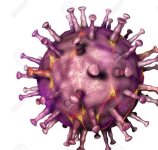
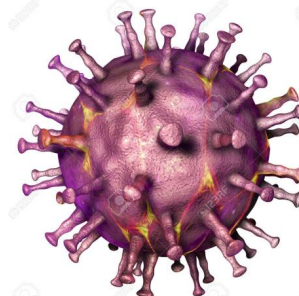




UNIwersytet Medyczny
IM. PIASTÓW ŚLĄSKICH WE WROCLAWIU



Subject: Faculty Lectures of Virology

Topic: Viral Structure and Replication

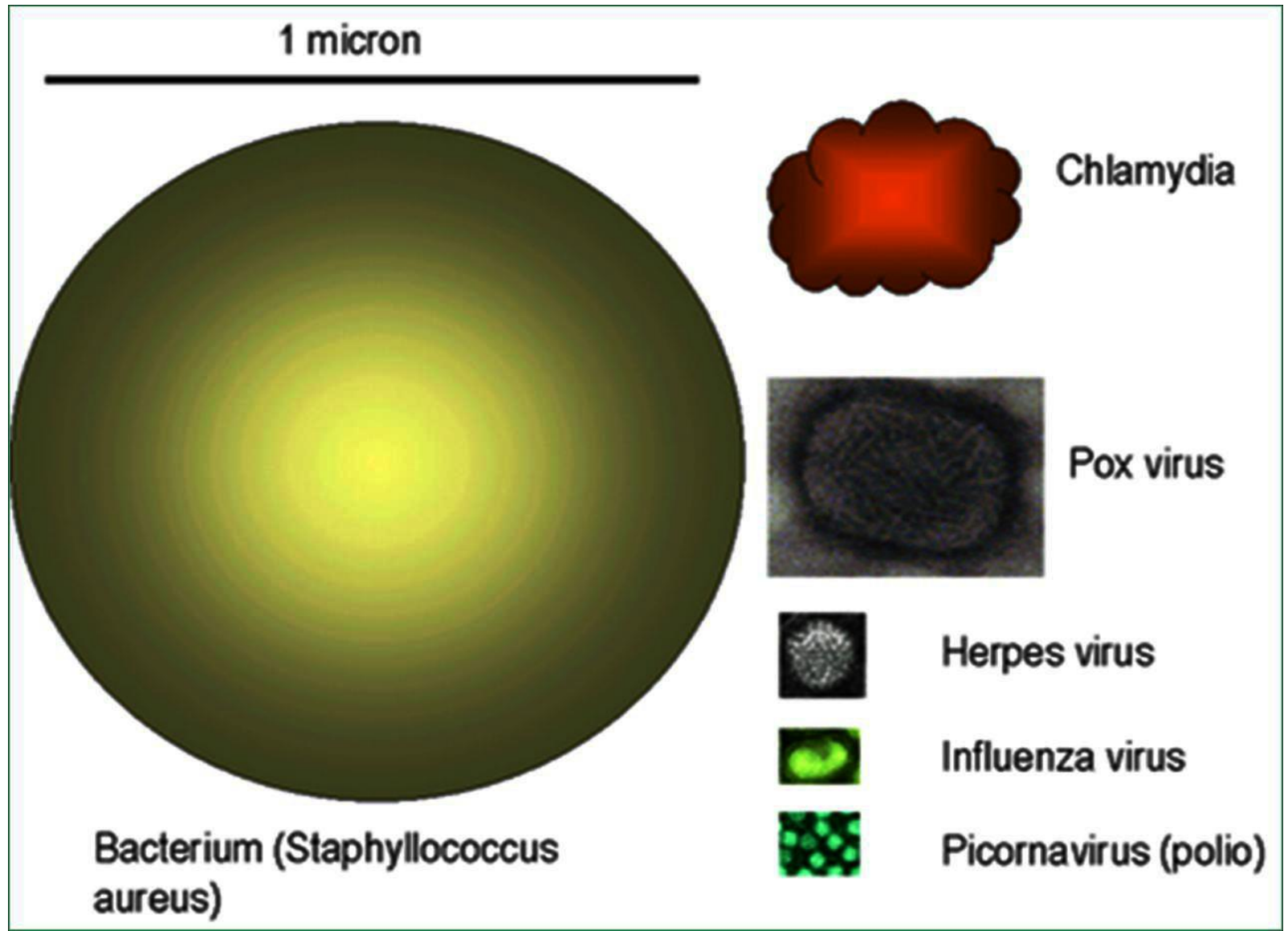
Academic Year 2024/2025

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Faculty: Medicine
Field of study: Virology
Level of study (uniform MA):
Form of study (full time):
Year of study: III

Academic title/professional title: professor
Name, last name of the lecturer: Beata Sobieszczkańska
Position of person conducting classes: teacher
Wrocław Medical University
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Viruses are very tiny creatures



Characteristics of viruses

1. Living characteristics of viruses:

- they reproduce only in living host cell
- they can mutate

2. Nonliving characteristics of viruses:

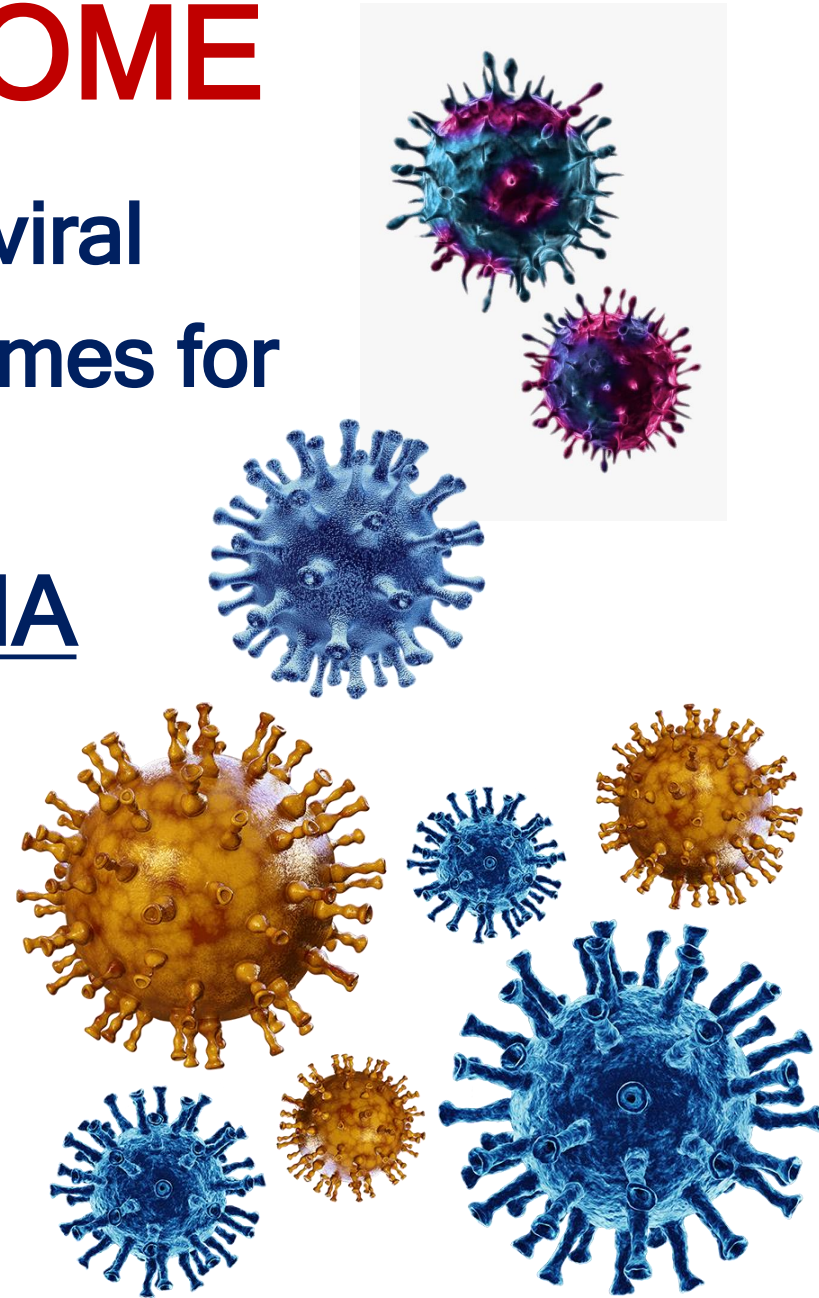
- they are acellular
- they carry out no metabolism on their own and must replicate using host cell's metabolic machinery

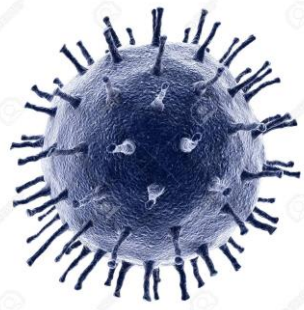
Viral structure: **GENOME**

Codes for the synthesis of viral components and viral enzymes for replication

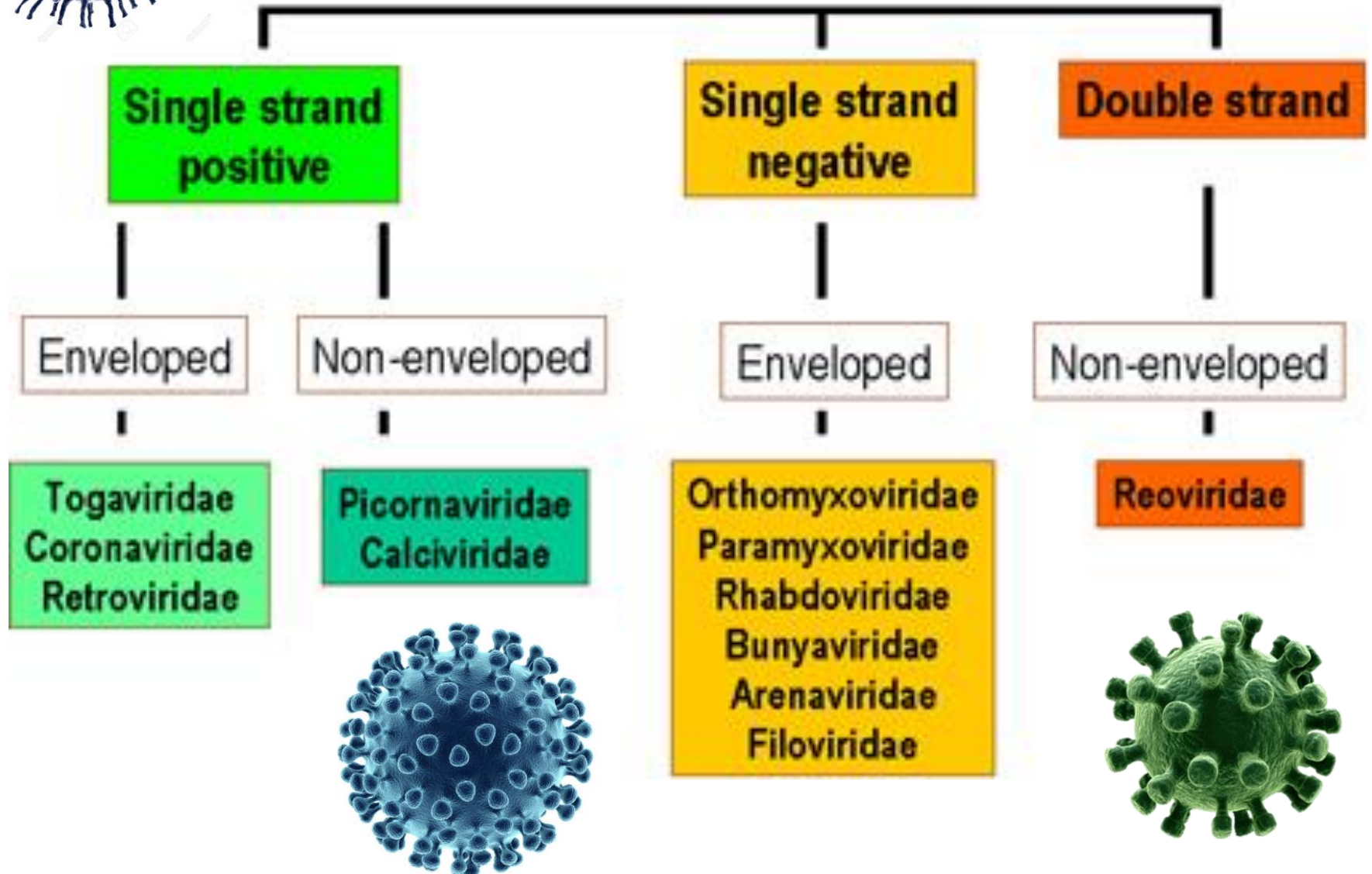
nucleic acid: DNA or RNA

- single or segmented
- circular or linear
- single-stranded
- double-stranded

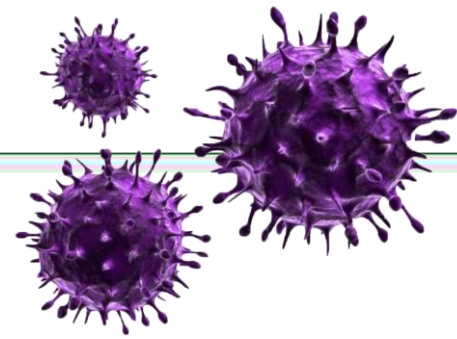
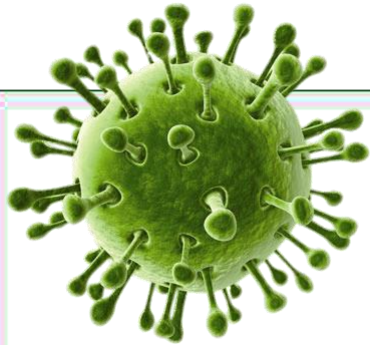




RNA VIRUSES



DNA VIRUSES



Double stranded

Enveloped

Herpesviridae
Hepadnaviridae

Non-enveloped

Circular

Papovaviridae

Linear

Adenoviridae

Single stranded

Enveloped

Parvoviridae

Non-enveloped

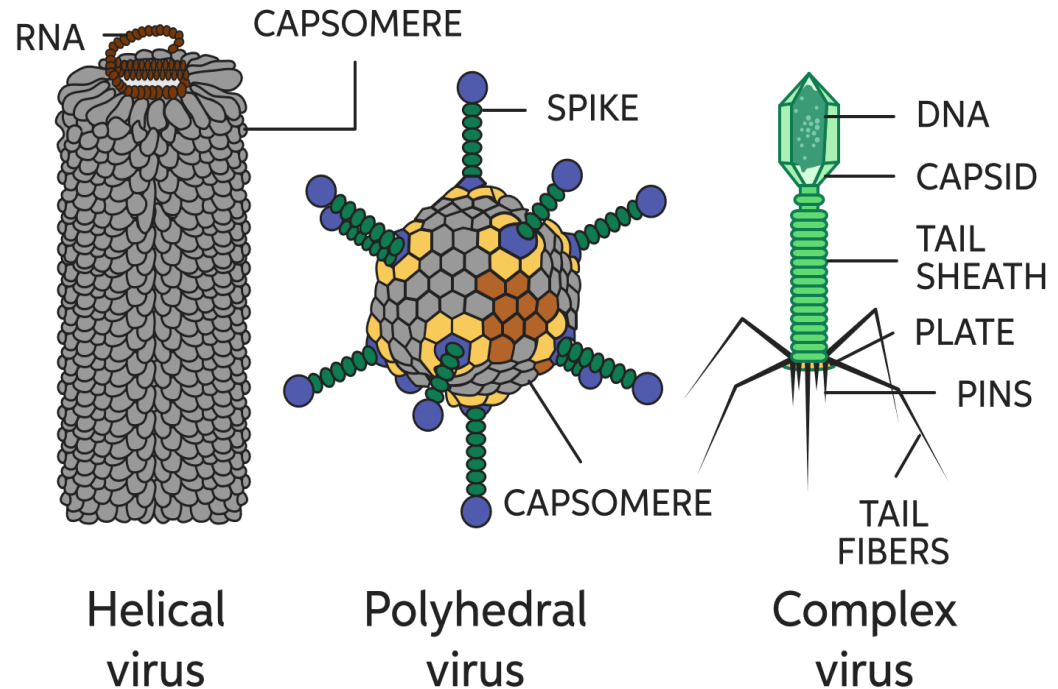
Poxviridae

Complex

Viral structure: **CAPSID**

Shapes of viral capsid:

