Kingdom Protista

Simple Eukaryotes

Green algae

Brown algae

Red algae

Radiolaria

Testaceofilosea

CHROMISTA

"green algae"

PLANTAE

Choanoflagellata

ANIMALIA

Fungi

slime molds

Rhodophyta

primitive flagellates, amoebae, & parasitic taxa
Kingdom Protista

Division Phaeophyta, first brown plants

- Recent plants, ~500 mya
- "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

Ocean lovers

2,000 species (60 in HI oceans)
250+ genera (29 in HI)

Morphological Range:
filaments to complex multicell organisms

Recently arrived eukaryotes - well suited to coastal habitats

Ocean Forests

- Reef algae
- Natives and invasives
- Subtidal
- Intertidal
Diversity

Division Phaeophyta
Kingdom Protista
**General features**

**Pigments** - photosynthesis

- Chlorophyll a
- Chlorophyll c
- Fucoxanthin

**Storage Products**

**Growth**

**Others**

- Carotenoids
- UV absorbing molecules
Photosynthesis & Pigments

- 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

Tetapyrrole Ring

Phytol Chain of Chl a missing in Chl c
## General features

### 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

Two essential parts:
- fibers of cellulose (rigid), a glucose polymer
- gels of polysaccharides (flexible) as ALGINATE
Cell wall structure

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

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

Simple cells

Autotrophs - green and red algae

Xenogenous hypothesis

heterotrophs

phagocytosis

Mereschowsky, 1905; 1910
General features

How are phaeophyte cells unusual?

- "New" membranes around chloroplast & nucleus

First step:

- cyanobacterium

Eukaryote

nucleus

Second step:

Second eukaryote

Repeated endosymbioses

Division Phaeophyta
Kingdom Protista
Life History as a "Strategy"

Gamete → "Asexual Reproduction"

Zygote: Meiosis does not occur in brown algae.

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"

Meiosis is associated with Spore Production

Division Phaeophyta
Kingdom Protista
Growth & morphology

Genetic change

Ectocarpus

Morphological Lineage #1
Order Ectocarpales

All cells appear virtually identical - internally

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

- Multi filamentous genera

Hincksia

Ralfsia
Diversity

Order Ectocarpales

Division Phaeophyta
Kingdom Protista

Ectocarpus

Hincksia sp

Ralfsia
Life history by observation

Ectocarpus

Same motile cell has 2 behaviors?

Where’s meiosis?
Life History as a Life History as a “Strategy”

Division Phaeophyta
Kingdom Protista

mitosis
Ectocarpus sp.
meiosis
spores
mitosis
isogametes
recognition
zygote
germling
mitosis
adults
mitosis
germlings
Life History as a "Strategy"

Meiosis is associated with Spore Production
Reproduction and gametes

2 Gametes – opposite strains always fuse

Zygote – diploid cell via fusion of gametes

Equally sized gametes
Isogamy

Unequal gametes
Anisogamy

Egg & sperm gametes
Oogamy
Minimal diversity in gamete shape...

Swimming gametes have 2 flagella like greens

- But flagella of swimming cells are unequal in length and HAIRY

Laterally inserted

Equal length flagella

Unequal length flagella

Division Phaeophyta

Kingdom Protista
Minimal diversity in gamete shape...

These males gametes show the limited diversity among brown algae

Reds – spermatium

Greens – biflagellate to stephanokont males
Minimal diversity in spore shape

- Most brown algal spores swim
- 2 flagella
- Settlement?
Diversity Tropical Orphans

Scytosiphon sp.

Colpomenia sp.

Rosenvingea sp.

Spatoglossum sp.

Hydroclathrus sp.

Division Phaeophyta
Kingdom Protista
Growth & morphology

Evolution has taken a simple filament:
Multiseriate tissues create sheets or blades
From apical cell or meristem areas

Dictyota

Dictyopteris

Padina

Order Dictyotales

Morphological Lineage #2

Division Phaeophyta
Kingdom Protista
Diversity

Order Dictyotaales

Division Phaeophyta
Kingdom Protista

Dictyota sp.

Padina sp.

Dictyota crenulata

1 cm
Life History as a "Strategy"

mitosis

recognition

oogametes

zygote

meiosis
tetra
spores

Dictyota

spores

germlings

mitosis

adults
Life History as a “Strategy”

Meiosis is associated with Spore Production
Growth & morphology

Evolution has taken a simple shape:
- constrained into lamina
- large sporophyte generations

Laminaria
Alaria
Macrocystis
Diversity

Division Phaeophyta
Kingdom Protista

Order Laminariales
Ecology

Kelp forests sustain coastal diversity
epiphytic
pelagic
benthic
understory
Life History as a "Strategy"

Division Phaeophyta
Kingdom Protista

Macrocystis
Life History as a "Strategy"

*Ecklonia cava*

Spores

Egg and sperm
Growth & morphology

Division Phaeophyta
Kingdom Protista
Morphological Lineage # 4
Order Fucales

Ectocarpus

Dictyopteris sp

Sargassum obtusifolium

5 cm
Diversity
Sargassum thunbergii  Gunma Japan

Order Fucales

Division Phaeophyta
Kingdom Protista

Sargassum cristaefolium Guam
Life History as a “Strategy”

Meiosis is associated with Gamete Production
Life History as a "Strategy"

Division Phaeophyta
Kingdom Protista

recognition → zygote → juvenile → meiosis → oogametes

Sargassum sp.

adult → vegetative cell detail

5 cm
Life History as a "Strategy"

1 free living entity

Cells must pass through this cycle

- to add new genetic individuals to population
Ecology of Hawaiian Reef Algae.

Frondose Algae of Wakiki, by M S. Doty 1969

Biomass - wet wt, g/m²

Duration of study, mo

Reef region, m from shore

Dictyotales, Fucales representatives on reefs

All browns were native species
Most abundant biomass near shore