Decarbonising the world economy with synthetic biology

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Macquarie University Distinguished Professor Ian Paulsen, discusses how synthetic biology can be used to decarbonise the global economy

Addressing atmospheric carbon from human activities is paramount to tackling climate change. Synthetic biology offers a likely way to accelerate this decarbonisation of the global economy while simultaneously building new industries and jobs. At the Australian Research Council's Centre of Excellence in Synthetic Biology (CoESB), our researchers play a pivotal role in creating a pathway for this possible future.

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Synthetic biology – what we need to know

Synthetic biology involves the management of microbes to transform sugars or waste into useful products. Among other things, it could offer commercially viable and scalable technology for capturing emissions and transforming them into high-value products that can be sold.

It uses genes as building blocks to make new microbes that have the potential to be applied in a whole range of different ways, such as the creation of biofuels, plastics and other materials that replace the need for fossil fuels and lessen the impact on our environment.

The production pathway of extraction, manufacture, single-use and long-lived waste once made sense. However, an economy based on non-renewable resources cannot infinitely grow. If developed successfully, next-generation biotechnology will literally boost renewable advanced manufacturing.

This is happening across multiple sectors. Transportation, for example, contributes 16.2% of annual global greenhouse gas emissions through petrochemical fuel consumption. Biofuels offer a solution for reducing emissions in difficult-to-decarbonise sectors, such as shipping and aviation. Genetically engineered microbes show potential for efficient biofuel production.

Several companies have made strides in the large-scale production of biofuel components using microbes that use simple carbon compounds as a fuel. Algae and cyanobacteria, which produce oil from light and carbon dioxide alone, have been explored, but cost-related obstacles hinder large-scale implementation.

Efforts to reduce agriculture emissions

Another critical front for SynBio's potential impact lies in agriculture which contributes 9.9% of global emissions. Through the application of biosynthetic techniques, efforts are underway to reduce emissions from livestock and fertilisers. Companies such as Number 8 Bio, one of our spin-out companies in Australia, have engineered cattle feed to curb methane production in the animals themselves, while Pivot Bio's nitrogen-fixing bacteria coated onto seeds enhance crop yields.

Alternative building materials and textiles are other areas of promise. For example, Biocement could significantly reduce carbon emissions while maintaining durability. Many companies are driving advances in engineered materials. Bolt Threads offers its pioneering spider silk products. Bolt Threads and Ecovative explore mycelia, a fungi form, as renewable replacements for fabrics and other materials.

Climate change and population growth

Climate change and population growth make it challenging to keep the world's food supply safe, nutritious and sustainable. Many companies are working on alternative foods, vegan substitutes for milk and meat that effectively mitigate methane emissions.

Other organisations, such as Nourish Ingredients and C16, are developing custom oils for meat flavours and sustainable alternatives to palm oil, respectively. Both applications potentially reduce agriculture's carbon footprint by minimising the land needed to sustain humanity.

Organic matter in wastewater and landfills contributes to 3.2% of global emissions, allowing SynBio to extract valuable resources while reducing greenhouse gas emissions. Engineered organisms can efficiently utilise all biodegradable waste, preventing uncontrolled decomposition into atmospheric-polluting methane and carbon dioxide.

Biomanufacturing

Traditional petrochemical manufacturing processes, contributing roughly 2.5% of global emissions – creating 1.3 tonnes of carbon dioxide per tonne of chemical produced present another domain where SynBio can offer potential alternatives.

Biomanufacturing has successfully made sustainable plastics, rubber, and other products with lower energy consumption and carbon dioxide emissions. Companies like Genomatica have commercially produced plastics and rubber building blocks, replacing fossil fuel-dependent processes with substantial energy and carbon dioxide emission reductions.

Plastic pollution

Worldwide, the problem of plastic pollution is well understood. It's predicted that on the current trajectory, there will be more plastic than fish in the ocean, by weight, by 2050. Yet enzymes developed by our spin-out company, Samsara Eco, can infinitely recycle PET-based plastics, transforming them back into their original form for new product manufacturing.

Synthetic biology the key to decarbonising the world economy

The U.S. Administration this year declared its bold goals for biotechnology. It is being hailed as the greatest economic transition of the 21st century – one that will convert agricultural waste to create bio-based solutions for climate change, agriculture, supply chain resilience, and human health.

It includes a target to displace 90% of petrochemical-derived plastics with bio-based alternatives within 20 years. The work underway in Australia and our Centre is actively contributing to decarbonising the world economy.

It could be argued that building a profitable enterprise in the next decade won't be possible without considering biology. Traditional industries will struggle with input costs, supply chain resilience, and environmental sustainability. That alone may be the impetus for the world to throw the necessary resources behind biotechnology.

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References

1. ARC Centre of Excellence in Synthetic Biology, School of Natural Sciences, Macquarie University, New South Wales.
2. Department of Primary Industries, Orange, NSW 2800, Australia.
3. Research Strategy Consultant.

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