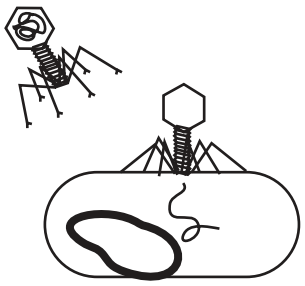
Viruses

An Illustrated Guide to

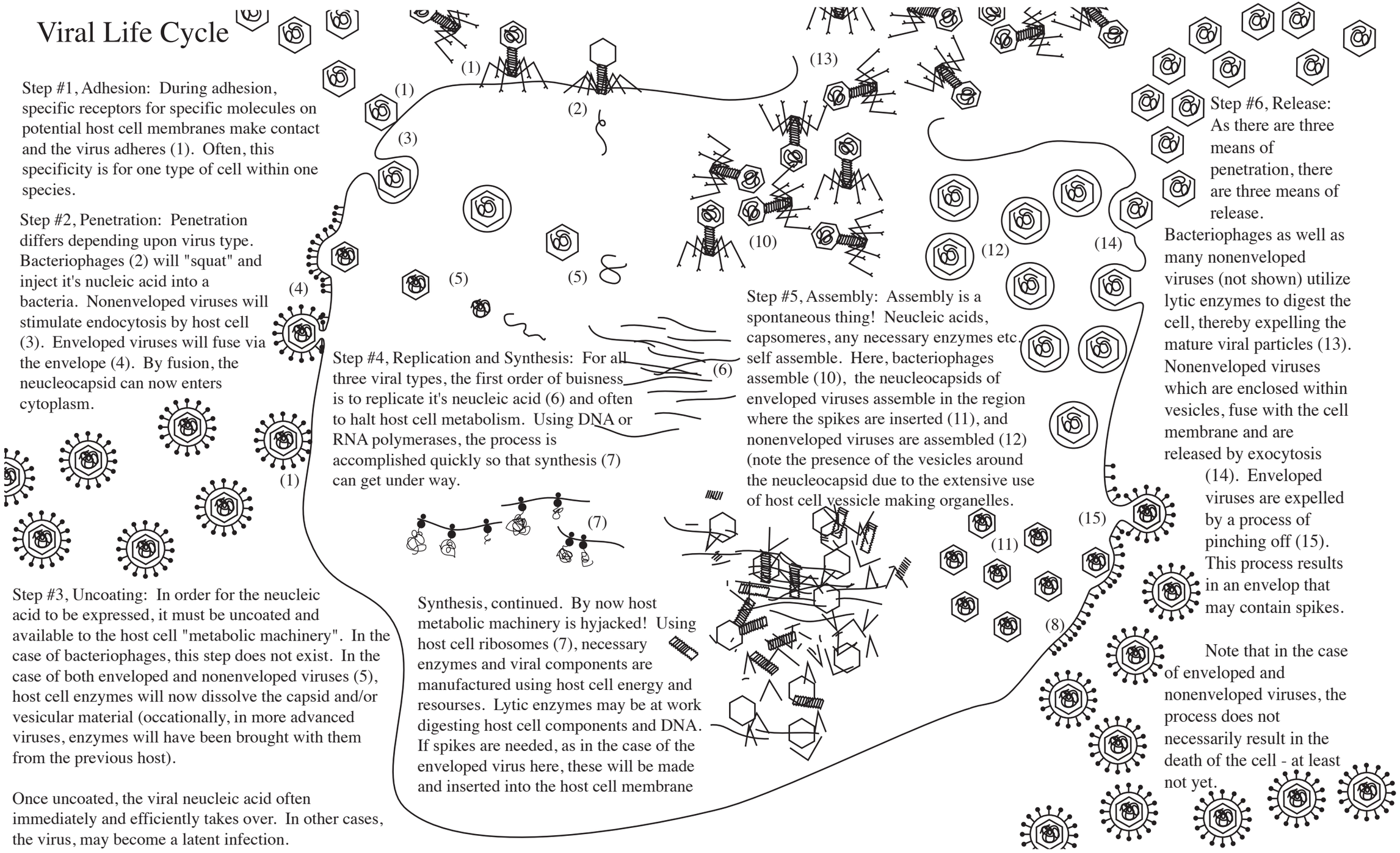
Viral Life Cycles

to Accompany Lecture



By Noel Ways

Viral Life Cycle



Step #1, Adhesion: During adhesion, specific receptors for specific molecules on potential host cell membranes make contact and the virus adheres (1). Often, this specificity is for one type of cell within one species.

Step #2, Penetration: Penetration differs depending upon virus type. Bacteriophages (2) will "squat" and inject it's nucleic acid into a bacteria. Nonenveloped viruses will stimulate endocytosis by host cell (3). Enveloped viruses will fuse via the envelope (4). By fusion, the neucleocapsid can now enters cytoplasm.

Step #3, Uncoating: In order for the neucleic acid to be expressed, it must be uncoated and available to the host cell "metabolic machinery". In the case of bacteriophages, this step does not exist. In the case of both enveloped and nonenveloped viruses (5), host cell enzymes will now dissolve the capsid and/or vesicular material (occationally, in more advanced viruses, enzymes will have been brought with them from the previous host).

Once uncoated, the viral neucleic acid often immediately and efficiently takes over. In other cases, the virus, may become a latent infection.

Step #4, Replication and Synthesis: For all three viral types, the first order of buisness is to replicate it's neucleic acid (6) and often to halt host cell metabolism. Using DNA or RNA polymerases, the process is accomplished quickly so that synthesis (7) can get under way.

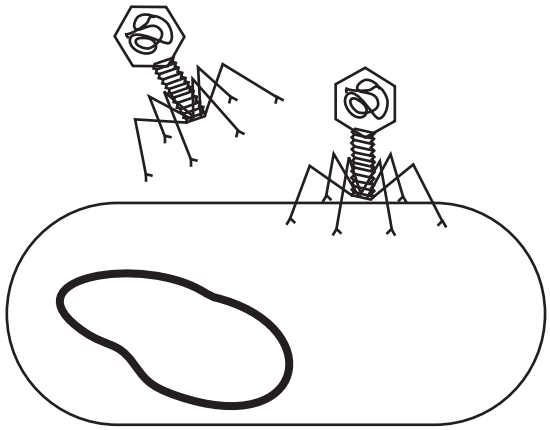
Synthesis, continued. By now host metabolic machinery is hyjacked! Using host cell ribosomes (7), necessary enzymes and viral components are manufactured using host cell energy and resourses. Lytic enzymes may be at work digesting host cell components and DNA. If spikes are needed, as in the case of the enveloped virus here, these will be made and inserted into the host cell membrane

Step #5, Assembly: Assembly is a spontaneous thing! Neucleic acids, capsomeres, any necessary enzymes etc. self assemble. Here, bacteriophages assemble (10), the neucleocapsids of enveloped viruses assemble in the region where the spikes are inserted (11), and nonenveloped viruses are assembled (12) (note the presence of the vesicles around the neucleocapsid due to the extensive use of host cell vessicle making organelles.

