Course: MSc MICROBIOLOGY SEMESTER II
Subject: Virology (MIC 204)

Lecture 2
Classification of Viruses

Dr Shilpa Kaistha
Dept of Microbiology
IBSBT, CSJMU, Kanpur

Virology; the study of viruses

Viruses have one major characteristic in common: they are obligate intracellular parasites.

Viruses are UNABLE to grow and reproduce outside of a living cell. No virus is able to produce its own energy (ATP) to drive macromolecular synthesis.

However, in many other respects, they are a highly diverse group.

How are viruses named?

- Based on:

  - the disease they cause

    poliovirus, rabies virus

  - the type of disease

    murine leukemia virus

  - geographic locations

    Sendai virus, Coxsackie virus

  - their discovers

    Epstein-Barr virus

  - how they were originally thought to be contracted

    dengue virus ("evil spirit"), influenza virus (the "influence" of bad air)

  - combinations of the above

    Rous Sarcoma virus

Virus classification and nomenclature

- Latin binomials were proposed first by Holmes in 1939

- Various other schemes proposed between 1940 and 1966

- 1966 the International Committee for the Nomenclature of Viruses formed; met in 1970

- Changed to the International Committee for the Taxonomy of Viruses in 1973

- Viruses not classified as members of Kingdoms
- Do not obey biological taxanomy
- Based
  - Classical system: host based
  - Genomics: Baltimore classification
  - Serology: Diagnostic virology Corona virus have antigenic differences but very few host or genetic differences (single/double mutant variants)

Virus Classification

Taxonomy from Order downward

- Family often the highest classification. Ends in -viridae.

- Many families have subfamilies. Ends in -virinae.

- Bacterial viruses referred to as bacteriophage or phage (with a few exceptions).

Examples

family *Myoviridae*
    genus T4-like phages
        type species *Enterobacteria phage* T4

family *Herpesviridae*, subfamily *Betaherpesvirinae*
    genus *Muromegalovirus*
        type species *Murine herpesvirus* 1

Holme's Classification

- 1948. Linnaean Taxanomy with binomial nomenclature
- Group I : Phaginae
- Group II: Phytophaginae
- Group III: Zoophaginae
- Rejectedas no consideration for morphological characteristics

LHT System of Classification

- **1962. Lwoff, Horne and Tournier** proposed system adopted by Provisional Committee on Nomenclaure of Viruses (PCNV) formed by International Association of Microbiological Society
- LHT based on
  - Nature of NA
  - Symmetry of viral particle
  - Envelop presence or absence
  - Diameter of capsid
  - Number of capsomere
- Phylum Vira
  - Subphylum Deoxyvira and SubPhylum Ribovira
    - Class
      - Order
        - » Family
- Disadv: No evolutionary relationship , not a natural classification (traits to find similarity/dissimilarity)

- **1967. Bellet classification** based on
  - MW
  - % GC
  - Phenotypic, serological and antigenic properties also considered
- **1969. Gibbs system of classification** for Plant Viruses (135 viruses into 6 broad groups
  - Shape of Capsid
  - Mode of transmission
  - Type of vector
  - Symptoms on host
  - Name of accessory particles

- **1975. Casjens and King's Classification**
  - NA type
    - (4 :ssRNA,dsRNA,ssDNA,dsDNA)
  - Capsid symmetry
    - (Helical, Iscosahedral, Icosahedral complex)
  - Presence /absence of envelop
  - Site of assembly of envelop (nuclear or cytoplasmic)

The Baltimore classification system

1971- 2008. David Baltimore: Based on genetic contents and replication strategies of viruses. According to the Baltimore classification, viruses are divided into the following seven classes:

1. dsDNA viruses
2. ssDNA viruses
3. dsRNA viruses
4. (+) sense ssRNA viruses (codes
       directly for protein)
5. (-) sense ssRNA viruses
6. RNA reverse transcribing viruses
7. DNA reverse transcribing viruses (added
later- modified Baltimore Classification)

where "ds" represents "double strand" and "ss" denotes "single strand".

Dimmock's modified Baltimore Classification

- 2001. Dimmock classified viruses into 6 sections (based on host preference): animal, plant, fungi, bacteria, satellite and viroid.

