Microbiology: A Systems Approach

First Edition

Cowan & Talaro

Chapter

6

An Introduction to the Viruses

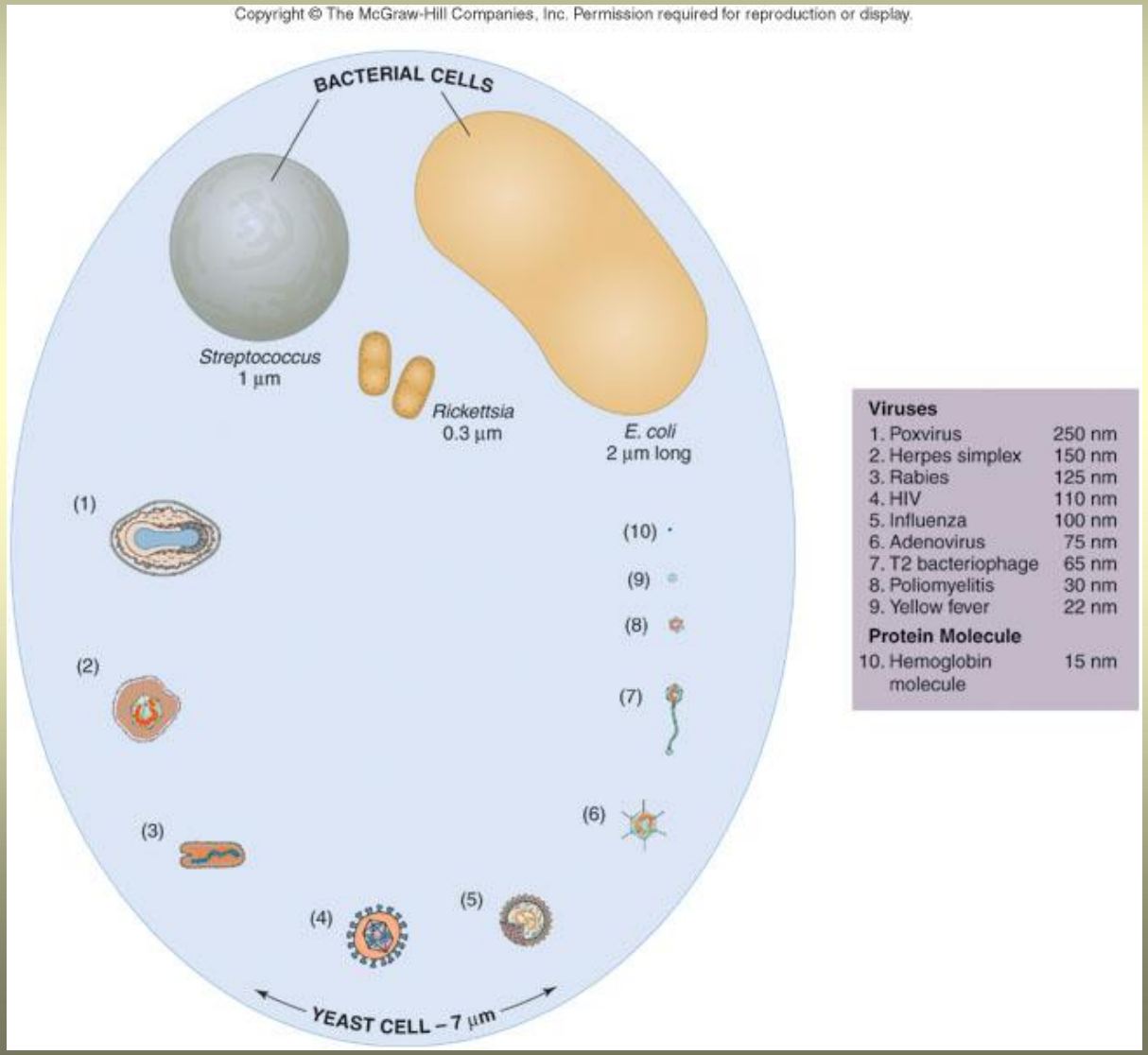
Chapter 6

TABLE 6.1

Novel Properties of Viruses

- Are obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter).
- Are not cells; structure is very compact and economical.
- Do not independently fulfill the characteristics of life (see chapter 2).
- Are inactive macromolecules outside of the host cell and active only inside host cells.
- Are geometric; can form crystal-like masses.
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.
- Nucleic acid can be either DNA or RNA but not both.
- Nucleic acid can be double-stranded DNA, single-stranded DNA, single-stranded RNA, or double-stranded RNA.
- Molecules on virus surface impart high specificity for attachment to host cell.
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses.
- Lack enzymes for most metabolic processes.
- Lack machinery for synthesizing proteins.

Size of viruses



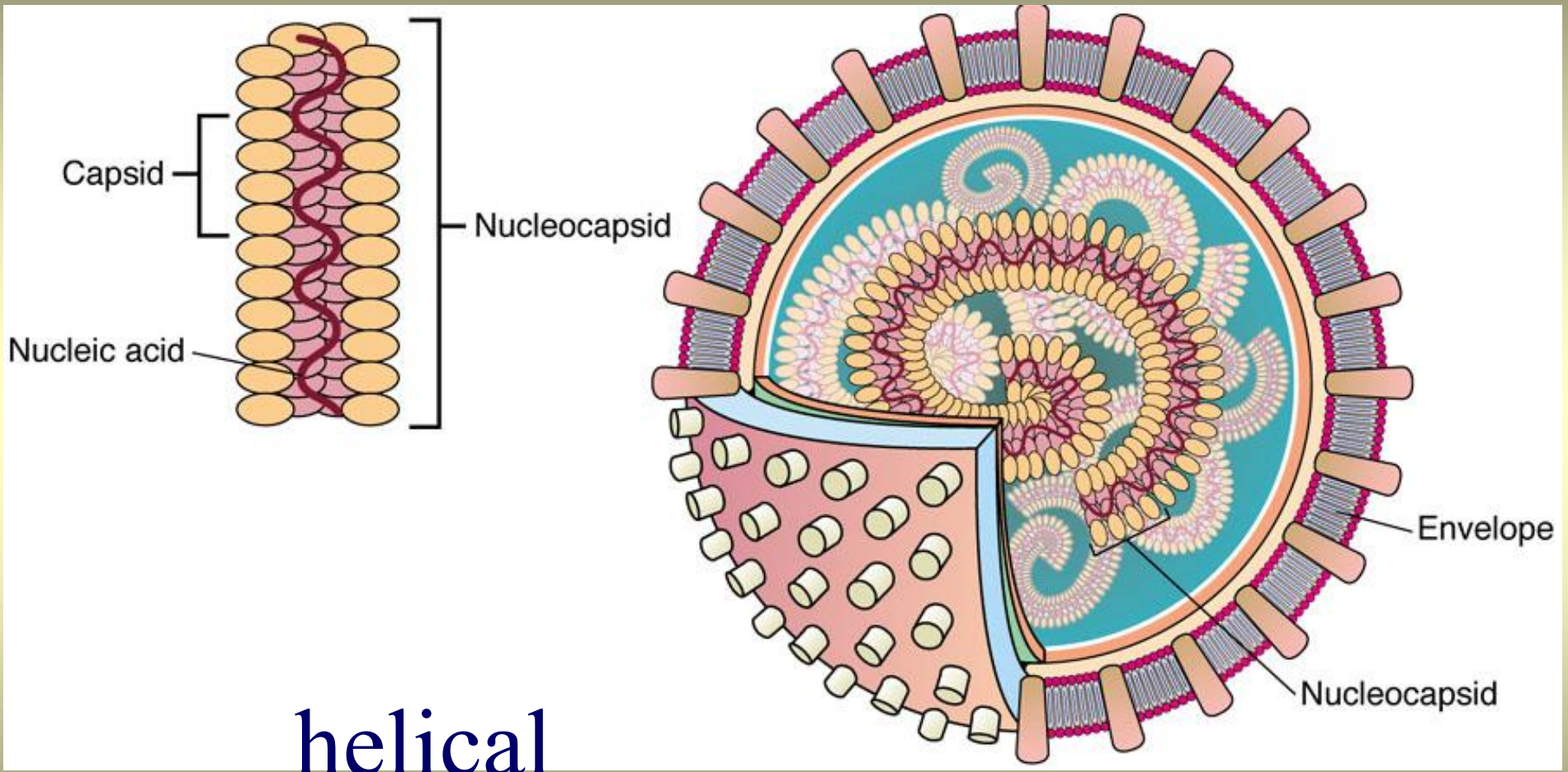
Naming viruses

- No taxa above Family (no kingdom, phylum, etc)
- 19 families of animal viruses
- Family name ends in -viridae , Herpesviridae
- Genus name ends in -virus, Simplexvirus
- Herpes simplex virus I (HSV-I)

