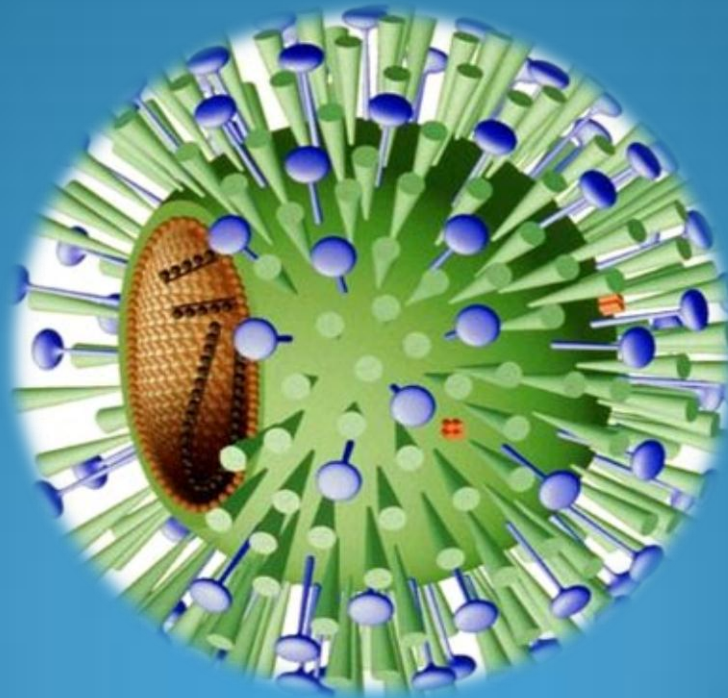


เอกสารประกอบการสอนวิชาจุลชีววิทยาทั่วไป (01419211)

เรื่อง ไวรัส ไรรอยด์และพรีออน (Virus, Viroid and Prion)

โดย อ.ดร. อิงอร กิมกง

ภาควิชาจุลชีววิทยา คณะวิทยาศาสตร์ มหาวิทยาลัยเกษตรศาสตร์



Microorganisms



Acellular

Viruses
Viroids
Prions

Particle = อนุภาค

Cellular

Prokaryotes

Archaea
Bacteria

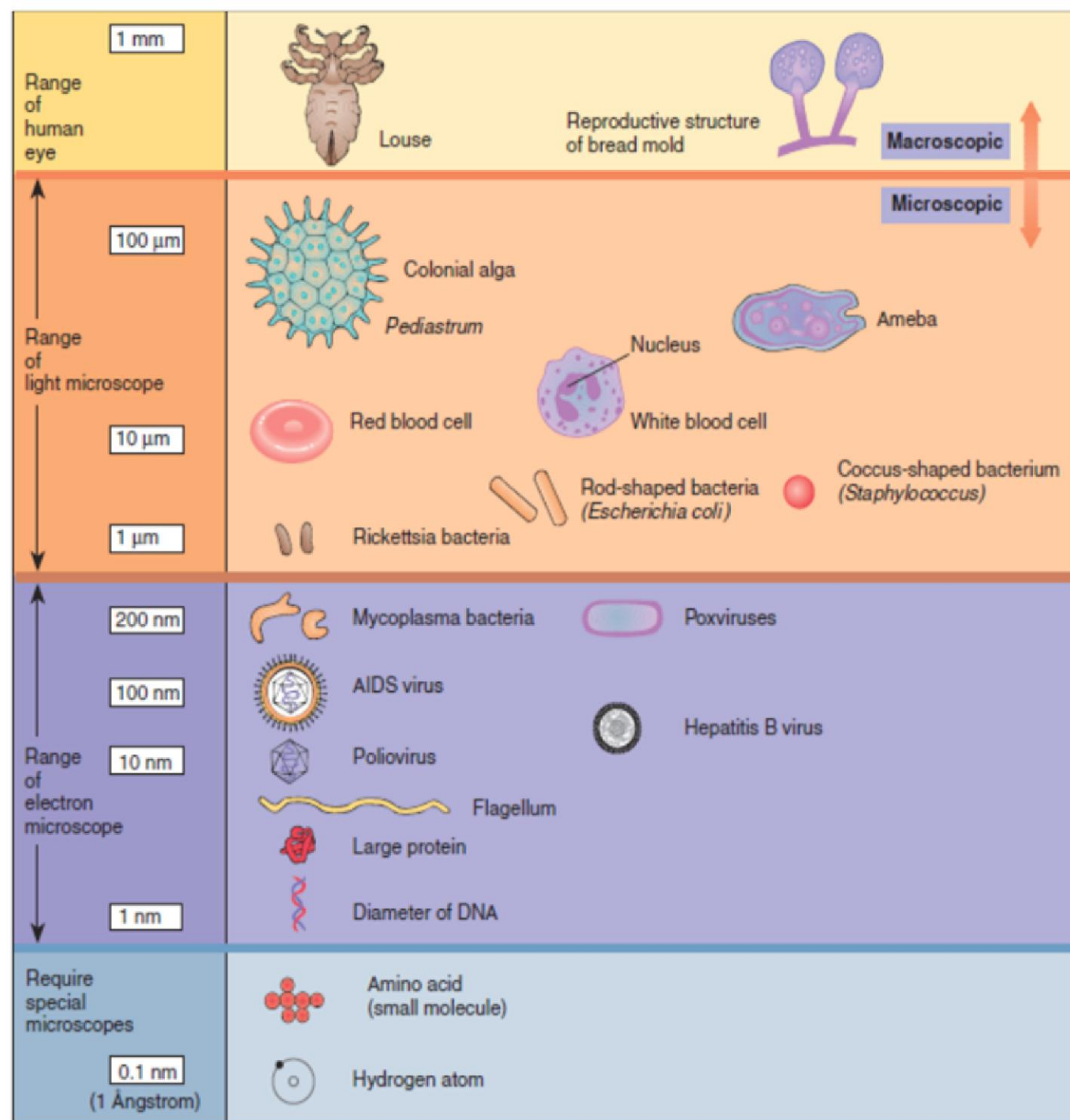
Eukaryotes

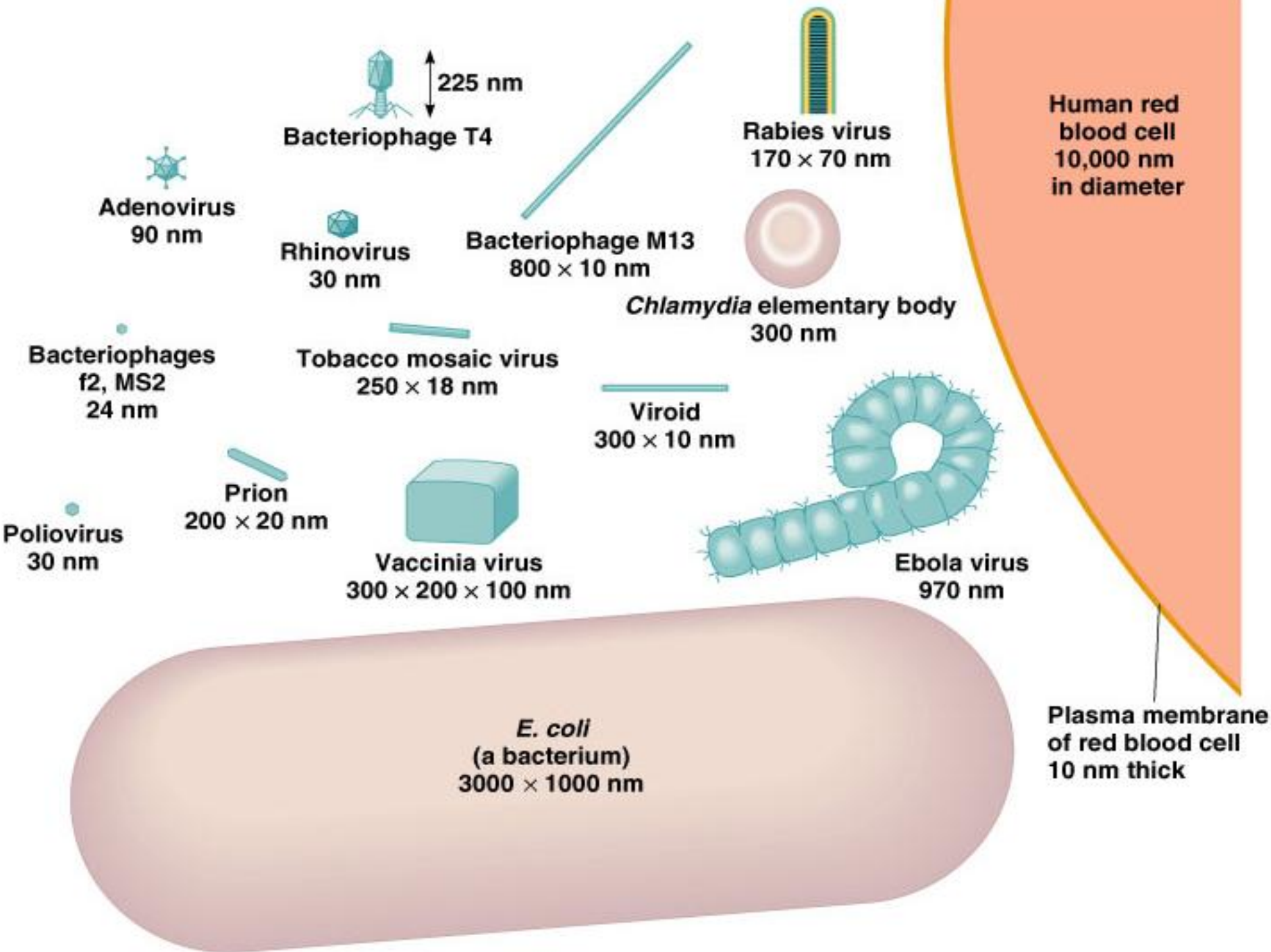
Algae
Protozoa
Fungi

ไวรัส (Virus)

คำว่า “virus” มาจากภาษาละติน หมายถึง “poison” แปลว่า พิษ ปัจจุบันคำว่า “ไวรัส” หมายถึงจุลินทรีย์ที่สามารถก่อให้เกิดการติดเชื้อได้ (infectious agents) ทั้งในมนุษย์ สัตว์ พืช และ สิ่งมีชีวิตอื่นๆ ที่เป็นสิ่งมีชีวิตมีเซลล์ (cellular life)

Size of Things





Human red blood cell
10,000 nm in diameter

Plasma membrane of red blood cell
10 nm thick

E. coli
(a bacterium)
3000 x 1000 nm

Adenovirus
90 nm

Bacteriophage T4
225 nm

Rabies virus
170 x 70 nm

Rhinovirus
30 nm

Bacteriophage M13
800 x 10 nm

Chlamydia elementary body
300 nm

Bacteriophages f2, MS2
24 nm

Tobacco mosaic virus
250 x 18 nm

Viroid
300 x 10 nm

Poliovirus
30 nm

Prion
200 x 20 nm

Vaccinia virus
300 x 200 x 100 nm

Ebola virus
970 nm

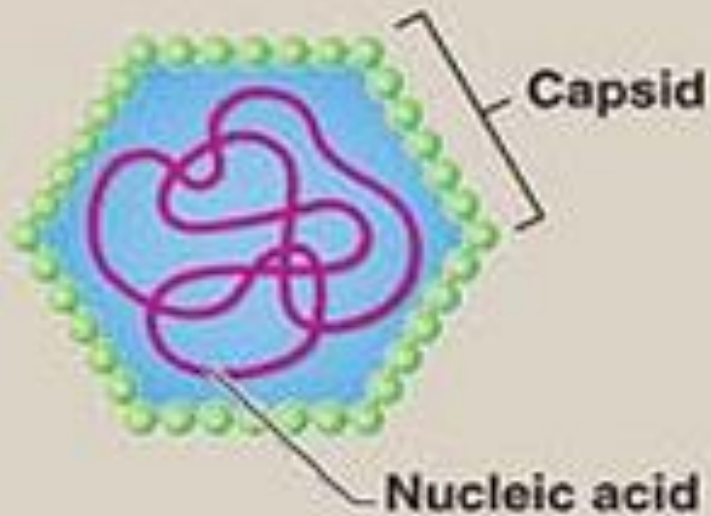
Table 1 Comparison of Viruses and Cells

Property	Viruses	Cells
Type of nucleic acid	DNA or RNA but not both	DNA and RNA
Proteins	Few	Many
Lipoprotein membrane	Envelope present in some viruses	Cell membrane present in all cells
Ribosomes	Absent	Present
Mitochondria	Absent	Present in eukaryotic cells
Enzymes	None or few	Many
Multiplication by binary fission or mitosis	No	Yes