- Each section divided into 7 Classes (revised Baltimore scheme) and each class into family

Virus Classification I
- the Baltimore classification

- All viruses must produce mRNA, or (+) sense RNA

- A complementary strand of nucleic acid is (–) sense

- The Baltimore classification has + RNA as its central point

- Its principles are fundamental to an understanding of virus classification and genome replication, but it is rarely used as a classification system in its own right

From Principles of Virology Flint et al ASM Press
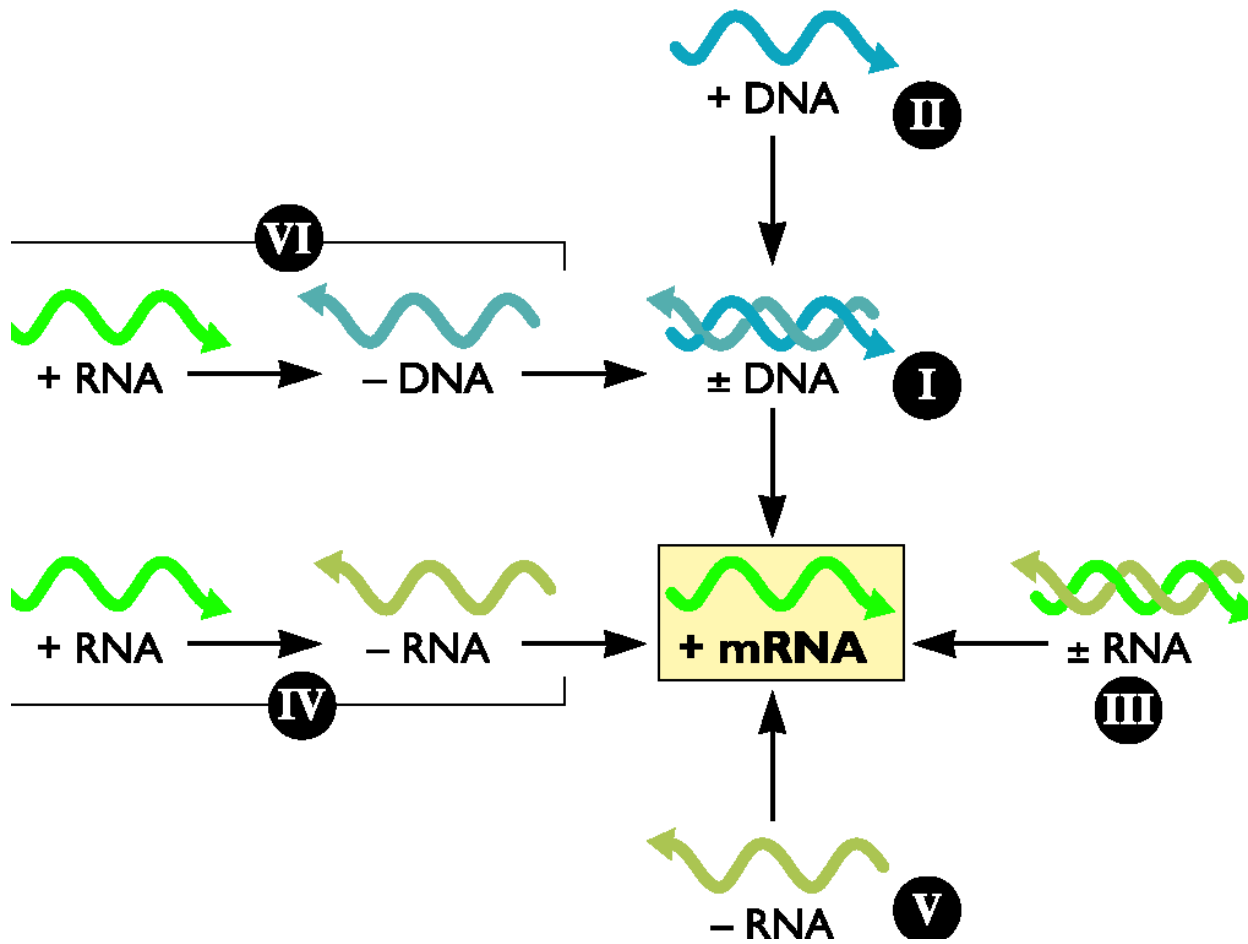
Virus classification II - the Classical system

