TOPIC: BACTERIAL TRANSDUCTION

CORE COURSE 1: PHYCOLOGY AND MICROBIOLOGY

(**FOR BOTANY SEM I HONOURS**)

Dr. Rimi Roy

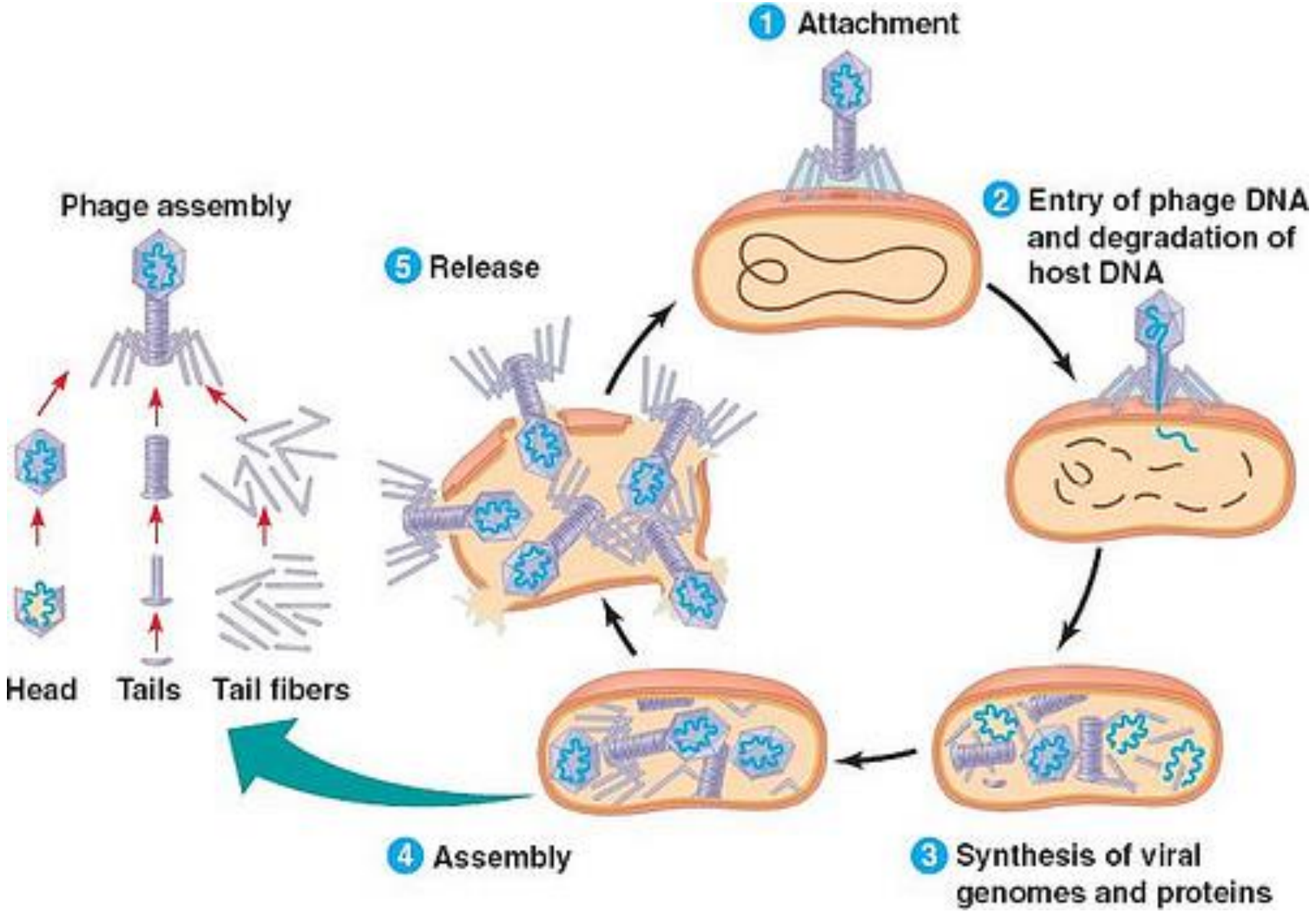
- Transduction is a phenomenan in which bacterial DNA is transferred from a donor cell to a recipient cell by bacteriophages.
- It was first discovered by N. Zinder and J. Lederberg in 1952, in Salmonella typhimurium, a mouse typhoid bacterium.
- In most cases only a small segment of the host (i.e. the donor) DNA is transferred.
- Transduction happens through either the lytic cycle or the lysogenic cycle.

