

Structural Virology

Lecture 2

Pavel Plevka

Infectious virus particle “virion”

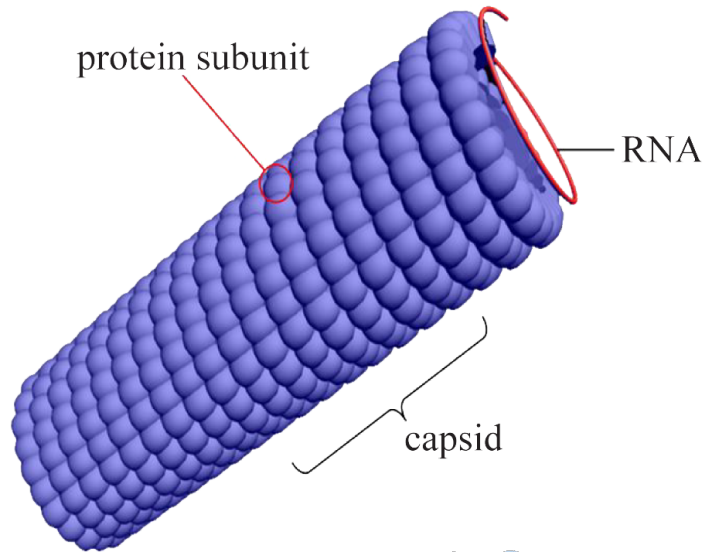
Carrier of genetic information from cell to cell:

- "extracellular organelle"
- packages viral genome
- escapes from infected cell
- survives transfer from cell to cell
- attaches, penetrates, initiates

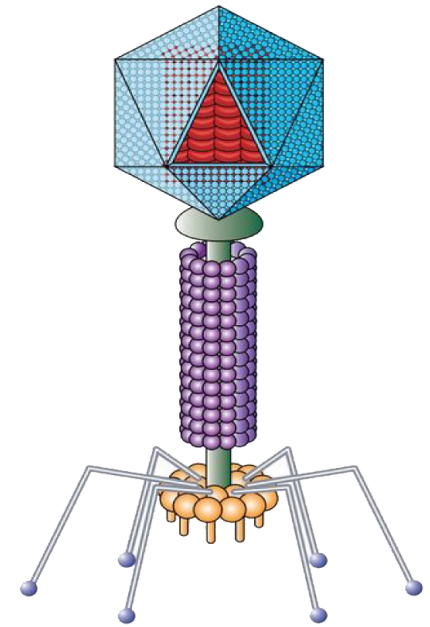
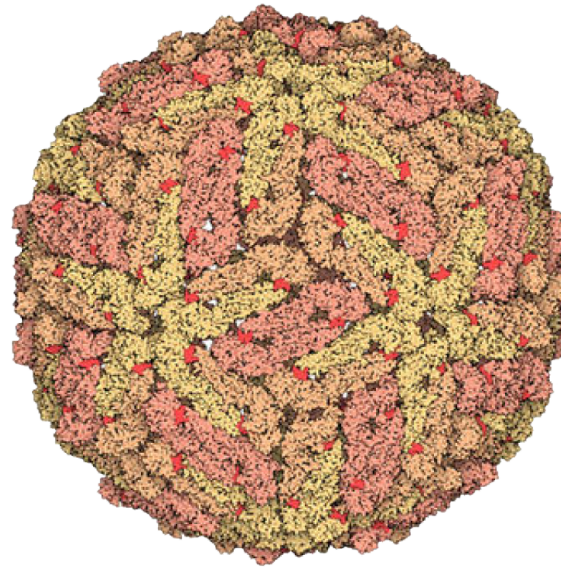
replication in new host cell

Virus structures

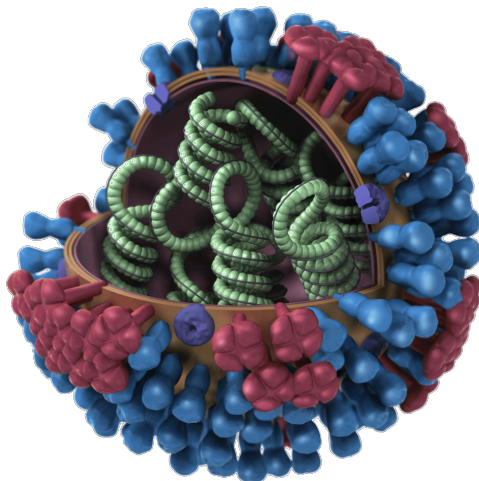
Helical



Icosahedral

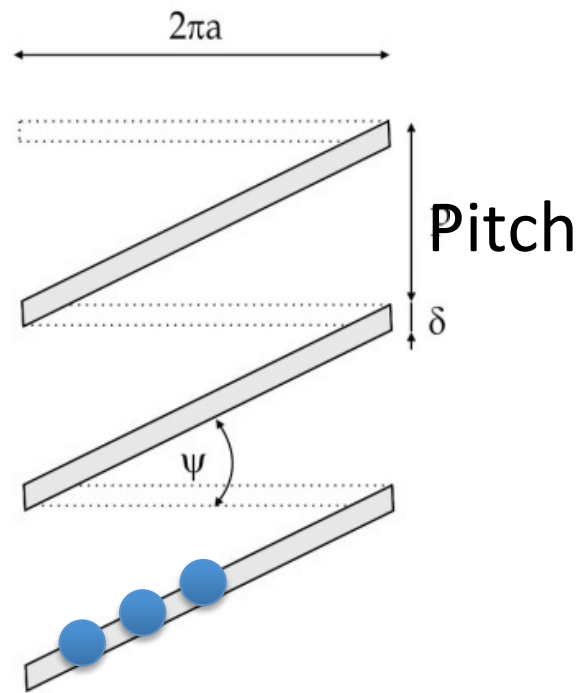
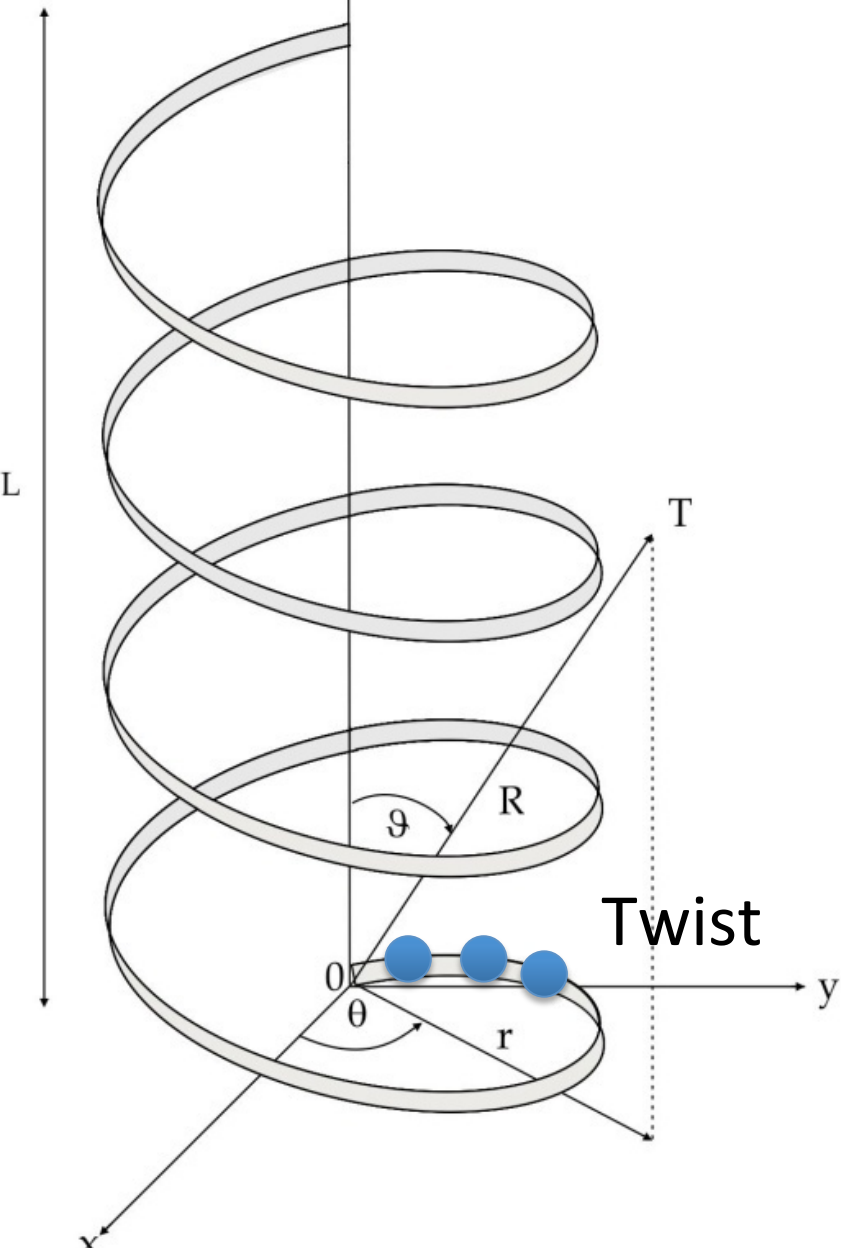


Complex



Irregular

Helical symmetry

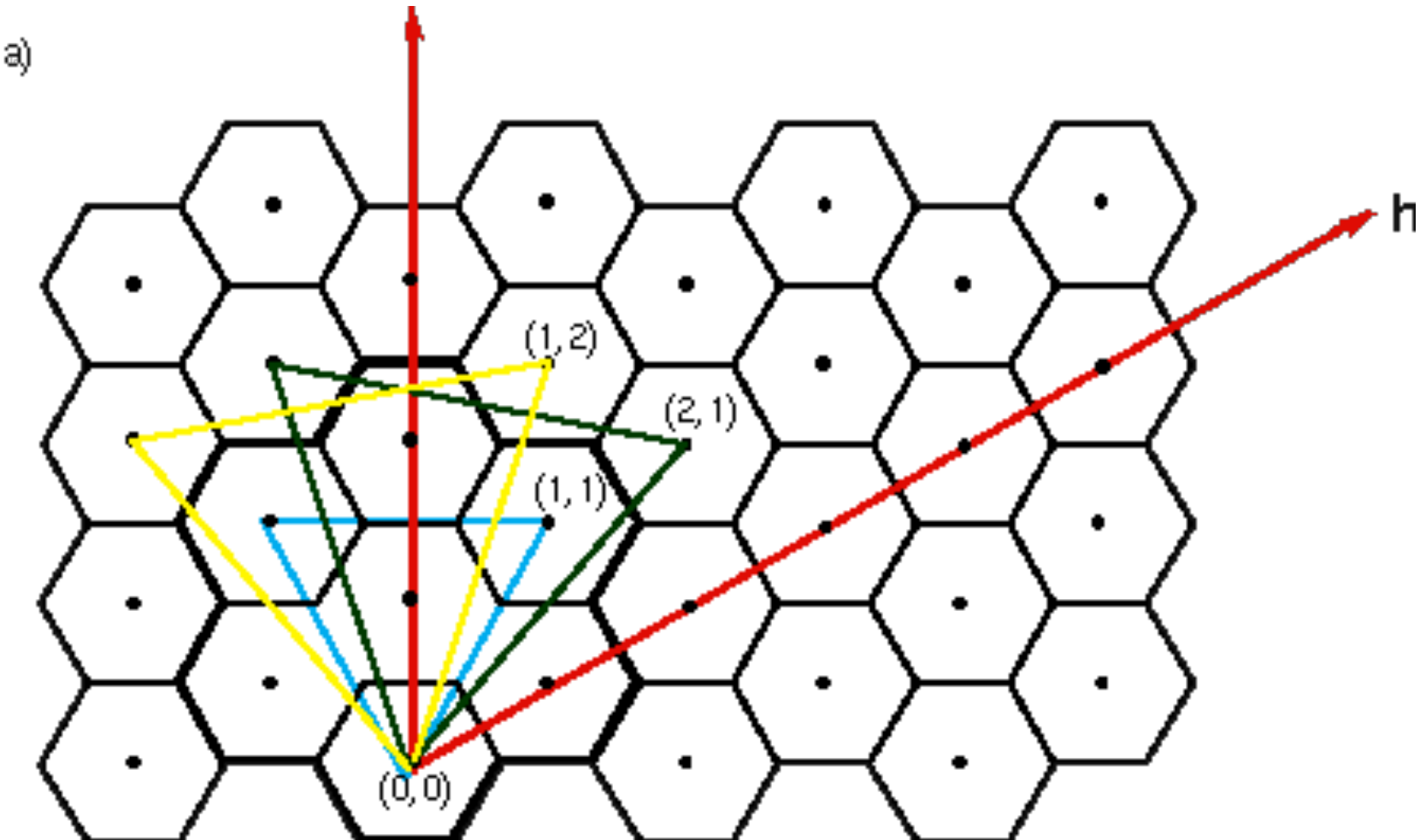


Pitch is the distance along the helix axis for one complete helix turn

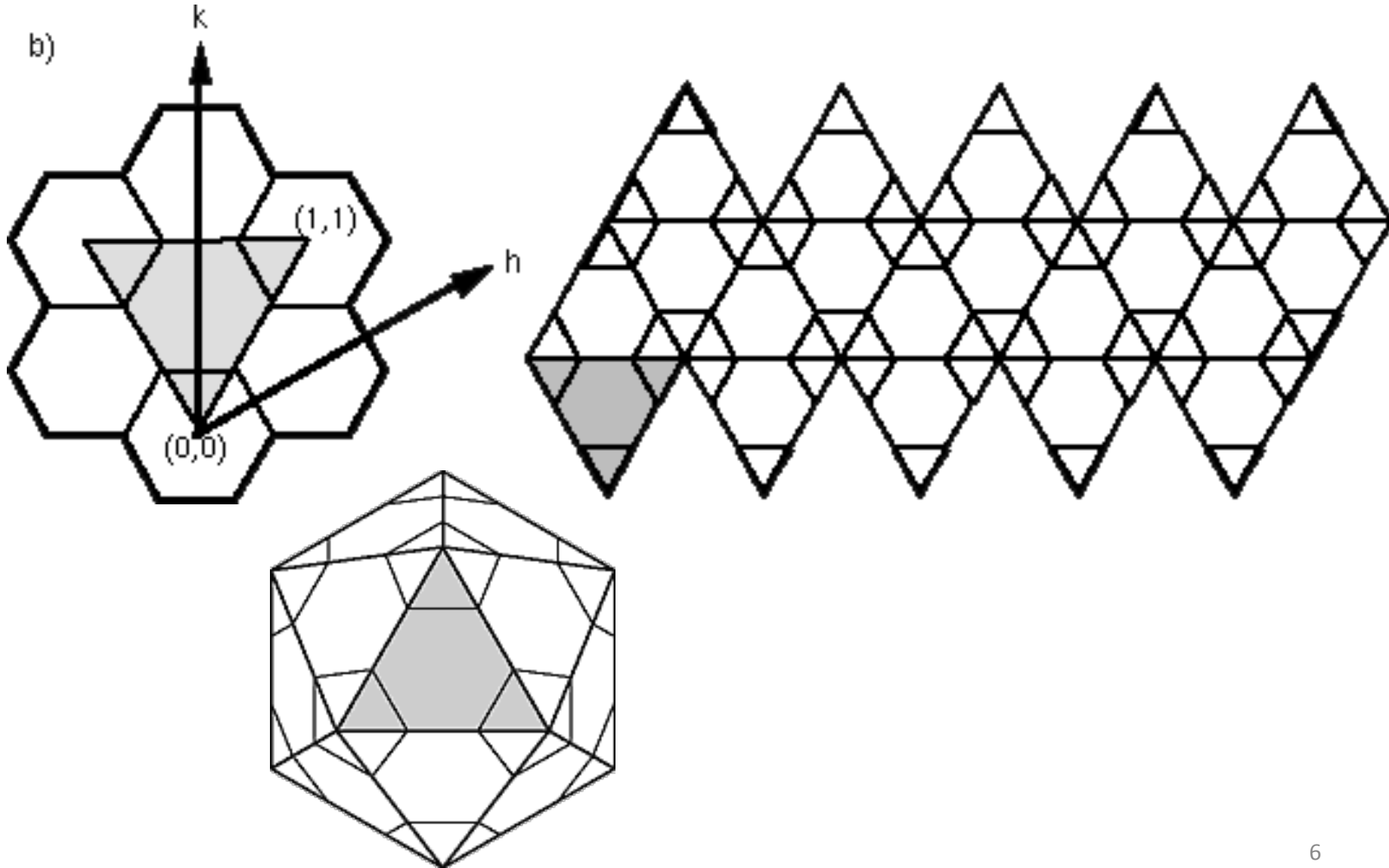
Twist is the rotation between neighboring nucleotides

