INTRODUCTION

Protein kinases and protein phosphatases are major post-translational regulators of numerous cellular processes. These enzymes regulate metabolic pathways and are intimately involved in cellular signaling networks. There are over 1000 genes (Wang et al., 2003) in Arabidopsis that encode protein kinases and another 112 genes (Kerk et al., 2002) that encode protein phosphatase catalytic subunits (Table 1). While Arabidopsis contains orthologs of many of the protein kinases found in other eukaryotes, Arabidopsis, and most likely plants in general, also has an unique set of protein kinases. These include the receptor-like protein kinases and related cytoplasmic protein kinases, the calcium-dependent protein kinases and several members of the putative mitogen-activated protein kinase kinase kinases (Wang et al., 2003). The Arabidopsis protein phosphatase catalytic subunits encompass orthologs of the majority of the protein phosphatases found in other eukaryotes. However, the type 2C protein phosphatase family is notably large in number in Arabidopsis (Kerk et al., 2002). The distinct representation of genes encoding protein kinases and phosphatases in the Arabidopsis genome, relative to other eukaryotes, is a reflection of the evolutionary history of plants. The understanding that plants have developed cellular communication systems and basic developmental mechanisms independently from other multicellular eukaryotes (Meyerowitz, 2002) explains why plants have evolved a unique collection of enzymes that regulate protein phosphorylation. Indeed, we pointed out over a decade ago (Stone and Walker, 1995), before the exceptionality of the Arabidopsis kinome was fully appreciated, that plants have an unique repertoire of protein kinases that control the early steps in signaling pathways which is reflective of the unique developmental and environmental responses that govern plant growth and development.

Progress in understanding the role of protein phosphorylation in plant development and environmental responses has made some significant steps in the past few years. While much of the research is focused on Arabidopsis, important insights are also being made in other plant species. Indeed, as genomic and functional data becomes more complete for other plant species, we should be better equipped to answer questions about the fundamental mechanisms plants employ to control their growth, development and responses to environmental stimuli and the role that protein phosphorylation plays in these processes.

This chapter on the protein phosphatases and protein kinases of Arabidopsis takes a gene-centric approach to summarize our current understanding of the functional roles of these important mediators of cellular processes. We have tried to focus on the unique aspects of protein kinases and phosphatases.

RECEPTOR-LIKE PROTEIN KINASES IN ARABIDOPSIS

Receptor-like protein kinases (RLKS) are defined by the presence of a signal peptide, an extracellular domain, a transmembrane domain region that anchors the receptor in a cell membrane, and a carboxy-terminal Serine/Threonine (Ser/Thr) kinase domain. Analysis of the Arabidopsis genome reveals there are at least 610 members in the RLK family (Shiu and Bleecker, 2001), thereby representing more than 2% of the predicted Arabidopsis coding sequences. Due to their large numbers and their diverse functions with roles in development, pathogen resistance, and hormone perception, RLKS have become a target of many investigations. Several reports describing the function of RLKs have been released since the cloning of the Arabidopsis RLK, ERECTA (ER), in 1996 (Torii et al., 1996).