Tikrit University/ Science College/ Biology Department

Forth class/ Microbiology / Virology

Lecture 5

Virus Phylogeny

Indeed, viruses are masters of regulation, both of their own life cycles and of the behaviors of their hosts.

In 1971 the International Committee on Taxonomy of Viruses (ICTV) developed a uniform classification system for viruses. Since then, the number of viruses and taxa has continued to expand. In its ninth report, the ICTV describes over 2,000 virus species and places them in 6 orders, 87 families, 19 subfamilies, and 349 genera. The committee considers many viral characteristics but places greatest weight on the following properties to define families: nucleic acid type, presence or absence of an envelope, symmetry of the capsid, and dimensions of the virion and capsid. Virus order names end in -*virales*; virus family names in -*viridae*; subfamily names in -*virinae*; and genus names in -*virus*.

As goal of taxonomy is to classify organisms based on their evolutionary history. To piece together the phylogenetic relationships of viruses, virologists are increasingly using two major approaches: comparisons of genome sequences and comparisons of protein folds observed in their major capsid proteins. Both approaches are challenging, in part because horizontal gene transfer among unrelated viruses and between viruses and their host cells is clearly evident.

Although ICTV reports are the official authority on viral taxonomy, many virologists find it useful to group viruses using a scheme devised by Nobel laureate David Baltimore. The Baltimore system complements the ICTV system but focuses on the viral genome and the process used to synthesize viral mRNA. All four nucleic acid types can be found in viruses: dsDNA, single-stranded (ss) DNA, dsRNA, and ssRNA. The characterization of the genome of a ssRNA virus is further differentiated by the sense of the ssRNA—that is, whether the genome is identical to or complementary to the mRNA produced by the virus. ssRNA viruses with an RNA genome that is identical in base sequence to that of the mRNA it produces are said to have **plus-strand** or **positive-strand RNA** genomes. Other ssRNA viruses have genomes that are complementary to the mRNA they produce. These viruses are said to have **minus-strand** or **negative-strand RNA**. Baltimore's system organizes viruses into seven groups. This system helps virologists (and microbiology students) simplify the vast array of viral life cycles into a relatively small number of basic types.

● **CLASSIFICATION OF VIRUSES** :(**Basis of Classification**)

The following properties have been used as a basis for the classification of viruses. The amount of information available in each category is not the same for all viruses. Genome sequencing is now often performed early in virus identification, and comparisons with databases provide detailed information on the viral classification, predicted protein composition, and taxonomic relatedness to other viruses.

1. **Virion Morphology**: including size, shape, type of symmetry, presence or absence of peplomers, and presence or absence of membranes.

2. **Virus genome properties**: including type of nucleic acid (DNA or RNA), size of the genome, strandedness (single or double), whether linear or circular, sense (positive, negative, ambisense), segments (number, size), nucleotide sequence, percent GC content, and presence of special features (repetitive elements, isomerization, 5′-terminal cap, 5′-terminal covalently linked protein, 3′-terminal poly(A) tract).

3. **Genome organization and replication**: including gene order, number and position of open reading frames, strategy of replication (patterns of transcription, translation), and cellular sites (accumulation of proteins, virion assembly, virion release).

4. **Virus protein properties**: including number, size, amino acid sequence, modifications (glycosylation, phosphorylation, myristoylation), and functional activities of structural and nonstructural proteins (transcriptase, reverse transcriptase, neuraminidase, fusion activities).

5. **Antigenic properties**: particularly reactions to various antisera.

6. **Physicochemical properties of the virion**: including molecular mass, buoyant density, pH stability, thermal stability, and susceptibility to physical and chemical agents, especially solubilizing agents and detergents.

7. **Biologic properties**: including natural host range, mode of transmission, vector relationships, pathogenicity, tissue tropisms, and pathology.

●GENETICS OF ANIMAL VIRUSES:

Genetic analysis is a powerful approach toward understanding the structure and function of the viral genome, its gene products, and their roles in infection and disease. Viral variants can arise naturally, with changes in

biologic properties caused by genetic mutations. Variation in viral properties is of great importance for human medicine. Genetic analysis will help identify virus-specific processes that may be appropriate targets for the development of antiviral therapy.

