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A brief description on optogenetics

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DESCRIPTION

The term “optogenetics” was first coined in 2006 by Deseroth et al. And it broadly refers to an elegant approach that utilizes genetic engineering and optical technology to regulate and monitor the biological functions of isolated or *in situ* cells, tissues, organs, or organisms modified to express photosensitive proteins. Allows light to change fluorescent readout or sequential cellular biological functions for changes in biological activity. Launched optogenetics to disrupt and monitor biological functions with high spatotemporal resolution in conjunction with photosensitization of specific cell type, tissue or organ of interest, application of specific light stimuli and effective light detection systems. Biomedical applications of optogenetics have evolved from neuroscience, which requires the precise and rapid regulation of individual cells in the vertebrate brain to understand the underlying neural circuits of behavior and disease, rather than precise mechanisms targeting specific neuron populations are very slow in kinetics. Recent advances in optogenetics have opened up new avenues for drug discovery, especially in neuroscience. Physiological cellular assays probe functional phenotypes that link genomic data to patient health. Optogenetic tools, and especially all-optical electrophysiology tools, now provide ways to investigate cellular disease patterns with unprecedented output and information content. These methods promise to identify functional phenotypes associated with disease states and compounds that enhance cellular function regardless of whether the compound works directly on target or bypass mechanism. Drugs aimed at pharmacotherapies for genetically defined neuronal populations or circuits may not only provide more selective control over neural circuits, but may also lead to the development of neural circuit specific pharmacological therapies.

Historically, the concept of optogenetics for neuroscience was developed in 1979 with Francis Crick’s reference to the potential benefit of light in providing rapid spatiotemporal regulation to target specific neurons; however, neuroscientists at the time did not know how to apply such photosensitive proteins to neuroscience. However, microbiologists at the time were aware of the presence of photosensitive proteins that regulate ion flow across the plasma membrane in some microorganisms. Seminal developed in this field with a pioneering study demonstrating the potential of microbial opsins in light mammalian cells to express light-sensitive ion channel proteins and enable rapid, light-induced cell depolarization by tens of mV. Similarly, another guideline demonstrated the ability of light to modulate the electrical excitation of neurons with high spatial and transient resolution on the expression of microbial opsin in mammalian neurons. These studies led to the unprecedented development of optogenetics in various fields of neuroscience, but at that time this field was not much explored for cardiovascular research. Fortunately, a new field of cardiac optogenetics was established application of optogenetics to regulate the localization of pacemaker cells *in vivo* and developing zebra fish heart *in vitro* and adult mouse hearts.

The total energy for optogenetic-based therapy is affected by light scattering, the optical properties of the tissue, the level, pattern and activity of the opsin expression, and the physical properties of the host cells/tissue, making it difficult to estimate energy requirements for *in vivo* applications. Despite these observations, *in vitro* and *in vivo* studies have provided proof-

of-concept for the translational potential of cardiac optogenetics. In addition, the growing range of optogenetics in expanding the scope of *in vitro* and *in vivo* research into modulating the dynamic roles of signaling movements required during key biological functions such as cell signaling, differentiation and migration. Future research on such emerging scopes could greatly enhance the field's clinical success for cardiovascular regenerative medicine.

One of the highlights of the clinical application of cardiac optogenetics is the safe, consistent and uniform opsin expression in the human heart. Toxicity and immunogenicity concerns may arise with opsin expression in cardiac applications that require high opsin levels for strong photocurrents. In addition, safe and appropriate vehicle types and maintenance routes must be well established for the intended applications. In this regard, although many novel techniques have emerged to address such needs, they have not yet been validated in appropriate animal models. Current research is still in its infancy in the development and implementation of multidisciplinary approaches for the treatment of complex brain disorders, but the disproportionate potential is certainly clear as revolutionary tools such as those discussed here are contributing to the future.