Genetic Recombination in Bacteria

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1. Introduction

Bacteria have four important advantages for "traditional types of genetic experiments":

1. They are haploid (no masking).
2. New generation is produced every 20 minutes.
3. Easy to grow in ENORMOUS NUMBERS.
4. Individual members of these large populations are GENETICALLY IDENTICAL (or very nearly so).

There are **THREE MAJOR TYPES** of genetic transfer found in bacteria:

1. Transformation - Somehow or another, the bacteria can take up externally provided DNA.
2. Conjugation - DNA is transferred from one bacteria cell to another, via "sex pilli".
3. Transduction - this is where DNA is introduced into bacteria by injection from a bacteriophage.

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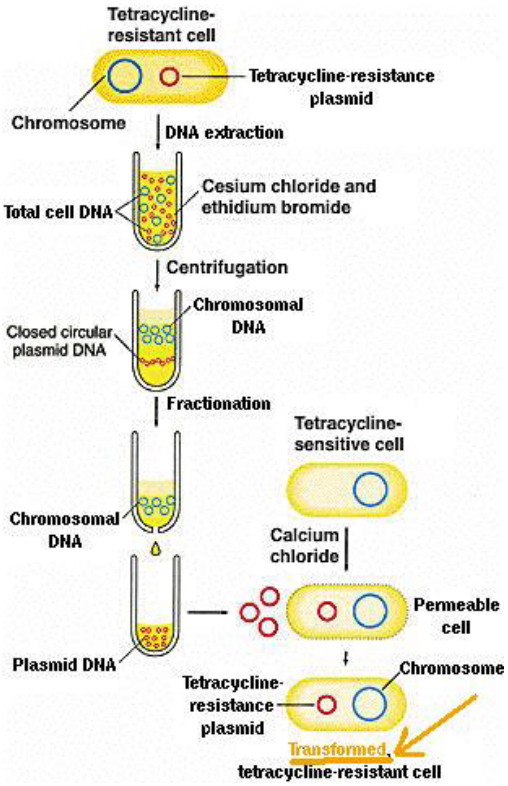
2. Bacterial Transformation

"Transformation" is simply the process where bacteria manage to "uptake" or bring in a piece of external DNA (somehow or another). Usually, this process is used in the laboratory to introduce a small piece of PLASMID DNA into a bacterial cell.

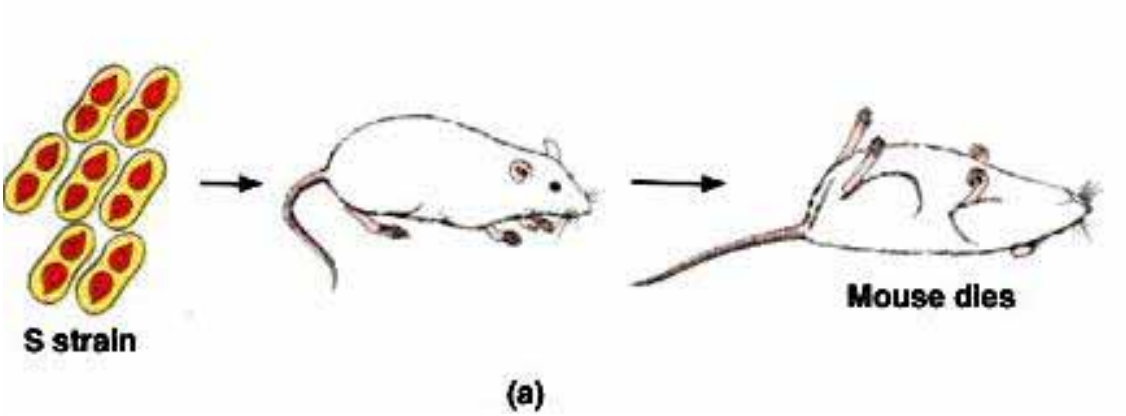


DNA is the genetic material -

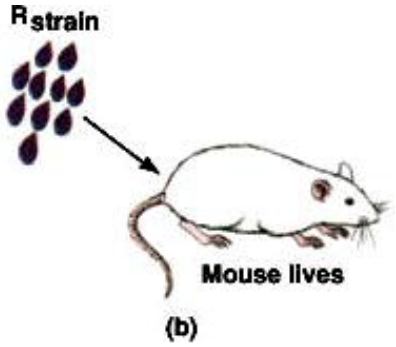
The First demonstration of **bacterial transformation**.

