

## **Chapter 6. Viruses**

- **General characteristics**
- **Classification**
- **Infection and Replication**
- **Effects on cells**
- **Diseases**
- **Virus-like agents**

## General characteristics of viruses

- Too small to be seen with a light microscope: Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter).
- Acellular: No cellular in nature
- Obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants and animals.
  - To multiply, must be inside a host cell
  - Infect bacteria, plant or animal cells
  - Take over host cell's metabolic machinery to:
    - Synthesize viral proteins and nucleic acids
    - Assemble infectious virus particles (virions)
- A cell infected with one virion may produce thousands more
  - Usually damages or results in death of the cell
  - Virus means poison in Latin

- Size range –
  - most  $<0.2 \mu\text{m}$ ; requires electron microscope

Figure 6.1

# Components of viruses

Figure 6.4

## 1. Core

DNA or RNA (not both)

## 2. Capsid

Protein coat that surrounds nucleic acid

**Naked viruses**

## 3. Envelope (some viruses, mostly animal viruses)

Membrane obtained from the host cell

(Naked viruses do not have an envelope)

**Enveloped viruses**

## 4. Spikes

Proteins that project out of the envelope

Help virus to attach to cell during infection

# **Virus shapes**

Figure 6.10

## 1. Helical capsid

Ex. Tobacco mosaic virus

Figure 6.5

Enveloped helical virus

Avian influenza virus

Figure 6.6

2. **Polyhedral** (many sided) **capsid**

Ex. Human adenovirus

**Figure 6.7**

Rotaviruses and Herpes simplex virus

**Figure 6.8**

### 3. Complex

- Have additional structural components
  - (a) **Smallpox virus (vaccinia virus)**
  - (b,c) **Bacteriophages (T4)**
    - Injects viral DNA into bacterial cell during infection

Figure 6.9

## **Nucleic Acids**

- **DNA viruses**

- Usually **double stranded** (ds) but may be single stranded (ss)

- Circular or linear

- **RNA viruses**

- Usually **single stranded**, may be double stranded, may be segmented into separate RNA pieces

- ssRNA** genomes ready for immediate translation are **positive-sense RNA**

- ssRNA** genomes that must be converted into proper form are **negative-sense RNA**

- **Pre-formed enzymes may be present**

- Polymerases – DNA or RNA

- Replicases (RNA-dependent RNA polymerase) – copy RNA

- Reverse transcriptase – synthesis of DNA from RNA (AIDS virus)

## Classification and Virus Names

- **Characteristics** used in classification
  - **Host cell** (bacterial, plant or animal)
  - **Type of nucleic acid** (DNA or RNA)
  - **Number of nucleic acid strands** (single or double stranded)
  - **Capsid symmetry**
    - Helical or polyhedral
  - **Enveloped or naked**
- **Common names** often include the disease the virus causes  
Ex. Herpes simplex virus, Poliovirus, Ebola virus, Influenza virus
- Viruses are also formally classified into Genera and Families  
Ex.  
Common name: Ebola virus  
Family: Filoviridae (Family name ends in –viridae)  
Genus: *Filovirus* (Genus name ends in –virus)

# **Viral Infection and Replication**

Ex. Animal virus

- **Steps**

1. **Adsorption** to host cell membrane proteins called receptors

- Provides specificity for host and cell type

Ex. Hepatitis B virus adsorbs to protein receptors found only on liver cells

2. **Penetration** of cell (and uncoating if enveloped)

3. **Production of viral components**

- Replication of nucleic acids

- Biosynthesis of proteins

4. **Maturation**

- Assembly of viral components into complete virions

5. **Exit** from cell

- Budding through membrane or

- Lysis of cell

# Viral Infection and Replication

Ex. Hepatitis B virus (enveloped animal virus)

