General Properties of Viruses

I. Viruses as Agents of Disease.

Viruses can infect every form of life. There are hundreds of different viruses that can produce diseases in animals, insects, plants and bacteria. More than 50% of all episodes of illness in humans are caused by viruses. Some viral diseases include influenza, measles, rubella, chicken pox, mumps, pneumonia, encephalitis, meningitis, hepatitis, hemorrhagic fevers, and the common cold. Emergence of new viruses, such as Human Immunodeficiency virus (HIV), Ebola virus and Hanta virus, have resulted in the recent appearance of serious new diseases. Also, genetic variation of existing viruses and/or virus-like infectious agents has altered symptoms and severity of the resulting diseases [e.g., influenza, hantavirus pulmonary syndrome, bovine spongiform encephalopathy (mad cow disease)].

There are at least 50 different disease syndromes caused by viruses. In some cases, many different viruses can produce the same disease syndrome. In other cases, the same virus may produce several different disease syndromes.

A. Types of virus infections

1. Subclinical - Many virus infections are asymptomatic. Viruses infect the individual without the production of disease. Yet the infected individual can develop protective immunity to the infecting virus.

2. Acute viral infections cause diseases that are self-limiting. The symptoms occur rapidly after infection and disappear upon elimination of virus.

   a. local infections have a short incubation time (period from initial
infection to appearance of symptoms). The symptoms usually occur at the site of viral entry (e.g. rhinitis). Anti-viral IgA production is usually necessary for immunity.
b. Systemic infections have a longer incubation time than local infections. The viruses replicate and are spread by viremia throughout the body. Thus the site of pathology is usually remote from the site of entry. Ebola fever, measles, chicken pox, mumps, and encephalitis are examples of acute systemic infections.

3. Persistent viral infections are ones in which the viruses are not eliminated for long periods of time or are never eliminated.

a. Chronic infections
1) Chronic carriers produce virus continuously without symptoms (e.g. hepatitis B virus infections)
2) Chronic expression of symptoms along with virus production (hepatitis C virus infections).

b. Latent infections
1) The virus remains in a non-infectious state until it is activated by a variety of stimuli. Most of the herpesviruses can cause latent infections. Diseases include stomatitis, shingles and genital herpes.
2) Recurrent symptoms can occur
c. Slow virus infections result in persistence of the viruses for long periods of time either before the appearance of symptoms (e.g., rabies) or with progressive degenerative symptoms (e.g., progressive multifocal encephalopathy). Both types of infections lead to death.
1). A special type of slow infection is caused by proteins that are similar to viruses only because they are transmissable. These infections occur in the central nervous system and are fatal (e.g. Creutzfeldt-Jacobs disease).

d. Congenital infections require vertical transmission of virus from mother to developing fetus. Surviving newborns retain and secrete virus for long periods of time (congenital rubella).

B. Factors in Viral Pathogenesis

1. Transmission of viruses
2. Route and extent of spread of viruses
3. Organ, tissue and cell tropisms
4. Type and extent of cellular damage
5. Clearance of viruses
6. Host defense mechanisms

II. Definition of a Virus

A. Viruses are obligate intracellular parasites that replicate intracellularly by using the synthetic machinery of their host cells. Thus, viruses are metabolically inert on their own.

B. Viruses are submicroscopic elements of genetic material (RNA or DNA) which contain the necessary information for production of new virus particles by the infected cell.

C. Viruses can be transmitted from one cell to another.

Therefore, a virus infection can be considered as parasitism at a genetic level.

III. Distinctive Properties of Infectious Virus Particles
A. Physical and Chemical Properties

1. Size
   a. Viruses are smaller than most other microorganisms (20-300 nanometers) and can be visualized only with an electron microscope.
   b. Although there is a wide size range for viruses, viruses of a particular type are uniform in size.

