BIO 311C
Spring 2010

Final Exam

Date: **Wednesday 12 May**

Time: **7:00 – 10:00 p.m.**

Location: **CMA A2.320**

Lecture 38 – Monday 3 May

Stages in the Life of a Virus

1. (recognition) A virus recognizes, and becomes attached to, the surface of a host cell.

2. (infection) The virus genetic content (nucleic acid) becomes incorporated into the host cell and inactivates host defense mechanisms, thereby stabilizing its genetic content within the cell. In some cases its genetic content may be further stabilized by integrating DNA into a chromosome of the host cell.

3. (synthesis) The virus genetic content dictates instructions for the cell to synthesize virus structural molecules, including its nucleic acid and proteins.

4. (assembly) The recently synthesized molecules are assembled to form new viruses.

5. (release) The new viruses, which are exactly like the virus that originally infected the host cell, are released from the cell.

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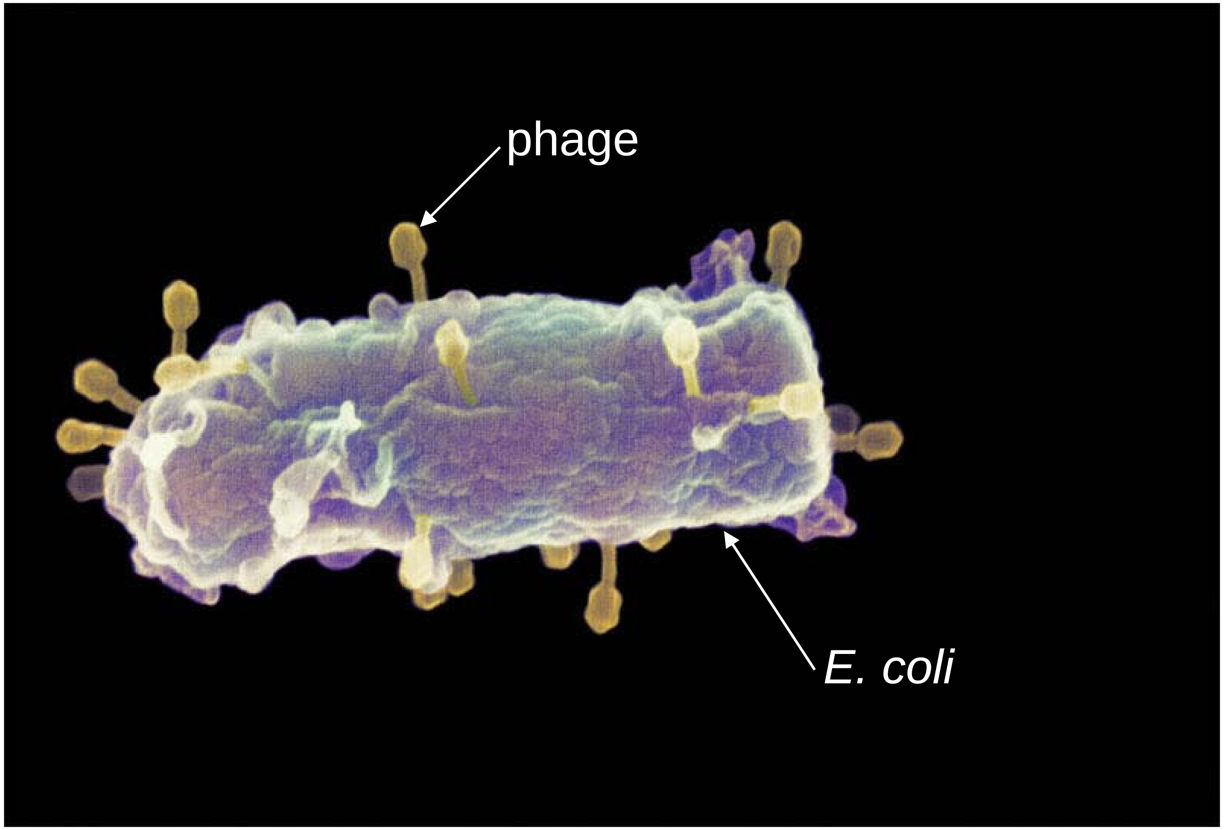
Bacteriophage Attached to the Surface of a Bacterial Cell

Textbook fig. 19.1, p. 381



Presumably these "phage" have injected, or will soon inject, their genetic material (DNA) through the envelope and into the cytoplasm of the bacterial cell.

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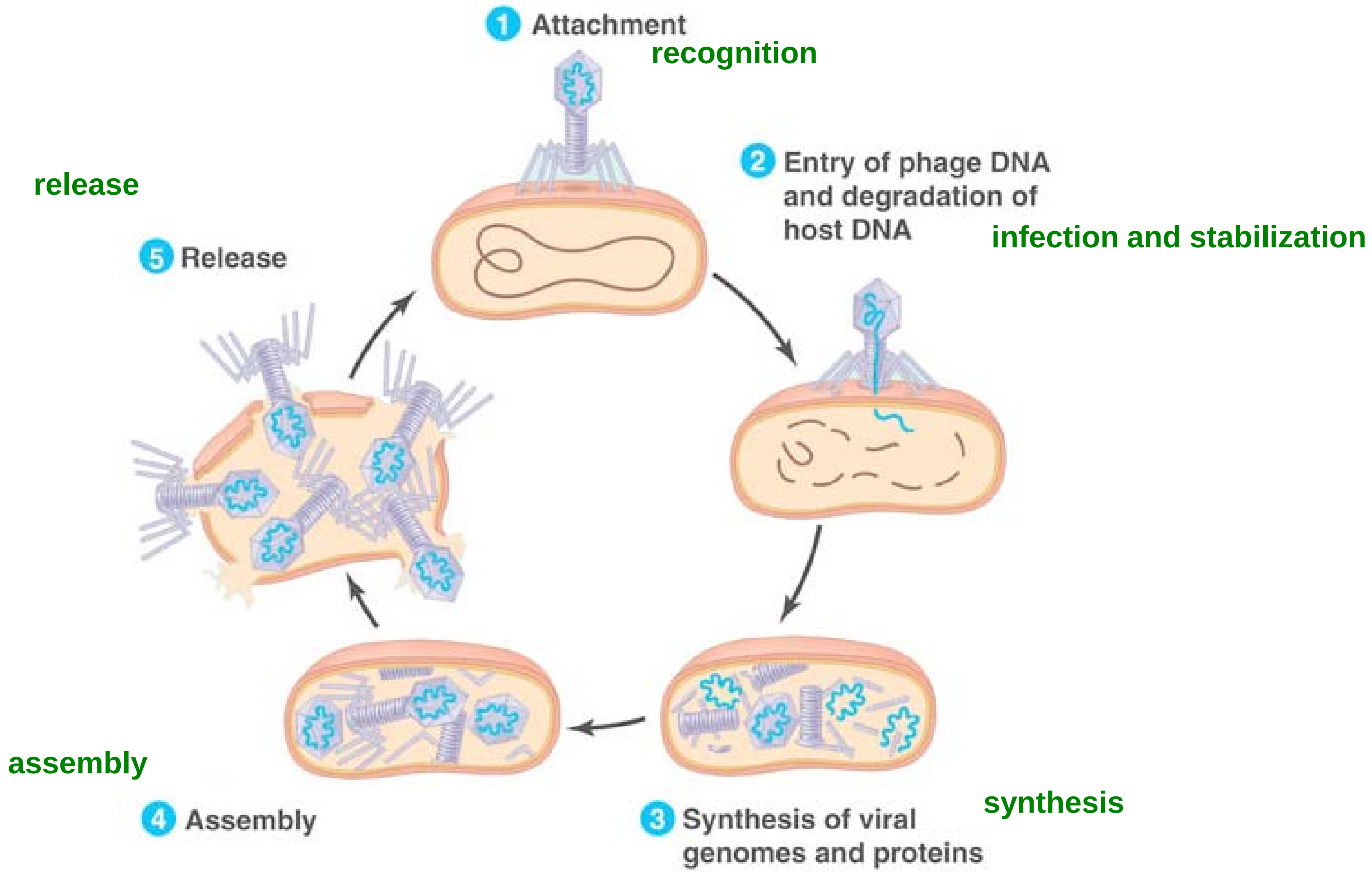
Lytic Cycle of a Typical Bacterial Virus (Bacteriophage)

