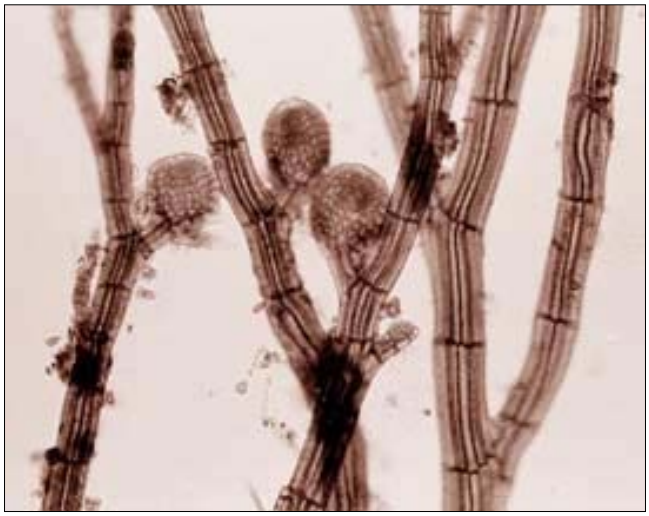
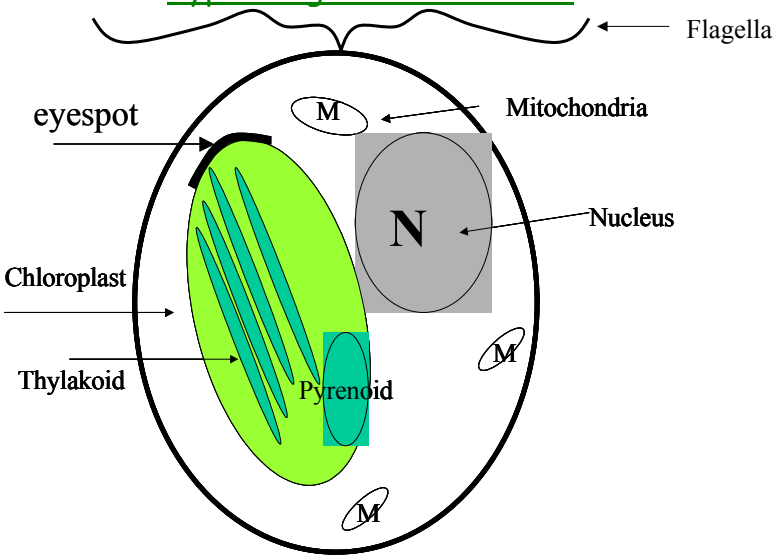
Algal Physiology and Morphology



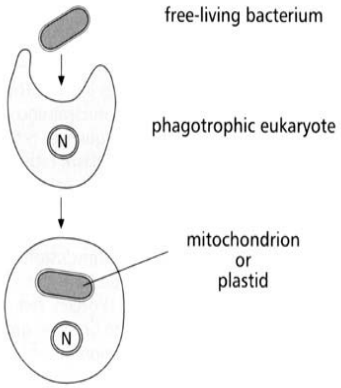
Typical algal cell structure:



Simplified Algal Cell

Endosymbiotic theory of organelle acquisition:

(L. Margolis)

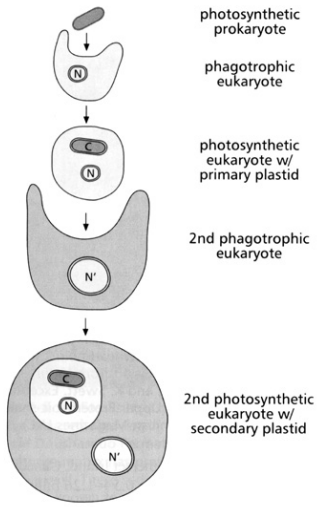


- phagocytosis of heterotrophic and photosynthetic prokaryotes = mitochondria and plastids

- transfer of DNA into host nucleus

- Plastid acquisition occurred independently multiple times in algal divisions

Secondary Endosymbiotic Events



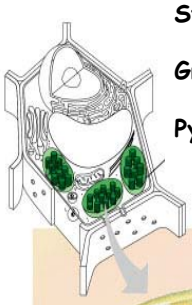
-phagocytosis of prey with a primary endosymbiont = 4 membranes around plastids

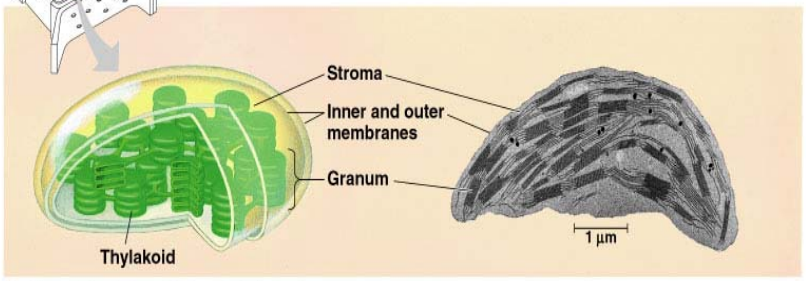
Chloroplasts

Thylakoid – flattened vesicles or sacks; thylakoid membrane is where the pigments are
Stroma - space between inner membrane and thylakoids