- Family – Herpesviridae
- Genus – Varicellovirus
- Common name – chickenpox virus
- Disease - chickenpox

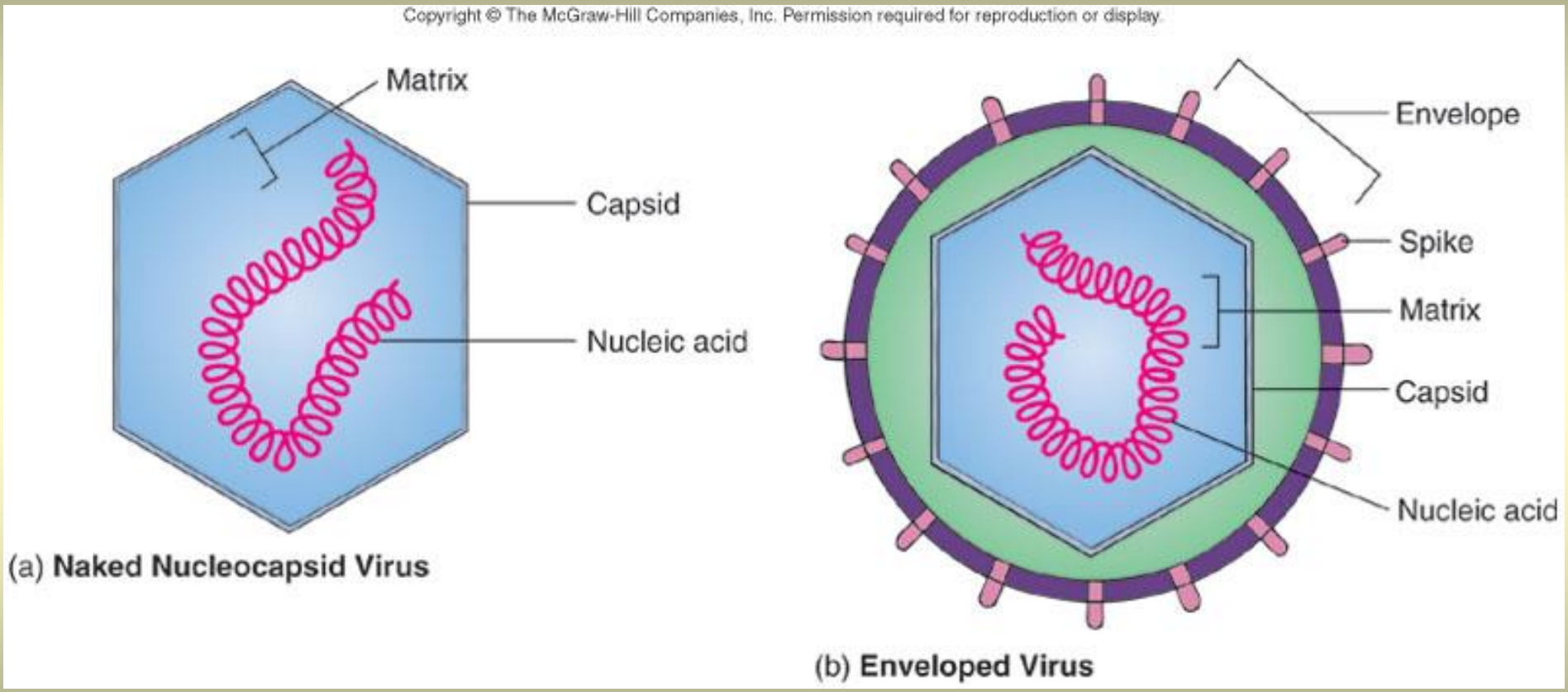
capsids

- All viruses have capsids- protein coats that enclose & protect their nucleic acid
- Each capsid is constructed from identical subunits called capsomers made of protein
- 2 types:
  - helical
  - iscosahedral



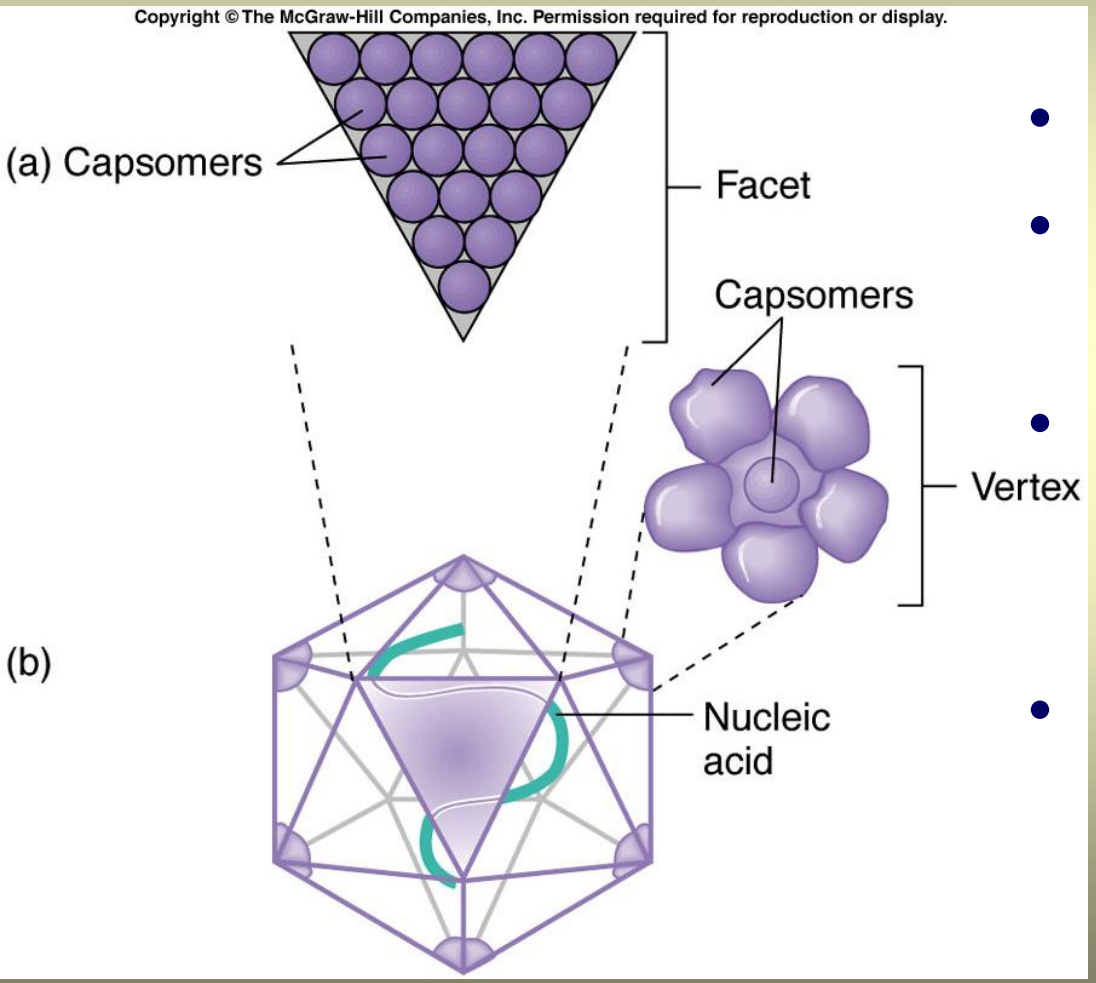
helical

Animation



icosahedral

icosahedral



- 20-sided with 12 corners
- Vary in the number of capsomers
- Each capsomer may be made of 1 or several proteins
- Some are enveloped

