# protists do not read textbooks!

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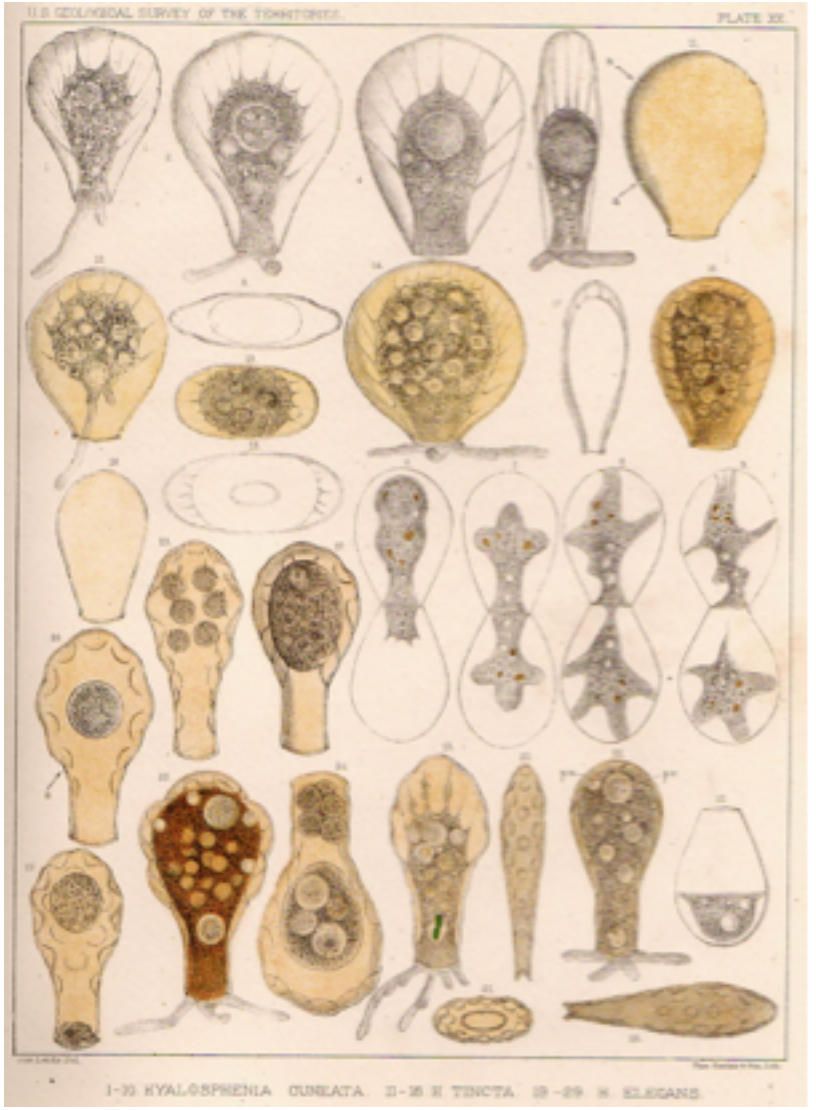
# conclusions

protists do not read textbooks!

# our microbial ignorance

J. J. Audubon, Birds of America
1827-38



J. Leidy, Freshwater Rhizopods of
North America 1879

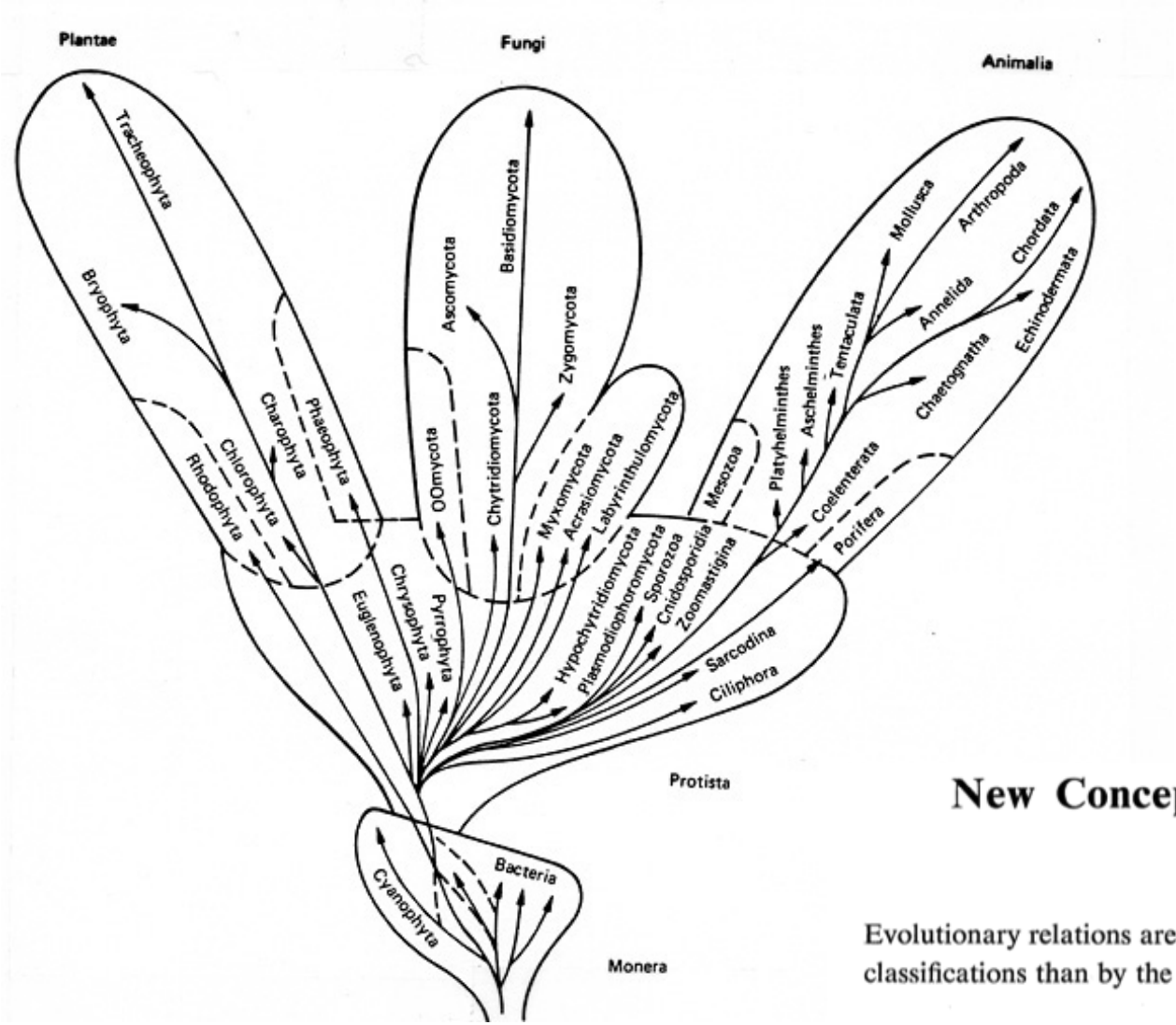
# outline

- modern phylogenetics of microbial eukaryotes
- chastity of amoebae
- protozoan immortality

# outline

- modern phylogenetics of microbial eukaryotes
  - five Kingdoms
  - historical reconstruction
  - modern hypothesis and dates
- chastity of amoebae
- protozoan immortality

# five kingdoms

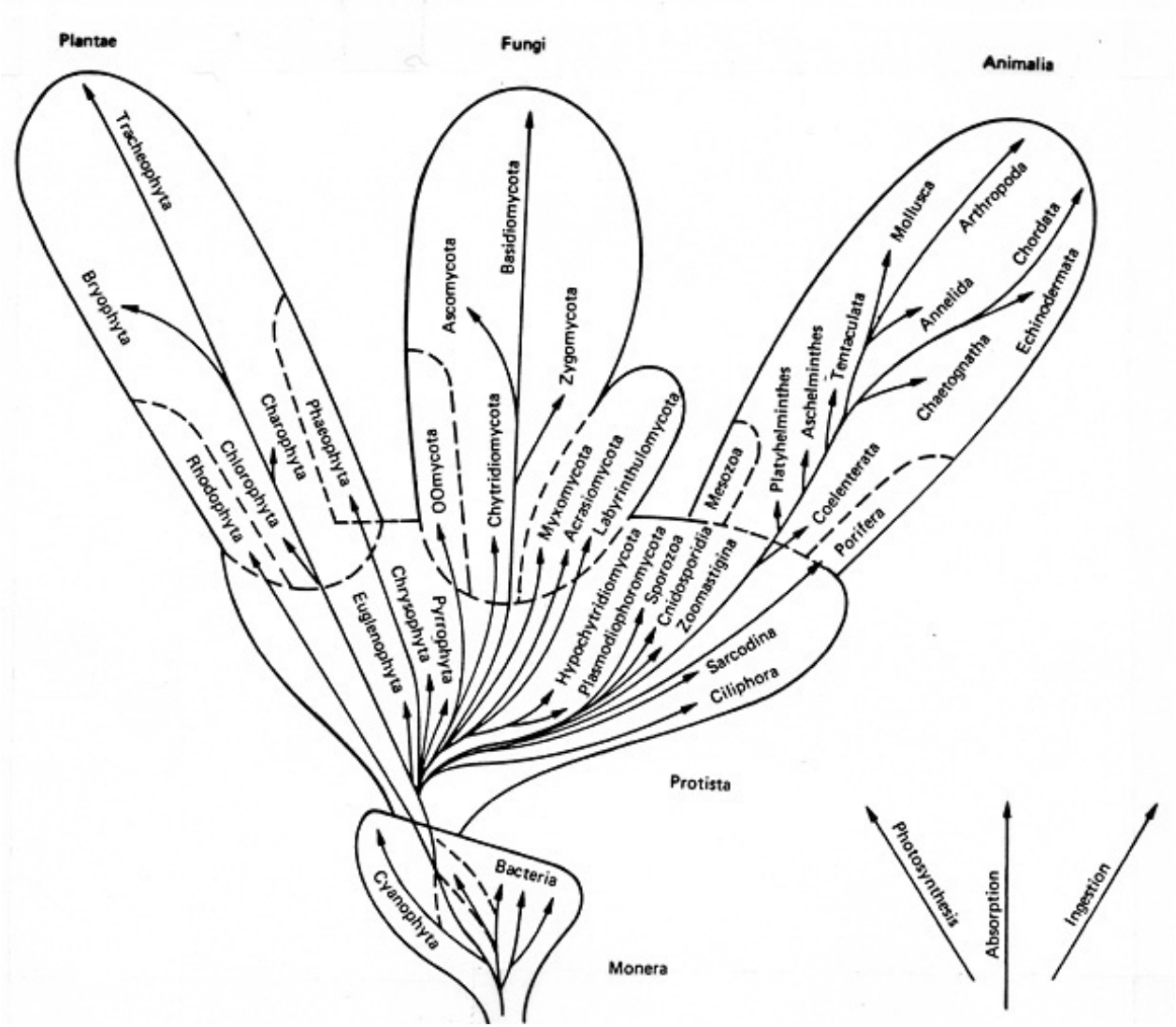



## New Concepts of Kingdoms of Organisms

Evolutionary relations are better represented by new classifications than by the traditional two kingdoms.

R. H. Whittaker

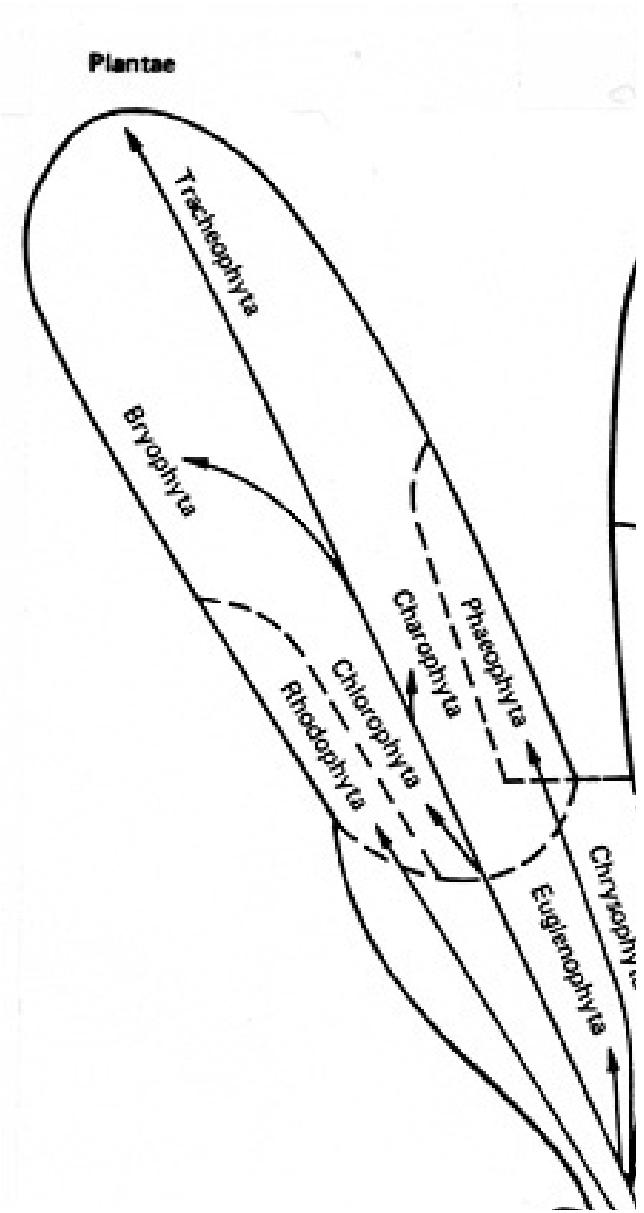
# five kingdoms



# modern historical reconstructions

- cladistics (Hennig)
  - monophyletic groups
  - synapomorphy

# monophyly and synapomorphy



# modern historical reconstructions

- cladistics (Hennig)
  - monophyletic groups
  - synapomorphy
- molecular sequencing
  - central dogma of molecular biology
  - sequences as basis for reconstructions