Virion

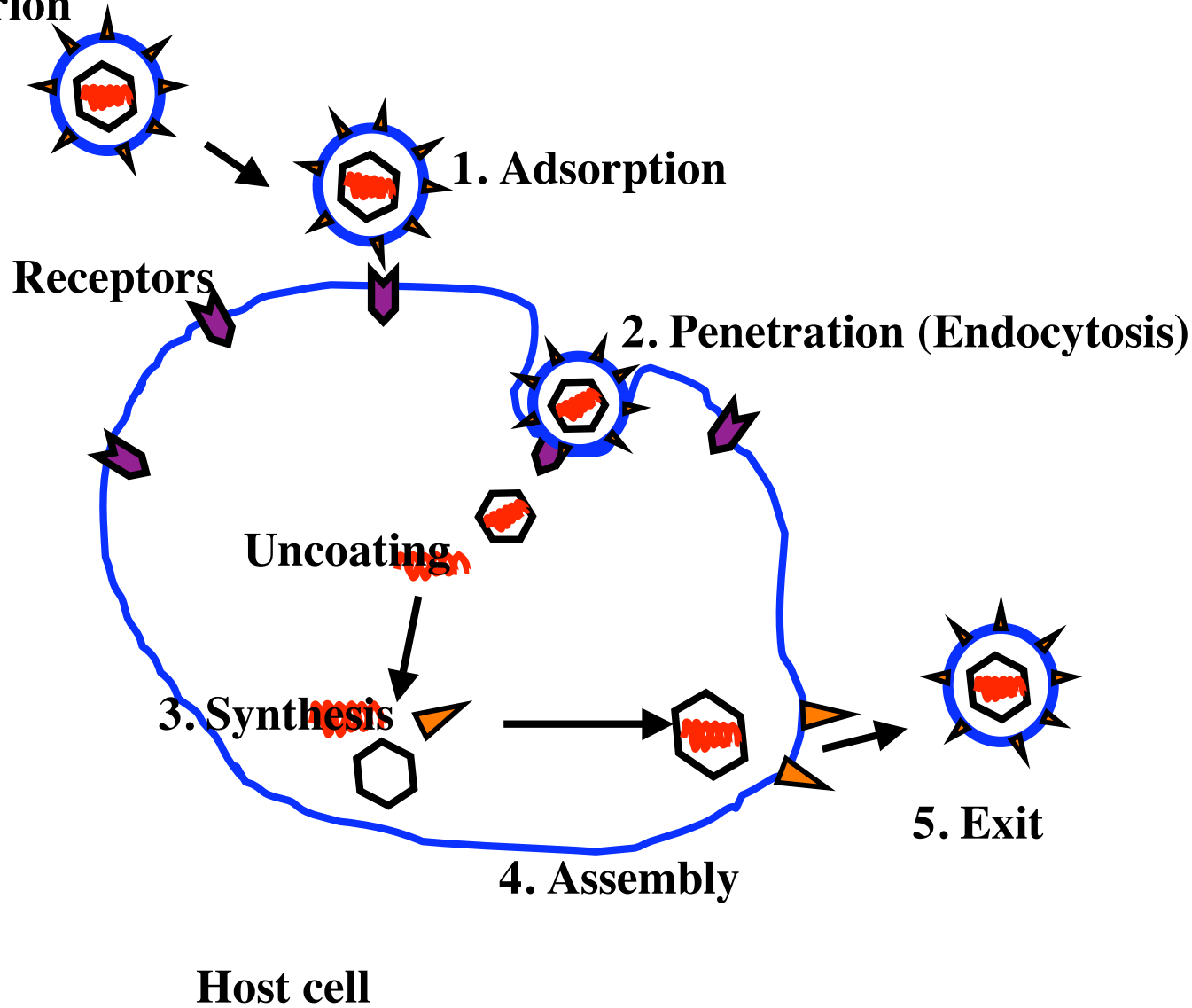


Figure 6.11

## Adsorption and Host Range

- Virus coincidentally collides with a susceptible host cell and adsorbs specifically to receptor sites on the cell membrane
- Spectrum of cells a virus can infect – **host range**
  - Hepatitis B – human liver cells
  - Poliovirus – primate intestinal and nerve cells
  - Rabies – various cells of many mammals

