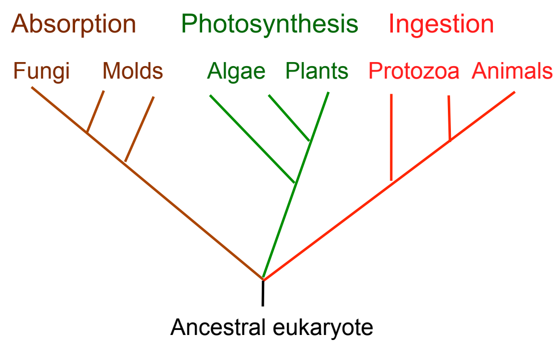
Eukaryotic Diversity II

1. We'll return the exams today or Friday.
2. Clickers today
3. Friday – endosymbiosis HW due.
4. Friday - GAE involves a computer simulations of diffusion.
5. 3-student groups - bring one laptop with downloaded application called Mathematica Player, plus the diffusion simulation from the course website; 4-student groups – 2 laptops, if possible
6. Fully charged laptop, watch/timer, calculator, and gmail account

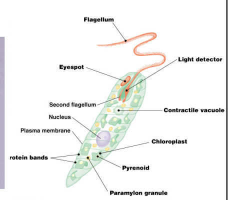
1970's hypothesis of eukaryote phylogeny



Protist diversity: 1) Poor coupling between protist phylogeny and nutritional strategy

Colloquial terms -

- Molds - absorptive, fungus-like protists
- Algae - photosynthetic, plant-like protists
- Protozoa - ingestive, animal-like protists



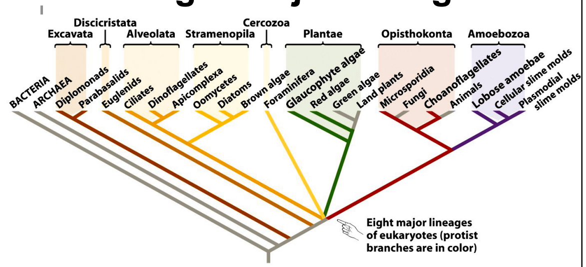
See F. Fig. 29.26

C & R 28.3

Euglena

Many lineages acquire, then lose plastids

"Protist" Diversity
Eight major lineages



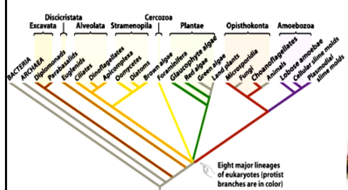
Nutrition – often results from convergence, only sometimes from phylogeny

Eukaryotic Diversity II

- Eukaryotes evolved as complex assemblages of several organisms due to endosymbiosis.
- Eukaryotes acquired aerobic respiration and oxygenic photosynthesis from bacterial endosymbionts.
- Prokaryotes – lateral gene transfer
  Eukaryotes – endosymbiosis (with LGT)
- Unifying features include: nucleus, linear chromosomes, endomembrane system, and complex cytoskeleton.
- Eukaryotes manifest more organellar, cellular, and multicellular diversity than prokaryotes
- Eukaryotes originated the sexual stages, i.e., syngamy and meiosis, in life cycles.
- Protists - paraphyletic group including all eukaryotes except plants, fungi, and animals

Plastid evolution - A tale of two metaphors

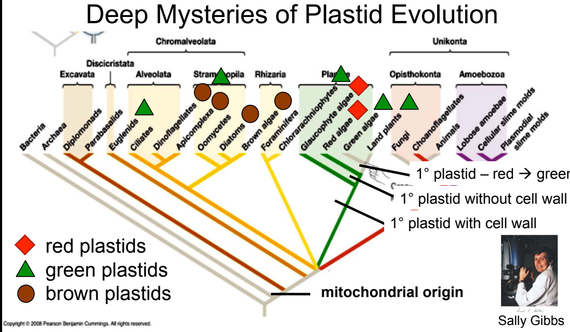
(Darwin's Tree of Life vs. Delwiche's Babushka Dolls)



F. Fig. 28.7

"It is the best of times, and it is the worst of times to be studying plastid evolution" - Chuck Delwiche (CBMG)

