ARTIFICIAL CELLS:

An Overview of Main Approaches and Applications

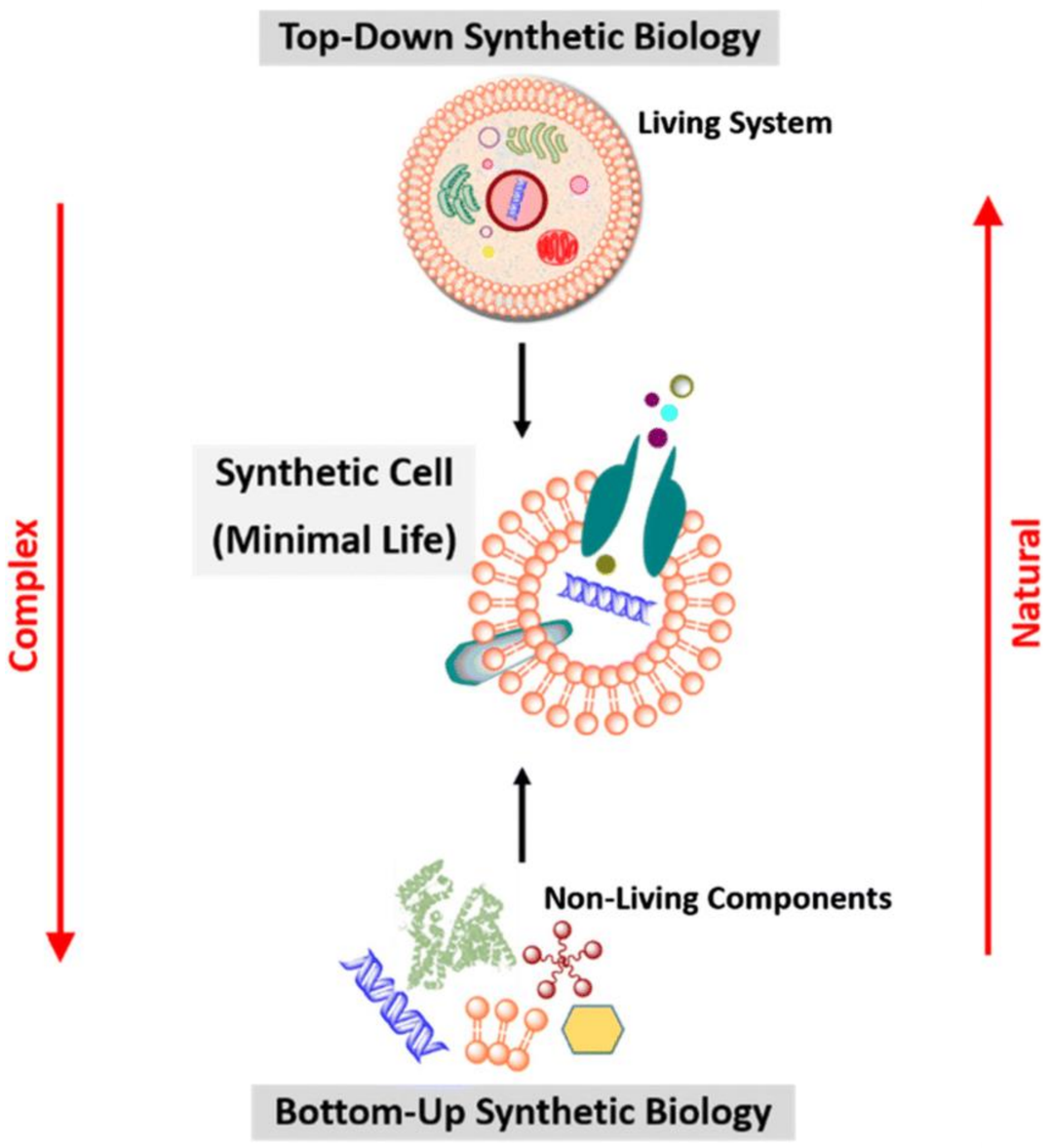
Abstract

It has been about 20 years since extended research on artificial cells kicked off around the world. Since then, many different developments on the preparation of artificial counterparts of cells and their machinery have been formulated by using a variety of strategies and building blocks. Cells are not of simple nature, and their study is not straightforward either, as research on artificial cells concentrates on separately deciphering the cell's numerous components one by one, rather than the entire lot at once. Furthermore, this research can be conducted by either altering and examining natural organisms and their parts or by attempting to recreate them from scratch. The central aim of this Matura paper is to provide comprehensive descriptions and summaries of the most efficient and commonly utilized methods for the creation of artificial cell-like structures that are used to recreate and study life on the cellular level. A few real-world applications of artificial cells that are currently relevant will also be considered.

What are artificial cells?

The concept of an "ideal" artificial cell involves two main connotations. First, this artificial structure would behave just like a natural, living organism, i.e., it would be able to capture, process, and make use of energy, regulate and balance its own resources, store and translate genetic information, and even be capable of reproduction and adaptability to its environment, among other things. Secondly, it would be assembled completely from artificially created parts. Each part of the ideal artificial cell, from the membrane to the genetic material, would be constructed entirely via artificial means. Naturally, construction of such an ideal artificial cell is a distant goal as of now, and much of the research on ideal artificial cells is conducted by experimentation with living organisms. Still, by altering and attempting to replicate natural cellular processes and parts, much can be discovered about the fundamental systems that drive all life on earth, and it is hoped that this field of research will also uncover some of the mysteries on the origin of the very first lifeforms.

Artificial cells are currently constructed by one of two approaches: via the top-down approach, which alters natural organisms, or via the bottom-up approach, which attempts to create a living cell from dead building blocks.



Top-down approach

Since there are still comparatively many aspects of cellular life that are still not fully understood, the focus of the top-down approach is not yet to create cells that exhibit particular functions, but rather to build a "minimal cell", a conceptual cell with only the minimum amount of genetic material needed to fulfil every living being's most fundamental goal: to survive. It is thought that the study and creation of such simple cells will help to understand the vital processes that regulate and define life, much like how the hydrogen atom was first used by physicists to understand the basic rules of atomic structures.

Bottom-up approach

Bottom-up creation of an organism that can be considered as living is much more challenging than creation by the top-down approach. Still, the top-down approach does not necessarily uncover in a satisfying way how the cell parts that remain interact and link with one another to sustain life. This research-oriented shortcoming can be relieved by the bottom-up approach, in which single parts and building blocks are assembled to recreate systems analogous, but not identical, to those of real cells. As it is still unfeasible to erect functioning systems that even marginally mirror the level of intricacy of even the simplest unicellular organisms in their entirety, bottom-up research is limited to single cell compartments at a time. This Matura paper considers genetic information, the cell membrane, and metabolism.

Applications

Simple structures that can be classified as artificial cells have been developed and put to use in a variety of medical applications. Although many of these structures are so simple that they may well be described as sacks of membrane carrying pharmaceuticals rather than artificial cells, they still represent one of many steps towards real-world usage of artificially created living beings for medical purposes. Several examples are considered in this Matura paper, ranging from vaccines to red blood cell substitutes.

Kantonsschule Hottingen

Author: Pietro Brusoni

Supervising teacher: Fabienne Häusler