Step #6, Release: As there are three means of penetration, there are three means of release. Bacteriophages as well as many nonenveloped viruses (not shown) utilize lytic enzymes to digest the cell, thereby expelling the mature viral particles (13). Nonenveloped viruses which are enclosed within vesicles, fuse with the cell membrane and are released by exocytosis (14). Enveloped viruses are expelled by a process of pinching off (15). This process results in an envelop that may contain spikes.

Note that in the case of enveloped and nonenveloped viruses, the process does not necessarily result in the death of the cell - at least not yet.

Lytic Cycle Stages

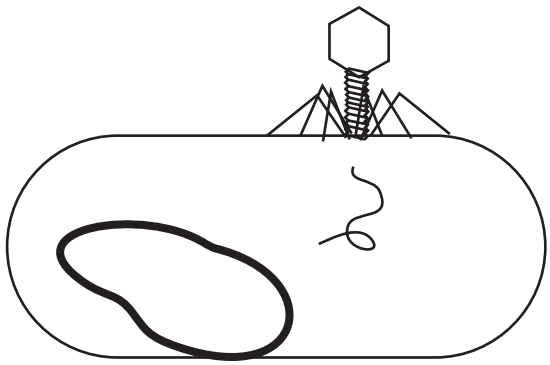


Attachement

Receptor specific molecules on bacteria binds to viral attachment sites

Penetration / Injection

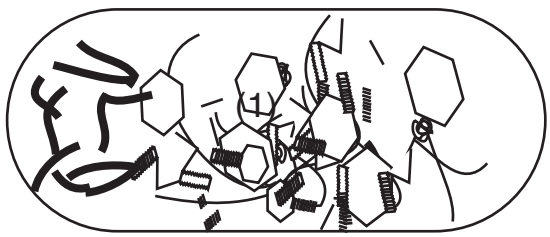
Lysozyme digests bacterial cell wall at attachment site and DNA is injected. Capsid remains outside.



Biosynthesis

Virus enzymes degrade host DNA and host RNA polymerase - Bacterial protein synthesis stops

Host cell enzymes and resourses are used for synthesis of new viral DNA and viral components.

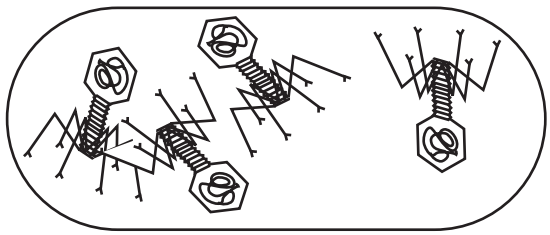


Viral genes code for capsomeres, tail fibers, etc.

Viral protein production is not random but controlled and occurs at appropriate times in the viral life cycle sequence.

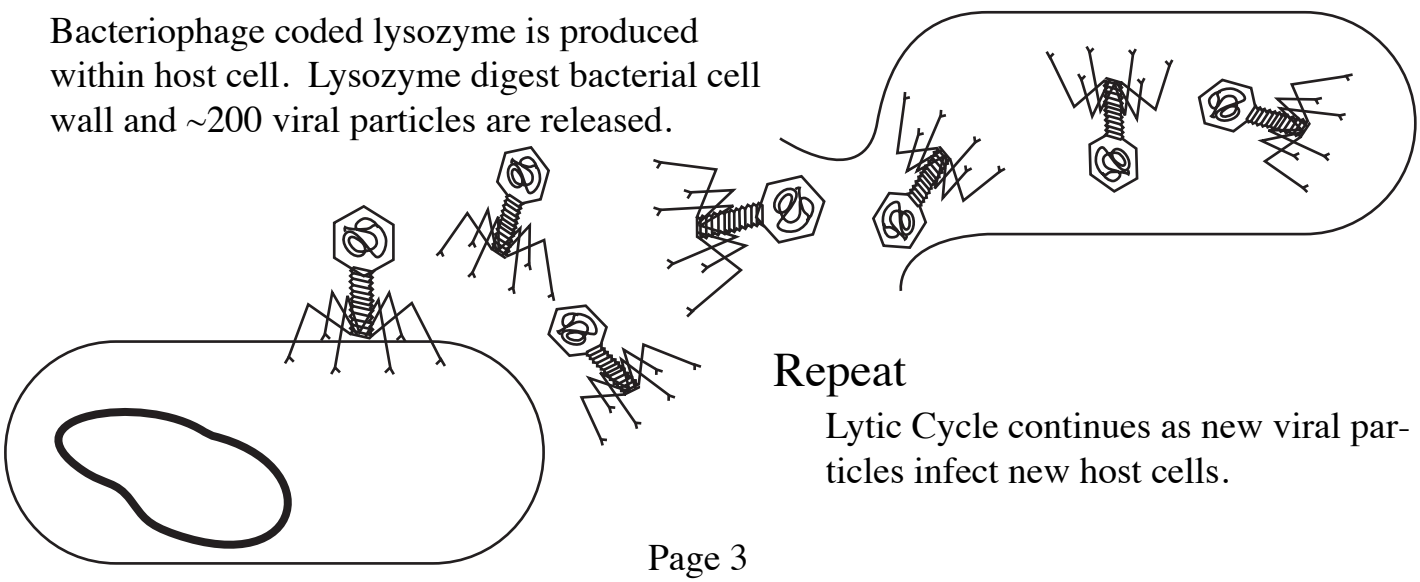
Assembly / Maturation

Complete viral particles self assemble spontaneously.



Release

Bacteriophage coded lysozyme is produced within host cell. Lysozyme digest bacterial cell wall and ~200 viral particles are released.



Repeat

Lytic Cycle continues as new viral particles infect new host cells.

Lysogenic Cycle

Attachement and Penetration

Receptor specific molecules on bacteria bind to viral attachment sites. DNA is injected.

Viral DNA forms circle

At this point Lytic cycle normally occurs, but Lysogenic Cycle may likewise be an outcome.