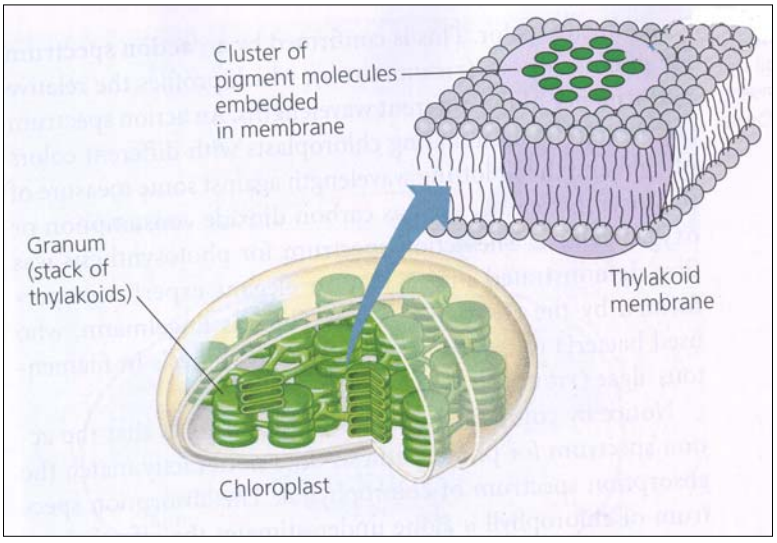
Granum (pl: grana) – stacks of thylakoids

Pyrenoid – holds enzyme ribulose bisphospate carboxylase (Rubisco) used in Calvin cycle





Pigment Location…..



Algal characteristics for distinguishing divisions:

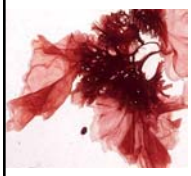
1. Pigments
2. Storage products
3. Cellular/plastid structure
4. Motility (e.g. +/- flagella)
5. Life history

Pigments → three types…

Chlorophyta:
- Chl A, **B**
- carotenoids: B-carotene, lutien, violaxanthin, neoxanthin

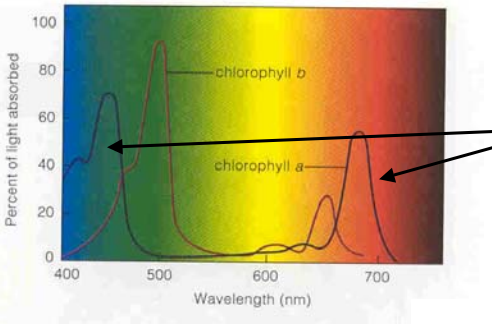
Heterokontophyta:
- Chl A, ***C***
- carotenoids: B-carotene, violaxanthin, fucoxanthin

Rhodophyta:
- Chl A
- carotenoids: A-carotene, B-carotene
- phycobilins: phycoerythrin, phycocyanin, allophycocyanin



Algal pigments:

1. ***Chlorophylls*** – green pigments, embedded in thylakoid membrane. ChlA is the main player: used in PSI of all algae and land plants.



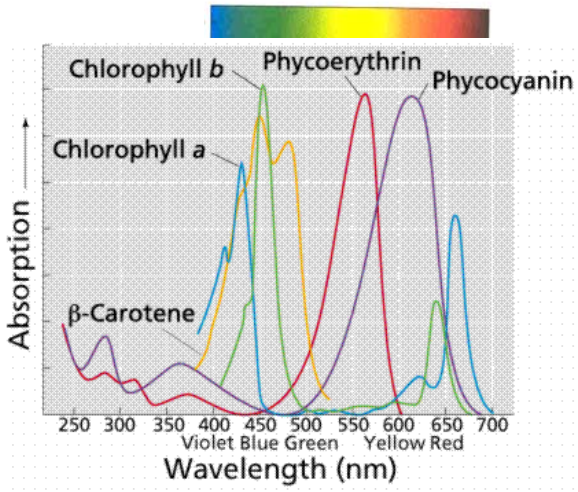
ChlA absorbs light primarily in the blue and far-red regions…

Reflects green → why most plants appear green

2. ***Carotenoids*** – brown, yellow, or red pigments. Hydrocarbons with or without an oxygen molecule = *carotenes* and *xanthophylls*.

3. ***Phycobilins*** – red or blue pigments. Water soluble. Located on the *surface* of thylakoids in red algae, associated with proteins to form *phycobilisomes*

Accessory pigments "fill in the gap" and channel energy to PSI and PSII



Algal characteristics for distinguishing divisions:

1. Pigments
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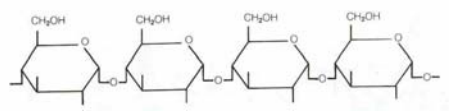
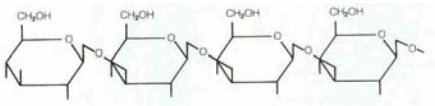
Storage products vary…..

