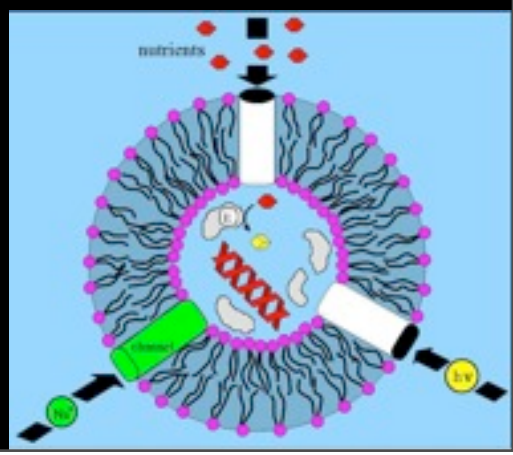
Artificial cells for space applications

Andrew Pohorille
NASA Ames Research Center



Different but related concepts:

- Reengineered cells
- Minimal cells
- Protocells
- Synthetic cells
- **Artificial cells**
- **Functionalized liposomes**

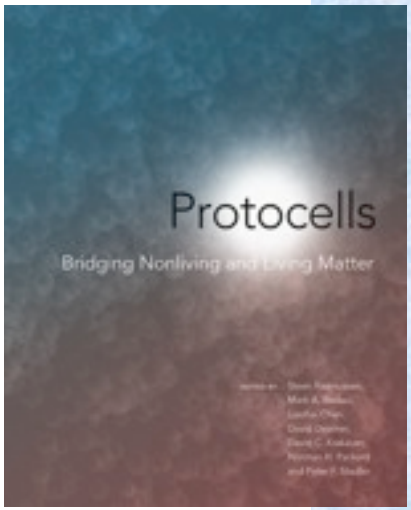
Welcome to the **ProtoCell** website

http://www.protocell.org/

A number of groups and projects world wide are now intensifying efforts to understand and harness the basic principles of chemical living systems. The protocell web site is intended to provide links to this research.

- Los Alamos Protocell Assembly
- PACE : Programmable Artficial Cell Evolution : www.istpace.org
- ECLT : European Center for Living Technology in Venice
- Protolife : the company
- The ribozyme-lipid artificial cell initiative and COST -1
- The ribozyme-lipid artificial cell initiative and Szostak's minimal cell
- Minimal living cell

website content manager: Steen Rasmussen



Traits of artificial cells:

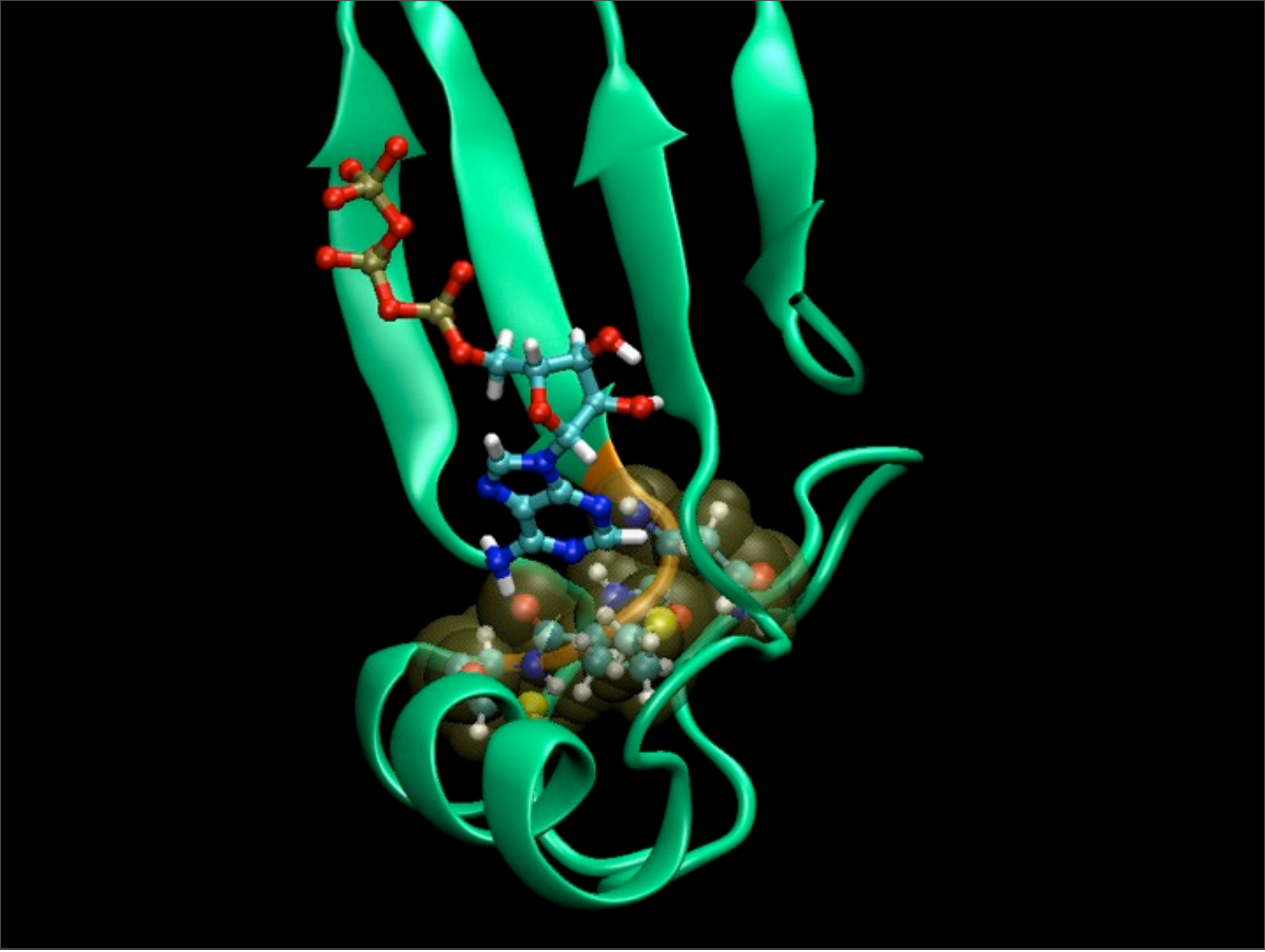
- Template-directed synthesis of information polymers
- Transduction of external energy to drive chemical reactions
- Catalytic activity coupled to replication
- The boundary membrane that grows
- Mechanism for division
- Catalysis, replication and growth must be well regulated

