What is Fungal Biotechnology?

Filamentous fungi are dominant producers of a range of small molecule compounds such as organic acids e.g. citric acid, fatty acids as well as antibiotics and human therapeutics e.g. penicillin, cephalosporin lovastatin, taxol. They are producers of biosurfactants and polysaccharides and can be considered a food source in their own right e.g. mushrooms, single cell protein/biomass. Some fungi are notable enzyme producers which have been exploited for the production of cellulases, pectinases, laccases/ligninases, amylases, amyloglucosidases, phytase, proteases, microbial rennets, lipases and glucose oxidase. Fungal enzymes have applications in a wide variety of sectors such as in production of food and feed, pulp and paper, textiles, detergents, beverages, and biofuels.

Fungi have an inherent ability to grow at high rates and to high biomass densities supported by low cost substrates in relatively simple fermenters. Filamentous fungi are renowned for high productivity characteristics making them naturally excellent producers of extracellular enzymes and metabolites. For example, the fungus *Trichoderma reesei* can produce cellulase at a level of 100g/L extracellular protein. They can also be used as candidate hosts for the expression of recombinant proteins.

Who are the fungal Biotechnologists at Shannon ABC?

Our fungal biotechnology research is led by Shannon ABC PI and Senior Scientist Dr Patrick Murray and Dr Catherine Collins. Together they have over several years' experience in fungal biotechnology and are acknowledged experts in all aspects of fungal biology including phylogenetic molecular identification, molecular genetics, molecular enzymology, fungal nanoparticle production and secondary metabolite production and screening.

Dr Patrick Murray has a PhD in fungal enzymology and has worked on several fungal projects since covering enzymology, molecular biology and nanoparticle production. His latest fungal related project is a Horizon 2020 project entitled BiolCEP dealing with plastic biodegradation using fungi. See details below.

Dr Catherine Collins has a PhD in fungal biotechnology. She had worked on a number of fungal projects both in Ireland and the U.K. prior to joining Shannon Applied Biotechnology Centre. While working at Shannon ABC, she has established her own research group which focuses on investigating mushrooms and fungi as functional foods and as sources of enzymes and other bioactives.

Fungal Biotechnology projects ongoing at Shannon ABC

Bio Innovation of a Circular Economy for Plastics (BioICEP)

Transforming plastic waste into new polymers

The Bio Innovation of a Circular Economy for Plastics (BioICEP) is a pan European-Chinese collaboration formed to reduce the burden of plastic waste in the environment. A research team led by Dr Margaret Brennan Fournet of Athlone Institute of Technology (AIT) that includes Dr Paudie Murray, Dr Catherine Collins and Dr Sushanta Saha of Shannon ABC, LIT are part of a consortium including Trinity College Dublin and nine other European and three Chinese Partners that have begun this project in January 2020 which will run for four years. The approach is a triple-action depolymerisation system where plastic waste will be broken down in three consecutive processes: 1) mechano-biochemical disintegration processes, including a new proprietary sonic-green-chemical technology to reduce the polymer molecular weight of the base polymer to make it amenable to biodegradation; 2) biocatalytic digestion, with enzymes enhanced through a range of innovative techniques including accelerated screening through novel fluorescent sensor and directed evolution; and 3) microbial consortia developed from best in class single microbial strains, which combined leads to highly efficient degradation of mixed plastic waste streams. The project aims to develop production line demonstration and validation of sustainable and environmentally friendly bioconversion of waste plastic mixtures into value added bioplastics which will underpin the knowledge and optimise the capacity for efficient microbial degradation of 20 % non-biodegradable mixed plastics and bio-produce high added value bioplastics from degraded plastic mixture feed stocks. The outputs from this degradation process will be used as building blocks for new polymers or other bioproducts to enable a new plastic waste-based circular economy. Shannon ABC's role in this project will be screeing fungi from their fungal biobanks and isolating new fungi which can play a role in plastic degradation and bioproduct formation.

Mushrooms and Fungi, Functional and Life Enhancing Reservoirs (MuFFLER)

This project investigating edible mushrooms and fungi as a source of nutrients and bioactive compounds and is funded by Department of Agriculture, Food and the Marine.

