

Winter 2020

PHYCOLOGY

An illustrated study guide

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Acknowledgements:

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Main characteristics among phyla

Phylum	Cyanophyta	Chlorophyta	Phaeophyta	Rhodophyta
Pigments	Chlorophyll a; phycobilins; B-carotene; xanthophylls	Chlorophylls a & b; B-carotene; siphonoxanthins	Chlorophylls a & c; fucoxanthin; B-carotene; xanthophylls	Chlorophyll a; B-carotene; phycobilins (phycocyanin, allophycocyanin, phycoerythrin)
Thylakoids	Unstacked	Stacks of 2-20	Stacked in 3's	Unstacked
Flagella?	No	Yes	Yes	No
Product	Plant-like starch	Plant-like starch	Laminarin	Floridean starch
Cell covering	Peptidoglycan	Cellulose / other polymers (some calcified)	Cellulose / alginates	Cellulose, polysaccharides including carrageenan and agar (some calcified)
Meiosis types	N/A	Zygotic, gametic, or sporic	Sporic or gametic	Sporic (triphasic)
Pit connections?	No	No	No (instead: plasmodesmata)	Yes

Taxonomic classification

- **Phylum** (ends in "-phyta")
 - **Class** ("-phyceae")
 - **Order** ("-ales")
 - **Family** ("-ceae")
 - **Genus**
 - **Species**

Some key vocabulary

Topic	Term	Definition
Reproduction	Holocarpic	Uses entire organism/plasma to reproduce once, then dies
Reproduction	Non-holocarpic	Regular sexual reproduction
Reproduction	Isogamy	Same-sized gametes
Reproduction	Anisogamy	Different-sized gametes
Reproduction	Oogamy	Different-sized gametes where the female (egg) is huge
Plastids	Heterplasticity	Plastids with different purposes (storage vs. photosynthesis)
Structure	Pericentral cell	Cell from axial cell; of equal length (polysiphonous)
Structure	Pericaxial cell	Cell from axial cell; of shorter length; forming cortex
Structure	Gland cell	Reflective clear cell, often in sacks; storage
Reproduction	Trichoblast	Hair-like cells (colorless)
Reproduction	Trichogyne	Hair on carpogonium
Reproduction	Carpogonium	Oogamete (female gamete on female gametophyte)
Reproduction	Cystocarp	(1n) Gametic cyst covering around (2n) carposporophyte
Reproduction	Carposporophyte	(2n) Divided zygote producing gonimoblasts & carpospores
Cell division	Coenocytic	Fused multinucleate cells
Cell division	Septate	Coenocytic with cross walls
Cell division	Siphonous	Coenocytic; lacking cross walls
Reproduction	Alternation of generations	Complex life cycles with haploid and diploid stages
Reproduction	Heteromorphic	Sporophyte and gametophyte forms look different
Reproduction	Isomorphic	Sporophyte and gametophyte forms look similar/identical

Cyanobacteria diagram

Examples: *Nostoc* and *Anabaena*

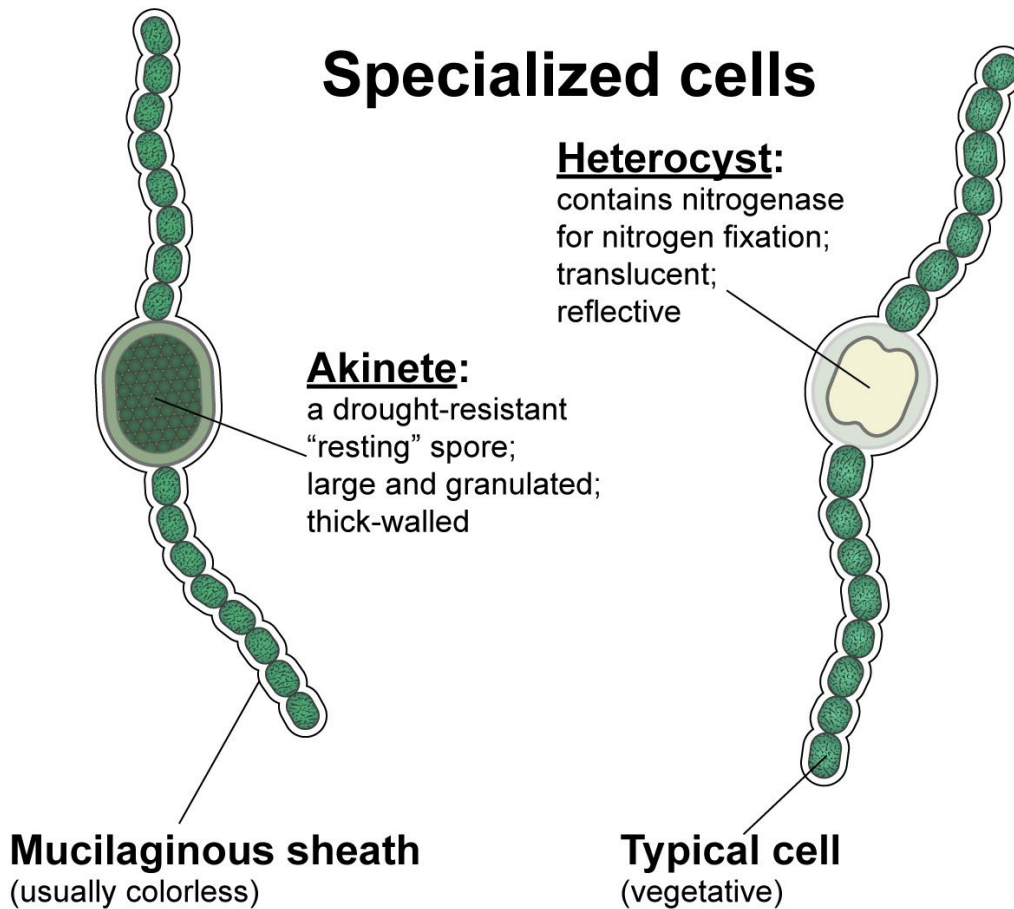
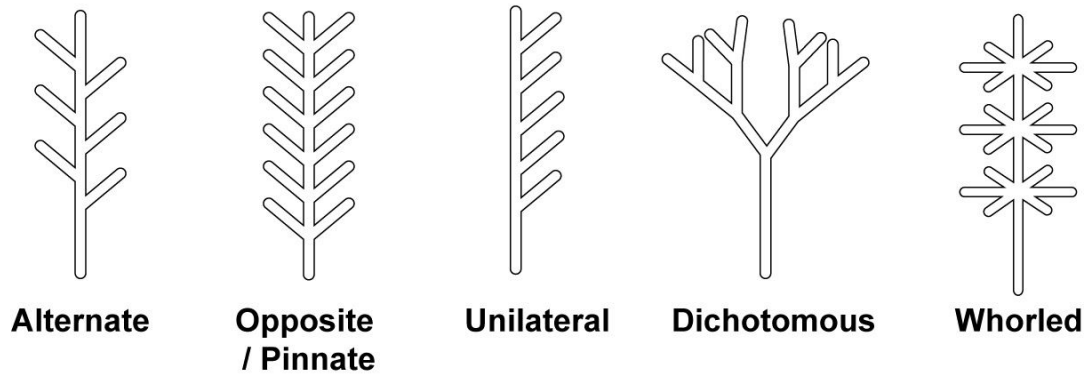


Figure 1: Diagram of cyanobacteria showing specialized cells.

