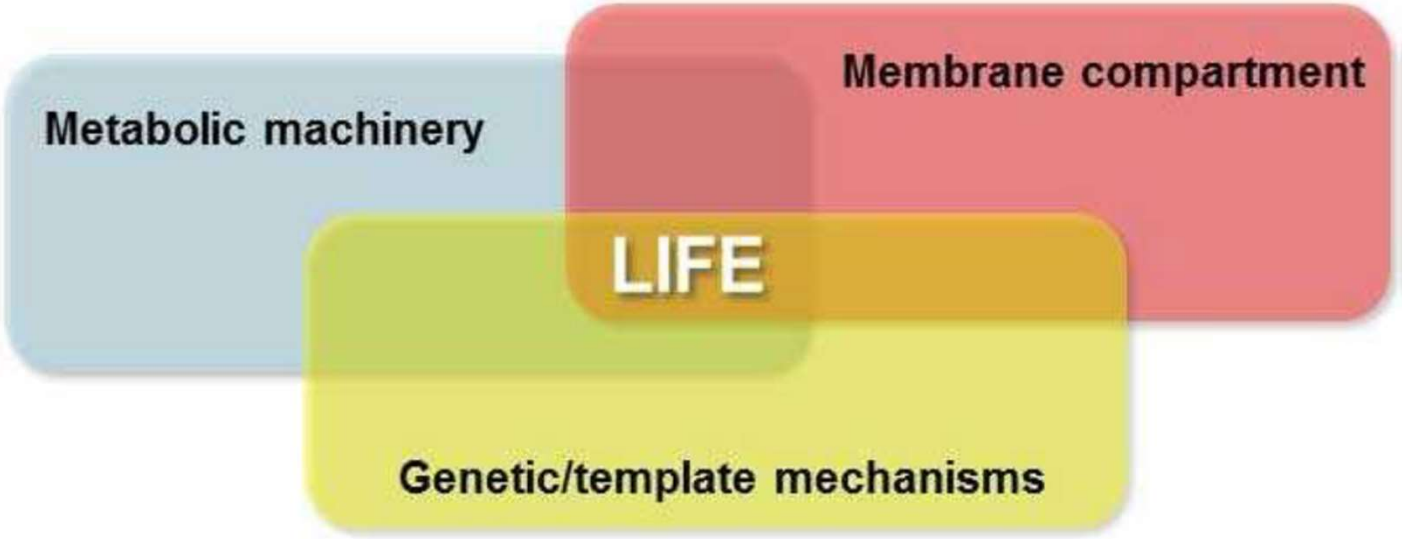
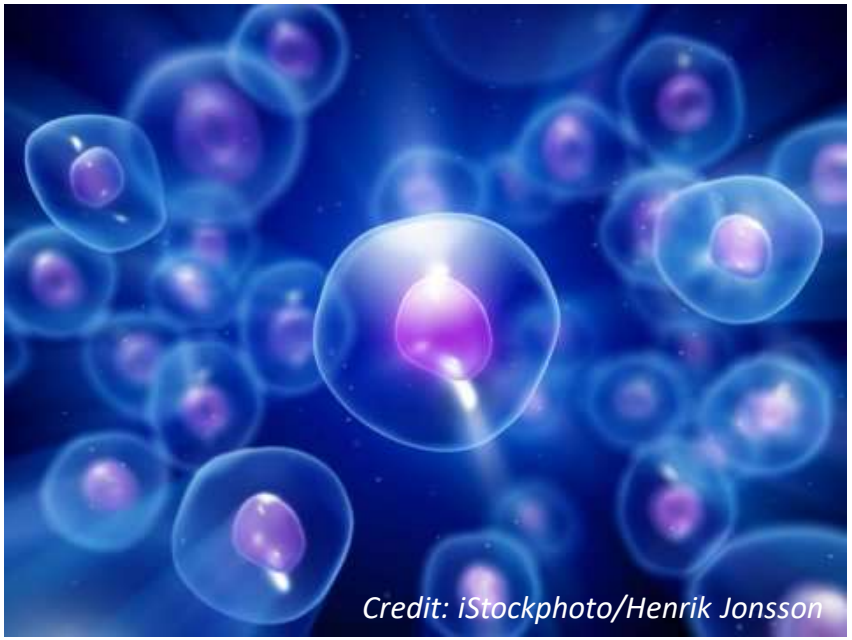
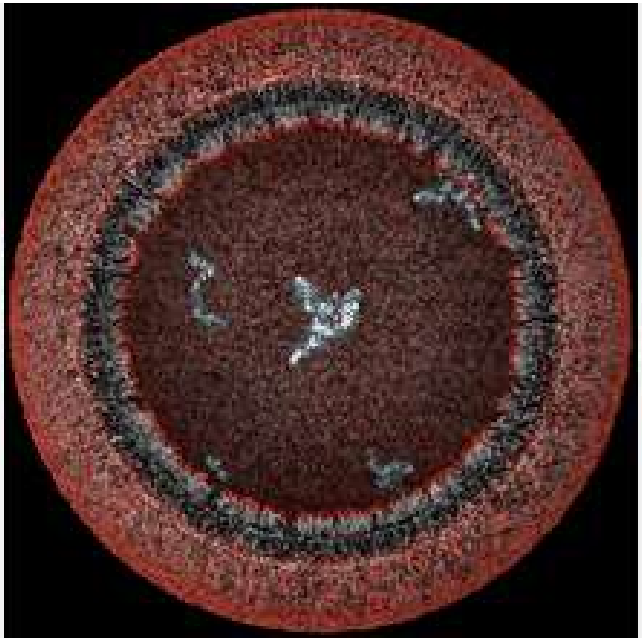

