BIOL 4640 Mol Micro
Lecture 22 10/16/26
Cell Structures Part 8

- Assignment 16 Lecture 21 In-class assignment – due on 10/21
- Assignment 17 Structures of your Microbe Due on 10/23
- Assignment 18 Lecture 22 Viruses Questions
- Exam 2 on Wednesday, Oct 28
  - Study guide and old exam posted

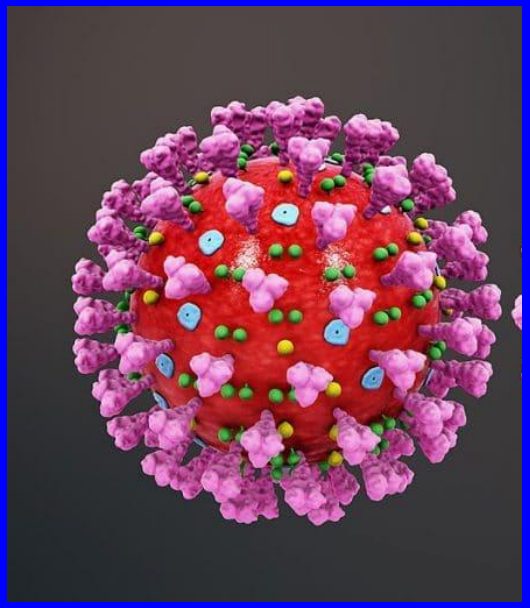
Unit 3. Features and Structures of Microbial Cells

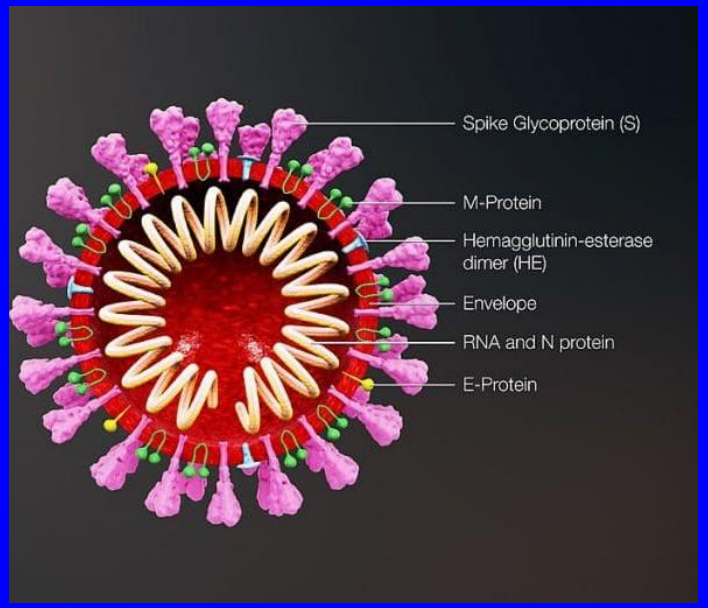
A. Size and Shape of bacteria
B. Specialized External Structures of bacteria
C. Cell envelope of bacteria
D. Internal structures of bacteria
E. Cell Division in Bacteria
F. Viruses – Chapter 6
G. Atypical bacteria and viruses

Mostly Chapter 3 in book

F. Viruses

- COVID-19 is caused by a coronavirus
- Coronavirus is described as a
  - Enveloped, single-stranded , + sense RNA virus
  - What does that mean to be enveloped?
  - What does single-stranded, + sense RNA virus tell us about the virus and its replication?



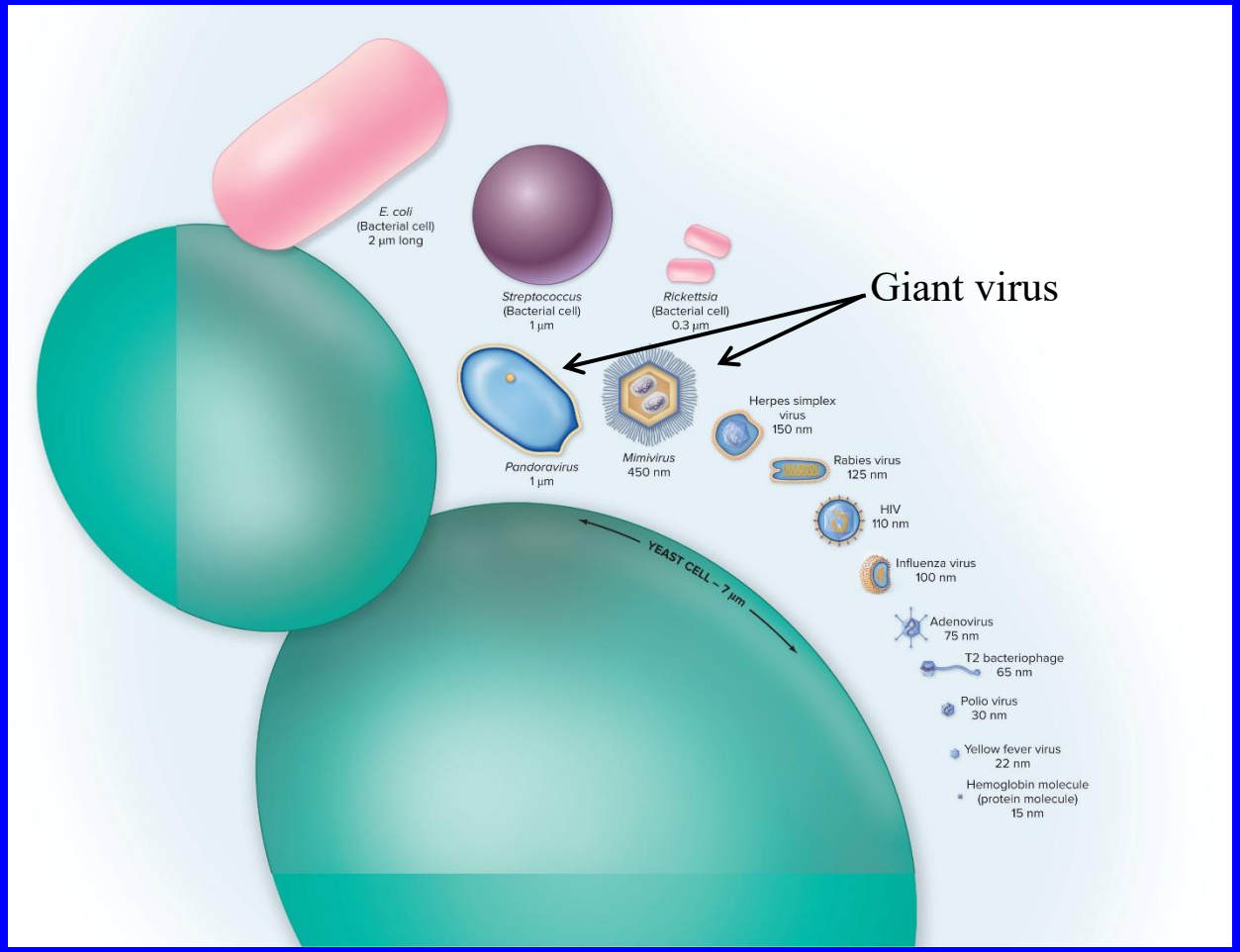


F. viruses - 2

1. Size
2. Shape
3. Structural Features/Components
4. Reproduction
5. Classification
6. Steps in Multiplication Cycle
7. Outcome of Virus infections

Features of Viruses

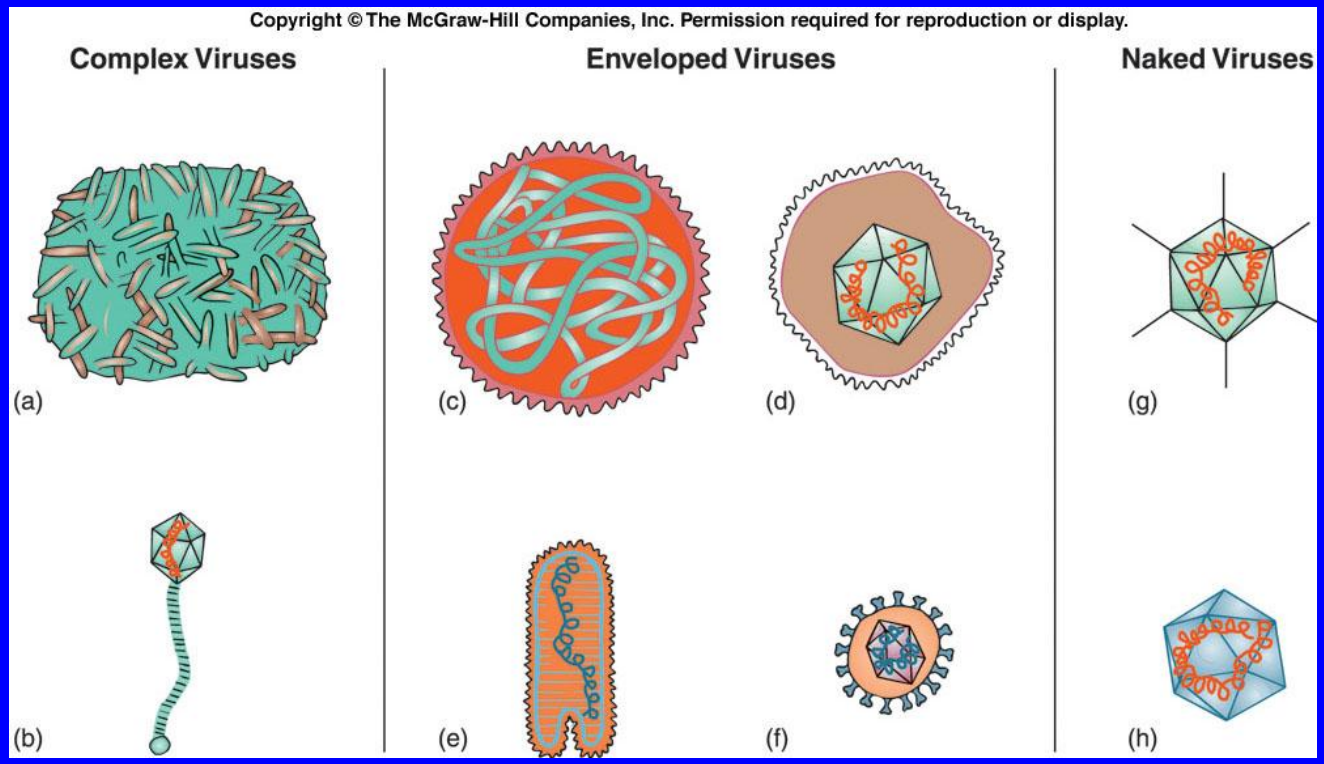
1. Size - Most between 0.02-0.2 µm or microns
   - Most 10-100x smaller than bacteria,
   - Need an electron microscope to see



Note: Pandoravirus and Mimivirus are giant viruses which are similar in size to some bacteria

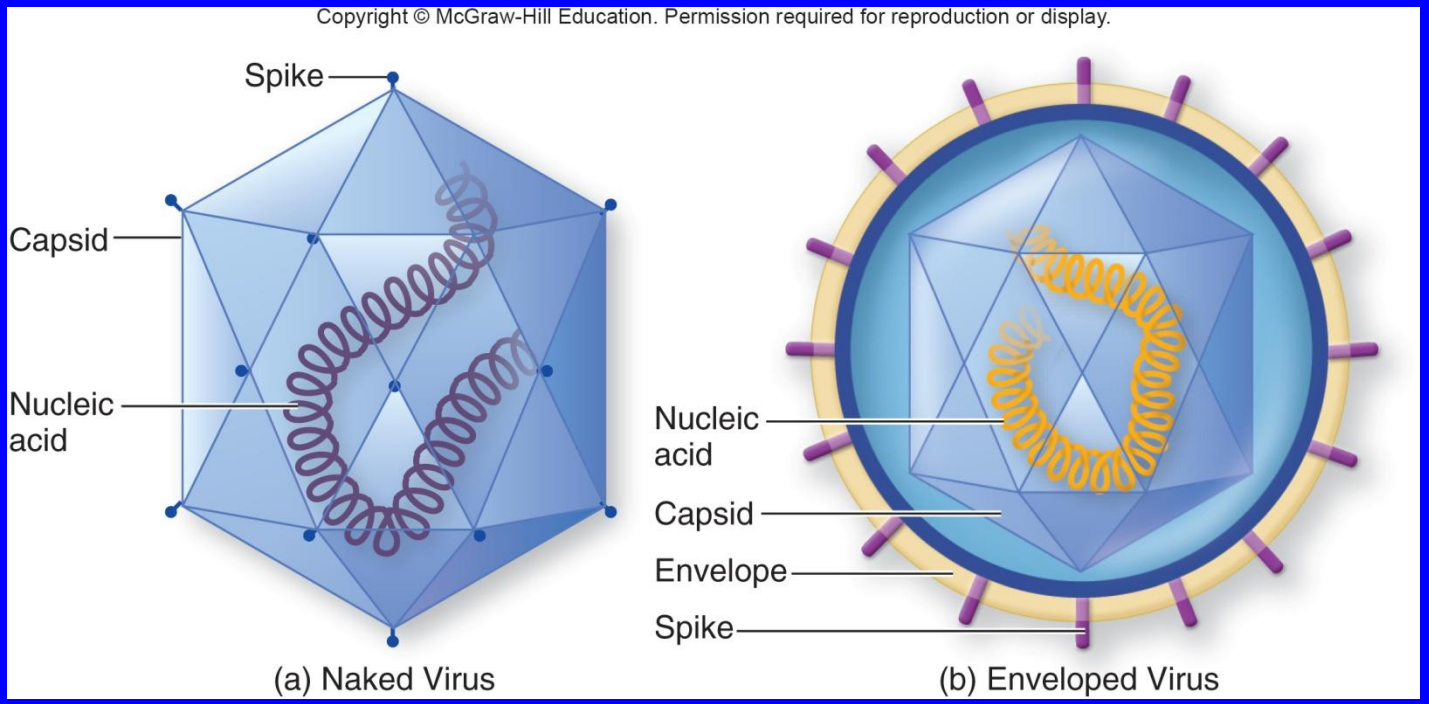
Features of Viruses - 2

2. Shape: large diversity
   a. Icosahedron – 20-sided polyhedron
   b. Spherical
   c. Complex – more complicated



Features of Viruses - 3

3. Structural Features -
   - Simpler than cells – considered acellular
   - Virus particles (virions) may contain just nucleic acid in a protein shell

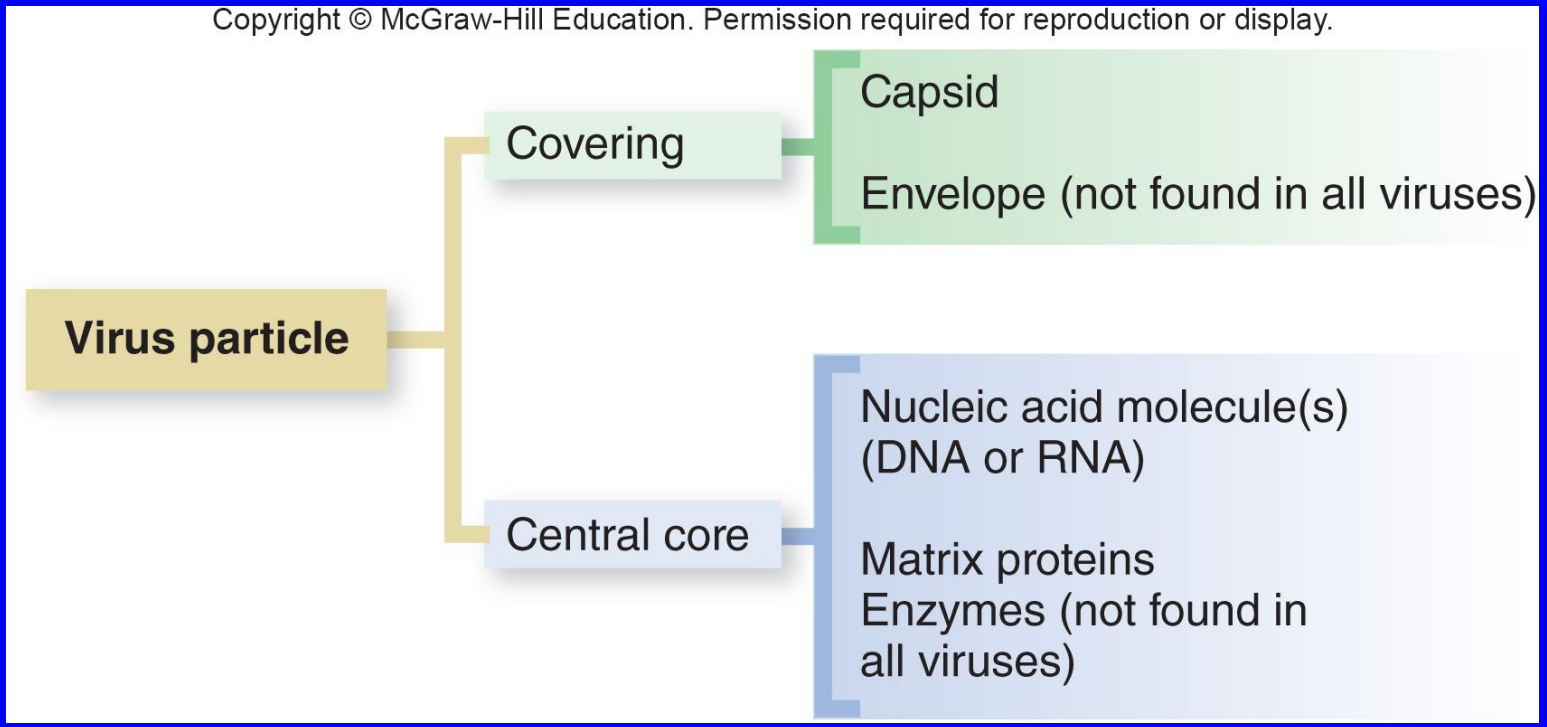


3. Components of Virus Particles

Can be divided into Core and Covering

- Core - Nucleic acid and enzymes
- Covering – capsid and envelope

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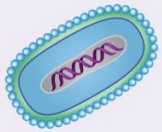


3. Components of Virus Particles - 2

a. Nucleic acid –
- Found in all viruses
- Can be DNA or RNA, but not both
- May be single or double stranded
- May be in multiple segments
- May contain more than 1 copy

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Table 6.2 Viral Nucleic Acid

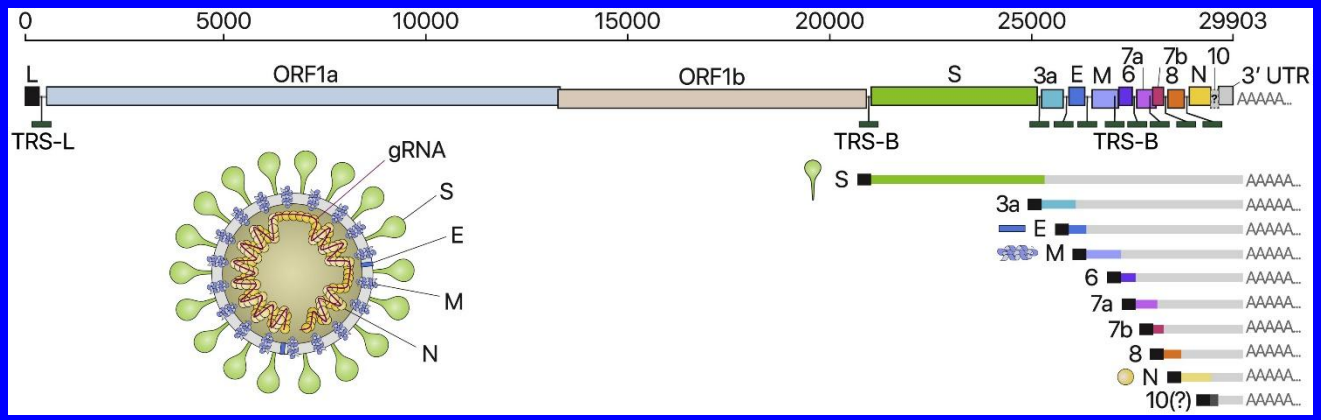
	Diagram	Virus Name	Disease It Causes
DNA Viruses			
Double-stranded DNA		Variola virus	Smallpox
		Herpes simplex 2	Genital herpes
Single-stranded DNA		Parvovirus	Erythema infectiosum (skin condition)
RNA Viruses			
Single-stranded (+) polarity		Poliovirus	Poliomyelitis
Single-stranded (–) polarity		Influenza virus	Influenza
Double-stranded RNA		Rotavirus	Gastroenteritis
Single-stranded RNA reverse transcriptase		HIV	AIDS