The following terms are basic to a discussion of genetics: **Genotype** refers to the genetic constitution of an organism. **Phenotype** refers to the observable properties of an organism, which are produced by the genotype in cooperation with the environment. A **mutation** is a heritable change in the genotype. The **genome** is the sum of the genes of an organism. **Wild-type virus** denotes the original virus from which mutants are derived and with which the mutants are compared; the term may not accurately characterize the virus as it is isolated in nature. Fresh virus isolates from the natural host are referred to as **field isolates** or **primary isolates**.

●**Defective Viruses**:

A defective virus is one that lacks one or more functional genes required for viral replication. Defective viruses require helper activity from another virus for some step-in replication or maturation.

One type of defective virus lacks a portion of its genome (i.e., deletion mutant). Another category of defective virus requires an unrelated replication-competent virus as helper. Examples include the adeno-associated satellite viruses and hepatitis D virus (delta agent), which replicate only in the presence of coinfecting human adenovirus or hepatitis B virus, respectively.

Pseudovirions, a different type of defective particle, contain host cell DNA rather than the viral genome. During viral replication, the capsid sometimes

encloses random pieces of host nucleic acid rather than viral nucleic acid. Such particles look like ordinary virus particles when observed by electron microscopy, but they are not able to replicate. Pseudovirions theoretically might be able to transduce cellular nucleic acid from one cell to another.

●**Interactions Among Viruses**:

When two or more virus particles infect the same host cell, they may interact in a variety of ways. They must be sufficiently closely related, usually within the same viral family, for most types of interactions to occur. Genetic interaction results in some progeny that are heritably (genetically) different from either parent. Progeny produced as a consequence of nongenetic interaction are similar to the parental viruses.

A. **Recombination**:

Recombination results in the production of progeny virus (recombinant) that carries traits not found together in either parent.

B. **Complementation**:

This refers to the interaction of viral gene products in cells infected with two viruses, one or both of which may be defective.

C. **Phenotypic Mixing**:

A special case of complementation is phenotypic mixing, or the association of a genotype with a heterologous phenotype. This occurs when the genome of one virus becomes randomly incorporated within capsid proteins specified by a different virus or a capsid consisting of components of both viruses. If the genome is encased in a completely heterologous protein coat, this extreme example of phenotypic mixing may be called “phenotypic masking” or “transcapsidation.”

D. **Interference**:

Infection of either cell cultures or whole animals with two viruses often leads to an inhibition of multiplication of one of the viruses, an effect called **interference**. Interference in animals is distinct from specific immunity. Furthermore, interference does not occur with all viral combinations; two viruses may infect and multiply within the same cell as efficiently as in single infections.

Several mechanisms have been elucidated as causes of interference: (1) One virus may inhibit the ability of the second to adsorb to the cell, either by blocking its receptors (retroviruses, enteroviruses) or by destroying its receptors (orthomyxoviruses). (2) One virus may compete with the second for components of the replication apparatus (e.g., polymerase, translation initiation factor). (3) The first virus may cause the infected cell to produce an inhibitor (interferon) that prevents replication of the second virus.

●NATURAL HISTORY (ECOLOGY) AND MODES OF TRANSMISSION OF VIRUSES:

Ecology is the study of interactions between living organisms and their environment. Different viruses have evolved ingenious and often complicated mechanisms for survival in nature and transmission from one host to the next. The mode of transmission used by a given virus depends on the nature of the interaction between the virus and the host.

Viruses may be transmitted in the following ways:

1. Direct transmission from person to person by contact. The major means of transmission include droplet or aerosol infection (e.g., influenza, rhinovirus, measles, and smallpox); by sexual contact (e.g., papillomavirus, hepatitis B, herpes simplex type 2, and human immunodeficiency virus); by hand–mouth, hand–eye, or mouth–mouth contact (e.g., herpes simplex and Epstein-Barr virus); or by exchange of contaminated blood (e.g., hepatitis B, hepatitis C, and human immunodeficiency virus).

2. Indirect transmission by the fecal–oral route (e.g., enteroviruses, rotaviruses, and hepatitis A) or by fomites (e.g., Norwalk virus and rhinovirus).

3. Transmission from animal to animal, with humans an accidental host. Spread may be by bite (rabies) or by droplet or aerosol infection from rodent-contaminated quarters (e.g., arenaviruses and hantaviruses).

4. Transmission by means of an arthropod vector (e.g., arboviruses, now classified primarily as togaviruses, flaviviruses, and bunyaviruses).

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