Quasi equivalence

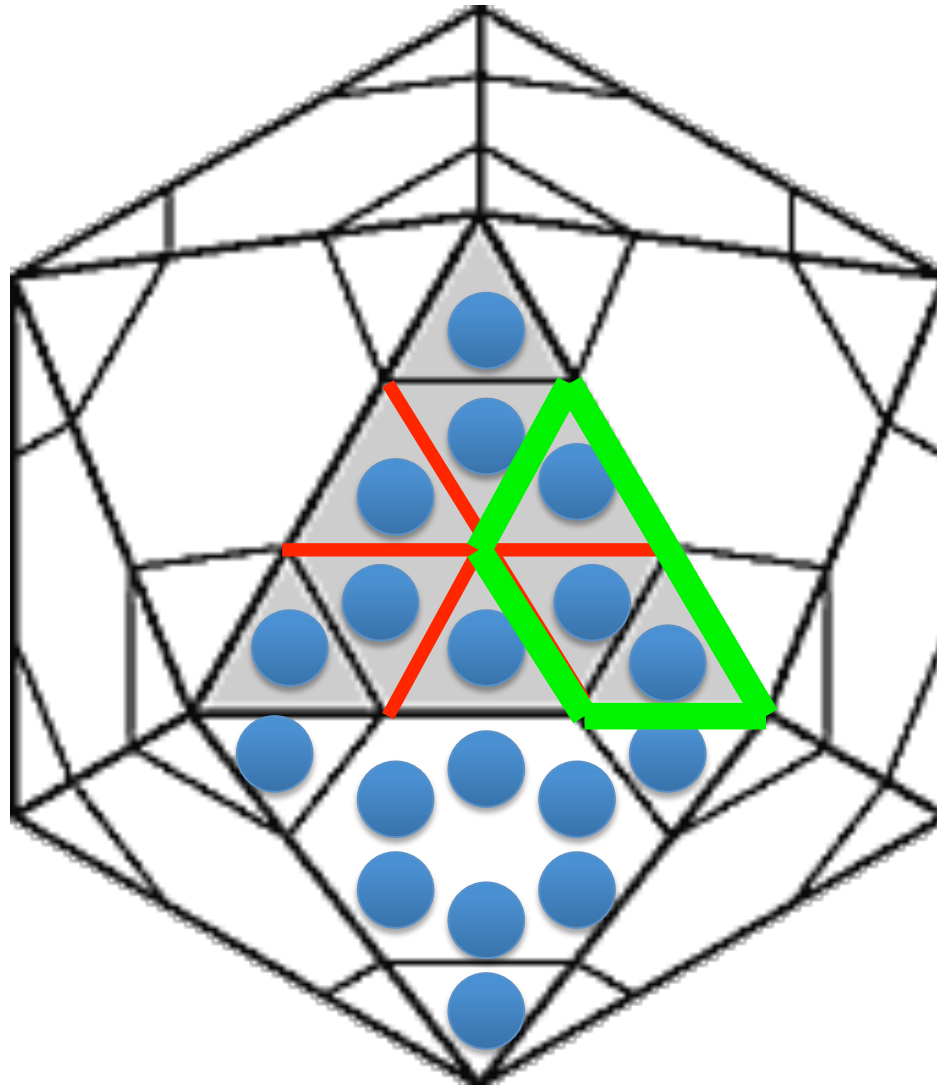
$$T = h^2 + hk + k^2$$



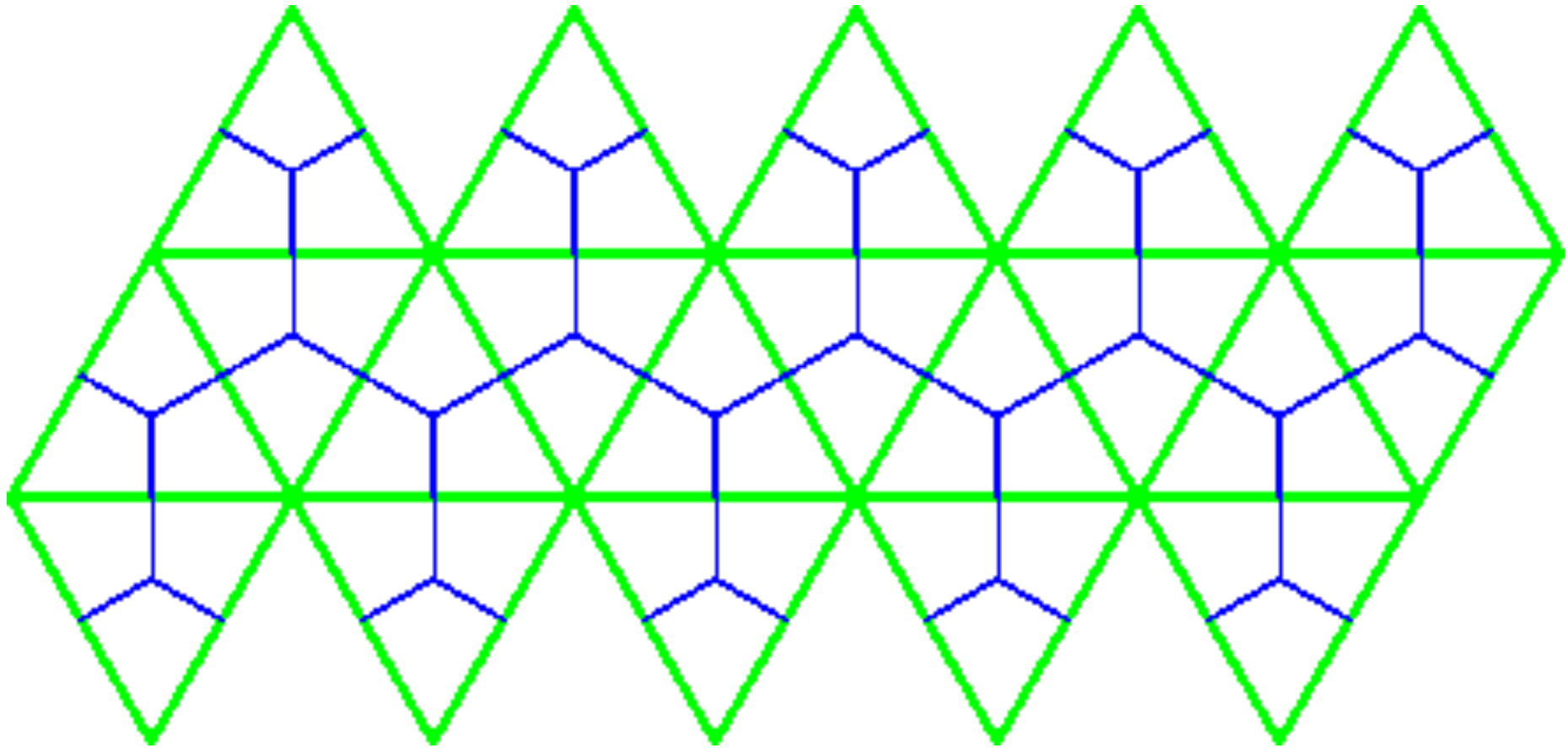
Quasi equivalence



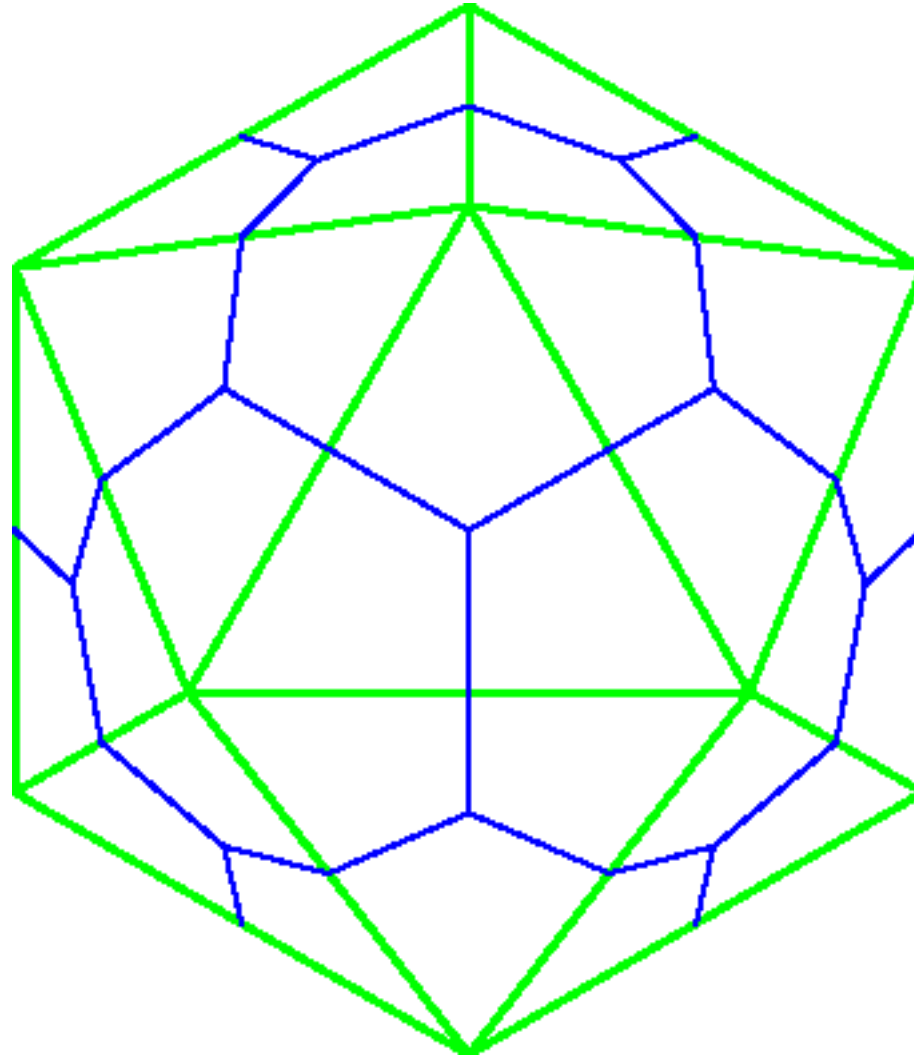
Quasi-equivalence



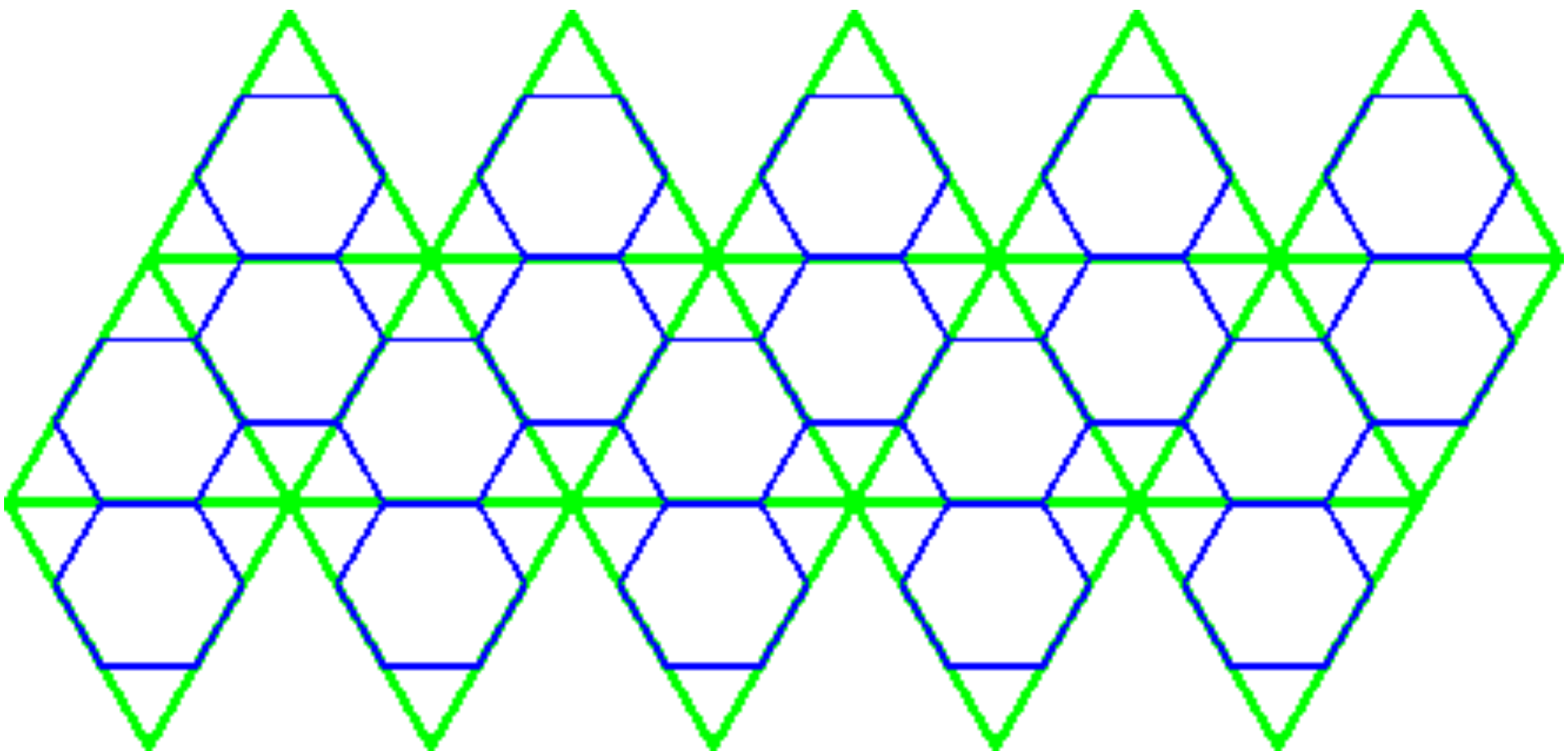
Equivalence



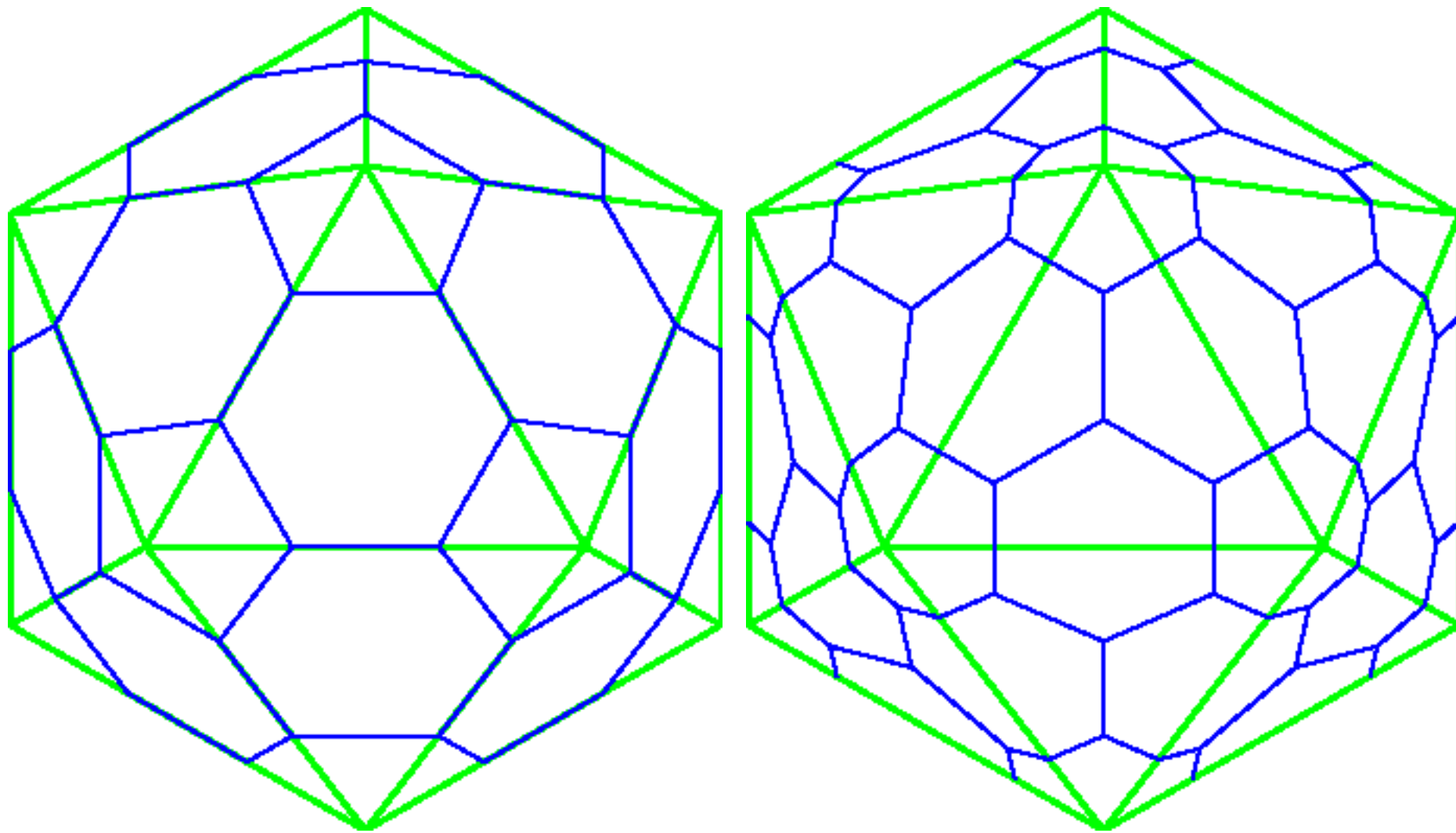
Equivalence



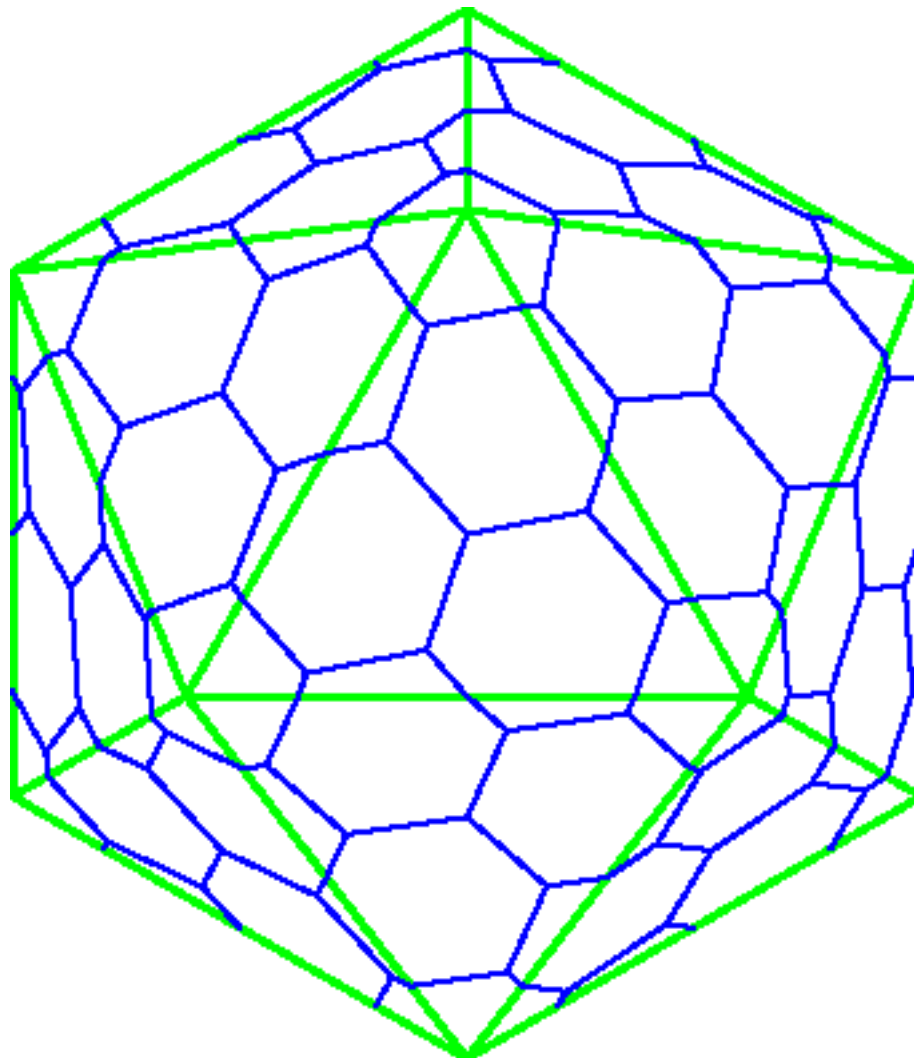
Quasi equivalence



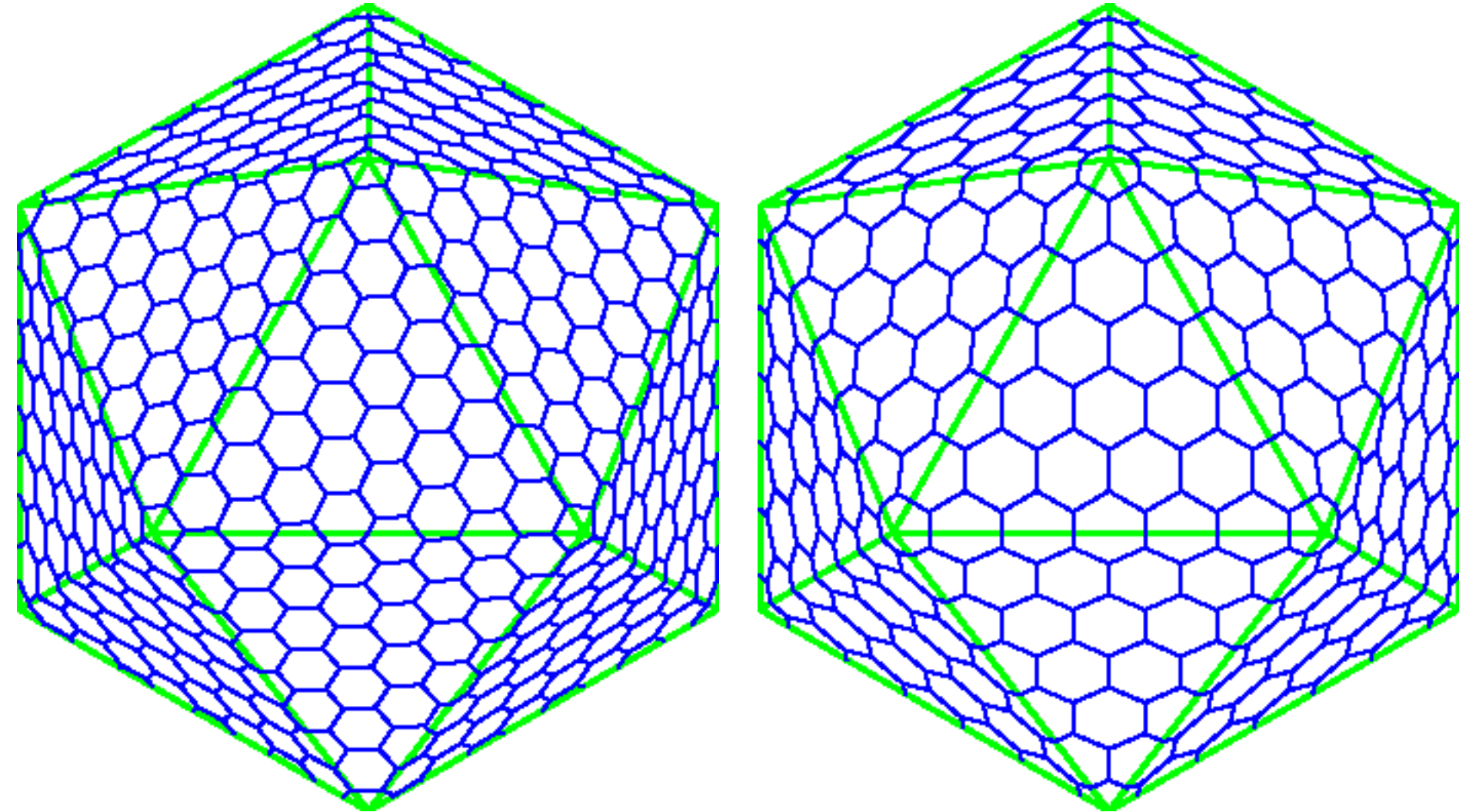
Quasi equivalence



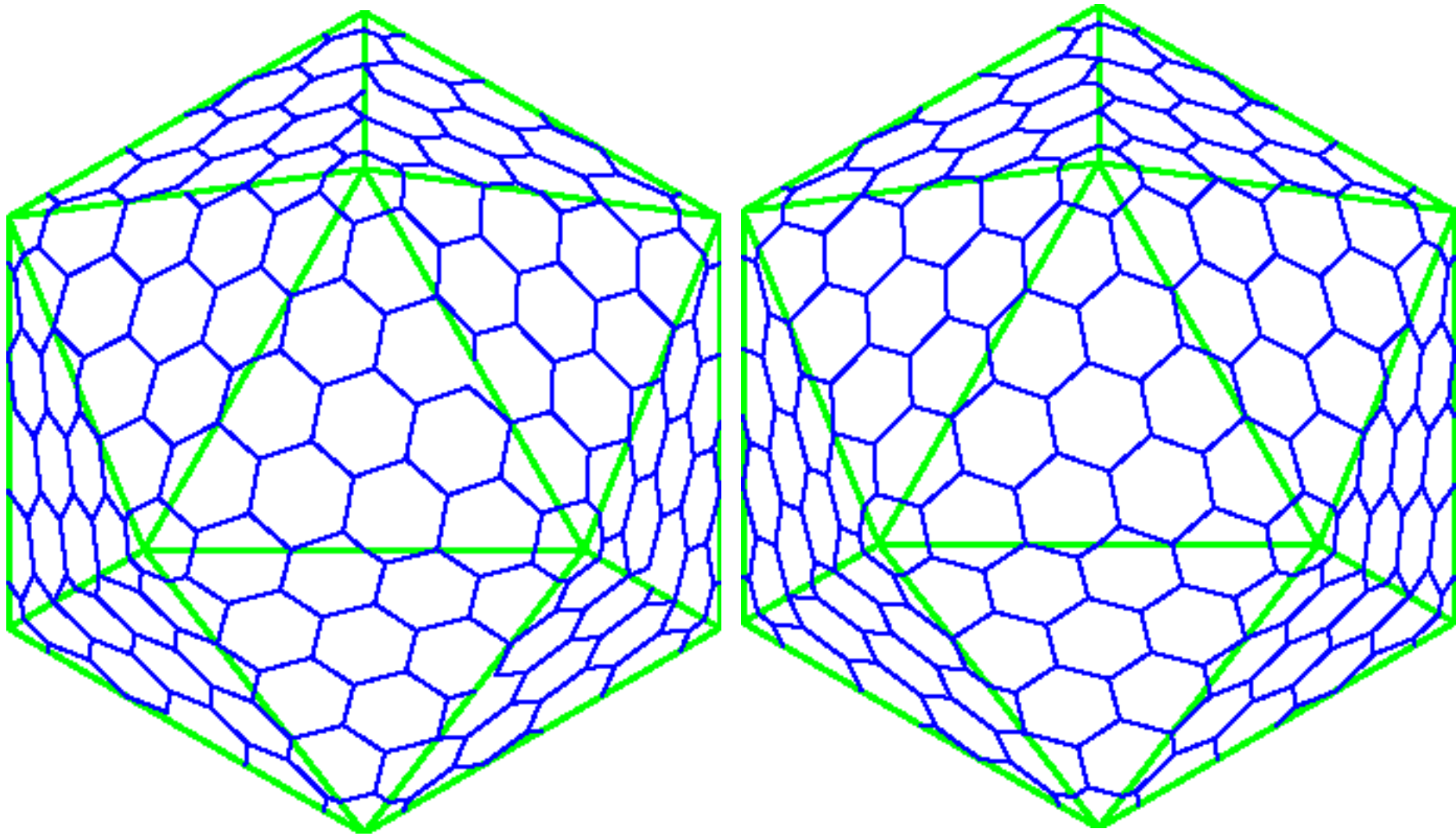
Quasi equivalence



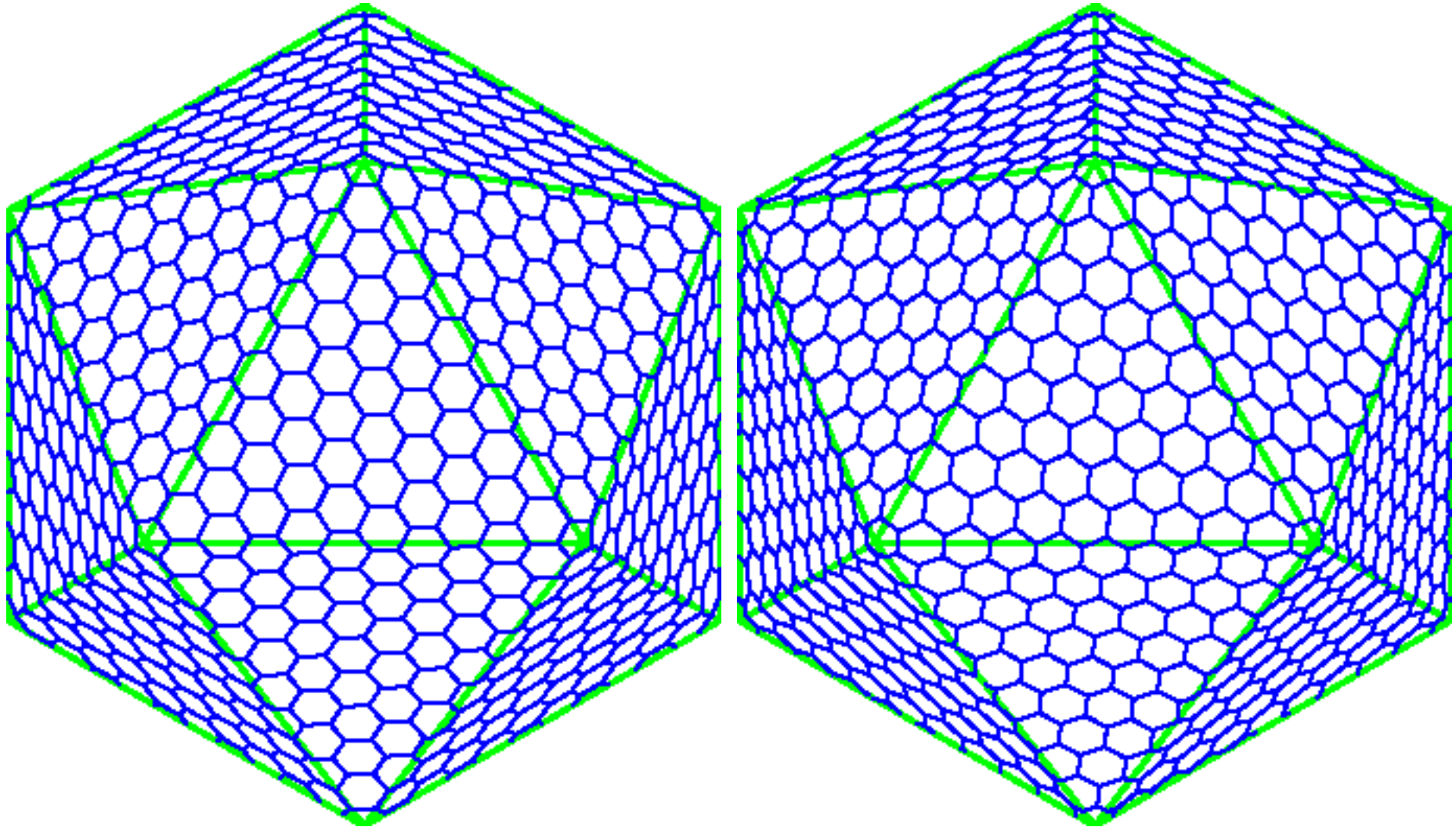
Quasi equivalence



Quasi equivalence



Quasi equivalence

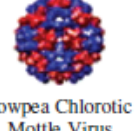




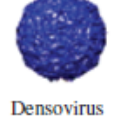
Satellite Tobacco Mosaic Virus



Ribgrass Mosaic Virus