Textbook Fig. 19.5, p. 385



A virus that attacks a prokaryotic cell is called a bacteriophage, or phage for short.

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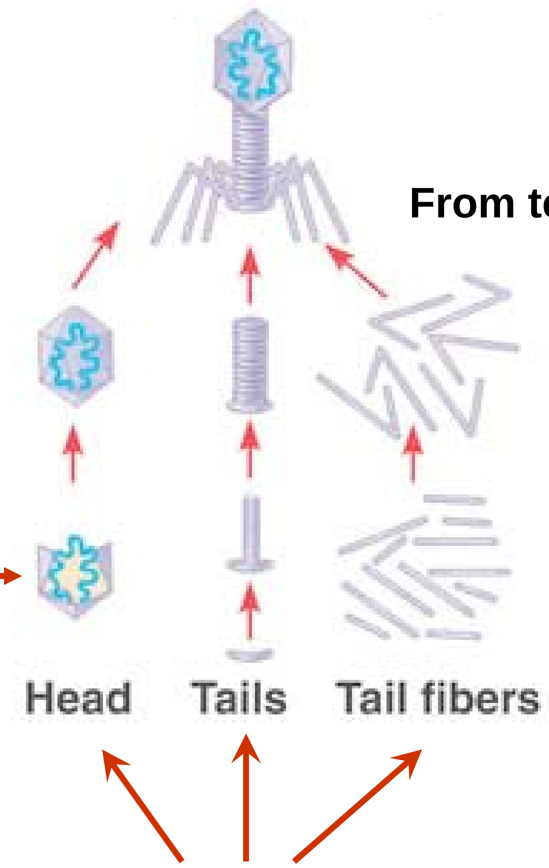
Synthesis and Assembly of Phage within a Bacterial Cell

The name bacteriophage is sometimes shortened to “phage”.

From textbook Fig. 19.5, p. 385

Phage DNA Replication produces new phage DNA



Transcription and translation of phage DNA produce new phage structural proteins

Synthesis of phage genetic information, head proteins, tail proteins and tail-fiber proteins utilize the replication, transcription and translation machinery of the host cell. Assembly then occurs spontaneously.

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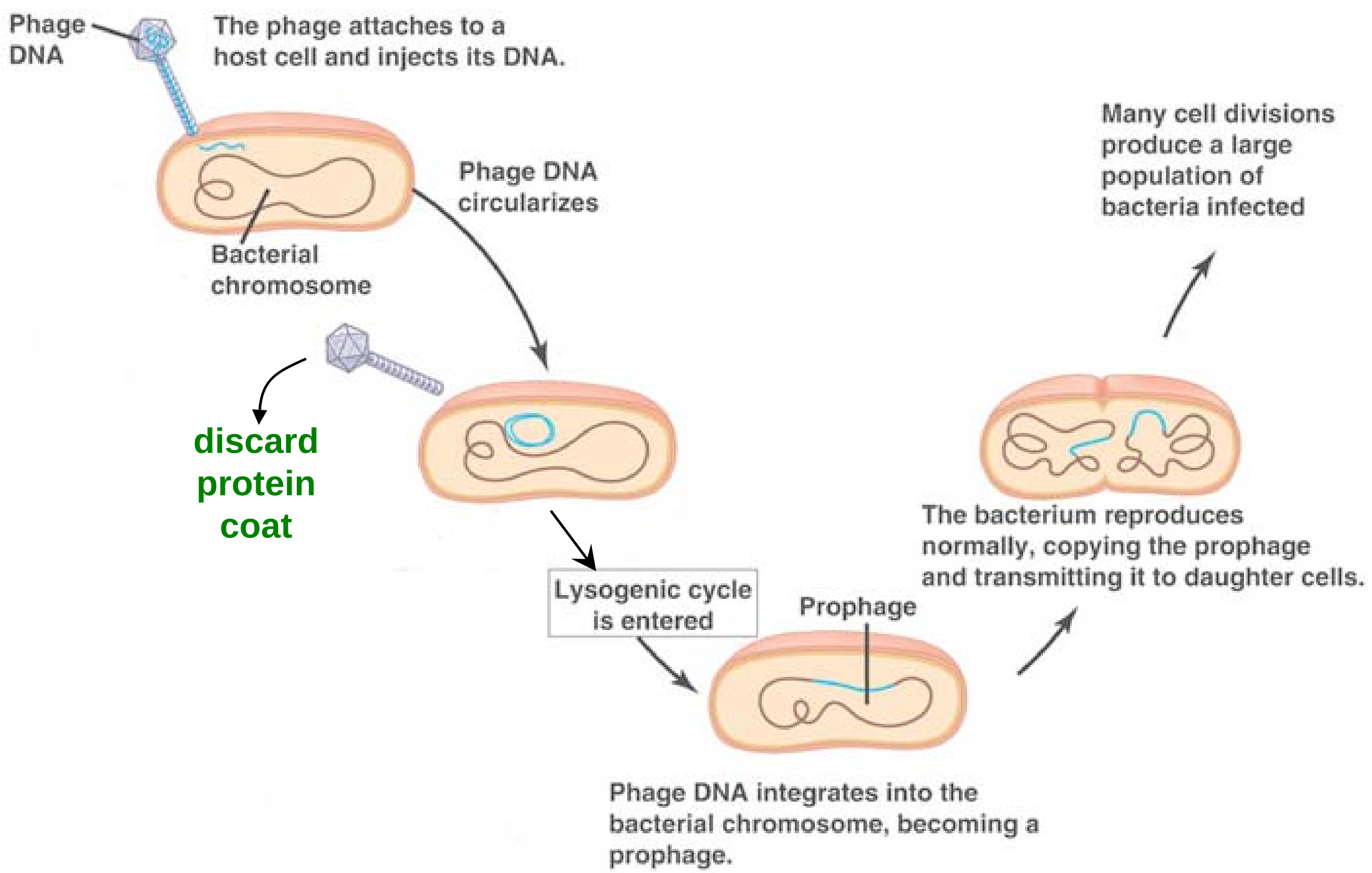
The Lysogenic Phase in the Life of a Bacteriophage

