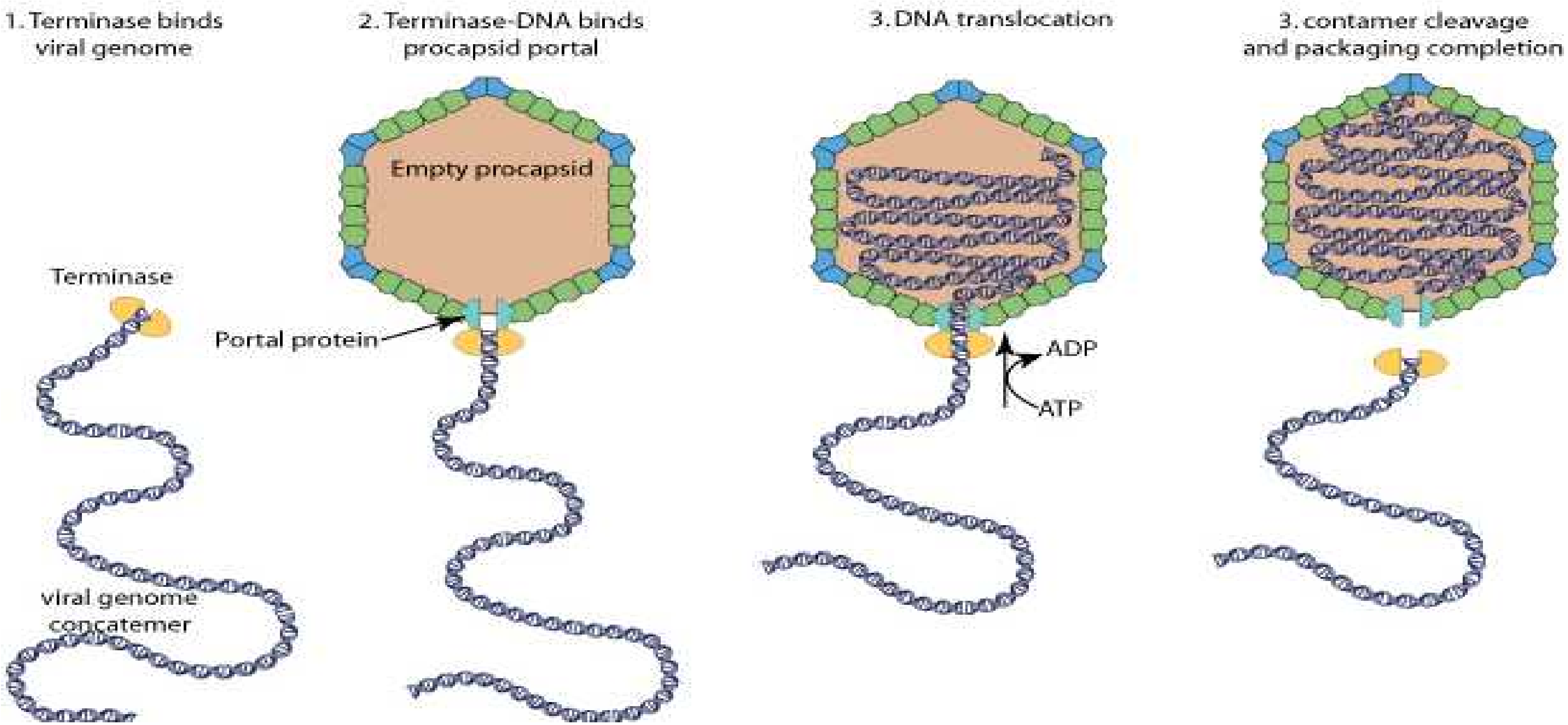


***Capsid assembly*: refers to the formation of the capsid shell.**
***Packaging*: refers to the viral genome placement inside a capsid or an envelope.**

Viral genome packaging

Large dsDNA bacteriophages, herpesviruses, adenoviruses and microviruses encode a powerful DNA-translocating machinenery that encapsidates a viral genome into a [preassembled capsid]() or procapsid . The packaging machine is often composed of a portal structure, which provides a gate for DNA entry, and an ATP-driven motor . This motor is composed of the large subunit whose ATPase activity fuels DNA translocation, and most frequently, a small subunit that binds to the viral packaging site. DNA cleavage can be coupled to genome packaging

