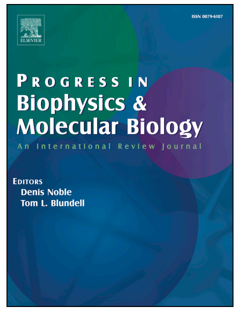

Bioelectrical control of positional information in development and regeneration: A review of conceptual and computational advances

Alexis Pietak, Michael Levin

PII: S0079-6107(18)30041-5

DOI: 10.1016/j.pbiomolbio.2018.03.008

Reference: JPBM 1328

To appear in: *Progress in Biophysics and Molecular Biology*

Received Date: 10 February 2018

Revised Date: 23 March 2018

Accepted Date: 26 March 2018

Bioelectrical control of positional information in development and regeneration: a review of conceptual and computational advances

Alexis Pietak[1,*] and Michael Levin[1,2]

1 Allen Discovery Center at Tufts

2 Center for Regenerative and Developmental Biology, Tufts University, Medford, MA, USA

* Corresponding author: alexis.pietak@allencenter.tufts.edu

Allen Discovery Center at Tufts, Science & Engineering Complex, Research East, 200 College Avenue, Medford, MA 02155

Abstract

Positional information describes pre-patterns of morphogenetic substances that alter spatio-temporal gene expression to instruct development of growth and form. A wealth of recent data indicate bioelectrical properties, such as the transmembrane potential (V_{mem}), are involved as instructive signals in the spatiotemporal regulation of morphogenesis. However, the mechanistic relationships between V_{mem} and molecular positional information are only beginning to be understood. Recent advances in computational modeling are assisting in the development of comprehensive frameworks for mechanistically understanding how endogenous bioelectricity can guide anatomy in a broad range of systems. V_{mem} represents an extraordinarily strong electric field (~1.0x10^6 V/m) active over the thin expanse of the plasma membrane, with the capacity to influence a variety of downstream molecular signaling cascades. Moreover, in multicellular networks, intercellular coupling facilitated by gap junction channels may induce directed, electrodiffusive transport of charged molecules between cells of the network to generate new positional information patterning possibilities and characteristics. Given the demonstrated role of V_{mem} in morphogenesis, here we review current understanding of how V_{mem} can integrate with molecular regulatory networks to control single cell state, and the unique properties bioelectricity adds to transport phenomena in gap junction-coupled cell networks to facilitate self-assembly of morphogen gradients and other patterns. Understanding how V_{mem} integrates with biochemical regulatory networks at the level of a single cell, and mechanisms through which V_{mem} shapes molecular positional information in multicellular networks, are essential for a deep understanding of body plan control in development, regeneration and disease.

1 Introduction

A deep understanding of morphogenesis is essential for the identification and application of strategies that will mitigate birth defects and restore damaged and diseased tissues, organs, and anatomy