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Short Communication

Functional equivalence between plant PRORP1 and bacterial RNase P Ribonucleic acid (RNA) raises questions on control and recognition mechanisms

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In this short communication we consider the recent results of the successful substitution of the *Escherichia coli* RNase P ribonucleic acid (RNA) with the *Arabidopsis* protein enzyme PRORP1. The interest of this result lies in the fact that a plant protein-only enzyme is able to rescue lethal knock-down of the RNA component of bacterial RNase P. Such findings raise interesting questions as well as theoretical hypotheses as to the control and recognition mechanisms at play in the experimental situation, thus emphasizing the importance of informational processes beside pure physical-chemical ones.

Keywords: *Arabidopsis thaliana*, *E. coli*, functional equivalence, information control, PRORP, RNase P RNA.

INTRODUCTION

A recent interesting paper by Gobert et al. (2010) reported, among other insightful findings, the fusion of *Arabidopsis thaliana* PRORP1 c deoxyribonucleic acid (DNA) to the bacterial *spac* promoter in plasmid pDG148, and the ability of PRORP1 to rescue the lethal knock-down of RNase P ribonucleic acid (RNA) in the *Escherichia coli* mutant strain BW. It has been shown that PRORP1 successfully perform its function in *E. coli*, deploying the RNase P activity that it has in the wild (that is, in *Arabidopsis*) and that in *E. coli* is normally performed by its ribonucleoprotein.

The experimental results by Gobert et al. (2010) show that the protein PRORP1 and the ribozyme RNase P, that are significantly different from a chemical and structural point of view, are functionally equivalent, in the sense proposed in the theoretical paper by Auletta et al. (2008), according to which two different biochemical pathways are functionally equivalent if they are able to bring to the same vital outcome (in the case under consideration here, to have mature tRNAs for protein synthesis). Indeed, the RNase P RNA alone is responsible for the catalysis of the 5' tRNA maturation in bacteria, whereas *Arabidopsis* PRORP1 is a conventional protein enzyme. At the end of their paper, Gobert et al. (2010) make the point "that a plant protein enzyme can be adapted to a bacterial tRNA biogenesis machinery that has co-evolved with a ribozyme-type RNase P".

DISCUSSION

Gobert et al. (2010) point out that the actual chemistry of PRORP1 and RNase P catalysis may turn out to be similar and draw attention to the work of Steitz and Steitz (1993), who have proposed a general two-metal ion mechanism for both RNA- and protein-based metallonucleases. In our view, this raises the crucial questions about (i) the control and (ii) the recognition mechanisms involved after the substitution of the bacterial RNase P with PRORP1 in *E. coli*. *E. coli* RNase

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Abbreviations: RNA, Ribonucleic acid; **DNA,** deoxyribonucleic acid.

P has two components: an RNA chain (M1 RNA) and a polypeptide chain, called C5 protein. The M1 RNA alone is fully able to perform the cleavage *in vitro* (Guerrier-Takada et al., 1983; Kirsebom 2007). *In vivo*, both components are necessary in order for the ribozyme to work. This implies that, although the chemistry of the catalysis may be similar in the two cases, the control mechanism, involving the RNase P C5 protein (Sun et al., 2006), could still be different after the substitution. As shown in Gobert et al. (2010), what is replaced in *E. coli* is only the RNase P RNA, and not the C5 protein. As the protein component plays a role in the regulation of RNase P activity, we think that it could be interesting to verify if this component has also some role in the regulation of the PRORP1 activity. Therefore, it would be worth checking whether or not, in *E. coli* cells, there is some interaction between the native C5 protein of RNase P and the complemented *Arabidopsis* PRORP1.

Moreover, as reported in Gobert et al. (2010), the efficiency of PRORP1 in *E. coli* is less than the native RNase P, although the protein is copiously produced. Might this decrease in efficiency be a witness of higher sophisticated control mechanisms in the *Arabidopsis* that are instead absent in *E. coli*? A decrease in efficiency in some vital reaction may obviously be a life threat, as the rate in which such reactions are performed may be crucial for survival. Would the bacterium react somehow trying to compensate such a reduction in efficiency? To investigate this matter in the case of the substitution of RNase P with PRORP1 in *E. coli* might provide interesting insights. Besides, the question arises of whether or not the bacterial cell recruits other bio-molecules within the tRNA biogenesis machinery for controlling PRORP1 in place of the native RNase P.

It is also possible that the recognition mechanism and the features of the enzymes that aid the binding of the active domain to the pre-tRNA that has to be cleaved (that is, the substrate of both PRORP1 and RNase P) is different in the two cases. The authors do not provide a detailed analysis of the recognition process by PRORP1. However, it is very unlikely that it is the same as for RNase P, since the latter recognizes its target molecule through base-pairing (a possibility obviously prevented for a protein like PRORP1). It is also stressed that the protein PRORP1 is able to cleave the t-element of the gene *nad6* transcript, which lacks an anticodon arm, suggesting that the latter is not required for substrate recognition by PRORP1. Does this imply that the specific recognition mechanism involved here is not relevant for cleavage? As a matter of fact, the protein is involved in a variety of endonucleolytic processes. As mentioned, moreover, as far as pre-tRNA maturation is concerned, *E. coli* RNase P RNA alone is responsible for cleavage *in vitro*. Since such a molecule requires, *in vitro*, higher concentration of Mg^{2+} than the physiological concentration, the RNase P protein component (C5 protein) may serve the task of increasing the rate of cleavage also with lower ions concentration *in vivo*, being not indispensable for the cleavage chemistry as such. May the decrease in efficiency observed after the substitution be a consequence of differences in the recognition processes? It would be worth investigating how PRORP1 recognizes the pre-tRNA substrate.

Results like those published by Gobert et al. (2010) raise, in our opinion, issues of general biological interest. Indeed, they may suggest that, besides the chemistry of the reactions, factors like constraints as well as mechanisms of control and/or compensation should be taken more extensively into account in molecular biology (Auletta, 2010). In particular, it is difficult to enquire about control mechanisms without assuming the relevance of truly informational processes. If the control mechanism deals ultimately with functional equivalence classes, that is, functions that can be performed through different chemical pathways, then this cannot be achieved without information control, that is, a control in which the general vital significance of certain signals and operations is crucial and not the chemical details. We suggest that this line of research could turn out to be promising for throwing light on certain aspects that up to now have been underestimated in this field of studies.

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