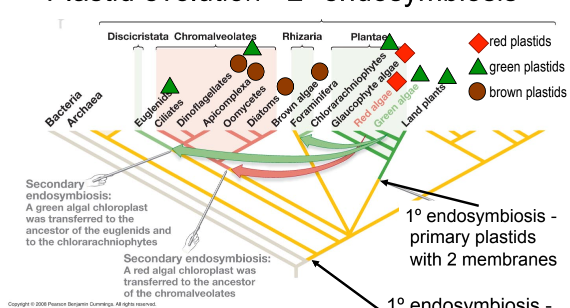
Deep Mysteries of Plastid Evolution



Sally Gibbs

All plastids have chlorophyll *a*, with different accessory pigments

Plastid evolution - 2º endosymbiosis



F Fig. 29.17

2°/sometimes 3° endosymbiosis of plastid origins in many lineages

Eukaryotic Diversity I

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Endomembrane system

- Complex cell relative to prokaryotes

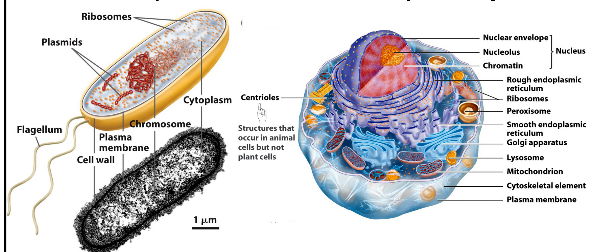
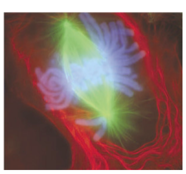
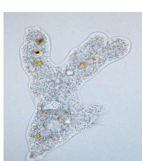


Fig. 7.1, 7.6

Complex cytoskeleton



Mitosis (green spindle, blue chromosomes)



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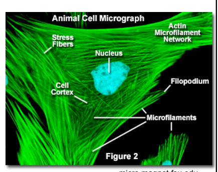
Amoeba



micro.magnet.fsu.edu

Microfilaments

Functions - structural support, movement, mitosis, shape change, cell division, engulfing (phagocytosis), intracellular transport, flagella and cilia

Eukaryotic Diversity II

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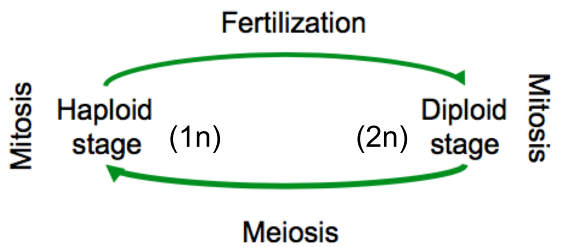
Generalized sexual life cycle in eukaryotes



Fertilization (syngamy) - the fusion of 2 haploid cells called gametes to form the diploid zygote
Meiosis – the division of one diploid cell to form 4 haploid cells

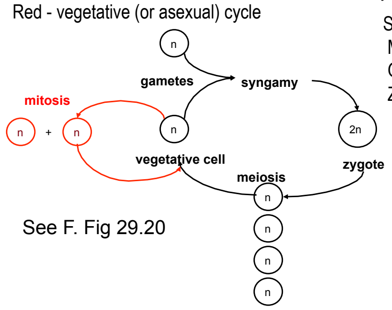
Life cycle variation – the number of mitoses in 1n and 2n stages

Are eukaryotes haploid or diploid for most of their life cycles?

1. Most lineages are predominantly haploid.
2. Most lineages are predominantly diploid.

Typical protist - haploid life cycle

Black - reproductive (or sexual) cycle
Red - vegetative (or asexual) cycle

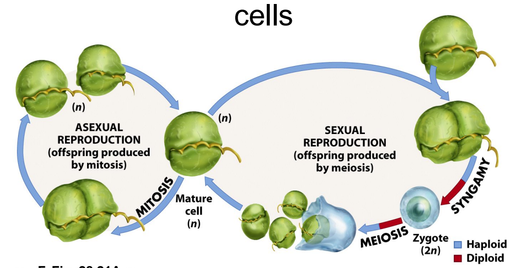


See F. Fig 29.20

Key terms for all life cycles:

Syngamy/fertilization:
Meiosis:
Gametes:
Zygote:

Unicellular life cycle – vegetative haploid cells



F. Fig. 28.21A

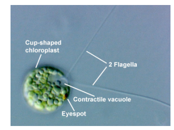
Isogamy - the gametes are the same size
Anisogamy - larger “female” gamete and smaller “male” gamete
Oogamy - non-motile egg and motile sperm

How do we in BSCI 207 try to make sense of the complexity and diversity in organismal biology?