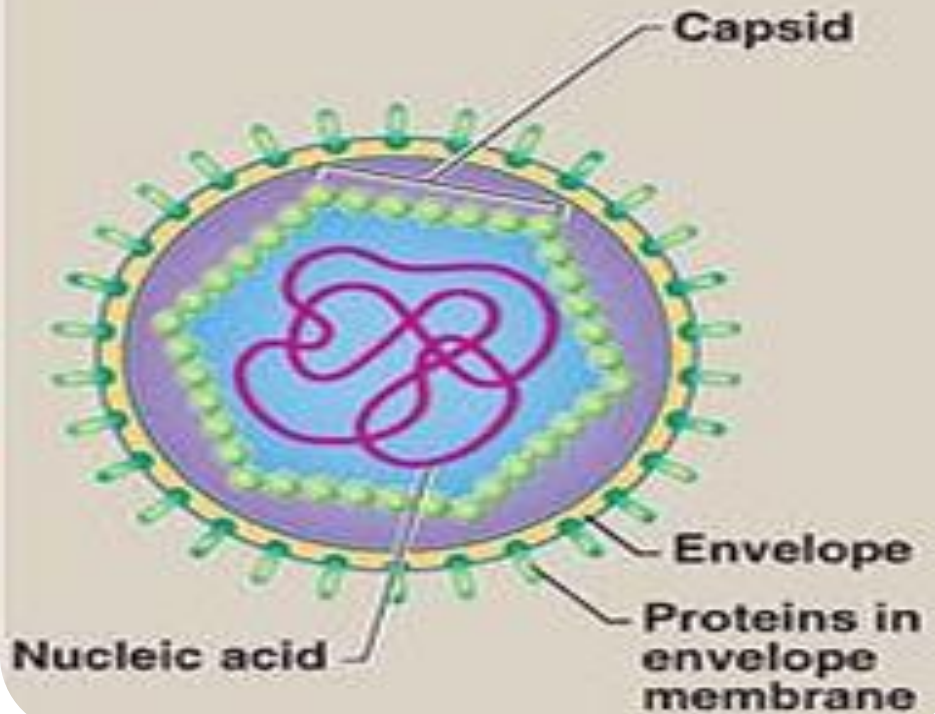
**** Obligate intracellular parasite**

GENERAL STRUCTURE OF VIRUS

A Nonenveloped virus /Naked virus



B Enveloped virus



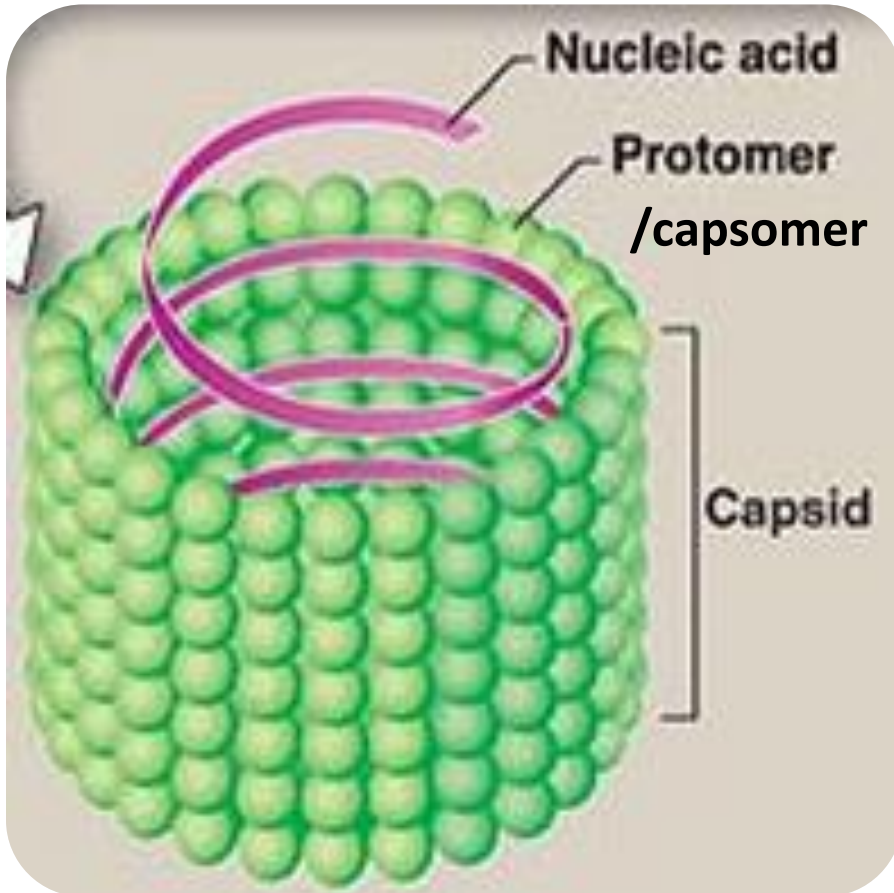
Virion => nucleocapsid



MORPHOLOGY OF VIRUS

แบ่งตามการเรียงตัวของ capsid ได้ 3 แบบ

1. Helical symmetry



ทรงกระบอก



TMV



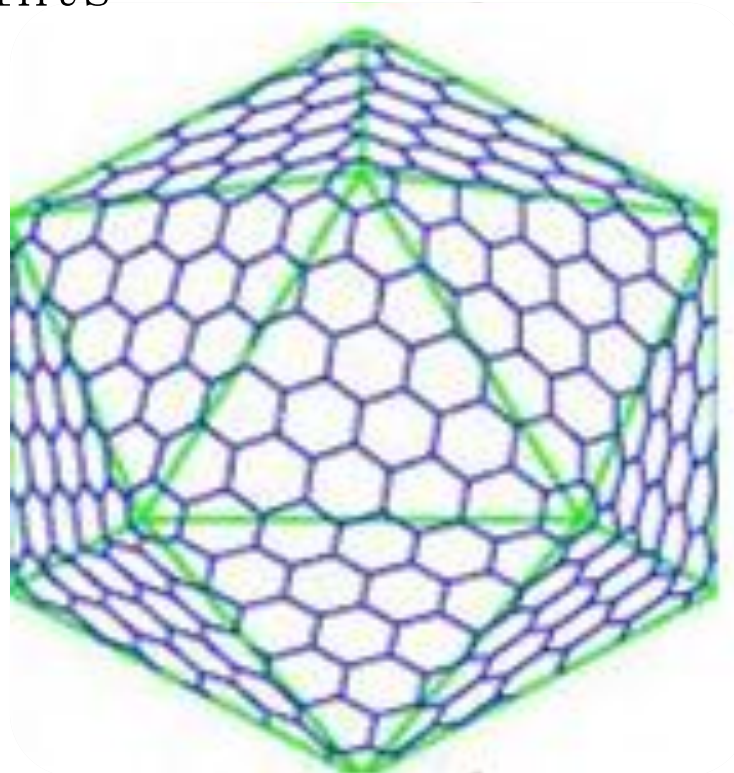
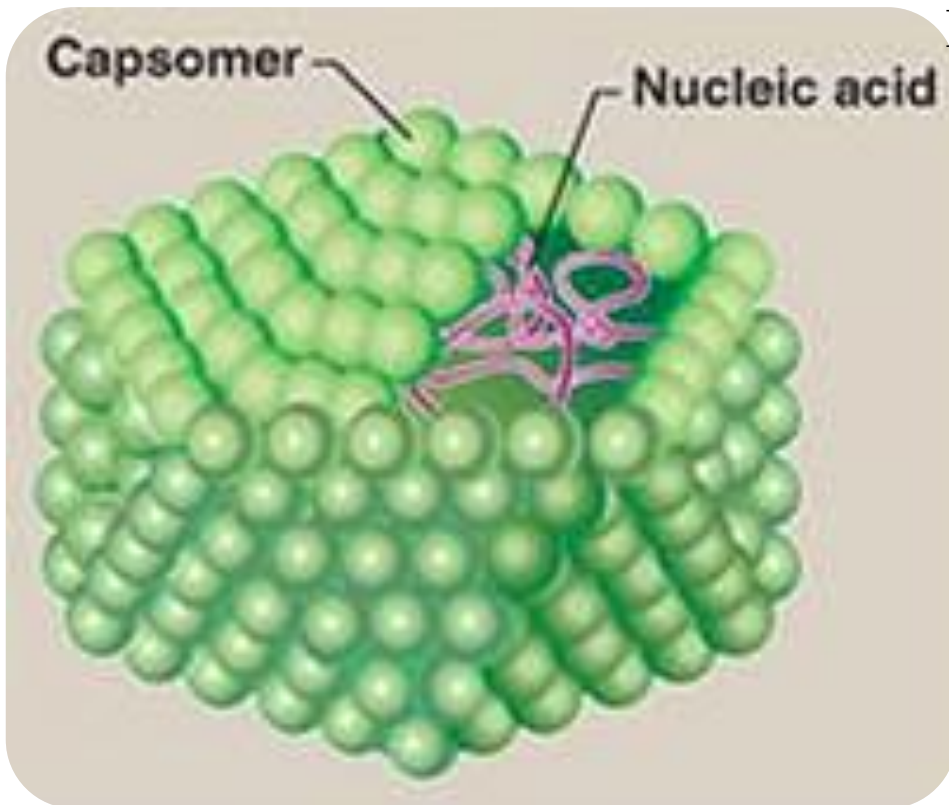
rabies
virus



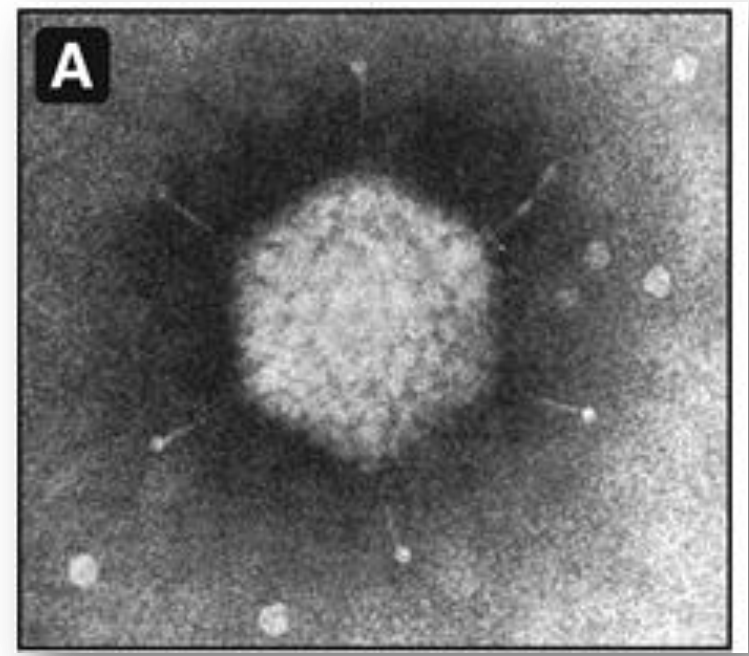
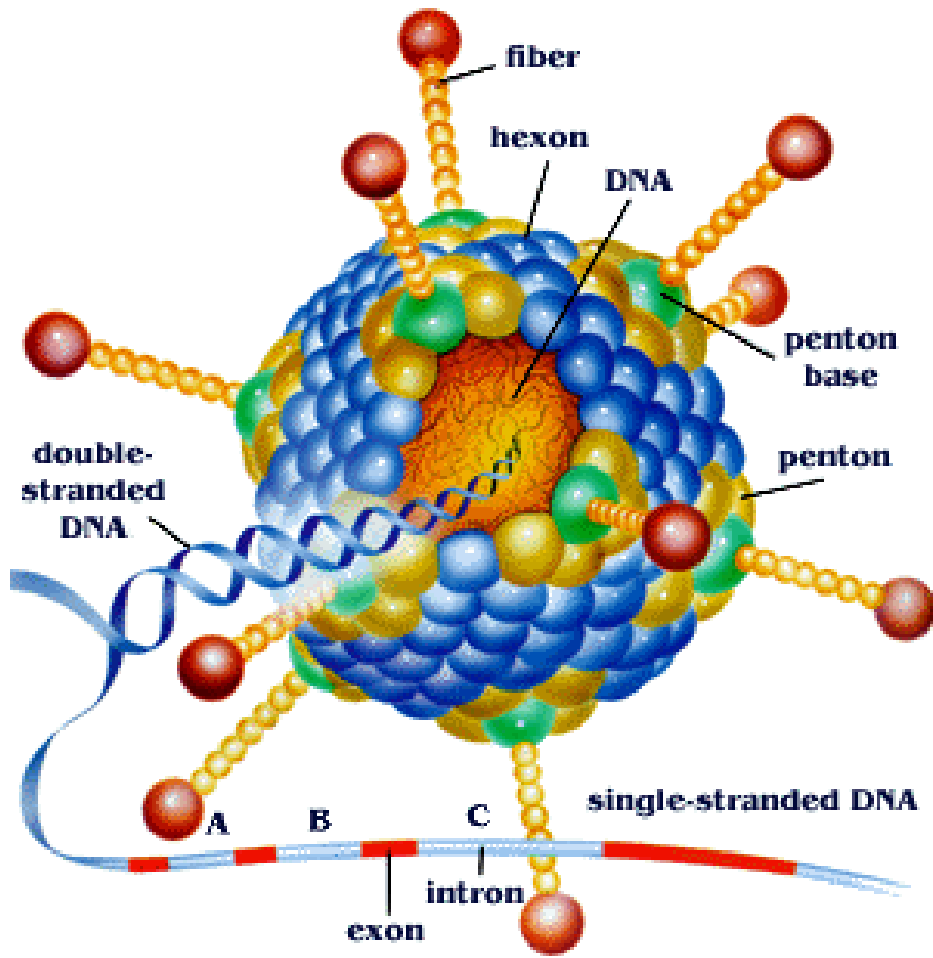
MORPHOLOGY OF VIRUS

2. Icosahedral symmetry

20 triangular faces & 12 intersecting points



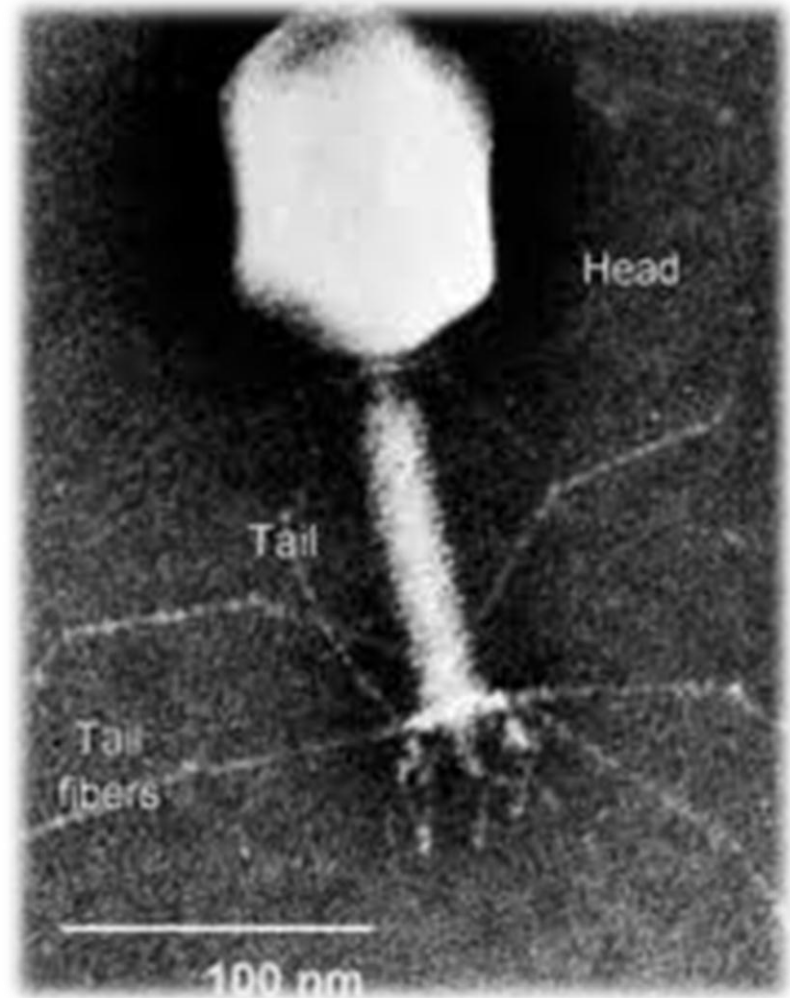
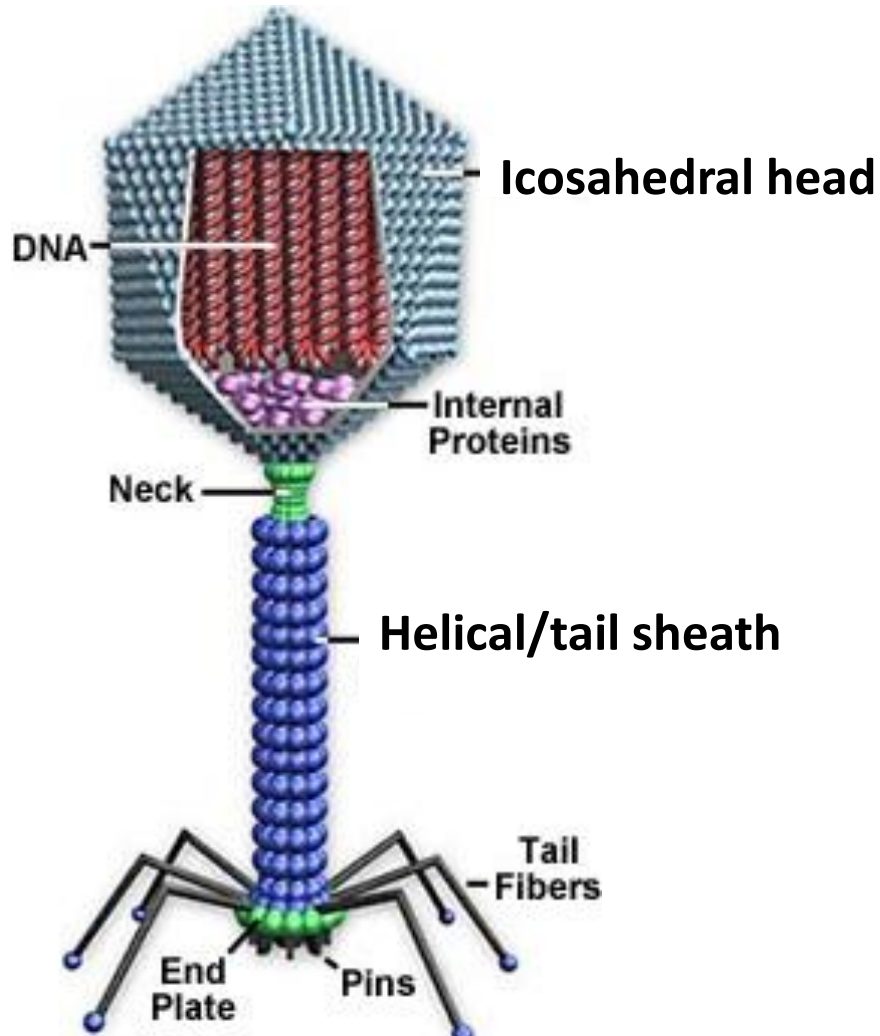
Adenovirus



