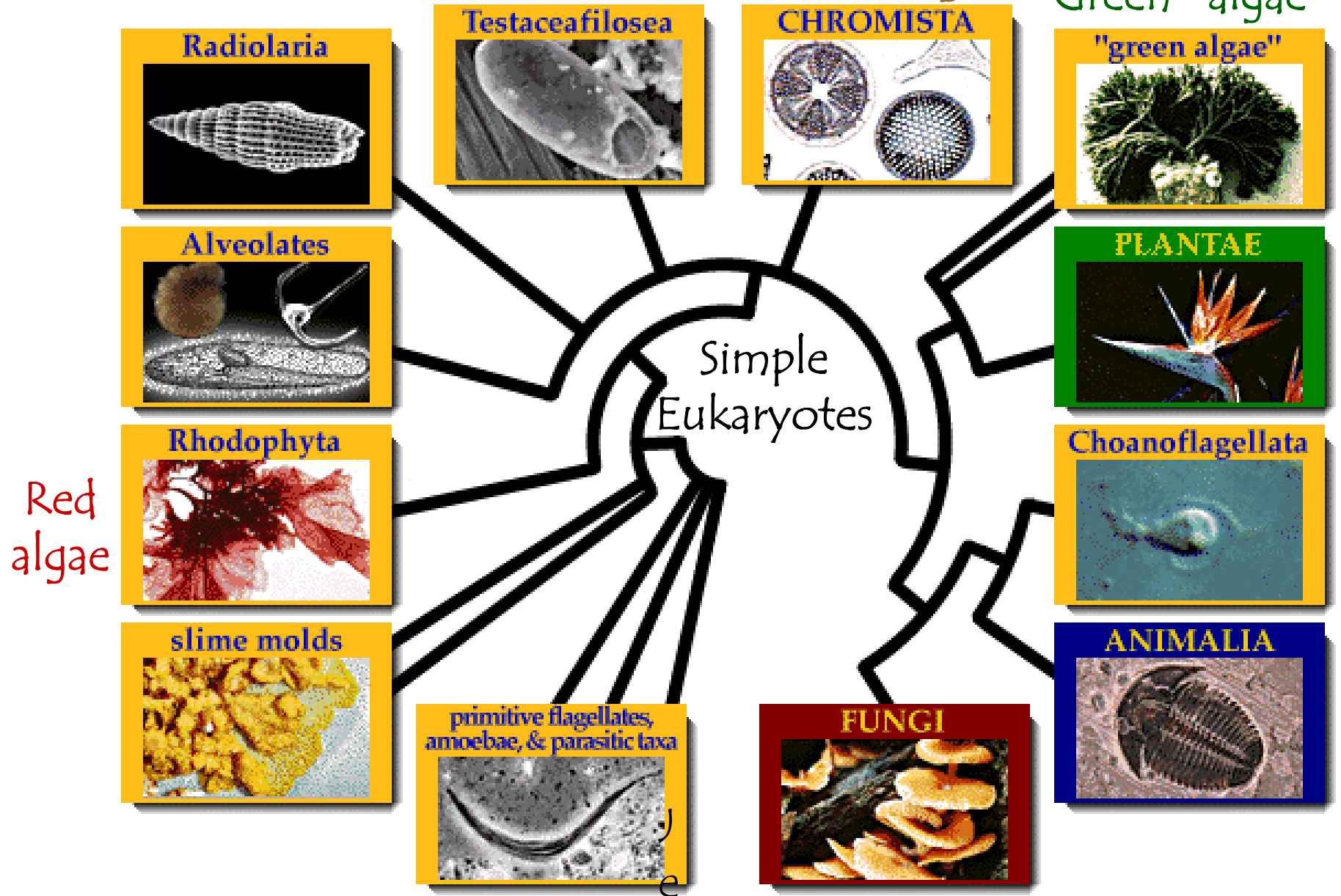


Kingdom Protista

Brown algae

Green algae



Kingdom Protista



Division Phaeophyta
Kingdom Protista

Division Phaeophyta, first brown plants

- Recent plants, ~500 mya

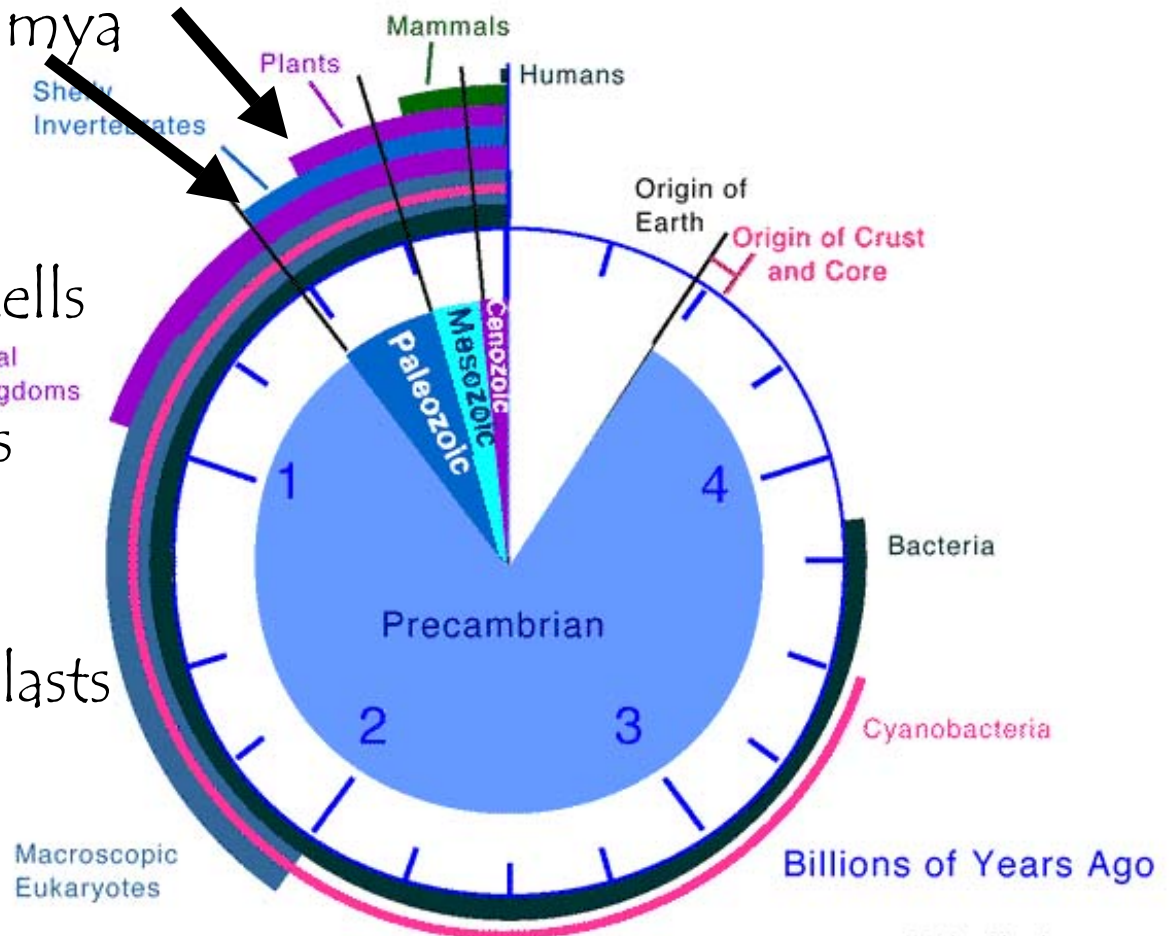
land plants evolve

- "Standard" eukaryote cells

No multinucleate cells

Motile cells usual

- Non-standard chloroplasts



Things we will cover for brown algae

- ◇ General features – defining characteristics
- ◇ Morphological lineages –
 - use morphology to anticipate evolution
 - reveal variations in life history & gametes
- ◇ Ecology – understanding interactions with environment and other species
- ◇ Commercial interests – exploit ecology & life history
- ◇ Evolution – diversity & change over time

General features



Division Phaeophyta
Kingdom Protista

Ocean lovers

2,000 species (60 in HI oceans)

250+ genera (29 in HI)

Ocean Forests

Morphological Range:

filaments to complex multicell organisms

Recently arrived eukaryotes -

well suited to coastal habitats



Intertidal

Reef algae



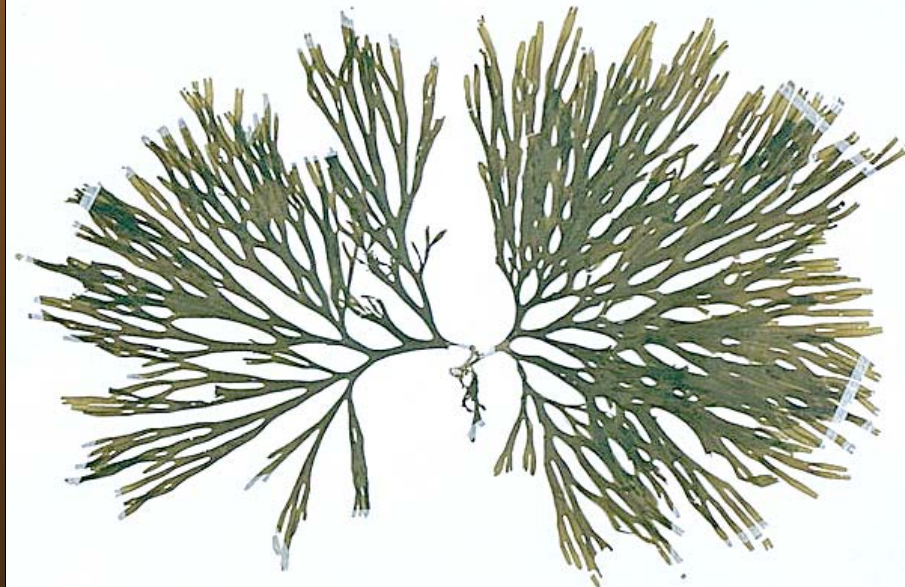
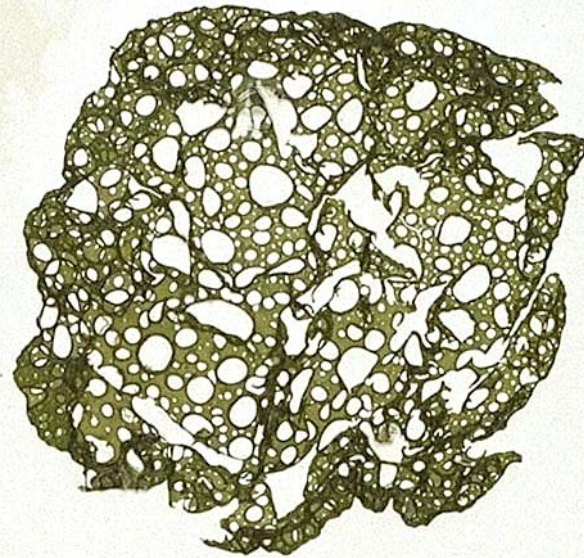
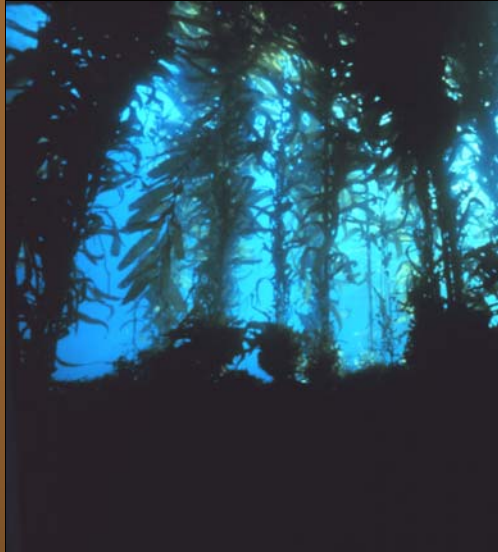
Subtidal

