Chapter 13B: Animal Viruses

1. Overview of Animal Viruses

2. DNA Viruses

3. RNA Viruses

4. Prions

1. Overview of Animal Viruses

Life Cycle of Animal Viruses
The basic life cycle stages of animal viruses differ from bacteriophages in some key ways:

1) attachment
   • requires specific interactions between host cell plasma membrane proteins & viral “spike” proteins (enveloped) or capsid proteins (non-enveloped)

2) entry
   • by endocytosis or fusion of envelope w/plasma membr.
   • involves uncoating of the virus (release of DNA, RNA)
   • some viruses may become lysogenic (i.e., “latent”) following entry
3) biosynthesis
• replication of viral RNA occurs in cytoplasm
• replication of viral DNA occurs in nucleus

4) maturation
• RNA viruses typically assemble in cytoplasm
• DNA viruses typically assemble in nucleus

5) release
• via lysis (rupture of plasma membrane) or budding
• host cell is not necessarily killed

Viral Life Cycle in Eukaryotic Hosts

Entry by Endocytosis

Following attachment, the plasma membrane will invaginate to enclose the virus by endocytosis
• the vesicle (now an “endosome”) typically fuses with a lysosome to degrade the contents
• results in the release of viral DNA/RNA in cytoplasm
Entry by Fusion

Following attachment, some enveloped viruses gain entry by fusion of the envelope with plasma membrane:

- releases capsid directly into cytoplasm
- host or viral proteins then cause the release of the viral genetic material

Uncoating of Animal Viruses

Unlike bacteriophages, in which only the DNA or RNA enters the host cell, the capsid of most animal viruses enters the host cell.

This requires the uncoating of the viral genetic material before biosynthesis can occur:

- dissociation of the capsid to allow viral DNA or RNA to be copied, viral genes to be expressed
- can occur in cytoplasm or in a lysosome via host or viral enzymes

Release via Budding

- capsid of enveloped viruses acquires envelope with spikes through budding of the plasma membrane
2. DNA Viruses

Types of DNA Viruses

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<th>Nucleic Acid</th>
<th>Virus Family</th>
<th>Special Features of Replication</th>
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<td>Single-stranded DNA (+ or – strand)</td>
<td>Paroviridae</td>
<td>Cellular enzyme transcribes viral DNA into nucleic acid</td>
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<tr>
<td>Double-stranded DNA</td>
<td>Poxviridae</td>
<td>Nucleic acid transcribes viral DNA into nucleic acid</td>
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<tr>
<td>Double-stranded DNA</td>
<td>Poxviridae</td>
<td>Viral nucleic acid is incorporated into host cell DNA</td>
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The genetic material of DNA viruses can be in 2 basic forms:
- single-stranded DNA (+ or – strand)
- double-stranded DNA

A 3rd type involves an RNA intermediate in the replication of viral DNA:
- involves reverse transcriptase (see “RNA” section)

Life Cycle of a DNA Virus

1. Virion attaches to host cell.
2. Virion enters cell and its DNA is uncoated.
3. The DNA of some viruses is then inserted into the host cell DNA (e.g., Herpesviridae)
4. Viral DNA and capsid proteins
5. Nucleus
6. Cytoplasm
7. DNA
8. Capsid

- following attachment & entry, DNA is uncoated & transported to nucleus
- the DNA of some viruses is then inserted into the host cell DNA (e.g., Herpesviridae)
Latent Viral Infections
Some DNA viruses integrate the viral DNA into the chromosomal DNA of the host cell:

- analogous to the lysogeny of bacteriophage λ
- the inserted viral DNA is considered a provirus which can remain dormant indefinitely
- such an infection is considered to be latent
- the provirus can become active due to various conditions of stress in the cell and re-enter the standard viral life cycle

**“early” viral genes are transcribed in nucleus**
**“early” viral gene products facilitate copying of viral DNA, expression of “late” viral genes**

**“single-stranded viruses acquire a 2nd strand before transcription, replication of single-stranded DNA”**

- capsid proteins (products of viral “late” genes) are transported into the nucleus
- virions self assemble in the nucleus, are transported to the cytoplasm
- virions are released from the cell by budding or lysis
3. RNA Viruses

Types of RNA Viruses
The genetic material of RNA viruses comes in 3 basic forms:

- double-stranded RNA
- + strand RNA (single coding or sense strand)
- - strand RNA (single noncoding or template strand)

A 4th type are the retroviruses which copy ssRNA into DNA (reverse transcriptase) after uncoating

Unique Features of RNA Viruses
Copying of viral RNA poses a unique problem:

1) viral RNA must be converted to DNA which can then be transcribed to produce more RNA

OR

2) viral RNA must somehow serve as a template to produce more RNA

In reality, RNA viruses use both approaches:

- retroviruses use reverse transcriptase to make DNA from an RNA template
- all other RNA viruses use RNA-dependent RNA polymerase to transcribe from an RNA template
attachment, entry & uncoating of viral RNA occurs “as usual” for all types of RNA viruses...

RNA Virus Life Cycle

- original + strand is used directly to express (translate) RNA-dependent RNA polymerase
- RNA-dependent RNA polymerase uses + strand as a template to produce – strands which are then used to produce more + strands
- late gene expression then follows

Biosynthesis for + strand Viruses...

...for – strand Viruses...

- RNA-dependent RNA polymerase already present in the capsid proceeds to produce + strands following uncoating
...and for double-stranded RNAViruses

- original + strand used directly to express RNA-dependent RNA polymerase
- + & – strands are replicated, other viral genes are expressed, etc...

Maturation & Release

- capsid proteins self assemble with + , – or both strands (depending on the type of virus) in cytoplasm
- virions are released in the usual manner

Unique Features of Retroviruses

Viral RNA must first be copied to DNA which is then inserted into host DNA:
- requires the enzyme reverse transcriptase which is present in the viral capsid
- produces DNA from an RNA template

Are frequently lysogenic (i.e., latent):
- DNA copy of viral RNA that is inserted into host chromosomal DNA can remain “quiet” indefinitely
- viral genes can become active due to various “cellular stressors”
Life Cycle of a Retrovirus

- once provirus is generated, biosynthesis, maturation & release occur as with other viruses

4. Prions

What is a Prion?

Prions are unique, infectious proteins that cause spongiform encephalopathies:

- e.g., “mad cow” disease, kuru, Creutzfeld-Jacob disease (CJD), scrapie
- involves NO nucleic acid (DNA or RNA)
- involves aberrant folding of a normal protein (PrP) expressed in neural tissue
  - normal = PrP\(^C\); aberrant & infectious = PrP\(^{SC}\)
  - PrP\(^{SC}\) is extremely stable, forms insoluble aggregates
  - consumed PrP\(^{SC}\) induces host PrP\(^C\) to become PrP\(^{SC}\)
Model of Prion based Illness

- contact between PrPC & PrPSC induces PrPSC
- insoluble PrPSC accumulates, kills cells

Key Terms for Chapter 13B

- uncoating
- latent
- RNA-dependent RNA polymerase
- reverse transcriptase, retrovirus
- prion

Relevant Chapter Questions

rvw: none  MC: 2-5, 9