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Korneel Rabaey is professor at the Laboratory of Microbial Ecology and Technology within the Department of Microbial and Biochemical Technology at Ghent University, Belgium. His research concerns microbial electrocatalysis, an emerging field that considers the interaction between microorganisms and electrodes in a broad sense. Examples include microbial electrosynthesis, electrofermentation, microbial fuel cells. He is also president of the International Society for Microbial Electrochemistry and Technology (www.is-met.org).

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Arthur J Ragauskas held the first Fulbright Chair in Alternative Energy and is a Fellow of American Association for the Advancement of Science, International Academy of Wood Science and TAPPI. His research program at Georgia Institute of Technology is seeking to understand and exploit innovative sustainable bioresources. He is GA Tech team leader for Biological Energy Science Center and recipient of the 2014 ACS Affordable Green Chemistry award and TAPPI's Gunnar Nicholson Gold Medal award.

The world population of approx. 7.1 billion will grow by 17–54% by 2050. The world economy in 2050 will be four times larger than today and is projected to need 80% more energy in 2050. And, global greenhouse gas (GHG) emissions are on track to increase by 50%, primarily due to growth in energy-related CO₂ emissions. The current boom in petroleum resources extracted by enhanced hydrocarbon recovery systems can deal with the increased demand for energy and fuels. However, we need to remember each barrel of hydrocarbons replaced by an alternative feedstock is one less barrel in the future and contributes to our atmospheric carbon challenges.

Several alternatives have emerged in the past decades. Whereas sustainable sources for electrical power can deal with personalized transport, aviation and shipping will remain reliant on liquid fuels. Biofuels are increasingly successful, the current sugarcane and corn ethanol industry vividly demonstrate the ability to generate substantial amounts of ethanol provided we can gain easy access to monosaccharides. To avoid the impact on land management of first generation biofuels and to maximize usage of available biomass resources, 2nd generation biofuels have come to the fore, produced from lignocellulosic feedstocks. The most successful biofuel thus far, anaerobic digestion, is effectively a 2nd generation biofuel already producing biogas at thousands of plants worldwide and thereby dealing with streams typically regarded as wastes. There are still routes to further enhance the outcomes of AD, and particularly the development of the peripheral technology (and the understanding of the microbial grey box ([Van Wongerghem et al.](#) and [Koch et al.](#)) will further broaden the range of feedstocks AD can use and the rates of production ([Batstone and Virdis](#)).

Key challenges to broad-spread adaption of 2nd generation biofuels other than methane is the recalcitrance of biomass ([Zeng et al.](#)), the amounts of deconstruction enzymes needed to yield simple sugars and efficient conversion of these sugars to fungible biofuels. Over the past decade substantial advances have been made in our fundamental understanding of plant cell wall recalcitrance ([Meng and Ragauskas, Foston](#)) and the efficient conversion of bioresources to biofuels ([Beckham et al.](#) and [Goacher et al.](#)). These fundamental findings have also highlighted the very multi-disciplinary nature of developing efficient conversion systems which requires researchers from biological, chemical, physical and computational sciences, mathematics and engineering and needs outreach to the agricultural, biorefining and petroleum sectors. In the U.S.A., the three DOE sponsored Bioenergy research centers and other USDA and DOE funded multidisciplinary energy centers are addressing these challenges. In its broadest content one can view the challenges of biofuels as the need to identify (1) the next generation of plants that have better deconstruction capabilities, (2) better biological conversion systems to biofuels and (3) improved analytical and computational modeling

systems that allow for an integrated fundamental understanding of the biological conversion process (see also [Xie *et al.*](#)).

Whereas typical biomass deconstruction and fermentation rely on pure culture systems, it is also possible to generate key building blocks, carboxylates, through mixed culture fermentation in the so-called carboxylate platform ([Spirito *et al.*](#)). This platform has truly emerged about 3 years ago and is gaining much traction due to a number of scientific breakthroughs and increasing demand of carboxylates. Europe is probably providing most traction for example due to the replacement of antibiotics by caproic acid in animal fodder. More mature as alternative approach is the fermentation starting from C1 such as syngas fermentation or homoacetogenesis ([Latif *et al.*](#)). In this case syngas can be obtained directly, or through the deconstruction of biomass in non-biological processes. Demonstration plants are up and running for example isoprene production.

And finally comes yet an alternative from an unexpected angle: the past decade research on microbial electrocatalysis, in which microorganisms are used as catalysts for

electrode reactions, has exploded from a mere ~40 studies in 2001 to now ~5000 published studies in 2014. In the context of this issue we focus on microbial electrosynthesis, where production processes starting from CO₂ (essentially the largest carbon source available worldwide) or substrate organics are driven by electrical current. This enables production independent of arable land, at higher efficiency than photosynthesis, and with low water and nutrient requirements. Major challenges face researchers in this area, going from understanding how electrons travel to and from bacteria ([Malvankar and Lovley](#)) to creating model based description of the process ([Torres](#)) and full scale demonstrations. In many of these and aforementioned technologies, molecular biotechnology paves the way for a better understanding and following a better operation of the system.

This special issue *Current Opinion in Biotechnology* brings together forward looking opinions of some the most recent advances and breakthroughs that will deliver us sustainable bio-energy, biochemicals and biofuels. We hope you catch the excitement these publications convey...