Introduction to the Classification of Green Algae

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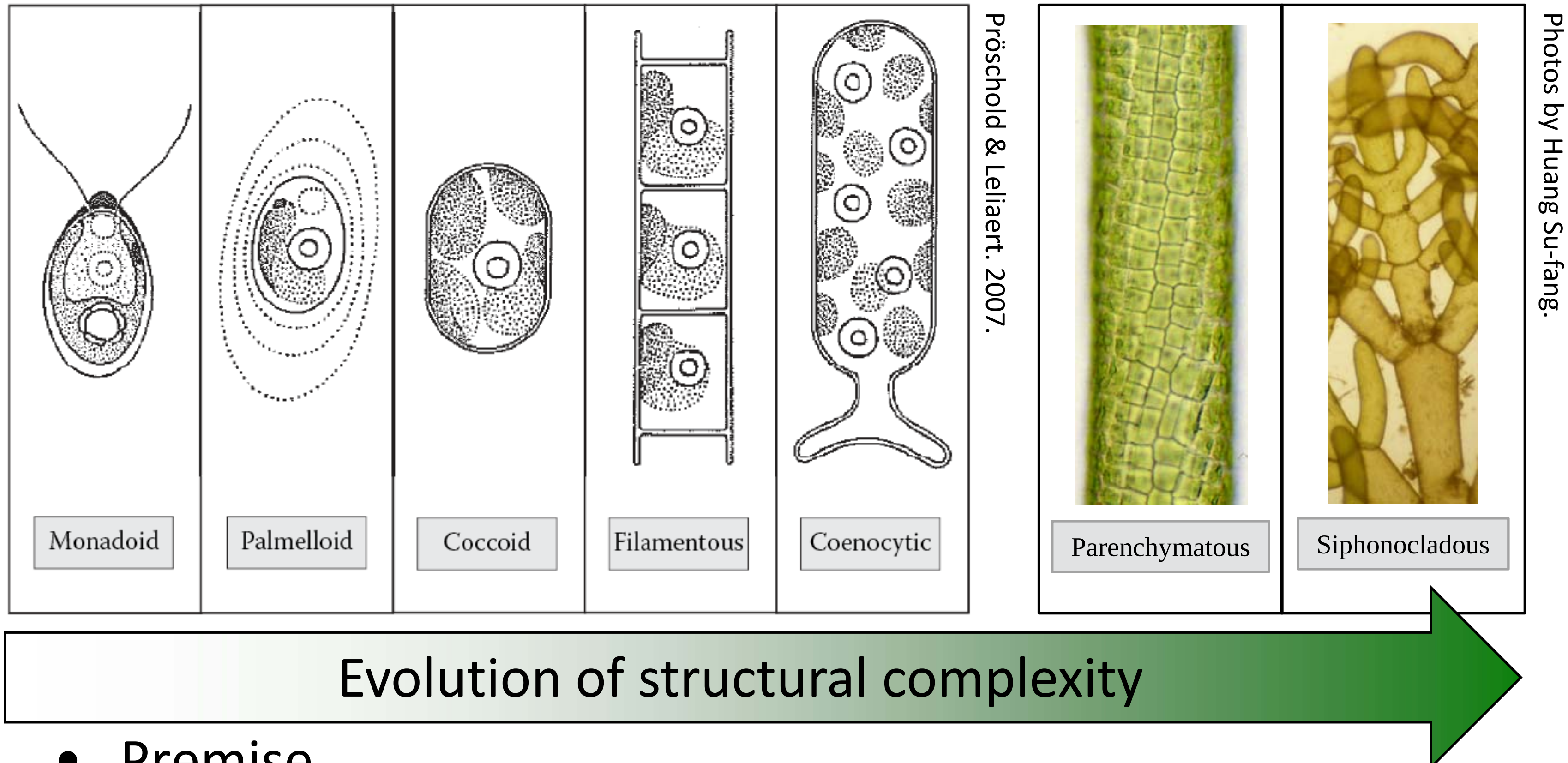
Classification