- a) **helical** – a hollow protein cylinder
- b) **polyhedral** (icosahedron)
- c) **complex** – pleomorphic



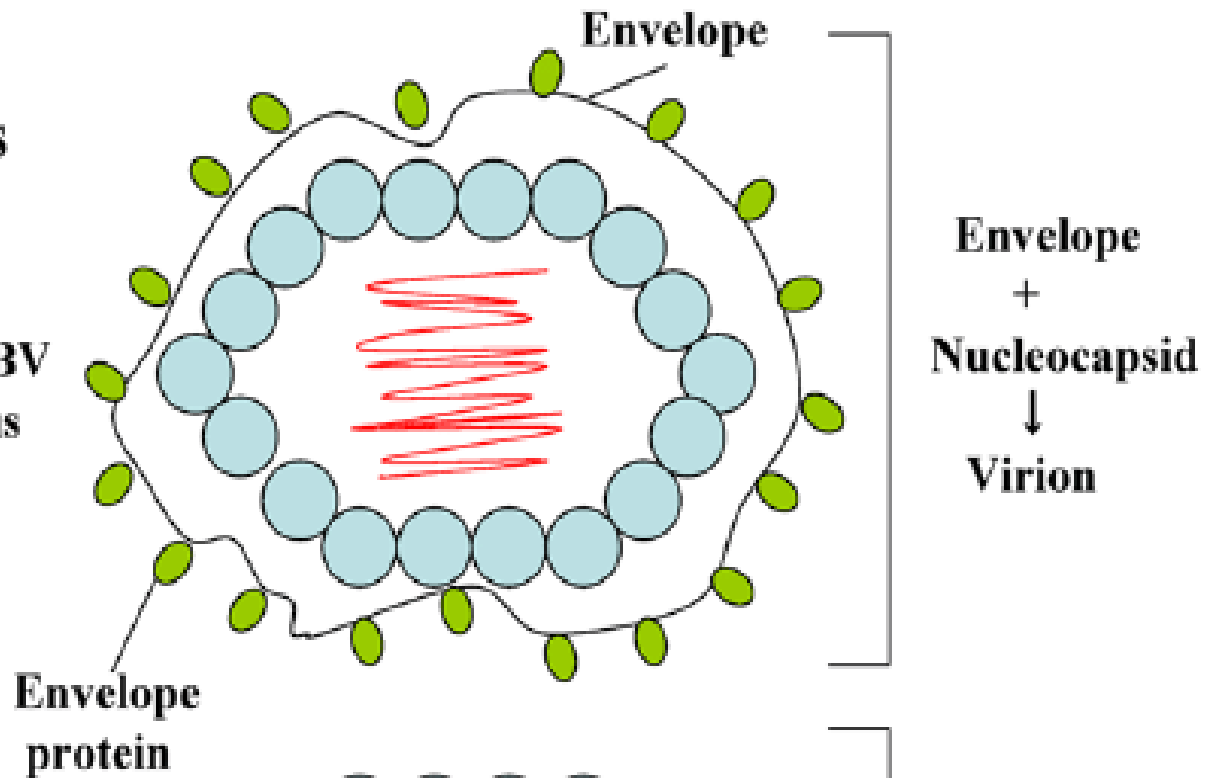
Viral structure: ENVELOPE

- **Composed of phospholipids and glycoproteins**
- **Derived from host cell membranes**
(nuclear, vacuolar, outer)
- **Role:** protection of virus particle
- **Not all viruses possess an envelope - naked viruses**

Examples

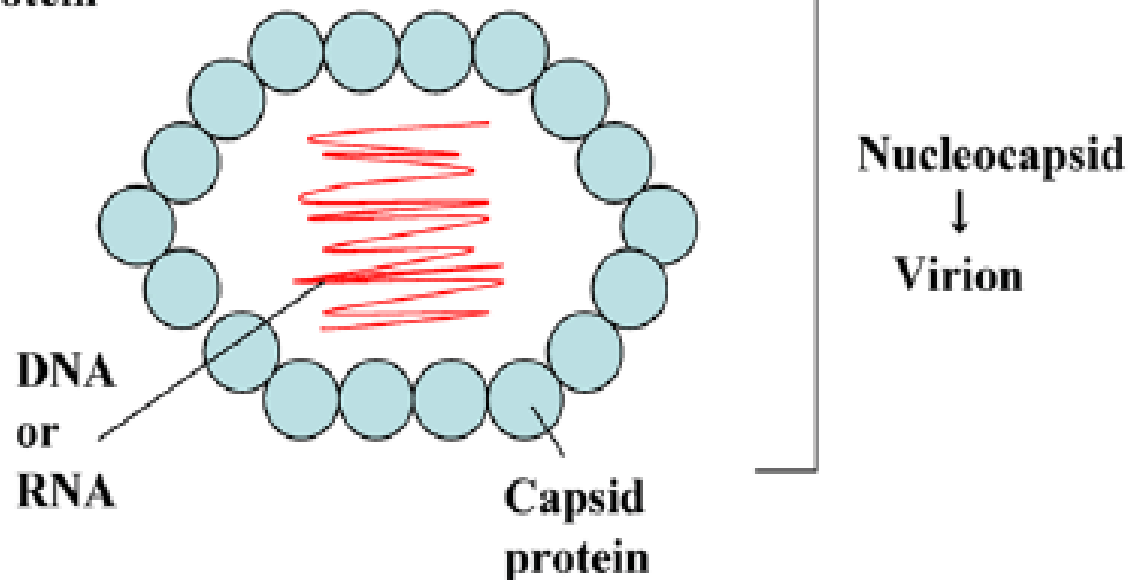
Enveloped virus

HIV, HSV, HBV
Influenza virus



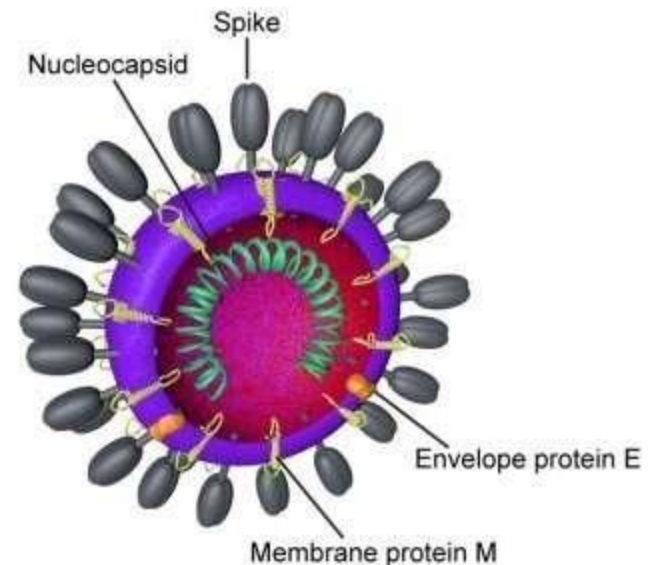
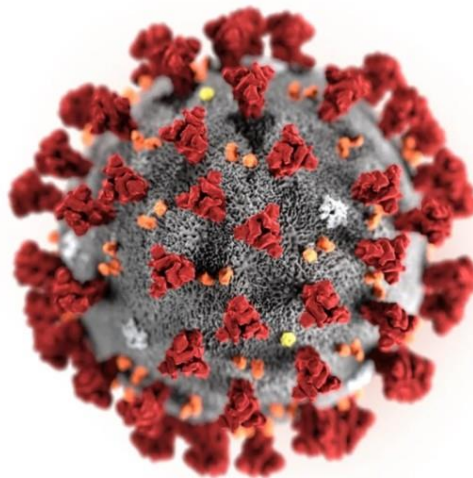
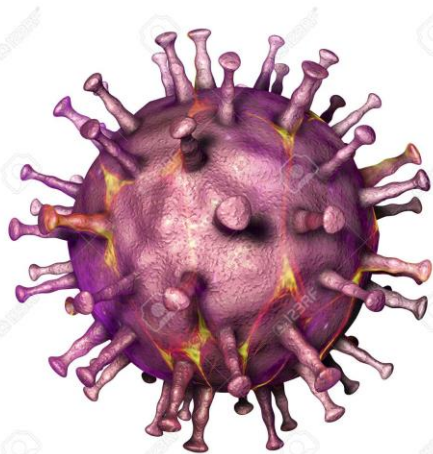
Non-enveloped virus

Norovirus,
Parvovirus
HAV, HEV



Viral structure: **RECEPTORS**

- Viral glycoprotein spikes incorporated into envelope or capsid
- Role: attaching to receptors of susceptible host cells
- A determinant of **virus host range and tissue tropism**



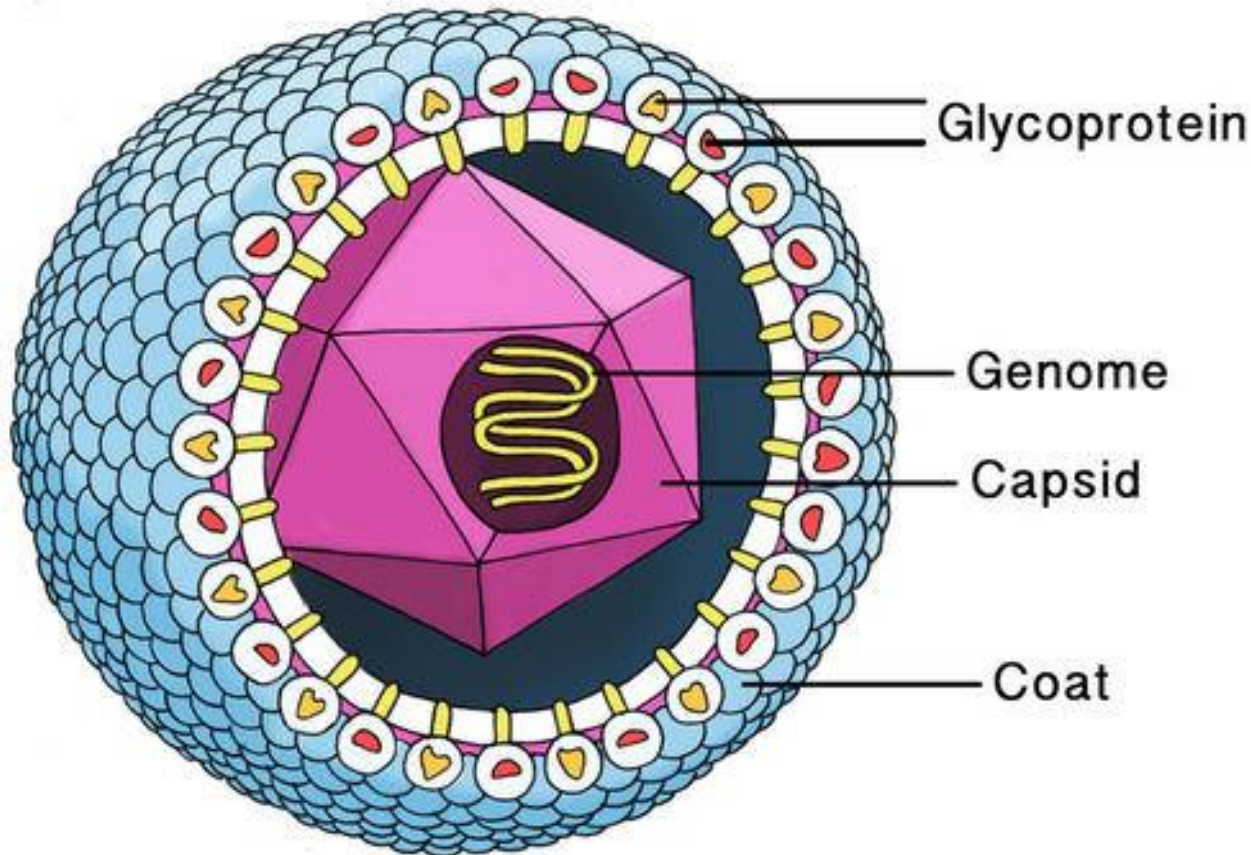
Host cell receptors

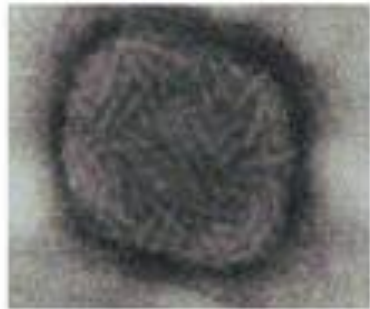
- Normal surface molecules involved in cellular function
- Rhinoviruses bind to ICAM-1 on cells of the nasal epithelium
- HIV adsorbs to CD4 and chemokine receptors on human T4-lymphocytes and macrophages

Size of viruses

Size: submicroscopic - most range in size from 5 to 300 nm

Viron

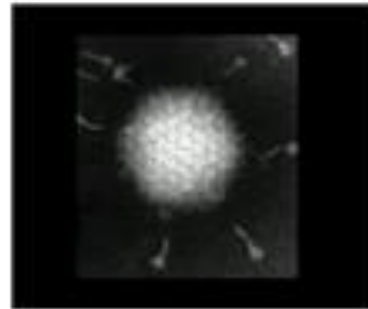




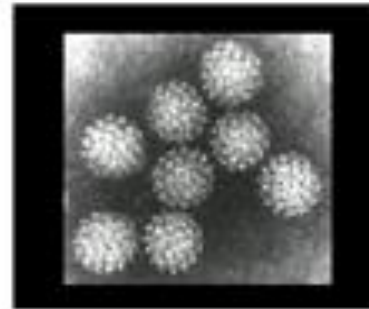
Poxviridae



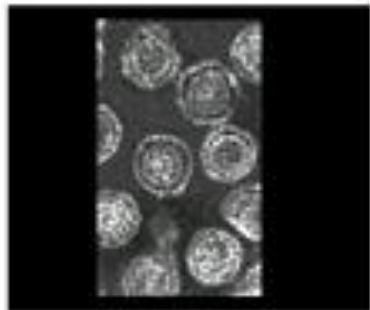
Herpesviridae



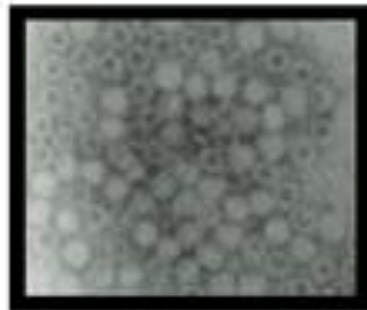
Adenoviridae



Papovaviridae
human papilloma



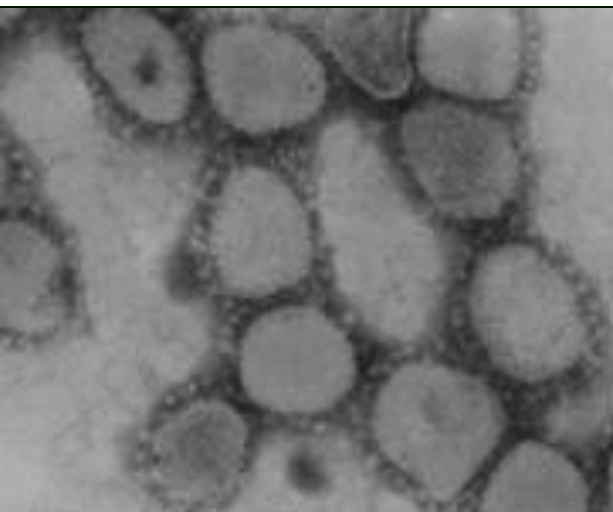
Hepadnaviridae



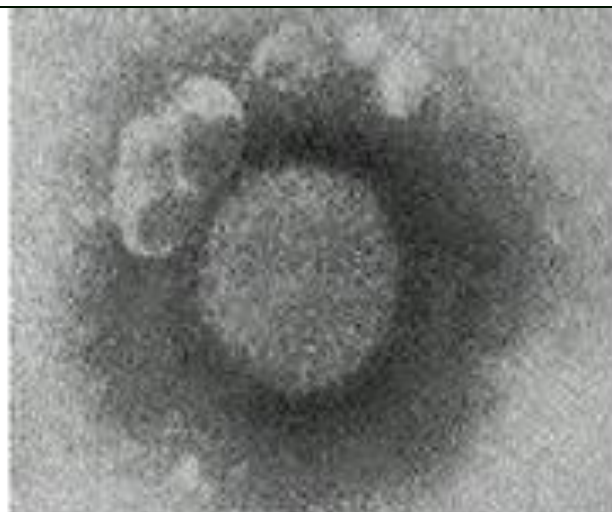
Parvoviridae

DNA Viruses

— 100 nanometers



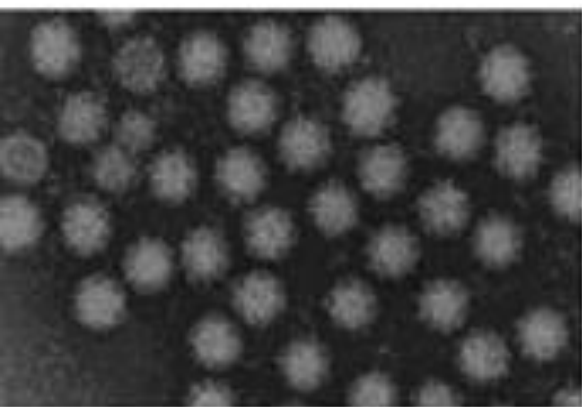
Coronaviridae (NS+)



