

Bioelectronic Medicine

Bioelectronic Medicine stands as an emerging field that rapidly evolves and offers distinctive clinical benefits, alongside unique challenges. It consists of the modulation of the nervous system by precise delivery of electrical current for the treatment of clinical conditions, such as post-stroke movement recovery or drug-resistant disorders. The unquestionable clinical impact of Bioelectronic Medicine is underscored by the successful translation to humans in the last decades, and the long list of preclinical studies.

Bioelectronics is a multidisciplinary field that combines principles from biology and electronics to develop devices and technologies that can interface with living organisms. These devices often leverage the electrical properties of biological systems to monitor or control various physiological processes. One notable subset of bioelectronics is bioelectronic medicine.

Bioelectronic medicine involves the use of electronic devices to modulate the electrical signaling in the nervous system, aiming to treat diseases and conditions. It often focuses on the interface between electronic devices and the nervous system, taking advantage of the body's natural electrical pathways. Some examples of bioelectronic devices include:

Neurostimulators: Implantable devices that deliver electrical impulses to specific nerves or areas of the brain. These are used to treat conditions such as chronic pain, epilepsy, and Parkinson's disease.

Bioelectronic Sensors: Devices that can detect and measure biological signals, such as glucose monitors for diabetes management or sensors that monitor neural activity.

Neuroprosthetics: Implantable devices that interface with the nervous system to restore lost or impaired functions. Examples include cochlear implants for hearing-impaired individuals and retinal implants for vision restoration.

Electroceuticals: Therapeutic interventions that use electrical impulses to modulate physiological processes, aiming to treat various medical conditions.

Wearable Bioelectronics: Devices that can be worn on or near the body to monitor physiological parameters, such as heart rate monitors, fitness trackers, and smart textiles.

Bioelectronic medicine holds the potential to revolutionize the treatment of various diseases by providing targeted and personalized therapies. Researchers and engineers in this field continue to explore new ways to understand and interact with the body's electrical signaling for improved healthcare outcomes.

Given the emergency of accelerating the progress in new [neuromodulation](#) treatments (i.e., drug-resistant hypertension, autoimmune and degenerative diseases), collaboration between multiple fields is imperative.

A work of González-González et al. intends to foster multidisciplinary work and bring together different fields to provide the fundamental basis underlying Bioelectronic Medicine.

They reviewed from the biophysics of the [cell membrane](#), which they consider the inner core of neuromodulation, to patient care. They discuss the discovered mechanism of neurotransmission switching and how it will impact neuromodulation design, and provide an update on neuronal and glial basis in health and disease. The advances in biomedical technology have facilitated the collection of large amounts of data, thereby introducing new challenges in data analysis. They discuss the current approaches and challenges in high throughput data analysis, encompassing big data, networks, artificial intelligence, and internet of things. Emphasis will be placed on understanding the electrochemical properties of neural interfaces, along with the integration of biocompatible and reliable materials and compliance with biomedical regulations for translational applications. Preclinical [validation](#) is foundational to the translational process, and they discuss the critical aspects of such animal studies. Finally, they focus on the patient point-of-care and challenges in [neuromodulation](#) as the ultimate goal of bioelectronic medicine ¹⁾.

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González-González MA, Conde SV, Latorre R, Thébault SC, Pratelli M, Spitzer NC, Verkhatsky A, Tremblay MÈ, Akcora CG, Hernández-Reynoso AG, Ecker M, Coates J, Vincent KL, Ma B. Bioelectronic Medicine: a multidisciplinary roadmap from biophysics to precision therapies. Front Integr Neurosci. 2024 Feb 19;18:1321872. doi: 10.3389/fnint.2024.1321872. PMID: 38440417; PMCID: PMC10911101.

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