- 20+ classes of green algae have been described since Linnaeus
- Many criteria have been used to establish classes
  - Morphology
  - Ultrastructure
    - + mitosis, cell division, cytokinesis, flagellar apparatus
  - Life history patterns
  - Molecular
    - Primarily rRNA genes, *rbc*L
- Ambiguity remains, but consensus is emerging

Classification: Morphological Concept



- Premise
  - Primitive unicells evolved structural complexity over time
  - Morphological divergence distinguishes groups

Problems with Morphological Concept

- Selective environmental pressure may drive convergence
  - Biologically/genetically distinct species appear similar

Charophyceae

Chlorophyceae
Ulvophyceae

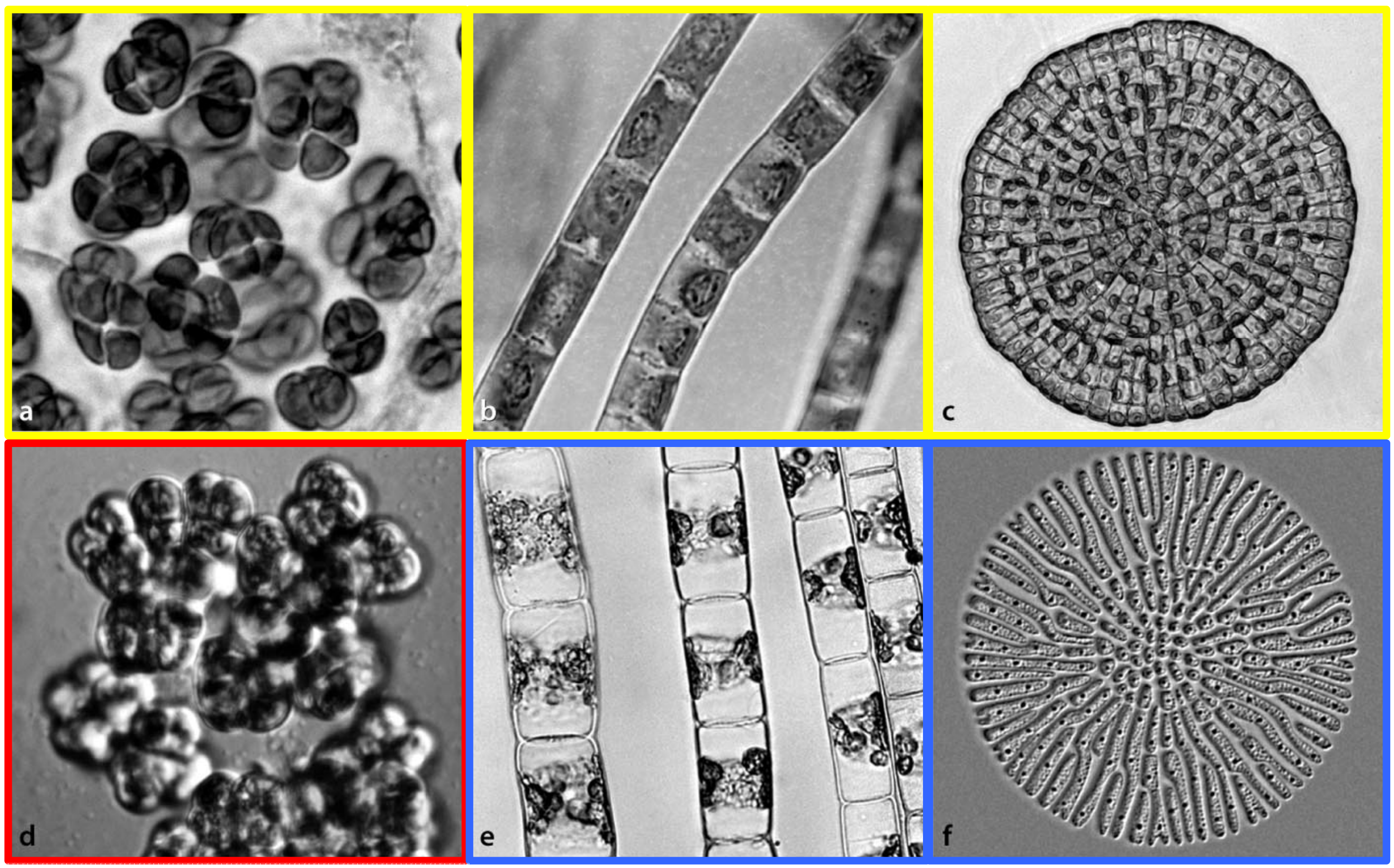


Fig. 16.18 Graham et al. 2008.