Mushrooms may provide an answer to the functional and general food production demands of a consistently expanding global population. There are many significant benefits to mushrooms that

can be targeted for industrial, medicinal and food use. Increasing consumer interest in health a functional food ensures that the bio-resource of Irish mushrooms could which is relatively overlooked could be of significant environmental and economic value. This potential is reflective of notable increasing trend of consumers taking an active interest in a healthy lifestyle, diet and sustainable foods. The project has created a detailed profile of the nutritional and bioactive benefits associated with this undervalued bio-resource of edible Irish mushrooms.

Figure 1. Shaggy ink cap mushroom collected from the Irish country side.

Figure 2. *Lactarius deterrimus* mushrooms collected from Irish country side

Twenty-nine species of commonly available wild and commercially grown Irish mushrooms have been analysed for nutritional value, antioxidants and bioactive properties. Resulting data is in agreement with the positive dietary attributes of mushrooms. The project profiled the biodiversity and value of Irish mushrooms and was performed by Emily Panter.

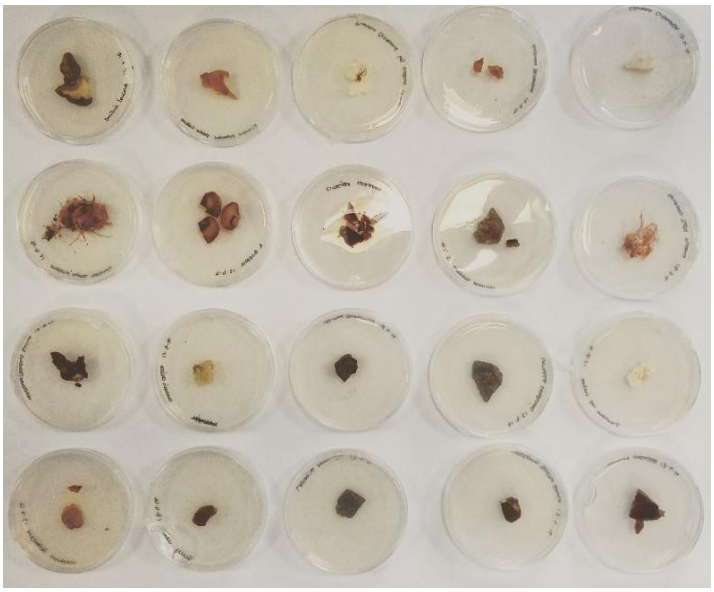

Figure 3 Generation of mushroom stocks from wild edible strains.

Having a large repertoire of bioactive molecules, fungi have been shown to provide many valuable compounds which are exploited for commercial usage (antibiotics, enzymes, vitamins, pharmaceutical compounds, fungicides, plant growth regulators, hormones and

proteins). It is estimated that only about 5-10% of fungi are known to mankind, suggesting that fungi may still harbour 'un-tapped' novel bioactive molecules for commercial usage. This study focused on fungi sourced from Irish habitats (forests, agricultural sites and marine habitats) which are largely understudied in relation to the current topic. This research is being performed by Martin Hayes.