# central dogma of molecular biology

NATURE VOL. 227 AUGUST 8 1970

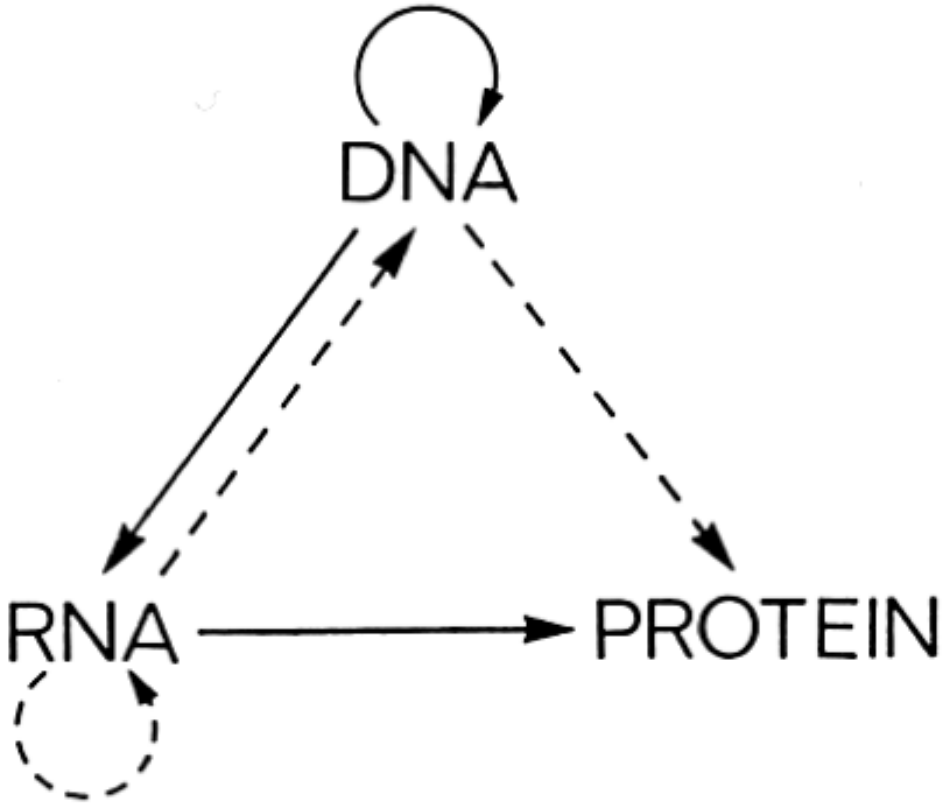
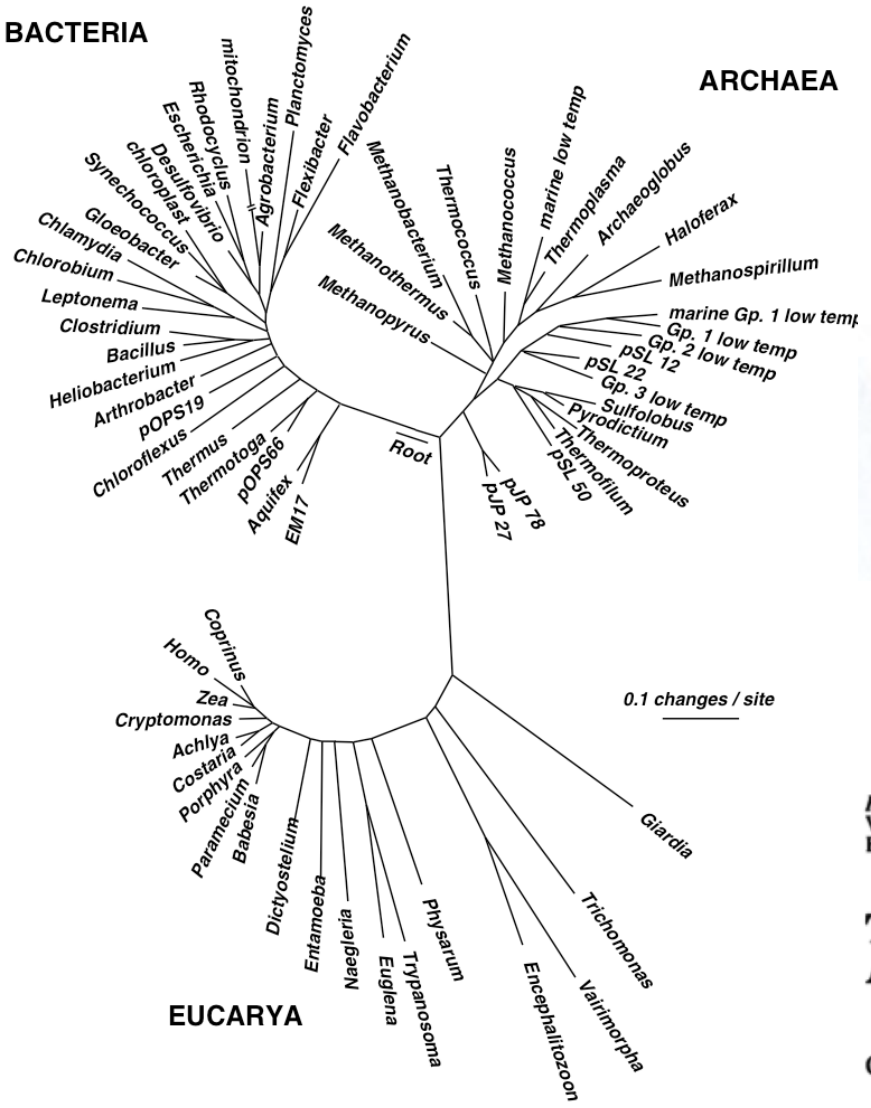
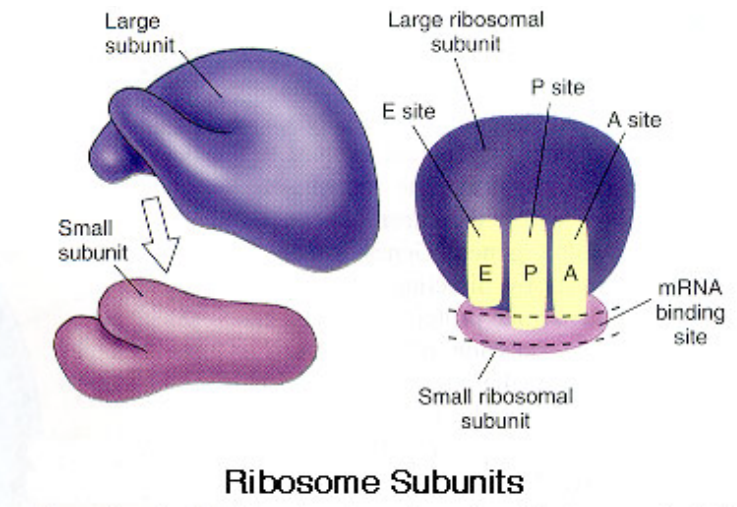



Fig. 3. A tentative classification for the present day. Solid arrows show general transfers; dotted arrows show special transfers. Again, the absent arrows are the undetected transfers specified by the central dogma.

# woesian revolution




Ribosome Subunits

*Proc. Natl. Acad. Sci. USA*
Vol. 87, pp. 4576–4579, June 1990
Evolution

**Towards a natural system of organisms: Archaea, Bacteria, and Eucarya**

(Euryarchaeota/Crenarchaeota/kingdom/evolution)