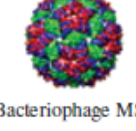
Cowpea Chlorotic Mottle Virus



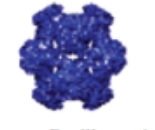
Dengue Virus



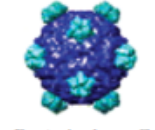
Feline Panleukopenia Virus



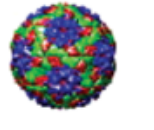
Bacteriophage MS2



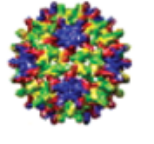
Human Papillomavirus L1 Capsid



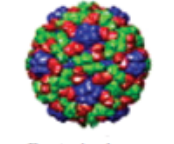
Bacteriophage G4



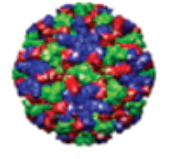
Foot and Mouth Disease Virus



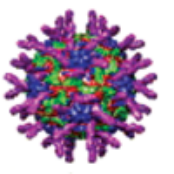
Hepatitis B Virus



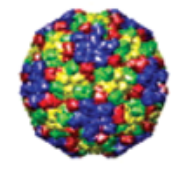
Bacteriophage Phi-X174 procapsid



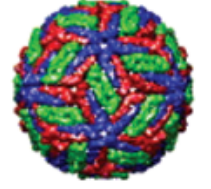
Norwalk Virus



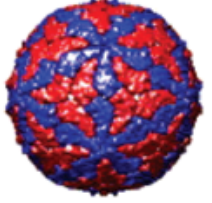
Human Rhinovirus 16 and cellular receptor



