

# ICT Potential of Artificial Cells in Biomedicine

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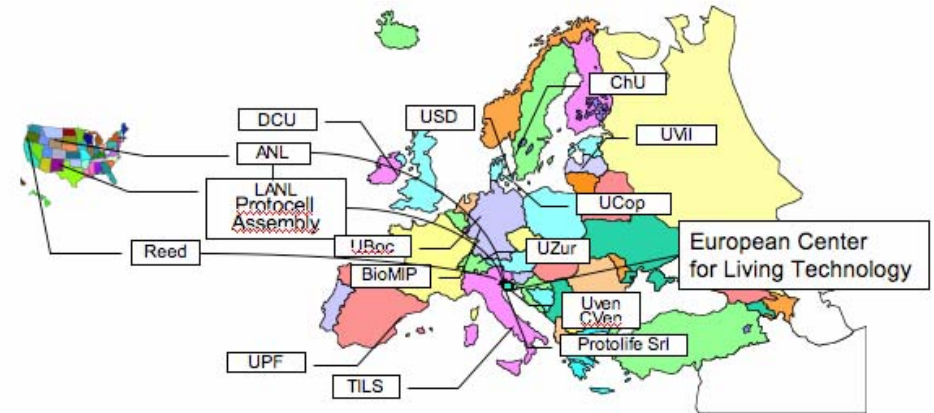
ProtoLife S.r.l.

Venice, Italy

PACE  
FP6 - IST / FET  
Integrated Project

## Programmable Artificial Cell Evolution

- Ultimate goal: living artificial cells made from non-living material
- Project goal: first steps, integration of necessary chemical functionalities, *artificial cells on life support*