Pohorille A. and Deamer, D. (2002) Artificial cells: Prospects for biotechnology, Trends Biotechnol., 20:123-128.

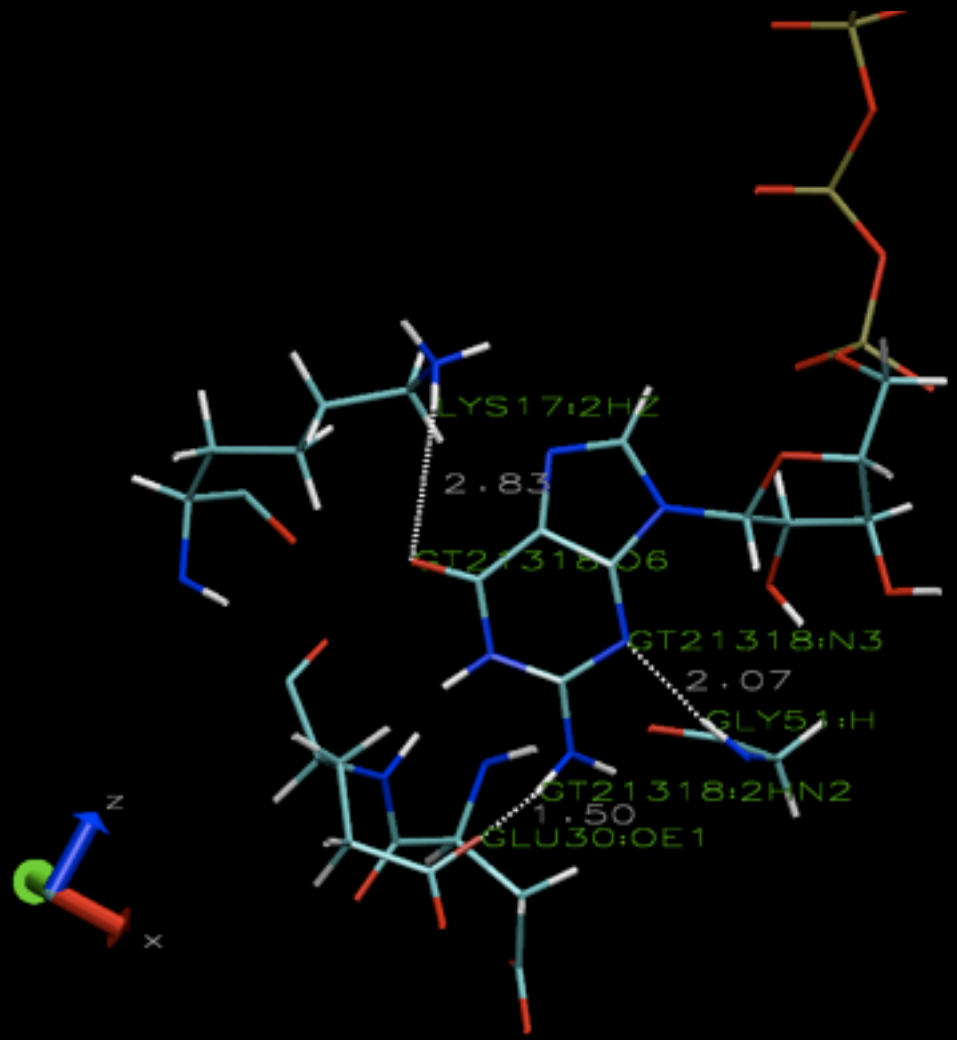
It appears that all classes of protein structures that exist in nature have been identified