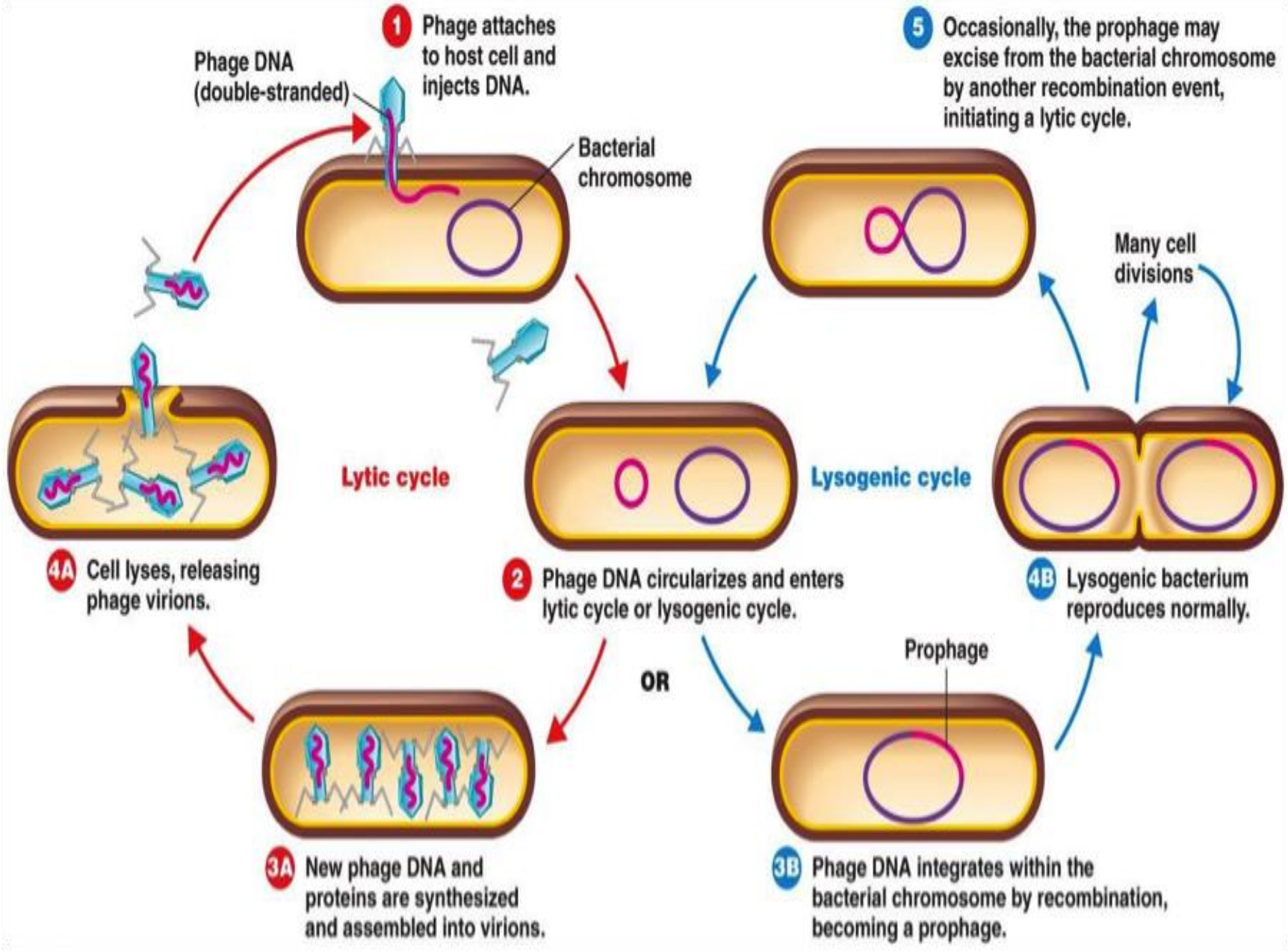
- Based on their interactions with the bacterial cell, bacteriophages are classified into two types:
- 1. virulent phages - these phages are replicated by host immediately after entry, when there is enough proportion of phages, hey cause the host to lyse, so that they can be released and infect new host cells. The process is called lytic cycle.
- 2. temperate phages- these phages enter host and instead of replicating, insert their genomes into bacterial chromosome. Once inserted, the viral genome is called prophage and it is passively replicated. The process is called lysogenic cycle and the bacteria that have been lysogenized are called lysogens.

- Temperate phages can remain dormant in their host cells for thousands of generations, and replicate like any other segment of the host chromosome.

- If the lysogen is induced (by UV light for example), the phage genome is excised from the bacterial chromosome and initiates the lytic cycle, which culminates in lysis of the cell and the release of phage particles

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
Phage assembly
Head
Tails
Tail fibers


1 Phage attaches to host cell and injects DNA.
Phage DNA (double-stranded)
Bacterial chromosome
5 Occasionally, the prophage may excise from the bacterial chromosome by another recombination event, initiating a lytic cycle.
Many cell divisions
Lytic cycle
Lysogenic cycle
4A Cell lyses, releasing phage virions.
2 Phage DNA circularizes and enters lytic cycle or lysogenic cycle.
4B Lysogenic bacterium reproduces normally.
Prophage
OR
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.

How does transduction occur?