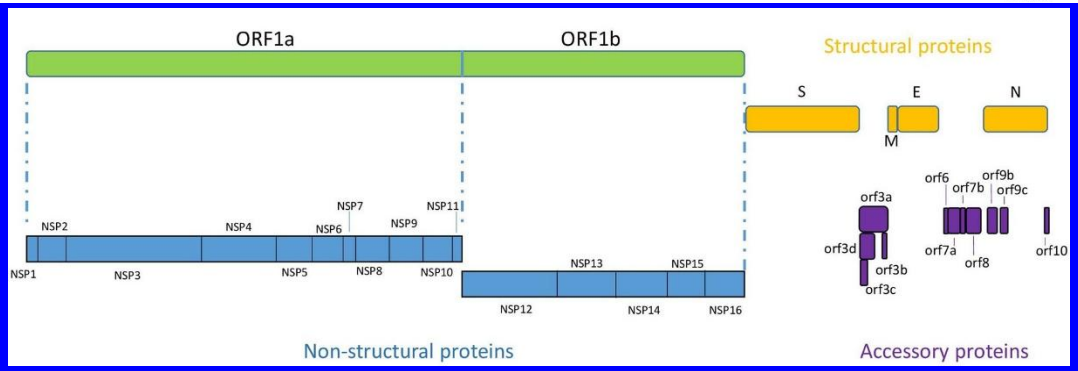
3. Components of Virus Particles - 3

a. Nucleic acid part 2

- Can see overlapping genes
- Multiple proteins from single RNA and polypeptide

Figure 6.27 6th edition SARS-CoV-2





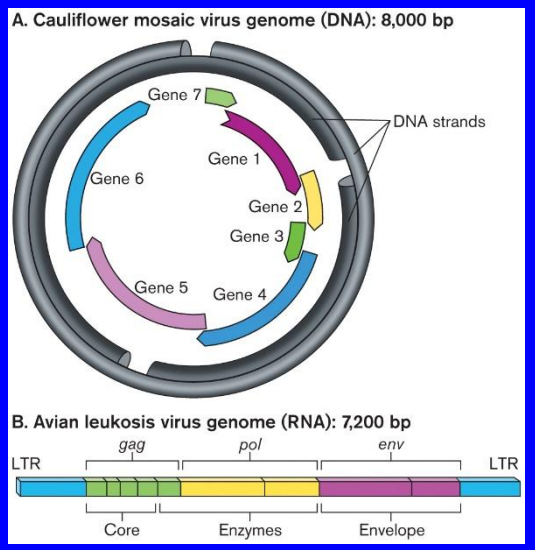


Figure 6.16 6th edition

3. Components of Virus Particles - 4

b. Enzymes - such as polymerase or reverse transcriptase
   - Inside capsid
   - Observed in some

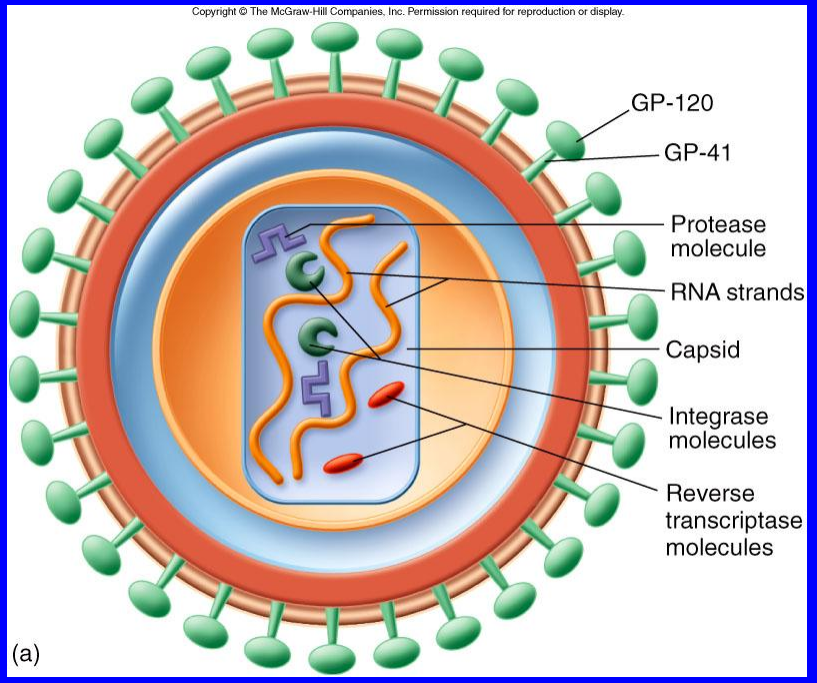
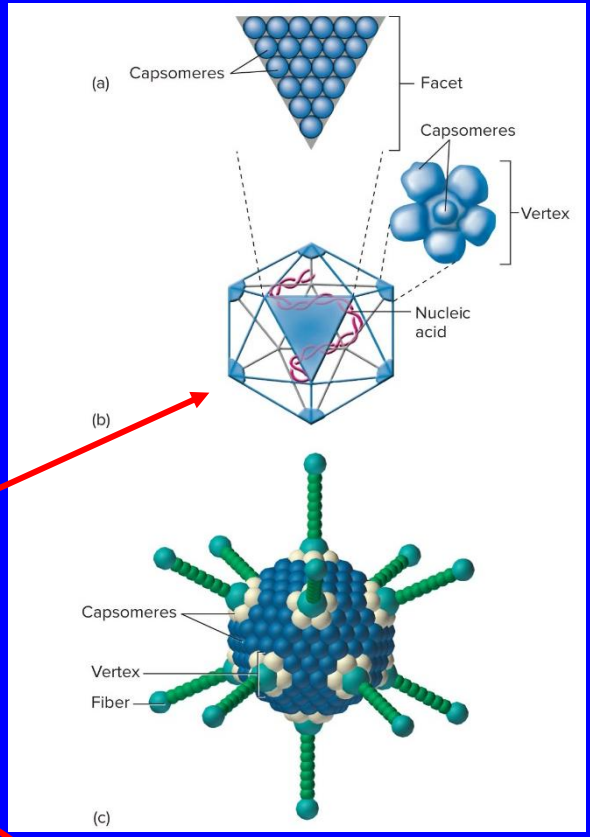
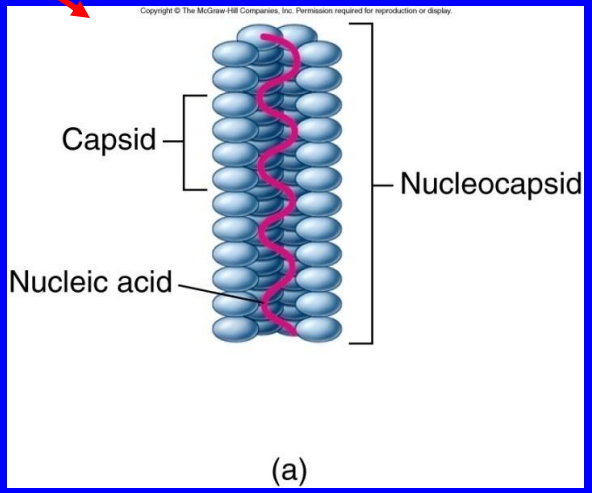


Figure: HIV Retro virus
Note: presence of enzymes reverse transcriptase, integrase and protease

3. Components - 5

c. Capsid – protein coat or shell
   - Found in all viruses
   - Usually has an icosahedral (20 sided) or helical shape
   - Viral capsid proteins form identical capsomeres which in turn form capsid
   - Capsid and nucleic acid form nucleocapsid





3. Components of Virus Particles - 6

d. Envelope –
   - Phospholipid bilayer membrane with proteins and glycoproteins (spikes)
   - Observed in some

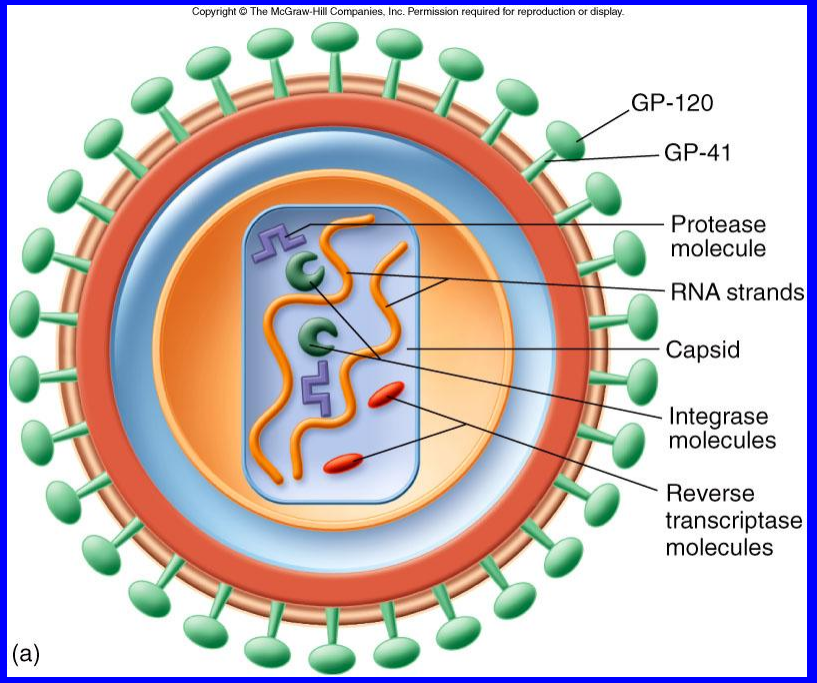


Figure: HIV Retro virus
Note: presence of enzymes reverse transcriptase, integrase and protease

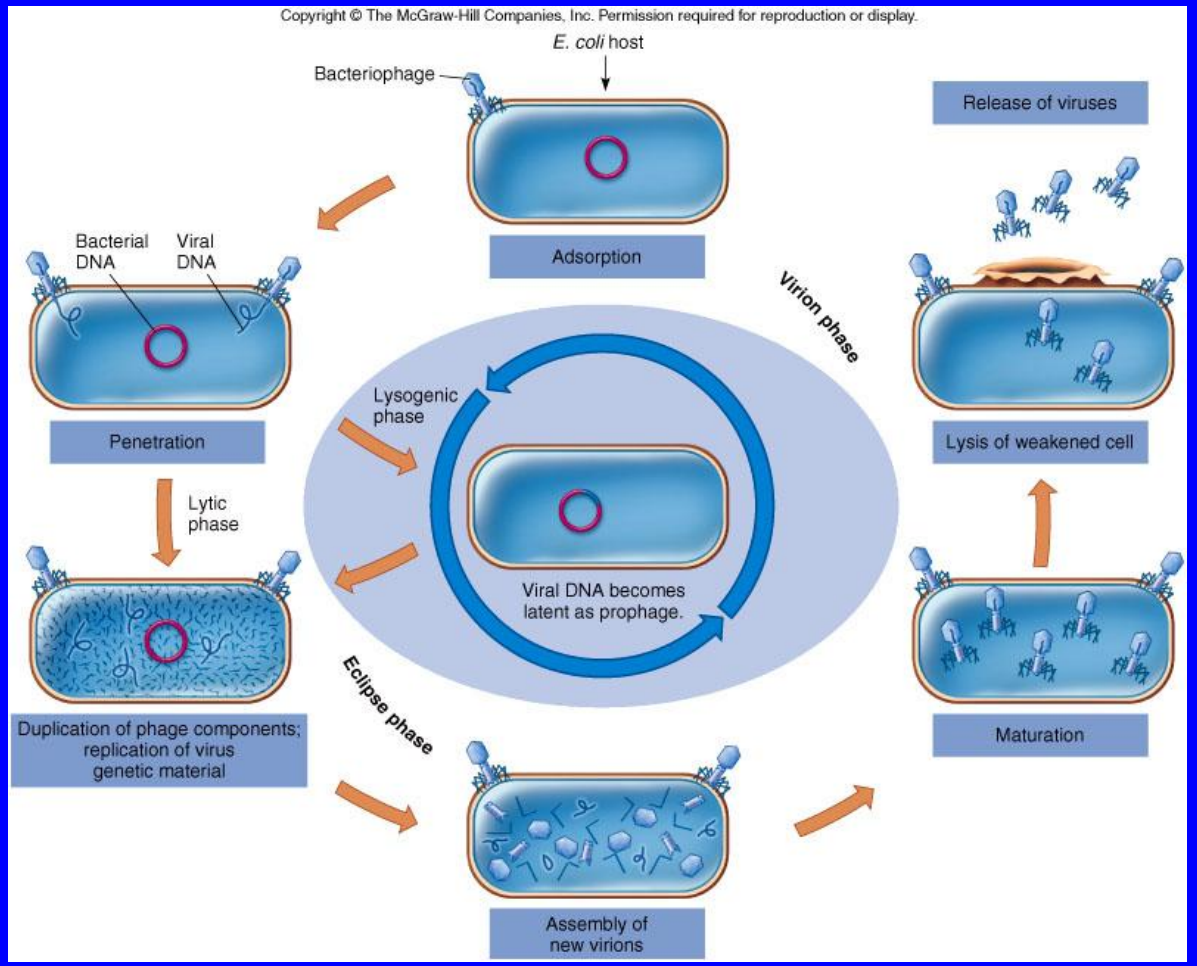
3. Components of Virus Particles - 7

- Significance of outer covering: Naked vs enveloped
  a. Affects ability of virus to remain viable (able to still cause an infection) when outside a host cell
     - Naked (No membrane) viruses – generally tougher, survive longer, more resistant to drying, detergents, acids
     - Enveloped - more sensitive, must remain wet
  b. Determines means of escape from infected cell
     - Naked (nonenveloped) must lyse cell
     - Enveloped can escape by budding

F. Features of Viruses

4. Reproduction .
   a. Obligate intracellular parasites
      Only replicate or multiple inside a host cell

Also observed in some bacteria and protozoans

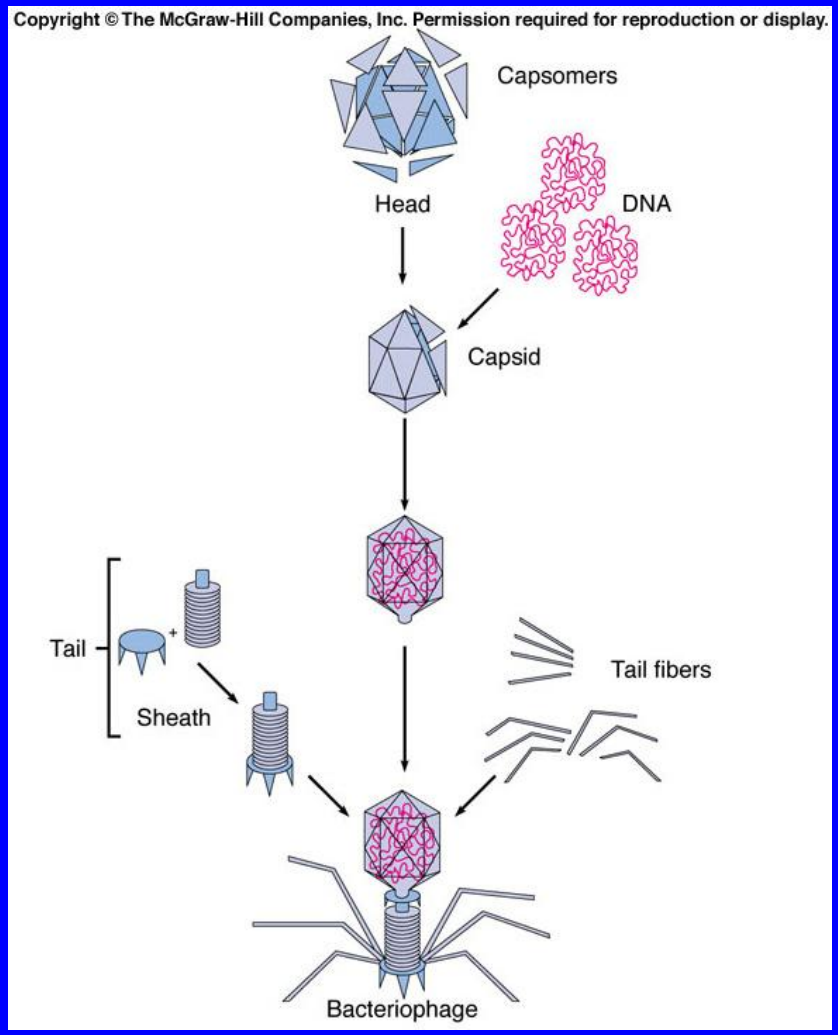


Similar to Figure 6.22 6th edition

F. Features of Viruses - 2

4. Reproduction.
   b. Assembled –
      - Assembled from parts inside host cell

      - Figure: Assembly of a T4 bacteriophage – a virus that infects bacteria



5. How are viruses classified or grouped?

Properties used to Organize into Groups

a. ___,
b. __

Properties used to organize into subgroups

a. ___
b. __
c. _

Look at Table A2.1 and determine

5. Classification of viruses

Organized in groups based on

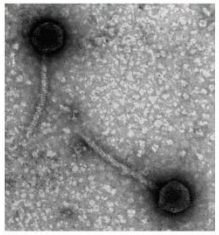
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See
Table A2.1 4/e
Expanded version of table 6.1 of SF Micro
Table 6.2 in 6th ed

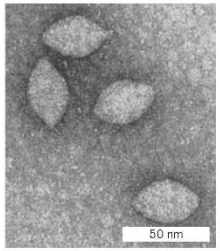
TABLE A4.1 Groups of viruses—Baltimore classification. (Expanded version of Table 6.1.)

Group I. Double-stranded DNA viruses

Replicate using host or viral DNA polymerase.



Bacteriophage lambda



Fusellovirus

Nonenveloped bacteriophages (structure includes head and tail)

Myoviridae. Bacteriophage T4 infects *Escherichia coli.*

Siphoviridae. Bacteriophages lambda and mu infect *E. coli.* Others infect Gram-positive hosts.

Tectiviridae. Infect enteric bacteria.

Nonenveloped viruses of animals and protists

Adenoviridae. Adenovirus generates tumors in humans.

Iridoviridae. Infect insects and amphibians.

Mimiviridae. Large viruses; infect *Acanthamoeba* and human macrophages.

Pandoraviridae. The largest known viruses; infect amebas.

Papillomaviridae. Papillomavirus causes genital warts.

Phycodnaviridae. Infect algae, controlling algal blooms. Some chloroviruses infect *Chlorella*, algal symbiont of paramecia and hydras.

Enveloped viruses of animals

Baculoviridae. Baculoviruses infect insects.

Herpesviridae. Herpes simplex causes oral and genital herpes; varicella-zoster virus causes chickenpox.

Poxviridae. Include smallpox and cowpox viruses.

Archaeal viruses

Ampullaviridae. Bottle-shaped viruses; infect *Acidianus.*

Fuselloviridae. Infect thermoacidophiles (*Sulfolobus*) and halophiles (*Haloarcula*).

