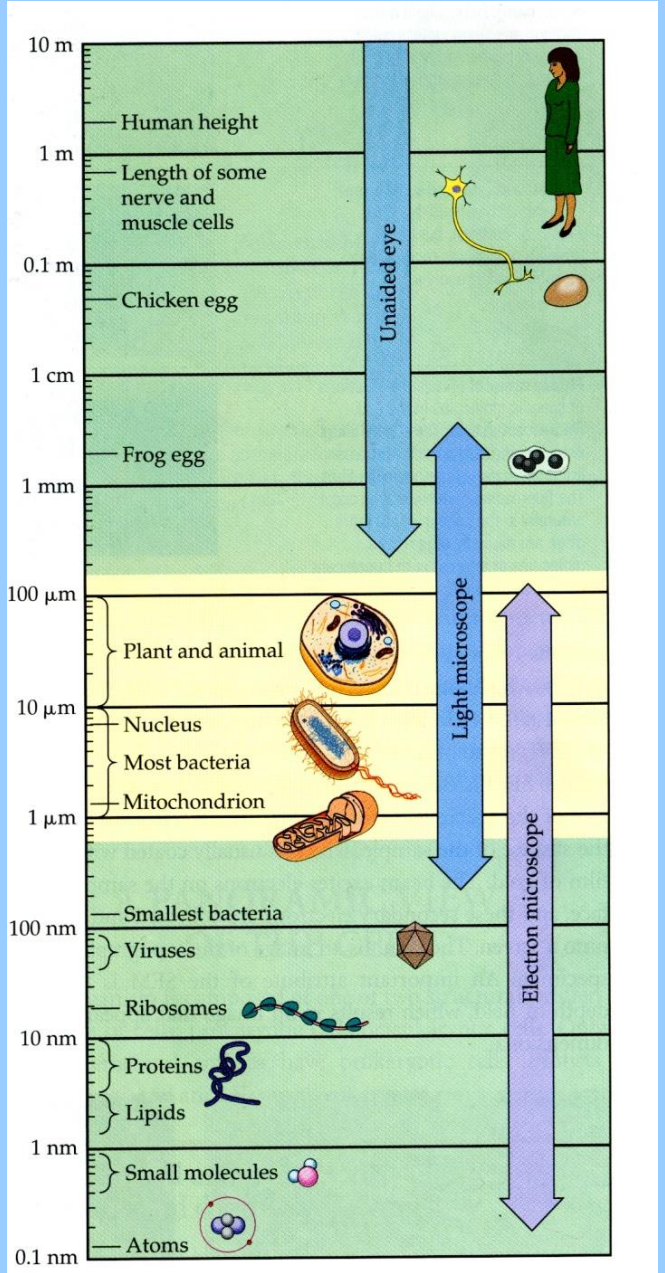
Viruses

Non-cellular organisms

Premedical - Biology

Size of
the smallest virus
20 nm and more



MEASUREMENTS
1 centimeter (cm) = 10^{-2} meter (m) = 0.4 inch
1 millimeter (mm) = 10^{-3} m
1 micrometer (μm) = 10^{-3} mm = 10^{-6} m
1 nanometer (nm) = 10^{-3} μm = 10^{-9} m

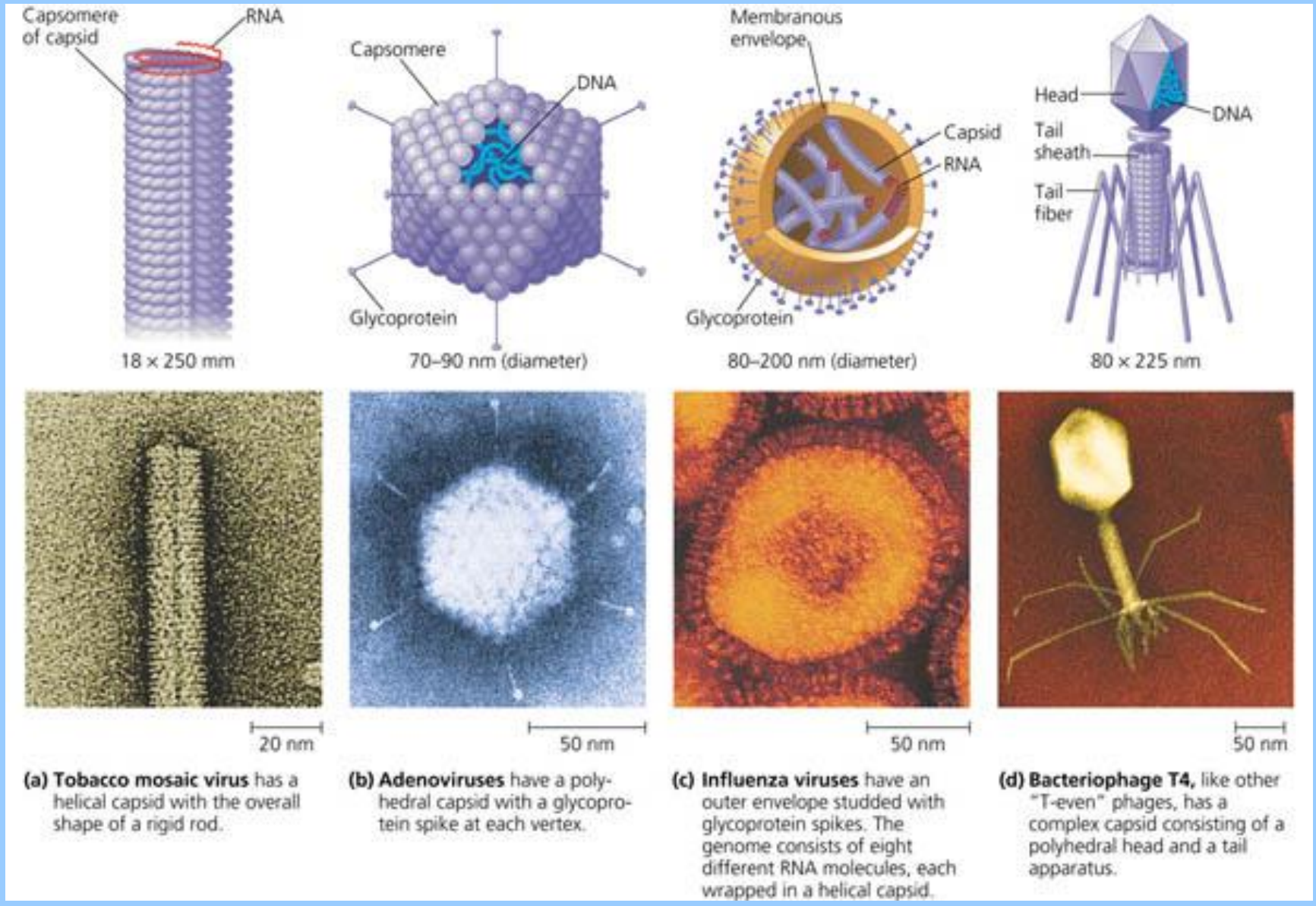
Non-cellular: viruses are infectious particles

plant, animal, bacterial = bacteriophages

- virion = nucleic acid + protein coat (capsid) = **naked** ones and another envelope derived from the plasmatic membrane of host cell = **enveloped viruses**
- bacteriophage = icosahedral head + tail, sheath, base plate, fibers

CAPSID

Capsid = protein shell, subunits = Capsomers



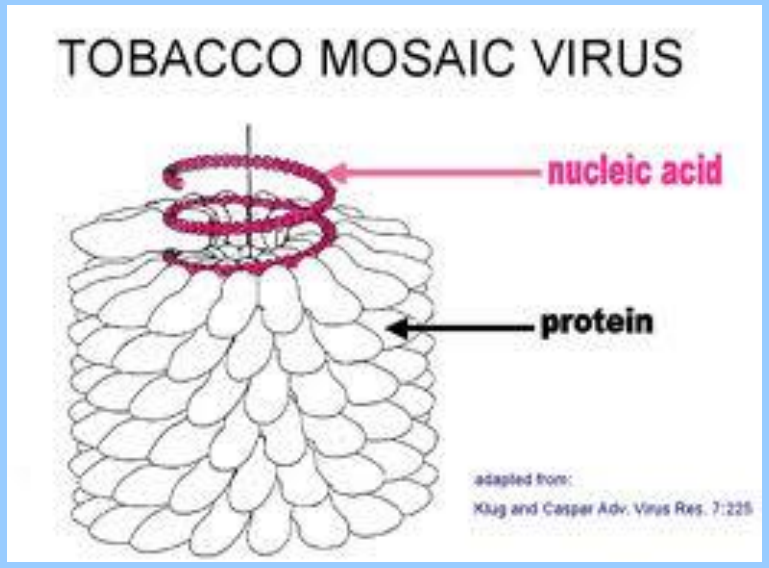
(a) Tobacco mosaic virus has a helical capsid with the overall shape of a rigid rod.

(b) Adenoviruses have a polyhedral capsid with a glycoprotein spike at each vertex.

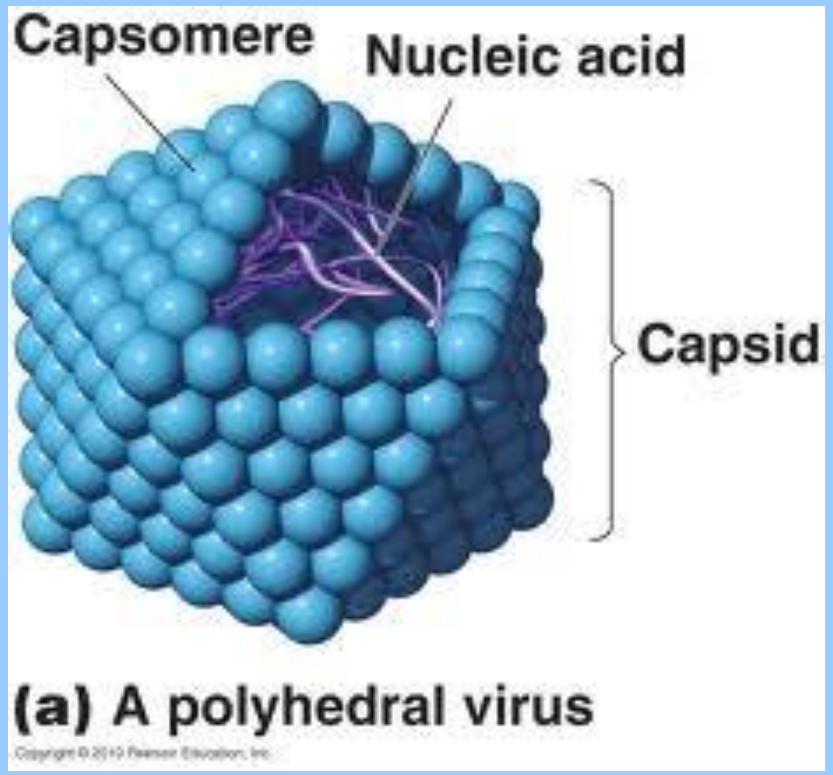
(c) Influenza viruses have an outer envelope studded with glycoprotein spikes. The genome consists of eight different RNA molecules, each wrapped in a helical capsid.