Natives and invasives

Diversity



Division Phaeophyta
Kingdom Protista

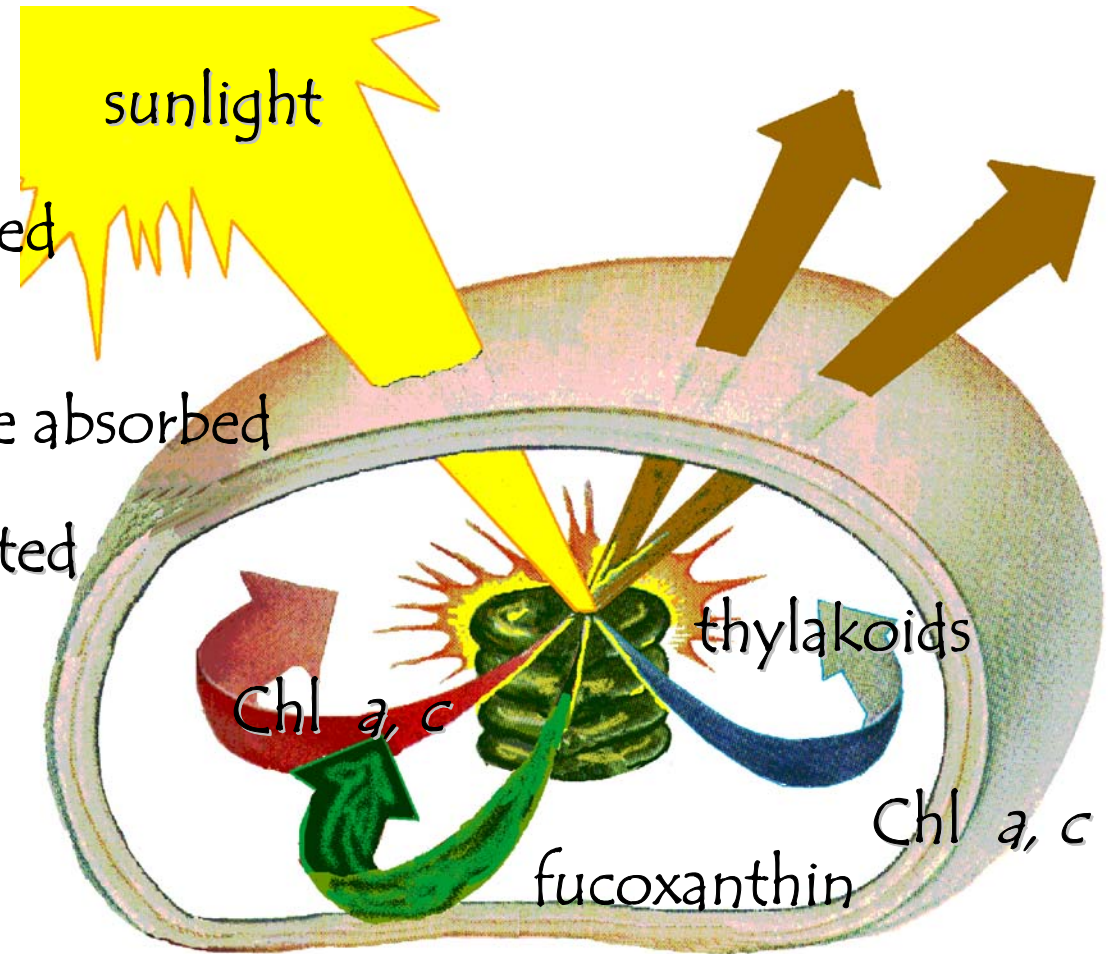


Photosynthesis & Pigments



Division Phaeophyta
Kingdom Protista

- ◇ Light energy is harvested by the cell
- ◇ Only specific colors are absorbed
- ◇ Other colors are reflected back to your eye



Light Absorbed by a Brown Alga

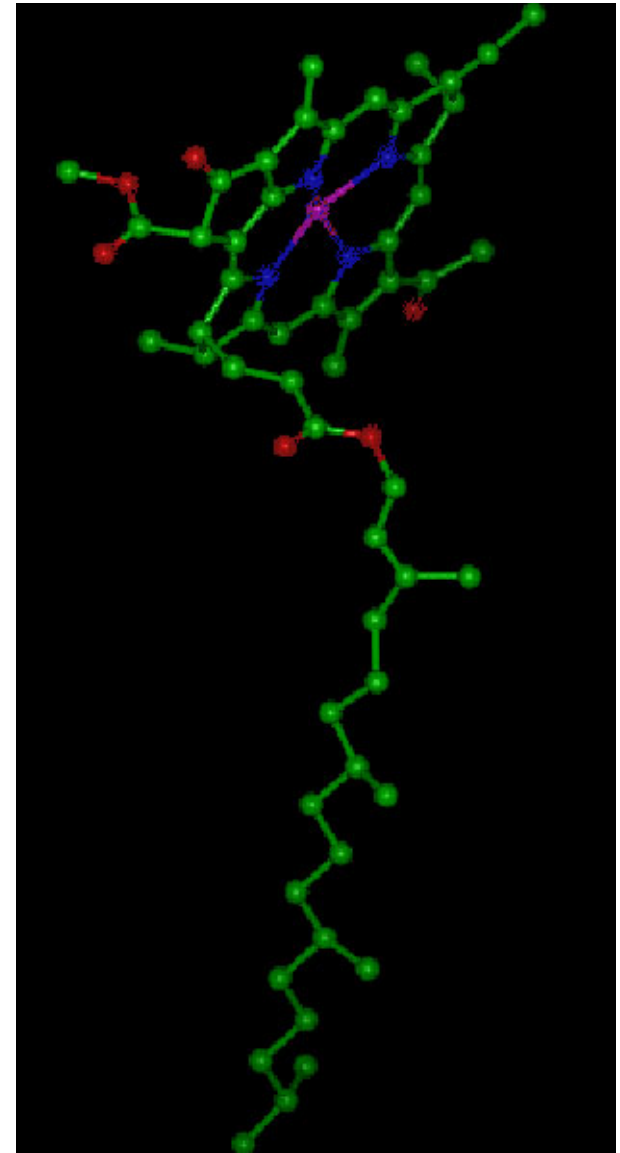
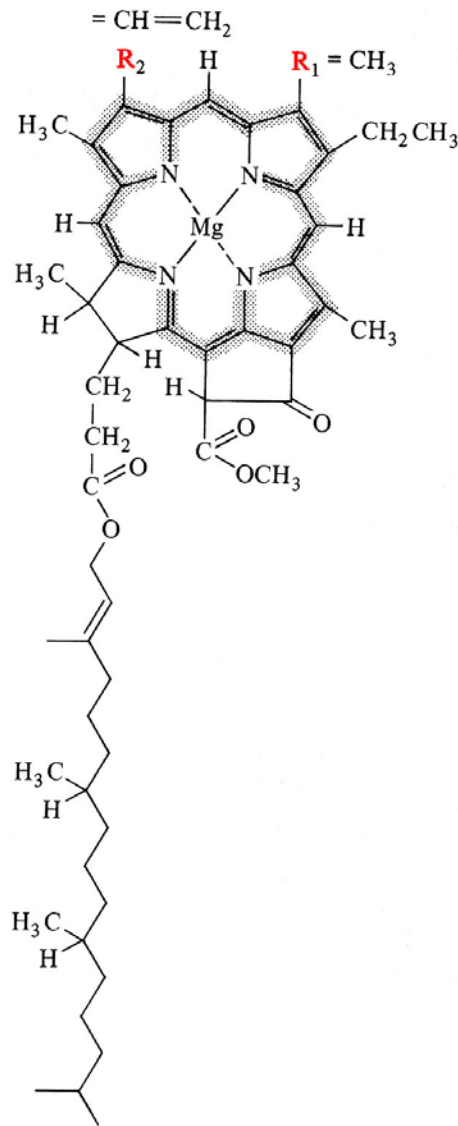
Chlorophyll a & c



Division Phaeophyta
Kingdom Protista

Tetrapyrrole Ring

Phytol Chain of
Chl a missing
in Chl c



General features



Division Phaeophyta
Kingdom Protista

Pigments - photosynthesis

- ◇ Chlorophyll a
- ◇ Chlorophyll c
- ◇ Fucoxanthin

Storage Products

- ◇ Laminarin
- Starch (C)
- ◇ Mannitol
- Sugar (C)

Growth

- ◇ Every cell can divide
- ◇ Multicellular organisms:
Fragments regrow
- ◇ True tissues

Others

- ◇ Carotenoids
- ◇ UV absorbing molecules

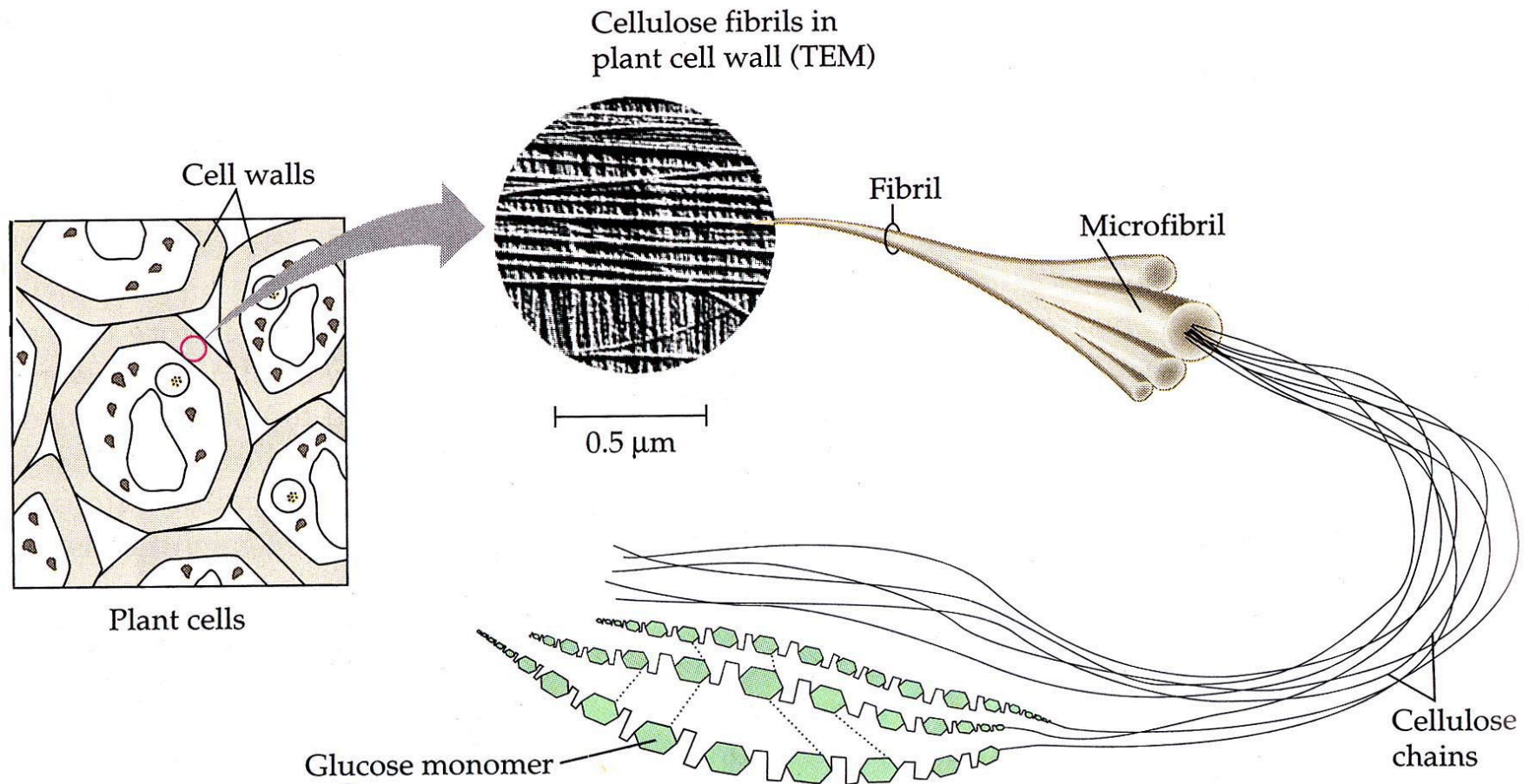
Cell wall structure



Division Phaeophyta
Kingdom Protista

Two essential parts:

- ◇ fibers of cellulose (rigid), a glucose polymer
- ◇ gels of polysaccharides (flexible) as ALGINATE



Cell wall structure

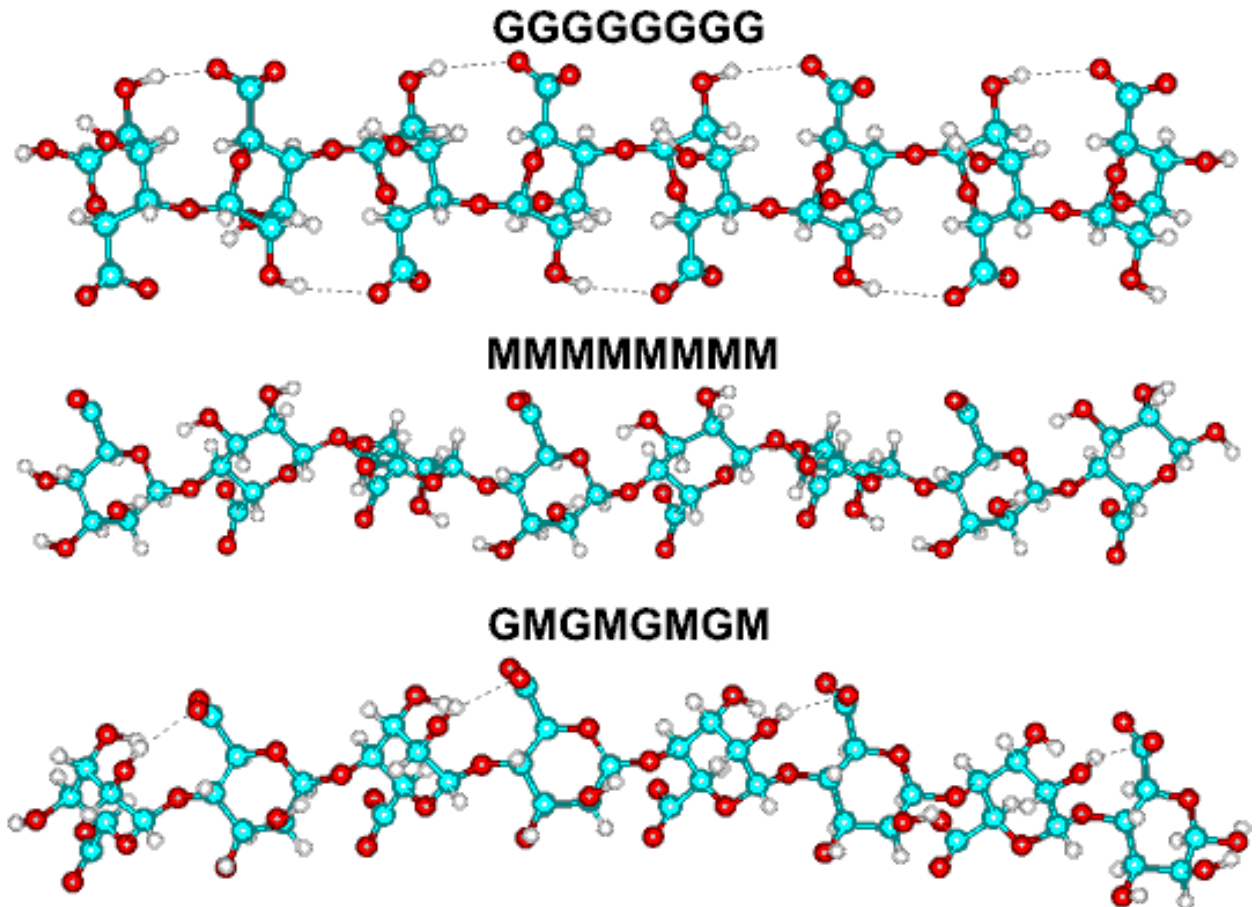


Division Phaeophyta
Kingdom Protista

Two essential parts:

- ◇ fibers of cellulose (rigid), a glucose polymer
- ◇ gels of polysaccharides (flexible) as ALGINATE

"Copolymer"
blocks of sugars
Guluronic (G)
Mannuronic (M)



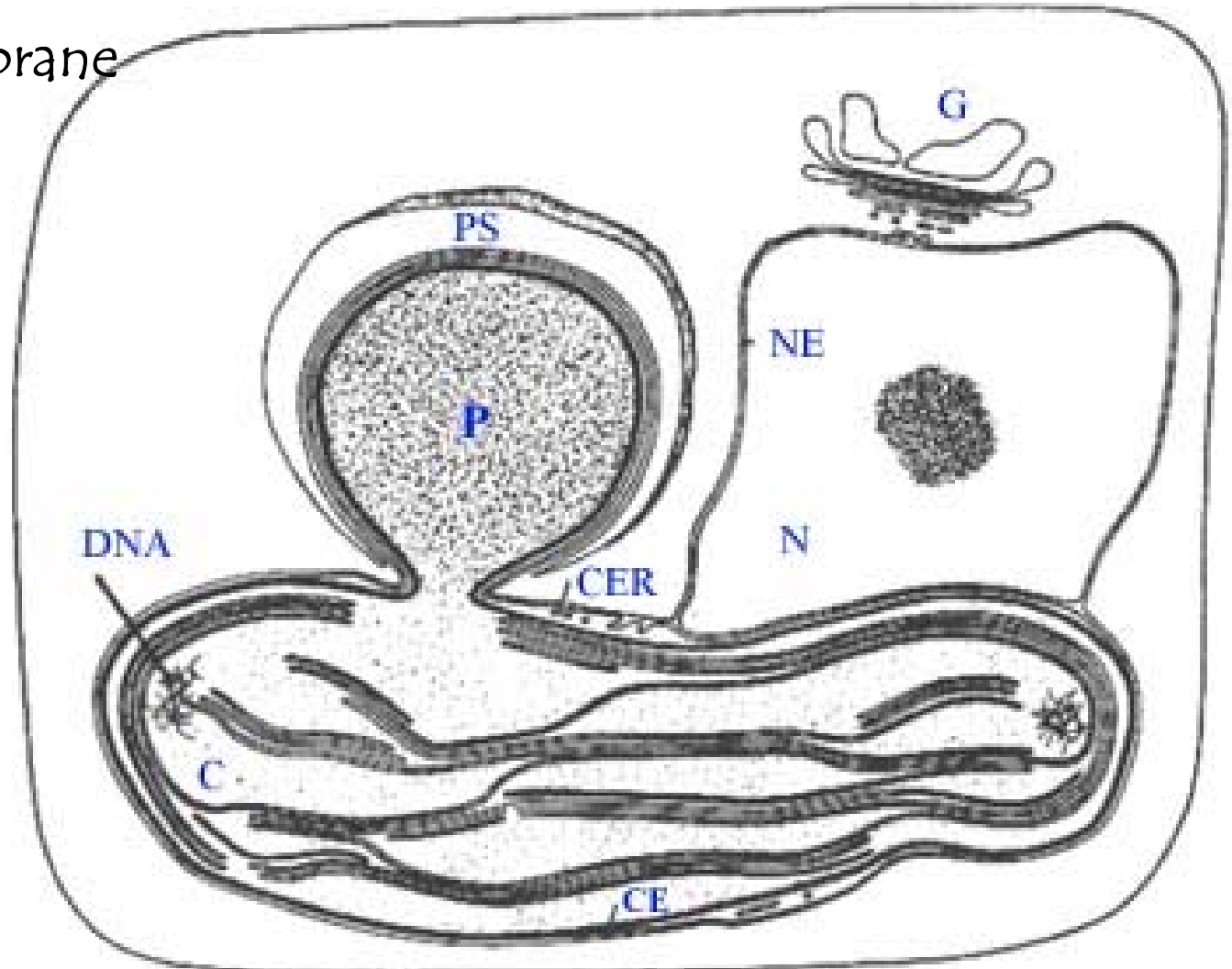
General features



Division Phaeophyta
Kingdom Protista

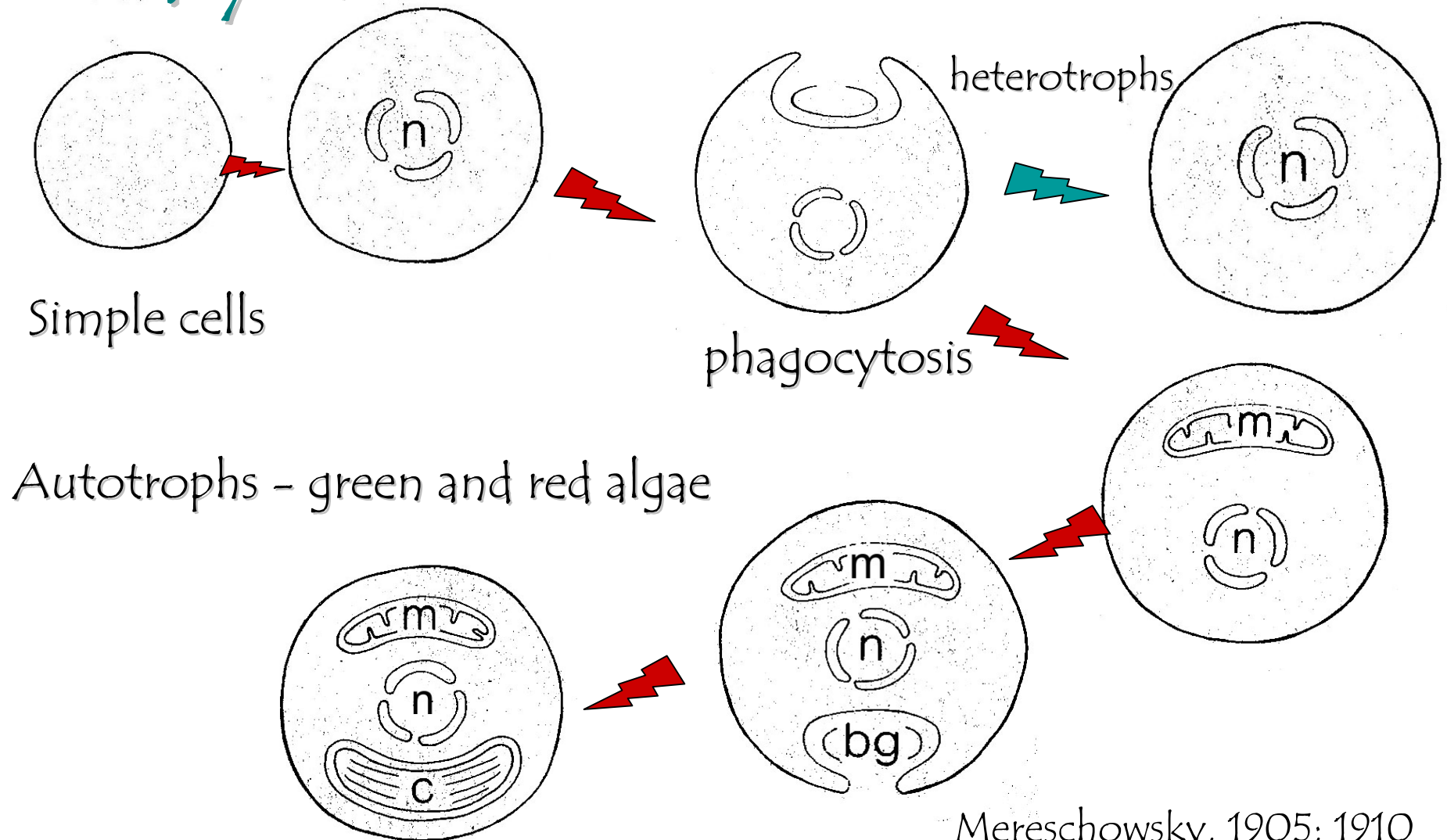
What is in a typical phaeophyte cell?

- ◊ Unusual membrane system around chloroplast and nucleus
- ◊ Pyrenoid large, stalked and surrounded by laminarin starch
- ◊ Chloroplasts have grana



Evolution of eukaryotes

Xenogenous hypothesis



Mereschowsky, 1905; 1910

General features

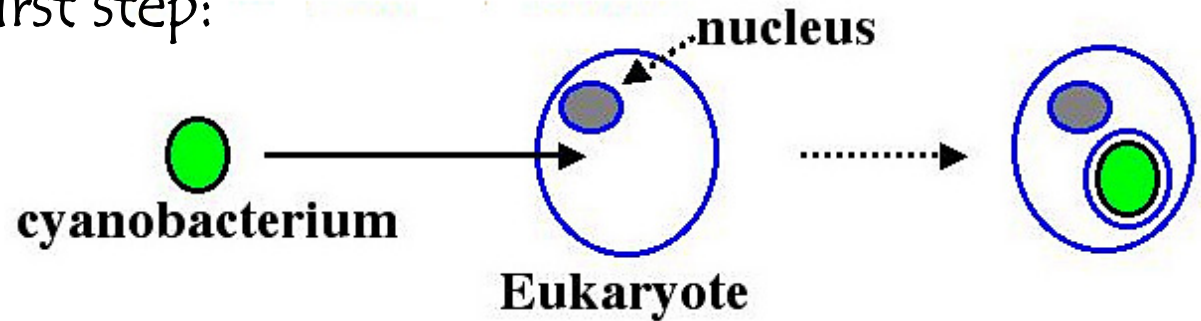


Division Phaeophyta
Kingdom Protista

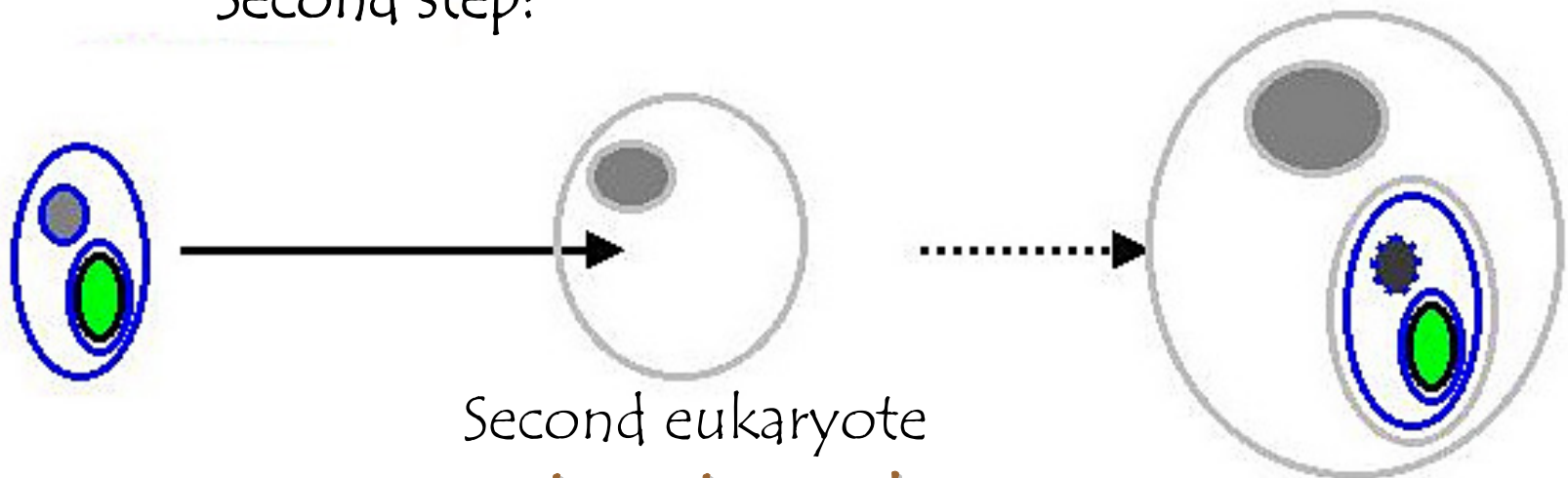
How are phaeophyte cells unusual?