Schematic diagram of genome packaging in dsDNA viruses

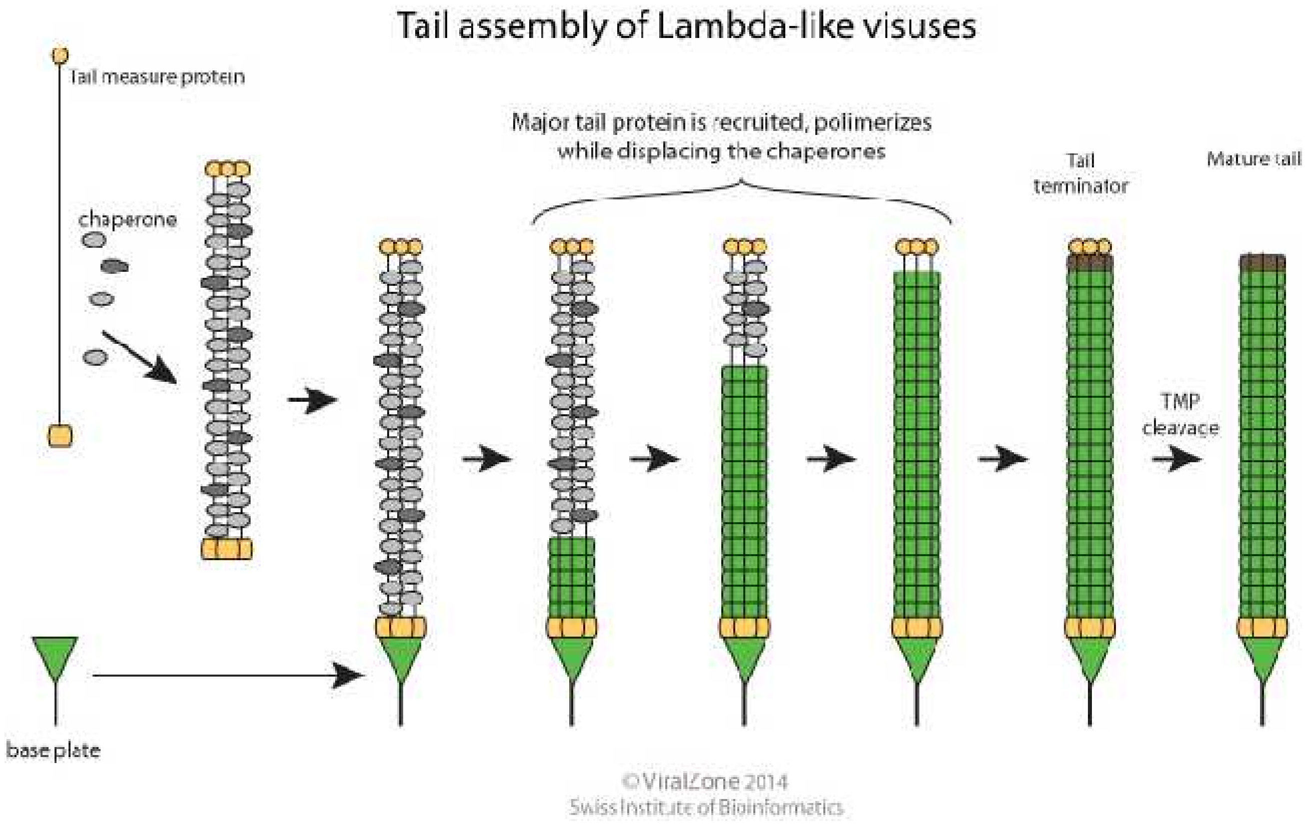


Viral tail assembly

Siphoviridae and Myoviridae tail and head assemblies occur independently. Tail assembly follows a sequential order . The tail measure protein (or tape measure protein, ruler) determines the length of Sipho- and Myoviridae tails .

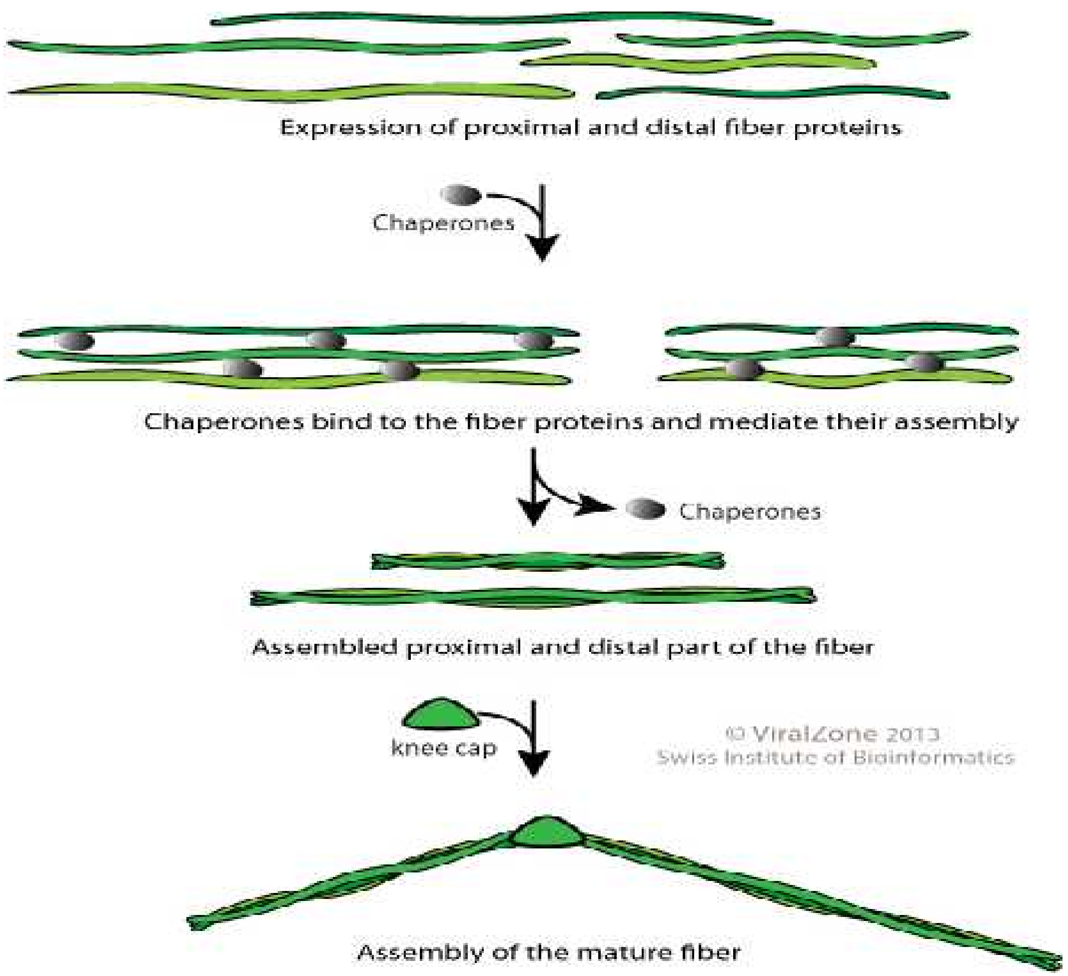
Tail tube protein polymerization starts from baseplate assembly . The tail measure protein possibly assembles with tail assembly chaperones, and the resulting complex interacts with baseplate to form the tail initiator. Tail tube protein polymerizes on this template and displaces the chaperones thereby creating the tube. It is unclear whether the tail measure protein is trapped inside.Once polymerization of the cylindrical part(s) of the tail has reached the expected length, terminator proteins stop the polymerization . In the phage lambda, the TMP is matured.