(d) Bacteriophage T4, like other "T-even" phages, has a complex capsid consisting of a polyhedral head and a tail apparatus.

Capsids

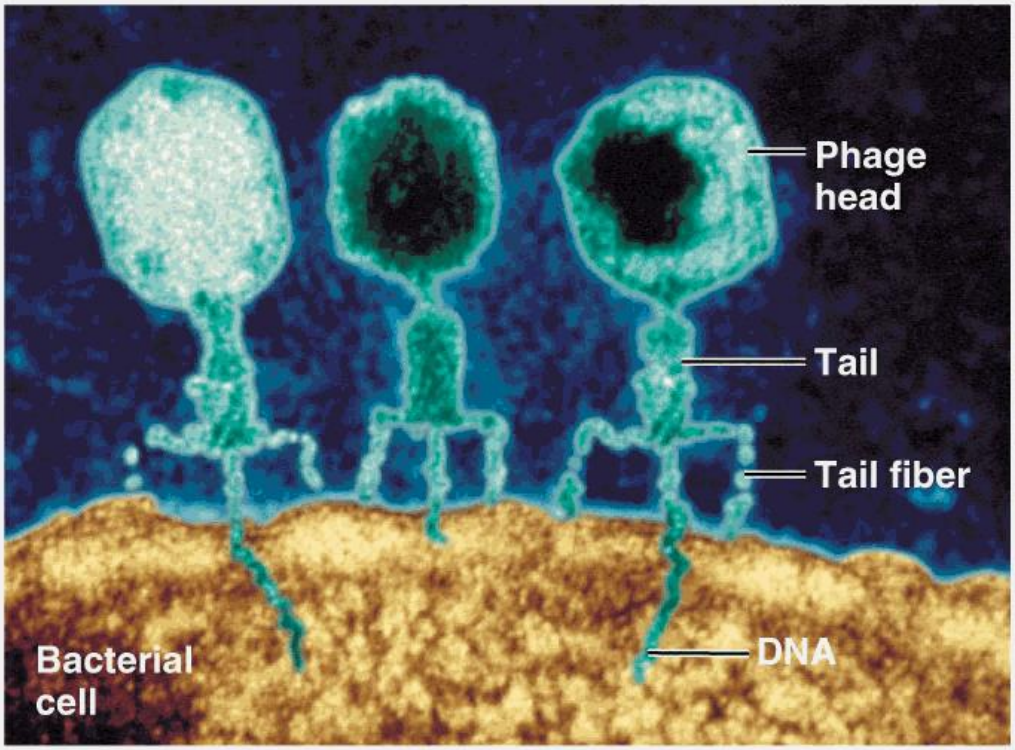


Helical



Polyhedral

Bacteriophages infecting a bacterial cell



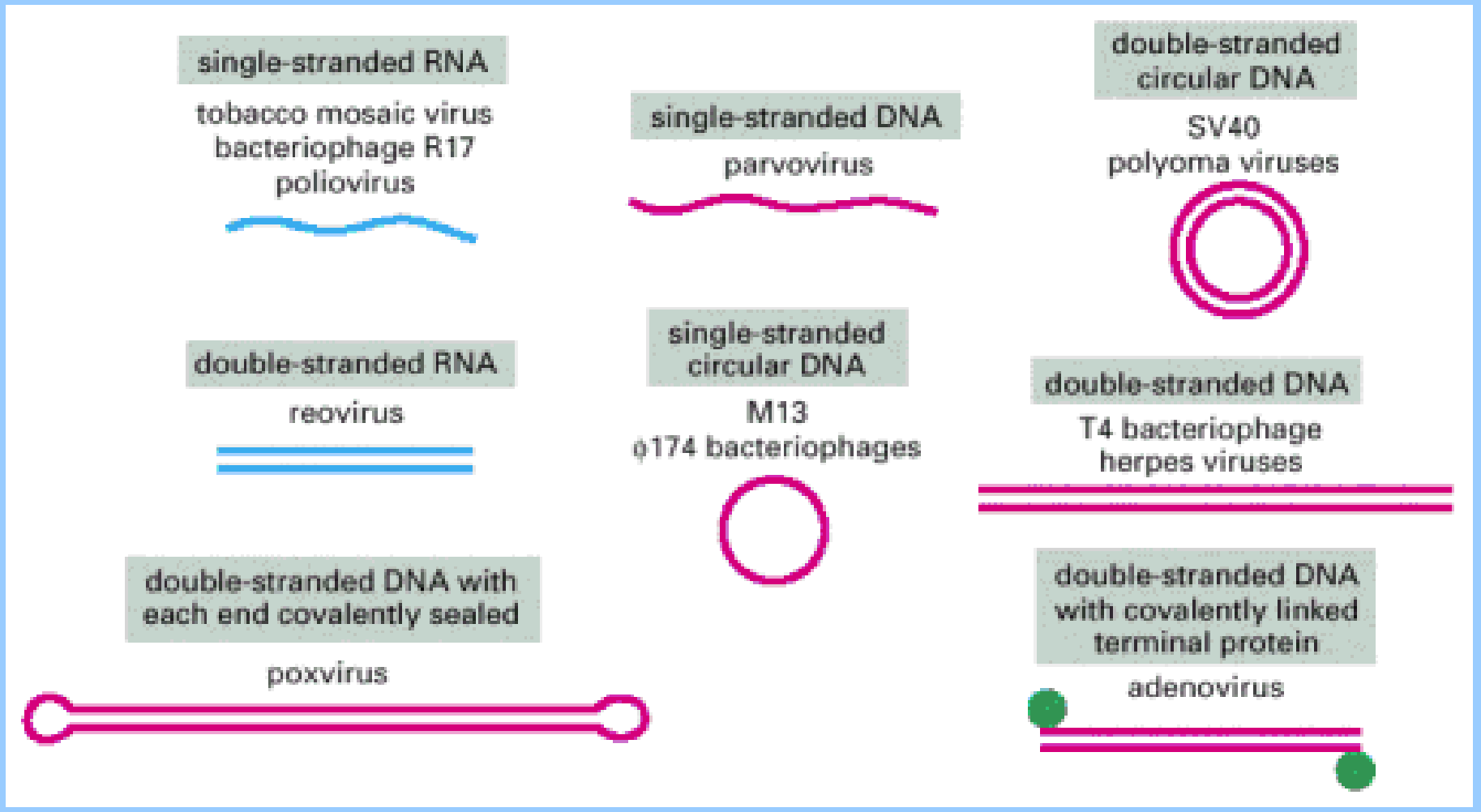
(a) T2 and related phages use their tail pieces to attach to the host cell and inject their genetic material (TEM).

viral DNA injection

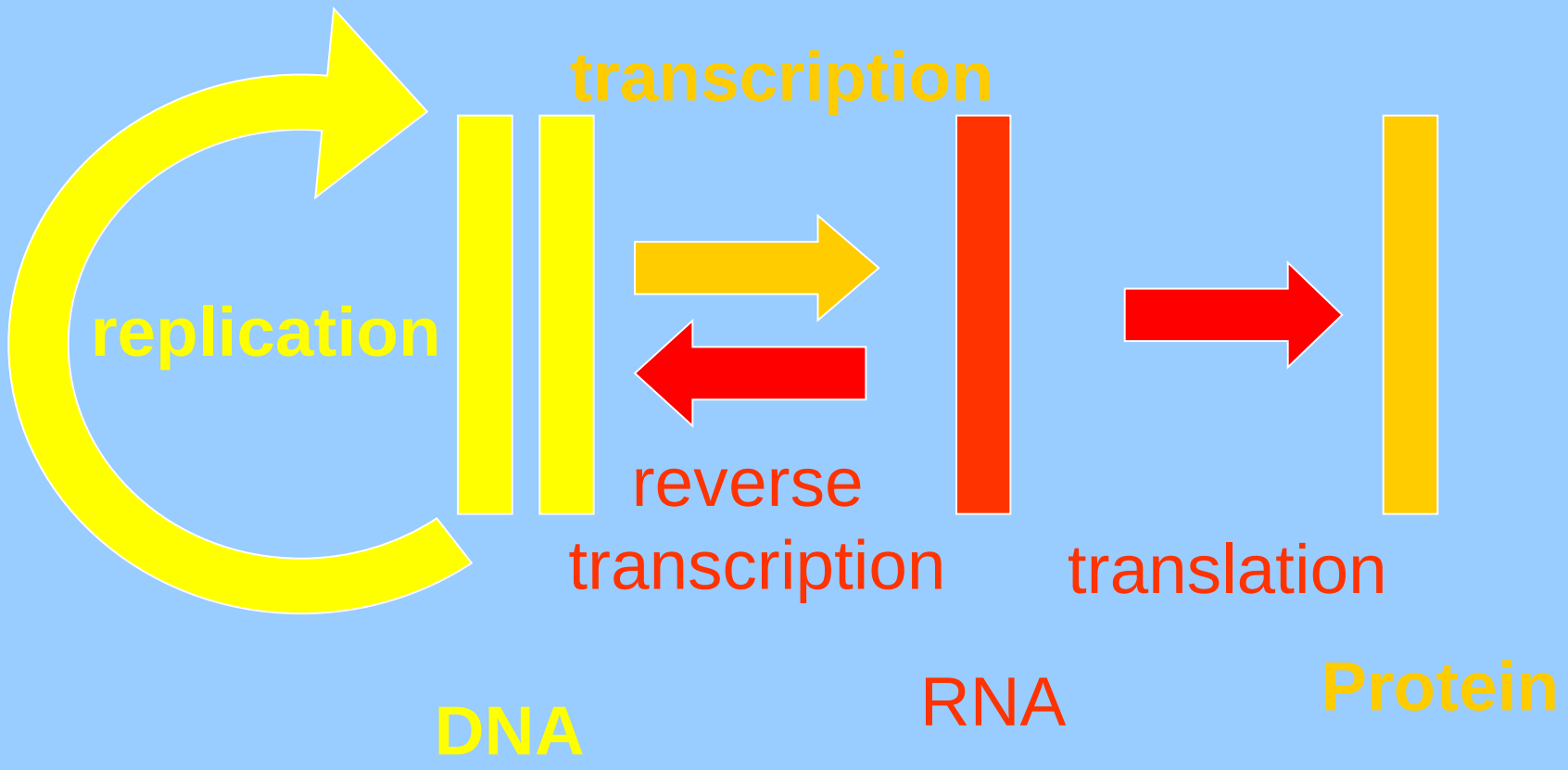
virus classification

- host specification: plant, animal, bacteria
- DNA a RNA virus: ds DNA (I.), ss DNA(II.), ds RNA(III.), pos ss RNA (VI.), neg ss RNA (V.), rev trans ss RNA (IV.), rev trans circular dsDNA (VII.)
- structure: symmetry helical, complex, icosahedral, capsid, envelope, number of capsomer

ds DNA, ss DNA, ds RNA, ss RNA, rev trans diploid ss RNA, rev trans circular dsDNA