Portion of Fig. 19.6, p. 386



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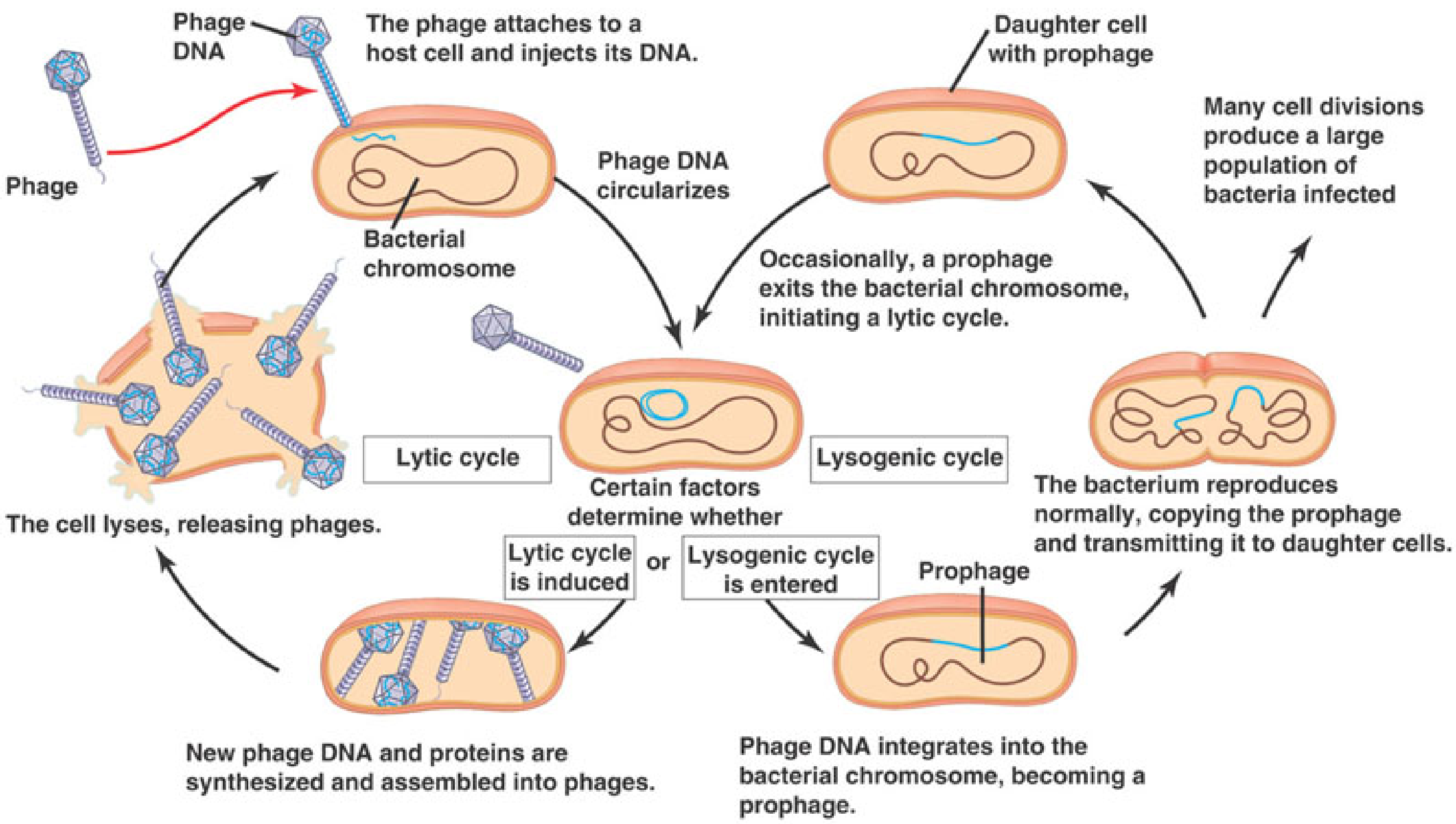
Lytic and Lysogenic Phases of a Typical Bacteriophage



A <u>temperate</u> phage is a bacterial virus that under most circumstances incorporates its DNA into host DNA, thereby becoming a prophage.

A <u>virulent</u> phage is a bacterial virus that typically does not undergo lysogeny, but instead causes host cell lysis soon after synthesis and assembly of new viruses.

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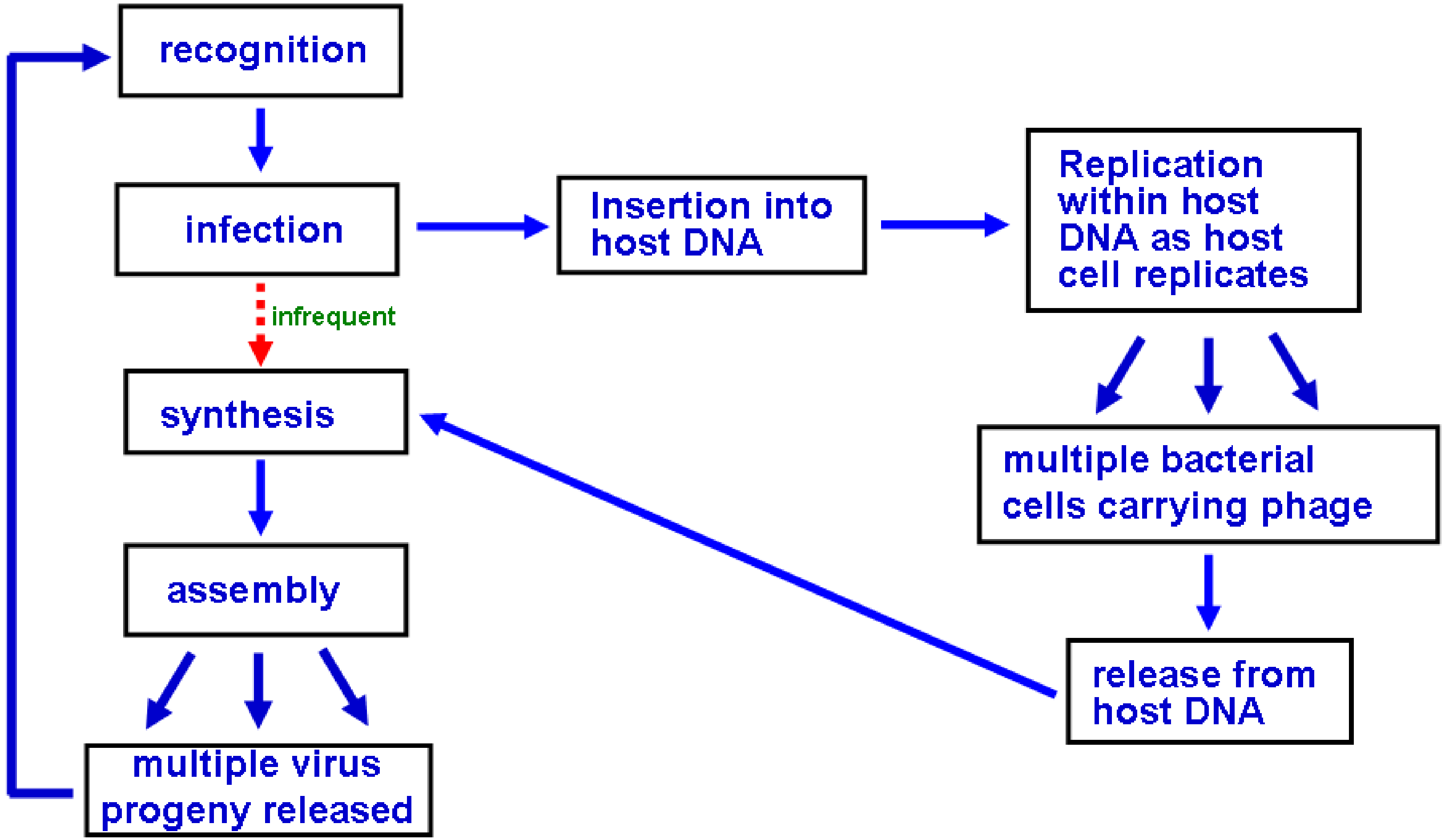
Stages in the Life Cycle of a Lysogenic Bacterial Virus



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Summary of some Differences Between Typical Prokaryotic and Eukaryotic Viruses

- Prokaryotic viruses are generally somewhat more complex in shape and in composition than are eukaryotic viruses.

