Discussion Club 2018-09-04:

Soil-persistent *E. coli* and Mobile elements

Nicholas Waters

September 4, 2018

National University of Ireland, Galway, Ireland
The James Hutton Institute, Dundee, Scotland

Outline

Background

Project Overview

- *E. coli* has been found to persist stably in the soil
- Isolates were cultured from lysimeter leachate
- Strains were sequenced, resulting in 149 soil-persistent *E. coli* genome

Research Questions

- What types of *E. coli* are able to persist in soil?

Research Questions

- What types of *E. coli* are able to persist in soil?
- What virulence factors are harboured by these strains?

Research Questions

- What types of *E. coli* are able to persist in soil?
- What virulence factors are harboured by these strains?
- What can we infer about adaptation from these?

Research Questions

- What types of *E. coli* are able to persist in soil?
- What virulence factors are harboured by these strains?
- What can we infer about adaptation from these?
- Can we differentiate soil-persistent *E. coli* from recent contamination?

What does 10 years look like to *E. coli*?

BoE Calculations for Doubling Time

High estimate:

0.013865 * 60 * 24 * 365 * 10 $\approx$ 72k generations

BoE Calculations for Doubling Time

Medium estimate: (5.9 / 2) * 365 * 10

$\approx$ 10k generations

Bååth 1998

(assuming generation time roughly equals half of turnover rate)

Other estimates

No remaining bacteria after:

- 32 days
- 22 days
- 8 weeks
- 114 days

Detection of Escherichia coli is sequenced soil

Escherichia coli approximately .092% prevelence in soil

Hypotheses

Highly diverse soil communities and environmental pressures favour rapid adaptation over incremental changes

Hypotheses

Highly diverse soil communities and environmental pressures favour rapid adaptation over incremental changes

Adaptations will occur more rapidly because of mobile elements rather than mutations to core functions

Mobile Genetic Elements

Insertion Sequence (IS) (Transposon)

Short, mobile sequence capable of jumping

- Size: 750bp – 1.5Kb
- Detection: inverted tandem repeat lollipop with a transposase and promoter.
- Maintenence: genome replication
- Mobility: encoded transposase

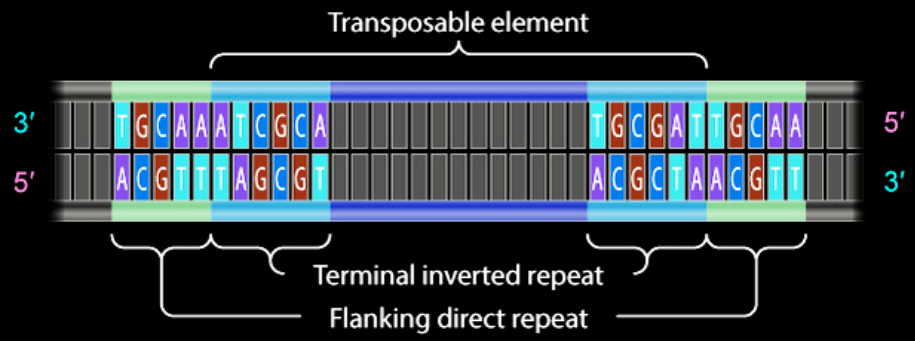


Figure: Insertion Sequence

Non-Composite Transposon

A DNA lolipop containing a transposase and promoter, and other accessory genes

- Size: < 3Kb
- Detection: inverted tandem repeat, transposase, bonus genes
- Maintenence: genome replication
- Mobility: encoded transposase

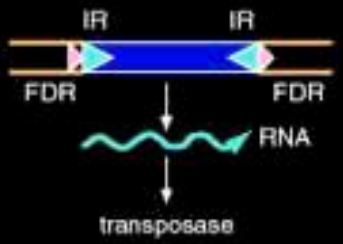
Composite Transposon

A DNA fragment with IS sequences on each end

- Size: < 5Kb
- Detection: double IS, promoters, and accessory genes
- Maintenence: genome replication
- Mobility: encoded transposase

Review

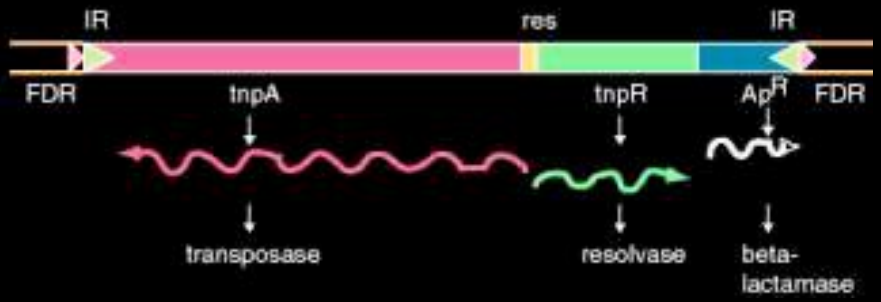
Insertion sequences



Transposons

Composite transposons, e.g. Tn5

Transposons lacking terminal ISs, e.g. TnA



Integrons

Mini-plasmids often containing AMR gene cassettes

- Size: < 10Kb
- Detection: integrase, recombination site (attI), promoter, and (optionally) a cassette of resistence genes
- Maintenance: integration into host genome
- Mobility: recombination, or transfer when circularized