Membrane compartment
Metabolic machinery
LIFE
Genetic/template mechanisms

Encapsulation – essential for life



Membrane compartments

Assembly of amphiphilic monomers into protocellular compartments

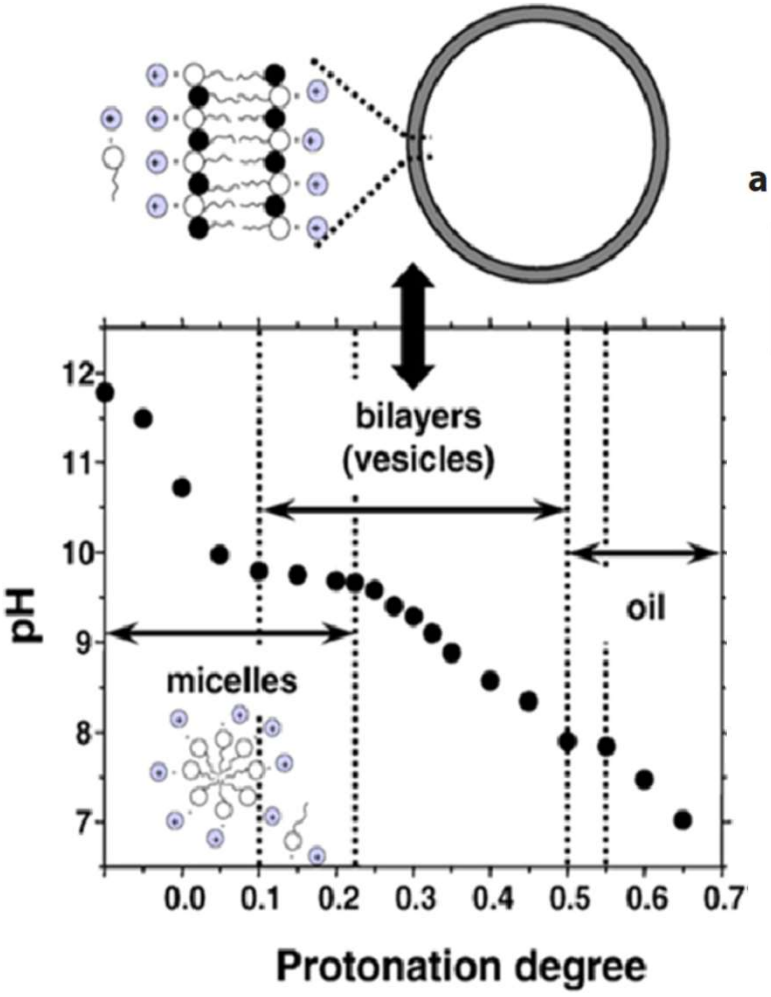


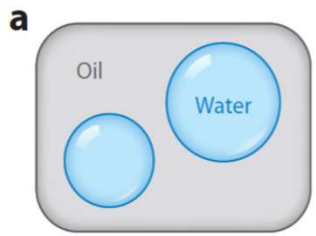
Credit: *Janet Iwasa*

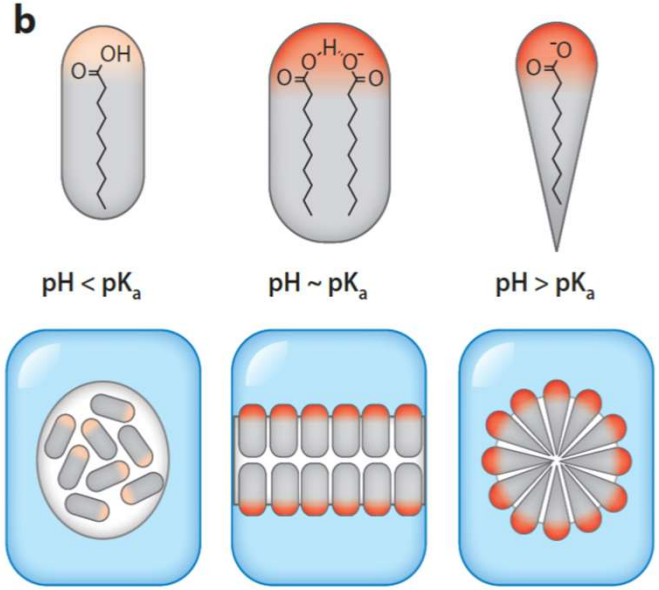
A three-dimensional view of a model protocell (a primitive cell) approximately 100 nanometers in diameter.

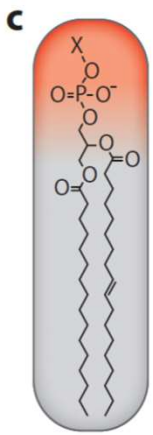
The protocell's fatty acid membrane allows nutrients and DNA building blocks to enter the cell and participate in non-enzymatic copying of the cell's DNA. The newly formed strands of DNA remain in the protocell