Figure 6.12

## Penetration/Uncoating

- Flexible cell membrane is penetrated by the whole virus or its nucleic acid by:
  - **Endocytosis** – entire virus is engulfed and enclosed in a vacuole or vesicle
  - **Fusion** – envelope merges directly with membrane resulting in nucleocapsid's entry into cytoplasm

Figure 6.13

## Replication and Protein Production

- Varies depending on whether the virus is a DNA or RNA virus
- DNA viruses generally are replicated and assembled in the nucleus
- RNA viruses generally are replicated and assembled in the cytoplasm
  - Positive-sense RNA contain the message for translation
  - Negative-sense RNA must be converted into positive-sense message

## Release

- Assembled viruses leave host cell in one of two ways:
  - **Budding** – exocytosis; nucleocapsid binds to membrane which pinches off and sheds the viruses gradually; cell is not immediately destroyed
  - **Lysis** – nonenveloped and complex viruses released when cell dies and ruptures
- Number of viruses released is variable
  - 3,000-4,000 released by poxvirus
  - >100,000 released by poliovirus

Figure 6.15

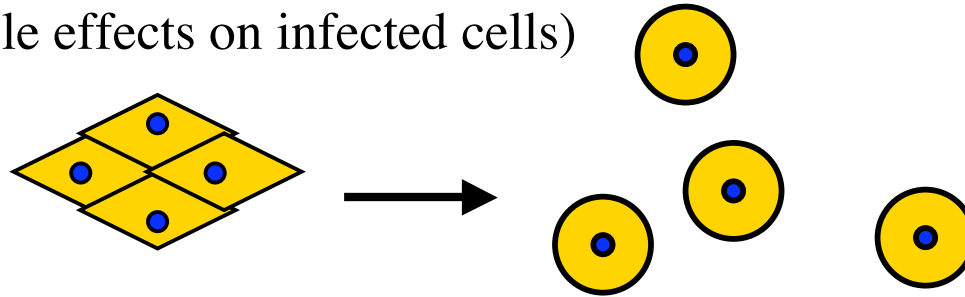
# Effects of viruses on cells

## 1. Disruption of normal cellular metabolism

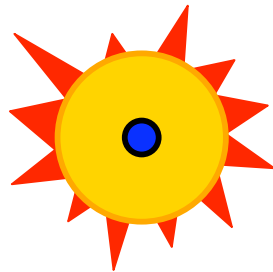
- Diverted to replication of viral nucleic acid & synthesis of viral proteins  
–Often kills cell

## 2. Cytopathic effects (visible effects on infected cells)

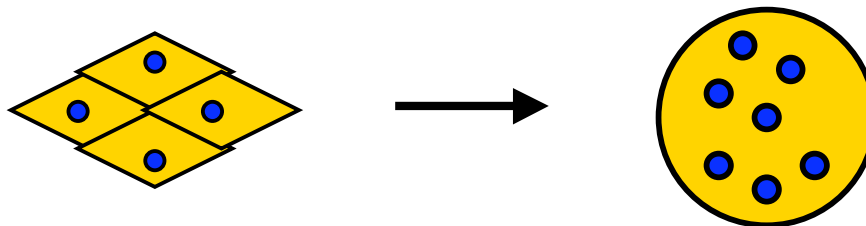
- Changed cell shape & detachment from adjacent cells



- Swelling and lysis



- Fusion into giant multi-nucleated cells (syncytia)



### 3. Teratogenesis

- **Teratogen** -A drug or agent that causes defects in a developing embryo
- Some viruses pass across the placenta into womb and infect the embryo

#### Ex. **Cytomegalovirus**

-Death, mental retardation, damaged organs

#### **Herpes simplex viruses**

-Damaged eyes

#### **Rubella virus**

-Deafness, mental retardation, damaged organs

### 4. Cancer

—Some animal viruses enter host cell and permanently alter its genetic material resulting in cancer – **transformation** of the cell