- It occurs when bacterial genes are incorporated into a phage capsid due to errors made by virus life cycle. The virus with these genes injects them into another bacterium, thus completing the transfer
- Phage particles that contain bacterial DNA are called transducing particles and are of two types- generalized and specialized

Generalized transduction

- In this type the transducing phage contains only DNA obtained from the host bacterium rather than phage DNA, and the DNA fragment can be derived from any part of the bacterial chromosome.
- It occurs during the lytic cycle of virulent and some temperate phages (whose chromosomes are not integrated at specified attachment sites on the host chromosome) and can transfer any part of bacterial genome.

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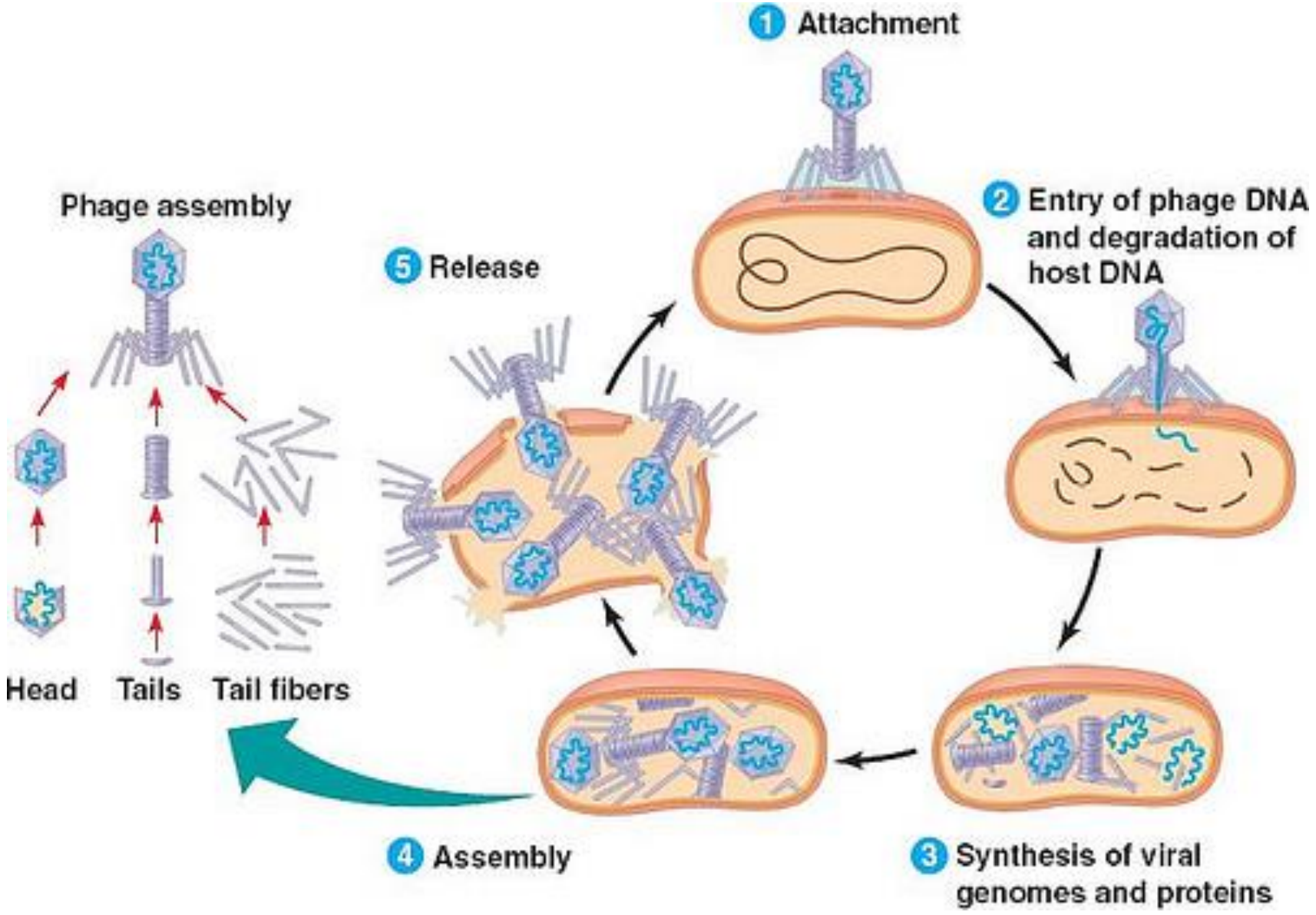
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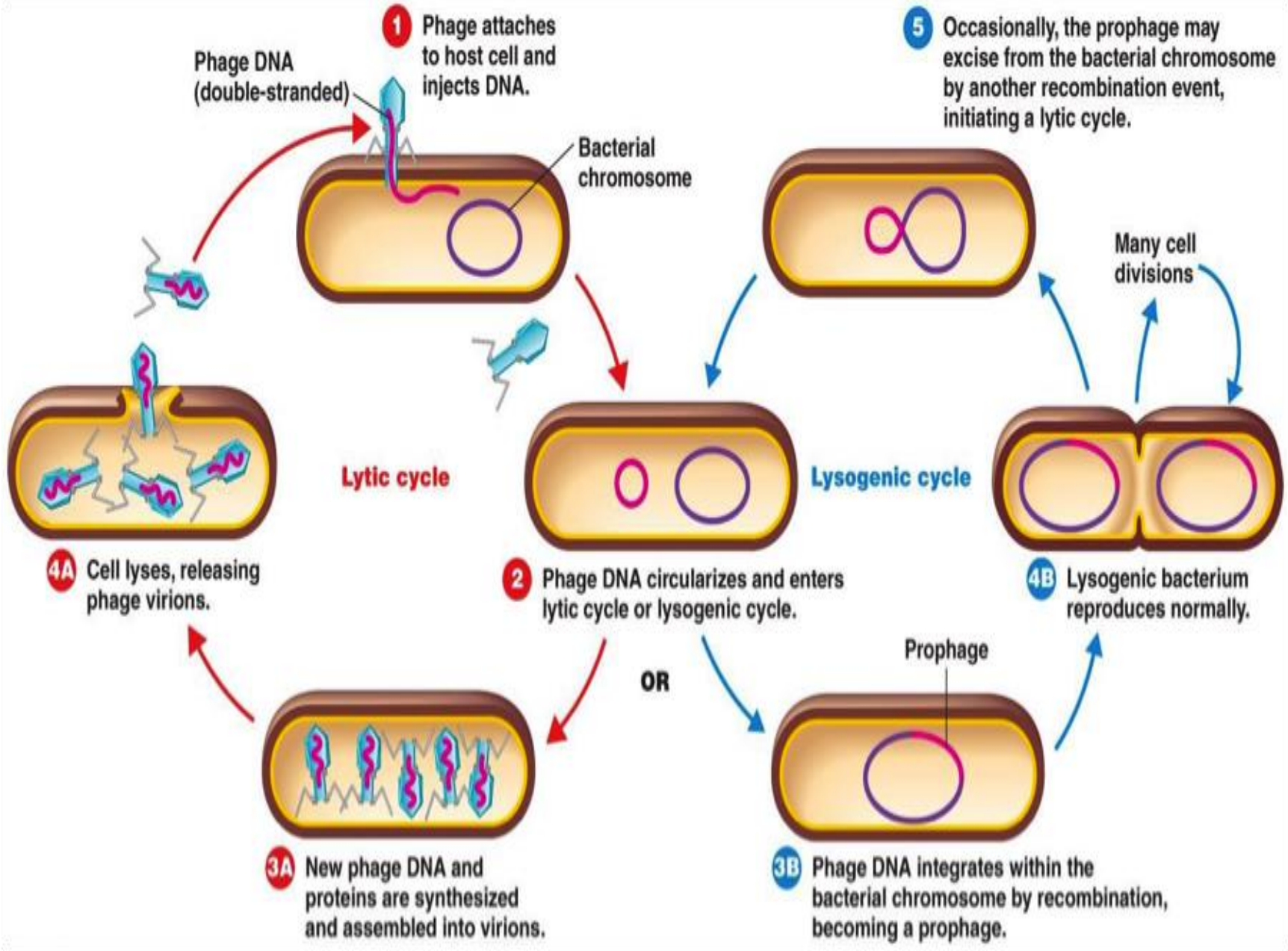
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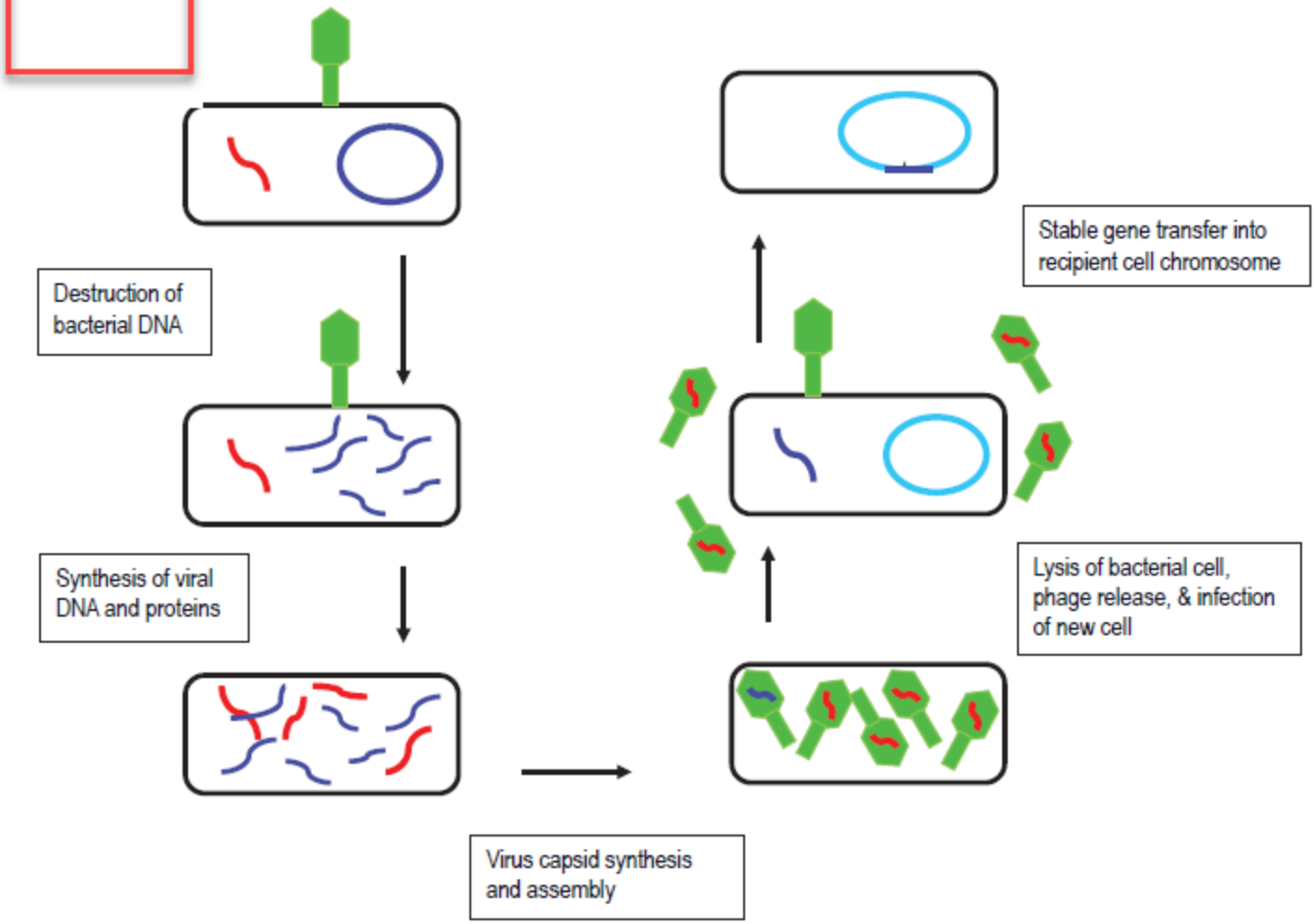
Generalized transduction



