Gene Transfer

All Types of Gene Transfer

• Involve unidirectional transfer of information (donor-->recipient)
Why won’t the fragment shown below replicate in the cell?

DNA without an Origin Must Integrate into the Chromosome
DNA without an Origin Must Integrate into the Chromosome

Homologous recombination (site-specific recombination)

Donor

Bacterial chromosome

Plasmid (a replicon)

Recipient
All Types of Gene Transfer

- Involve unidirectional transfer of information (donor-->recipient)
- Transferred DNA must replicate to be passed onto daughter cells

Gene Transfer in Bacteria

- Genes are naturally transferred between bacteria using three mechanisms
  1. Transformation
  2. Transduction
  3. Conjugation
What is the transforming principle in Griffith’s experiments?

DNA-Mediated Transformation

Uptake of naked DNA
Process is sensitive to the addition of DNAse

Some species secrete DNA
DNA-Mediated Transformation

Uptake of naked DNA
Process is sensitive to the addition of DNAse

Recipient cell must be competent

Natural competence
Observed in only certain species
Example - *Streptococcus pneumoniae* (GPC)
  • Becomes competent in late log phase
  • Competent cell binds ds DNA
  • Enzymes cut DNA into smaller fragments (5 - 15 kb)
  • Single strand is taken up by cell
Example - *Haemophilus influenzae* (GNR)
  • Cell binds DNA only from related species

Artificial competence
In the laboratory, treat cells with specific chemicals
(plasmids taken up)

Some species secrete DNA
Artificial Competence

- Not all bacteria become naturally competent

- In one technique called **electroporation**, bacteria and DNA are mixed together

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Transduction

DNA is transferred via a bacteriophage
- Generalized transduction - lytic or temperate phage
- Specialized transduction - temperate phage only
Generalized Transduction

Initial steps of a typical productive infection

Error in packaging

Transducing particle carries bacterial DNA

Specialized Transduction

Initial steps generate a lysogen

Lysogen

- begins lytic cycle
- incorrect excision

• Only DNA that flanks the site of integration can be excised with phage DNA

• Some phage genes are left behind
Specialized Transduction

Initial steps generate a lysogen

Lytic cycle:
- replication of phage parts
- assembly
- release

Specialized Transduction

Initial steps generate a lysogen

Lytic cycle:
- replication of phage parts
- assembly
- release
Specialized Transduction

Initial steps generate a lysogen

Lysogen

- begins lytic cycle
- incorrect excision

Transduction

Generalized
Error in packaging

Transducing particle carries bacterial DNA

Specialized
Error in excision

Defective phage

Transduction - DNA transferred by a bacteriophage

Transformation - uptake of naked DNA
Gene Transfer in Bacteria

- Genes are naturally transferred between bacteria using three mechanisms
  1. Transformation
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  3. Conjugation

Conjugation

Requires cell-to-cell contact
Involves a conjugative plasmid
F plasmid (fertility plasmid) serves as a model
Three types of donors:
  - F*
  - Hfr
  - F (won’t be covered in this course)
Conjugation: F⁺ donor

“male”

F plasmid

Chromosome

Origin of transfer

Donor cell F⁺

“female”

Recipient cell F⁻

Note: some R plasmids (encode resistance to one or more antibiotics) are conjugative

F⁺ + F⁻ → F⁺ + F⁺

In donor cell, replication replaces strand that's being transferred

In recipient cell, complement to transferred strand is synthesized
Conjugation: Hfr donor

Formation of an Hfr cell

Hfr = High-frequency recombination

- Some F plasmid DNA is transferred first, followed by chromosomal DNA
- In donor cell, replication replaces strand that’s being transferred
- In recipient cell, complement to transferred strand is synthesized

Cells inevitably separate before entire chromosome is transferred
Conjugation: Hfr donor

Hfr + F⁻ → Hfr + F⁻

Significance of Hfr strains:
• Chromosomal DNA transfer
• Allowed mapping of *E. coli* chromosome

Conjugation: Hfr donor

2 min  4 min  6 min
Red  Yellow  Green

Blue  Black  Orange
Green Magenta Blue

Significance of Hfr strains:
• Chromosomal DNA transfer
• Allowed mapping of *E. coli* chromosome
The Mobile Gene Pool

Core genome

Mobile genetic elements
- plasmids
- transposons
- genomic islands (pathogenicity islands)
- phages

*E. coli* K12, 4.6 x 10^6 bp
*E. coli* O157:H7, 5.5 x 10^6 bp

Example of the implications

Resistant to most other antibiotics