- Prokaryotic viruses actively insert their DNA into their host cell, while typical eukaryotic viruses are actively taken up by the host cell.

- Most prokaryotic viruses are DNA viruses, while a large percentage of eukaryotic viruses carry RNA as their genetic material.

- Prokaryotic viruses typically have a lytic stage and a lysogenic stage, while a large percentage of eukaryotic viruses are budding viruses.

- The intracellular life cycle of typical eukaryotic viruses is much more complex than that of prokaryotic viruses.

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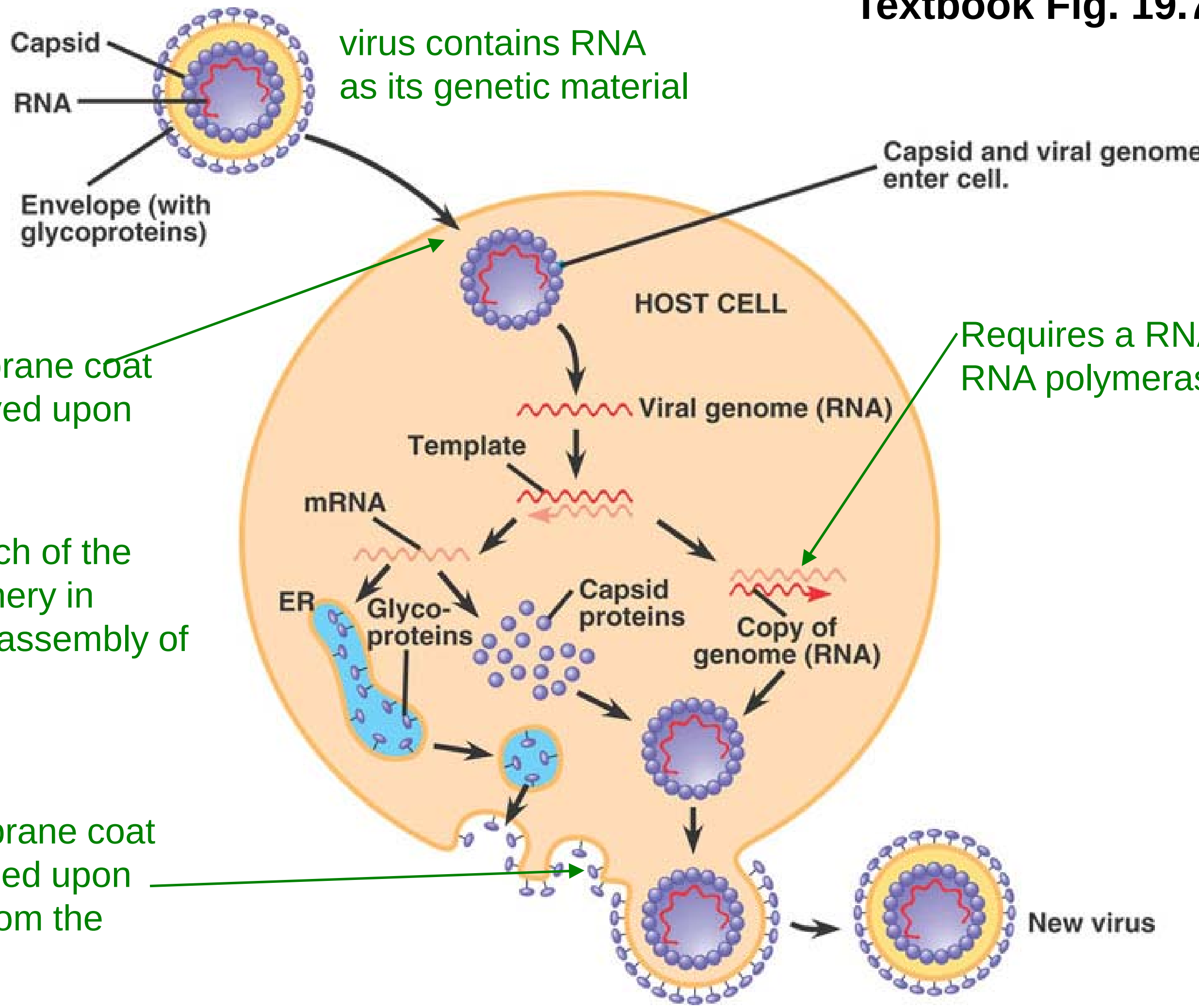
Life Cycle of a Typical Enveloped RNA Virus

Textbook Fig. 19.7, p. 388



virus contains RNA as its genetic material

membrane coat removed upon entry

Requires a RNA-dependent RNA polymerase.

Virus uses much of the cellular machinery in synthesis and assembly of new viruses

membrane coat is added upon exit from the cell.

Animal viruses typically contain a surrounding membrane that resembles, yet complements, the plasma membrane of their host cell.

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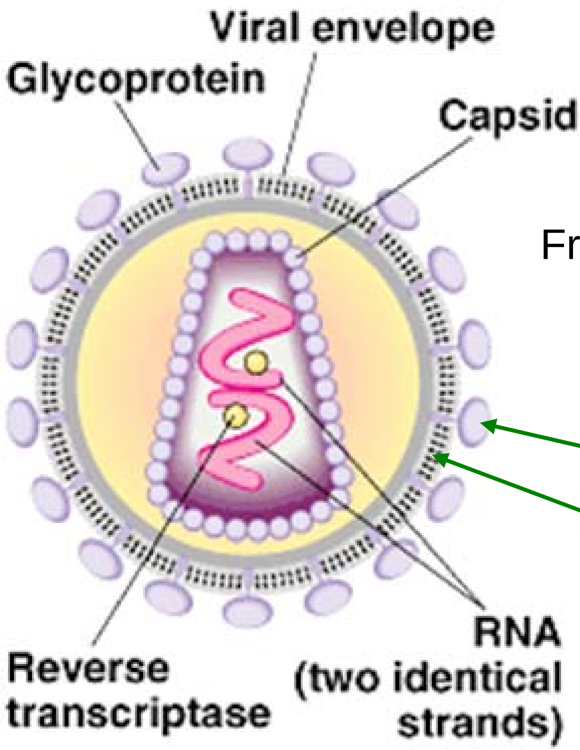
Structure of the HIV (Human Immunodeficiency Virus)



From textbook Fig. 19.8, p. 389

Recognition site for host cell

Membrane similar to host cell membrane

Animal viruses typically contain a surrounding membrane that resembles, yet complements, the plasma membrane of their host cell.

Some, but not all, kinds of eukaryotic viruses carry their genetic information as RNA.