Courtesy of M. Mulks (MSU)

- During assembly stage, when viral chromosomes are packaged into protein capsids, random fragments of partially degraded bacterial chromosomes also may be packaged by mistake.
- Because capsid can contain only limited amount of DNA, the viral DNA is left behind.
- Quantity of bacterial DNA carried depends on size of the capsid e.g.-

  P22 phage of Salmonella enterica serovar Typhimurium usually carries 1% of bacterial genome.

  P1 phage of E. coli and few Gram negative bacteria carries about 2 to 2.5% of genome.

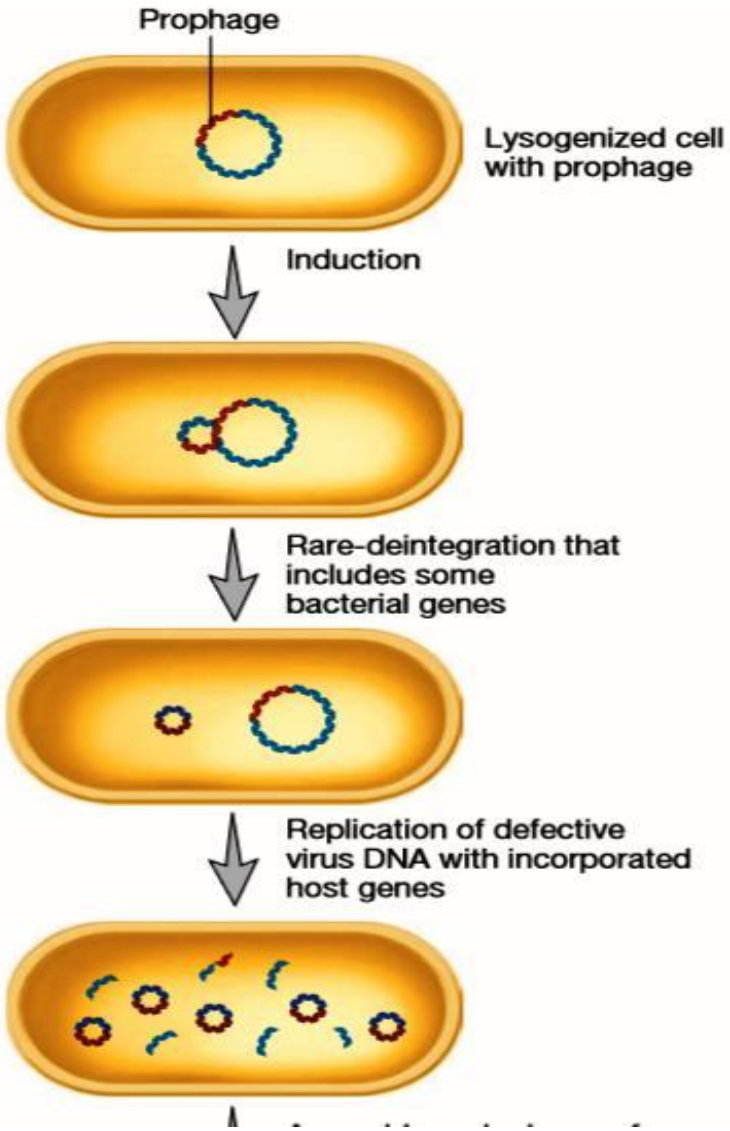
- Resulting virus particle often injects the DNA into another bacterial cell but cannot initiate lytic cycle and often act as a carrier of gene.
- Like transformation, once DNA has been injected, it must be incorporated into recipient cell's chromosome to preserve transferred genes.
- DNA remains double stranded during transfer and both strands integrated into endogenote's genome.
- About 70-90% of transferred DNA is not integrated but often is able to survive temporarily.
- Abortive transductants are bacteria that contain this non-integrated and are partial diploids.