Genetic (Chromosomal) Islands

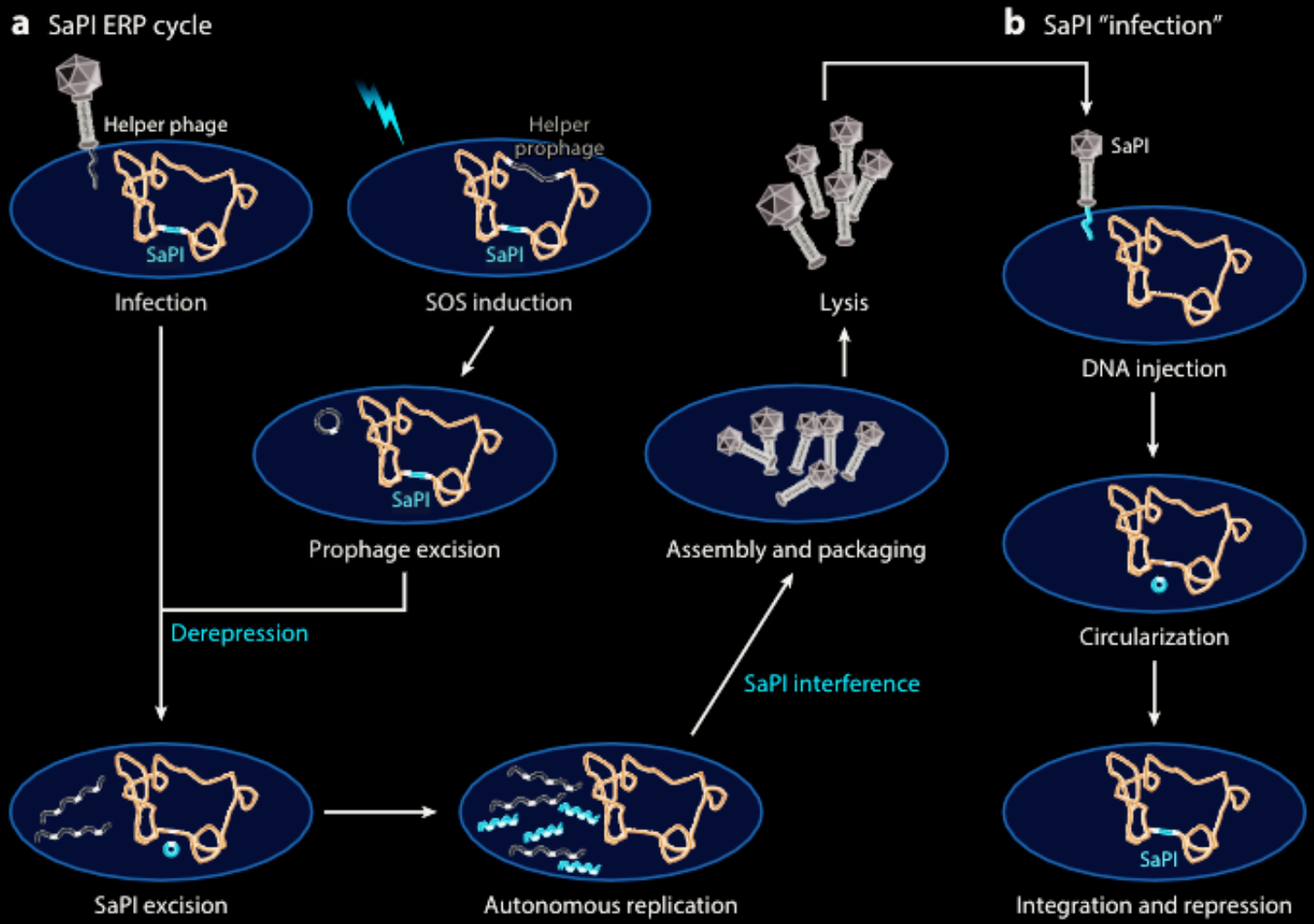
- Size: >10Kb
- Detection: GC Skew, phylogenetic analysis of ORFs
- Maintenence: genome replication
- Mobility: various

Phage-inducible Chromosomal Islands

Phage parasites

- Size: 5 – 15Kb
- Detection: Look for phage proteins along with phage inhibitors
- Maintenence: lysogeny
- Mobility: phage-like particles

Phage-inducible Chromosomal Islands



Prophages

Virus integrated into the host genome

- Size: ~ 50Kb
- Detection: Look for phage integrases, tail and capsule proteins
- Maintenence: genome replication
- Mobility: lysogenic and lytic phases

Plasmids

Freely replicating DNA not required for survival

- Size: <1Kb – 1Mb
- Detection: run a gel; look for circular contigs
- Maintenence: self-replicating or integrating
- Mobility: conjugation (directly or indirectly)

In Closing

Future plans

- Develop mobile pangenome tool for detecting "recent" adaptations
- Characterize trends in MGEs in environmental vs enteric *E. coli*

Sources

- https://www.nature.com/scitable/topicpage/transposons-the-jumping-genes-518
- https://www.nature.com/scitable/topicpage/transposons-the-jumping-genes-518
- https://www.researchgate.net/publication/283707425_The_Phage-Inducible_Chromosomal_Islands_A_Family_of_Highly_Evolved_Molecular_Parasites
- https://www.sciencedirect.com/science/article/pii/S0043135416302226
- http://www.bx.psu.edu/~ross/workmg/TranspositionCh9_files/
- https://www.frontiersin.org/articles/10.3389/fmicb.2018.00762/full

Acknowledgments

NUIG Microbiology

- Dr. Fiona Brennan
- Dr. Florence Abram
- Soil and Environmental Microbiology Research Group
- Functional Environmental Microbiology Group

James Hutton Institute, Dundee

- Dr. Leighton Pritchard
- Dr. Ashleigh Holmes

Acknowledgments

NUIG Microbiology

- Dr. Fiona Brennan
- Dr. Florence Abram
- Soil and Environmental Microbiology Research Group
- Functional Environmental Microbiology Group

James Hutton Institute, Dundee

- Dr. Leighton Pritchard
- Dr. Ashleigh Holmes

Questions?