

Transduction

Transduction is the process by which cellular genes can be transferred from a donor to a recipient cell by a virus particle (phage-mediated transfer), the recipient being known as a transductant following transfer .

This process is normally highly specific for phage DNA. However, with some phages, errors can be made and fragments of bacterial DNA (produced by phage-mediated degradation of the host chromosome) are occasionally packaged by mistake leading to phage-like particles that contain a segment of bacterial genome . These transducing particles are capable of infecting a recipient cell, since the information necessary for attachment and injection of DNA is carried by the proteins of the phage particle, irrespective of the nucleic acid it contains. The transduced segment of DNA will therefore be injected into the new host cell.

Not all bacteriophages are capable of carrying out transduction. The basic requirements of an effective transducing phage are that infection should result in an appropriate level of degradation of the chromosomal DNA to form suitably sized fragments at the right time for packaging and that the specificity of the packaging process should be comparatively low.

In some cases, the transduced DNA is a bacterial plasmid, in which case the injected DNA molecule is capable of being replicated and inherited. More commonly the DNA incorporated into the transducing particle is a fragment of chromosomal DNA which will be unable to replicate in the recipient cell. For it to be replicated and inherited, it must be incorporated into the recipient chromosome (by homologous recombination), as is the case with other mechanisms of gene transfer. This process is known as generalized transduction since essentially any gene has an equal chance of being transduced.

Specialized transduction

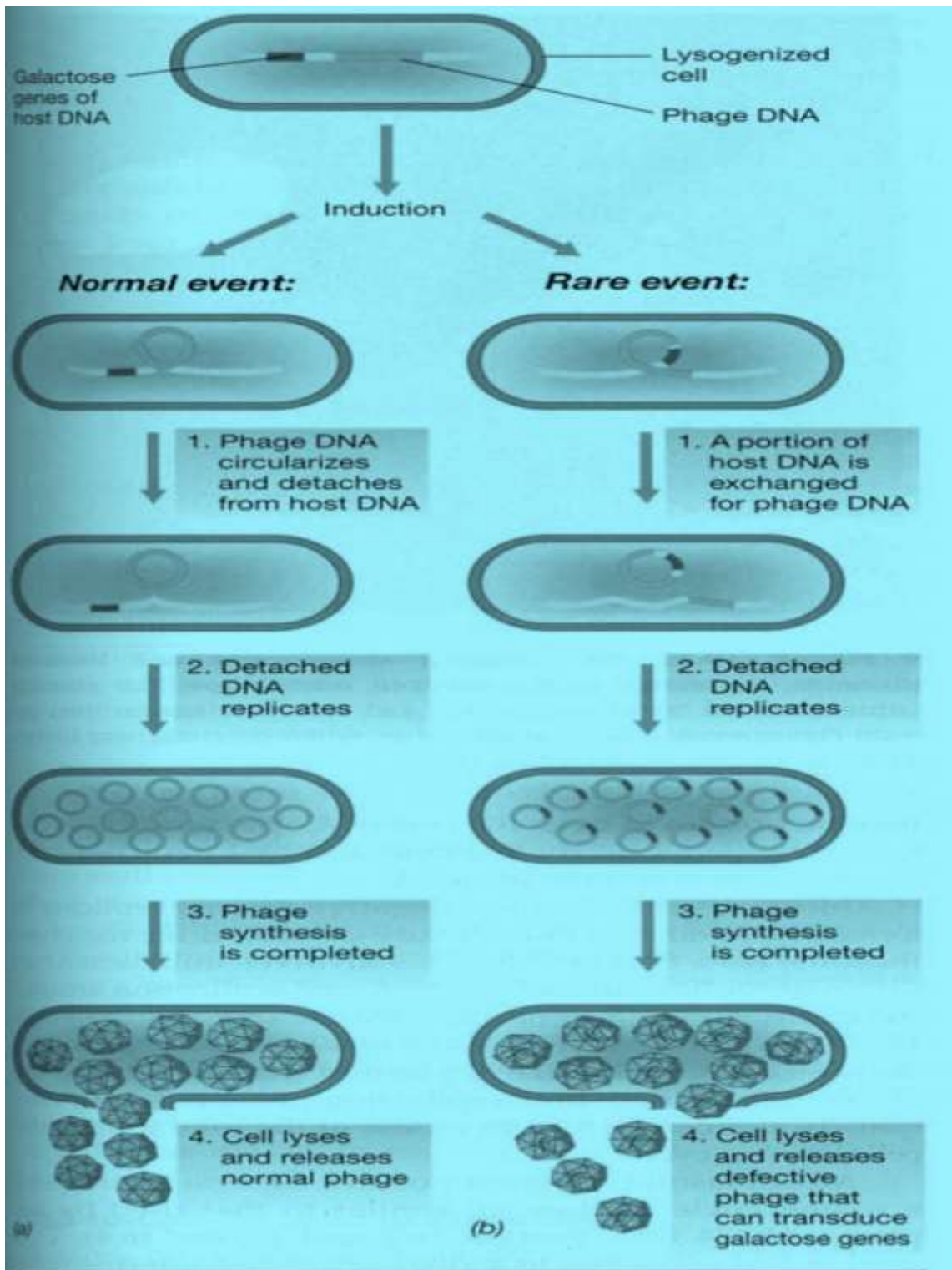
Some phages (temperate phages) are able to establish a state known as lysogeny, in which expression of phage genes and replication of the phage is repressed. In many cases the prophage is inserted into the bacterial DNA and replicates as part of the chromosome. When lysogeny breaks down and the phage enters the lytic cycle, it is excised from the chromosome by recombination between sequences at each end of the integrated prophage. If this recombination event happens in the wrong place, an adjacent region of bacterial DNA is incorporated into the phage DNA.