Specialized transduction

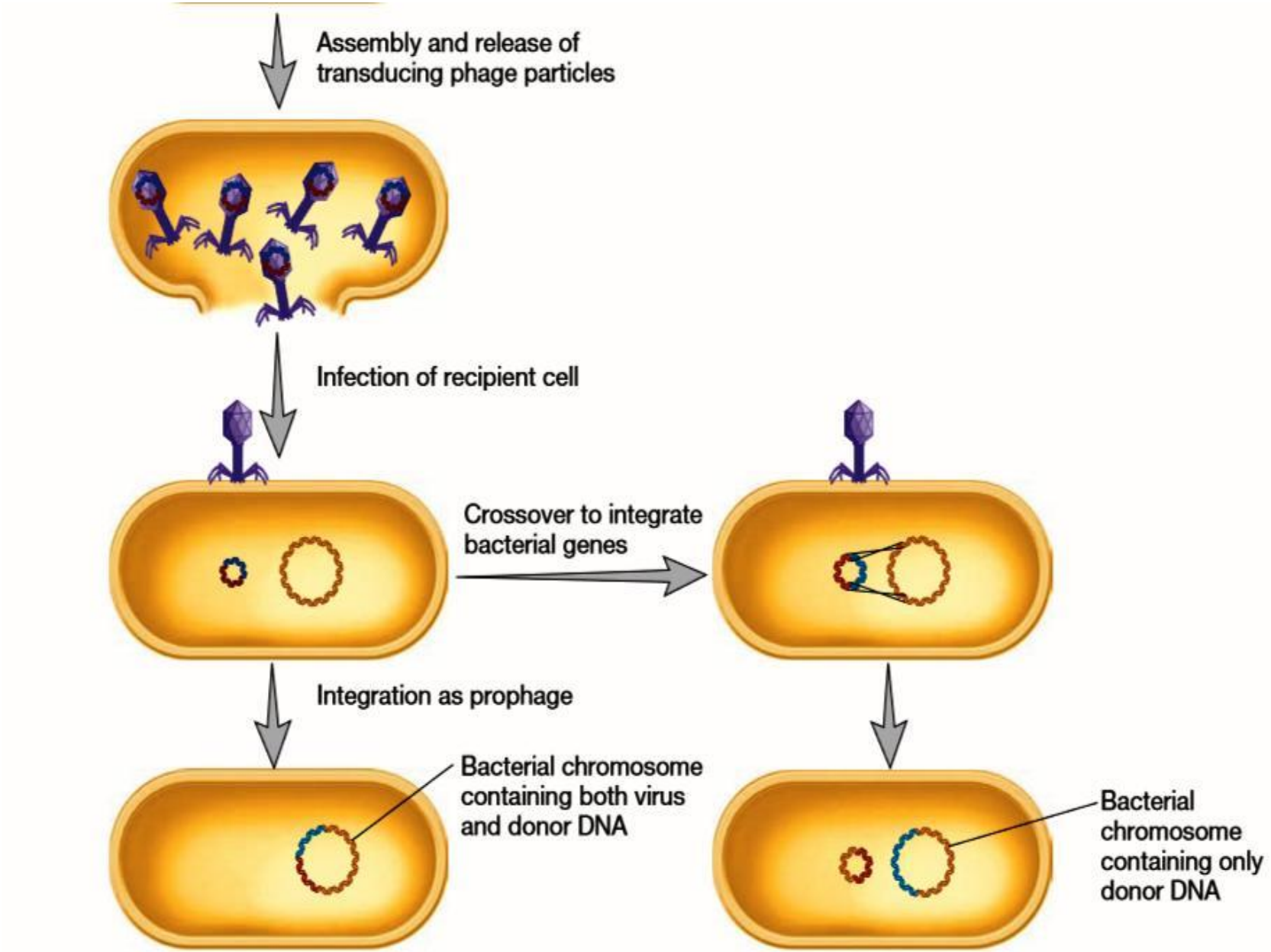
- In this type the transducing phage contains both phage and bacterial genes linked in a single DNA molecule and the bacterial genes are obtained from a particular region of the bacterial chromosome.
- These phages are produced only by induction of a lysogen
- The best studied example is carried out by *E. coli* phage λ

- λ genome inserts into host chromosome at specific locations known as att (attachment) sites. The phage and bacterial att sites can complex with each other (attP site is on the phage DNA and attB site is on the bacterial genome).
- The att site for λ is next to gal and bio genes on *E. coli* DNA.
- Consequently, specialized transducing particle/phage carries these genes.