complex

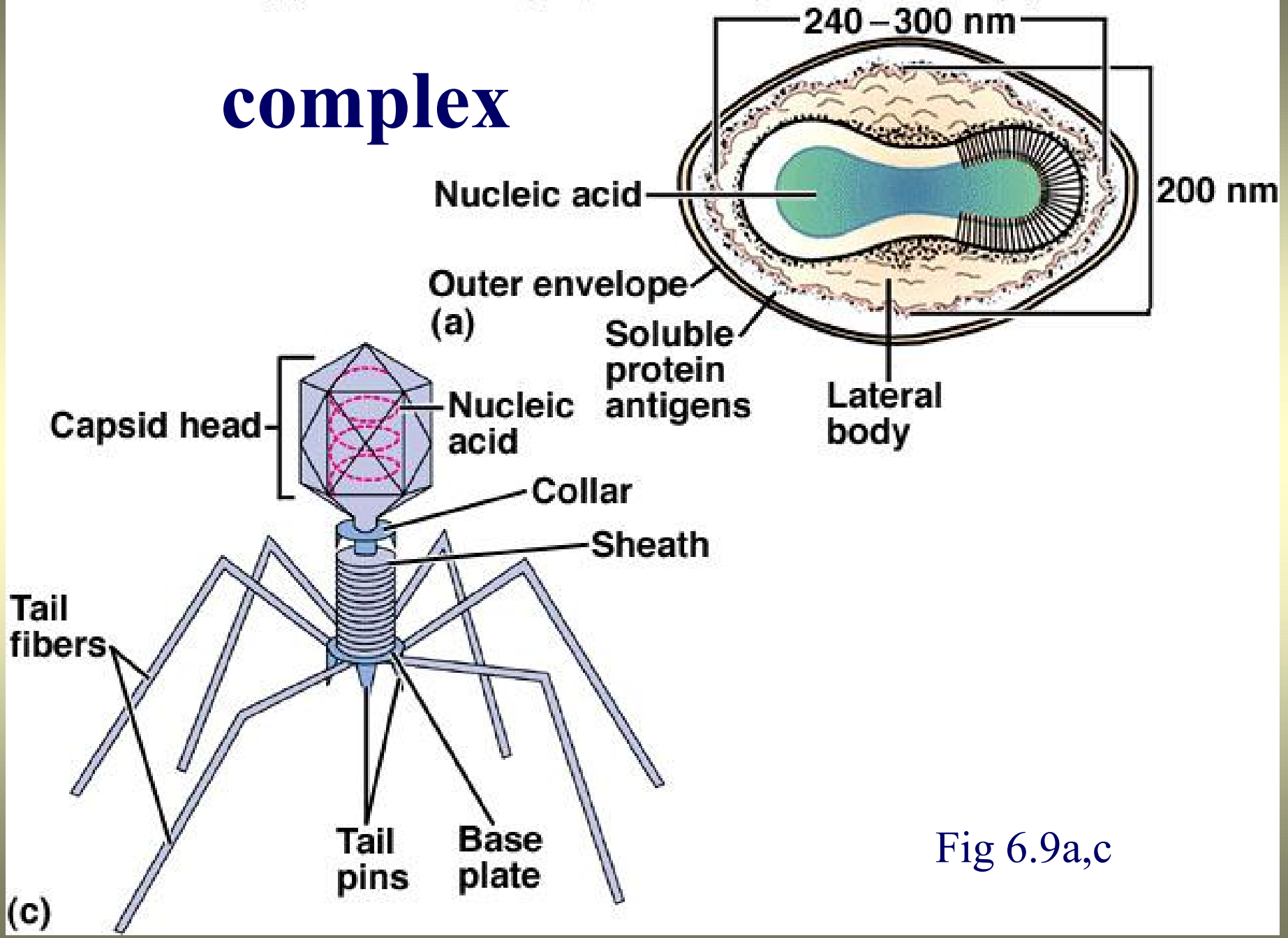


Fig 6.9a,c

6 steps in phage replication

1. **adsorption** – binding of virus to specific molecule on host cell
2. **penetration** –genome enters host cell
3. **replication** – viral components produced
4. **assembly -** viral components assembled
5. **maturation** – completion of viral formation
6. **release** – viruses leave cell to infect other cells

Video

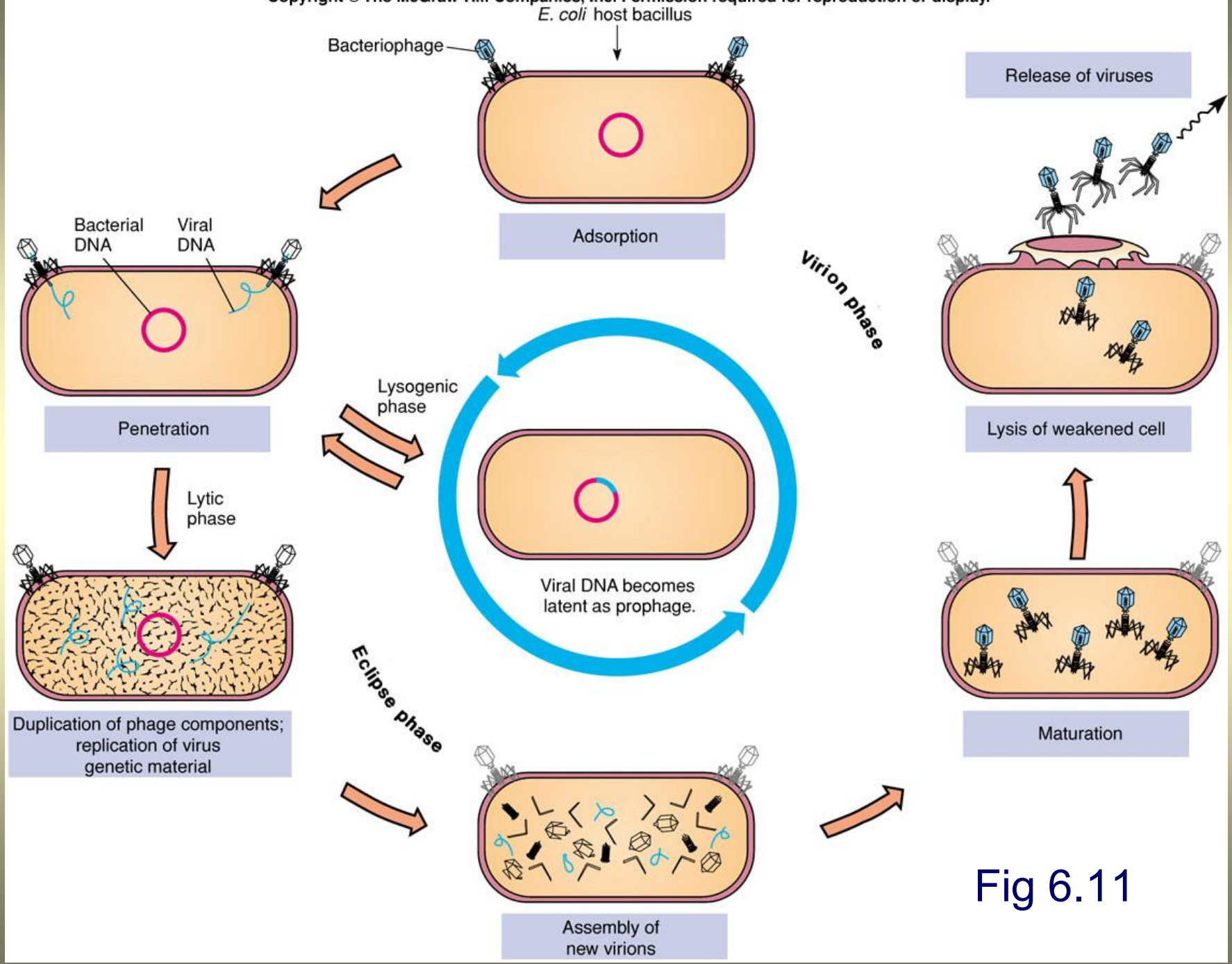
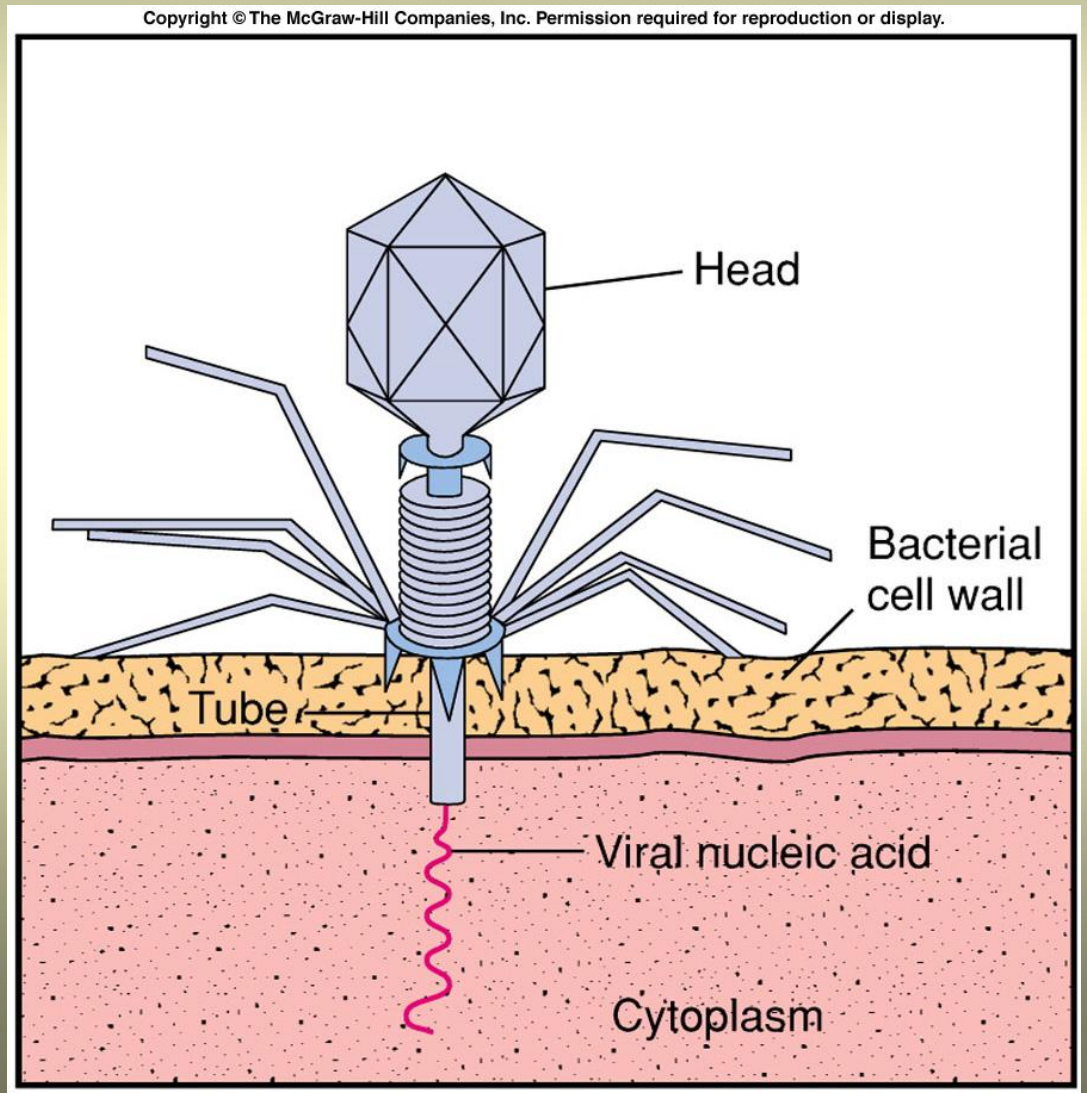
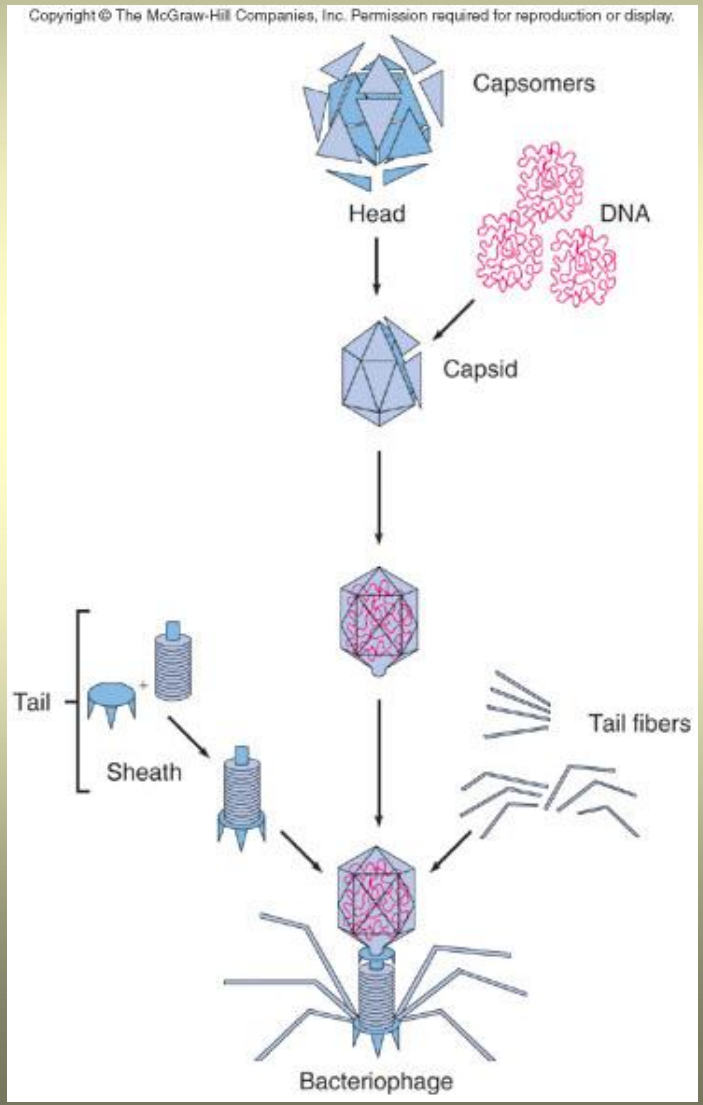


