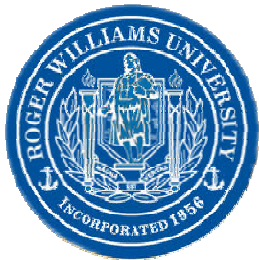




General Introduction and Characterization of the Green Algae



Brian Wysor, Ph.D.
Roger Williams University

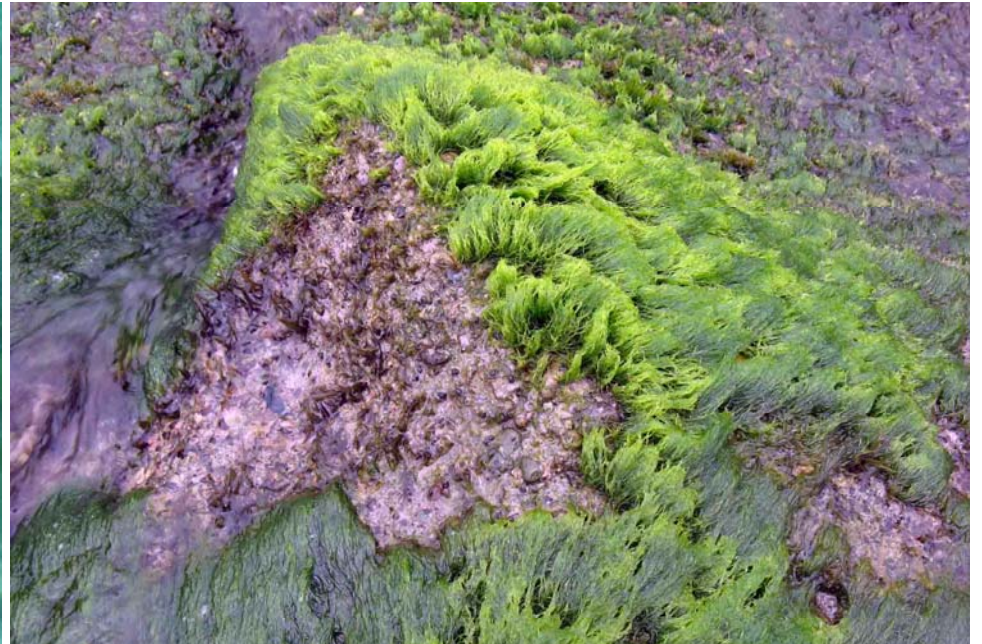


Green Algae: General Features

- A group of “grass green” algae
 - Chl *a*, *b*
 - (generally) non-masking accessory pigments
- Occur in terrestrial, freshwater and marine habitats
 - Primarily (~90%) a freshwater group
- Considered to be among the most diverse groups of eukaryotes



Nombre del Dios, Colón, Panamá



Cuango, Colón, Panamá



Parque de Joventud, Colón, Panamá



Photo by: shyzaboy@flickr.com.
http://www.ubcbotanicalgarden.org/potd/2008/02/acetabularia_sp.php

Working Classification

(McCourt & Lewis 2004)

Chlorophyta

Streptophyta

(Charophyceae +
Drier Green Algae)

Viridiplantae or Chlorobionta

----- Uncertain Relationships



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Trentepohlia sp. - an orange Chlorophyte



Fort Diamant, area of Rémire-Montjoly, French Guiana; forming orange coating on bamboo reeds facing sea, 10-15 m from shoreline, 25 Jun 2006. Photograph by: Juan Lopez-Bautista.

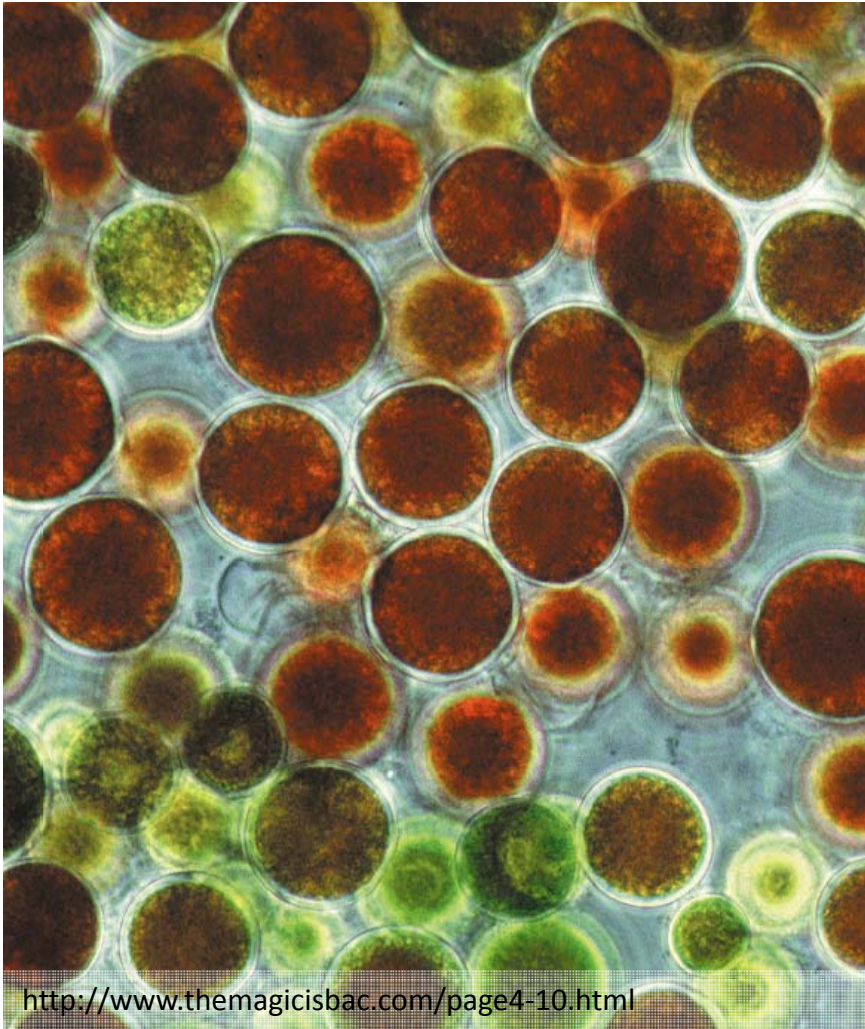
Carotenoid pigments, such as Astaxanthin & β -carotene impart orange color



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Haematococcus pluvialis - an orange Chlorophyte



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Chlamydomonas nivalis - a red snow Chlorophyte



Alaska, USA. http://www-es.s.chiba-u.ac.jp/~takeuchi/snowalgae_ak.html



Sierra Nevadas, USA.
<http://waynesword.palomar.edu/plaug98.htm>

© W.P. Armstrong 2004



- For more information on snow algae:
 - <http://www.orgs.muohio.edu/uvlakes/UVecology/Phyto/snowalg.html>
 - <http://waynesword.palomar.edu/plaug98.htm>



General Features: Structural Diversity

“...one of the most diverse groups of eukaryotes...”