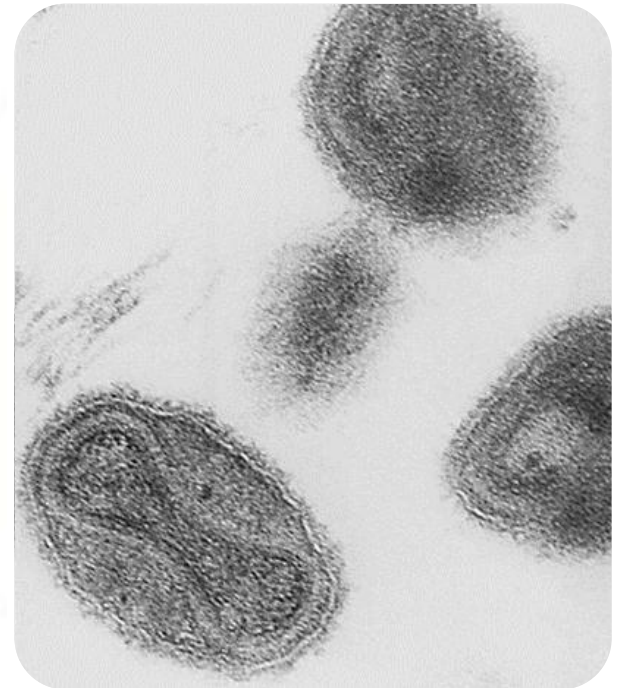
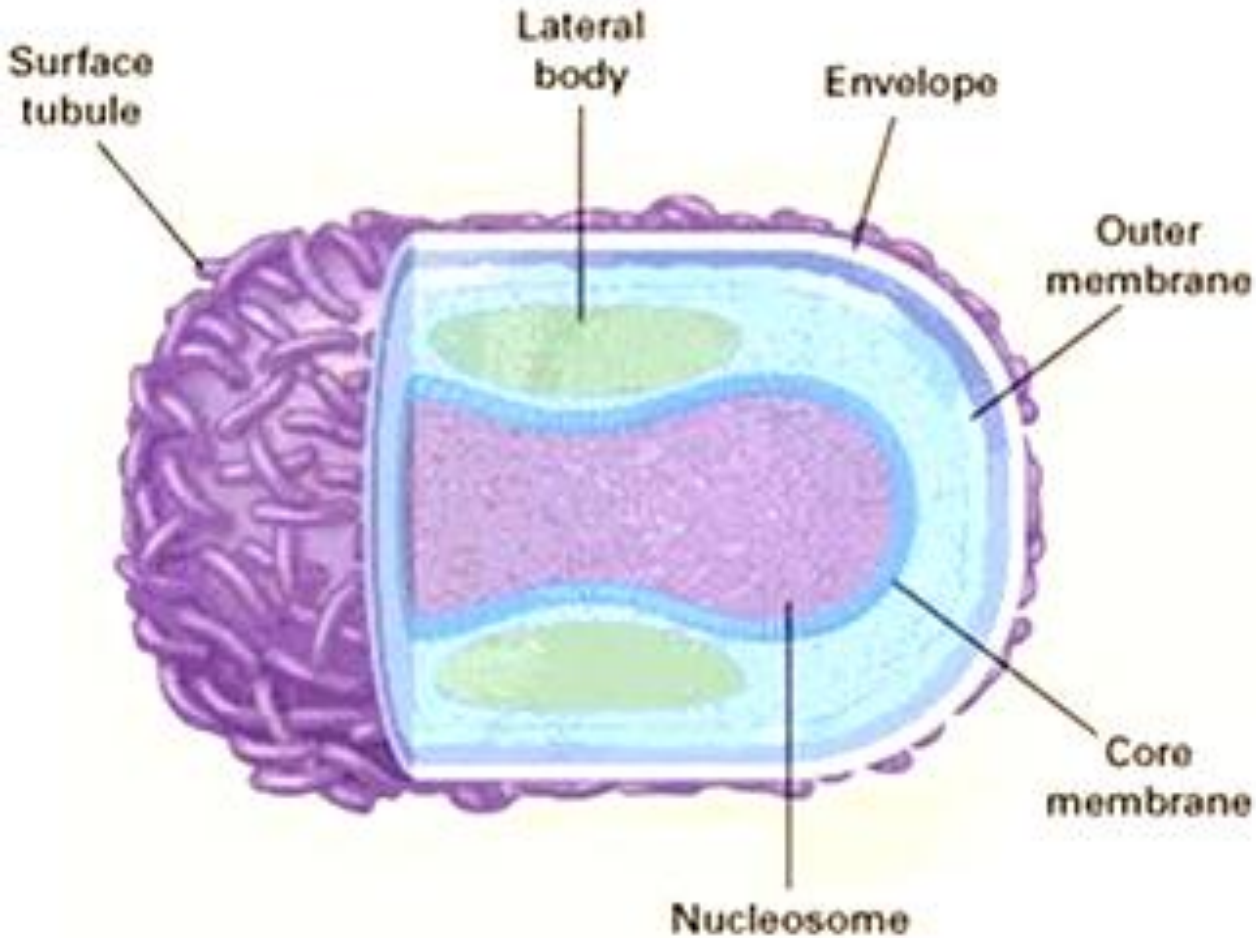
polio virus and herpes virus

MORPHOLOGY OF VIRUS

3. Complex structure

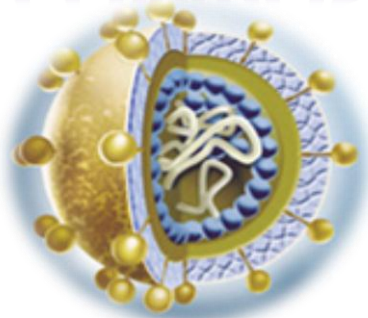


Smallpox virus



CHEMICAL COMPOSITION OF VIRUS

1. NUCLEIC ACID



Property	Parameters
Nucleic acid	DNA or RNA
Shape	Linear; Circular; Segmented
Strandedness	Single-stranded; Double-stranded
Sense	Positive sense (+) Negative sense (-) Ambisense (+/-)

