The quest for synthetic cells is a world-wide effort, in which the United States and Europe are playing a major role. In the United States, a top-down approach that aims at stripping down the genome of existing cells to a minimal size is prevalent. The European community, on the other hand, has a stronger focus on the currently more challenging bottom-up approach. Recently, a group of European top researchers have taken the initiative to establish a dedicated European platform with a common ambition to engineer synthetic cells using this approach. Promoted by researchers from the Netherlands, Germany, the United Kingdom and France, the initiative has garnered the support of both academia and industry across Europe, e.g. in Spain, Croatia and Scandinavia.

Europe harbours ambitious top scientists who are leaders in their respective fields. The Synthetic Cell Initiative is a unique opportunity to combine the efforts of the various relevant networks already operating in Europe in life sciences, physics and chemistry. Together, we would put Europe in a fantastic position to be in the lead of what will be a global and rapidly expanding endeavour, with major impact on a broad range of application areas.

Europe’s unique position

Promoters:

Marileen Dogterom  
Delft University of Technology

Cees Dekker  
Delft University of Technology

Petra Schwille  
Max Planck Institute of Biochemistry

Hagan Bayley  
University of Oxford

Manuel Théry  
French Alternative Energies and Atomic Energy Commission

Laurent Blanchon  
French Alternative Energies and Atomic Energy Commission

Contact: www.syntheticcell.eu, email: info@syntheticcell.eu or m.dogterom@tudelft.nl

The deeper understanding of cellular behaviour at the molecular level that will result from the construction of a synthetic cell has the potential to lead or contribute to:

- Drugs that are able to target specific locations and tissues in the body
- Patient-tailored treatments in personal medicine (a.o. for cancer)
- New applications in drug delivery systems
- Novel screening methods for antibiotics and drugs, biosensors and against antimicrobial resistance
- New, smart and environment-friendly materials for high-tech industry
- New biodegradable polymers
- Facilitating sustainable production of safe and healthy food
- New materials for food biotechnology
- New methods for pathogen control

The promises synthetic cells hold

Building a synthetic cell

Engineering a minimal cell from its molecular building blocks

‘Europe is playing a major role in the quest for synthetic cells.’
A grand challenge

Building a synthetic cell is one of the grand scientific and intellectual challenges of the 21st century. In synthetic biology, we use knowledge about the genetic code to engineer biological systems for industrial and research applications. However, while we have extensive knowledge about the genetic code and the molecular building blocks of life, we currently still do not understand how these building blocks work together to enable life.

In order to answer the fundamental question “How does life work?”, we propose to build a functioning synthetic cell bottom-up, i.e. starting from its basic molecular components. Truly understanding the mechanisms of cellular life will bring huge intellectual, scientific, and technological rewards. At the same time, it will raise fascinating philosophical and ethical questions about how society may cope with these new fundamental insights.

Thanks to the tremendous progress in understanding the functioning of molecular machinery made in the last years, the design and building of a synthetic cell is now within reach. It is a worldwide grand scientific challenge with huge potential to help face many of the global challenges in health, food and sustainability. If sufficiently funded, progress in this area in the coming 5 to 20 years will position Europe as the leader in this scientific and technological revolution.

Short-term objectives (< 5 years) - Life-like molecular systems and functional modules

In this early phase, the focus will be on the systematic dissection and bottom-up reconstitution of the most important features of living cells, such as: metabolism, energy conversion, growth and division. Synthetic modules with these features can serve as the starting point for technological developments towards cell-free drug screening and drug delivery, smart bio-inspired materials and bioenergy.

We will bring scientists from different disciplines (physics, chemistry, biology) together, since multiple strategies have to be explored in parallel to be integrated at a later stage. Involving the humanities will also be of considerable importance at this early stage, due to the possible implications of synthetic cells in terms of ethics and philosophy.

Medium-term objectives (5-10 years) - From functional modules to autonomously replicating cells

The largest challenge facing synthetic cell technology is the integration of individual biological modules into an autonomously replicating synthetic cell. It will be essential to combine bottom-up approaches by physicists, chemists and biologists with cutting-edge (computational) modelling and engineering to guide experimental strategies. Our unique and ambitious bottom-up approach to synthetic biology can also benefit from existing top-down approaches. The first integrated systems with (partial) autonomy will provide the basis for novel smart drug delivery technology and, eventually, biofactories that produce specific materials, drugs or other compounds. Strategies for biosafety and responsible innovation will be increasingly important at this stage.

Long-term objectives (10-20 years) - Towards human cell models

A successful “proof of principle” will open up a range of opportunities for scientific exploration. Once we understand the rules that allow for the simplest forms of cellular life to exist, aspects that are important for the formation of multi-cellular tissues and organisms can be quantitatively explored. Such insight will be instrumental in bringing synthetic cell technology to its full potential in health applications, including regenerative medicine. Replacing diseased cells with artificial cells and the creation of artificial organs are just two possible future health applications.

The road towards synthetic cells

The picture on the left gives an impression of the route towards the synthetic cell and its impact in terms of technological output. Targeted new technologies will find their origin at different stages of this scientific quest and will further develop as progress towards the ultimate synthetic cell goal is made.

The road towards synthetic cells

2018

Science

Functional modules

Integrated functional modules

Autonomously replicating cells

Human cell models

2038

Technology

Cell-free systems

Smart materials

Drug delivery systems

Programmable bio-reactors

Synthetic cell technologies for health

Paradigm shift

- Fundamental insight into life's processes
- EU in leading position
- Radically new solutions for health and other global challenges

Understanding the mechanisms of cellular life will bring huge intellectual, scientific, and technological rewards.