539b Wave Propagation Patterns in 2d Astrocytic Networks

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Glial cells, or glia, were considered to have just passive/supporting role for the neurons in the mammalian brain. However, astrocytes, a special type of glia, have been experimentally shown to be able to become chemically stimulated by various neurotransmitters, such as ATP, and to propagate the signal over many cell lengths in the form of a wave. Ultimately the wave becomes blocked by an unknown mechanism. Blocking can also be generated artificially by creating cell free lanes, as has been experimentally demonstrated by recent studies. Furthermore, various wave patterns, such as circular or spiral waves, have been observed experimentally. Pathological conditions, such as spreading depression and epilepsy, have been linked to abnormal wave propagation in astrocytic cellular networks. Mathematical modeling and computational experiments can contribute towards revealing the mechanisms responsible for the generation of various wave patterns and identifying factors that control the speed and range of wave propagation.

Motivated by the above, we constructed a single cell model which accounts for ATP-mediated IP3 production, the subsequent Ca2+ release from the ER through IP3R channels and Ca2+-dependent ATP release into the extracellular space. To realistically model the coupled astrocytic network, the single cell model was incorporated in a 2D reaction-diffusion framework. Patterns that can be observed in a homogeneous network include planar and circular waves. Spiral wave formation was also possible by two different stimuli protocols: different-site excitation for an isotropic domain and same-site excitation for an anisotropic domain. Furthermore, the inclusion of non excitable regions (blocks) in the (isotropic) domain can result in wave reflections or front breaks. In the first case the block acts as a pacemaker and in the second case spiral waves evolve from the free ends of the broken wave front. Some of these patterns have been observed experimentally and may provide possible prototypes for the observed abnormal wave propagation in pathological situations.