2. Shapes
   a. quasi-spherical - polygon composed of 20 equilateral triangles (icosahedron).
   b. rod - variations are filamentous, brick and bullet shapes
   c. tadpole - seen with some bacteriophages
3. Structure and composition

a. capsid = protein coat surrounding nucleic acid
b. nucleocapsid = the capsid together with the nucleic acid core.
c. envelope = lipid containing membrane enclosing nucleocapsid. It often contains glycoprotein projections.

4. Architecture

a. helical symmetry
   nucleic acid is coiled completely between turns of a protein helix
b. cubic symmetry
   particle is composed of orderly array of identical protein subunits (capsomers) that surrounds compact nucleic acid.
c. complex - additional structures

![Diagram A](image1.png)

![Diagram B](image2.png)

Figure 29-1. Schematic diagram illustrating the components of the complete viral particle (the virion). A: Enveloped virus with icosahedral symmetry. B: Virus with helical symmetry.
5. Function of viral components

a. nucleic acid (RNA or DNA) = genome
   encodes genetic information

b. proteins
   1) structural function - surrounds nucleic acid and protects it from environment.
   2) biological functions
      a) facilitate attachment and entry of virus into cells - host specificity
      b) antigenicity
      c) enzyme activity (e.g. polymerases)

c. glycoproteins
   1) facilitate attachment of enveloped viruses
   2) antigenic - stimulate production of protective antibodies

d. lipids
   1) acquired by budding through cellular membranes
   2) confer sensitivity to ether and other organic solvent

IV. Classification of Viruses

A. Based on Biological, Chemical and Physical Properties

1. Nucleic acid
   a. type - RNA or DNA
   b. strandedness - single or double
   c. single or multiple segments
   d. replication strategy

2. Size and morphology

3. Susceptibility to physical and chemical agents
   a. heat stability
   b. pH stability
   c. ether sensitivity
   d. inactivation by radiation
   e. inactivation by detergents and formaldehyde
f. resistance to antibiotics
4. Presence of enzymes in virion
5. Immunologic properties
6. Modes of transmission
7. Host, tissue and cellular tropisms

B. Viruses Classified by Organ Systems

1. Skin and Mucous Membranes
   herpes simplex viruses (types I & II)
   molluscum contagiosum virus, papilloma viruses, coxsackie A viruses, measles virus, herpes zoster virus, human herpes virus 6, echoviruses, rubella virus, dengue virus, reovirus.

2. Respiratory Tract
   influenza and parainfluenza viruses, respiratory syncytial virus, adenoviruses, coxsackie viruses, echoviruses, rhinoviruses, coronaviruses, and hanta viruses, Epstein-Barr virus, herpes simplex virus, cytomegalovirus, varicella-zoster virus.

3. Gastrointestinal Tract
   rotaviruses, Norwalk virus and other caliciviruses, adenoviruses

4. Liver
   hepatitis A, B, C, D, E and G viruses, yellow fever virus, rubella virus

5. Central Nervous System
   enteroviruses (polioviruses, coxsackieviruses and echoviruses), rabies virus, togaviruses, flaviviruses, bunyaviruses, mumps, measles, SV40, herpes simplex viruses, varicella-zoster, cytomegalovirus, rubella virus

6. Circulatory and Lymphatic Systems
   filoviruses (Ebola and Marburg), Epstein-Barr virus, flaviviruses, enteroviruses, arenaviruses (Lassa Fever) and human deficiency virus (HIV)
C. Virus Families

1. RNA-Containing Viruses
   a. Picornaviruses - polio, meningitis, colds, HAV, FMVD
   b. Caliciviruses - gastroenteritis, hepatitis E
   c. Reoviruses - Colorado tick fever, gastroenteritis
   d. Togaviruses - encephalitis and Rubella
   e. Flaviviruses - hemorrhagic fevers, hepatitis C
   f. Filoviruses - ebola
   g. Bunyaviruses - renal and pulmonary syndromes
   h. Arenaviruses - hemorrhagic fevers, meningitis
   i. Orthomyxoviruses - influenza
   j. Paramyxoviruses - measles, mumps, RSV
   k. Coronaviruses - colds
   l. Rhabdoviruses - rabies
   m. Retroviruses - AIDS, leukemia