- This is a based on three principles -

    - 1) that we are classifying the virus itself, not the host
    - 2) the nucleic acid genome

    - 3) the shared physical properties of the infectious agent (e.g capsid symmetry, dimensions, lipid envelope)
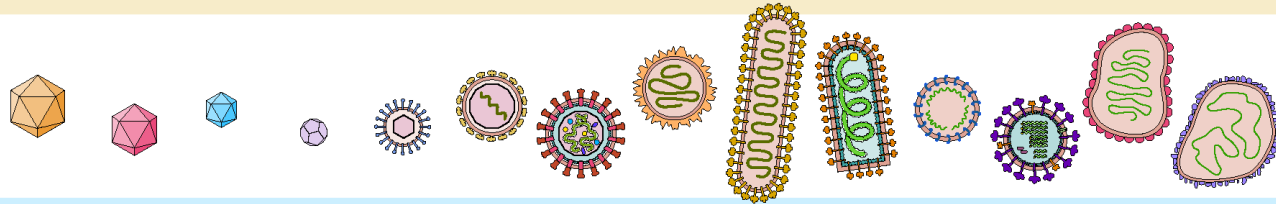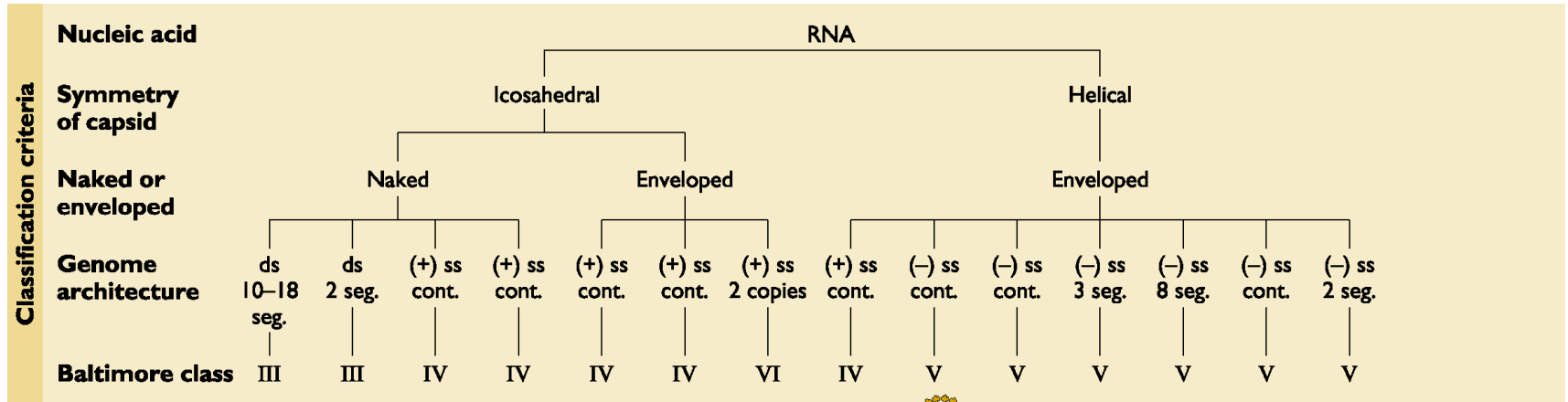
Virus classification III - the genomic system

- More recently a precise ordering of viruses within and between families is possible based on DNA/RNA **sequence**

- 2019. ICTV agreed to adopt a 15-rank classification system for viruses, ranging from realm to species

- 4 realms, 9 kingdoms, 16 phyla, 2 subphyla, 36 classes, 55 orders, 8 suborders, 168 families, 103 subfamilies, 1421 genera, 68 subgenera, 6590 species (ictvonline.org/taxonomy)

- *Four virus realms are recognized by ICTV based on specific highly conserved traits (based on genomics & proteomics) but no common ancestor (polyphyletic)*
- Duplodnaviria, which contains all double-stranded DNA (dsDNA) viruses that encode the HK97-fold major capsid protein;
- Monodnaviria, which contains all single-stranded DNA (ssDNA) viruses that encode a circular rep (replication associated protein) encoding ssDNA (CRESS DNA), HUH superfamily endonuclease and their descendents;
- Riboviria, which contains all RNA viruses that encode RNA-dependent RNA polymerase and all viruses that encode reverse transcriptase; and ~paraphyletic
- Varidnaviria, which contains all dsDNA viruses that encode a vertical jelly roll major capsid protein.

