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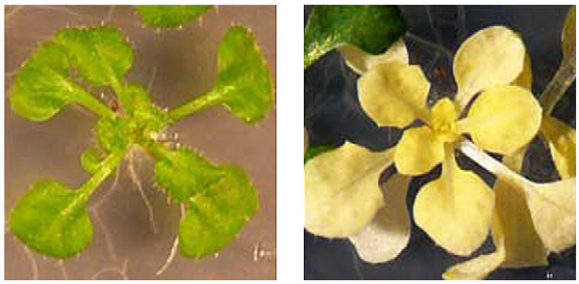
IN BRIEF

A New Thioredoxin Is Involved in Plastid Gene Expression

Thioredoxins (TRXs), small proteins with disulfide reductase activity, are important players in redox regulation of protein function (the reversible modification of thiol groups that affects protein activity; reviewed in Buchanan and Balmer, 2005). First described as regulating chloroplast photosynthetic enzymes, TRXs are now known to participate in redox regulation in virtually all organisms and are especially abundant in plants, with at least 20 TRXs in *Arabidopsis thaliana* (reviewed in Gelhaye et al., 2005). In addition to their roles in photosynthesis, TRXs are involved in a wide variety of processes, including protein assembly, DNA replication, and sulfur metabolism, among others. Now, **Arsova et al. (pages 1498–1515)** have identified a previously unrecognized TRX that is required for chloroplast development and could be a link between plastid transcription and light signals.

This protein, which they name TRX *z*, is distantly related to other known TRXs but contains the active site signature typical of TRXs and has in vitro disulfide reductase activity. Furthermore, Arsova et al. found TRX *z* homologs in both monocots and dicots, indicating that it represents a widespread class of thioredoxin. All TRX *z* proteins examined had predicted chloroplast transit peptides, and the authors showed that the *Arabidopsis* sequence targeted fusion proteins to plastids. Both an *Arabidopsis* T-DNA knockout of TRX *z* (see figure) and *Nicotiana benthamiana* plants in which TRX *z* levels were diminished via virus-induced gene silencing showed chlorosis and abnormal thylakoid development. Intriguingly, TRX *z* was previously identified in a proteomic study as a component of transcriptionally active chromosomes in plastids (Pfalz et al., 2006). When Arsova et al. checked for changes in chloroplast gene expression in TRX *z* mutant or silenced plants, they found lower expression specifically of those genes transcribed by the plastid-encoded plastid RNA polymerase (PEP) and higher expression of those transcribed by the nuclear-encoded RNA polymerase.

The authors went on to look for TRX *z* targets and identified two plastid fructokinase-like proteins, FLN1 and FLN2. They further showed that the interaction between TRX *z* and the FLN proteins is thiol dependent and involves a conserved double Cys motif in the FLNs. Strikingly, both FLNs also were identified as components of transcriptionally active plastid chromosomes (Pfalz et al., 2006). When Arsova et al. examined plants with reduced levels of FLNs, they found phenotypes very similar to those of the TRX *z* mutant and silenced plants: chlorosis and disrupted thylakoid development. In addition, PEP-dependent gene expression was diminished. Interestingly, neither FLN showed fructokinase activity; it appears that instead they have gained a new function in plastid transcription. Overall, Arsova et al. provide a remarkably complete characterization of a previously unknown TRX and offer compelling evidence that TRX *z* and the FLN proteins are involved in PEP-dependent transcription, thus paving the way for future studies on redox regulation of plastid transcription.



The *Arabidopsis* TRX *z* knockout mutant is impaired in chloroplast development. Wild-type (left) and chlorotic *trx z* mutant (right) plants are shown after 3 weeks of growth on plates supplemented with sucrose. (*Reprinted from Arsova et al. [2010]*.)

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