8.3.2. Transformation

The uptake of naked DNA cannot be done by all genera of bacteria. Even within transformable genera, only certain strains are transformable (*competent*). Competent cells have a much higher capacity for binding DNA to the cell surface than do noncompetent cells. Competency can depend on the physiological state of the cell (current and previous growth conditions). Even in a competent population not all cells are transformable. Typically, about 0.1% to 1.0% are transformable.

E. coli are not normally competent, but their importance to microbial genetics has led to the development of empirical procedures to induce competency. This procedure involves treating *E. coli* with high concentrations of calcium ions, coupled with temperature manipulation. The competency of treated cells varies among strains of *E. coli* but is typically rather low (about one in a million cells becomes successfully transformed). With the use of selective markers, this frequency is still high enough to be quite useful.

Transformation is useful only when the information that enters the cell can be propagated. When doing transformation, we typically use a vector called a *plasmid*. This element forms the basis for most industrially important fermentations with recombinant DNA. A plasmid is an autonomous, self-replicating, double-strand piece of DNA that is normally extrachromosomal. Some plasmids are maintained as low-copy-number plasmids (only a few copies per cell), and others have a high copy number (20 to 100 copies per cell). These plasmids differ in their mechanisms for partitioning at cell division and in the control of their replication. Plasmids encode genes typically for proteins that are nonessential for growth, but that can confer important advantages to their host cells under some environmental circumstances. For example, most plasmids encode proteins that confer resistance to specific antibiotics. Such antibiotic resistance is very helpful in selecting for cells that contain a desired plasmid.

8.3.3. Transduction

DNA transfer from one cell to another can be mediated by viruses and certainly plays an important role in nature. In the most common type of transduction, *generalized transduction*, infection of a recipient cell results in fragmentation of the bacterial DNA into 100 or so pieces. One of these fragments can be packaged accidentally into a phage particle. The defective phage particle then injects bacterial DNA into another cell, where it can recombine with that cell's DNA. With generalized transduction, any bacterial gene may be transferred.

Another method of transfer, which is far more specific with respect to the genes that are transferred, is *specialized transduction*. Here the phage incorporates into specific sites in the chromosome, and the frequency of transduction of a gene is related to its distance away from the site of incorporation. This process is summarized in Fig. 8.5. A *lysogenic cell* is one carrying a prophage or phage DNA incorporated into chromosomal DNA. Phage lambda is an example of such a *temperate phage* (a phage that can either lyse a cell or become incorporated into the chromosome). Such phages almost invariably insert at a specific site in the chromosome. The conversion of a *prophage* (the phage DNA in the chromosome) into the lytic cycle is normally a rare event (10^{-4} per cell division), but it can be induced in almost the whole culture upon exposure to UV light or other agents that interfere with DNA replication.