RNA viruses

Nucleic acid						RNA									
Symmetry of capsid			Icosahedral							Helical					
Naked or enveloped		Naked				Enveloped				Enveloped					
Genome architecture	ds 10–18 seg.	ds 2 seg.	(+) ss cont.	(+) ss cont.	(+) ss cont.	(+) ss cont.	(+) ss 2 copies	(+) ss cont.	(–) ss cont.	(–) ss cont.	(–) ss cont.	(–) ss 3 seg.	(–) ss 8 seg.	(–) ss cont.	(–) ss 2 seg.
Baltimore class	III	III	IV	IV	IV	IV	VI	IV	V	V	V	V	V	V	V

Family name	Reo	Birna	Calici	Picorna	Flavi	Toga	Retro	Corona	Filo	Rhabdo	Bunya	Ortho-myxo	Para-myxo	Arena
Virion polymerase	(+)	(+)	(–)	(–)	(–)	(–)	(+)	(–)	(+)	(+)	(+)	(+)	(+)	(+)
Virion diameter (nm)	60–80	60	35–40	28–30	40–50	60–70	80–130	80–160	80 × 790–14,000	70–85 × 130–380	90–120	90–120	150–300	50–300
Genome size (total in kb)	22–27	7	8	7.2–8.4	10	12	3.5–9	16–21	12.7	13–16	13.5–21	13.6	16–20	10–14