In many viruses, the tail assembly gene is expressed through a programmed translational frameshift and gives rise to two chaperone proteins with overlapping sequences



Viral tail fiber assembly

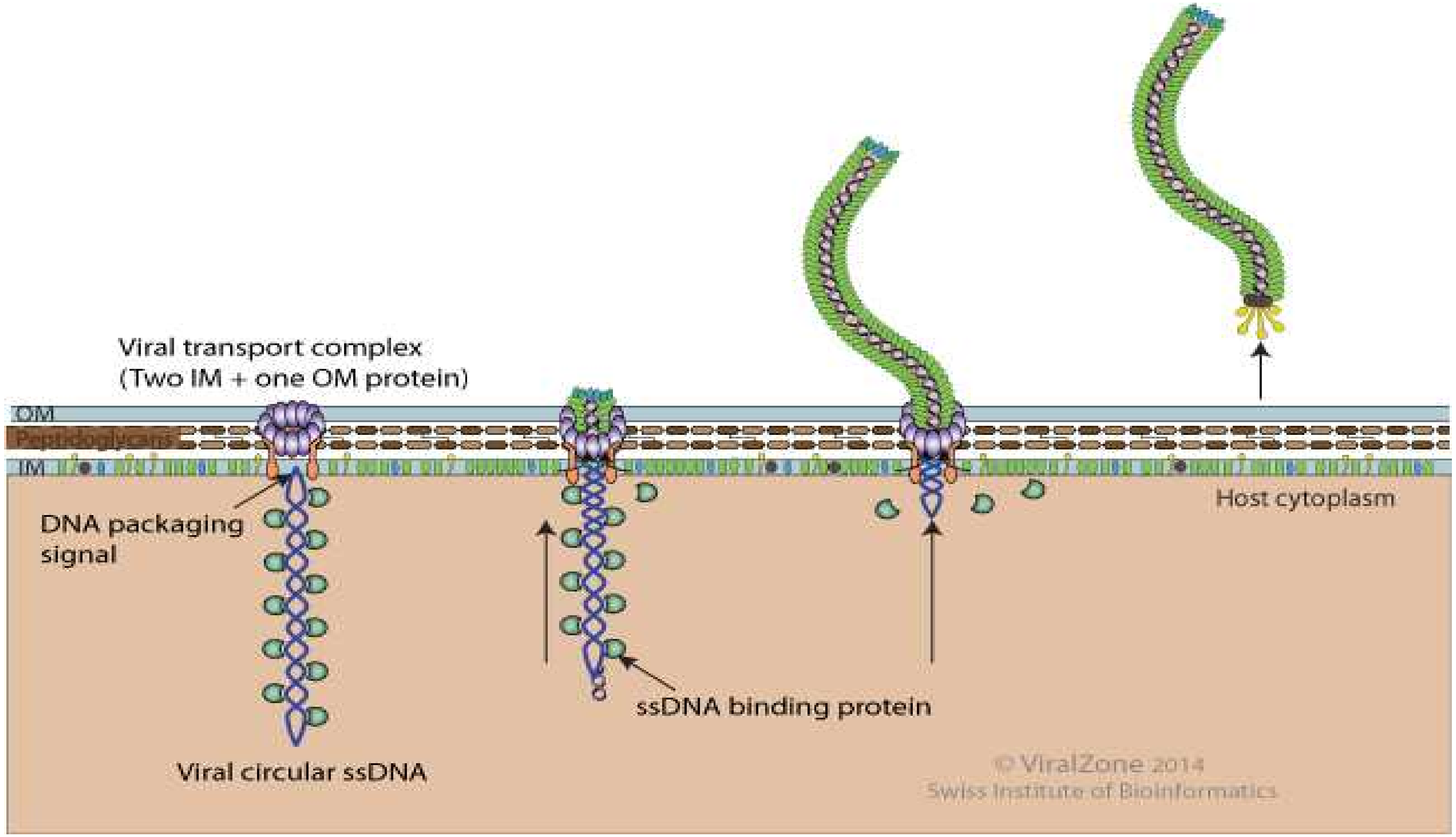
Caudovirales (tailed bacterial viruses) usually have fibers attached to the distal end of their tail. The preassembled are attached to the tail. The pathway of fibers assembly has been well studied in bacteriophage T4 _ . Chaperoning is needed for the correct assembly of the fiber proteins.