pH-dependent phase behavior of fatty acids in water



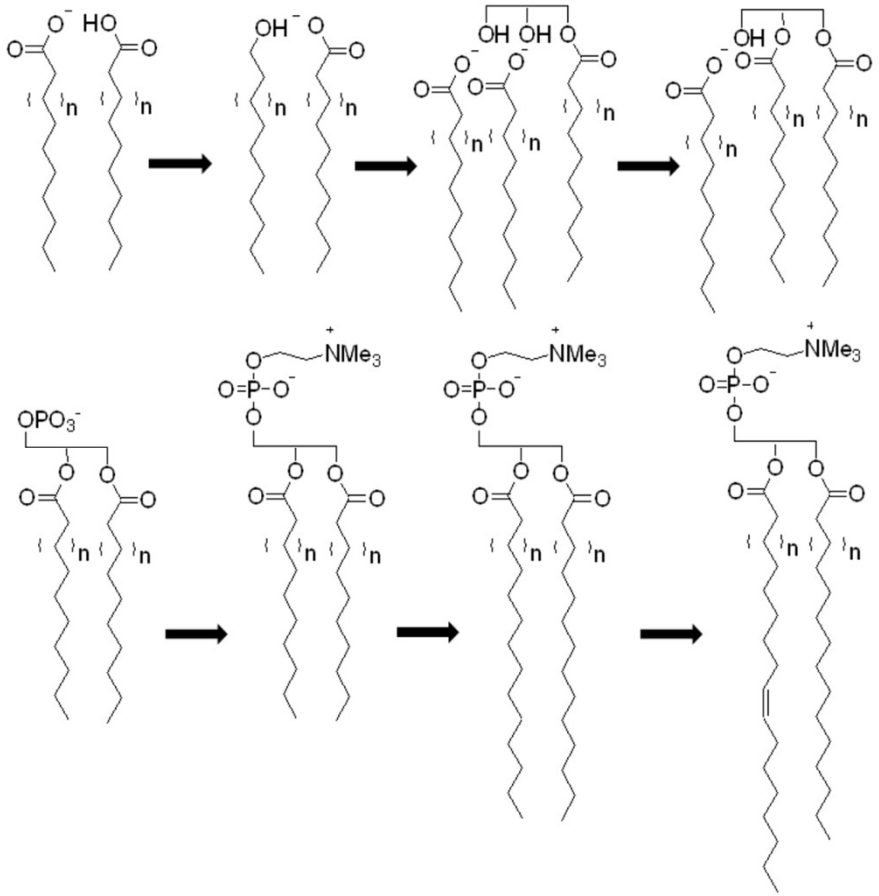




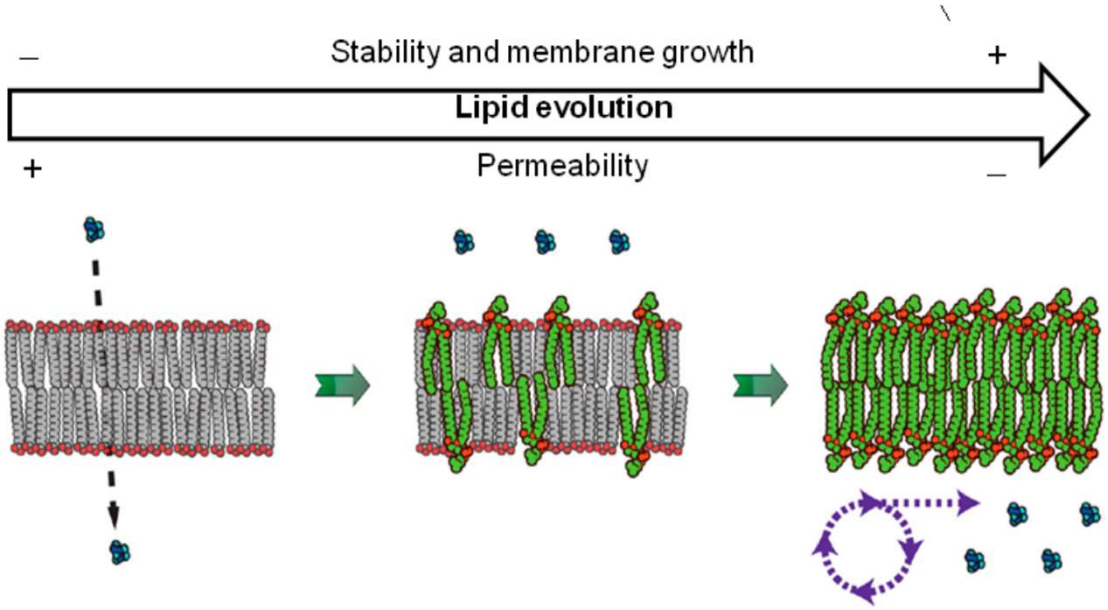


80 mM oleic acid/ sodium oleate in water

Scheme of the membrane evolution

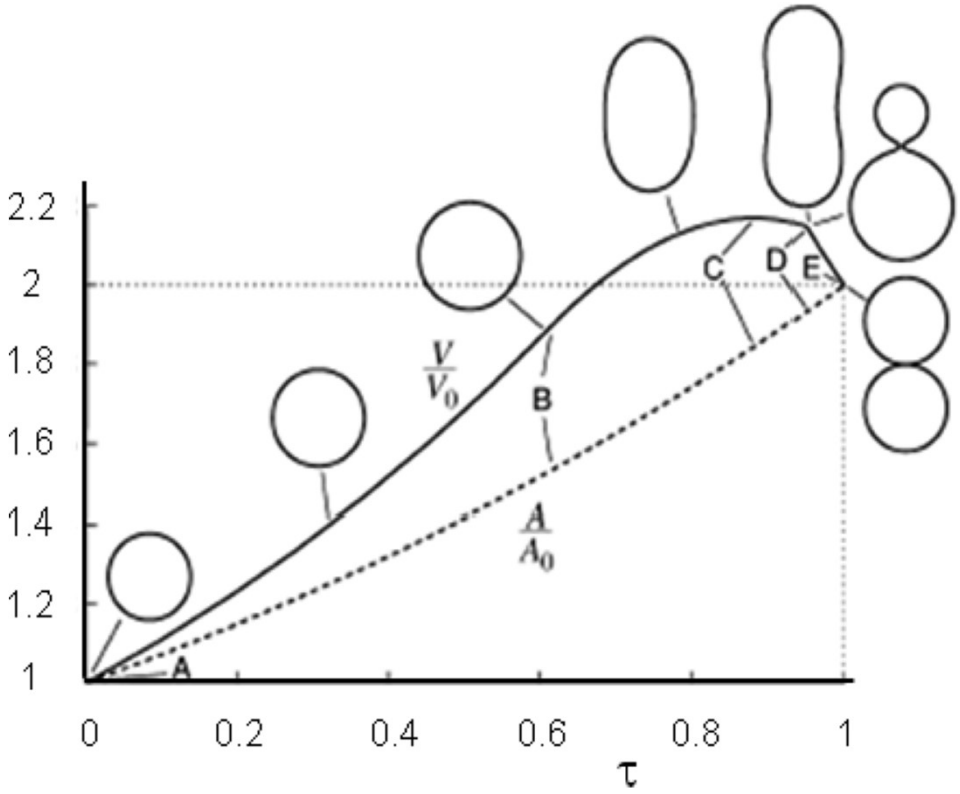