Morphological Convergence w/in Class

Class: Ulvophyceae	Ulvophyceae
Order: Ulvales	Ulotrichales
Genus: *Ulvaria*	*Monostroma*

Chlorophyta: Morphological Convergence

- How can green algae be classified if they exhibit both divergent and convergent patterns of morphology?

7 Systematics of the green algae: conflict of classic and modern approaches

Thomas Pröschold and Frederik Leliaert

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ABSTRACT

Traditionally the green algae were classified in orders or classes according to the morphological species concept. For example, monadoid species (flagellates) were summarized in the order Volvocales, coccoids in the Chlorococcales, filaments in the Ulotrichales or Chaetophorales, and siphonocladous algae in the Cladophorales or Siphonocladales. Later, a new classification was proposed based on ultrastructural investigations of the basal bodies in the flagellar apparatus and cell division. The species with basal bodies in clockwise (CW) or directly opposite (DO) orientation were classified in the class Chlorophyceae, the counterclockwise (CCW)-orientated species in the Ulvophyceae and Trebouxiophyceae (= Pleurastrophyceae). Phylogenetic analyses of nuclear-encoded SSU and ITS rDNA sequences have basically confirmed the classification based on ultrastructural characters. However, most genera and orders are polyphyletic and the relationships between

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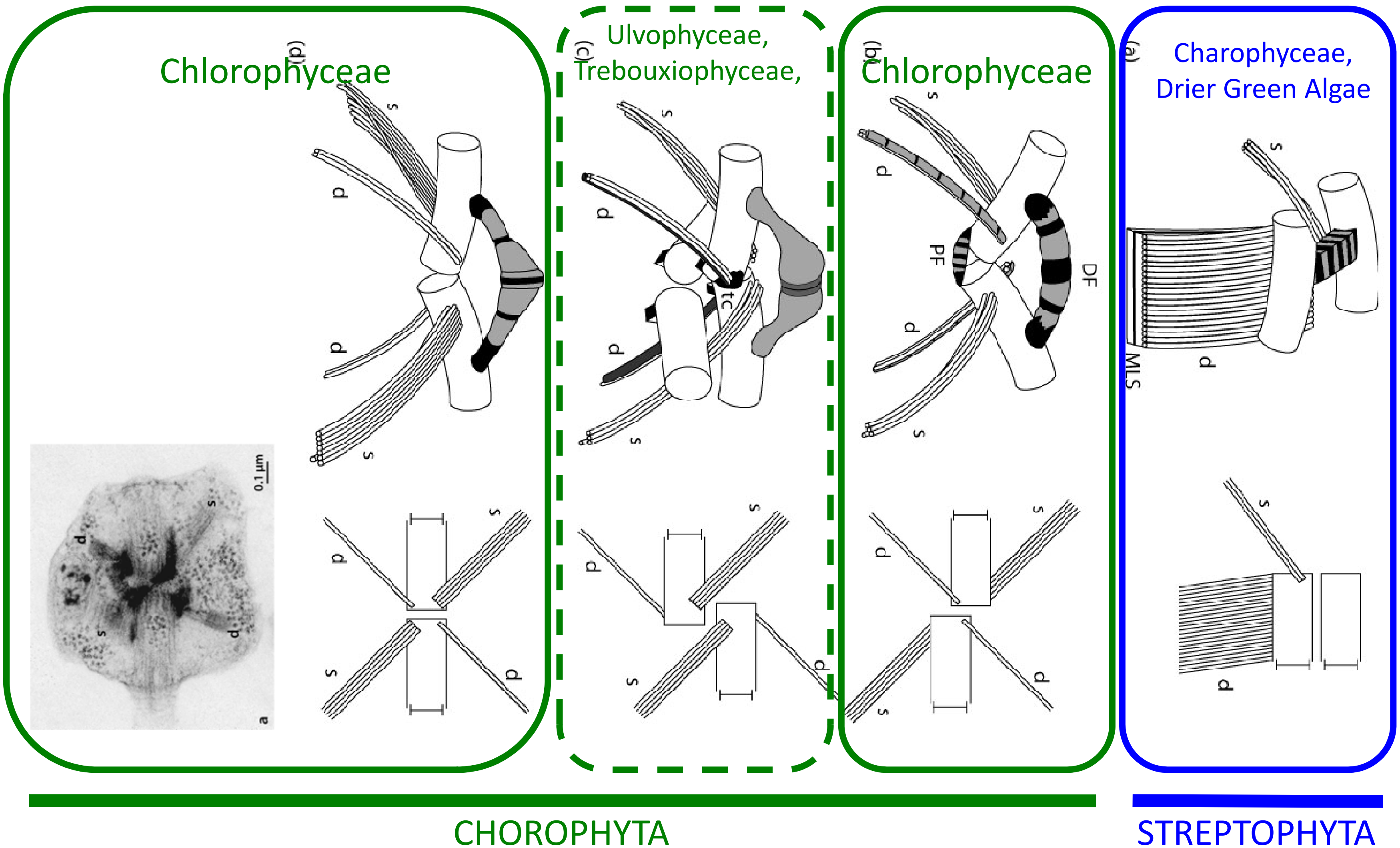
Ultrastructural Concept