Common algae branching types



Actual examples

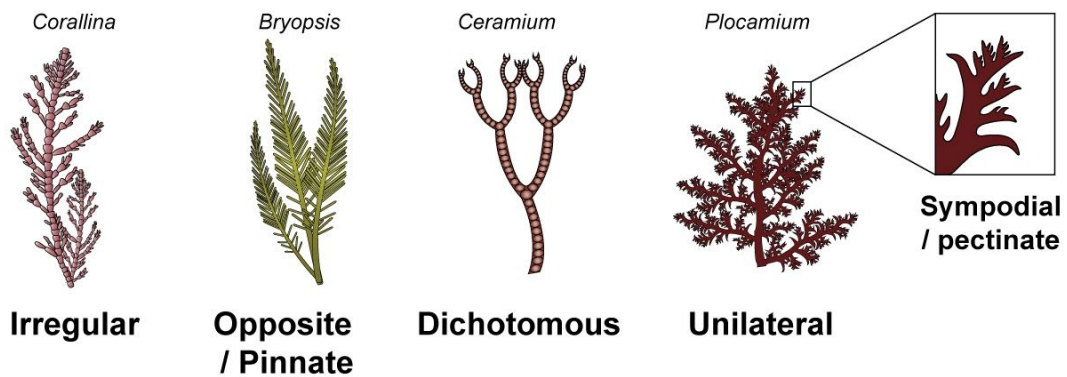
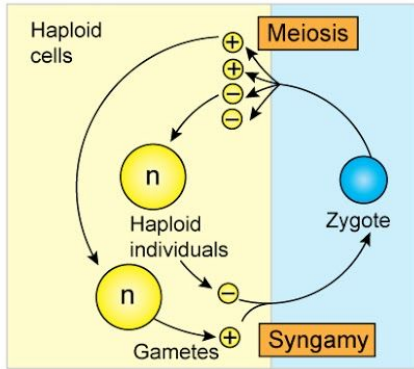


Figure 2: Common branching types found in algae (additional ones not pictured include spiral, decussate, trichotomous, and cervicorn) with actual examples. Sympodial means that the branch tips curve, reaching over the apical region; pectinate is “comb-shaped” as seen in the closeup of *Plocamium*.

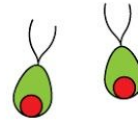
Sexual reproduction in algae

(a) Zygotic meiosis

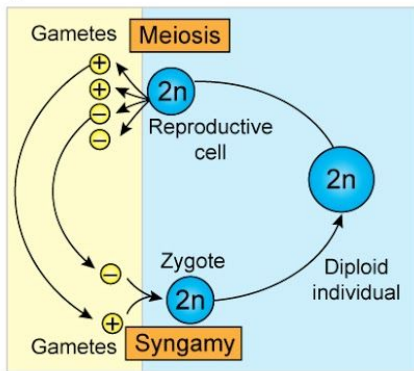


Isogamy

Equally-sized gametes (1n each)

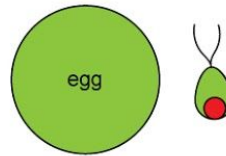


(b) Gametic meiosis

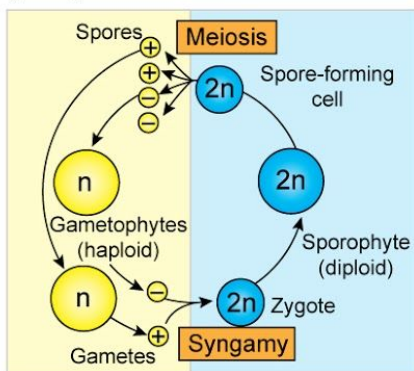


Oogamy

Egg and sperm gametes (1n each)

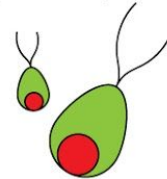


(c) Sporic meiosis



Anisogamy

Unequal gametes (1n each)



Zygote from gamete fertilization (2n)

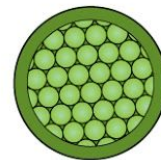


Figure 3: Types of sexual reproduction (zygotic, gametic, and sporic) in algae with examples of possible male-female gamete pairs.