Central dogma of Biology, Molecular biology, Genetics



Viruses can reproduce via a host cell

- Obligate intracellular parasites
- Virus infects only a limited range of host cells – **host specificity**
- Eukaryotic viruses are **tissue specific**
- Lytic cycle – cytolysis by **virulent viruses**

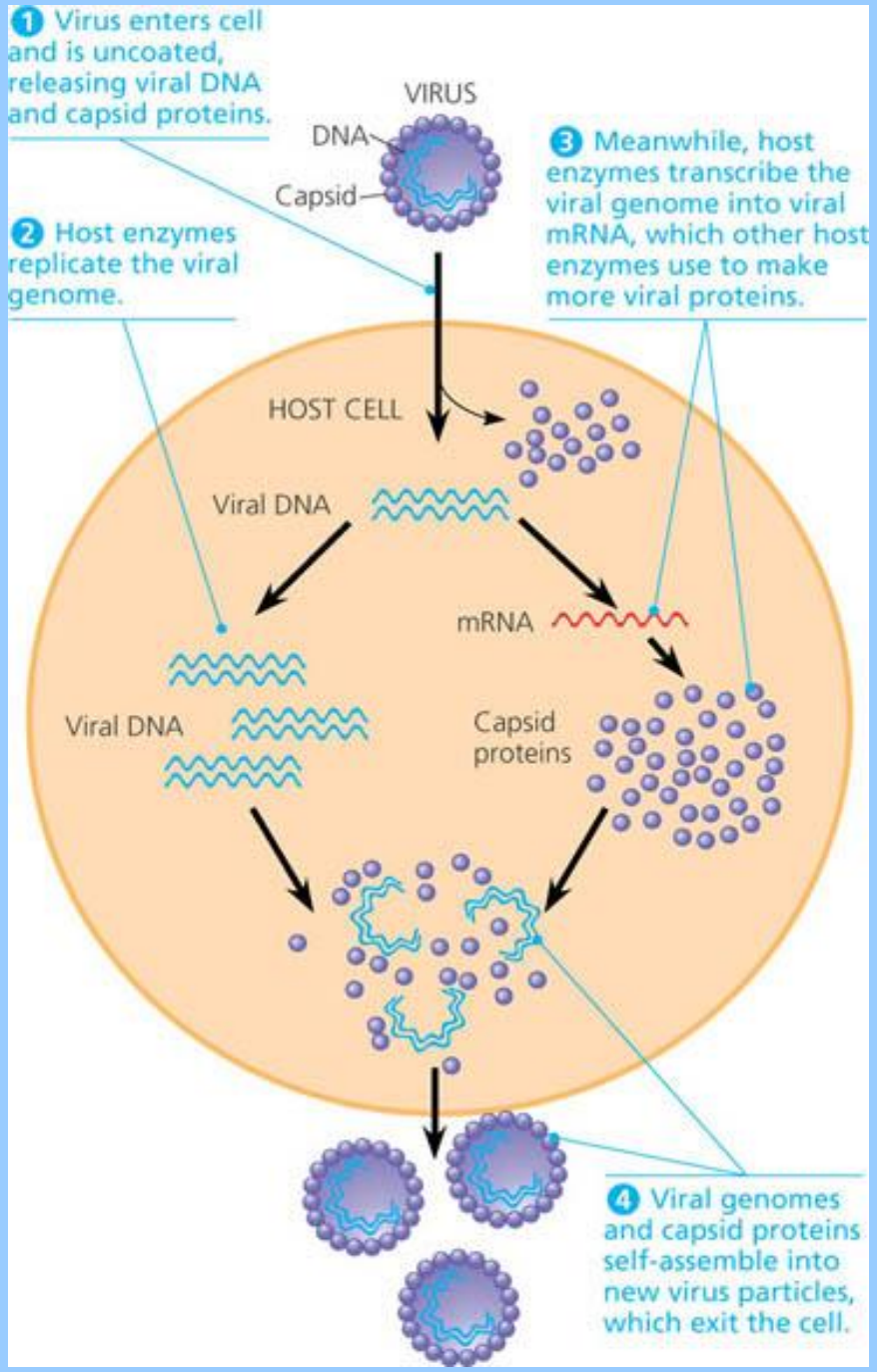
Lytic cycle of virus reproduction

- adsorption of the virus to the cell – spike protein
- penetration of the virus or viral NA into cytoplasm
- replication, transcription and translation
- assemble of new viral particles (self-assembly)
- transfer to daughter cells: effect on the cell:

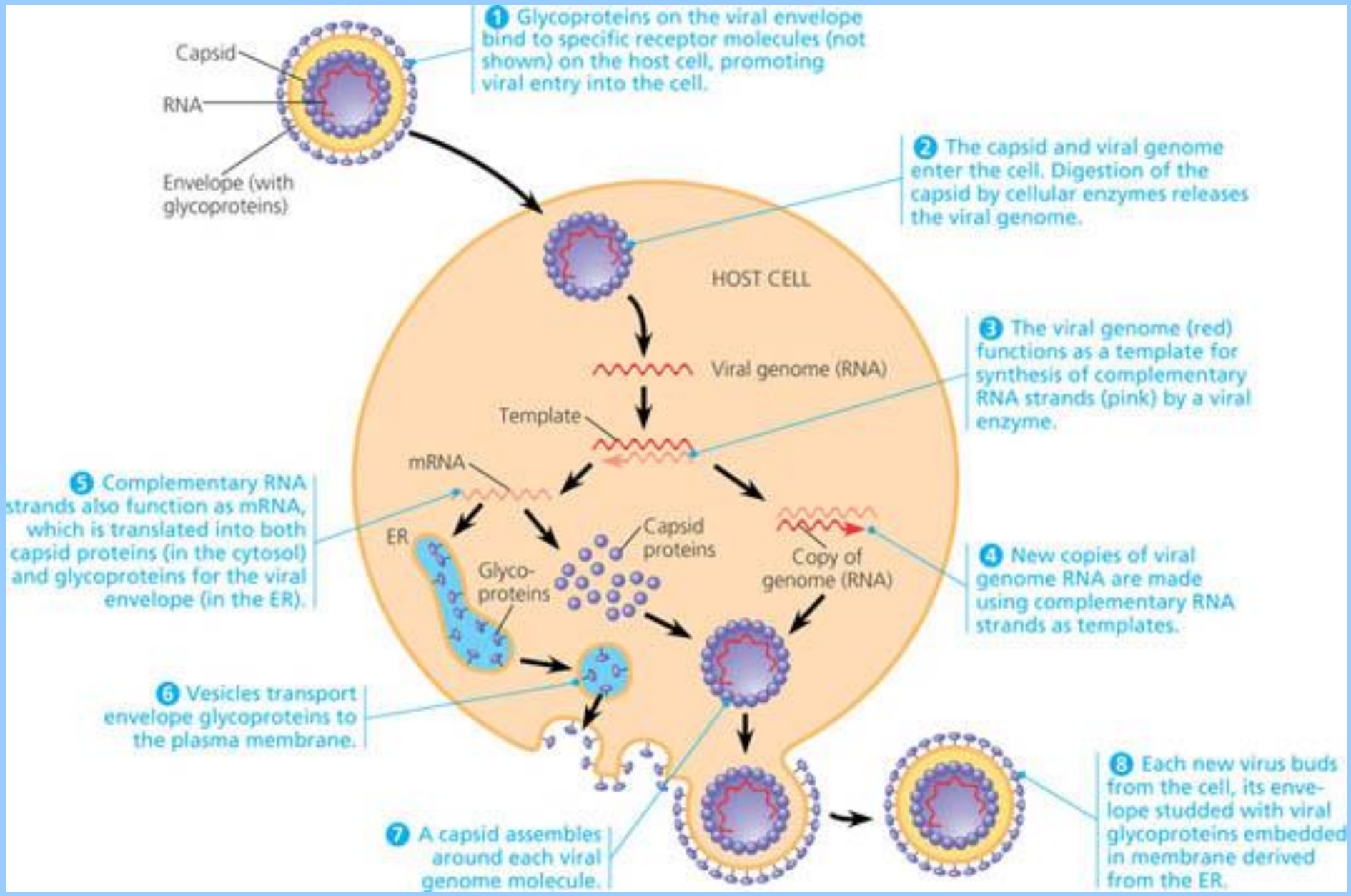
death of the cell – lysis (hundreds or thousand)

cytopathy effect (exocytose)