◇ "New"
membranes
around
chloroplast
& nucleus

First step:



Second step:



Repeated endosymbioses

Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista

Zygotic Meiosis Life History

MITOSIS

DOES NOT OCCUR
IN BROWN ALGAE

Meiosis

Meiosis is associated with Zygote Germination

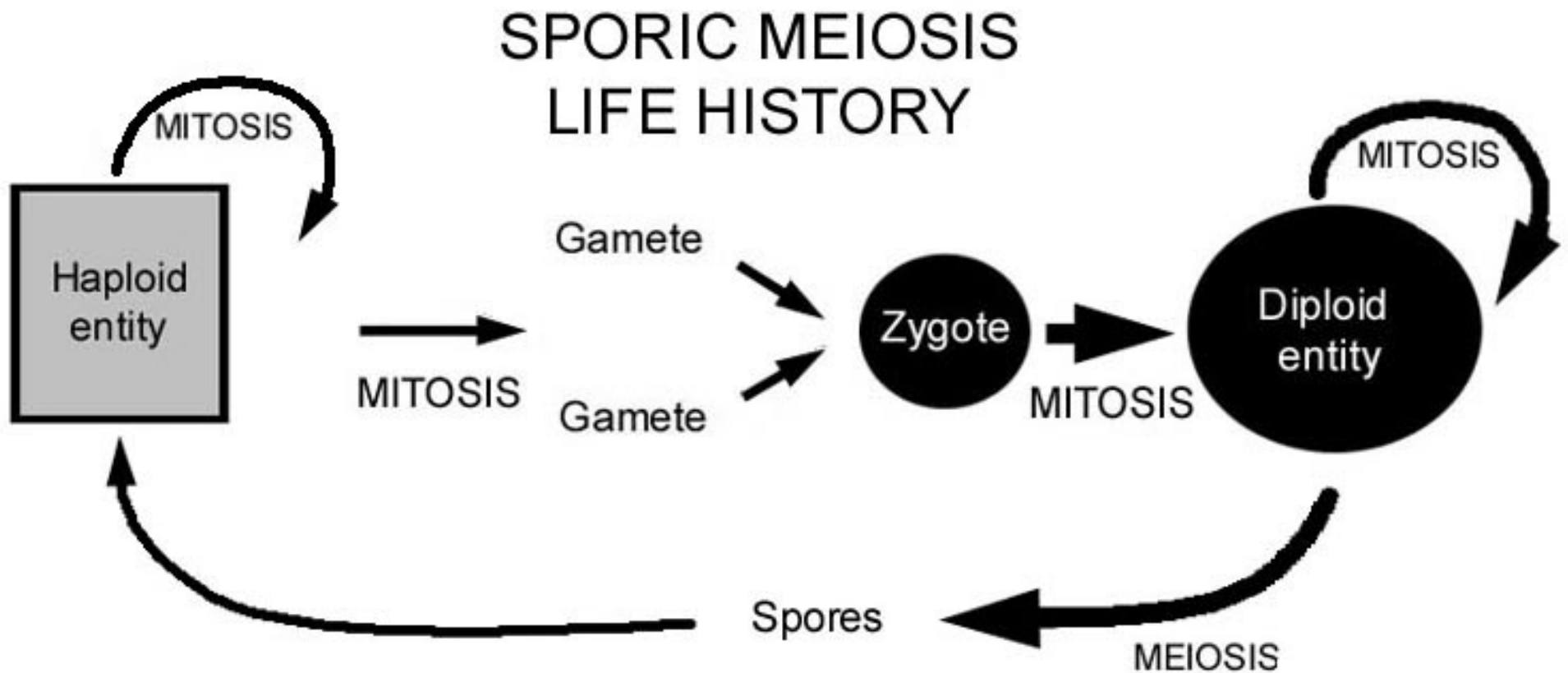
Morphological lineages

- ◇ Evaluate adult form to gain insight in possible evolutionary processes.
- ◇ Step-by-step acquisition of new traits via genetic change.
- ◇ Examine reproductive cells and other characters as additional data.
- ◇ Useful means to construct evolutionary hypotheses to test with molecular data.

Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista



Meiosis is associated with Spore Production

Growth & morphology

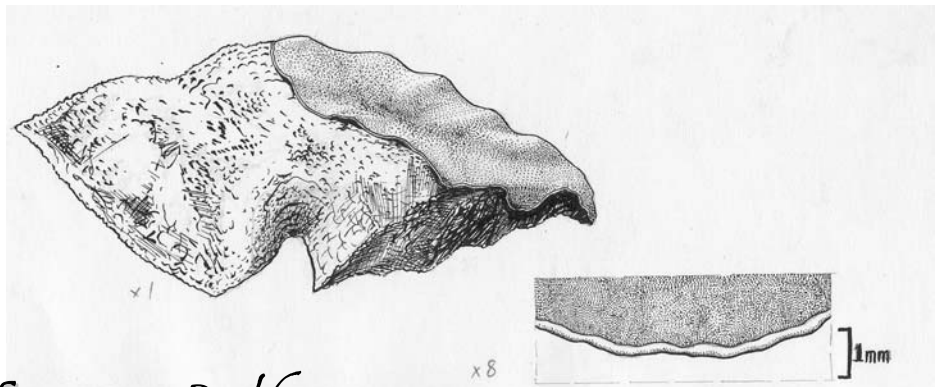
Genetic change



Ectocarpus



Hincksia



Ralfsia

Evolution has taken a simple shape to more complex but related forms:

- ◇ Multi filamentous genera



Division Phaeophyta
Kingdom Protista

Morphological Lineage #1
Order Ectocarpales

All cells appear virtually identical – internally

Diversity



Division Phaeophyta
Kingdom Protista

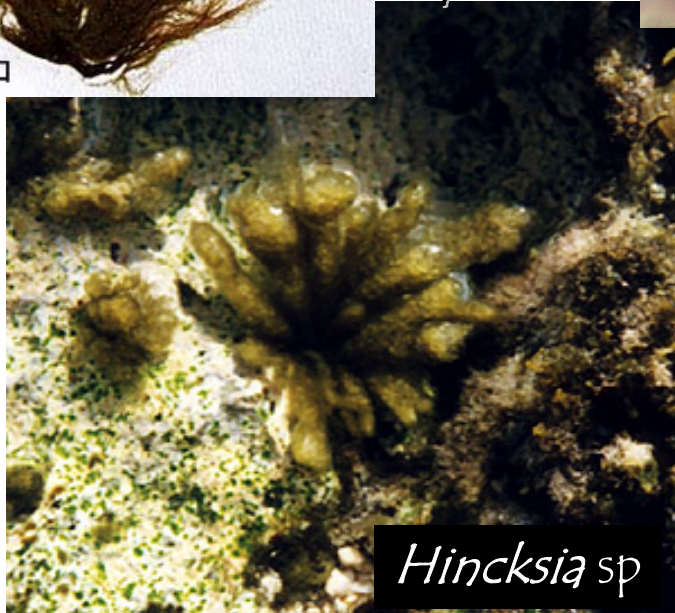


Ectocarpus

シオミドロ



Order Ectocarpales



Hincksiopsis sp

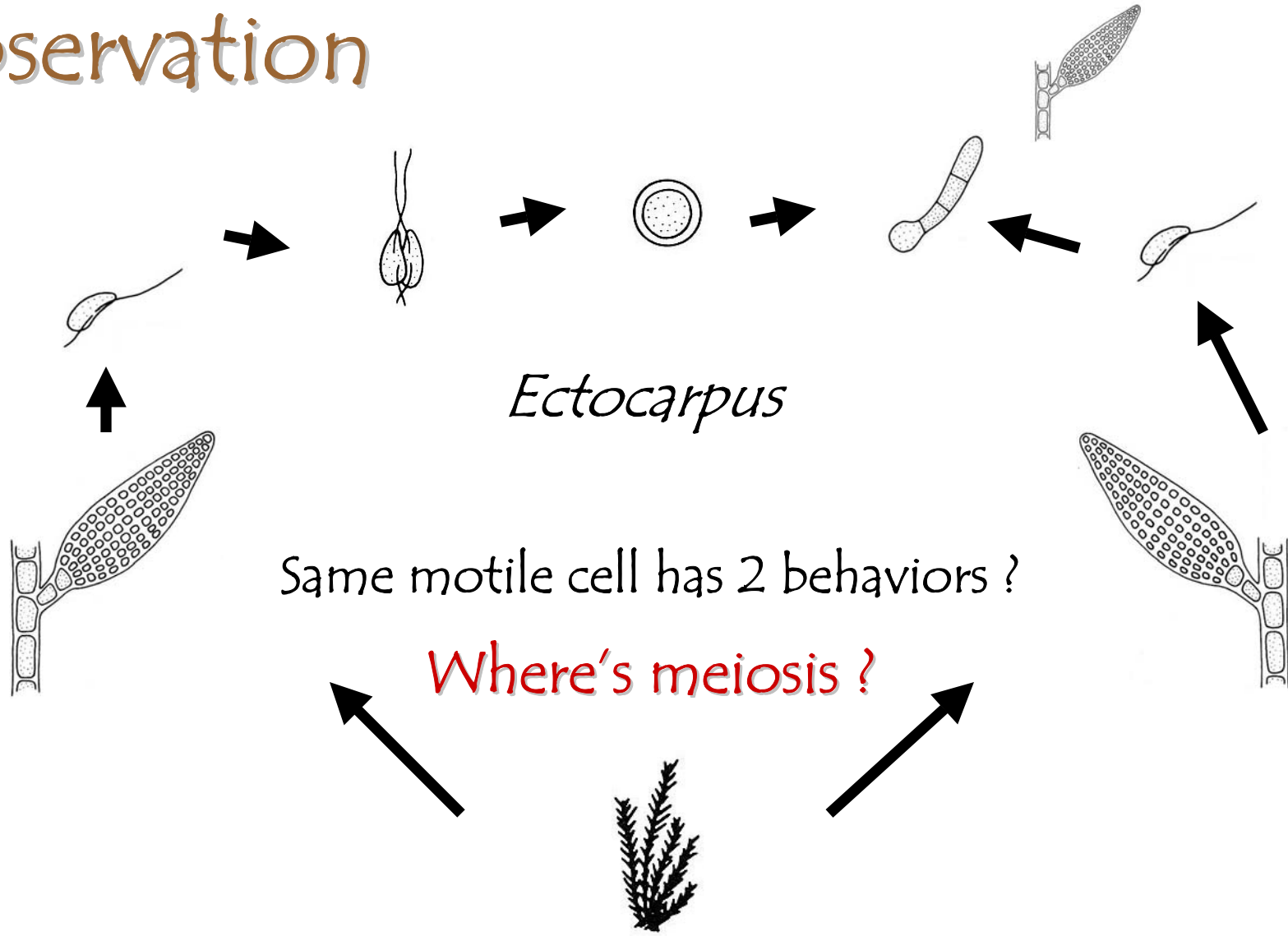


Ralfsia

Life history by observation



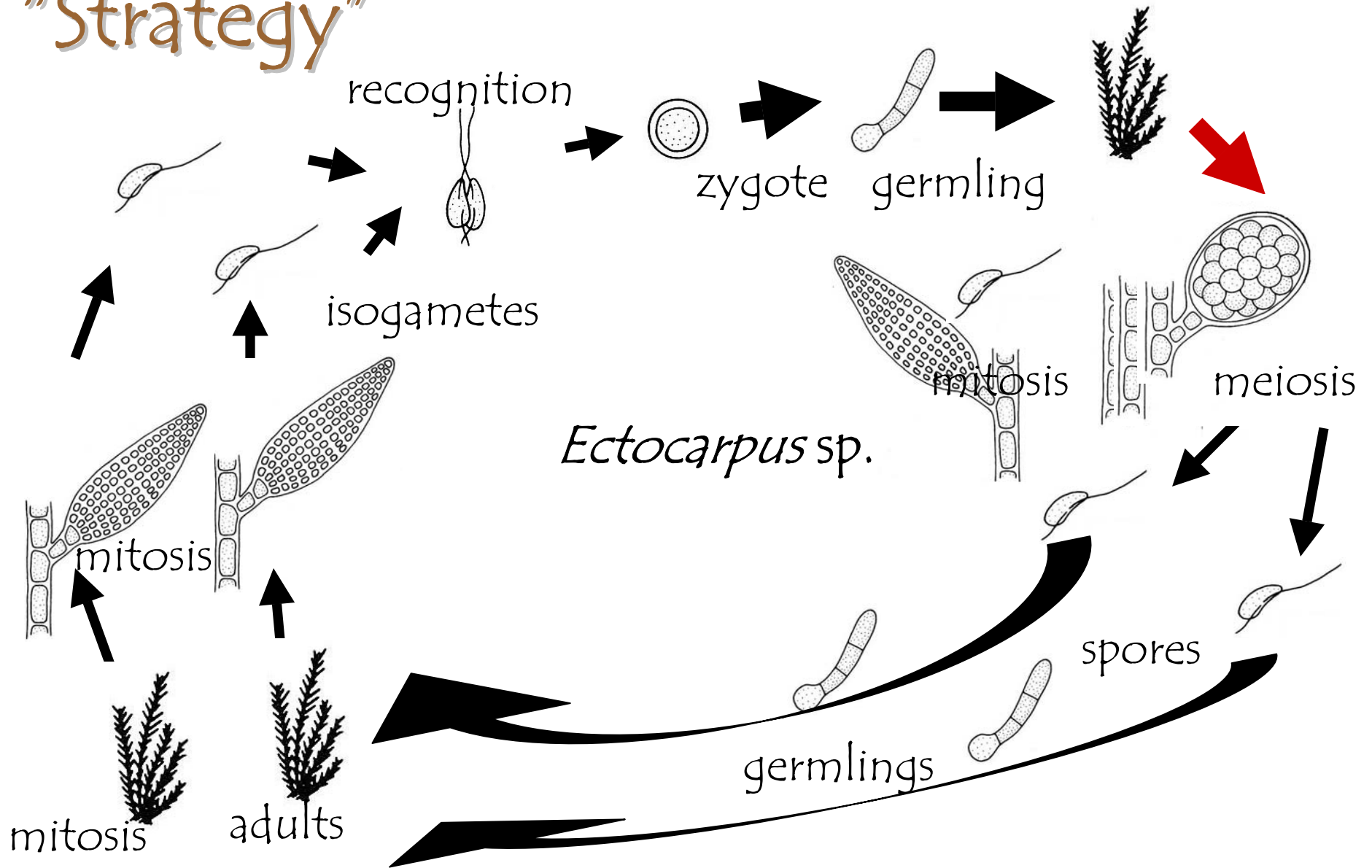
Division Phaeophyta
Kingdom Protista



Life History as a "Strategy"