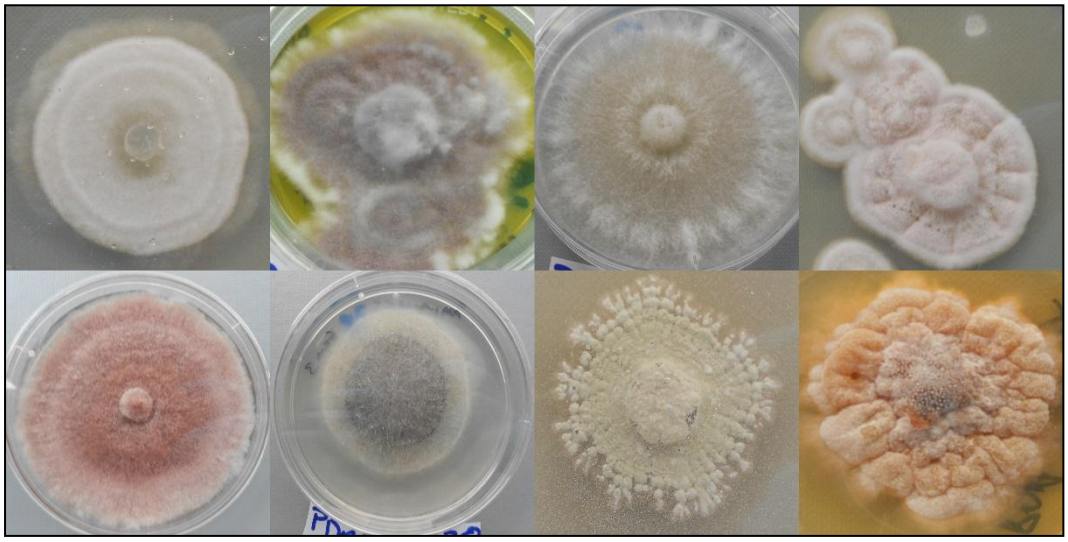

Figure 4 A number of purified fungi, propagated from substrates from Irish habitats.

MuFFLER's large-scale screen for bioactive compounds with applications within the healthcare industry and industrial processes revealed the previously undocumented potential from Irish fungi. Most of the 100 fungi were found to have various antioxidant capacities, whereby the greatest antioxidant producers were also found to have blood pressure lowering abilities, highlighting the dual functionality of such extracts. Eighteen fungi were found to have antimicrobial properties for a variety of bacterial and the yeast *Candida albicans*.

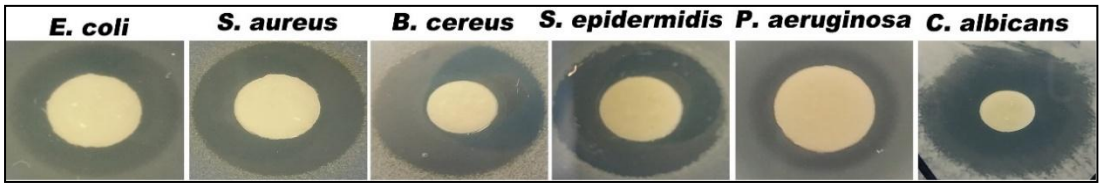

Figure 5 Various antimicrobial properties of fungal extract. Inhibition is assessed by circular zone of clearance on microbial lawn around white diffusive disc containing fungal extract.

Additionally, 22 of the tested strains were found to produce industrially relevant enzymes including laccase, which were also found to degrade the commercially relevant industrial textile dye reactive black 5.

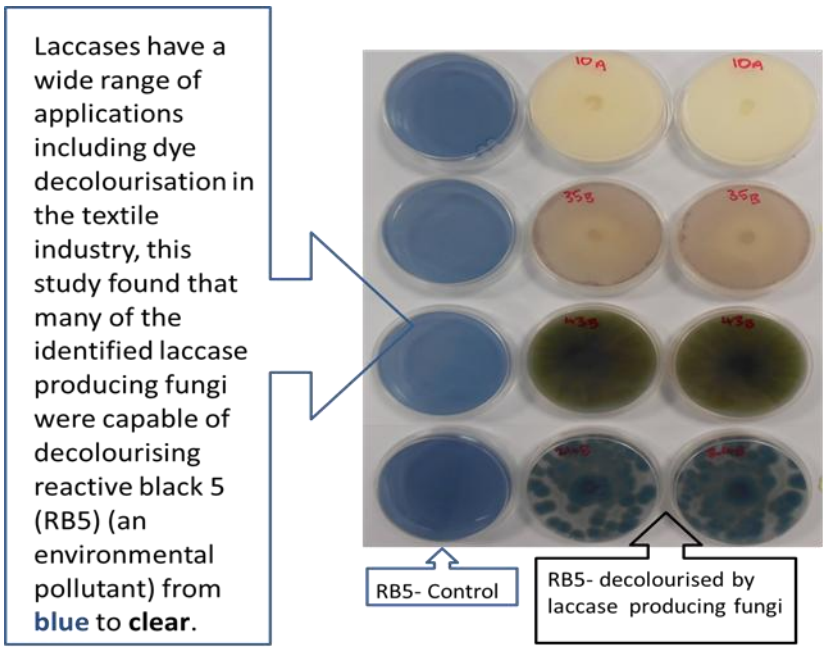

Figure 6. Many identified lignin degrading fungi were found to degrade (blue to clear) RB5 (environmental pollutant).

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