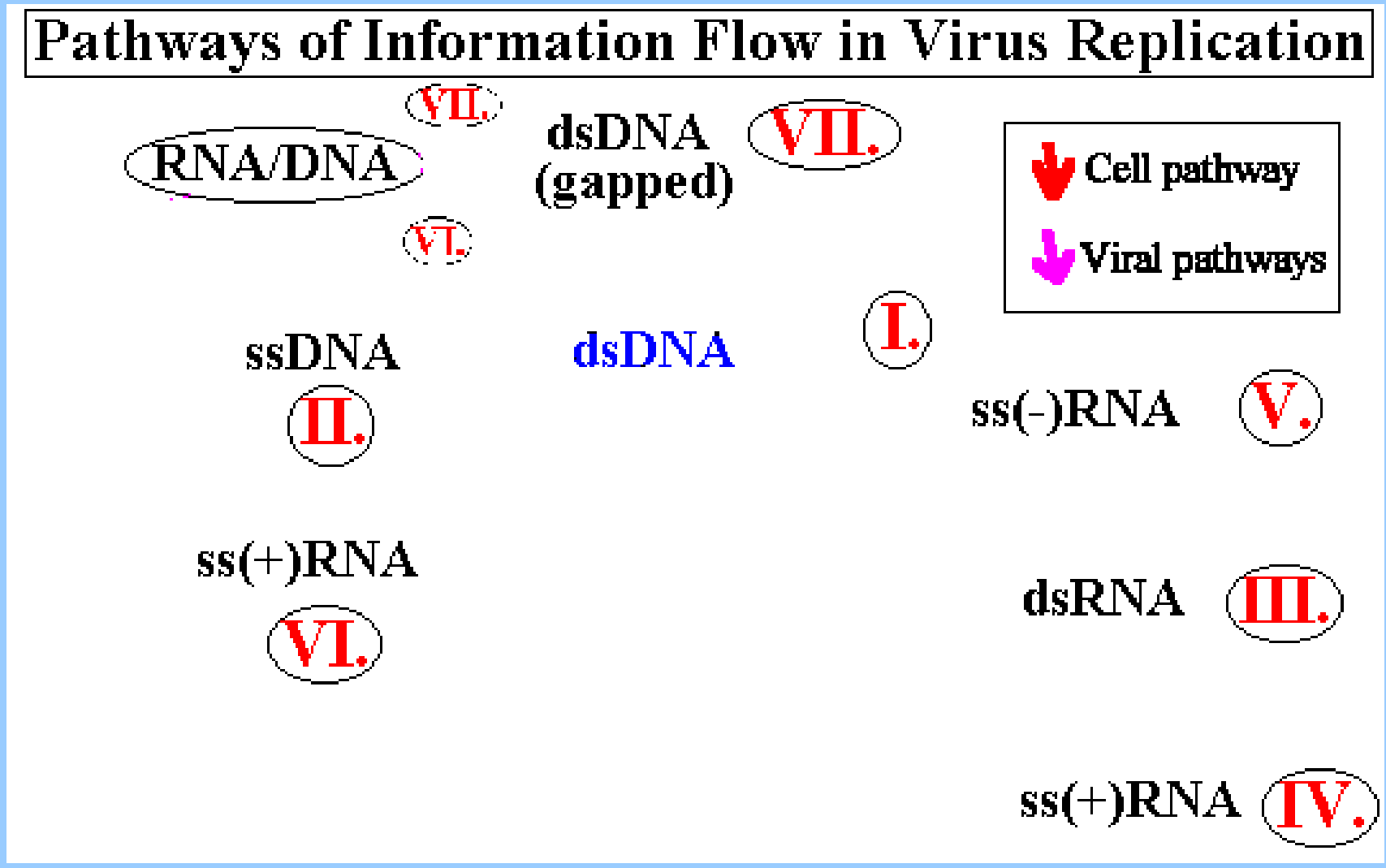
A reproductive cycle of DNA virus



The reproductive cycle of an enveloped RNA virus



Pathways of Information Flow in Virus Replication



RNA viruses:

+ssRNA: RNA serve as genetic material, i.e. is replicated to new copies

serve as mRNA for translation, i.e. production of viral proteins, e.g. virus of hepatitis C, rhinoviruses (cold), SARS

-ssRNA: RNA is converted to +ssRNA by viral RNA replicase

+ssRNA serve as mRNA for translation of viral proteins and as template for replication of viral RNA, e.g. measeles, mumps, rabies

Retroviruses - reproduction:

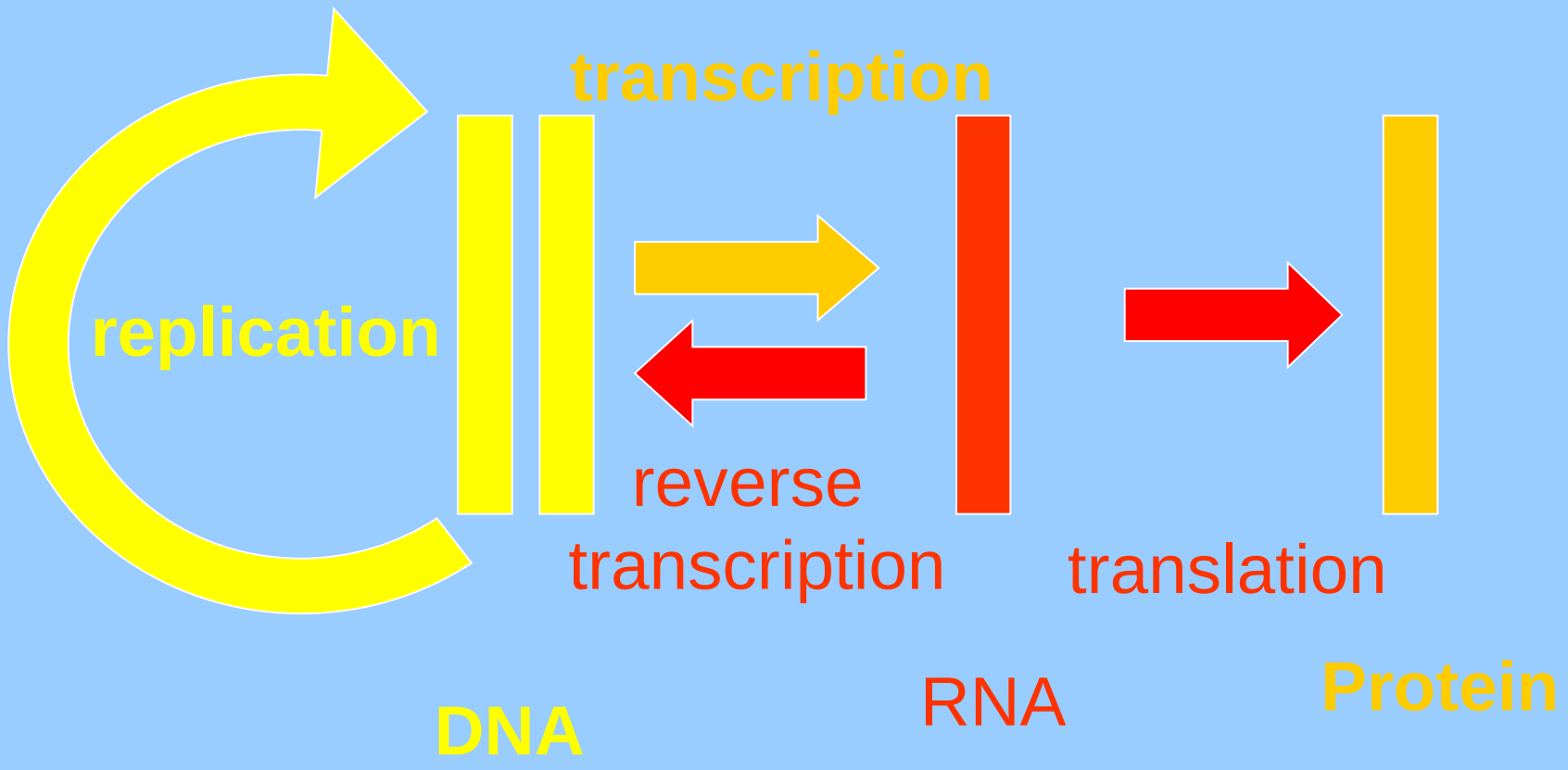
retroviruses: single-stranded positive-sense **RNA** viruses

reverse transcriptase – produces DNA from RNA template, DNA replicates to double stranded DNA, which is transferred to nucleus and integrated to the host DNA or can be transcribed to mRNA for translation of viral proteins

e.g. HIV, Rous sarcoma virus (RSV)

Some retroviruses can cause tumors, e.g. RSV src gene (=oncogene)