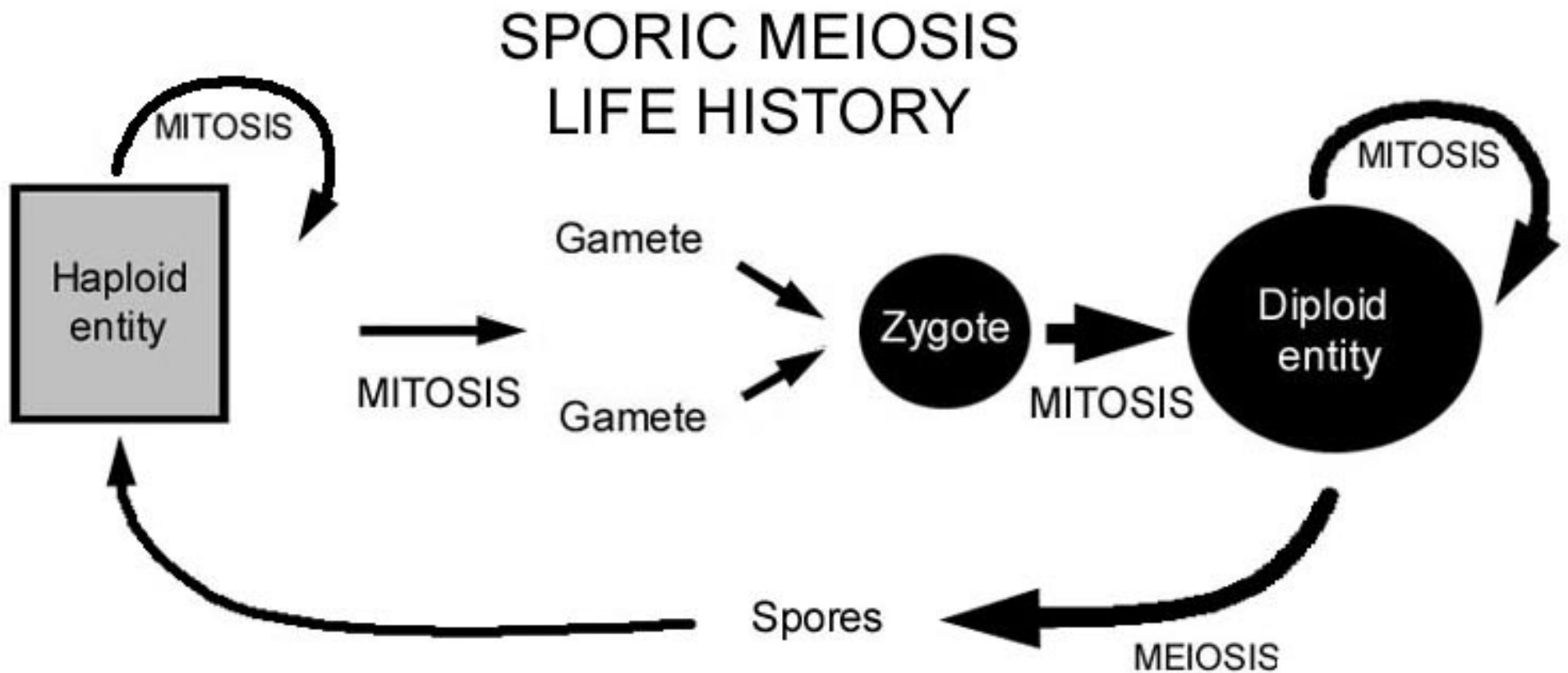
Division Phaeophyta
Kingdom Protista



Life History as a "Strategy"



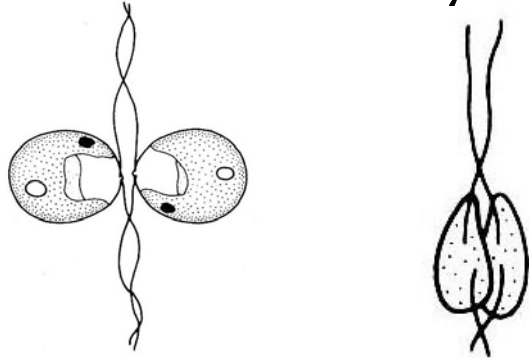
Division Phaeophyta
Kingdom Protista



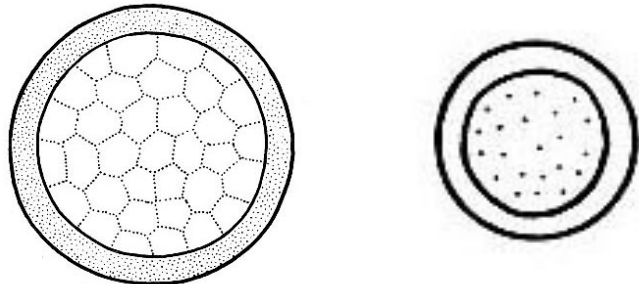
Meiosis is associated with Spore Production

Reproduction and gametes

2 Gametes – opposite
strains always fuse



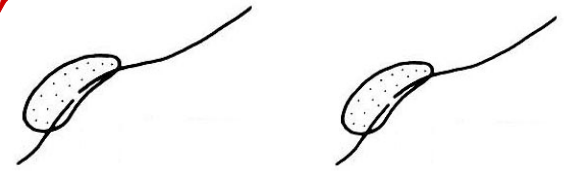
Zygote – diploid cell
via fusion of gametes



Division Phaeophyta
Kingdom Protista

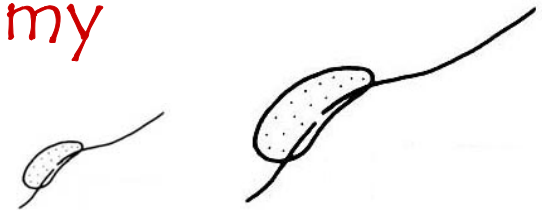
Equally sized gametes

Isogamy



Unequal gametes

Anisogamy



Egg & sperm gametes

Oogamy

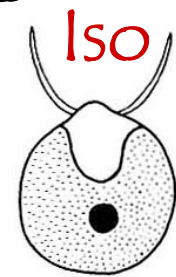


Minimal diversity in gamete shape...



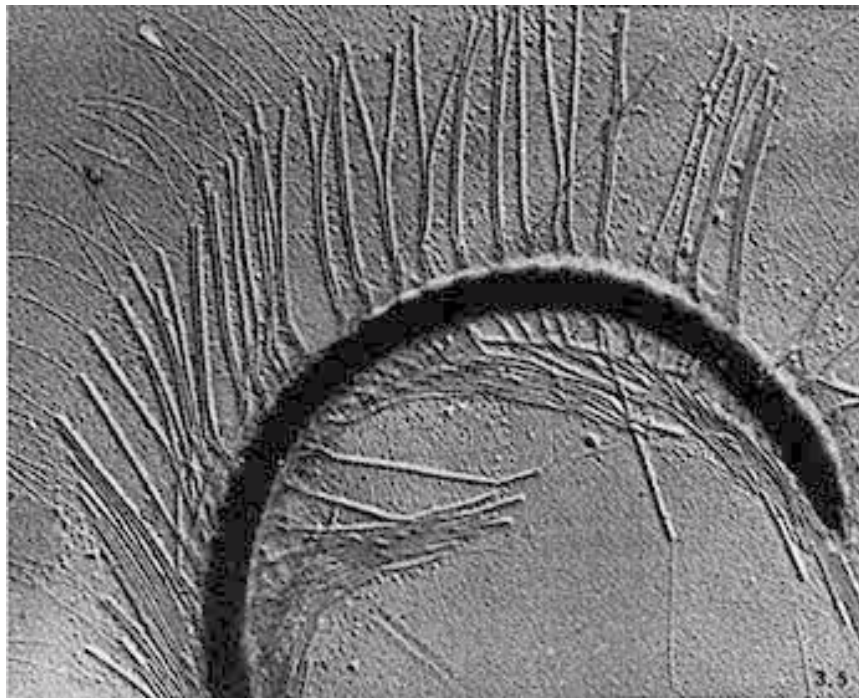
Division Phaeophyta
Kingdom Protista

Equal length flagella
Iso kont

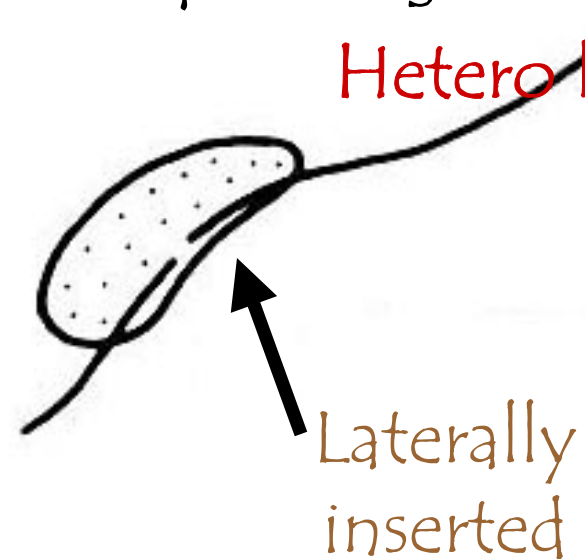


Swimming gametes have 2 flagella like greens

◇ But flagella of swimming cells
are **unequal** in length and HAIRY



Unequal length flagella
Hetero kont



Minimal diversity in gamete shape...