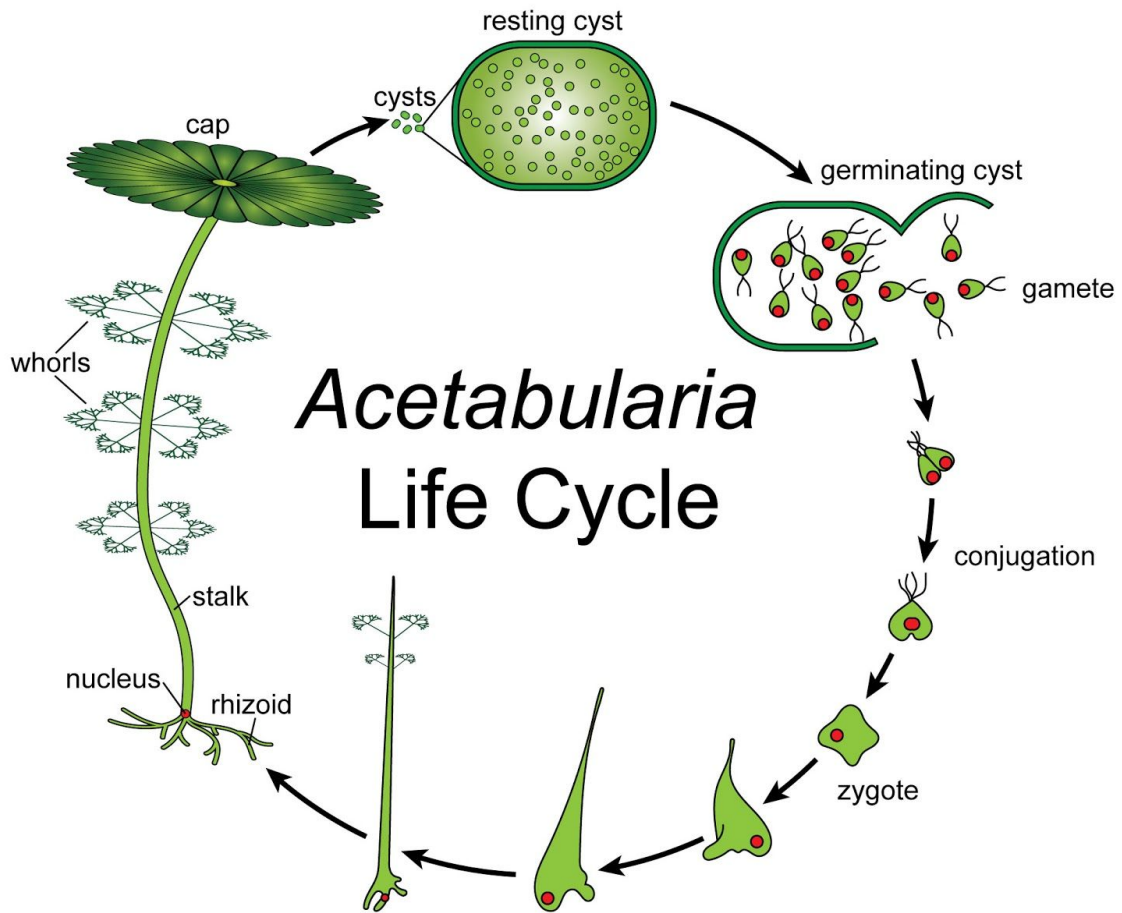


Figure 4: Life cycle of a tropical green alga, *Acetabularia* (Phylum Chlorophyta; Class Ulvophyceae; Order Dasycladales) commonly known as “mermaid’s wine glass.” This is an example of **gametic meiosis**.

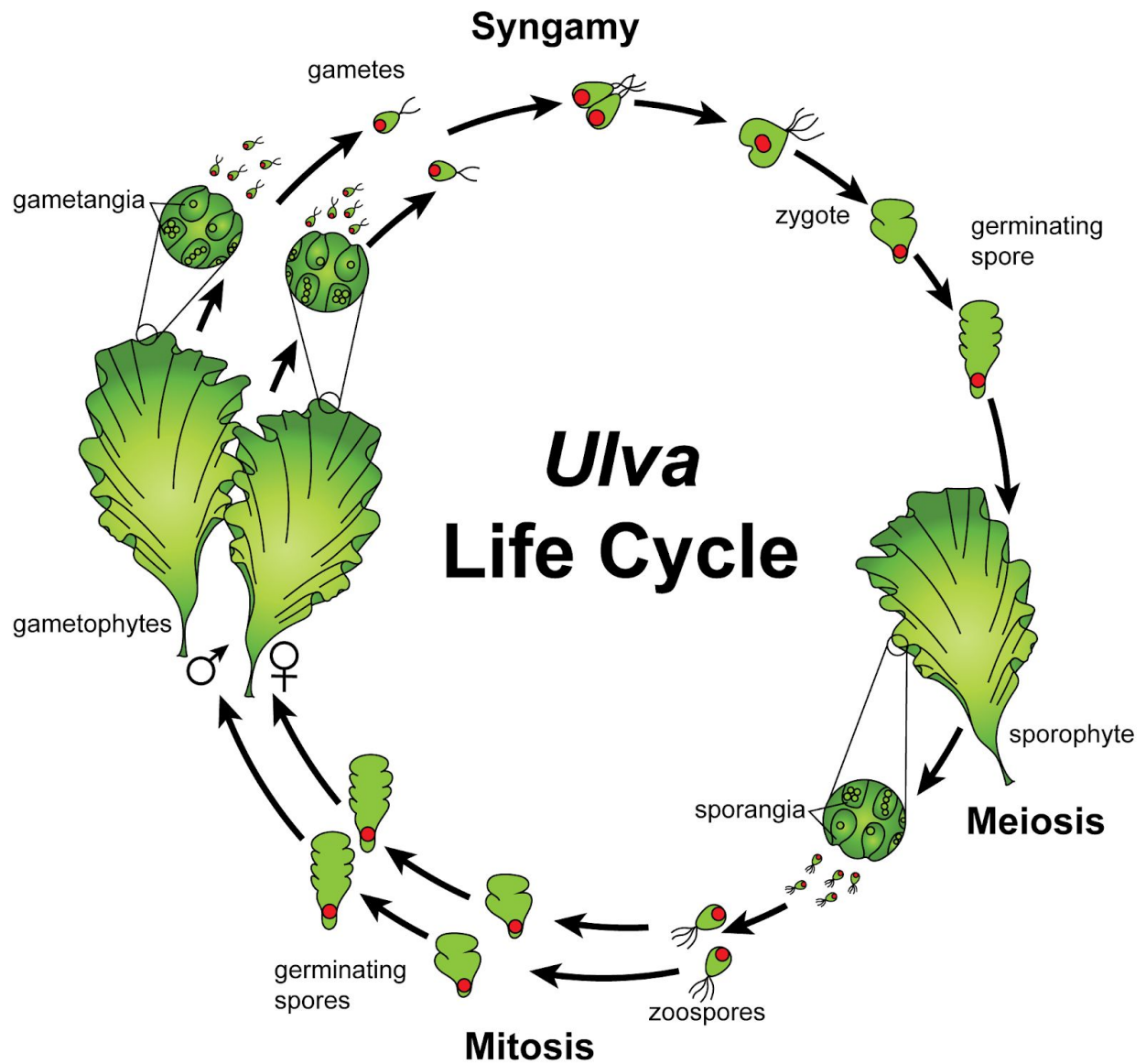


Figure 5: Life cycle of a green alga, *Ulva* (Phylum Chlorophyta; Class Ulvophyceae; Order Ulvales) commonly known as “sea lettuce.” This is an example of **sporic meiosis**.

Solar-Powered Sea Slug



The sea slug *Elysia* pierces the green alga *Codium*, sucks out the cell contents and incorporates the chloroplasts into its own cells. It's then able to photosynthesize!

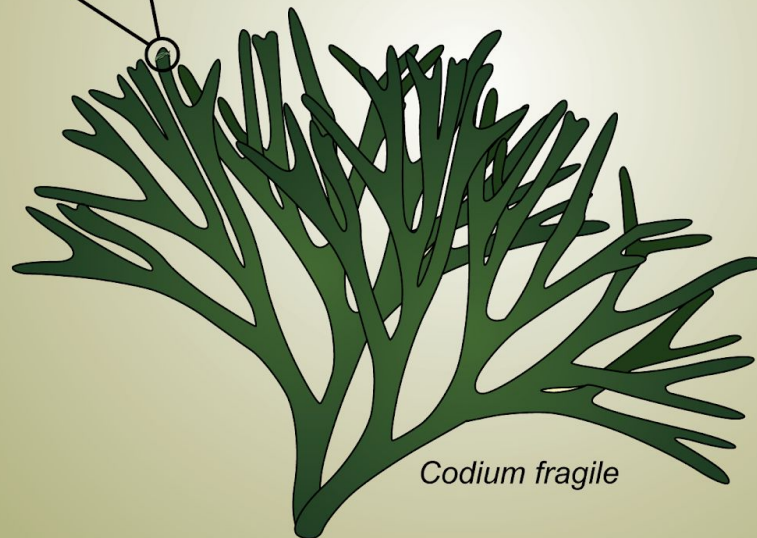


Figure 6: Example of kleptoplastidy involving the emerald sea slug *Elysia* and the green alga *Codium fragile* (Phylum Chlorophyta; Class Ulvophyceae; Order Bryopsidales).

