The phylogenetic distribution of chromalveolate plastids favors independent tertiary origins

Red algal descended plastids are found in clearly polyphyletic taxa, each nested within lineages containing aplastidic relatives (Figure 1). Moreover, photosynthetic taxa frequently occur at derived positions, with multiple heterotrophic groups branching ancestrally. The number of independent losses required to account for this pattern is unreasonable (see above); it is far more parsimonious to presume several tertiary transfers (Figure 1).

It is clear that plastid evolution in eukaryotes has resulted in a complex phylogenetic pattern with many conflicts among molecular data. Although the chromalveolate model cannot be rejected formally, neither should it serve as the a priori framework for interpreting plastid character evolution, endosymbiotic gene transfers or other intragenomic phylogenetic conflicts. We argue that an alternative model of serial tertiary endosymbioses is more consistent with available data, and should be taken into account in phylogenomic investigations of eukaryotic diversity.

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References


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Letters Response

Reply to Bodył, Stiller and Mackiewicz: “Chromalveolate plastids: direct descent or multiple endosymbioses?”

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Bodył, Stiller and Mackiewicz [1] have written in response to our recent Opinion piece [2] in which we discussed progress and problems in resolving the deepest branches of the eukaryotic tree using phylogenomics. The focus of our paper was the challenge of inferring accurate phylogenies from multigene data sets that include sequences from organisms that have acquired plastids by secondary (i.e. eukaryote-eukaryote) endosymbiosis and whose nuclear genomes are a composite of genes from two (or more) distinct nucleocytoplasmic lineages. We highlighted the controversial eukaryotic supergroup ‘chromalveolates’ as a case in point and discussed changing views on the evolution of photosynthesis in this diverse lineage in light of recent large-scale phylogenomic studies. Bodył, Stiller and Mackiewicz [1] take issue with the chromalveolate hypothesis [3] and our views on the tempo and mode of

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plastid gain and loss among chromalveolates which aim to minimize secondary endosymbiotic events. They favor a model of ‘serial plastid transfer,’ whereby red algal-derived secondary plastids have been passed between ‘chromalveolate’ taxa on multiple occasions by tertiary endosymbiosis.

We agree with several of the points raised by Bodyl, Stiller and Mackiewicz [1]: the apparent conflicts between molecular data sets brought to bear on the chromalveolate hypothesis need to be taken seriously, and alternative hypotheses for the spread of plastids among ‘chromalveolate’ lineages should not be discounted [4,5]. However, it should be pointed out that the recent phylogenomic analysis [6] cited by the authors as indicating ‘that Archaeoplastida is descended from the same ancestor as chromalveolate taxa’ [1] was not published at the time we wrote our article. Indeed, we would caution against unconditional acceptance of even the most strongly supported multigene phylogenies, such as the 135-gene Burki et al. analysis [6]. To be sure, such trees provide an important framework for assessing plastid gain/loss scenarios, but they are not immune to phylogenetic artifacts (e.g. [7]) and might strongly support erroneous relationships for the very reasons we discussed [2].

Finally, Bodyl, Stiller and Mackiewicz argue that complete plastid loss is ‘exceedingly rare’ [1]. We agree, but rather than view the recent data suggesting a plastid relict in the alveolate Oxyrrhis [8] and the discovery of a remnant plastid in Perkinsus [9] as evidence against the chromalveolate model, we consider such findings as providing data where it was previously missing. Cryptic mitochondria [10,11] and plastids [12] have been discovered time and time again in organisms once thought to lack them: demonstrating the absence of an organelle is extraordinarily difficult, but it only takes a single discovery to fill in a key gap and push the origin of a particular organelle further back in time. In the case of dinoflagellates, Bodyl has argued previously for the recent tertiary endosymbiotic origin of the peridinin plastid [5,13], but the above-mentioned discoveries in Oxyrrhis [8] and Perkinsus [9] now lead him to conclude that the ancestor these organisms shared with dinoflagellates was photosynthetic (Figure 1 in Ref. [1]). We predict that further investigation, particularly of poorly studied non-photosynthetic lineages within the alveolates (e.g. colpodellids, gregarines) and heterokonts (e.g. bicosoecids, labyrinthulids) will reveal additional examples of previously undescribed plastid relics. With each new piece of information, the process that gave rise to plastids in both non-photosynthetic and photosynthetic lineages will need to be reconsidered in the context of the most comprehensive and rigorous multigene phylogenies we have available to us.

**References**


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