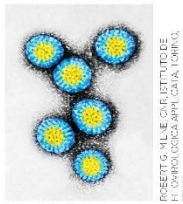
Guttaviridae. Spindle-shaped viruses; infect *Sulfolobus.*

Haloviridae. Haloviruses infect haloarchea such as *Haloferax*, *Halobacterium*, and *Haloarcula.*

Rudiviridae, Lipothrixviridae. Infect *Sulfolobus* and *Thermoproteus.*

Group II. Single-stranded DNA viruses

Genome consists of (+) sense DNA; host DNA polymerase used; nonenveloped.



Geminivirus

Bacteriophages

Inoviridae. Bacteriophage M13 infects *E. coli* and has a slow-release life cycle.

Microviridae. Bacteriophage ϕX174 infects *E. coli.*

Animal viruses

Anelloviridae. Found in human blood plasma; cause no known harm.

Circoviridae. Infect pigs and birds, causing immunosuppression.

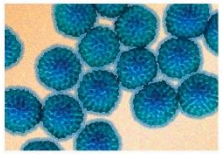
Parvoviridae. Cause various diseases in cats, pigs, and other animals.

Plant viruses

Geminiviridae. Transmitted by aphids to tomato plants and other important crops. Their virions group in "twins," each member of the pair carrying one DNA circle with part of the genome.

Group III. Double-stranded RNA viruses

Require viral RNA-dependent RNA polymerase; usually package the polymerase before exiting host cell.



Rotavirus

Nonsegmented, enveloped bacteriophages

Cystoviridae. Infect *Pseudomonas* species of bacteria.

Segmented, nonenveloped viruses of animals and plants

Birnaviridae. Infect marine and freshwater fish.

Reoviridae. Orthoreoviruses and rotaviruses infect humans and other vertebrates. Cypovirus infects insects. Rice dwarf virus (phytoreovirus) devastates rice crops worldwide.

Varicosaviridae. Infect plants.

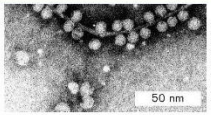
5. Classification of viruses - 2

- Page 2 of Table A2.1 4/e
- Expanded version of table 6.1 of SF Micro

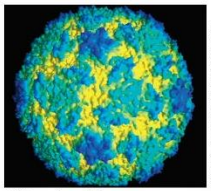
Some refer to groups as families

Group IV. (+) sense single-stranded RNA viruses

Require viral RNA-dependent RNA polymerase to generate (–) template for progeny (+) genome; usually nonsegmented.



Bacteriophage MS2


Rhinovirus 14

Nonenveloped bacteriophages

Leviviridae. Bacteriophages MS2 and Qβ infect *E. coli.*

Nonenveloped animal and plant viruses

Bromoviridae. Infect many kinds of plants and are often carried by beetles.

Picornaviridae. Poliovirus causes poliomyelitis. Rhinovirus causes the common cold. Aphthovirus causes foot-and-mouth disease in cattle and other stock.

Potyviridae. Viruses such as plum pox virus infect fruits, peanuts, potatoes, and other plants.

Tobamoviridae. Tobacco mosaic virus infects plants.

Enveloped animal and plant viruses

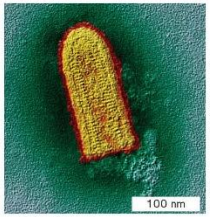
Coronaviridae. Include SARS (severe acute respiratory syndrome) and animal viruses.

Flaviviridae. Include West Nile virus, yellow fever virus, hepatitis C virus, and Zika virus.

Togaviridae. Include rubella virus and equine encephalitis virus.

Group V. (–) sense single-stranded RNA viruses

Require viral RNA-dependent RNA transcriptase. Genome often segmented. Some viruses include (+) and (–) strand regions.



Rabies virus

Segmented, enveloped viruses

Orthomyxoviridae. Influenza virus causes major epidemics among humans and animals.

Nonsegmented, enveloped viruses

Filoviridae. Ebola virus causes outbreaks among humans and chimpanzees.

Paramyxoviridae. Infect humans and cause measles, mumps, and parainfluenza.

Rhabdoviridae. Rabies virus infects mammals (virion length 130–300 nm).

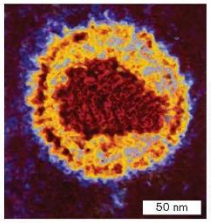
Segmented (+/–) strand, enveloped viruses

Arenaviridae. Spread by rodents; cause hemorrhagic fever and lymphocytic choriomeningitis.

Bunyaviridae. Hantaviruses are spread by rodents and infect humans. Tospoviruses are transmitted by thrips, infecting plants. Rift Valley fever virus infects livestock.

Group VI. Retroviruses (RNA reverse-transcribing viruses)

Viral reverse transcriptase copies RNA to DNA for integration into host chromosome.

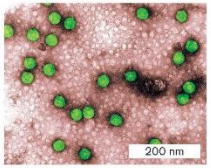


HIV-1

Retroviridae. Simple retroviruses include oncogenic retroviruses: feline leukemia virus, Rous sarcoma virus, avian leukosis virus. Lentiviruses (complex retroviruses) include human immunodeficiency virus (HIV, the cause of AIDS) and simian immunodeficiency virus (SIV). Lentiviruses are engineered to make lentiviral vectors (lentivectors) for gene therapy.

Group VII. Pararetroviruses (DNA reverse-transcribing viruses)

DNA transcribed to RNA; reverse-transcribed to DNA using host reverse transcriptase or packaged viral reverse transcriptase.



Cauliflower mosaic virus

Nonenveloped plant viruses

Badnaviridae. Infect bananas, cocoa plants, citrus, yams, and sugarcane.

Caulimoviridae. Transmitted by aphids; cauliflower mosaic virus and related viruses infect cauliflower, broccoli, groundnuts, soybeans, and cassava. The cauliflower mosaic virus promoter sequence is used to construct vectors to insert genes into transgenic plants.

Enveloped animal viruses

Hepadnaviridae. Hepatitis B virus causes widespread disease of the human liver.

5. How are viruses classified or grouped? - 2

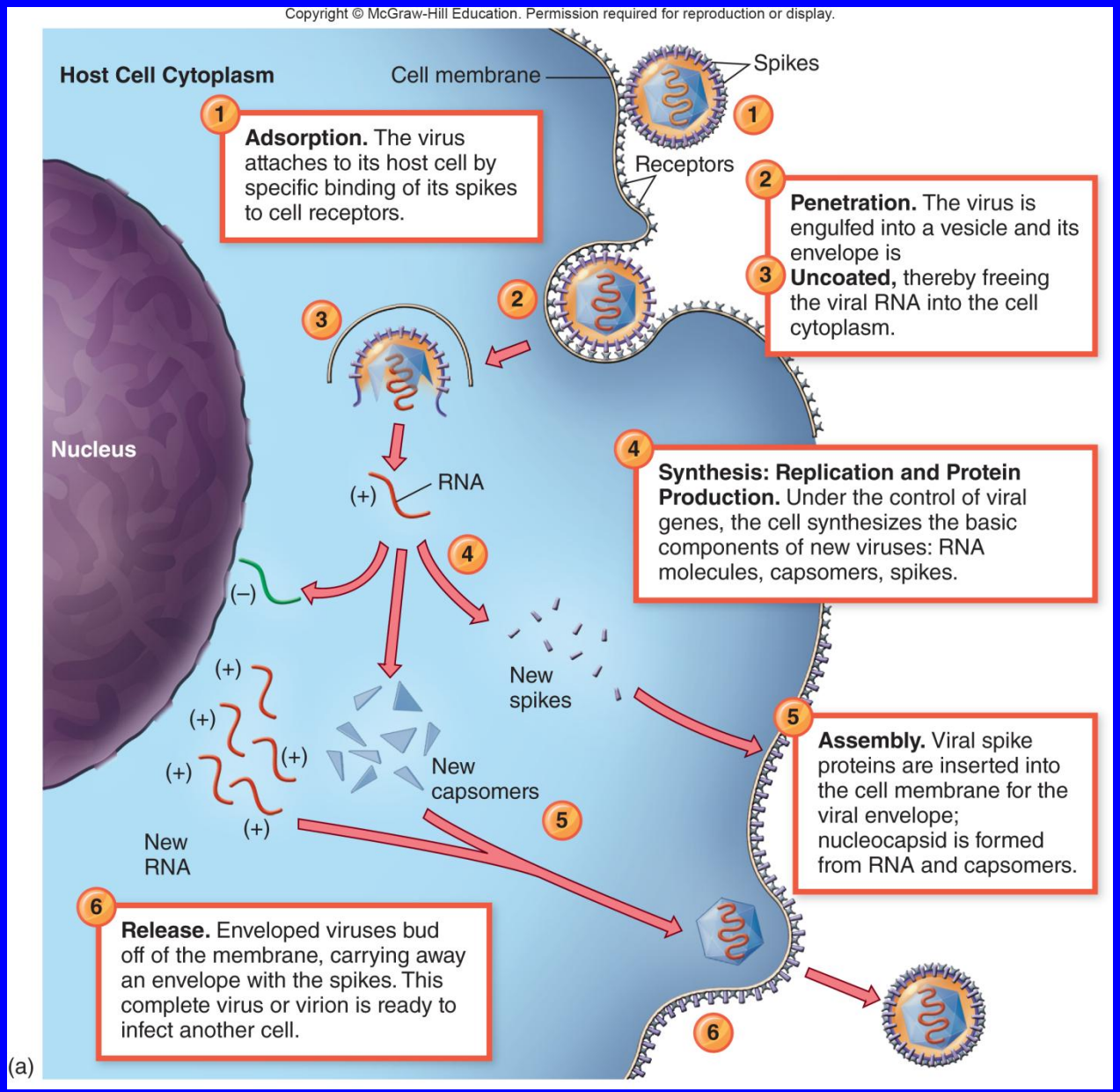
Properties used to Organize into Groups

a. Nature of genetic material –
   - DNA or RNA, ss vs ds

b. Means of replication -

Properties used to organize into subgroups

a. Outer covering – whether have envelope or not (nonenveloped)
b. Shape of virus particle/capsid
c. Organisms, cells the virus infects
d. If genome segmented or not

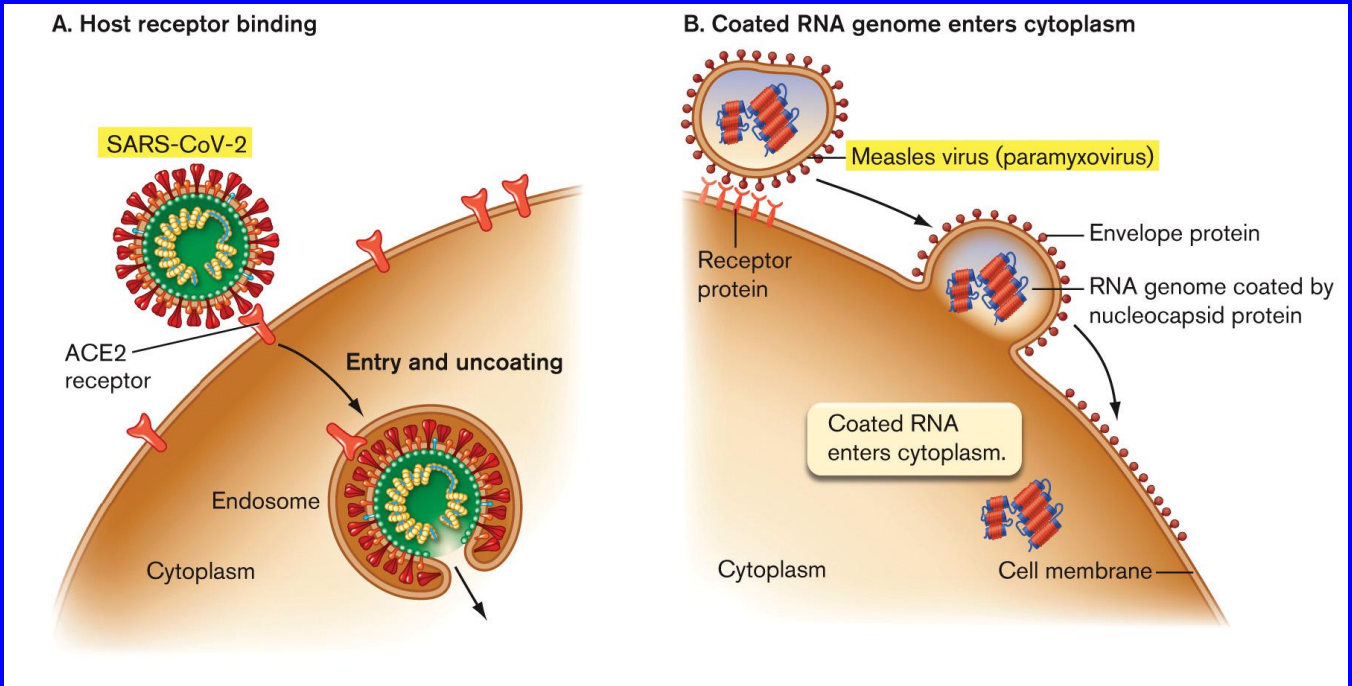


6. Multiplication Cycle of an Animal Virus

6. Steps in Viral Multiplication in Animal Cells

a. Adsorption – attachment to receptors on host cell to be infected

Major factor determining host range (kinds of cells that can be infected by virus)



6. Steps in Viral Multiplication

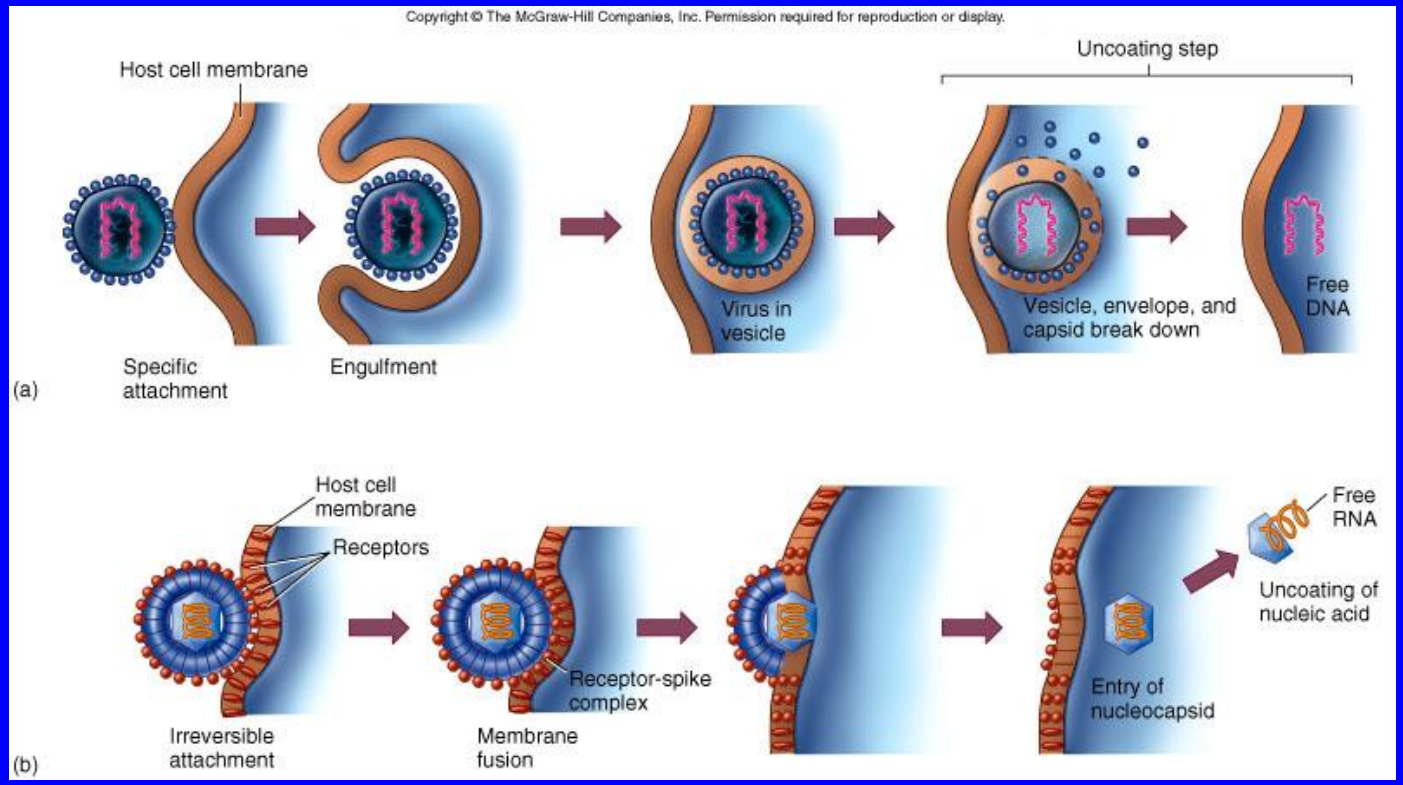
b. Penetration – entry into cell

c. Uncoating– release of viral genome

Figure: Two Examples for animal viruses

1) Endo-cytosis – to endosome vesicle

2) Fusion of membranes

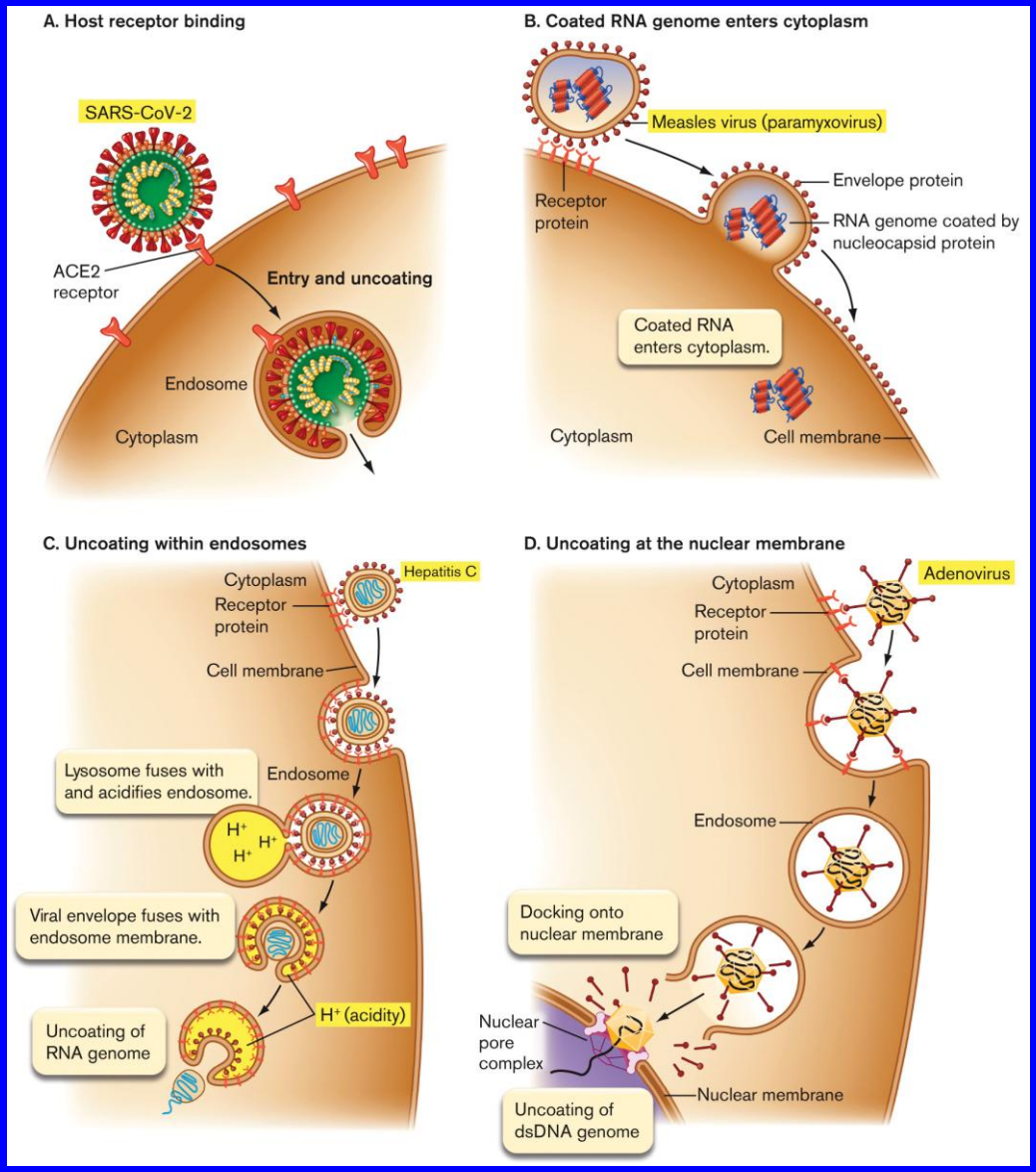


6. Steps in Animal Virus Multiplication

b. Penetration –
c. Uncoating–

Figure 6.26 6th edition Mechanisms

A. Endocytosis to endosome and uncoating
B. Fusion and release
C. Uncoating within Endosome
D. Endosome to nucleus



6. Steps in Viral Multiplication - 2

d. Synthesis –

Need to do two things

1) Replicate or make copies of their genetic material

DNA → more DNA, usually double-stranded (ds)