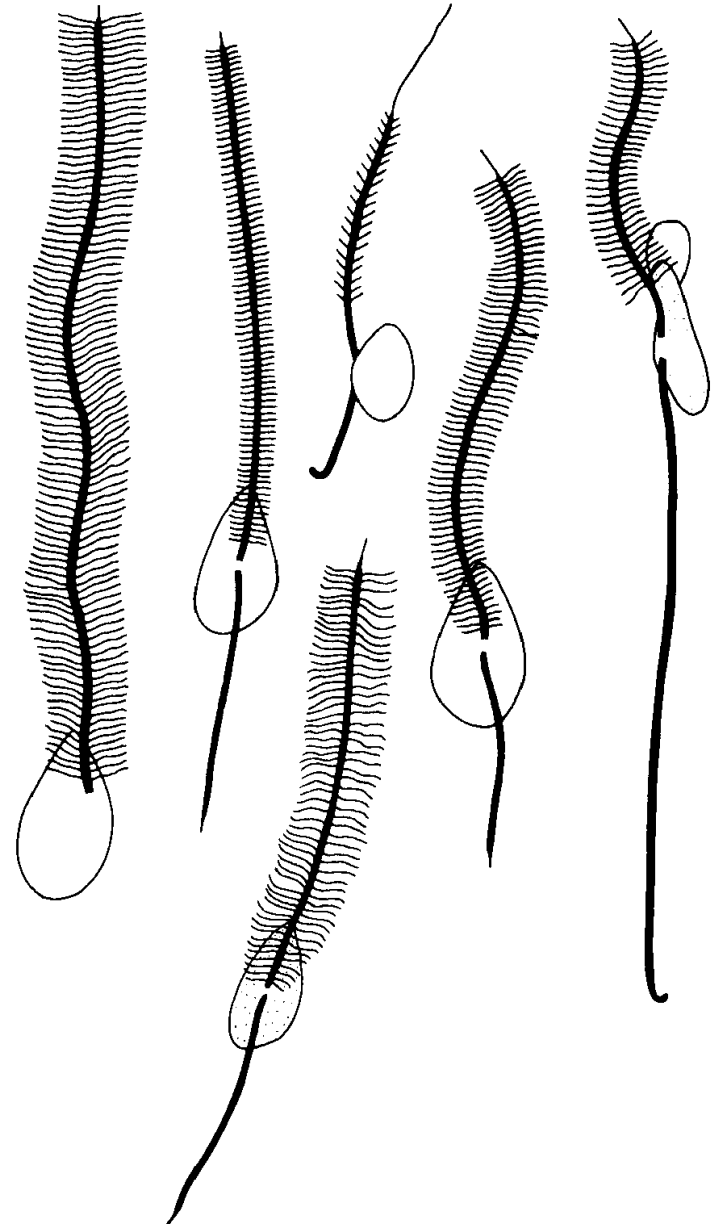


Division Phaeophyta
Kingdom Protista

These males gametes show the
limited diversity among
brown algae

Reds – spermatium

Greens – biflagellate to
stephanokont males

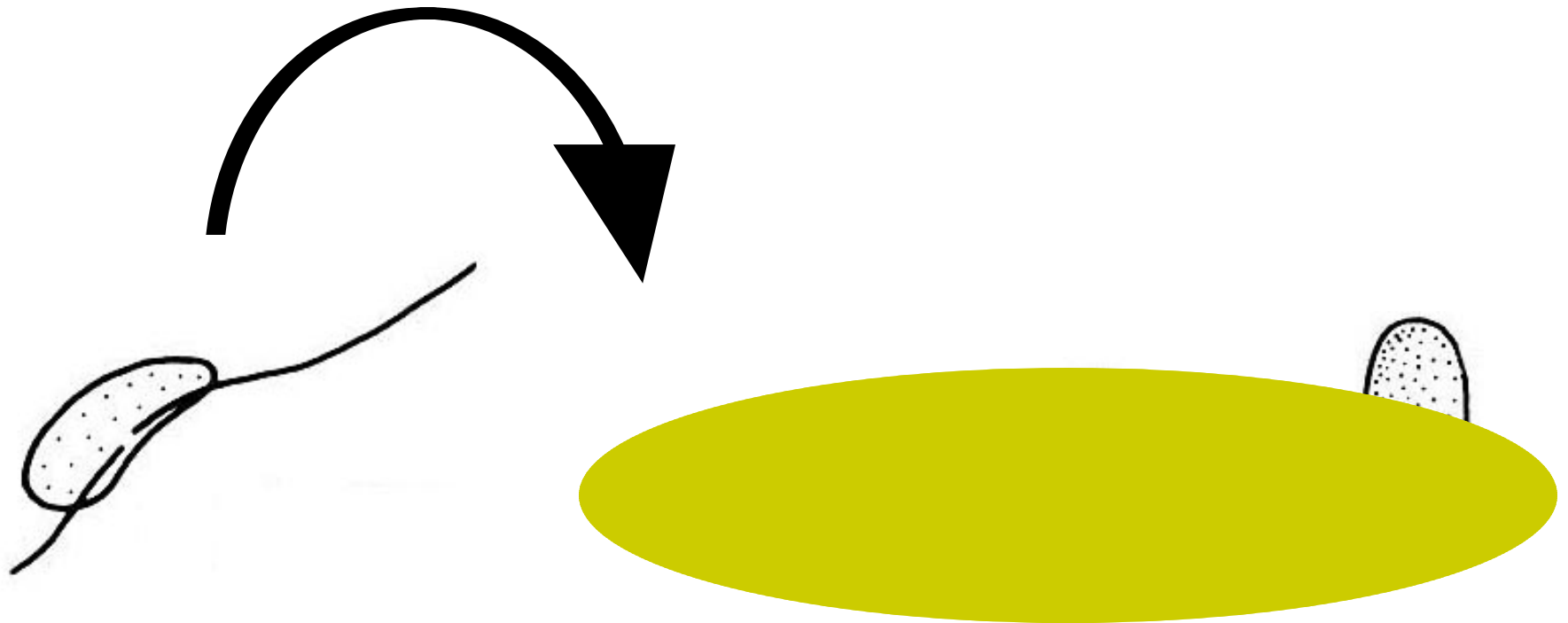


Minimal diversity in spore shape



Division Phaeophyta
Kingdom Protista

- ◇ Most brown algal spores swim
- ◇ 2 flagella
- ◇ Settlement ?



Diversity Tropical Orphans



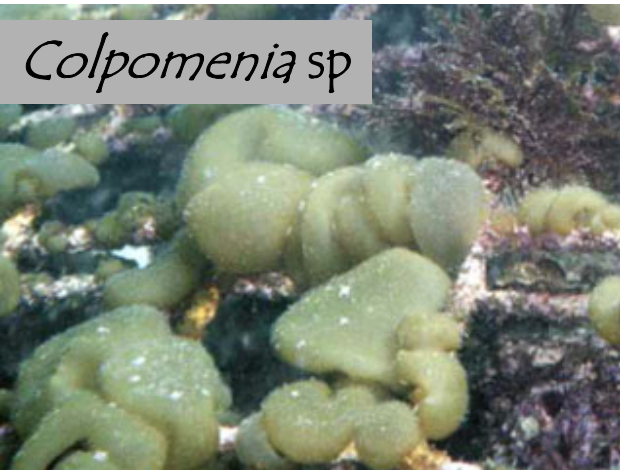
Division Phaeophyta
Kingdom Protista



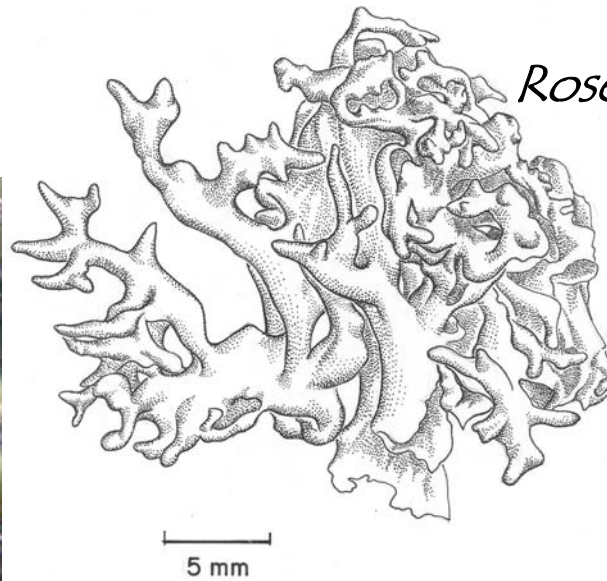
Scytosiphon sp.



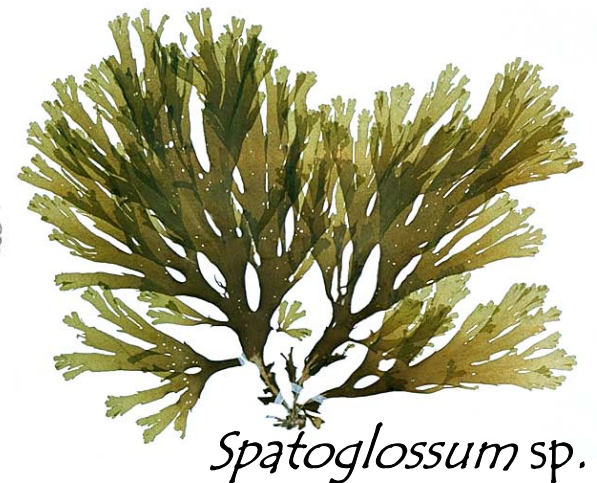
Hydroclathrus sp.



Colpomenia sp.



Rosenvingea sp.



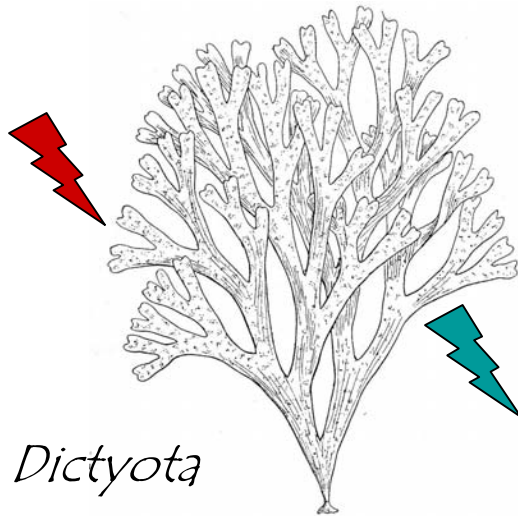
Spatoglossum sp.

Growth & morphology

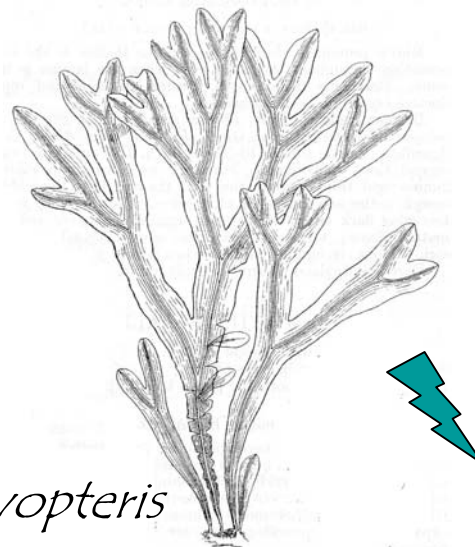


Division Phaeophyta
Kingdom Protista

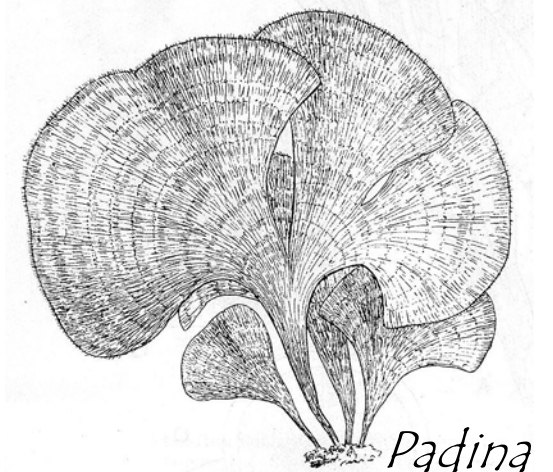
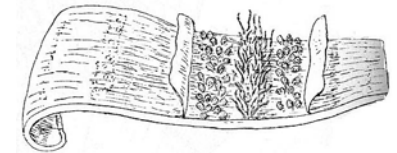
Morphological Lineage #2
Order Dictyotales



Dictyota



Dictyopteris



Padina

Evolution has taken a simple filament:

Multiseriate tissues create sheets or blades

From apical cell or meristem areas

Diversity



Division Phaeophyta
Kingdom Protista

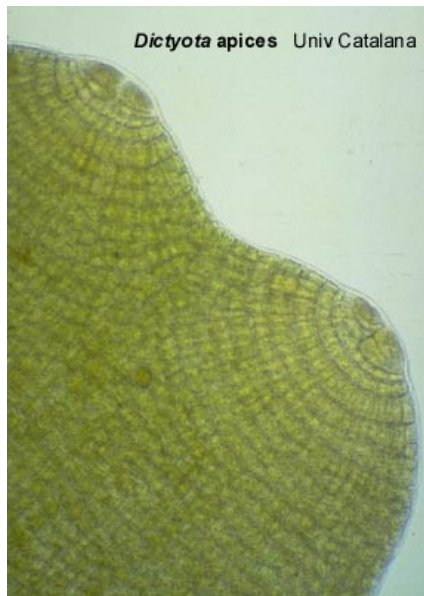
Order Dictyotales



Dictyota sp.



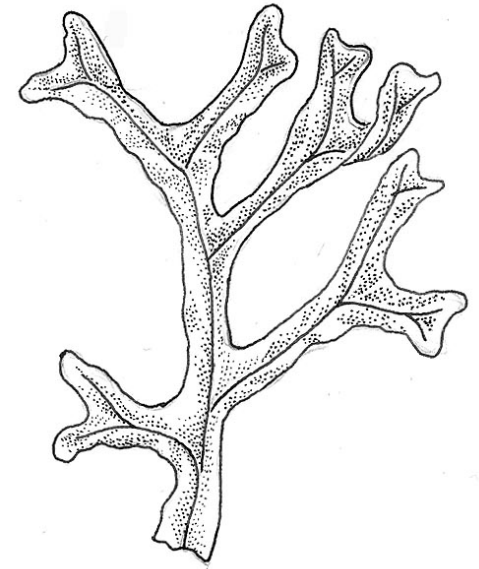
Padina sp.



Dictyota apices Univ Catalana



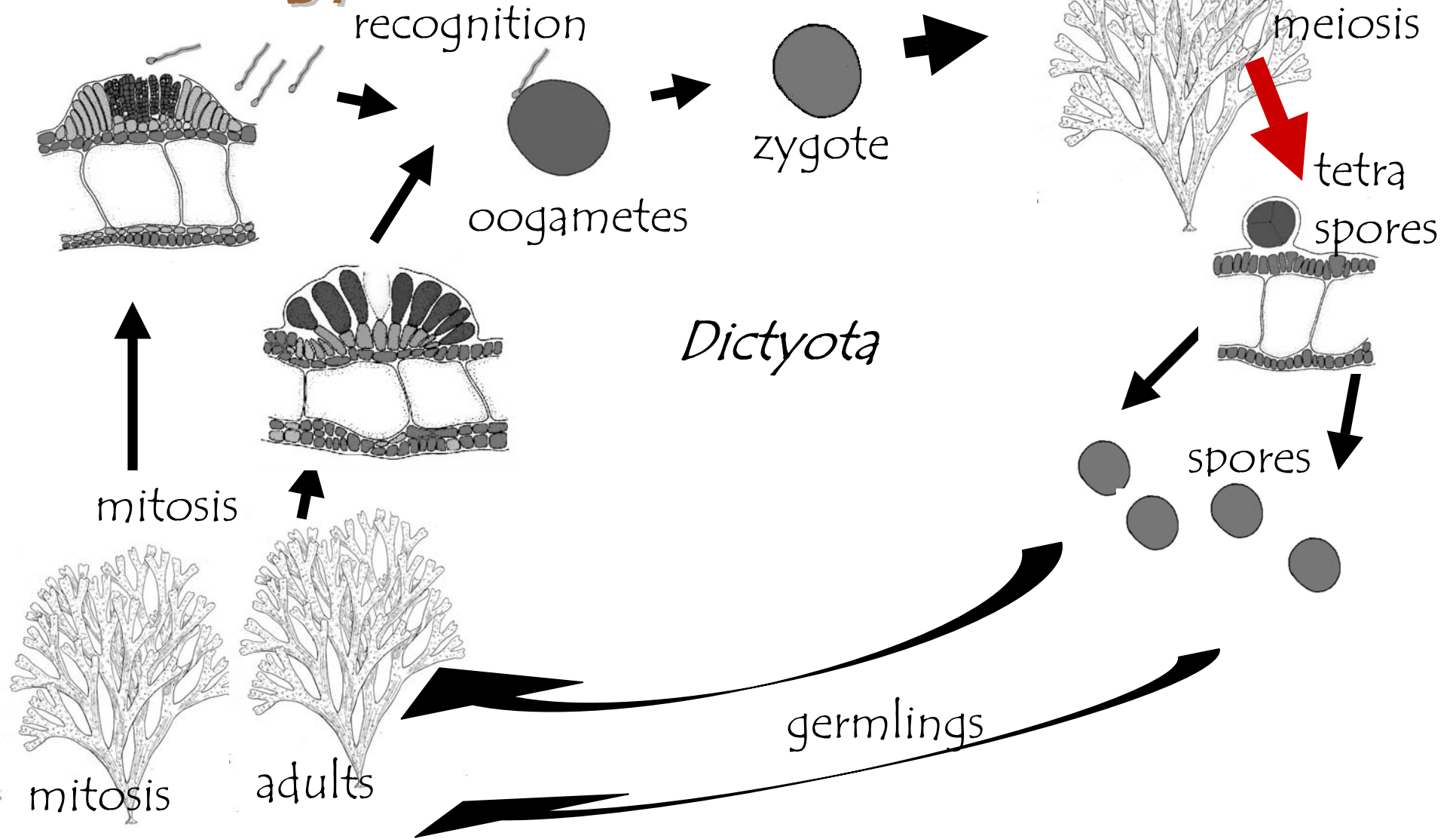
Dictyota crenulata



Life History as a "Strategy"