DNA genomes

Examples



ss, linear

Parvoviruses



ds, linear

Poxviruses



ss, circular

Phage ϕ X174



ds, circular

Baculoviruses

RNA genomes



ss, linear

Examples

Tobacco mosaic virus



ds, linear

Reoviruses

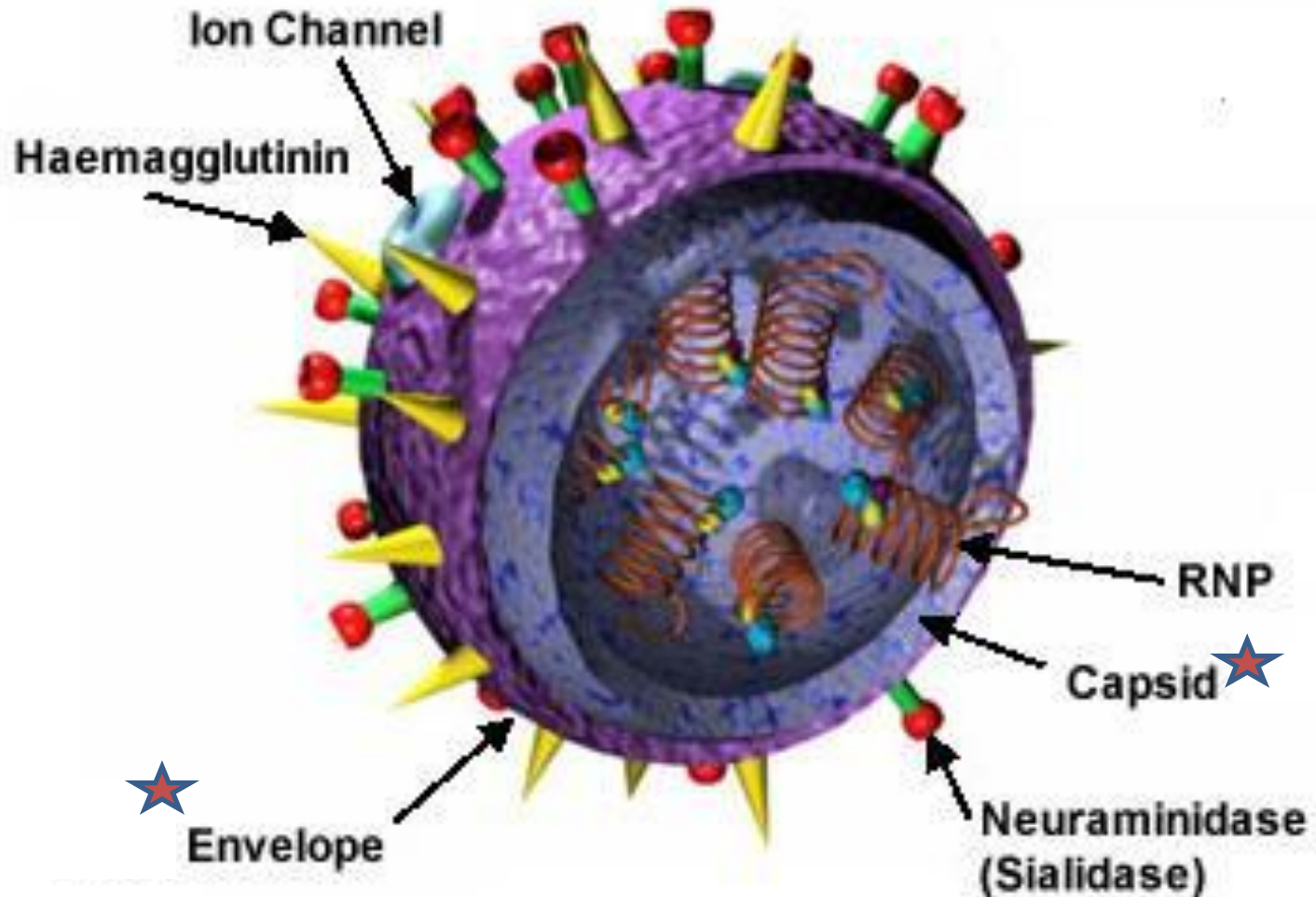


ss, circular

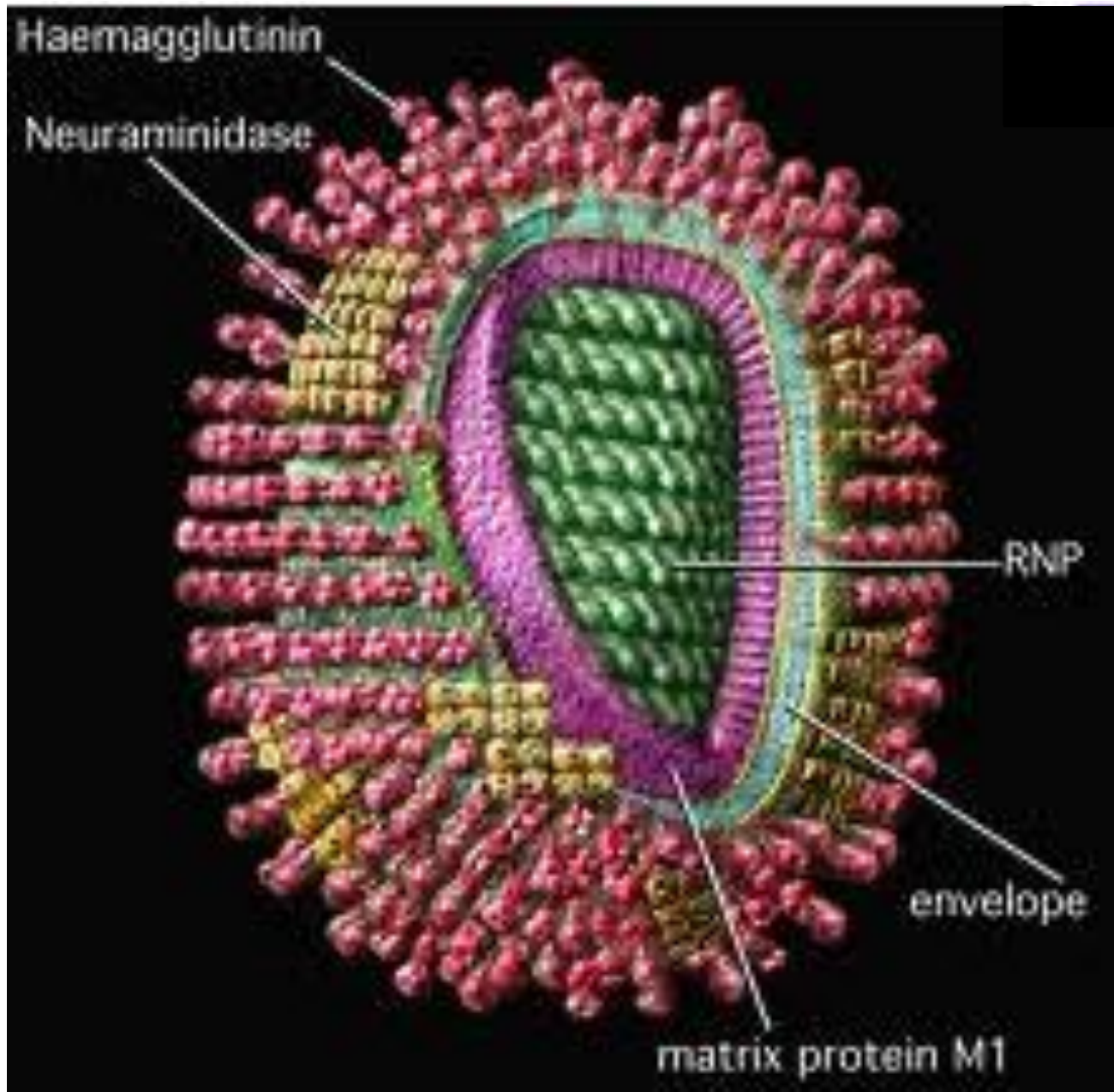
Hepatitis delta virus

CHEMICAL COMPOSITION OF VIRUS

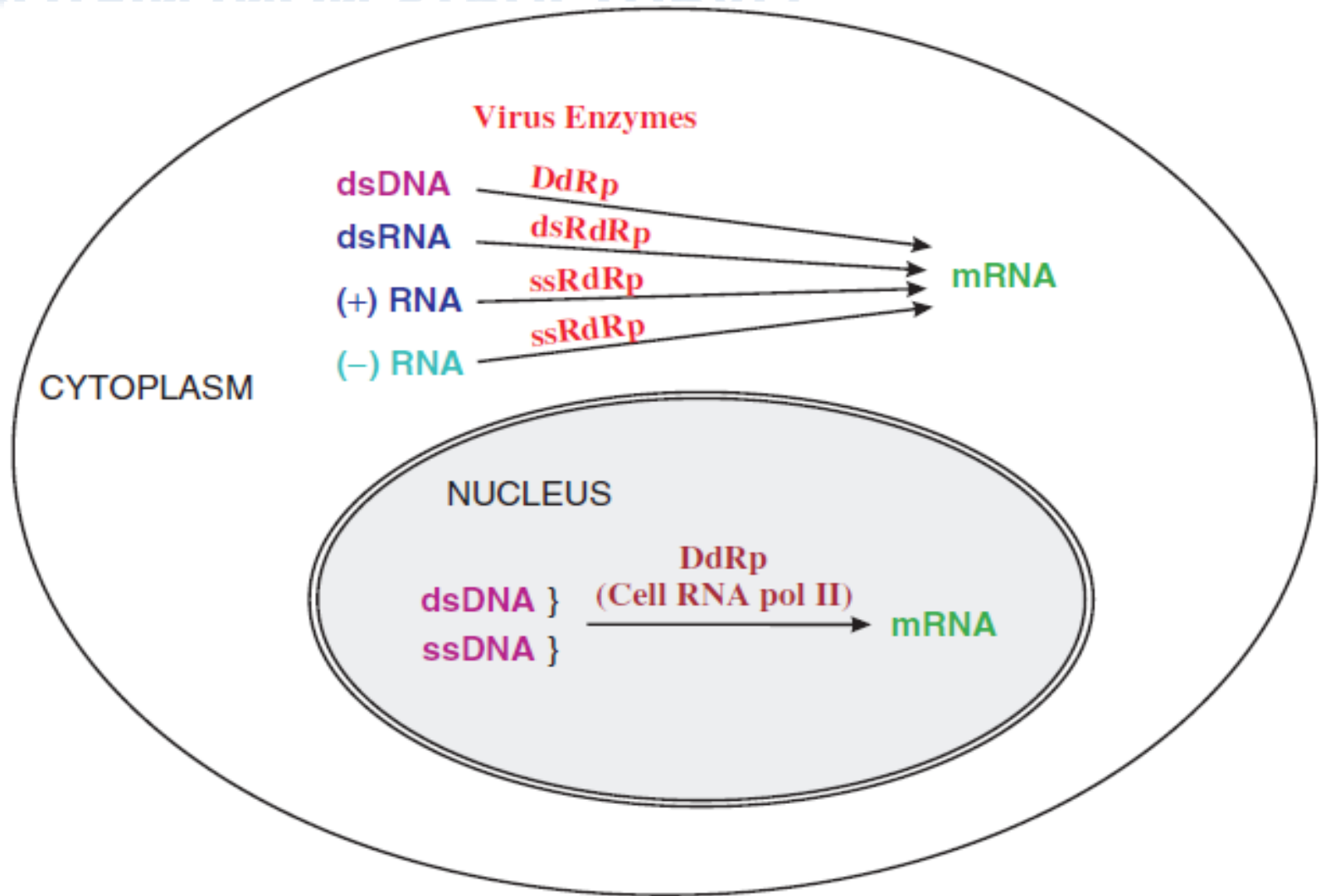
2. PROTEIN (STRUCTURAL)



Matrix protein



2. PROTEIN (NON-STRUCTURAL)



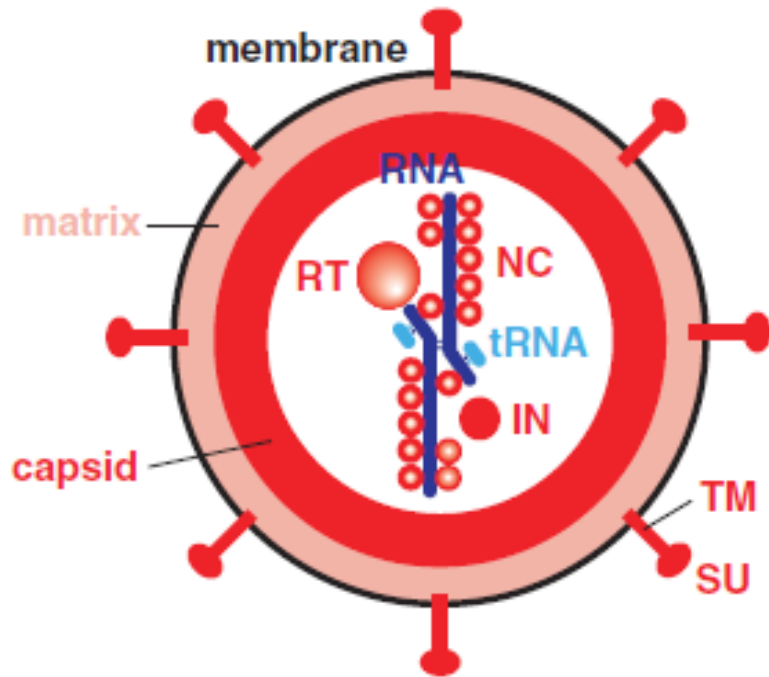
DdRp: DNA-dependent RNA polymerase eg. Poxvirus

dsRdRp: double-stranded RNA-dependent RNA polymerase eg. Reovirus

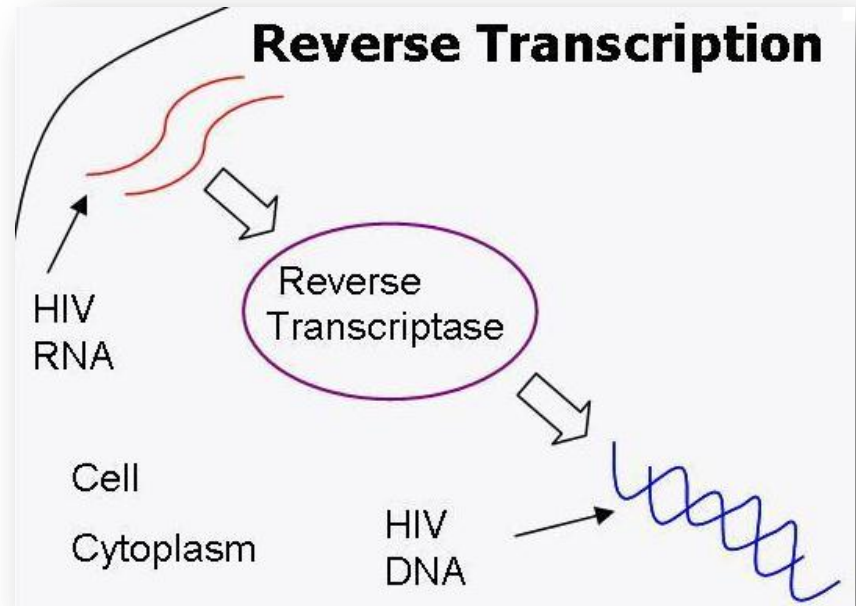
ssRdRp: single-stranded RNA-dependent RNA polymerase eg. Rabies virus

2. PROTEIN (NON-STRUCTURAL)

Retrovirus

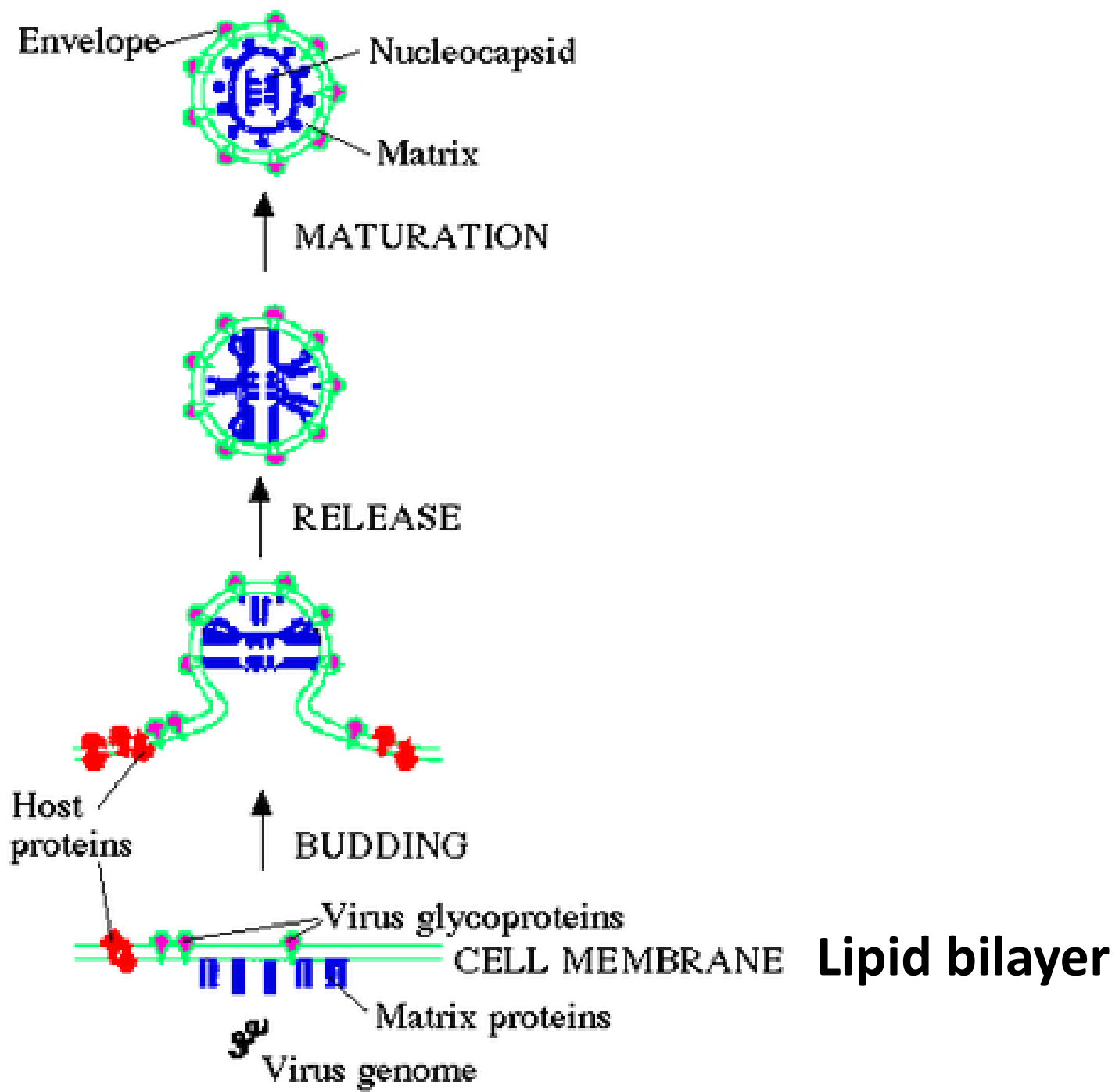


RT = reverse transcriptase
(RNA-dependent DNA polymerase)

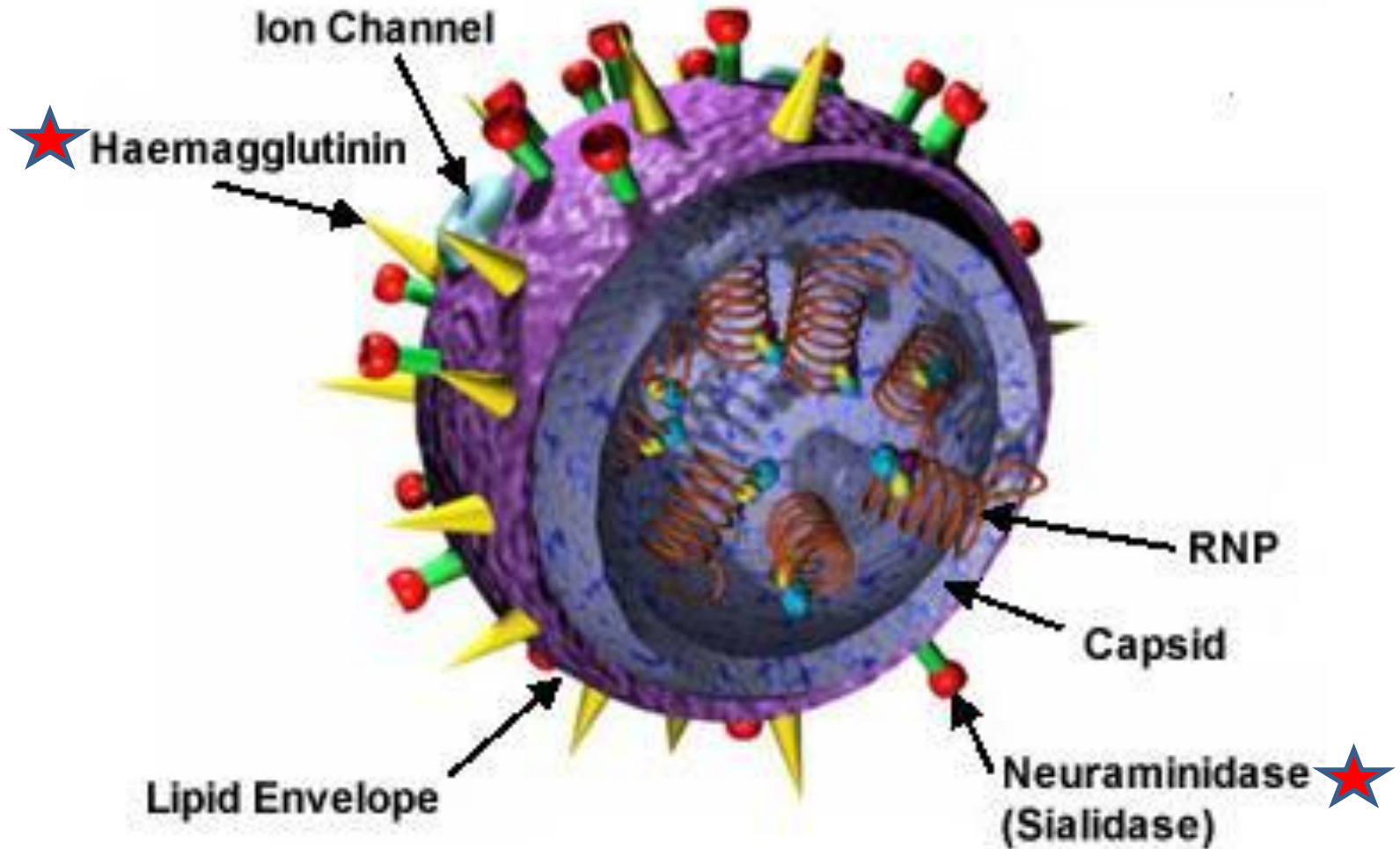


DNA-dependent DNA polymerase
Ribonuclease H (RNase H)
Integrase
Protease

3. LIPID



4. CARBOHYDRATES glycoprotein



Viral classification



International Committee on Taxonomy of Viruses

VIROLOGY DIVISION - IUMS

[Home](#) | [Contact](#)

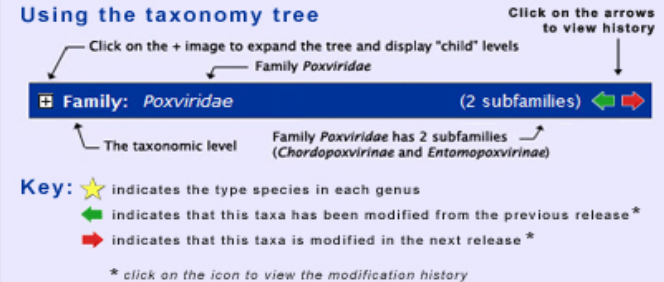
[The ICTV](#) | [Taxonomy](#) | [ICTV Files](#) | [ICTV Discussions](#) | [News and Information](#) | [ICTV Directory](#)

Virus Taxonomy: 2011 Release (current)

Taxa name search:

Select to search across all ICTV releases

Using the taxonomy tree



Order: <i>Caudovirales</i>	(3 Families)	◀ ▶
Order: <i>Herpesvirales</i>	(3 Families)	◀ ▶
Order: <i>Mononegavirales</i>	(4 Families)	◀ ▶
Order: <i>Nidovirales</i>	(3 Families)	◀ ▶
Order: <i>Picornavirales</i>	(5 Families)	◀ ▶
Order: <i>Tymovirales</i>	(4 Families)	◀ ▶
Virus families not assigned to an order	(72 Families)	◀ ▶

Year/Report	Orders	Families	Subfamilies	Genera	Species
2005 (8 th Report)	3	73	11	289	1898
2008	5	82	11	307	2078
2009 (9 th Report)	6	87	19	349	2285
2011	6	94	22	395	2475

<http://www.ictvonline.org/virusTaxInfo.asp>

Viral classification

- 1) Type and structure of the viral nucleic acid,
- 2) The strategy used in its replication,
- 3) Type of symmetry of the virus capsid (helical versus icosahedral),
- 4) Presence or absence of a lipid envelope.