Survival of the fittest or the luckiest?

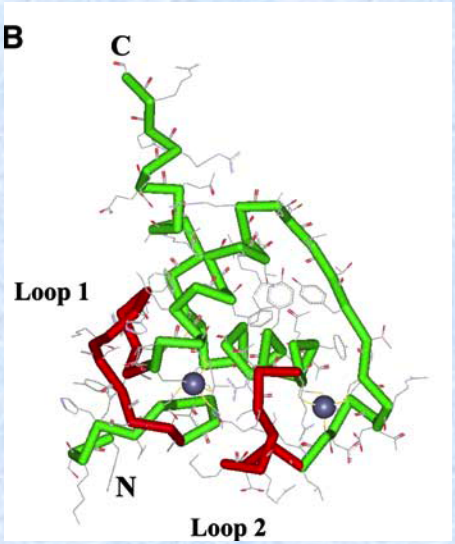
- The initial set of protein structures was selected through extensive "evolutionary pruning". Criteria other than folding were also important.
- The initial set of protein structures was selected through "evolutionary accident". Other sets of structures are possible.

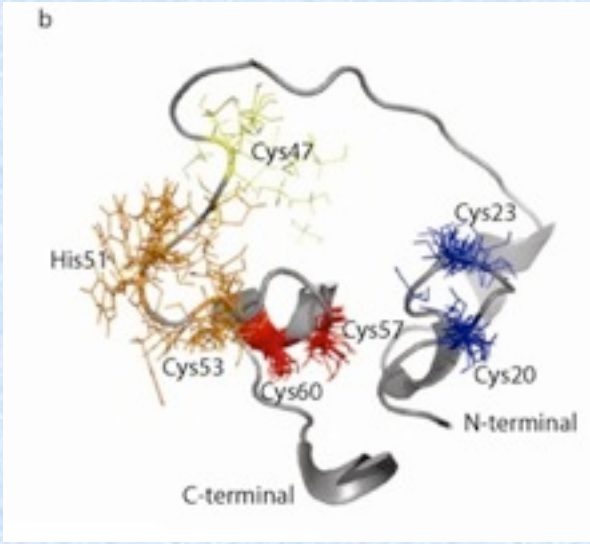


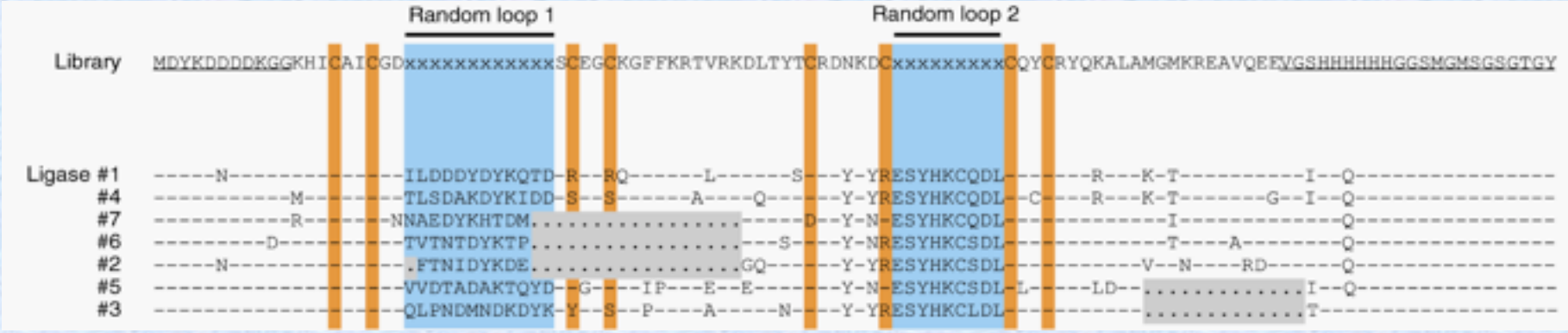
In silico mutation