- Mattox & Stewart (1984) proposed new Class-level taxonomy on the basis of basal body orientation
  - 1^{st} radiation of green algae occurred among unicellular flagellates
  - Numerous ancient flagellate lineages diversified into contemporary forms along different evolutionary paths, but many with similar morphological results
- 4 different basal body patterns identified

Basal Body Orientations

Ancestral condition



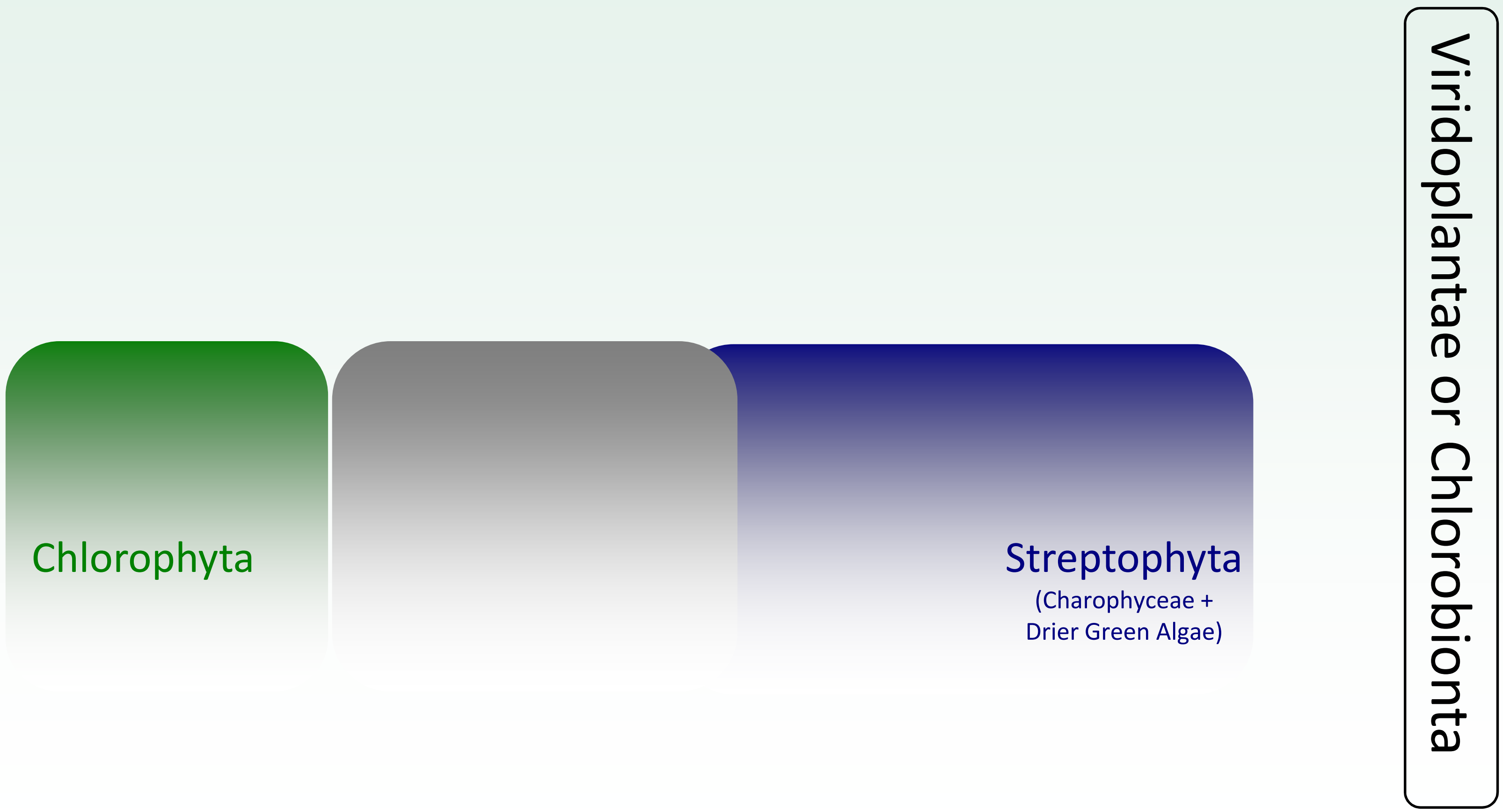
Molecular Concept

- Elucidation of green algal phylogeny in molecular context commenced in early 1990s
- Early studies
  - confirmed distinction between Chlorophyta & Streptophyta already suggested by cellular and ultrastructural characters elucidated from EM
  - recognized 5 lineages:
    - Prasinophyceae, Chlorophyceae, Trebouxiophyceae, Ulvophyceae, Streptophyta + Land plants
  - Subsequent studies have confirmed these lineages, but relationships among & within the lineages remains unclear

Molecular Concept

(McCourt & Lewis 2004, Working Classification)

molecular data support the recognition of two phyla and a poorly resolve graded of early diverging flagellates informally known as Prasinophyceans



SSU rDNA Molecular Concept

(Pröschold & Leliaert 2007)

