Algae of Australia

Introduction
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Plates 1–6, 18, 20, 21, 26, 27, 31–34, 39, 40, 42, 43, 45, 47, 51, 52.
CHLORARACHNIOPHYTA:
CHLORARACHNIOPHYCEAE

Geoffrey I. McFadden

The type species of the Chlorarachniophyceae, Chlorarachniun repons Geitler, was described by Lothar Geitler in 1930 from Las Palmas in the Canary Islands (Fig. 46). The cells are amoeboid with pseudopodia interconnecting as many as 150 cells into a reticuloplasmodial continuum (Geitler, 1930). The reticulopodia (interconnecting pseudopodia from separate cells) entrap bacteria, flagellates and eukaryotic algae which are transported to the cell and digested (Geitler, 1930). An extraordinary feature of Chlorarachniun is the presence of grass-green plastids with a pyrenoid. The combination of green plastids and reticuloplasmodial habit presented a systematic dilemma to Geitler who considered that Chlorarachniun could be either a rhizopodial euglenoid or a heterokont (Geitler, 1930).


Chlorarachniophytes are now known to have arisen through a process termed "secondary endosymbiosis" in which a eukaryotic phagotroph engulfed and retained a photosynthetic eukaryote (McFadden et al., 1994). This process, which results in lateral transfer of photosynthetic capacity into heterotrophic lineages, has spawned at least two algal lineages, chlorarachniophytes and cryptomonads (McFadden & Glibson, 1995). The endosymbionts of chlorarachniophytes and cryptomonads are drastically reduced and located within the host's endomembrane system, retaining only the plastid, a modicum of cytoplasm, a relict nucleus (known as the 'nucleomorph') and a plasma membrane (McFadden & Glibson, 1995). Secondary endosymbiosis is also invoked for the origin of plastids in heterokonts, haplophytes, euglenoids and dinoflagellates but, since these algae apparently do not retain any relict endosymbiont nucleus, it has been difficult to substantiate these hypotheses (for recent reviews see Cavalier-Smith, 1993; Palmer & Delwiche, 1996, p. 74 in this volume). Thus, Chlorarachniophytes are a valuable model for understanding the origins of plastids (Palmer & Delwiche, 1996).

Anatomy and morphology

Cells exist as solitary or reticulopodial amoebae, as flagellates with a single flagellum and as cysts.

Cellular organisation

The plastids, which number five, six or seven in the amoeboid cell of Chlorarachniun repons, are surrounded by four membranes. Between the inner and outer pairs of chloroplast membranes there is a small volume of cytoplasm containing particles resembling ribosomes, of dimensions similar to those of eukaryotes. Also situated between the inner and outer pairs of membranes is a double membrane-bound organelle, the nucleomorph. The two membranes surrounding the nucleomorph are interrupted by pores similar to those observed in nuclei generally (Hibberd & Norris, 1984). The nucleomorph was recognised as possibly representing a vestigial nucleus by Hibberd & Norris (1984) who postulated that the plastid is a reduced, eukaryotic endosymbiont.

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Photosynthetic pigments

The pigment repertoire includes chlorophylls a and b, β,β-carotene and some unusual xanthophylls unique to prasinophytes, which is consistent with the plastid being derived from a green alga (Hibberd & Norris, 1984; Ludwig & Gibbs, 1989; Hartkevich et al., 1991).

Characteristics

Chlorarachniophytes are marine, amoeboid flagellate unicells. Distribution is worldwide, but most records are tropical and subtropical. Currently, four genera are recognised (Chlorarachnion, Lotharella, Gymnochloa, Cryptochloa), but several undescribed forms that undoubtedly represent new genera are also known (Ishida et al., 1999). Without electron microscopical or molecular evidence it is not clear if Cryptochloa perforans Caeders-Saenz & Schnetter (1987) is really a chlorarachniophyte, but Chlorarachnion, Gymnochloa and Lotharella undoubtedly are. The amoeboid forms are typically found in sand and sediments, but the minute flagellate forms (< 3 µm) may be planktonic (Gilson & McFadden, 1999). A sexual cycle may occur, but its details are not understood.

A defining feature of the group is the presence of vestigial, green algal endosymbionts within modified food vacuoles. The endosymbionts are greatly reduced, having lost many subcellular structures such as mitochondria and cell walls. A dramatic reduction of the endosymbiont's nucleus has produced a minute nucleus-like structure, the nucleomorph, that
CHLORARACHIOPHYCEAE

is housed within a vestige of cytoplasm. The only other significant structure remaining within the endosymbiont is a prominent, green chloroplast. Molecular studies of chlorarachiophyte nucleomorphs indicate their genomes are radically reduced. Nucleomorphs accommodate just three small linear chromosomes whose total genome size is less than 500 kb, making them among the smallest eukaryotic genomes discovered thus far. Whilst the nucleomorph encodes genes that perform some genetic house-keeping and chloroplast-associated functions, it is clear that many nucleomorph genes have been either lost or transferred to the host cell’s nucleus. With only 300 or so genes retained within the nucleomorph, it is apparent that most of the endosymbiont’s needs are met by the host cell. Plastid proteins synthesised by the host are apparently targeted to the semi-autonomous endosymbiont via the host endomembrane system (Gibson et al., 1997).

The host cell stores carbohydrate reserves as a β-1,3 glucan within a cytoplasmic vesicle appressed to the chloroplast’s bulbous pyrenoid (McFadden et al., 1997). The chloroplast contains no starch (McFadden et al., 1997).

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<td><strong>Form:</strong> solitary or reticulopodial amoebae, flagellates, cysts.</td>
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<tr>
<td><strong>Size:</strong> 2–20 μm.</td>
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<tr>
<td><strong>Major pigments:</strong> chlorophylls a and b, β,β-carotene, luteoxanthin dodecanol.</td>
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<tr>
<td><strong>Energy reserves:</strong> β-1,3 glucan.</td>
</tr>
<tr>
<td><strong>Chloroplasts:</strong> 1–5, bounded by 4 membranes; nucleomorph in periplastidal space between inner and outer plastid membrane pairs; bulbous pyrenoid.</td>
</tr>
<tr>
<td><strong>Cell covering:</strong> lamellate wall surrounding cysts; otherwise none observed.</td>
</tr>
<tr>
<td><strong>Flagella:</strong> single with a hair-point.</td>
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<td><strong>Culture colour:</strong> grass-green.</td>
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Classification

Phylogenetic analyses confirm that the chlorarachiophyte endosymbiont was once a green alga (Ishida et al., 1997, 1999), whereas analyses of host genes demonstrate that chlorarachiophytes belong in the recently recognised Phylum Cercozoa, a collection of amoeboid and flagellate heterotrophs (Keeling et al., 1998; Ishida et al., 1999). Cavalier-Smith (1995) argued that the chlorarachiophytes are a small branch within this phylum which acquired a chloroplast through secondary endosymbiosis, and that chlorarachiophytes by themselves do not warrant phylum or division status.

References


(CCCP#621)

Unio reptans.

...some unusual derived from...

...1991.

...worldwide, but...
CHLORARACHNIOPHYCEAE


