Preface

Bioelectricity was discovered by Galvani in the late 1700s. During a public experiment in Bologna, Italy, in 1794, he showed that the cut end of a frog sciatic nerve from one leg could stimulate contractions when it touched the muscles of the opposite leg, a demonstration of the injury potential. Over two hundred years later, we have strong evidence that direct current, electric field gradients (bioelectricity) exist in all developing and regenerating animal tissues and have, more recently, been measured around tumors and sites of inflammation. Ion flow appears to be fundamental in all aspects of bioelectricity. Indeed, we have evolved to use about half of our cells' energy, in the form of ATP, maintaining ion concentration gradients and electric fields, highlighting their importance to life. Moreover, ionic current flow and electric field gradients are interdependent and inseparable vectors with both magnitude and direction, providing cues for the spatial organization of developing/regenerating multicellular tissues.

In recent years, advances in technology have facilitated the accurate measurement of endogenous electric fields around sites of tissue disruption. Meanwhile, state-of-the-art molecular approaches have demonstrated that bioelectricity can control the directionality of cell migration, the speed of migration, proliferation, apoptosis, differentiation, and orientation. This level of physiological control can initiate and coordinate complex regenerative responses in development and wound repair and may play a role in cancer progression and metastasis.

Here we bring together, for the first time, current research in the area of bioelectricity.

Methods for detecting endogenous electric field gradients and studying applied electric fields in the lab are provided. The roles of bioelectricity in guiding cell behavior during morphogenesis and orchestrating higher-order patterning are described. The response of stem cells to applied electric fields reveals bioelectricity as an exciting new player in tissue engineering and regenerative medicine. How electric signals control corneal wound repair and skin reepithelialization, angiogenesis, and inflammation is explored in depth, and the bioelectric responses of cells derived from the musculoskeletal system are described. The bioelectrical guidance of neurons and the beneficial application of voltage gradients to promote regeneration in the spinal cord are also explored in depth. Finally, we reveal that bioelectricity can play a significant role in the progression of cancer. This relatively new field has the potential of revealing novel cancer biomarkers, providing a new method for early detection of cancer and producing bioelectricity-based therapies to target both the tumor and metastatic cancer cells.

This book is a multidisciplinary compilation intended for biologists, biomedical scientists, engineers, and clinicians, but would be beneficial to anyone with an interest in development, regeneration, cancer, and tissue engineering. It would also make an ideal textbook for students in biology, medicine, biophysics, and biomedical engineering.

Finally, I thank all the authors who contributed their time and effort to make this book a reality and hopefully a success!

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