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Guest Editorial

Industrial Biotechnology

NON-PEER REVIEWED FEATURE

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Biotechnology employs engineering approaches to the life sciences with global economic, environmental, health and societal impacts. Biotechnologies are classified in a colour coded fashion that encompasses their broad areas of use:

- Blue biotechnology: use of marine and sea resources to create products and industrial applications
- Brown biotechnology: innovation and creation of biotechnologies to enable and manage agriculture in arid lands and deserts
- Dark biotechnology: biotechnology related to defence against bioterrorism, biological weapons and biowarfare, for example microorganisms and toxins that cause diseases or death in humans, livestock and crops
- Gold biotechnology: *in silico* or computational biotechnology and bioinformatics for the development and production of products, for example compound identification and toxicity or function screening
- Grey biotechnology: biotechnologies focused on environmental applications such as the maintenance of biodiversity and the remediation of pollutants
- Green biotechnology: use of agricultural processes, for example transgenic plants, to produce feedstocks and materials
- Purple/violet biotechnology: issues surrounding the ethics, laws and philosophy of biotechnology
- Red biotechnology: biotechnology for medical, pharmaceutical and health applications
- White biotechnology: biotechnology applied to industrial processes, for example enzyme-mediated synthesis, synthetic and engineering biology, for the development, production and processing of valuable chemicals and materials
- Yellow biotechnology: biotechnology used to produce food or to control and use insects.

The breadth and diversity of areas covered in the classifications of industrial biotechnology demonstrates what an exciting field this is to work in. The subject has its roots in a wide variety of subjects ranging from pure sciences to computing, economics and law. This multidisciplinary approach is crucial in achieving solutions which will bring societal benefits into the future.

Global Sustainability

The growing appreciation of the importance of sustainability globally is recognised by the United Nations (UN) Sustainable Development Goals (SDGs) which have been adopted by all UN member states with the aim of ending poverty, protecting the planet and ensuring all people enjoy peace and prosperity by 2030. The SDGs are complex real-world problems and biotechnologies have the potential to play important roles in solutions to these challenges.

The focus of this special issue is industrial biotechnology, with a variety of types of contributions including reviews, research articles, book reviews and profile features covering industrial applications of biotechnology especially for the production or processing of valuable chemicals and materials, energy materials, decarbonisation and sustainability. The special issue demonstrates a spread of topics beginning with reviews from Desai and Zimmerman (1) focusing on microbubble intensification of bioprocessing and the role of

direct microorganism and bubble interactions, and from Akgedik *et al.* (2) on the utilisation of insect gut as a biosource for the development of future biotransformation processes.

Fuels, Chemicals and Energy

The special issue features a number of research articles including contributions from: Dunbar, Hingley-Wilson and Keddie (3) on microbial production of hydrogen and opportunities for a low-energy source of hydrogen, not reliant on fossil fuels, using bacteria confined in coatings; from Dodds *et al.* (4) on amine synthesis using the new amine donor (*N*-phenyl putrescine, NPP) and the Johnson Matthey transaminase biocatalyst library; from Egan-Morriss *et al.* (5) on the impact of solution chemistry on the biotechnological synthesis and properties of palladium nanoparticles; and from Yu *et al.* (6) on the impact of fermentation conditions and purification strategy on the properties of bacterial cellulose, a renewable material with the potential to replace fossil carbon in a number of applications.

There are three 'In the Lab' features. Jarvis (7) describes her research group's exciting work on artificial metalloenzymes for sustainable chemical production; Wang (8) describes his research group's efforts to employ heterogeneous catalysts in enzymatic transformations *via* cofactor regeneration, paving the way to a potential new regeneration technology; and Robinson (9) presents an exciting initiative from the UK Research and Innovation (UKRI)-funded Biotechnology and Biological Sciences Research Council (BBSRC) networks in industrial biotechnology and bioenergy.

Creating the Future

The special issue rounds off with book reviews from Hardy (10) on the exciting book "In Silico Dreams" which explains how artificial intelligence and biotechnology will create the medicines of the future; and Phillips (11) on the fascinating book "Biotechnology Entrepreneurship: Leading, Managing and Commercializing Innovative Technologies" which discusses the commercialisation of biotechnological advances with the goal of creating a more sustainable future.

With a view to the future, it is noteworthy that the biotechnological advances discussed in the articles in this special issue may play a role in helping society achieve the UN SDGs, and we believe that societies growing appreciation of sustainability and circularity at a global level will deliver exciting developments in novel processes and products involving biotechnology.

Finally, we would like to thank Sara Coles (Editor of *Johnson Matthey Technology Review*) and the editorial team for their support regarding this special issue.

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