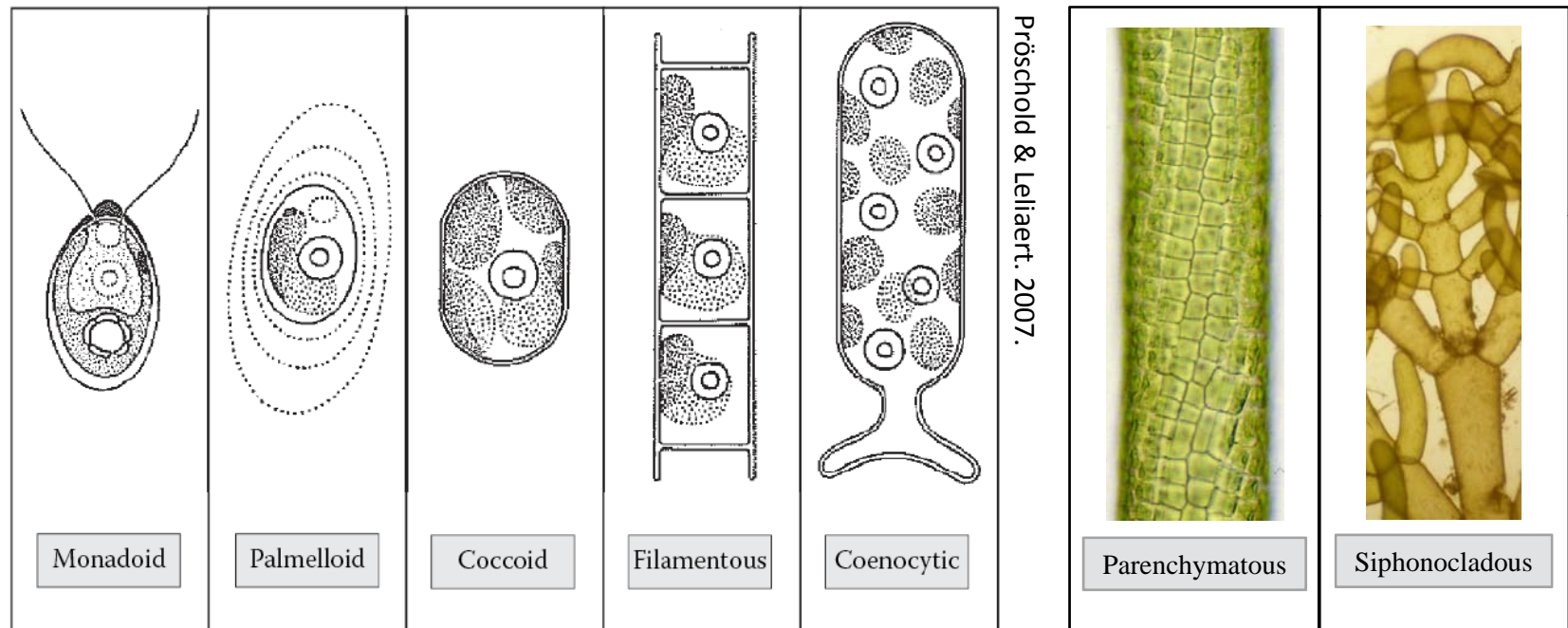
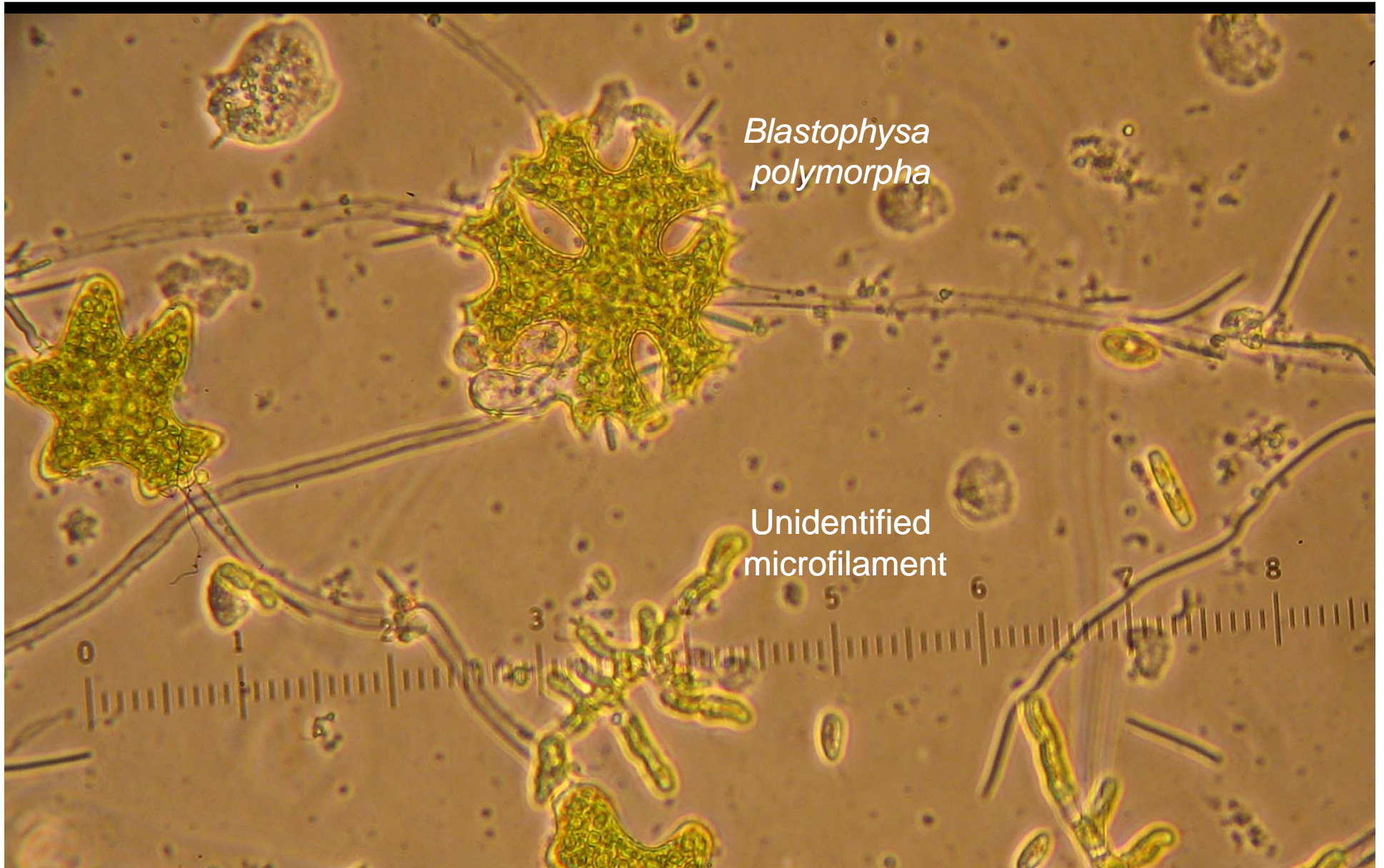


FIGURE 7.1 Different morphological organization in green algae (modified after Ettl, H. and Gärtner, G., *Syllabus der Boden-, Luft- und Flechtenalgen*. Gustav Fischer, Stuttgart, 1995). Parenchymatous and siphonocladous organization are not illustrated.



Unicells & Microfilaments



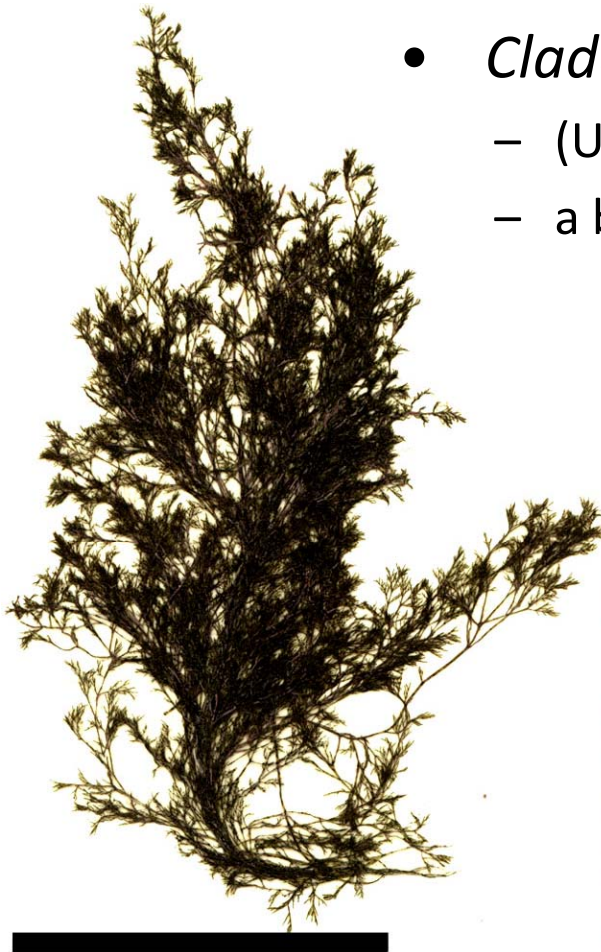
Unbranched Filaments



- *Chaetomorpha antennina*
 - (Ulvophyceae: Cladophorales)
 - an unbranched, uniseriate, green algal filament



Branched Filaments



- *Cladophora ordinata*
 - (Ulvophyceae: Cladophorales)
 - a branched, uniseriate, green algal filament

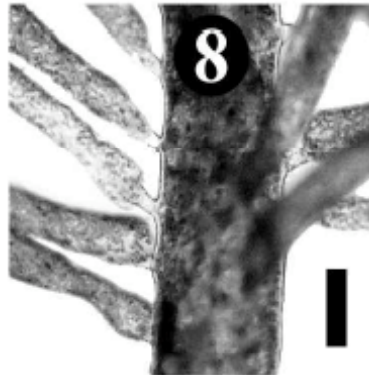


Branched Filaments (Pseudoparenchyma)

- *Anadyomene lacerata*
 - Ulvophyceae: Cladophorales
 - a pseudoparenchymatous, blade



Coenocytic/Siphonous



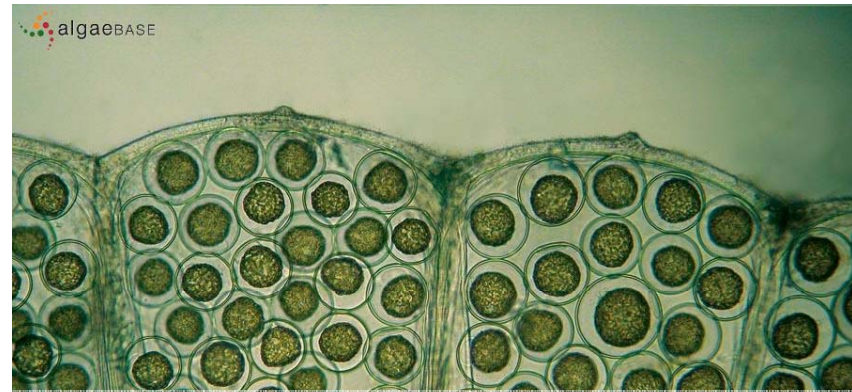
- *Bryopsis rhizophora*
 - Ulvophyceae:
Caulerpales
 - a siphonous, multi-nucleate, unicellular green alga

Siphonous



From Littler, D.S., M.M. Littler & M.D. Hanisak (2008)
Submersed Plants of the Indian River Lagoon. Purchase
information. Photographer: Diane Littler © Diane Littler

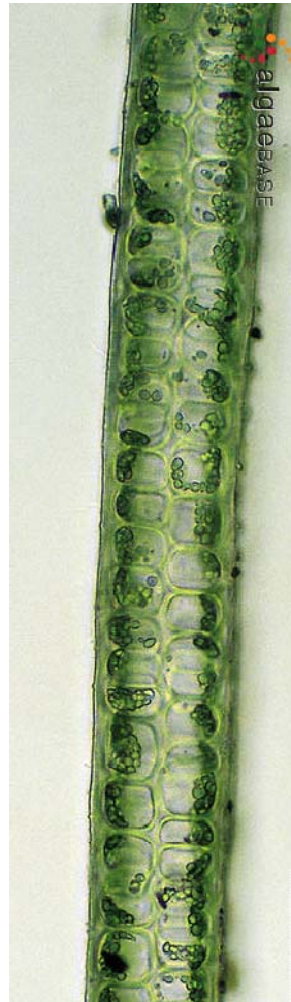
- *Acetabularia calyculus*
 - Ulvophyceae: Dasycladales
 - siphonous, uni-nucleate, unicellular green alga
 - Becoming multi-nucleate at reproductive maturity



From Littler, D.S., M.M. Littler & M.D. Hanisak (2008)
Submersed Plants of the Indian River Lagoon. Purchase
information. Photographer: Diane Littler © Diane Littler