Novel function AND novel structure



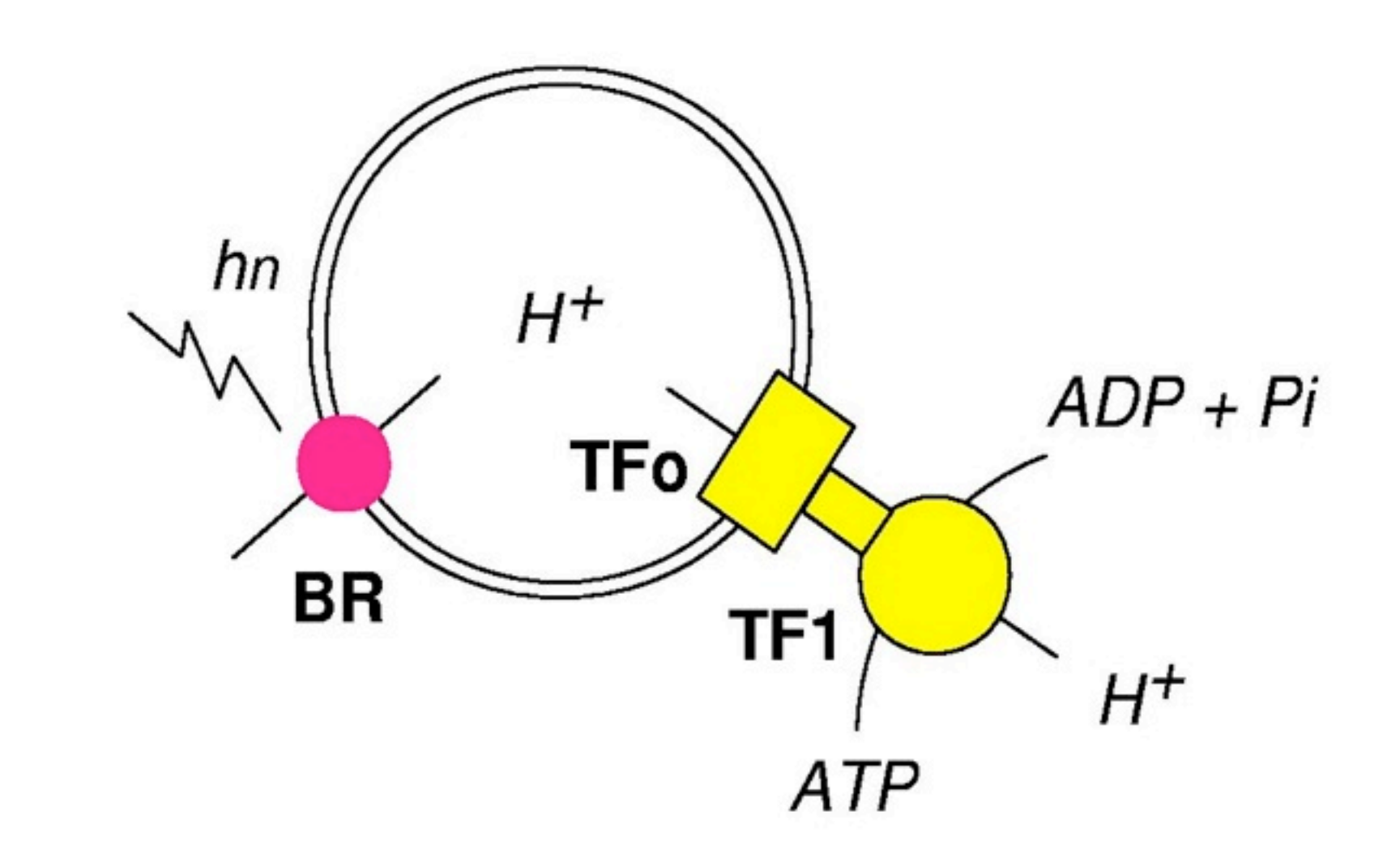




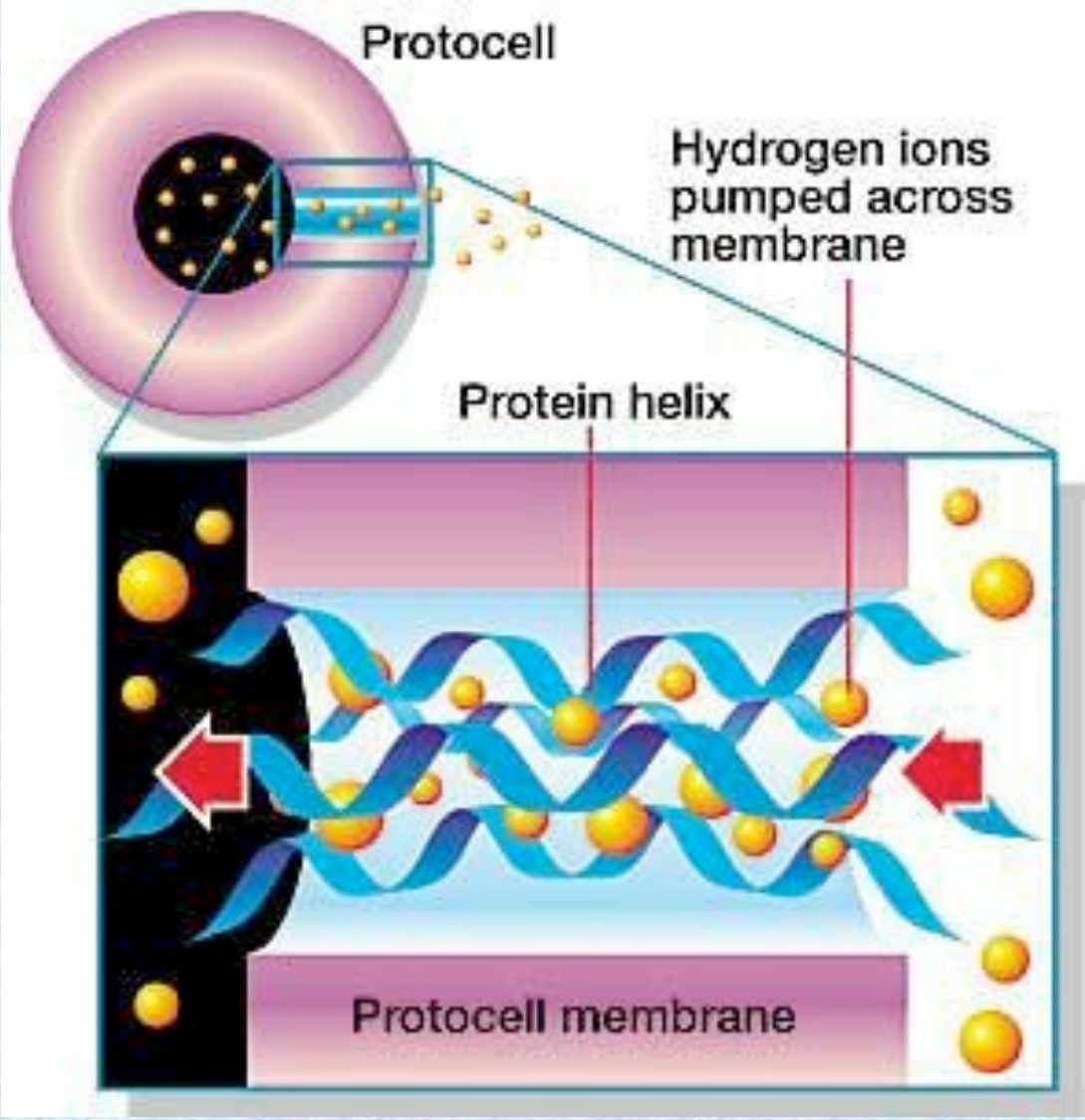
Comparison to original scaffold:

- mutated cysteines (orange)
- deletions of whole regions (gray)

