

# Why is the Land Green and the Ocean Red?

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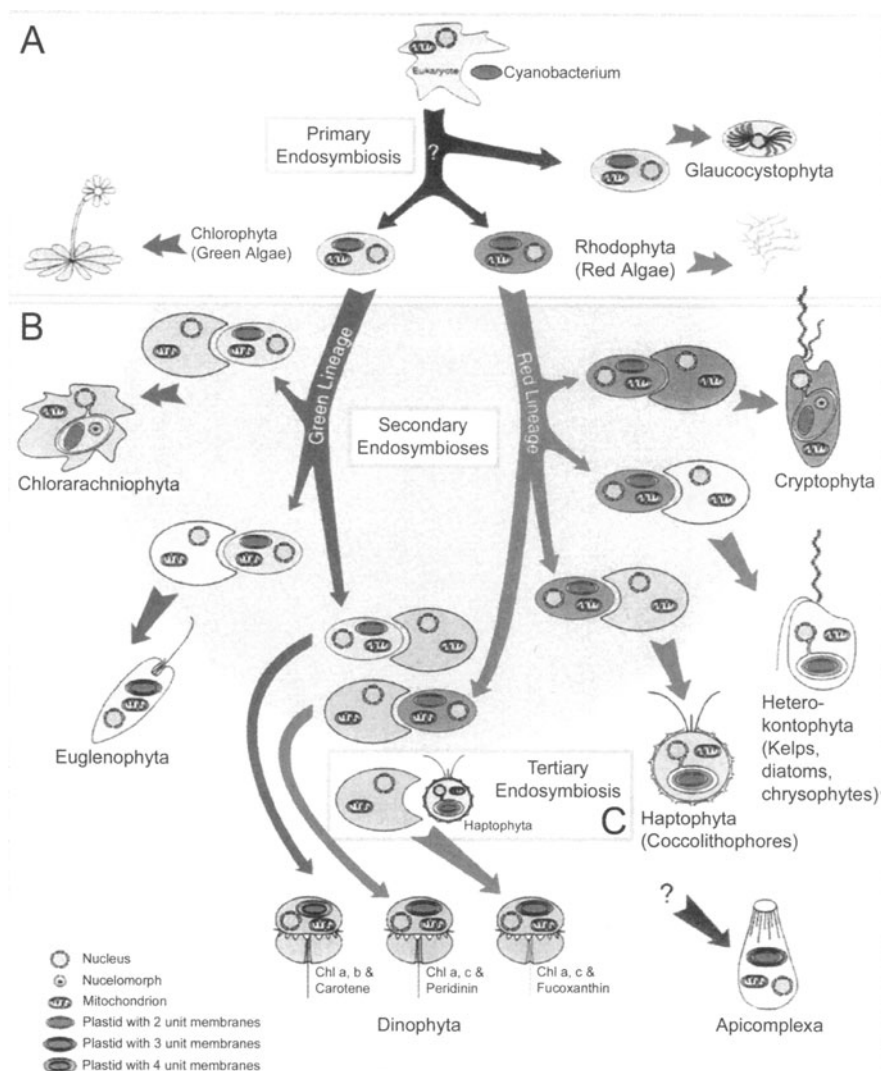
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## Summary

Fossil evidence suggests that during the Paleozoic Era, green algae dominated eukaryotic phytoplankton taxa. One branch of this originally aquatic clade colonized terrestrial ecosystems to form what would become a green hegemony on land – with few exceptions, terrestrial plants are green. In contrast to land plants, contemporary oceanic phytoplankton are represented by relatively few species that are phylogenetically deeply branching. Since the Triassic Period, the major taxa of eukaryotic phytoplankton preserved in the fossil record have been dominated by organisms containing plastids derived from the “red”, chlorophyll *c* containing algal clade. The ocean became “red” sometime during the Triassic or early Jurassic periods. The evolutionary success of the red line in Mesozoic and younger oceans appears related to changing oceanic conditions. In this chapter, we briefly explore the evolutionary processes and ecological traits that potentially led to the success of the red line in the oceans.

## Introduction

All eukaryotic photosynthetic organisms are oxygenic (Falkowski and Raven 1997). The apparatus responsible for the photochemical production of oxygen is contained within distinct organelles, called plastids, that retain a complement of DNA, but are incapable of self-replication without supporting genes that are resident in the host cell's nuclear genome. Based on small subunit ribosomal RNA



**Fig. 1.** The evolutionary inheritance of red and green plastids in eukaryotic algae. The ancestral eukaryotic host cell appropriated a cyanobacterium to form a primary photosynthetic symbiont. Three groups split from this primary association: one formed a “green” line, one a “red” line and the third is represented by the Glaucocystophyta. One member of the green line was the progenitor of higher plants. Two members of the extant green line form secondary eukaryotic associations, however neither of these taxa are ecologically significant. Several, independent secondary associations were formed from the primary red symbiont, including the haptophytes, heterokonts, and chrysophytes. The dinoflagellates appropriated plastids from both red and green lineages; however, the dominant group in the contemporary ocean is overwhelmingly red. (Adapted from Delwiche (1999), with permission).