EMERGEMAT

8th INTERNATIONAL CONFERENCE
EMERGING TECHNOLOGIES IN MATERIALS ENGINEERING
06-07 October 2025, Bucharest, ROMANIA

Advanced Astrophysics Discovery Technology

THE PULSATORY LIPOSOME FUNCTIONS AS A PERCEPTRON

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EmergeMAT 8th, October, 2025 – Bucharest. Romania

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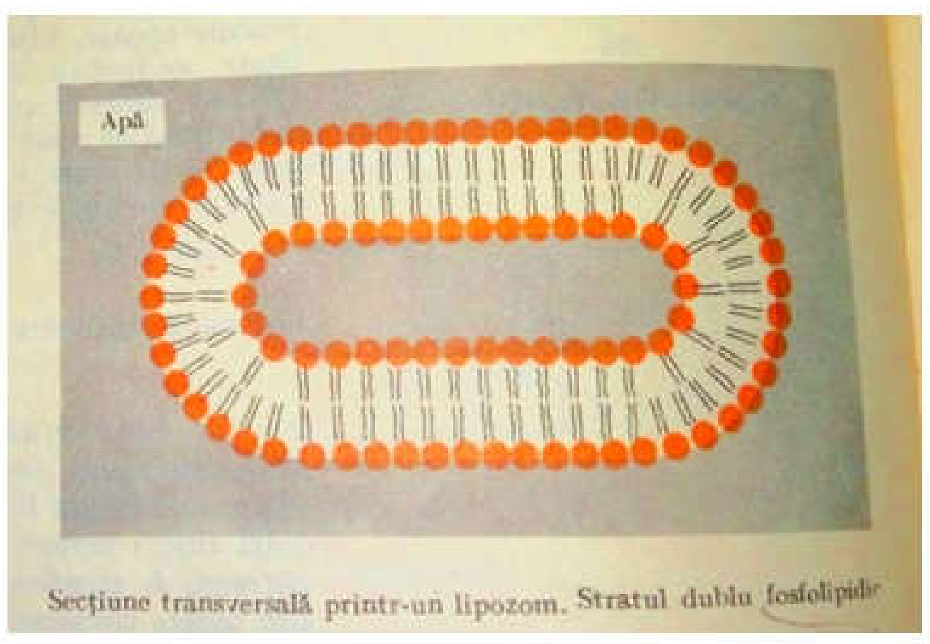
Abstract

We consider unilamellar liposome filled with an aqueous solution of an osmotic solute. This liposome is introduced into an aqueous medium. Due to the osmosis process the lipid vesicle swells up to a maximum size, when a transbilayer pore suddenly appears. Part of the internal solution leaks through this pore. The liposome deflates and returns to its initial size. All the processes which contribute to the liposome relaxing and its coming back to the initial size (pore evolution and internal solution delivery) are described by three differential equations that describes the evolution of the pulsatory liposome during a cycle and can be integrated using numerical methods. After performing a number of cycles, the pulsatory liposome stops. It can be assimilated to a intelligent biophysical engine and a neural network. A neural layer corresponds to a cycle. A neural layer corresponds to a cycle. Each neuronal layer learns to solve the equations that describe the evolution of the liposome during a cycle. So, a pulsed liposome works according to its own program that can be learned by a neural network.

AIM

We modelate the pulsating liposome to function as a neural network.

Introduction



Credit: BioChim AL, ch 11

We consider an unilamellar liposome filled with an aqueous solution of an osmotic soluteinserted in a hypotonic aqueous medium.

The description of the model

STEP 1
Due to the osmosis process the liposome swells up to a critic size,
when a transbilayer pore suddenly appears.
STEP 2
The appearance of the pore changes the evolution of the lipos
The internal solution comes out through the pore and the lipos starts its deflation (relaxation).
The evolution of the pore has two phases:
first, the radius of the pore increases to its maximum value, r_M
STEP 3
Then the radius decreases until it disappears, and the liposom reaches its initial size.
A new cycle will begin.
So this liposome will have a cyclic evolution. Each cycle has tl stages.