CARL R. WOESE*†, OTTO KANDLER‡, AND MARK L. WHEELIS§

# probabilistic reconstructions

```
A   aat tcg ctt cta gga atc tgc cta atc ctg
B   ... ..a ..g ..a .t. ... ... t.. ... ..a
C   ... ..a ..c ..c ... ..t ... ... ... t.a
D   ... ..a ..a ..g ..g ..t ... t.t ..t t..
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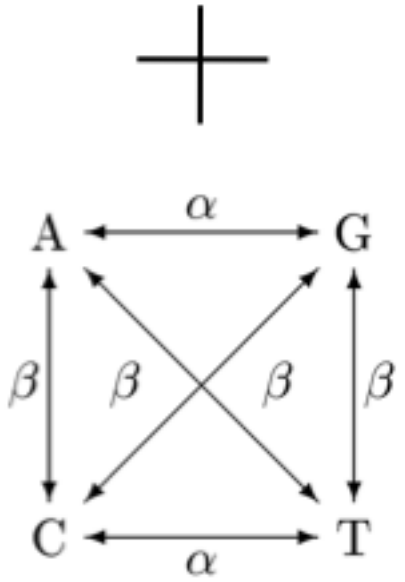
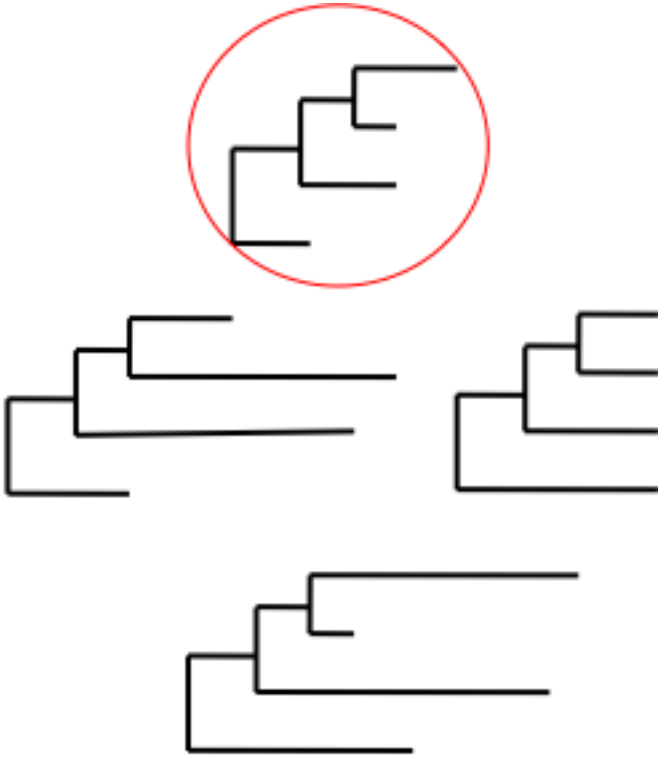
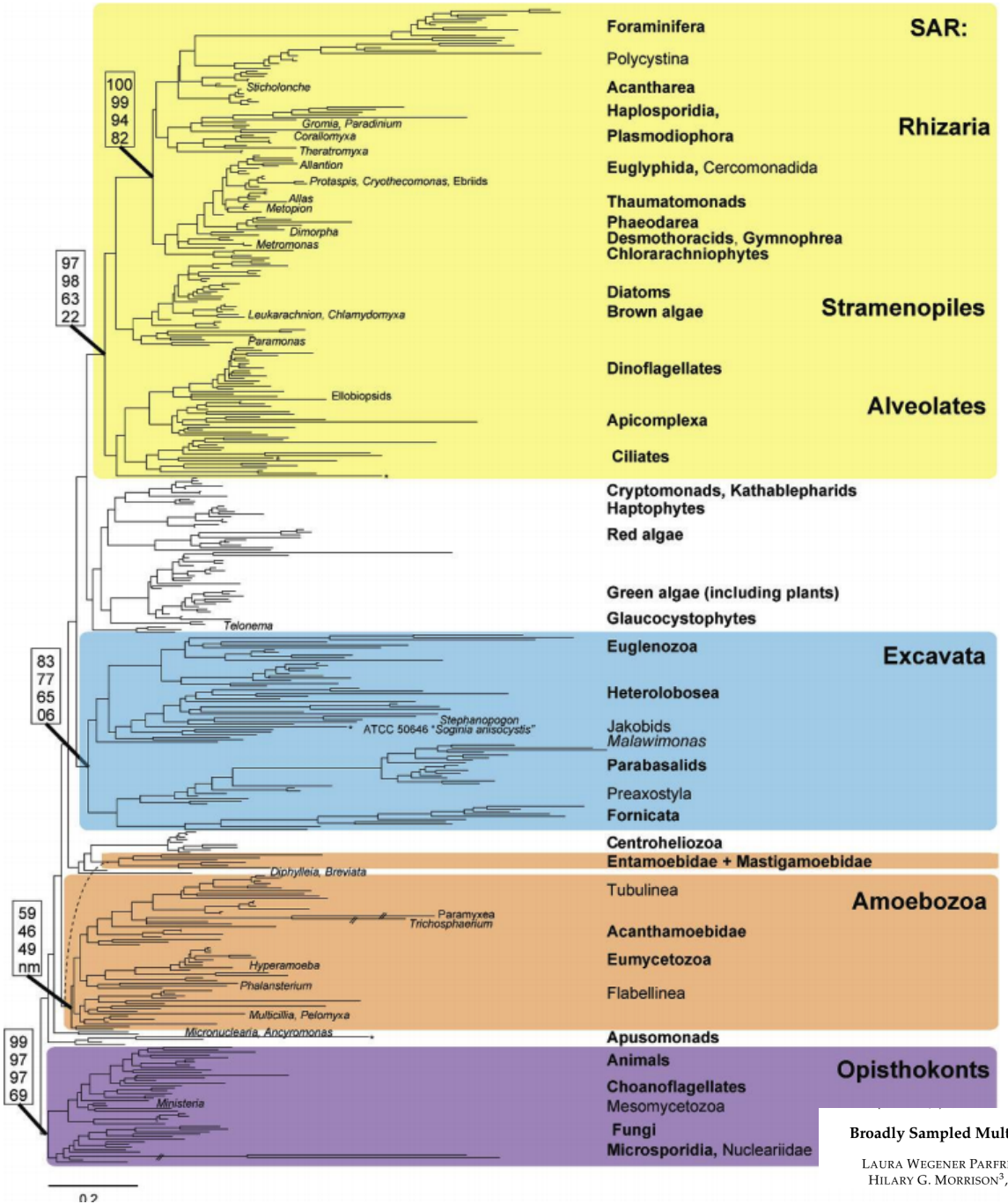


tree space

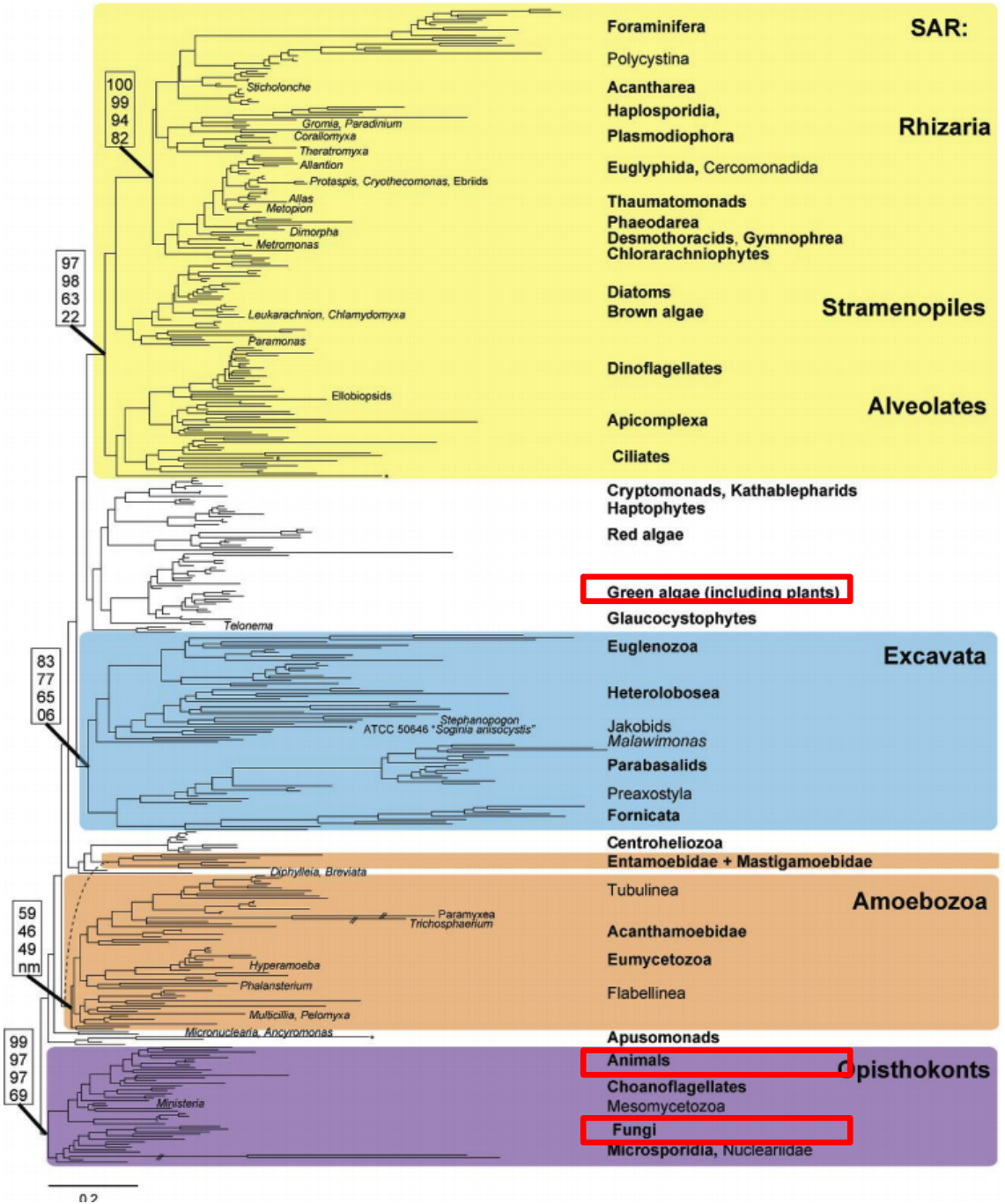
# modern eukaryotic phylogeny



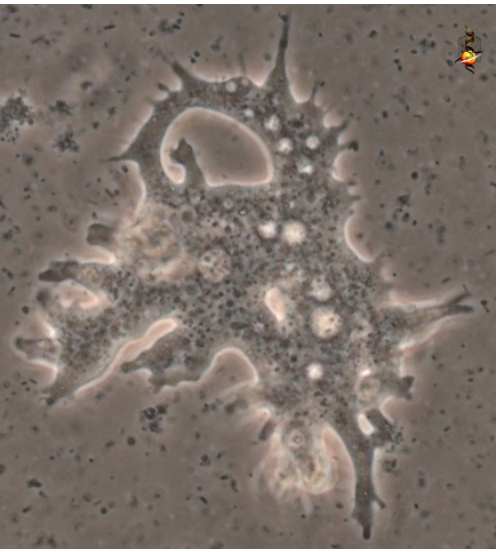

**Broadly Sampled Multigene Analyses Yield a Well-Resolved Eukaryotic Tree of Life**


Laura Wegener Parfrey[1], Jessica Grant[2], Yonas I. Tekle[2,6], Erica Lasek-Nesselquist[3,4], Hilary G. Morrison[3], Mitchell L. Sogin[3], David J. Patterson[5], and Laura A. Katz[1,2,*]

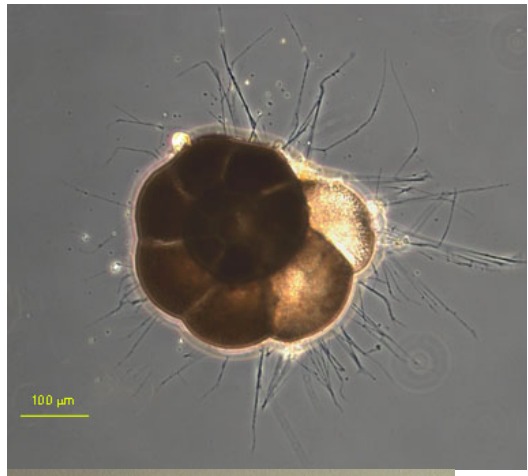
# modern eukaryotic phylogeny

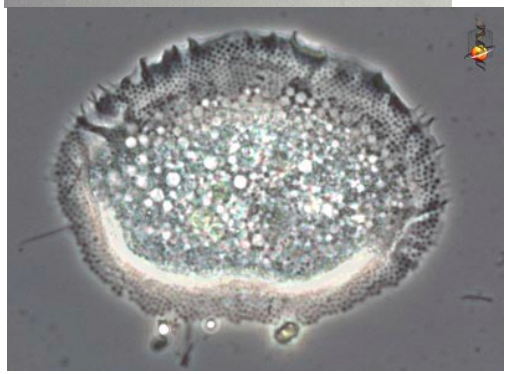


# modern eukaryotic phylogeny





# summary 1

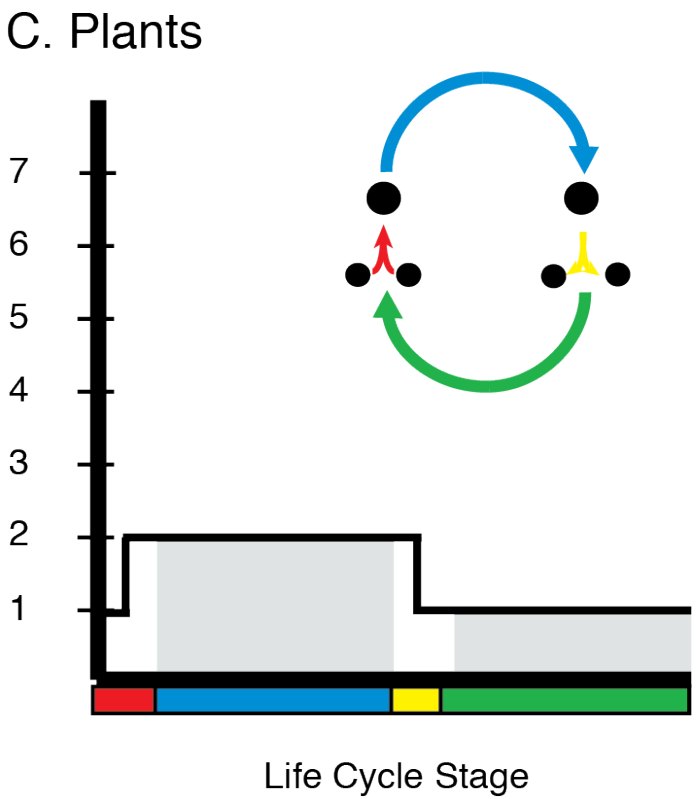
- bulk of diversity is microbial
- modern historical reconstructions are based on sequences and probabilistic models

# outline

- modern phylogenetics of microbial eukaryotes
- chastity of amoebae
  - sex and asex
  - Muller's ratchet
  - re-evaluating the evidence
- protozoan immortality

# sex

- meiosis followed by nuclear fusion (Kondrashov, 1988)




**The Dynamic Nature of Eukaryotic Genomes**

*Laura Wegener Parfrey,* Daniel J. G. Lahr,* and Laura A. Katz*†*

