

# Evolutionary Advantage of Sex

Ancestral eukaryote probably alternated asexual and sexual reproduction.

If so, all strictly asexual organisms lost sexual reproduction.

S = Sexual only  
 A = Asexual only  
 S/A = Sexual and asexual

Possible locations of root

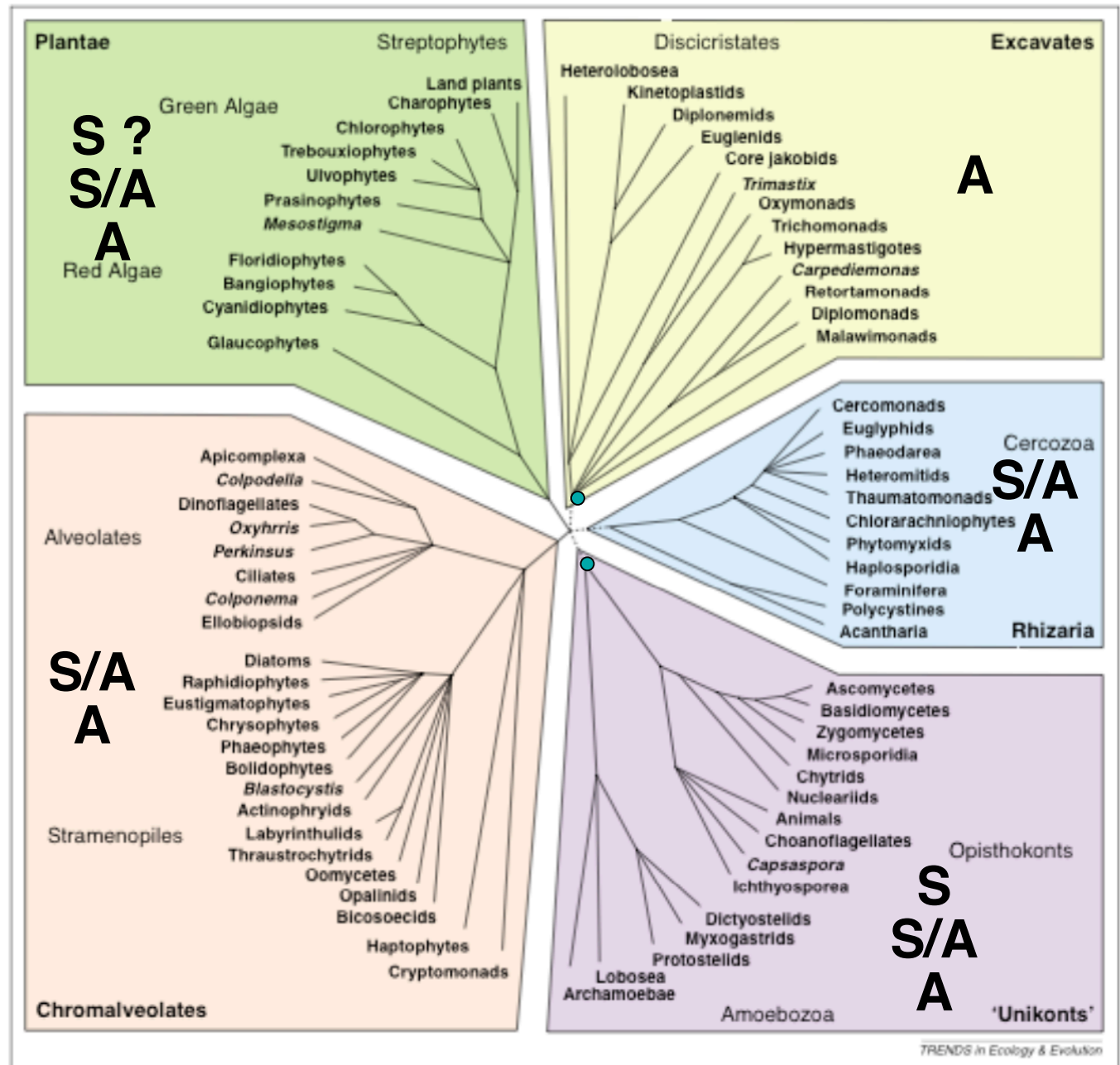


Figure 1. A tree of eukaryotes. The tree is a hypothesis composed from the various types of data discussed in the text, including molecular phylogenies and other molecular characters, as well as morphological and biochemical evidence. Five 'supergroups' are shown, each consisting of a diversity of eukaryotes, most of which are microbial (mostly protists and algae). Relationships are left unresolved (i.e. where several branches emerge simultaneously) when there is little or no evidence for the branching order. Other branches are shown dotted when there are only preliminary indications for this relationship. A handful of 'orphan' genera and two groups, Apusozoa and centrohelid Heliozoa, are not shown. There are few data from these organisms and they are not yet associated with any of these groups.

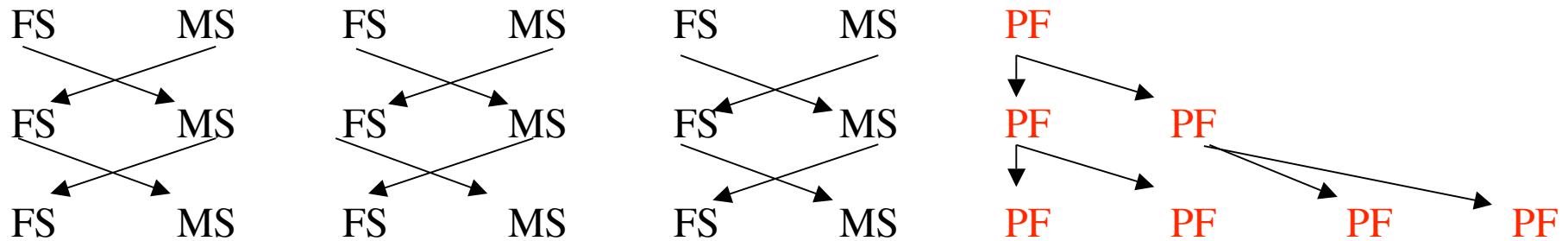
Sexual reproduction is easily lost.

- S/A Any null mutation in any gene required for transition from asexual to sexual part of life cycle would make organism obligatorily asexual.
- S Animal hybrids are often parthenogenetic.

Loss of sex is usually irreversible.

Asexual mutants or hybrids have selective advantages over sexuals and will often replace them:

- Parthenogenetic animals and plants have two-fold advantage over sexuals.



- Asexuals reproduce faster.
- Asexuals are better colonizers.

Why are any sexual organisms left?