Experiments done by Frederick Griffith (in London) in 1928 found there were two different types of the bacterium *Streptococcus pneumoniae:*

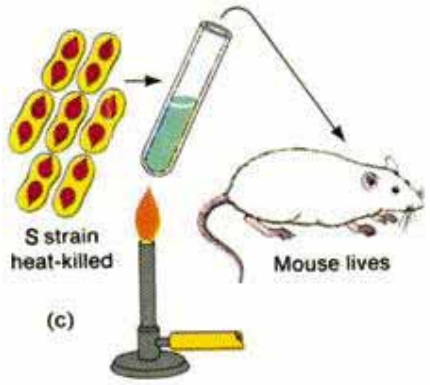
An "S" or SMOOTH coat strain, which is lethal to mice.



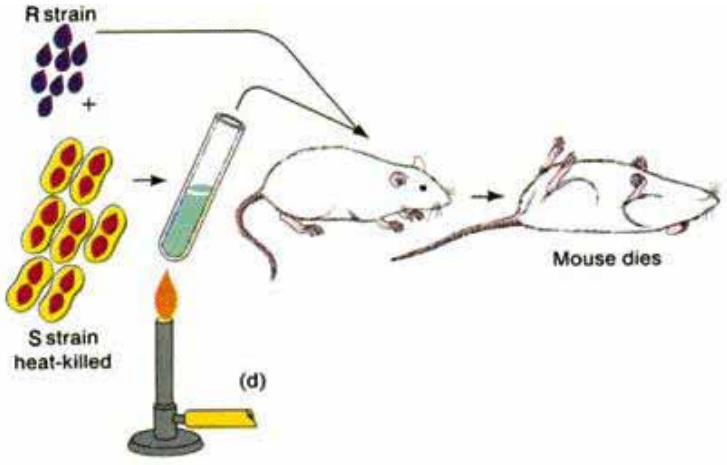
An "R" or rough strain, which will not hurt the mouse.



Griffith found that he could heat inactivate the smooth strain.



However, if he were to take a mixture of the heat-inactivated S strain, mixed with the R strain, the bacteria would die. Thus there was some Material in the heat-killed S strain that was responsible for "transforming" the R strain into a lethal form.



Fred Griffith (and a lab co-worker) was killed in their laboratory in 1940 from a German bomb. However, their work continued on in the U.S., and in 1944, Oswald Avery, C.M. MacLeod, and M. McCarty carefully demonstrated that the ONLY material that was responsible for the transformation was DNA - thus, DNA was the "Genetic material" - however, many scientists were still not sure that it was REALLY DNA (and not proteins) that was the genetic material.

Co-transformation is simply the simultaneous transformation of two different DNA fragments.

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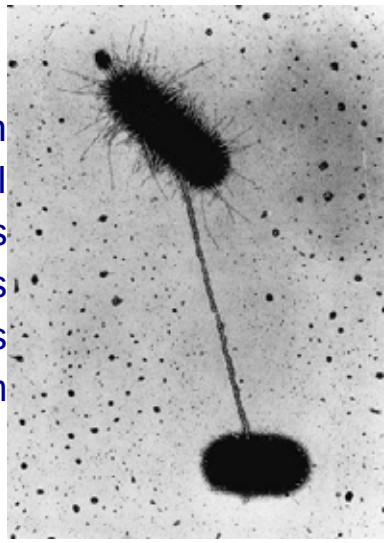
3. Bacterial Conjugation



"Bacterial conjugation is the pocess in which DNA is transferred from a bacterial donar cell to a recipient cell by cell-to-cell contact. It has been observed in many bacterial species and is best understood in E.coli, in which it was discovered by Joshua Lederberg in 1951." (from page 314 in Hartl & Jones).

The ability to transfer DNA by conjugation is dependenton the presence of a cytoplasmic entity termed the **fertility factor**, or **F**. Cells carrying F are termed $\mathbf{F^+}$; cells without F are $\mathbf{F^-}$. F is a small, circular DNA element that acts like a minichromosome. It is an example of a class of elements termed plasmids, which are self-replicating extrachromosomal DNA molecules. F contains approximately 100 genes; these give F several important properties:

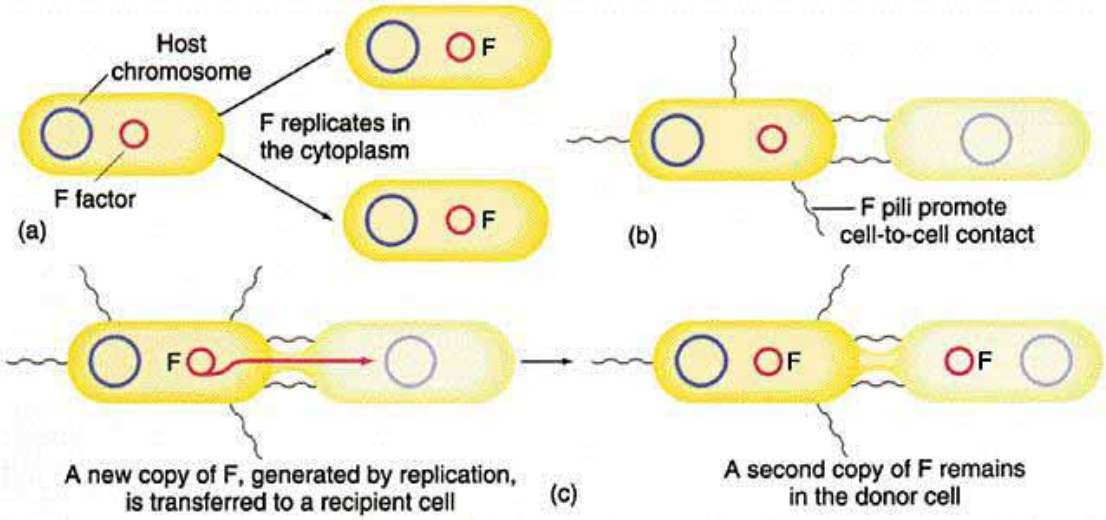
1. F can replicate its DNA, which allows F to be maintained in a cellular population that is dividing.