Prophage

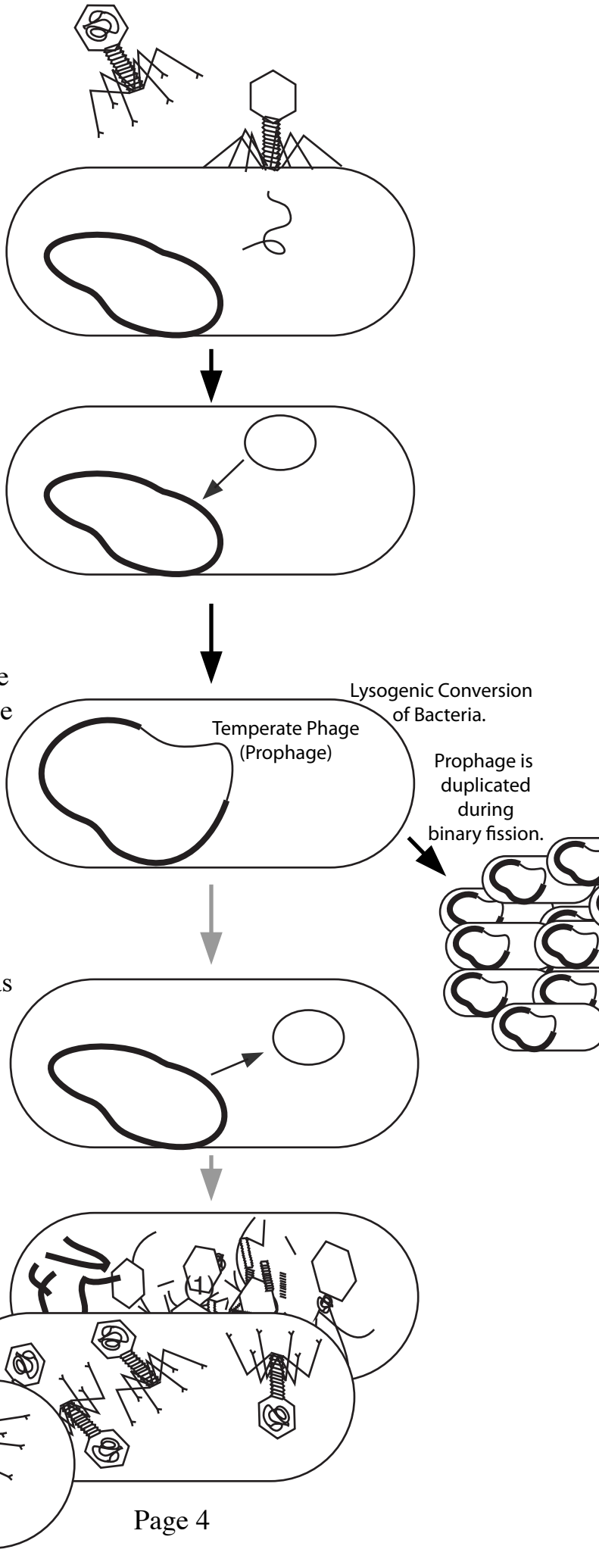
Upon incorporation into host cell genome, the bacteriophage is known as a Prophage; and the bacteria is said to have undergone a Lysogenic Conversion. Some bacteria that have undergone Lysogenic Conversion produce toxins or provide auxiliary functions for the bacteria. Examples:

- *Corynebacterium diphtheriae*: Diphtheria
- *Streptococcus pyogenes*: Scarlet Fever
- *Clostridium botulinum*: Botulism

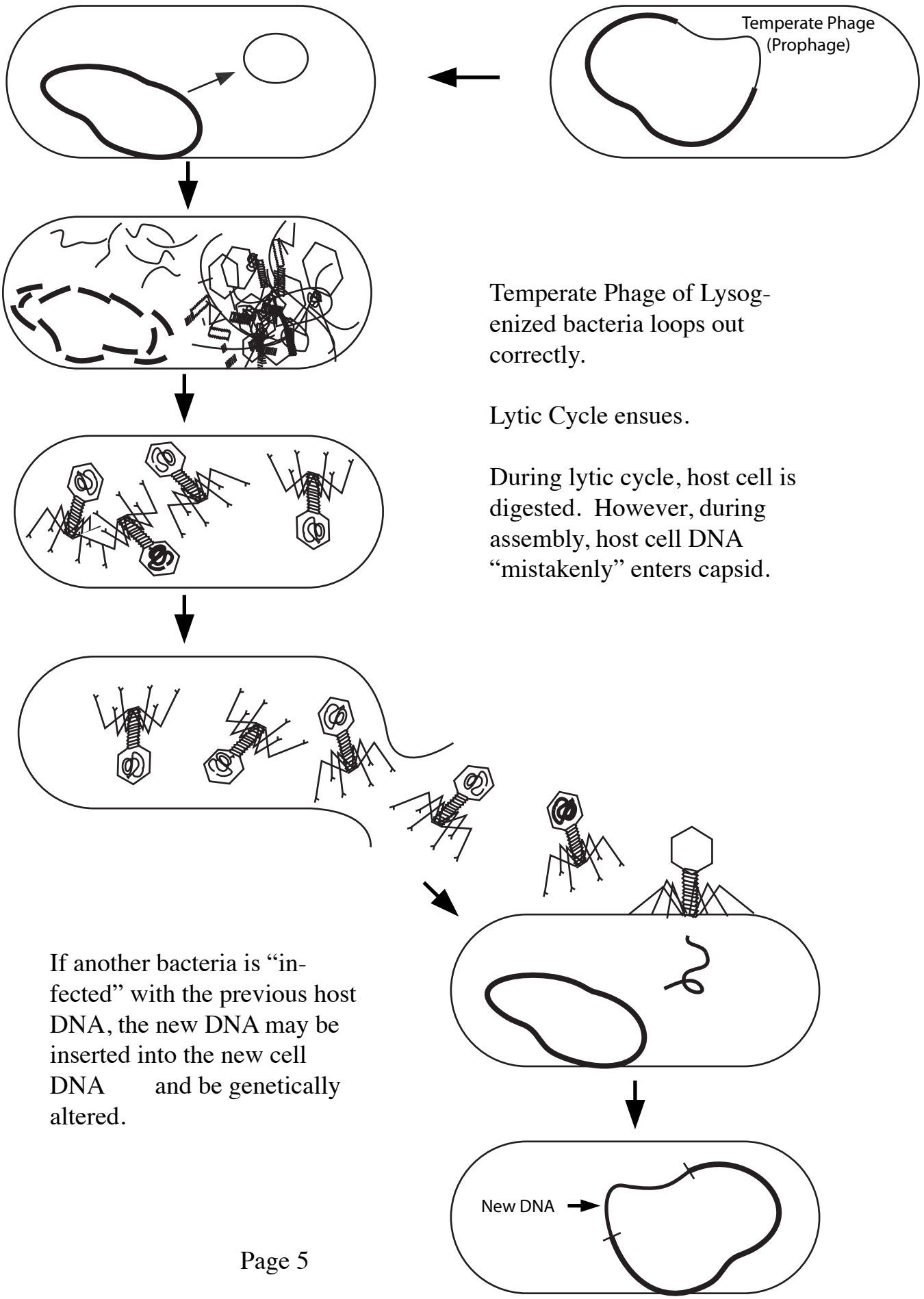
Phage repressor proteins inhibit the lytic cycle. As the bacteria divide, the phage is duplicated as well.

