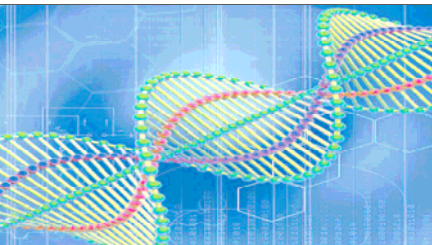


Genes and Ecosystems

Dr Eshwar Mahenthiralingam (Esh)

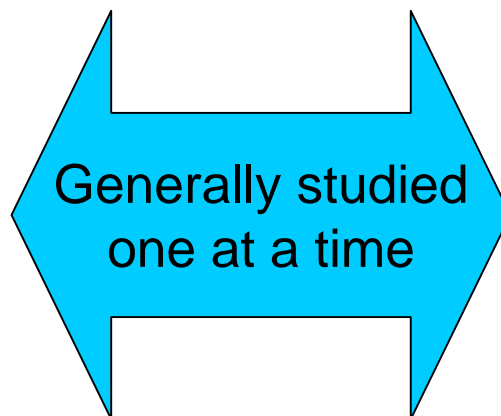
Cardiff University



Genes and Ecosystem Services

Genes

(Functional proteins and enzyme pathways involved in the natural processes)



Ecosystems

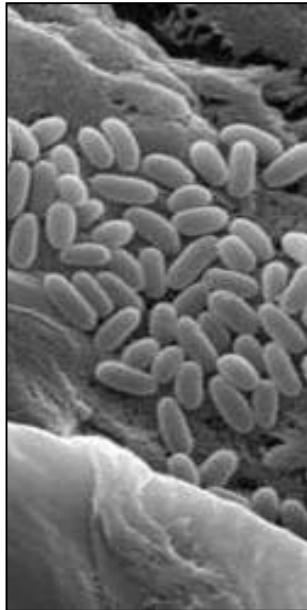
(food, medicine, soil regeneration, waste recirculation, nutrient cycling)

Environmental Genomics

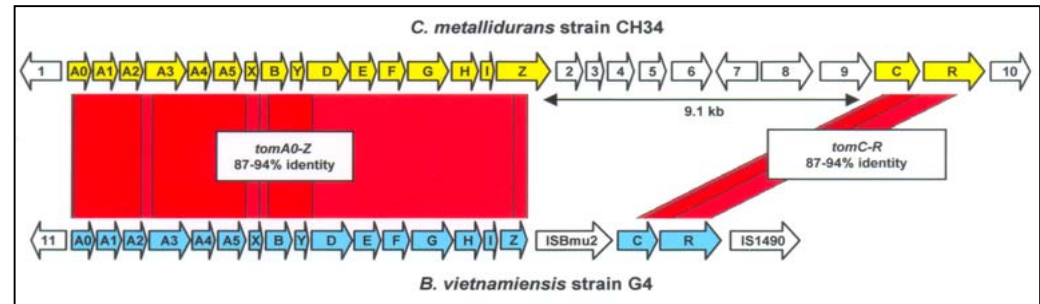
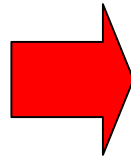
Ecosystem