The **stages** of the **model**

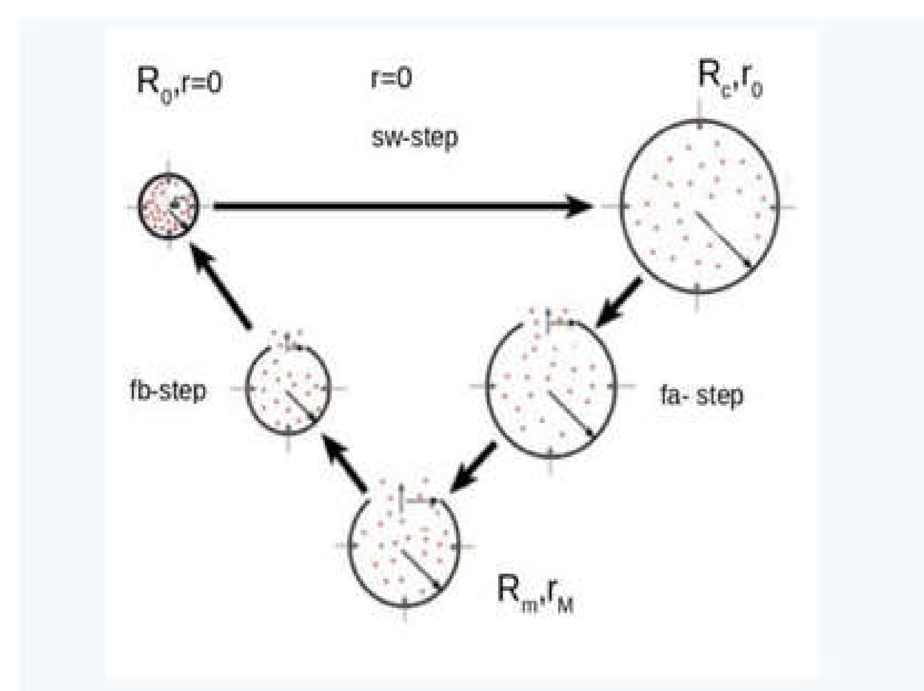


Fig.2 The evolution of a pulsatory liposome during a cycle.

Base Equations

$$\frac{\partial R}{\partial t}=\frac{-r^3}{6\cdot\eta_\ell\cdot R^3}\cdot E\left(\frac{R^2}{R_0^2}-1-\frac{r^2}{4R_0^2}\right)+$$

$$+\mathrm{P}_w V_{\mu w}\cdot\left(1-\tfrac{r^2}{4R^2}\right)\cdot\left[C-\tfrac{2\beta E}{R}\left(\tfrac{R^2}{R_0^2}-1-\tfrac{r^2}{4R_0^2}\right)\right]$$

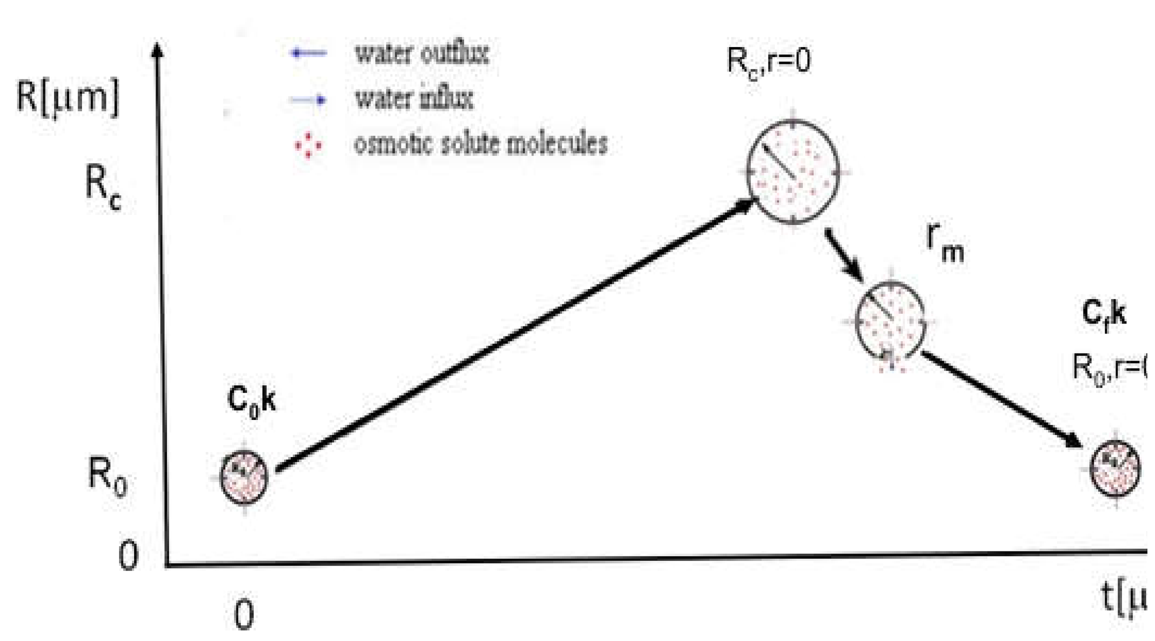
$$\frac{dr}{dt}=r\cdot\tilde{E}\left[\frac{R^2}{R_0^2}-\left(1+\frac{r^2}{4R_0^2}\right)\right]-G,$$

$$\frac{d[ln(C\cdot V)]}{dt}=\frac{-r^3}{2\cdot\eta_\ell\cdot R^4}\cdot E\left(\frac{R^2}{R_0^2}-1-\frac{r^2}{4R_0^2}\right),$$