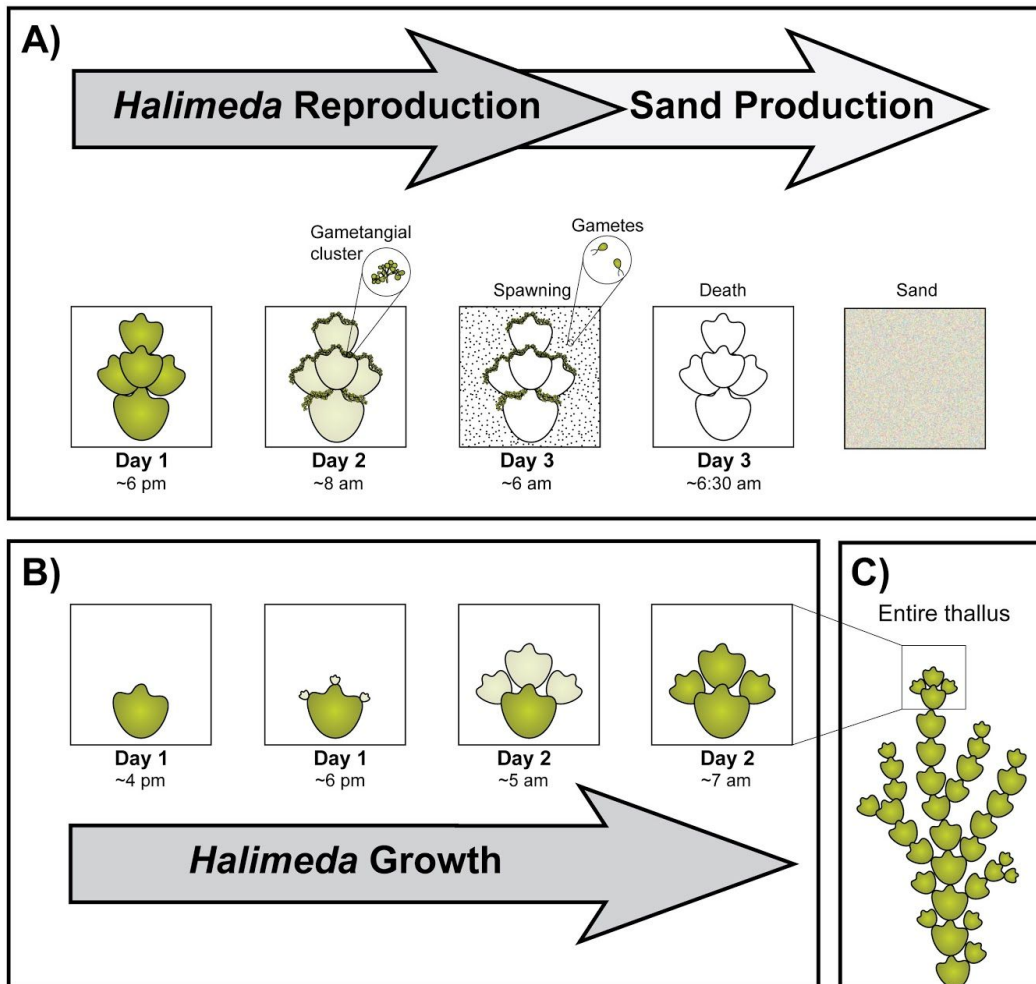
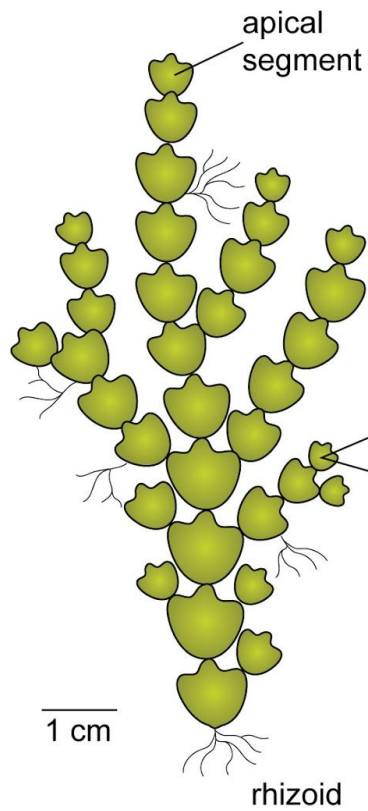


Figure 7: Processes of reproduction (and consequently, death) and new segment growth in the calcareous tropical green alga, *Halimeda*.

Halimeda opuntia

External Organization



Internal Structure

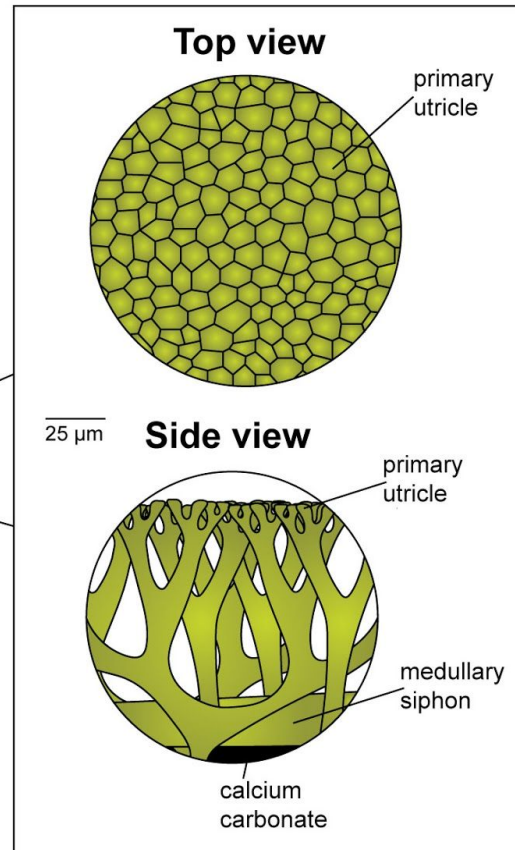


Figure 8: Macroscopic and microscopic views of the calcareous tropical green alga, *Halimeda opuntia* (Phylum Chlorophyta; Class Ulvophyceae; Order Bryopsidales).