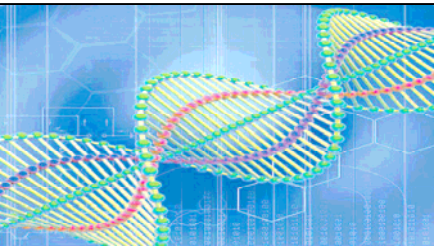
Plants



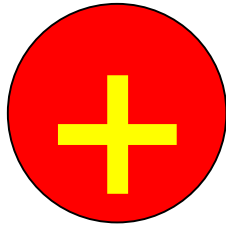
Bacteria on roots



Genes involved in pollutant degradation mediated by bacteria at the root surface



Environmental Bacteria

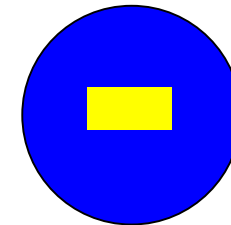
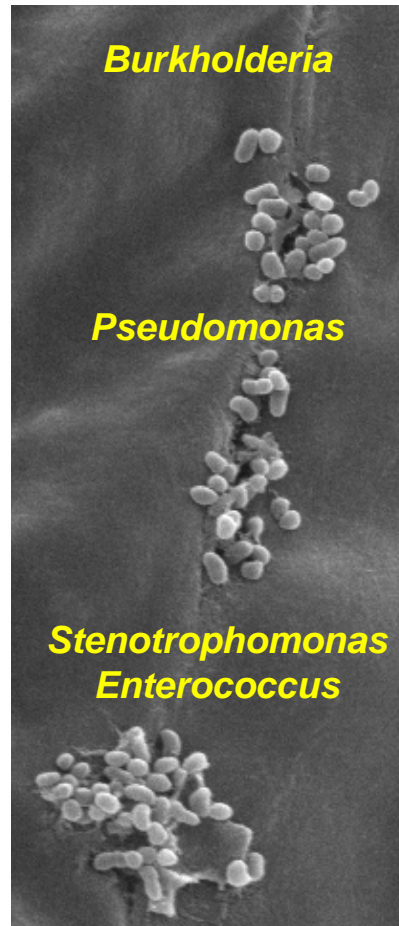


**Destroy pollutants
(bioremediation)**

**Enhance plant growth
(natural fertilisers)**

**Protect Plants from disease
(biological control)**

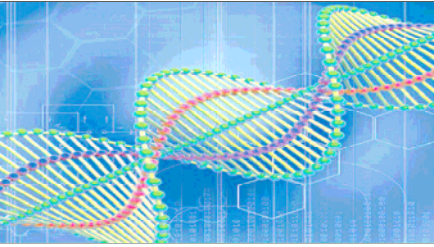
**Nutrient recycling
(Carbon and Nitrogen)**