Within a virus family, differences in additional specific properties, such as host range, serologic reactions, amino acid sequences of viral proteins, degree of nucleic acid homology.

Table 2 Taxonomic groups of viruses

Taxonomic group	Suffix	Example
Order	<i>-virales</i>	<i>Mononegavirales</i>
Family	<i>-viridae</i>	<i>Paramyxoviridae</i>
Subfamily	<i>-virinae</i>	<i>Paramyxovirinae</i>
Genus	<i>-virus</i>	<i>Morbillivirus</i>
Species	<i>-virus</i>	<i>Measles virus</i>

Major families of human viruses and their characteristics

DNA viruses

Virus Family <i>-viridae</i>	Envelope Present	Capsid Symmetry	Particle Size (nm)	DNA MW ($\times 10^6$)	DNA Structure ¹	Medically Important Viruses
Parvovirus	No	Icosahedral	22	2	SS, linear	B19 virus childhood rash, anemia
Papovavirus	No	Icosahedral	55	3-5	DS, circular, supercoiled	Papillomavirus wart, cancers of the cervix
Adenovirus	No	Icosahedral	75	23	DS, linear	Adenovirus illness of the respiratory system
Hepadnavirus	Yes	Icosahedral	42	1.5	DS, incomplete circular	Hepatitis B virus
Herpesvirus	Yes	Icosahedral	100 ²	100-150	DS, linear	Herpes simplex virus, varicella-zoster virus, cytomegalovirus, Epstein-Barr virus
Poxvirus	Yes	Complex	250 \times 400	125-185	DS, linear	Smallpox virus, vaccinia virus

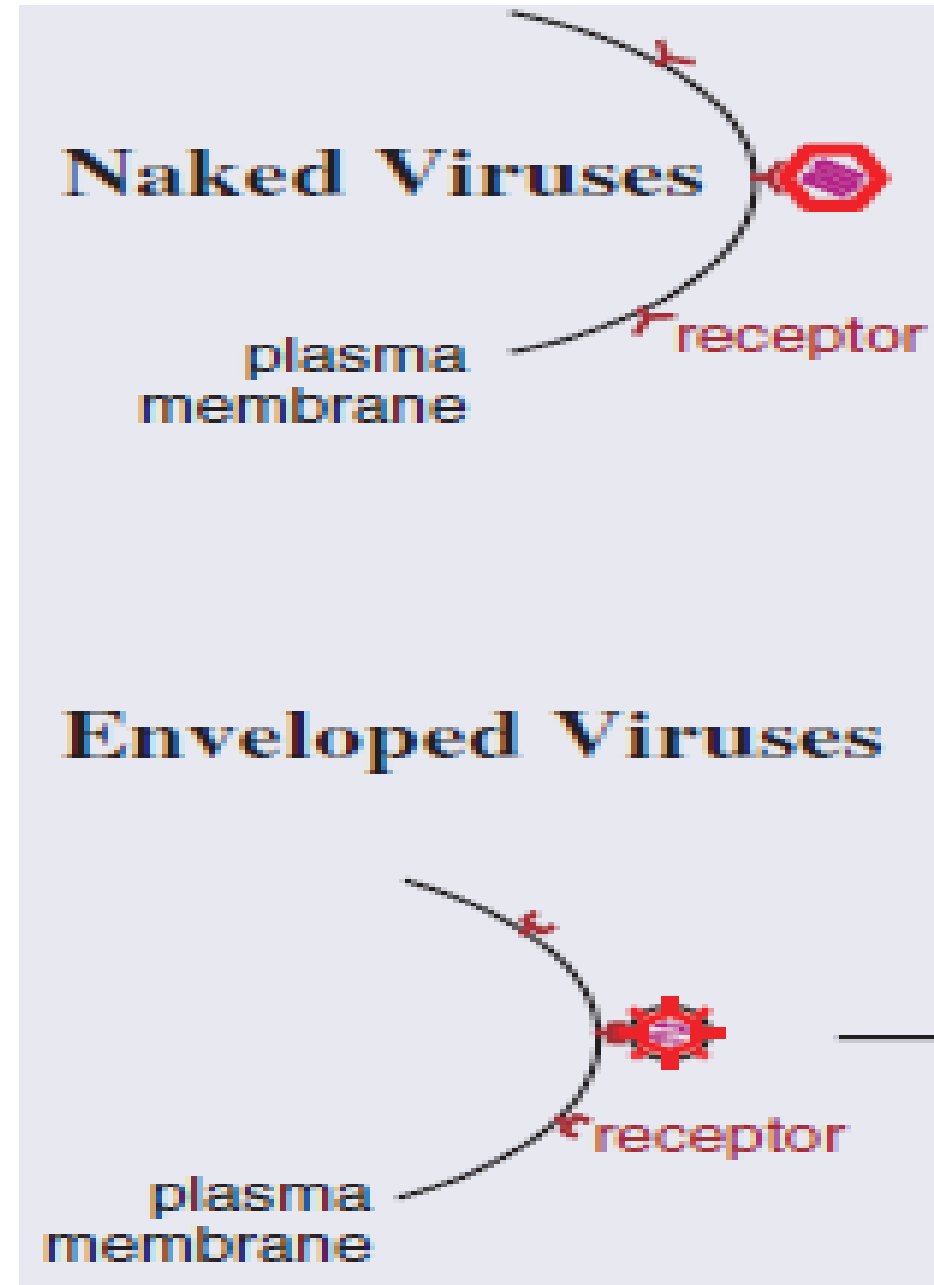
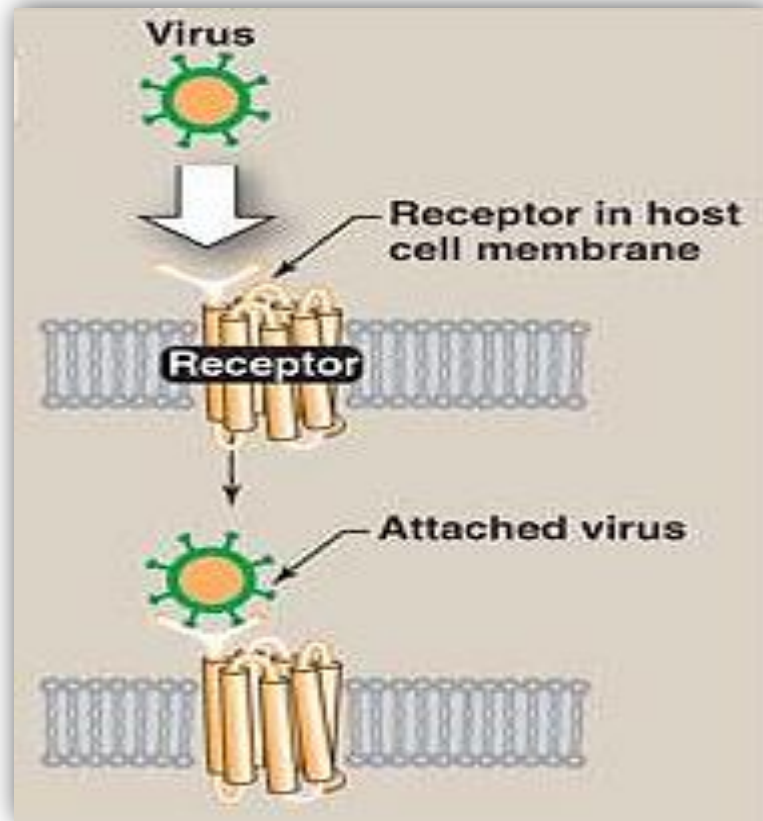
RNA viruses

Virus Family <i>-viridae</i>	Envelope Present	Capsid Symmetry	Particle Size (nm)	RNA MW ($\times 10^6$)	RNA Structure¹	Medically Important Viruses
Picornavirus	No	Icosahedral	28	2.5	SS linear, nonsegmented, positive polarity	Poliovirus, rhinovirus, hepatitis A virus
Calicivirus	No	Icosahedral	38	2.7	SS linear, nonsegmented, positive polarity	Norwalk virus, hepatitis E virus
Reovirus	No	Icosahedral	75	15	DS linear, 10 segments	Rotavirus
Flavivirus	Yes	Icosahedral	45	4	SS linear, nonsegmented, positive polarity	Yellow fever virus, dengue virus, West Nile virus, hepatitis C virus
Togavirus	Yes	Icosahedral	60	4	SS linear, nonsegmented, positive polarity	Rubella virus
Retrovirus	Yes	Icosahedral	100	7 ²	SS linear, 2 identical strands (diploid), positive polarity	HIV, human T-cell leukemia virus
Orthomyxovirus	Yes	Helical	80–120	4	SS linear, 8 segments, negative polarity	Influenza virus
Paramyxovirus	Yes	Helical	150	6	SS linear, nonsegmented, negative polarity	Measles virus, mumps virus, respiratory syncytial virus
Rhabdovirus	Yes	Helical	75 × 180	4	SS linear, nonsegmented, negative polarity	Rabies virus
Filovirus	Yes	Helical	80 ³	4	SS linear, nonsegmented, negative polarity	Ebola virus, Marburg virus
Coronavirus	Yes	Helical	100	10	SS linear, nonsegmented, positive polarity	Coronavirus
Arenavirus	Yes	Helical	80–130	5	SS circular, 2 segments with cohesive ends, negative polarity	Lymphocytic choriomeningitis virus
Bunyavirus	Yes	Helical	100	5	SS circular, 3 segments with cohesive ends, negative polarity	California encephalitis virus, hantavirus
Deltavirus	Yes	Uncertain ⁴	37	0.5	SS circular, closed circle, negative polarity	Hepatitis delta virus

Viral replication (animal viruses)