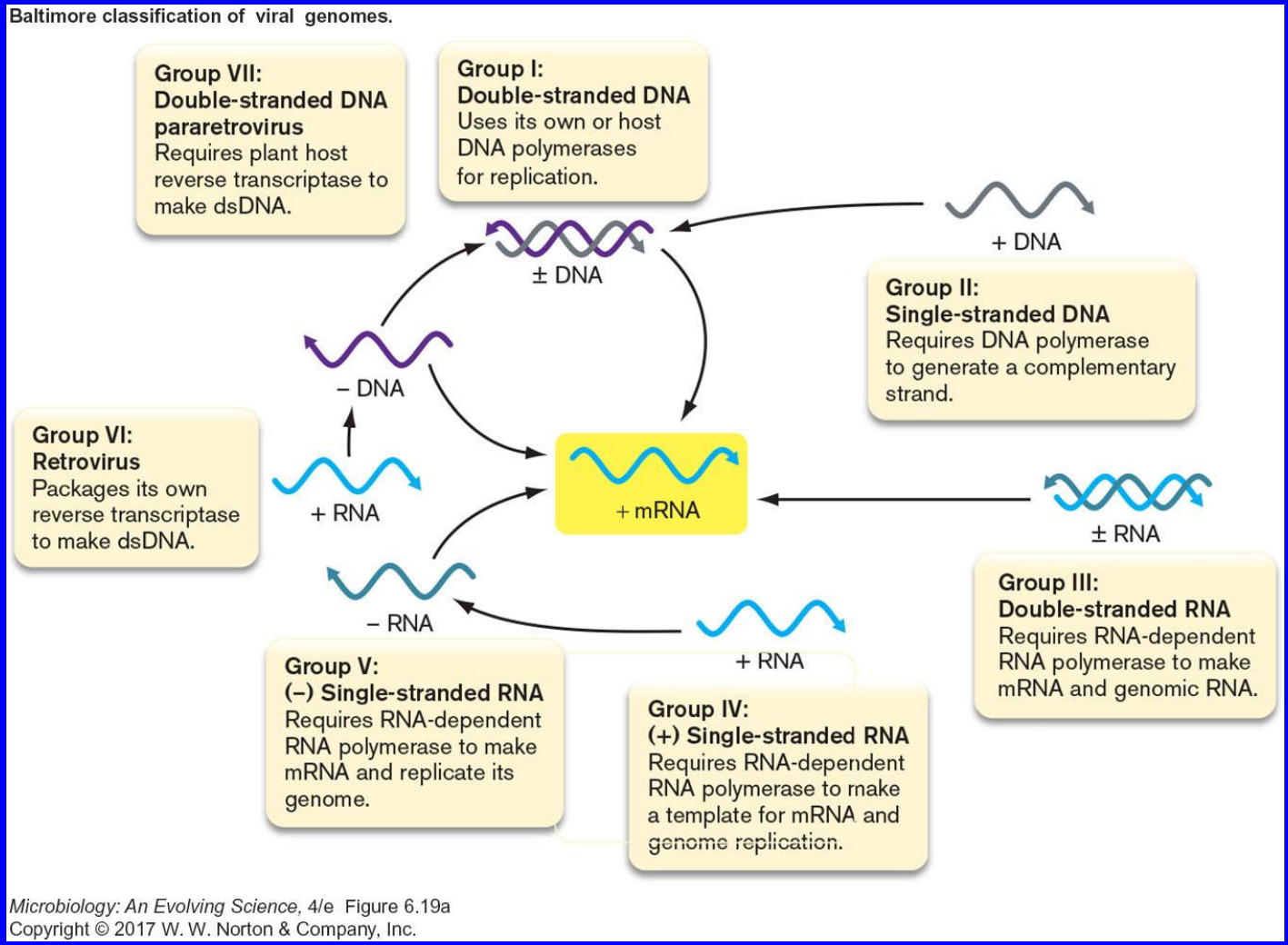
Single stranded (ss) RNA → more ssRNA

2) Synthesis multiple copies of their proteins

Viral mRNA → proteins.

- Done in different ways by different viruses
- Depends on nature of genetic material
- Needed enzymes can be encoded by virus or found in host cell

Source of Enzymes for Synthesis Stage



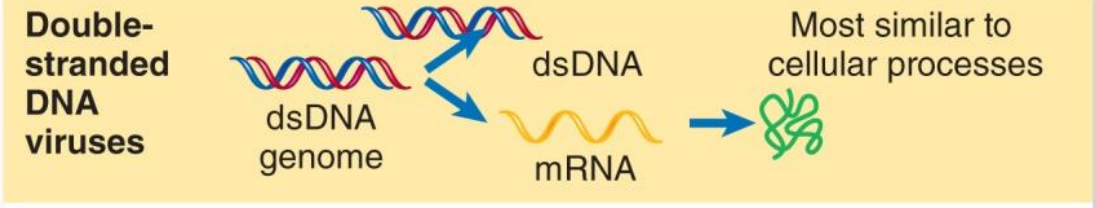
Microbiology: An Evolving Science, 4/e Figure 6.19a

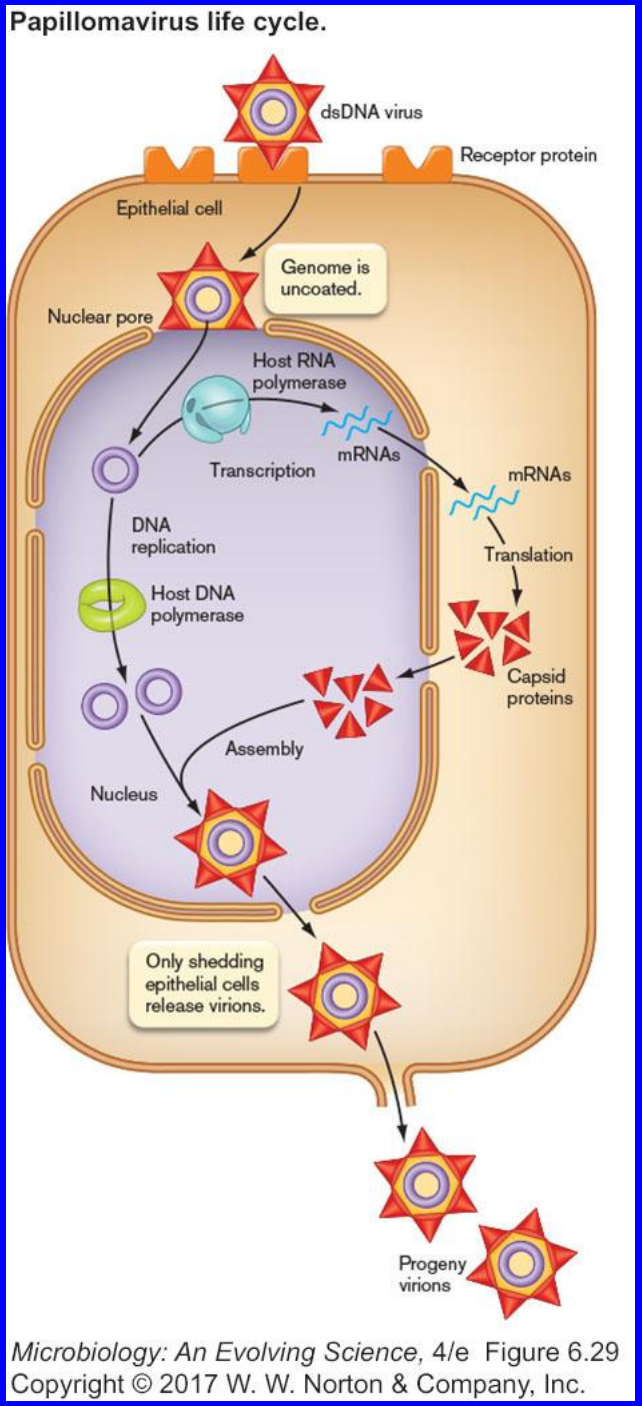
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Group I: dsDNA viruses

Duplication/replication of Genome
- dsDNA → more dsDNA molecules
- Source DNA polymerase: host cell or viral encoded

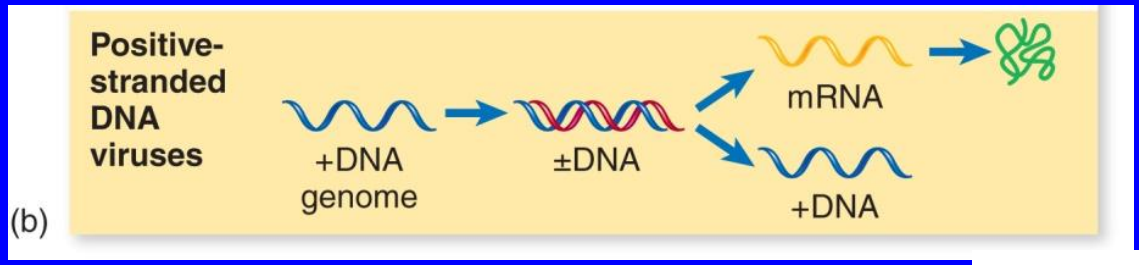
Synthesis of virus proteins
- dsDNA → ssRNA → proteins
- DNA-dependent RNA pol: Host or virus derived
- Source ribosome: host cell





Microbiology: An Evolving Science, 4/e Figure 6.29
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Group II ssDNA viruses

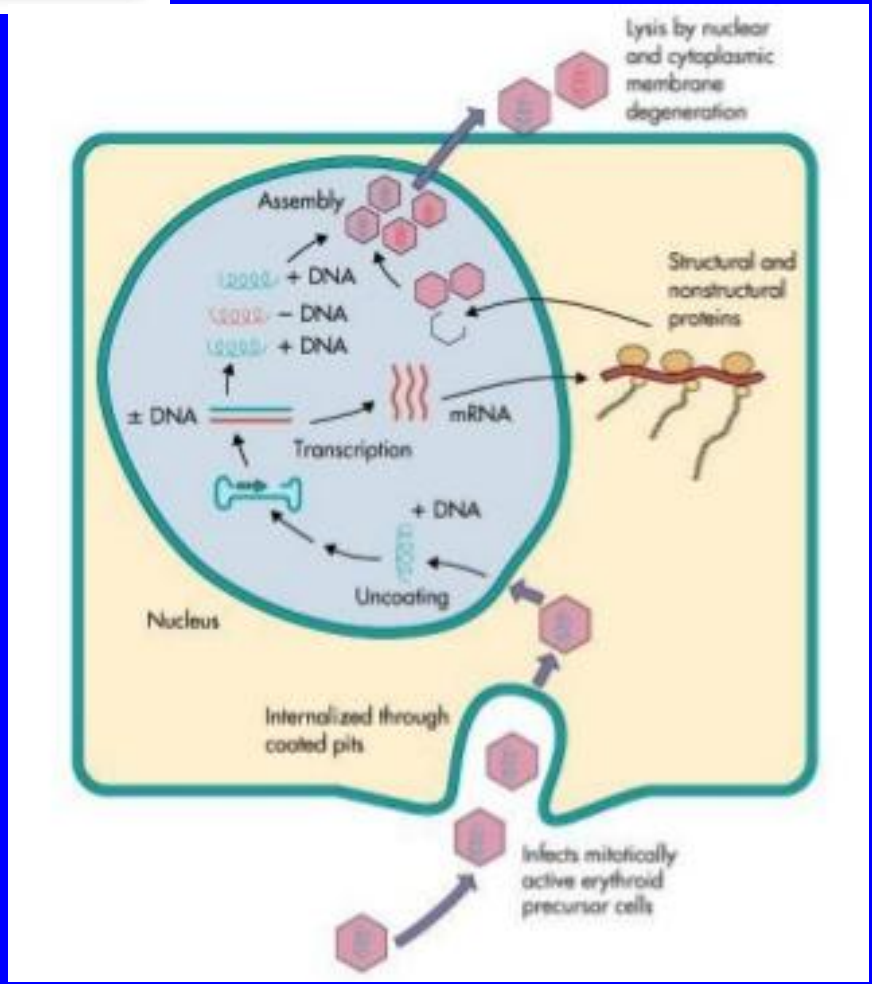


ssDNA → dsDNA → ssDNA

- Source DNA polymerase: host

dsDNA → RNA → protein

- Source of RNA polymerase: host or virus
- Source of ribosome: Host

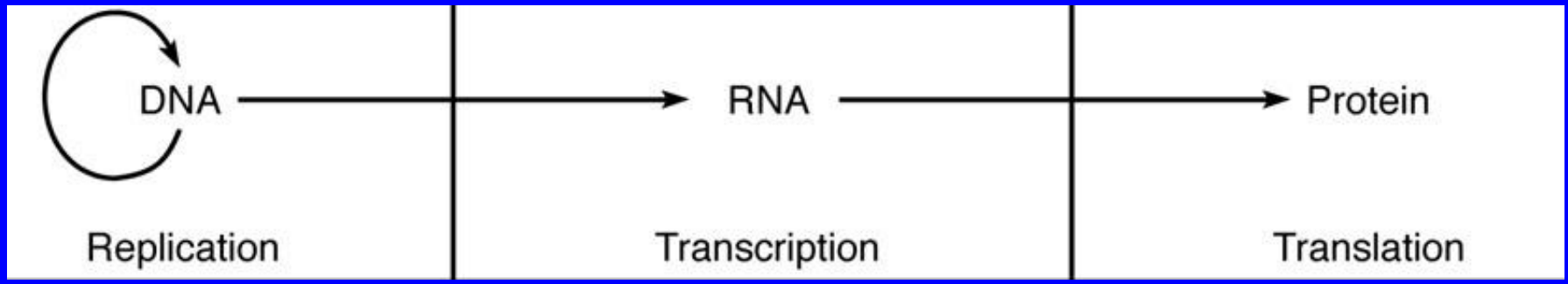


Replication of Viral RNA genomes

Genetic material – RNA, usually single stranded (ss)

Problem - Have to use RNA as template to make more RNA (RNA-dependent RNA polymerase – RdRP)

- Main host cell DNA pol and RNA pol use DNA as template
- Most host cells do not have RNA dep. RNA polymerase or vary low levels



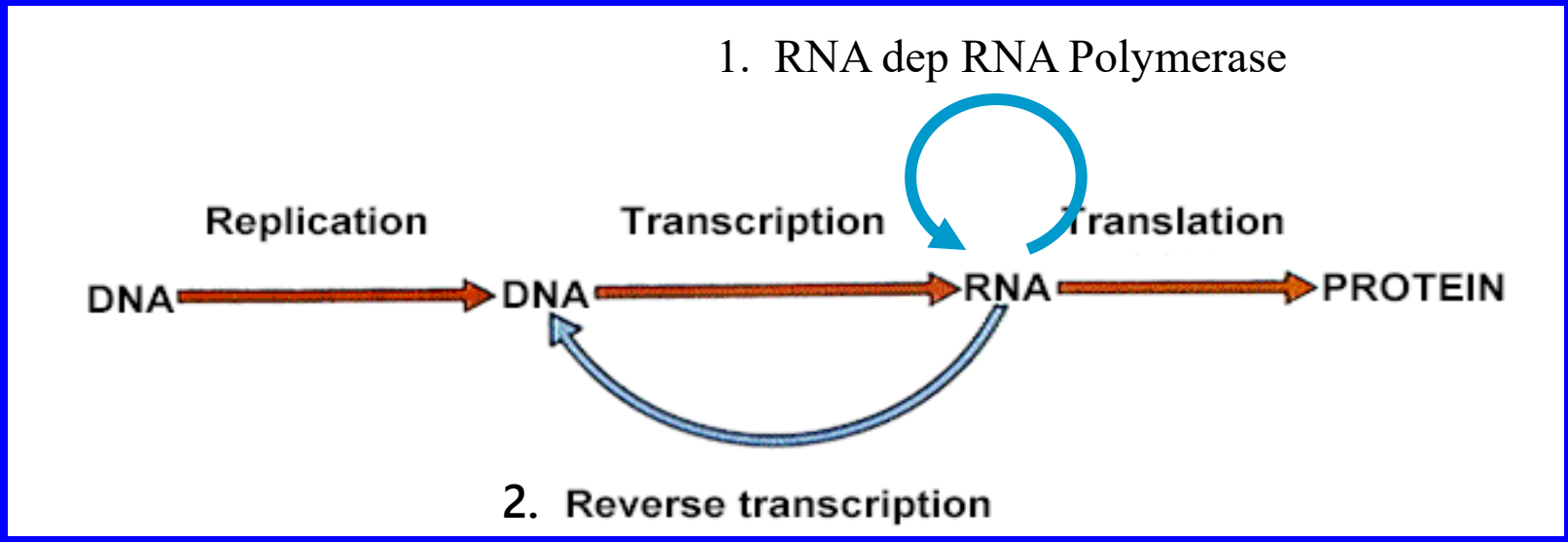
Replication of Viral RNA genomes - 2

Solution

- Viruses usually encode enzymes that can replicate RNA

Two different replication mechanisms

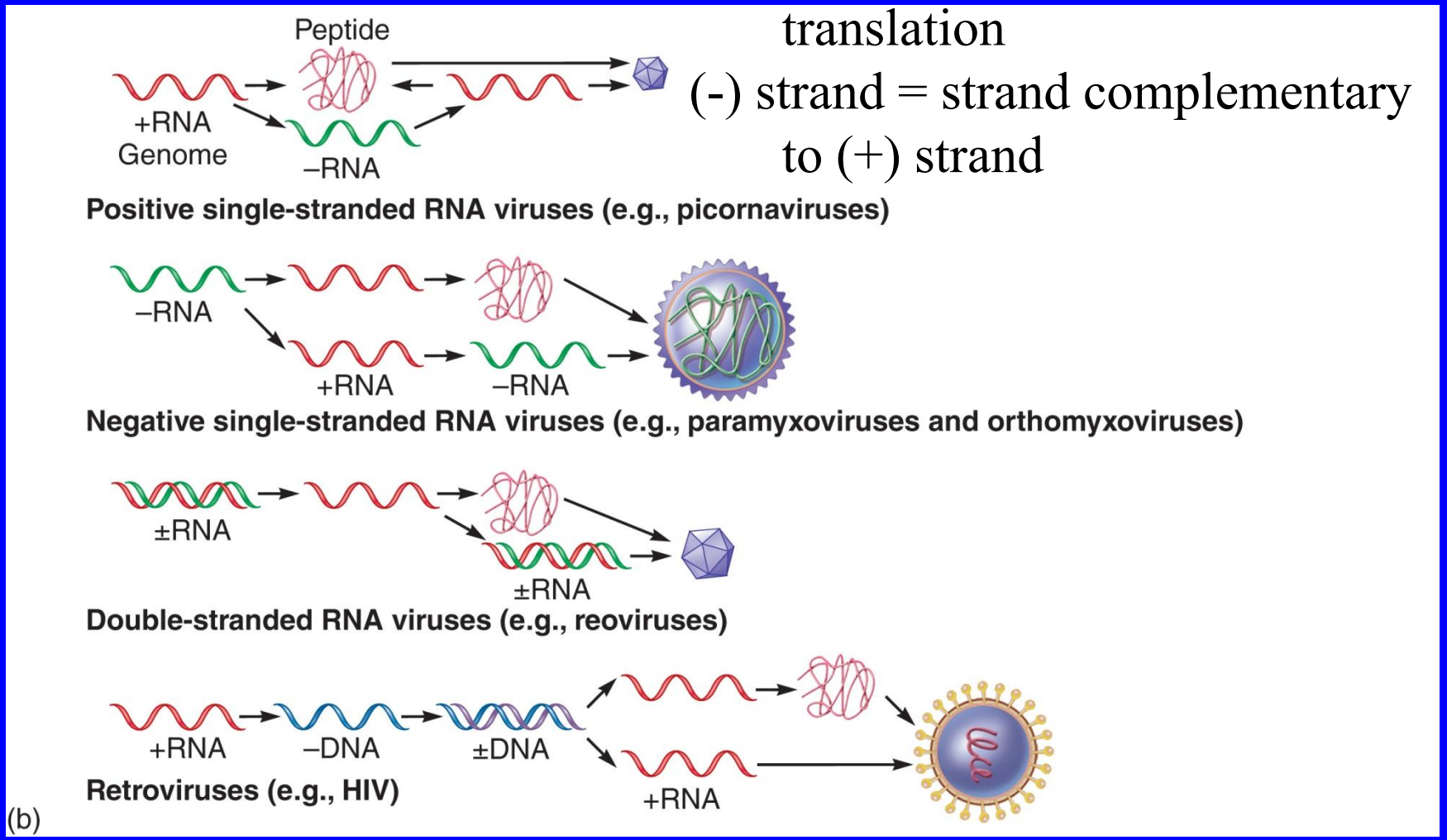
1. RNA dependent RNA polymerases
   ssRNA → complementary ssRNA → ssRNA
2. Reverse transcriptase of retroviruses
   ssRNA → ssDNA → dsDNA → ssRNA