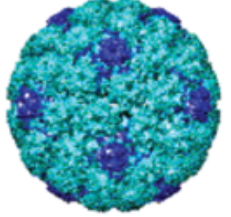
Nudaurelia Capensis Omega Virus



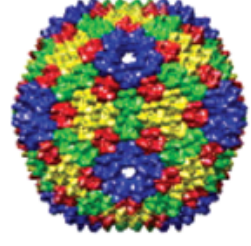
Dengue Virus



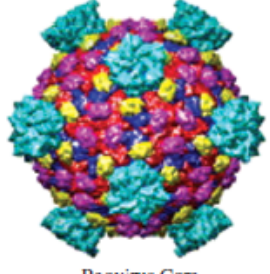
Bluetongue Virus inner layer



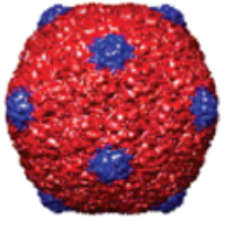
Human Papillomavirus



Bacteriophage PRD1



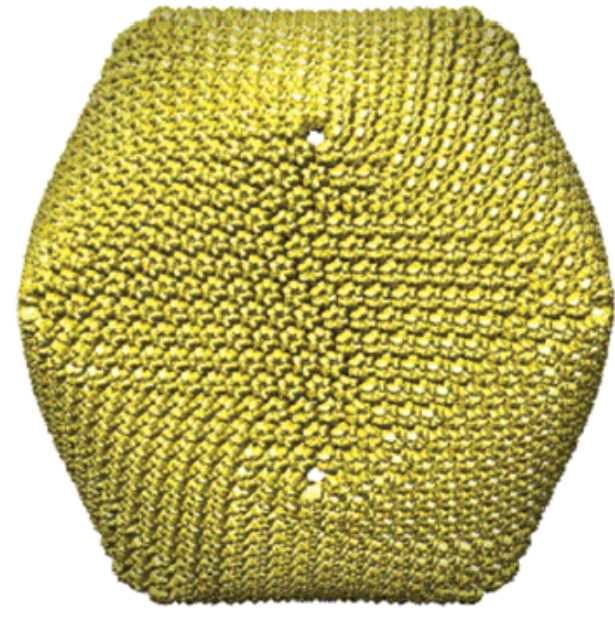
Reovirus Core



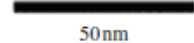
Bacteriophage HK97



Rice Dwarf Virus



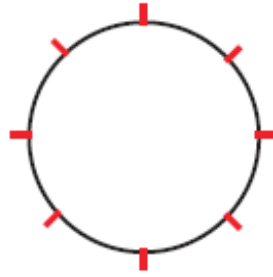
Paramecium Bursaria Chlorella Virus



50nm

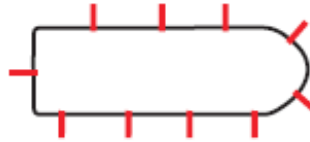
Enveloped Viruses

Sphere



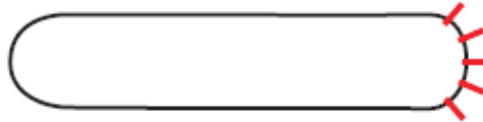
Influenza virus

Bullet



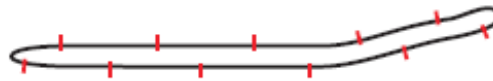
Rabies virus

Rod



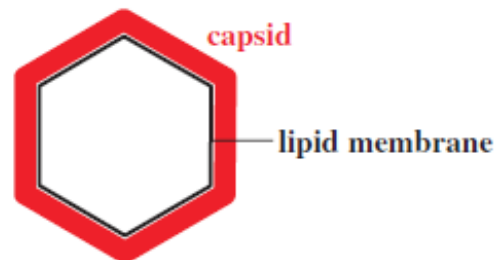
Baculoviruses

Thread



Ebola virus

Viruses with an Internal Lipid Membrane



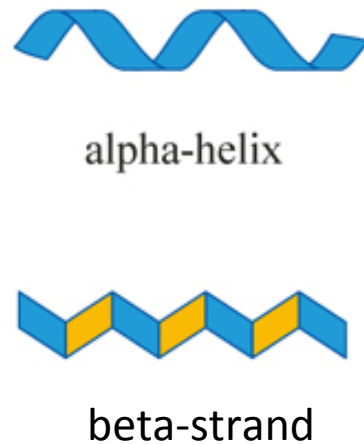
Iridoviruses

Levels of description of protein structures

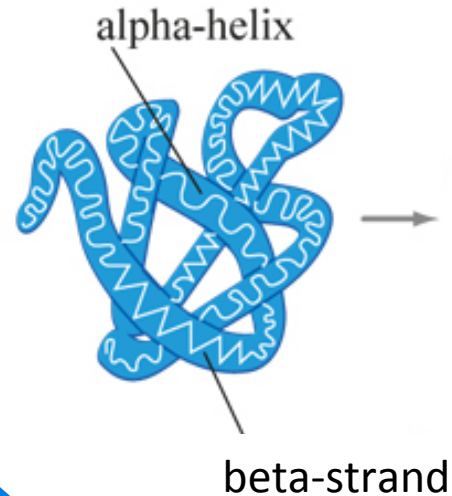
Primary structure



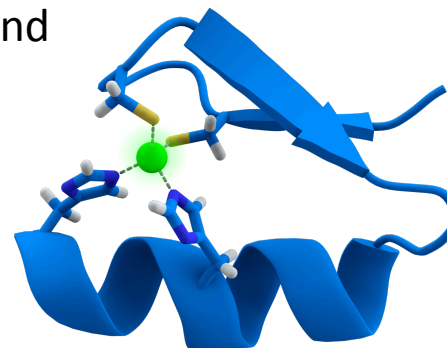
Secondary structure



Tertiary structure

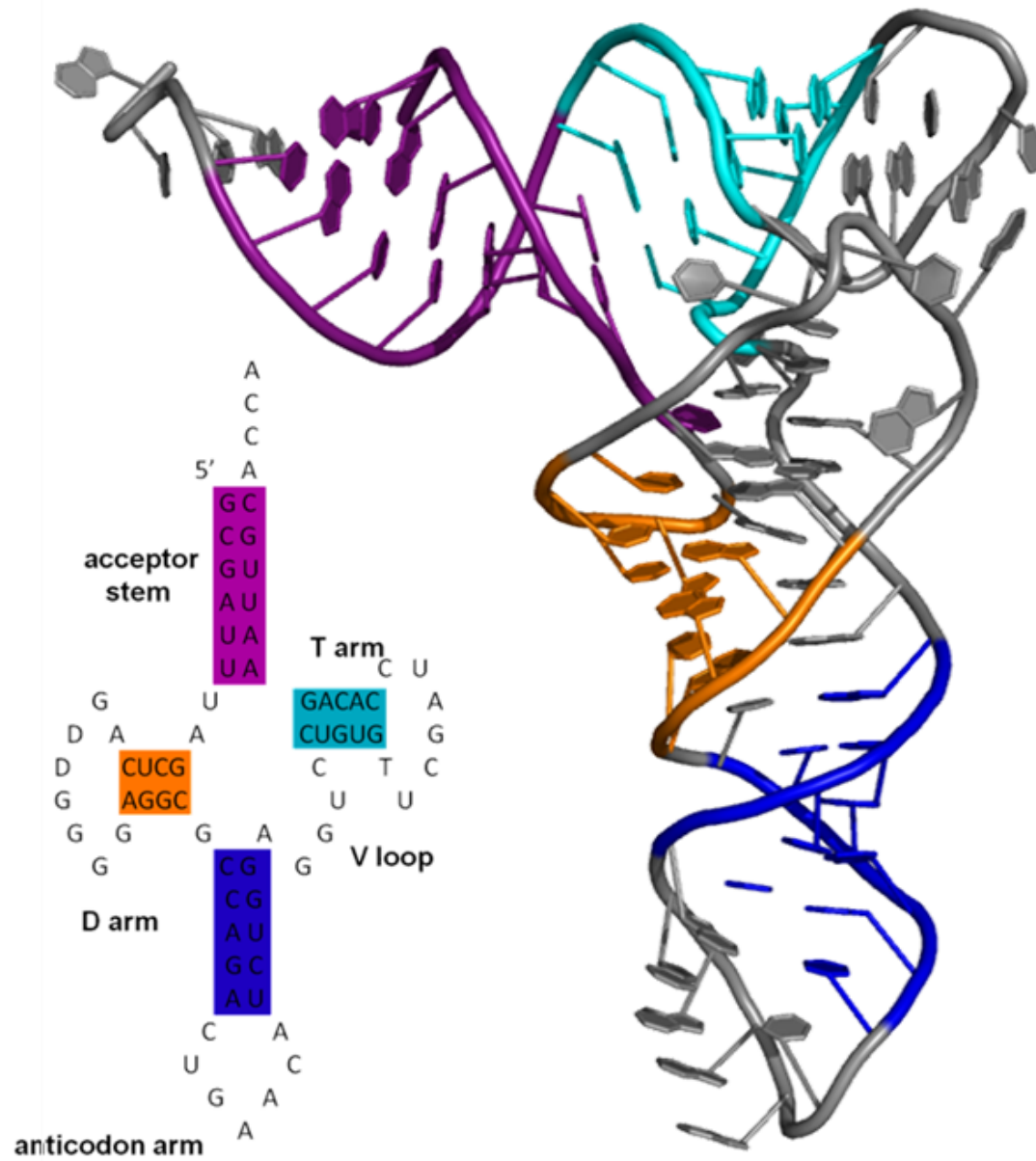


Quaternary structure

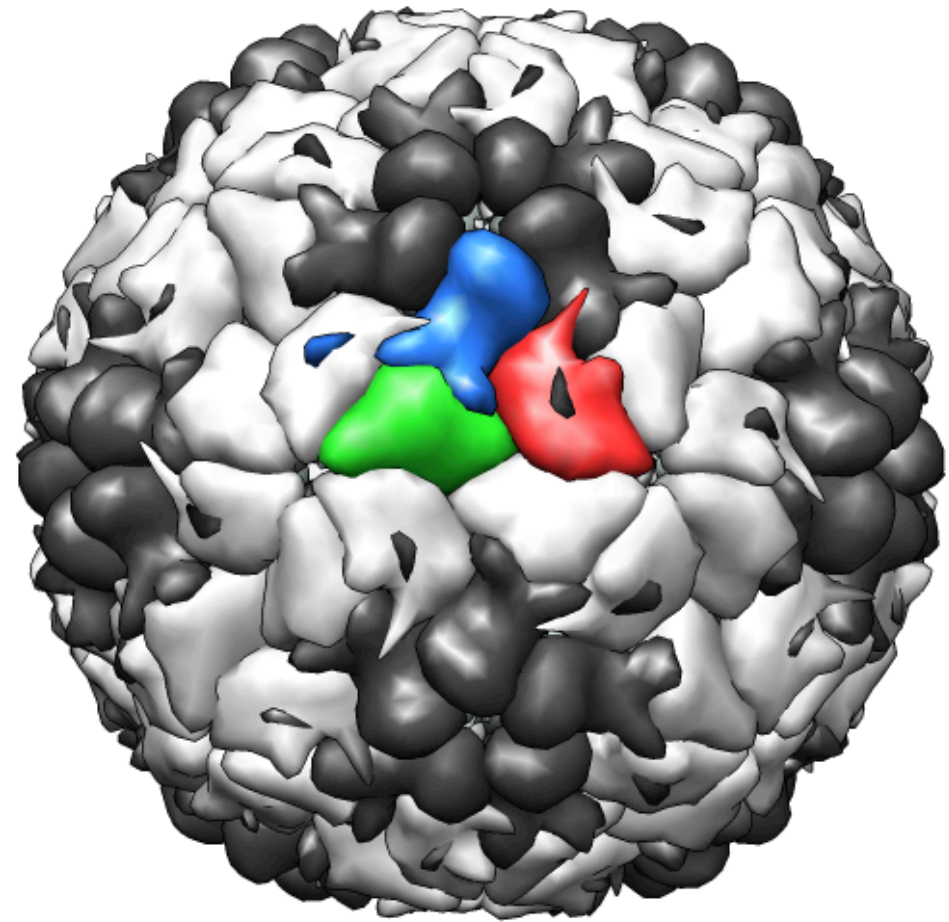
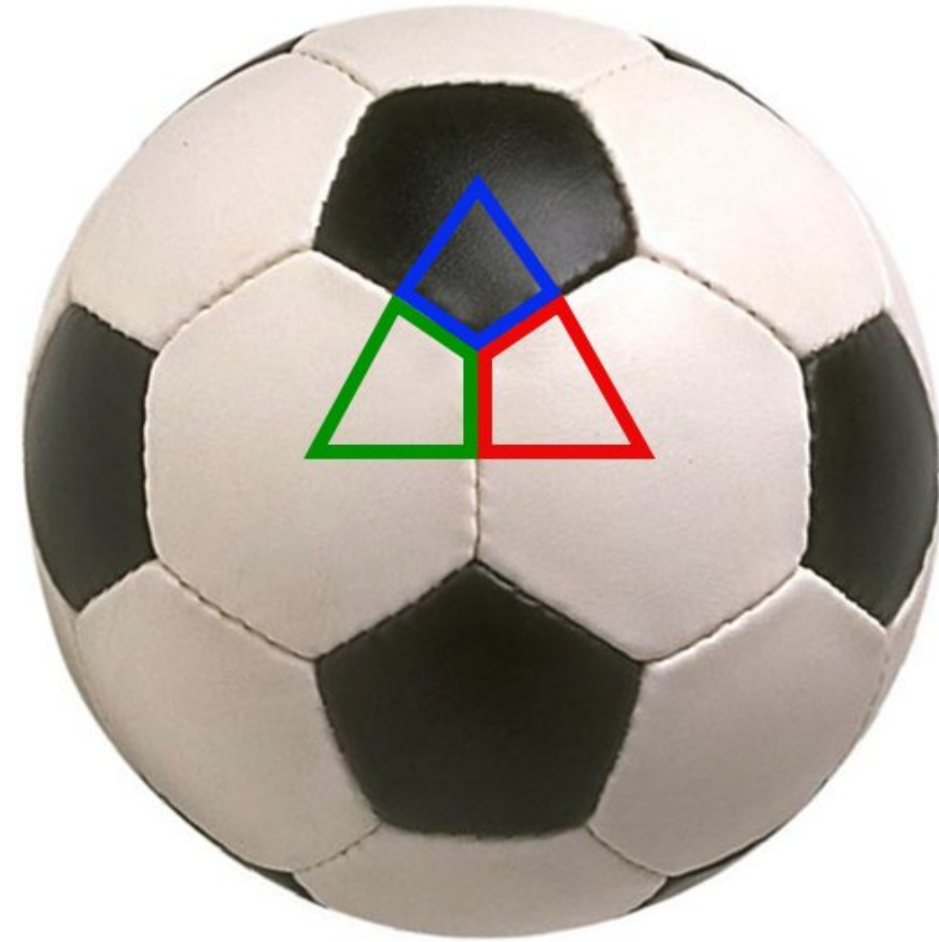


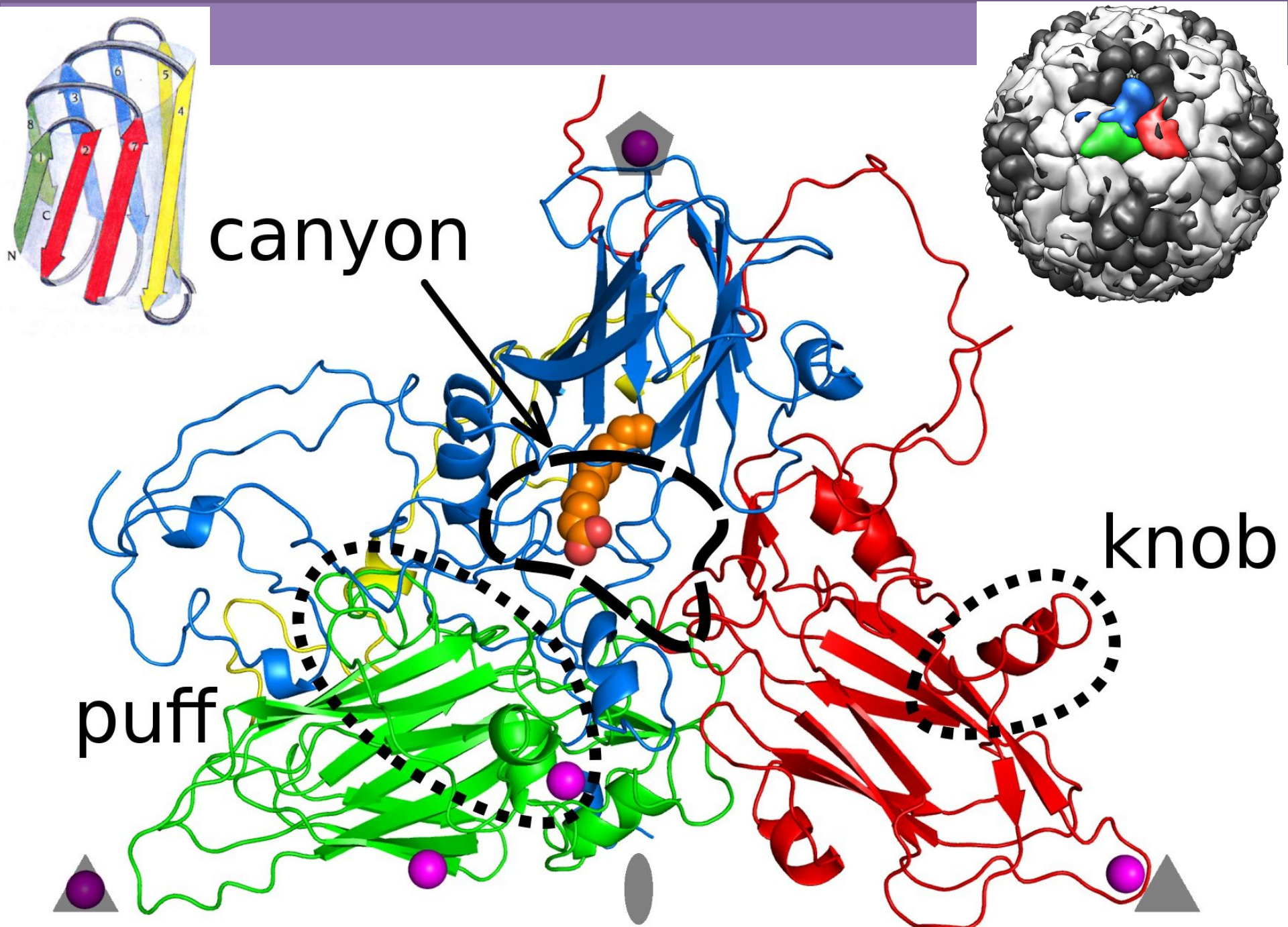
Motif

Levels of description of RNA structures

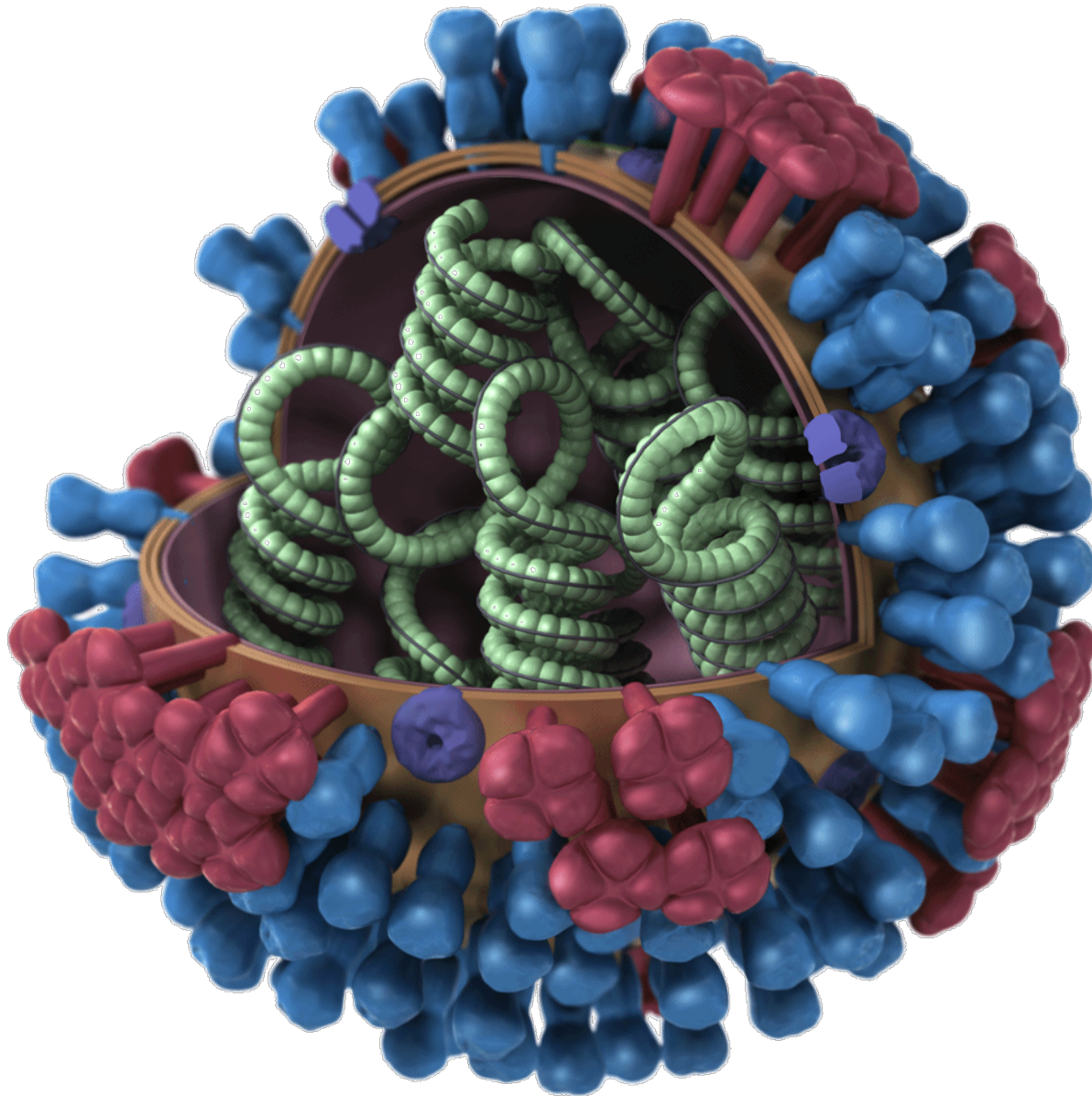


Picornavirus virion





Molecular components of virions



DNA genomes of viruses



ss, linear

Parvoviruses



ds, linear

Poxviruses



ss, circular

Phage ϕ X174



ds, circular

Baculoviruses

RNA genomes of viruses



ss, linear

Tobacco mosaic virus



ds, linear

Reoviruses



ss, circular

Hepatitis delta virus

Sizes of virus genomes



Hepatitis B virus 3.2kB



Phage lambda 48kB

Pandoravirus

1.1-2.5MB

TNSV

1239B (RNA)