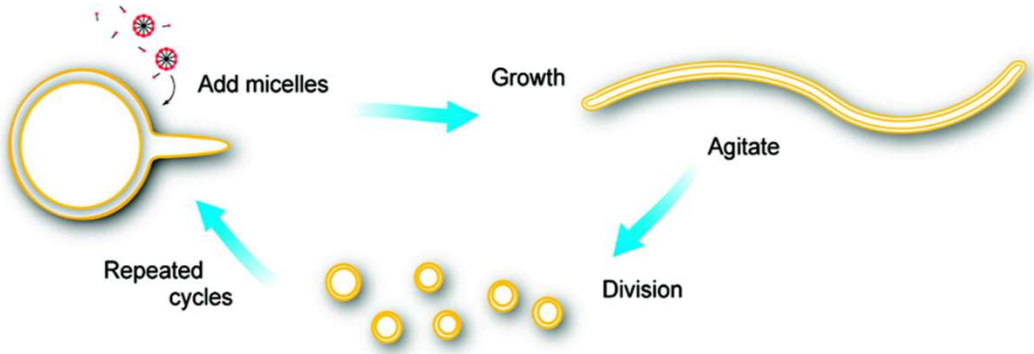
Chemical evolution of membrane components



More complex components lead to slower amphiphile desorption and thus faster growth of the protocell. Decreasing permeability is a selective pressure for the emergence of internalized metabolic and transport machinery in the system