All the progeny of this phage will then contain this bacterial gene which will therefore be transduced at a very high frequency (effectively 100 per cent per phage particle) once the transducing phage has been isolated. Since the DNA transferred is limited to a very small region of the chromosome, the phenomenon is known as specialized (or restricted) transduction. This is very similar to the formation of F- plasmids referred to earlier. As with the F- plasmids, it is now much easier to add genes to DNA by creating recombinants *in vitro*.

When a normal temperate phage (that is, a nondefective phage) lysogenizes a cell and its DNA is converted to the prophage state, the cell is immune to further infection by the same type of phage. This acquisition of immunity can be considered a change in phenotype. However, other phenotypic alterations can often be detected in the lysogenized cell that are unrelated to phage immunity. Such a change, which is brought about through lysogenization by a normal temperate phage, is called phage conversion.

Two cases of phage conversion have been especially well studied. One involves a change in structure of a polysaccharide on the cell surface of *Salmonella anatum* on lysogenization with bacteriophage 815. The second involves the conversion of non toxin-producing strains of *Corynebacterium diphtheriae* (the bacterium that causes the disease diphtheria) to toxin-producing (pathogenic) strains upon lysogenization with phage *f3*. In both of these situations, the genes encoding the necessary molecules are an integral part of the phage genome and hence are automatically (and exclusively) transferred upon infection by the phage and lysogenization.

Lysogeny probably carries a strong selective value for the host cell because it confers resistance to infection by viruses of the same type. Phage conversion may also be of considerable evolutionary significance because it results in efficient genetic alteration of host cells. Many bacteria isolated from nature are natural lysogens. It seems reasonable to conclude, therefore, that lysogeny is a common condition and may often be essential for survival of the host in nature.



Specialized transduction. Normallytic events, and the production of particles transducing the galactose genes in an *Escherichia coli* cell containing a lambda prophage.

Generalized transduction

Transduction is the phage-mediated transfer of genetic material. The key step in transduction is the packaging of DNA into the phage heads during lytic growth of the phage. This process is normally highly specific for phage DNA. However, with some phages, errors can be made and fragments of bacterial DNA (produced by phage-mediated degradation of the host chromosome) are occasionally packaged by mistake leading to phage-like particles that contain a segment of bacterial genome. These transducing particles are capable of infecting a recipient cell, since the information necessary for attachment and injection of DNA is carried by the proteins of the phage particle, irrespective of the nucleic acid it contains. The transduced segment of DNA will therefore be injected into the new host cell.

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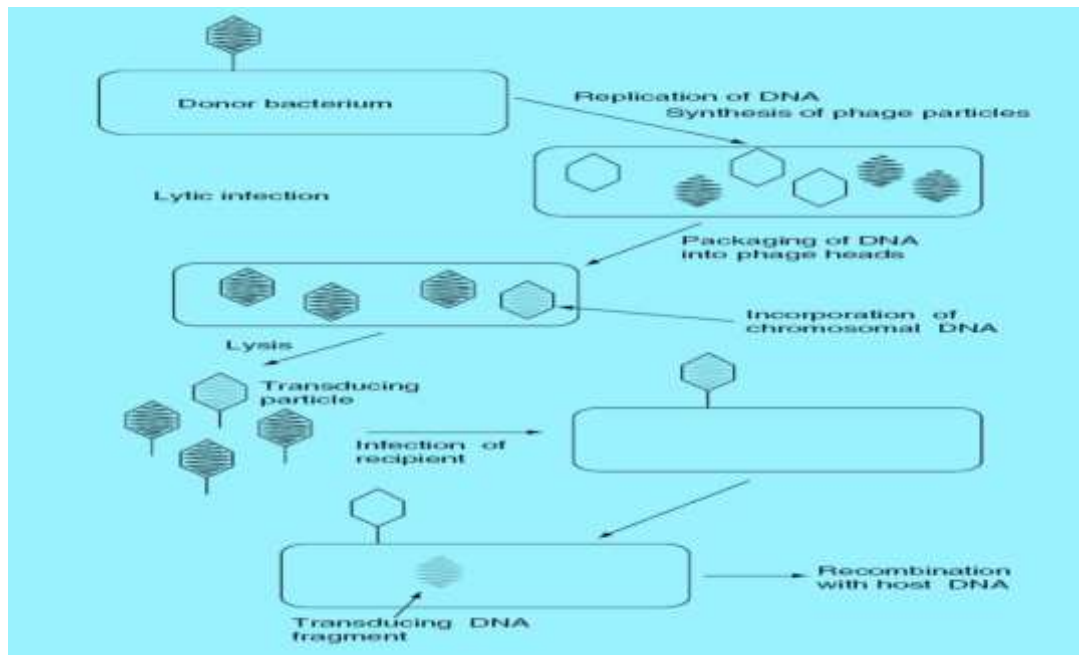


Figure : Generalized transduction [Dale and Park ,2004]

Recombination

General (homologous) recombination

A common feature of all the forms of gene transfer between bacteria, except for the transfer of plasmids (which can replicate independently), is the requirement for the transferred piece of DNA to be inserted into the recipient chromosome by breaking both DNA molecules, crossing them over and rejoining them. This process, known as recombination. There are several different forms of recombination, but the mechanisms that require the presence of homologous regions of DNA which must be highly similar but do not have to be identical are of specific interest in this context. It is therefore known as homologous recombination. Of the alternative forms of recombination, site-specific recombination is particularly important.

Site-specific and non-homologous (illegitimate) recombination

Does not require homology between recombining partners. The proteins mediating this process (site-specific recombinases) recognize short, specific DNA sequences in the donor and recipient molecules, and interaction between the proteins facilitates recombination. Homology often exists between the donor and recipient sites because the same recombinase protein binds to both recognition sites.