2. Cells carrying F produce pili (singular, pilus) - minute proteinaceous tubules that allow the F^+ cells to attach to other cells and maintain contact with them.

3. F^+ cels can transfer the newly synthesized copy of the circular F genome to a recipeint (F^-) cell that lacks such a genome; note that a copy of F always remains behind in the donating cell. When a donor cell transfers a copy of its cytoplasmic F to an F^- cell, the recipeient cell also becomes an F^+ cell, because it now contains a circular F genome.

4. F+ cells are usually inhibited from making contact with other F+ cells and do not usually transfer the F genome to F^+ cells.

5. Occasionally, F leaves the cytoplasm and integrates itself into the host bacterial chromosome. When this occurs, F can also transfer the host chromosomal markers to the recipient cell along with its own DNA.



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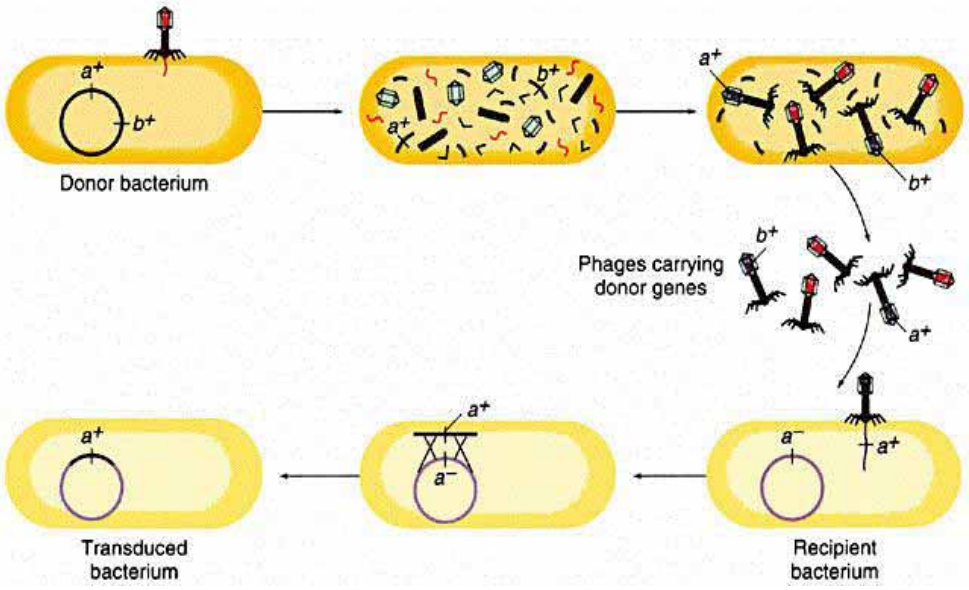
4. Transduction



The third way that DNA is transferred between bacterial cells is through a **phage** particle in the process of transduction. Joshua Lederberg and Norton Zinder first discovered transduction in 1956. When phages inject their DNA into a recipient cell, a process occurs that produces new bacteriophage particles and kills the host cell (lytic growth). Some phage do not always kill the host cell (temperate phage), but instead can be inherited by daughter host cells. Therefore acquisition of a so-called temperate "prophage" by a recipient cell is a form of transduction. Many phages also have the ability to transfer chromosomal or plasmid genes between bacterial cells. During generalized transduction any gene can be transferred from a donor cell to a recipient cell. Generalized transducing phages are produced when a phage packages bacterial genes into its capsid (protein envelope) instead of its own DNA. When a phage particle carrying bacterial chromosomal genes attaches to a recipient cell, the DNA is injected into the **cytoplasm** where it can recombine with a **homologous** DNA sequences.

Some bacteriophage can pick up a subset of chromosomal genes and transfer them to other bacteria. This process is called specialized transduction since only a limited set of chromosomal genes can be transferred between bacterial cells.