*Mol. Biol. Evol.* 25(4):787–794. 2008
doi:10.1093/molbev/msn032
Advance Access publication February 6, 2008

# amoebae are asexual

Europ. J. Protistol. 39, 349–355 (2003)

http://www.urbanfischer.de/journals/ejp

European Journal of
PROTISTOLOGY

## The species problem in protozoa revisited

**Martin Schlegel[1,*] and Ralf Meisterfeld[2]**

[1]Institut für Zoology, Universität Leipzig, Talstraße 33, 04103 Leipzig, Germany;
E-mail: schlegel@rz.uni-leipzig.de
[2]Institut für Biologie II, RWTH Aachen, Kopernikusstraße 16, 52056 Aachen, Germany

Received: 2 September 2003; 22 October 2003. Accepted: 24 October 2003

**The biological species concept as coined by Ernst Mayr is not applicable to many protists which reproduce by inbreeding or asexually. An extended concept supplementing the biological species concept was suggested by T. M. Sonneborn after intensive studies on differently reproducing species of the *Paramecium aurelia* complex. In his concept based on the hypothesis that inbreeding or asexually reproducing taxa also evolve as discrete units, he suggested that a species should be recognized as an evolving entity that has undergone a threshold of minimum evolutionary divergence. However, Sonneborn´s idea was poorly received. We examine different morphological and molecular characters discovered and applied in taxonomy since Sonneborn developed his hypothesis. We conclude that there is now an abundance of objective characters to arrive at sound judgement about the complexity of the genetic