Arenaviridae (S, ambi)



Picornaviridae (NS+)



Caliciviridae (NS+)

RNA viruses Positive strand (+)

S=segmented NS=non-segmented

Ambi: part + and part -

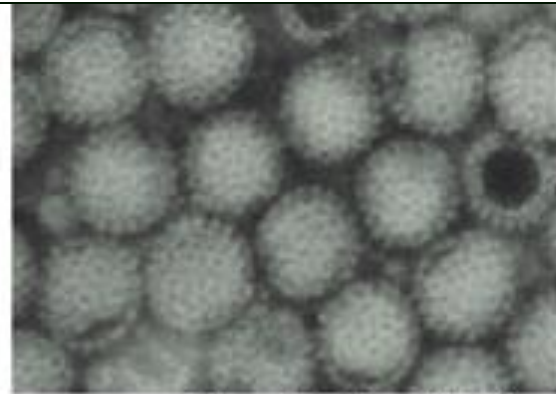
—
100nm



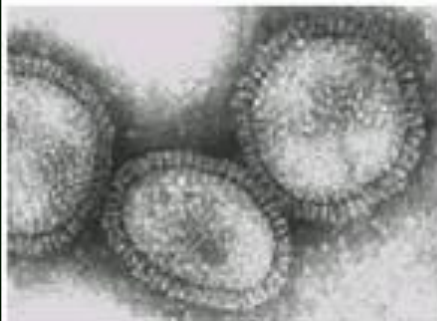
Paramyxoviridae (NS-)



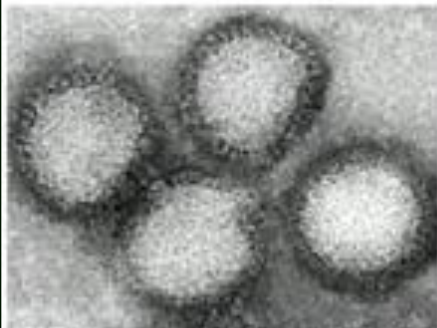
Rhabdoviridae (NS-)



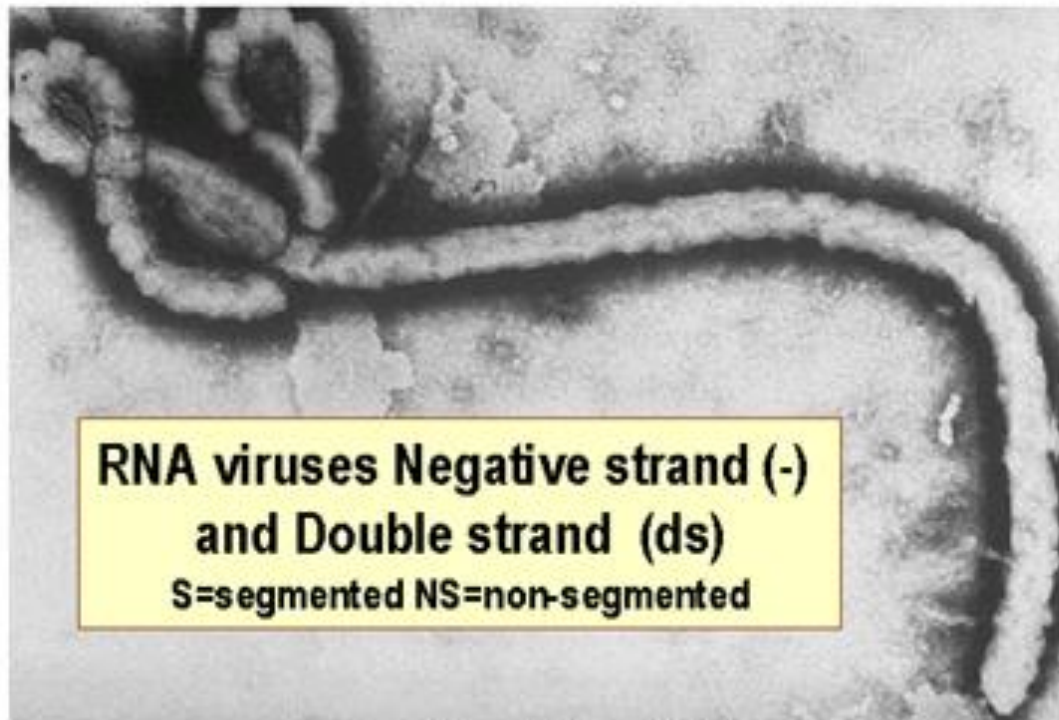
Reoviridae (S,ds)



Orthomyxoviridae (S-)



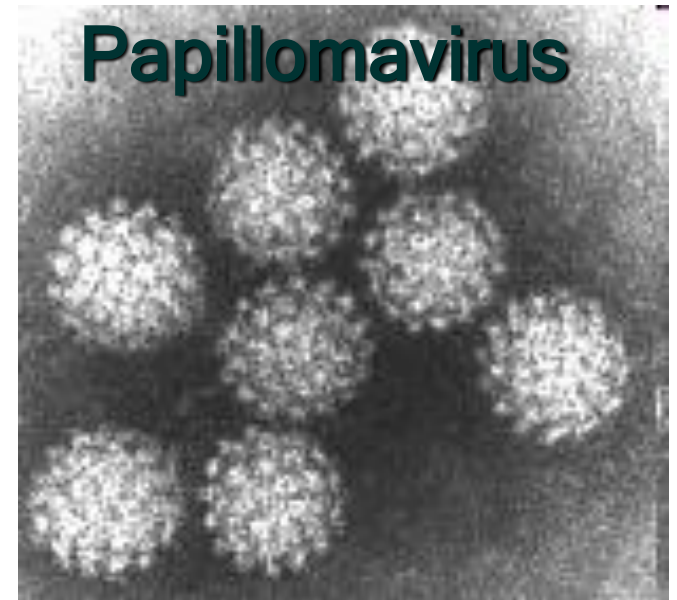
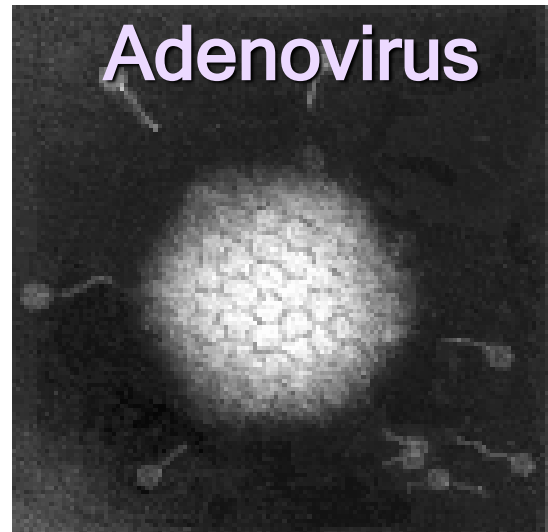
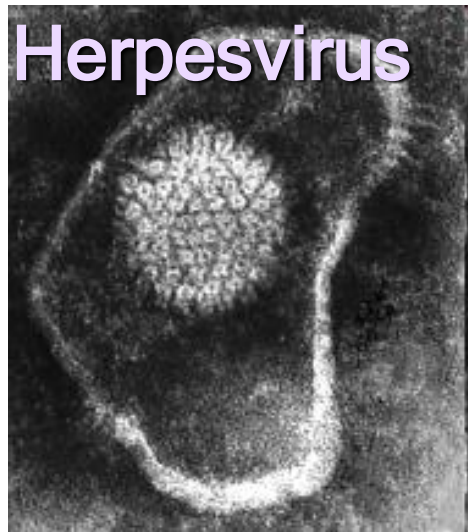
Bunyaviridae (S-)



100nm

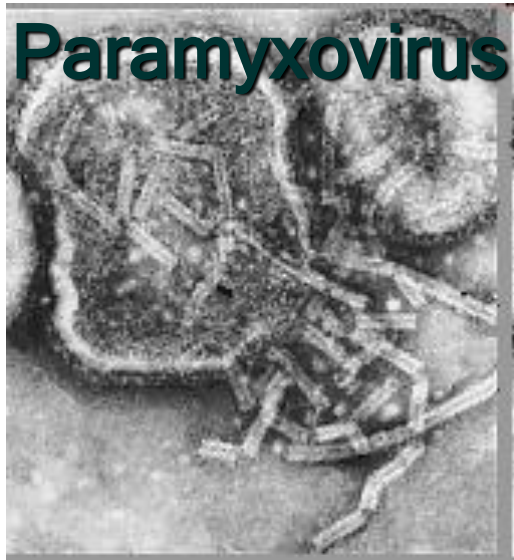
**RNA viruses Negative strand (-)
and Double strand (ds)
S=segmented NS=non-segmented**

Filoviridae (NS-)



DNA viruses

RNA viruses

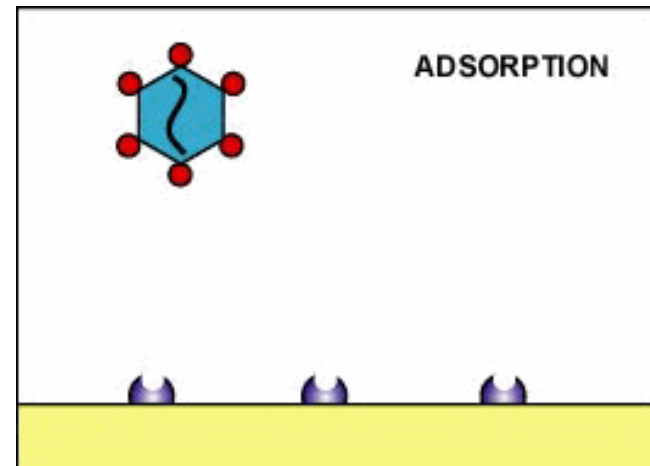
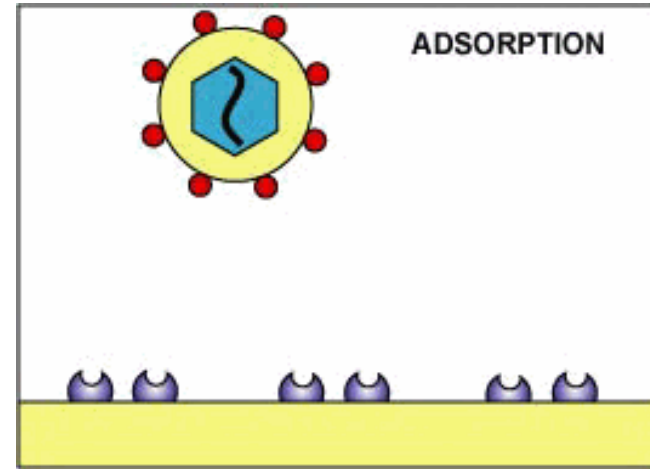


Life cycle of animal viruses

Productive life cycle consist of:

attachment or adsorption

binding of attachment sites on the viral surface with receptors sites on the host cell cytoplasmic membrane



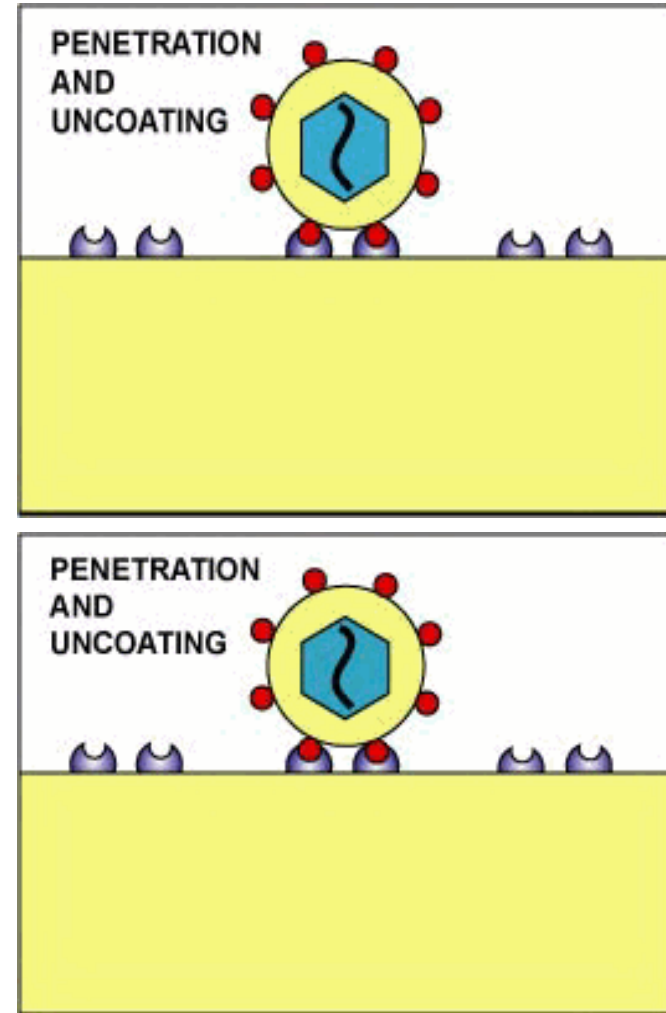
Life cycle of animal viruses

Penetration and uncoating

Enveloped viruses:

- envelope fuse with the host cell membrane
- endocytosis

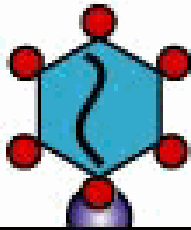
Uncoating = release of viral genome



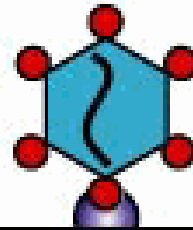
Life cycle of animal viruses

Naked viruses' penetration

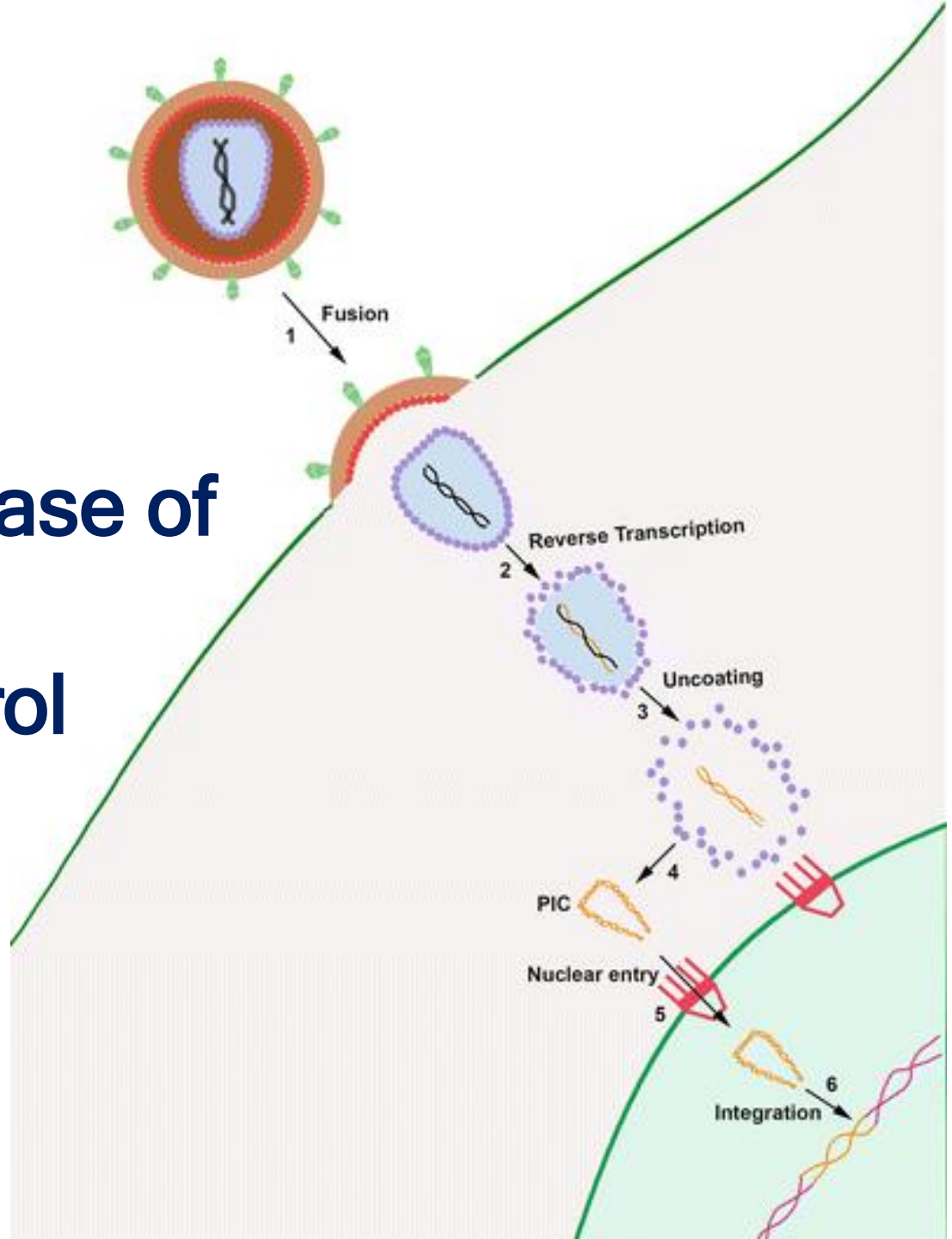
PENETRATION
AND
UNCOATING



PENETRATION
AND
UNCOATING

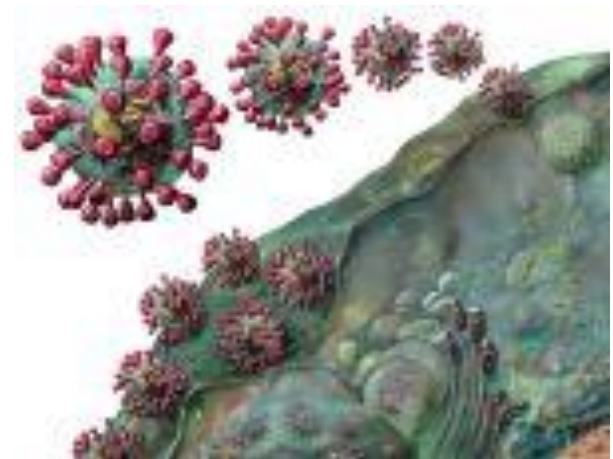


Uncoating = release of
viral genome
Virus takes control
over the cell

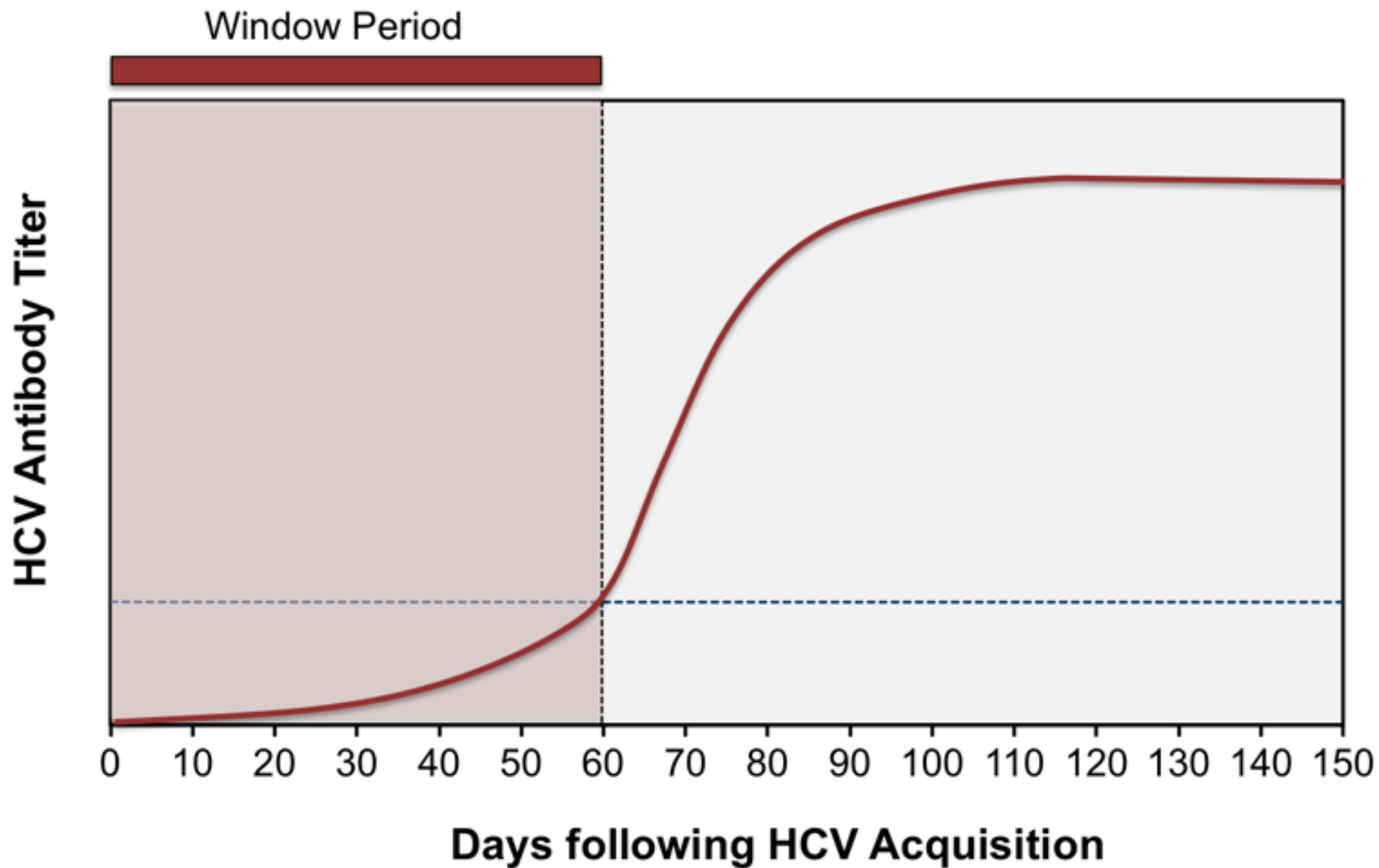


During the uncoating and replication stages the virus is not infectious

Eclipse period:
no intact virions
can be detected
within the cell



Serologic window period - time between
first infection and when the infection can
reliably be detected

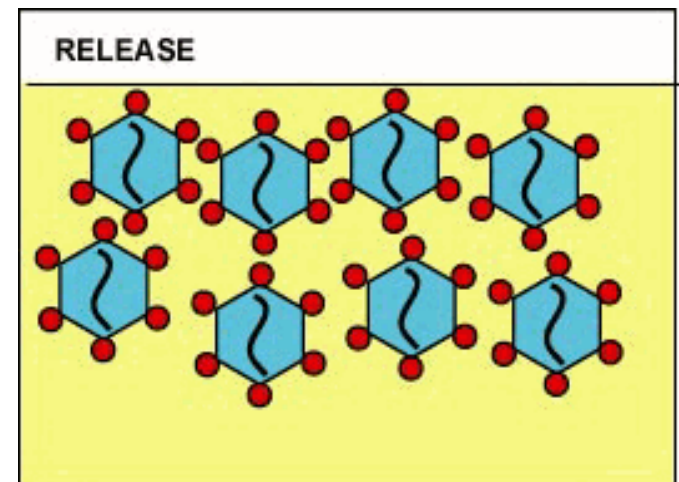
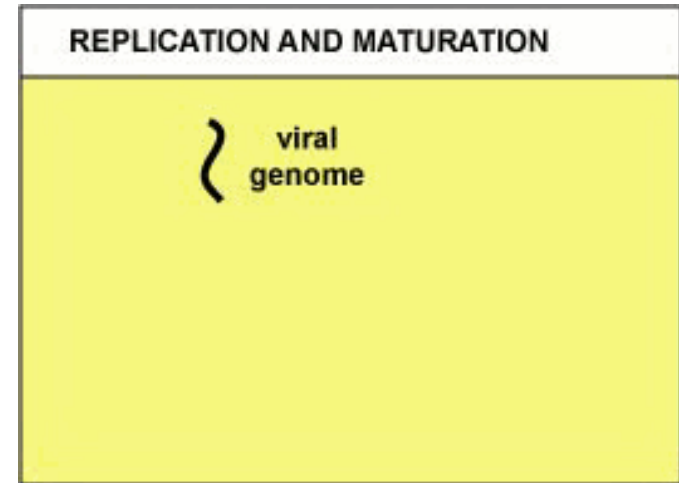


Life cycle of animal viruses

Maturation

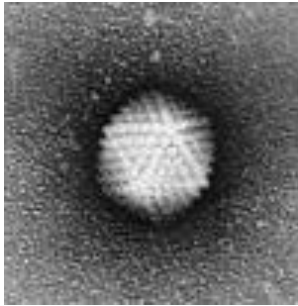
Naked viruses:
disintegrates cell

Enveloped viruses:
budding or exocytosis



The life cycle of animal viruses:

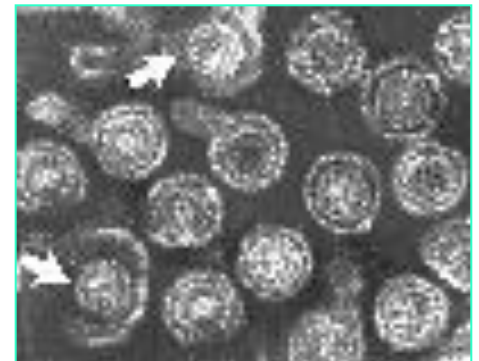
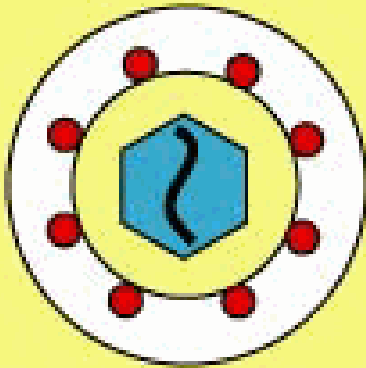
release



RELEASE
BY BUDDING

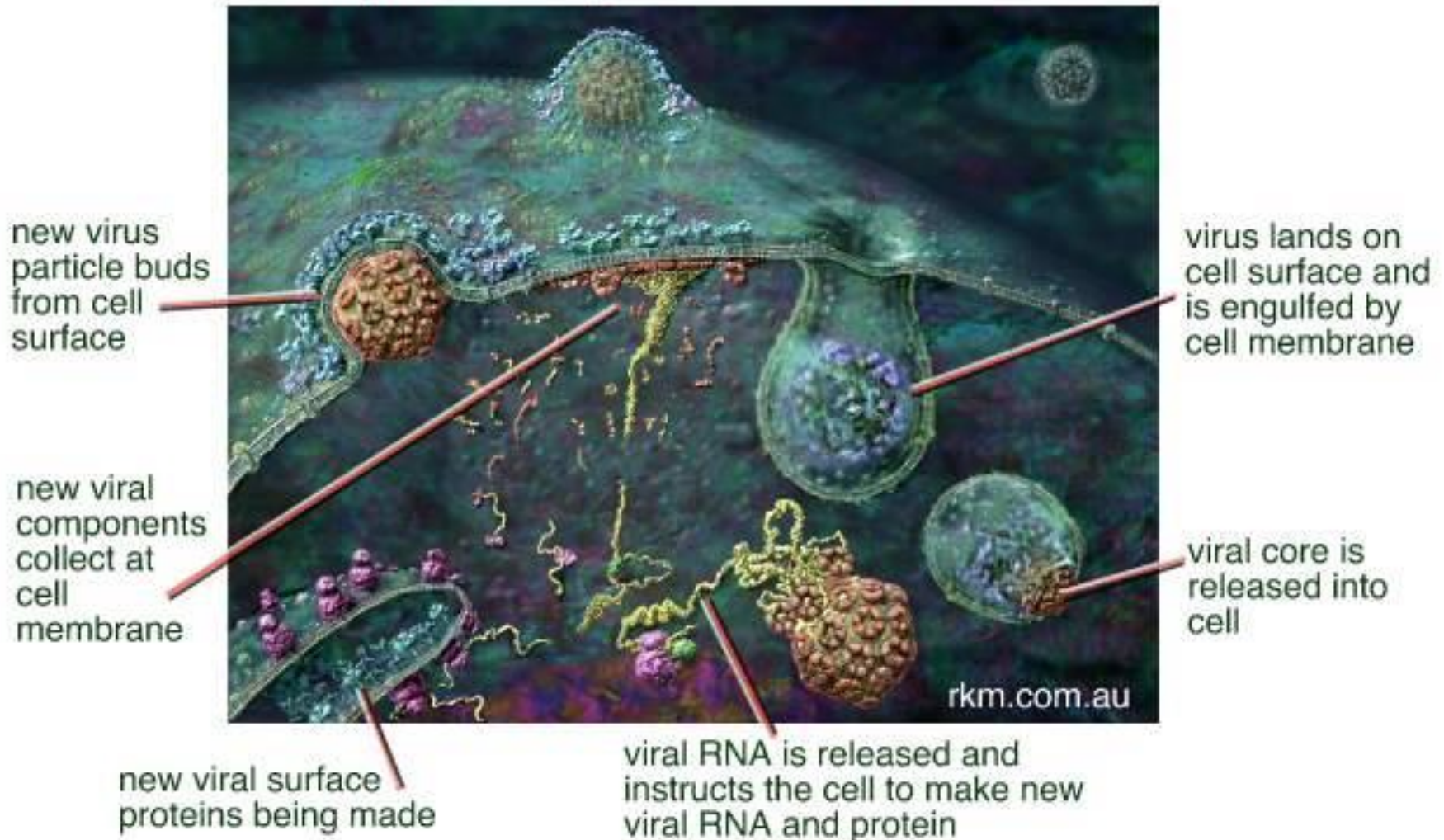


RELEASE BY
EXOCYTOSIS



10,000 – 50,000 viruses may be produced by a single infected host cell

simplified life-cycle of Ross River Virus



Mechanisms of viral cytopathogenesis

- **Inhibition of cellular protein synthesis (Polio, HSV, Toga, Pox)**
- **Inhibition and degradation of cellular DNA (HSV)**
- **Alteration of cell membrane structure (enveloped viruses)**
 - **glycoprotein insertion (all enveloped viruses)**
 - **syncytia formation (HSV, VZV, Paramyxo, HIV)**
 - **disruption of cytoskeleton (non-enveloped viruses/accumulation, HSV)**
 - **permeability (Toga, Herpes)**
- **Inclusion bodies**
- **Toxicity of viron components**