Classification criteria

Properties

From Principles of Virology Flint et al ASM Press
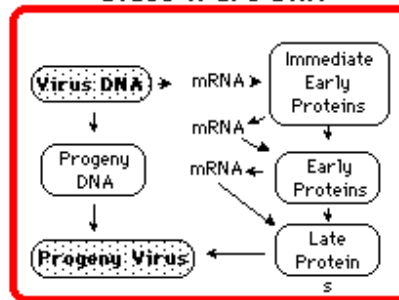
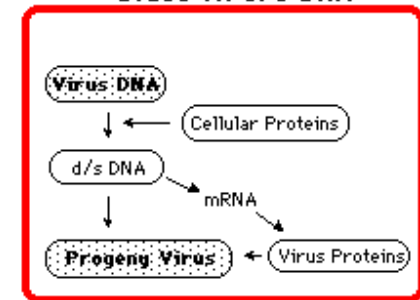# DNA viruses
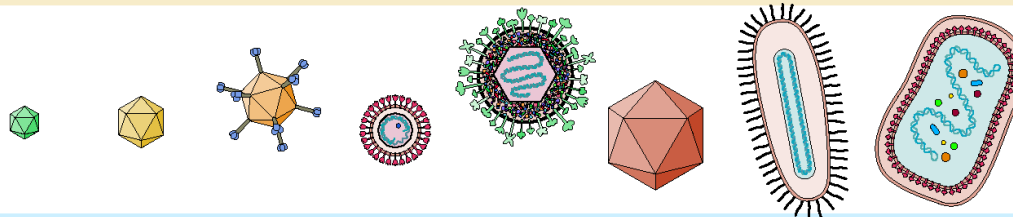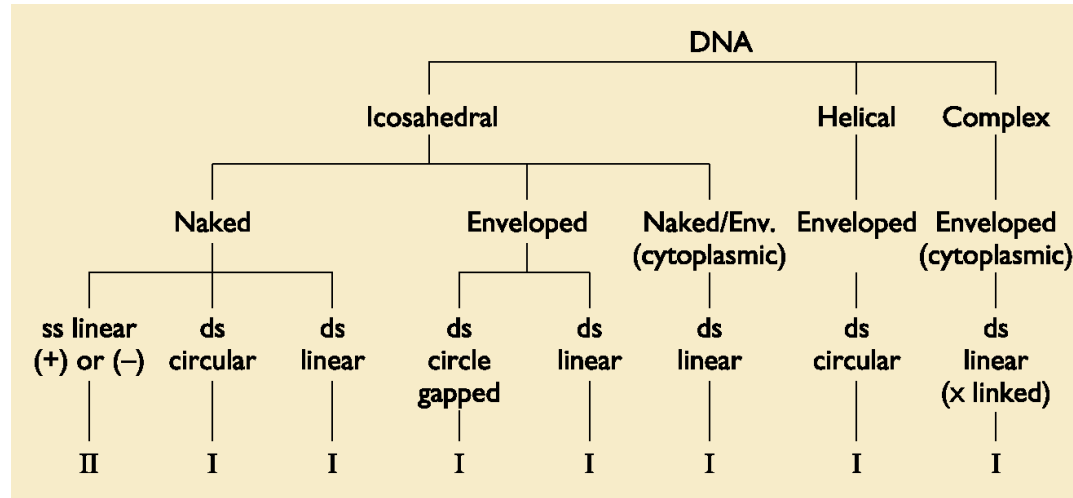
From Principles of Virology Flint et al ASM Press
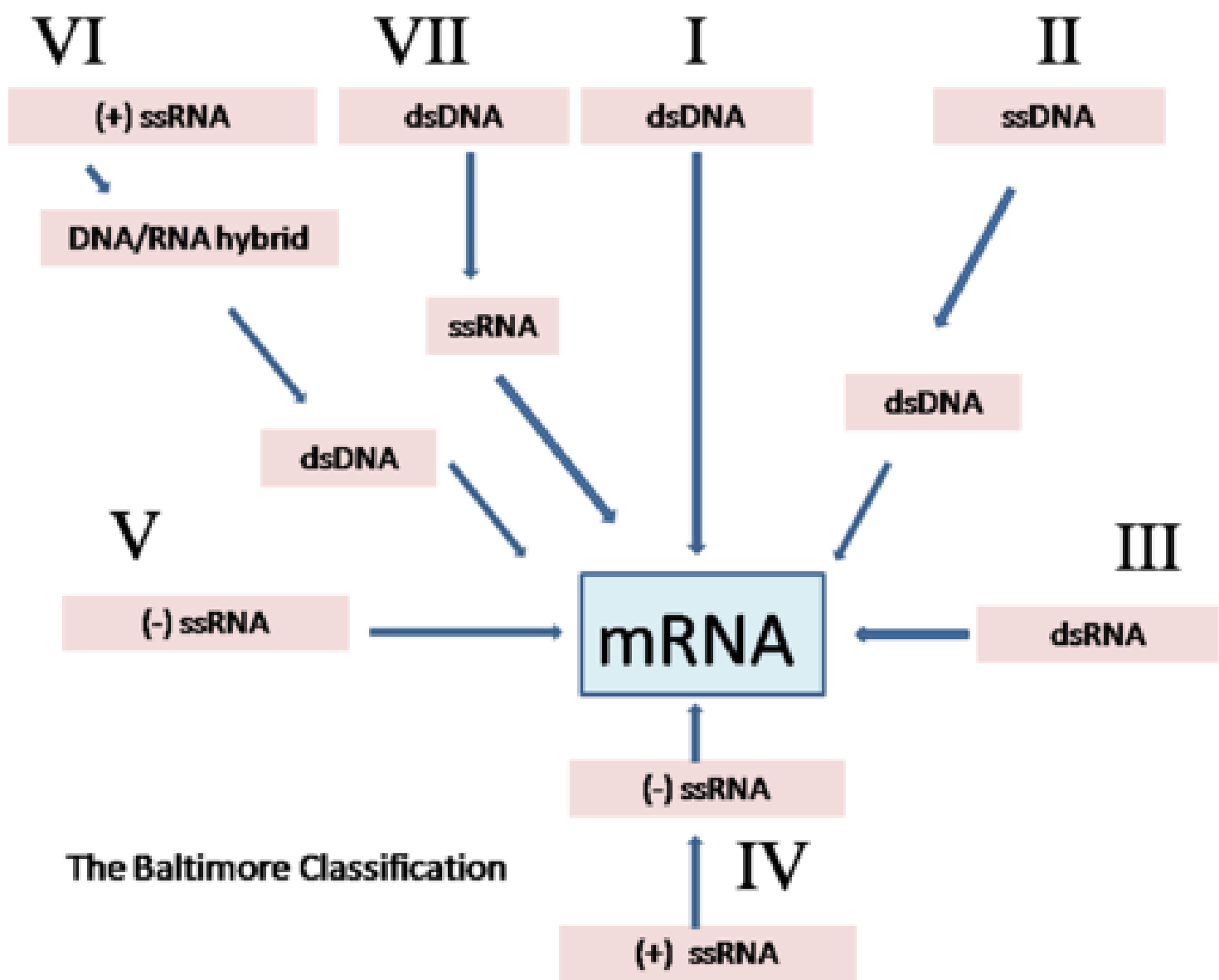
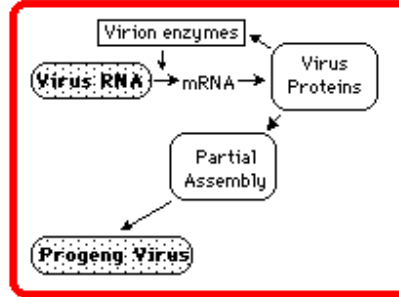The Baltimore Classification

