MINI-REVIEW

Transplasma Membrane Electron Transport in Plants

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Abstract

The presence of transplasma membrane electron transport in a variety of plant cells and tissues is reported. It is now agreed that this property of eukaryotic cells is of ubiquitous nature. Studies with highly purified plasma membranes have established the presence of electron transport enzymes. Two types of activities have been identified. One, termed “Standard” reductase, is of general occurrence. The other, inducible under iron deficiency and relatively more active, is “Turbo” reductase. However, the true nature of components participating in electron transport and their organization in the plasma membrane is not known. The electron transport is associated with proton release and uses intracellular NAD(P)H as substrate. The electron flow leads to changes in intracellular redox status, pH, and metabolic energy. The responsiveness of this system to growth hormones is also observed. These findings suggest a role for electron flow across the plasma membrane in cell growth and regulation of ion transport. Involvement of this system in many other cellular functions is also argued.

Key Words: Transplasma membrane electron transport; plasma membranes.

Introduction

Considerable work has been done over the past 10 years to understand the nature of transplasma membrane electron transport and its relationship to intracellular electron donors, associated proton release, cell respiration, and growth in plants. Conflicting claims have been made vis-a-vis studies with mammalian cells. Since a number of reviews have appeared on this subject in recent years (Crane et al., 1985; Moller and Lin, 1986; Bienfait and Lütte, 1988; Crane, 1989; Crane and Barr, 1989), a comprehensive survey of the

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literature is not intended. My purpose in this article is to sketch out a possible role for such an electron transport from the data these studies have provided. I begin by asserting that the presence of redox activity at the surface of plant cells provides an additional mechanism to control its metabolism.

**Electron Transport**

The presence of transplasma membrane electron transport in plants was reported by Craig and Crane (1981) as a preliminary demonstration of extracellular ferricyanide reduction in cultured carrot cells, and subsequently established to be an enzymatic process (Barr et al., 1985a). In the meantime, a number of laboratories provided evidence for the existence of such a reaction in a wide variety of plant cells including yeast (Crane et al., 1982; Yamashoji and Kajimoto, 1986a), plant roots (Federico and Giartosio, 1983; Sijmons and Bienfait, 1983; Roemheld and Marschner, 1983; Rubinstein et al., 1984; Boettger and Hilgendorf, 1988; Buckhout et al., 1989), tobacco cells (Barr et al., 1984), Elodea (Ivankina and Novak, 1981; Marré et al., 1988), Anacystis nidulans (Craig et al., 1984), Lemma gibba (Lass et al., 1986), sycamore cells (Blein et al., 1986), angiosperm parasites (Revis and Misra, 1986), mesophyll cells of Asparagus (Neufeld and Bown, 1987) and guard cells of Vicia faba (Vani and Raghavendra, 1989). In most cases ferricyanide is used as electron acceptor because of its impermeability to the plasma membrane and the relative ease with which its reduction is monitored. Sijmons and Bienfait (1983) used extracellular Fe(III) • EDTA as electron acceptor at the root surface of iron-deficient bean plants. Further studies helped to distinguish two types of redox activities (Bienfait, 1985; Bienfait and Lütge, 1988). One is induced by iron deficiency and is present in dicots and nongrass monocots (but see Rensch and Boettger, 1988) and is called the “Turbo” system. The second type, generally present in all plant materials, is constitutive in nature and is called the “Standard” system. The high reducing activity of roots as observed in bean plants, attained upon iron deficiency, is able to reduce many other electron acceptors (Sijmons and Bienfait, 1983; Buckhout et al., 1989). The use of ferricyanide as the sole electron acceptor in most of the studies appeared to be a serious limitation to Luethen and Boettger (1988), and they showed that hexachloroiridate(IV) could be used as a new electron acceptor for the plasmalemma redox system in maize roots. The high redox potential for hexachloroiridate \( (E_0 = 0.87) \) makes it a preferred electron acceptor under certain conditions. For example, the slower rate of ferricyanide reduction by yeast cells encouraged Yamashoji and Kajimoto (1986a) to use the catalytic action of vitamin K, as a redox mediator for the reduction of ferricyanide by Saccharomyces cells. Similarly,