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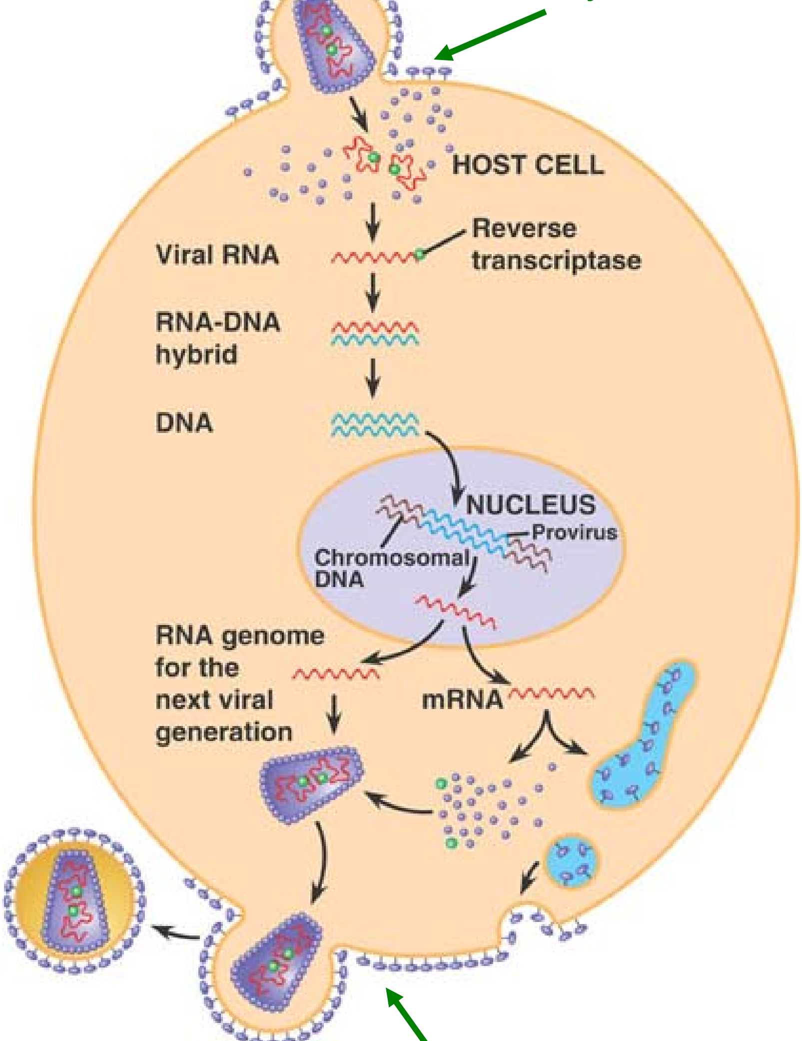
Reproductive Cycle of the HIV

Textbook Fig. 19.8, p. 389

endocytosis



exocytosis

This virus carries an enzyme called a <u>reverse transcriptase</u>. That enzyme converts the genetic information of RNA into complementary DNA immediately after infection.

The viral DNA moves into the cell nucleus, where it incorporates into host DNA to become a <u>provirus</u>.

The provirus provides information for the continuous synthesis and assembly of new HIV units.

New viruses continually leave the cell, one at a time, by a kind of exocytosis called <u>budding</u>. Each budded virus becomes surrounded by modified host plasma membrane by placing a membrane around the virus as it is exocytosed from the host cell.

RNA viruses like HIV that use reverse transcriptase are called <u>retroviruses</u>.

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Eukaryotic Viruses are classified in various ways.
Two examples are given here.

Most viruses may be classified as lytic viruses or budding viruses.

Bacterial viruses (phage) are lytic.

Some eukaryotic virus are lytic and some are budding.

Viruses may be classified as RNA viruses or DNA viruses, depending on the nature of their genetic information.

Bacteria viruses (phage) are DNA viruses.

Some eukaryotic viruses are DNA viruses and some are RNA viruses.

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Table 18.1 Classes of Animal Viruses

Class/ Family	Envelope	Examples/ Disease
I. Double-stranded DNA (dsDNA)		
Adenovirus (see Figure 18.4b)	No	Respiratory diseases; animal tumors
Papovavirus	No	Papillomavirus (warts, cervical cancer); polyomavirus (animal tumors)
Herpesvirus	Yes	Herpes simplex I and II (cold sores, genital sores); varicella zoster (shingles, chicken pox); Epstein-Barr virus (mononucleosis, Burkitt's lymphoma)
Poxvirus	Yes	Smallpox virus; cowpox virus
II. Single-stranded DNA (ssDNA)		
Parvovirus	No	B19 parvovirus (mild rash)
III. Double-stranded RNA (dsRNA)		
Reovirus	No	Rotavirus (diarrhea); Colorado tick fever virus
IV. Single-stranded RNA (ssRNA); serves as mRNA		
Picornavirus	No	Rhinovirus (common cold); poliovirus, hepatitis A virus, and other enteric (intestinal) viruses
Coronavirus (see Figure 18.11b)	Yes	Severe acute respiratory syndrome (SARS)
Flavivirus	Yes	Yellow fever virus; West Nile virus; hepatitis C virus
Togavirus	Yes	Rubella virus; equine encephalitis viruses
V. ssRNA; template for mRNA synthesis		
Filovirus	Yes	Ebola virus (hemorrhagic fever)
Orthomyxovirus (see Figure 18.4c)	Yes	Influenza virus
Paramyxovirus	Yes	Measles virus; mumps virus
Rhabdovirus	Yes	Rabies virus
VI. ssRNA; template for DNA synthesis		
Retrovirus (see Figure 18.9)	Yes	HIV, human immunodeficiency virus (AIDS); RNA tumor viruses (leukemia)

Textbook Table 19.1, p. 387

Illustration of the Diversity of Kinds of Animal Viruses

You are not required to learn this table.

Illustrative Sequence of Events that Demonstrates the Value of Viruses to a Population of Living Organisms.

The following illustrations describe a sequence of events that result in a change in the genetic content of a bacterial population as described below.

1. There are two populations of bacteria, isolated geographically. Population 1 bacteria can make the amino acid alanine (Ala) from readily available foods in the environment while Population 2 bacteria must obtain pre-made Ala from the environment. Ala is very scarce in the environment, so population 2 bacteria can barely survive.

2. A lysogenic temperate phage carries the genetic information for making Ala from a Population 1 bacterium to a Population 2 bacterium, thus allowing the altered Population 2 bacterium and its progeny to thrive in its environment.

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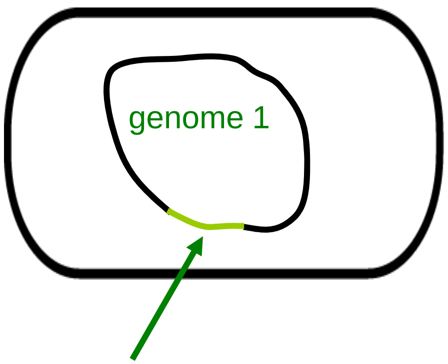
Population 1 of bacteria in lake A contains the gene for making the amino acid Ala.

bacterial cell 1

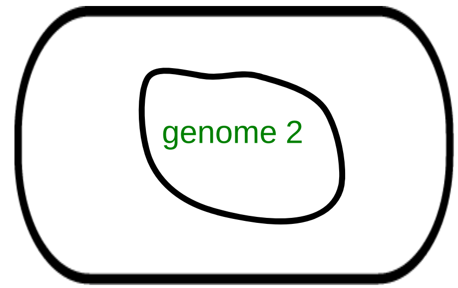


ala
(gene for making alanine)

Lake A

Population 2 of bacteria in lake B does not contain a gene for making the amino acid Ala.

bacterial cell 2



Lake B

A <u>genome</u> of a living organism is the sum of all of its genes. The genome of a typical bacterial cell is contained in the DNA of a single circular chromosome.