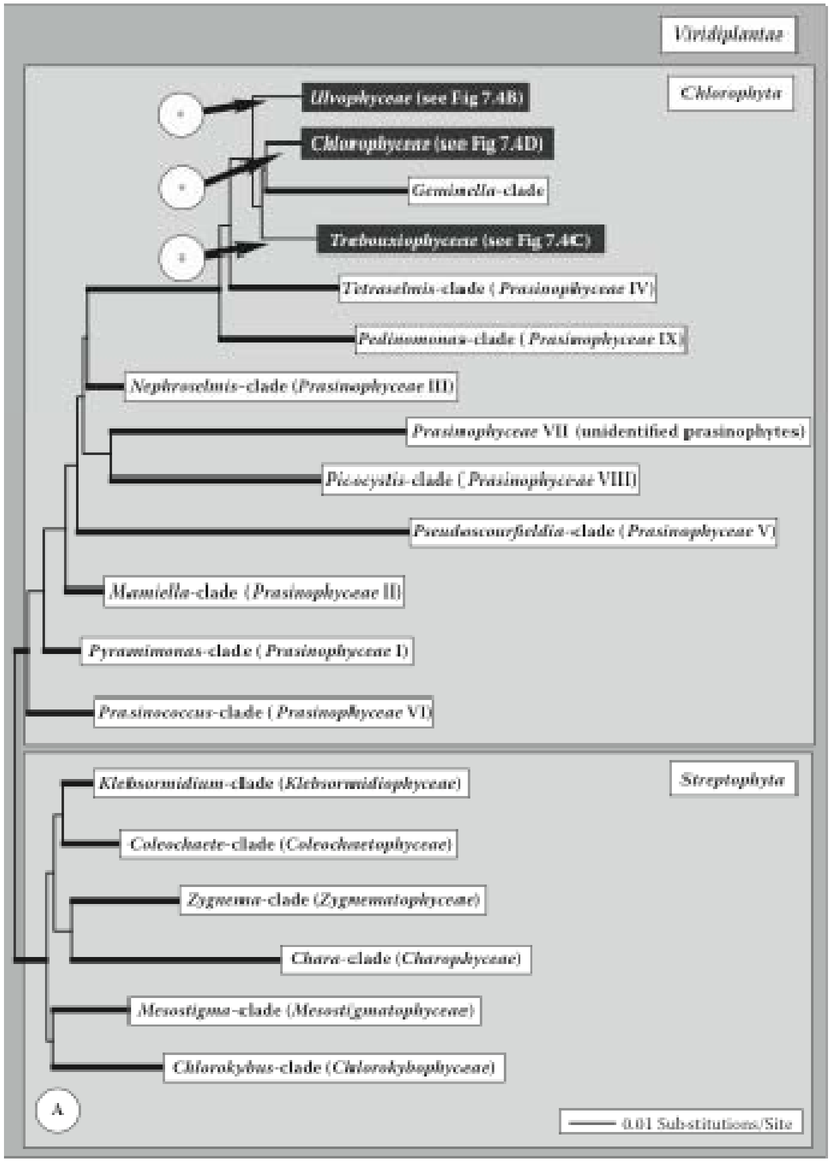


FIGURE 7.4 [illegible]

- Chlorophyta + Streptophyta recovered
- UTC clade recovered with low BS support (no bold lines)
- Poorly resolved Prasinophycean grade

Class Ulvophyceae

- Most macroscopic marine green algae belong to Class Ulvophyceae
- Ulvophyceae is circumscribed on the basis of a suite of pleisiomorphic characters
  - Closed mitosis, persistent spindle, furrowing, CCW, flagellate cells with scales
- The absence of well-defined, shared-derived characters has resulted in uncertain relations within the class

Class Ulvophyceae

- Generally, 5 (or 6) orders are distinguished
  - flagellar apparatus
  - zoosporangial & gametangial structures
  - life history
- Orders are generally supported by molecular analysis, but relationships among orders are largely uncertain

McCourt & Lewis. 2004.

