20 - Viruses and Prokaryotes

20.1 - Viruses
Discovery of Viruses

- **Dmitri Ivanovski** – realized an ‘invisible’ agent (substance) was causing disease in *tobacco plants* (Tobacco Mosaic disease)

- **Martinus Beijerink** – determined small particles cause the disease, which he called *Viruses* (Latin for poison)

- **Wendell Stanley** – isolated *crystals* of the Tobacco Mosaic Virus
  - Determined that viruses are not *living* because living things cannot be *crystallized*
Structure

- Nonliving particles made of proteins, nucleic acids (DNA, RNA) and sometimes lipids (membrane)

- Many shapes and sizes, but can only be seen with an electron microscope
A. Smallpox virus  
B. Orf virus  
C. Rhabdovirus  
D. Paramyxovirus  
E. Bacteriophage T2  
F. Flexuous-tailed bacteriophage  
G. Herpes virus  
H. Adenovirus  
I. Influenza virus  
J. Filamentous flexuous virus  
K. Tobacco mosaic virus  
L. Polyoma/papilloma virus  
M. Alfalfa mosaic virus  
N. Poliovirus  
O. Bacteriophage phiX174.
• **Parts of a Virus:**

  • **Capsid** – protein coat surrounding the virus

  • **DNA or RNA** is found within capsid

  • Some viruses have an additional **lipid membrane (envelope)** around capsid (such as **influenza**).
• **Capsid proteins** – protein markers on surface, used to enter a cell (host)

• Proteins bond to specific receptors on cell, allowing most viruses to only infect specific types of cells or specific species

• Viruses can use either **RNA** or **DNA** as their genetic material
Bacteriophages attacking cell
Infections

- Viruses can only ‘reproduce’ by entering a cell and using it to make more copies of itself

- Two methods of infection in bacteria (Eukaryote infections are very similar)

  - Bacteriophage – virus that infects bacteria
**Lytic Infection:**

- Virus attaches to cell at receptor site
- **Virus enters cell** or injects its DNA into cell
- **Viral DNA** instructs the cell to make **viral proteins** that destroy the cell’s own DNA
- Cell is used to make thousands of copies of the viral DNA
• Viral DNA is used to make **new capsids (proteins)** for the new viruses

• New viruses are **assembled**

• Cell **lyses, or bursts**, releasing the newly made viruses, which will infect more cells
Lysogenic infections:

• Virus enters or injects its DNA into cell

• DNA isn’t used immediately, but it is inserted into the cell’s DNA
• **Provirus** – viral DNA that has been inserted into the cell’s own DNA

• **Prophage** – bacteriophage DNA that has been inserted into cell’s DNA
Viral DNA will be copied along with the cell’s DNA during cell division, so all daughter cells are also infected.
• The prophage remains dormant (unused) for a long time

• Certain conditions in environment trigger the viral DNA to begin building more viruses

• Lytic cycle begins and new viruses are made
The virus injects DNA into a bacterium.

Viral enzymes lyse the bacterium's cell wall. The new viruses escape and infect other bacterial cells.

The proteins and nucleic acids assemble into new viruses.

Viral genes are transcribed by the host cell.

The prophage may replicate with the bacterium for many generations.

The prophage can exit the bacterial chromosome and enter a lytic cycle.

The bacterium makes new viral proteins and nucleic acids.

The viral DNA inserts itself into the bacterial chromosome, where it is called a prophage.

LYSOGENIC INFECTION

LYTIC INFECTION
RNA Viruses

- 70% of viruses use RNA as their genetic information, instead of DNA

Common Cold:
- Virus inserts its RNA into host cell
- RNA copies are made, which are then used to build more capsids
- Cell lyses and viruses infect more cells
- Process takes about 8 hours
HIV: Human immunodeficiency virus
- Virus that causes Acquired Immune Deficiency Syndrome (AIDS)
• Retrovirus – virus inserts RNA into cell, which is used to make a DNA copy through reverse transcription
  • DNA copy is inserted into cell’s DNA

• Similar to lysogenic cycle – viral DNA may remain inactive for long periods of time

• Once activated, viral DNA is used to make copies of the virus

• Virus will begin to destroy the immune system
Viral Disease

- Diseases are caused when viruses disrupt the body’s normal homeostasis.