Viral extrusion

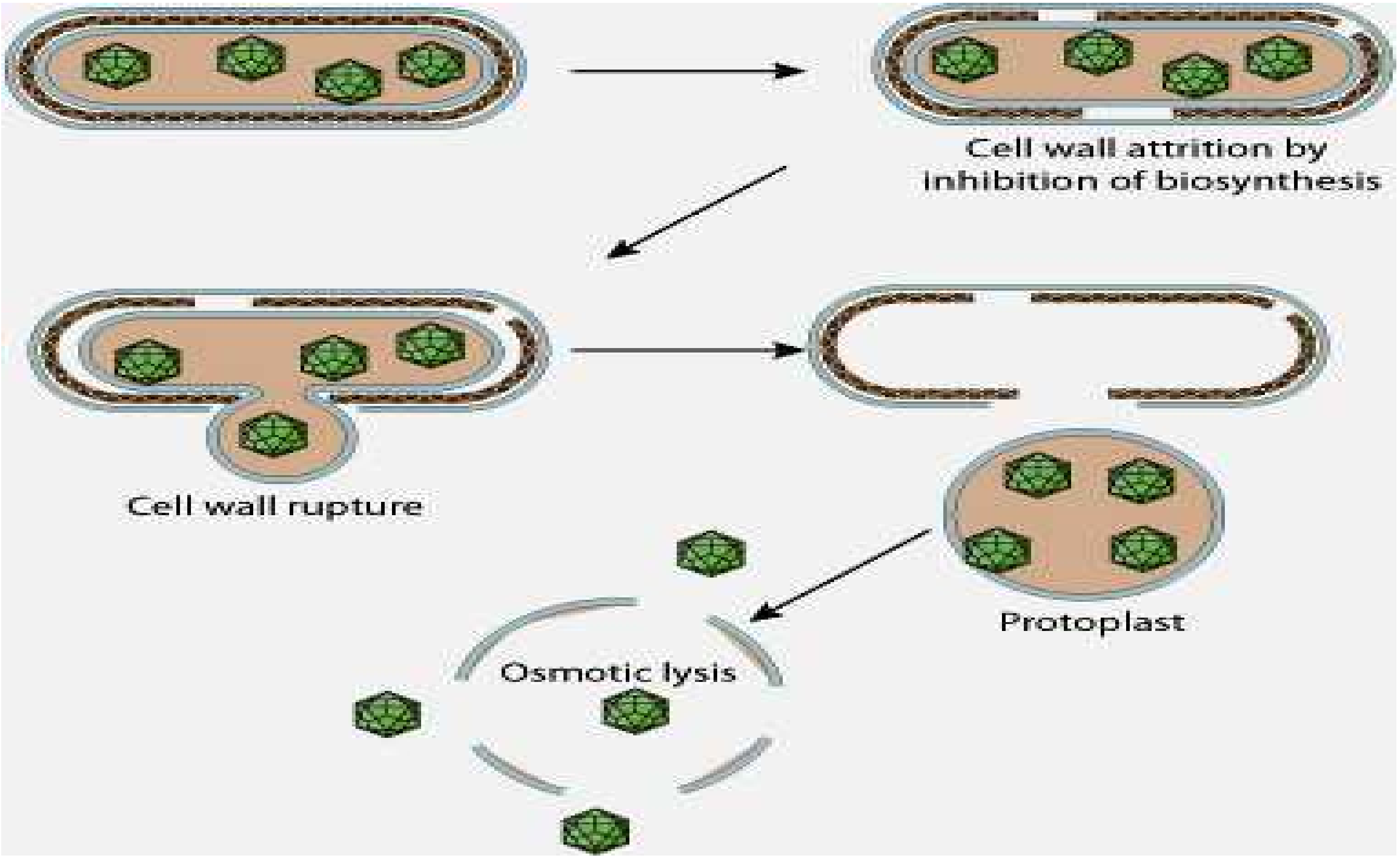
Filamentous phages are released by a concerted mechanism of assembly and secretion called extrusion. The neosynthesized virions are coordinately exported as they are assembled at the cell surface in a secretory process that leaves the host cell fully viable. Extrusion requires three non-capsid proteins, two of them allowing translocation through the inner membrane (IM) and one secretin-like protein forming the transmembrane channel in the outer membrane (OM).