differences necessary to delimit species in Sonneborn´s sense when the biological species concept is not applicable. In addition, combined morphological and molecular studies reveal that, although many free-living protists may be globally distributed, geographical patterns and local distribution also occur.**

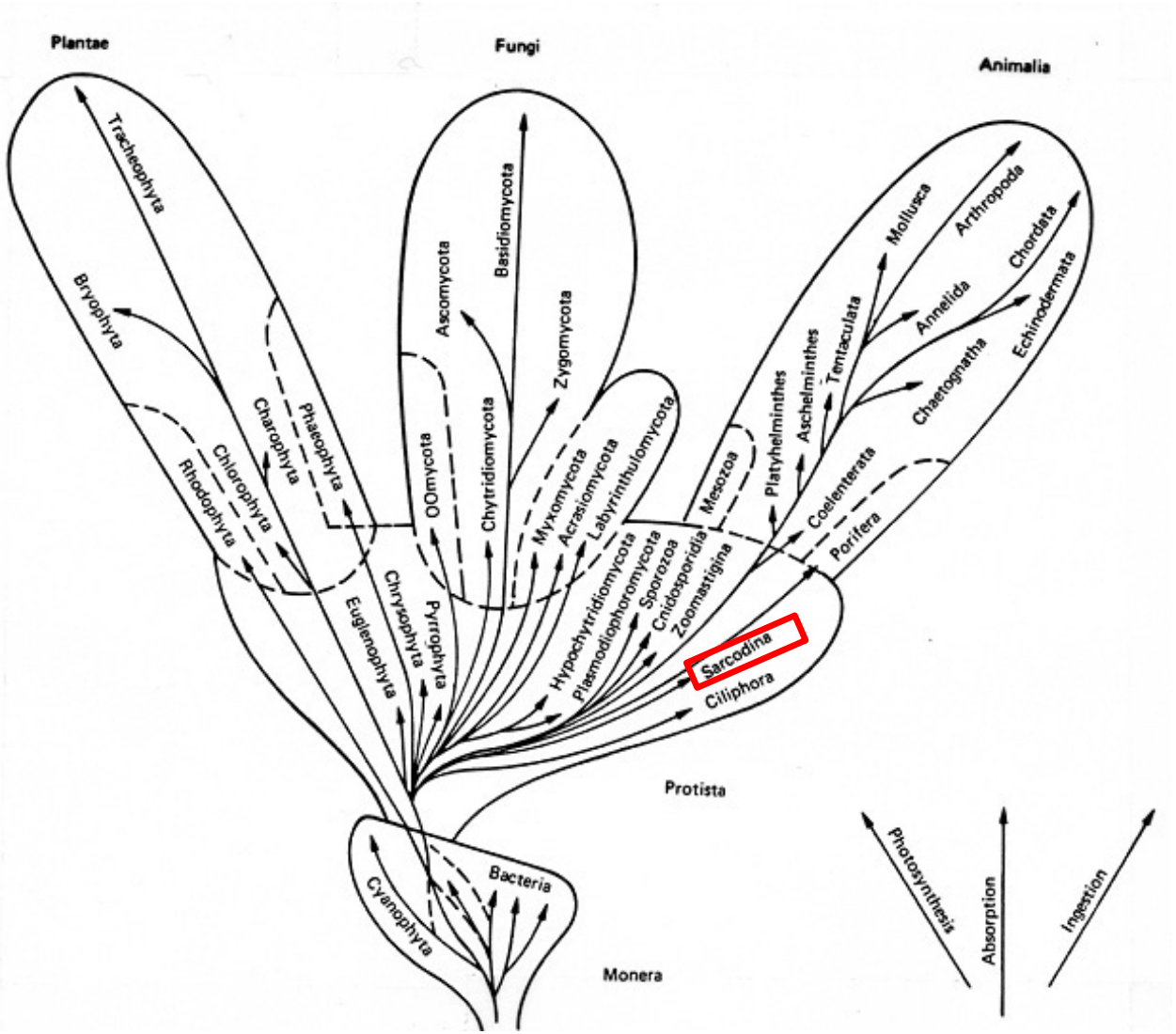
**Key words: Asexual reproduction; Evolutionary threshold; Inbreeding; Protozoa; Species concept.**

# amoebae are asexual?

- sarcodina?

# amoebae are asexual?

- sarcodina?

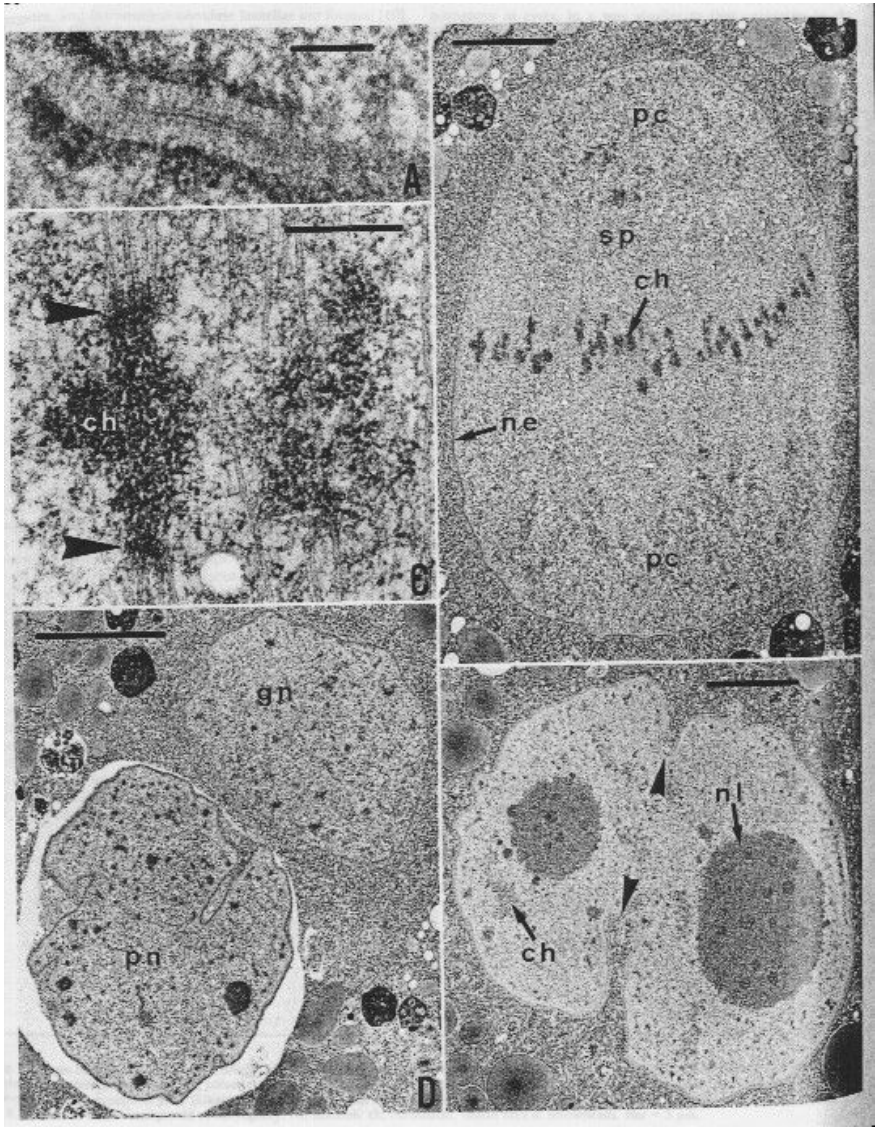


# amoebae are asexual?

- sarcodina?
- exceptions?

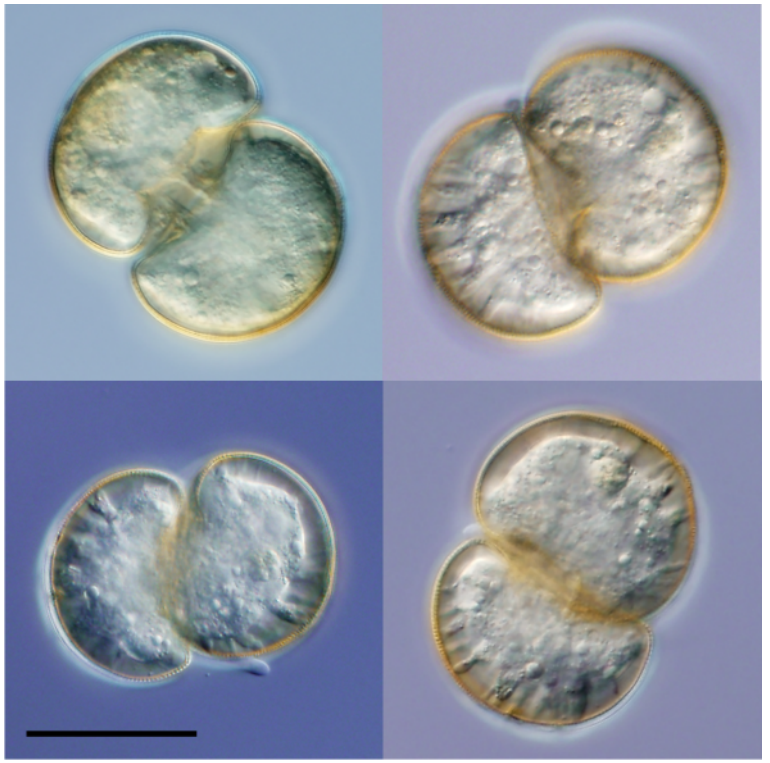
# amoebae are asexual?

- sarcodina?
- exceptions?
  - gamete fusion
  - synaptonemal cplx



# amoebae are asexual?

- sarcodina?
- exceptions?
  - gamete fusion
  - synaptonemal cplx
  - strange things



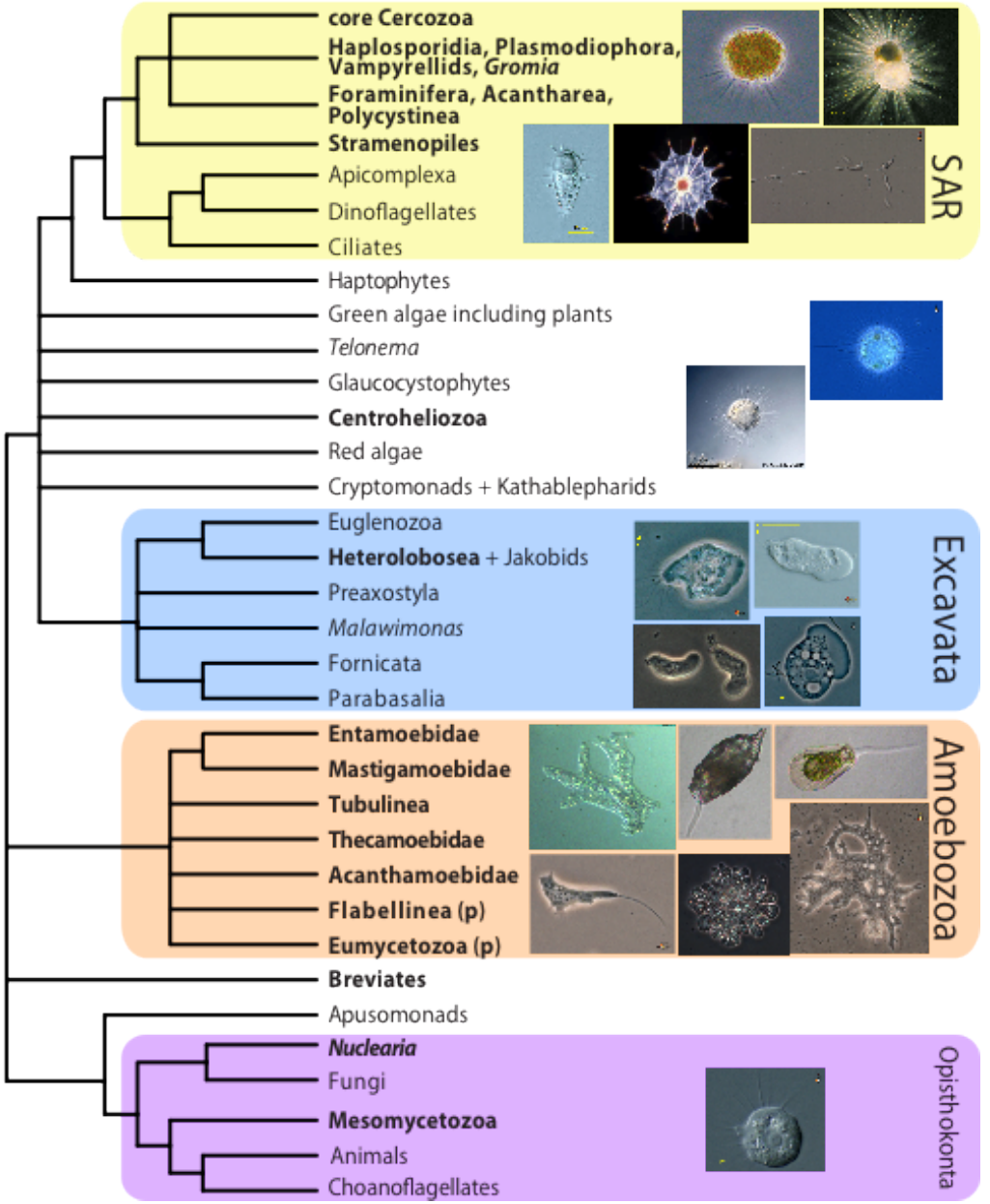
# amoebae are asexual?

- phylogeny

PROCEEDINGS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

**The chastity of amoebae: re-evaluating evidence for sex in amoeboid organisms**

Daniel J. G. Lahr, Laura Wegener Parfrey, Edward A. D. Mitchell, Laura A. Katz and Enrique Lara



# amoebae are asexual?

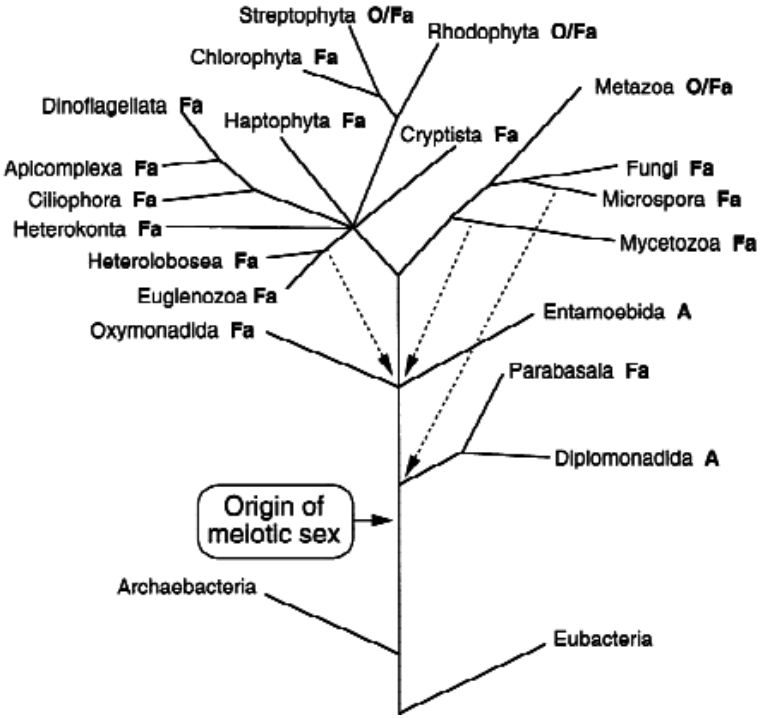
- phylogeny
- sexual eukaryotic ancestor

**The First Sexual Lineage and the Relevance of Facultative Sex**

**Joel Dacks, Andrew J. Roger**

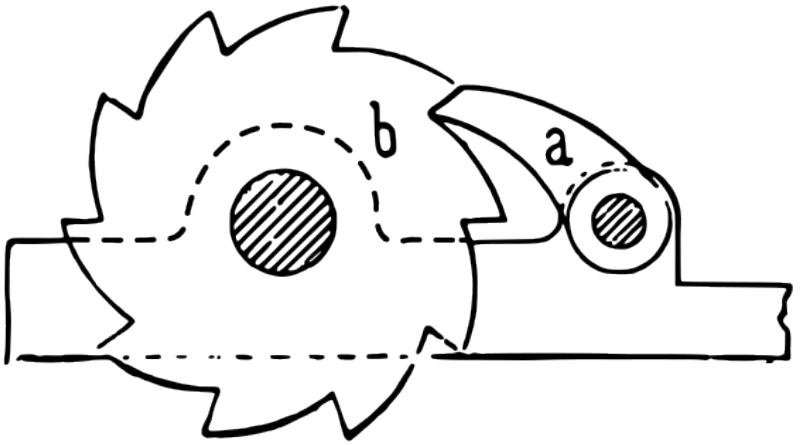
JOURNAL OF MOLECULAR EVOLUTION



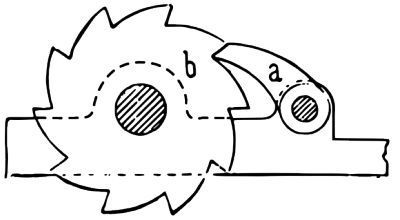


