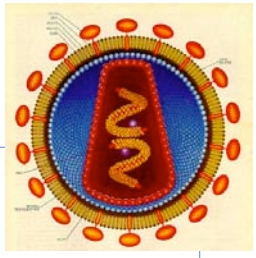


Chapter 18.

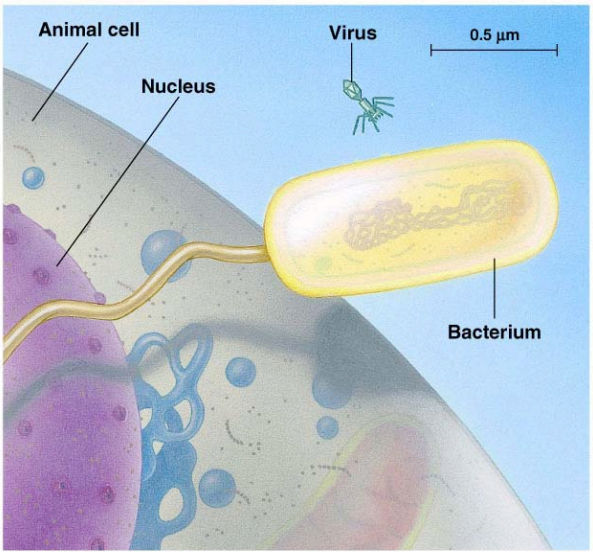
Viral Genetics

AP Biology

2003-2004

A sense of size

Comparing
- eukaryote
- bacterium
- virus



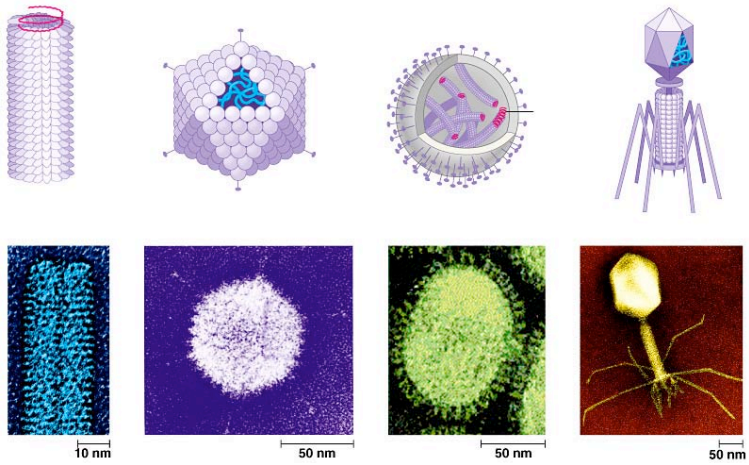
What is a virus? Is it alive?

- DNA or RNA enclosed in a protein coat
- Viruses are not cells
- Extremely tiny
  - electron microscope size
  - smaller than ribosomes
  - ~20–50 nm

1st discovered in plants (1800s)
- tobacco mosaic virus
- couldn't filter out
- couldn't reproduce on media like bacteria

Variation in viruses

plant virus | pink eye | influenza | bacteriophage



a package of genes in transit from 1 host cell to another

Viral genomes

Viral nucleic acid varies

- double-stranded DNA (dsDNA)
- single-stranded DNA (ssDNA)
- double-stranded RNA (dsRNA)
- single-stranded RNA (ssRNA)

Linear or circular molecule of nucleic acid

- smallest viruses have only 4 genes, while largest have several hundred

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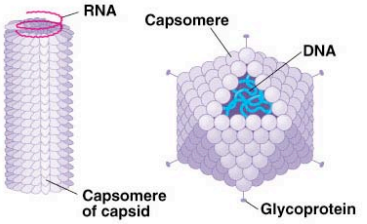
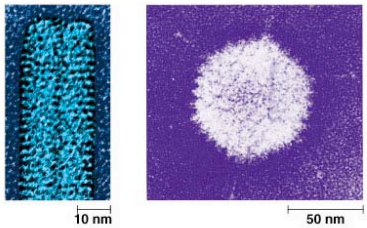
Table 18.1 Classes of Animal Viruses, Grouped by Type of Nucleic Acid