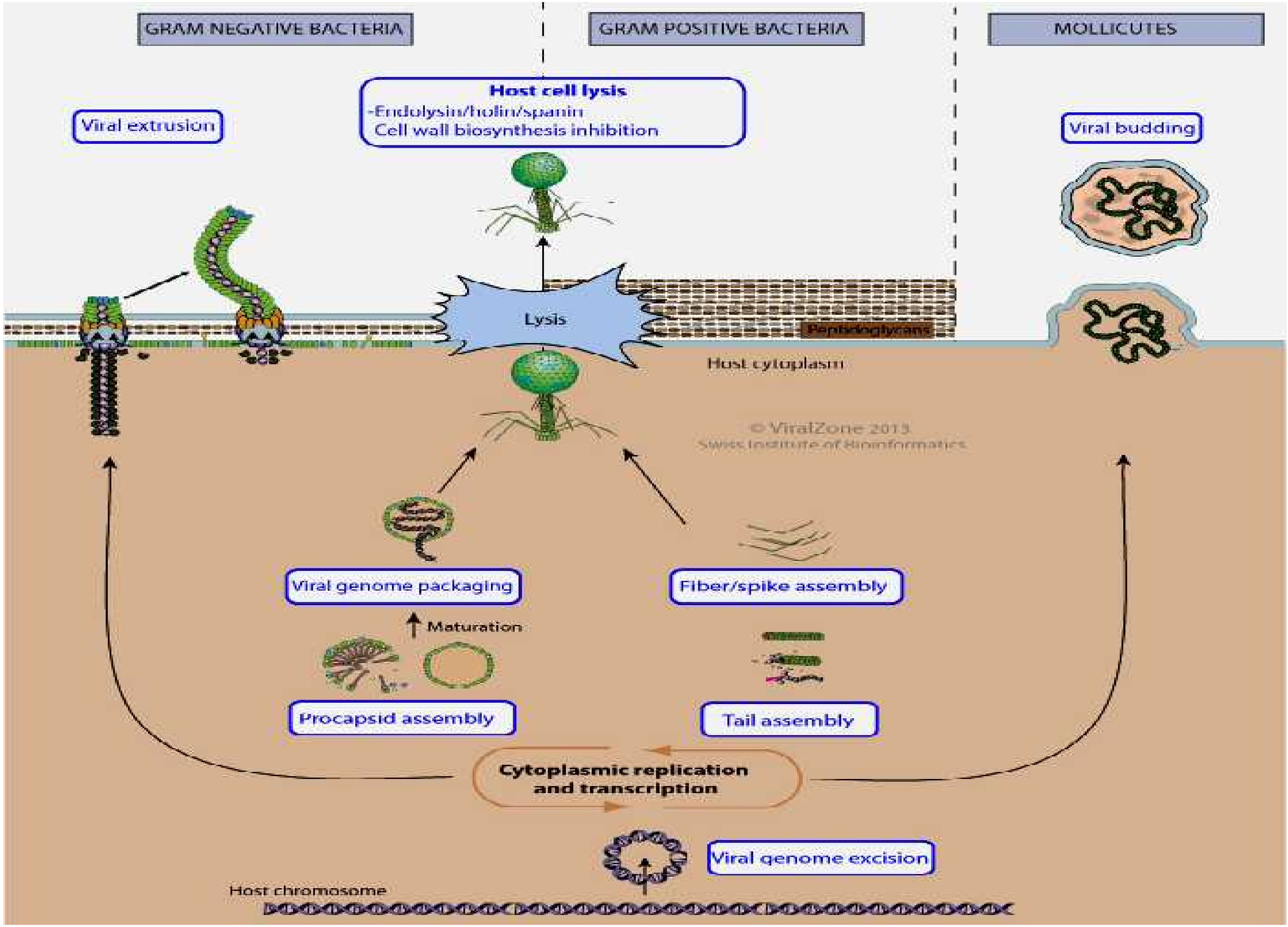
A viral single-stranded DNA binding protein coats progeny viral DNA molecules to generate the intracellular precursor for assembly of phage particles as they are extruded through the membranes of the bacterial host. The five structural proteins of the virus are anchored in the inner membrane before their incorporation into the phage particle. As assembly proceeds, the phage genome traverses the inner and outer membranes until the entire DNA molecule has been coated and extruded



Lysis by cell wall biosynthesis inhibition

Microviridae and *Leviviridae* accomplish bacterial host lysis by expressing cell wall biosynthetic inhibitors. A single protein inhibits cell wall regeneration, which induces breaks in the wall. The cell then loose it's wall to become a protoplast, which in turn is lysed by osmotic pressure.