Some cause infection

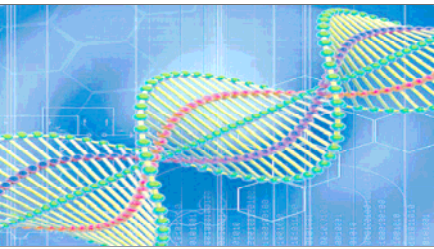
**(Human, animal and
plant diseases)**

Antibiotic resistance



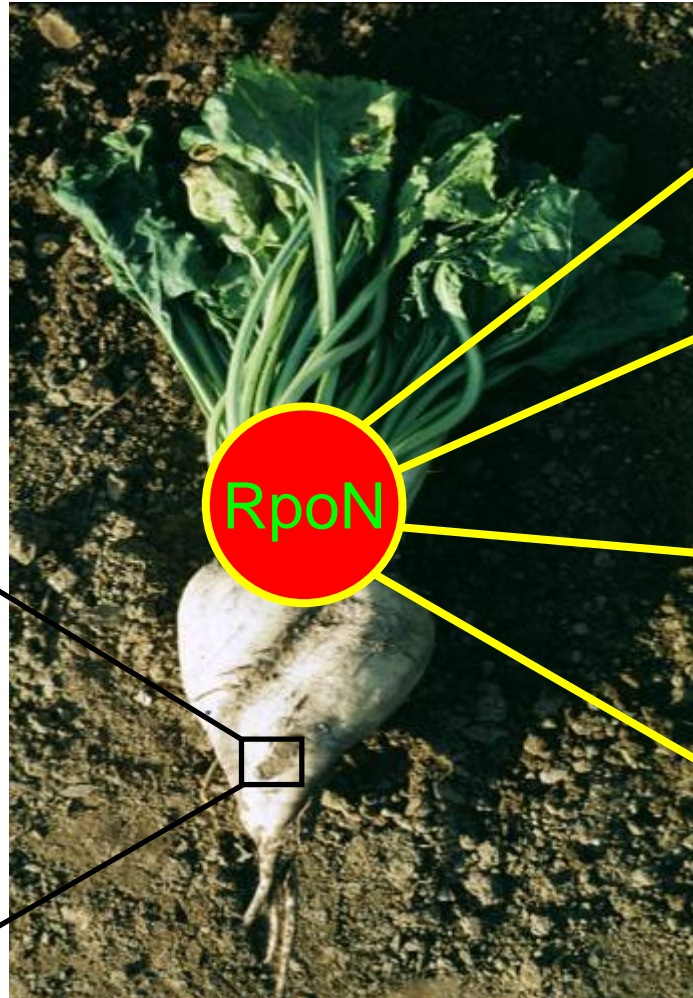
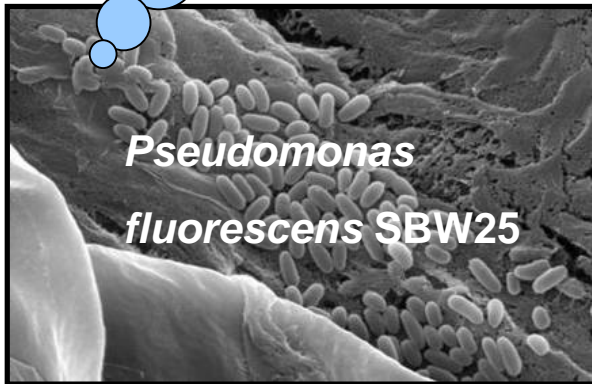
Bacterial Project Examples

- ***Bacterial switches*** – turning genes on and off in environments
- ***Nutrient cycling*** – genes involved in nitrogen fixation
- ***Pollutant degradation*** – identifying bioremediation genes
- ***Root colonisation*** – studying genes for plant interaction



Bacterial Switches: RpoN

Nitrogen levels
are low
What can I do ?

