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NUS helms effort to use microbes to green the manufacturing sector

Researchers hope to use carbon-munching microbes to produce sustainable products

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A $120 million national research effort is under way to harness the power of carbon-sucking microbes to green the manufacturing sector, from the production of speciality chemicals to sustainable aviation fuel.

Known more broadly as synthetic biology, this is an emerging field in which scientists alter the DNA of fast-growing microbes, like algae, imbuing them with the capabilities to produce desired end products.

Ideally, the researchers at the National University of Singapore hope to devise an economically viable method whereby these microbes feed on carbon dioxide (CO2), using it as fuel to produce a range of chemicals and materials, Professor Liu Bin, NUS deputy president (research and technology), told The Straits Times.

This would reverse the process of refining or "cracking", in which crude oil – a heavy hydrocarbon molecule – is broken down to create petroleum products used for fuel, and to make chemicals and materials such as plastic.

Plans are in place to turn Jurong Island into a sustainable chemicals and refinery hub, including to increase the output of sustainable products by 1½ times from 2019 levels, and the research initiative could spur research and development (R&D) that will help to achieve Singapore's decarbonisation goals, said Prof Liu.

Mr Lim Wey-Len, executive vice-president of the Economic Development Board (EDB), said that he sees synthetic biology as a "potential pathway" by which manufacturers can produce more sustainable products and contribute to Singapore's sustainability goals.

Associate Professor Matthew Chang (left) and NUS deputy president (research and technology) Liu Bin with some finished products of synthetic biology in a pilot-scale lab at the NUS Centre for Life Sciences on Oct 10. ST PHOTO: GAVIN FOO

He expects there to be growth in demand for its use, driven by rising consumer demand in Asia coupled with the growing pressure to reduce environmental footprints.

According to an article by EDB in May 2023, the market for synthetic biology is expected to be worth US$55.37 billion (S$73.2 billion) by 2030, quadruple today's valuation.

This can be attributed to its potential as a needle-moving solution for governments and companies looking to achieve their sustainability goals, and the technological breakthroughs in the field which make it easier and quicker for scientists to edit and reprogramme the genomic DNA of these microbes, the article said.

EDB will continue to work with research institutes to build up R&D capabilities, said Mr Lim.

Prof Liu said: "To advance the potential of Singapore's bio-manufacturing sector and take synthetic biology research to new heights, we want to anchor national research efforts in NUS, working closely with other research institutes, such as the Nanyang Technological University, and polytechnics like Temasek Polytechnic and Nanyang Polytechnic."

NUS will also be establishing collaborations with global leaders in synthetic biology in the hopes of creating a "powerful multiplier effect" if Singapore's national research efforts are more visible on the international stage, added Prof Liu.

A key prong of the research efforts will be to achieve cost-effectiveness by using artificial intelligence to design these cell factories, and thus improve the microbe's productivity.

One of NUS' projects involves working with Shanghai Jiao Tong University to develop efficient cyanobacterial factories, a type of blue-green algae, converting CO2 into biomaterials that can be used in medical and consumer products; as well as biofuels, an alternative to petroleum-based products.

Cyanobacteria, found in a wide range of aquatic and land-based ecosystems and habitats, use sunlight to produce energy through photosynthesis.

As part of the three-year project, scientists will conduct studies to improve the efficiency of the bacteria's photosynthesis process, and convert the CO2 more efficiently into its end products.

In another project, NUS teamed up with researchers from the

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Synthetic biology used in biomed, pharma sectors

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French National Centre for Scientific Research to engineer new plant-based molecules that are energy-dense, so that they can be used as high-performance aviation fuels, amid rising demand for sustainable aviation fuel.

Flights departing from Singapore will be required to use sustainable aviation fuel, typically made of waste residues like used cooking oil, as a component of their fuel mix, from 2026.

While synthetic biology is not new, it has so far been largely used in the biomedical and pharmaceutical sectors, said Associate Professor Matthew Chang, director of the NUS Synthetic Biology for Clinical and Technological Innovation (SynCTI).

Since 1978, bacteria have been used in the production of synthetic insulin for diabetic patients.

It is also used now to produce structurally complex drug molecules more efficiently, said Prof Chang.

Synthetic biology, for example, has been used in the manufacture of chimeric antigen receptor T-cells, which are engineered for more effective cancer immunotherapy treatment.

Scientists essentially collect immune cells, or T-cells, from cancer patients, and re-engineer them so that the cells produce proteins on their surface that allow them to bind to the surface of cancer cells, and kill them.

SynCTI was established in 2014, when synthetic biology was still an emerging field. In the last decade, it has received over $150 million in funding, covering research in several areas, ranging from the use of microbes in developing key pharmaceutical ingredients and therapeutics, to engineering them to recover precious metals like gold from electronic waste.

The formation of SynCTI also catalysed the creation of the Singapore Consortium for Synthetic Biology, which works closely with industrial players to create a globally connected bio-based economy in Singapore, said NUS.

To date, the consortium has nine academic and 27 industry partners.

One of them is Singapore agribusiness group Wilmar, which has had a corporate laboratory with NUS since 2018.

The partnership has led to the successful development of enzymes and microbes for the biomanufacturing of oleochemicals, compounds derived from animal or vegetable oils, said Prof Chang.

Synthetic biology can be used to create valuable oleochemicals that are rare in nature and have unique properties.

The Wilmar corporate lab, which has received close to $110 million over five years, has developed rare fatty acids that are used in the production of plastics, pharmaceuticals and cosmetics.

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