Cancer --uncontrolled cell division

~15% of human cancer may be from viral infections

—Transformed cells have increased rate of growth, alterations in chromosomes, and capacity to divide for indefinite time periods resulting in tumors

—Mammalian viruses capable of initiating tumors are called **oncoviruses**

Epstein-Barr virus  
Human papillomavirus  
Hepatitis B virus

Burkitt's lymphoma  
Cervical cancer  
Liver cancer

## Multiplication Cycle in Bacteriophages

- **Bacteriophages** – bacterial viruses (phages)
- Most widely studied are those that infect *Escherichia coli* – complex structure, DNA
- Multiplication goes through similar stages as animal viruses
- Only the nucleic acid enters the cytoplasm - uncoating is not necessary
- Release is a result of cell lysis induced by viral enzymes and accumulation of viruses - **lytic cycle**

Figure 6.17

## **Lysogeny: The Silent Virus Infection**

- Not all phages complete the lytic cycle
- Some DNA phages, called **temperate phages**, undergo adsorption and penetration but don't replicate
- The viral genome inserts into bacterial genome and becomes an inactive **prophage** – the cell is not lysed
- Prophage is retained and copied during normal cell division resulting in the transfer of temperate phage genome to all host cell progeny – **lysogeny**
- **Induction** can occur resulting in activation of lysogenic prophage followed by viral replication and cell lysis
- Lysogeny results in the spread of the virus without killing the host cell
- Phage genes in the bacterial chromosome can cause the production of toxins or enzymes that cause pathology – lysogenic conversion
  - Corynebacterium diphtheriae
  - Vibrio cholerae
  - Clostridium botulinum

## **Virus-like agents (i.e. small, acellular, infectious)**

### **1) Viroids**

- Much smaller than virus particles, composed only of RNA  
No capsid or envelope
- Cause some plant diseases, 1 human disease  
Tomato apical stunt disease  
Hepatitis D

### **2) Prions --Infectious protein particle in the brain**

- Contain no nucleic acids
- A brain cell protein that is folded incorrectly
- Contact between the normal protein with a prion converts the normal protein into a prion
- Prion formation kills brain cells --->mental degeneration, loss of motor function, death

Ex.

Creutzfeldt-Jakob Disease --humans

Scrapie --sheep

Bovine spongiform encephalopathy --mad cow disease

Chronic wasting disease --deer and elk

**Bacteriophage**  
**DNA**

**Viroid RNA**

**Normal** brain protein



Prion protein



The green regions are amino acids that form  $\beta$ -pleated sheets which cause the protein molecules to stick together and form **plaques** in the brain.

## Some viral diseases

### I. RNA viruses

### Disease

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**Poliovirus**

**Polio**

**Hepatitis A virus**

**Hepatitis A**

**Hepatitis C virus**

**Hepatitis C**

**Rhinovirus**

**Common cold**

**Human immunodeficiency virus  
(HIV-1 and HIV-2)**

**AIDS**

**Rubella virus**

**Rubella (German measles)**

**Measles virus**

**Measles (Red)**

**Mumps virus**

**Mumps**

**Influenza virus**

**Flu virus (Human, Swine, Bird)**

**Rabies virus**

**Rabies**

**West Nile fever virus**

**West Nile fever**

## II. DNA viruses

## Disease

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**Herpes simplex 1 virus**

**Oral herpes**

**Herpes simplex 2 virus**

**Genital herpes**

**Varicella zoster virus**

**Chickenpox & Shingles**

**Variola virus**

**\*Smallpox**

**Human papillomavirus**

**Warts, Cervical Cancer**

**Hepatitis B virus**

**Hepatitis B**

**Parvoviruses**

**Erythema infectiosum  
(Fifth disease), infant rash**

**Dogs: severe diarrhea, heart  
complications**

**\*Eliminated from human population through vaccination**