Induction of Lytic Cycle

In a rare event, the phage is excised and the lytic cycle occurs.



Generalized Transduction



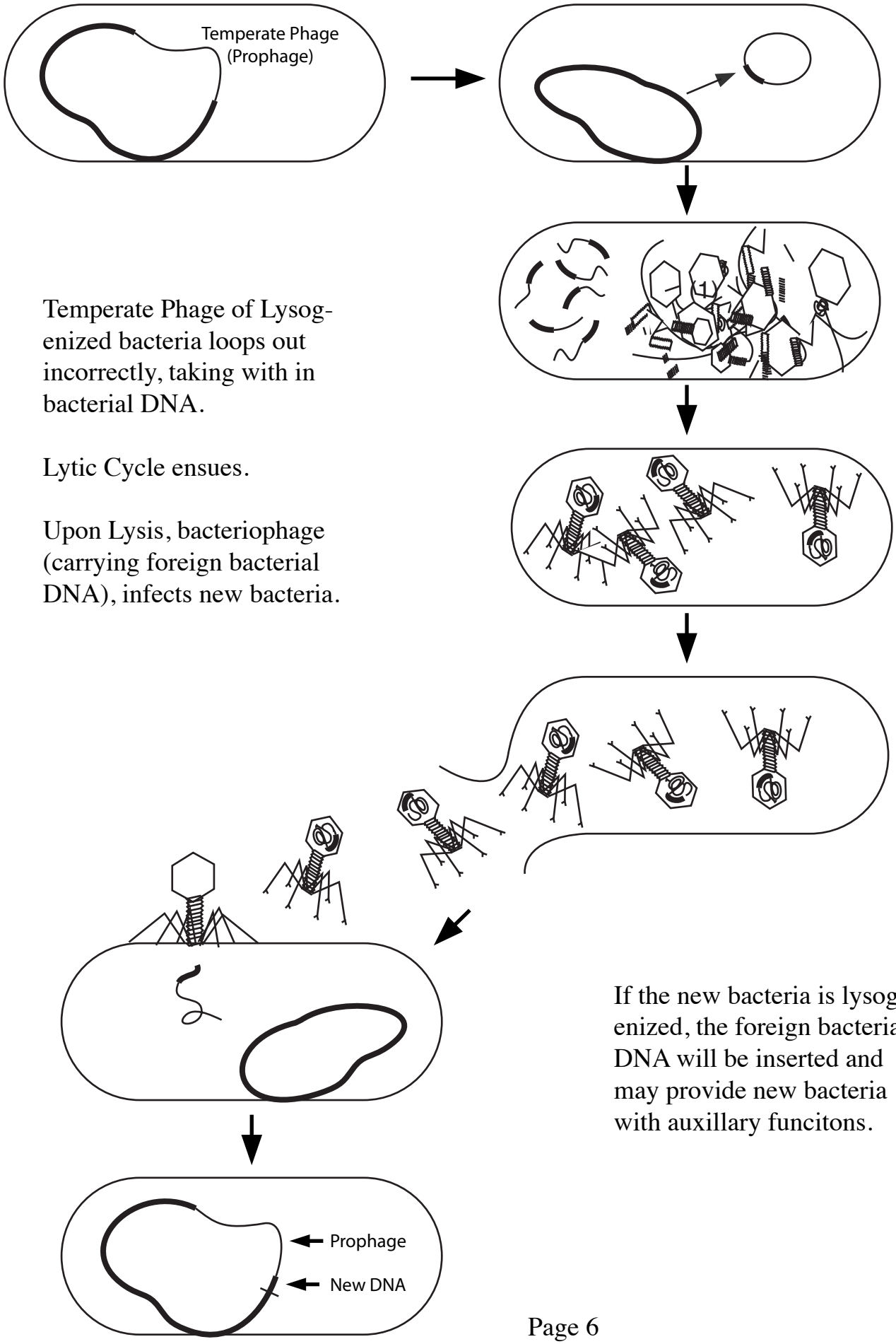
Temperate Phage of Lysogenized bacteria loops out correctly.

Lytic Cycle ensues.

During lytic cycle, host cell is digested. However, during assembly, host cell DNA "mistakenly" enters capsid.

If another bacteria is "infected" with the previous host DNA, the new DNA may be inserted into the new cell DNA and be genetically altered.