- If the lysogen is induced to follow lytic cycle, it gives rise to a normal phage
- But sometimes the lysate becomes defective transducing phage due to uptake of gal or bio genes.
- These particles are called either λdgal or λdbio (d means defective).
- Because these lysates contain only a few transducing particles, they often are called low-frequency transduction lysates (LFT lysates).



Source: Microbiology by Prescott (2002), fifth edition



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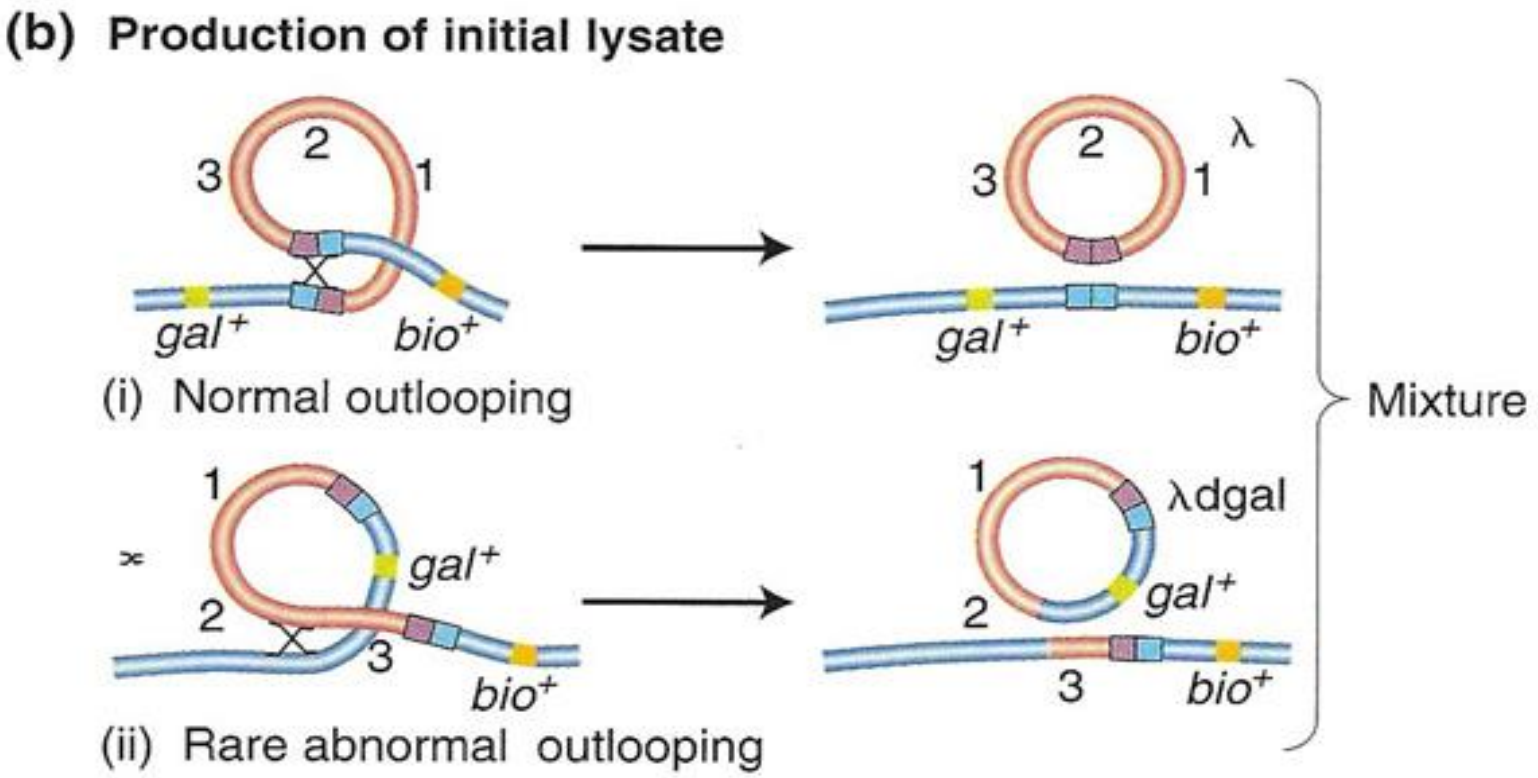
Defective excision picks up host genes



