Viruses

- **Virology** - study of viruses

- **Characteristics:**
  - acellular
  - obligate intracellular parasites
  - no ribosomes or means of protein synthesis
  - no ATP generating system
  - NOT ALIVE!
Typical Viruses

Two parts:
1) Nucleic acid
   - either DNA or RNA (never both)
2) Capsid (protein coat)
   - Some capsids surrounded by envelopes
Viral Size

*20-14000 nm
*Need electron microscope to view
Host Range

- Variety of host cells that a virus can infect
- Specific viruses often have narrow host range
- Some viruses only infect:
  - plants
  - invertebrates
  - protozoans
  - fungi
  - bacteria
Host/Virus Interaction

- Host range is determined by the viruses ability to interact with host cell
- Binding sites on viral capsid or envelope combine with receptor sites on host cell membrane
Viral Structure

- **Nucleic acid-DNA or RNA**
- **Capsid (coat protein)**
  - **Function:**
  - **Subunits:**
  - **Some have envelopes**
    - made of lipids, proteins, and carbs
    - contain spikes-binding sites that help attach viruses to host/aid in viral ID
Viral Morphology

(a) A polyhedral virus

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Viral Morphology

(a) An enveloped helical virus

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Viral Morphology

(a) A helical virus
Viral Morphology

(a) A T-even bacteriophage

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Viral Classification

- Based on one of the following:
  - nucleic acid
  - morphology
  - strategy of replication
Isolation and Cultivation of Viruses

- Viruses must be grown in living cultures

- Bacteriophages:
  - easiest viruses to grow in the lab
Growing Bacteriophages

- Prepare a spread plate (lawn) of bacteria
- Add bacteriophages
- As virus replicates, bacteria in area destroyed, leaving a clear zone known as ________________.
Growing Animal Viruses

- Three methods:
  - Living animals
  - Chicken embryos
  - Cell culture
    - Primary cell lines
    - Diploid cell lines
    - Continuous cell lines
Viroids

Viroids:
- infectious pieces of naked RNA
- cause plant diseases
- 300-400 nucleotides long
- closed, folded 3D shape
Prions

- Infectious proteins
- 1st discovered in the 1980’s
- Diseases:
  - Mad cow
  - Creutzfeldt-Jakob
  - Chronic wasting
    - holes form in brain tissue
Viral Replication

- One virion may enter host and produce 1000’s of viruses
- Viruses lack necessary enzymes for ATP/protein synthesis
- Utilizes host metabolic machinery
Replication of Bacteriophages

- **Two mechanisms:**
  - Lytic cycle
  - Lysogenic cycle
Lytic Cycle

Five steps:

1) Attachment: binding sites must match receptor sites on host bacterial cell
2) Penetration: viral DNA is injected into bacterial cell
3) Biosynthesis: virus uses host cells enzymes and machinery
   * genome replication
   * transcription
   * translation
**Bacteriophage Replication**

**Lytic Cycle**

1. **Attachment:** Phage attaches to host cell.
2. **Penetration:** Phage penetrates host cell and injects its DNA.
4) Maturation: viral particles are assembled

5) Release: lysis occurs
Bacteriophage Replication
Lytic Cycle

3 Biosynthesis: Phage DNA directs synthesis of viral components by the host cell.

4 Maturation: Viral components are assembled into virions.

5 Release: Host cell lyses and new virions are released.

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Lysogenic Cycle

1) Attachment
2) Penetration
3) Integration: viral genome integrated into host cell genome
   *virus is latent
   *prophage
Lysogenic Cycle (continued)

4) Biosynthesis: viral genome activated
   * genome replication
   * transcription
   * translation
5) Assembly
6) Release: lysis
Lysogenic Convergence

- Results when a bacterial cell infected by a virus that has entered the lysogenic cycle
  - Examples:
    - Corynebacterium diptheria
    - Clostridium botulinum
    - Streptococcus pyogenes (may cause scarlet fever if lysogenic convergence occurs)
Lytic vs Lysogenic Cycle

1. Phage attaches to host cell and injects DNA
2. Phage DNA circularizes and enters lytic cycle or lysogenic cycle
3. NEW phage DNA and proteins are synthesized and assembled into virions
   3A. New phage DNA and proteins are synthesized and assembled into virions
   3B. Phage DNA integrates within the bacterial chromosome by recombination, becoming a prophage
4. Lysogenic bacterium reproduces normally
   4A. Cell lyses, releasing phage virions
   4B. Many cell divisions
5. Occasionally, the prophage may excise from the bacterial chromosome by another recombination event, initiating a lytic cycle