2 forms:
alpha 1,4 linked = starches (Chlorophyta, Rhodophyta)



(e.g. floridean, amylopectin, amylose starches)

beta 1,3 linked = sugars (Heterokontophyta)



(e.g. laminarin, chrysolaminarin, mannitol)

Algal characteristics for distinguishing divisions:

1. Pigments
2. Storage products
3. Cellular/plastid structure
4. Motility (e.g. +/- flagella)
5. Life history

Chloroplast structure varies……

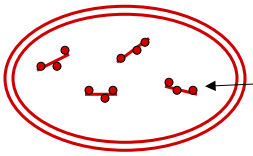
Chlorophyta:

granna stacks = 2-6

Heterokontophyta:

granna stacks = always 3

Rhodophyta:



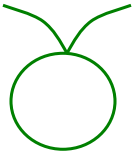
granna = always single, no stacks

Algal characteristics for distinguishing divisions:

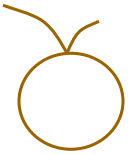
1. Pigments
2. Storage products
3. Cellular/plastid structure
4. Motility (e.g. +/- flagella)
5. Life history

To have or not to have……

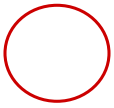
Chlorophyta:



Heterokontophyta:



Rhodophyta:

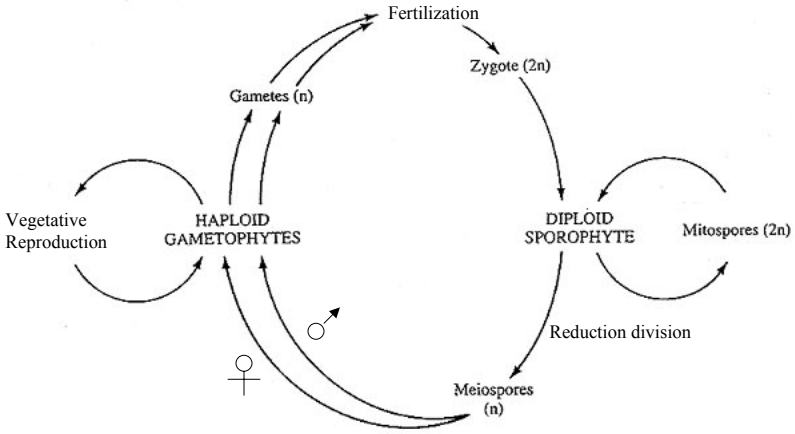


…….flagella

Algal characteristics for distinguishing divisions:

1. Pigments
2. Storage products
3. Cellular/plastid structure
4. Motility (e.g. +/- flagella)
5. Life history

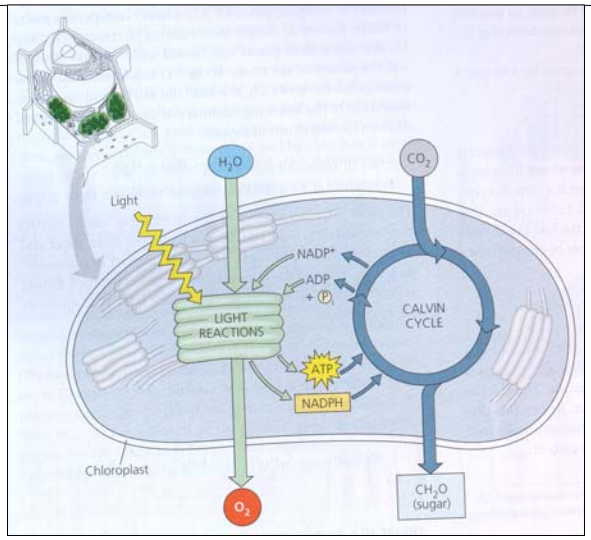
Algal life histories vary….

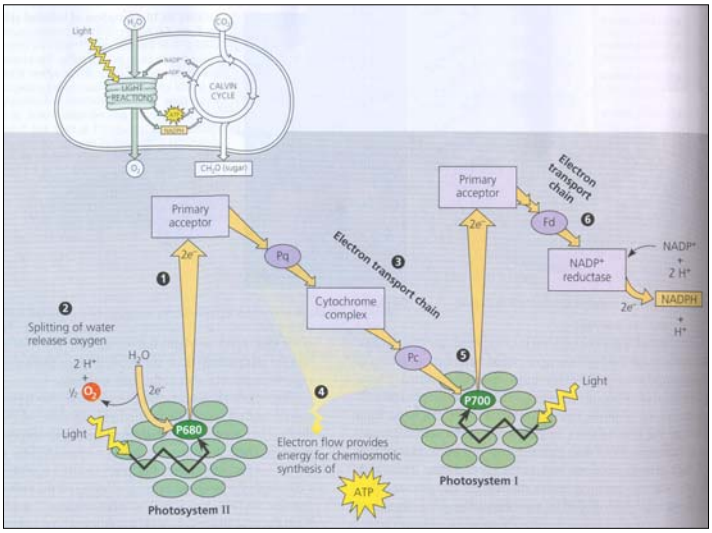


Fiugre 1.28. Some possible seaweed life-history progressions. Most species use only a small part of this range.