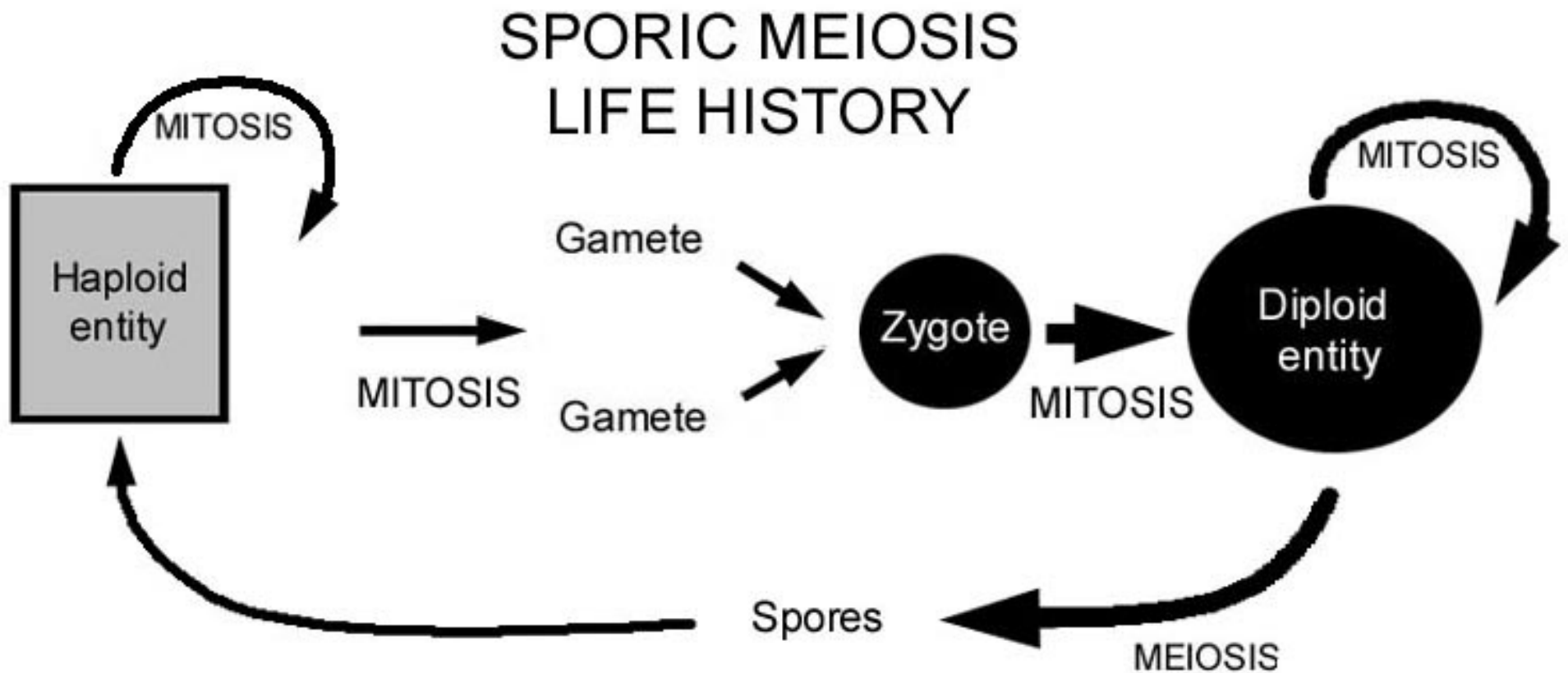
Division Phaeophyta
Kingdom Protista



Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista



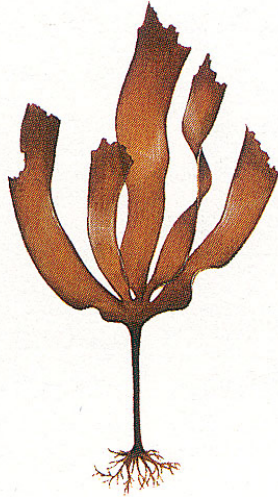
Meiosis is associated with Spore Production

Growth & morphology



Division Phaeophyta
Kingdom Protista

Morphological Lineage #3
Order Laminariales



Laminaria



Alaria



Macrocystis

Evolution has taken a simple shape:

- ◇ constrained into lamina
- ◇ large sporophyte generations

Diversity



Division Phaeophyta
Kingdom Protista

Order Laminariales



photo: Kip Evans



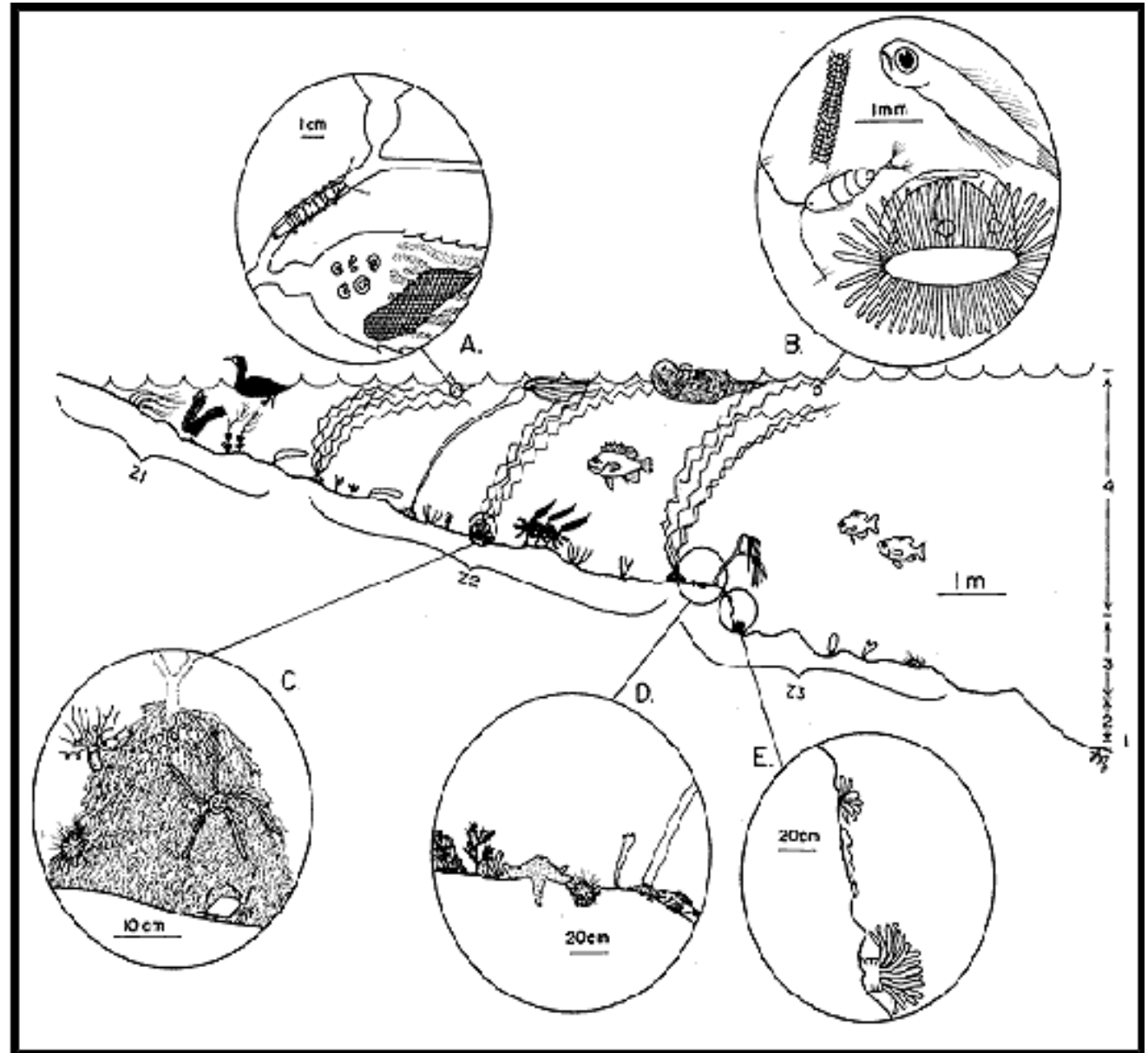
Kip Evans

Ecology

Kelp forests
sustain coastal
diversity
epiphytic
pelagic
benthic
understory



Division Phaeophyta
Kingdom Protista



Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista

Ecklonia cava

Spores

Egg and sperm

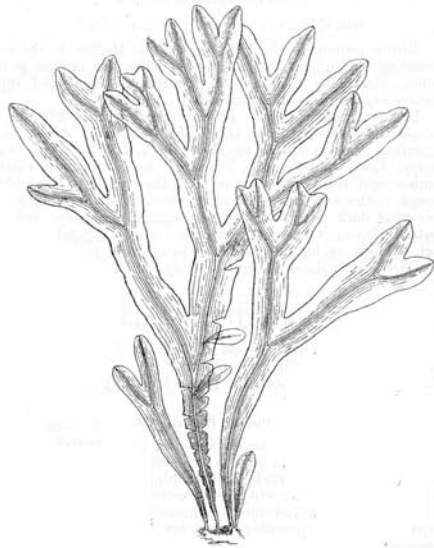
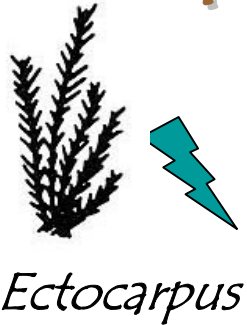


