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RESEARCH ARTICLE

MICROBIAL ENGINEERING TECHNOLOGY AND ITS ENORMOUS SCOPE

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ABSTRACT

Microorganisms are powerful workhorses for engineering biological functions and have been used for applications in healthcare, environmental remediation and in the manufacture of desired chemicals. Bacterial and yeast cells with engineered metabolic pathways have been used to streamline the synthesis of chemical products, such as drugs and fuels(1). For example, *Escherichia coli* and *Saccharomyces cerevisiae* have been engineered to efficiently convert biomass sugars into advanced biofuels, such as butanol, farnesane and bis-abolane. In addition, owing to their relatively simple genetics and physiology, microorganisms (in particular, *E. coli* and *S. cerevisiae*)(5) have been used as experimental chassis to test and redesign genetic systems, which has strengthened our understanding of how complex bio-logical systems function.

INTRODUCTION

Production of advanced biofuels

Progress in metabolic engineering, and synthetic and systems biology, have allowed the engineering of microbes to produce advanced bio-fuels with similar properties to petroleum-based fuels. In an effort to improve butanol production(8), species of the natural host *Clostridium* have been engineered to use feedstocks such as glucose, liquefied cornflour, glycerol (a by-product in the production of biodiesel from fats and even syngas (a mixture of hydrogen and carbon monoxide).

Synthesis of drugs

Synthetic biology has generated many examples of what microbes can do and what we can learn from them when they are creatively engineered in the laboratory environment(2). From the synthesis of an anti-malarialdrug to the study of microbial genetic competency, engineered microbes have advanced technology while providing insight into the workings of the cell. Interest has recently emerged in engineering microbial consortia – multiple interacting microbial populations –because consortia can perform complicated functions that individual populations cannot and because consortia can be more robust to environmental fluctuations(3).

Data driven and synthetic biology approaches maximize fuel production

Advanced biofuels produced by microorganisms have similar properties to petroleum-based fuels, and can 'drop in' to the existing transportation infrastructure. However, producing these biofuels in yields high enough to be useful requires the engineering of the microorganism's metabolism (4). Such engineering is not based on just one specific feedstock or host organism. Data-driven and synthetic-biology approaches can be used to optimize both the host and pathways to maximize fuel production. Despite some success, challenges still need to be met to move advanced biofuels towards commercialization, and to compete with more conventional fuels (6).

Microbial metabolite production depend on controlled environmental conditions

The biochemical reactions involved in the microbial cell growth, the metabolite production and the maintenance are under the control of the environmental conditions and the limiting substrate concentration. However, the microorganisms used in the microbial process are never under optimized conditions but rather under limitations and stressed conditions . The models of consumption rate of limiting substrate used in the microbial cell growth(7) , the metabolites productions and the maintenance are the basis of the development of algorithms for processes and their applications to the control, of critical variables, e.g., temperature, pH and nutrient addition, to optimize productivity.

Development of Microbial Factories

Recent advances in protein engineering, metabolic engineering, and synthetic biology have revolutionized our ability to discover and construct new biosynthetic pathways and engineer

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platform organisms or so-called microbial factories to produce a wide variety of value-added product such as alkaloids, terpenoids, Xavonoids, polyketides, non-ribosomal peptides, biofuels, and chemicals in a cost-effective manner(9).

Microbial fuel cells generating electricity

The possibility of generating electricity with microbial fuel cells has been recognized for some time, but practical application shave been slow to develop. The recent development of a microbial fuel cell that can harvest electricity from the organic matter stored in marine sediments has demonstrated the feasibility of producing useful amounts of electricity in remote environments. Further study of these systems has led to the discovery of microorganisms that conserve energy to support their growth by completely oxidizing organic compounds to carbon dioxide with direct electron transfer to electrodes. This suggests that self-sustaining microbial fuel cells that can effectively convert a diverse range of waste organic matter or renewable biomass to electricity are feasible. Significant progress has recently been made to increase the power output of systems designed to convert organic wastes to electricity , but substantial additional optimization will be required for large-scale electricity production(10).

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