Halimeda opuntia

(internal structure)

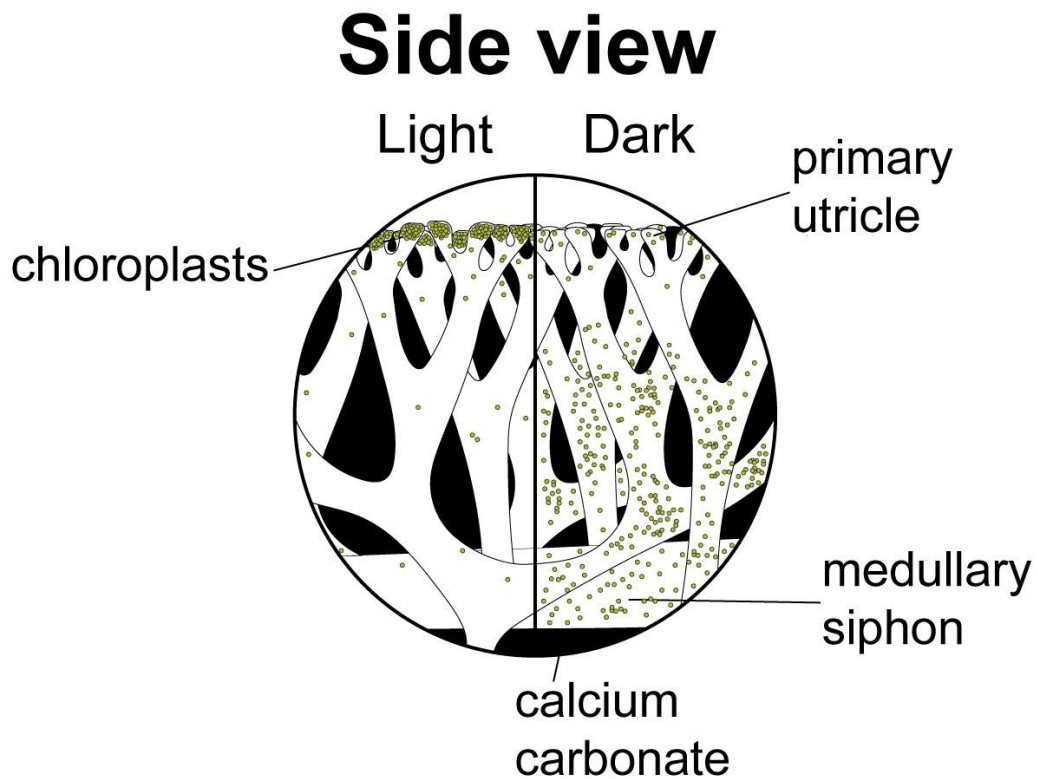


Figure 9: Internal view of a segment of the calcareous tropical green alga, *Halimeda opuntia*, showing chloroplast distribution (in both light and dark) within the surface utricles and medullary filaments.

Example of red algae reproduction*

(triphasic “alternation of generations”)

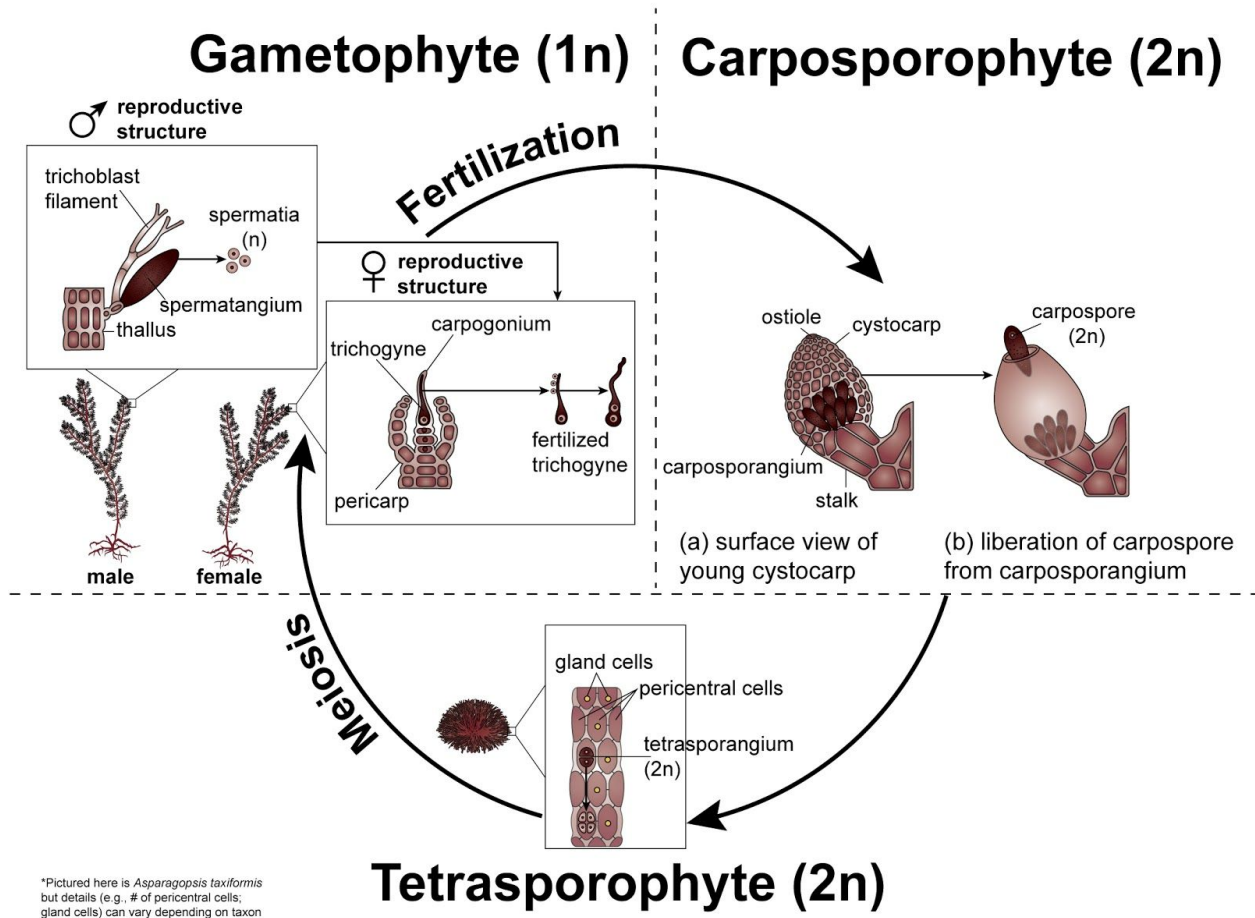
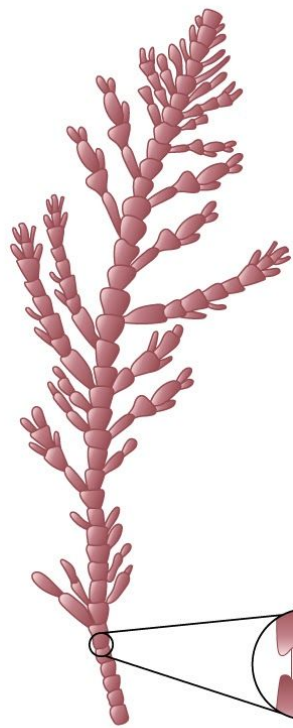


Figure 10: Life cycle in the red alga, *Asparagopsis taxiformis* (Phylum Rhodophyta; Class Florideophyceae; Order Bonnemaisoniales). This is an example of **triphasic sporic meiosis**.