Central dogma of Biology, Molecular biology, Genetics

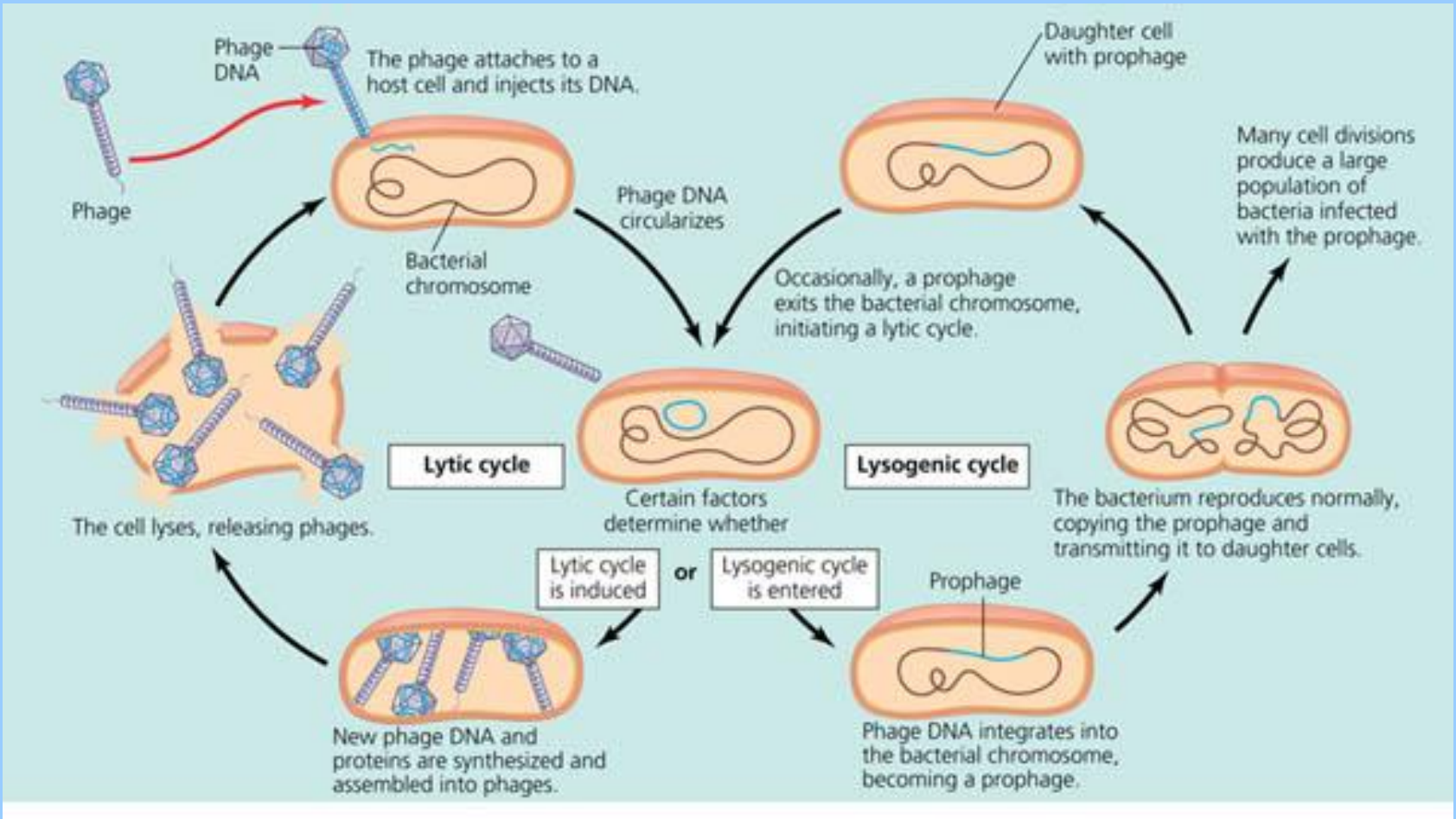


Lysogenic - virogenic cycle

= integration of viral nucleic acid into the host genome as provirus (prophage)

- replication with the DNA of the host cell
- virus is transferred to daughter cells
- **Temperate viruses**: latent viruses – the cell is not damaged
- viruses as vectors of **oncogenes**

Temperate phages

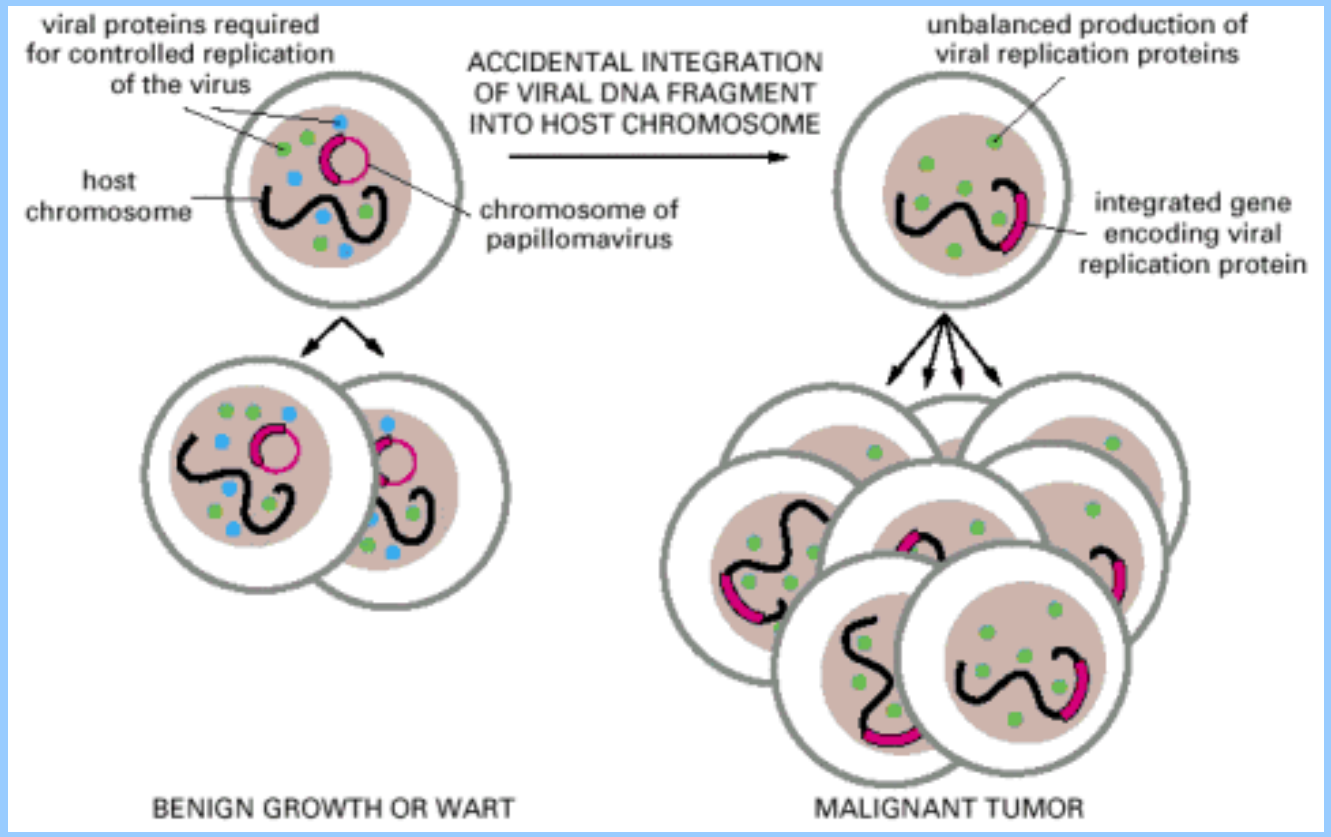


The lytic and lysogenic cycles of phage λ, a temperate phage. After entering the bacterial cell and circularizing, the λ DNA can immediately initiate the production of a large number of progeny phages (lytic cycle) or integrate into the bacterial chromosome (lysogenic cycle).