Mammals and birds can't reproduce by parthenogenesis.

In other organisms sexuals must have advantage(s) at the species level to compensate for disadvantages at the individual level:

- Higher rate of extinction
- Lower rate of speciation

Most asexual animals and plants are of recent origin, and have not produced many species.

Why?

Many different models and theories:

Hill-Robertson effect

Muller's ratchet

Kondrashov's hatchet

Red Queen

Etc, etc, etc *ad infinitum* and *ad nauseum*

Most can be included in one general statement: Natural selection works better with sex than without it.

Simplistic model:

*AB*      *AB*      *AB*      *AB*

detrimental mutations  
↓

*Ab*      *aB*      *AB*      *AB*

sex  
↓

*ab*      *AB*      *AB*      *AB*

Selection against *b* and *a* is balanced by selection for *A* and *B*.

Without sex, asexuals tend to

- lose advantageous mutations needed to adapt to different habitats (lower speciation rate) and adapt to changing environments (higher extinction rate)
- fix detrimental mutations, leading to higher rate of extinction (Muller's ratchet)

Some puzzling exceptions:

Animal mitochondrial genomes are effectively asexual, so why haven't they (and we) gone extinct?

Darwinulid ostracods, oribatid mites, and bdelloid rotifers have reproduced only by parthenogenesis for tens of millions of years and have undergone some speciation. Bdelloid rotifers show no accumulation of detrimental mutations; why not? Dehydration rejuvenates?

Many groups of asexual eukaryotic microorganisms are ancient and have many species:

- green alga "genus" *Chlorella*
- all of the Excavates

Having rare, furtive, or cryptic sex?