Restricted (Specialized) Transduction



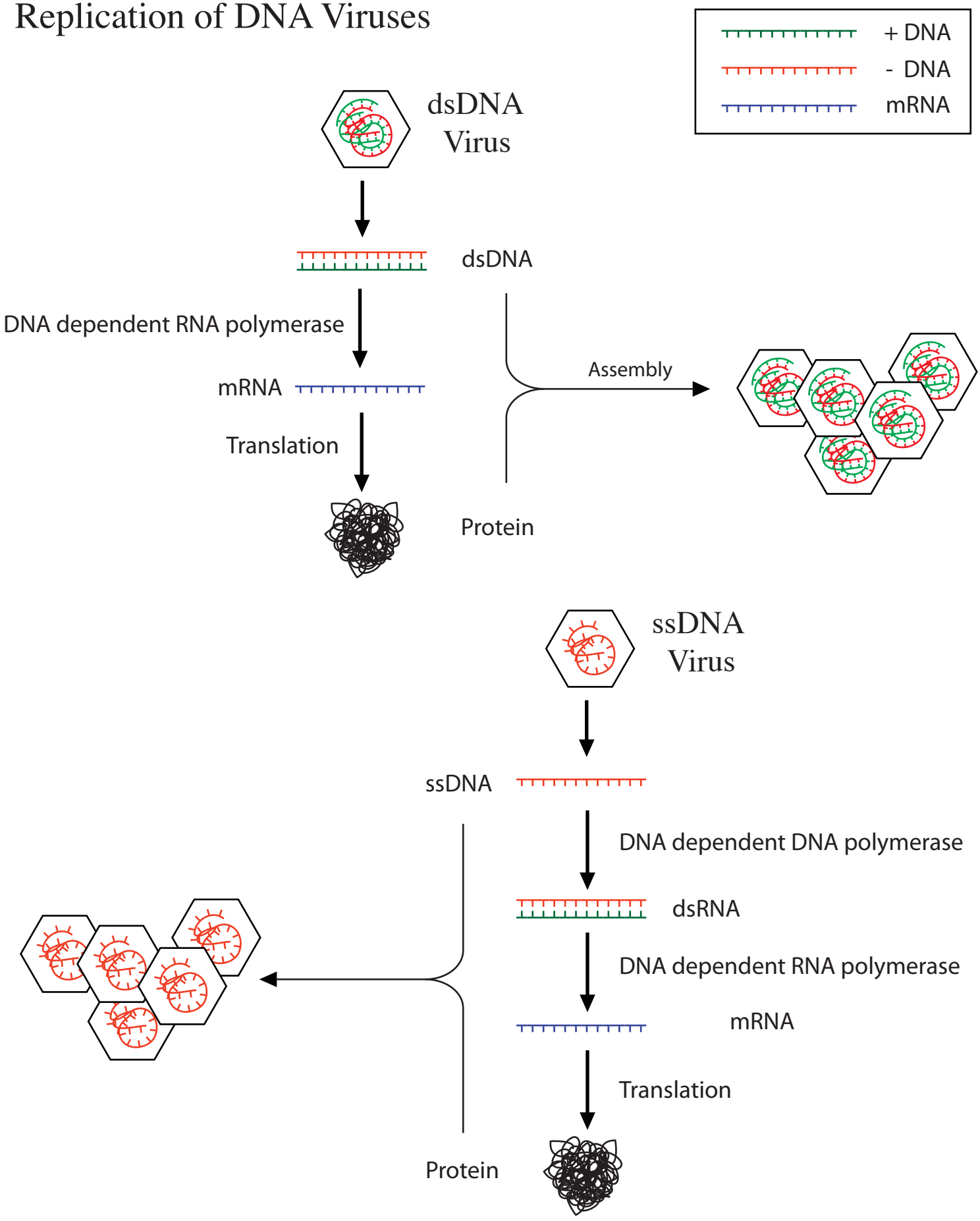
Temperate Phage of Lysogenized bacteria loops out incorrectly, taking with in bacterial DNA.

Lytic Cycle ensues.

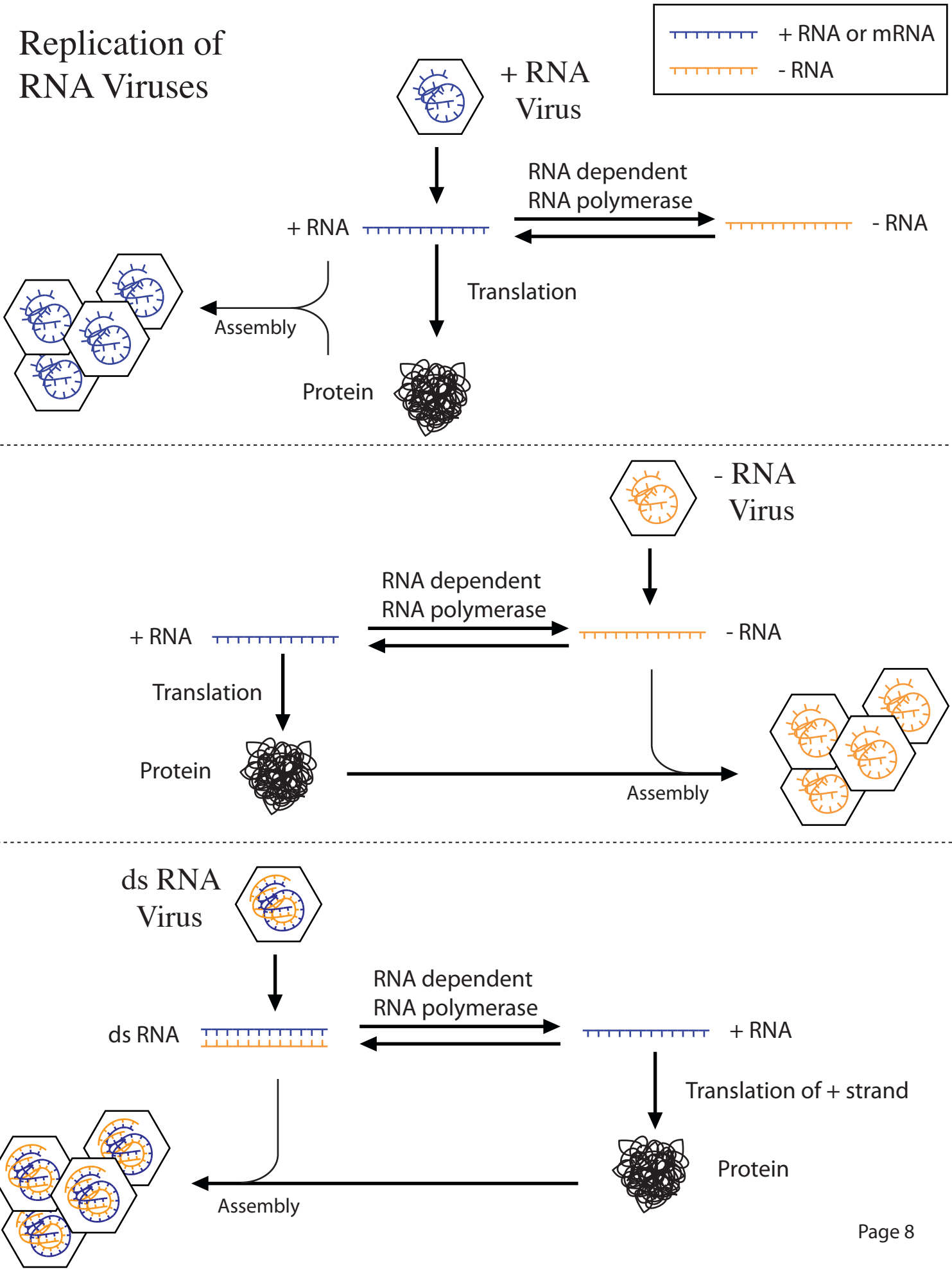
Upon Lysis, bacteriophage (carrying foreign bacterial DNA), infects new bacteria.