Replication of Viral RNA Genomes - 3

Note: + strand = the strand that serves as template for translation

(-) strand = strand complementary to (+) strand



Group III ds RNA viruses

Genome:

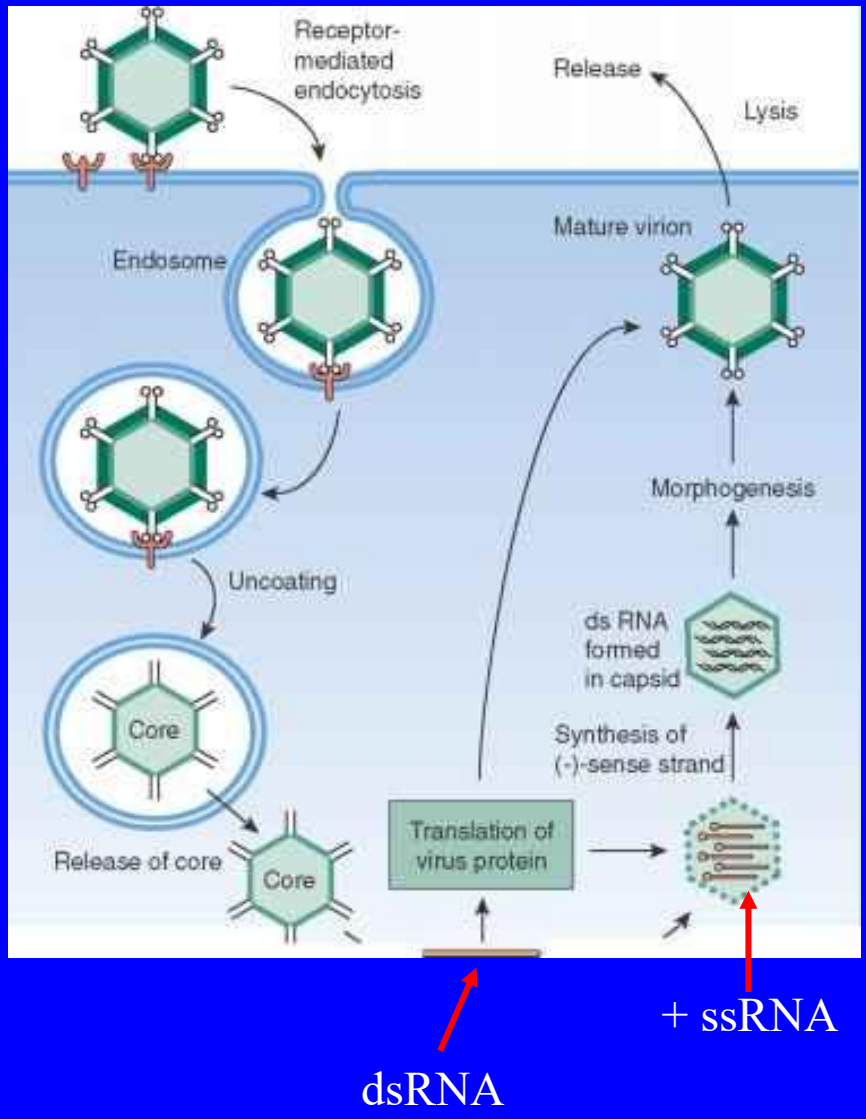
dsRNA → (+) ssRNA → dsRNA

- Use RNA dependent RNA polymerase from virus

Proteins

(+) ssRNA → proteins

Ribosomes: Host



Group IV Positive sense (+) RNA viruses

Genome:

(+) ssRNA → (-) ssRNA → (+) ssRNA

- Use RNA dependent RNA polymerase from virus

Proteins

(+) ssRNA → proteins

- (+) ssRNA carried in particle can be translated immediately
- Ribosomes: Host

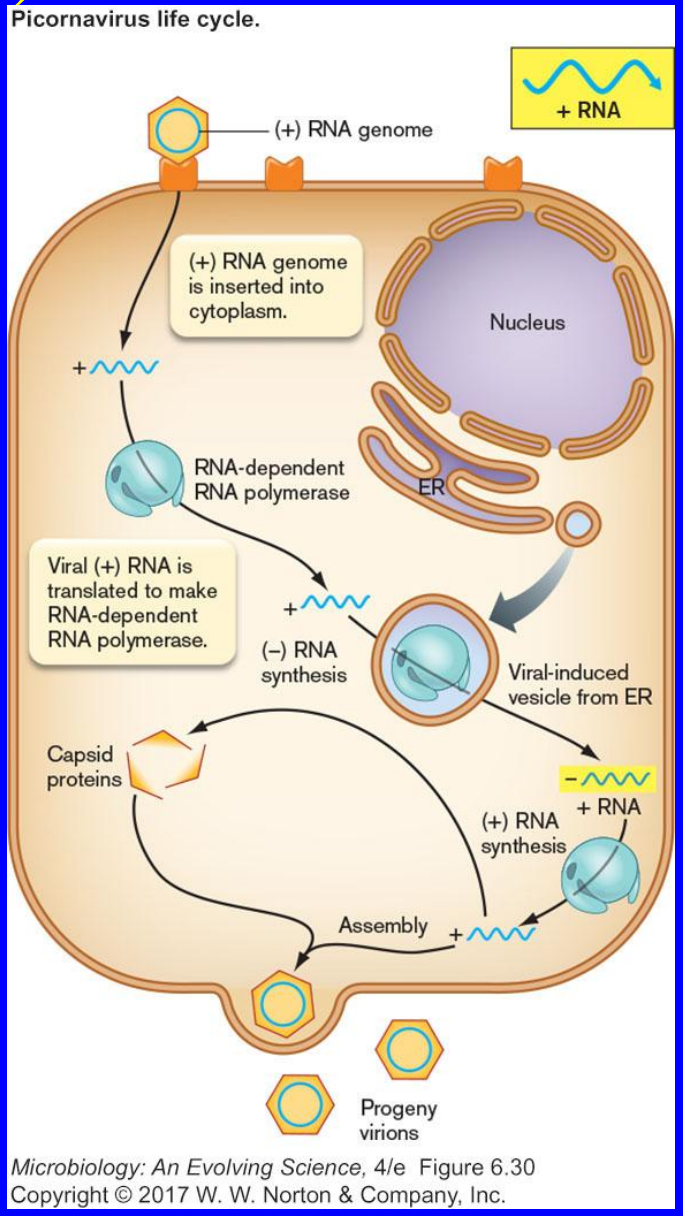


Figure 6.30
4th edition

Group V Negative sense (-) ssRNA viruses

Genome:

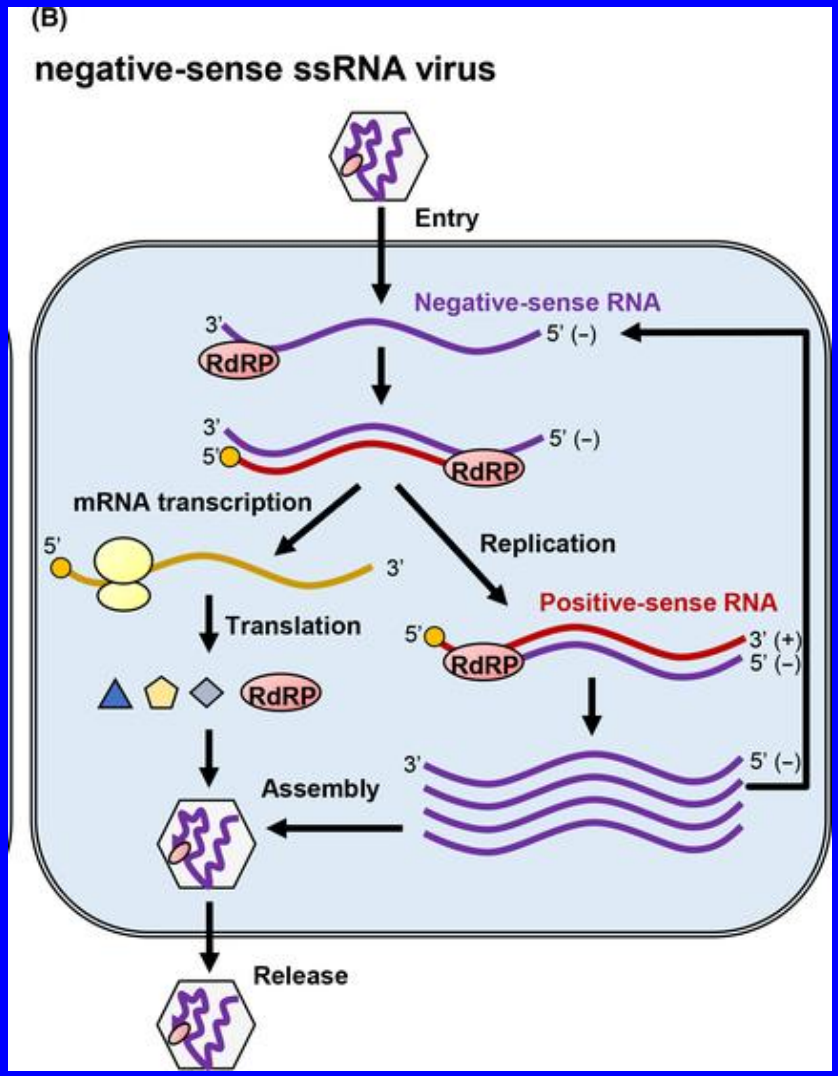
(-) ssRNA → (+) ssRNA → (-) ssRNA

- RNA dependent RNA polymerase (RdRP) from virus

Proteins

(+) ssRNA → proteins

- Ribosome: Host



Group VI RNA retroviruses

Genome

(+)ssRNA → ssDNA → dsDNA → (+)ssRNA

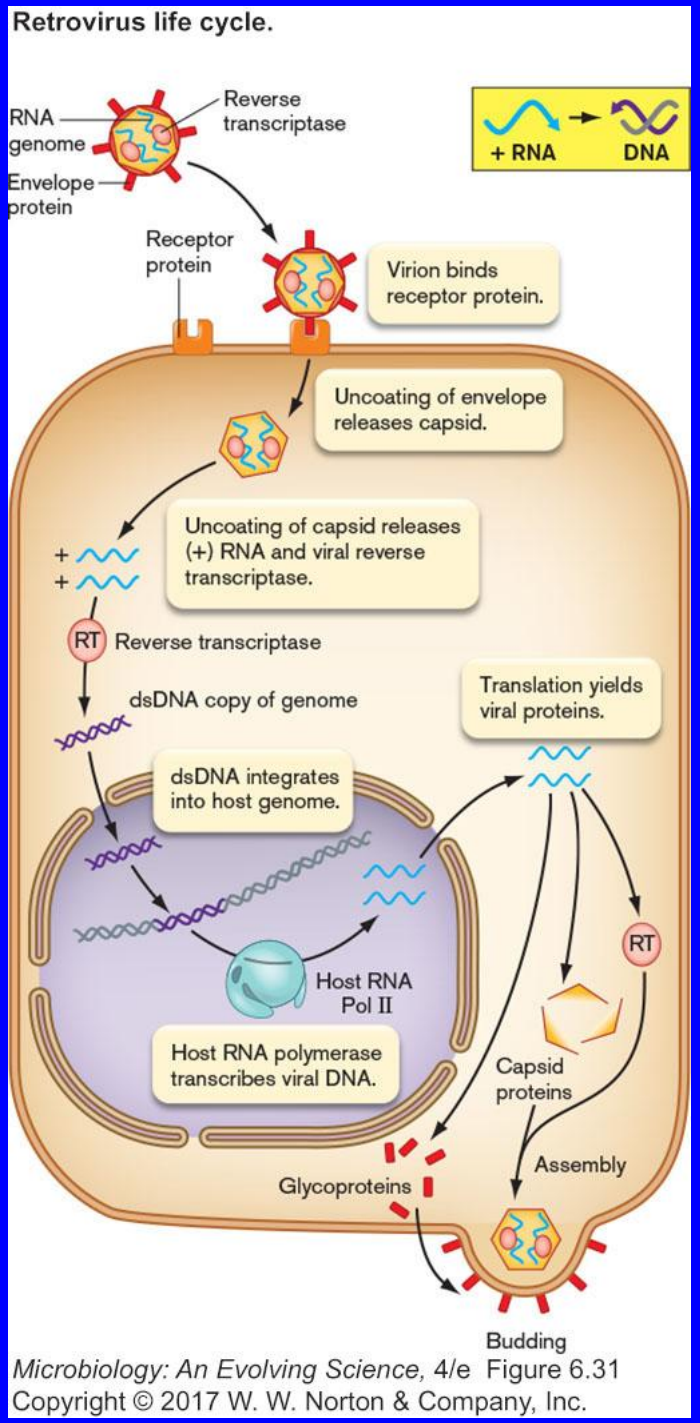
- Source reverse transcriptase: virus
- Last step DNA dependent RNA polymerase: host derived

Protein

dsDNA → (+)ssRNA → protein

- Source of RNA polymerase: host
- Source of ribosome: Host

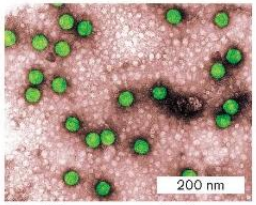
Figure 6.31
4th edition



Group VII DNA reverse-transcribing viruses

Group VII. Pararetroviruses (DNA reverse-transcribing viruses)

DNA transcribed to RNA; reverse-transcribed to DNA using host reverse transcriptase or packaged viral reverse transcriptase.



Cauliflower mosaic virus

Nonenveloped plant viruses

Badnaviridae. Infect bananas, cocoa plants, citrus, yams, and sugarcane.

Caulimoviridae. Transmitted by aphids; cauliflower mosaic virus and related viruses infect cauliflower, broccoli, groundnuts, soybeans, and cassava. The cauliflower mosaic virus promoter sequence is used to construct vectors to insert genes into transgenic plants.

Enveloped animal viruses

Hepadnaviridae. Hepatitis B virus causes widespread disease of the huma

Figure 6.38 6th edition

Genome

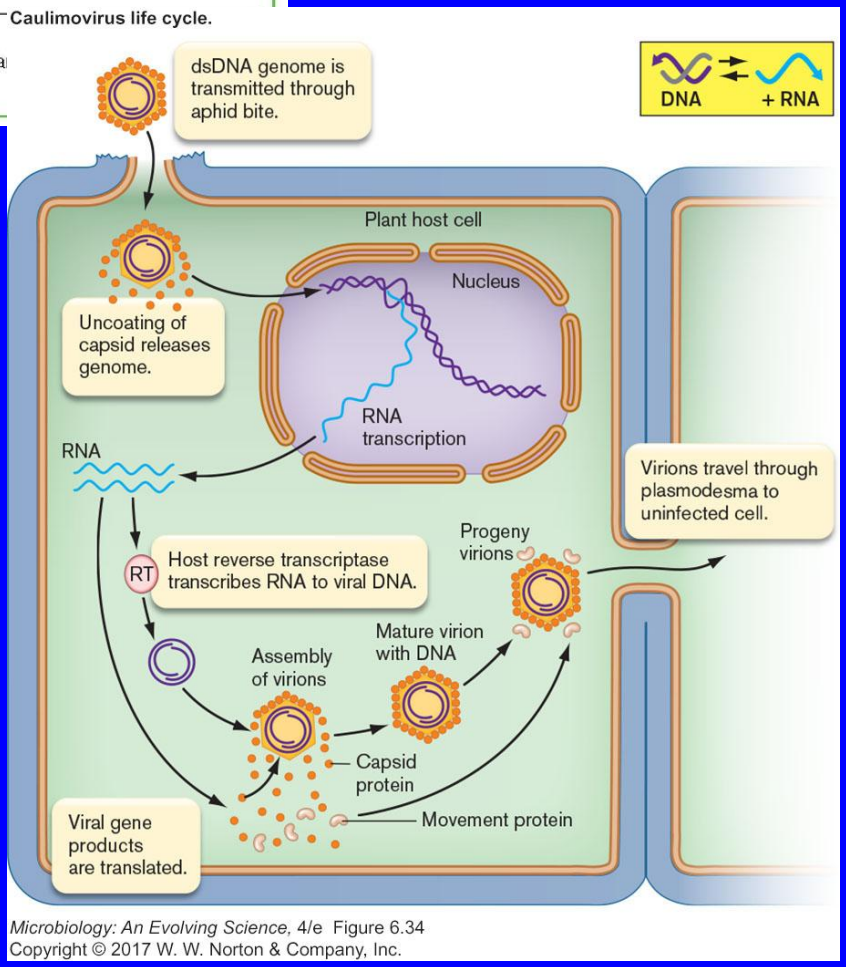
dsDNA → (+)ssRNA → dsDNA

- Source reverse transcriptase: virus or host cell

Protein

dsDNA → (+)ssRNA → protein

- Source of RNA polymerase: host?
- Source of ribosome: Host



Microbiology: An Evolving Science, 4/e Figure 6.34
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Source of Enzymes for Synthesis Stage - 2

Viruses Families	**Source of replication polymerase**	**Source of RNA polymerase for transcription**	**Source of ribosome for translation**
ds DNA viruses: Parvovirus, papilomavirus	Host DNA pol (first step)	Host	Host
ds DNA viruses: Adenovirus, Herpesvirus, Poxvirus	Virus encoded DNA dep. DNA pol (first step)	Host, except for poxvirus (virus encoded)	Host
RNA retro	Virus encoded RNA-dependent DNA polymerase (first step)	Host	Host
(+) ssRNA (-) ssRNA	Virus encoded RNA-dependent RNA pol (First step for (-) RNA)	Not applicable	Host (First step for (+) RNA)