Parenchymatous

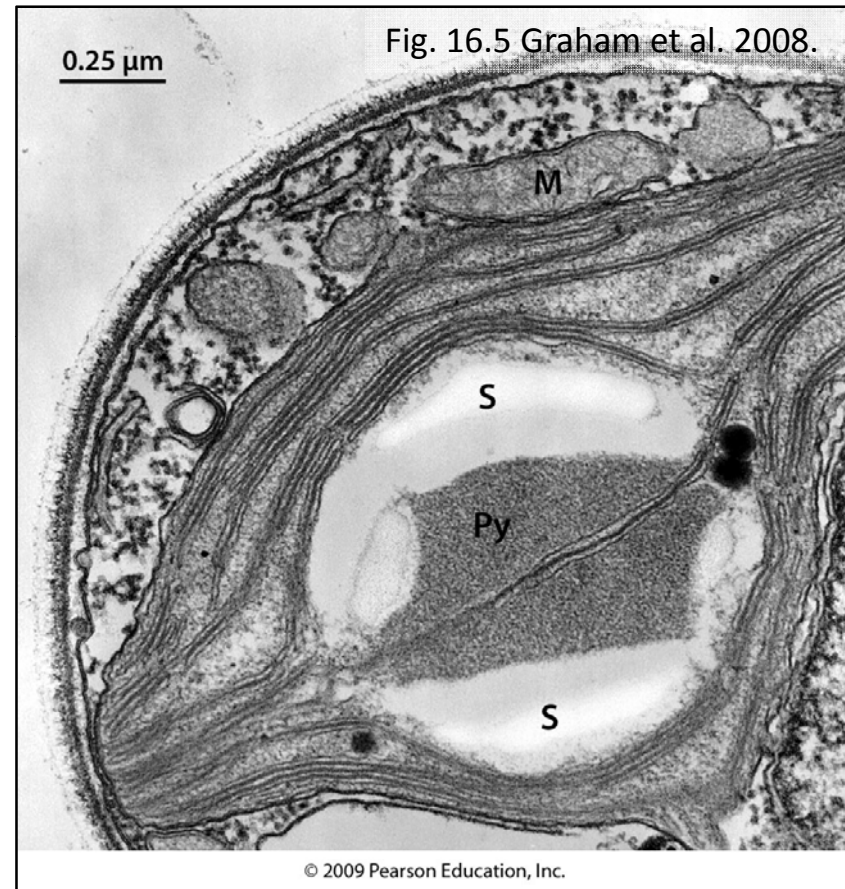


- *Ulva reticula* & *U. lactuca*
 - Ulvophyceae: Ulvales
 - a parenchymatous, distromatic blade



General Features: Plastids

- All cells contain at least one primary plastid with:
 - 2 encircling membranes
 - thylakoids in stacks of 3-5
 - Starch (S) stored in plastid stroma, frequently around proteinaceous pyrenoid (Py)
- No instances of plastid loss known
 - leucoplasts (colorless plastids of heterotrophic species) maintain important biochemical functions



General Features: Plastid Morphology

- Features of green algal plastid may be useful taxonomic characters
 - shape
 - distribution
 - abundance

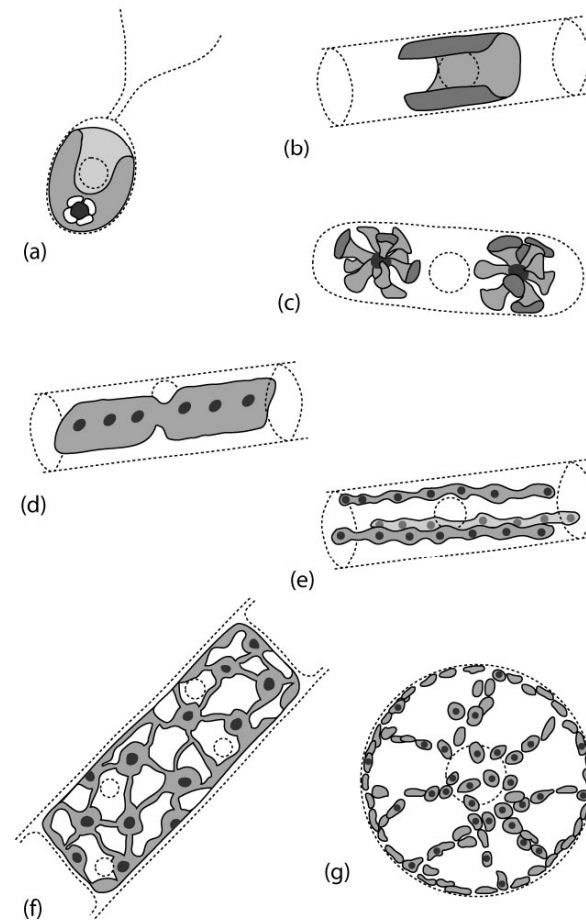
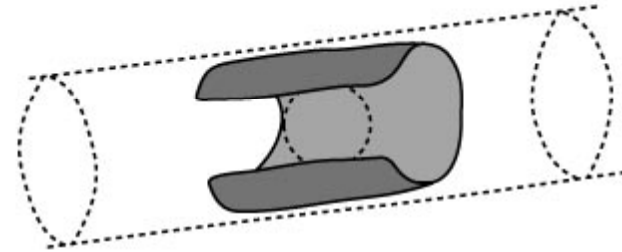
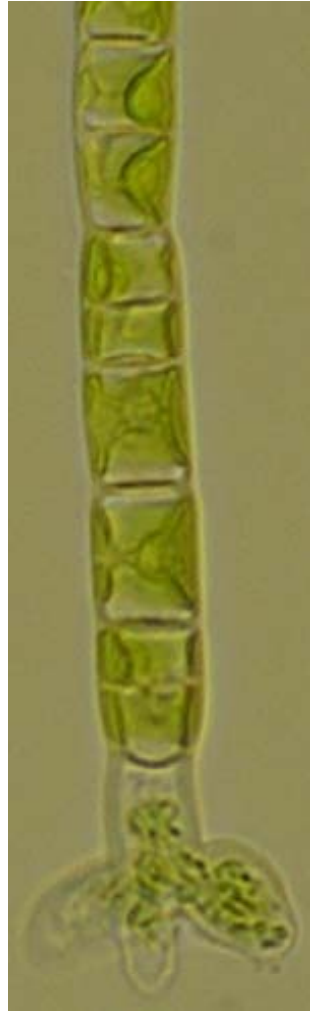


Fig. 16.3 Graham et al. 2008.



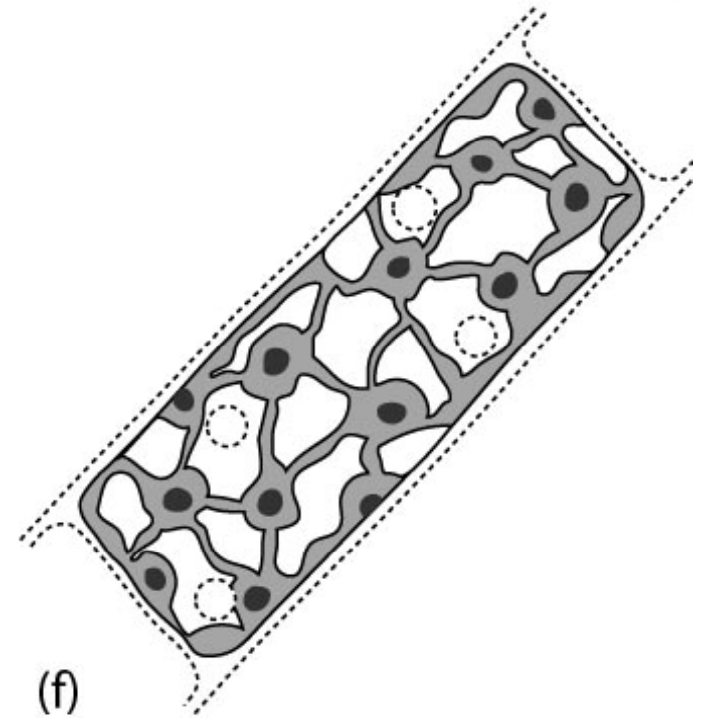
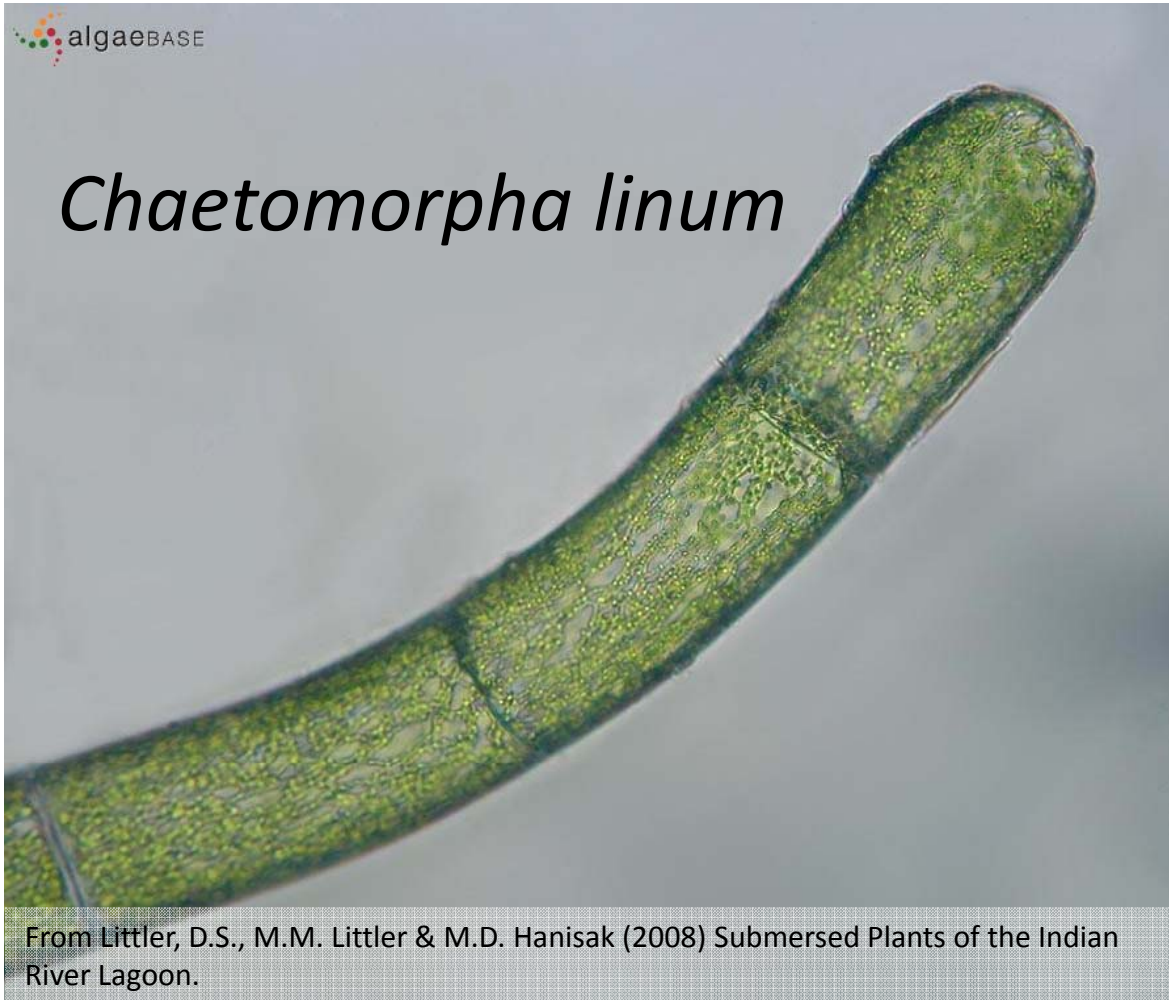
Cup-shaped Chloroplasts



