Synthetic Minimal Cells: A Scientific Breakthrough

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What are Synthetic Minimal Cells?

Synthetic Minimal Cells are cells whose genome only codes for the least amount of genes necessary for the cell to survive. (Lachance, Rodrigue, Bernhard O Palsson, 2019) Creating minimal cells is a recent discovery, with the first being the synthetic material cell, JCVI-SYN 3.0, found in 2016. This cell was created with only essential genes that were composed in the Mycoplasma mycoides bacterium. The synthetic cells can only do basic processes such as the replication of DNA, the translation of proteins, and regeneration. While synthetic minimal cells may not have many unique features, they are used to better understand the molecular processes in cells. Understanding each molecular process will lead to more insights on the fundamental principles of life.

Creating Synthetic Cells

Before creating synthetic cells, scientists were focused on acquiring knowledge of natural organisms. Synthetic Cells are constructed in labs with pieces of DNA; by using the right biology and chemistry techniques, scientists were able to assemble the DNA in the 'right order.' (Glass, J. I., Merryman, C., Wise, K. S., Hutchison, C. A., 3rd, & Smith, H. O., 2017). The first synthetic cell was created in 2008 by scientists at the J. Craig Venter Institute, who artificially recreated the genome of the bacteria *Mycoplasma genitalium*. This breakthrough allowed for researchers to build biological entities in labs rather than just observing them.

The next problem was discerning which genes were essential to life. Genes code for function that are enzymatic, regulatory, or structural, while essential genes only code for essential functions. To determine essential functions, researchers investigate whether a cell can

grow due to a lack of a specific function. If it cannot, the function is essential. After many trials and errors, the cell *mycoides* JCVI-syn3.0 was believed to have the smallest genome of any free organism. It was first reported that the cell, whose functions are still unknown, had 149 genes but was shrunk to 91.

Medical Applications

Minimal synthetic cells have many real world applications, including in nanomedicine to improve vaccine efficiency in the pharmaceutical industry. Minimal synthetic cells have lots of potential in the medical field by being able to mimic biological functions. For instance, symmetry breaking occurs when a cell's molecules are reorganized into asymmetric patterns from stimuli. Controlling symmetry breaking in cells can change its chemical profile to induce chemical reactions. By creating cells that can be controlled when the system breaks, researchers can create medicines that release drugs at appropriate time intervals to make the treatments more effective. Synthetic minimal cells can also be used in nanomedicine where gene expression, metabolism, and high stability are hard to achieve in normal cells but can be replicated in synthetic minimal cells. The ‘bottom-up’ engineering of synthetic minimal cells leads to more clinical applications (Carolan&Wasta, 2024). Currently, natural living cells and liposomal drug delivery exist, but synthetic natural cells offer new advantages, such as responding to a patient's condition in real time and increasing speed in design interactions for new variants. These cells will be able to provide researchers with the full chemical makeup and programmability, lowering the cost of drug testing. Finally, with the ability to fully customize synthetic minimal cells, scientists in engineering medicine could use these cells as vaccines. Synthetic cell delivery systems do not exist currently, but in the future, when clinical trials are able to test these cells, synthetic minimal cells could help improve vaccine efficiency.

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