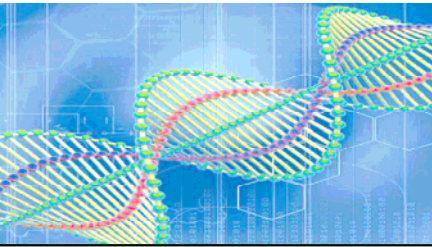


Move

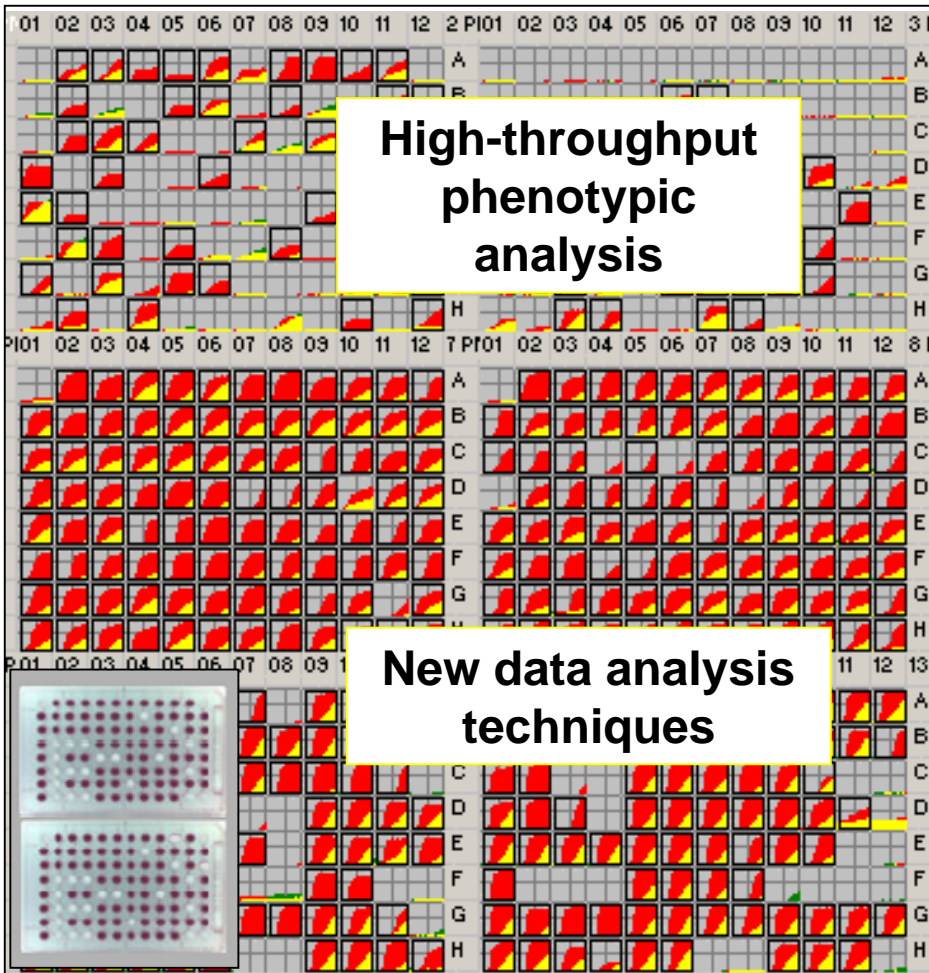
Degrade
complex
chemicals

Parasitism
and disease

Mutually
beneficial
relationship



Looking for new RpoN functions



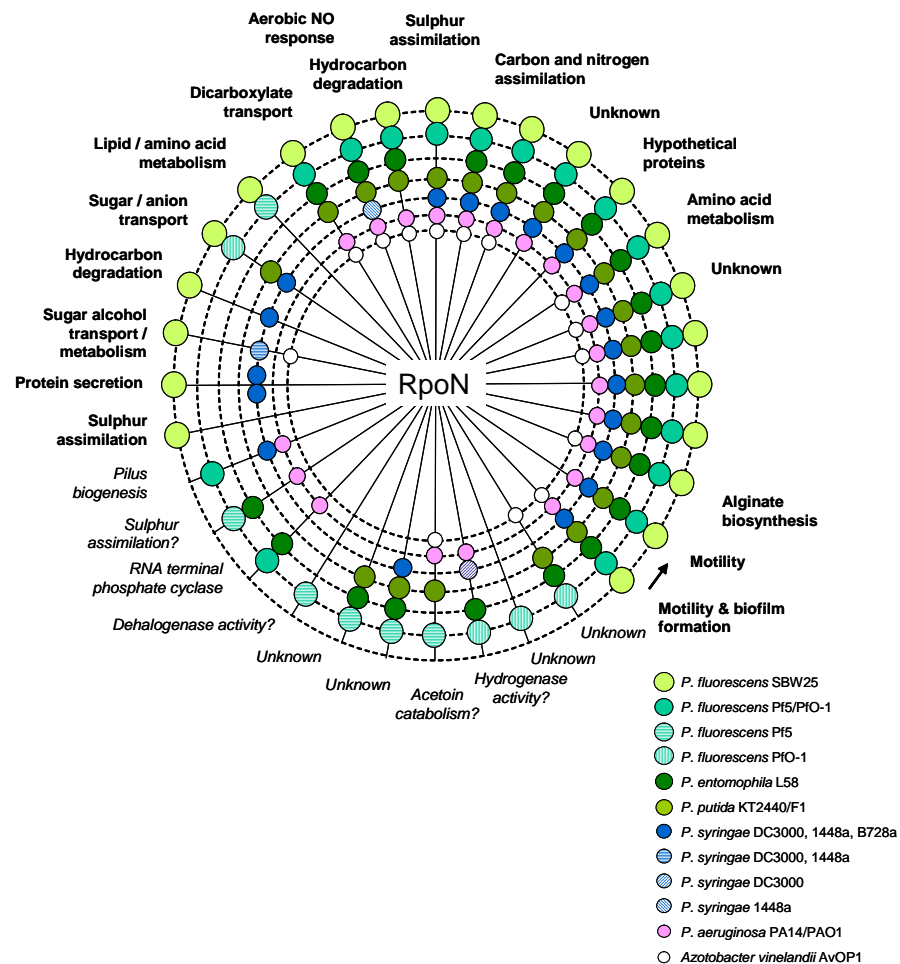
Analysis of *P. fluorescens* with a defective RpoN gene showed novel functions in:

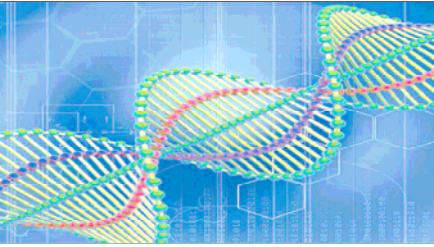
- Plant colonisation
- Novel carbon and nitrogen sources
- Antibiotic resistance
- Acid tolerance
- Metal tolerance

Bioinformatic Analysis of *Pseudomonas* genomes

New RpoN functions were mapped to *Pseudomonas* genomes including those that were:

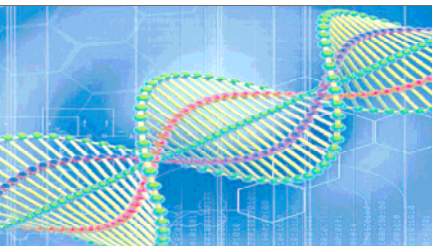
- Broadly conserved
- Absent in *P. fluorescens* SBW25
- Unique to *P. fluorescens* SBW25





Bacterial Project Examples

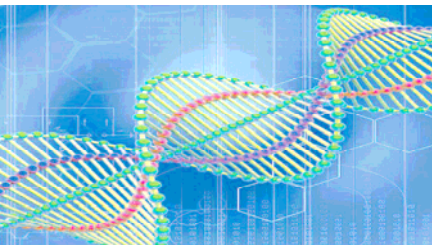
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Genes involved in nitrogen fixation



A lot of biodiversity here



Genes involved in nitrogen fixation



But a great deal more here in a few grams of soil



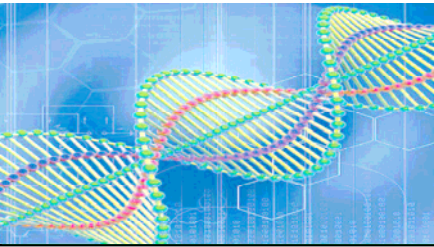
Genes involved in nitrogen fixation



Soil biodiversity and
nutrient cycling functions

Nearly all of it bacterial

**.... in species that have never been identified or
grown in the lab**

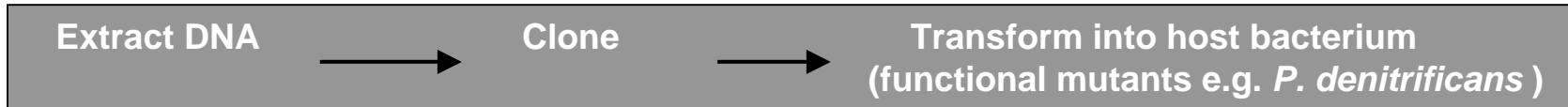


Study functions by capture of environmental DNA

‘Functional Metagenomics’

