Complex origin of tetrapyrrole biosynthesis in algae with secondary plastid

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Tetrapyrroles are organic compounds essential for a cellular life. So far, only a single organism has been found to survive without heme. Living organisms are either synthesizing tetrapyrroles or they have to obtain them from surrounding environment, host or prey. We showed that the composition of the biosynthetic pathway is substantially shaped by passed endosymbiotic evens in eukaryotes. We map the pathway in phototrophic eukaryotes, particularly in algae with secondary or other advanced plastids, investigating origins of involved enzymes and predicting their location in the euglenophyte *Euglena gracillis*, the chlorarachniophyte *Bigelowiella natans*, the cryptophyte *Guillardia theta*, the dinoflagellate with green secondary plastid *Lepidodinium chlorophorum*, and dinoflagellates bearing diatom endosymbiont (also called "dinotoms") – *Glenodinium foliaceum*, *Kryptoperidinum foliaceum* and *Durinskia baltica*. It appears that chlorarachniophytes and euglenophytes still possess two independently operating tetrapyrrole pathways with the first common precursor δ-aminolevulinic acid synthesized by the C4 (Shemin) pathway using a single mitochondrially located ALA synthase (ALAS), and by the plastid located C5 pathway using consecutive enzymes glutamyl-tRNA reductase (GTR) and glutamate-1-semiladehyde 2,1 aminomutase (GSA-AT), respectively. We propose that such arrangement of the pathway was ancestral for all phototrophic eukaryotes. Other algae show partial (cryptophyte) or total (dinoflagellates) reduction of the redundant mitochondrially-cytosolic pathway. In the case of dinotoms, two redundant pathways are present in the cell, however, both are plastid located, suggesting a presence of the two plastids of different origins in the dinotom cell. Although *L. chlorophorum* and *B. natans* contain chlorophyte-derived plastids, enzymes involved in tetrapyrrole biosynthesis are dominantly of rhodophyte origins.