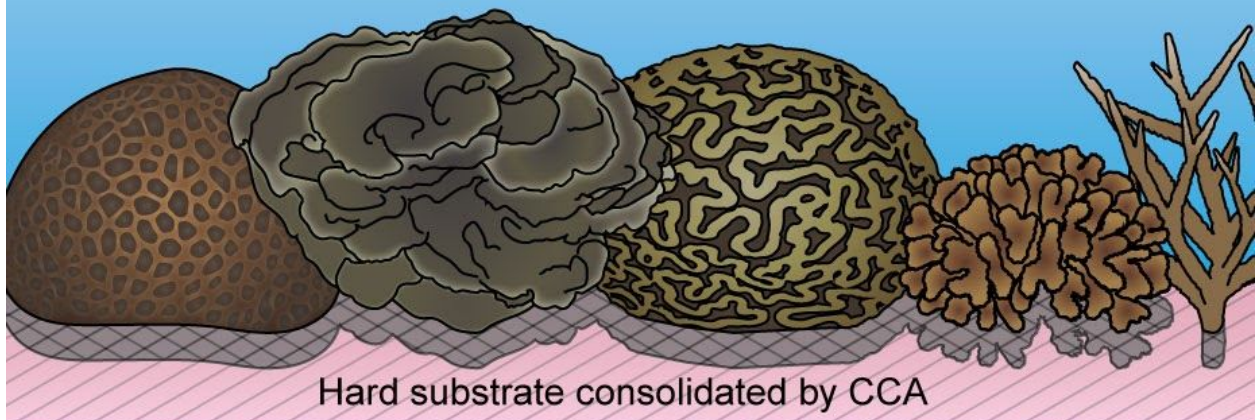
Genicula are the non-calcified “knees” or hinges between the calcified **intergenicula** in articulated coralline algae (e.g., *Corallina*).

Geniculum

Intergeniculum

Figure 11: Diagram of genicula (joints) and intergenicula (segments) in a red articulated coralline alga, *Corallina*.

Crustose Coralline Algae: Coral Reef “Architects”



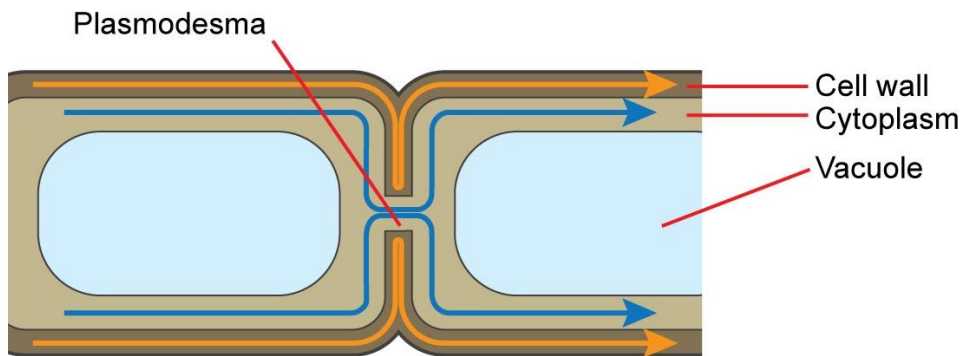
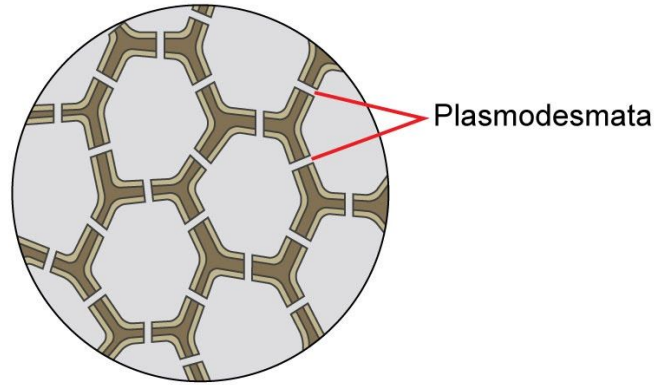
If we think of corals as the “bricks” of the reef, then crustose coralline algae (CCA) are the “cement” that fills in the gaps and holds everything together. They also provide cues for new corals to settle.

Figure 12: Importance of crustose coralline algae (CCA; which are encrusting, red, and calcareous) as reef-builders.

Plasmodesmata are present in the cross walls of all brown algal cells; they are generated during cytokinesis

Functions:

- Provide intracellular connectivity among cells
- Symplastic communication (cytoplasm to cytoplasm)
- Used to translocate photosynthetic products in some kelps



- Apoplastic pathway (through cell wall)
- Symplastic pathway (through cytoplasm)

Figure 13: Diagram of plasmodesmata (found in brown algae).

Examples of apical growth in brown algae

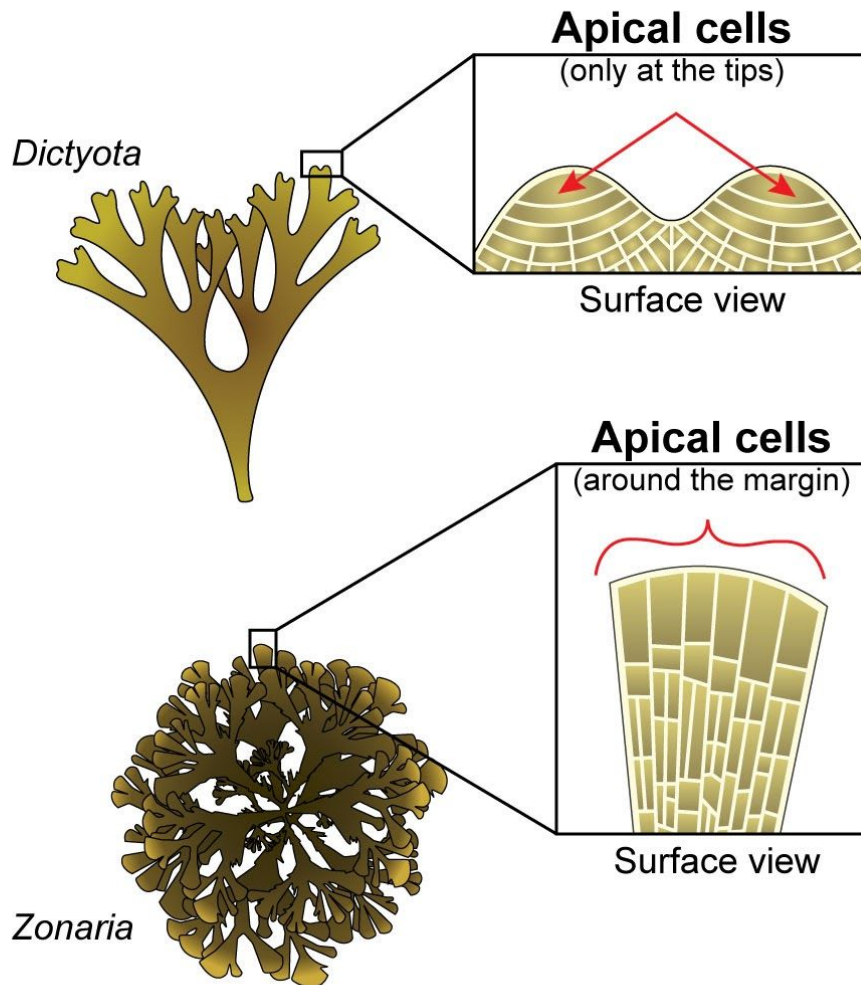


Figure 14: Examples of growth via apical cells only at the tips in *Dictyota* (Phylum Ochrophyta; Class Phaeophyceae; Order Dictyotales) and a row of apical cells around the margin in *Zonaria* (Phylum Ochrophyta; Class Phaeophyceae; Order Dictyotales).