Class*	Examples/Diseases
I. dsDNA**	
Papovavirus	Papilloma (human warts, cervical cancer); polyoma (tumors in certain animals)
Adenovirus	Respiratory diseases; some cause tumors in certain animals
Herpesvirus	Herpes simplex I (cold sores), herpes simplex II (genital sores); varicella zoster (chicken pox, shingles); Epstein-Barr virus (mononucleosis, Burkitt's lymphoma)
Poxvirus	Smallpox; vaccinia, cowpox
II. ssDNA	
Parvovirus	Roseola; most parvoviruses depend on co-infection with adenoviruses for growth
III. dsRNA	
Reovirus	Diarrhea; mild respiratory diseases
IV. ssRNA that can serve as mRNA	
Picornavirus	Poliovirus; rhinovirus (common cold); enteric (intestinal) viruses
Togavirus	Rubella virus; yellow fever virus; encephalitis viruses
V. ssRNA that is a template for mRNA	
Rhabdovirus	Rabies
Paramyxovirus	Measles; mumps
Orthomyxovirus	Influenza viruses
VI. ssRNA that is a template for DNA synthesis	
Retrovirus	RNA tumor viruses (e.g., leukemia viruses); HIV (AIDS virus)

Viral protein coat

- **Capsid**
  - crystal-like protein shell
  - 1-2 types of proteins
  - many copies of same protein = capsomere

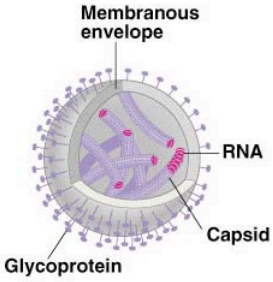


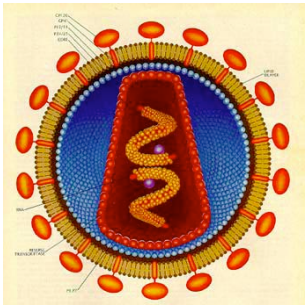


(a) Tobacco mosaic virus (b) Adenoviruses

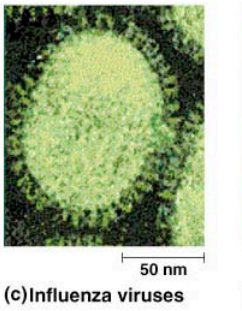
Viral envelope

- Lipid bilayer membranes cloaking viral capsid
  - envelopes are derived from host cell membrane
    - glycoproteins on surface





HIV



(c) Influenza viruses

Generalized viral lifecycle

- **Parasites**
  - lack enzymes for metabolism
  - lack ribosomes for protein synthesis
  - need host "machinery"
- **Entry**
  - virus DNA/RNA enters host cell
- **Assimilation**
  - viral DNA/RNA takes over host
  - reprograms host cell to copy viral nucleic acid & build viral proteins
- **Self assembly**
  - nucleic acid molecules & capsomeres then self-assemble into viral particles
  - exit cell

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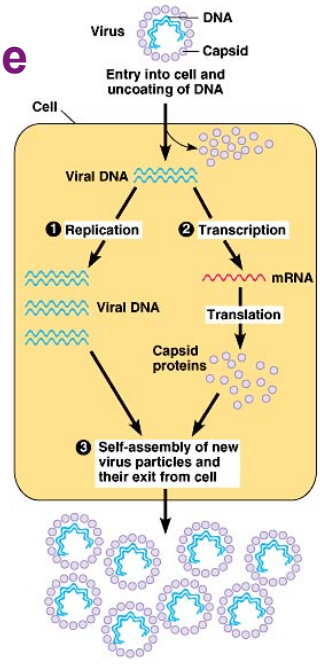
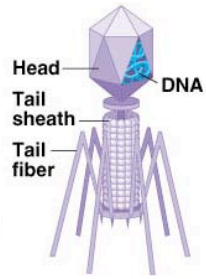
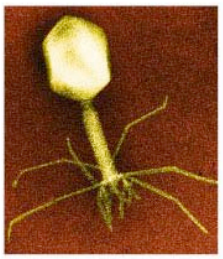


