RNA silencing and its application in plants

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RNA silencing, also known as gene silencing, is a sequence-specific RNA degradation mechanism that is highly conserved in eukaryotic organisms, including plants, animals, nematodes, and fungi. In eukaryotes, RNA silencing has a pivotal role in the regulation of development, genome stability, and responses to biotic and abiotic stresses through controlling gene expression. RNA silencing has become the focus of many studies in biology since its discovery in the 1990s. In plants, RNA silencing can be divided into post-transcriptional gene silencing (PTGS) and transcriptional gene silencing (TGS), on the basis of the target of action. PTGS targets mRNA for sequence-specific degradation or inhibition of translation, while TGS represses transcription by methylating specific regions of gene promoters and histone proteins, resulting in chromatin remodeling. Both PTGS and TGS are recognized as a major immune system targeted on plant viruses. Virus infection of plants leads to the accumulation of a large quantity of virus-derived small interfering RNAs (vsiRNA) that mediate the degradation (PTGS) or transcriptional repression (TGS) of the virus genome. Consequently, during the co-evolution with their hosts, plant viruses have evolved to encode one or more viral suppressors of RNA silencing (VSR) to counteract and escape from plant RNA silencing defense mechanisms. Recently, a number of studies have shown that VSRs can interact with key components of the host RNA silencing pathway, leading to the suppression of host defenses and interference of normal host physiology. Therefore, studies on the origin and composition of vsiRNA, its potential role in gene regulation, and the modes of action of VSRs, will

facilitate a better understanding of the complex interplay between virus pathogen and plant host during co-evolution. This, in turn, may provide new insights and measures for the control of plant viral diseases.

With increasing knowledge of RNA silencing mechanisms, it has been used for the validation of gene functions and molecular breeding for virus resistance in plants. One application of RNA silencing is virus-induced gene silencing (VIGS), in which a recombinant virus harboring a cDNA fragment of a plant gene triggers sequence-specific degradation of the endogenous gene upon virus infection. The effects of silencing a target gene can be further inferred by measuring the phenotypic or physiological changes of infected plants. VIGS has been successfully adopted for the identification and validation of gene functions in a variety of monocotyledon and dicotyledon plants. Further understanding of the mechanisms for RNA silencing and development of new VIGS vectors will certainly assist gene function analysis in more host plants, especially among those not readily amenable to traditional genetic approaches. In addition, RNA silencing-derived approaches also offer an effective means for pest control. Genetic engineering for virus resistance mediated by RNA silencing is highly specific, environmentally friendly, and capable of targeting multiple virus pathogens. Moreover, examples of RNA silencing-mediated crop resistance against insect, fungus, and nematode infections have been recently described. Overall, RNA silencing technology has emerged as a promising strategy to create transgenic germplasm resources for sustainable pest control.

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Biographical Sketch

Dr. Zhou XuePing is currently a Professor and Executive Dean of College of Agriculture, Zhejiang University. He also serves as Vice President of the Chinese Society for Plant Pathology, a member of the International Committee on Taxonomy of Viruses, a member of the International Society for Plant Pathology, Associate Editor of Virology Journal, editor of the Journal of Biomedicine and Biotechnology, and editor of Frontiers in Plant Microbe Interaction. His research interests include plant virus etiology, molecular aspects of virus pathogenesis, and genetic engineering for virus resistance. Dr. Zhou has published more than 200 papers in numerous peer-reviewed journals, including *Genes and Development*, *Plant Cell*, *PLoS Pathogens*, *Plant Journal*, *Plant Physiology*, and *Journal of Virology*. He has established biological, serological, and molecular diagnostic methods for over 20 plant viruses and identified more than 30 novel virus species infecting a wide range of crops and weeds in China. His discovery that a novel recombinant virus between two different geminivirus species can cause disease outbreak in nature is featured in a *New Scientist* article entitled “Lethal hybrid decimates harvest”. Dr. Zhou’s laboratory has also characterized the molecular function of geminivirus-associated DNA satellites and adapted them as virus-induced gene silencing vectors.

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