2. DNA-Containing Viruses
   a. Adenoviruses - acute respiratory diseases
   b. Parvoviruses - B19
   c. Papovaviruses - papillomas, leukoencephalopathy
   d. Poxviruses - skin lesions
   e. Herpesviruses - skin lesions, mononucleosis,
   f. Hepadnaviruses - hepatitis B

<table>
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<th>Nucleic Acid Core</th>
<th>Capsid Symmetry</th>
<th>Virus: Enveloped or Naked</th>
<th>Ether Sensitivity</th>
<th>No. of Capsomers</th>
<th>Viral Particle Size (nm)</th>
<th>Molecular Weight of Nucleic Acid in Virion (x 10^6)</th>
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<td>ss</td>
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* Diameter, or diameter x length.
* The naked virus, ie, the nucleocapsid, is 100 nm in diameter; however, the enveloped virus varies up to 200 nm.
* The genus Orthopoxivirus, which includes the better studied poxviruses (eg, vaccinia, variola, cowpox, ectromelia, rabbitpox, monkeypox), is ether-resistant. Some of the poxviruses belonging to other genera are ether-sensitive.
* One strand has a constant length of 3162 bases, and the other varies between 1700 and 2600 bases.
* Rhabdoviruses possess a double protein capsid shell in which the exact number and spatial arrangement of capsomers are difficult to determine.
* ss = single-stranded
* ds = double-stranded
D. Sub-viral agents

1. Hepatitis delta virus
2. prion proteins - Creutzfeldt-Jacob disease

V. Cultivation and Assay of Viruses

A. Isolation of viruses
   1. animals
   2. fertile eggs
   3. cell cultures

B. Detection of virus-infected cells

1. cytopathology
   a. cell death (lysis)
   b. alteration in cell morphology

2. appearance of antigenic viral protein
   a. hemagglutination
   b. hemadsorption

3. abnormal growth of infected cell

**Study Questions:**

1. All viruses share some properties. Which of the following statements is **not** true?
   
   a. viruses cannot be seen with a light microscope  
   b. virions are not infectious  
   c. viruses consist of either DNA or RNA  
   d. viral proteins are antigenic  
   e. viruses are obligate, intracellular parasites  

   **Answer:** b

2. Classification of viruses by symptomatology is not satisfactory because:
   
   a. all viruses produce the same disease syndrome.  
   b. viruses isolated from humans cannot cause symptoms in lower animals.  
   c. many different viruses may produce the same disease syndrome.  
   d. viruses do not induce immune responses.  
   e. viruses are not transmitted from one person to another  

   **Answer:** c

3. Viral envelopes are composed of which of the following substances:
   
   a. viral DNA  
   b. viral RNA  
   c. viral antibodies  
   d. viral lipids  
   e. viral glycoproteins  

   **Answer:** e

4. Which of the following substances are required for synthesis of new viral proteins?
   
   a. viral mRNA  
   b. cellular mRNA  
   c. cellular DNA  
   d. viral DNA  
   e. cellular lipids
5. Viruses may be detected by all of the following methods **except**:  
   a. cytopathology of virus-infected cells  
   b. growth in fertile eggs  
   c. disease production in animals  
   d. growth on agar  
   e. hemagglutination  
   Answer: d

6. Sub-clinical virus infections:  
   a. occur infrequently  
   b. do not result in immune responses  
   c. result in disease production  
   d. do not produce symptoms  
   e. occur only in children  
   Answer: d

7. Systemic virus infections have all of the following characteristics **except**:  
   a. growth of viruses in cells remote from the entry site  
   b. short incubation period  
   c. production of protective immunity  
   d. spread of virus in circulating blood  
   e. can be transmitted from one person to another  
   Answer: b

8. Persistent viral infections:  
   a. usually result in acute disease syndromes  
   b. occur in the absence of anti-viral antibodies  
   c. may produce chronic disease  
   d. result in rapid elimination of viruses  
   e. do not occur in the central nervous system  
   Answer: c