Coronaviruses

33kB (RNA)



Mimivirus

1.2MB



HIV ~100nm

Flu ~120nm



Pandoravirus ~1000nm

Mimivirus ~400nm

E. coli ~2000nm (bacterium)

Genomes of cellular organisms (kB)



Mycoplasma genitalium

580



Escherichia coli

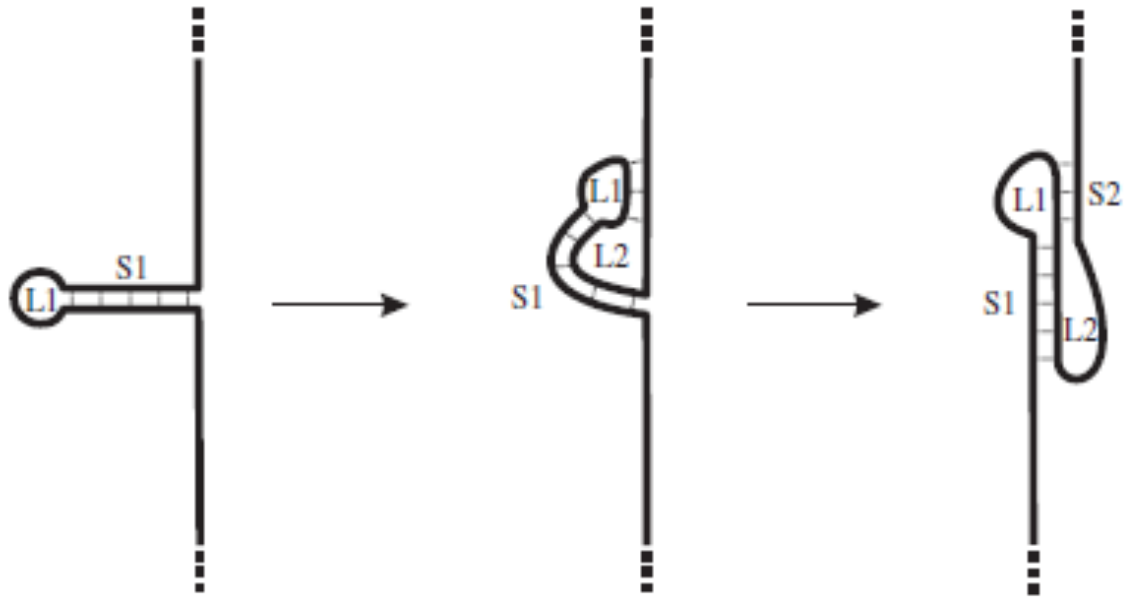
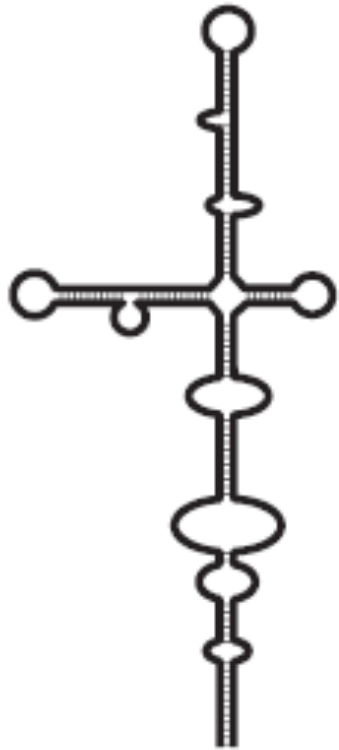
4700



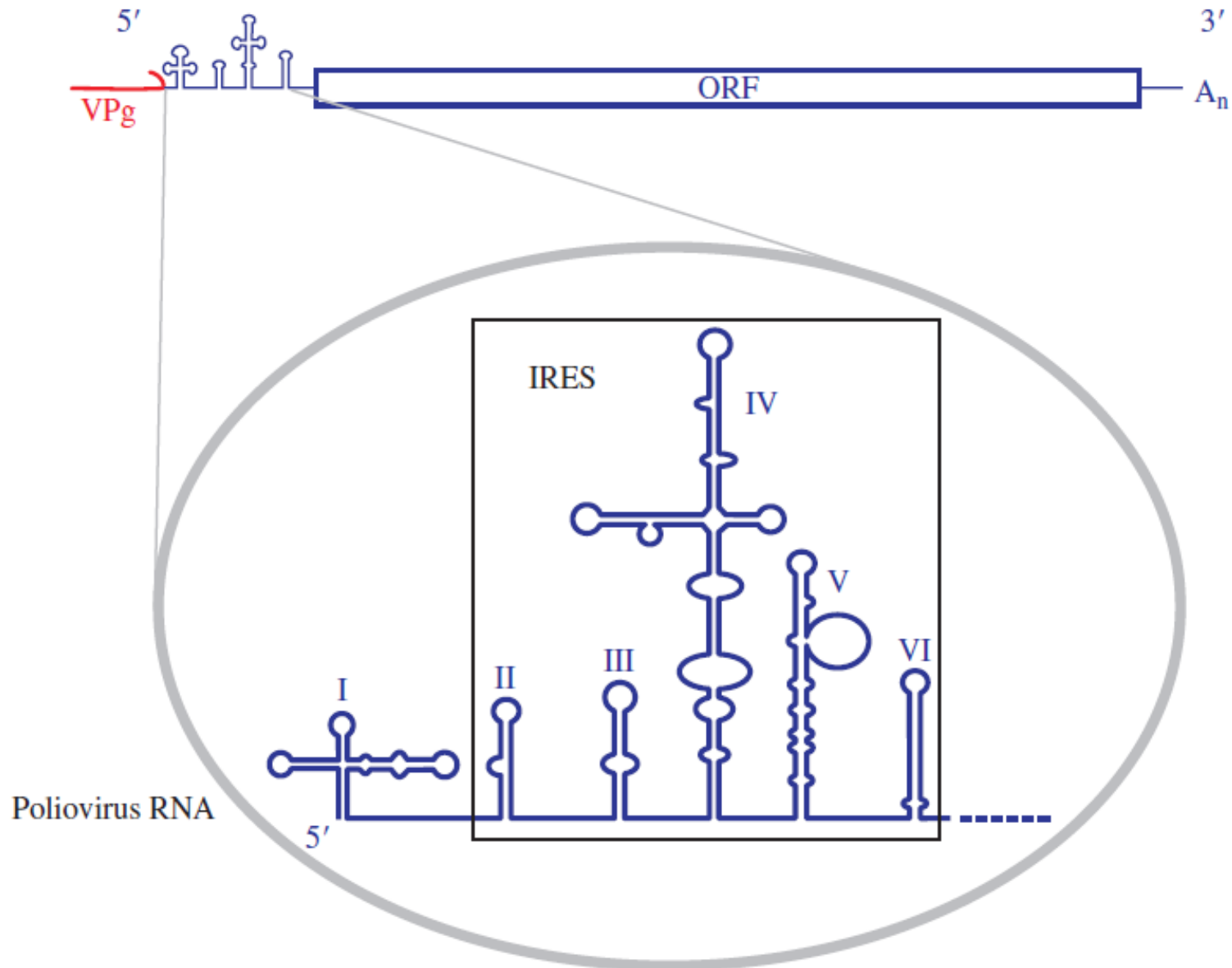
Human

3200000

Secondary structures in ssRNA genomes



Internal Ribosome Entry Site in poliovirus

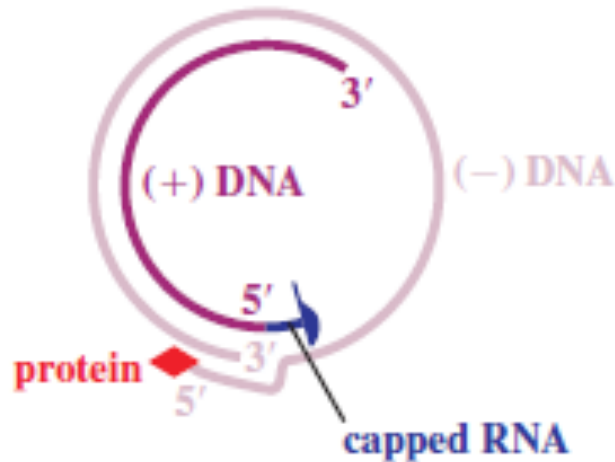


Modifications of genome ends

dsDNA



Adenoviruses
Phage PRD1 (*E. coli*)



Hepatitis B virus

ssDNA



Parvoviruses

More end modifications (ssRNA)



Poliovirus
Cowpea mosaic virus



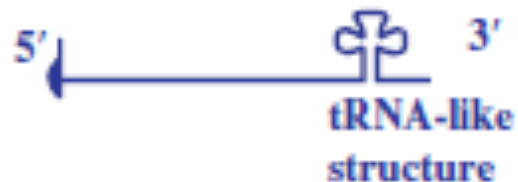
Barley yellow dwarf virus



SARS coronavirus
Retroviruses



Black beetle virus



Cucumber mosaic virus

dsRNA genome modifications

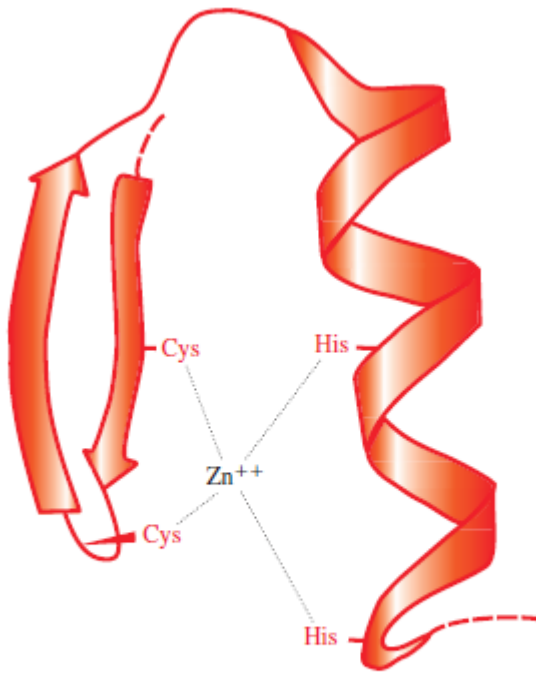


Rotaviruses

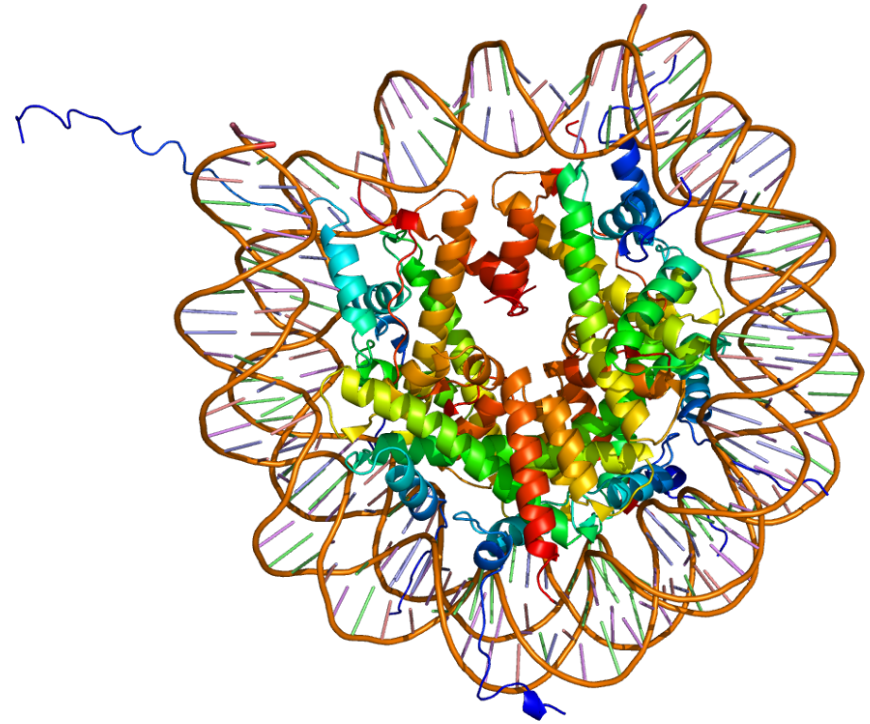


Infectious pancreatic
necrosis virus

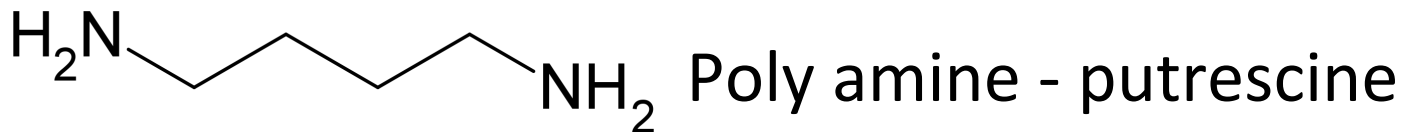
(Macro)-molecules non-covalently associated with virus genomes