Tumor viruses - transformation of eukaryotic cells

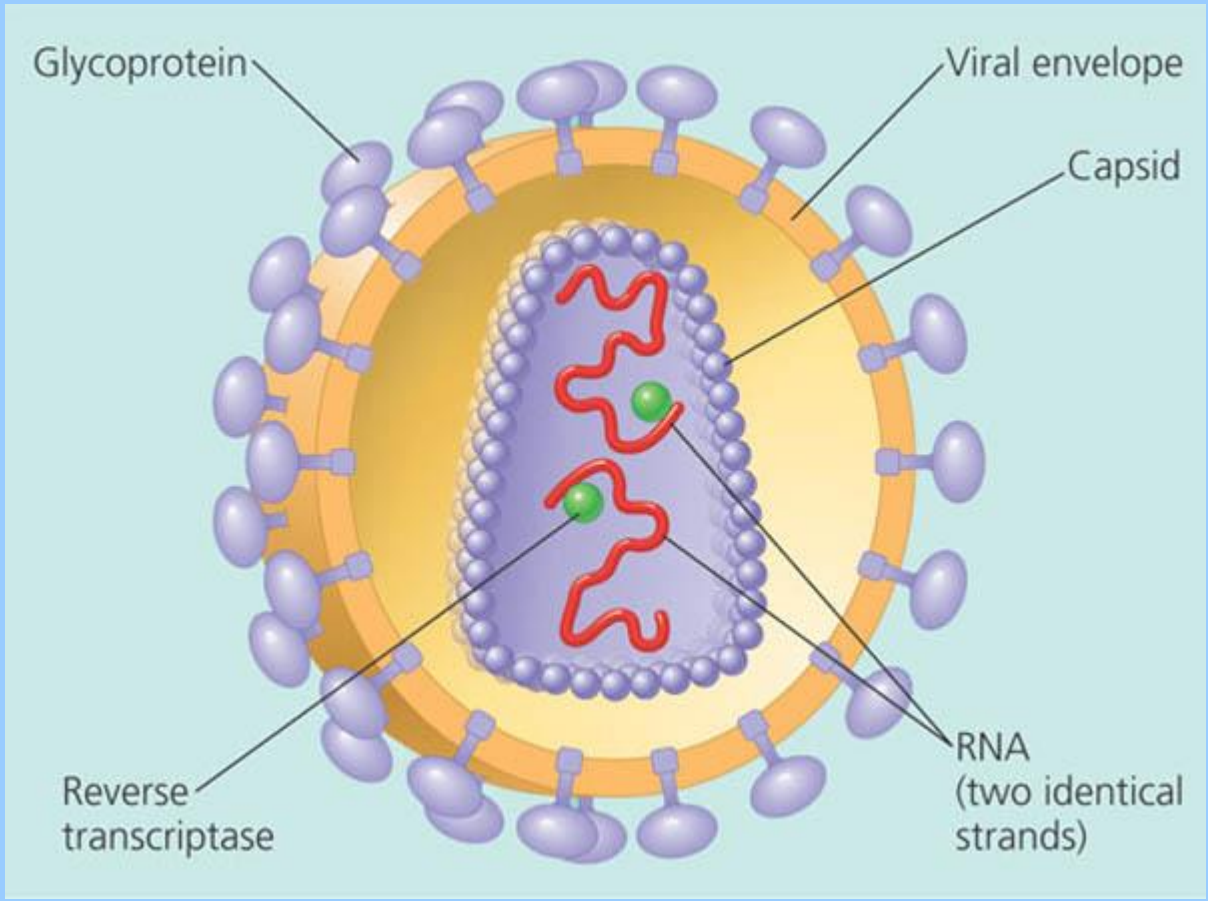
DNA viruses – oncogenes

RNA viruses = retroviruses



Transforming papilomavirus

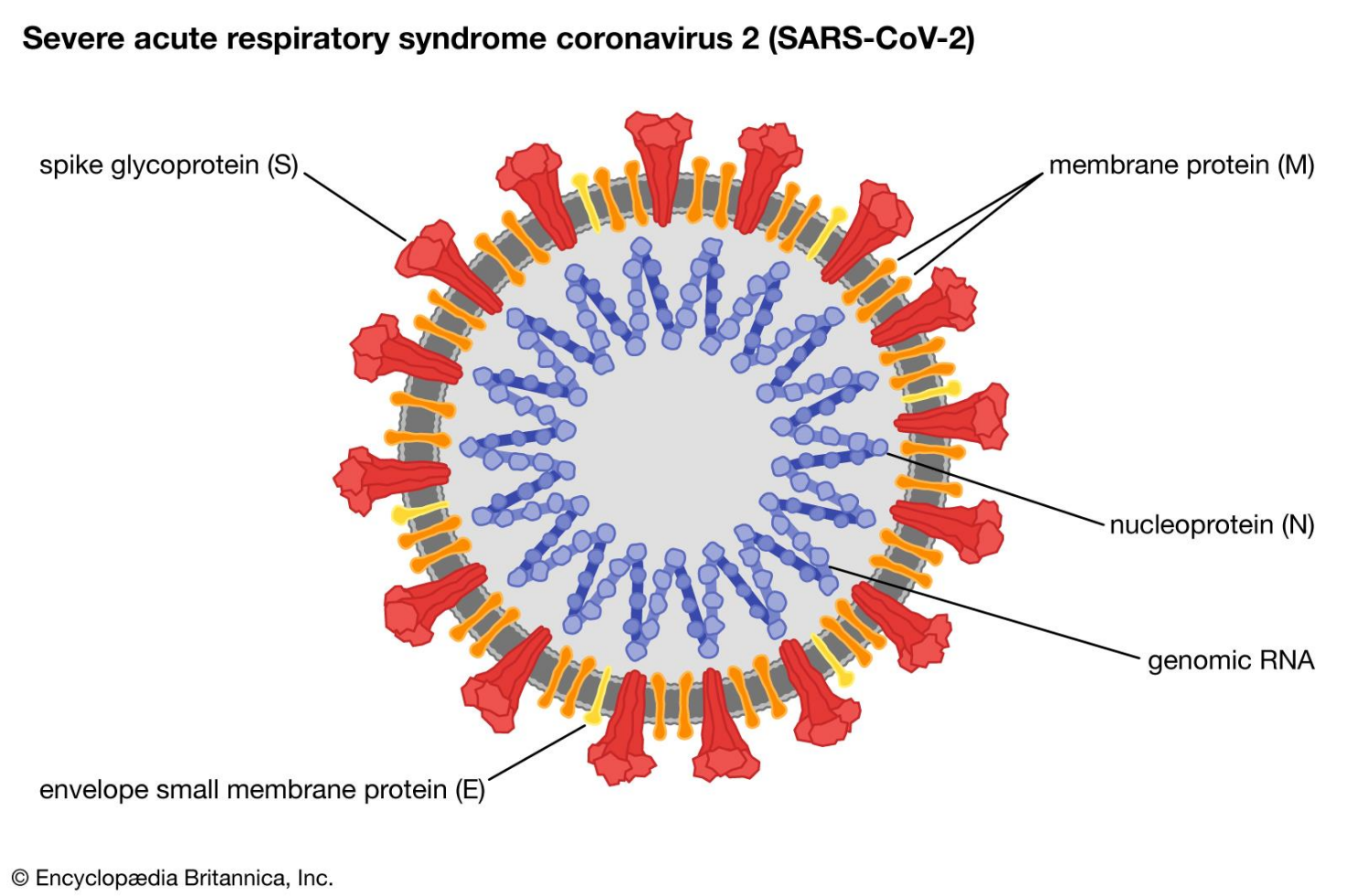
family **Retrovirus,** genus **Lentivirus, pos ssRNA-RT, encapsulated: HIV-1, HIV-2**



family **Coronaviridae,** genus **Betacoronavirus,**

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), positive-sense single-stranded RNA virus

The structural proteins of SARS-CoV-2 include membrane glycoprotein (M), envelope protein (E), nucleocapsid protein (N), and the spike protein (S).



virus classification

I: dsDNA viruses e.g. Adenoviruses, Herpesviruses, Poxviruses (smallpox), Papilomavirus (wart,cervical cancer)

II: ssDNA viruses (+ strand or sense) DNA (e.g. Parvoviruses)

III: dsRNA viruses (e.g. Reoviruses (diarrhoea)

IV: (+)ssRNA viruses (+ strand or sense) RNA (e.g. Coronaviruses, Picornaviruses (poliomyelitis/paralysis), Togaviruses)

V: (−)ssRNA viruses (− strand or antisense) RNA (e.g. Orthomyxoviruses, Rhabdoviruses, Paramyxoviridae)

VI: ssRNA-RT viruses (+ strand or sense) RNA with DNA intermediate in life-cycle (e.g. Retroviruses)

VII: dsDNA-RT viruses DNA with RNA intermediate in life-cycle (e.g. Hepadnaviruses)

RNA viruses

Poliomyelitis – polio +ss

Rhinitis – cold +ss

Influenza – flu -ss

Encefaliti +ss

Rubella – measles Ger. +ss

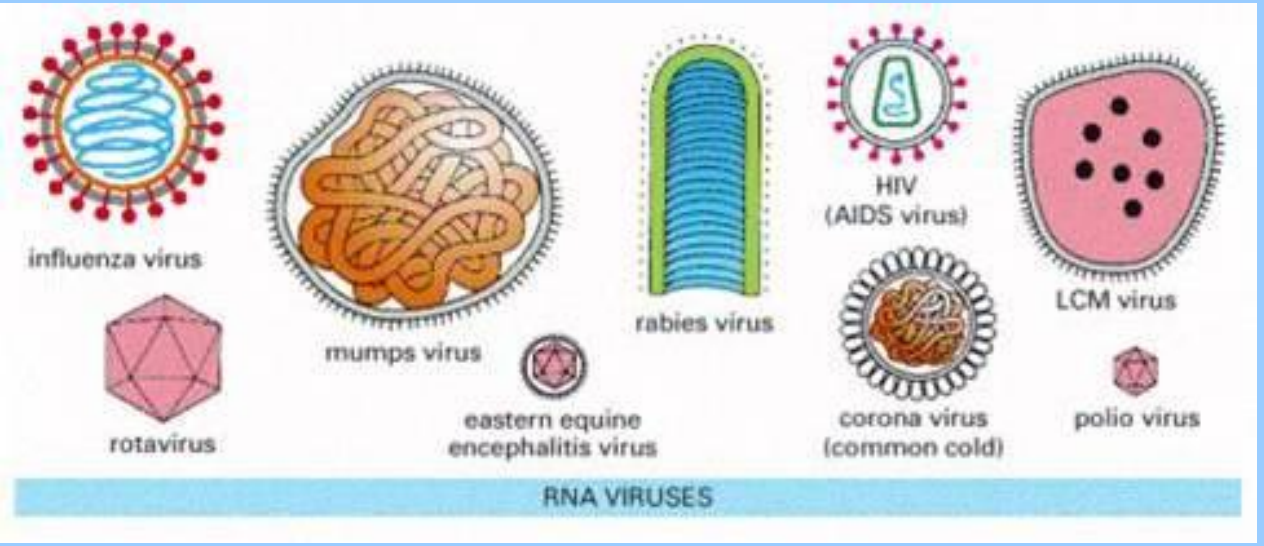
Parotitis – mumps -ss

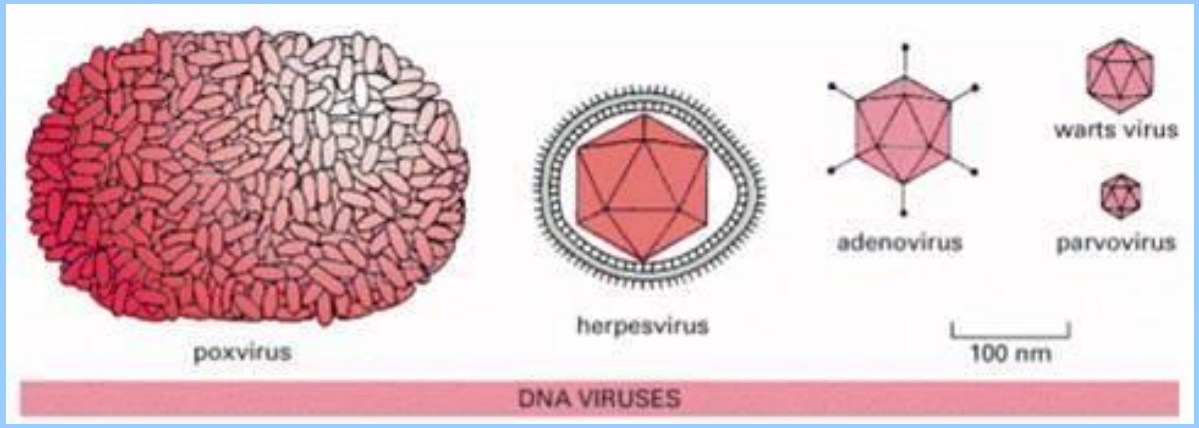
Morbilli – measles -ss

Rabies +ss

HIV-AIDS

SARS-COV-2 +ss





DNA viruses:

Adenoviruses - respiratory disease, conjunctivitis gastroenteritis

Oral herpes - herpes simplex virus, chickenpox

infectious mononucleosis - Epstein-Barr virus (EBV)

