Currently, farmers tend to indiscriminately fertilise their fields before planting crops. This is wasteful, as it can fertilise areas which already have abundant nutrient levels.

We plan to spread agrEcoli bacteria, encapsulated in beads, onto the soil. This can be done during the tilling process using a bead dispenser attached to the tractor.

Farmers can map the nutrient content of their fields. This allows them to fertilise only the areas that require it, saving up to £45 per hectare.1

### Modelling

**BioBrick Mechanism**

Action of the Biobrick is usually blocked by NsrR, a repressor native to E.coli that binds to the promoter. Nitrate entering the cell is converted to Nitric Oxide, which binds to the repressor, lifting its action on PykA1 and allowing production of GFP.

**GFP Assay**

To overcome misleading signals due to differing colony sizes, all cells contained a baseline level of GFP against which varying levels of GFP are compared. Results of characterising this ratio method, showing the relationship between GFP/RFP and levels of Potassium Nitrate.

**Gellan**

High levels of cell death when bacteria were spread freely in the soil made signal detection difficult. To overcome this, concentrated levels of bacteria were encapsulated inside nutrient rich gellan gel beads. This aids survival, increases signal strength and separates E.coli from the environment.

Preliminary experiments showing the difference in fluorescence of a bead after exposure to nitrate saturated soil for 24 hours. Image software analysis showed an increase in fluorescence by a factor of 2.16.

**Meshes**

Common analytical shapes are limited when representing real-world objects. A polyhedral mesh can represent almost any three dimensional structure to an arbitrary degree of precision. BSim now supports triangle meshes, ‘Octree’ chemical fields and collisions.

**Bacterial Micro-Environments**

When modelling populations of cells it is usually assumed that they are in a homogeneous medium. This approximation holds for many situations; however, there are times when it is important to factor in a more complex micro-environment. The interaction between bacteria and soil is crucial to the function of agrEcoli. To understand the behaviour of agrEcoli in the field, we needed to analyse how the E.coli would behave when encapsulated in a gel matrix. We did this by extending our agent-based modelling system, BSim, with 3 new features: meshes, ‘Octree’ chemical fields and collisions.

**Graphical User Interface (GUI)**

BSim 2009 required knowledge of JAVA, mathematics and biochemistry. We have added a GUI, removing the need for JAVA knowledge and opening up BSim to a much wider category of users. The GUI only requires users to be able to express their biological system mathematically; it can then translate the user’s description of a system into JAVA code. The point-and-click interface makes it easy to create new simulations.

**Chemical Fields**

To calculate chemical diffusion across regions of space, we decided to implement an ‘Octree’ structure. This is a hybrid between finite element and finite difference methods for solving partial differential equations. It uses a regular lattice of cubes but changes the resolution of the lattice as it is partitioned by a mesh surface. Computational resources are used efficiently and numerical instability is avoided.

**Collisions**

We have added routines for computing collision events. This allows the user to detect when any object comes into contact with a mesh boundary and to respond as re-

### Wetlab

**Summary**

We built and characterised our Biobrick, developed a reliable method of getting quantitative data and a novel delivery method to ensure an easily detectable signal. We also further characterised a pre-existing Biobrick (Bba_2116005) from the parts registry.

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**Feature Comparison**

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### Human Practices

**agrEcoli as a product**

Our novel response to human practices is a publicity campaign: describing our project as a hypothetical product for use in the UK, and considering how to persuade the public that it is safe and useful. We build on previous teams’ work to identify and address public concerns by analysing their survey conclusions and recommendations. With these issues in mind we have constructed a public information leaflet as a quick and accessible way to promote our research, ideas and the iGEM competition.

**Public Information Leaflet**

- explains what the beads are and what they’re for
- gives reassurance that they’re safe
- details the motivation for their development
- explains E.coli out of the context of illness and highlights some of the legal approval processes

**Public Engagement**

Claydon School Visit (Above), BBC Radio Bristol, Bristol Community Radio (Right)

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**References**


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**Team**

- Neeraj Oak: Complexity Science
- Katherine Coyte: Biology
- Thomas Todd: Complexity Science
- Roz Sandwell: Engineering Maths
- Thomas Layland: Biochemistry
- Antoni Matyjaszkiewicz: Engineering Maths
- Kira Kowalska: Engineering Maths

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