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Three pool model of self sustained calcium oscilations

In addition to energy production, mitochondria are involved in crucial cellular signaling processes. They are one of the most important organelles responsible for the Ca^{2+} regulatory pathways in the cell. Several mathematical models explaining these mechanisms were created but only few of them describe an interplay between calcium concentration in endoplasmic reticulum (ER), cytoplasm and mitochondria (see e.g. [1]). Experiments measuring calcium concentrations in mitochondria and ER suggest the existence of cytosolic microdomains with locally increased calcium concentration (CMDs) in the nearest vicinity of the outer mitochondrial membrane. CMDs allow Ca^{2+} to be taken up by mitochondria rapidly and form a steep concentration gradient. Such microdomains have been described lately as a MAM - mitochondria-associated ER membrane. To simulate calcium oscillations more accurately, we propose a model with an additional direct calcium flow between ER and mitochondria which takes into account recently discovered specific physical connections between these two organelles. For the proposed model we have shown the global existence of nonnegative solutions. We examined numerically the existence of stable limit cycles of Ca^{2+} oscillations, basin of their attraction, and the dependence of the cycles period on the parameters.

References

[1] M. Marhl, T. Haberichter, M. Brumen, R. Heinrich *Complex calcium oscillations and the role of mitochondria and cytosolic proteins* BioSystems **57** 75–86.