Two alternative approaches:

1) Characterize the underlying physical, chemical, molecular, and/or physiological mechanisms governing a particular phenomenon in all organisms.
2) Understand the evolutionary history of the phenomenon in related organisms.

Ursula Goodenough and *Chlamydomonas* sex

Many protists including *Chlamydomonas,* do not form distinct sperm and eggs.

Haploid cells carry the genes for expressing either plus and minus mating types.

Vegetative haploid cells →→→→→→ Mating type gene expression
adverse conditions
(e.g., limited N)

+ locus acts as a transcription factor for expressing + proteins in the + gamete

- locus acts as a transcription factor for expressing – proteins in the – gamete

Thus, gamete identity is controlled by the specific gene at the mating-type locus

Ursula Goodenough's great discovery about *Chlamydomonas* sex

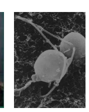

Lee, J-H., H. Lin, S. Joo, and U.W. Goodenough. 2008. Knox and Bell-related homeoprotein heterodimers initiate *Chlamydomonas* zygote development. **Cell** 133: 829-840.

Mating locus proteins from the two gametes interact to form a heterodimer transcription factor in the fused diploid cell.

This novel transcription factor initiates the expression of the genes for zygote development, including meiosis.

Transcription factors from mt locus	Cell type	Function
As separate proteins		
As combined heterodimer		

Ursula Goodenough's great discovery about *Chlamydomonas* sex

Lee, J-H., H. Lin, S. Joo, and U.W. Goodenough. 2008. Knox and Bell-related homeoprotein heterodimers initiate *Chlamydomonas* zygote development. **Cell** 133: 829-840.

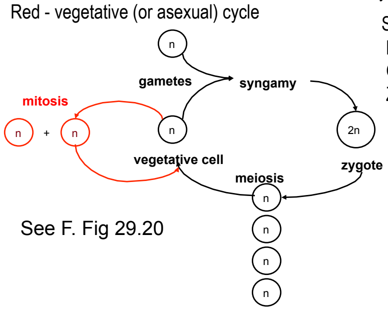
The simplest model is that sex evolved in the common eukaryotic ancestor as integrated genetic machinery at the mating type loci encoding for the abilities:

1) to transform into + or - gametes,
2) to carry out syngamy,
3) to develop as a zygote, and
4) to undergo meiosis.

So the answer to why haploid life cycles – they evolved in the common ancestor

Typical protist - haploid life cycle

Black - reproductive (or sexual) cycle
Red - vegetative (or asexual) cycle



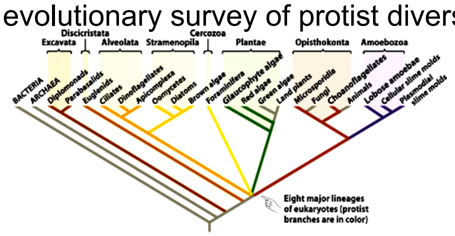
Key terms for all life cycles:

Syngamy/fertilization:
Meiosis:
Gametes:
Zygote:

See F. Fig 29.20

How did multicellular diploid organisms evolve?