**Disease Mechanisms:**

- Viruses attack and destroy certain cells in the body, causing symptoms associated with those cells/systems.
  - Poliovirus attacks nerve cells, causing paralysis.

- Viruses change the patterns of growth and development in cells, sometimes causing cancer.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Effect on Body</th>
<th>Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common cold</td>
<td>Sneezing, sore throat, fever, headache, muscle aches</td>
<td>Contact with contaminated objects; droplet inhalation</td>
</tr>
<tr>
<td>Influenza</td>
<td>Body aches, fever, sore throat, headache, dry cough, fatigue, nasal congestion</td>
<td>Flu viruses spread in respiratory droplets caused by coughing and sneezing.</td>
</tr>
<tr>
<td>AIDS (HIV)</td>
<td>Helper T cells, which are needed for normal immune-system function, are destroyed.</td>
<td>Sexual contact; contact with contaminated blood or body fluids; can be passed to babies during delivery or during breastfeeding.</td>
</tr>
<tr>
<td>Chicken pox</td>
<td>Skin rash of blisterlike lesions</td>
<td>Virus particles are spread in respiratory droplets caused by coughing and sneezing; highly contagious</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>Jaundice, fatigue, abdominal pain, nausea, vomiting, joint pain</td>
<td>Contact with contaminated blood or bodily fluids</td>
</tr>
<tr>
<td>West Nile Virus</td>
<td>Fever, headache, body ache</td>
<td>Bite from an infected mosquito</td>
</tr>
<tr>
<td>Human papillomavirus (HPV)</td>
<td>Genital or anal warts, also cancer of the cervix, penis, and anus</td>
<td>Sexual contact</td>
</tr>
</tbody>
</table>
• Preventing disease:

• **Hygiene** – washing hands to prevent virus from transferring between people

• **Vaccine** – inactive viruses used to build up a person’s **immunity** to a particular virus
• **Treating disease:**
  
  • Cannot use **antibiotics** (only work on bacteria – bio=living)

  • Some **antiviral drugs** have been developed to prevent virus from infecting cells
Emerging Diseases

- Pathogens (disease causing agents) such as bacteria and viruses replicate very quickly
  - This allows them to evolve rapidly

- New diseases can develop quickly, or existing diseases can become harder to treat

- Dangerous because new treatments take time to develop
New Viruses

- Rapid evolution in viruses may allow certain viruses to infect a new species
  - HIV – believed to have ‘jumped’ from primates to humans (not through sex!)
  - Influenza – certain forms (bird flu, swine flu) may be able to infect humans (more dangerous than our standard flu)
Prions

- Proteins that have been improperly folded and function irregularly
  - Existing prions cause other proteins to misfold, producing more prions
- Causes damage to the brain, causing various neurological disorders
Scrapie – infections disease in sheep causes a sheep to continuously scrape/scratch its body and breaks down nervous tissue in the brain
• Mad Cow disease – degenerative brain disease in cows which breaks down brain and spinal cord tissue, causing increased aggression, lethargy, and involuntary movements, and inability to stand
- Creutzfeldt-Jakob disease – degenerative brain disease, causing dementia, memory loss, problems with speech and movement, and death
Brain shrinkage and deterioration occurs rapidly.

Brain section showing spongiform pathology characteristic of Creutzfeldt-Jakob.
Fatal familial insomnia – disorder in which a person loses the ability to sleep (insomnia), develops anxiety and panic attacks, hallucinations, and eventually death.

Can be genetic or sporadic (random mutation)