The types of viral infections at cellular level

The effect on cells/
type of infection

1. Abortive

2. Productive

- cytolytic

- non-cytolytic

3. Non-productive

- latent

- transformation

Virus production

viruses not produced

viruses produced

viruses produced

viruses not produced

viral NA present

viral NA present

Productive infections in permissive cells:

a) **cytolytic infections**

- virus replicate and produce progeny
- cell death or **cytopathic effect** (**CPE**)

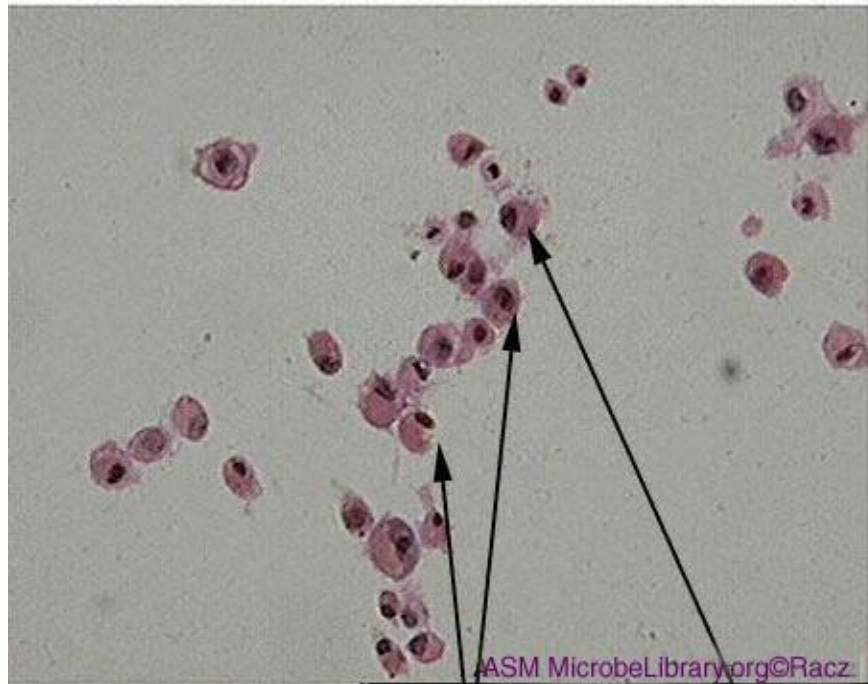
b) **non-cytolytic infections**

- virus replicate and produce progeny
- virus released by cell budding = little or no CPE

CPE can take several forms:

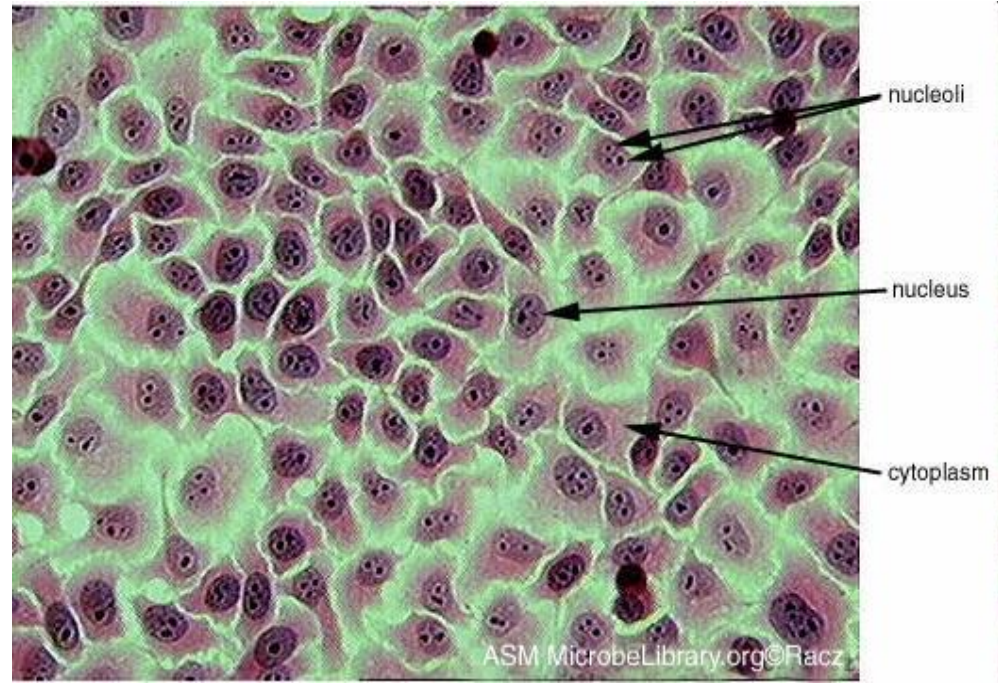
- **cell lysis**
- **cell rounding**
- **syncytium (giant) cell formation**
- **inclusion body formation**

Poliovirus



rounded shrunken cells

nucleus

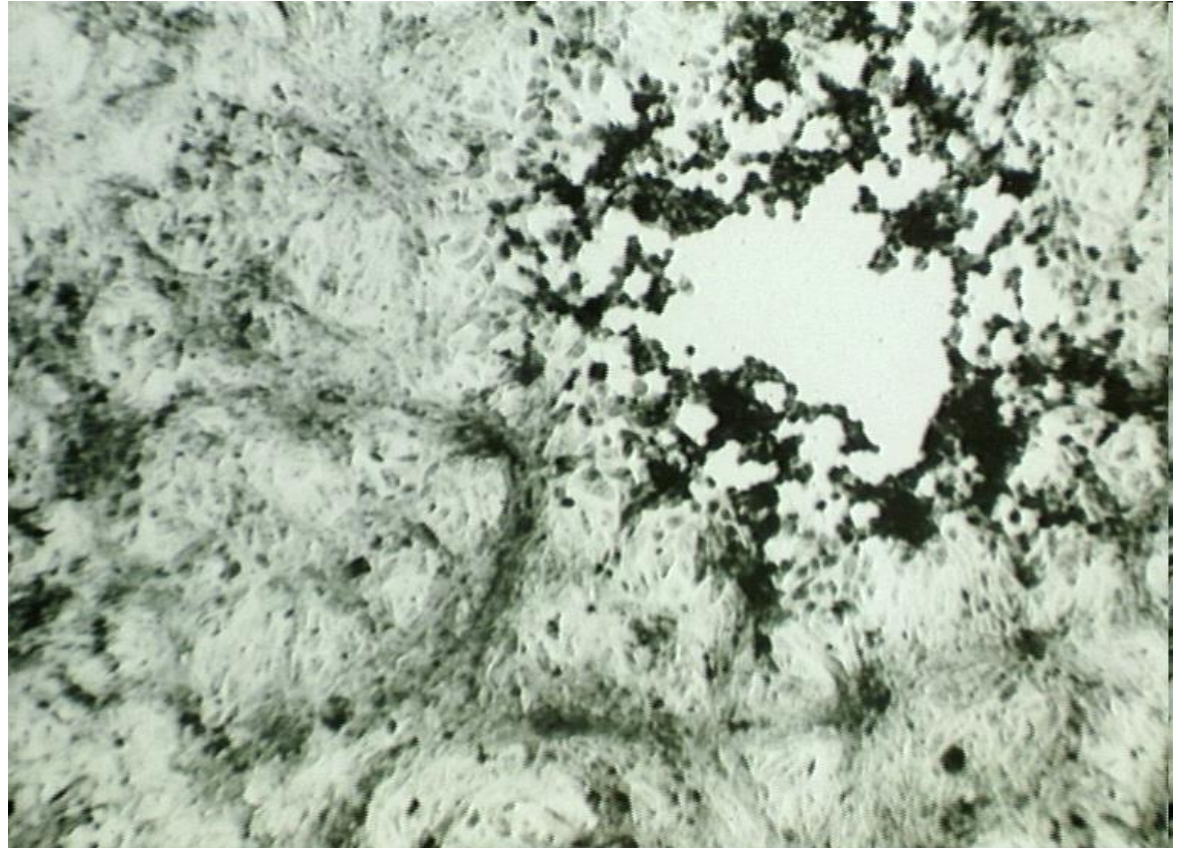
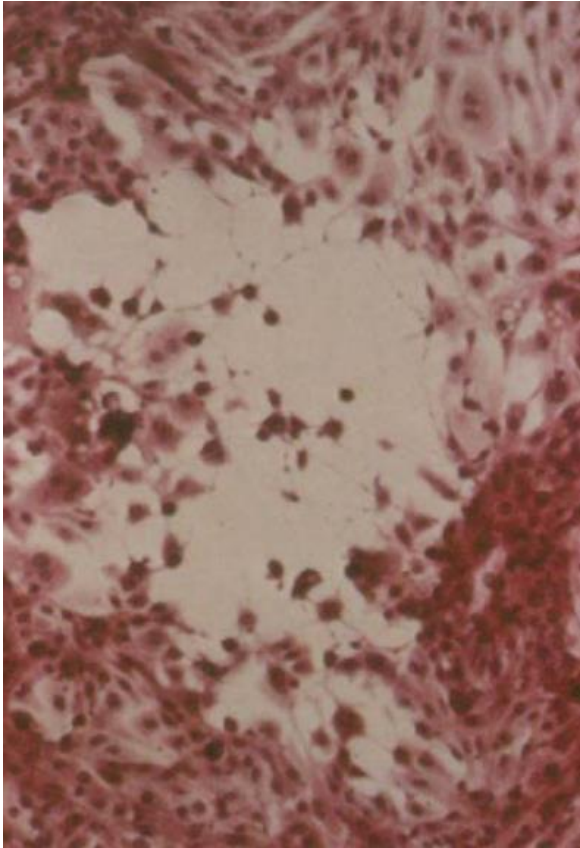


nucleoli

nucleus

cytoplasm

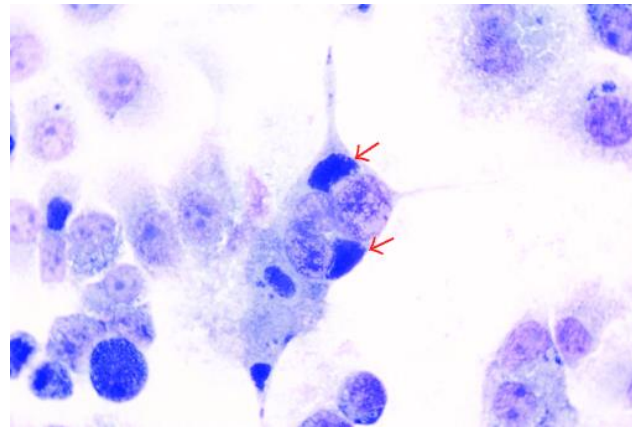
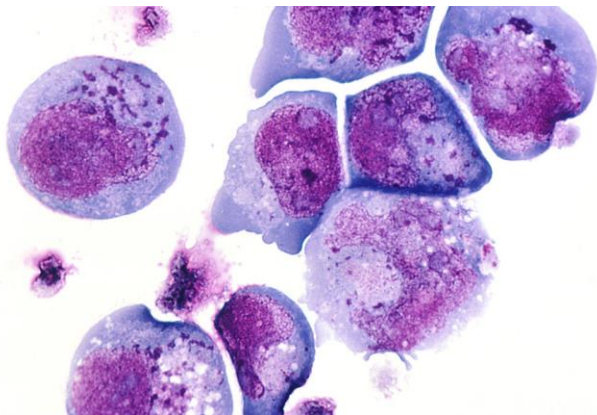
Herpesvirus (HSV)



CPE: **inclusion bodies**

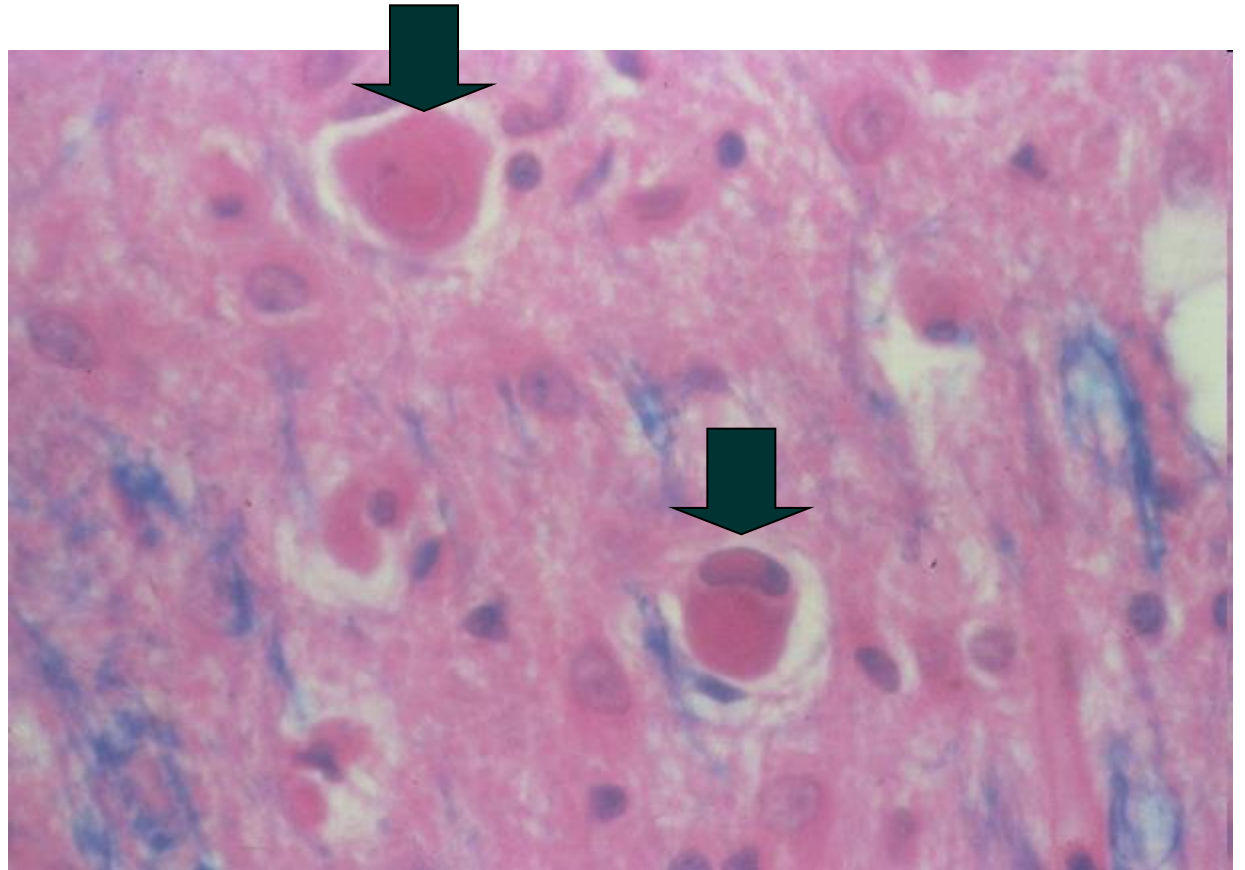
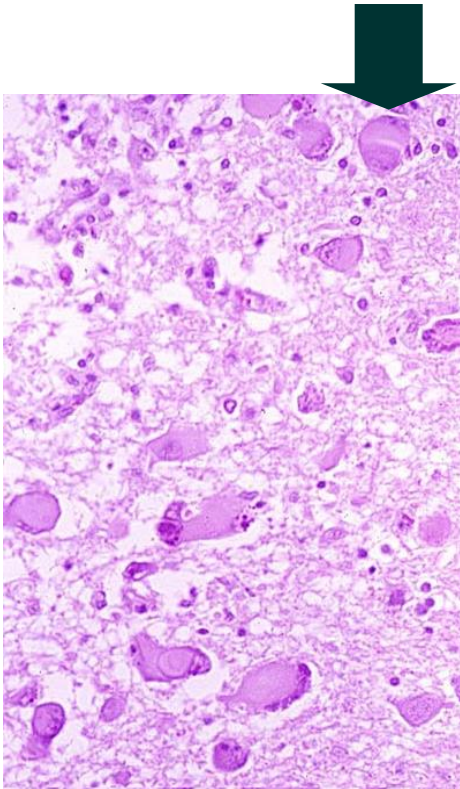
The site of viral multiplication and protein synthesis