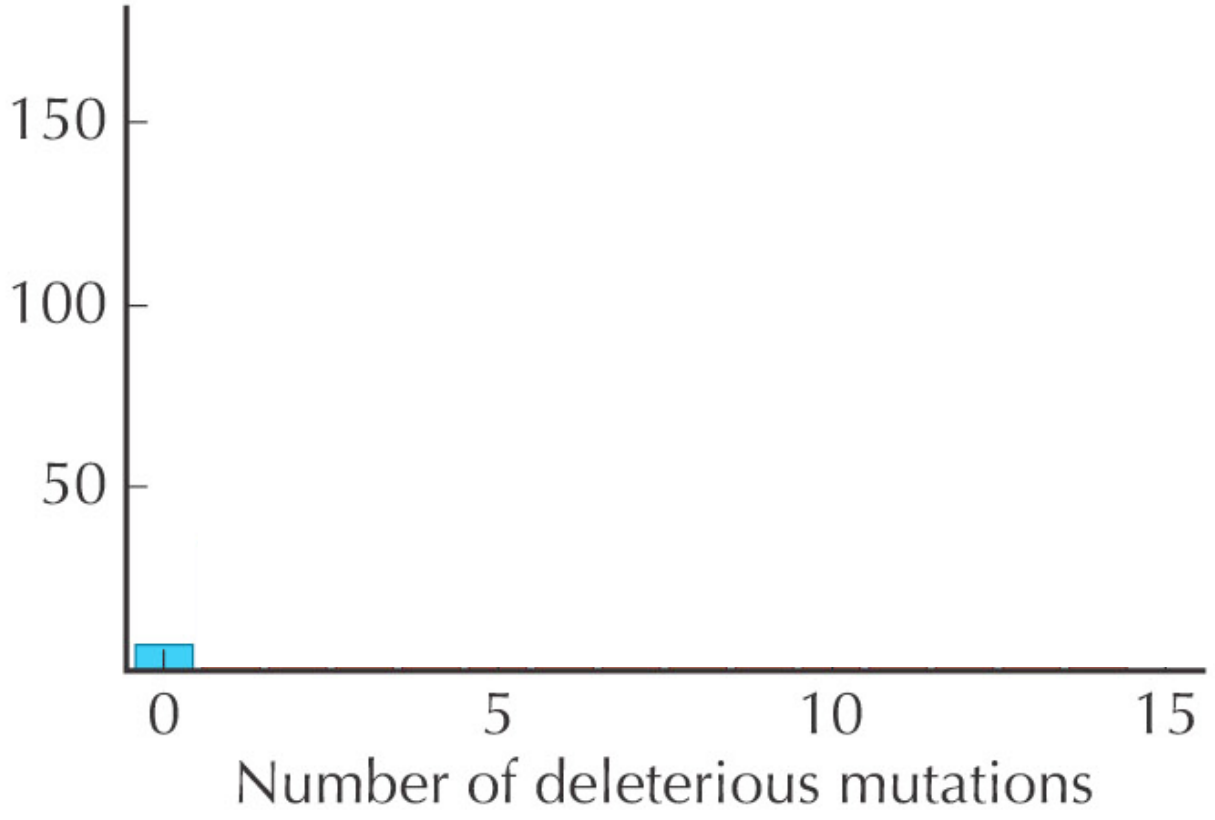
# amoebae are asexual?

- phylogeny
- sexual eukaryotic ancestor
- inviability of long-lived asexual lineages



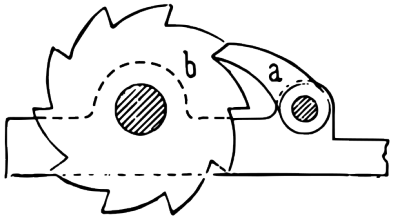
# Müller's ratchet

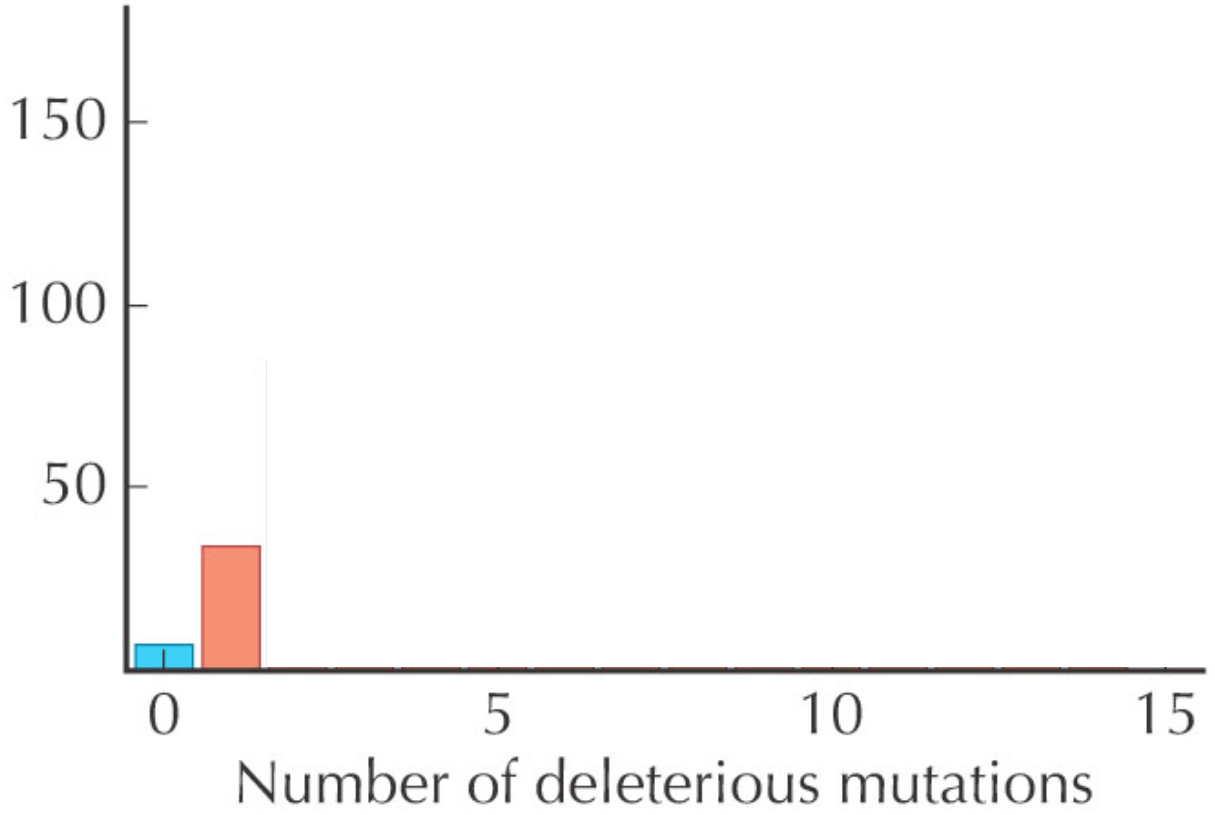



**t=0**

# Müller's ratchet

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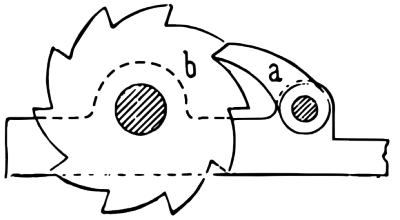
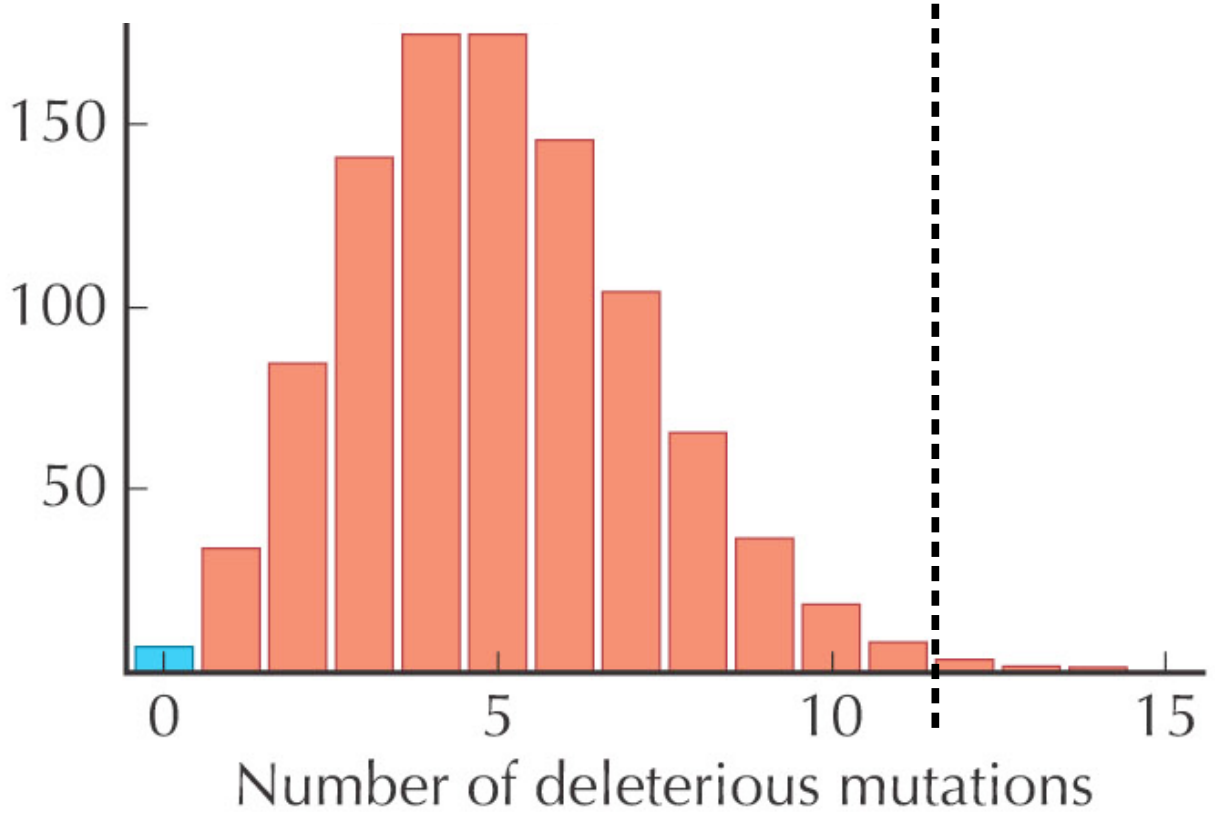
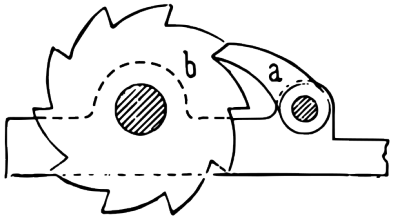
# Müller's ratchet

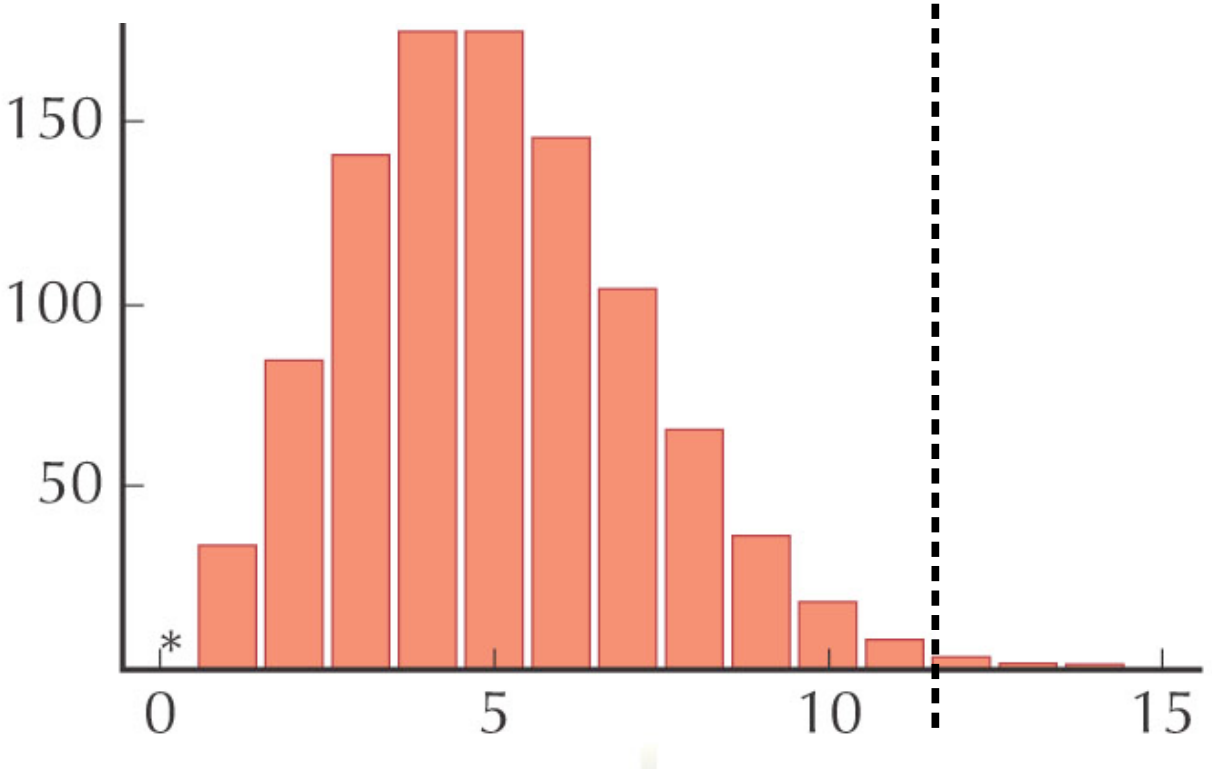



**t=0**

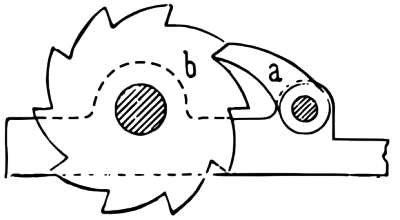
# Müller's ratchet

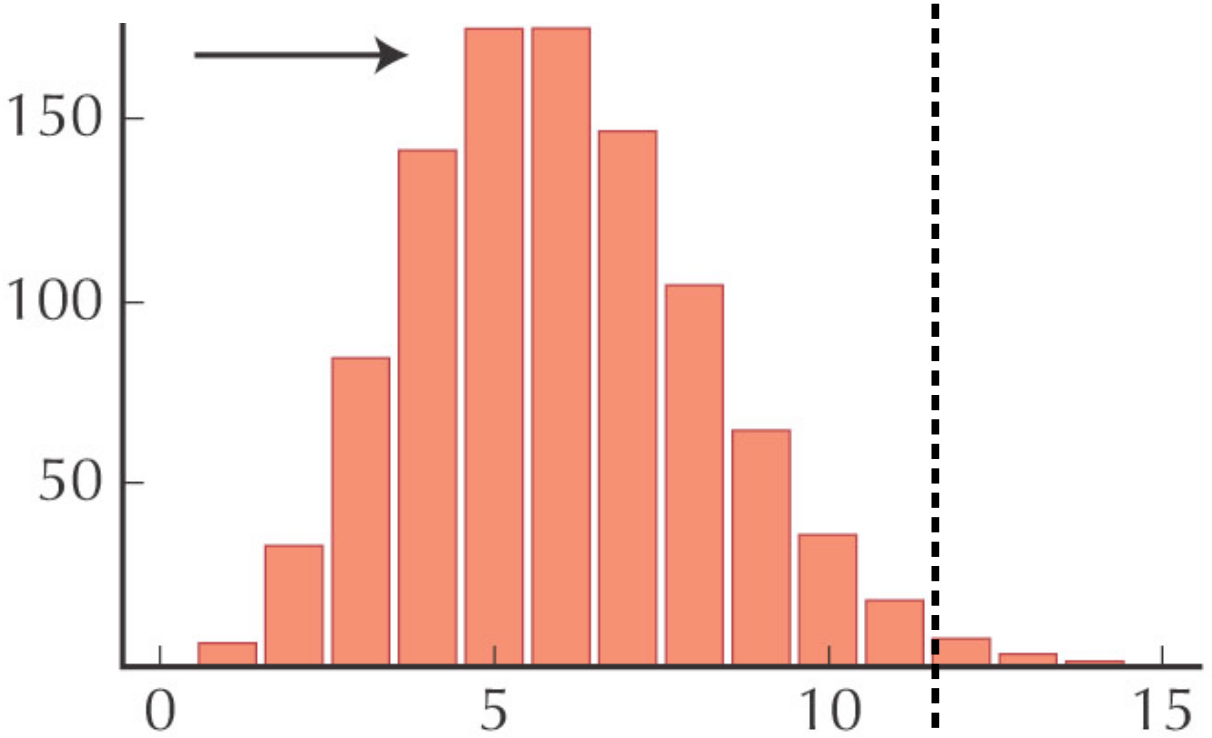



**t=1**

# Müller's ratchet




**t=2**

# Müller's ratchet

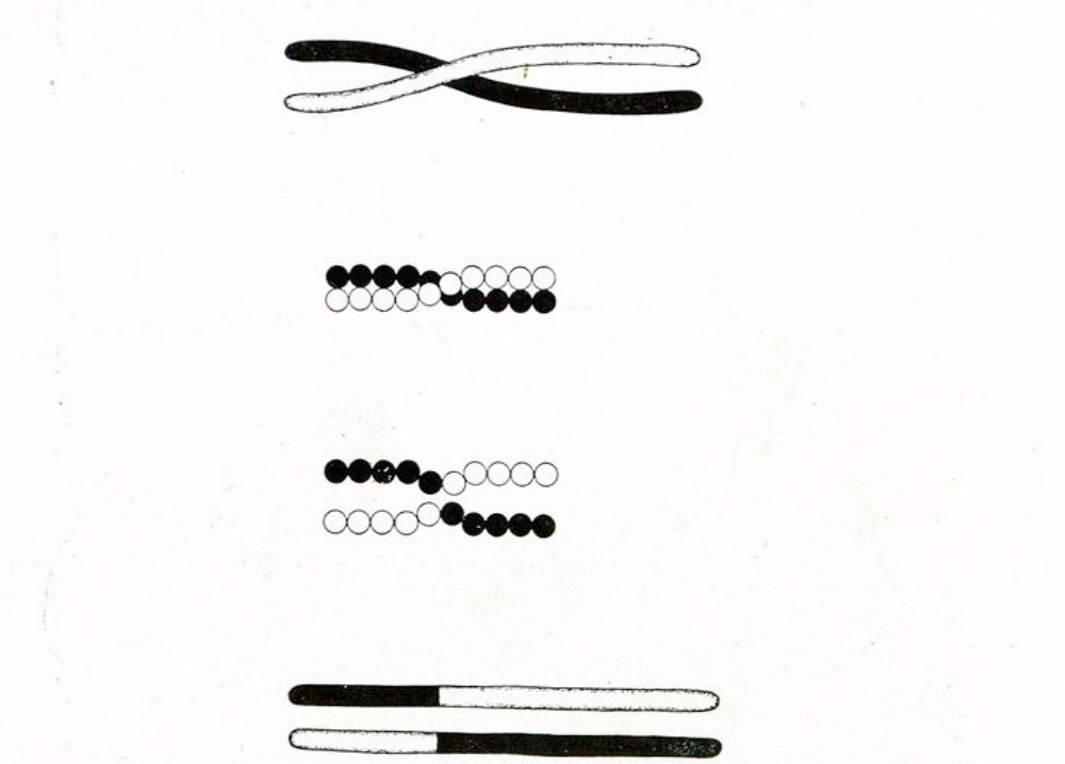
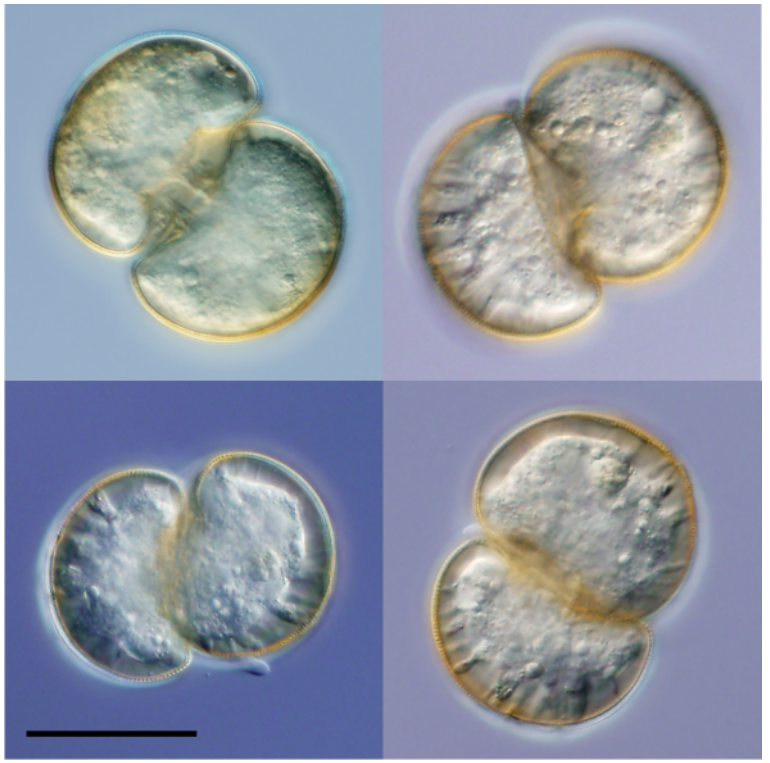


FIG. 64. Scheme to illustrate a method of crossing over of the chromosomes.

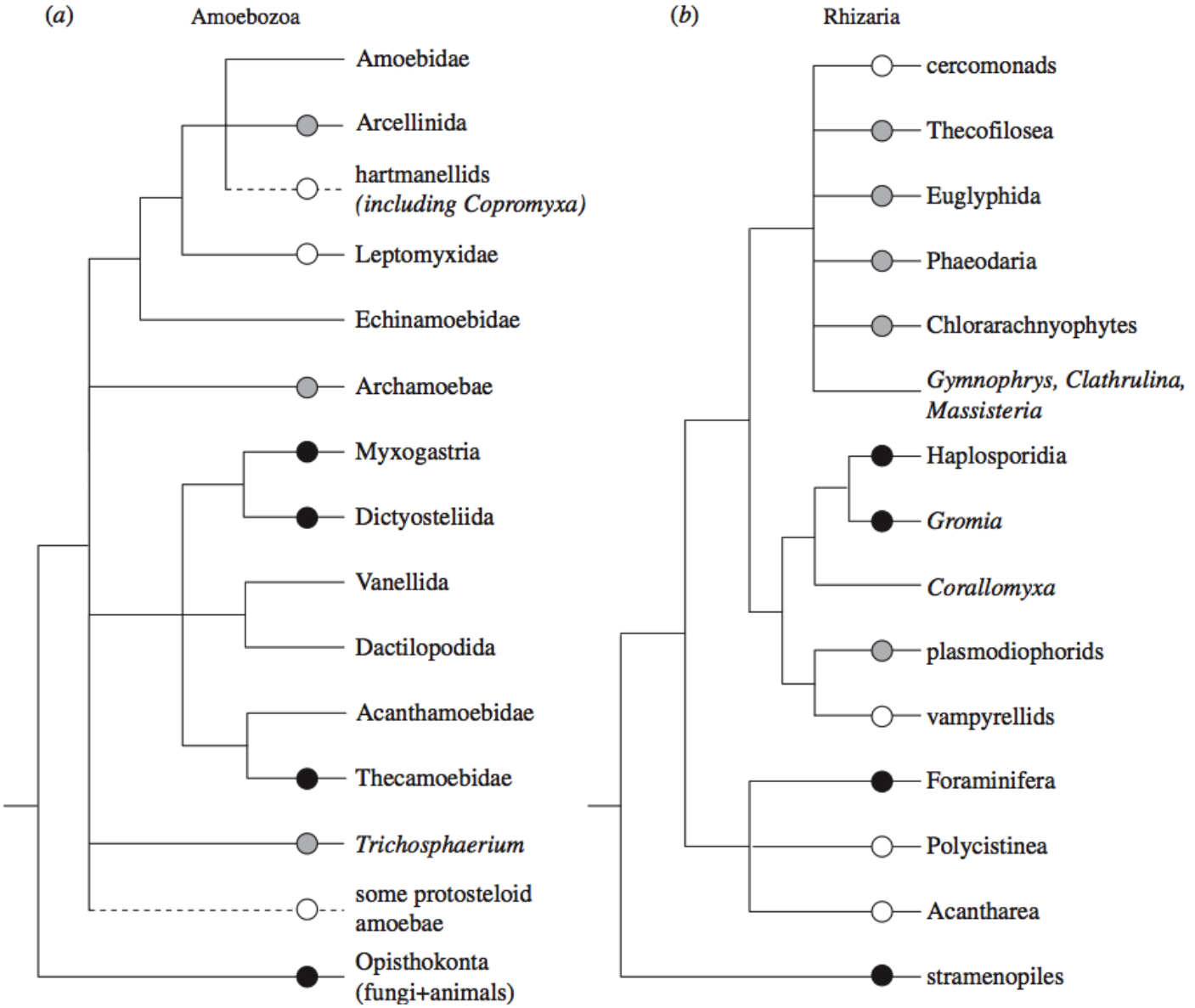
Recombination Morgan, 1916

# amoebae are asexual?

- sarcodina – no
- exceptions - no
  - gamete fusion
  - synaptonemal cplx
  - strange things
- ratchet
- eukaryotic phylogeny



# asexuality is inconsistent



# asexuality is inconsistent – or not!

- adequate cultures
- adequate observation
- gender?
- genetic determination?

> We do not solve them: we get over them. Old questions are solved by disappearing, evaporating, while new questions corresponding to the changed attitude of endeavor and preference take their place. (Dewey, 1910:19)

# summary 2

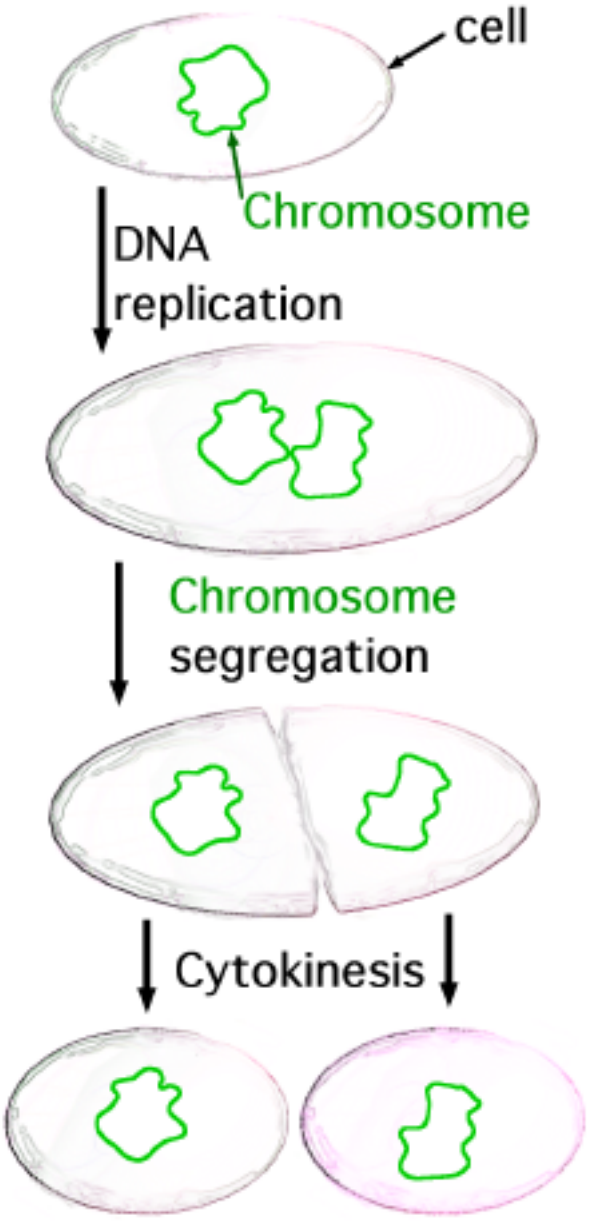