If the new bacteria is lysogenized, the foreign bacterial DNA will be inserted and may provide new bacteria with auxillary funcitons.

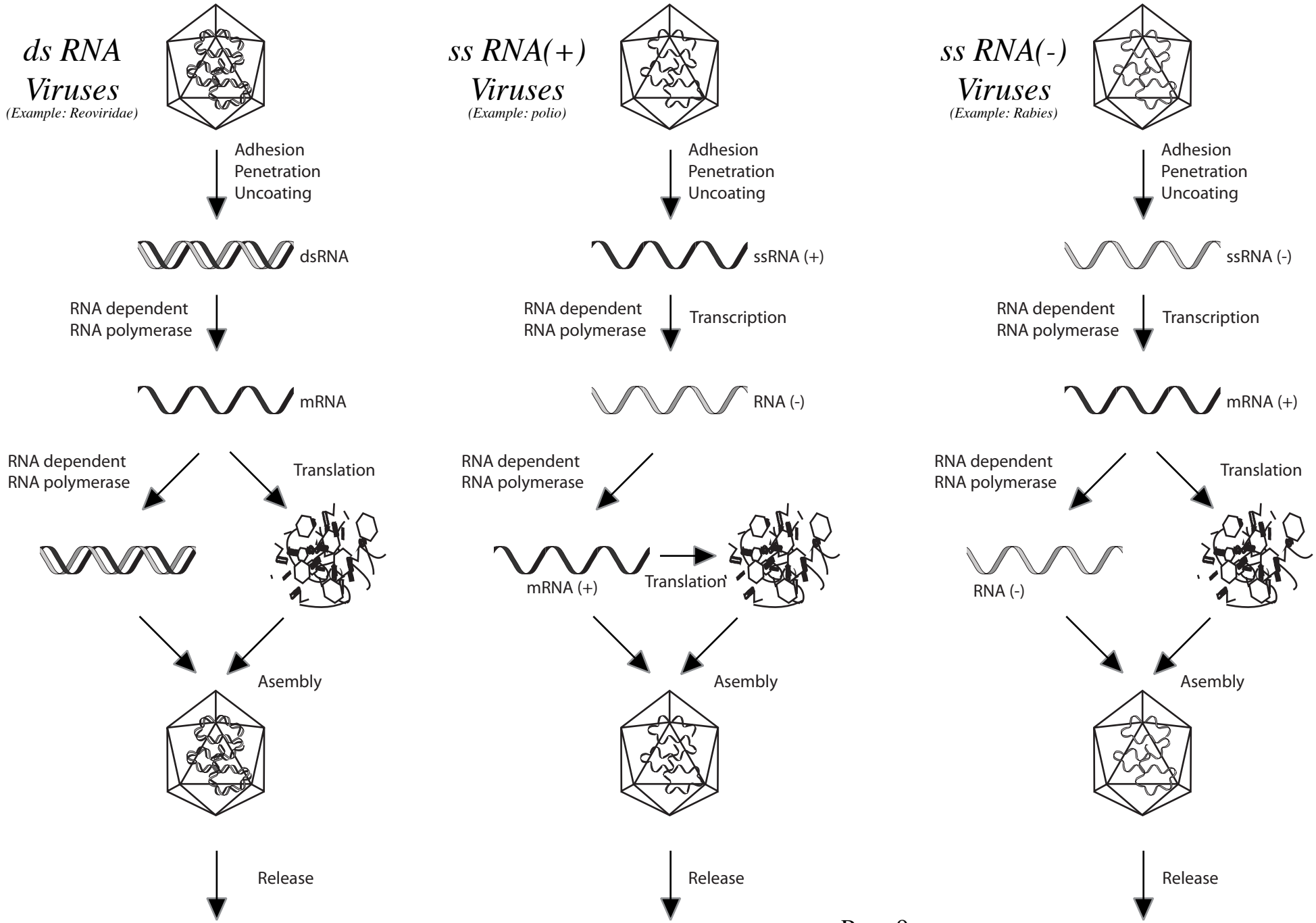
Replication of DNA Viruses



Replication of RNA Viruses



RNA Viruses

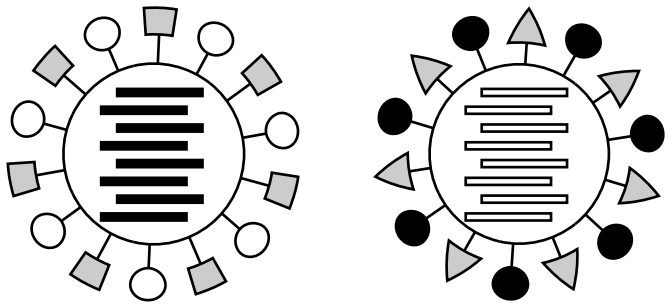

ds RNA Viruses
(Example: Reoviridae)
Adhesion
Penetration
Uncoating
dsRNA
RNA dependent
RNA polymerase
mRNA
RNA dependent
RNA polymerase
Translation
Asembly
Release
ss RNA(+) Viruses
(Example: polio)
Adhesion
Penetration
Uncoating
ssRNA (+)
RNA dependent
RNA polymerase
Transcription
RNA (-)
RNA dependent
RNA polymerase
mRNA (+)
Translation
Asembly
Release
ss RNA(-) Viruses
(Example: Rabies)
Adhesion
Penetration
Uncoating
ssRNA (-)
RNA dependent
RNA polymerase
Transcription
mRNA (+)
RNA dependent
RNA polymerase
Translation
RNA (-)
Asembly
Release