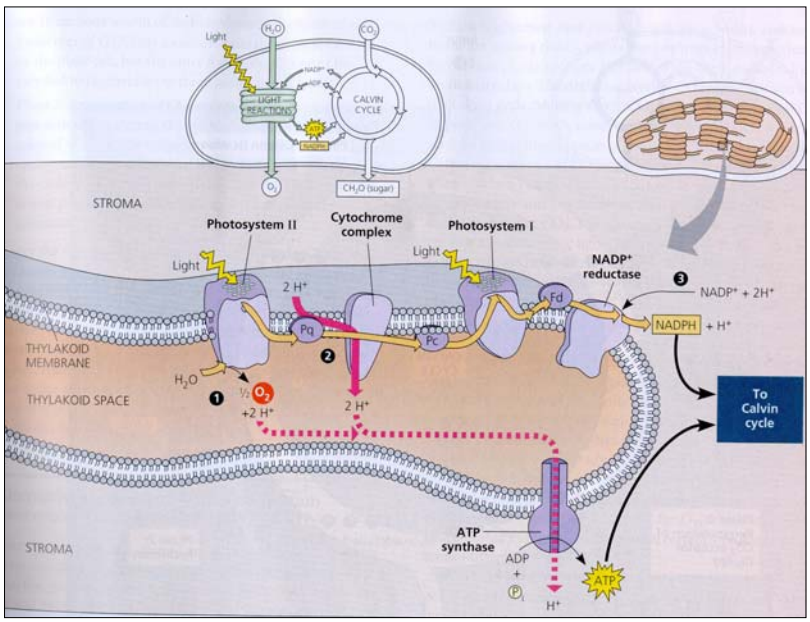
We will revisit this in detail within each division later……..

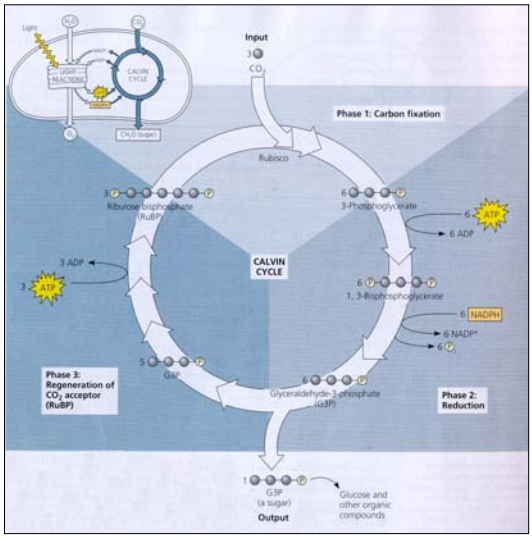
Photosynthesis





Light reactions: solar energy is harvested and transferred into the chemical bonds of ATP and NADPH





Calvin Cycle: C fixation from CO_2 to sugar using energy from ATP and NADPH

External thallus morphologies…

Can affect:

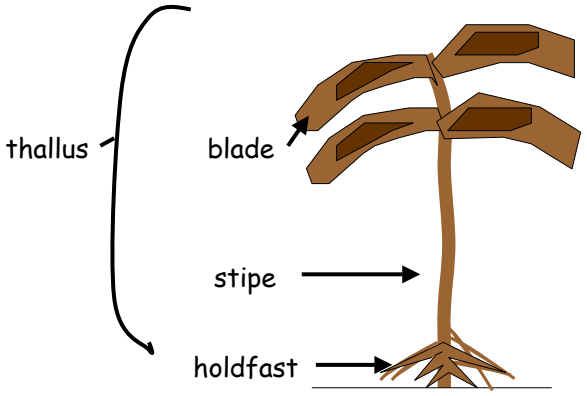
-photosynthesis

-nutrient uptake

-resistance to herbivory

-resistance to physical disturbance (e.g. wave stress)

Algal morphology:

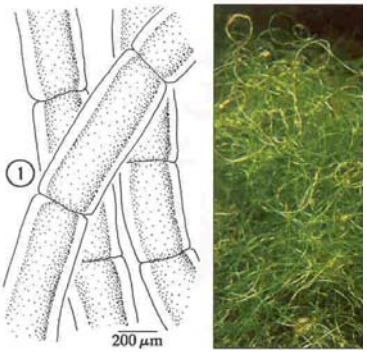


Stipitate = has a stipe

Filamentous

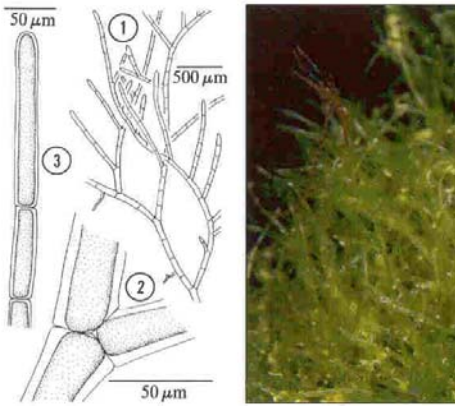
Filamentous

non-branching forms



Chaetomorpha

branching forms



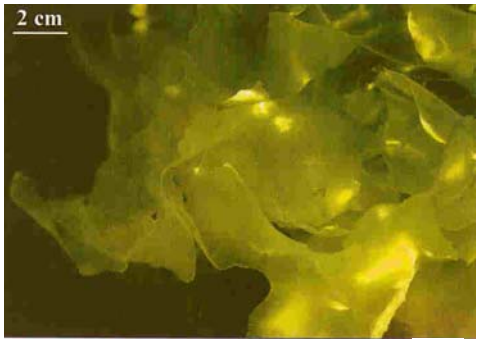
Cladophora

Foliose
leaf/blade/sheet like


Durvillaea

Flattened Blades-Rolled

Padina



Ulva sp.


"Petrocelis" stage

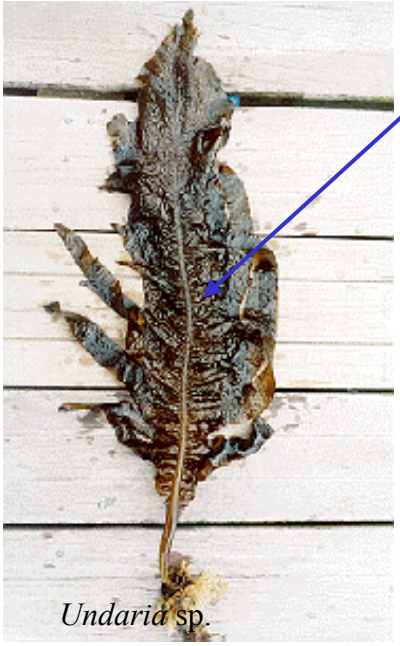

Petrospongium

Prostrate / Procumbent: trailing on the ground


Hildenbrandia

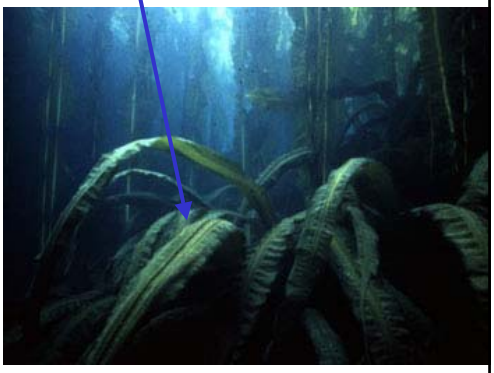

Ralfsia

Saccate = sac-like



Undaria sp.

Midrib



Alaria fistulosa

Geniculate corallines

Geniculum
(flexible joint)

Intergeniculum
(hard part
between genicula)

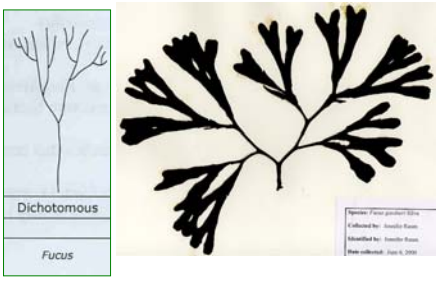
- upright
- articulated
- geniculate

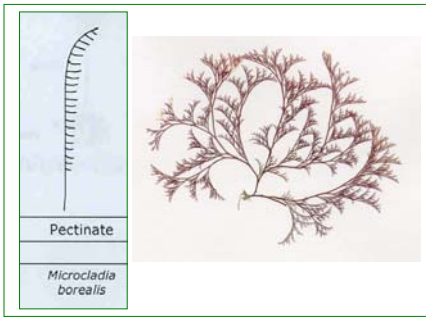
Calliarthron cheiliosporiodes

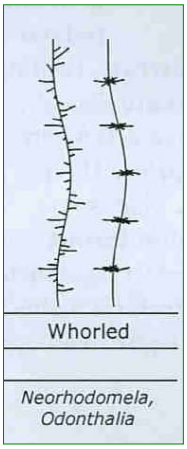
Non-geniculate corallines

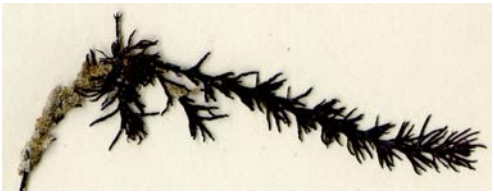
- crustose
- encrusting
- non - geniculate