GRAM NEGATIVE BACTERIA
GRAM POSITIVE BACTERIA
MOLLICUTES
Host cell lysis
-Endolysin/holin/spanin
Cell wall biosynthesis inhibition
Viral extrusion
Viral budding
Lysis
Peptidoglycans
Host cytoplasm
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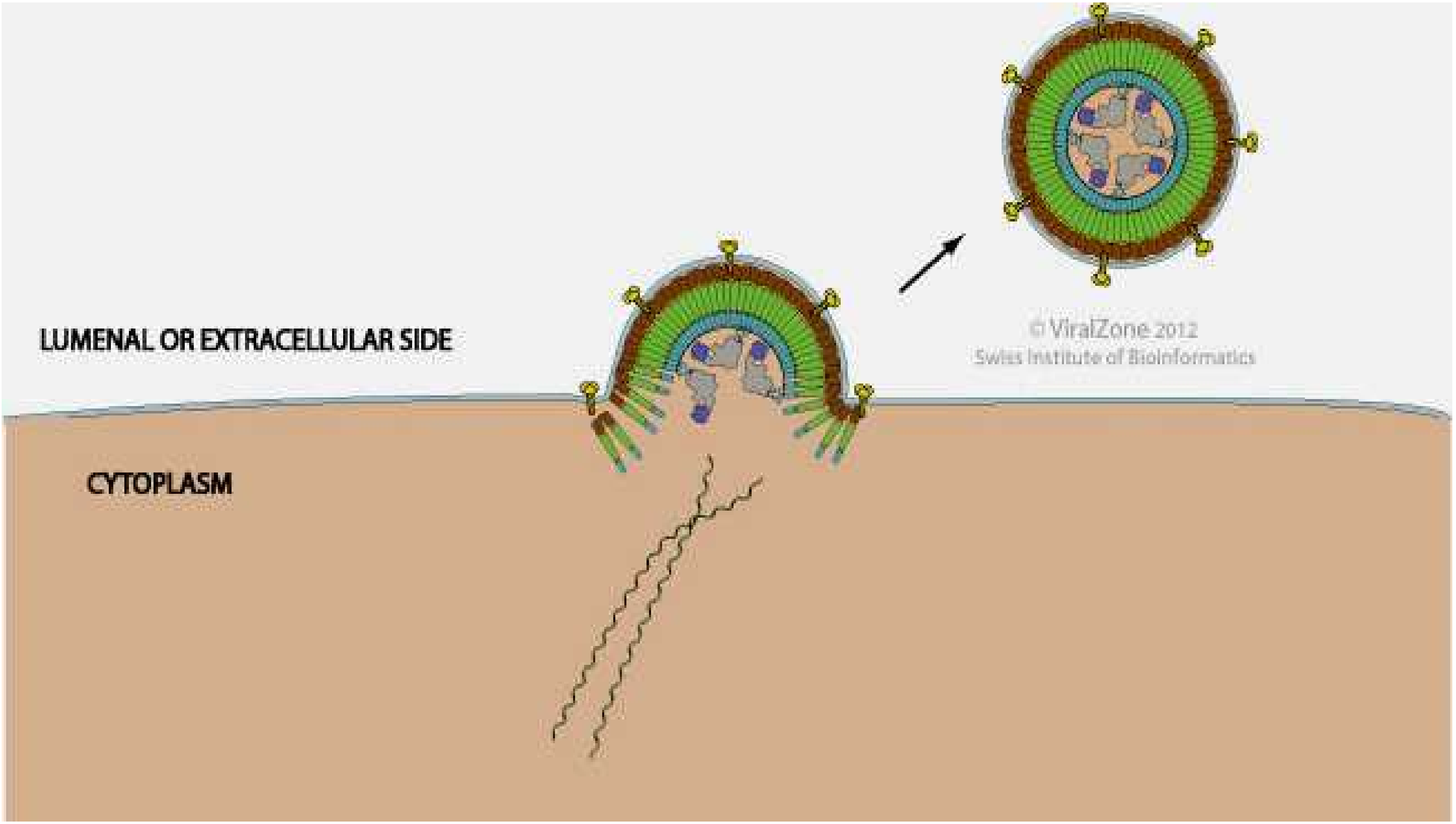
Swiss Institute of Bioinformatics
Viral genome packaging
Fiber/spike assembly
Maturation
Procapsid assembly
Tail assembly
Cytoplasmic replication
and transcription
Viral genome excision
Host chromosome


LUMENAL OR EXTRACELLULAR SIDE
CYTOPLASM
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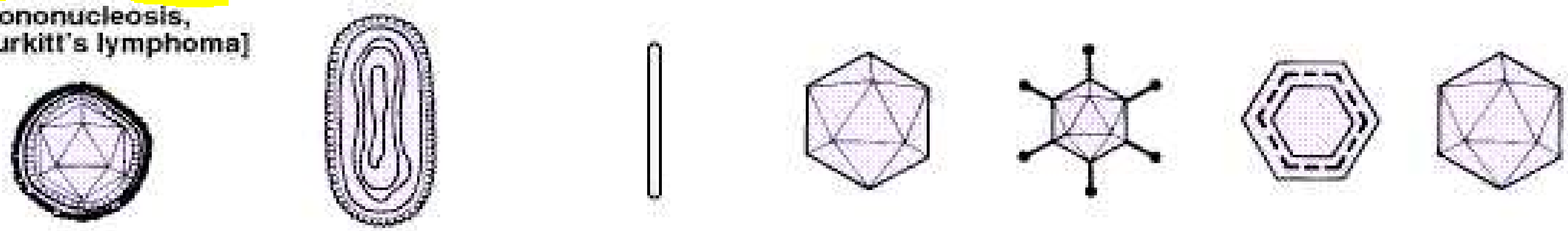
Swiss Institute of BioInformatics