Bacteriophages

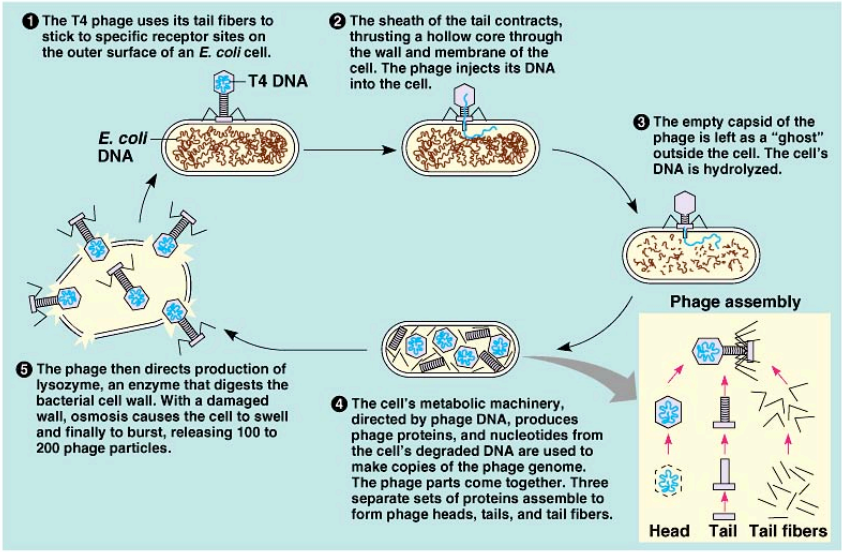
- Viruses that infect bacteria
  - ex. phages that infect *E. coli*
  - 20-sided capsid head encloses DNA
  - protein tail attaches phage to host & injects phage DNA inside



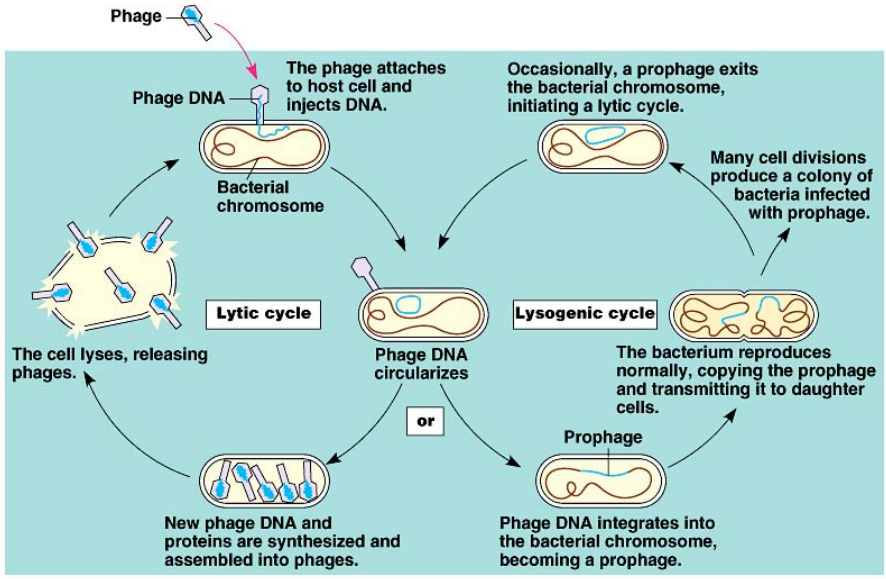


(d)Bacteriophage T4

Lytic lifecycle of phages



Lysogenic lifecycle of phages



Viral hosts

- **Host range**
  - each type of virus can infect & parasitize only a limited range of host cells
  - identify host cells via "lock & key" fit
    - between proteins on viral coat & receptors on host cell surface
  - broad host range
    - rabies = can infect all mammals
  - narrow host range
    - human cold virus = only cells lining upper respiratory tract of humans
    - AIDS virus = binds only to specific white blood cells

Defense against viruses

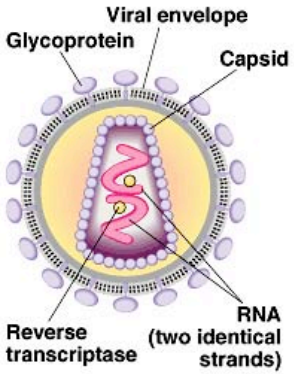
- **Bacteria have defenses against phages**
  - natural selection favors bacterial mutants with receptors sites that are no longer recognized by a particular type of phage
  - bacteria produce restriction enzymes that recognize & cut up foreign DNA
    - modifications to bacteria's own DNA prevent its destruction by restriction enzymes
- **It's an escalating war!**
  - natural selection favors phage mutants resistant to the bacterial defenses

RNA viruses

- **Retroviruses**
  - use an enzyme = reverse transcriptase
  - copies viral RNA into DNA in host
    - viral DNA can be integrated into host chromosome
    - can be passed on to other cells
  - host's RNA polymerase now transcribes viral DNA into viral RNA molecules
    - produces viral components