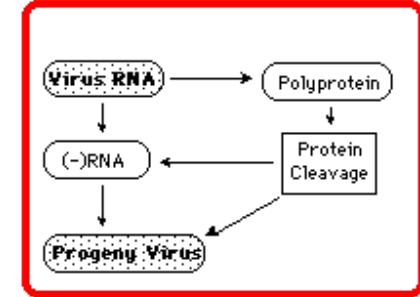# The seven "Baltimore" replication classes

Class I: d/s DNA

Virus DNA → mRNA → Immediate Early Proteins
Virus DNA → Progeny DNA
mRNA ← Immediate Early Proteins
mRNA → Early Proteins
Progeny DNA → Progeny Virus
Early Proteins → Late Proteins
Late Proteins → Progeny Virus

Class II: s/s DNA

Virus DNA → ← Cellular Proteins
d/s DNA → mRNA
d/s DNA → Progeny Virus
Progeny Virus ← Virus Proteins
mRNA → Virus Proteins

Class III: d/s RNA

Virion enzymes
Virus RNA → mRNA → Virus Proteins
Virus Proteins → Partial Assembly
Partial Assembly → Progeny Virus

Class IVa: s/s (+)RNA

Virus RNA → Polyprotein
Virus RNA → (-)RNA
Polyprotein → Protein Cleavage
(-)RNA ← Protein Cleavage
(-)RNA → Progeny Virus
Protein Cleavage → Progeny Virus

Class IVb: s/s (+)RNA

Virus RNA → Non-structural proteins
Virus RNA → (-)RNA
Non-structural proteins → mRNA
(-)RNA → Progeny Virus
mRNA → Structural proteins
Structural proteins → Progeny Virus

Class V: s/s (-)RNA

Virion enzymes
Virus RNA → mRNA → Virus Proteins
Virus RNA → (+)RNA
Virus Proteins → (+)RNA
(+)RNA → Progeny Virus
Virus Proteins → Progeny Virus

Class VI: s/s RNA + DNA

Virion enzymes
Virus RNA → d/s DNA
d/s DNA → mRNA
mRNA → Progeny Virus
mRNA → Virus Proteins
Virus Proteins → Progeny Virus

Class VII: d/s DNA + RNA

Virus DNA → Supercoiled DNA
Supercoiled DNA → mRNA
mRNA → Progeny Virus
mRNA → Virus Proteins
Virus Proteins → Progeny Virus