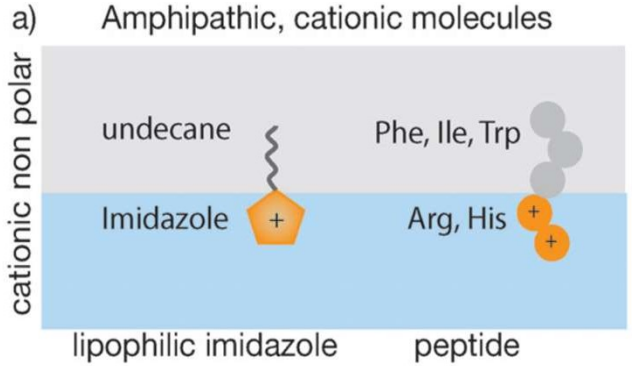
Growth and division of vesicles

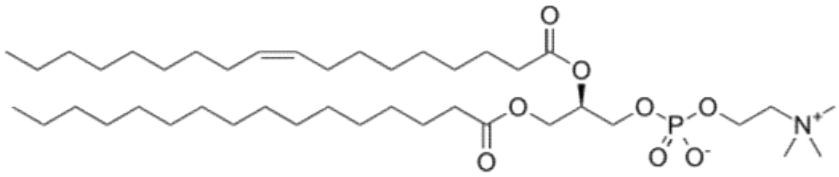


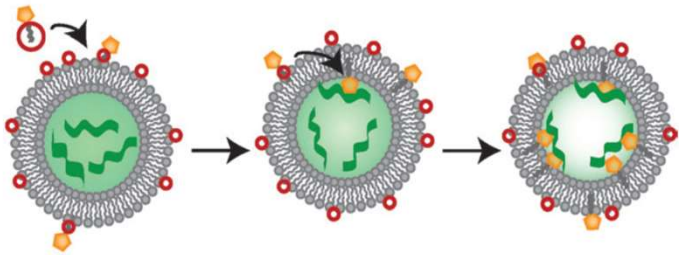


Ting F. Zhu, and Jack W. Szostak *J. Am. Chem. Soc.*, **2009**, 131 (15), 5705-5713