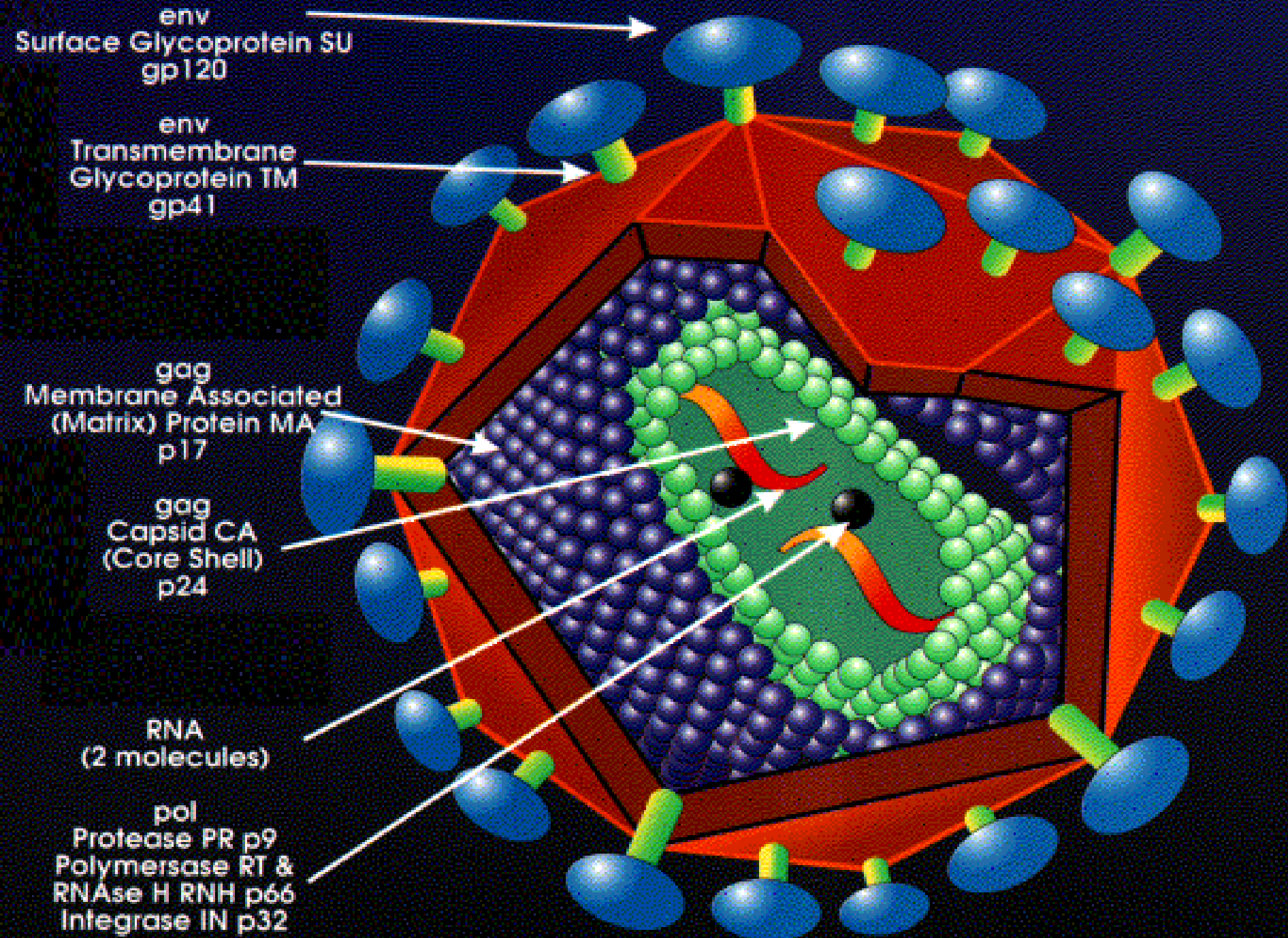
1. Attachment

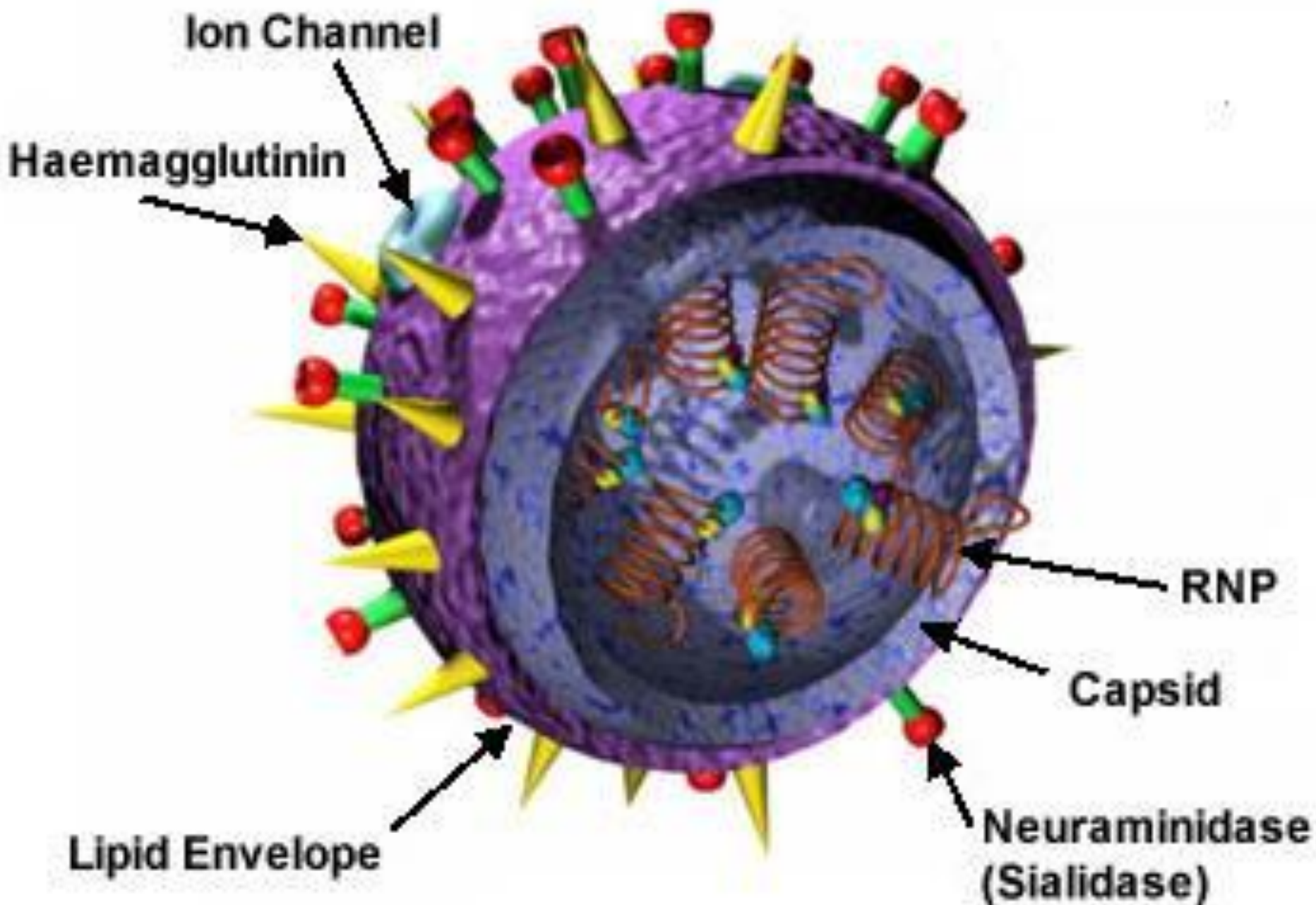
- glycoprotein spikes found in viral envelopes
- the unique folding of the capsid proteins forms the attachment sites



Examples of cell receptors, virus proteins involved in attachment

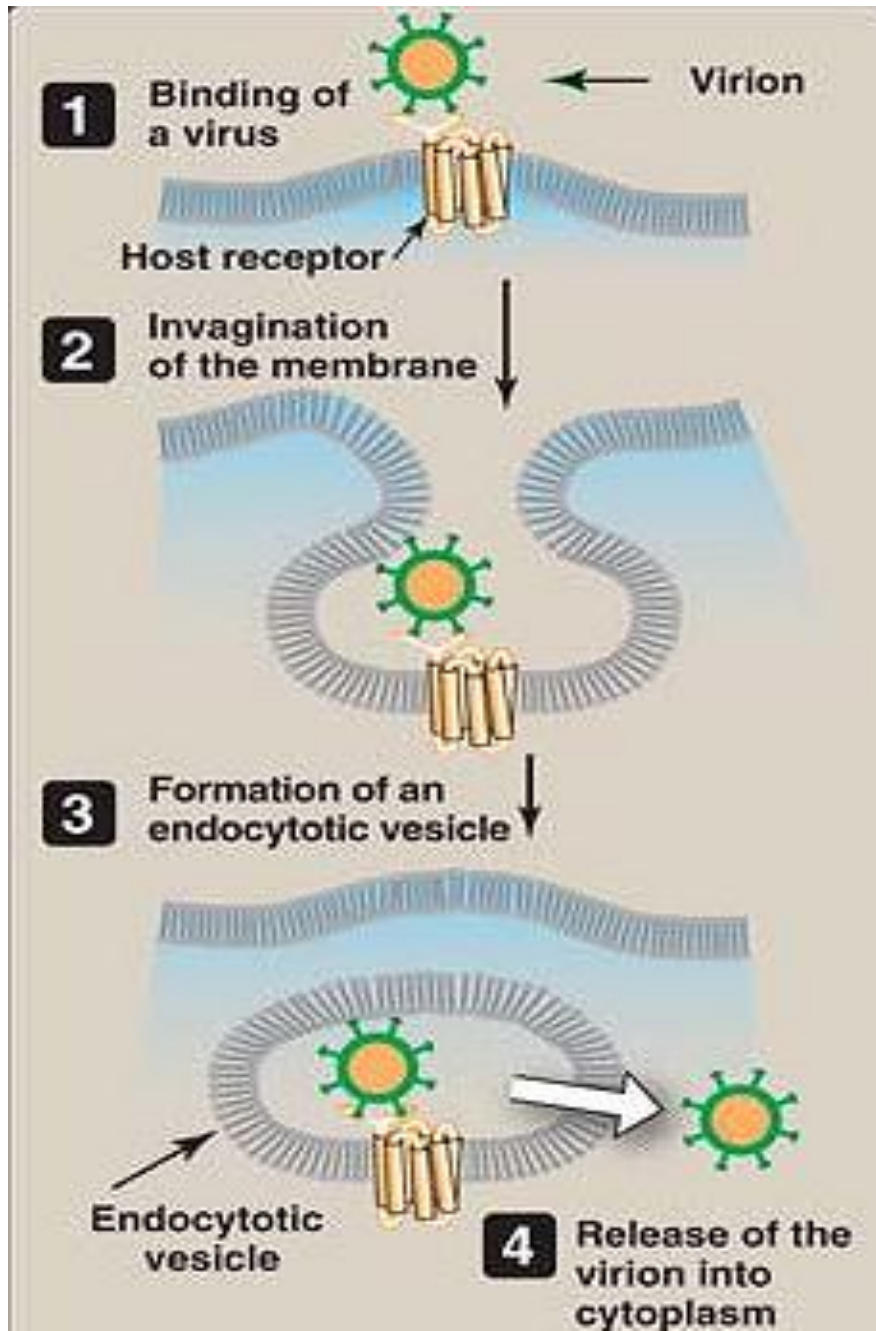
Virus	Cell receptor	Virus protein(s)
Naked viruses		
Approx. 90% of human rhinoviruses	Intercellular adhesion molecule-1 (ICAM-1)	VP1 + VP3
Approx. 10% of human rhinoviruses	Low-density lipoprotein receptors	VP1
Poliovirus	CD155	VP1
Enveloped viruses		
Murine leukaemia viruses	Mouse cationic amino acid transporter	SU (surface glycoprotein)
HIV-1	CD4	gp120
Influenza viruses A & B	Sialic-acid-containing glycoproteins	Haemagglutinin
Measles virus	Signalling lymphocyte activation molecule (CD150)	Haemagglutinin