An evolutionary survey of protist diversity



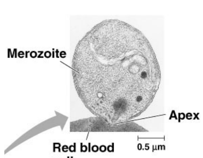
General protist features

- incredible structural diversity in each major lineage
- different nutritional strategies in each lineage
- repeated evolution and different modes of multicellularity

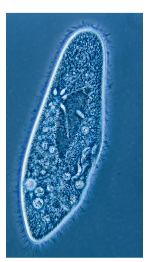
1. Alveolates

- Unicellular protists including flagellated protists (dinoflagellates), parasites (apicomplexans), and ciliated protists (the ciliates).
- Alveoli are small membrane-bound cavities under the cell surface with unknown function.

dinoflagellate



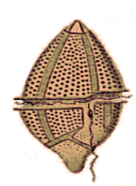
apicomplexan



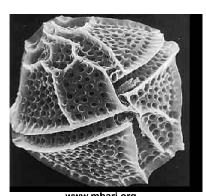
ciliate

1A. Dinoflagellates

- Very abundant component of marine phytoplankton
- Internal armor of cellulose plates with two perpendicular grooves with flagella.
- Most common species of symbiotic zooxanthellae in corals - primary producers of coral reefs
- Dinoflagellate blooms cause red tides, sometimes resulting in paralytic shellfish poisoning



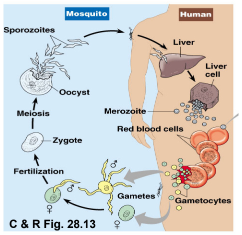
www.ucmp.berkeley.edu/



www.mbari.org

www.botany.hawaii.edu

1B. Apicomplexans - all animal parasites



Plasmodium life cycle

Plasmodium infection in red blood cells

- Intricate life cycles with several hosts - very evasive
- Most familiar example - *Plasmodium* causes malaria
- Complete sequencing of all genomes involved in malaria - human, mosquito, and *Plasmodium*
- Vestigial plastid from ancient 2° endosymbiosis

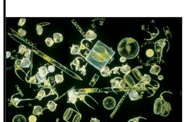
1C. Ciliates

- Diverse protist group unified by their use of cilia for feeding and movement.
- Submembrane microtubules act to coordinate ciliary beating.
- Large macronucleus ($\geq$50 total genomes) for RNA synthesis and asexual binary fission.
- Tiny micronuclei for exchange during sexual conjugation.

2. Stramenopiles

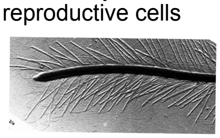

www.unikassel.de

oomycetes


F Fig. 29.2

diatoms

- Diverse unicellular and multi-cellular protists
- Heterotrophic group - oomycetes (water molds and downy mildews)
- Photosynthetic group - heterokont algae (diatoms and brown algae)
- Stramenopile refers to hair-like projections on their flagella that are usually restricted to motile reproductive cells


flagellum

F Fig. 29.7

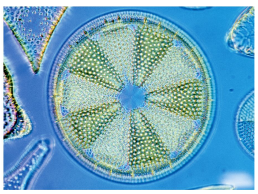
2A. Oomycetes - water molds and relatives

- Often multi-nucleate branched hyphae
- Major decomposers in aquatic habitats
- Convergent body plan and nutritional strategy with the fungi

- Devastating plant pathogens
- For example, *Phytophthora infestans* causes potato late blight that led to the Irish famines in mid 1800s.
- *P. ranorum* causes a new disease known as sudden oak death in California.

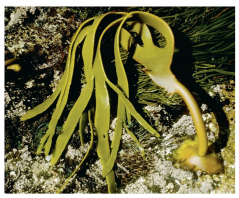
2B. Heterokont algae

- All groups have brown plastids resulting from 2º and 3º endosymbiosis
- Amazing structural diversity



F Fig. 29.32

Diatoms - the grass of the seas



F Fig. 29.34

Kelps - the trees of the seas

Lecture 14 - Study Questions

- Evaluate the 1960's hypothesis about eukaryotic phylogeny.
- Define primary endosymbiosis, and provide the molecular and structural evidence used to support the endosymbiotic origin of primary plastids in red and green algae.
- Define secondary endosymbiosis, and provide the molecular and structural evidence used to support the endosymbiotic origin of secondary plastids in other algae.
- Describe the basic life cycle of unicellular protists, being certain to specify the names and ploidy levels of all cells and the names of all processes in that life cycle.
- Describe Ursula Goodenough's research, and explain its significance for understanding the origins of sex and the evolution of eukaryotic life cycles.
- Identify key features of the different groups in alveolate, stramenopile, and red algal lineages.