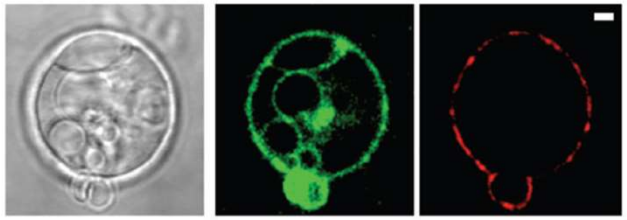
Noncovalent nucleotide association with membranes

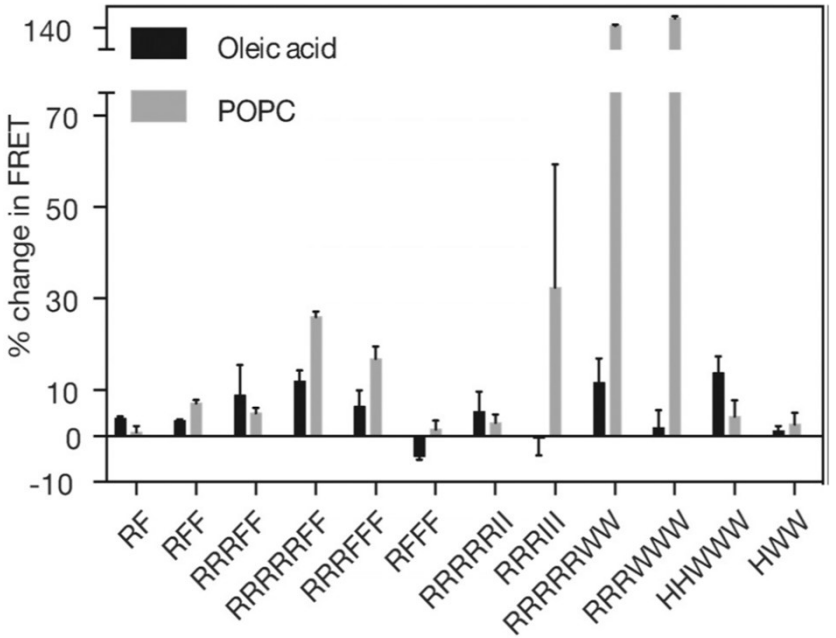






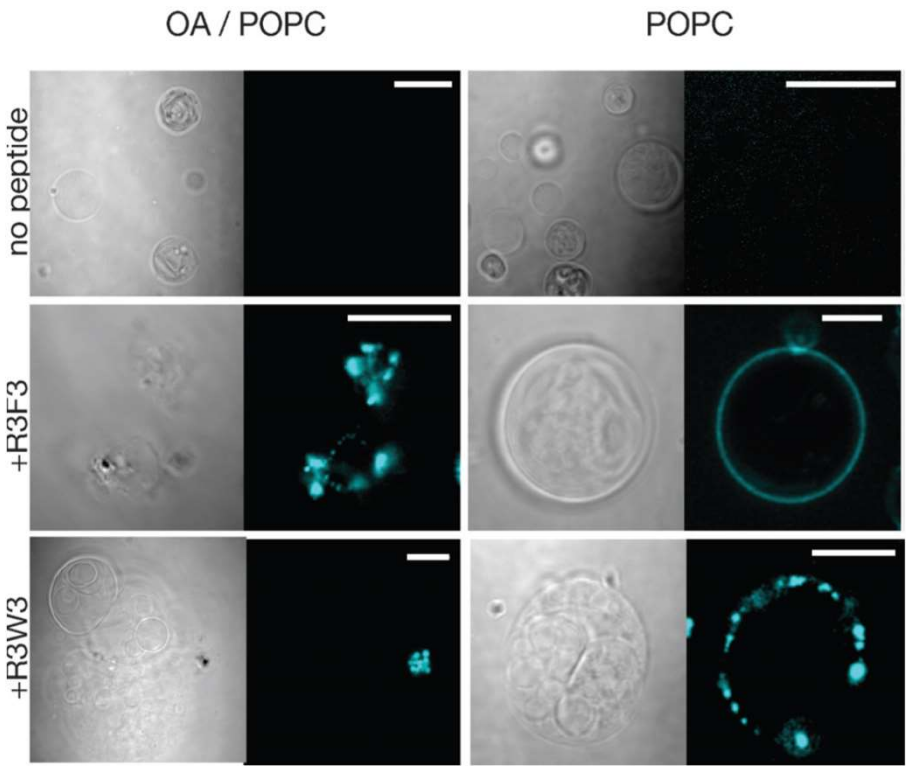