- the most characteristic viral morphological changes
- round or irregular, single or multiple, large or small, intranuclear (INI), intracytoplasmic (ICI), acidophilic, basophilic

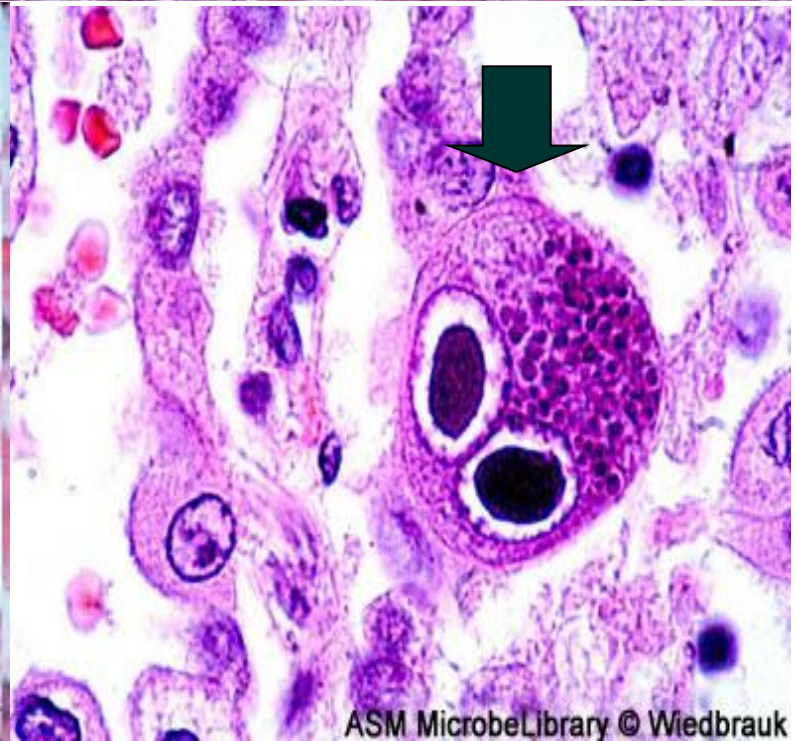
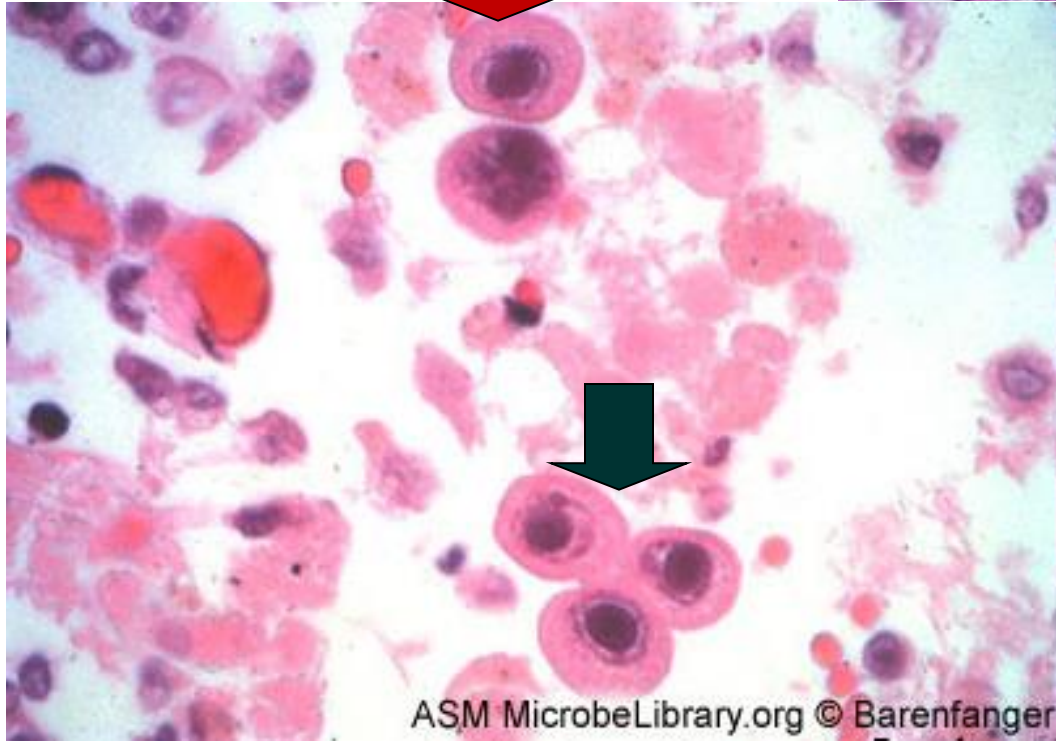
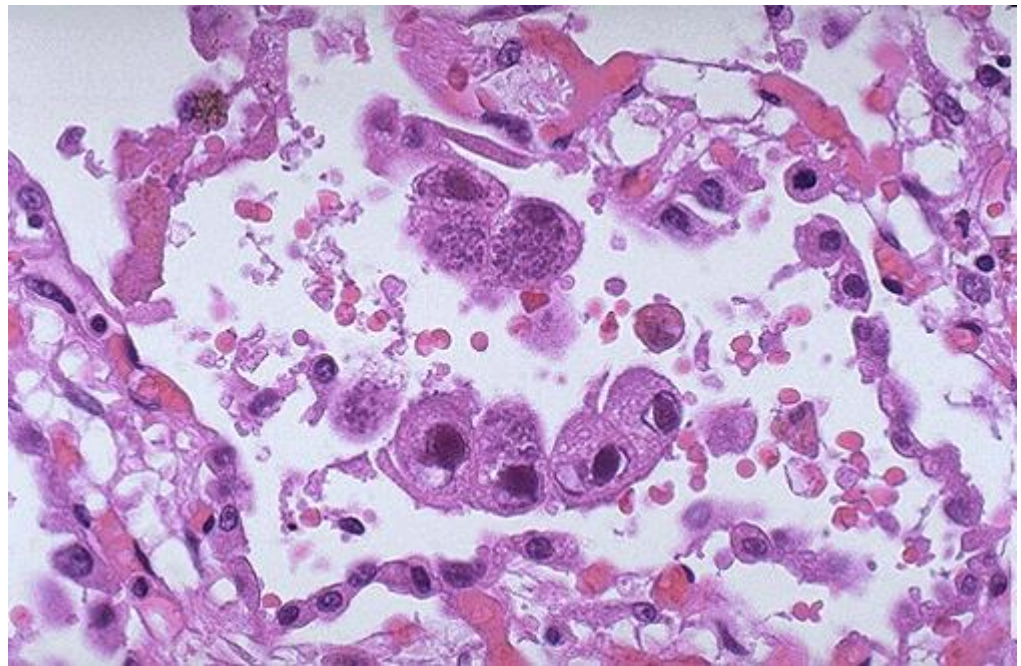


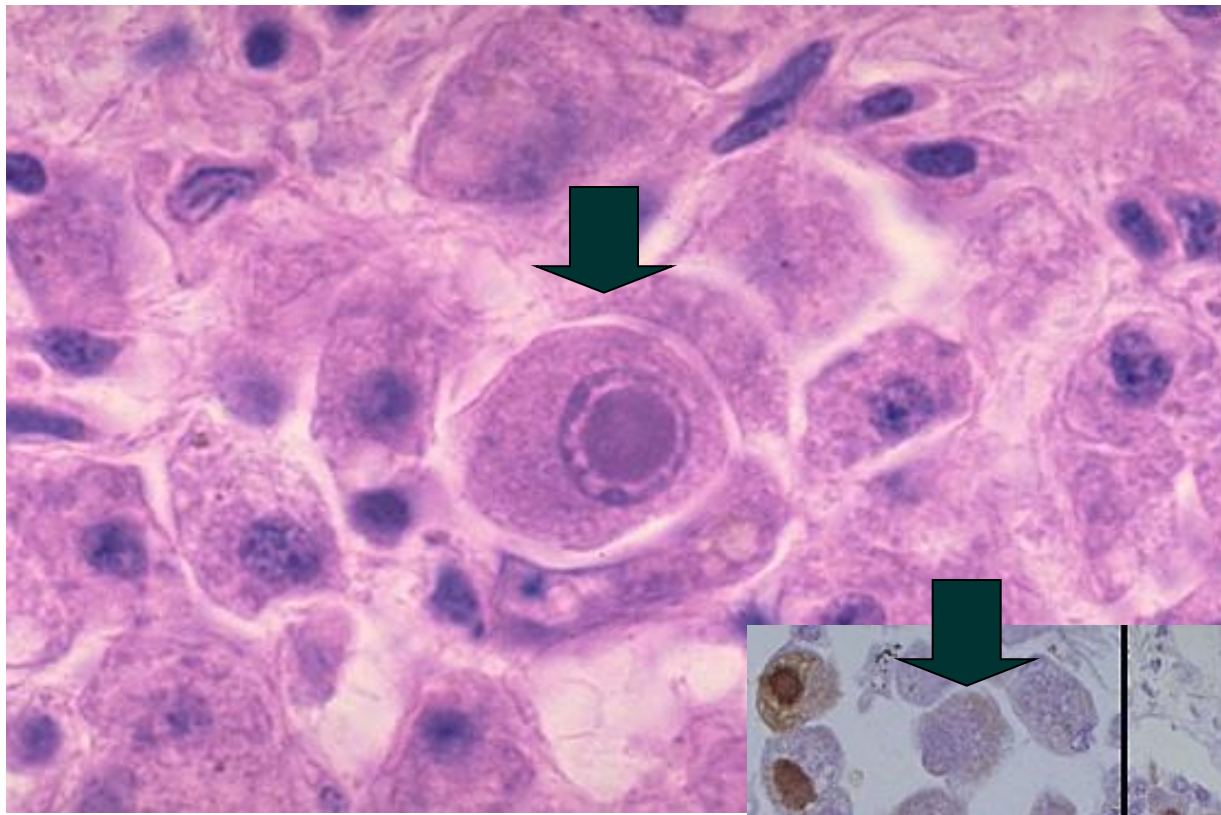
Cowdry bodies type A

HSV, VZV, sclerosing subacute panencephalitis
(measles)

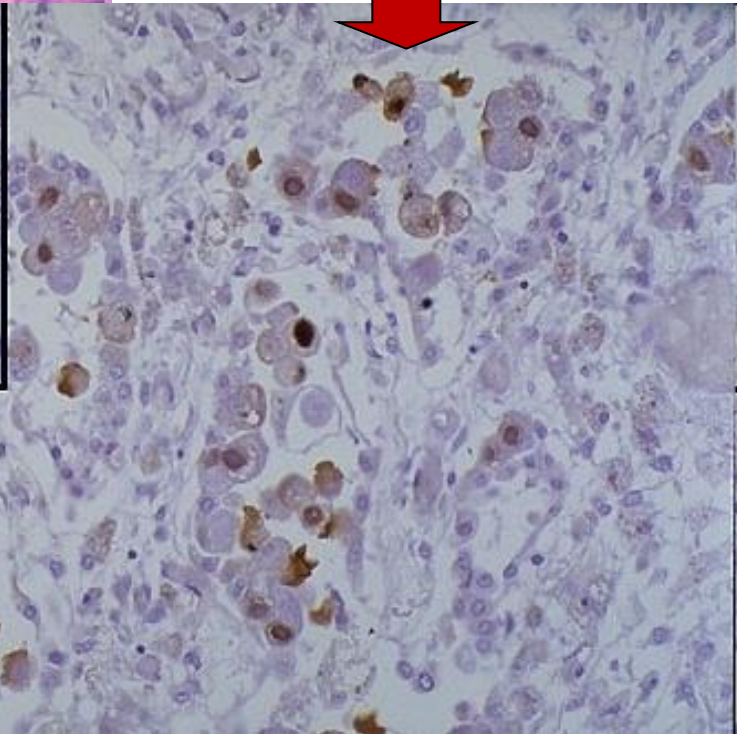
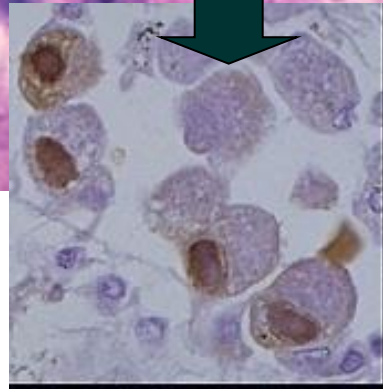


