# Electrochemical Interfaces in Plants

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Plant electrochemistry is the study of the electrochemical phenomena associated with biological cells and tissues in plants. It involves measurements of electrical potentials and currents on a wide variety of scales from single ion channels to whole plant tissues. Electrical properties of plant cells mostly derive from the electrochemical properties of their membranes. Electrophysiological study of plants includes measurements of the electrical activity of the phloem, xylem, plasmodesmata, stomata and particularly the electrical signals propagation along the plasma membrane. Action potentials are characteristic responses of excitation that can be induced by stimuli such as: applied pressure, chemical substances, thermal stimuli, electrical or magnetic stimuli, and mechanical stimuli. There are two major divisions of electrophysiology: intracellular recording and extracellular recording.

The electrical phenomena in plants have attracted researchers since the eighteenth century and have been discussed in a variety of books.[1-6] The identification and characterization of bioelectrochemical mechanisms for electrical signal transduction in plants would mark a significant step forward in understanding this underexplored area of plant physiology. Although plant mechanical and chemical sensing and corresponding responses are well known, membrane electrical potential changes in plant cells and the possible involvement of electrophysiology in transduction mediation of these sense-response patterns represents a new dimension of plant tissue and whole organism integrative communication. Plants continually gather information about their environment. Environmental changes elicit various biological responses. The cells, tissues, and organs of plants possess the ability to become excited under the influence of certain environmental factors. Plants synchronize their normal biological functions with their responses to the environment. The synchronization of internal functions, based on external events, is linked with the phenomenon of excitability in plant cells. The conduction of bioelectrochemical excitation is a fundamental property of living organisms.

Electrical impulses may arise as a result of stimulation. Once initiated, these impulses can propagate to adjacent excitable cells. The change in transmembrane potential can create a wave of depolarization which can affect the adjoining resting membrane. Action potentials in higher plants are the information carriers in intracellular and intercellular communication during environmental changes.

The conduction of bioelectrochemical excitation is a rapid method of long distance signal transmission between plant tissues and organs. Plants promptly respond to changes in luminous intensity, osmotic pressure, temperature, cutting, mechanical stimulation, water availability, wounding, and chemical compounds such as herbicides, plant growth stimulants, salts, and water potential. Once initiated, electrical impulses can propagate to adjacent excitable cells. The bioelectrochemical system in plants not only regulates stress responses, but photosynthetic processes as well. The generation of electrical gradients is a fundamental aspect of signal transduction.

All processes of living organisms that have been examined with suitable and sufficiently sensitive measuring techniques generate electric fields. The conduction of electrochemical excitation must be regarded as one of the most universal properties of living organisms. It arose in connection with a need for the transmission of a signal about an external influence from one part of a biological system to another. The study of the nature of regulatory relations of the plant organism with the environment is a basic bioelectrochemical problem, one that has a direct bearing on the tasks of controlling the growth and development of plants.

Conductive bundles of vegetative organisms support the movement of material and trigger the transfer of bioelectrical impulses. This feature motivates the harmonization of processes of the fundamental activity of vegetative organisms. Electrical impulses arise under the impact of various chemical compounds such as herbicides, plant growth stimulants, salts, and water. Physical factors such as electromagnetic or gravitational fields, mechanical wounding, and temperature effects also elicit electrical impulses.

The speed of propagation of action potentials depends upon the varying types of induced stress. Action potentials in higher plants may be the information carriers in intercellular and intracellular communication in response to environmental changes. A potential pathway for transmission of this electrical signal might be the phloem sieve-tube system, since it represents a continuum of plasma membranes. A phloem is an electrical conductor of bioelectrochemical impulses over long distances. Despite the existence of great amounts of information concerning electric effects in plants, their physiological and electrochemical mechanisms still remain poorly understood. Further investigation could provide information into the outlook of possible uses of these phenomena for improvement of agricultural technologies. These reasons provide significant basis to the importance of further profound investigations of electrical phenomena in plants.

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