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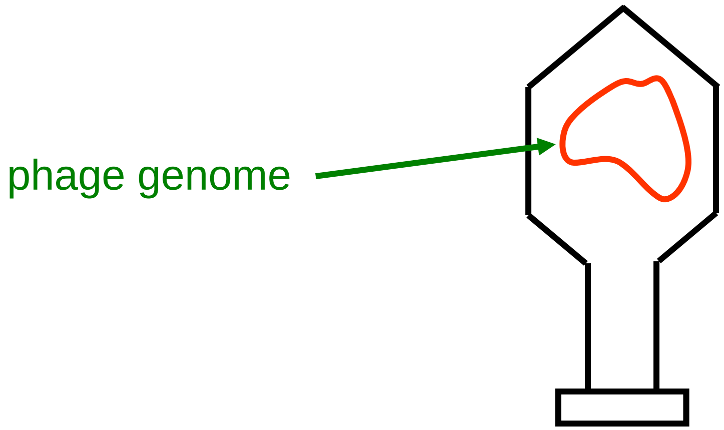
There exists a temperate phage that can infect both Population 1 bacteria and Population 2 bacteria.



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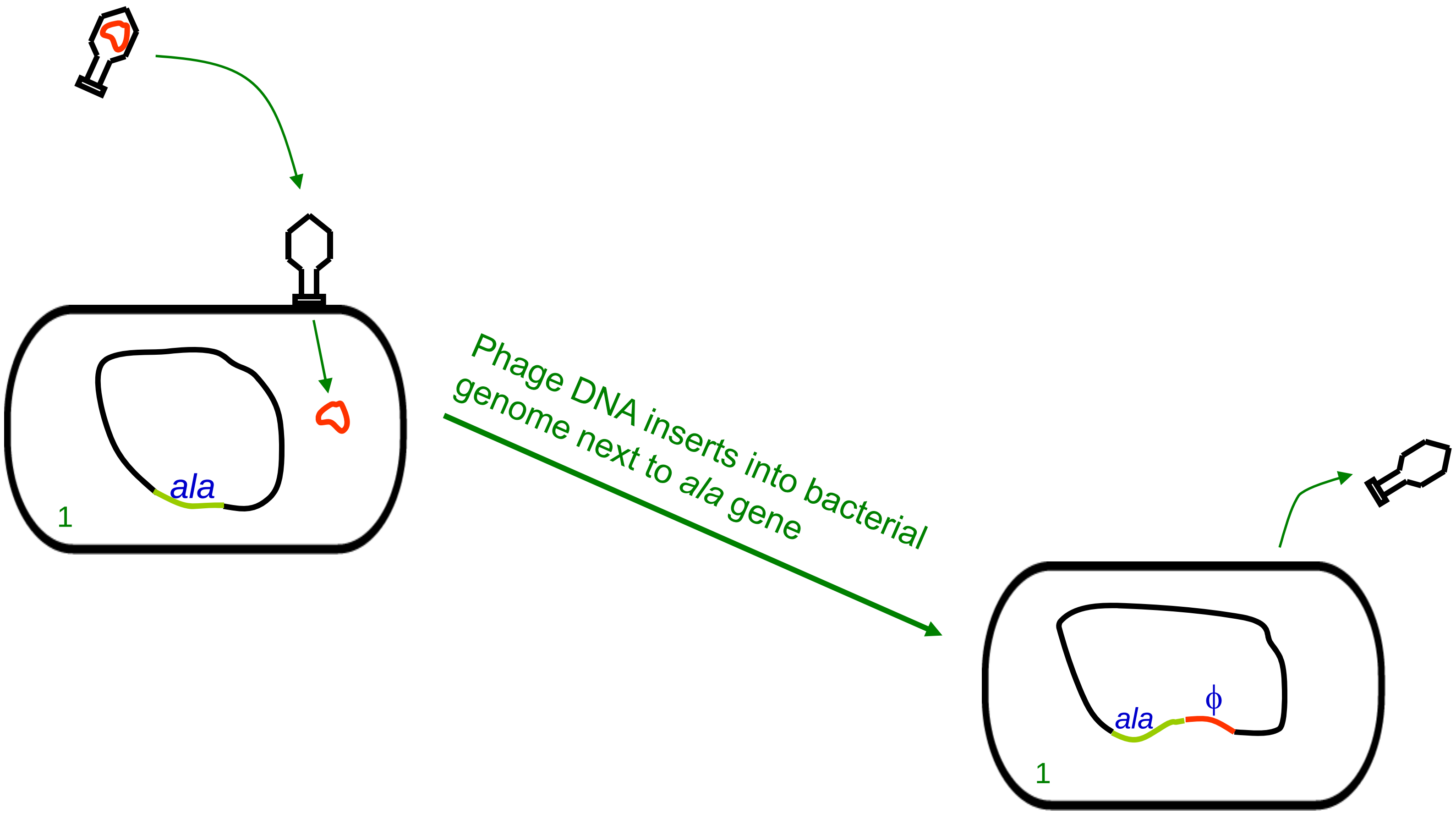
A Population 1 bacterium becomes infected.



A number 1 or 2 written within a cell indicates that the cell is a member of bacterial population 1 or 2, respectively.