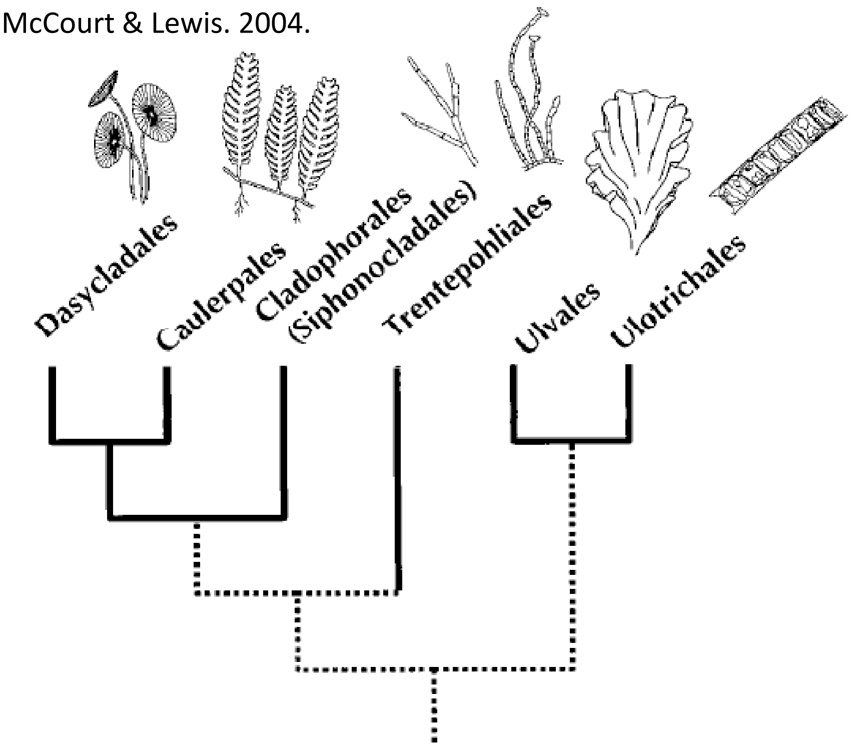
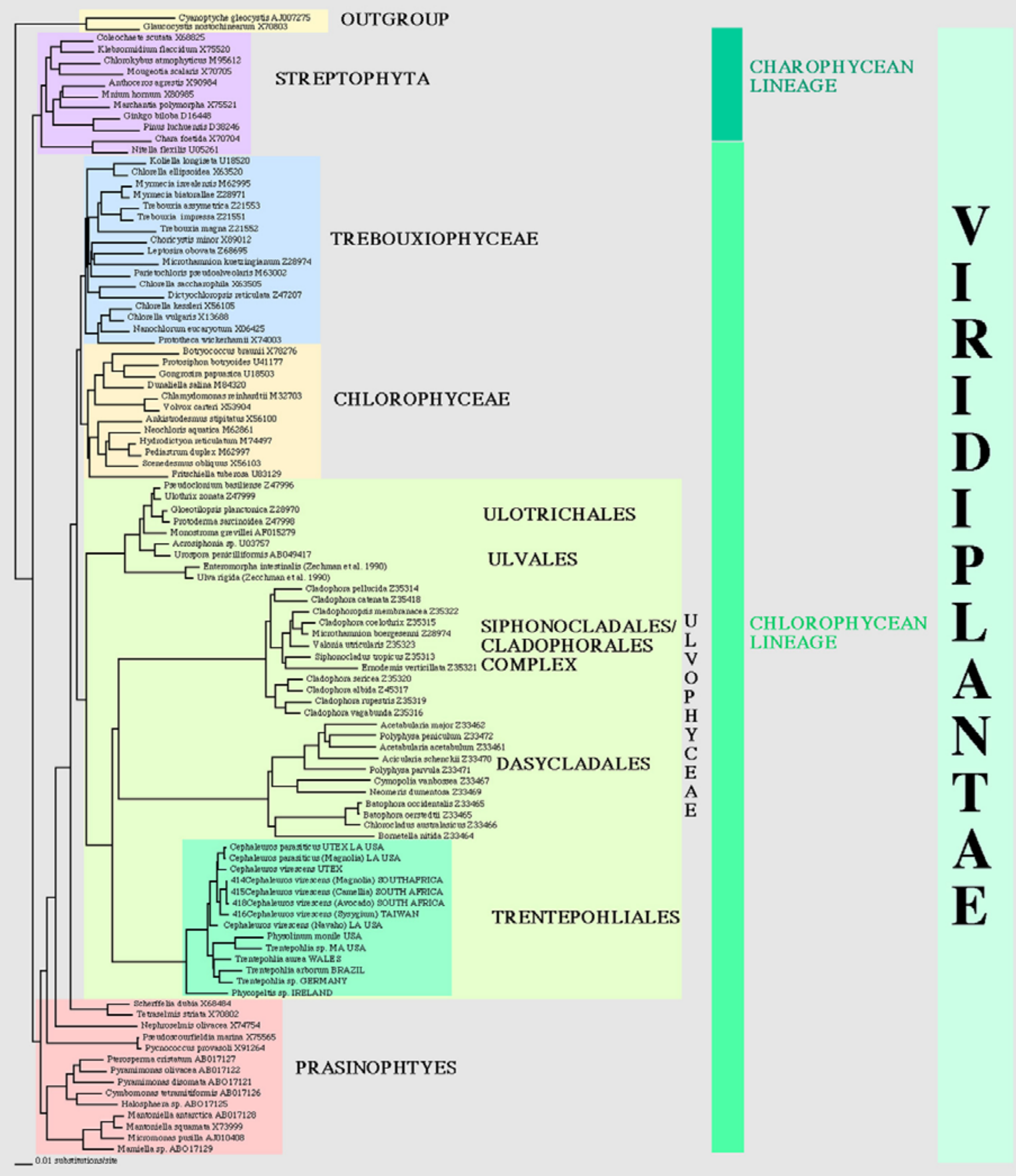


Fig. 19. Summary of the phylogenetic relationships of major lineages within Ulvophyceae based on DNA sequence data (Hayden and Waaland, 2002; O'Kelly et al., 2004) and a preliminary analyses of 18S rDNA sequences (F. Zechman, California State University at Fresno, personal communication). The drawings are thumbnail composites meant to show representative taxa.