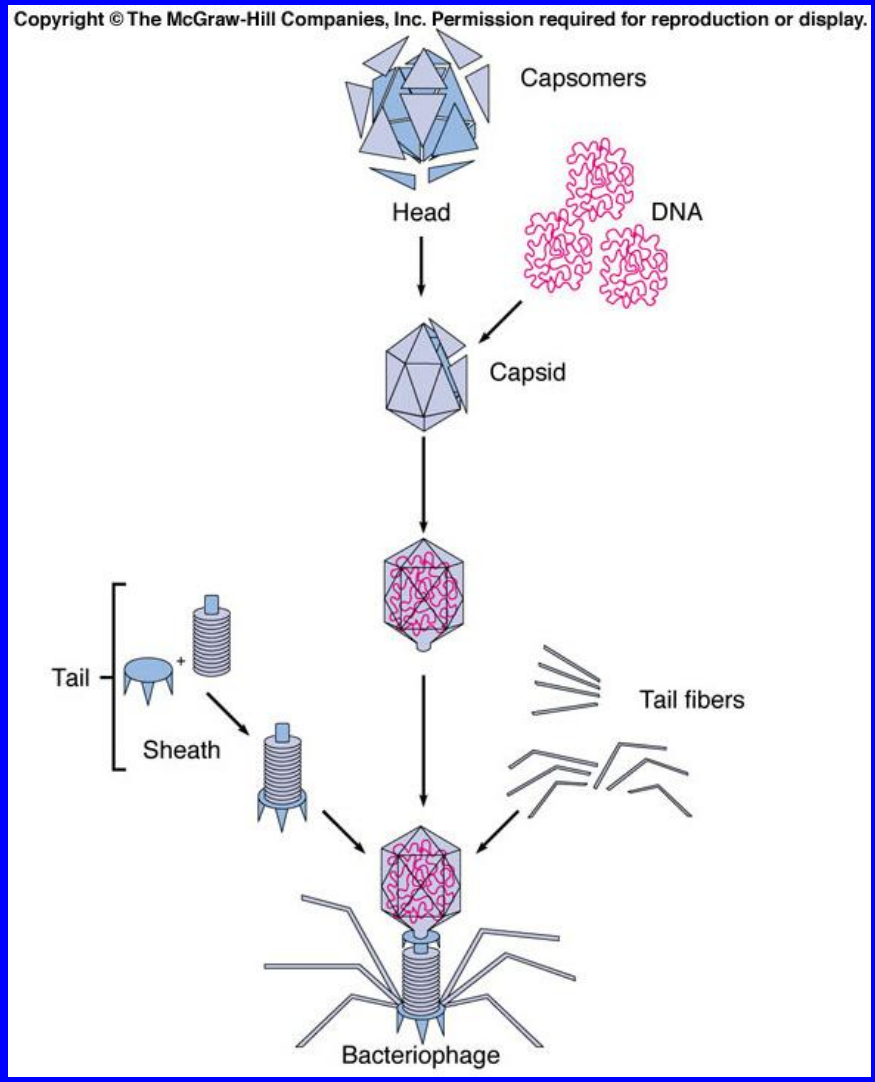
6. Steps in Viral Multiplication - 3

e. Assembly –

Assembled from parts, not by splitting

1) Proteins assemble to make capsomers, sheath

2) Parts of virus assembled



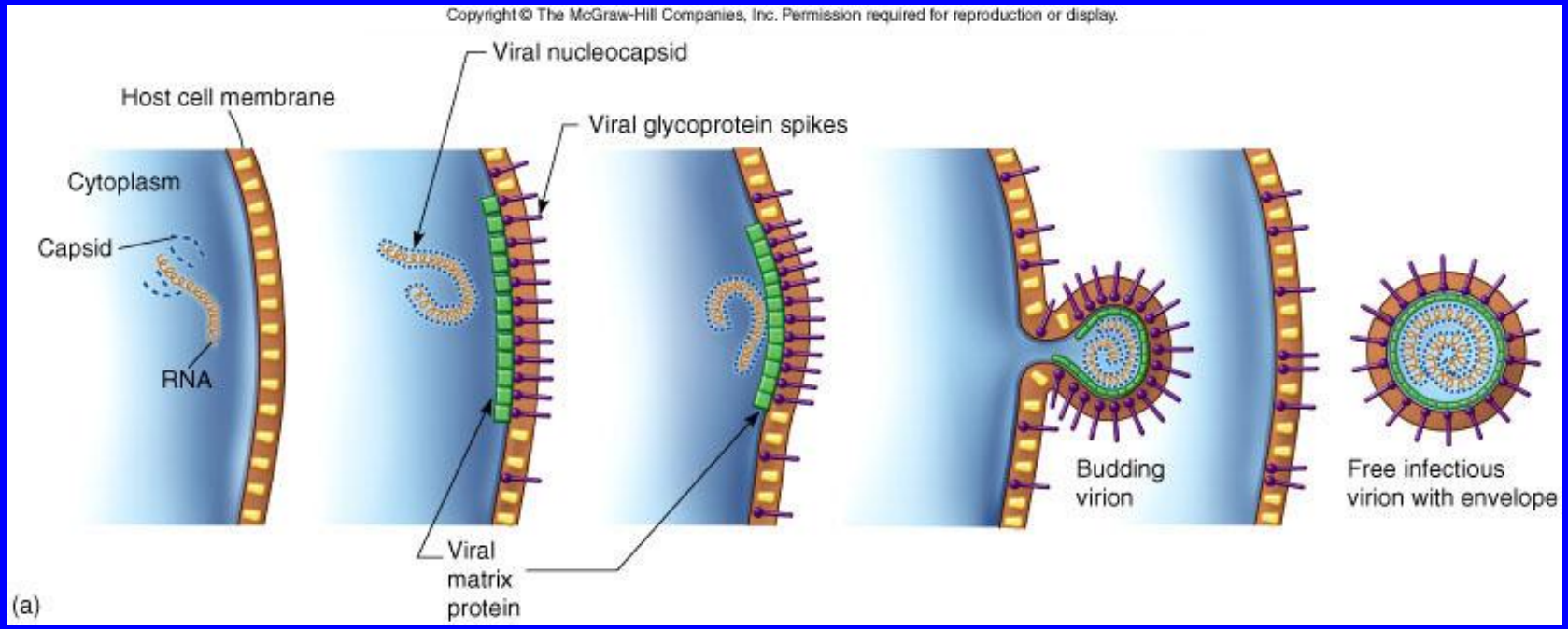
6. Steps in Viral Multiplication - 4

f. Release or escape

1) Lysis of host cell

2) Budding by enveloped viruses

- Can results in a Persistent infection



6. Steps in Viral Multiplication - 5

f. Release or escape

2) Budding by enveloped virus

- Budding by Filamentous Ebola virus Fig 6.10 6/3

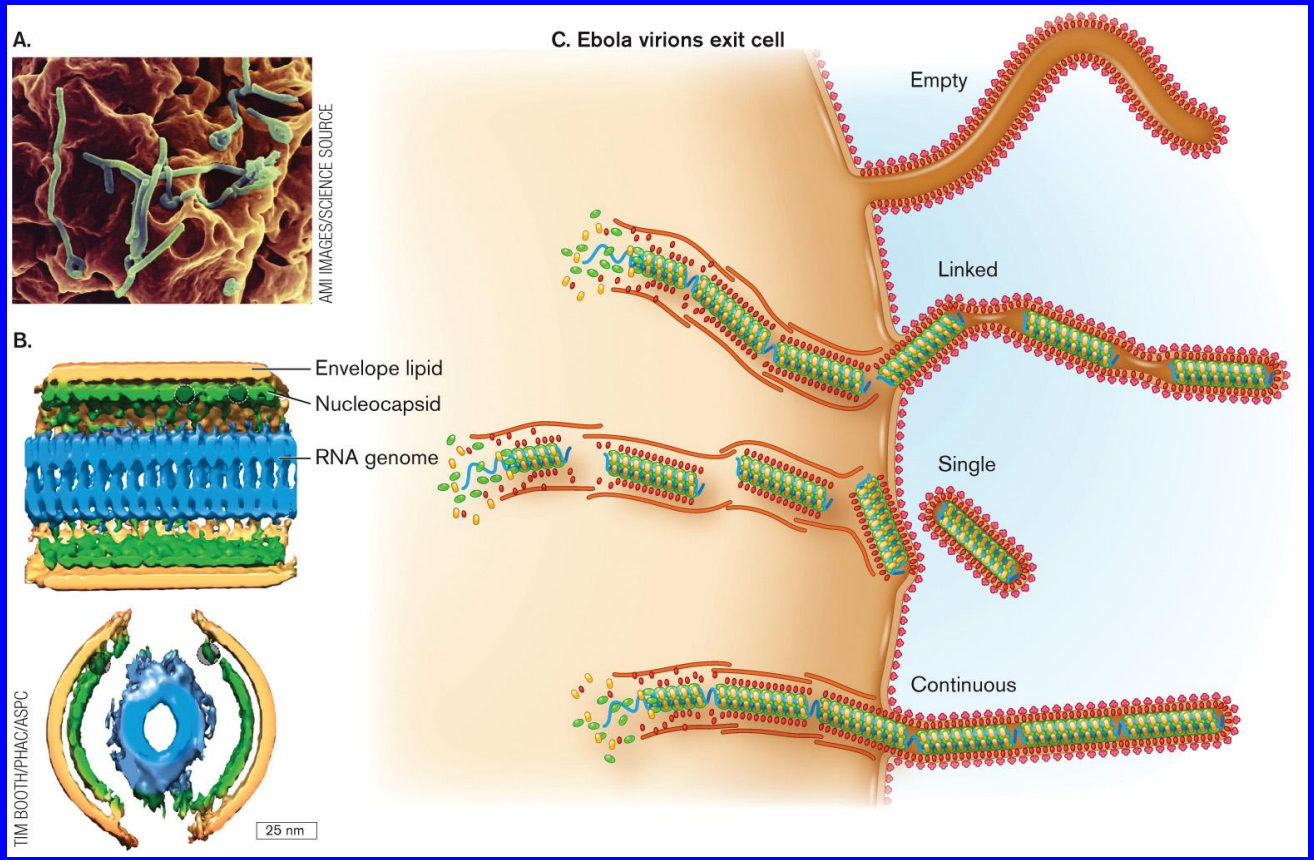


Figure 6.10
6th edition

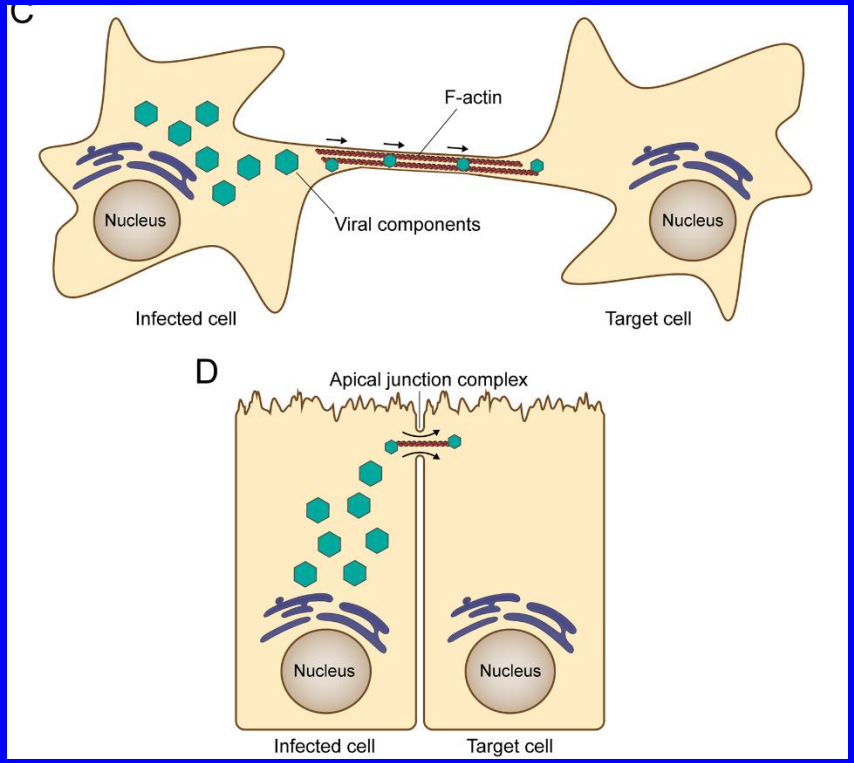
6. Steps in Viral Multiplication - 6

f. Release or escape

3) Cell-to-cell spread

– May lead to cell fusion

– syncytia formation



PLOS Pathogen 14(6): e1007015

6. Multiplication Cycle of SARS-CoV-2

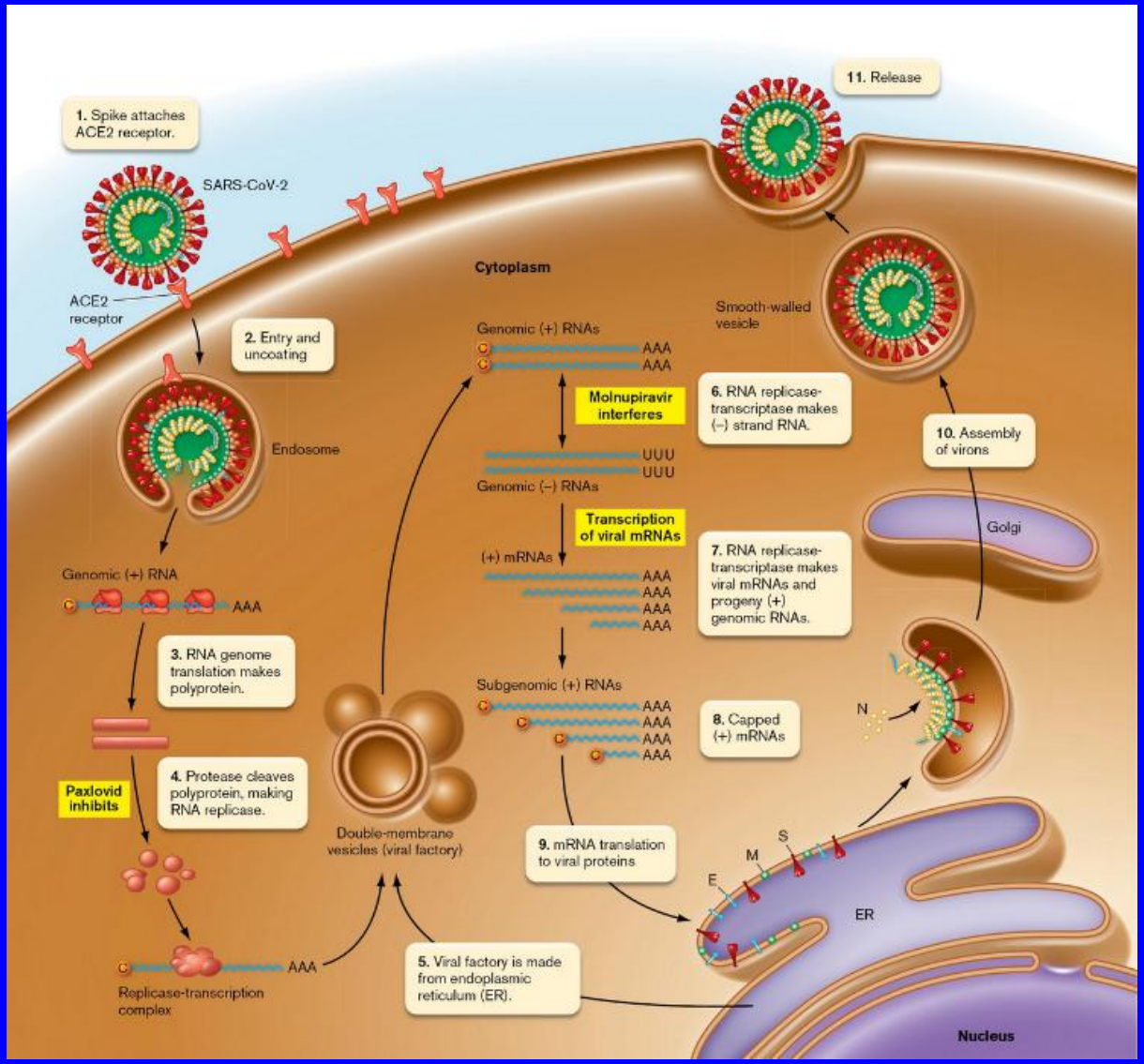


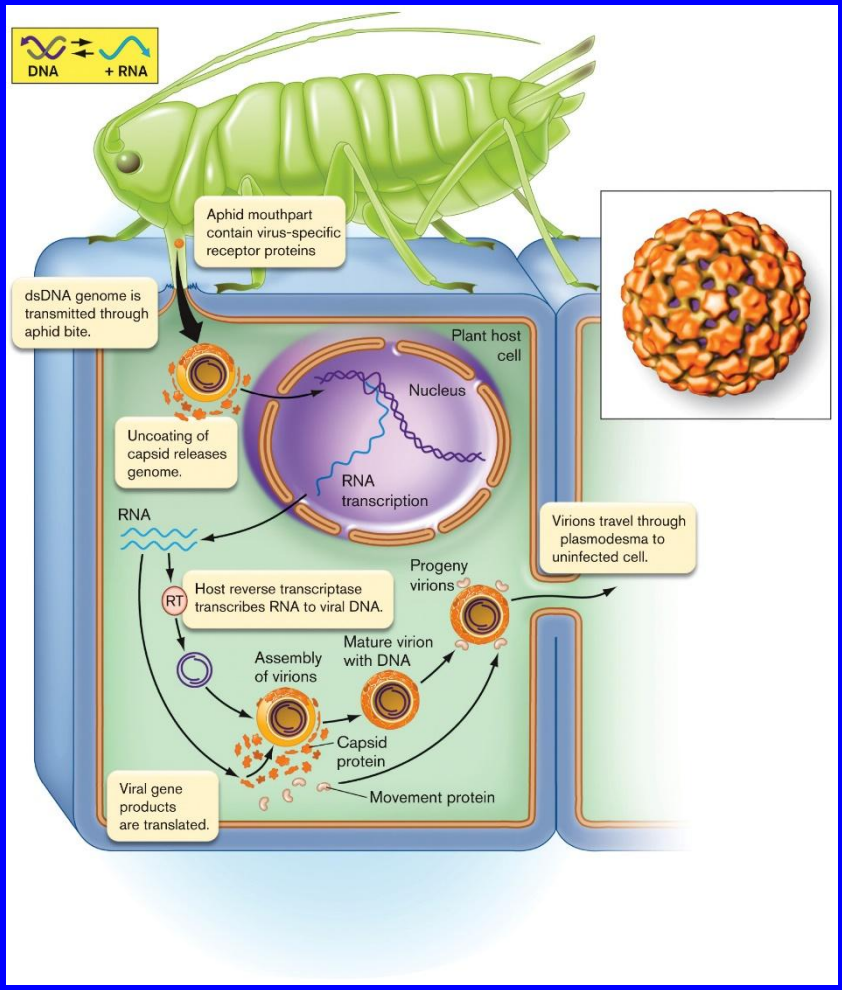
Figure 6.28 6th edition
See notes on slide for full explanation

6. Steps for Plant Viruses

a. Entry and penetration different

- Cell wall blocks entry without help
  1) Transmitted by animal vector (insect) – damages cells
  2) Contact damaged tissues with broken cells
  3) Infect seeds
- Then moves cell to cell through plasmodesma connections