Fig 6.11

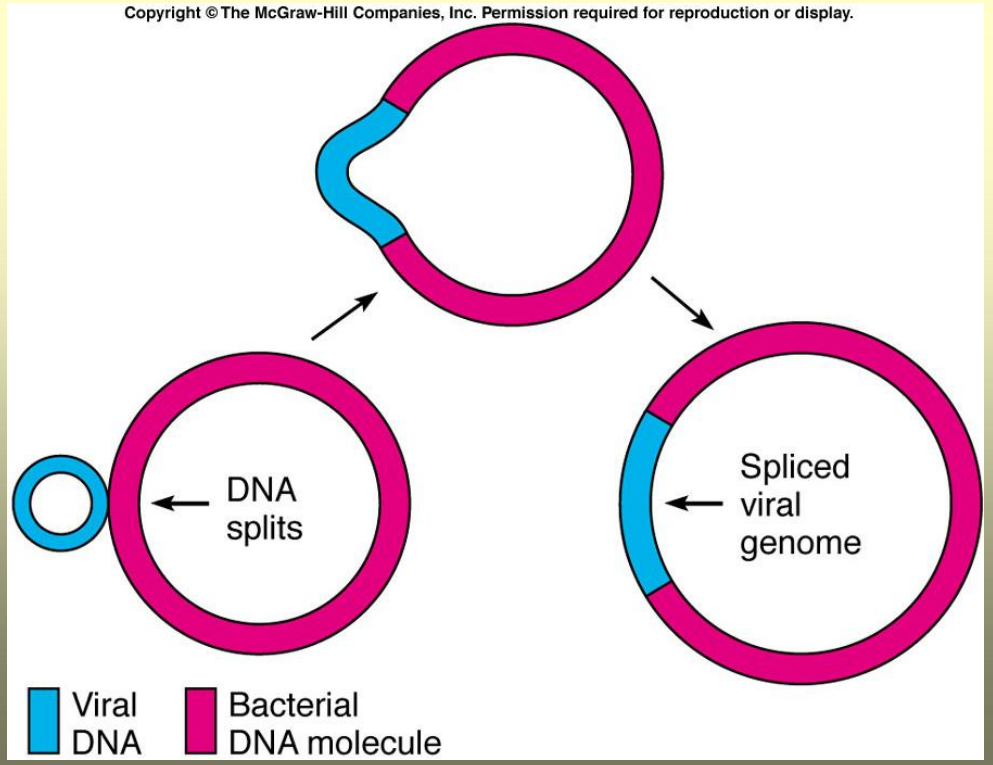
penetration



Bacteriophage assembly line



- Not all bacteriophages lyse cells
- Temperate phages insert their viral DNA into the host chromosome & viral replication stops at there until some later time.
- **Lysogeny**- bacterial chromosome carries phage DNA