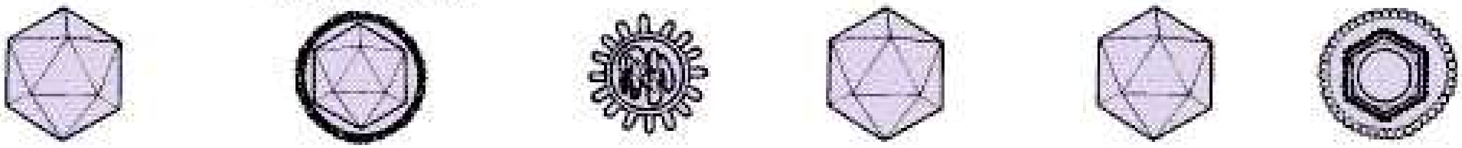
Taxonomy of DNA Animal Viruses

Strandedness	Double						Single
Enveloped or naked	Enveloped			Naked			Naked
Capsid symmetry	Icosahedral	Complex	Cylindrical	Icosahedral			Icosahedral
Size (nm)	180–200 (enveloped) 100–110 (capsid)	200–260 x 250–290 (enveloped)	40–110 x 200–400 (enveloped) 35–40 x 200–350 (capsid)	45–55	60–90	130–180	22
Site of capsid assembly	Nucleus	Cytoplasm	Nucleus	Nucleus	Nucleus	Cytoplasm	Nucleus
Virus family	*Herpesviridae*	*Poxviridae*	*Baculoviridae*	*Papovaviridae*	*Adenoviridae*	*Iridoviridae*	*Parvoviridae*
Re-presentative genera [Host, disease]	Herpes simplex virus, Type 1 [Humans: fever blisters, respiratory infections, encephalitis] Type 2 [Humans: genital infections] Varicella-zoster [Humans: chickenpox] Epstein-Barr virus [Humans: infectious mononucleosis, Burkitt's lymphoma]	Orthopoxvirus [Humans: smallpox] [Humans, cattle: cowpox] Avipoxvirus [Chickens: fowlpox]	Nuclear polyhedrosis virus Granulosis virus [Insects]	Papillomavirus [Humans, rabbits: benign tumors (warts)] Polyomavirus [Humans, mice: tumors in mice]	Mastadenovirus [Humans: respiratory infections] Aviadenovirus [Birds]	Iridovirus [Arthropods] African swine fever virus	Parvovirus [Humans, canines: gastroenteritis]



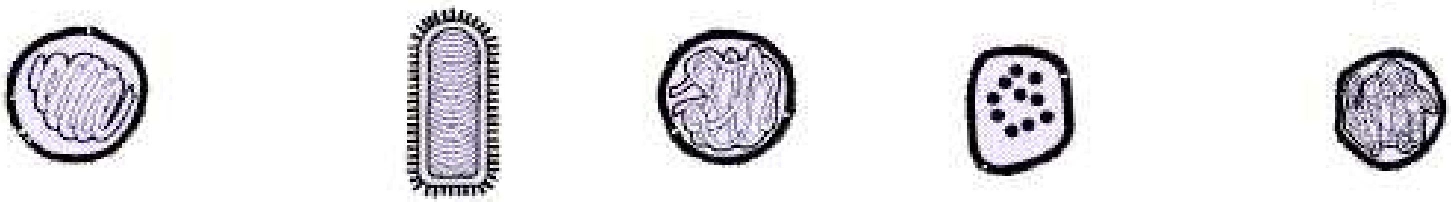
Taxonomy of RNA Animal Viruses

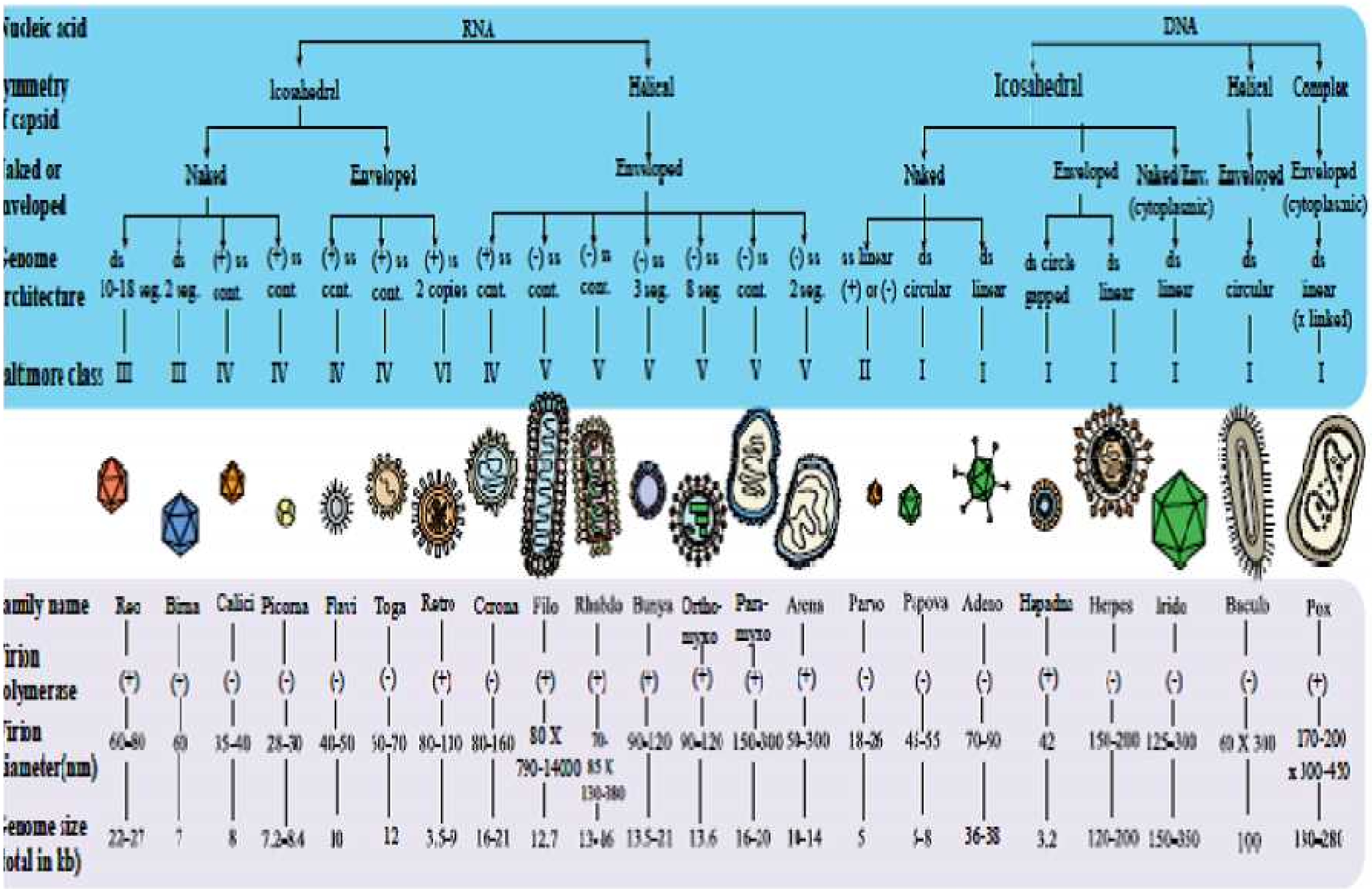
Strandedness	Double	Single				
Single-strand sense		Positive				DNA intermediate during replication
Enveloped or naked	Naked	Enveloped	Enveloped	Naked	Naked	Enveloped
Capsid symmetry	Icosahedral	Icosahedral	Helical	Icosahedral	Icosahedral	Icosahedral
Size (nm)	75–80	40–75 (enveloped) 25–35 (capsid)	80–160 (enveloped) 14–16 (capsid diameter)	22–30	35–40	80–100 (enveloped)
Site of capsid assembly	Cytoplasm	Cytoplasm	Cytoplasm	Cytoplasm	Cytoplasm	Cytoplasm
Virus family	*Reoviridae*	*Togaviridae*	[illegible]	*Picornaviridae*	*Calciviridae*	*Retroviridae*
Representative genera and groups [Host, disease]	Orbivirus [Humans: e[illegible]] Rotavirus [Humans: diarrhea] Cypovirus [Insects: cytoplasmic polyhedrosis virus	Alphavirus [Humans: encephalitis] Flavivirus [Humans: y[illegible]r, [illegible]] Rubivirus [[illegible]: rub[illegible]] Pestivirus [Pigs: hog cholera]	Infectious bronchitis [illegible] [Humans: upper respiratory [illegible]]	Enterovirus [Humans: polio] Rhinovirus [Humans: [illegible]] Hepatovirus [[illegible] hepatitis A]	Vesicular exanthema of swine Norwalk virus [illegible]	Oncornavirus C [Birds, mice: sarcomas, [illegible]] Human T-cell [illegible] Human [illegible] virus