Coupling BR with ATPase to generate ATP



M2 protein in the membrane



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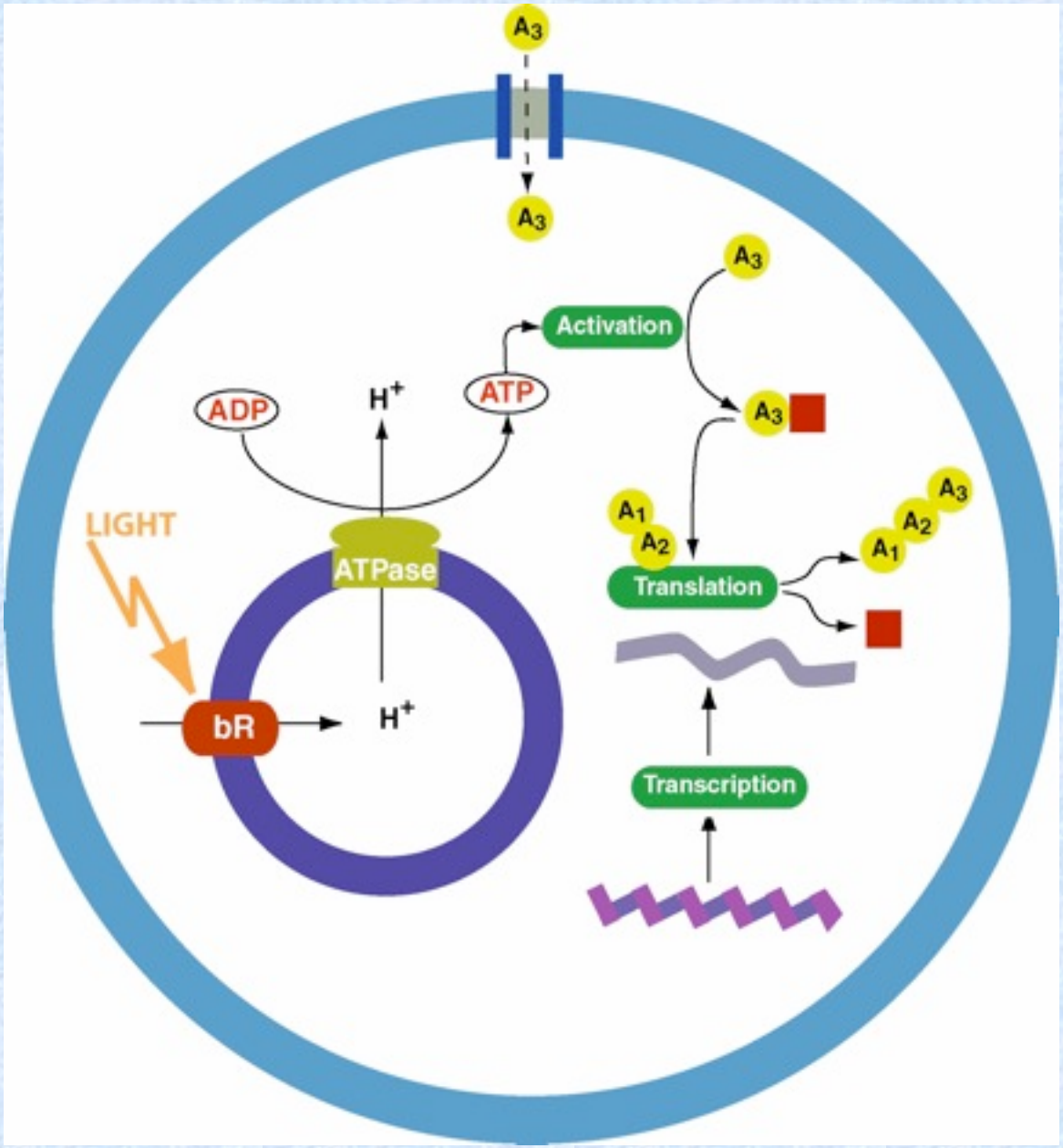
Artificial cells: prospects for biotechnology

Andrew Pohorille and David Deamer

A variety of techniques can now be used to alter the genome of a cell. Although these techniques are very powerful, they have limitations related to cost and efficiency of scale. Artificial cells designed for specific applications combine properties of biological systems such as nanoscale efficiency, self-organization and adaptability at relatively low cost. Individual components needed for such structures have already been developed, and now the main challenge is to integrate them in functional microscopic compartments. It will then become possible to design and construct communities of artificial cells that can perform different tasks related to therapeutic and diagnostic applications.