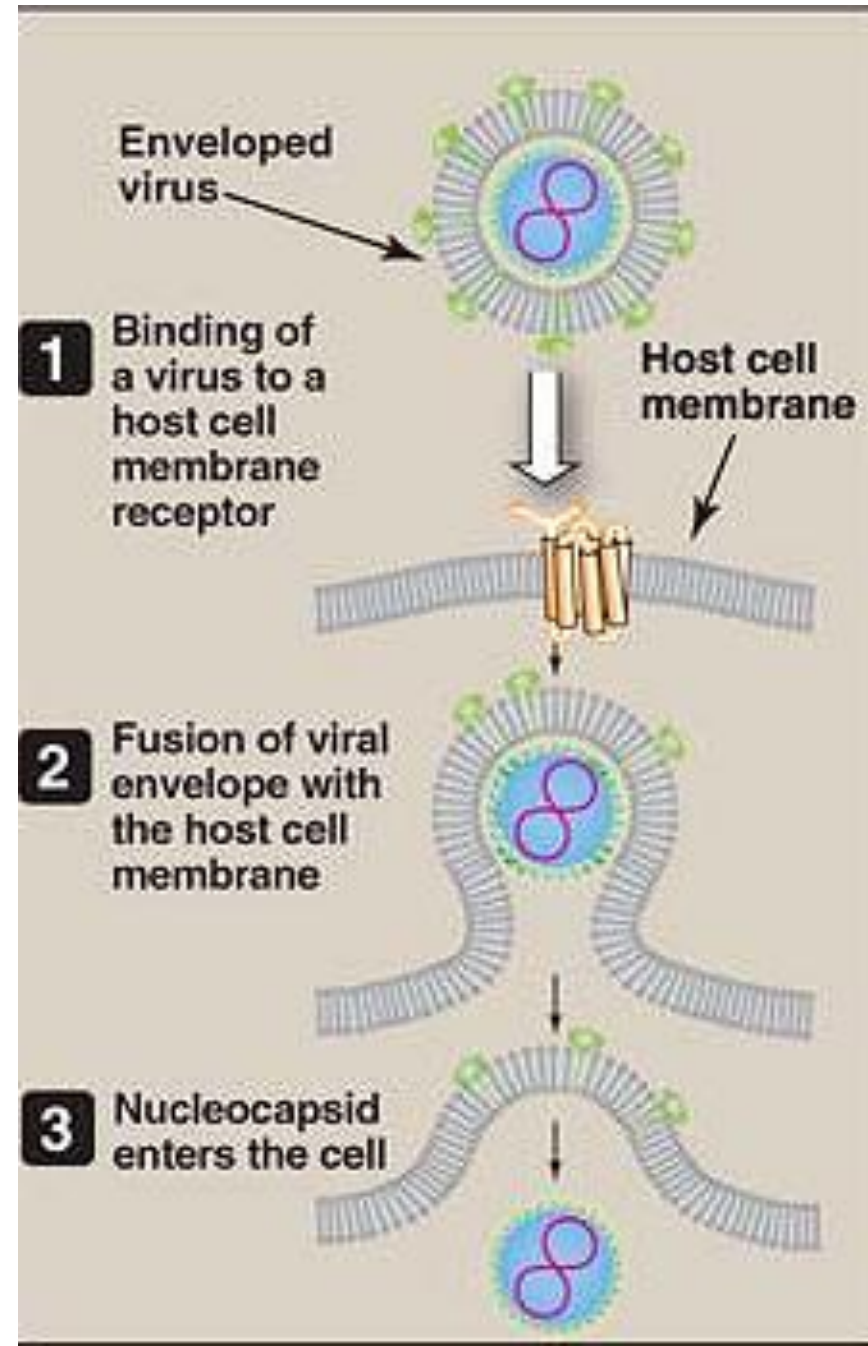


2. Penetration

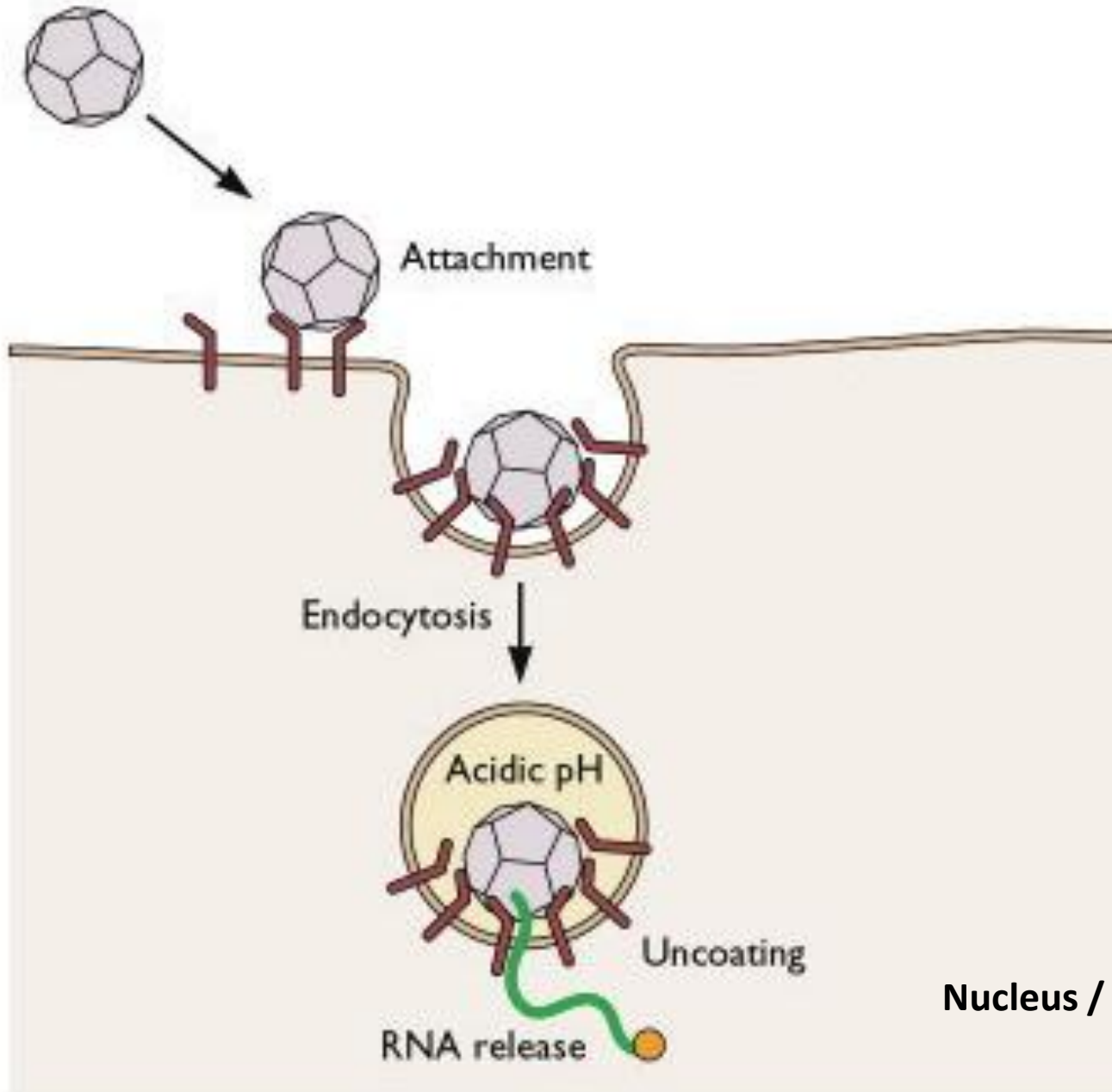
Endocytosis



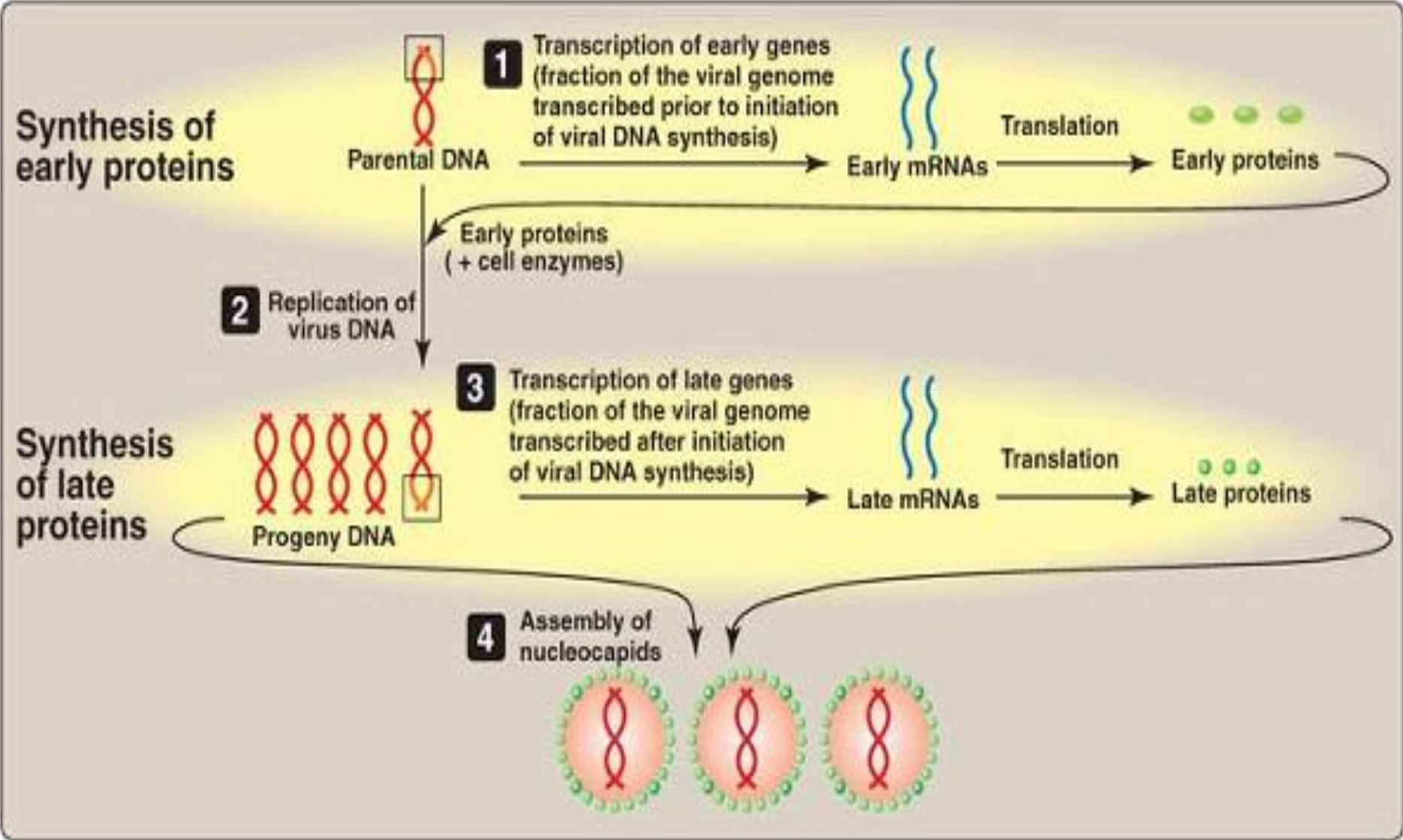
Fusion



3. Uncoating



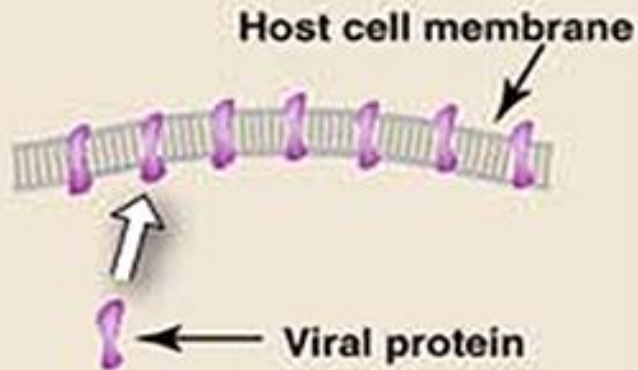
4. Synthesis and 5. Assembly



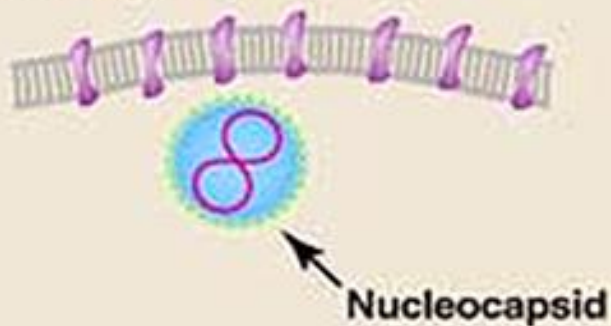
6. Release

Release of enveloped virus from a host cell by budding

- 1** Virus-specific glycoproteins are synthesized and transported to the host cell membrane.



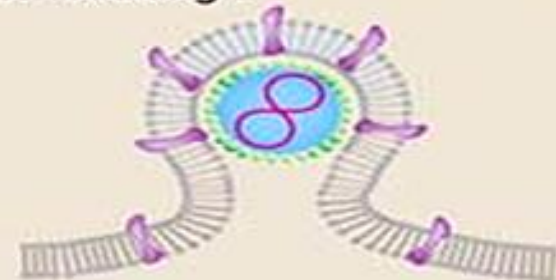
- 2** The cytoplasmic domains of membrane proteins bind nucleocapsids.



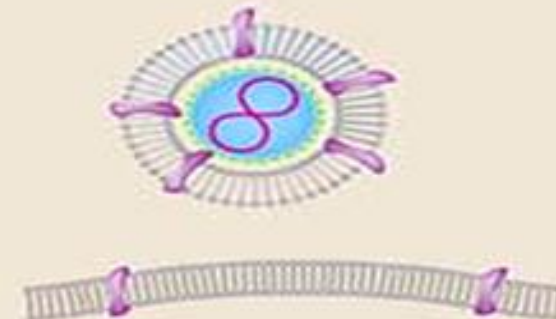
- 3** A nucleocapsid is enveloped by the host cell membrane.



- 4** The host cell membrane provides the viral envelope by a process of "budding".



- 5** The enveloped virion is released from the host cell.



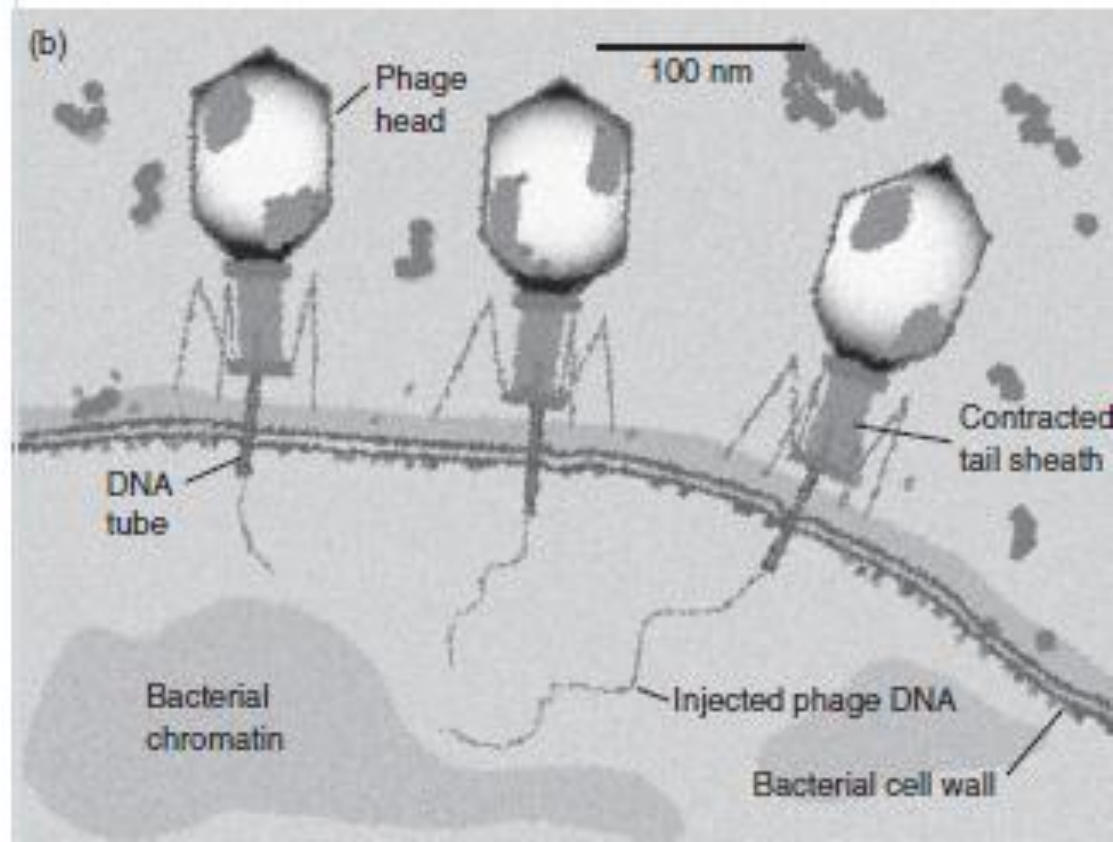
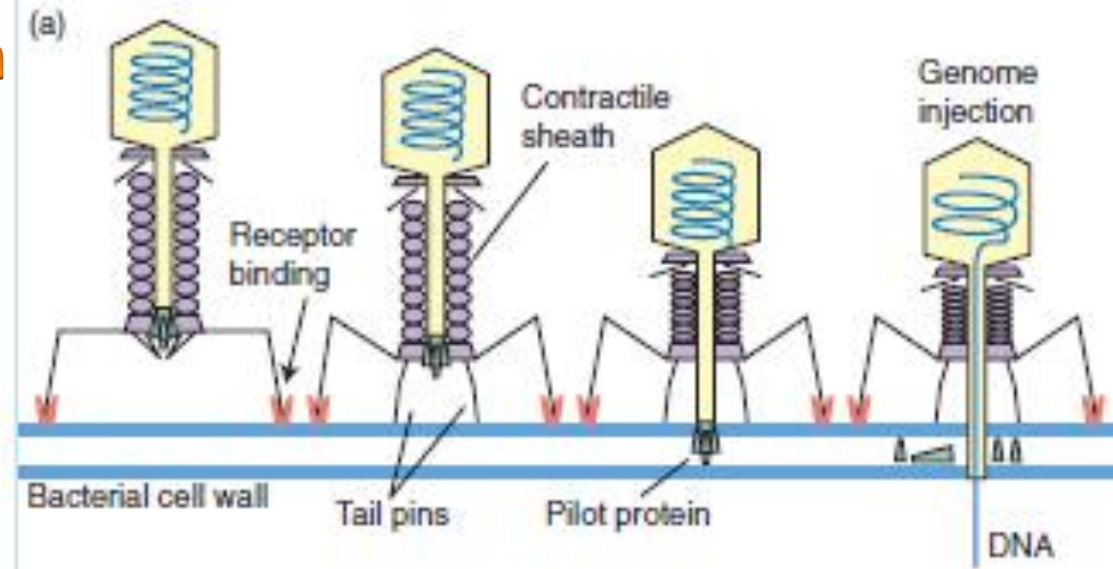
Bacteriophage replication

1. Attachment

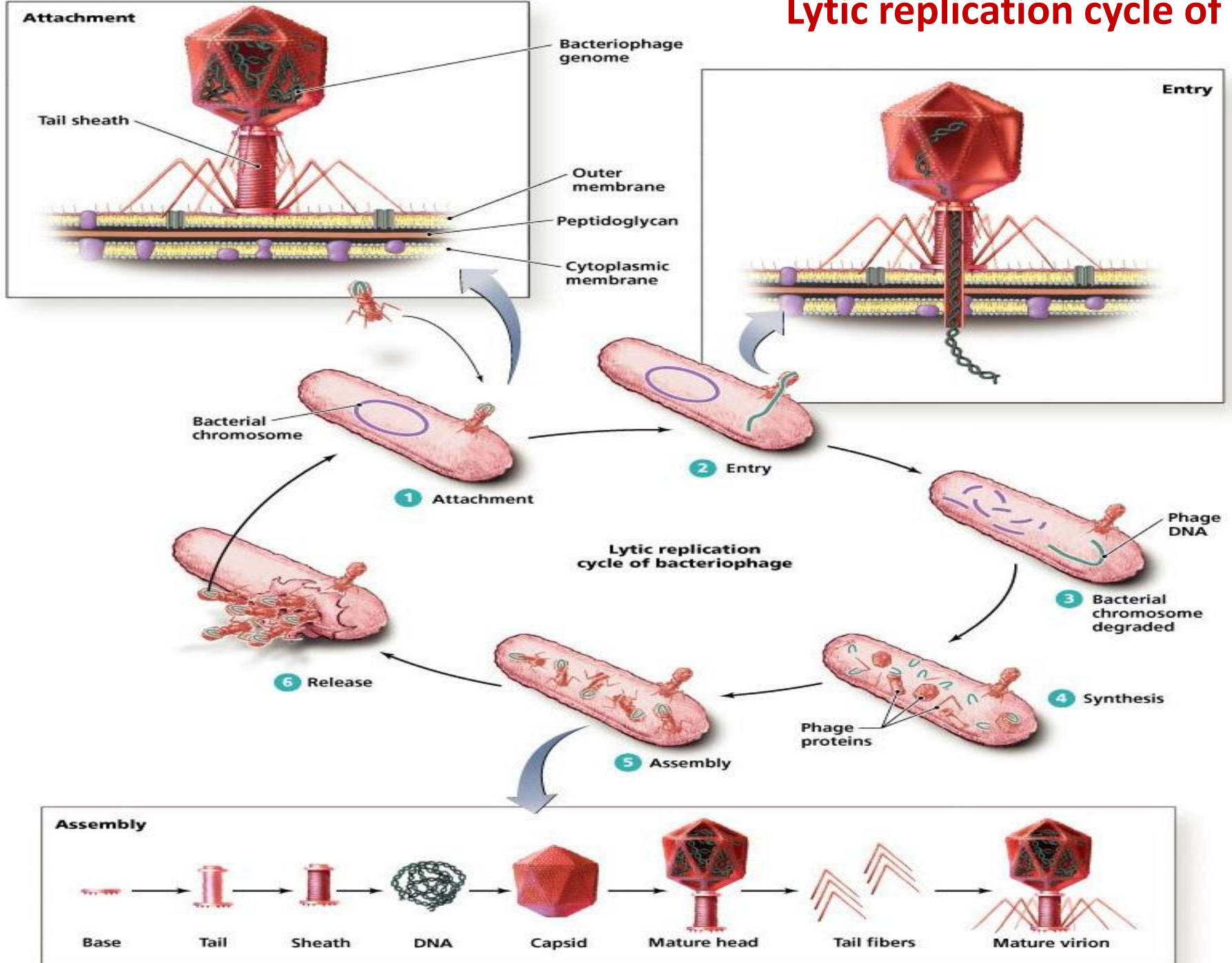
- the fibers bind to receptor on the bacterial cell wall