Segmented Genome

and production of new strains of flu

From Bird

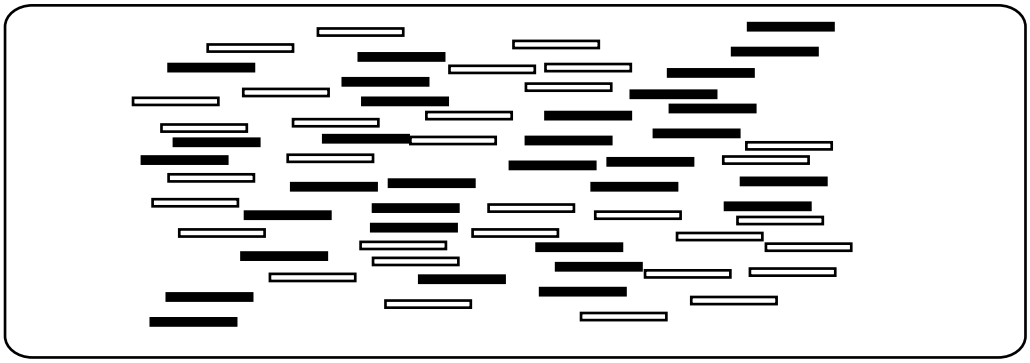
From Animal



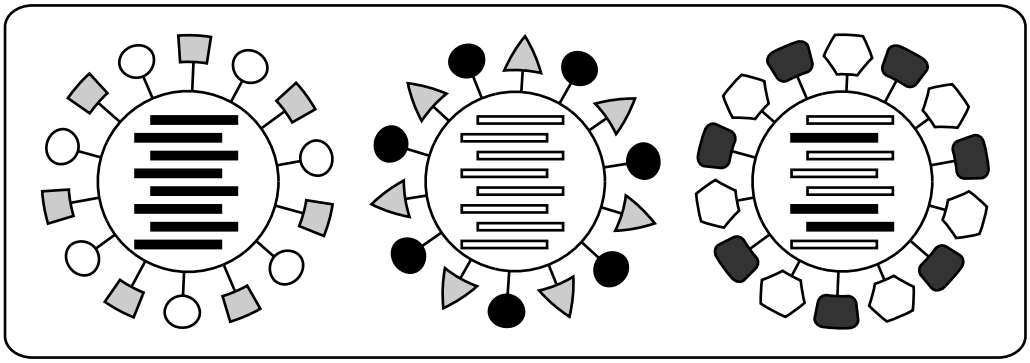
Two antigenically different strains of flu simultaneously infect the same eukaryotic cell

Note Hemagglutinin (function: adhesion) and Neuraminidase (function: penetration) spikes differ.

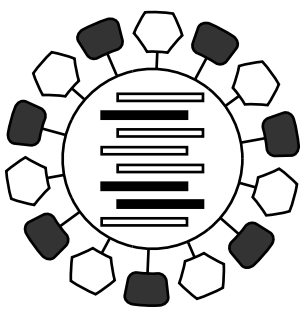
Both are antigenic.



During synthesis stage, RNA from both strains multiply.



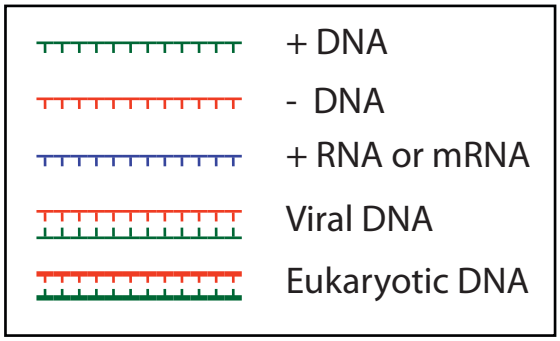
During assembly stage, RNA from different strains may end up in a new virus. New combination of RNA codes for antigenically different characteristics and / or virulence characteristics



The new strain of flu has antigenically unique neuraminidase and hemagglutinin spikes and will meet no resistance from the human population as no person will have antibodies against it.

This new strain of flu may spread rapidly and cause a pandemic

Replication of Retro Viruses



ssRNA (+)
Virus

RNA dependent DNA polymerase
(or Reverse Transcriptase)