Membranous vesicles composed of pure lipid bilayers have been in the laboratory repertoire for more than 30 years. The second component is a replicating molecular system. A variety of nucleic acid polymerases are commonly used to catalyze the synthesis of DNA and RNA from template molecules, using nucleotide triphosphates as substrates. The third component is a translation system, in which genetic information present in nucleic acids is used to direct the synthesis



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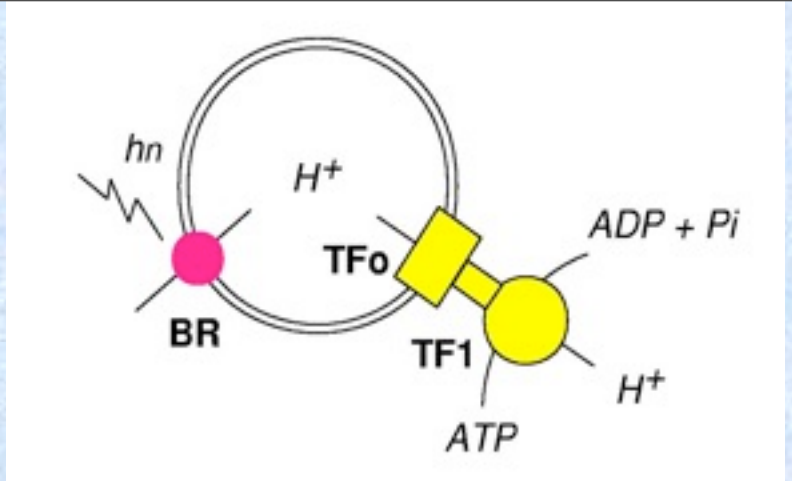
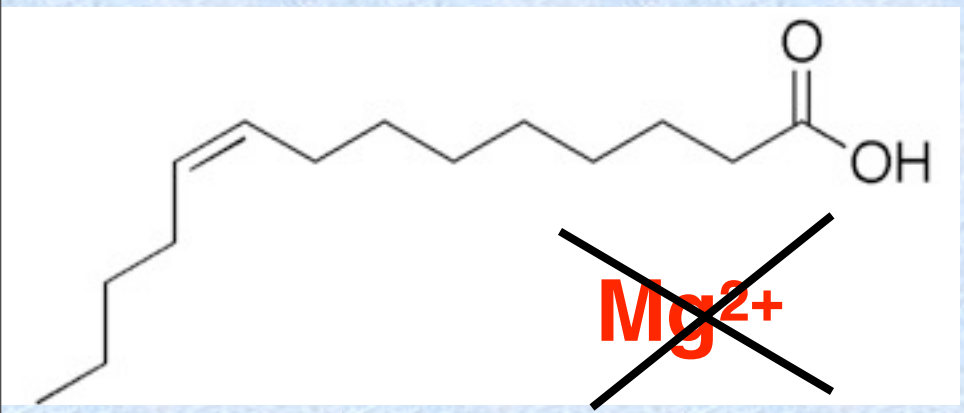
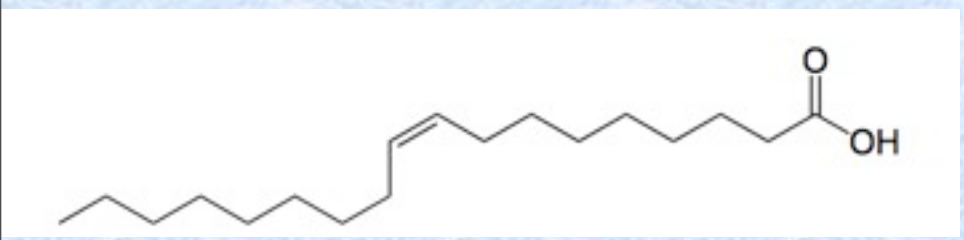