(b)

Ulothrix sp.

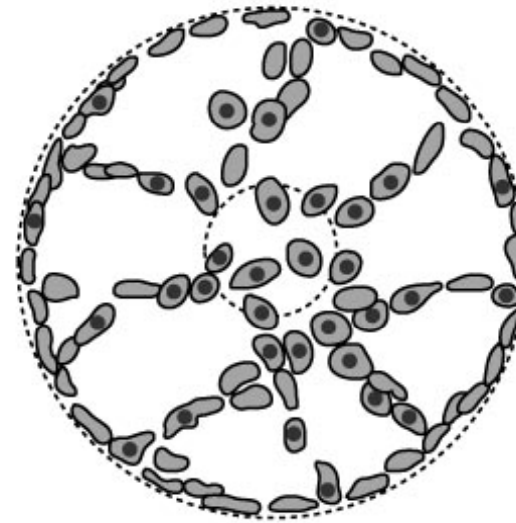
Reticulate (net-like) Chloroplasts



Multiple, Discoidal Chloroplasts



From Littler, D.S., M.M. Littler & M.D. Hanisak (2008)
Submersed Plants of the Indian River Lagoon.



*Trichosolen
duchassaingii*



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General Features: Pigmentation

- Chl *a*, *b*
- Non-masking accessory pigments include:
 - β -carotene
 - Xanthophylls
 - lutein, zeaxanthin, violaxanthin, antheraxanthin, and neoxanthin
 - Siphonein, Siphonoxanthin



General Features: Life History

- Many, diverse life histories
 - Typical pattern is alternation of generations
 - Isomorphy and heteromorphy common
 - Generally with zygotic meiosis
 - Ulvophyceae also exhibit sporic meiosis



Zygotic Meiosis (het-AoG)

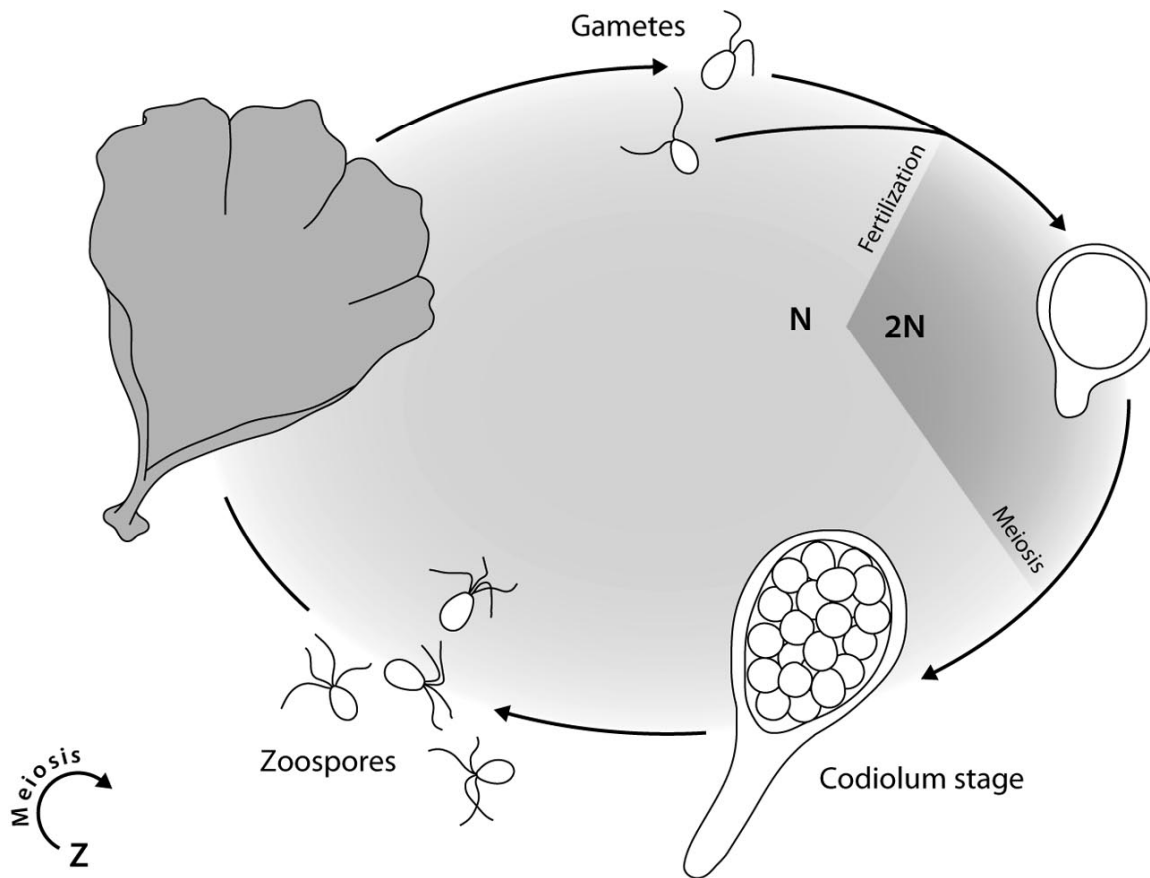
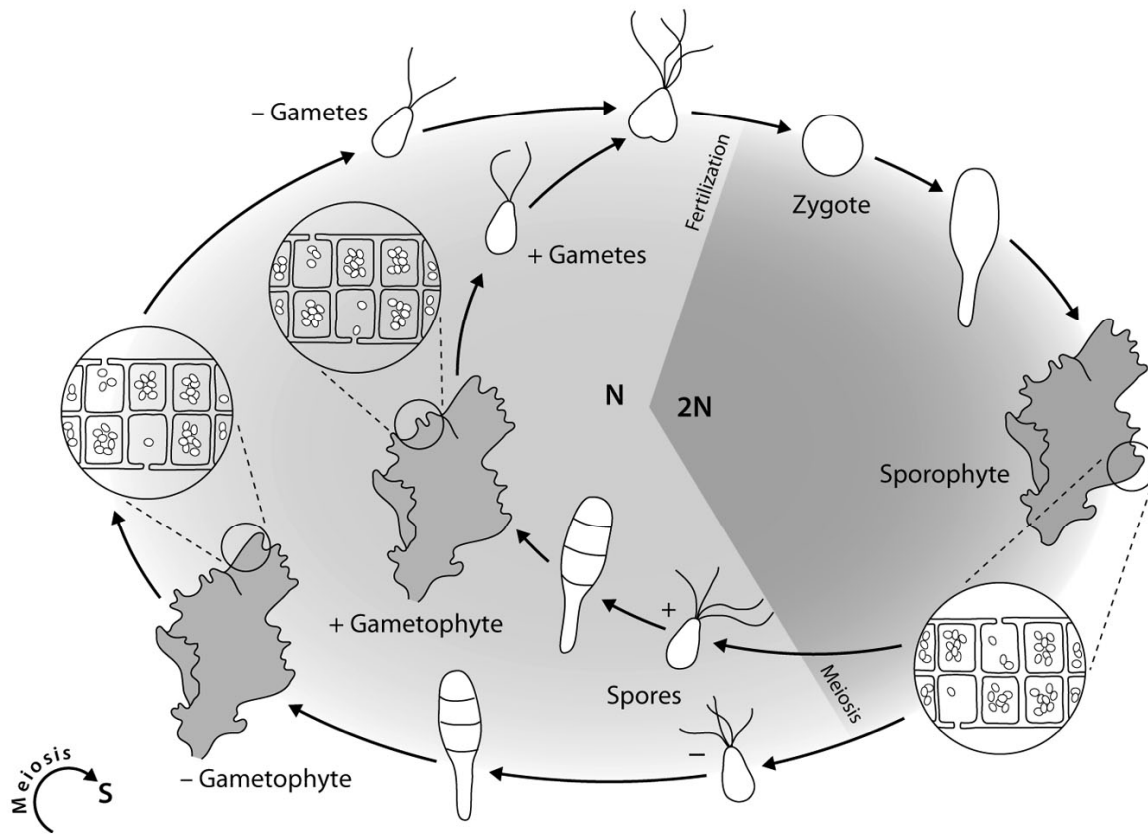


Fig. 17.7 Graham et al. 2008.