+POPC SUVs with undecylimidazole

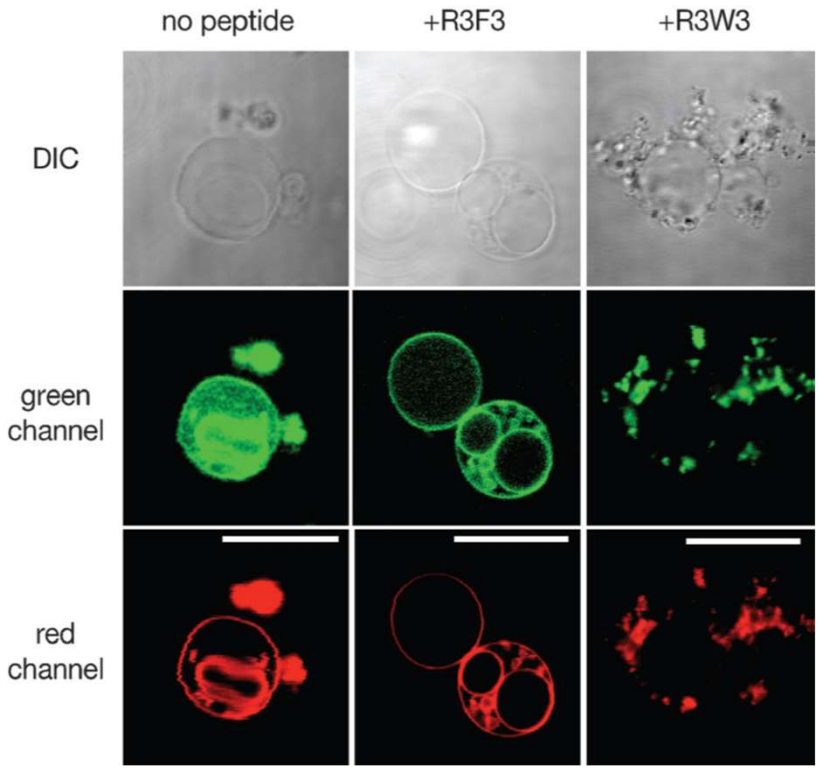




Neha P. Kamat, Sylvia Tobe, Ian T. Hill, and Jack W. Szostak *Angew. Chem. Int. Ed.* **2015**, *54*, 11735 –11739