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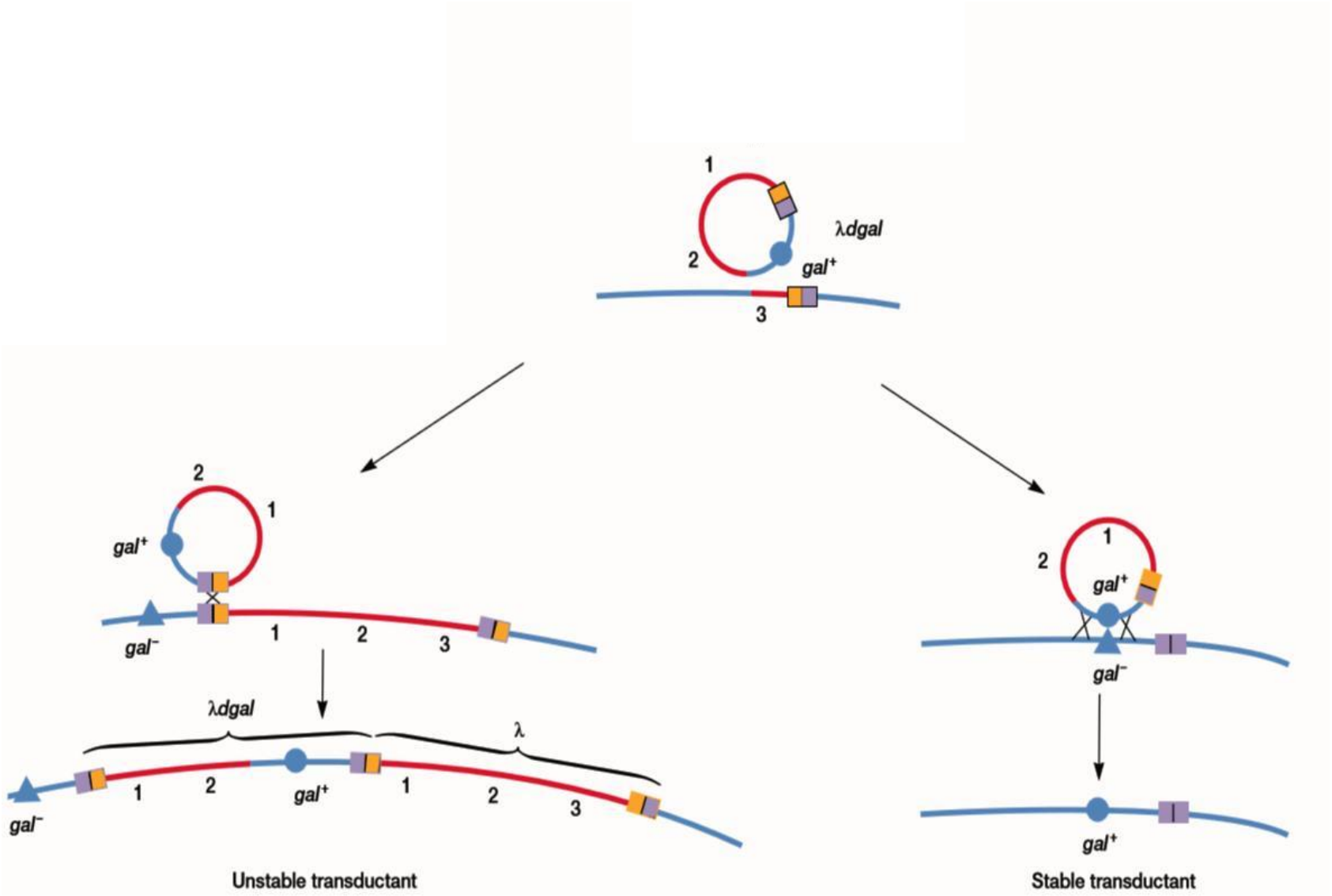

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- defective transducing particles have a nonfunctional hybrid integration site that is part bacterial and part phage in origin.
- Integration of the defective phage chromosome does not readily take place. Transducing phages also may have lost some genes essential for reproduction.
- Stable transductants can arise only if there is a double cross-over event on each side of the gal site

- Defective lambda phages carrying the gal or bio genes can integrate if there is a normal lambda phage in the same cell
- The normal phage integrates, yielding two bacterial/phage hybrid att sites where the defective lambda dgal phage can insert
- It also supplies the genes missing in the defective phage. The normal phage in this instance is termed the helper phage because it aids integration and reproduction of the defective phage

- These transductants are unstable because the prophages can be induced to excise by agents such as UV radiation. Excision,however, produces a lysate containing a fairly equal mixture of defective lambda dgal phage and normal helper phage.
- Because it is very effective in transduction, the lysate is called a high-frequency transduction lysate (HFT lysate). Reinfection of bacteria with this mixture will result in the generation of considerably more transductants.
- LFT lysates and those produced by generalized transduction have one transducing particle in 10^5 or10^6 phages; HFT lysates contain transducing particles with a frequency of about 0.1 to 0.5.