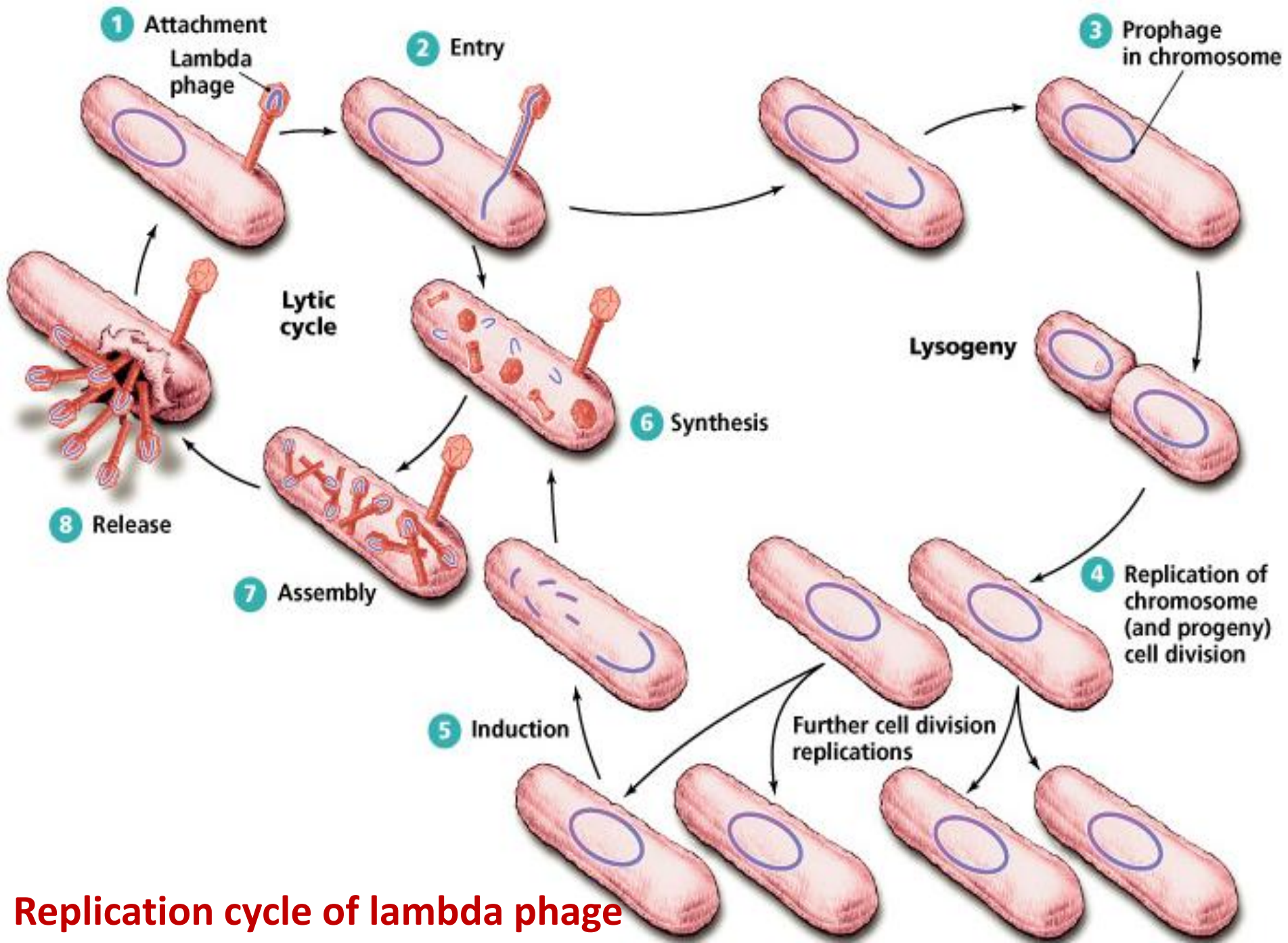
2. Penetration

- tail sheath contracts
- tail core drives through the cell wall and reaches cell membrane
- DNA is ejected



Lytic replication cycle of T4





Replication cycle of lambda phage

Microorganisms

Acellular

Viruses
Viroids*
Prions

Cellular

Prokaryotes

Archaea
Bacteria

Eukaryotes

Algae
Protozoa
Fungi

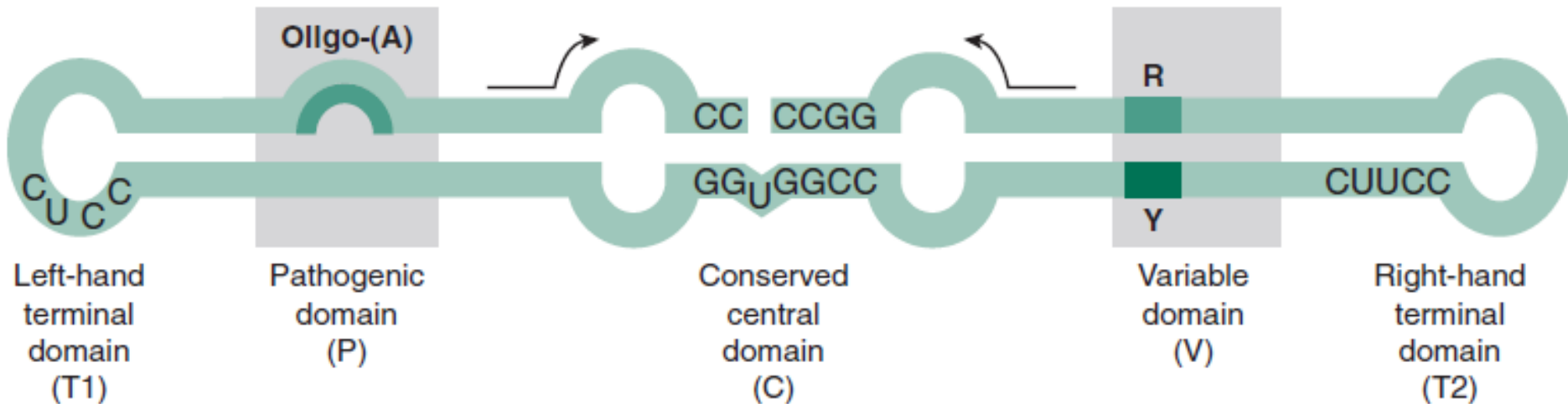


ไวรอยด์ (Viroids)

เป็นเชื้อก่อโรคในพืช (plant pathogen) ที่มีขนาดเล็กที่สุดเท่าที่มีรายงาน สมัยก่อนถูกจัดจำแนกไว้ร่วมกับไวรัส (virus) แต่ปัจจุบันถูกจัดจำแนกมาเป็นกลุ่มของตัวเองเนื่องจากความแตกต่างทางโครงสร้างและระดับ RNA

Structure of Viroid

Potato spindle tuber viroid



-Closed, circular, single-stranded RNA (246–375 nucleotides) does not encode a protein

-Viroid RNA is replicated with cellular RNA polymerase, forming large multimeric structures of both positive and negative sense. Individual viroid RNA is released by RNA self-cleavage.

Taxonomy

Family Pospiviroidae

Genus *Pospiviroid*; type species: Potato spindle tuber viroid

Genus *Hostuviroid*; type species: Hop stunt viroid

Genus *Cocadviroid*; type species: Coconut cadang-cadang viroid

Genus *Apscaviroid*; type species: Apple scar skin viroid

Genus *Coleviroid*; type species: Coleus blumei viroid 1

Family Avsunviroidae

Genus *Avsunviroid*; type species: Avocado sunblotch viroid

Genus *Pelamoviroid*; type species: Peach latent mosaic viroid

Genus *Elaviroid* ; type species: Eggplant latent viroid

Microorganisms

Acellular

Viruses
Viroids
Prions*

Cellular

Prokaryotes

Archaea
Bacteria

Eukaryotes

Algae
Protozoa
Fungi



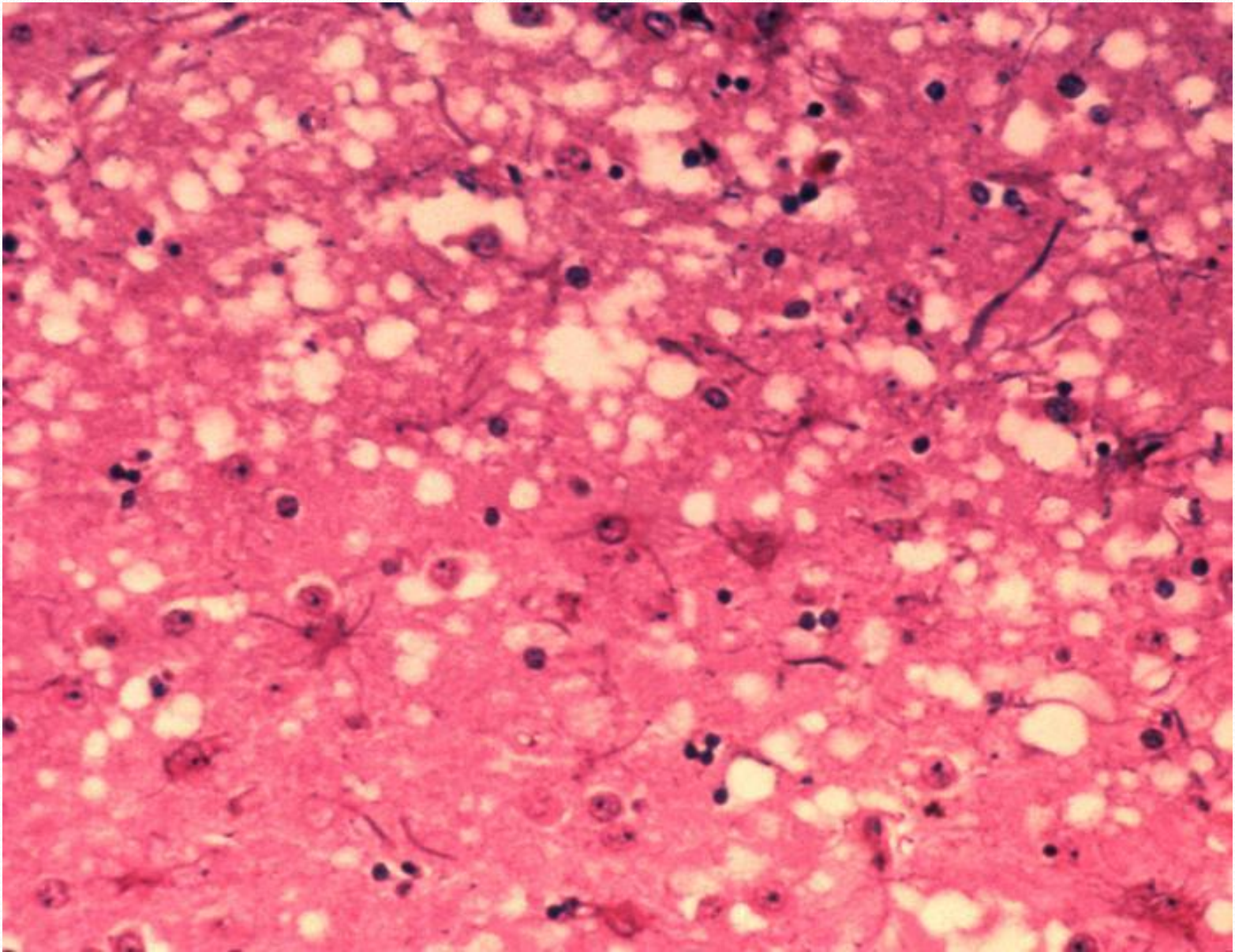
พรีออน (Prion)

คำว่า Prion นิยามโดยนักวิทยาศาสตร์ที่ได้รับรางวัลโนเบล (ปี 1997) ชื่อ Stanley B. Prusiner แห่งมหาวิทยาลัยแคลิฟอร์เนีย ในปี ค.ศ. 1982 มาจากคำว่า *proteinaceous infectious particle*

มีส่วนประกอบเป็นโปรตีนอย่างเดียว ไม่มีกรดนิวคลีอิก มีความทนทานต่อความร้อน ทนต่อความแห้ง แสงยูวี และทนต่อการย่อยสลายโดยเอนไซม์ nuclease, protease

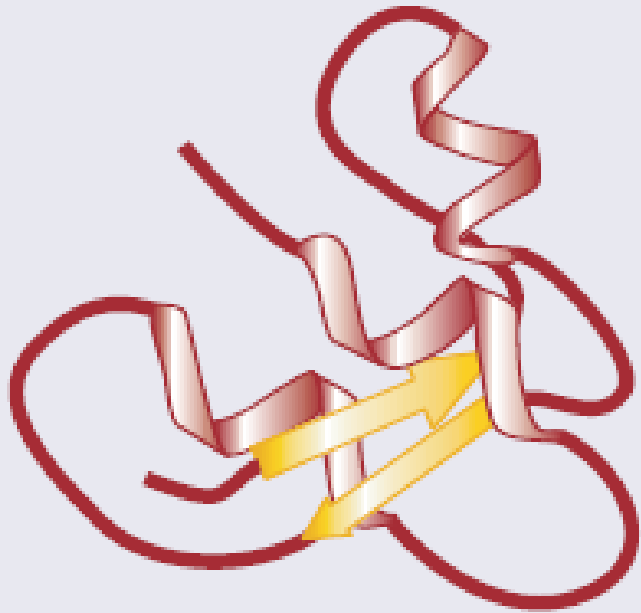
Affected animal(s)	Disease
sheep, goat	Scrapie ^[39]
cattle	Bovine spongiform encephalopathy (BSE), mad cow disease ^[39]
mink ^[39]	Transmissible mink encephalopathy (TME)
white-tailed deer, elk, mule deer, moose ^[39]	Chronic wasting disease (CWD)
cat ^[39]	Feline spongiform encephalopathy (FSE)
nyala, oryx, greater kudu ^[39]	Exotic ungulate encephalopathy (EUE)
ostrich ^[40]	Spongiform encephalopathy (Not been shown to be transmissible.)
human	Creutzfeldt–Jakob disease (CJD) ^[39]
	iatrogenic Creutzfeldt-Jakob disease (iCJD)
	variant Creutzfeldt-Jakob disease (vCJD)
	familial Creutzfeldt-Jakob disease (fCJD)
	sporadic Creutzfeldt-Jakob disease (sCJD)
	Gerstmann–Sträussler–Scheinker syndrome (GSS) ^[39]
	Fatal familial insomnia (sFI) ^[41]
Kuru ^[39]	

Microscopic "holes" are characteristic in prion-affected tissue sections, causing the tissue to develop a "spongy" architecture



Cellular: PrP^C

Normal protein

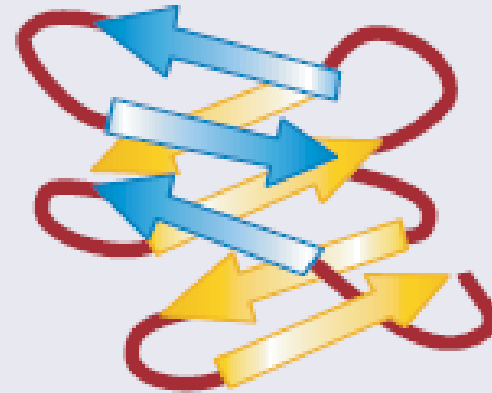


More α helix than β sheet

Soluble, ไม่ทนต่อ protease

Scrapie form: PrP^{Sc}

Misfolded protein



Mainly β sheet

Insoluble, ทนต่อ protease

Property	Bacteria	Viruses	Viroids	Prions
Width	200-2000 nm	10-300 nm	2 nm	5 nm
Length	200-550,000 nm	20-800 nm	40-130 nm	5 nm
Nucleic acid	both DNA and RNA	DNA or RNA	RNA	None
Protein	Present	Present	Absent	Present
Cellular	Yes	No	No	No
Cytoplasmic membrane	Present	Absent	Absent	Absent
Ribosomes	Present	Absent	Absent	Absent
Self-replicating	Yes	No	No	Yes
Metabolism	Present	Absent	Absent	Absent