The naked and the dead: the ABCs of gymnosperm reproduction and the origin of the angiosperm flower.

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Abstract

20 years after establishment of the ABC model many of the molecular mechanisms underlying development of the angiosperm flower are relatively well understood. Central players in the gene regulatory network controlling flower development are SQUA-like, DEF/GLO-like, AG-like and AGL6/SEP1-like MIKC-type MADS-domain transcription factors. These provide class A, class B, class C and the more recently defined class E floral homeotic functions, respectively. There is evidence that the floral homeotic proteins recognize the DNA of target genes in an organ-specific way as multimeric protein complexes, thus constituting 'floral quartets'. In contrast to the detailed insights into flower development, how the flower originated during evolution has remained enigmatic. However, while orthologues of all classes of floral homeotic genes appear to be absent from all non-seed plants, DEF/GLO-like, AG-like, and AGL6-like genes have been found in diverse extant gymnosperms, the closest relatives of the angiosperms. While SQUA-like and SEP1-like MADS-box genes appear to be absent from extant gymnosperms, reconstruction of MADS-box gene phylogeny surprisingly suggests that the most recent common ancestor of gymnosperms and angiosperms possessed representatives of both genes, but that these have been lost in the lineage that led to extant gymnosperms. Expression studies and genetic complementation experiments indicate that both angiosperm and gymnosperm AG-like and DEF/GLO-like genes have conserved functions in the specification of reproductive organs and in distinguishing male from female organs, respectively. Based on these findings novel models about the molecular basis of flower origin, involving changes in the expression patterns of DEF/GLO-like or AGL6/SEP1/SQUA-like genes in reproductive structures, were developed. While in angiosperms SEP1-like proteins play an important role in floral quartet formation, preliminary evidence suggests that gymnosperm DEF/GLO-like and AG-like proteins alone can already form floral quartet-like complexes, further corroborating the view that the formation of floral quartet-like complexes predated flower origin during evolution.

Identifier

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