METHOD & RESULTS

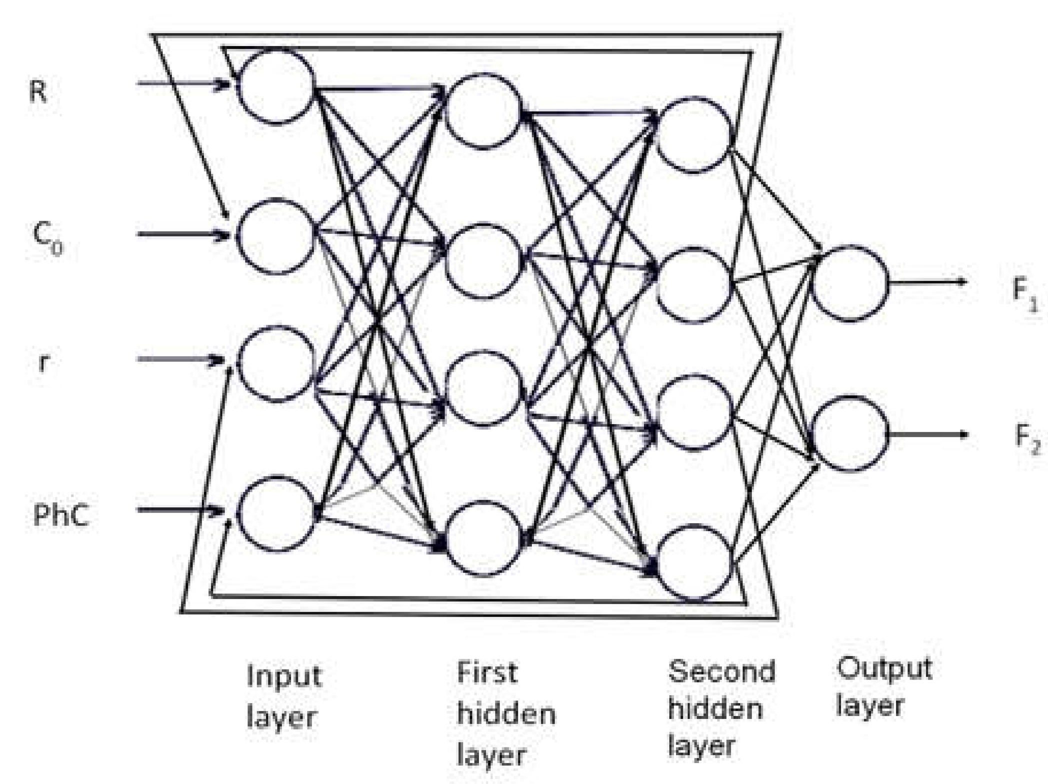
THE PULSATORY LIPOSOME AS A NEURAL NETWORK

Cycle k

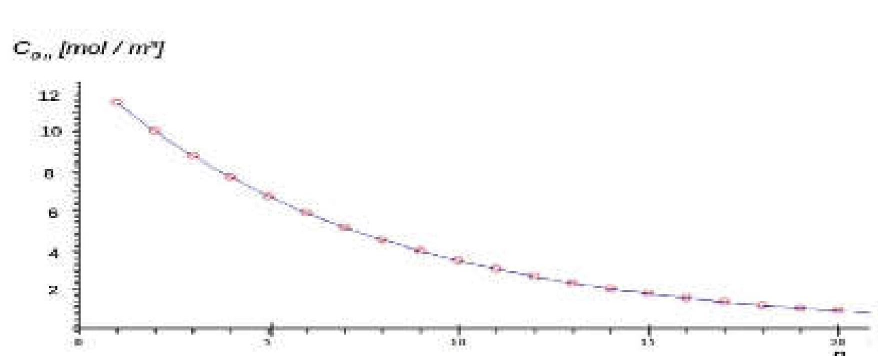


A PERCEPRTON for the Pulsatory Liposome

Each cycle can be assimilated with a layer of neurons for which:



Feedback consists of : C_f_k:=C_0_k+1



–THE INPUT DATA ARE:
The initial concentration of osmotic solvite C_o;
Initial value of lyposome radius (in a relaxed state), $R_0=R(0)=19.7$ μm;
Lyposome radius when the pore appears, $R_c=20.6$ μm;
Initial pore radius, $r_0=r(0)=1.57$ μm ;
Material constants.

–THE OUTPUT RESULTS ARE:
The final concentration of osmotic solvate C_f; Swelling time, t_s;
Deflating time, t_d; Amount of solution released, $\Delta Q=(C_0-C_f)V$.
The concentration of osmotic solvite at the end of one cycle,
C_f, is the initial concentration, C_0, for the next cycle.
For the first cycle $C_0=C(0)=11$ mol.m^{-3}
The number of neural layers of the neural network associated with the liposome, is equal to the number of cycles of the pulsatory liposome.

CONCLUSIONS

We have proved that the functioning of the pulsatory liposome is determined by the transmembrane concentration gradient of the osmotic solute and by the appearance of the pore through the liposome membrane.

We also showed that the pore changes the direction of the liposome evolution, bringing it back to its original geometric size.

The operating energy is ensured by the transmembrane concentration gradient of the solute. So, the solute is the fuel of the pulsatory liposome.

The solute (the fuel) may be a pharmacological substance,
or any other special substance.
The preparation of pulsatory liposomes with such properties and their delivery at a site of action remains a biotechnology challenge.

*Artificial neural networks may be a way for the transmembrane pore mechanism to find application **in astrochemistry and astrobiology***

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Acknowledgement:
We would like to thank the team of EmergeMAT Conference.