CMV

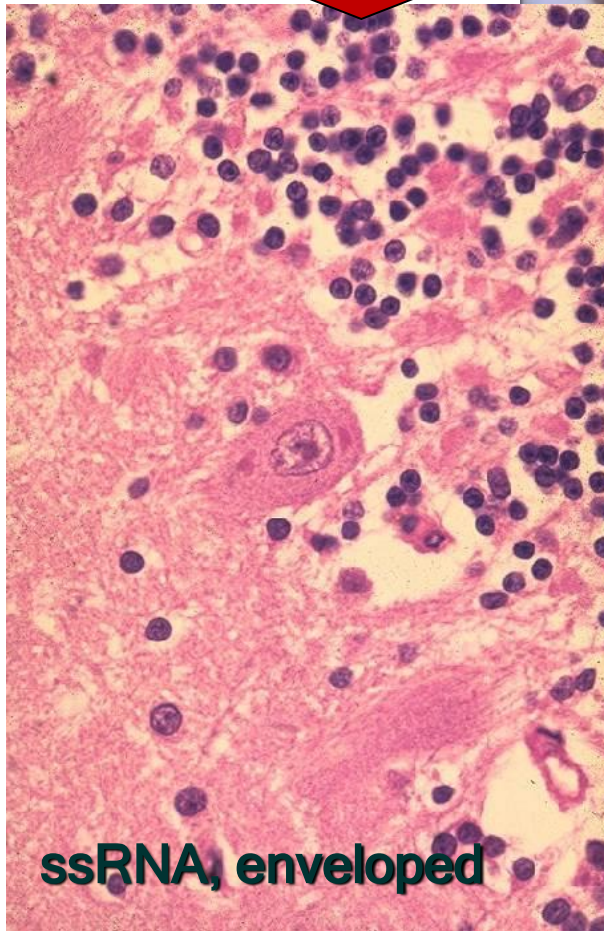
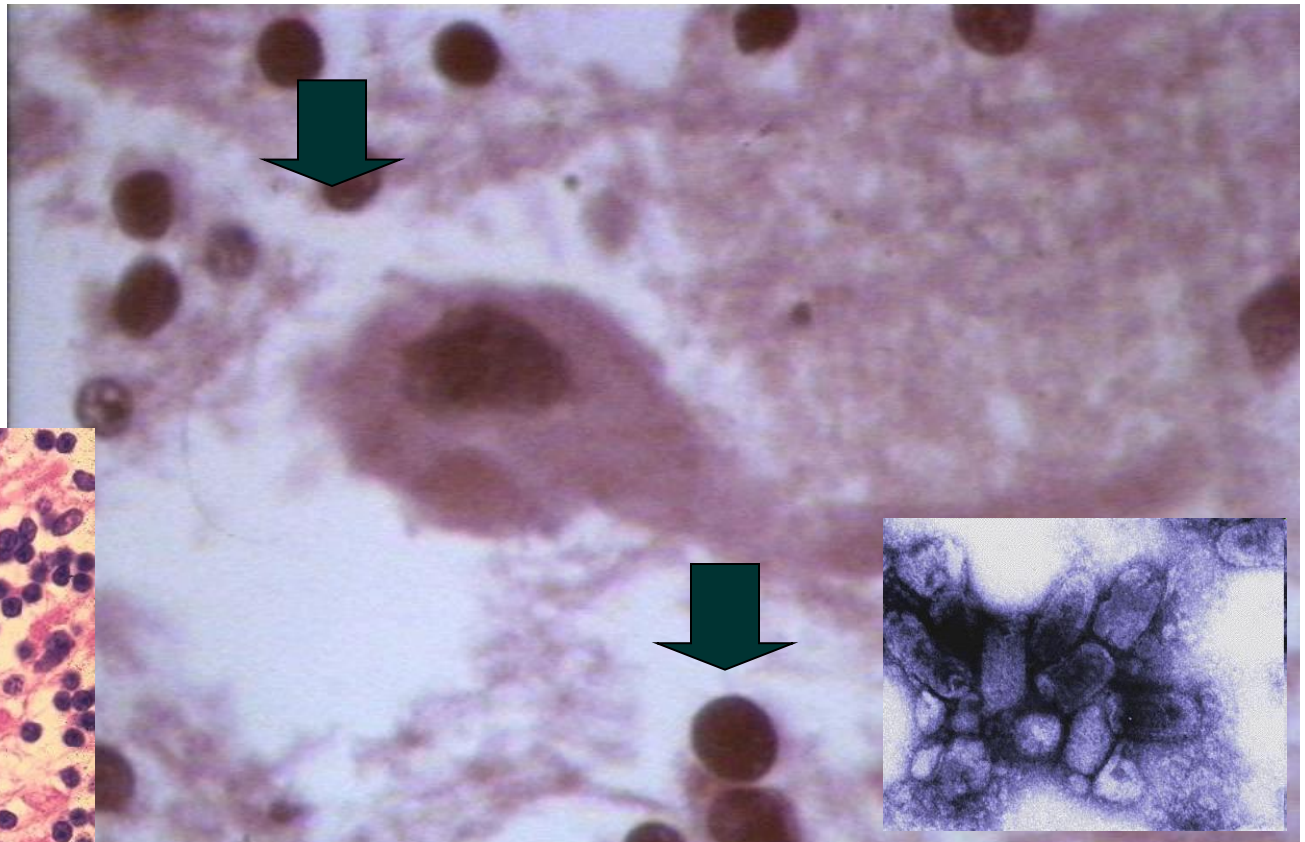




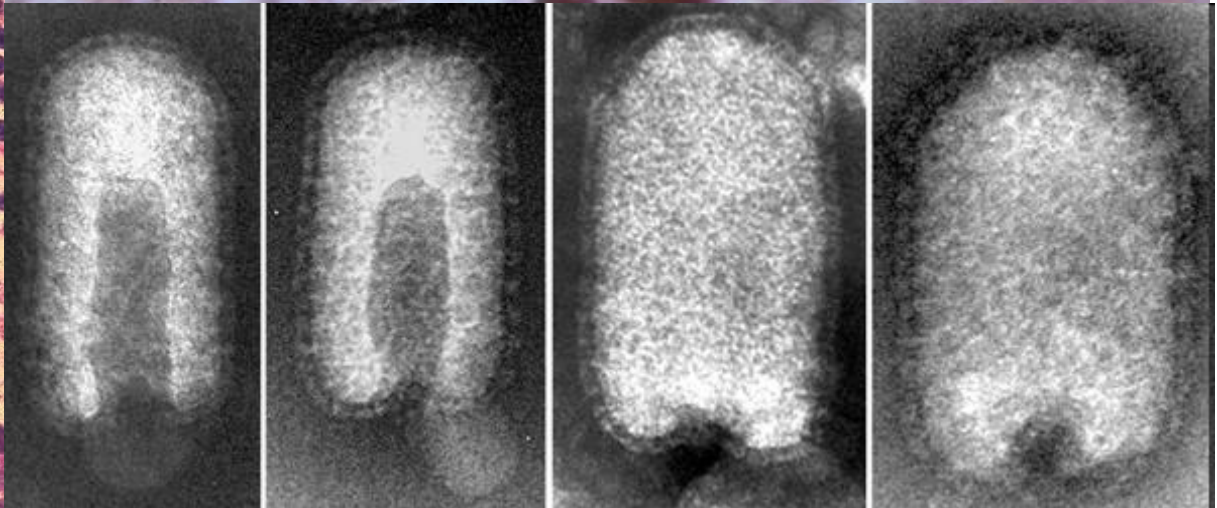
CMV



Negri bodies

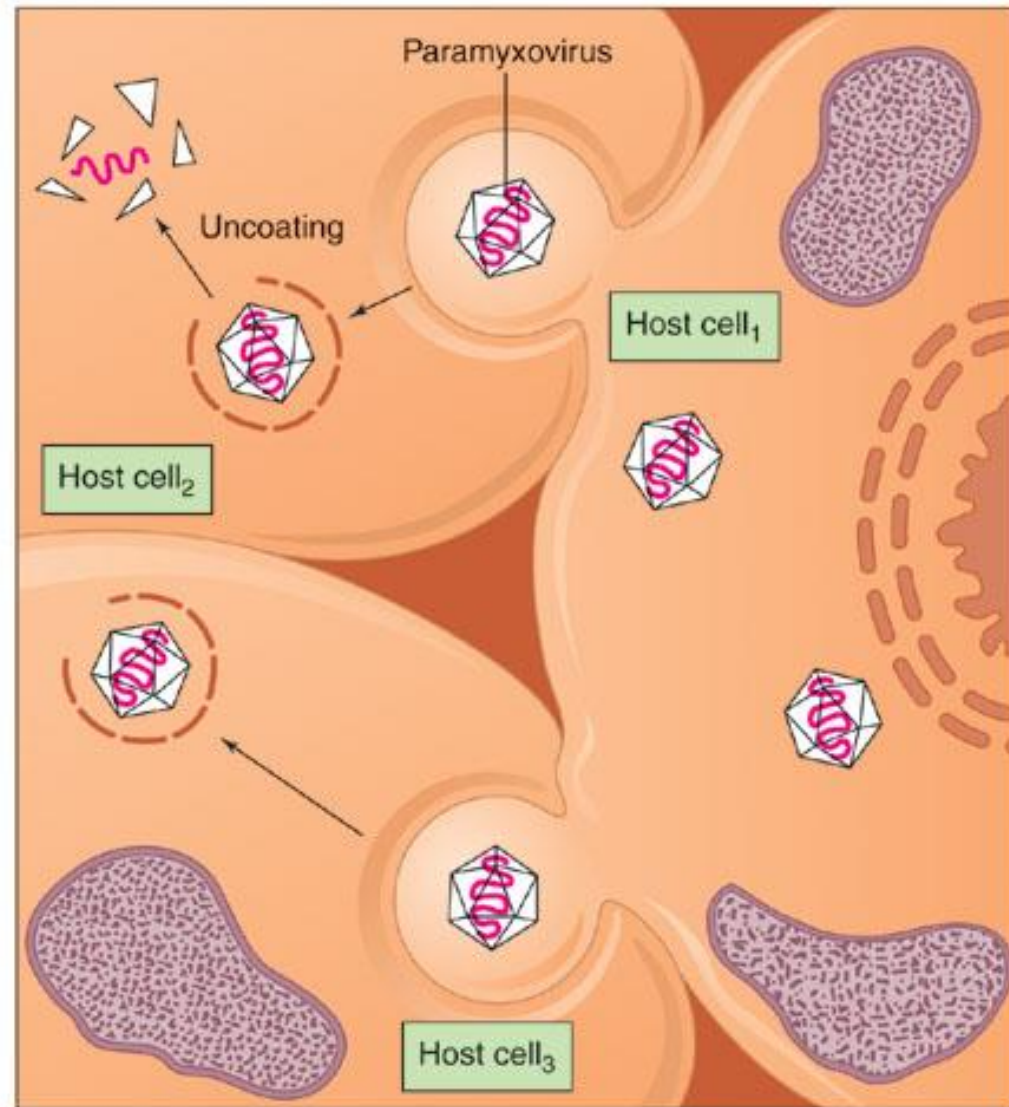
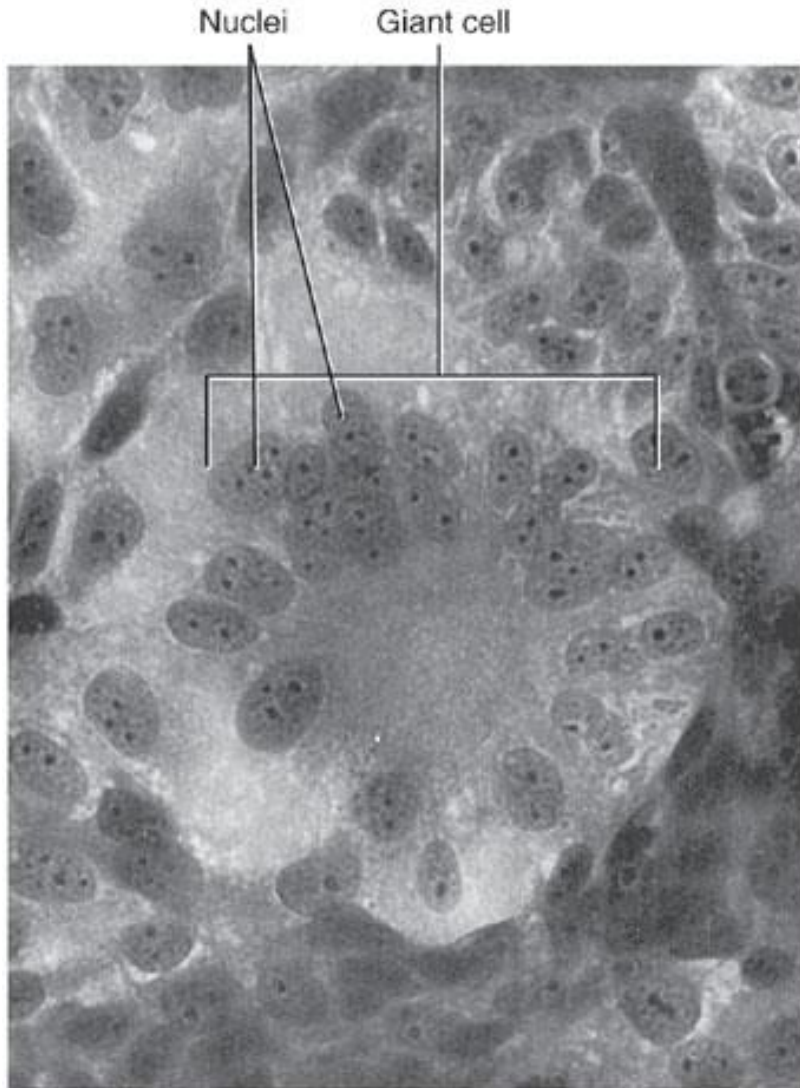


ssRNA, enveloped



Syncytium (giant) cell formation

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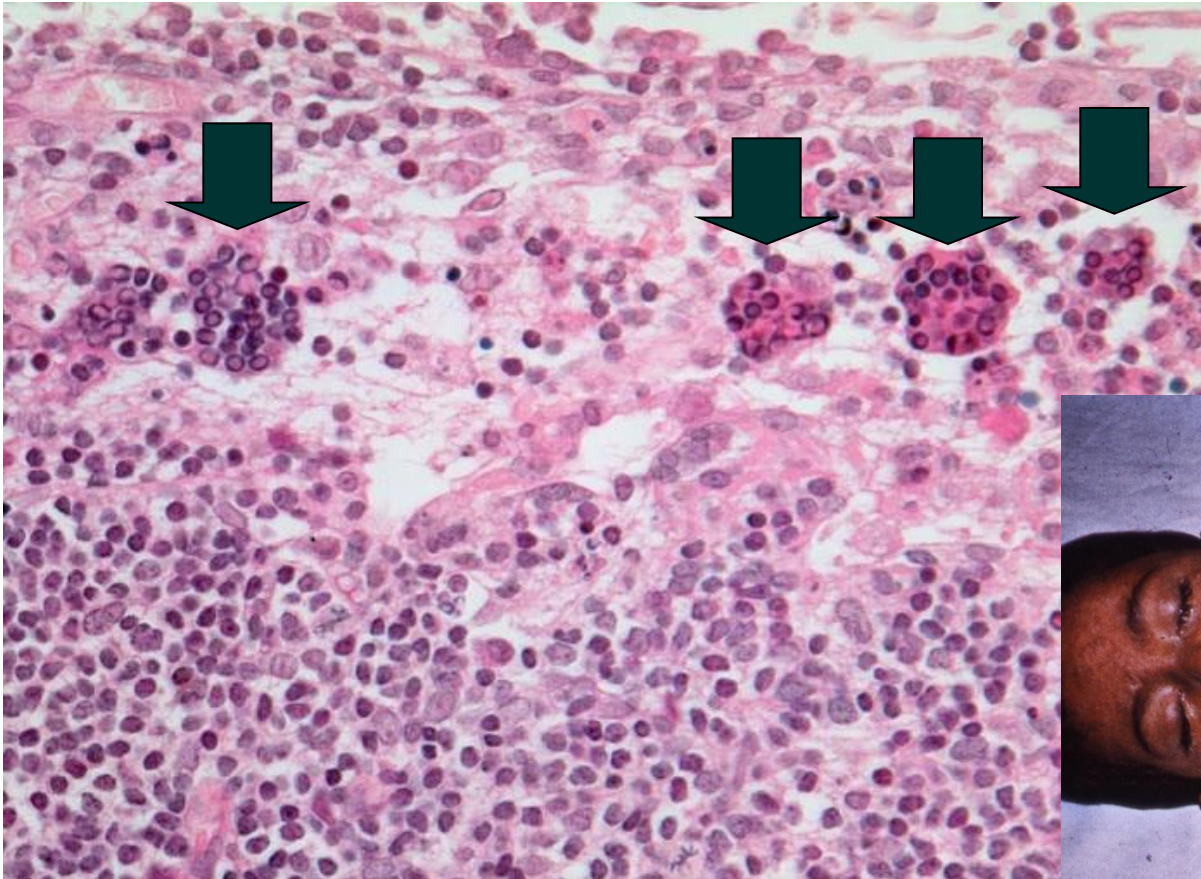


(a)