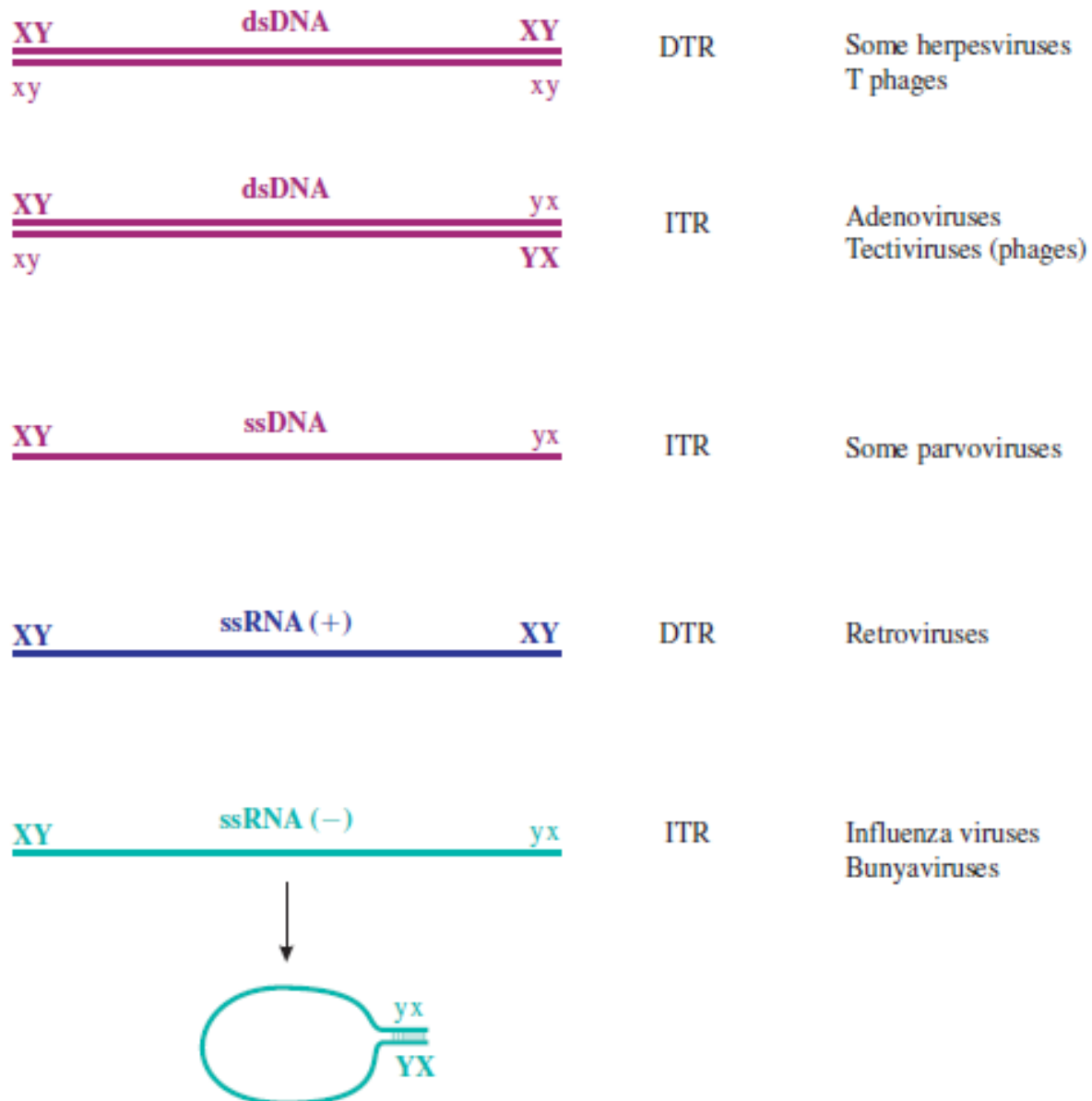
Zinc finger motif



Histone core



Terminal repeats in virus genomes



Main types of virion structure

Genomes

dsDNA ssDNA dsRNA ssRNA

Icosahedral,
naked



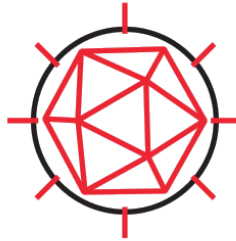
✓

✓

✓

✓

Icosahedral,
enveloped



✓

✓

✓

Helical,
naked

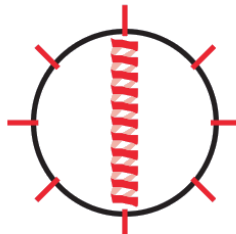


✓

✓

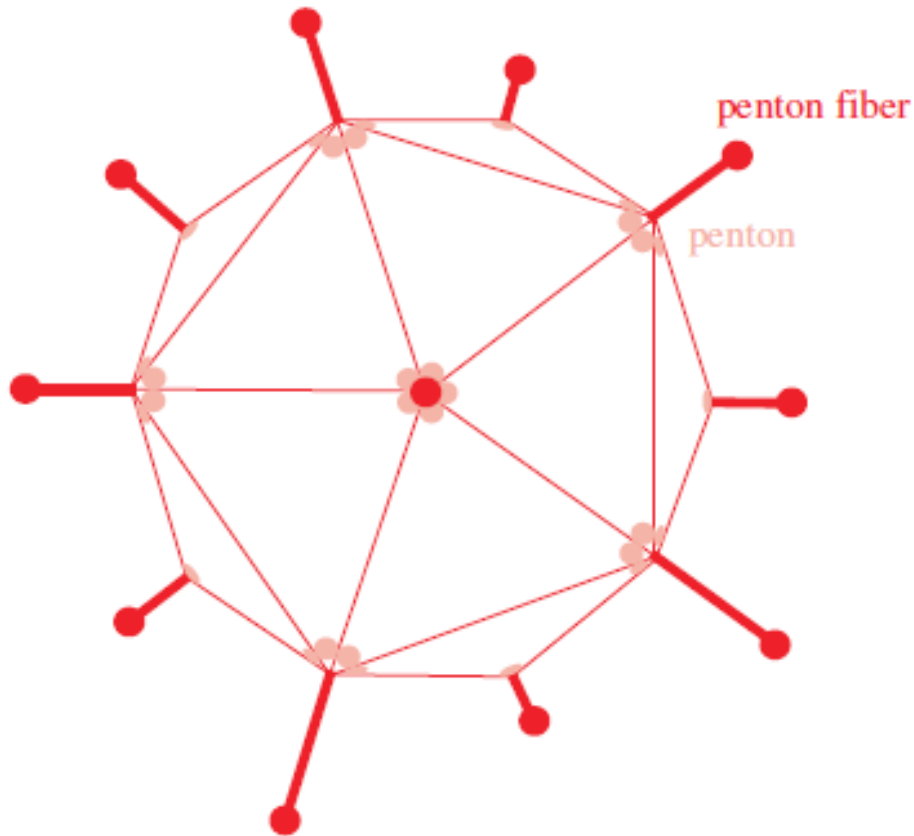
✓

Helical,
enveloped

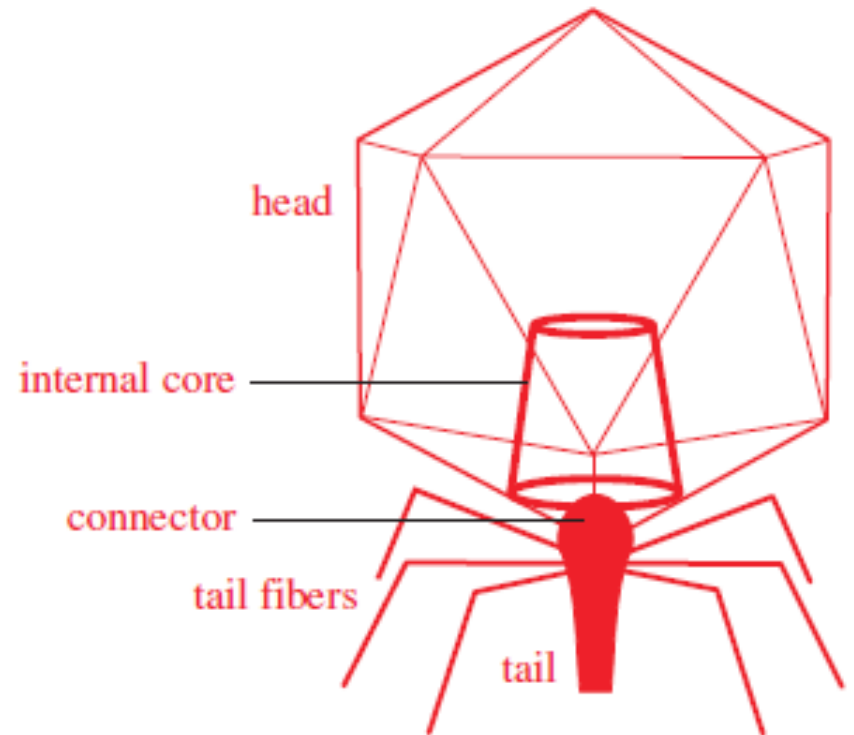


✓

Adenovirus virion



Phage T7



Learning outcomes

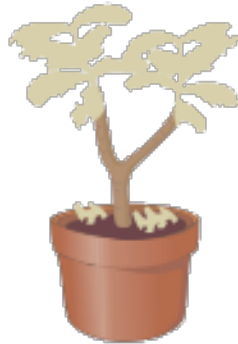
- describe the components of virions
- illustrate the variety of virus genomes
- outline the functions of virus structural proteins
- define the terms ‘helical symmetry’ and ‘icosahedral symmetry’
- describe the virions of a selection of naked and enveloped viruses

Reading

Why / when / for what are
structures important?

Virus transmission

Plant viruses



- Vectors**
- insects
 - mites
 - nematodes
 - fungi

Human and animal viruses



- via the air, e.g. influenza virus
- via food and water, e.g. rotaviruses
- sexually, e.g. HIV
- via vectors, e.g. yellow fever virus

Insects



Potato virus Y
Cauliflower mosaic virus



Beet yellows virus
Bean yellow mosaic virus

Leafhoppers



Rice dwarf virus

Whiteflies



Tomato yellow leaf curl virus

Beetles



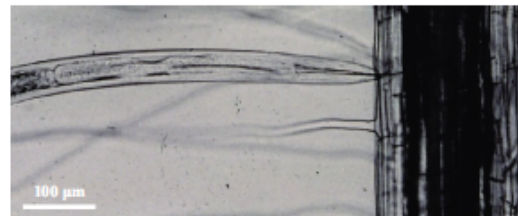
Maize chlorotic mottle virus

Mites



Ryegrass mosaic virus

Nematodes



Grapevine fanleaf virus

Mites

Nematodes

Living Vectors

Mosquitoes



Yellow fever virus
West Nile virus
Chikungunya virus

Humans

Midges



Bluetongue virus

Sheep

Ticks



Louping ill virus

Sheep

Inanimate Vectors

Syringes and
Needles



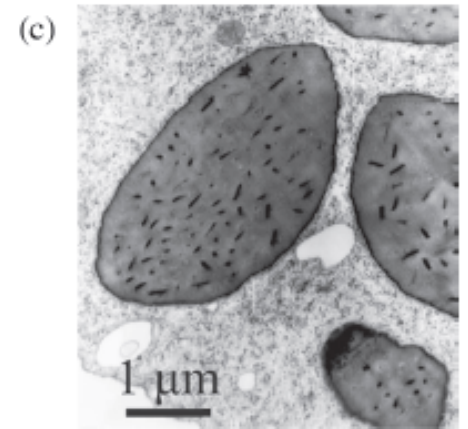
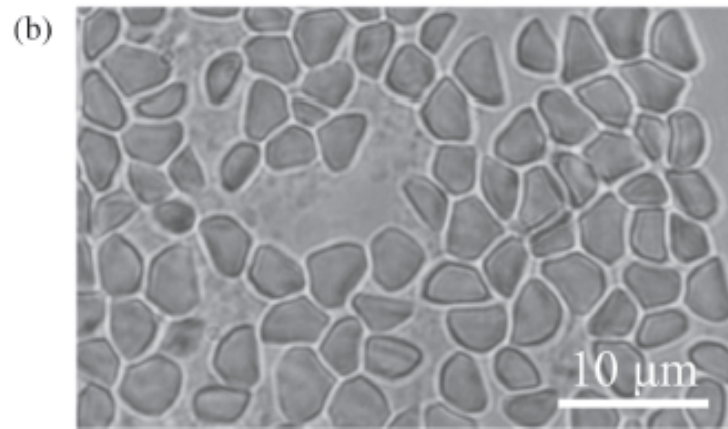
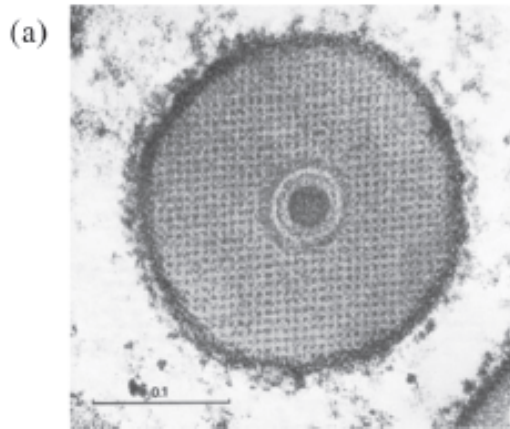
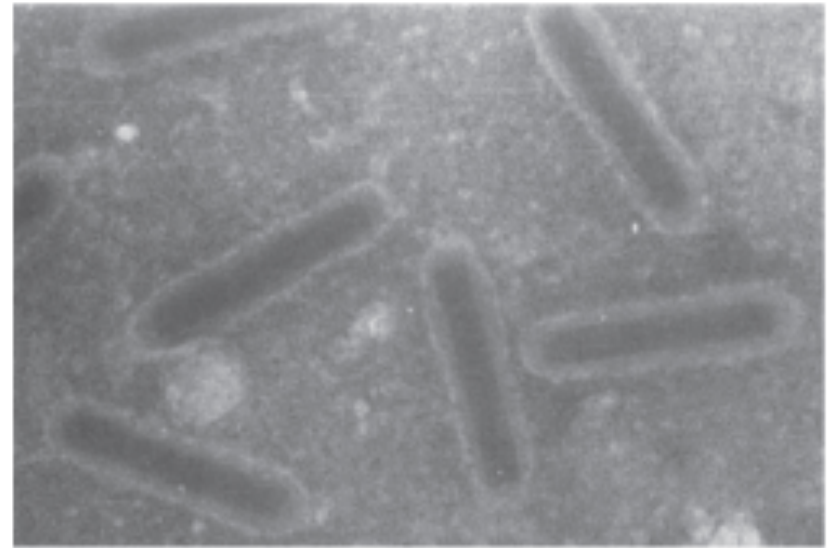
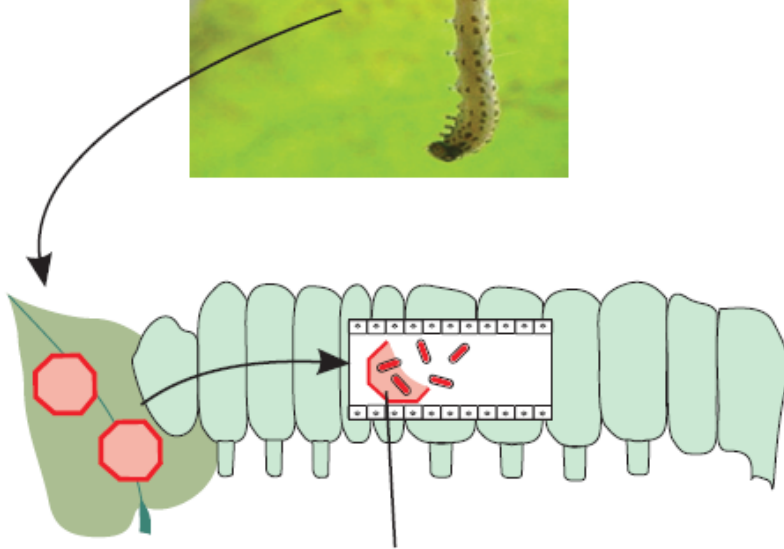
Hepatitis B virus
HIV

Humans

Baculovirus transmission



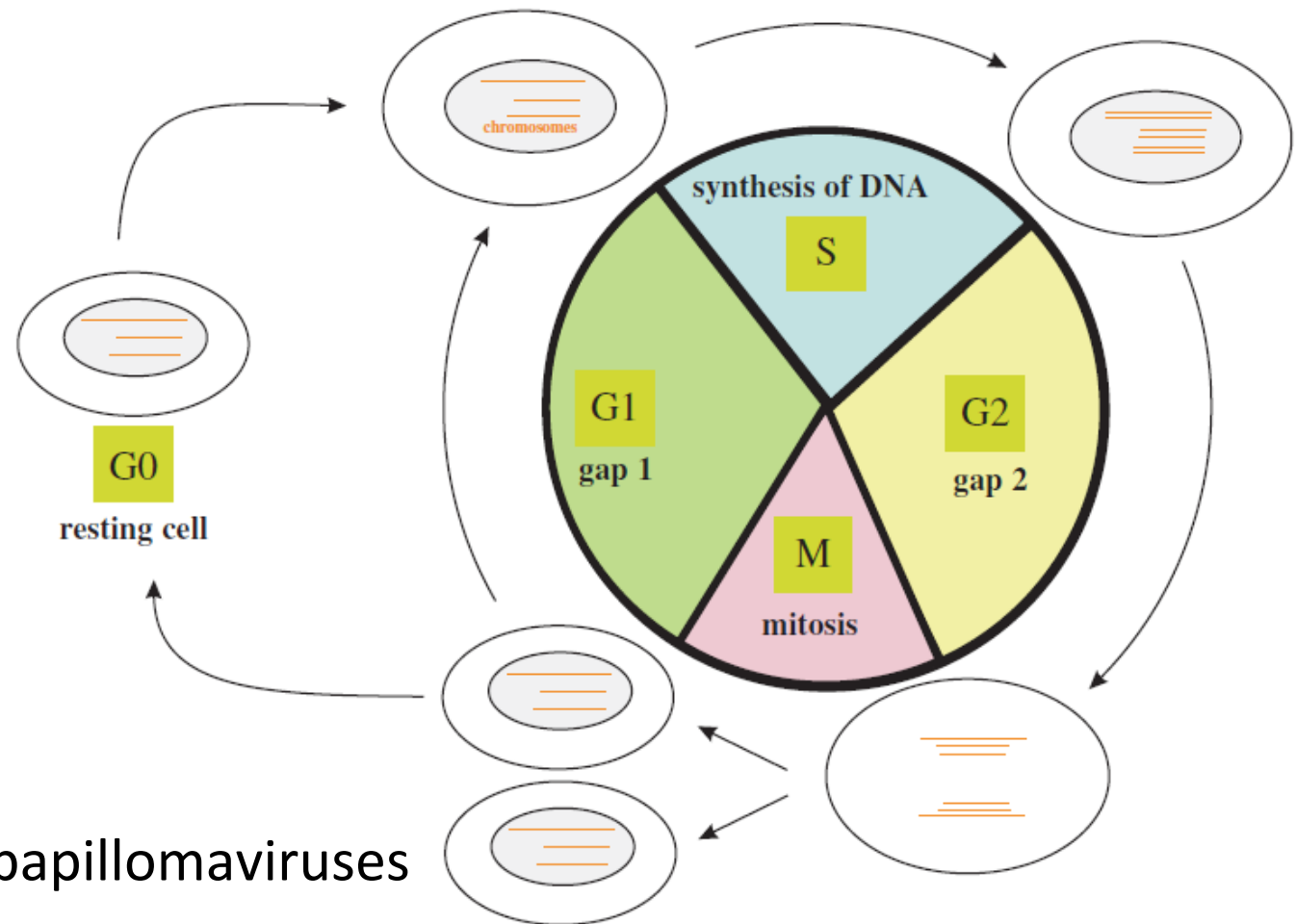
Caterpillar that has died from baculovirus infection



Non-vector transmission of vertebrate viruses

Transmission route	Examples of viruses transmitted
Horizontal transmission	
Respiratory tract	Influenza viruses (mammals) Common cold viruses Measles virus
Intestinal tract	Influenza viruses (birds) Rotaviruses
Abrasions and wounds	Papillomaviruses Rabies virus
Genital tract	HIV Papillomaviruses
Vertical transmission	
Mother to foetus via the placenta	Rubella virus
Mother to baby via milk	HIV