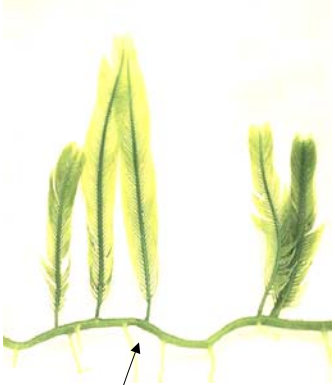
"Branched" in different ways…

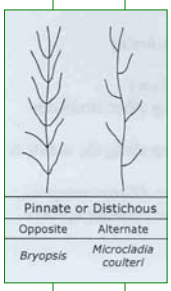










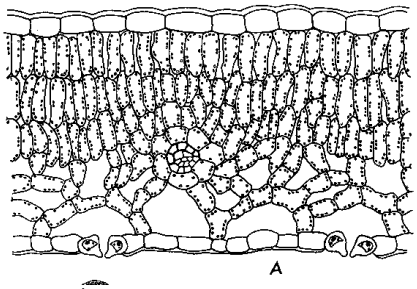


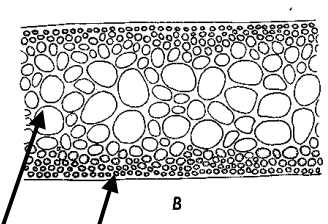
Also → rhizomatous, stoloniferous

Internal thallus morphologies…

Limited cell differentiation compared to terrestrial plants…
e.g. no real dorso-ventral differentiation…

Terrestrial Leaf **Algal blade**





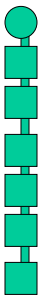
- cuticle
- parenchyma (palisade, spongy)
- veins
- epidermal
- guard cells
- stoma

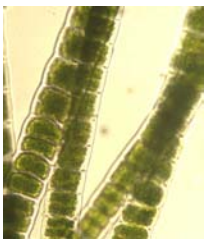
Cortical cells - pigmented

Medullary cells - unpigmented

Filamentous –

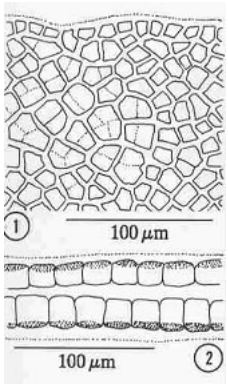
simplest internal individual/external morphology after unicells; cell division in 1-D = row of cells



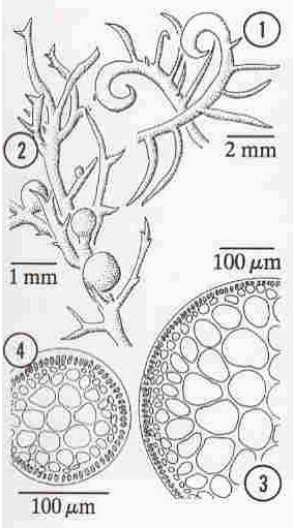


Foliose = Cell division in (at least) 2-D…

monostromatic – one cell thick
distromatic - two cells thick
polystromatic – many cells thick

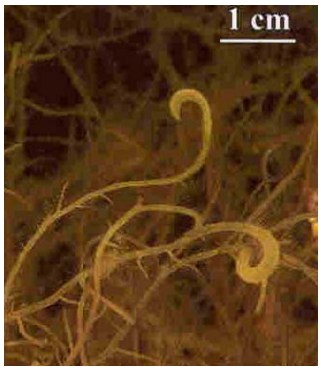


Ulva



<u>Parenchymetous</u> –

cells division in any plane (3D), not filamentous

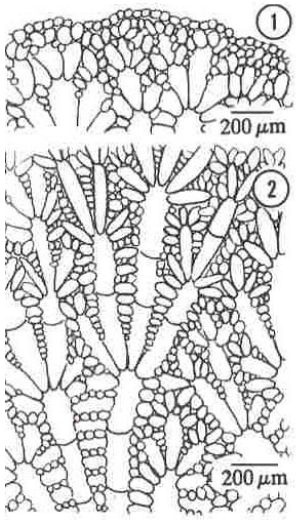


Hypnea

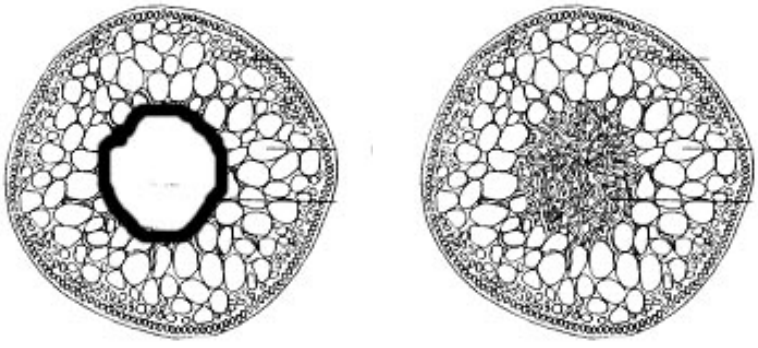
Pseudoparenchymatous

Central core cuboidal or spherical in shape (*looks* 3-D…) but still made up of compressed filaments

Filaments



Uniaxial vs. Multiaxial

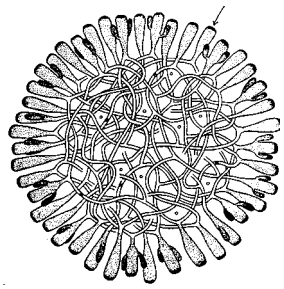


Within the Pseudoparenchymatous catagory…

Coenocytic – Multi-nucleate; lacking crosswalls ("siphonous")

Codium

Utricles -swollen, terminal end of the siphon



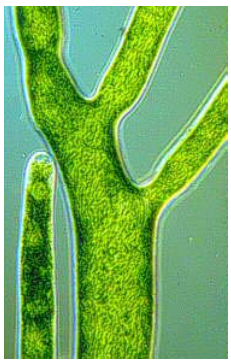
Coenocytic thallus construction -

what does this allow?

