Technology Strategy Board
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Knowledge Transfer Network

Biosciences

Boosting biofuels using ruminant enzymes

A new industry-academia collaboration aims to unlock the secrets of the cow rumen to find new enzymes for developing biofuels that don't impact on food production.

The need

There is significant global pressure to find sustainable alternatives to fossil fuels. Improving the efficiency of energy release from plants is a major area of focus for biofuel research and development. Even small improvements in efficiency would carry significant economic benefits.

Ruminant animals such as cattle, sheep and reindeer have a unique ability to digest plant matter efficiently due to the additional compartments, such as the rumen, they have in their digestive system specifically for this purpose. Crucially it is the microbes contained within the rumen that hold the secret to the efficient release of energy from plant matter through specific enzyme action. Understanding and harnessing these enzymes could lead to significant improvements to the biofuel production process.

The results

Ingenza is a synthetic biology company which develops and applies proprietary manufacturing technology in the fine chemical, food, fuel and pharmaceutical industries.

Advances in genomic technologies mean that unprecedented amounts of data can be generated with ever increasing speed and decreasing costs using high-throughput sequencing. For the first time it is feasible to sequence large numbers of rumen microbes.

After facilitating an initial collaboration between Ingenza and ARK-Genomics (a leading centre of excellence in genomics and genetics, based at The Roslin Institute) through a SPARK Award, the Biosciences KTN assisted Ingenza to secure Technology Strategy Board funding for a collaborative project with Ark Genomics and also the Rowett Institute of Nutrition and Health. The project will use state-of-the-art high throughput sequencing to generate around 300Gb of DNA sequence data of various rumen metagenomes. Rumens from upland sheep, dairy cattle and reindeer will all be sampled to identify those microbially-derived genes that encode enzymes of potential economic interest. The livestock will be fed on specific diets in order to provide substantial rumen flora diversity.

Multi-million pound revenues are predicted for Ingenza within 3 years of project completion from licensing more effective microbial strains derived from this project, incorporating 1-2 suitable cellulase enzymes. This will lead to further growth of the company and job creation in the UK.

Improving the efficiency of biofuel production through use of novel enzymes would also have significant environmental benefits by reducing the amount of land and resources used to provide the required feedstocks per unit volume. In addition, the project could contribute to the mitigation of methane emissions from ruminants and the replacement of metal and waste intensive chemical manufacturing practices with renewable feedstocks and bioprocesses.

Additional applications

In addition to the significant revenues from developing improved biocatalysts for biofuels, there is a second business opportunity in identifying enzymes for use in the pharmaceutical industry.

Biocatalysis is now recognised as a potentially cost-effective route to prepare chiral pharmaceutical intermediates such as chiral amines. The rumen has yet to be explored as a novel source of biocatalysts to address this market, and there is potential to discover new enzymes for the synthesis of high value compounds that cannot currently be produced.

Pharmaceutical applications of new enzymes identified in this project represents an additional, significant market area. Novel, competitive routes for drug manufacture will support and accelerate drug development providing benefits to healthcare and the quality of life in the UK and beyond.

Given the size of this global market ($6.2 billion in 2010), if suitable novel enzymes can be identified, there is significant potential return on investment for Ingenza.

The rumen:

- Is the storage container for the food the animal eats - a cow's rumen can hold over 100 litres of material
- Contains microbes that digest or ferment the food that has been consumed
- Is home to huge numbers of bacteria, protozoa and fungi - one gram of rumen fluid contents contains more than 100 million bacteria. Only a tiny proportion of the bacterial species have been cultivated and studied in detail.

Next-generation sequencing and metagenomics enables the cultivation phase to be circumvented and the genes and enzymes from all species can be studied without the need to grow the microbes in pure culture.

The livestock used in the project have been selected and fed diets to ensure a diverse range of microbes can be obtained:

Reindeer: *from the far north of Finland, consuming their winter diet of mainly lichens, which they forage for under the snow.*

Upland Sheep: *grazing rough pasture in North East Scotland.*

Dairy Cows: *receiving a predominantly maize silage diet in South East England.*

"Society is looking towards how greener practices can contribute to economic growth and more sustainable living in a meaningful way – this project has proven to be a real step towards that."

Ian Fotheringham, Ingenza

Project Details

Project partners:

Ingenza Ltd
Rowett Institute (University of Aberdeen)
The Roslin Institute and the Royal (Dick) School of Veterinary Studies (University of Edinburgh)

Project investment:

Ingenza: £192,504
Technology Strategy Board:£357,505
Total investment: £550,009

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