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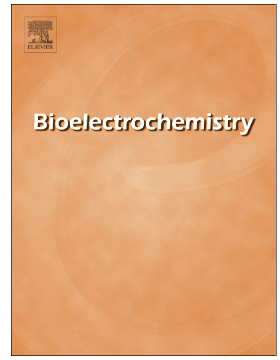

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Bioelectrical coupling in multicellular domains regulated by gap junctions: a conceptual approach

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ABSTRACT

We review the basic concepts involved in bioelectrically-coupled multicellular domains, focusing on the role of membrane potentials (V_{mem}). In the first model used, single-cell V_{mem} is modulated by two generic polarizing and depolarizing ion channels, while intercellular coupling is realized via voltage-gated gap junctions. Biochemical and bioelectrical signals are integrated via a feedback loop between V_{mem} and the transcription and translation of a protein forming an ion channel. The effective rate constants depend on the single-cell V_{mem} because these potentials modulate the local concentrations of signaling molecules and ions. This electrochemically-based idealization of the complex biophysical problem suggests that the spatio-temporal map of single-cell potentials can influence downstream patterning processes by means of the voltage-gated gap junction interconnectivity, much as in the case of electronic devices where the control of electric potentials and currents allows the local modulation of the circuitry to achieve full functionality. An alternative theoretical approach, the *BioElectrical Tissue Simulation Engine* (BETSE), is also presented. The BETSE modeling environment utilizes finite volume techniques to simulate bioelectric states from the perspective of ion concentrations and fluxes. This model has been successfully applied to make predictions and explain experimental observations.

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