Diagram of *Macrocystis*

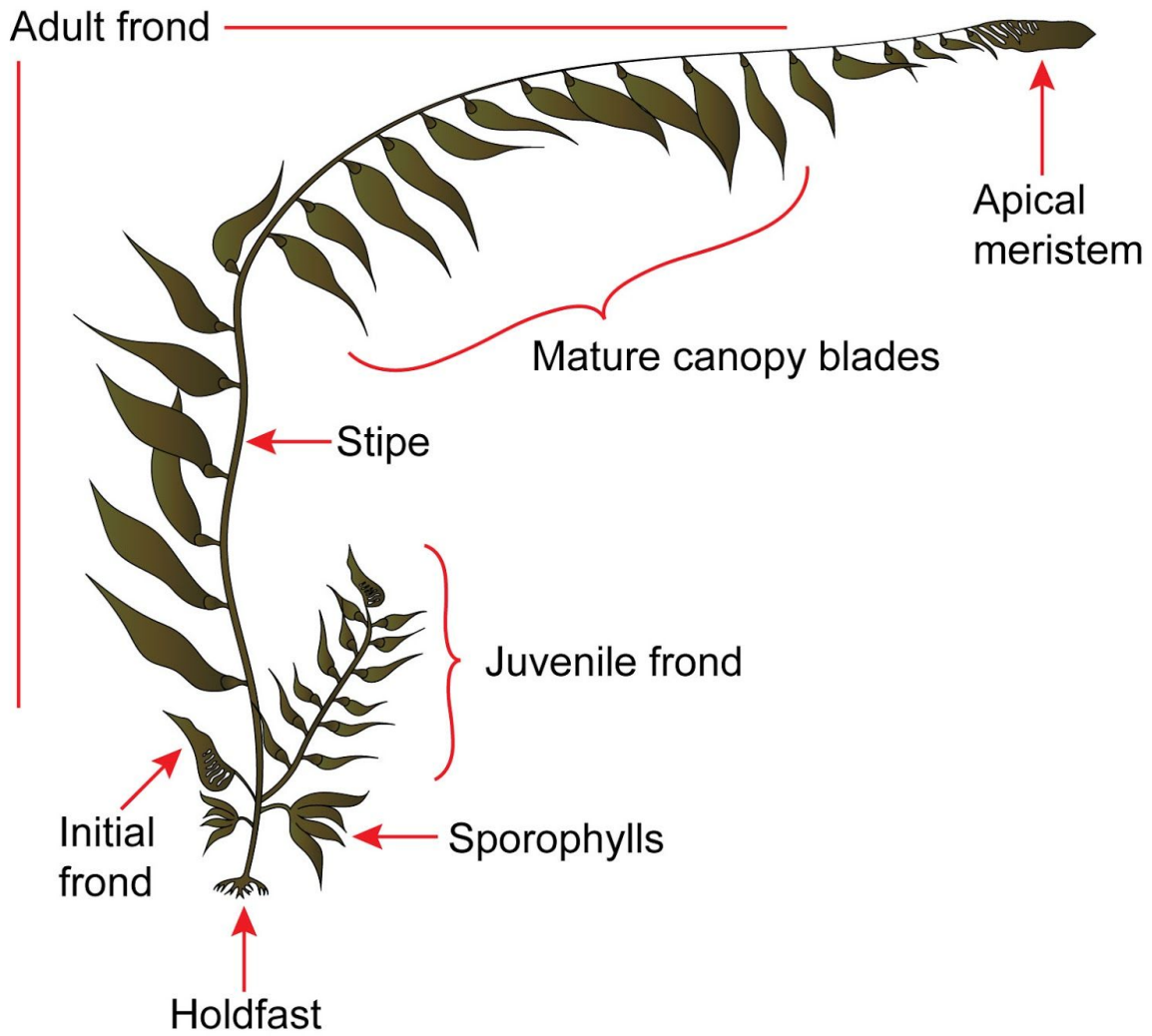


Figure 15: Labeled diagram of the giant brown kelp, *Macrocystis pyrifera*.