Noncovalent nucleotide association with membranes

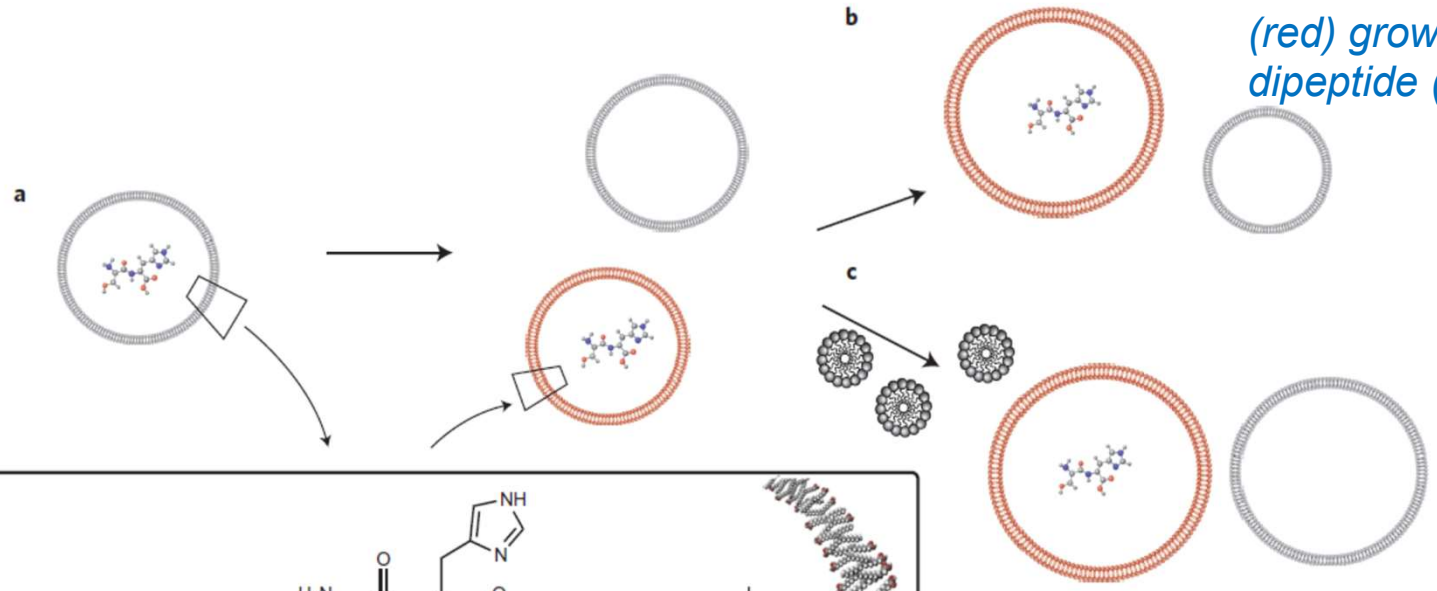




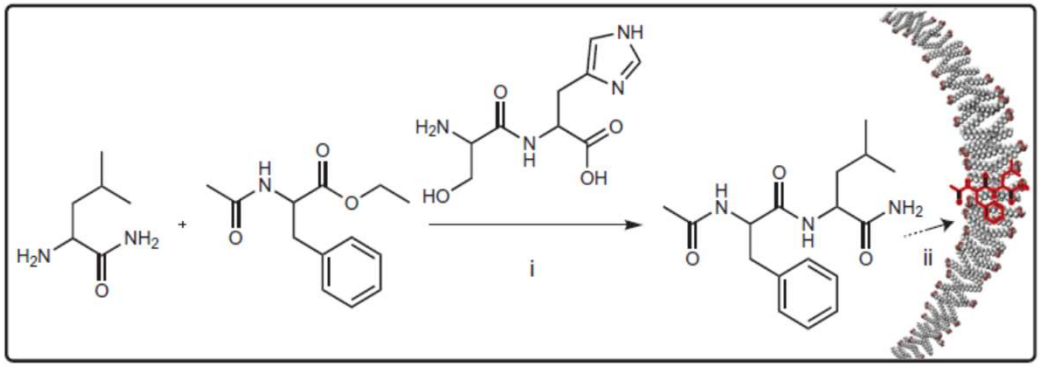
Neha P. Kamat, Sylvia Tobe, Ian T. Hill, and Jack W. Szostak *Angew. Chem. Int. Ed.* **2015**, *54*, 11735 –11739

Adaptive changes and competition between protocell vesicles

Vesicles with $AcPheLeuNH_2$ in the membrane (red) grow when mixed with vesicles without dipeptide (grey), which shrink

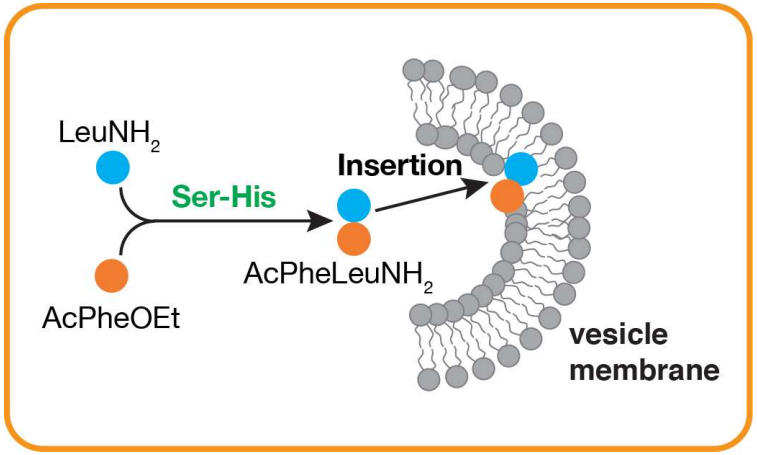


After micelle addition vesicles with $AcPheLeuNH_2$ in the membrane grow more than vesicles without the dipeptide.



Synthesis of $AcPheLeuNH_2$ by catalyst encapsulated in fatty-acid vesicles.
The dipeptide Ser-His catalyses the reaction between substrates $LeuNH_2$ and AcPheOEt (i), which generates the product of the reaction, $AcPheLeuNH_2$.

The product dipeptide $AcPheLeuNH_2$ localizes to the bilayer membrane



K. Adamala, J. W. Szostak *Nature Chem.* **2013**, *5*, 495-501