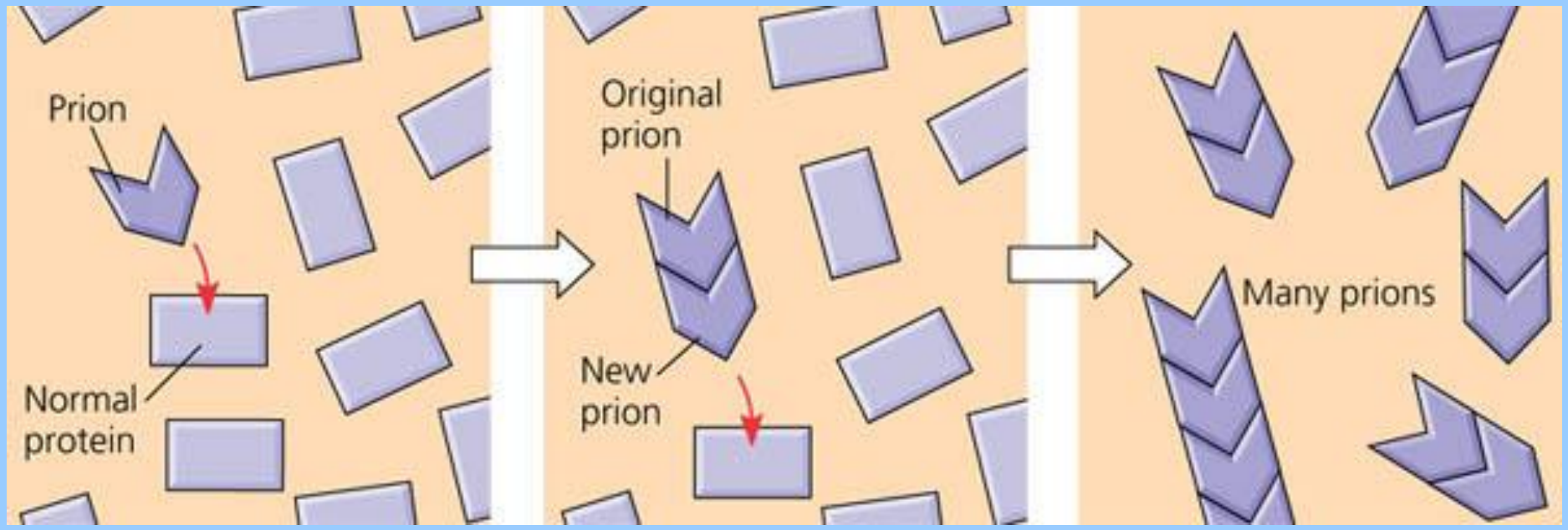
Smallpox - Variola major and minor

Human Papilomavirus (HPV) - warts (verrucae), cancers of cervix, vulva, vagina

Prions

- degenerative brain disease
- infectious particles
- contain proteins, NA wasn‘t proved
- abnormal prion = product of mutated genes

- In the 1950s, Carleton Gajdusek began research which eventually showed that kuru could be transmitted to chimpanzees by what was possibly a new infectious agent, work for which he eventually won the 1976 Nobel prize. Mr. Prusiner won the Nobel Prize in Physiology or Medicine in 1997 for his research into prions.



Model for how prions propagate. Prions are misfolded versions of normal brain proteins. When a prion contacts a normal “twin,” it may induce the normal protein to assume the abnormal shape.

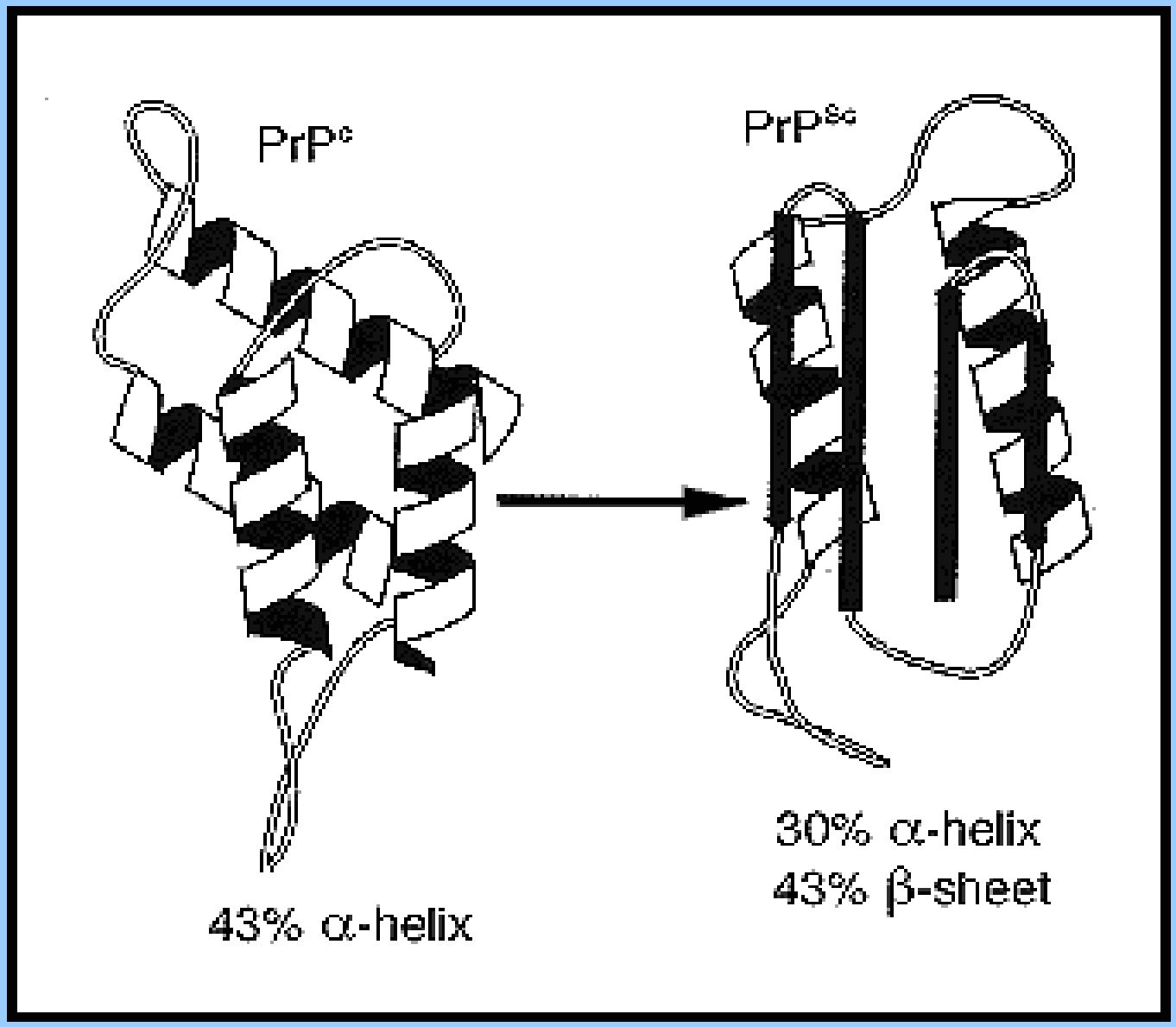
Prion protein

- occurrence in two isoforms:

normal PrPC (C=cellular)

abnormal PrPSC (SC=scrapie)

- PrPC – prevalence of alpha helix
- PrPSC – prevalence of beta structure, presence of PrPSC induces PrPC change = from normal protein to abnormal - runs as chain reaction


PrP^c
PrP^sc
43% α-helix
30% α-helix
43% β-sheet

- **transfer** between species is rare,

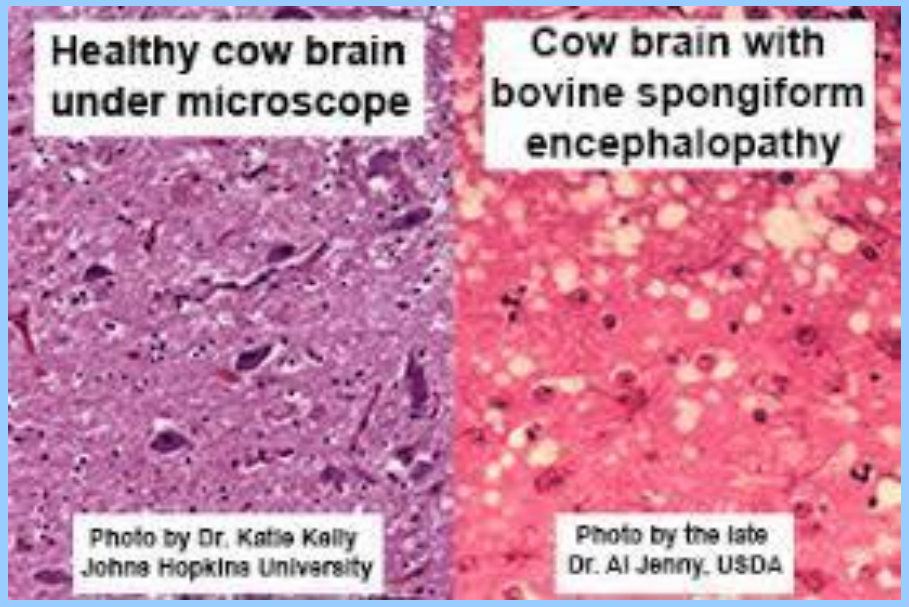
  but might be possible with a long period of latency

- **transfer from human to human**: by growth hormone, brain electrodes

- **Hereditary disease** AD caused by gene **mutation** → abnormal protein

Animal disease

They cause an infection in sheep called **scrapie** and cattle **bovine spongiform encephalopathy** ("mad cow" disease).



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Human diseases

- **Creutzfeld-Jacob** disease: affection of the grey brain cortex, severe neurological symptoms with quickly proceeded dementia
- **kuru: Papua-New Guinea:** disability of movement coordination, paralysis, dementia – disease is spread by ritual cannibalism

Figure 1. *Gajdusek et Zigas examinant, en 1957, un jeune enfant papou atteint du kuru (© D.C. Gajdusek).*

