The great basic question of science:
Membrane compartment or non-membrane phase compartment
is the physical basis for origin of life?

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Fundamentally different mechanisms of making of the physical conditions necessary for the origin of life.
Fundamental physical properties of the living cell

1. Selective permeability (semipermeability).
2. Selective accumulation of solutes (accumulation of K⁺ and exclusion of Na⁺).
3. Osmotic stability.
4. Generation of electric potentials.

Our understanding of the physical nature of these properties dramatically affect our understanding of cellular function and, accordingly, on the methodology of solving the problem of the origin of life.
The standard, membrane, model of the living cell

The physical state of water and ions inside the cell and outside is the same.

The origin of life is reduced to the problem of the origin of the "living" membrane and the mechanism of energy supply of sodium pump.
The phase model of the living cell

Adsorption by proteins of the main portion of intracellular water and basic cation ($K^+$) leads to a change in the physical state of particle majority in the system and makes the cell a phase immiscible with surrounding solution.

The origin of life is reduced to only one key event – to spontaneous formation of polypeptides.
Proteins with extended conformation only are phase-making ones.
Dipole moments of functional groups of peptide bond are stronger than that of water.

Dipole moment of carbonyl group: 2.7 D (1.85 + 46%);
peptide bond: 3.5 D (1.85 + 89%).

The dipole moment of water molecules interacting with protein is stronger than their dipole moment in liquid phase.

Hydrophilicity / hydrophobicity of a polypeptide is determined by its conformation.
The structure of biophasosome, protein-adsorbed water complex

- Bulk phase (free) water
- Adsorbed/free water interface
- Adsorbed water, aqueous phase with reduced solvency
- Polypeptide chain as adsorbent

**Adsorbed K⁺**
Dialysis as a method of investigation of solute distribution in condition of diffusion equilibrium

A quantitative measure of equilibrium (steady state) distribution of solutes is the distribution coefficient

$$q = \frac{C_c}{C_s}$$

where $C_c$, concentration of tested solute in water of dialysis bag (or some another system), $C_s$, concentration of the same solute in the medium.
Equilibrium distribution coefficients ($q$) of solutes between studied systems (solutions of macromolecules, coacervates, living cells), on the one hand, and bathing solution, on the other, depending on their molecular mass. $q = C_2/C_1$, where $C_2$, concentration of tested solute in water of dialysis bag (or some another system), $C_1$, concentration of the same solute in the medium.

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<th>d-Hem</th>
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<th>Galacta</th>
<th>Coacervates</th>
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</table>


The dependence of distribution coefficient \((q)\) of solutes between tested system and bathing solution depending on their molecular mass (see Table 1).

The non-uniform distribution of solutes (when \(q < 1\)) indicates the phase differences between bulk water and (i) aqueous polymer solutions, (ii) models and (iii) living cells.
Experimental evidences for existence of adsorbed water phase at hydrophilic surfaces


<--Red arrows indicate thickness of adsorbed water phase with a reduced solvency
Biophasosome or Nanocell, minimal cell/protocell providing the physical conditions required for origin of life and evolution.

Cardinal adsorbate, ATP or its predecessor (pyrophosphate, polyphosphates)

Protein molecule with extended conformation

Multilayer phase of water adsorbed on protein molecular surface

Separation of internal environment from external one occurs without lipid membrane, ion channels and pumps; energy generation mechanism is not needed.
The standard (membrane) model of the living cell is not able to explain the electrical activity of Fox's proteinoid microspheres.

Microspheres have no lipid membranes or sodium pumps, or specific ion channels, but nevertheless they generate action potentials.

"The criterion of the scientific status of a theory is its falsifiability, or refutability, or testability."


To falsify the phase bulk approach is necessary to give another explanation for the non-uniform distribution of solutes between the considered phase systems and the environment without involvement of the properties of water.
Since the origin of the first protocell and up today the physical mechanism of the equilibrium distribution of solutes between the cell and its environment has remained unchanged.
Membrane or phase? What do experiments argue?

Membrane approach

- Spontaneous synthesis of lipids.
- Spontaneous synthesis of amino acids.
- Spontaneous synthesis of polypeptides.
- Self-assembly of lipids to form membrane.
- Spontaneous formation of Na,K-pumps.
- Spontaneous formation of specific ion channels.
- Spontaneous formation of functional lipid membrane with built-in ion channels and Na,K-pumps.
- Spontaneous formation of energy supply mechanism needed for molecular pumps.

Not proved

Phase bulk approach

- Spontaneous formation of amino acids.
- Spontaneous formation of polypeptides.
- Spontaneous association of polypeptides to form a protocell.
- Multilayer adsorption of water by polypeptides.
- Protocell ability to accumulate K$^+$ (Fox's microspheres).
- Maintaining an integrity of protocell (biophasosome) does not require permanent supply of energy.
- Spontaneous formation of ATP precursors, pyrophosphate, polyphosphates.

Proved
Main conclusions:

- The sorption properties of phase-making proteins are able to explain earliest, elementary steps of the origin of life creating physical conditions needed for life processes and, therefore, for evolution;

- The fundamental physical properties of the living cell remains qualitatively unchanged throughout all stages of evolution — from the origin of life to the present;

- The minimal cell is a minimal single-protein-based structure, which has inseparable four fundamental physical properties of the living cell.

Matveev, V.V. (2017) Comparison of fundamental physical properties of the model cells (protocells) and the living cells reveals the need in protophysiology, International Journal of Astrobiology, 16(1): 97–104
The Biophase is the Physical Basis of Life

Astrobiology
The first version of this video was published on July 24, 2016. This version has only technical improvements. An internet robot has read the text.