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Animal Virus Replication

1) Attachment: binding sites must match receptor sites on host cell
2) Penetration: endocytosis occurs and entire virus enters cell
3) Uncoating: separation of the viral genome from the capsid
Animal Virus Replication (continued)

4) Biosynthesis
   * genome replication
   * transcription
   * translation

5) Maturation: virus particles assembled

6) Release: lysis
Enveloped Virus Replication

1) Attachment
2) Penetration
3) Uncoating
4) Biosynthesis
5) Maturation: assembly
6) Release: budding
Retro Viruses

- Unique
- 1975
  - RNA----> DNA---->mRNA---->protein
  - utilizes reverse transcriptase

- Normal virus
  - DNA---->mRNA---->protein
  - Central Dogma of Molecular Genetics
Retro Viruses

- Include many cancer causing viruses
- HIV
  - Human Immunodeficiency Virus
  - causes AIDS
  - Acquired Immunodeficiency Syndrome
HIV

- Leads to AIDS
  - results in immune system failure
  - death usually results from opportunistic infection (pneumonia)
  - HIV-discovered in 1984
HIV Structure

- Retro virus
- RNA nucleic acid (two strands)
- Envelope (gp 120 binding sites)
- Reverse transcriptase
1) Attachment:
   * HIV gp 120 binding sites must match CD4 receptor sites
   CD4 receptor sites
     a) macrophages
     b) CNS cells
     c) T4 helper cells (CD4 cells)
HIV Infection (continued)

2) Penetration: viral membrane fuses with host cell membrane

3) Uncoating: capsid removed and viral genome exposed

4) Integration: viral genome enters host
   Two possibilities:
   a) nothing-virus remains latent
   b) HIV genome expressed or “turned on”
If HIV genome turned on--->
- death usually results within 2 yrs
- What causes HIV genome to be turned on?
  - stress
  - alcohol/drug abuse
  - nutrition
  - exercise
Now that HIV genome in turned on....

5) Biosynthesis:
   * genome replication
   * transcription
   * translation

6) Maturation: viral particles put together

7) Release: by budding
Methods of HIV Transmission

- HIV transmitted by exposure to infected body fluids
  - Four body fluids
    - ________________
    - ________________
    - ________________
    - ________________
Ways in which infected fluids can be transferred from one person to another?

- High risk sexual contact
- Contaminated needles
- Blood to blood contact
- Mother to child
The Immune System and HIV

- **Cellular Response**
  - cells phagocytize microorganisms

- **Humoral Response**
  - antibodies destroy or inactive microorganisms
1) Acute Infection

*Initial infection of HIV (exposure to infected body fluids)

*Viremia:

*May last for a couple of weeks

*Normal CD4 count__________
2) Asymptomatic Disease
   * CD4 count now less than_______
   * Virus latent inside CD4 cells
   * Average latency=
   * No signs/symptoms of illness
   * HIV positive-antibodies detected in blood
3) Symptomatic Disease
   * CD4 cell count________________
   * viral genome turned on
   * symptoms appear: chronic fatigue, fever, diarrhea, weight loss
   * Susceptible to infections: bacterial pneumonia, meningitis, TB, yeast infections
4) Advanced Disease (AIDS)
CD4 cell count ______________
*Severe opportunistic infections
- Pneumocystic carini pneumonia
- Kaposi’s sarcoma (cancer)
- Cryptosporidiosis (GI tract)
- Toxoplasmosis (brain)
- other bacterial, fungal, viral infections
Testing for HIV

- ELISA-enzyme linked immunosorbant assay
  - tests for HIV antibodies
  - after two positives, test for viral antigens completed

- Western blot
  - tests for HIV viral antigens
HIV Treatment

- NO CURE
- AZT (azidothymidine)
  - inhibits reverse transcriptase
- AIDS cocktail
  - AZT, 3TC, and a protease inhibitor
HIV Vaccine

- NONE AVAILABLE
- HIV mutates too quickly
- reverse transcriptase forms at least 1 mutation each time it is used
- 1 million variants during asymptomatic stage
- 100 million variants during AIDS