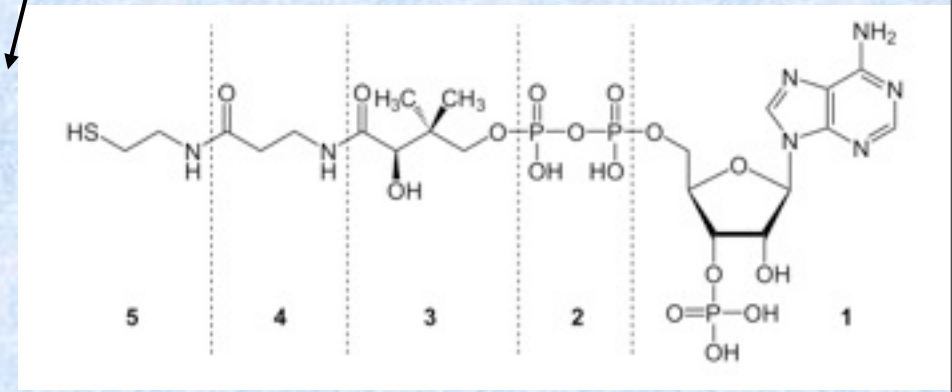
Mg^{2+}

ATP ⟶ ADP





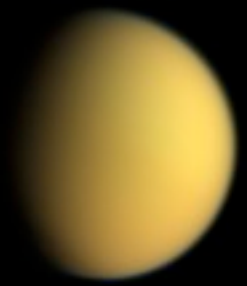
Acetyl CoA synthetase



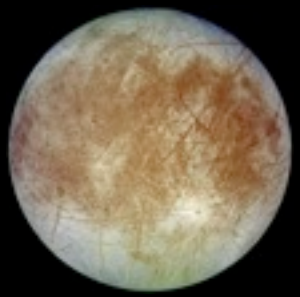
Search for Life

MARS:

Enceladus
(Saturn)



Titan
(Saturn)



Europa
(Jupiter)

Triton
(Neptun)

Observations:

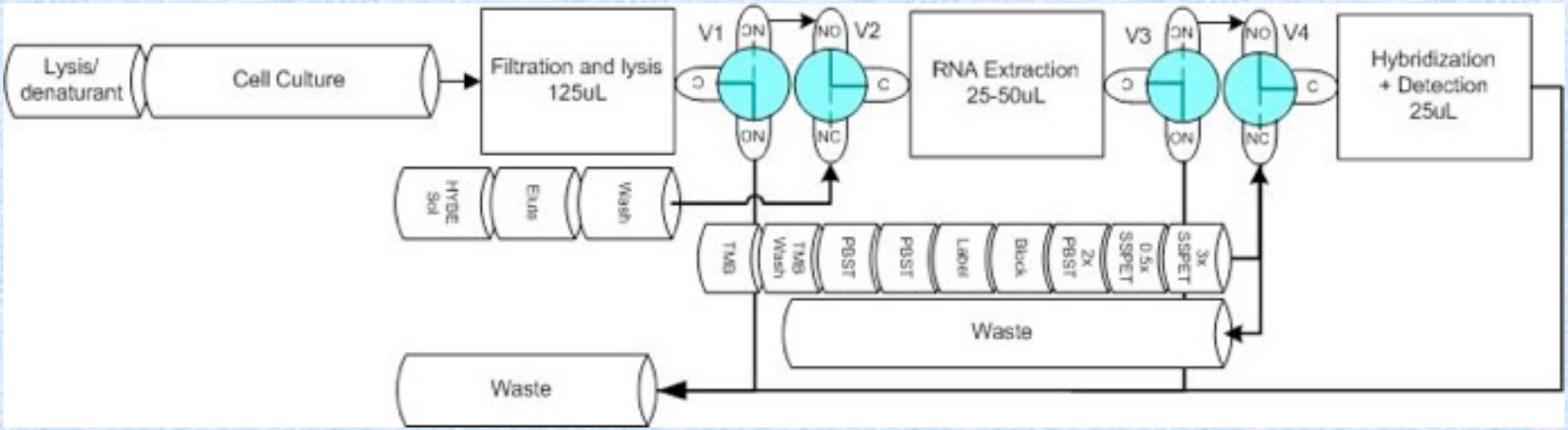
Exosolar
planets

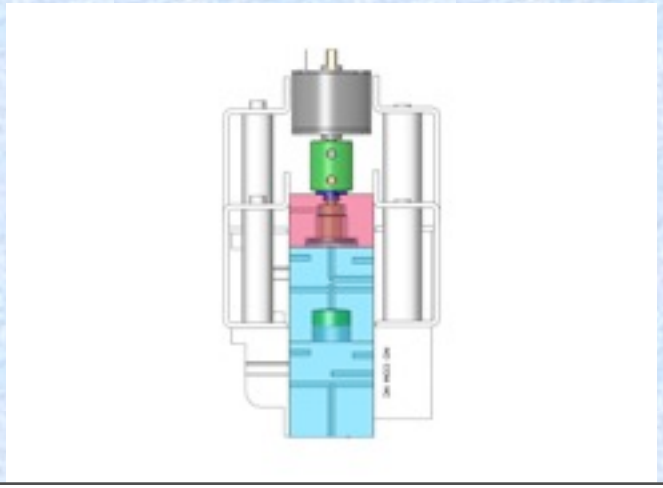
SETI

Can terrestrial life expand into environments in space and adapt to these conditions over time?

What are the limits of (minimal requirements for) life in space environment?

Automated, miniaturized instrument for measuring gene expression in space





Schematic of a research program