Virus infection X cell cycle



Retroviruses
Polyomaviruses, papillomaviruses

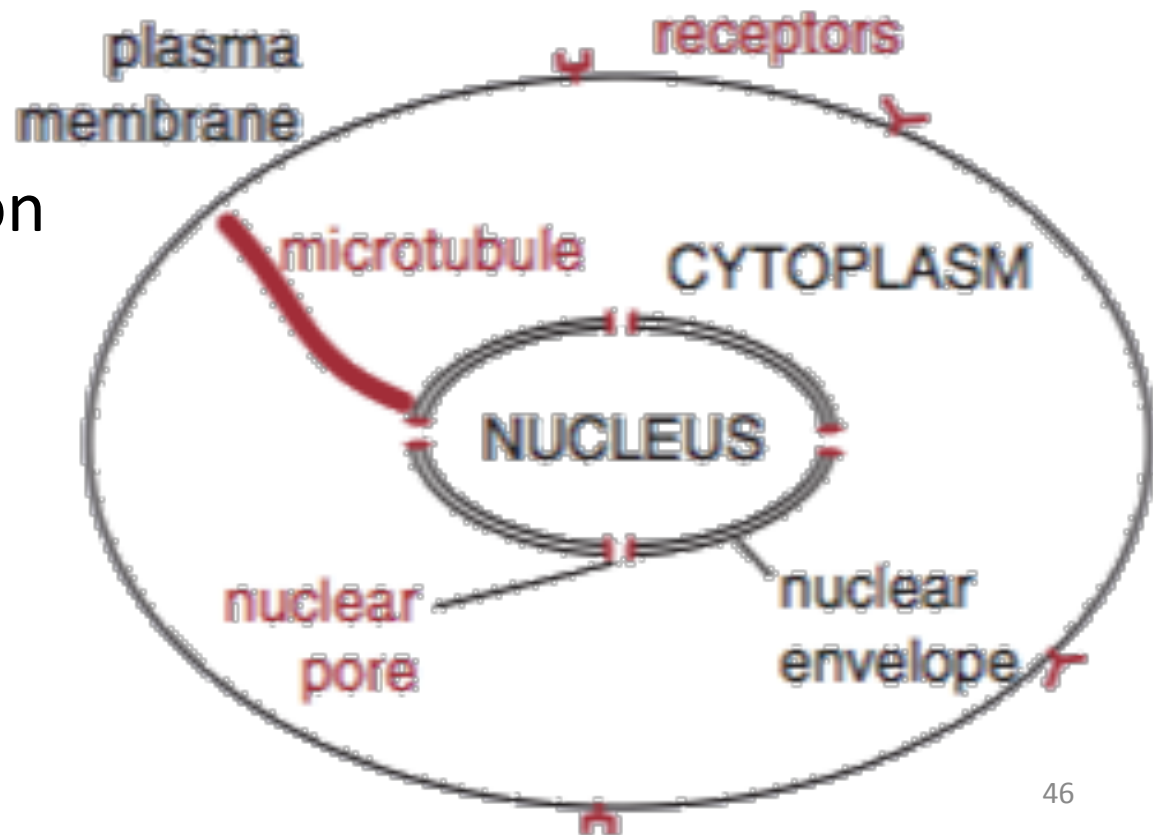
Restriction endonucleases
RNAi response

Learning outcomes

- describe the modes of transmission of plant viruses and animal viruses
- evaluate the roles of vectors in virus transmission
- discuss the immune mechanisms encountered by an animal virus when it enters the body of a new host

Attachment and entry of viruses into cells

1. **A**ttachment
2. **E**ntry
3. **T**ranscription
4. **T**ranslation
5. **G**enome replication
6. **A**ssembly
7. **E**xit

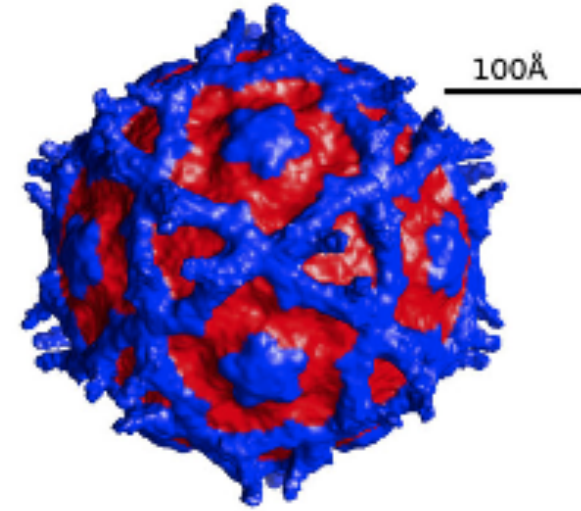
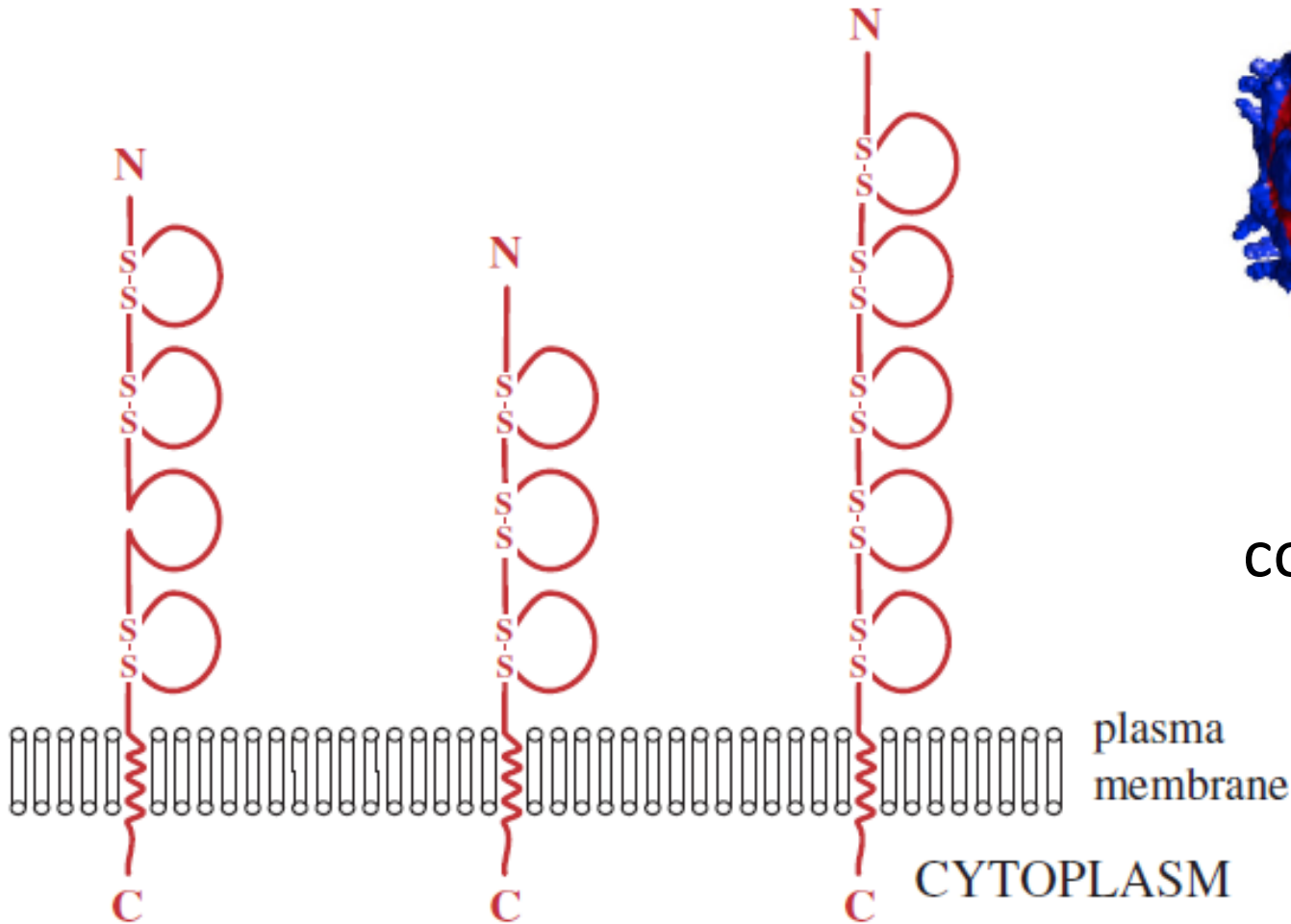