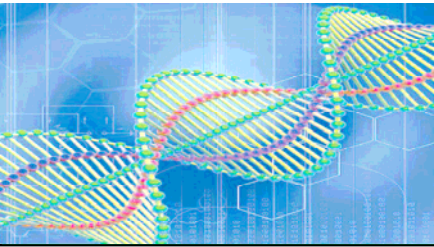


Metagenomic library construction



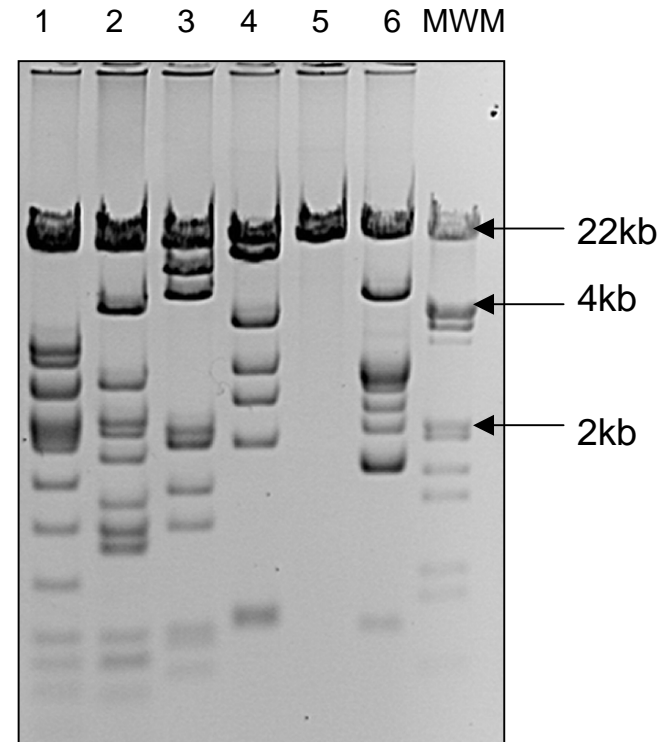
Screen for expression of particular phenotypes e.g.

Can the insert confer the ability on the host to utilise nitrate or nitrite?

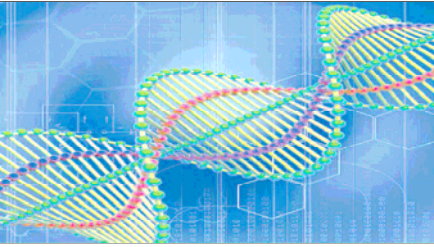


Capture strategy successfully implemented

- Genomic DNA libraries created
- Can large DNA fragments confer new functions?
- Can DNA complement known mutations?
- Identified novel model genes eg. amino acid synthesis
- ***But where are nitrogen fixation genes?***
 - unable to capture them in this first attempt



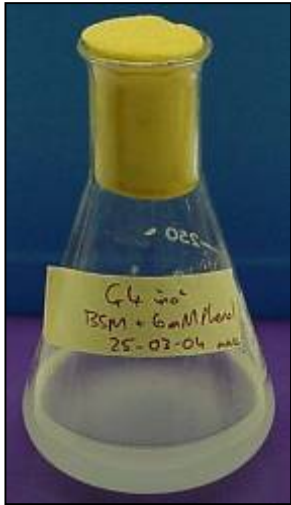
Pst I & Eco RI
plasmid digests



Bacterial Project Examples

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Bacterial pollutant degradation

