Biotechnology Unit: Viruses
What is the cause: bacteria or virus?

- In the late 1800’s Martinus Beijerinck performed this experiment and saw that something “smaller” than bacteria was causing tobacco mosaic disease.
Types of Viruses

(a) Tobacco mosaic virus
(b) Adenoviruses
(c) Influenza viruses
(d) Bacteriophage T4
What are the components of viruses?

- A virus typically consists of two main types of biological molecules:
  - Protein
  - Nucleic Acids
- Basically, there is a protein capsid encasing the genetic material. The capsid is made up of capsomeres. Many viruses have other accessory parts made up of protein.
- However, some are encased in membranes (phospholipids), some consisting of glycoproteins.
  - Which biological molecules make up these two structures?
Basic reproduction of a virus

1. Entry and uncoating
2. Replication
3. Transcription and manufacture of capsid proteins
4. Self-assembly of new virus particles and their exit from the cell
A cell full of viruses!!!

- The lytic cycle destroys the host cell.
- It produces many new virus particles (phages).
- If a phage is only capable of reproducing via the lytic cycle then we call it a **virulent phage**.
- Restriction enzymes have the ability to cut DNA at certain sequences. Some bacteria use these enzymes as a defense mechanism against viral DNA.
Lytic Cycle

1. Attachment

2. Entry of phage DNA and degradation of host DNA
Lytic Cycle

1. Attachment

2. Entry of phage DNA and degradation of host DNA

3. Synthesis of viral genomes and proteins
Lytic Cycle

1. Attachment
2. Entry of phage DNA and degradation of host DNA
3. Synthesis of viral genomes and proteins
4. Assembly

Phage assembly

Head  Tail  Tail fibers
Lytic Cycle

1. Attachment
2. Entry of phage DNA and degradation of host DNA
3. Synthesis of viral genomes and proteins
4. Assembly
5. Release
Look at the following sentence and then take turns with another student elaborating and explaining what the sentence means. Don’t be afraid to draw some diagrams!!

*Viruses replicate via a component assembly model allowing one virus to produce many progeny simultaneously via the lytic cycle!*
...or, the viral DNA can remain dormant

• Phages can also reproduce by making copies of its genetic material without actually making any new viruses…YET!

• We call this the *lysogenic cycle*. The viral genetic material gets incorporated into the host cell’s genome. When this happens we call the viral DNA a *prophage*.

• Every time the host cell undergoes cell division…the prophage is copied!
Lytic vs. Lysogenic Cycles

Lytic cycle
- Virulent or temperate phage
- Destruction of host DNA
- Production of new phages
- Lysis of host cell causes release of progeny phages

Lysogenic cycle
- Temperate phage only
- Genome integrates into bacterial chromosome as prophage, which (1) is replicated and passed on to daughter cells and (2) can be induced to leave the chromosome and initiate a lytic cycle
What implications will this have?

How could the following aspects of the lytic and lysogenic cycles increase rates of evolution?

1. Viruses have highly efficient replicative capabilities that allow for rapid evolution and acquisition of new phenotypes.
2. Virus replication allows for mutations to occur through usual host pathways.
3. RNA viruses lack replication error-checking mechanisms, and thus have higher rates of evolution.
4. Related viruses can combine/recombine information if they infect the same cell.
Lytic vs. Lysogenic Cycles

The phage injects its DNA.

Phage DNA circularizes.

Occasionally, a prophage exits the bacterial chromosome, initiating a lytic cycle.

Cell divisions produce a population of bacteria infected with the prophage.

The bacterium reproduces, copying the prophage and transmitting it to daughter cells.

Phage DNA integrates into the bacterial chromosome, becoming a prophage.

The cell lyses, releasing phages.

New phage DNA and proteins are synthesized and assembled into phages.

Lytic cycle

Lysogenic cycle

Phage DNA

Bacterial chromosome

Daughter cell with prophage

Prophage

Lytic cycle is induced

Lysogenic cycle is entered

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Viral Reproduction including membranous envelopes
Viruses that attack animals

• Viruses that infect animals have the widest range of RNA genomes.

• Some of these, called retroviruses, use an enzyme called reverse transcriptase to copy their RNA genome into DNA.
  – Yes, this goes opposite of the central dogma of biology:
    • DNA is used to make RNA which is used to make PROTEIN.

• HIV is a well-studied system where the rapid evolution of a virus within the host contributes to the pathogenicity of viral infection.
T4 Cell infected with HIV

AIDS poster

HIV ATTACKS YOUR T-CELLS
AND USES THEM TO MAKE COPIES OF ITSELF
Plant viruses

- Most plant viruses have an RNA genome.
- They spread disease in two main ways:
  - Horizontal transmission
    - Entering through the cell walls
  - Vertical transmission
    - Inherited from a parent
Viroids are small, circular RNA molecules that can replicate within the host cell, but do not encode proteins.

- They cause disruptions in the regulatory systems that control plant growth.
Prions are infectious proteins that cause brain diseases in mammals. They “reproduce” by turning healthy proteins into infectious proteins (prions). Some diseases caused by prions are Creutzfeldt-Jakob disease in humans, mad cow disease, and scrapie in sheep.
Creutzfeldt-Jakob Disease

How Creutzfeldt-Jakob disease works

**Cause**
Creutzfeldt-Jakob disease is caused by abnormal proteins called prions that are not killed by standard methods for sterilizing surgical equipment.

**Consequences**
Those affected lose the ability to think and to move properly and suffer from memory loss. It is always fatal, usually within one year of onset of illness.

As prions build up in cells, the brain slowly shrinks and the tissue fills with holes until it resembles a sponge.

**Sources:** World Health Organization, Centers for Disease Control and Prevention, National Institute of Neurological Disorders and Stroke, AP
Viral Emergence
Next time: Increasing Variation Through DNA Transfer!
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