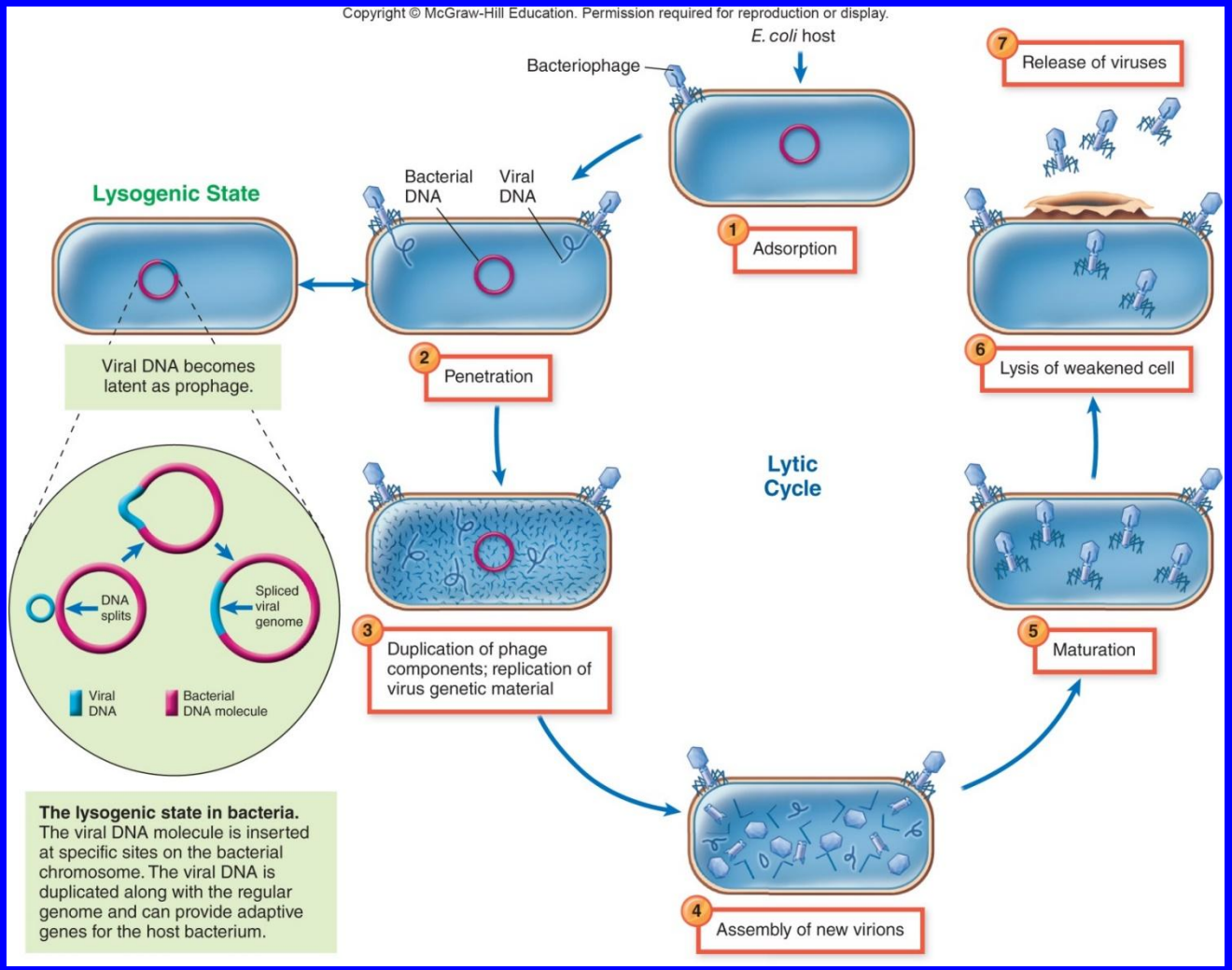
Figure 6.36 6th edition



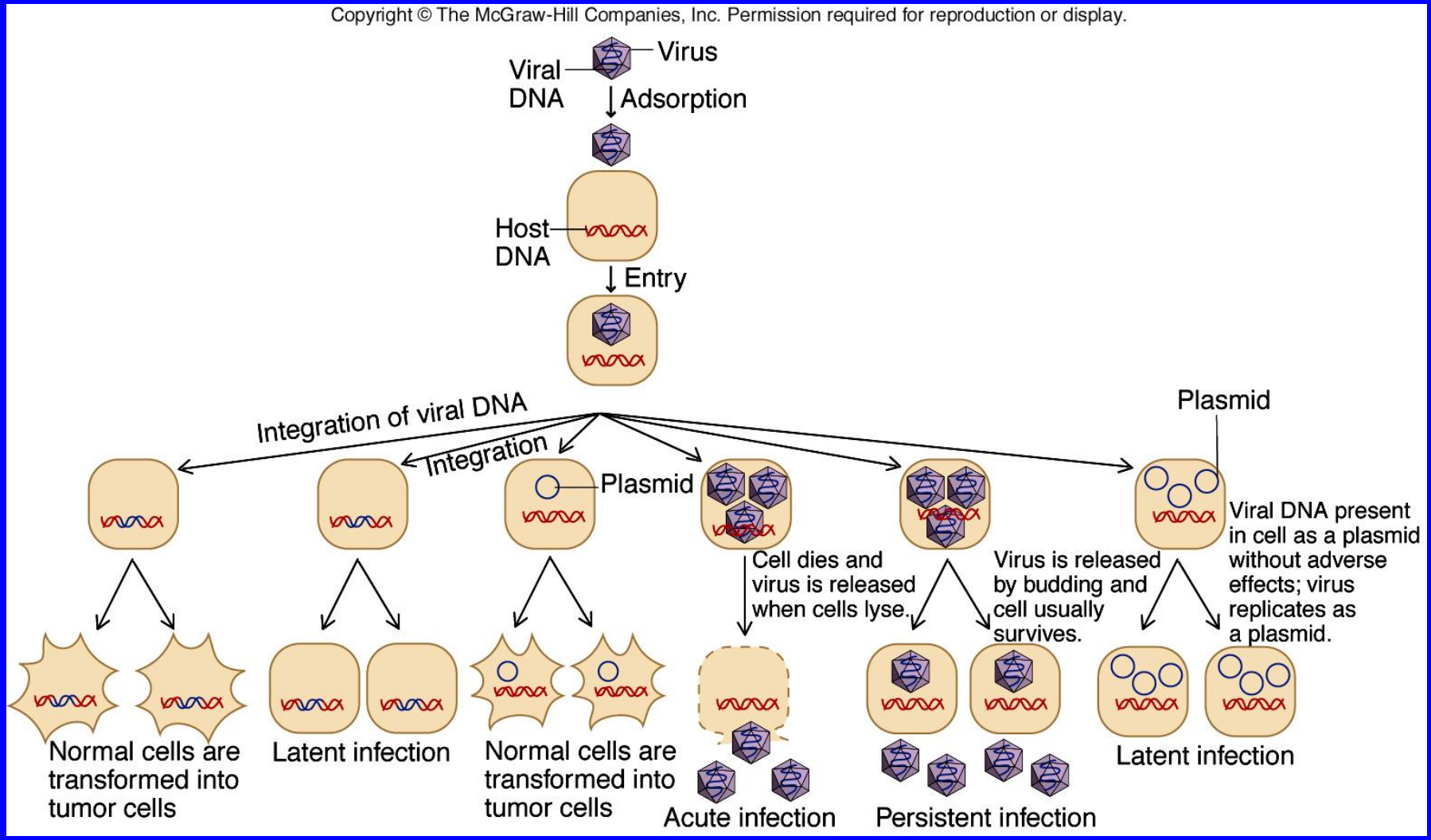
6. Multiplication Cycle of Bacteriophage

Differences/ Features

1. Most inject DNA into cell, leave particle on outside
2. Some can go latent (lysogen)
2. Most released by lysis



7. Outcomes of Viral Infection



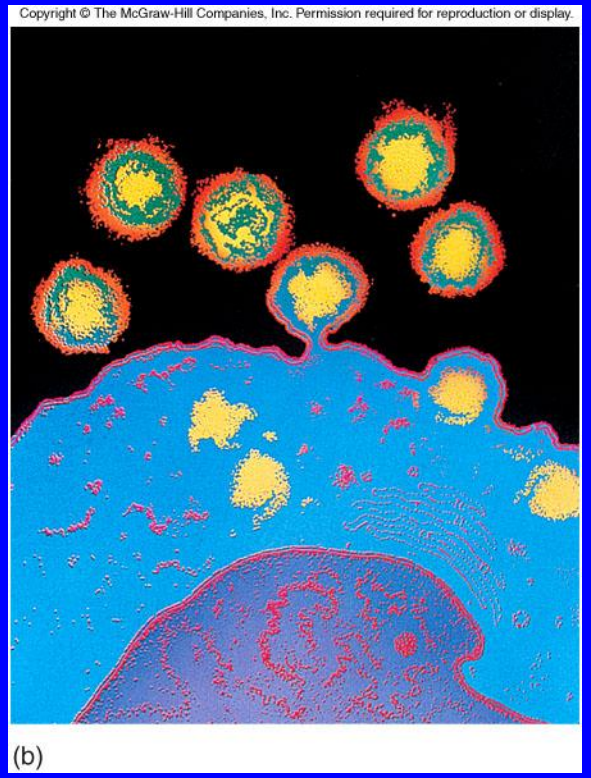
7. Outcome or Effect of Viral infection on Host Cell

a) Acute infection –

Death of host cells due to cell lysis

b) Persistent infection –

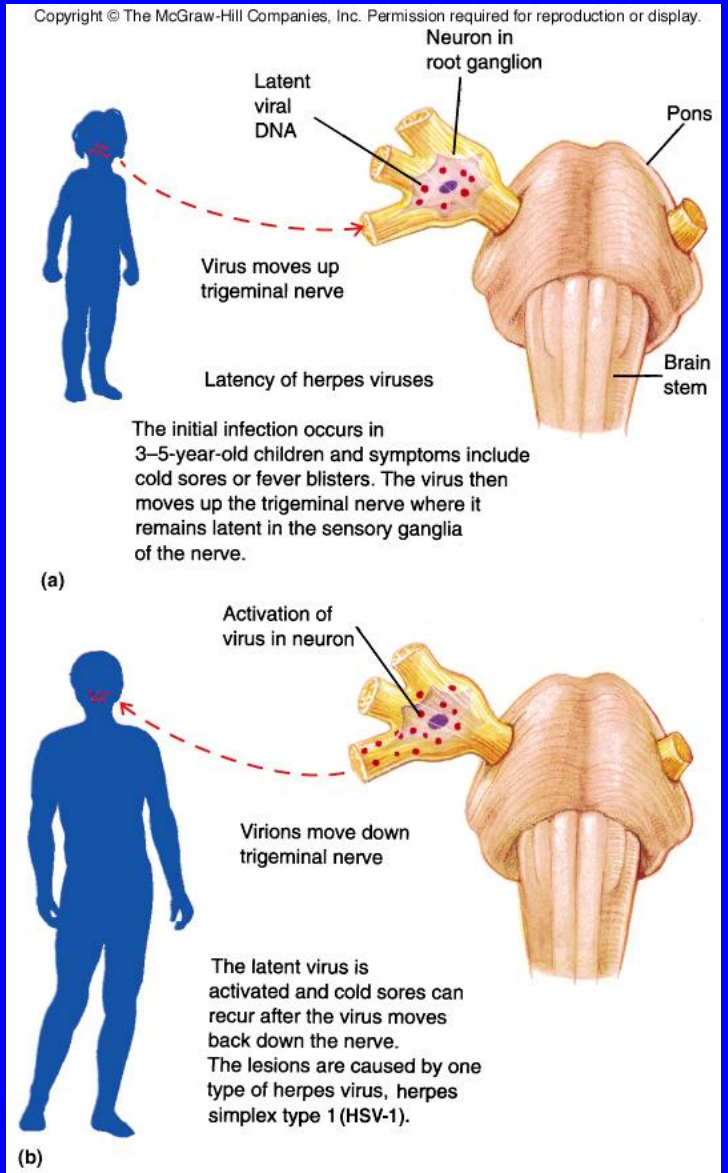
- Host cells continue to produce virus particles over a long period of time
- Slow release of virus
- Only done by enveloped virus which leave by budding



7. Outcome or Effect of Viral infection on Host Cell - 2

c. Chronic, latent infection –
   - Virus goes dormant in host cell
   - Can later reactivate and release virus particles

   Ex: Herpes virus
   - Virus goes latent in nerve cell
   - Will occasionally release virus particles which cause skin lesions



7. Outcome or Effect of Viral infection on Host Cell - 3

d. Cytopathic Changes
   – Infection alters appearance of cell (Table 6.5)

- Sometimes used in diagnosis

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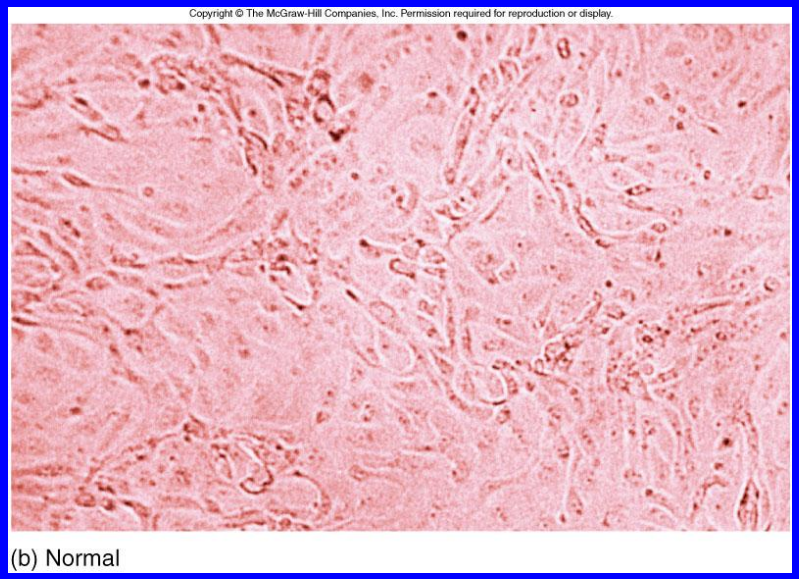
Table 6.5 Cytopathic Changes in Selected Virus-Infected Animal Cells

Virus	Response in Animal Cell
Smallpox virus	Cells round up; inclusions appear in cytoplasm
Herpes simplex	Cells fuse to form multinucleated syncytia; nuclear inclusions (see figure 6.17)
Adenovirus	Clumping of cells; nuclear inclusions
Poliovirus	Cell lysis; no inclusions
Reovirus	Cell enlargement; vacuoles and inclusions in cytoplasm
Influenza virus	Cells round up; no inclusions
Rabies virus	No change in cell shape; cytoplasmic inclusions (Negri bodies)
Measles virus	Syncytia form (multinucleate)

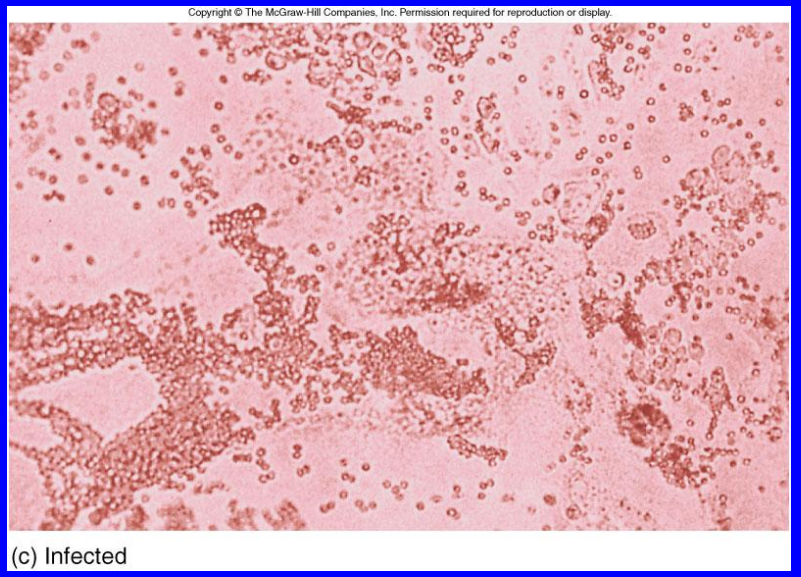
7. Outcome or Effect of Viral infection on Host Cell - 4

e. Transformation – cell becomes cancerous

- Some viruses contains oncogene or their integration generates an oncogene that promotes growth of host cell
- Altered appearance of cell (cytopathic effects)