DNA dependent
DNA polymerase

- ssDNA

dsDNA

Host dsDNA

Integrase

Provirus in Host DNA

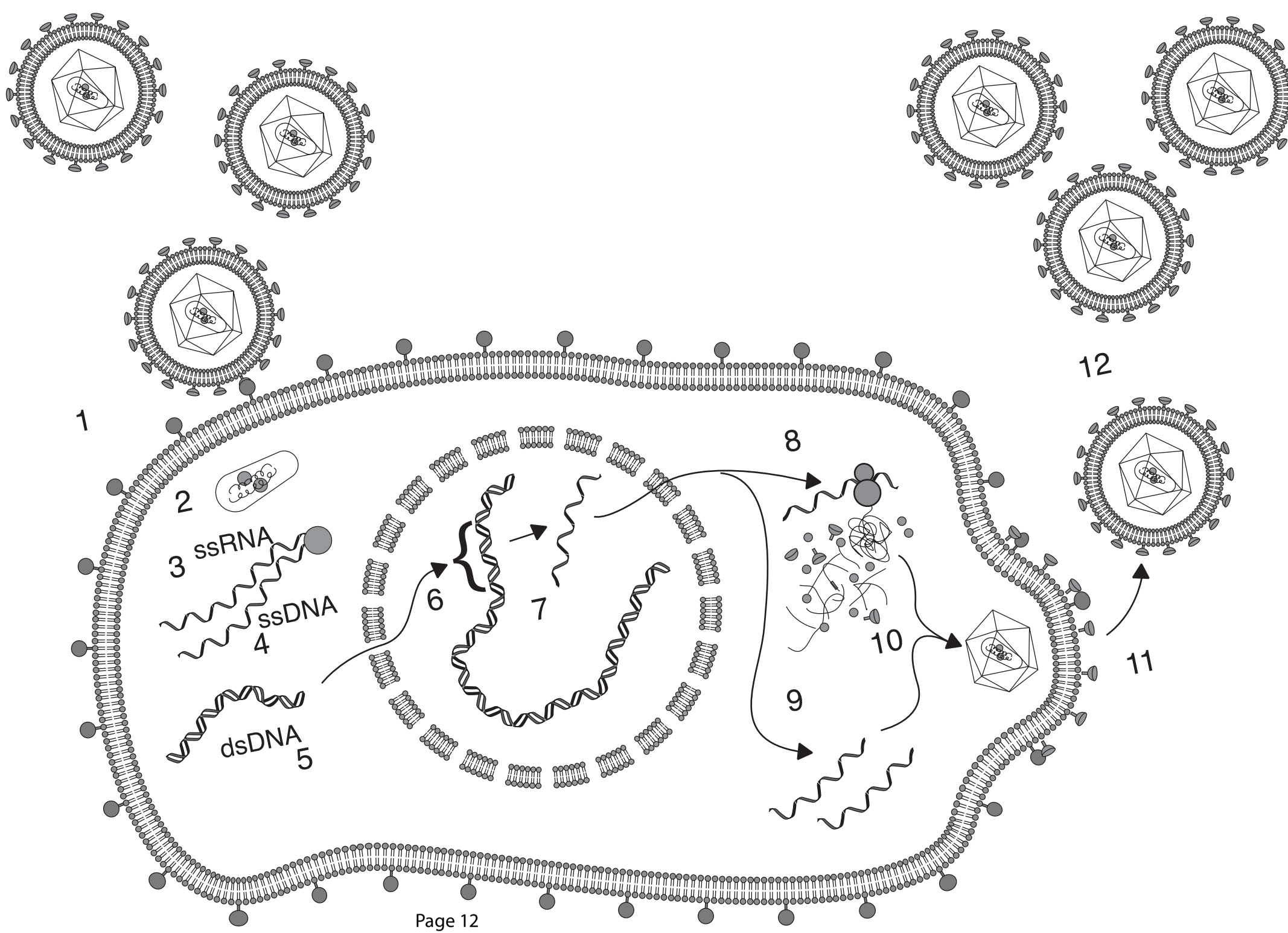
DNA dependent RNA polymerase

+ RNA

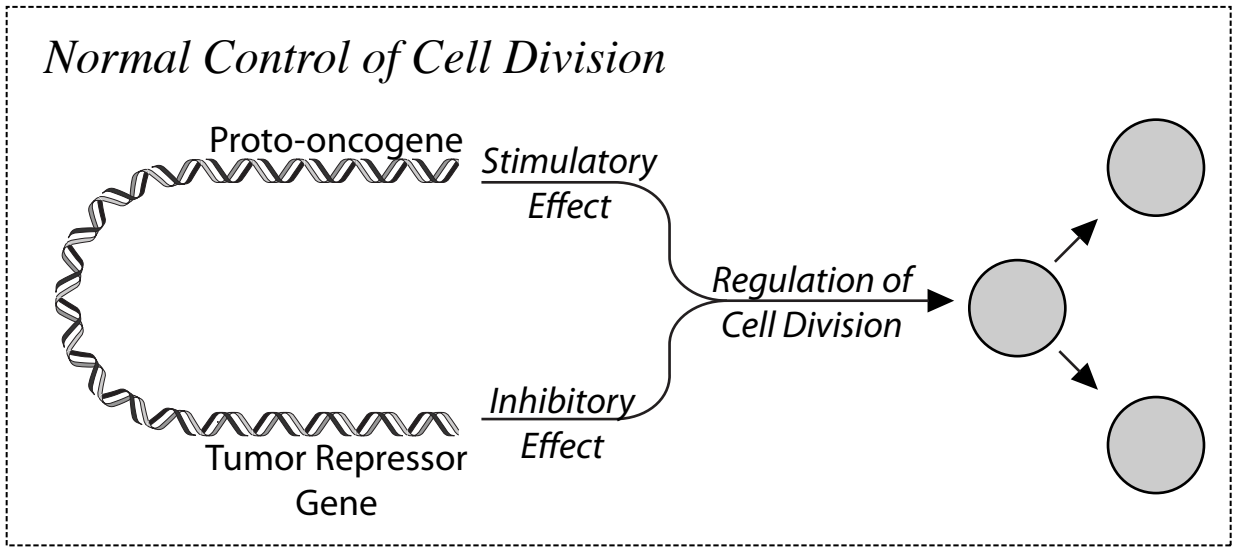
Translation

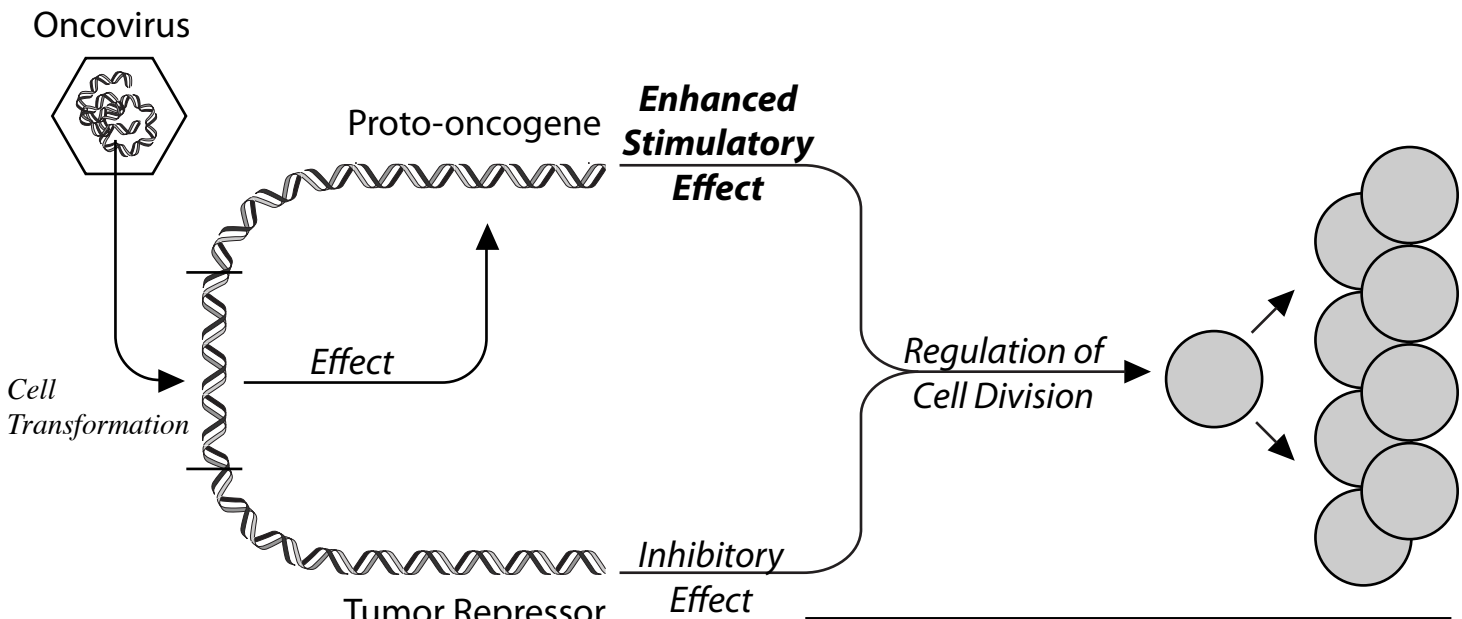
Assembly

Protein


1
2
3
ssRNA
4
ssDNA
5
dsDNA
6
7
8
9
10
11
12

Oncogenic Viruses





DNA Oncogenic Viruses

- Papilomaviruses → Uterine Cancer
- Epstein-barr (EB) Virus → Burkitts Lymphoma
- Hepatitis B → Liver Cancer