

The problems of living in the sea: the uptake of inorganic carbon and nutrients in *Posidonia oceanica* (L.) Delile.

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The genus *Posidonia* exhibits a peculiar geographical distribution. It is composed by nine species, eight of which are distributed along the Australian coasts and only one, *Posidonia oceanica* (L.) Delile, is a Mediterranean endemism. Like other angiosperms, *P. oceanica* has adapted secondarily to the marine environment, and has developed anew mechanisms to face a liquid and alkaline medium (pH 8.2) that contains a high salt concentration (0.5 M NaCl). The liquid environment limits the diffusive flow of CO₂ and nutrients and, furthermore, CO₂ dissolves in water and forms HCO₃⁻, the more abundant chemical species of inorganic carbon at pH 8.2.

Like other green plants *P. oceanica* uses CO₂ for photosynthesis. In addition, this species shows a transport system in the plasma membrane for the direct uptake of HCO₃⁻, that uses H⁺ as the driving ion. The addition of HCO₃⁻ provokes a transient hyperpolarization of the plasma membrane followed by a depolarization; at the same time, the cytosolic pH (pH_c) becomes transiently acidic and next it gets alkaline, and remains alkaline throughout the HCO₃⁻ pulse. The alkalization of the pH_c is due to the cytosolic accumulation of HCO₃⁻ and OH⁻ and it is sensitive to the addition of ethoxzolamide, an inhibitor of the internal carbonic anhydrase. The increase of negative charges in the cytosol triggers the release of Cl⁻ to recover the values of the resting membrane potential. The plasmalemma of *P. oceanica* exhibits a reduced Na⁺ permeability and shows a H⁺/Na⁺ antiporter activity that keeps low and relatively constant the cytosolic Na⁺ concentration (17 mM Na⁺). The inside negative membrane potential (-178 mV) and the low [Na⁺]_c generate a tremendous Na⁺-motive force that this plant uses for the high affinity transport of NO₃⁻ (Km= 21 μM), and of the amino acids alanine (Km= 37 μM) and cysteine (Km= 10 μM). The uptake of these compounds shows a strict dependence on the presence of Na⁺ in the medium. Moreover, the addition of micromolar concentrations of NO₃⁻, alanine or cysteine gives rise to millimolar increments of [Na⁺]_c. Experiments with external LIX pH mini-electrodes show that the uptake of glucose is not Na⁺ but H⁺ dependent. Thus, the model for the ion transport energization in this species seems to be mixed, with a H⁺-ATPase as the primary pump and a series of carriers that use H⁺ (HCO₃⁻, Na⁺, glucose) or Na⁺ (NO₃⁻, amino acids) as the driving ion.

Project Funding: CTM 2011-30356 (MEC)