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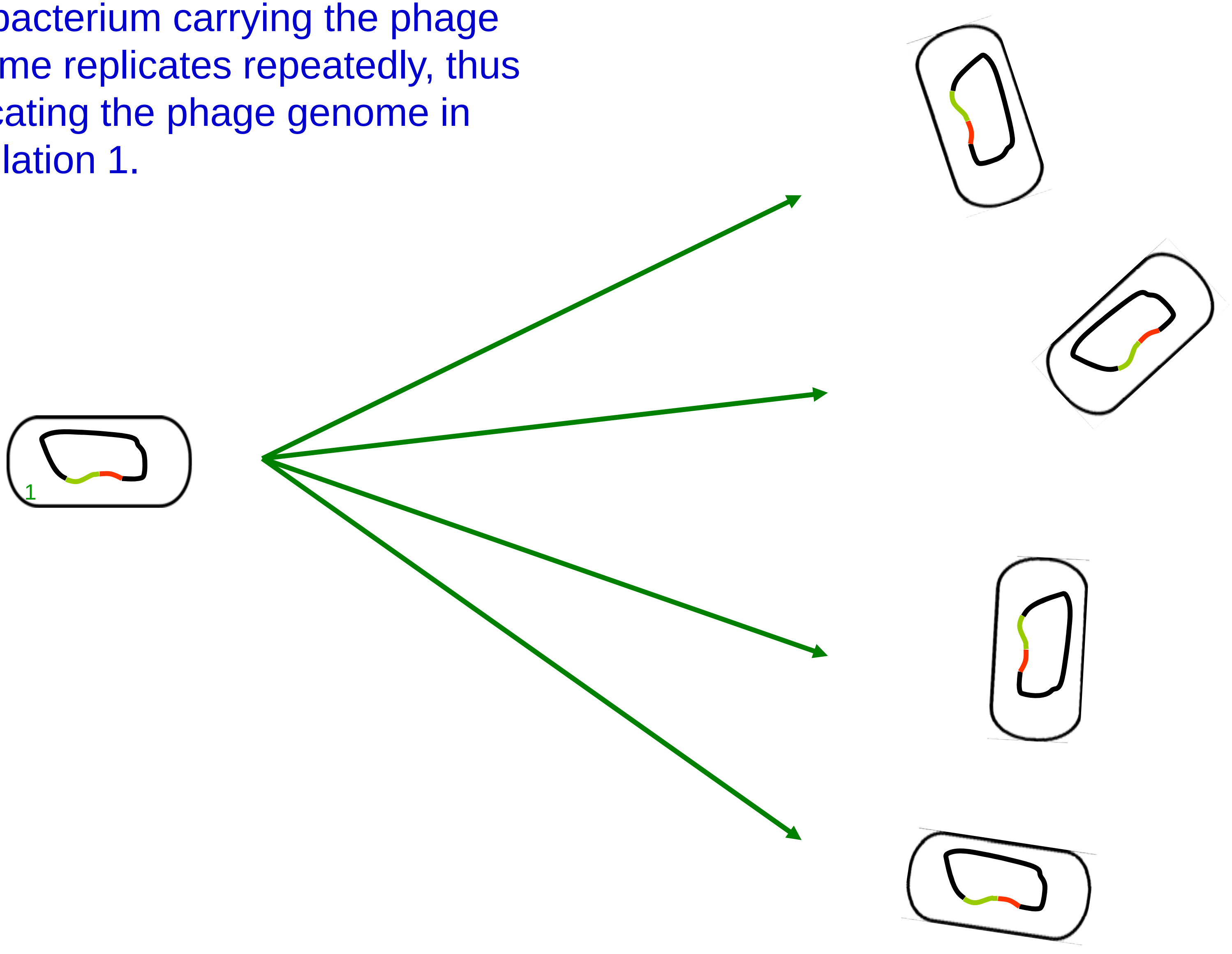
The bacterium carrying the phage genome replicates repeatedly, thus replicating the phage genome in Population 1.



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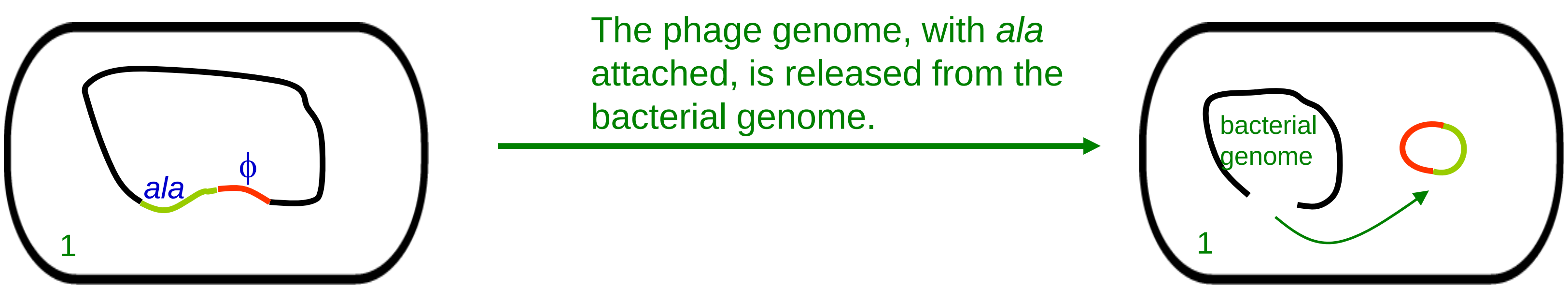
The DNA of a bacterium carrying the prophage is eventually disrupted, releasing the phage DNA. This bacterium may be many generations later than the bacterium that originally incorporated the phage DNA. In this case the DNA released also includes the *ala* gene.



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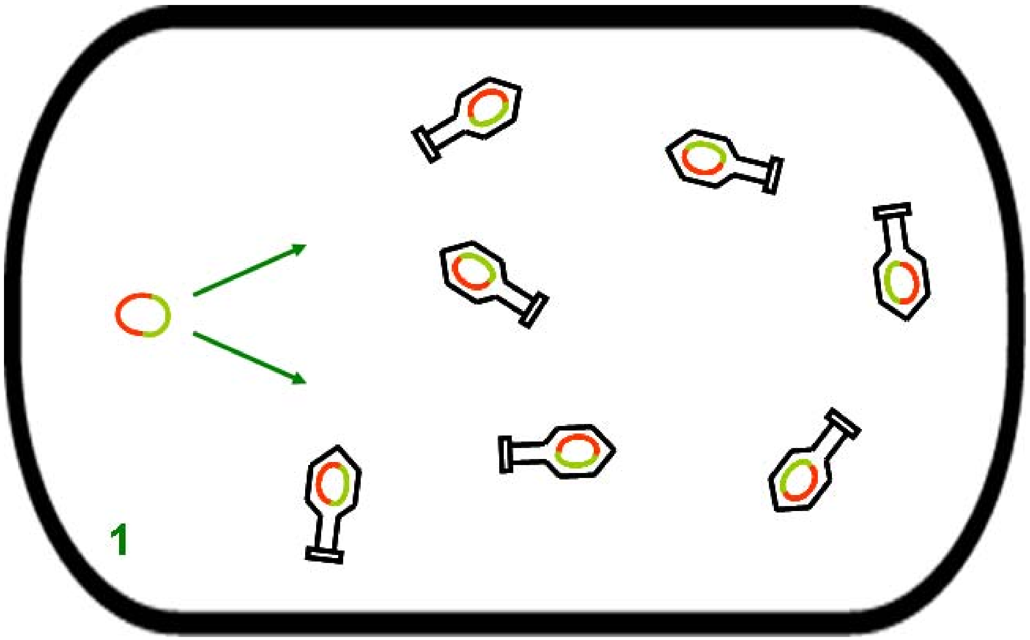
The phage DNA dictates the production of many new phage units within the dying bacterial cell. The DNA content of the new phage units is identical to the DNA excised (removed) from the bacterial genome, which carries the *ala* gene.



