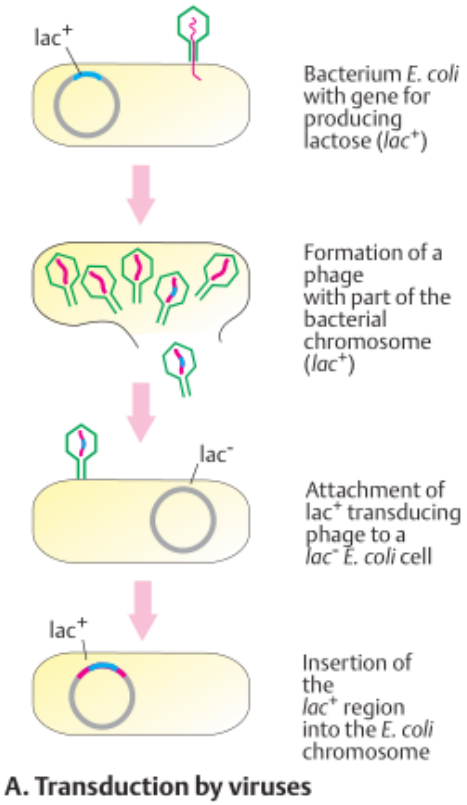
DNA Transfer between Cells

Transfer of DNA occurs not only by fusion of gametes in sexual reproduction but also between other cells of prokaryotic and eukaryotic organisms (conjugation of bacteria, transduction between bacteriophages and bacteria, transformation by plasmids in bacteria, transfection in cultures of eukaryotic cells). Cells altered genetically by taking up DNA are said to be transformed. The term transformation is used in different contexts and refers to the result, not the mechanism.

A. Transduction by viruses

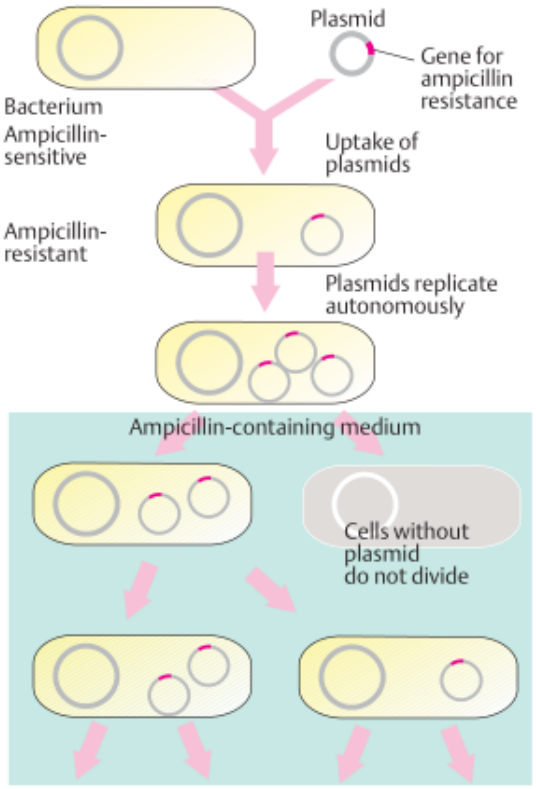
In 1952, N. Zinder and J. Lederberg described a new type of recombination between two strains of bacteria. Bacteria previously unable to produce lactose (lac –) acquired the ability to produce lactose after being infected with phages that had replicated in bacteria containing a gene for producing lactose (lac +). A small segment of DNA from a bacterial chromosome had been transferred by a phage to another bacterium (transduction). General transduction (insertion of phage DNA into the bacterial genome at any unspecified location) is distinguished from special transduction (insertion at a particular location). Genes regularly transduced together (cotransduction) were used to determine the positions of neighboring genes on the bacterial chromosome (mapping of genes in bacteria).



