GÖTEBORGS UNIVERSITET

# ION TRANSPORT IN CHLOROPLASTS WITH ROLE IN REGULATION OF PHOTOSYNTHESIS

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Akademisk avhandling för filosofie doktorsexamen i Naturvetenskap med inriktning Biologi, som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras fredagen den 2 oktober kl. 10.00 i Hörsalen, Institutionen för biologi och miljövetenskap, Carl Skottsbergs gata 22B, Göteborg.

Fakultetsopponent: Professor Giovanni Finazzi, Laboratoire de Physiologie Cellulaire Végétale, Université de Grenoble, France

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# Ion transport in chloroplasts with role in regulation of photosynthesis


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### ABSTRACT

Photosynthesis is the primary energy source of almost all ecosystems on Earth. Oxygenic photosynthesis has appeared approximately 2.4 billion years ago and has since then gradually evolved into the complex process that land plants, algae and cyanobacteria perform today. During the course of evolution, these organisms have also developed mechanisms to improve photosynthetic efficiency, to cope with changes in the environment, and effectively use the available resources.

The environment in which photosynthetic organisms grow contains numerous ionic compounds. These compounds are taken up and used in numerous important processes, including photosynthesis in chloroplasts. As in the rest of the cell, specialized proteins named channels and transporters mediate ion transport across membranes and control ion homeostasis in chloroplasts.

The work presented in this thesis addresses the role in regulation of photosynthesis of ion channels and transporters from the chloroplast inner envelope **(Paper I)**, and the thylakoid membrane **(Paper I to V)** of *Arabidopsis thaliana*. Potassium ion fluxes mediated by the chloroplast $K^+/H^+$ antiporters KEA1, KEA2 and KEA3 regulate the composition of the proton motive force (PMF) across the thylakoid membrane that activates photoprotective mechanisms (NPQ) **(Paper I)**. In **Paper II**, an Arabidopsis mutant named *pam71* is found disturbed in photosystem II efficiency and the adjustment of PMF, due to altered $Ca^{2+}$ homeostasis in the chloroplast. In **Paper III**, it is shown that the thylakoid phosphate transporter PHT4;1 affects the availability of phosphate for ATP synthesis, and also alters NPQ activation kinetics and PMF composition. A novel thylakoid voltage-dependent chloride channel (VCCN1) is identified in **Paper IV**, and shown to affect PMF and NPQ activation upon illumination and after rapid shifts from low light to high light. In **Paper V** it is shown that the thylakoid chloride channel CLCe contributes to the modulation of PMF as well as to the regulation of electron transfer and state transition.

Taken together, the findings of this thesis bring novel mechanisms of anion and cation transport across the thylakoid membrane and the chloroplast inner envelope with role in regulation of photosynthesis.