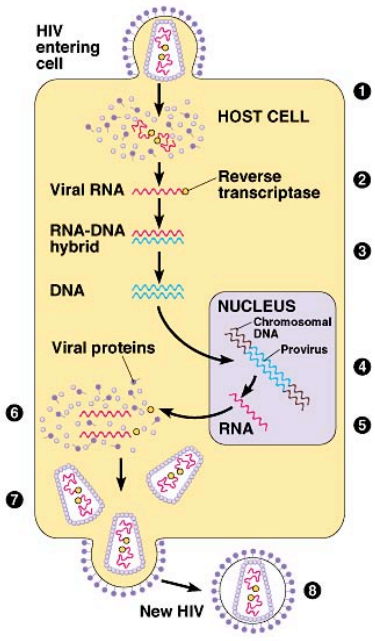
Retroviruses

- **HIV**
  - human immunodeficiency virus
  - causes AIDS
    - acquired immunodeficiency syndrome
  - envelope with glyco-proteins for binding to specific WBC
  - capsid containing 2 RNA strands & 2 copies of reverse transcriptase



HIV infection

- HIV enters host cell
  - reverse transcriptase synthesizes double stranded DNA from viral RNA
- Transcription produces more copies of viral RNA
  - translated into viral proteins
  - proteins & vRNA self-assemble into virus particles & leave host



Symptoms of viral infection

- Link between infection & symptoms varies
  - kill cells by lysis
  - cause infected cell to produce toxins
  - viral components, such as envelope proteins, may be toxic
- Damage?
  - depends…
    - lung epithelium after the flu is repaired
    - nerve cell damage from polio is permanent

Cancer viruses

- Viruses appear to cause certain human cancers
  - hepatitis B virus
    - linked to liver cancer
  - Epstein-Barr virus = infectious mononucleosis
    - linked to Burkitt's lymphoma
  - Papilloma viruses
    - linked with cervical cancers
  - HTLV-1 retrovirus
    - linked to type of adult leukemia

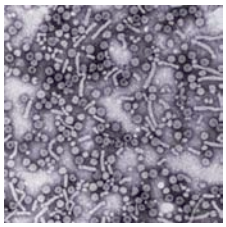
Cancer viruses

- **Transform cells into cancer cells after integration of viral DNA into host DNA**
  - **carry oncogenes that trigger cancerous characteristics in cells**
  - **version of human gene that normally controls cell cycle or cell growth**
- **Most tumor viruses probably cause cancer only in combination with other mutagenic events**

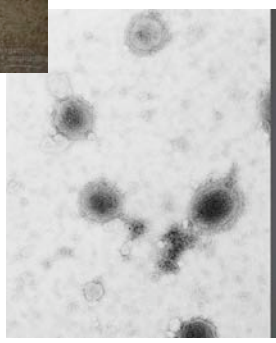
Viral diseases

Polio

Hepatitis



Measles



Influenza: 1918 epidemic

RNA virus

30-40 million deaths world-wide

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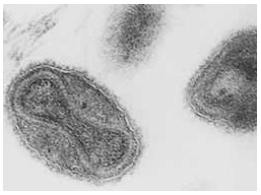
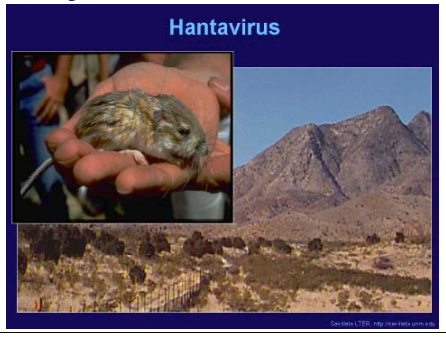
Smallpox

- Eradicated in 1976
  - vaccinations ceased in 1980
  - at risk population?



Emerging viruses

- Viruses that mutate & “jump” host
  - Hanta virus
  - Ebola virus
    - digests human body & every opening in body bleeds, no matter how small



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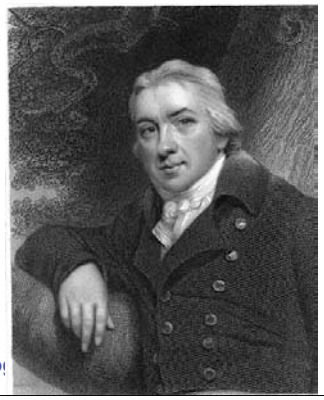
Vaccines

- Injections of harmless variants of virus
  - stimulate immune system to mount rapid defense against future attack



Edward Jenner
1st vaccine

And there's more….

Prions

- Spongiform encephalopathies
  - misfolded versions of normal brain proteins
    - induce normal proteins to take on abnormal shape
    - destroy brain cell & brain function
    - mad cow disease
    - Creutzfeldt-Jakob disease