What Is Bioelectricity?

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I just had a great telephone conversation with Associate Editor Richard Kramer. Dr. Kramer has done some amazing work, restoring light sensitivity to blind mice, for example. I recommend reading more. The reason I bring it up is that our conversation took me back to the discussion among editors that became the roundtable (see page 8). Certain questions came up a few times, and they are the questions Richard and I discussed and that I continue to ponder.

1. Is there an essential criterion for inclusion in bioelectricity?

2. How can we make bioelectricity inclusive?

In other words, what is the smallest unit of bioelectricity and what is the largest?

Like any self-respecting freshman essay, we start with a definition.

"Bioelectricity is any electrical phenomenon that is actively generated by cells or that is applied to cells to affect cell phenotype."

By electrical phenomenon I mean any biological-cell function or activity that depends on either the separation of charge (voltage), generally due to separation of ions, or the movement of ions (current), generally through channels or by pumps.

By actively generated, I mean the cell uses energy to make it happen. In other words, dead cells do not produce bioelectricity; likewise, if there is no bioelectricity, the cell is dead.

By cells, I mean individual cells or groups of cells.

By applied, I refer to the research and biomedical tools that depend on the effects of externally supplied current or voltage, for example, electroporation.

By phenotype, I mean cell shape, size, distribution of charges in space and time, physiology, and/or gene expression. Phenotype includes the condition of the cell, for example, polarized, as if it were in an electrophoresis apparatus, or dead, as from a pulsed electric field (see the review on page 30, by Senior Editor Richard Nuccitelli).

I hear you, and yes, bioelectricity is electrophysiology. But language evolves; I am sure the definition of bioelectricity will evolve from what I have said here. Electrophysiology has come to mean the use of electrodes to measure or manipulate the voltage or current of a single cell and monitor the result. Electrode arrays are making it possible to do electrophysiology on multiple cells simultaneously, but the word electrophysiology is, I believe, inextricably linked to the study of action potentials. Bioelectricity expands on that definition to include all cells, because all cells are bioelectric. It also accounts for discoveries and inventions that now allow us to observe the multiple voltages found within an individual cell membrane, and bioelectric differences among cells in both homogeneous and heterogeneous populations, such as brain slices or whole organs. These discoveries and approaches are not what come to mind when someone says electrophysiology, so we have a new term.

The goal of the journal Bioelectricity is to create a “one stop shop” for the already familiar and the newly interested. We want to introduce scientists who are studying voltage in flatworms and scientists who are studying voltage in developing neurons. We want the people studying ion pumps in plants to have a forum they share with those studying the electric fields required for wound healing and those studying the cystic fibrosis chloride channel. We need a meeting place where readers can watch the interactions of those studying how to use electricity to cure cancer with those studying the bioelectricity of cancer with those learning how to use animal venom to treat cancer.

As disparate as these contexts sound, these researchers share something that is fundamentally different from the vast majority of biological scientists: they have discovered that up there in the pantheon of foundational approaches, such as biochemistry and genetics, there is another virtually untapped source of mechanistic explanations. Phenomena that have remained mysterious for centuries are becoming clear as more and more of us search using new tools and simple ideas borrowed from electrical engineers. People are finding explanations for diseases, the vast
majority of which are not genetic. The pioneers of bioelectricity, from Lucia and Luigi Galvani, (see “Original Sin” by Sally Adee, page 16), through Hodgkin and Huxley and on through to the Editorial Board of this journal, have given us exceptionally strong evidence for the importance of voltage and current in cells of all types. From those roots, the field is starting to grow. Bioelectricity will report the advances, and by that means we will let the scientists themselves establish the range of smallest to largest bioelectricity.

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