Growth & morphology



Division Phaeophyta
Kingdom Protista

Morphological Lineage # 4
Order Fucales



Sargassum obtusifolium



Diversity

Sargassum thunbergii Gunma Japan



Division Phaeophyta

Kingdom Protista

Order Fucales

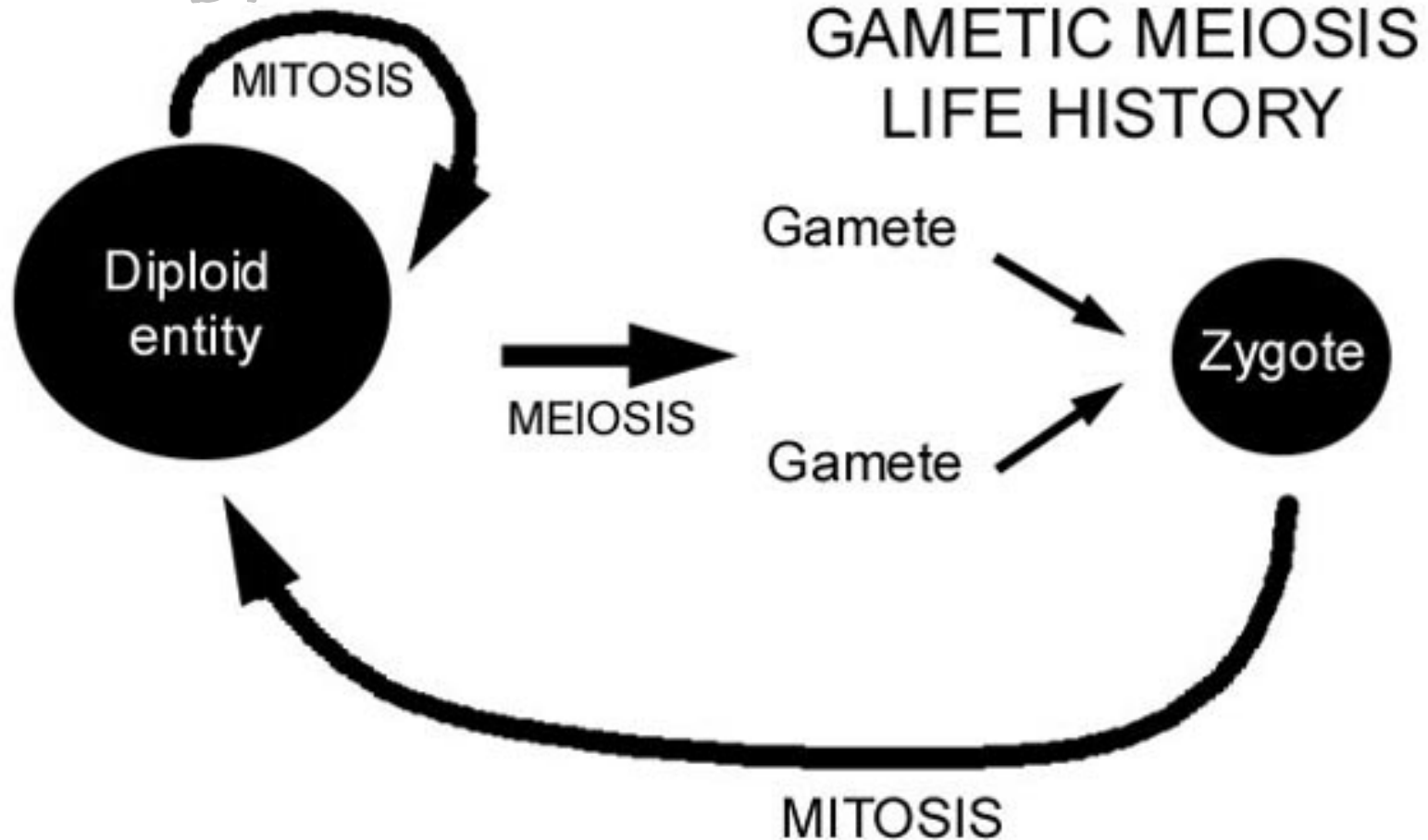


Sargassum cristaefolium Guam

Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista

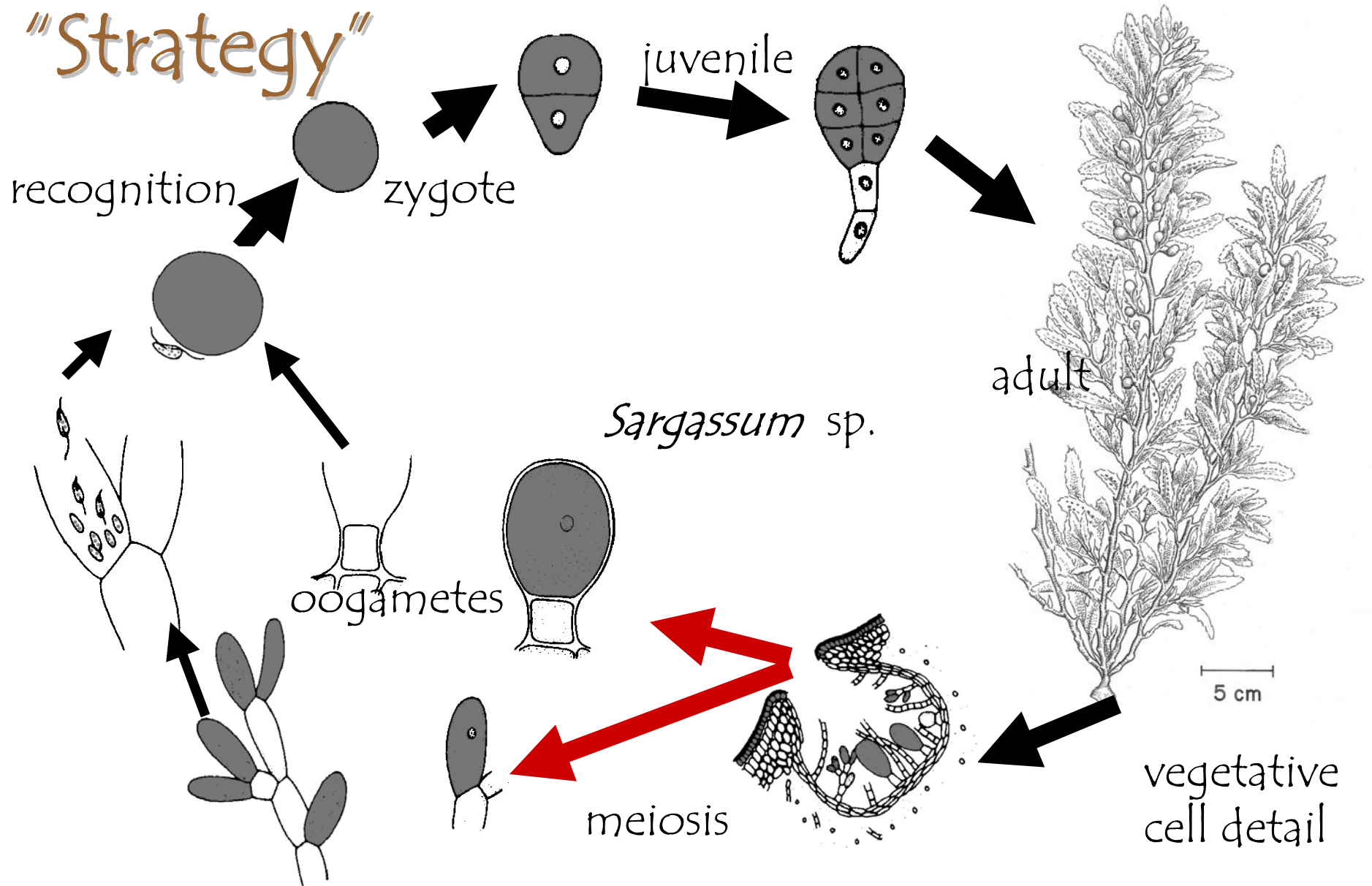


Meiosis is associated with Gamete Production

Life History as a "Strategy"



Division Phaeophyta
Kingdom Protista

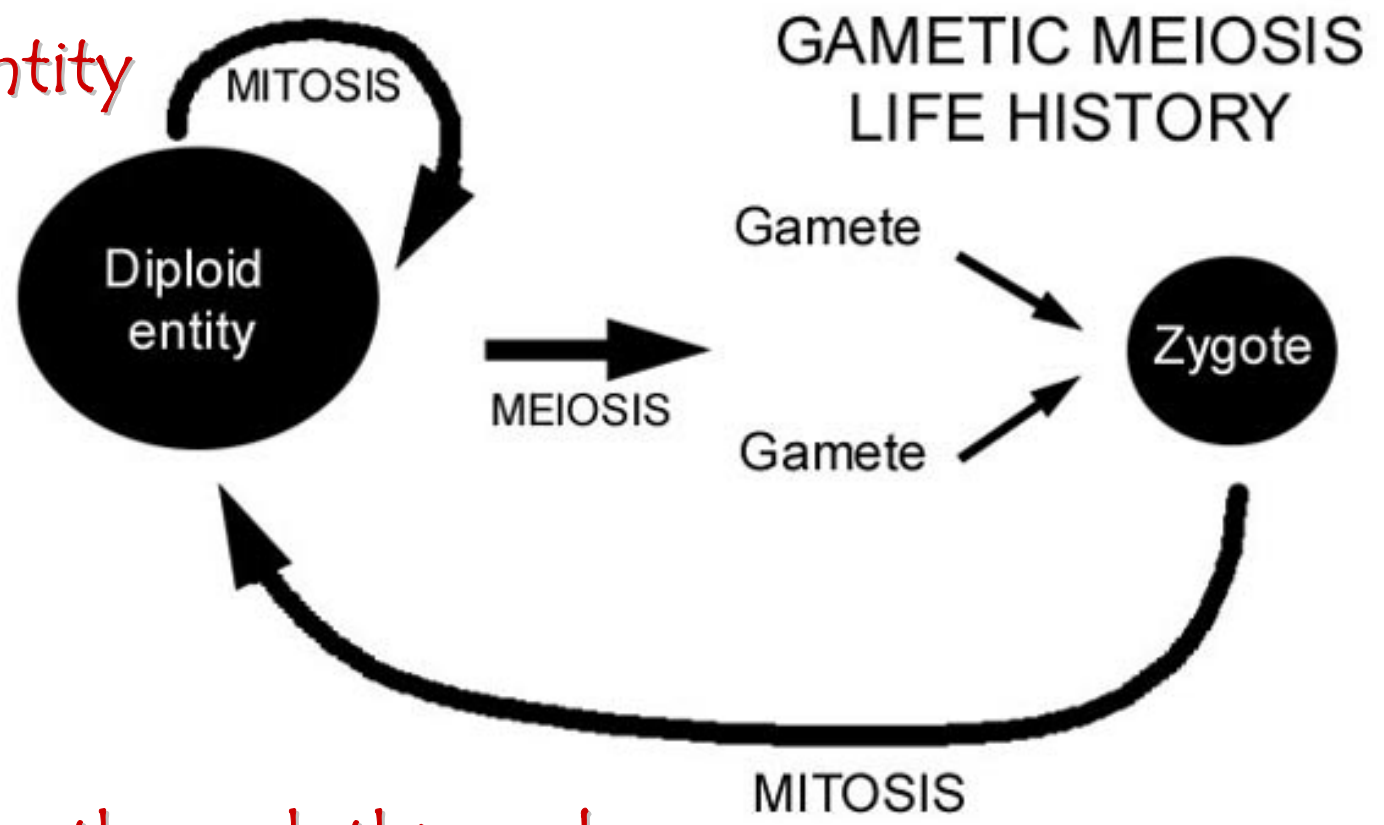


Life History as a "Strategy"

1 free living entity



Division Phaeophyta
Kingdom Protista



Cells must pass through this cycle

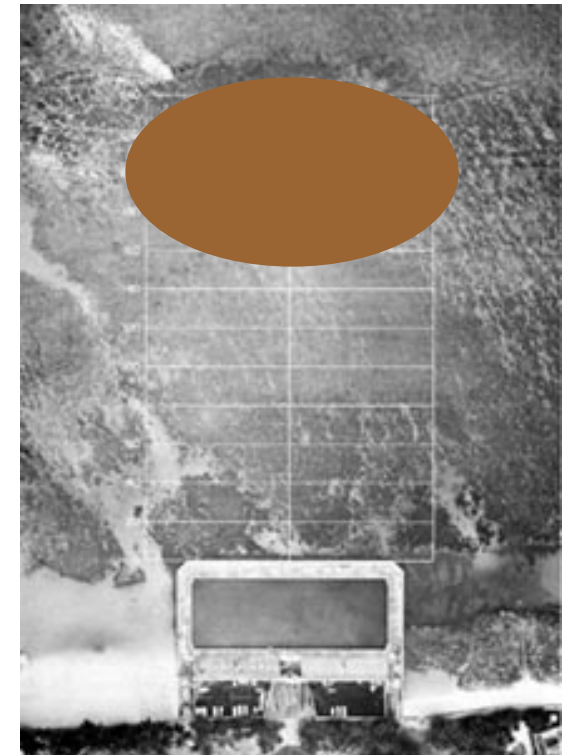
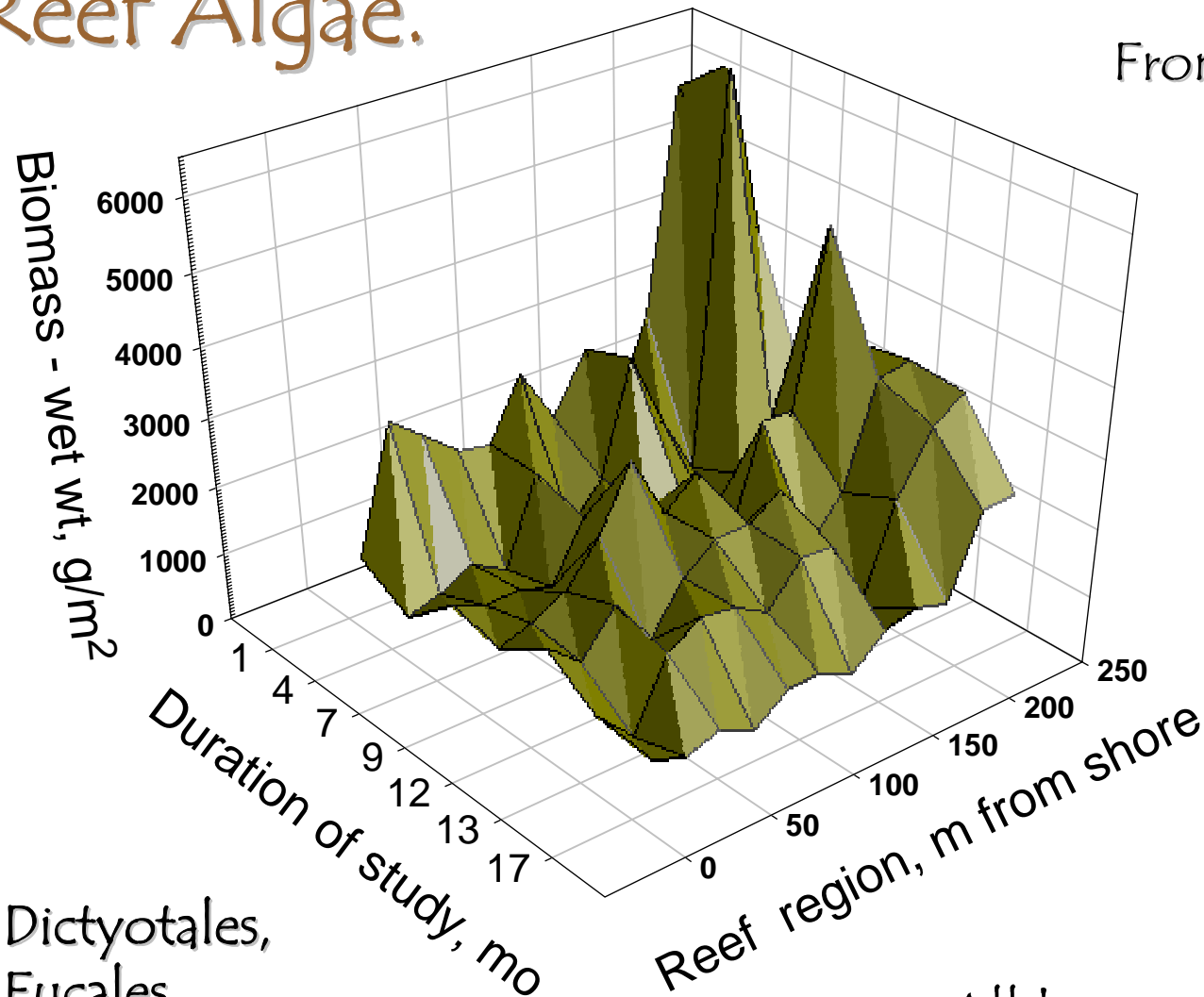
- ◇ to add new genetic individuals to population

Ecology of Hawaiian Reef Algae.



Division Phaeophyta
Kingdom Protista

Frondose Algae of Waikiki,
by M S. Doty 1969



Dictyotales,
Fucales
representatives on
reefs

All browns were native species
Most abundant biomass near shore