Molecular Concept
(Lopez-Bautista et al. 2002)

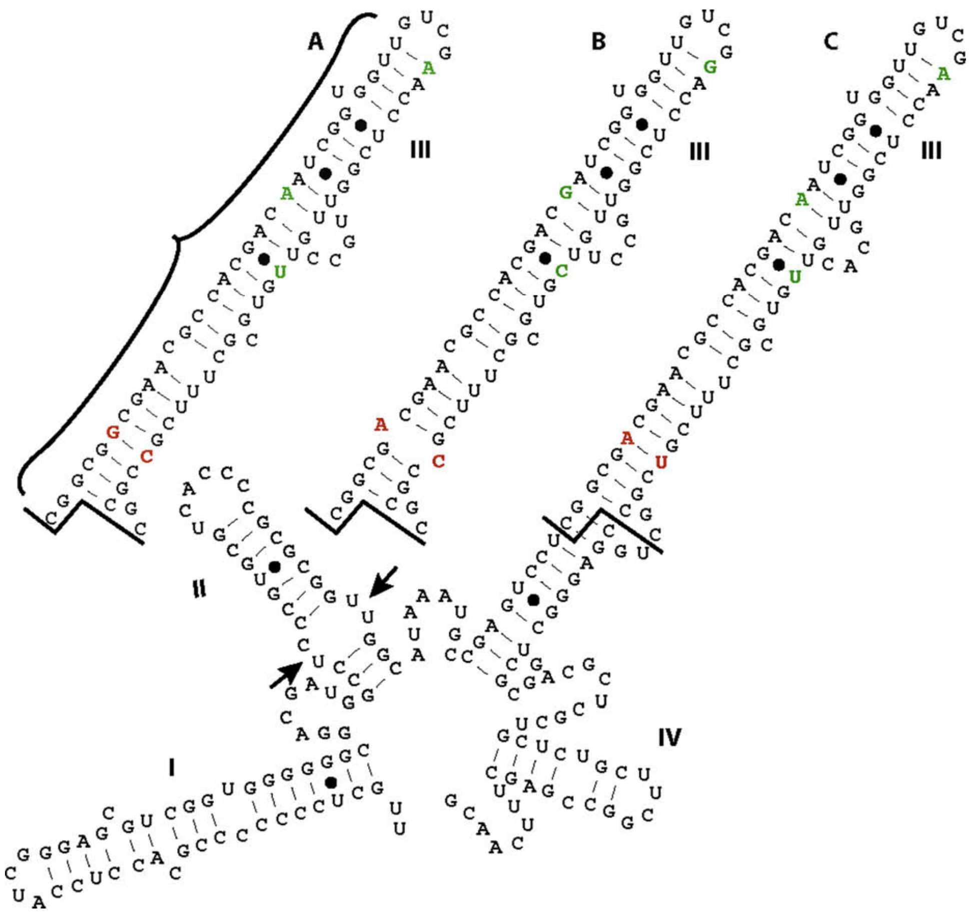
Figure 22. Maximum likelihood tree, estimated from Kimura two-parameter model of sequence evolution using Modeltest parameters. -lnL = 22774.1914. A total of 102 taxa with 1720 positions are represented in the phylogram. Genbank accession numbers are given after the scientific name.



Sub-ordinal classification

- Generic and species level classification is frequently based on morphology which can be problematic
  - Phenotypic plasticity
  - Morphological convergence
- Integrated approaches are required to resolve these problems
- DNA sequencing (and distance clustering) is a start that can lead to the recognition of novel morphological, physiological or biological features

Z-clades & Biological Species inferred from ITS2 2°structure (see Coleman 2009)



- As ITS2 differences between potential mates increase, sexual compatibility and zygote productivity decrease
- Organisms that differ by even one CBC in helix III are completely unable to cross
- Identity for the entire ITS2 correlates with significant interbreeding potential.

Literature Cited

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This presentation is a contribution of the Pan-American Advanced Studies Institute

Advanced Methods in Tropical Phycology

14 Aug - 4 Sep 2009, Bocas Research Station, Bocas del Toro, Panama