- $2n$ zygote undergoes meiosis to produce n spores
- n spores germinate into gametophytes
- Gametophytes produce n gametes by mitosis

Sporic Meiosis (iso-AoG)



- 2n zygote germinates into 2n sporophyte
- Specialized cells undergo meiosis to produce n spores
- N spores germinate into haploid gametophytes that produce n gametes by mitosis

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Fig. 17.2 Graham et al. 2008.



General Features: Flagella

- Isokonty for flagellate stages
 - Bi-flagellate (and isogamous) gametes, generally
 - Spores
 - Quadri-flagellate
 - Stephanokont
- Ultrastructure of the flagellar apparatus (basal bodies + flagella + anchoring microtubules) important class-level character



General Features: Flagellum Ultrastructure

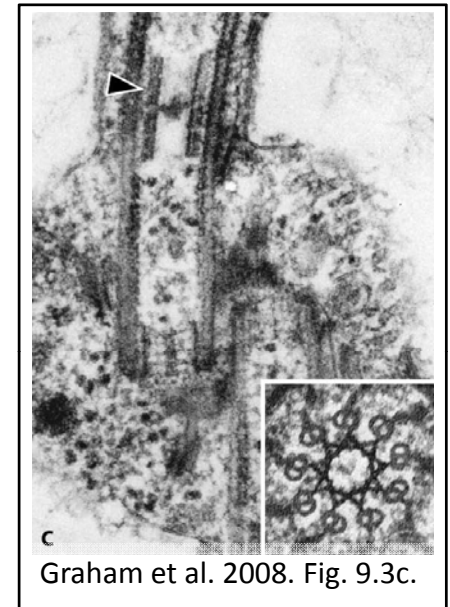
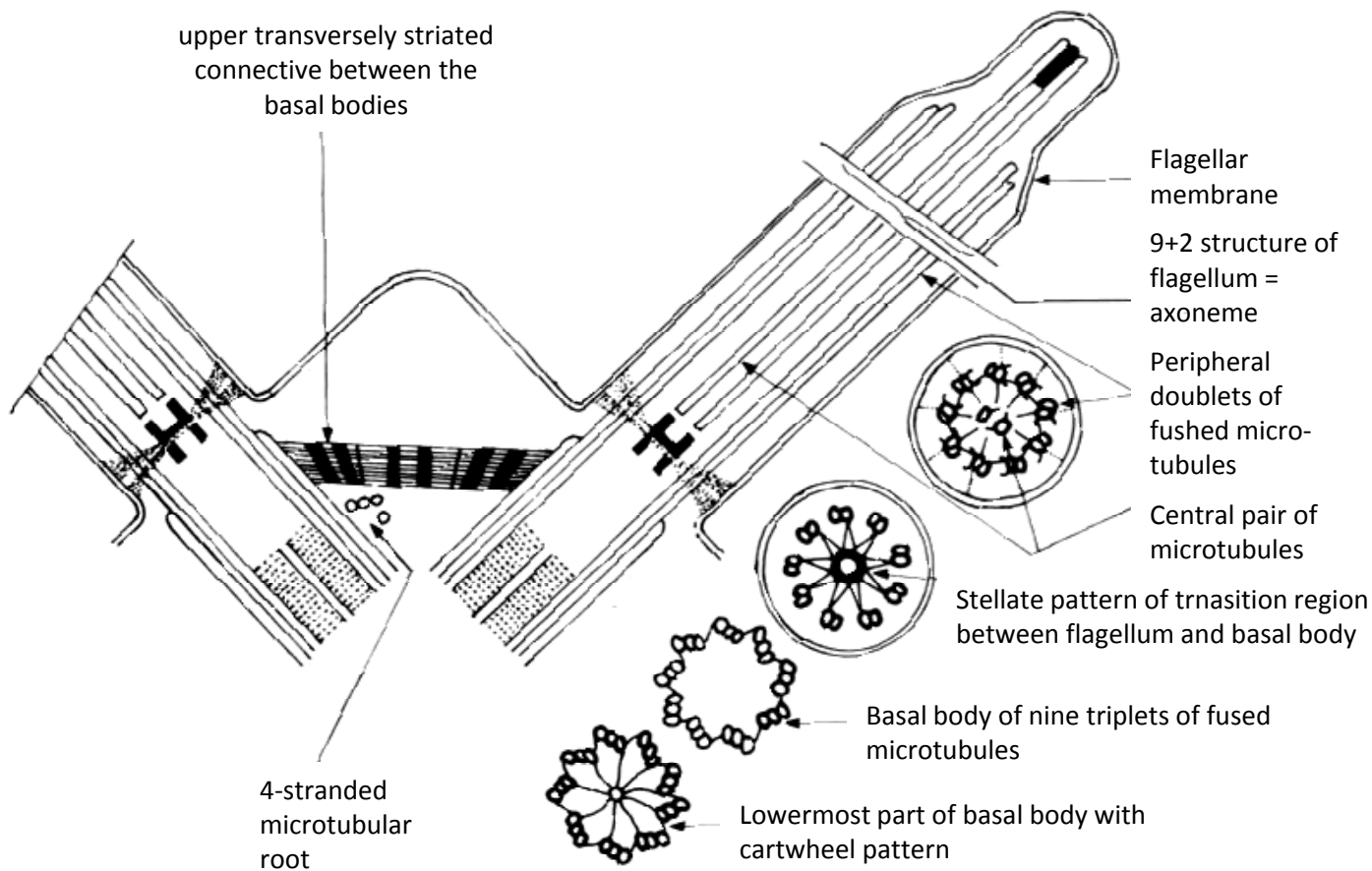


Fig. 19.4 *Chlamydomonas reinhardtii*. Longitudinal section through the flagellar apparatus, shown in a schematic diagram. Adapted from Harkness et al. 1995.



Understanding Basal Body Orientation

1. Orientation is assumed to be top-down

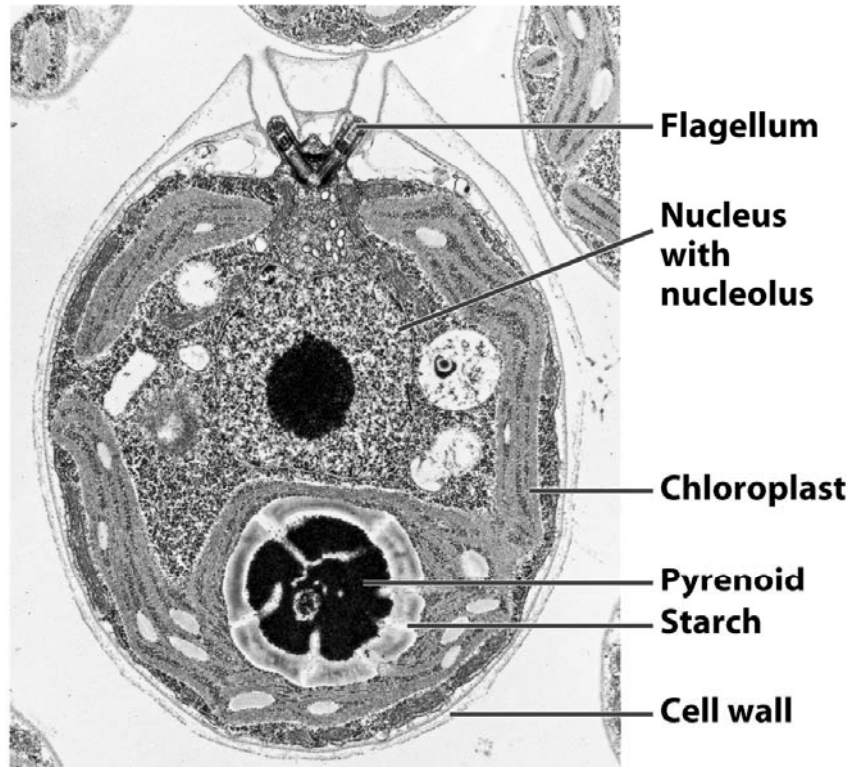
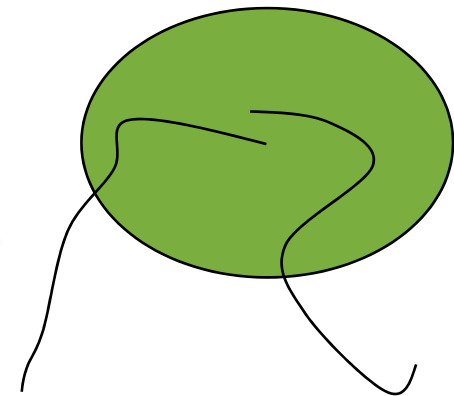
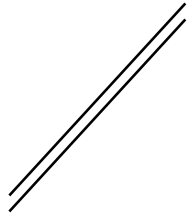