Host range

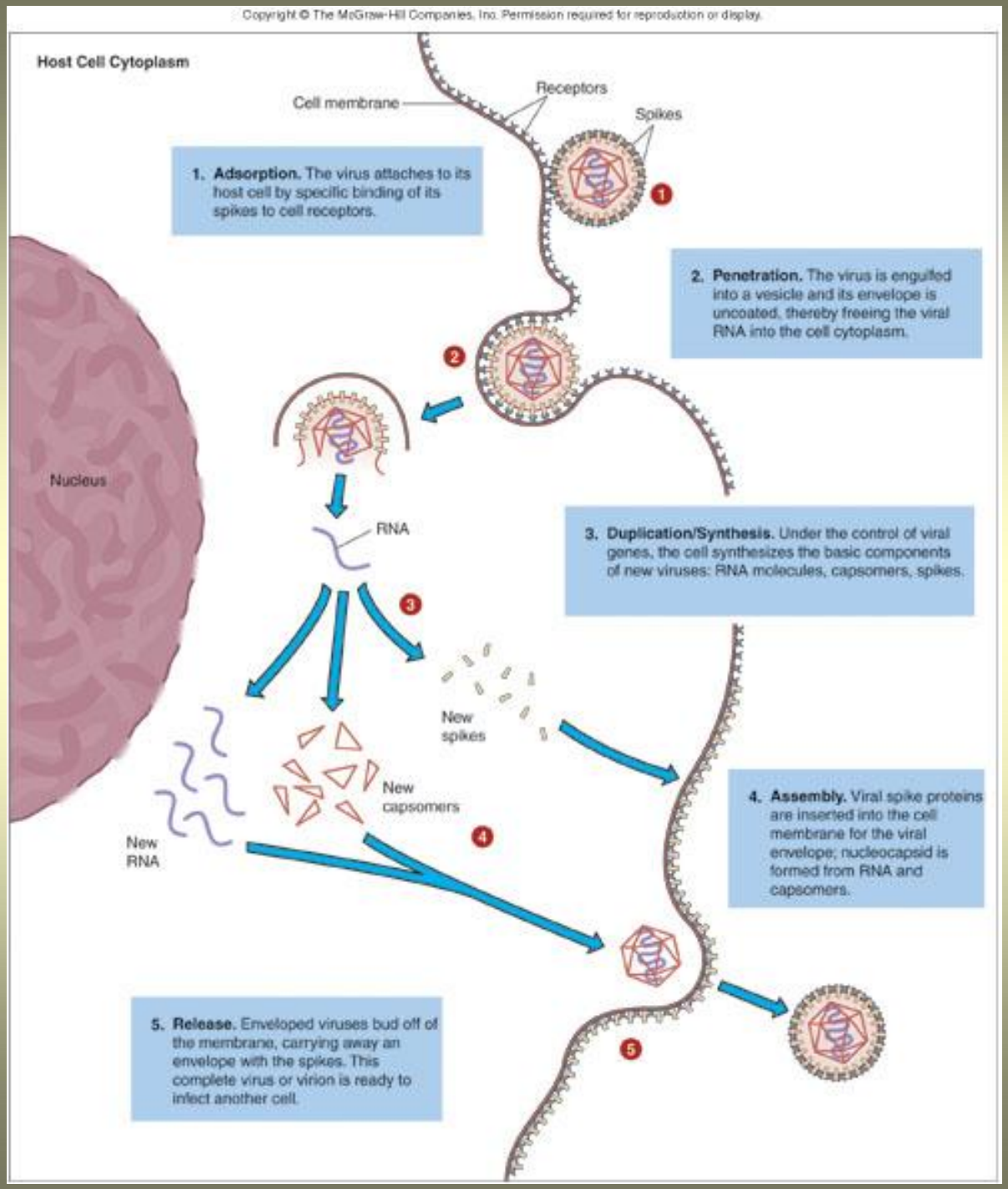
- Spectrum of cells a virus can infect
  - cell has to have a specific structure (receptor) on its surface for viral attachment
  - cell has to contain all of the enzymes and materials needed to produce new virions
- May be one species or many
  - HIV (only humans) vs rabies (many animals)
- May be one tissue or many within a host
  - Hepatitis (liver) vs polio (intestinal & nerve cells)

Differences between phage and animal virus replication

1. Animal virus replication is more complex than phage replication because host cells are more complex.
2. Animal viruses cannot inject their DNA.
3. Lysogeny for phage, latency for animal viruses

Animal virus replication

1. adsorption Video 1
2. penetration/uncoating of genome
3. duplication/synthesis
4. assembly
5. release Video 2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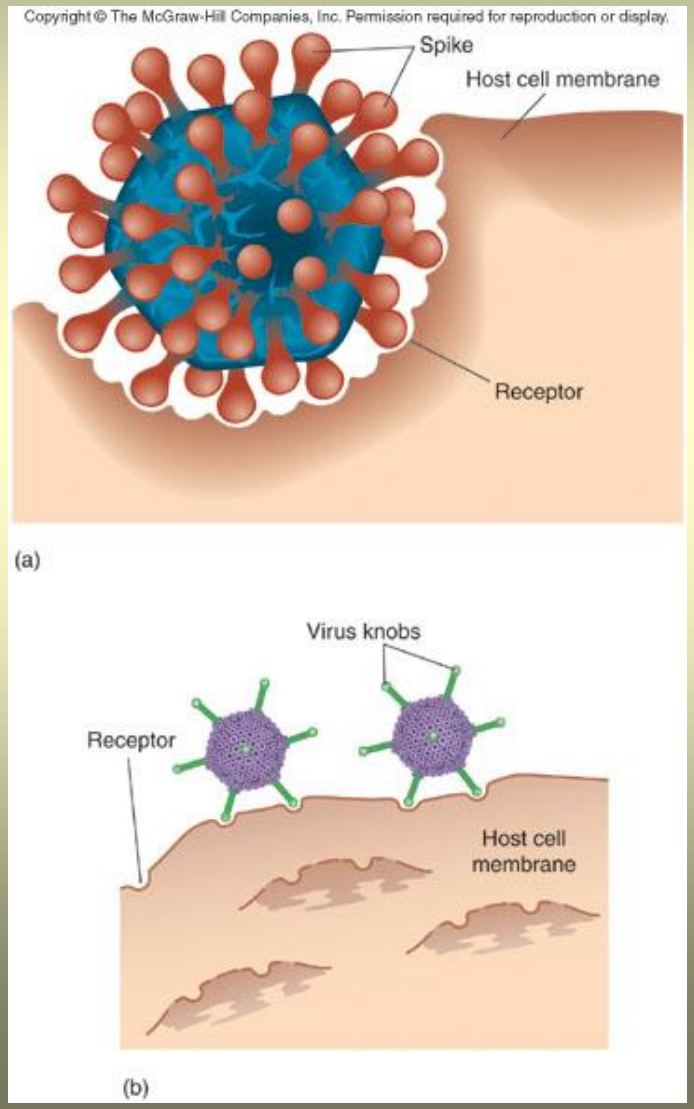
Host Cell Cytoplasm
Cell membrane
Receptors
Spikes
1. Adsorption. The virus attaches to its host cell by specific binding of its spikes to cell receptors.
2. Penetration. The virus is engulfed into a vesicle and its envelope is uncoated, thereby freeing the viral RNA into the cell cytoplasm.
Nucleus
RNA
3. Duplication/Synthesis. Under the control of viral genes, the cell synthesizes the basic components of new viruses: RNA molecules, capsomers, spikes.
New spikes
New capsomers
New RNA
4. Assembly. Viral spike proteins are inserted into the cell membrane for the viral envelope; nucleocapsid is formed from RNA and capsomers.
5. Release. Enveloped viruses bud off of the membrane, carrying away an envelope with the spikes. This complete virus or virion is ready to infect another cell.