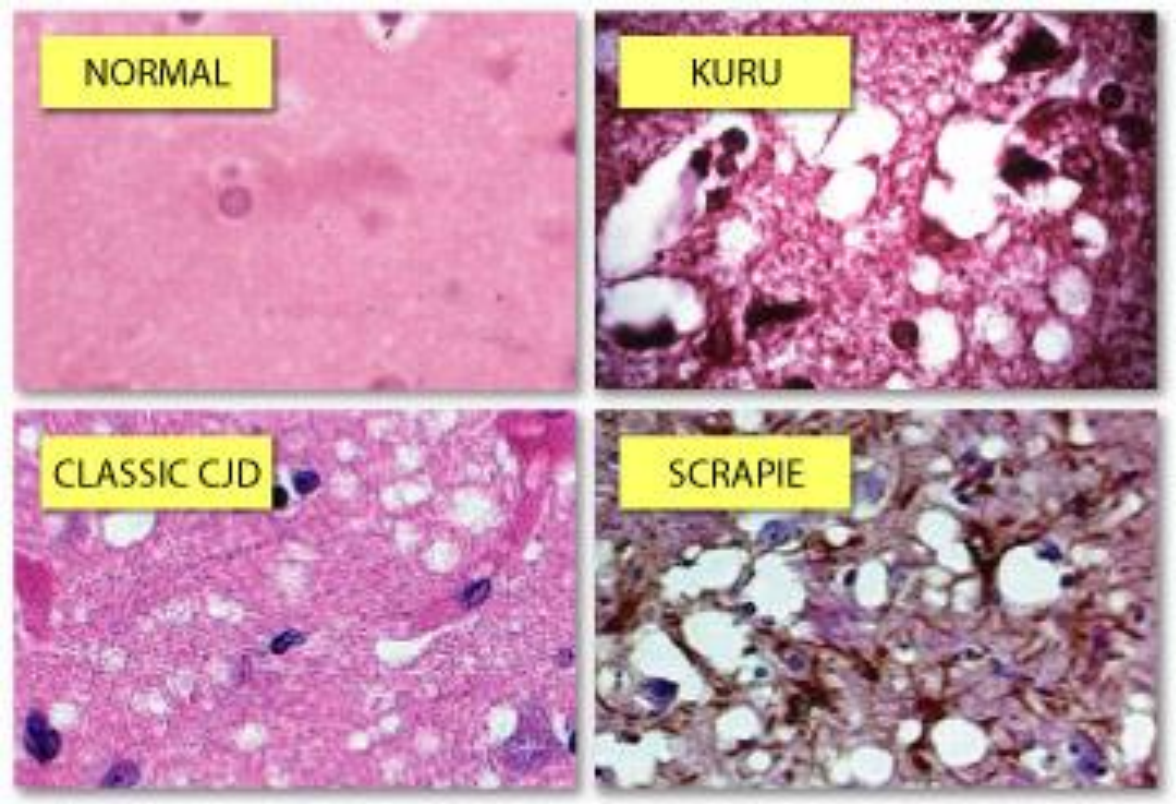
Figure 1. Gajdusek et Zigas examinant, en 1957, un jeune enfant papou atteint du kuru (© D.C. Gajdusek). Published in 1999. L'exemplaire histoire du kuru. M. Laurent

Neural degeneration in a prion infection.

It is a slice from the brain of a person who died of kuru.

The large fluid-filled holes are places where neurons have died.

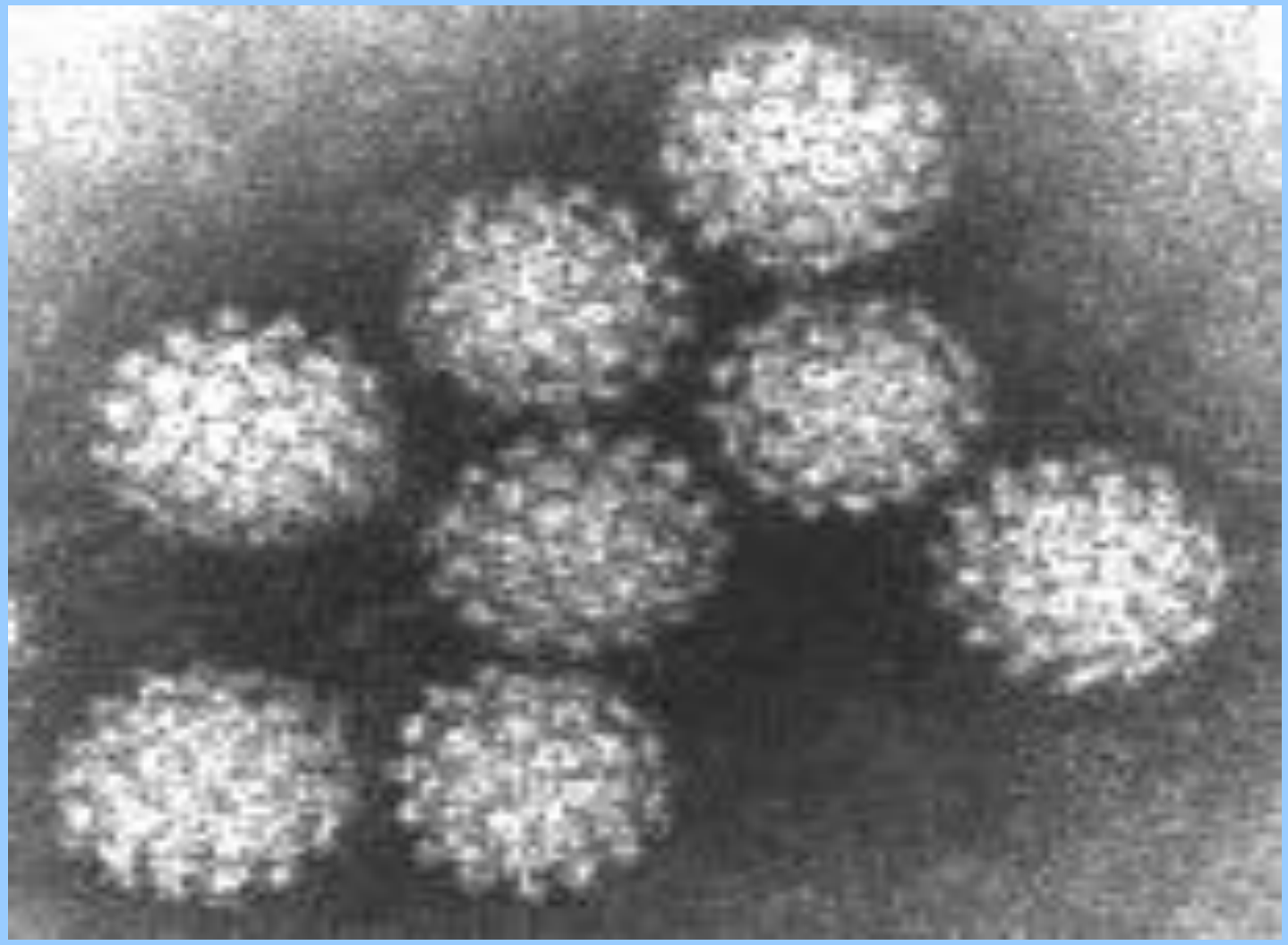
It accumulates and completely fills the given nerve cell. It dies without being replaced. So we see empty spaces where nerve tissue should be.



http://learn.genetics.utah.edu/content/molecules/prions/images/BrainSections.jp

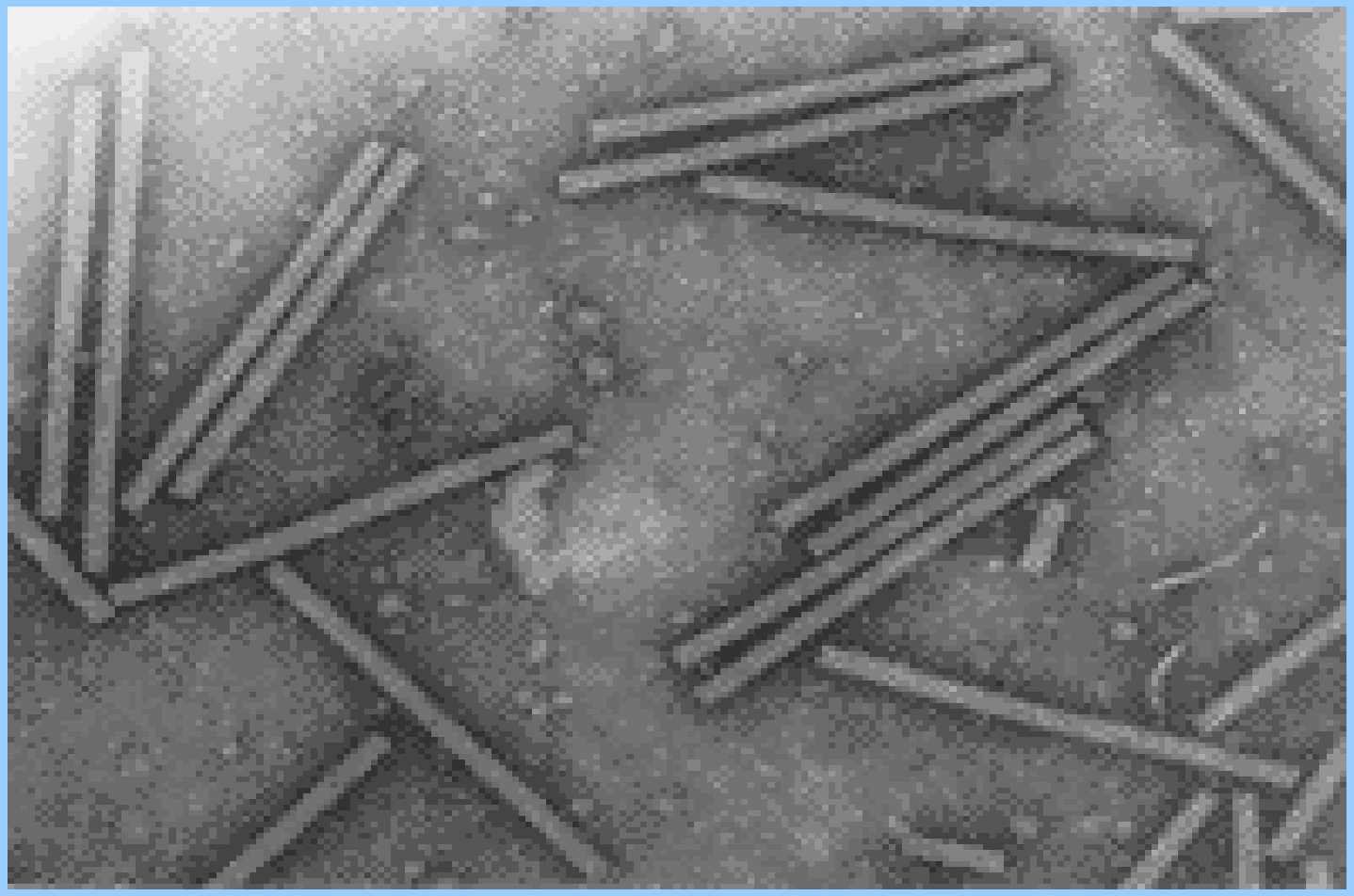
Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V., Biology, Benjamin-Cummings Publishing Company, 1996 – 2010.

Papillomavirus



Electron micrograph of papillomavirus particles. (Courtesy of Linda M. Stannard, University of Cape Town)

Tobacco mosaic virus



Dallwitz, M.J., Gibbs, A.J., Watson, L. and Zurcher, E.J. (eds.) (1996 onwards). `Plant Viruses Online: Descriptions and Lists from the VIDE Database.

Classification of viruses due to nucleic acid