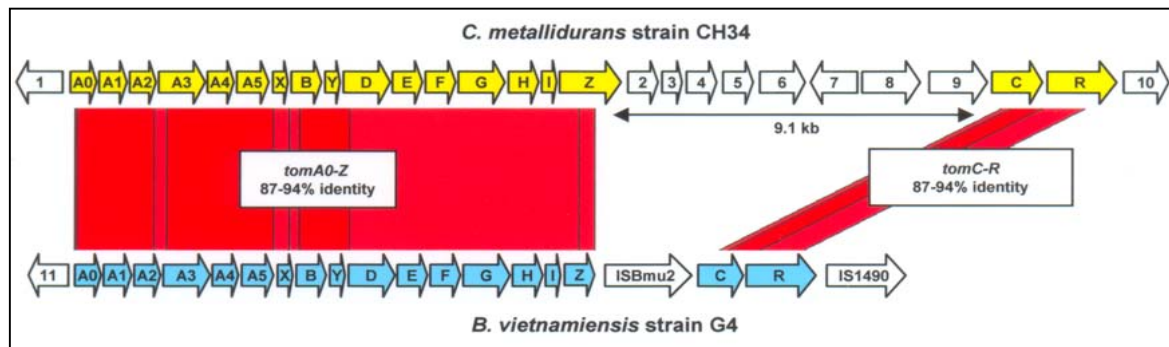


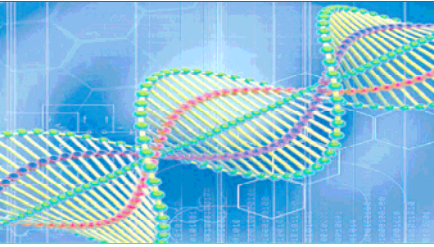
Phenol as a model pollutant



Burkholderia vietnamiensis

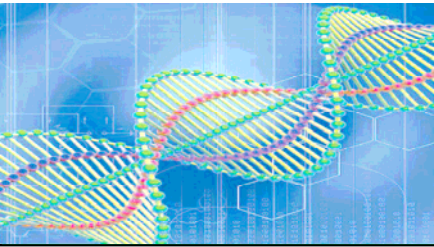
- Genomic mutagenesis applied to an environmental question
- Genes for pollutant degradation marked in derivative strains
- Functional tagging of bioremediation genes on a genomic scale
- Comparisons made to other bacterial genomes
- Can we engineer these gene pathways to be more efficient?



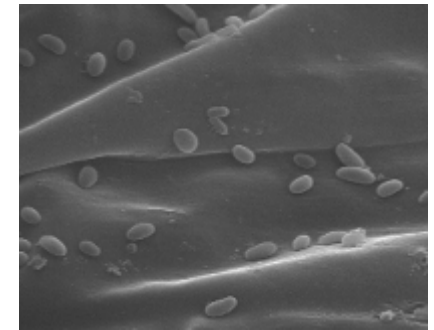
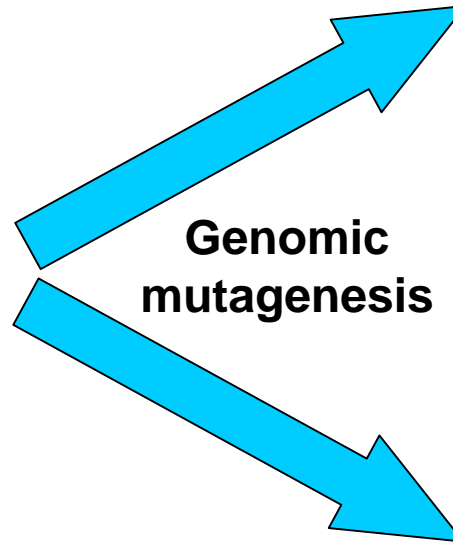
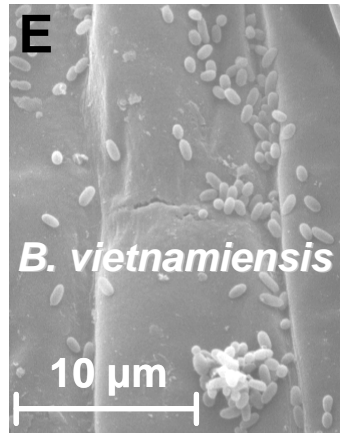
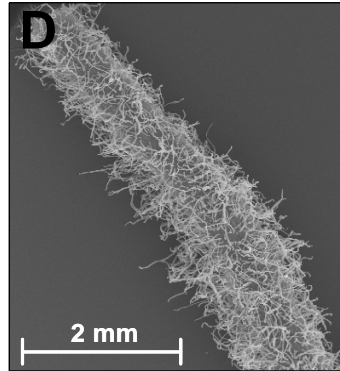