Macrocystis Life Cycle

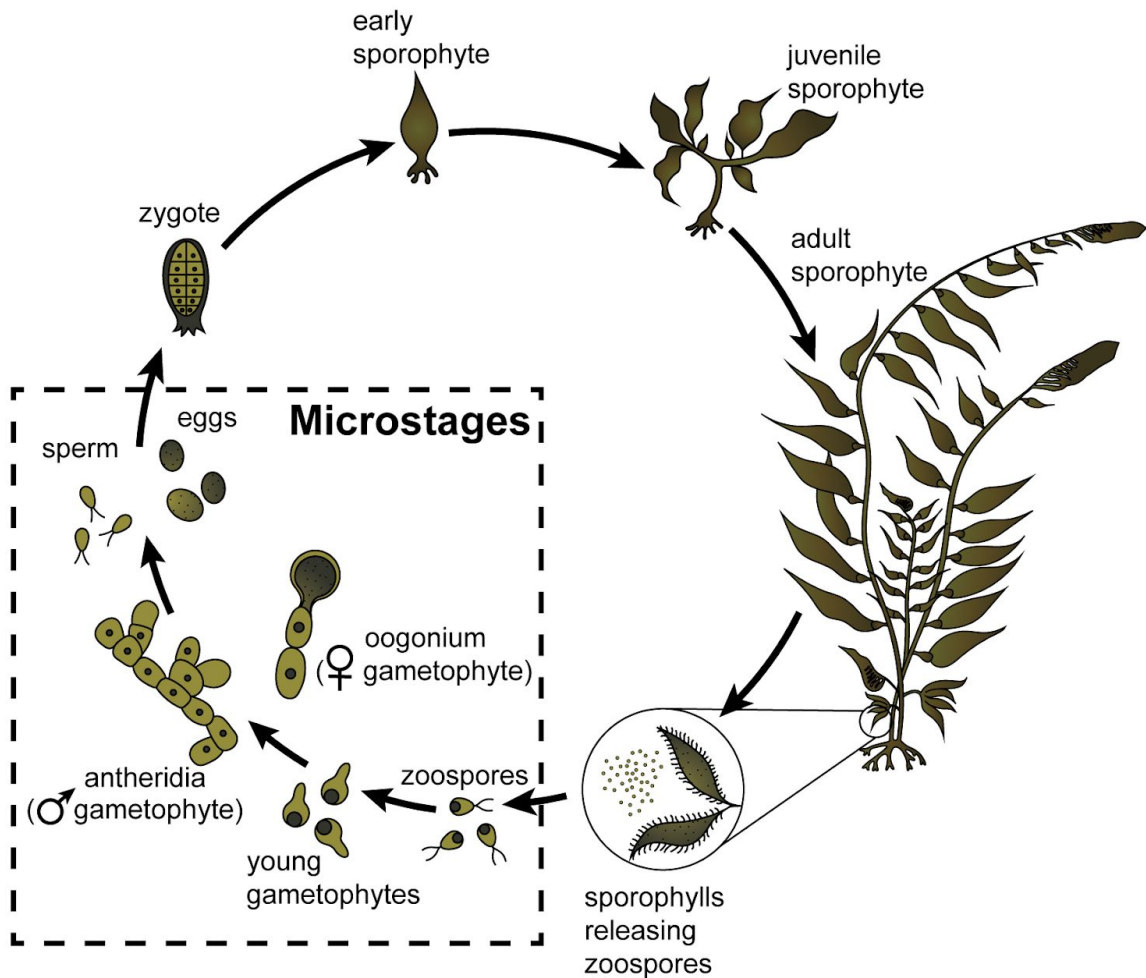


Figure 16: Life cycle of a brown alga, *Macrocystis pyrifera* (Phylum Ochrophyta; Class Phaeophyceae; Order Laminariales) commonly known as “giant kelp.” This is an example of **sporic meiosis**-- heteromorphic alternation of generations.

Fucus Anatomy

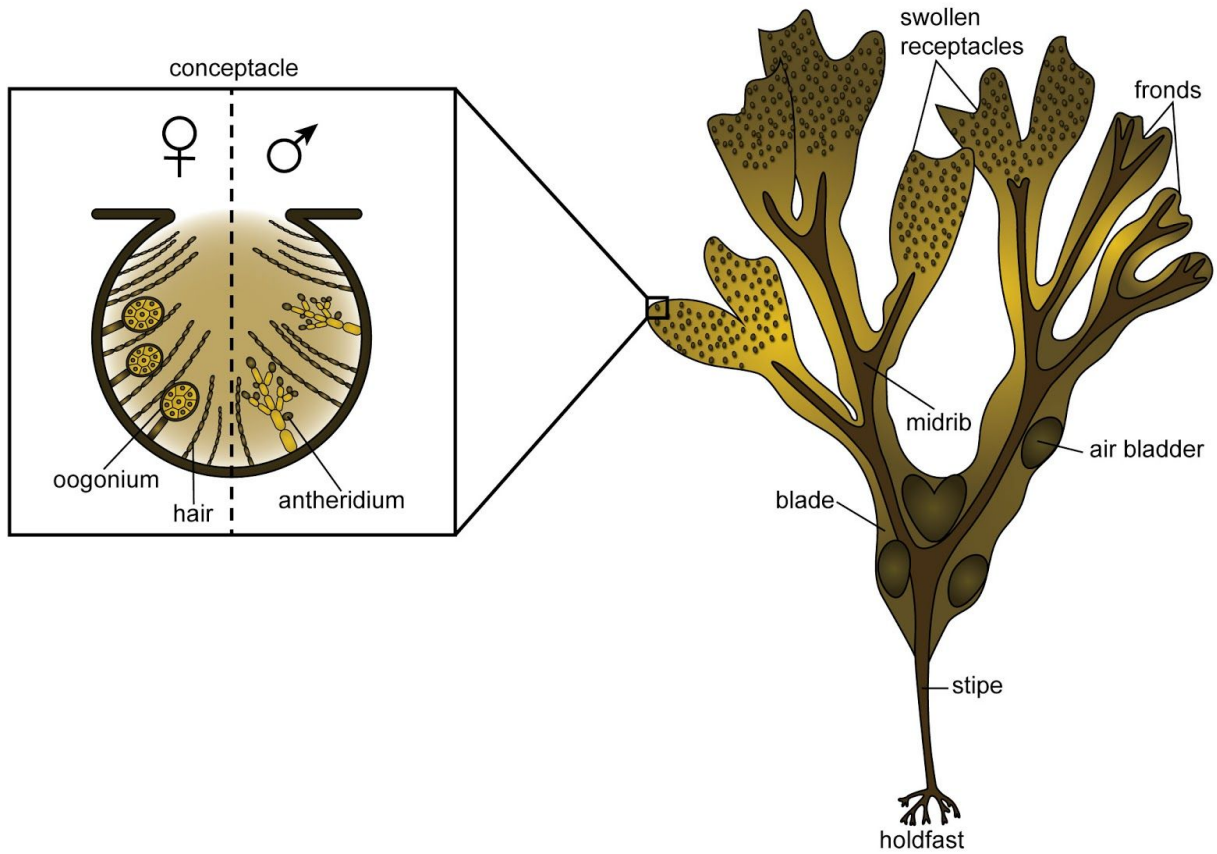


Figure 17: Anatomy of a brown alga, *Fucus* (Phylum Ochrophyta; Class Phaeophyceae; Order Fucales) showing reproductive structures.


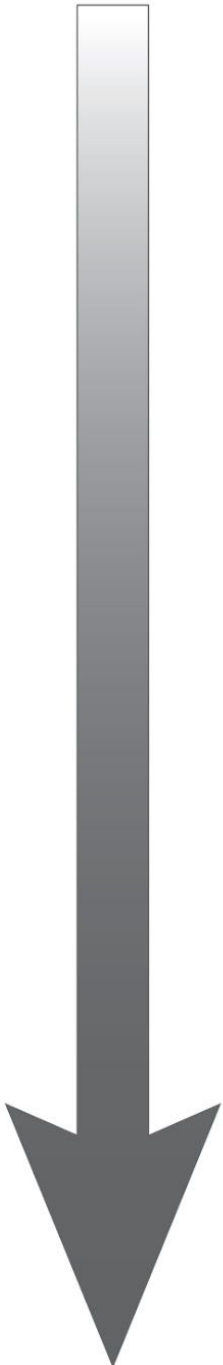






Functional group	Morphology	Grazing difficulty
1. Microalgae	 Diatom	
2. Filamentous algae	 <i>Cladophora</i>	
3. Foliose algae	 <i>Ulva</i>	
4. Corticated macrophytes	 <i>Plocamium</i>	
5. Leathery macrophytes	 <i>Fucus</i>	
6. Articulated calcareous algae	 <i>Corallina</i>	
7. Crustose coralline algae	 CCA	

Figure 18: Examples of algae from different functional groups, ranked by grazing difficulty.