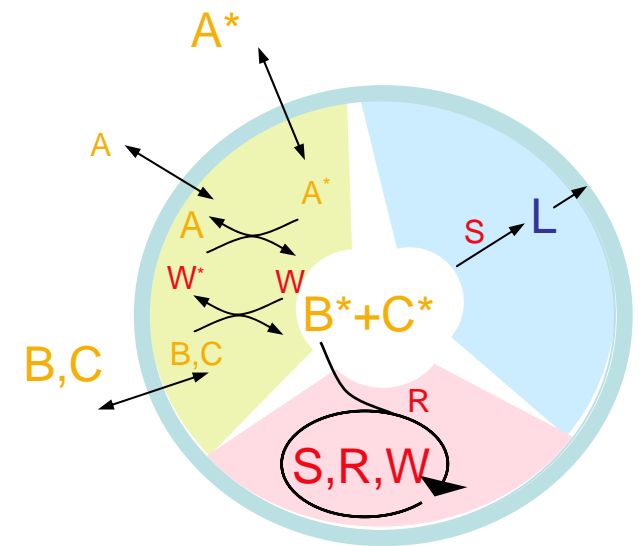
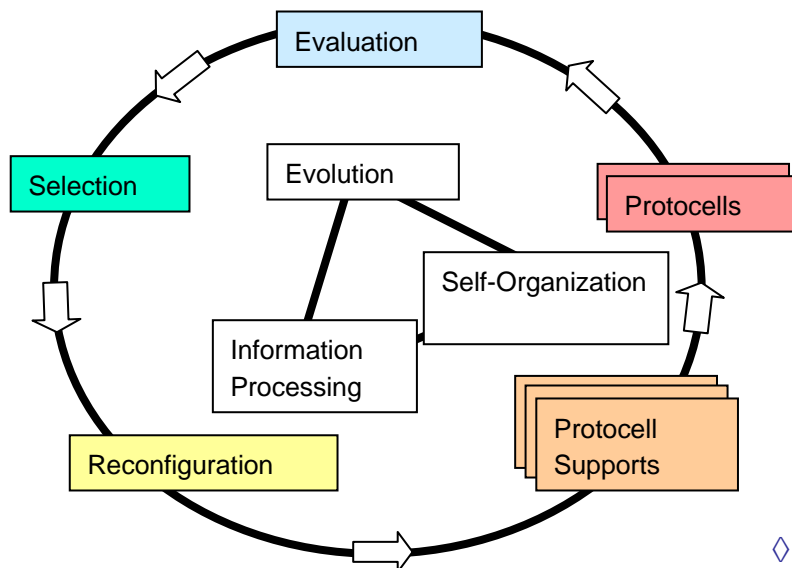
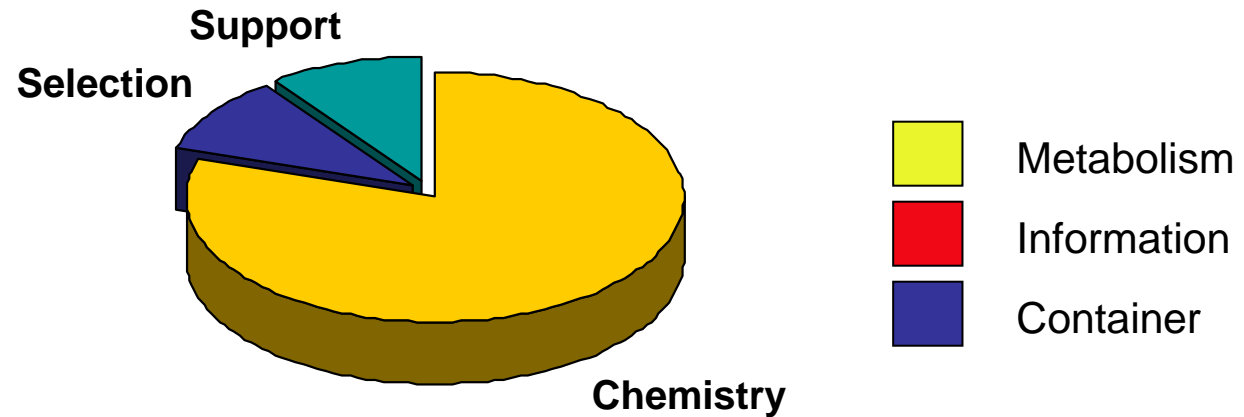
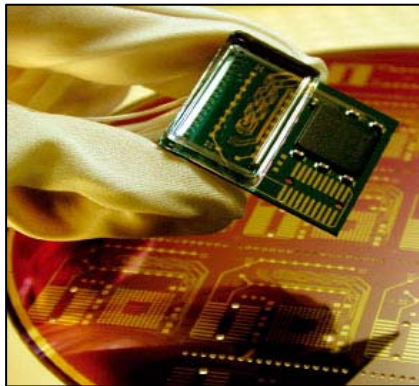
Living cell:

- self-maintaining
- self-reproducing
- evolvable

Chemical functionalities:

- container
- metabolism
- information

Evolutionary stable integration = key to chemical artificial cell



- drug delivery
  - targeted delivery, targeted release
  - build on existing vesicle / liposome technology (Doxil ~ \$350M/yr revenue; Liplasome targeted release technique in live □clinical trials)
- tissue cleaning
  - arterial plaque, dental plaque
- distributed diagnostic systems
  - programmed information gathering
  - medical biosensors
- tissue repair / reinforcement
  - artificial tissue
  - programmed patterning of artificial cell aggregates

- what are the computational problems inherent in the design of artificial cells?
- once artificial cells exist, how may they be programmed?
- what is the computational potential of artificial cells?

- Chemical reactions and self-assembly processes are virtually impossible to simulate for engineering objectives
- Current approach is to use evolutionary optimization to discover engineering design solutions

- The appropriate low-level “assembler language” for molecular-scale reaction and self-assembly processes must be discovered.
- Some reactions and morphological structures may not have a genetic code (DNA).
- Need for compiler

- programmability of functionality, timing, context dependence
- programmability of patterning
- programming of selective information gathering for diagnostics