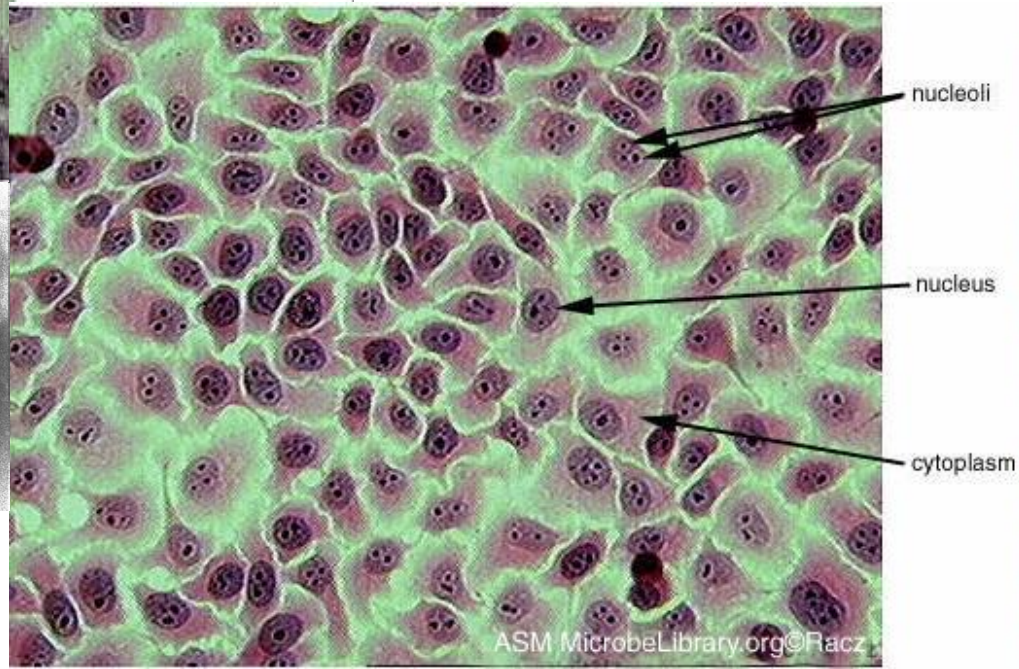
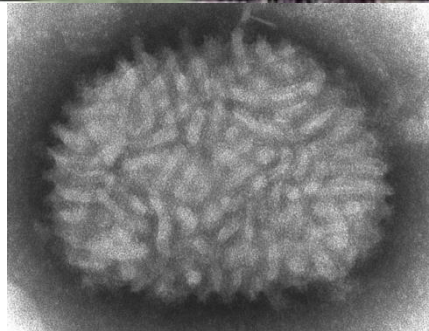
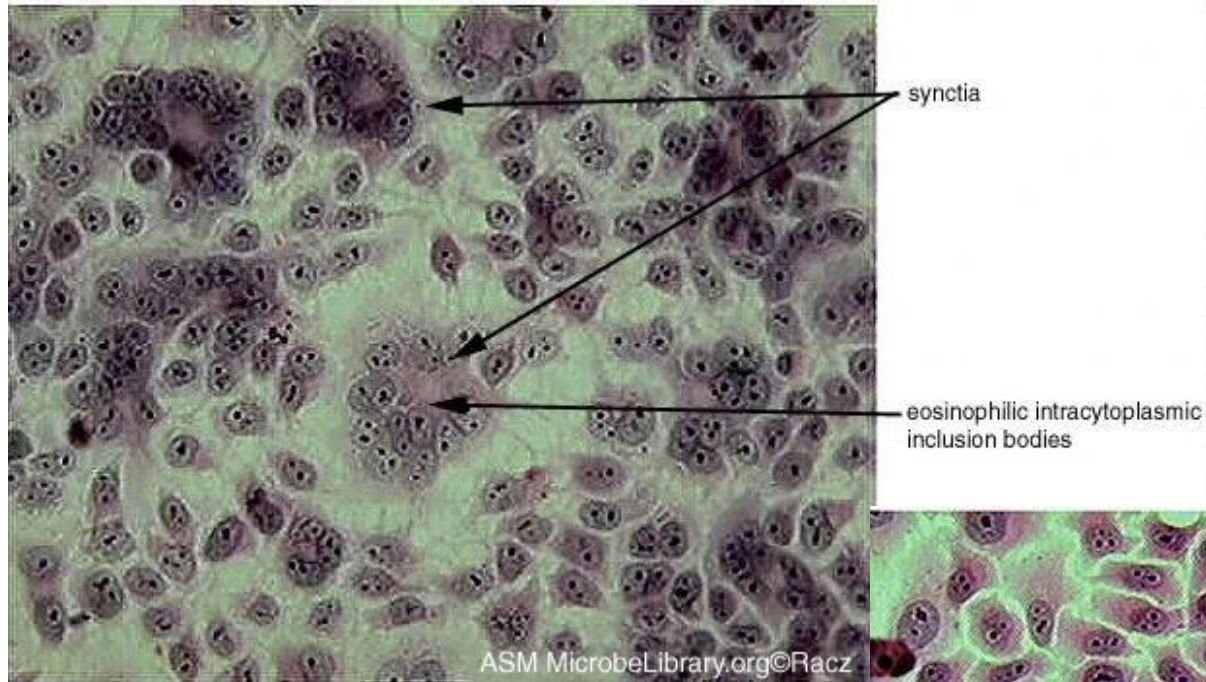
(b)

Measles virus

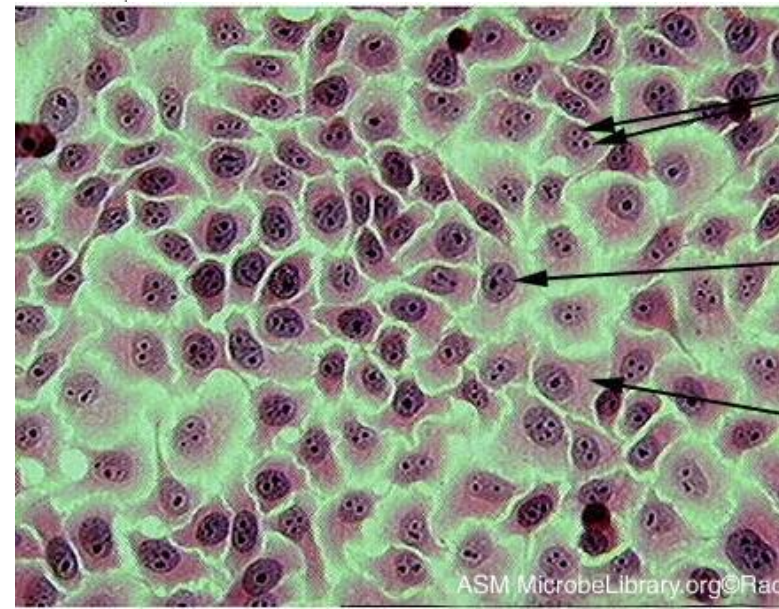
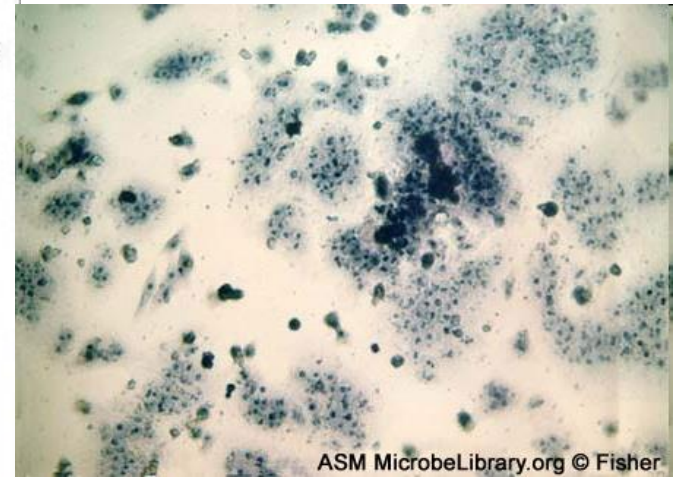
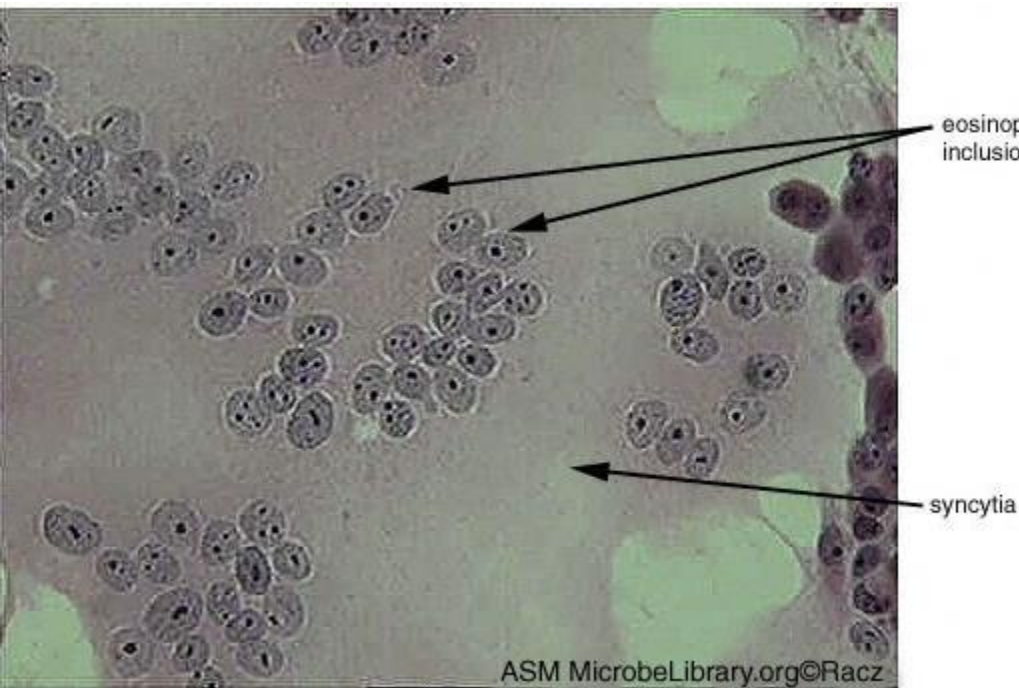
- Giant Warthin-Finkeldey cells in lymphoid tissue



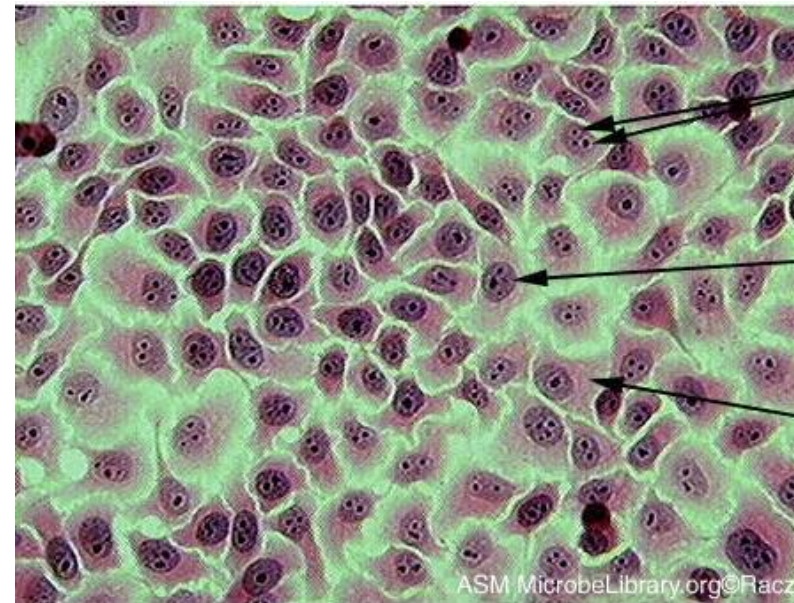
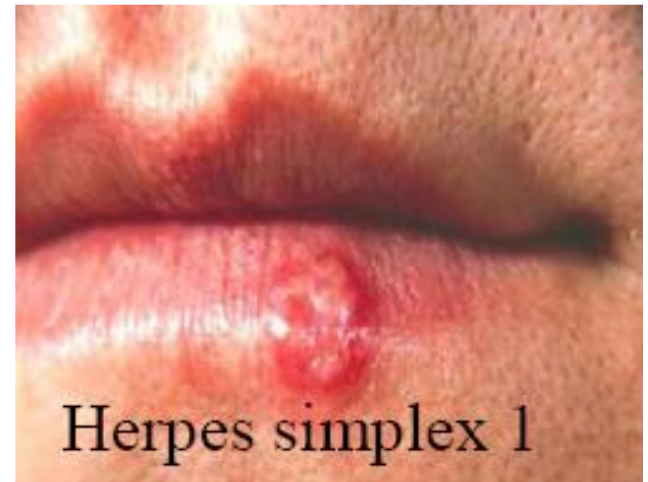
Vaccinia virus (Smallpox virus) - culture on Vero cell line



Measles virus - culture on Vero cell line

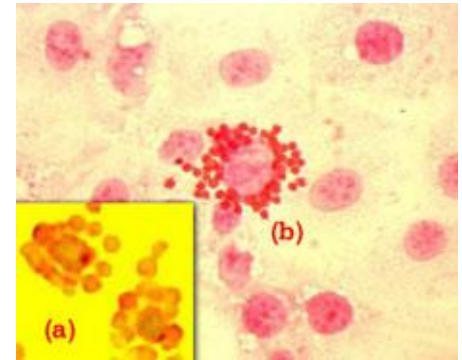


HSV virus - culture on Vero cell line



Non-cytocidal infection

1. Infected cells:
 - produce and release viruses but no CPE
 - can grow and divide - not killed
2. Does not occur with DNA viruses
3. Occur with several RNA viruses (Lassa, Retro, Toga, some Paramyxo)
4. Viruses released by cell budding
5. Demonstrated by hemadsorption, DIF



Non-productive infections:

- viruses infect cells that restrict or lack the machinery for transcribing viral genes
- viral genome is found either integrated into cell DNA or as a circular episome or both

a. Latent infections:

- persistent infections
- there is limited expression of viral genes
- the cell retains its normal properties

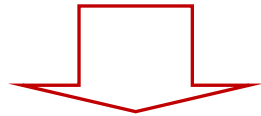
b. Transformation:

- cause tumors in animals and can transform cells in culture

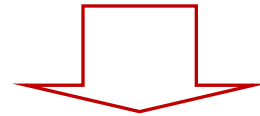
Viral pathogenesis

It is the process by which viral infection leads to disease

Infection vs disease



- **Disease:** virus at target organ
- Signs and symptoms associated with disease



- **Infection:** entry of virus into the body
- No symptoms or transient symptoms

Outcome of viral infection

Asymptomatic infection:

- most viral infections are subclinical
- body's defense mechanisms arrest most infections before disease symptoms become manifest
- great epidemiologic importance:
 - major sources for dissemination of virus through the population
 - confers **herd immunity**

Virus transmission

```
graph TD; A[Virus transmission] --> B(HORIZONTAL); A --> C(VERTICAL); B --> D(DIRECT); B --> E(INDIRECT); C --> F[TRANSPLACENTAL<br/>PERINATAL<br/>VIA BREAST MILK];
```

The diagram is a hierarchical flowchart. At the top is a rectangular box labeled 'Virus transmission'. Two red arrows point down from this box to two ovals: 'HORIZONTAL' on the left and 'VERTICAL' on the right. From the 'HORIZONTAL' oval, two blue arrows point down to two rectangular boxes: 'DIRECT' and 'INDIRECT'. From the 'VERTICAL' oval, a single blue arrow points down to a rectangular box containing the text 'TRANSPLACENTAL', 'PERINATAL', and 'VIA BREAST MILK' stacked vertically.

HORIZONTAL

DIRECT

INDIRECT

VERTICAL

**TRANSPLACENTAL
PERINATAL
VIA BREAST MILK**

Virus transmission

- **Respiratory or salivary** (influenza, Rhino, HSV, EBV, CMV, Orthomyxo, Paramyxo)
- **Conjunctiva** (Adeno, HSV, Entero, Cox 24)
- **Alimentary** (Entero, Rota)
- **Sexual** (HSV-2, HPV's, HIV)
- **Urogenital** (CMV, HBV, HCV)
- **Blood** (HBV, HCV, HIV, Entero, Arbo)
- **Neural** (Rabies, HCV, VZV)
- **Skin, mucous membranes** (Rabies, HSV, HPV)

The stages of a typical viral infection

- 1. Incubation period**
- 2. Prodromal period**
- 3. The specific-illness period**

The signs and symptoms of viral disease are the result of cell killing by:

- inhibition of cellular macromolecular synthesis**
- immunologic attack (immunopathogenesis)**

- 4. Recovery period**

Answer questions

1. What is the role of viral capsid?
2. The main divisions of viruses into groups rely on which viral structures?
3. When does the eclipse period occur during viral infection of the host cells, and what is its role in the diagnosis?
4. What's the effect of viral envelope disruption on the infectivity of the virus?
5. What are inclusion bodies detected in the host cells?
6. How syncytial cells are formed during viral infections?
What are examples of viral diseases running with syncytium production?



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IM. PIASTÓW ŚLĄSKICH WE WROCŁAWIU

Thank you for your attention!

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