6 Viruses and Other Acellular Infectious Agents

LEARNING OUTCOMES

- define the terms virology, bacteriophages, viroids, satellites and prions
- identify the parts of a virion
- describe, compare and contrast the major steps of the life cycles of virulent phages and temperate phages
- know a few examples of viral and prion diseases

CHAPTER OUTLINE

I. Viruses
   A. Viruses are acellular infectious agents that cannot reproduce outside of living cells; virology is the study of viruses
   B. Viruses can infect all types of cells but are specific for certain organisms; bacteriophages (phages) infect bacteria

II. Virion Structure
   A. Virion size—ranges from 10 nm to 400 nm (0.01 micrometers to 0.4 micrometers)
   B. General structural properties
      1. Nucleocapsid—the nucleic acid plus the surrounding capsid (protein coat that surrounds the genome); for some viruses this may be the whole virion; other viruses may possess additional structures
      2. Three types of capsid symmetry: icosahedral, helical, complex
      3. Viral capsids are constructed from many copies of one or a few types of proteins (protomers), which are assembled together with the viral genome
      4. Enveloped viruses have an outer membranous layer (envelope) surrounding the nucleocapsid; naked (nonenveloped) viruses lack an envelope
      5. Some bacteriophages have complex, elaborate shapes composed of heads (icosahedral symmetry) coupled to tails (helical symmetry); the structure of the tail regions is particularly variable; such viruses are said to have binal symmetry
   C. Viral envelopes and enzymes
      1. Envelopes are membrane structures surrounding some (but not all) viruses
         a. Lipids and carbohydrates are usually derived from the host membranes
         b. Proteins are virus-specific
         c. Many have protruding glycoprotein spikes (peplomers) such as the enzymes neuraminidase and hemagglutinin
      2. Although viruses lack true metabolism, they may carry one or more enzymes, many of which are involved in viral nucleic acid replication; in some cases the enzyme is capsid-associated, but in most cases the enzyme is located within the capsid
   D. Viral genomes
      1. Viral genome may be either RNA or DNA, single- or double-stranded
      2. DNA viruses - most use double-stranded DNA (dsDNA) as the genome
      3. RNA viruses—most have single-stranded RNA (ssRNA) as their genome

III. Viral Multiplication
   A. Common steps in virulent viral life cycles – lytic cycle
      1. Attachment (adsorption) to the host cell
      2. Entry of the nucleocapsid or viral genome into the host cell
      3. Expression of viral genes in host cell (synthesis stage); virus takes control of cell's machinery and produces viral proteins and genomes
      4. New virions self-assemble into mature virions
      5. Virions released by cell lysis
IV. Types of Viral Infections
   A. Infections of bacterial and archaeal cells: lysis and lysogeny
      1. Virulent phages are only capable of the lytic cycle, where multiplication begins once entering
         the host and continues until the host lyses
      2. Temperate phages are capable of lysogeny, a nonlytic relationship with their hosts, they can be
         induced or spontaneously enter the lytic cycle
         a. In lysogeny, the viral genome (called a prophage) remains in the host (usually integrated
            into the host chromosome) but does not kill (lyse) the host cell; the cells are said to be
            lysogenic (or are called lysogens)
         b. It may switch to the lytic cycle at some later time; this process is called induction
      3. Lysogenic conversion is a change that is induced in the host phenotype by the presence of a
         prophage, and that is not directly related to the completion of the viral life cycle; examples
         include:
            a. Modification of lipopolysaccharide structure in infected Salmonella
            b. Production of diphtheria toxin by lysogenized strains of Corynebacterium diphtheriae
      4. Most bacteriophages are temperate
   B. Infection of eukaryotic cells
      1. Cytocidal infections lead to cell death; some viruses persist in the host for many years; in some
         cases degenerative changes occur in cells (cytopathic effects) without causing lysis
      2. Viruses have been implicated in a number of human cancers including, Epstein-Barr virus
         (Burkitt's lymphoma), human herpesvirus 8 (Kaposi's sarcoma), Hepatitis B and C (liver
         cancer), human papillomavirus (cervical cancer), human T-cell lymphotropic virus I (T-cell
         leukemia)

V. Cultivation and Enumeration of Viruses
   A. Cultivation requires a suitable host since viruses cannot reproduce outside of cells
   B. Bacterial and archaeal viruses are usually cultivated in broth or agar cultures of suitable host cells;
      broth cultures are usually clear, while areas of localized destruction (plaques) form in bacterial
      lawns on agar plates
   C. Embryonated eggs have long been used to culture animal viruses
   D. In tissue (cell) culture monolayers of animal cells host viruses
   E. Virus assays
      1. Particle counts
         a. Direct counts can be made with an electron or epifluorescence microscope
         b. Indirect counts can be made using methods such as hemagglutination (virus particles can
            cause red blood cells to clump together or agglutinate)
      2. Measures of infectivity
         a. Plaque assays involve plating dilutions of virus on a lawn of host cells; clear zones result
            from viral damage to the cells; results expressed as plaque-forming units (PFUs)

VI. Viroids and Satellites
   A. Viroids are circular ssRNA molecules that lack a capsid and cause a variety of plant diseases
   B. Satellites (Virusoids) are circular ssRNA molecules (satellite RNAs) that encode proteins and need
      helper viruses for infectivity; the hepatitis D virusoid requires the help of the hepatitis B virus

VII. Prions
   A. Prions are proteinaceous infectious particles (PrP) that are not associated with a nucleic acid
      genome
   B. Genes that encode PrP have been identified in normal animal tissue
      1. It is hypothesized that abnormal PrP causes prion diseases by inducing a change from the
         normal conformation of the cellular PrP to the abnormal form
      2. This new abnormal PrP then causes other normal cellular PrP molecules to change to the
         abnormal form
   C. Prions cause progressive, degenerative central nervous system disorders, including scrapie (sheep
      and goats), bovine spongiform encephalopathy (BSE) (mad cow disease), Kuru (related to New
      Guinea tribal ritual cannibalism), Creutzfeldt-Jakob disease (CJD), fatal familial insomnia and
      Gerstmann-Strassler-Scheinker syndrome