Bacterial Project Examples

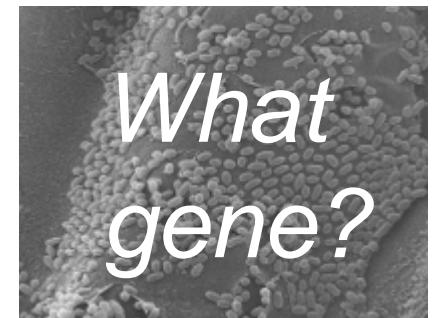
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Genes for bacteria-plant interactions



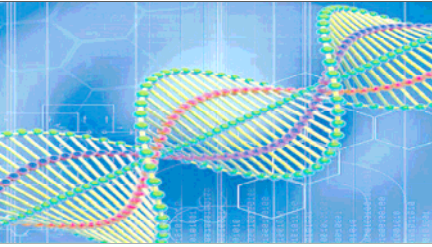
Poor colonisers



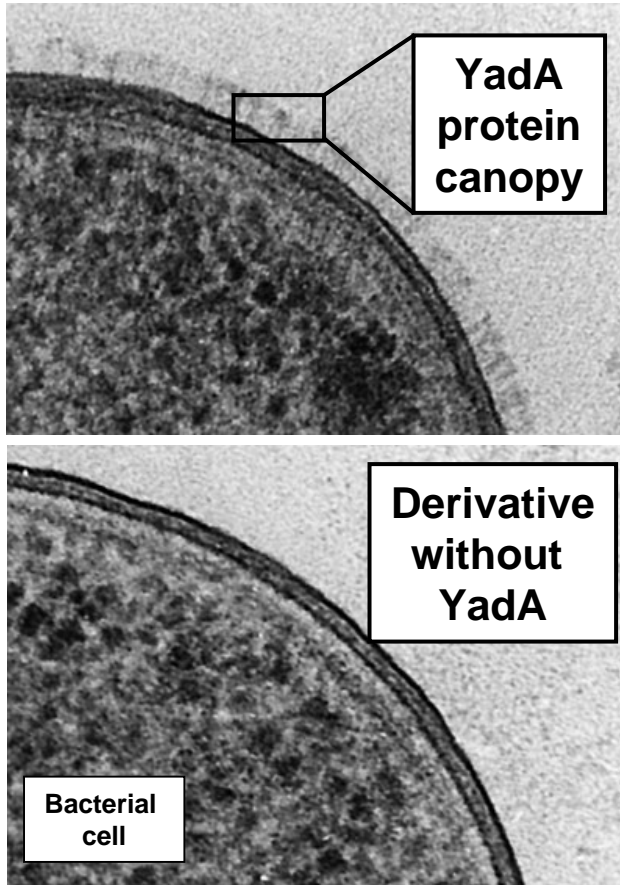
What gene?

Enhanced colonisers

Plant root colonisation model

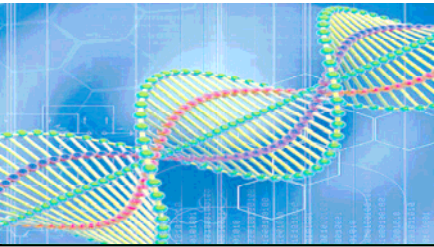


Enhanced plant coloniser lacks sticky protein for mammal cell invasion



Adapted from Hoiczky *et al.* 2000 *Embo J*
19: 5989-5999

- Genomic analysis identified gene as an invasin
- Invasins well studied in plague bacterium
- Allow invasion and destruction of human cells
- Does YadA canopy hide plant root adhesins?
- Is *B. vietnamiensis* YadA negative derivative less able to cause infection?
- *A platform for safe biotechnological strains?*



GENES and ECOSYSTEMS SERVICES: **CONCLUSIONS**

- Genomic strategies enabled the dissection of very diverse ecosystem functions
- Many new gene functions discovered
- Considerable future resources generated
- Post-genomic analysis in progress