Figure 15-40
Biology of Plants, Seventh Edition
© 2005 W.H. Freeman and Company



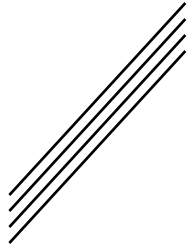
Understanding Basal Body Orientation



2-microtubule rootlet



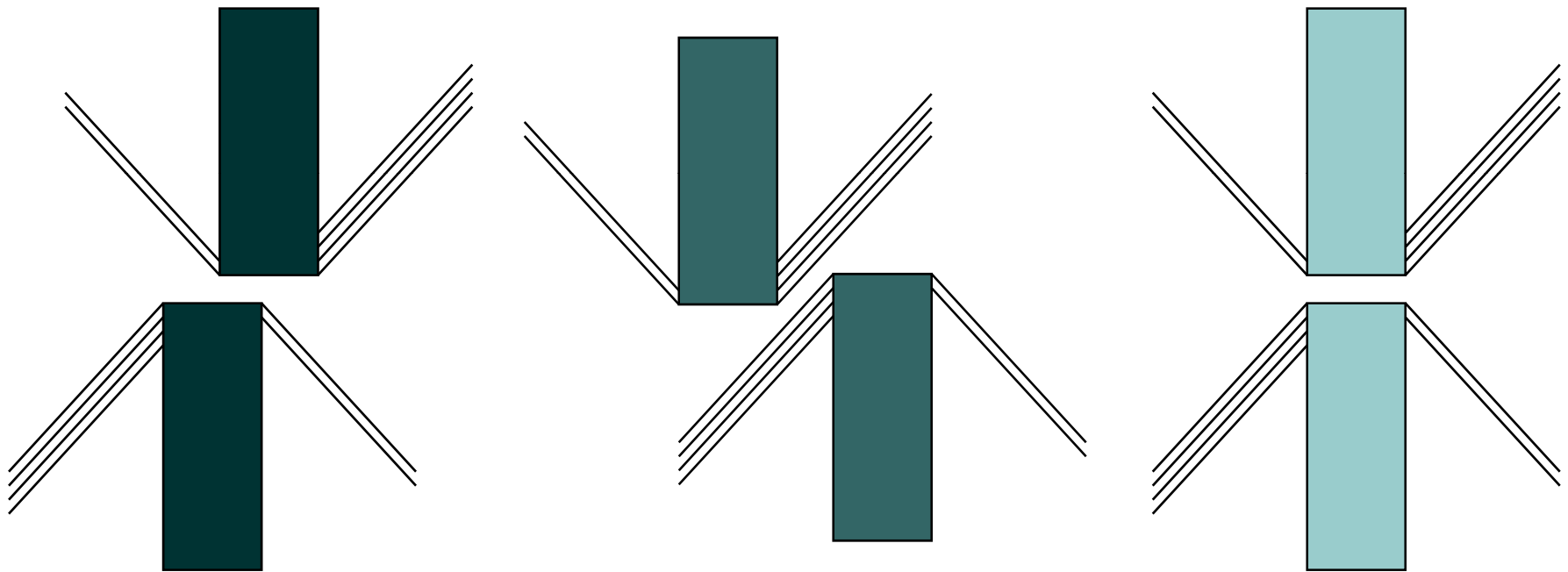
Basal body: cylindrical basal portion of flagellum lying within the cell



4-microtubule rootlet

Understanding Basal Body Orientation

2. Microtubule rootlets anchor basal bodies to cytoskeleton

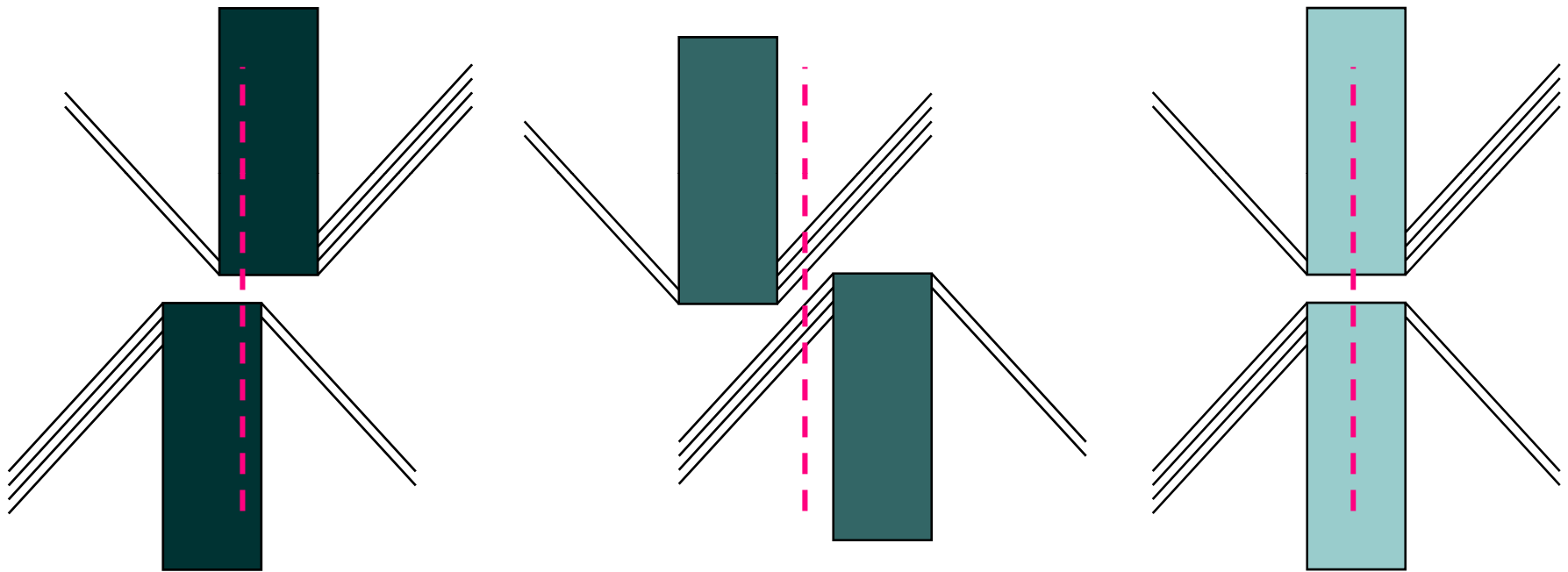


3. A cruciate (cross-shaped) arrangement of rootlets is shown
(X-2-X-2); (4-2-4-2)



Understanding Basal Body Orientation

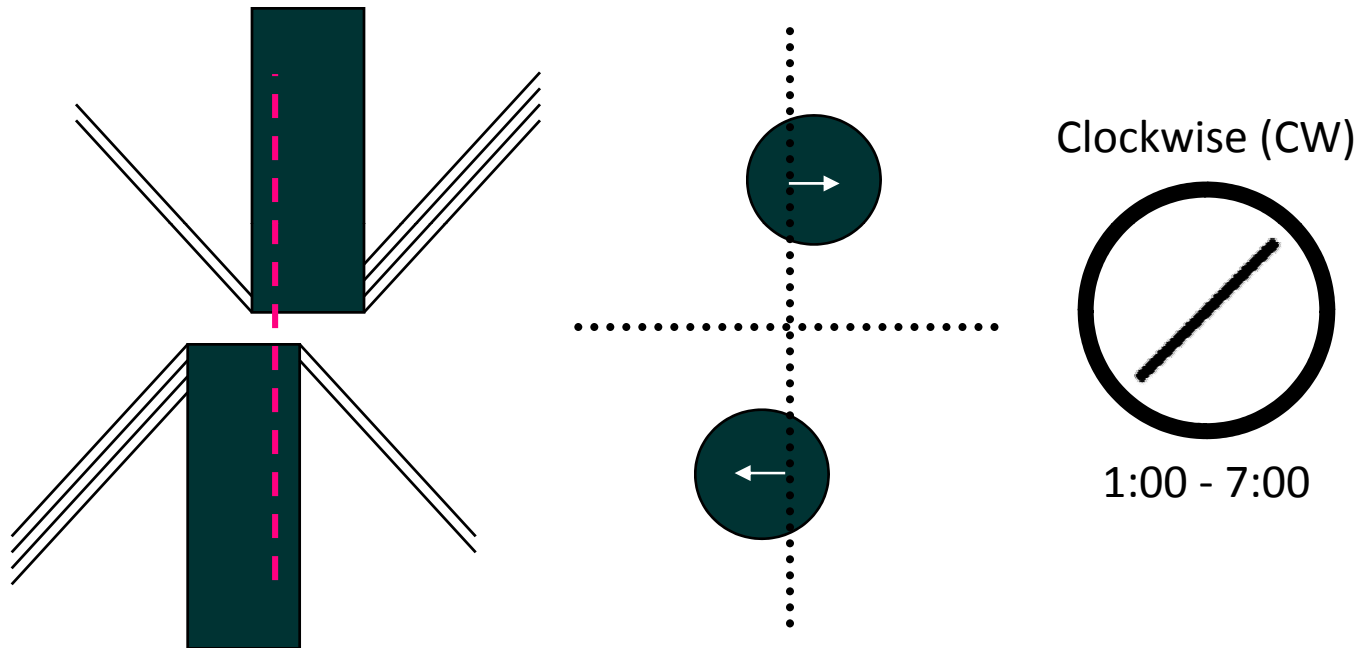
4. There are 3 main variations in the orientation of basal bodies, when viewed top-down (anterior-posterior direction)



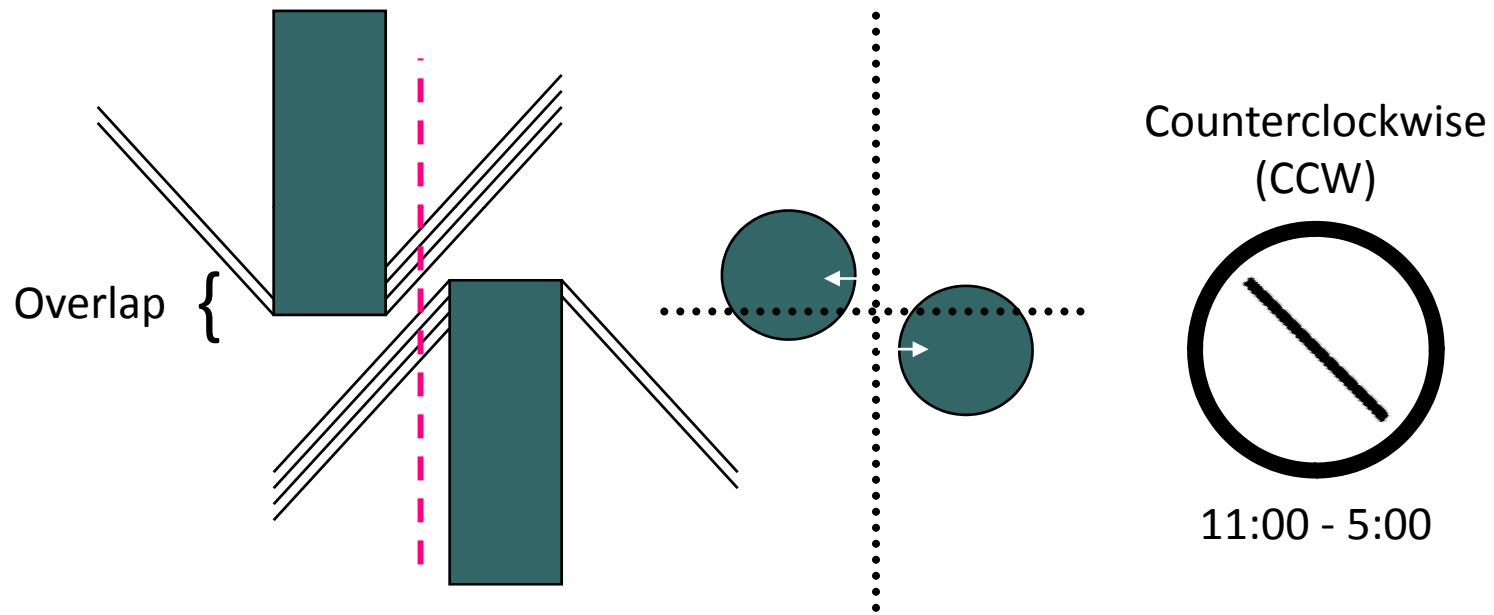
5. Orientation is around a line drawn parallel to and between basal body axis