RNA virus replication

Class V: s/s (−)RNA

Virion enzymes → Virus RNA → mRNA → Virus Proteins → (+)RNA → Progeny Virus

Class IVa: s/s (+)RNA

Virus RNA → Polyprotein → Protein Cleavage → (−)RNA → Progeny Virus

Class IVb: s/s (+)RNA

Virus RNA → Non-structural proteins → (−)RNA → mRNA → Structural proteins → Progeny Virus
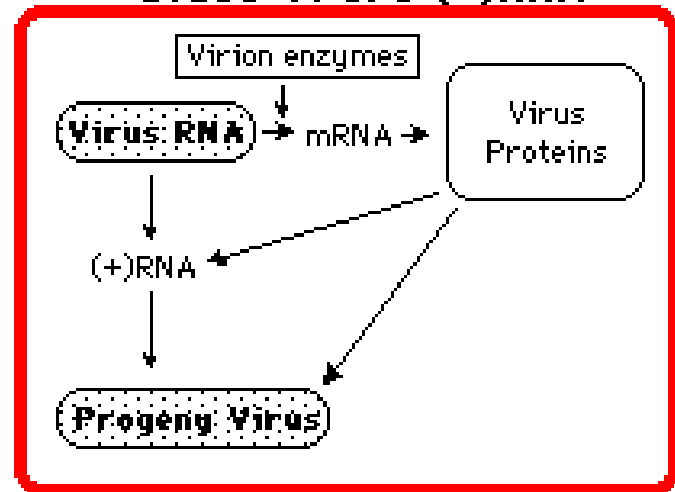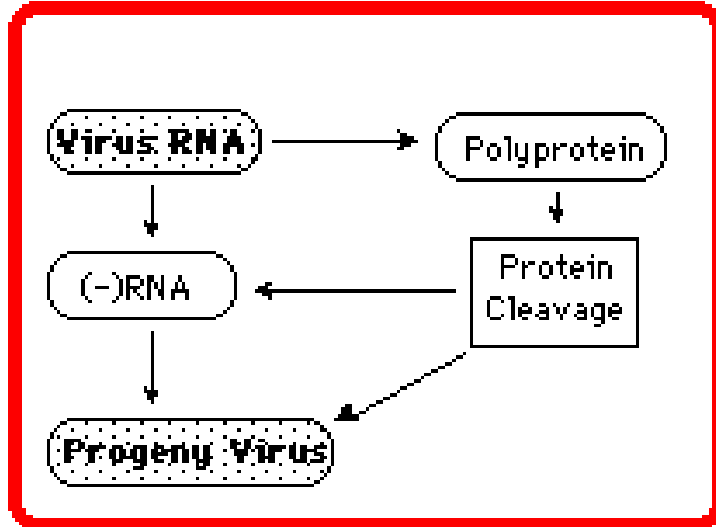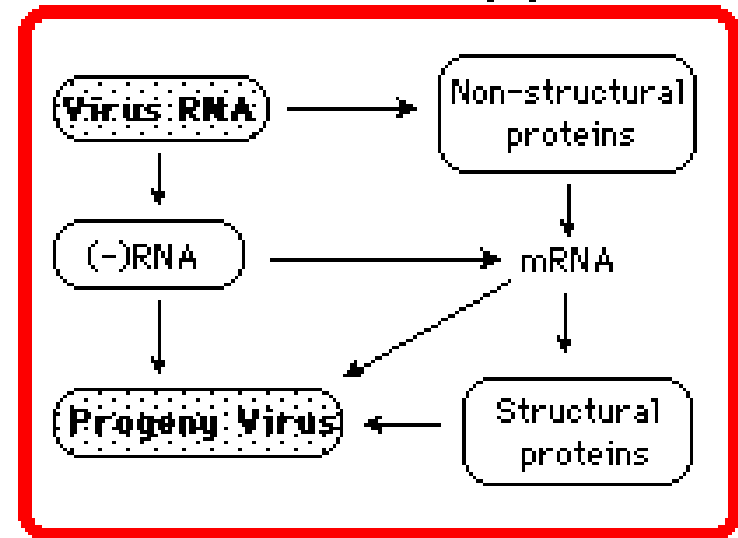
Replication Strategy of ss(-)RNA Viruses

Steps in Replication

1. Primary transcription of virion (-)sense RNA by RNA-Dependent RNA Pol in virion core in cytoplasm, production (mainly) mRNA and (+)sense RNA, formation replicative complex (RC)

2. Translation mRNAs, accumulation of products

3. Virion proteins interact with RC, bias it towards production of full-length (+)sense RNA and therefore of genomic (-)sense RNA

4. Secondary transcription from progeny (-)sense RNA, translation, accumulation structural proteins

5. Nucleocapsid assembly and maturation, budding of nucleocapsid through host membrane containing viral envelope proteins