The powerhouse of the future: Artificial cells

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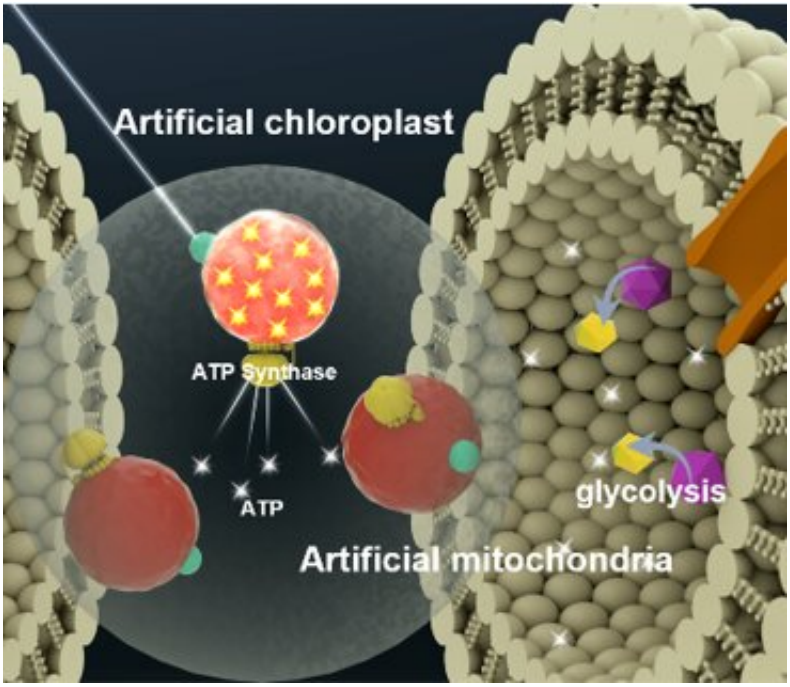

Concept of artificial chloroplasts and mitochondria within a liposome for self-sustaining energy generation through photosynthesis and cellular respiration. Credit: Biological Interface Group, Sogang University

Energy production in nature is the responsibility of chloroplasts and mitochondria and is crucial for fabricating sustainable, synthetic cells in the lab. Mitochondria are not only "the powerhouses of the cell," as the middle school biology adage goes, but also one of the most complex intracellular components to replicate artificially.

Researchers from Sogang University in South Korea and the Harbin

Institute of Technology in China have identified the most promising advancements and greatest challenges of artificial mitochondria and chloroplasts. The article, "Artificial organelles for sustainable chemical energy conversion and production: Artificial mitochondria and chloroplasts," is published in *Biophysics Reviews* .

"If scientists can create artificial mitochondria and chloroplasts, we could potentially develop synthetic cells that can generate energy and synthesize molecules autonomously. This would pave the way for the creation of entirely new organisms or biomaterials," author Kwanwoo Shin said.

In plants, chloroplasts use sunlight to convert water and carbon dioxide into glucose. Mitochondria, found in plants and animals alike, produce energy by breaking down glucose.

Once a cell produces energy, it often uses a molecule called adenosine triphosphate (ATP) to store and transfer that energy. When the cell breaks down the ATP, it releases energy that powers the cell's functions.

"In other words, ATP acts as the main energy currency of the cell, and it is vital for the cell to perform most of the cellular functions," said Shin.

The team describes the components required to construct synthetic mitochondria and chloroplasts and identifies proteins as the most important aspects for molecular rotary machinery, proton transport, and ATP production.

Previous studies have replicated components that make up the energy-producing organelles. Some of the most promising work investigates the intermediate operations involved in the complex energy-generating process. By connecting the sequence of proteins and enzymes, researchers have improved energy efficiency.

One of the most significant challenges remaining in trying to reconstruct the energy production organelles is enabling self-adaptation in changing environments to maintain a stable supply of ATP. Future studies must investigate how to improve upon this limiting feature before synthetic cells are self-sustainable.

The authors believe it is important to create artificial cells with biologically realistic energy-generation methods that mimic natural processes. Replicating the entire cell could lead to future biomaterials and lend insight into the past.

"This could be an important milestone in understanding the origin of life and the origin of cells," Shin said.

More information: Artificial organelles for sustainable chemical energy conversion and production: Artificial mitochondria and chloroplasts, *Biophysics Reviews* (2023). DOI: 10.1063/5.0131071

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