adsorption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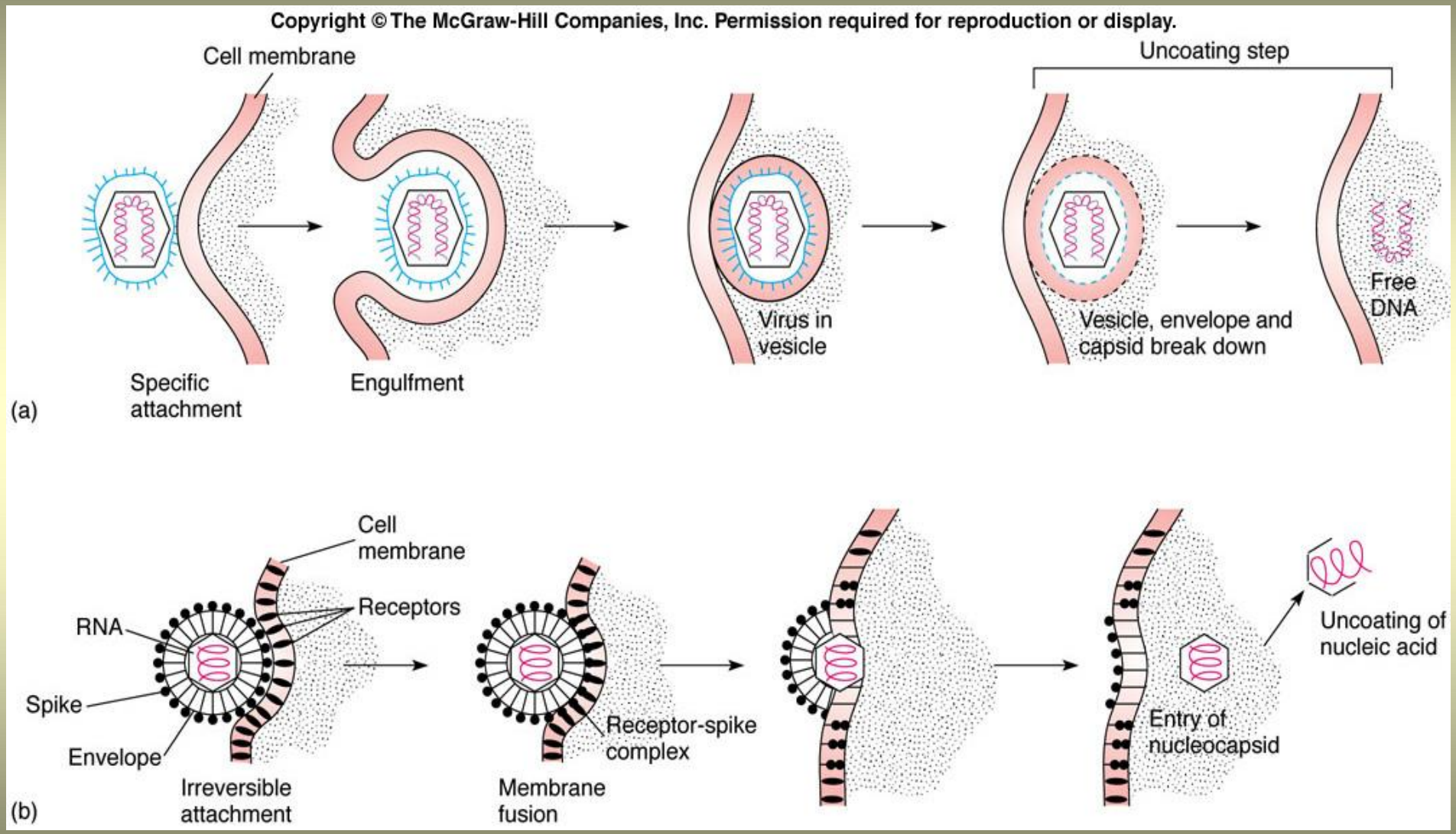
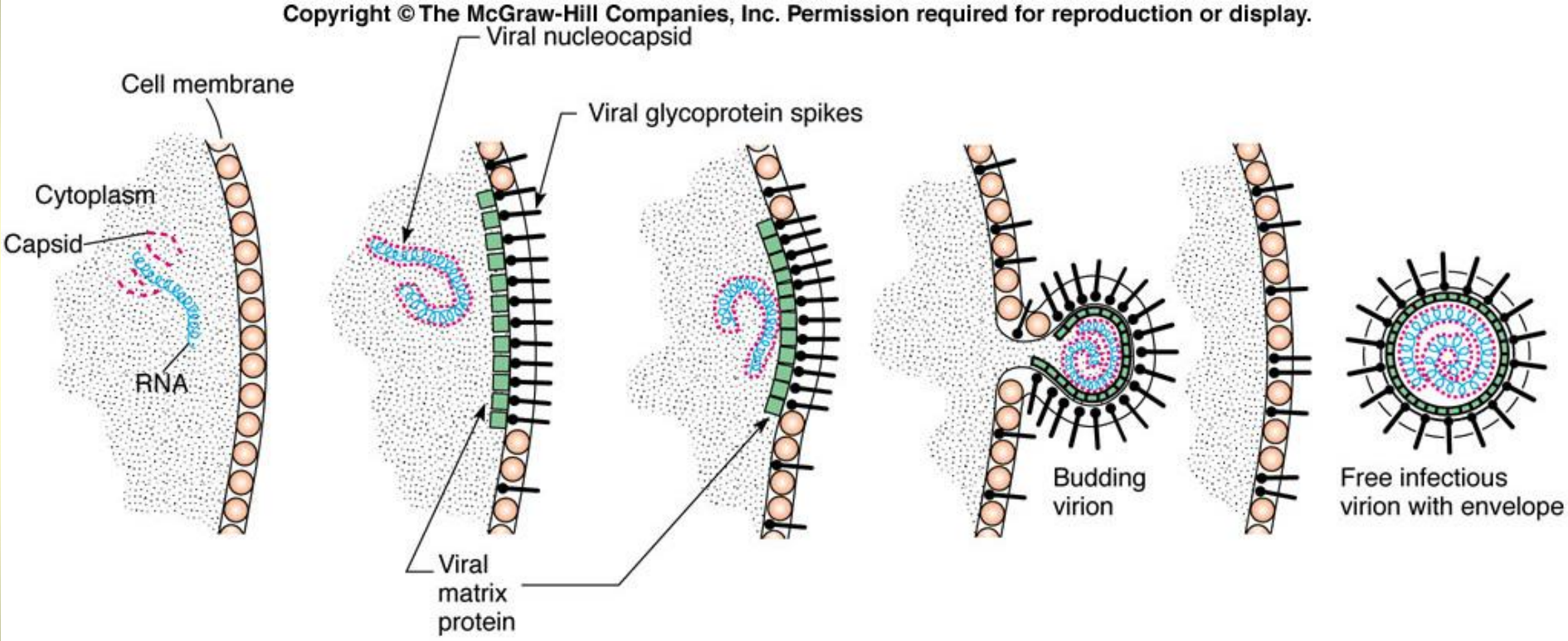
Spike
Host cell membrane
Receptor
(a)
Virus knobs
Receptor
Host cell membrane
(b)

penetration



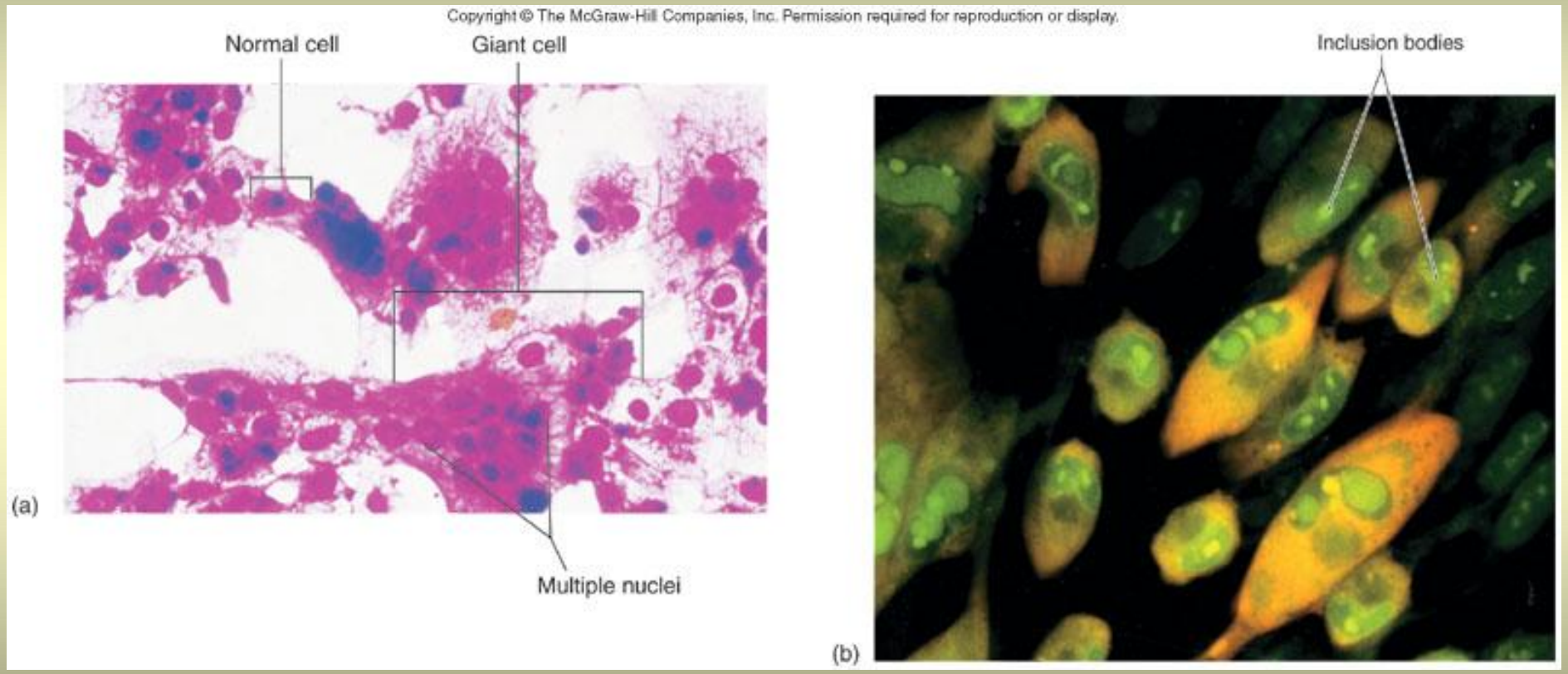
Release by budding



Cytopathic effects- virus-induced damage to cells

1. changes in size & shape
2. cytoplasmic inclusion bodies
3. nuclear inclusion bodies
4. cells fuse to form multinucleated cells
5. cell lysis
6. alter DNA
7. transform cells into cancerous cells