Taxonomy of RNA Animal Viruses

Strandedness	Single				
Single-strand sense	Negative				
Enveloped or naked	Enveloped	Enveloped	Enveloped	Enveloped	Enveloped
Capsid symmetry	Helical	Helical	Helical	?	Helical
Size (nm)	80–120 (enveloped) 9 (capsid diam.)	70–80 x 130–240 (bullet-shaped)	90–100 (enveloped)	50–300	125–250 (enveloped) 18 (capsid diam.)
Site of capsid assembly	Cytoplasm	Cytoplasm	Cytoplasm	Cytoplasm	Cytoplasm
Virus family	*Orthomyxoviridae*	*Rhabdoviridae*	*Bunyaviridae*	*Arenaviridae*	*Paramyxoviridae*
Representative genera and groups [Host, disease]	Inf[illegible] [H[illegible] swine]	Lyssavirus [Warm-blooded animals: rabies]	Ca[illegible] en[illegible] vi[illegible] [Humans]	Las[illegible]virus [H[illegible] he[illegible]agic fever]	Paramyxovirus [Humans: [illegible] respiratory [illegible]s, mumps] Pne[illegible] [H[illegible], common col[illegible] Mo[illegible]rus [Humans: measles]




Nucleic acid
RNA
DNA
Symmetry of capsid
Icosahedral
Helical
Icosahedral
Helical
Complex
Naked or enveloped
Naked
Enveloped
Enveloped
Naked
Enveloped
Naked/Env. (cytoplasmic)
Enveloped
Enveloped (cytoplasmic)
Genome architecture
ds 10-18 seg.
ds 2 seg.
(+) ss cont.
(+) ss cont
(+) ss cont.
(+) ss cont.
(+) ss 2 copies
(+) ss cont.
(-) ss cont.
(-) ss cont.
(-) ss 3 seg.
(-) ss 8 seg.
(-) ss cont.
(-) ss 2 seg.
ss linear (+) or (-)
ds circular
ds linear
ds circle gapped
ds linear
ds linear
ds circular
ds linear (x linked)
Baltmore class
III
III
IV
IV
IV
IV
VI
IV
V
V
V
V
V
V
II
I
I
I
I
I
I
I
Family name
Reo
Birna
Calici
Picorna
Flavi
Toga
Retro
Corona
Filo
Rhabdo
Bunya
Ortho-myxo
Para-myxo
Arena
Parvo
Papova
Adeno
Hepadna
Herpes
Irido
Baculo
Pox
Virion polymerase
(+)
(-)
(-)
(-)
(-)
(-)
(+)
(-)
(+)
(+)
(+)
(+)
(+)
(+)
(-)
(-)
(-)
(+)
(-)
(-)
(-)
(+)
Virion diameter(nm)
60-80
60
35-40
28-30
40-50
50-70
80-110
80-160
80 X 790-14000
70-85 X 130-380
90-120
90-120
150-300
50-300
18-26
45-55
70-90
42
150-200
125-300
60 X 300
170-200 x 300-450
Genome size (total in kb)
22-27
7
8
7.2-8.4
10
12
3.5-9
16-21
12.7
13-16
13.5-21
13.6
16-20
10-14
5
5-8
36-38
3.2
120-200
150-350
100
130-280