Virus receptors

CD4
Receptor
for HIV

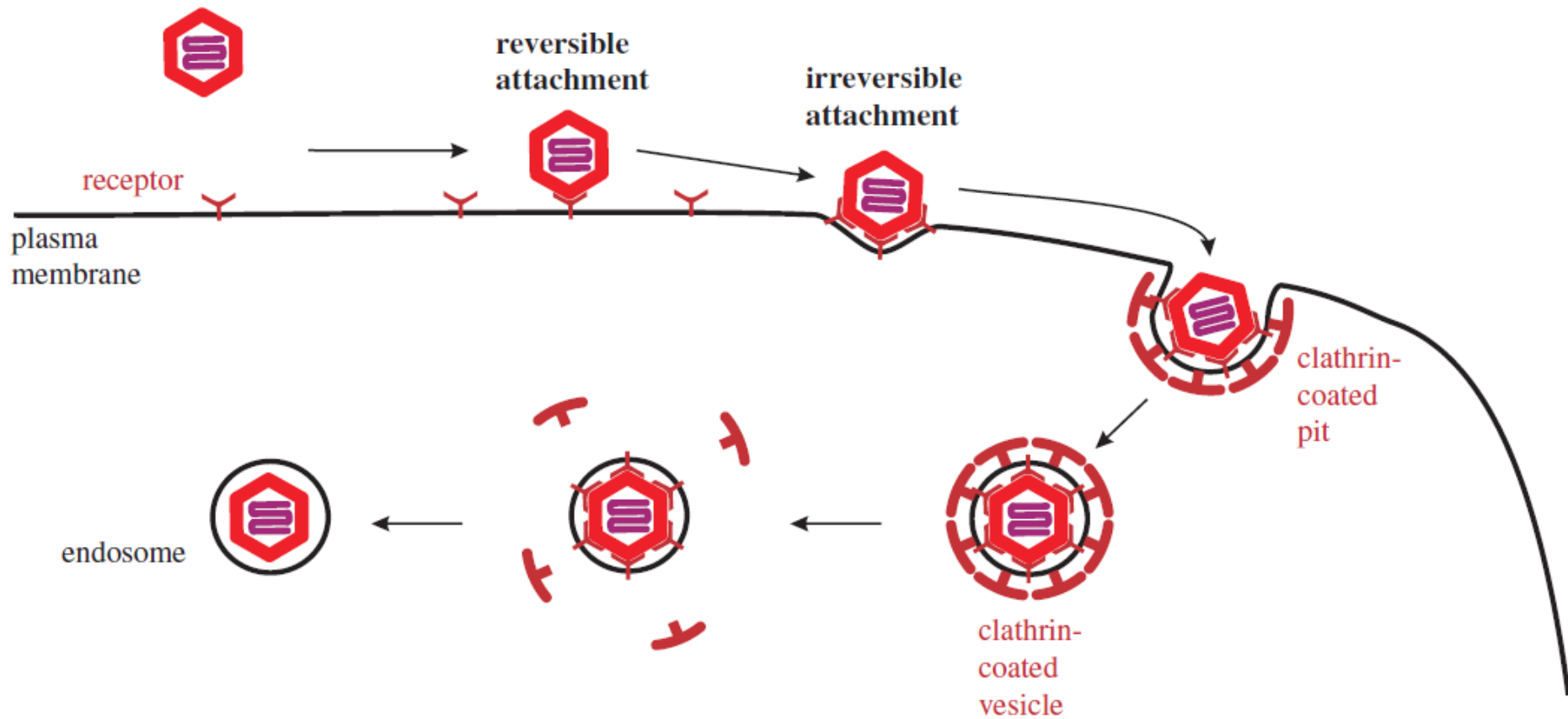
CD155
Receptor
for poliovirus

ICAM-1
Receptor for most
rhinovirus strains

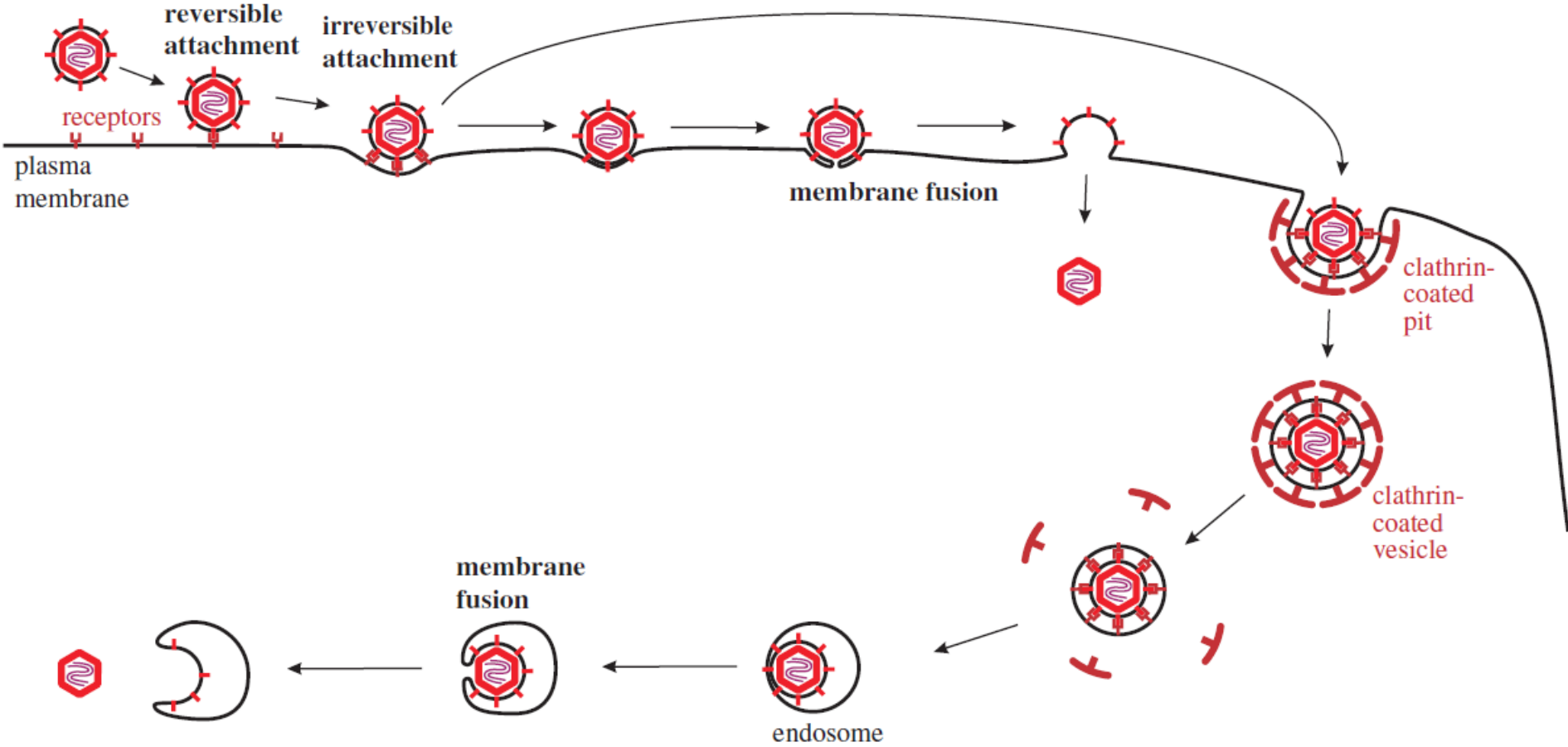


Echovirus 7 in
complex with DAF

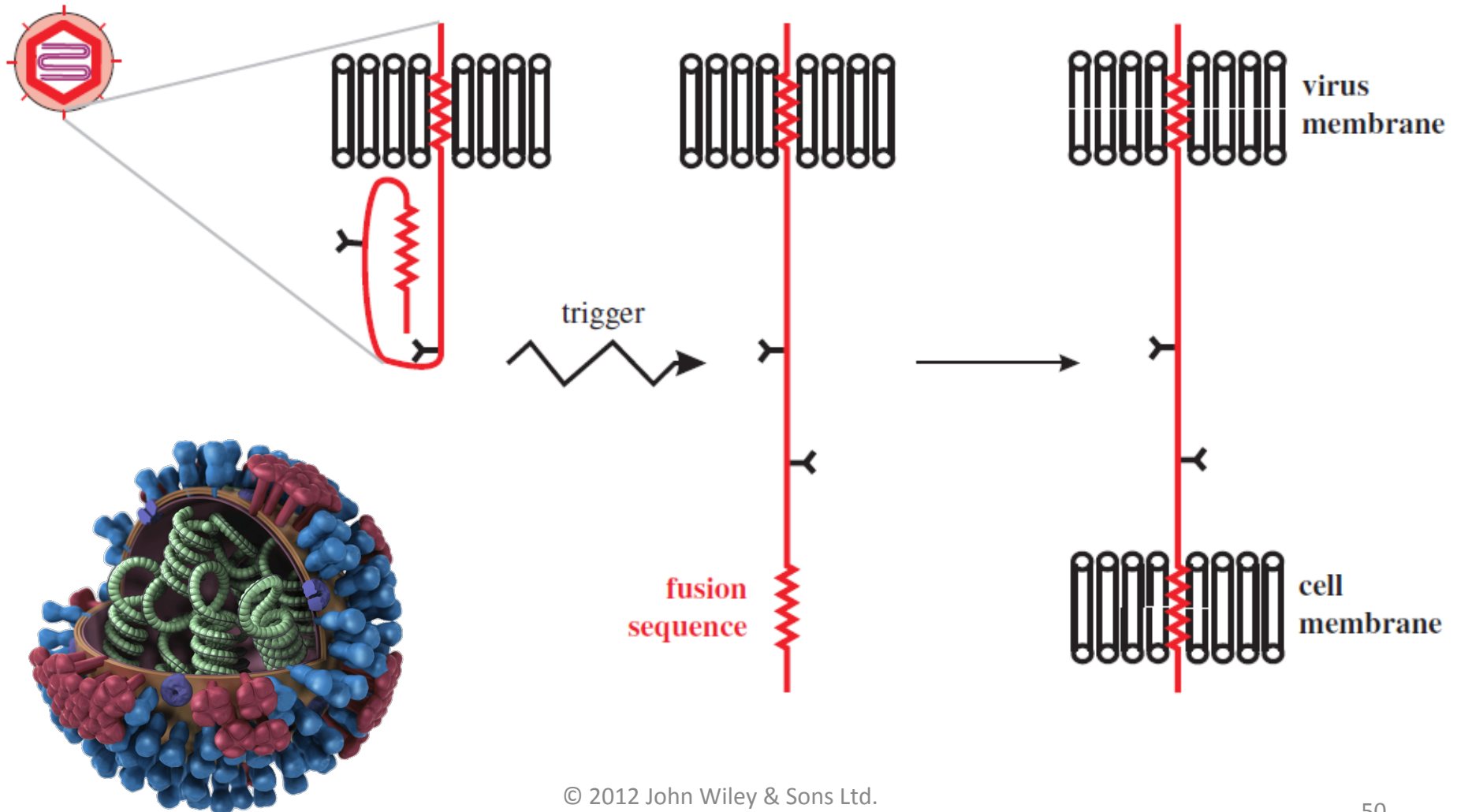
Attachment and entry of a naked virion



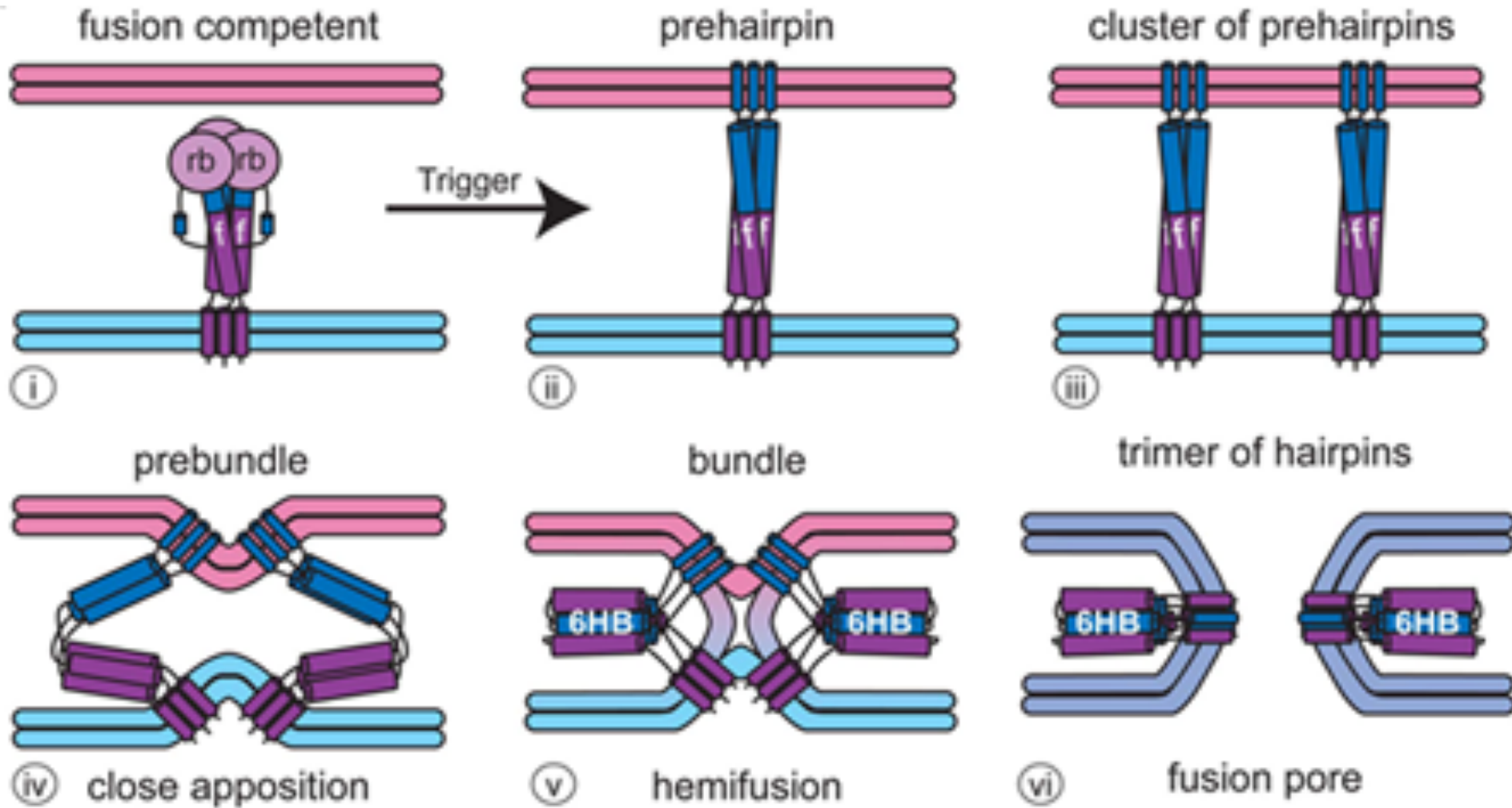
Attachment and entry of an enveloped virion



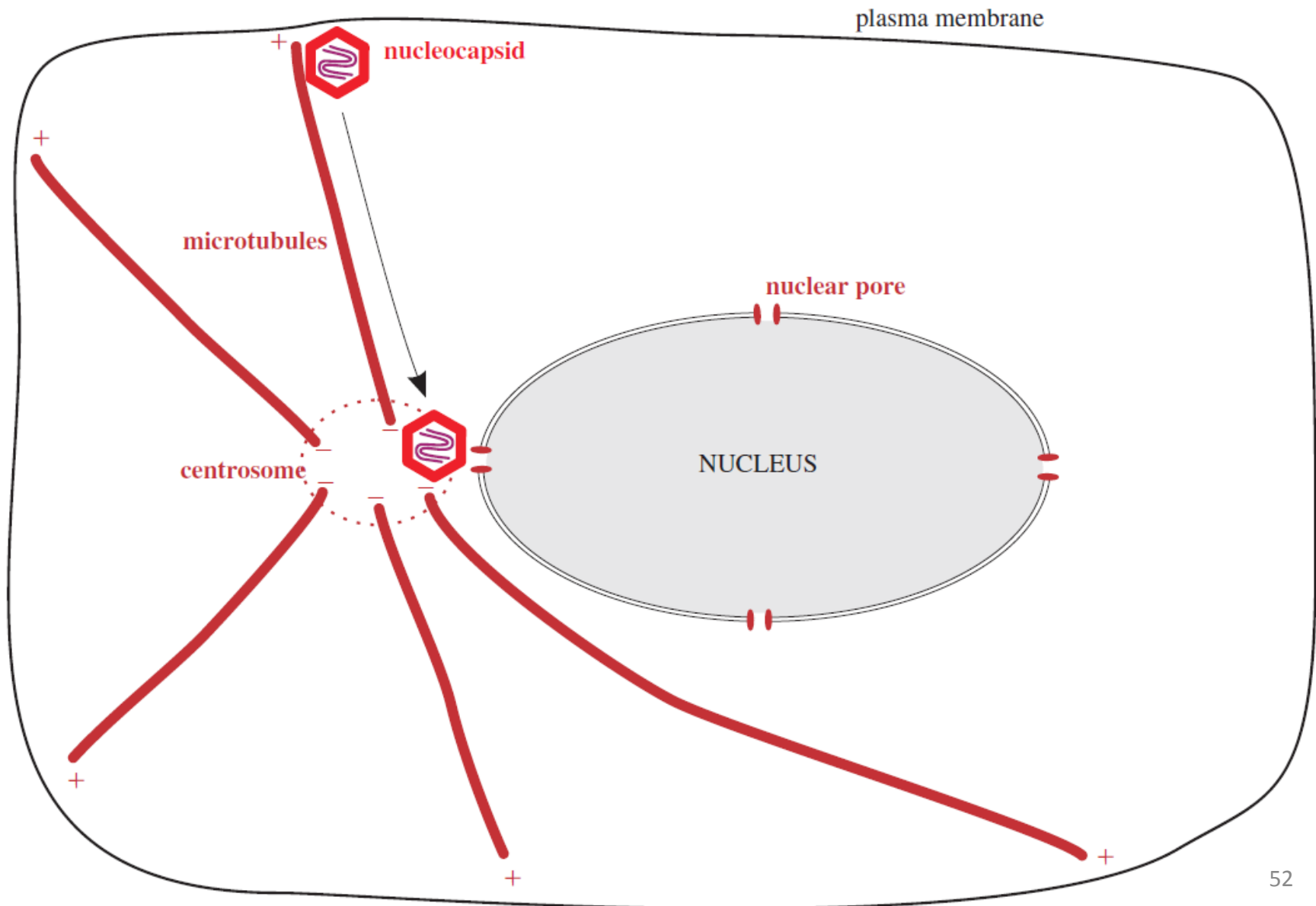
Virus membrane fusion



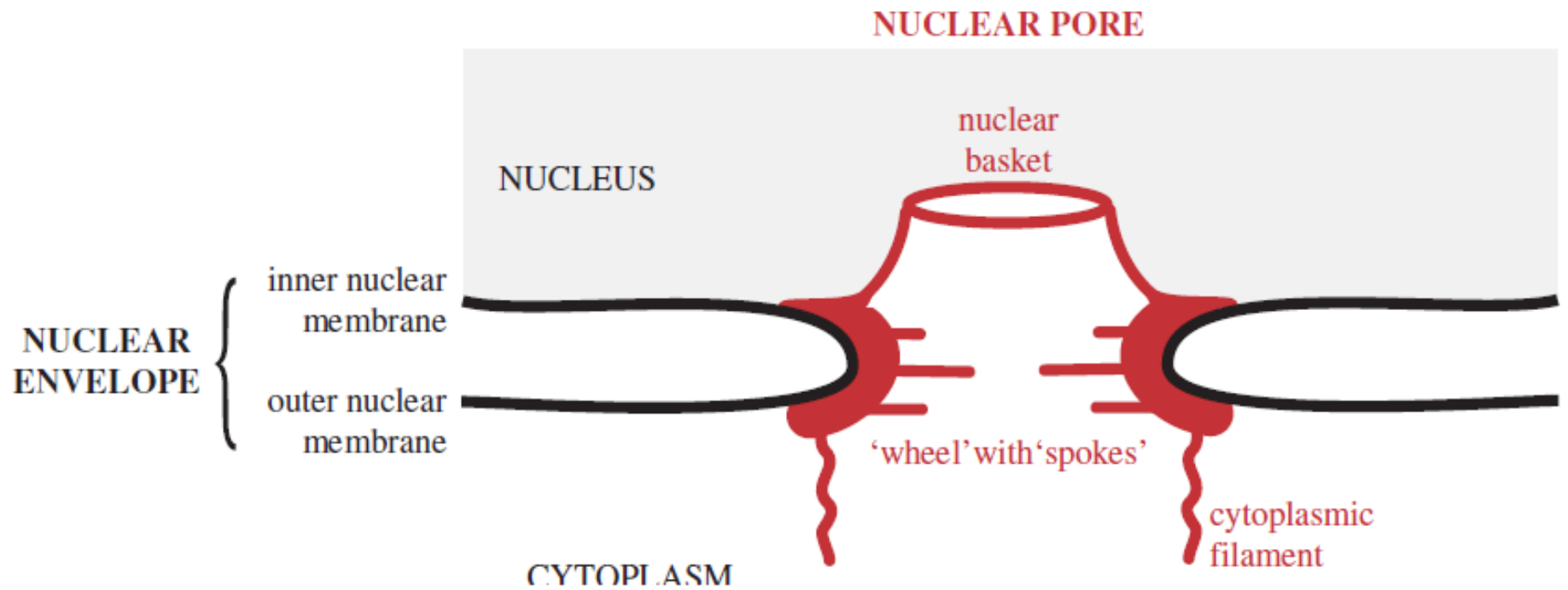
Virus membrane fusion



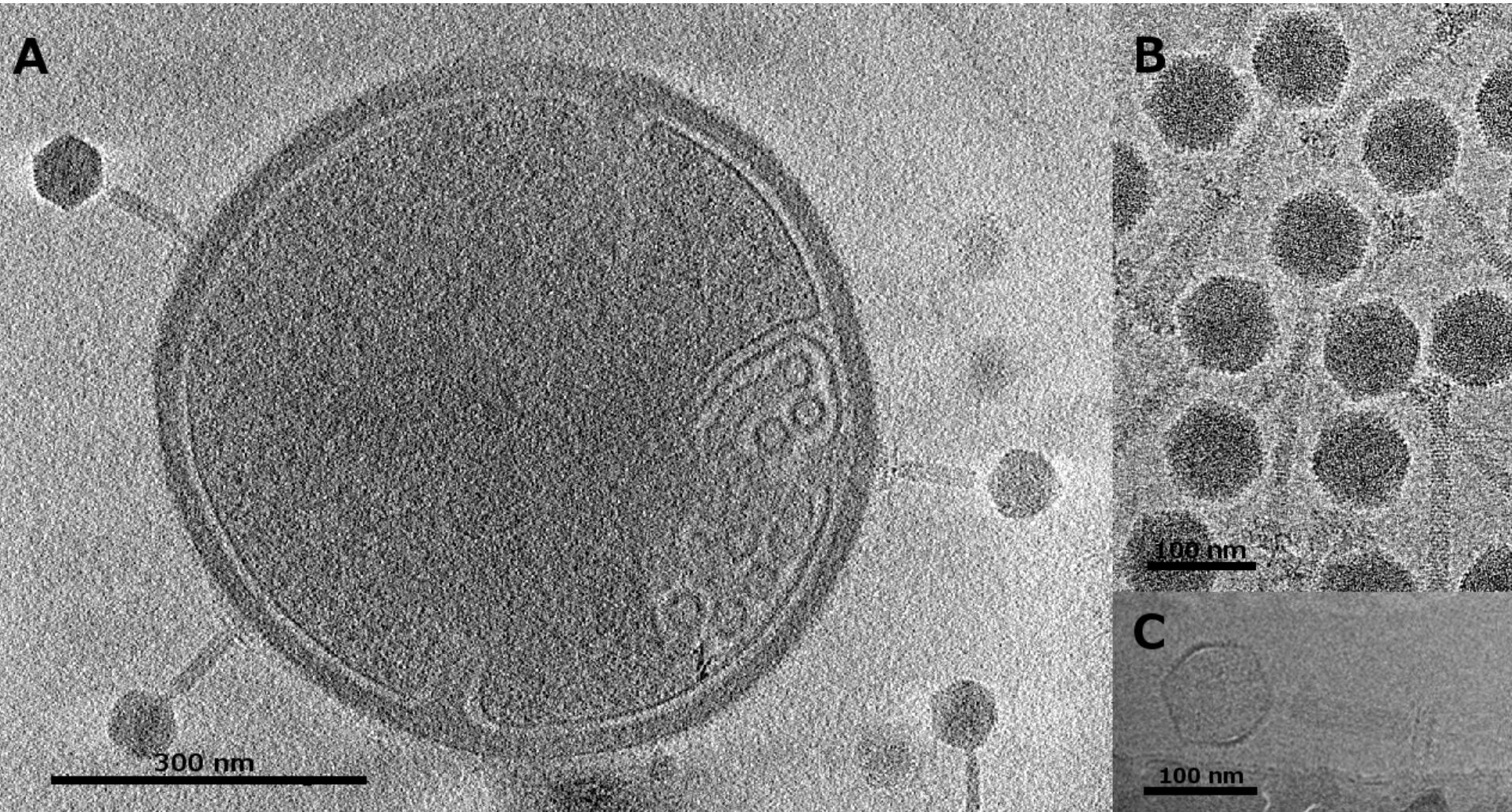
Intracellular transport of viruses



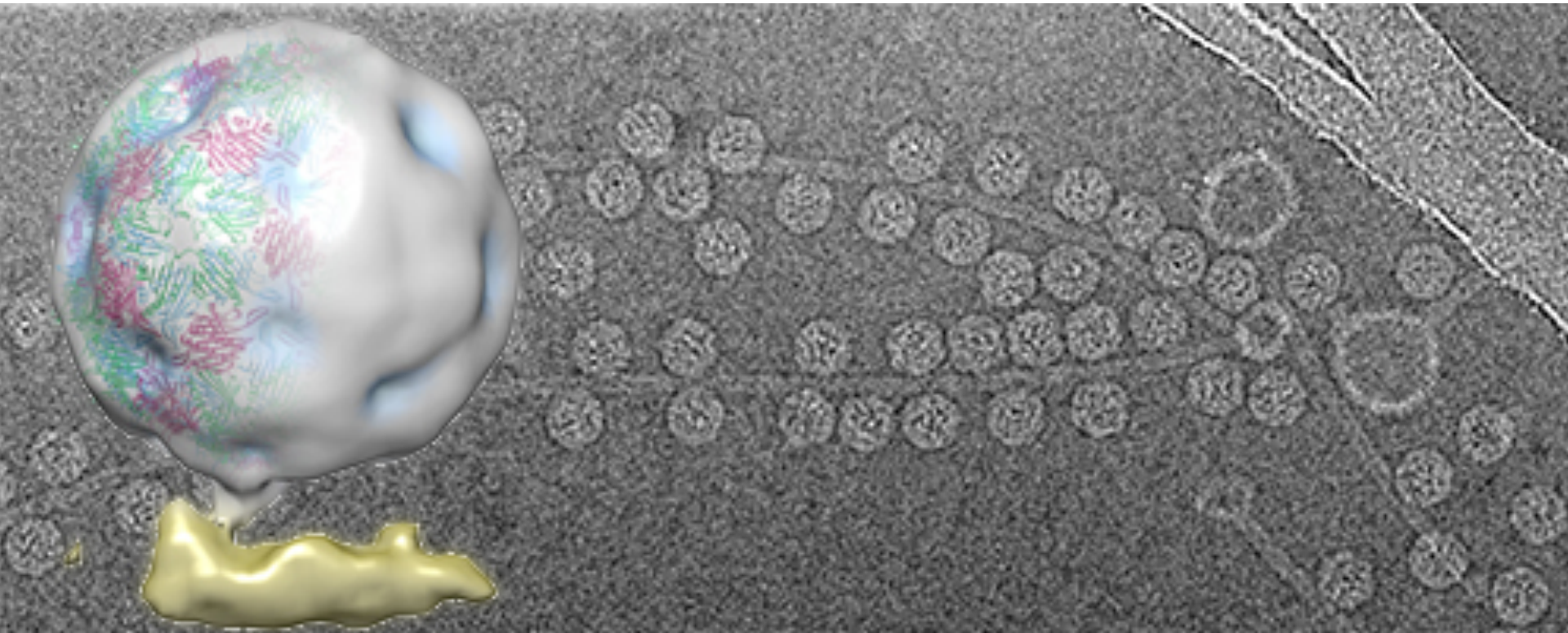
Intracellular transport of viruses



Phage phi812 genome injection



Phage MS2 infection



Learning outcomes

- outline a generalized scheme of virus replication involving seven steps
- describe how animal viruses attach to and enter their host cells
- differentiate between the entry mechanisms of naked and enveloped animal viruses
- describe the roles of cell components in the delivery of some viral genomes to the nucleus
- outline the infection mechanisms of phages