Cytopathic changes in cells

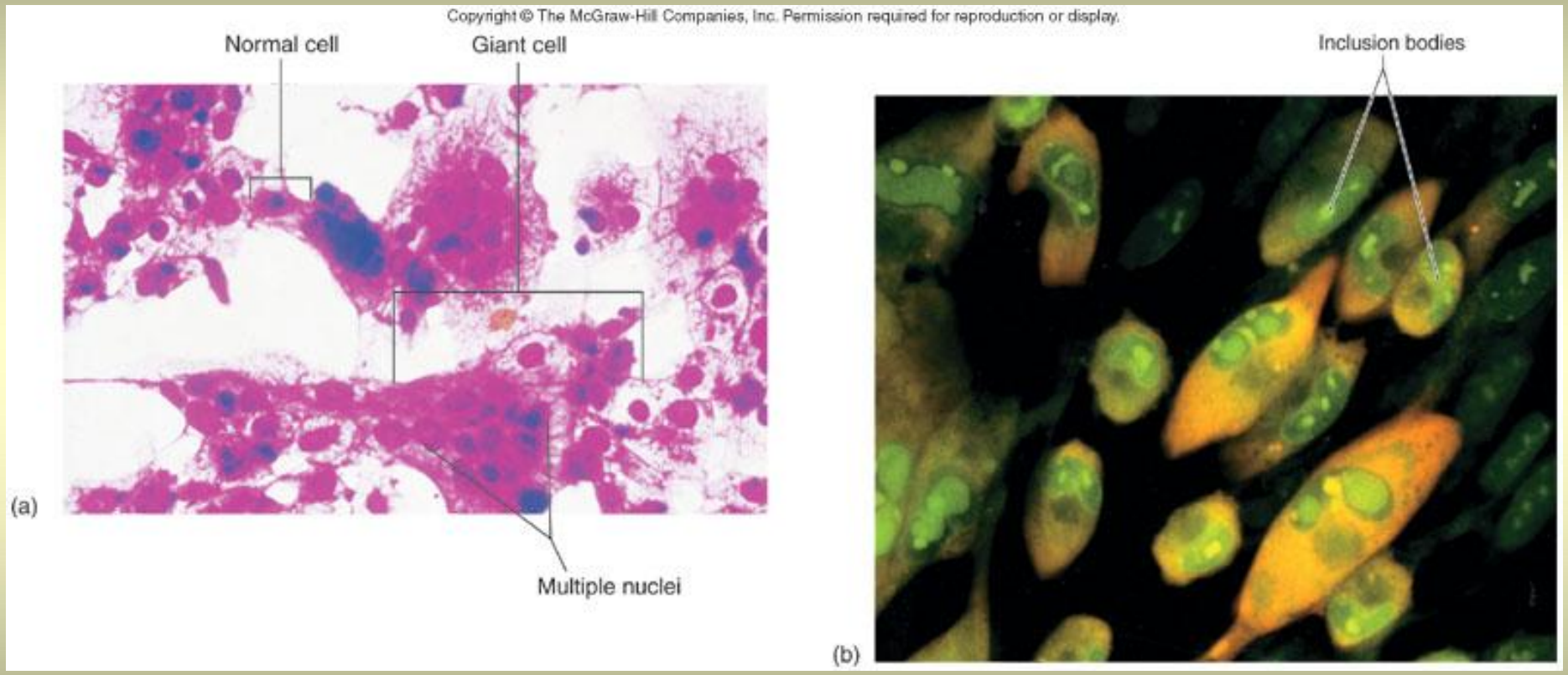


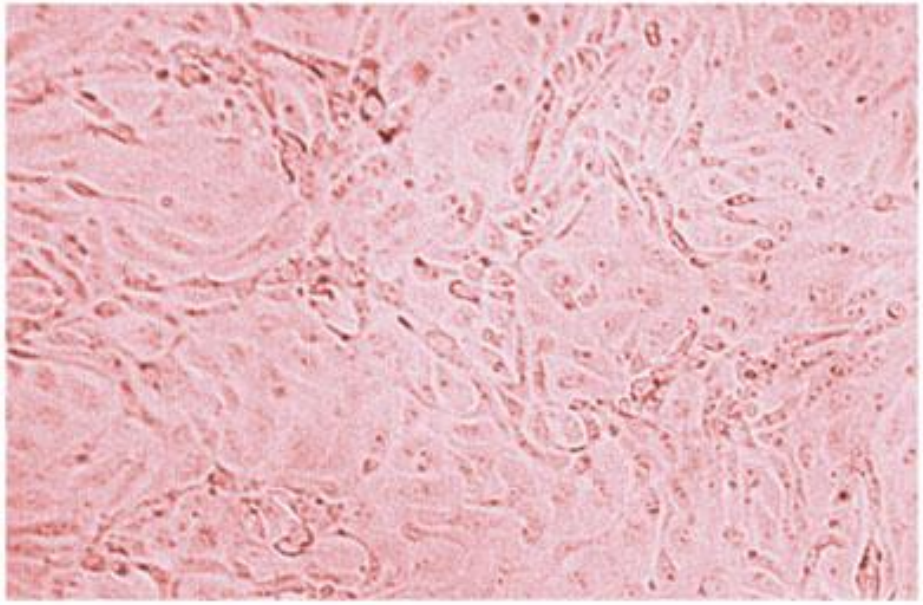
How do we grow viruses?

Obligate intracellular parasites require appropriate cells to replicate.

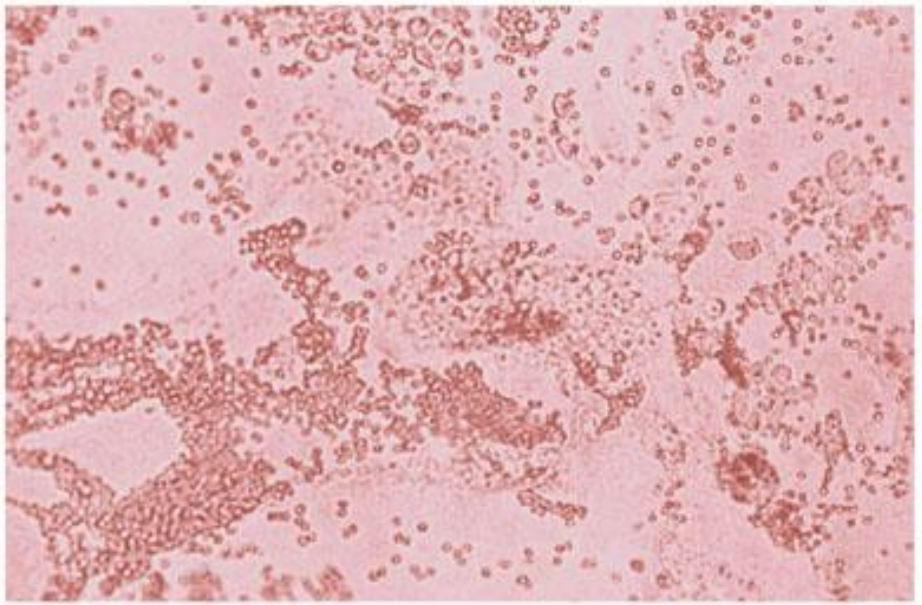
Growing animal viruses

1. live animals
2. bird embryos – chicken, duck; intact, self-supporting unit, sterile, self-nourished
3. cell culture