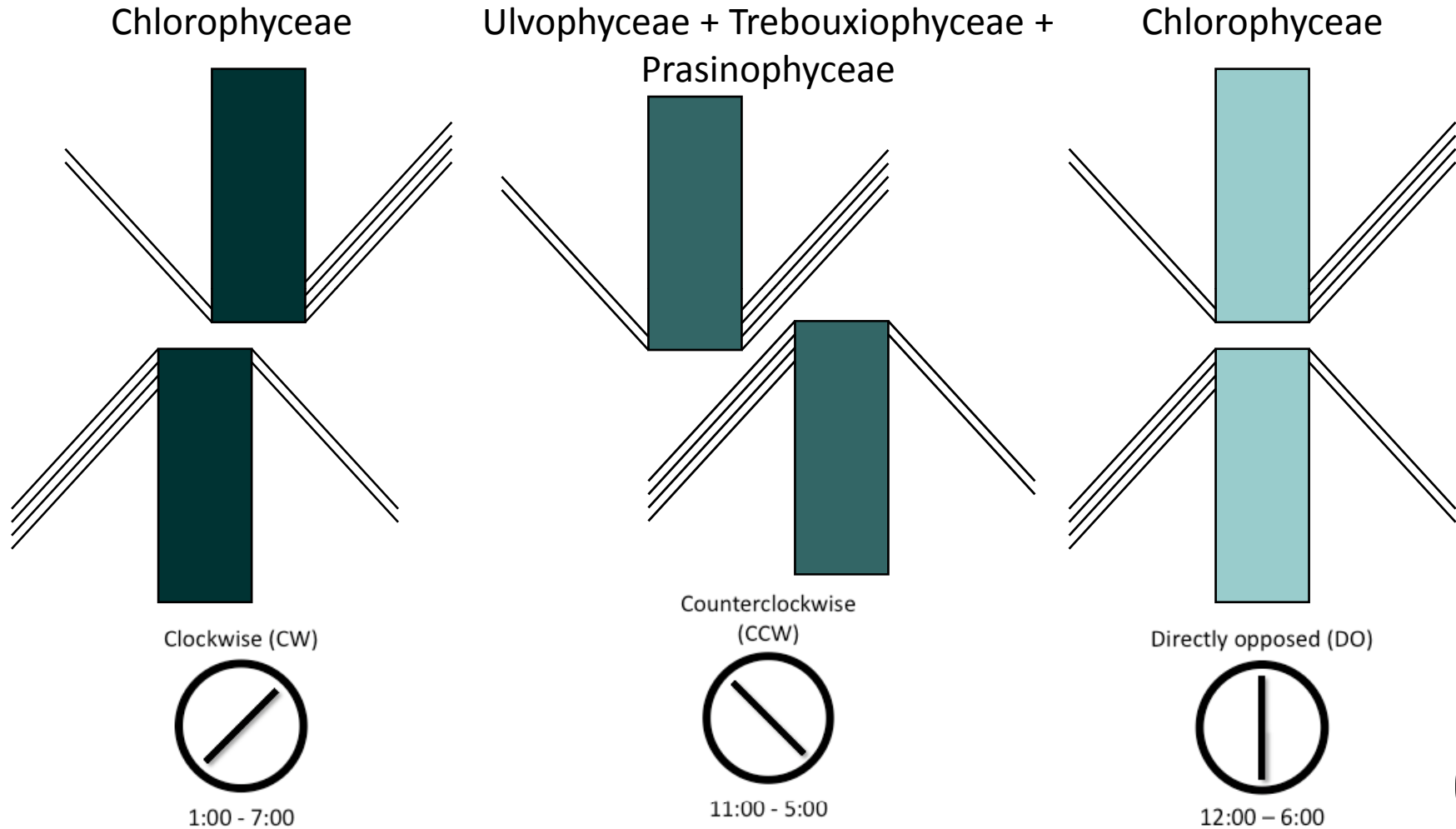
Chlorophyceae



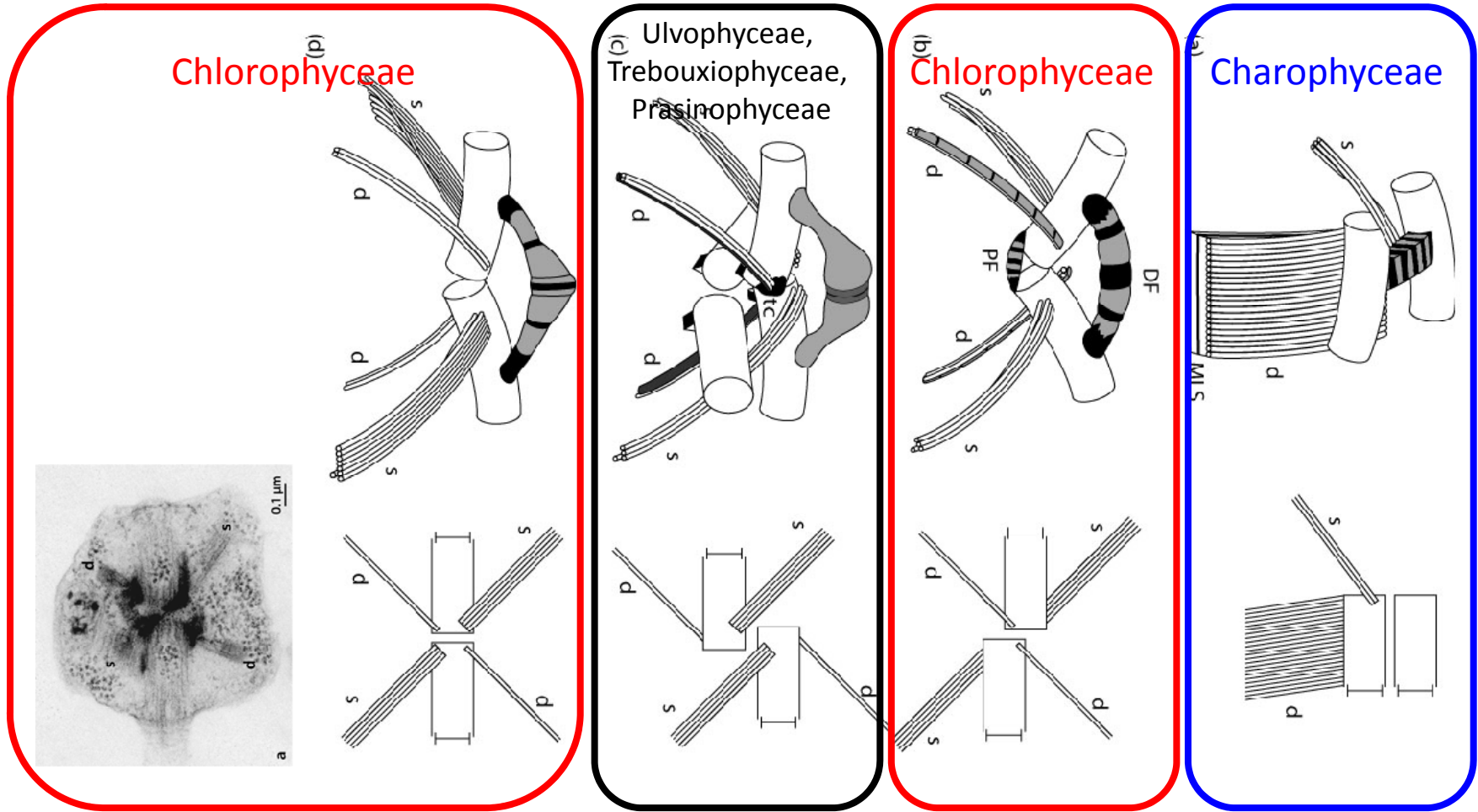
Ulvophyceae



Understanding Basal Body Orientation



Basal Body Orientations



Ancestral condition.