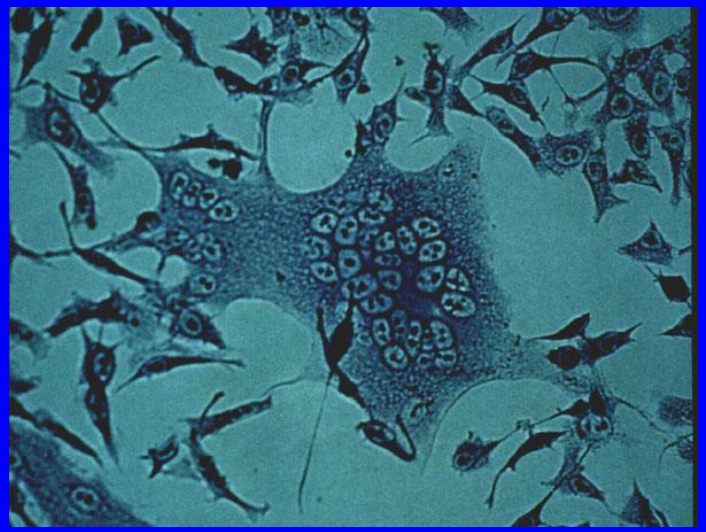
Normal, uninfected cells



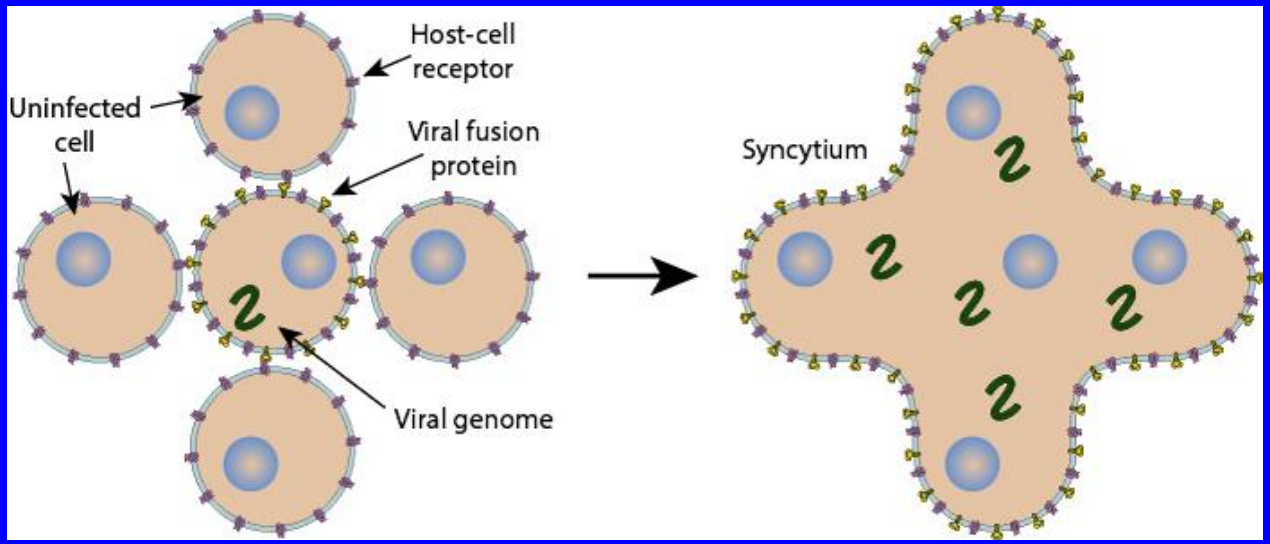
Virus-infected cells

7. Outcome or Effect of Viral infection on Host Cell - 5

f. Can cause the formation of large, multi-nucleated cells - syncytia



Observed in measles, RSV and herpes



7. Outcome or Effect of Viral infection on Host Cell - 6

g. Affects populations of microbes in various ecosystems

1) Mammalian gut

- Lots of bacteriophages that act against bacteria in intestine

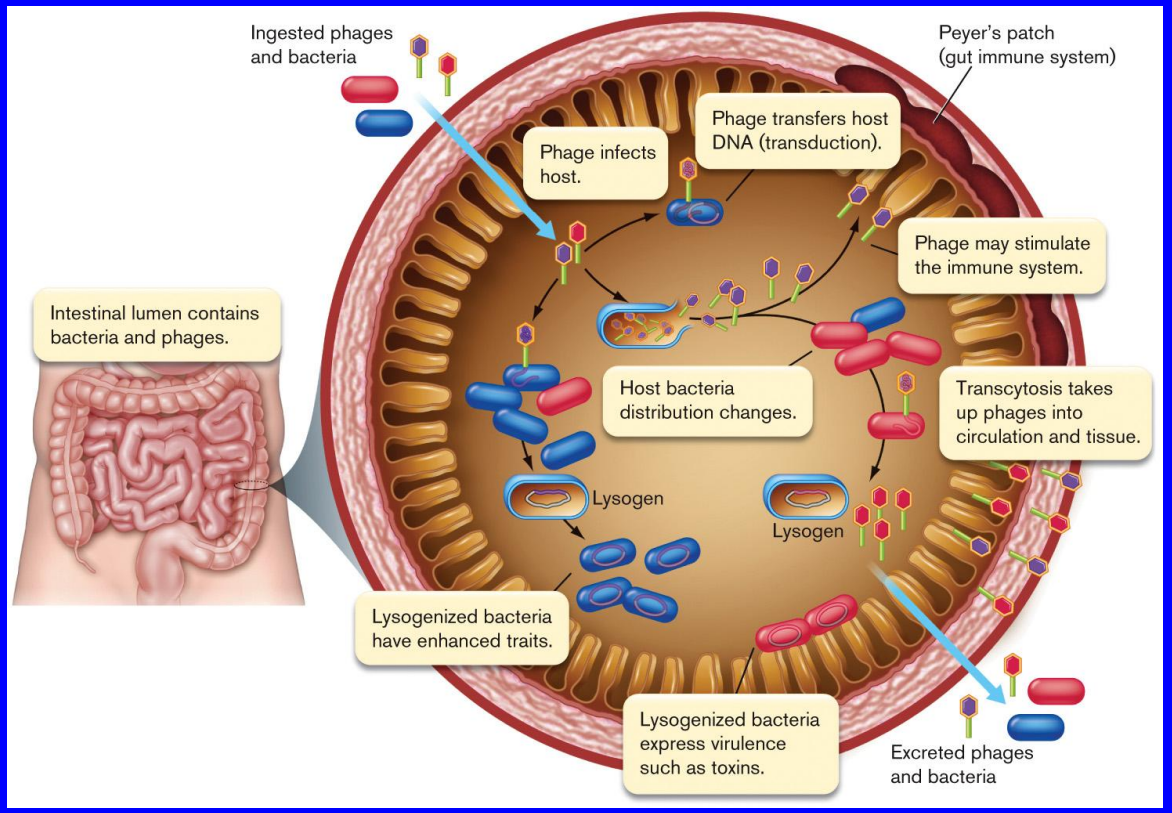
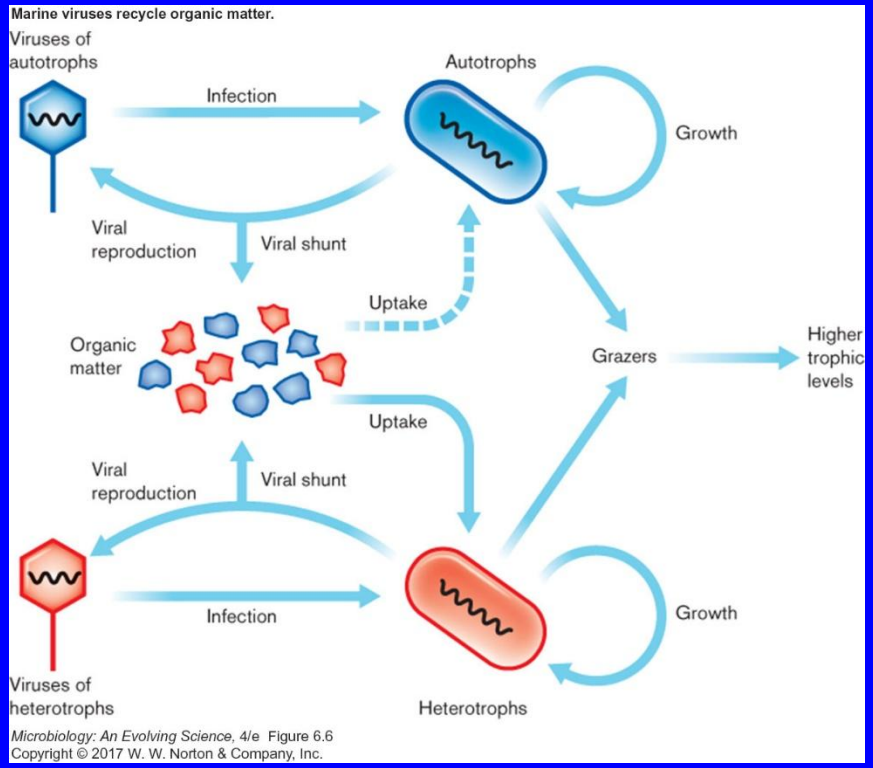


Figure 6.25 6th edition

7. Outcome or Effect of Viral infection on Host Cell - 7

g. Affects populations of microbes in various ecosystems



2) Marine ecosystems

- Also help recycle nutrients
- When autotrophs and bacteria die, they sink to bottom of ocean and the nutrients they contain are hard to recycle
- Phage lysis occurs at surface and releases organic matter for use by other organisms
- Help control population of *Vibrio cholera* bacteria and phototrophs

Comparison of Microbes

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Table 5.2 The Major Elements of Life and Their Primary Characteristics

Function or Structure	Characteristic*	Bacterial/ Archaeal Cells	Eukaryotic Cells	Viruses**
Genetics	Nucleic acids	+	+	+
	Chromosomes	+	+	–
	True nucleus	–	+	–
	Nuclear envelope	–	+	–
Reproduction	Mitosis	–	+	–
	Production of sex cells	+/–	+	–
	Binary fission	+	+	–
Biosynthesis	Independent	+	+	–
	Golgi apparatus	–	+	–
	Endoplasmic reticulum	–	+	–
	Ribosomes	+***	+	–
Respiration	Mitochondria	–	+	–
Photosynthesis	Pigments	+/–	+/–	–
	Chloroplasts	–	+/–	–
Motility/locomotor structures	Flagella	+/–***	+/–	–
	Cilia	–	+/–	–
Shape/protection	Membrane	+	+	+/–
	Cell wall	+***	+/–	– (have capsids instead)
	Capsule	+/–	+/–	–
Complexity of function		+	+	+/–
Size (in general)		0.5–3 μm****	2–100 μm	< 0.2 μm

*+ means most members of the group exhibit this characteristic; – means most lack it; +/– means some members have it and some do not.

**Viruses cannot participate in metabolic or genetic activity outside their host cells.

***The bacterial/archaeal type is functionally similar to the eukaryotic type, but it is structurally unique.

****Much smaller and much larger bacteria do exist, but they are not common.

G. Atypical Bacteria and Viruses

For comparison, properties of typical bacteria and viruses

- Typical Bacteria
  - Size: 1 – 3 μm
  - Genome: 500 – 10,000 KB, 1000-10,000 genes
  - Free-living – reproduces by itself

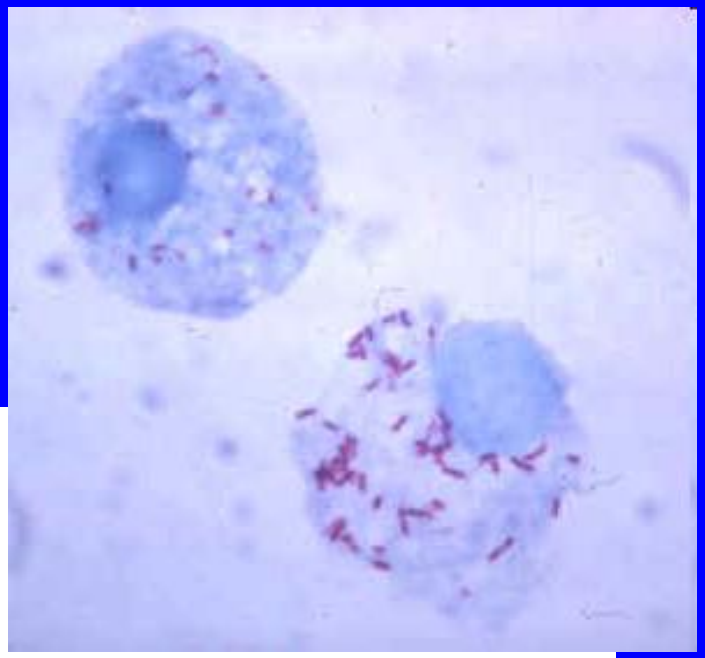
- Typical Viruses
  - Size: 0.02- 0.2 um
  - Genome 1.8 – 100 kB, 1 – 100 proteins
  - Obligate intracellular parasites – only reproduces inside cells

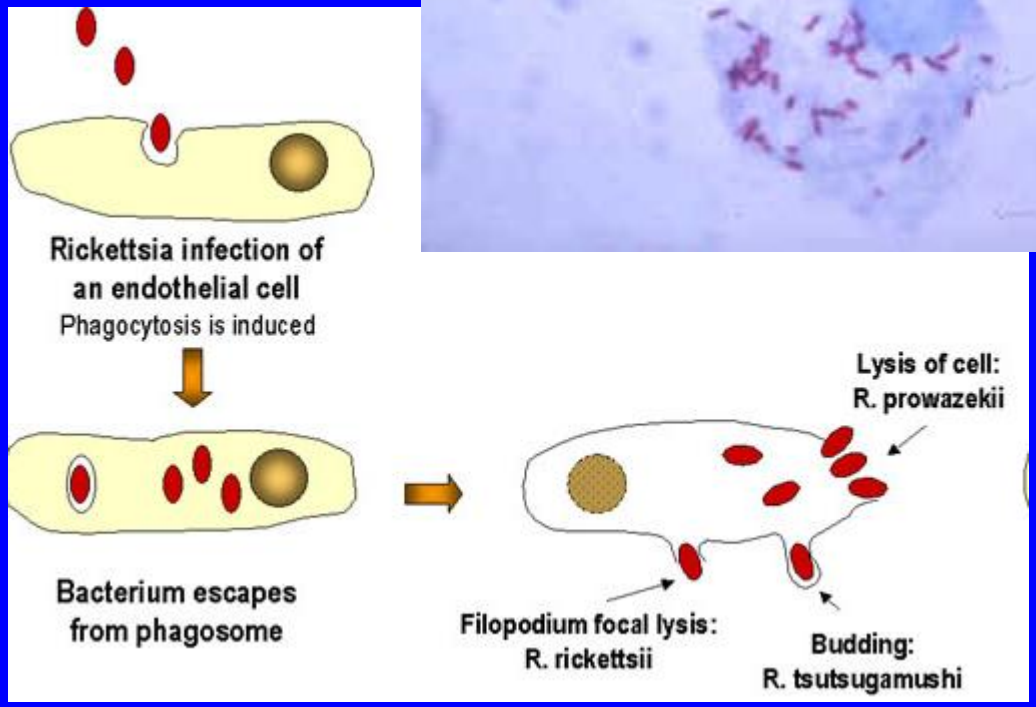
1. Atypical Small Bacteria

- Original identified in searches for causative agents of certain diseases
- Initial Observations of causative agent
  - No bacteria observed in Gram stain (So agent too small or does not stain)
  - Agent not removed by 1 micron filters. Thus Size $< 1\mu m$
  - Some stuff observed inside some host cells (obligate intracellular parasitism?)
  - Some concluded diseases must be caused by a virus
- Later observations
  - Agent contained DNA, RNA and protein
  - Agent contained ribosomes
  - Agent contained metabolic enzymes

a. *Rickettsia*

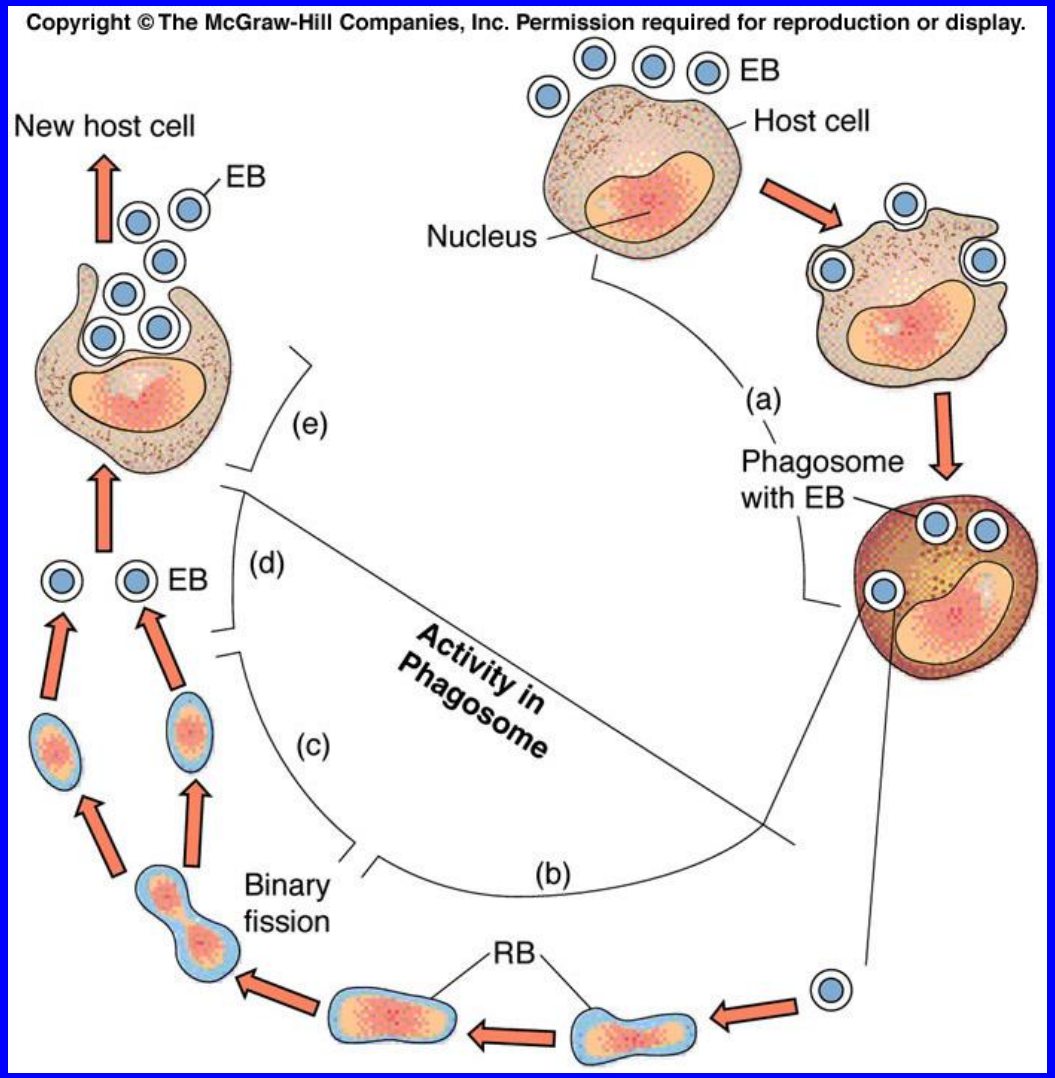
Gimenez stain of tick hemolymph





- Size: 0.3 x 1 μm
- Genome: ~1000 kB, ~830 genes
- Multiplication only inside host cells
- Gram-negative morphology, but stain poorly
- Energy parasites – lack full metabolic systems (lack glycolysis, biosynthetic pathways), will steal ATP if available (translocase transporter),

b. *Chlamydia*



- EB form only 0.3 μm
- Genome: 1000 kB, ~900 genes
- Multiplication only inside host cells - Obligate intracellular parasite
- Two forms:
  - RB: Growing form inside cell
  - EB – Dormant, infectious form found outside cells
- Gram negative morphology, but stain poorly
- Energy parasite
  - Will steal ATP
  - But has a near complete metabolic system

2. Endosymbiotic Bacteria

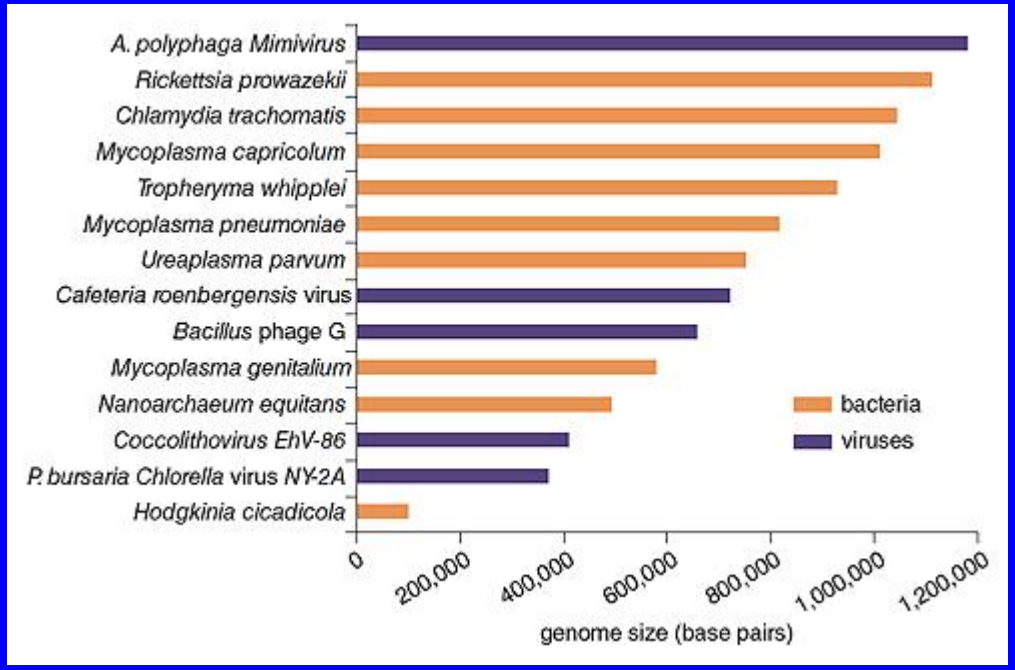
- Live inside cells or a body part of another organism
- Some are obligate endosymbionts
- Genome: as small as 150 kB, 182 genes
  - Smallest bacterial genomes
- Have own DNA, ribosomes and some metabolic enzymes
- Grow independently by dividing

3. Mitochondria and chloroplasts

- Obligate intracellular symbionts
- Genome:
  - Mitochondria: 6 - 300 kB, 30-60 genes
  - Chloroplast: 70-200 kB, ~ 120 genes
- Grow independently by dividing, fusion
- Synthesize own DNA, RNA, ribosomes, tRNA and some metabolic enzymes
- Generate ATP for their own use but get many metabolites from host cell
- Mitochondria hypothesized to be derived from an ancestor of *Rickettsia* bacterium and chloroplast from a cyanobacterium

4. Giant Viruses

- Size: > 0.15 µm
- Genome: 100-1000 kB, 100-1100 genes
- Some contain both DNA and RNA
- Some produce enzymes involved in translation
- Some can be infected by viruses
- Has been proposed as a fourth domain of life



Size of genomes of some bacteria and some giant viruses

Which of the following would you consider as a living organism? Explain your reasoning.

- Typical bacteria
- *Chlamydia* bacteria
- Endosymbiotic bacteria
- Mitochondria and chloroplasts
- Giant viruses
- Typical viruses