Ion Dynamics and the Regulation of Cellular Development

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ABSTRACT

Cells apeared and evolved surrounded by ion-rich media. It would thus be surprising if evolution had not taken advantadge of certain ions' specific characteristics to regulate specific cellular functions. We propose that "ion dynamics"- which we define specifically as the regulation of ion membranar fluxes and cytosolic free ion concentration [1]- maybe a common denominator of the central regulation phenomena in living cells. Taking advantadge of ion-vibrating probes to study extracellular ion fluxes [2] and ion-ratiometric imaging, we have tried to test this concept in a number of plant cell systems, namely root hairs [3,4], BY2 tobbaco cells [5], filamentous algae, angiosperm gamete fusion [6,7] and growing pollen tubes [8,9; review in 10]. This last system will be explored in detail since it grows extensively, can be induced to change growth behavior, but never divides, being ideal for focus on cellular growth and morphogenesis regulation. Ion-vibrating probe data concerning the polarisation of current carriers for protons, calcium, chloride and potassium shows clear non-linear patterns in space (polarised distribution of carriers) and time (oscillatory and chaotic behaviors), which will be explored in terms of correlaton with function: Ca2+ is nvolved on growth regulation, H+ with the basis of polarity, Cl- with water flow and K+ with membrane potential rectification. Likewise H+ (pH) and [Ca2+] cytosolic free concentrations, show specific spatial and temporal non-linear patterns, directly correlated with the cellular organisation of the system. We will explore the dynamics of these patterns to develop models of cellular regulation, namely through actin cytoskeleton modulation and spatial coordination through reaction-diffusion mechanisms. The fact that all these parameters oscillate will be explored in terms of homesotasis and functional control loops. Space-phase analysis shows that these oscillations seem to veiculate a limit cycle attractor-like behavior. Since all these parameters are measured on real time, living, non-invasing conditions, we propose that pollen tubes may be considered one of the most plastic and high potential models to system biology at the cellular level. Current experimental data now calls for consistent theoretical analysis.

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