- theory of sex says amoebae should be sexual
- data says amoebae should be sexual
- there are a number of experimental issues

# outline

- modern phylogenetics of microbial eukaryotes
- chastity of amoebae
- protozoan immortality
  - the issue
  - the data
  - the future

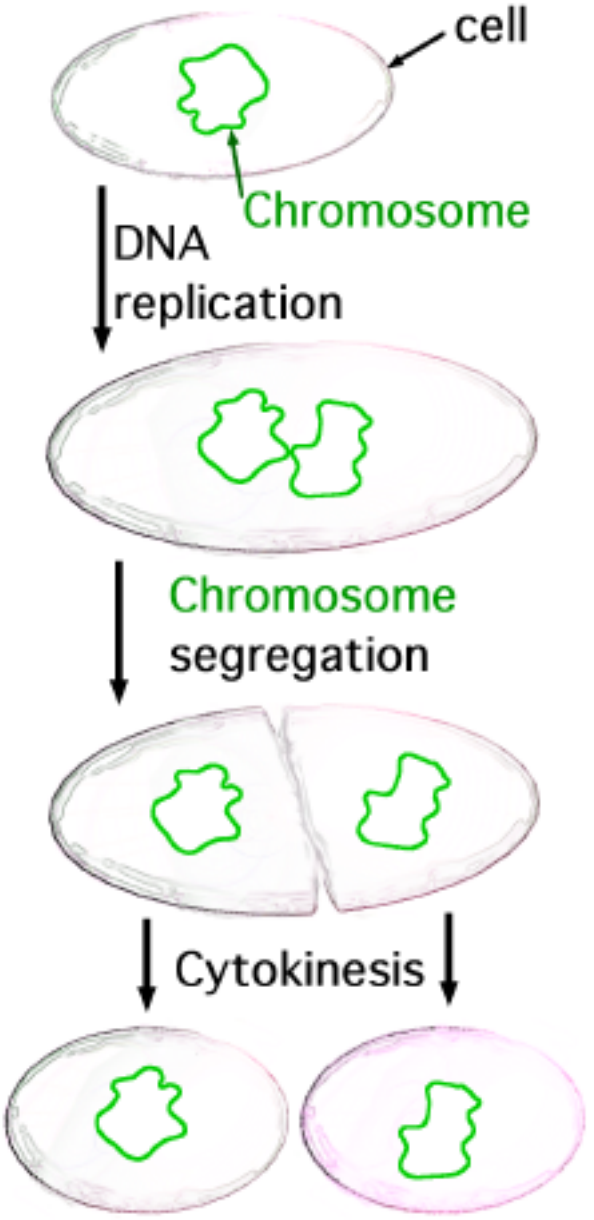
# immortality

- 1890 – 1920
- binary fission



# immortality

- 1890 – 1920
- binary fission
- senescence

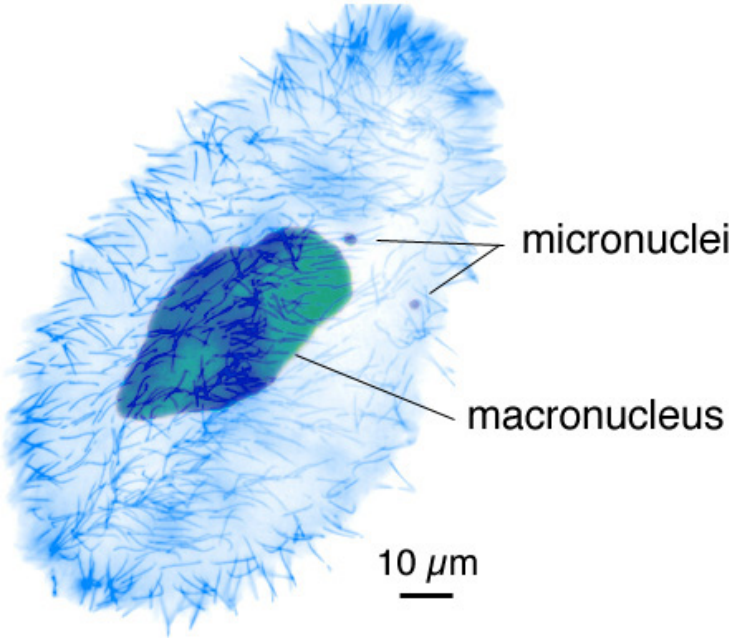



"One thing is certain, however: because amoebae reproduce by division, endlessly, passing everything on yet giving up nothing, the first amoeba that ever lived is still alive. Whether four billion years old or merely three hundred, he/she is with us today."

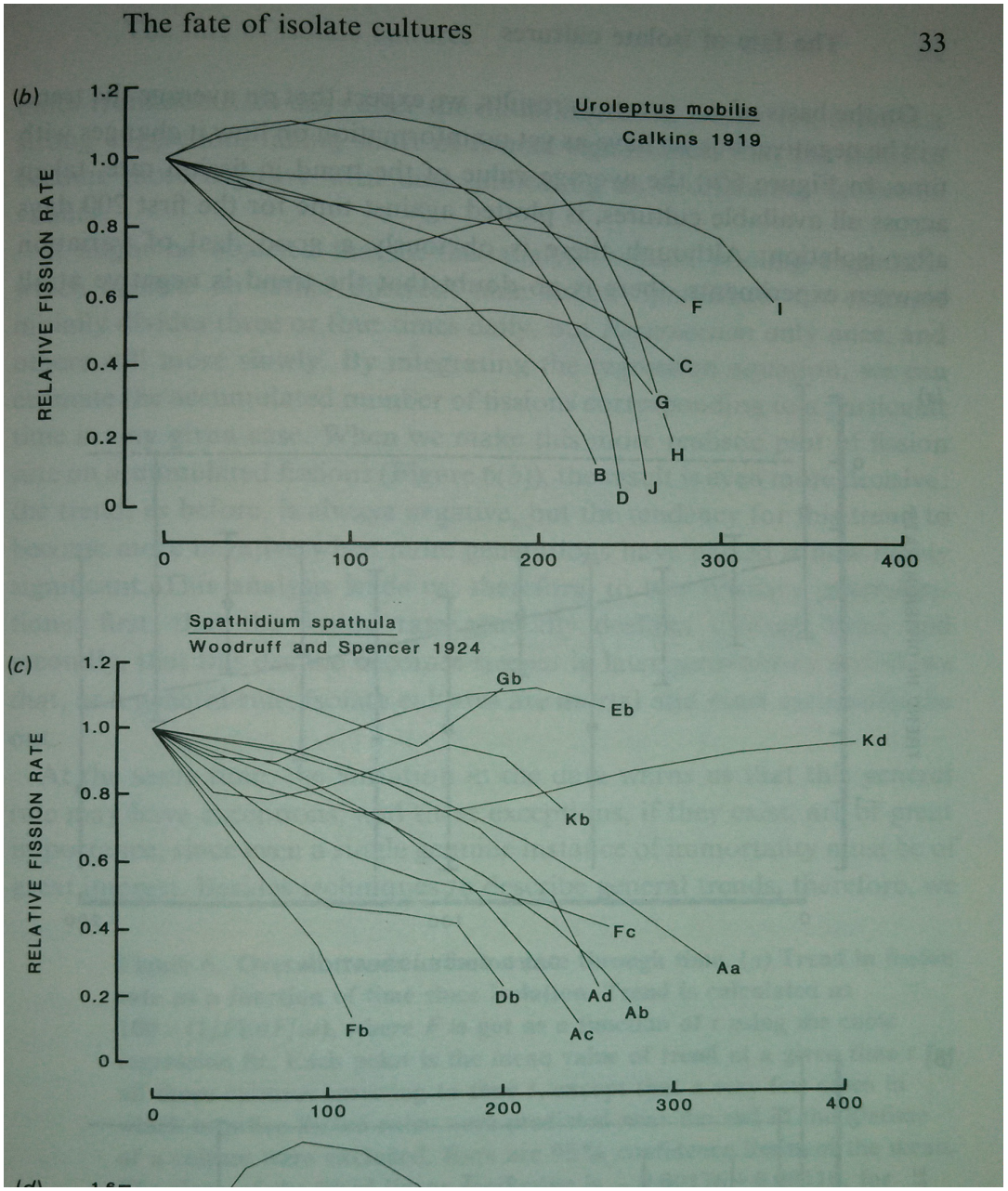
Tom Robbins, *Even Cowgirls get the Blues.*

# clonal lines

- culture lineages of mostly ciliates
  - cilia
  - nuclear dualism

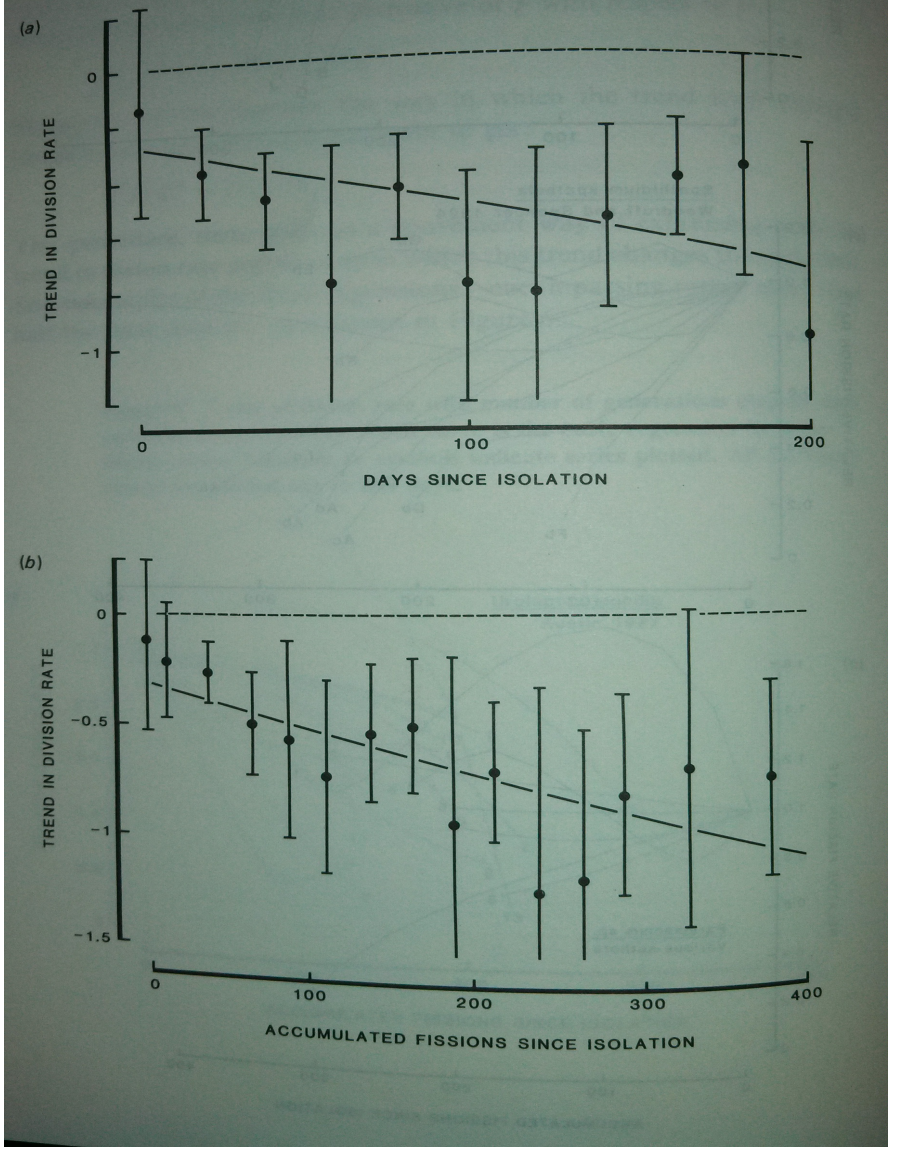


# fate of clonal lines

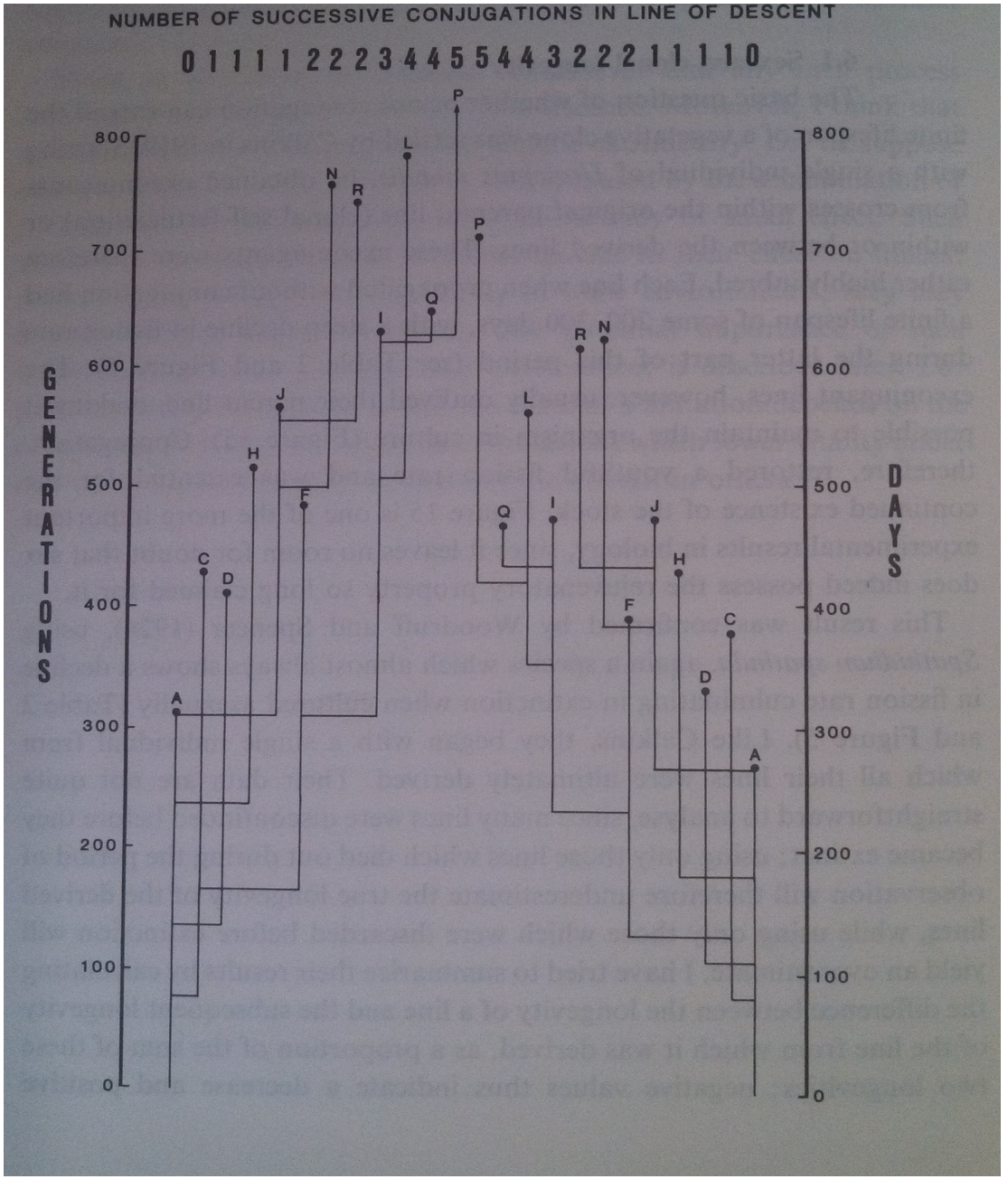


# fate of clonal lines

time. In Figure 6(*a*) the [illegible] across all available cultures, is plotted against time for the first 200 days after isolation. Although there is obviously a good deal of variation between experiments, there is no doubt that the trend is negative at all



# fate of clonal lines



# experimental issues

- “slides were wiped with a very clean cloth”
- “dead lineages were substituted for siblings”

ECOLOGY

VOL. 18 APRIL, 1937 NO. 2

EXPERIMENTAL POPULATIONS OF MICROSCOPIC ORGANISMS

