Please discuss ways in which this cutting-edge technology could be applied to solve a current technical challenge in biology (e.g., medicine, energy, environment, etc.).

- Kidneys are very delicate and critical filtering organs[1], but many medical conditions can strain them, including diabetes, obesity and high blood pressure. By 2030, 5.4 million people worldwide are projected to be getting dialysis or a transplant. The patients are connected to a machine weighing more than 100 kg, and it is a long and painful process (12 hours of dialysis across 3 sessions a week), to rebalance their blood and clear out their toxins. The mass transfer at the micro diameter of artificial cells is 100 times of that an artificial kidney. Using artificial cells, hemoperfusion could be performed more efficiently and at a lower cost [1] [2][3].
- Another important application is the release of different substances like antibodies, vaccines, insulin at a different rate. In an experience of genetically engineered mouse model of breast cancer, PLGA-docetaxel, a tumor growth inhibitor, nanoparticles significantly increased survival time. The cell mimics, described in the article, could bind to cancerous cells, and in coordinate fashion release this drug in more targeted manner with potential increase efficacity [4].
- Gene therapy uses often viral vectors to implement the mutagenesis. Some of these vectors are not infectious, nevertheless concerns exist since there have been cases of immune response reactions leading to tumor growth or deaths. Allogeneic artificial cells could reduce the risks presented by viral injection; for example, in a relatively recent experiment, engineered myoblast cells partially corrected the effects of a transcription factor mutation in the Snell dwarf mice and remained active for 6 months [5].
- More recently, researchers at NYU created cell mimics which act as a pump, tiny vacuums, triggered by light, ingesting impurities in the water. In a near future the same cells could be used to clean polluted water[6].
- Artificial cells can also revolutionize the food industry by constructing food-based cell factories. Food like meat analog, or animal-free bioengineered milk, could be produced from renewable energies, less prone to environmental conditions which in turn could decrease the use of pesticides and fertilizers, save water or other natural energies and improve land usage. Researchers can also identify beneficial metabolic pathways which are triggered by specific foods and use synthetic cells to stimulate these pathways. Another application can relate to the fermentation process which could be better controlled, or tuned (synthetic biology created soy sauce and Chinese red wine) [7].
- Artificial cells can have major impact in agriculture with outcomes ranging from increase in productivity, nutritive value, food safety, creation of new crop types, or pest management: as an example, yeast 2.0 project aims at creating a synthetic yeast genome which can grow at the same rate, on the same compound as the original yeast can, but 80% smaller by removing junk DNA, including minimizing genome instability, and introducing genetic flexibility [8] [9].
- The U.S. army is very conscious about, not leaving polluting traces, or reducing their environmental signature. Researchers believe that, by 2040, they will have molecules with self-healing properties, which could assemble into any products they want. Today they are looking for self-healing cracks in rotor blades of helicopters [10].

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[1] They filter some 140 liters of blood each day, from which one or two liters are released in the form of urine.

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