Transduction by viruses

B. Transformation by plasmids

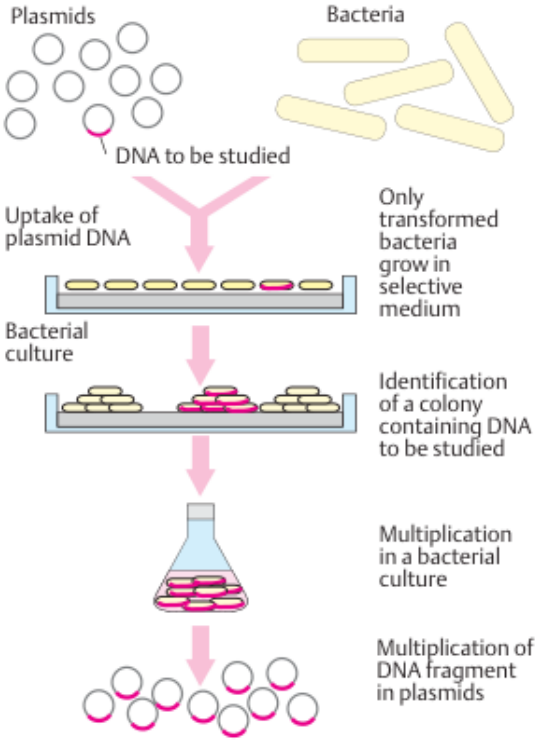
Plasmids are small, autonomously replicating, circular DNA molecules separate from the chromosome in a bacterial cell. Since they of ten contain genes for antibiotic resistance (e.g., ampicillin), their incorporation into a sensitive cell renders the cell resistant to the antibiotic (transformation). Only these bacteria can grow in culture medium containing the antibiotic (selective medium).



Transformation by plasmids

C. Multiplication of a DNA segment in transformed bacteria

Plasmids are well suited as vectors for the transfer of DNA. A selective medium is used so that only those bacteria that have incorporated a recombinant plasmid containing the DNA to be investigated can grow.

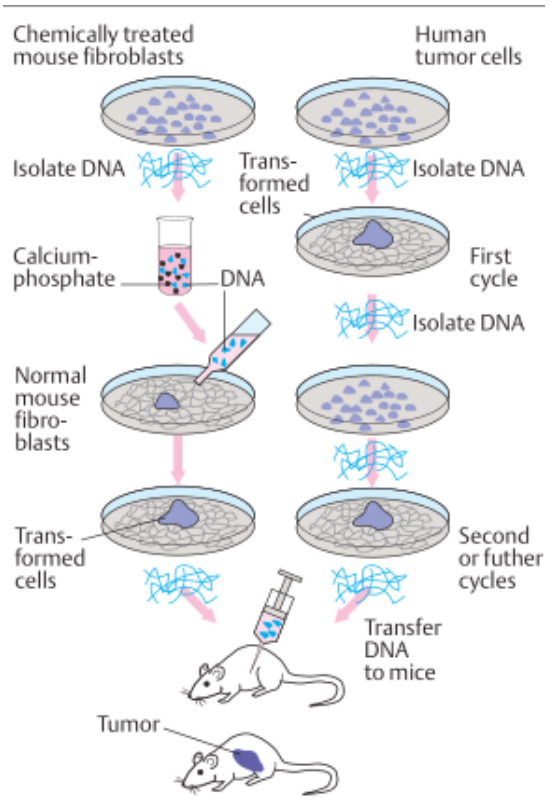


Multiplication of a DNA segment in transformed bacteria

D. Transfection by DNA

The transfer of DNA between eukaryotic cells in culture (transfection) can be used to examine the transmission of certain genetic traits (transfection assay). Left, a DNA transfer experiment is shown in a culture of mouse fibroblasts; right, in a culture of human tumor cells (Weinberg, 1985, 1987). The mouse fibroblast culture (see p. 122) is altered by the chemical carcinogen methylcholanthrene (left). DNA from these cells is precipitated with calcium phosphate, extracted, and then taken up by a normal culture (transfection). About 2 weeks later, cells appear that have lost contact inhibition (transformed cells). When these cells are injected into mice that lack a functional immune system (naked mice), tumors develop. DNA from cultured human tumor cells (right) also can transform normal cells after several transfer cycles. The DNA segment must be of limited size (e.g., a gene), since long DNA segments do not remain intact

after repeated cycles of extraction and precipitation. Detailed studies of cancer-causing genes (oncogenes) in eukaryotic cells were first carried out using transfection (see p. 90). (Figures in A–C adapted from Watson et al. 1987, D from Weinberg 1987).



Transfection by DNA