Initialize population



Evaluate population



Select fittest



Reproduce fittest with variation

Population = population of chemical systems



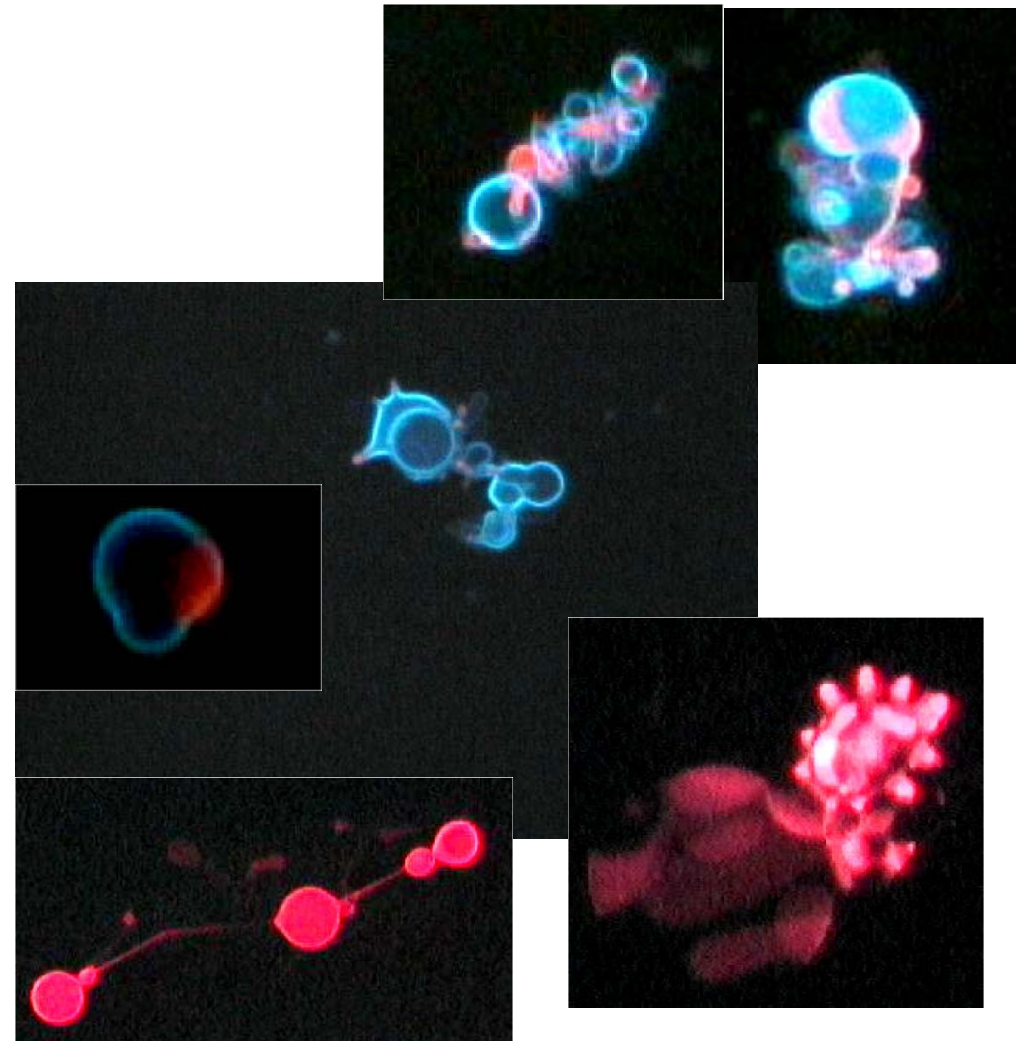
Evaluation = chemical, fluorescent, morphological

# Vesicles and their morphology

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- Explore space of chemical reactions combined with complex container morphologies
- Use evolutionary algorithm for optimization of functionality of reaction + morphology
- Evolutionary algorithm works best with complex search space

Experiments of  
**M. Hanczyc, M. Theis at  
ProtoLife Srl**



## Artificial Cell Technology in Biomedicine

- Develop evolutionary optimization chemical engineering techniques
- Seek large partners for developing initial target applications
  - Use of evolutionary optimization for applications using artificial cell precursors
- Determine path to artificial cells via stages of increasingly *Living Matter*
- Use evolutionary optimization to develop programmability, design “chemical compiler” for living matter