G. F. GAUSE

*Zoölogical Institute, University of Moscow*

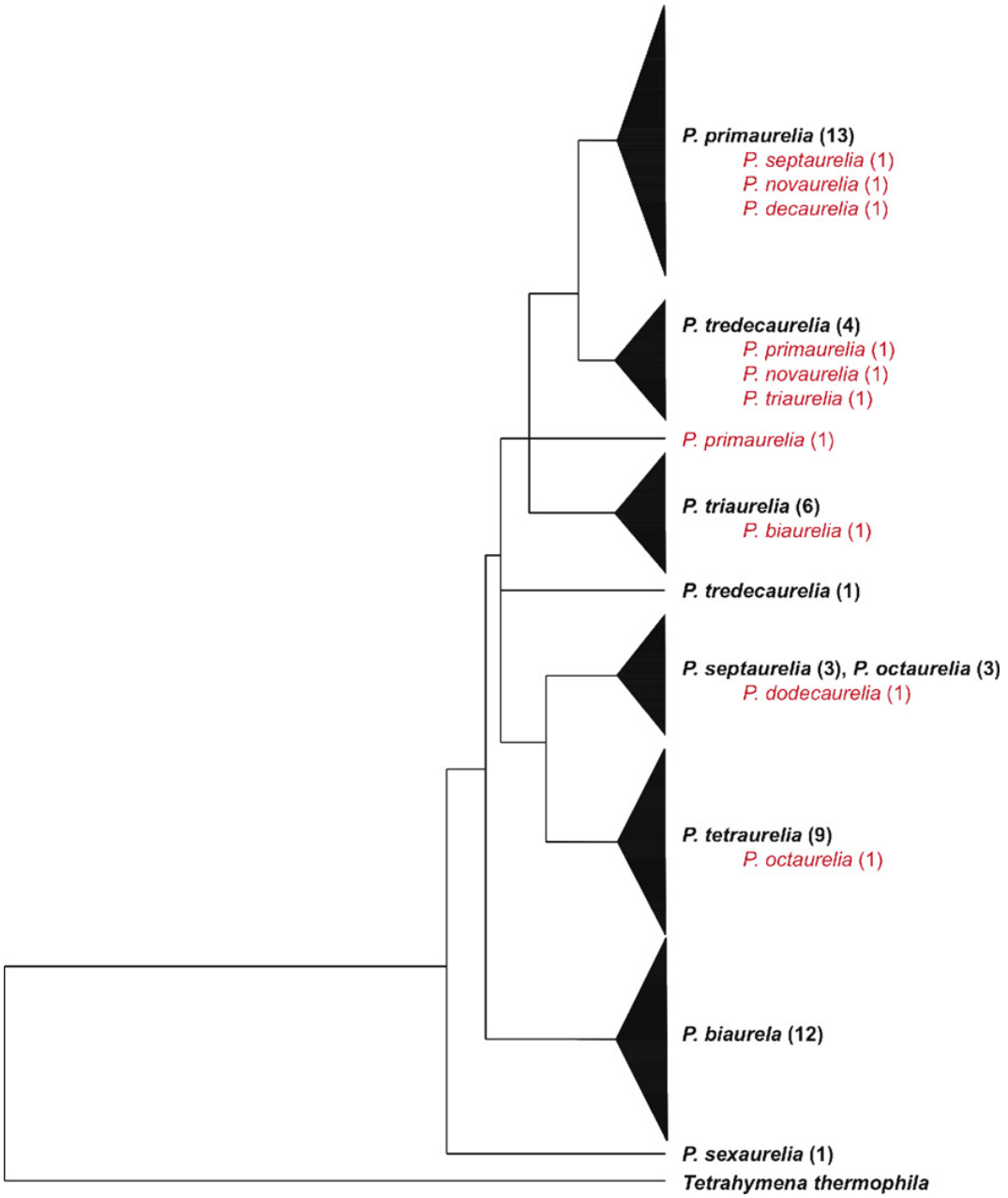
I

THE INFLUENCE OF BIOLOGICALLY CONDITIONED MEDIA ON THE GROWTH OF A MIXED POPULATION OF *PARAMECIUM CAUDATUM* AND *P. AURELIA*

BY G. F. GAUSE, O. K. NASTUKOVA AND W. W. ALPATOV.

(*Zoological Institute, Moscow University.*)

# experimental issues



# experimental issues

## Endosymbionts in *Paramecium*

Masahiro Fujishima[a], , , Yuuki Kodama[b]

Show more

http://dx.doi.org/10.1016/j.ejop.2011.10.002

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Abstract

*Paramecium* species are extremely valuable organisms to enable experiments for the reestablishment of endosymbiosis. This is investigated in two different systems, the first with *Paramecium caudatum* and the endonuclear symbiotic bacterium *Holospora* species. Although most endosymbiotic bacteria cannot grow outside the host cell as a result of their reduced genome size, *Holospora* species can maintain their infectivity for a limited time. We found that an 89-kDa periplasmic protein has an important function for

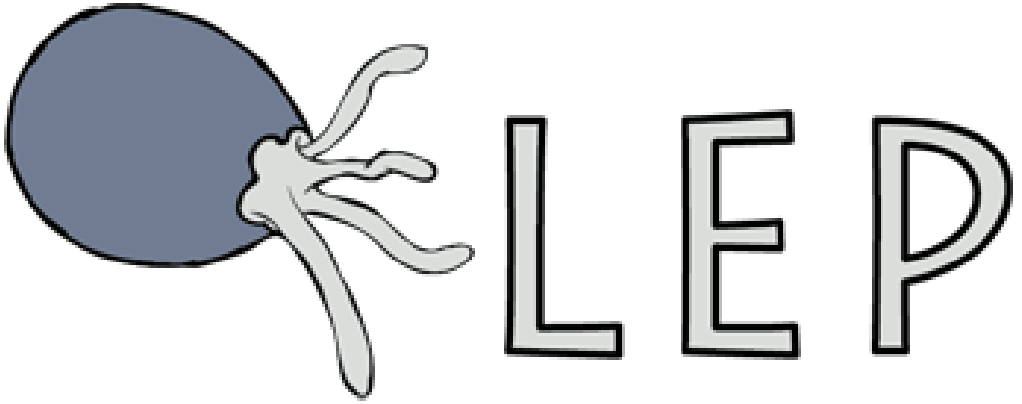
# summary 3

- microbes get old!
- sex rejuvenates
- although great tools, much is unknown about biology to make claims based on model microbes

# conclusions

- five Kingdoms is nonsense
- eukaryotes including amoebae are sexual
- the first amoeba that ever lived is not still with us today

# Laboratório de Evolução em Protistas

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