(b) Normal



(c) Infected

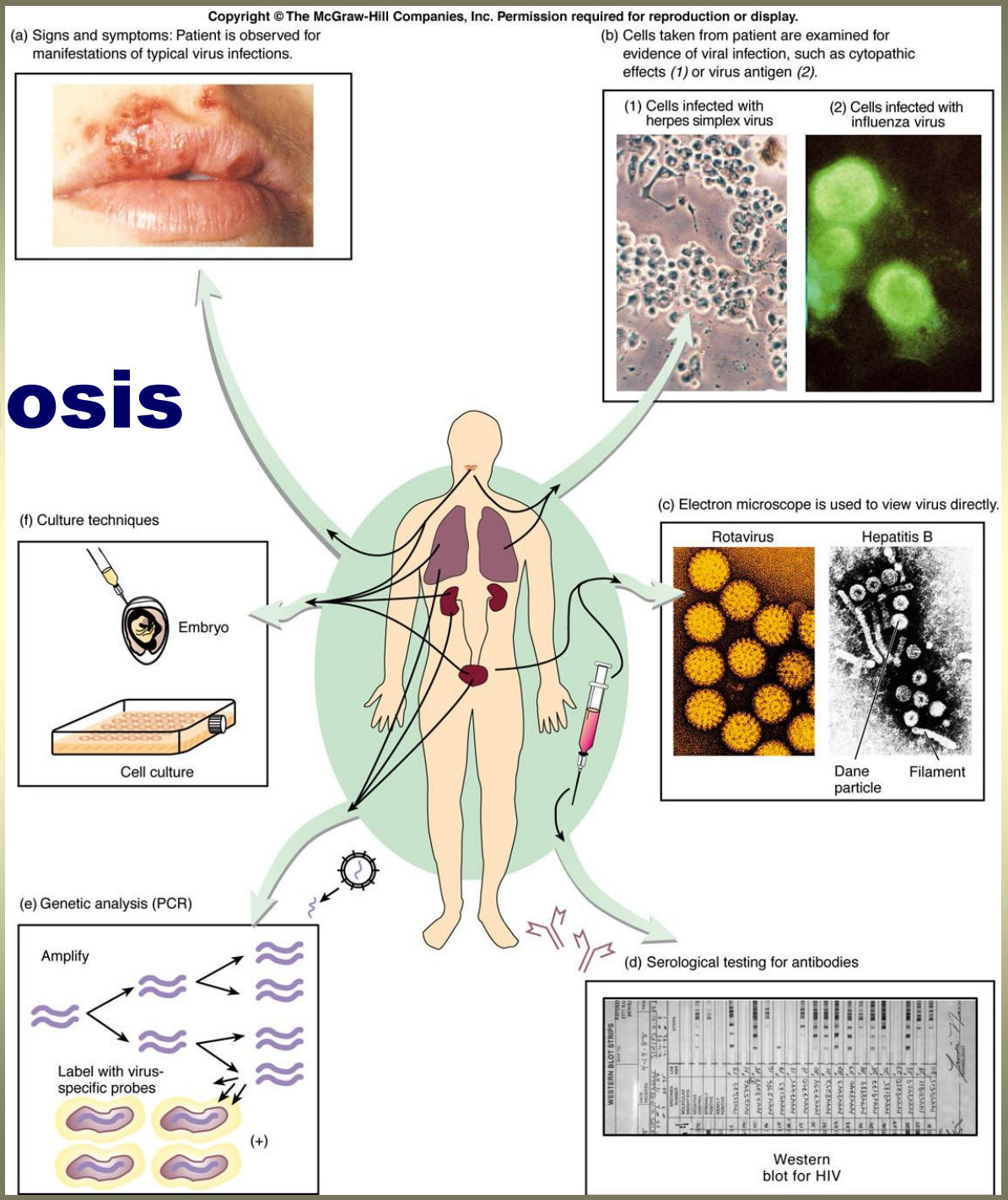
Other noncellular infectious agents

1. **prions** - misfolded proteins, contain no nucleic acid
   - cause spongiform encephalopathies – holes in the brain
   - common in animals
     - scrapie in sheep & goats
     - bovine spongiform encephalopathies (BSE), aka mad cow disease
     - humans – Creutzfeldt-Jakob Disease
2. **viroids** - short pieces of RNA, no protein coat
   - only been identified in plants, so far

Diagnosis of viral diseases

- More difficult than other agents
- Consider overall clinical picture
- Take appropriate sample
  - Infect cell culture- look for characteristic cytopathic effects
  - Screen for parts of the virus
  - Screen for immune response to virus (antibodies)

diagnosis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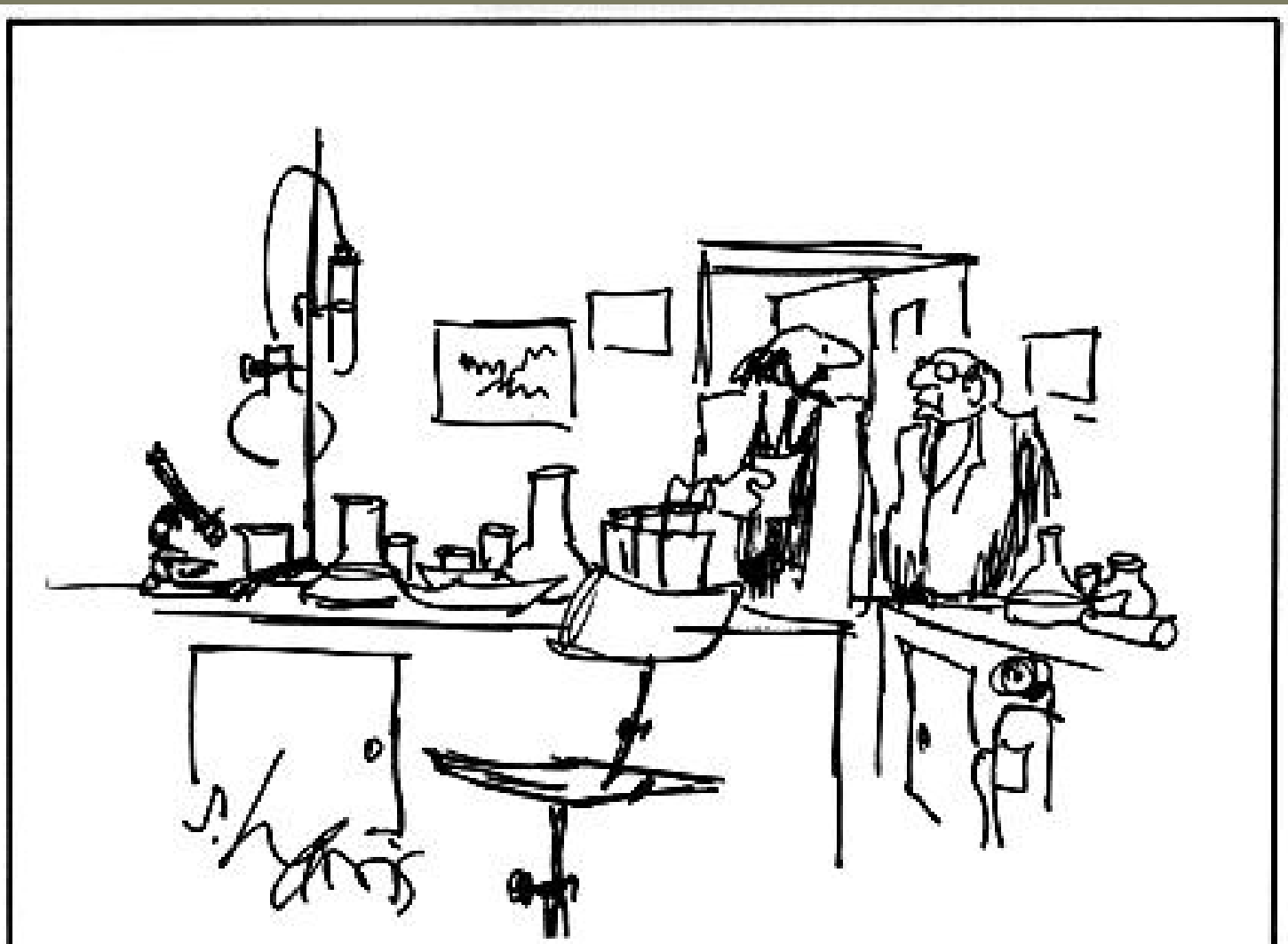
(a) Signs and symptoms: Patient is observed for manifestations of typical virus infections.
(b) Cells taken from patient are examined for evidence of viral infection, such as cytopathic effects (1) or virus antigen (2).
(1) Cells infected with herpes simplex virus
(2) Cells infected with influenza virus
(c) Electron microscope is used to view virus directly.
Rotavirus
Hepatitis B
Dane particle
Filament
(d) Serological testing for antibodies
Western blot for HIV
(e) Genetic analysis (PCR)
Amplify
Label with virus-specific probes
(+)
(f) Culture techniques
Embryo
Cell culture



"We know he didn't discover that new virus - we're just naming it after Rheinblatt because it looks like Rheinblatt."