- chloroplast movement

what special issues does it raise?

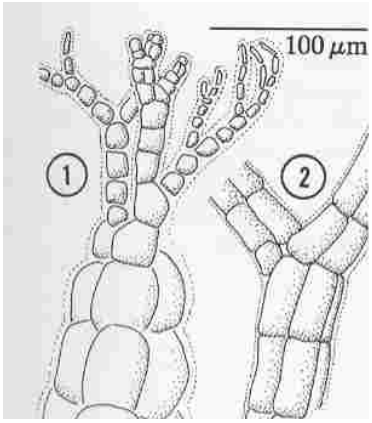
- herbivory – healing
- well developed cytoskeleton
- repairs membrane in 1-2 seconds



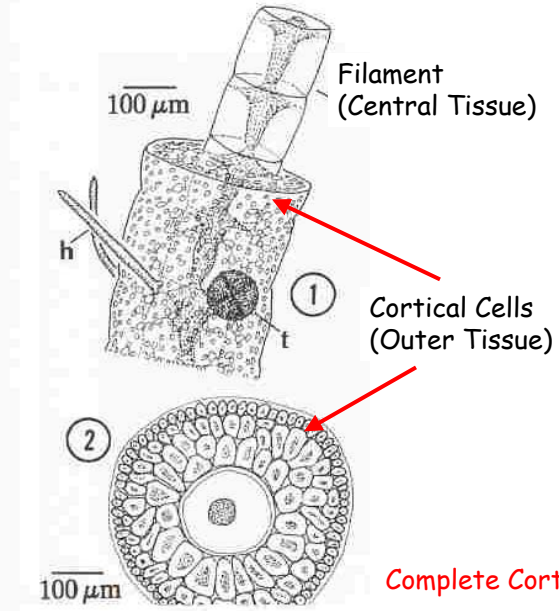
Within the Pseudoparenchymatous catagory…

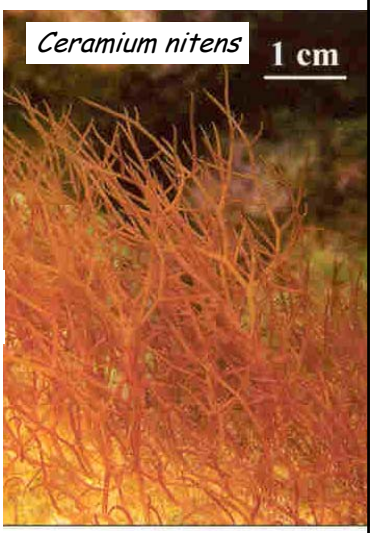
Polysiphonous (confusingly, nothing to do with 'siphonous…') -

central cell surrounded by 4 or more pericentral cells

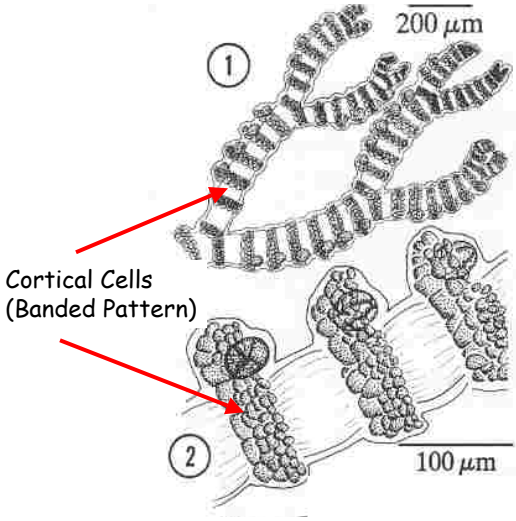


Cortication – elaboration of polysiphonious condition where pericentral cells continue to proliferate

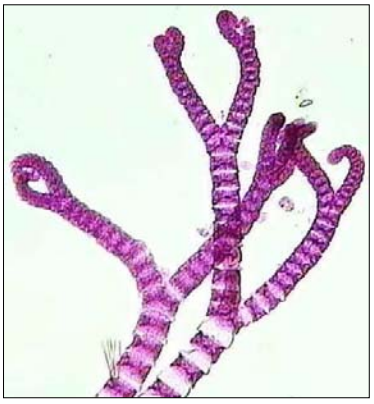




Complete Cortication



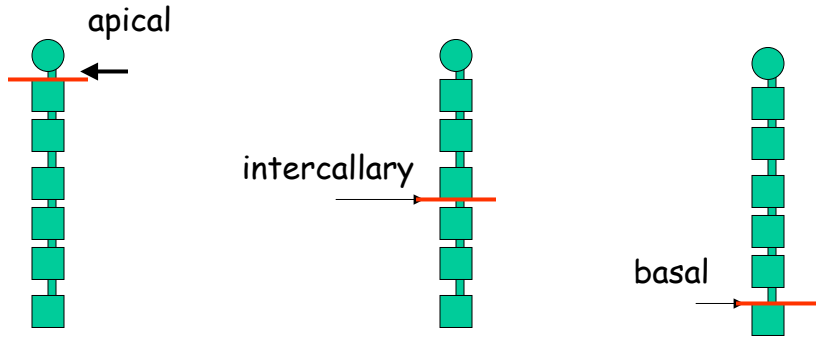
Ceramium



Partial Cortication

Algal Growth….