General Features: Mitosis

- Nuclear membrane
 - (a) Open, (b) Closed, (c) metacentric

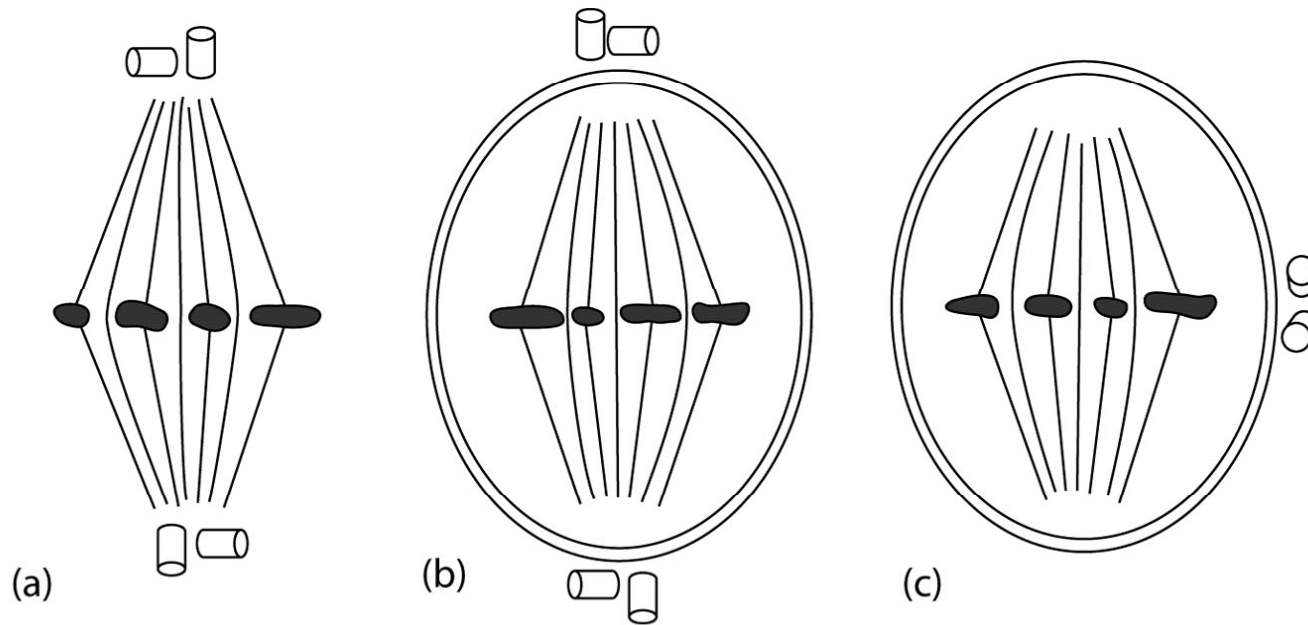


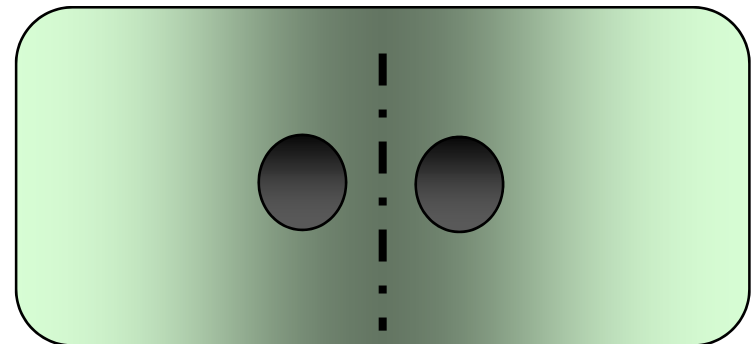
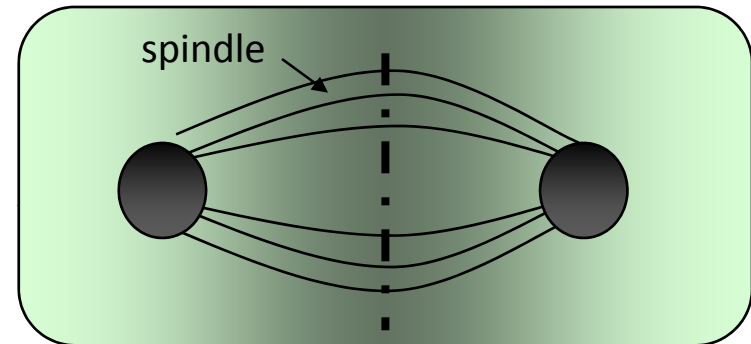
Fig. 16.8. Graham et al. 2008.

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General Features: Mitosis

- Telophase spindle
 - Persistent
 - Spindle separating daughter nuclei remains intact even after nuclei are separated
 - Result = daughter nuclei remain separated
 - Collapsing spindle
 - Spindle degrades following completion of mitosis
 - Result = daughter nuclei in close proximity to one another

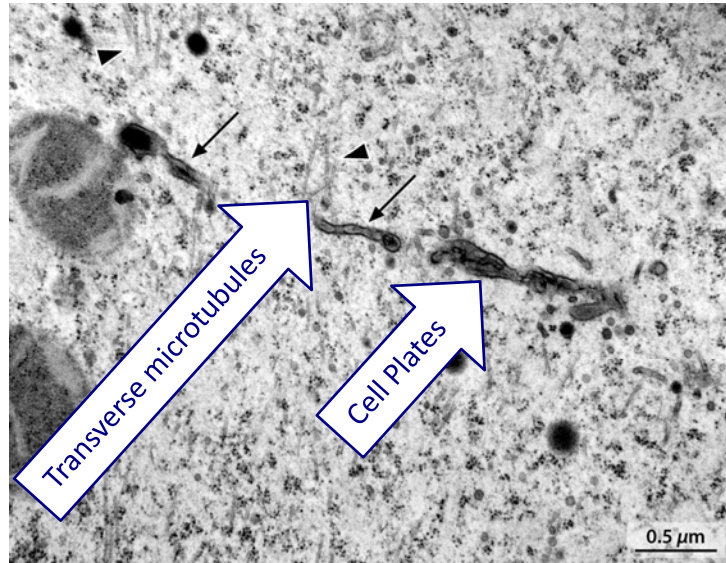
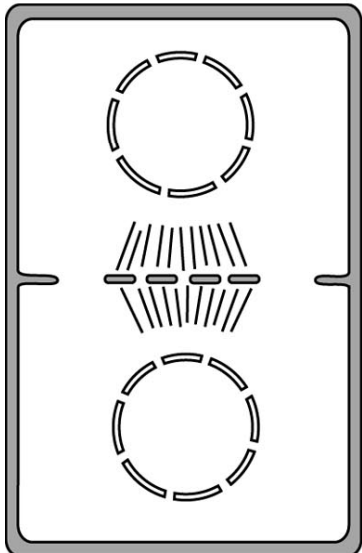


General Features: Cytokinesis

- 2 mechanisms
 - Furrowing
 - Vesiculation (cell plate: a planar array of vesicles containing cell wall material)
 - Golgi-derived vesicles
 - ER-derived vesicles
 - Furrowing + Vesiculation
- 2 basic microtubule arrangements
 - phycoplast
 - phragmosplast



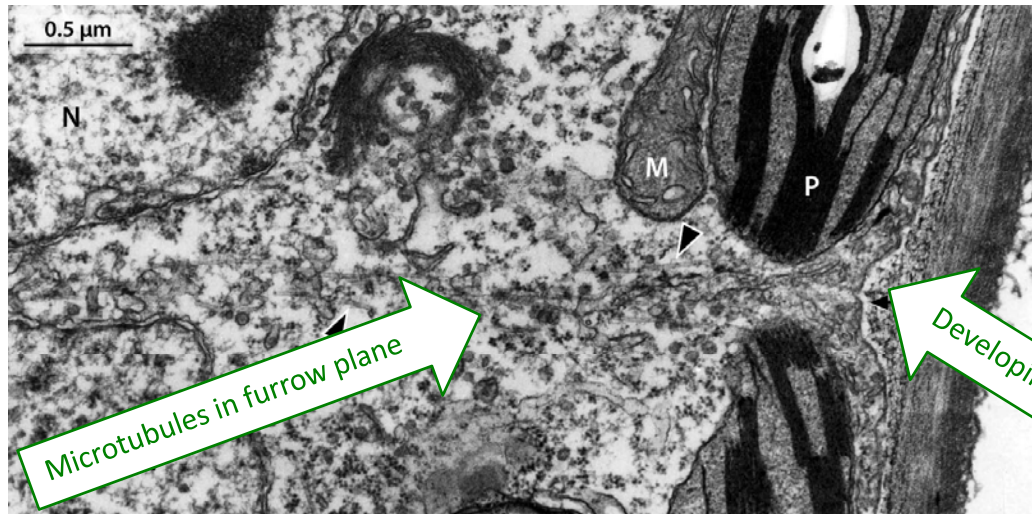
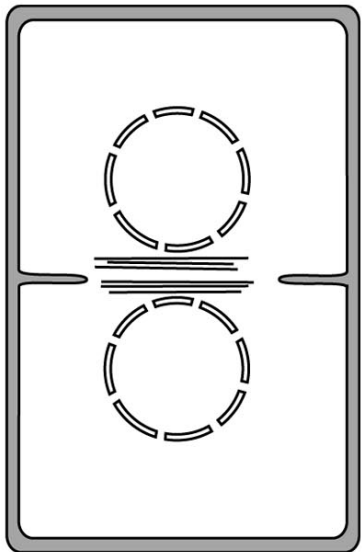
General Features: Cytokinesis



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Phragmoplast

- Streptophyta
- Trentepohliales (Ulvophyceae)



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Phycoplast

most
Chlorophyceae

General Features: Mitosis & Cytokinesis

- Substantial variation exists in mitosis & cytokinesis among green algae

Mitosis	Telophase Spindle	Cytokinesis	Microtubules
Open	Persistent	Furrowing	Phycoplast
Closed	Collapsing	Vesiculation	Phragmoplast
Metacentric		Both	

- Van den Hoek et al. 1995 recognized 7 classes on the basis of mitosis and cytokinesis patterns (in addition to other traits)
- Not clear whether diagnostic patterns exist across taxa, but variability lent credence to weakness of strict morphological concepts (O'Kelly pers. comm.)



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- van den Hoek, C., Mann, D.G., & Jahns, H.M. (1995) *Algae. An Introduction to Phycology*. Cambridge University Press, Cambridge.



*This presentation is a contribution of the
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***Advanced Methods in
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14 Aug - 4 Sep 2009, Bocas Research Station,
Bocas del Toro, Panama