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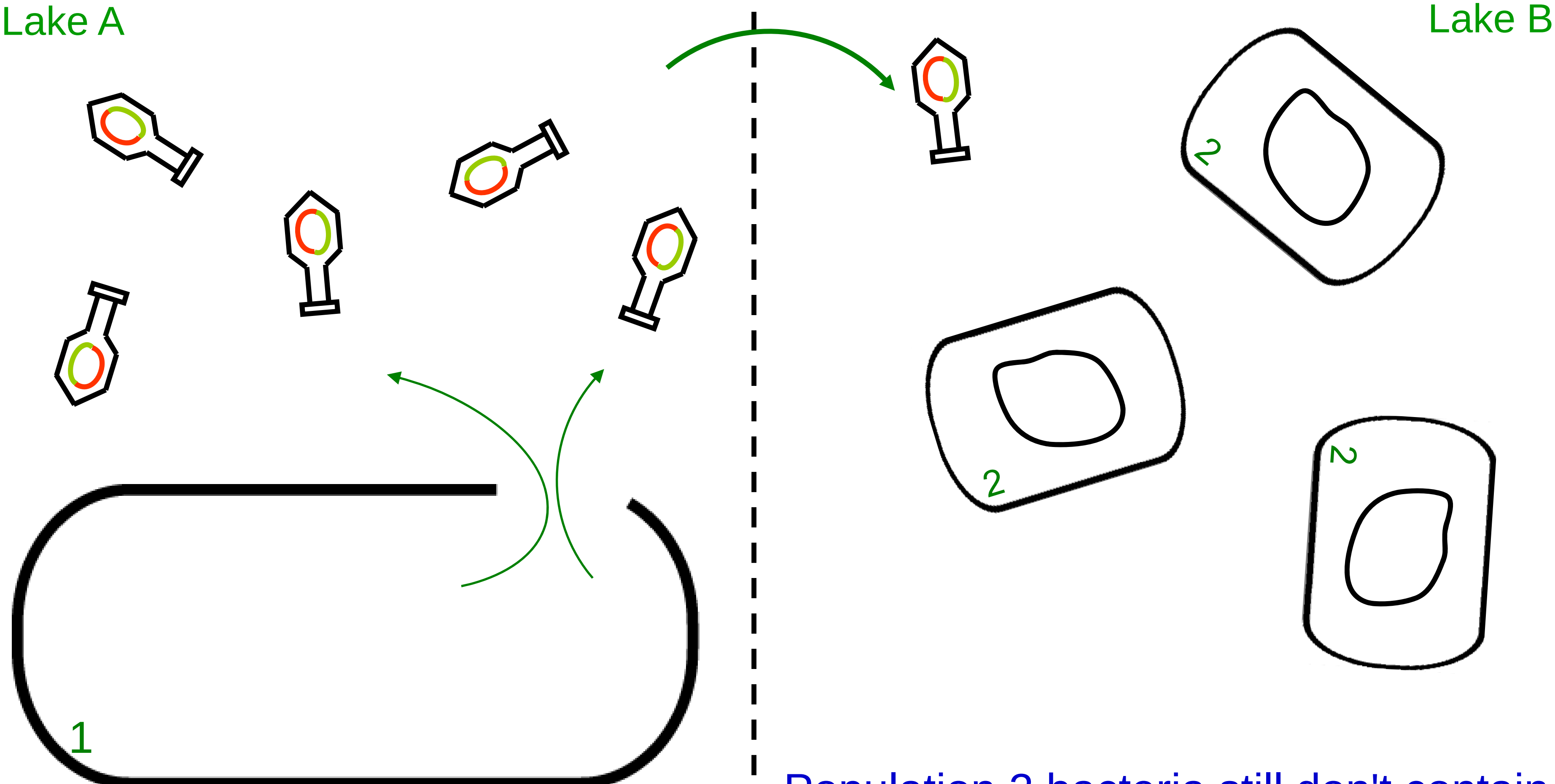

Phage units are released from the dead, lysed bacterial cell. Some are carried away in the wind.

Population 2 bacteria still don't contain the *ala* gene and are struggling to obtain Ala from the environment.

The tiny virus units can be carried in the air for long distances, where one of them may land in Lake B, encountering a Population 2 bacterium.

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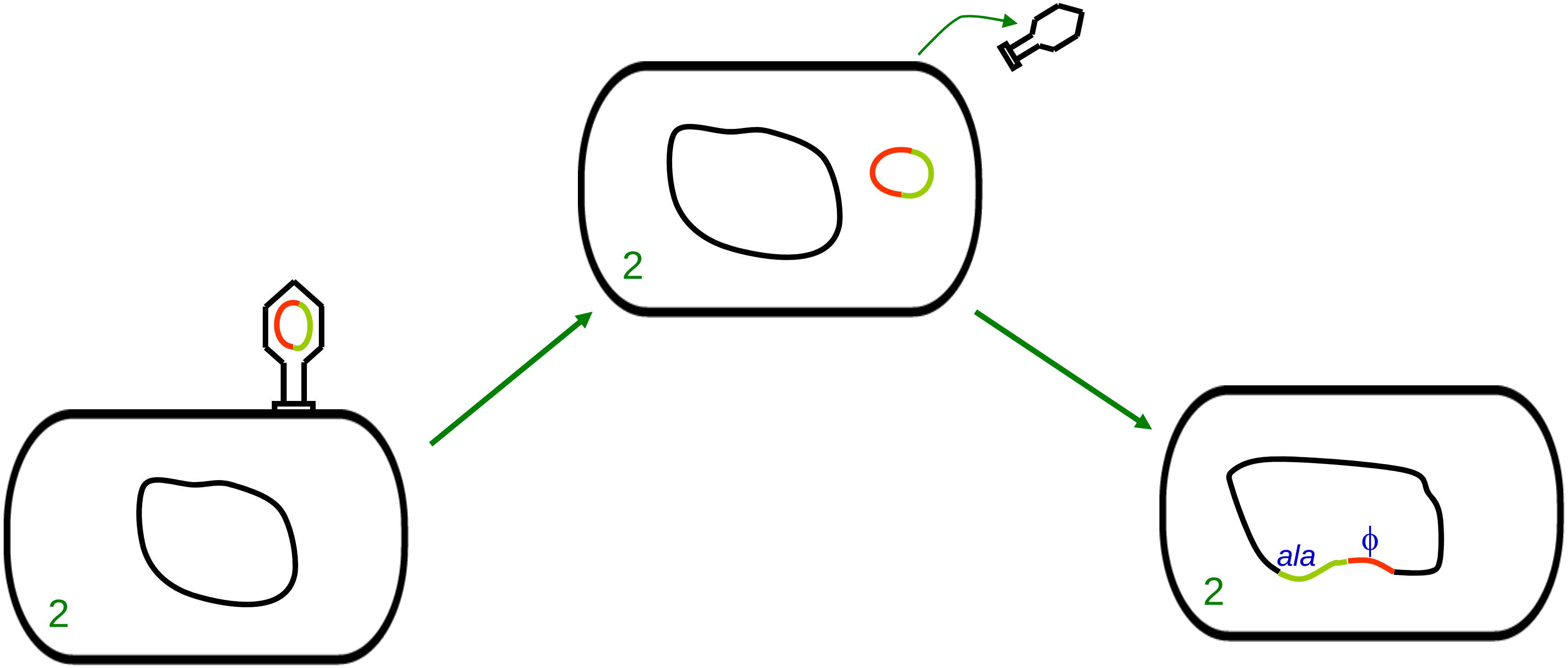

Bacterium struggling to survive.

Same bacterium, now thriving and able to reproduce rapidly.

The phage infects a Population 2 bacterium and becomes lysogenic within the bacterium. The *ala* gene provides instructions for the synthesis of the amino acid Ala. The bacterium and its progeny can now survive much better than before infection by the virus, and this growing population displaces the population of bacteria lacking *ala*.

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Examples of Realized and Potential Benefits of Viruses to Human Activities

Temperate viruses are used extensively in modern research and in biotechnology. A gene is genetically engineered into a cell of a living organism. This cell is allowed to grow into a complete organism. The new organism and its progeny are genetically altered permanently.

Tissue-specific temperate viruses may make it possible to perform genetic engineering treatments of human beings that carry genetic disorders. A virus may deliver the correct gene to the affected tissue, thus permanently correcting the disorder. This kind of treatment is called gene therapy.

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Philosophical Question:

Is a virus a living organism?

Consider the following when contemplating an to answer the question:

- the black box properties of the living state,

- general characteristics of living cells and living organisms,

- the properties of a virus when it is in a host cell as well as its properties when not residing in a cell.

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