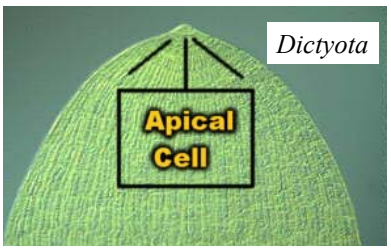
Where on the algal thallus does cell division actually occur?

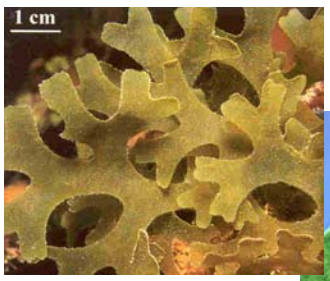


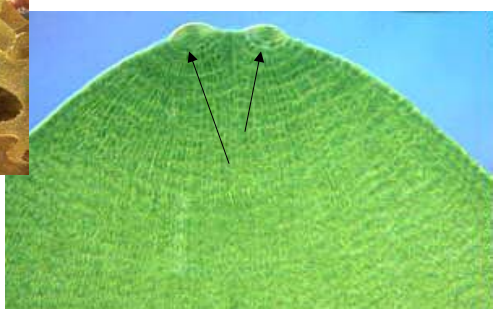
"Meristem" = area of cell division and growth

Apical growth =

Apical cell or apical maristem

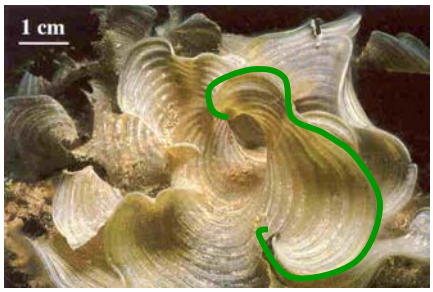




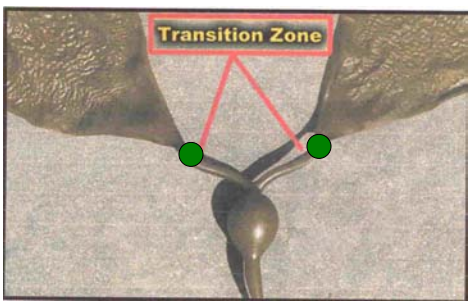


Diffuse growth =

no defined area of cell division or growth;
occurs throughout the thallus



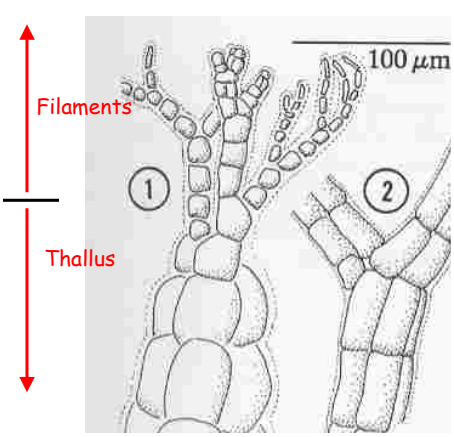
apical around margin

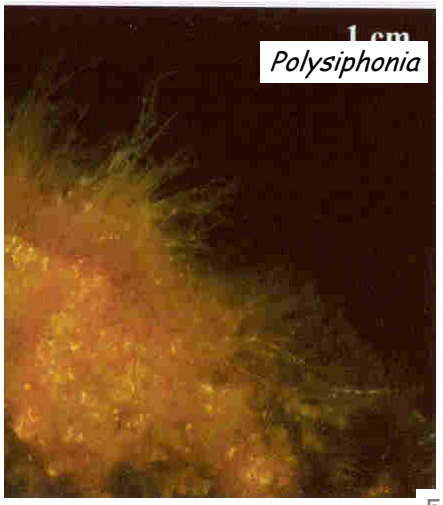


intercalary

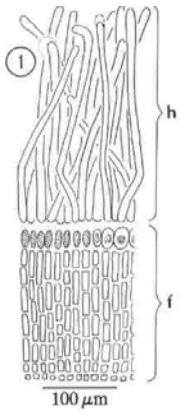
Trichothallic Growth: Cells divide to form hair (filament) above and thallus below

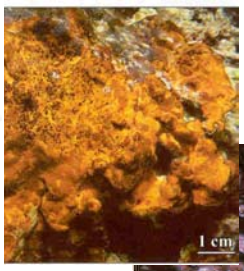
(in this case, psuedoparenchymatous polysiphonous…)





Heterotrichous – filamentous growth in 2 directions, results in thallus composed of both prostrate + erect components





Upright Form

Prostrate Form
(Crustose, spreading)