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# A life started $10^9$ years ago: Introduction to Ciliates

(based on microbiological review, June 1994, p.233-267 by D.Prescott)

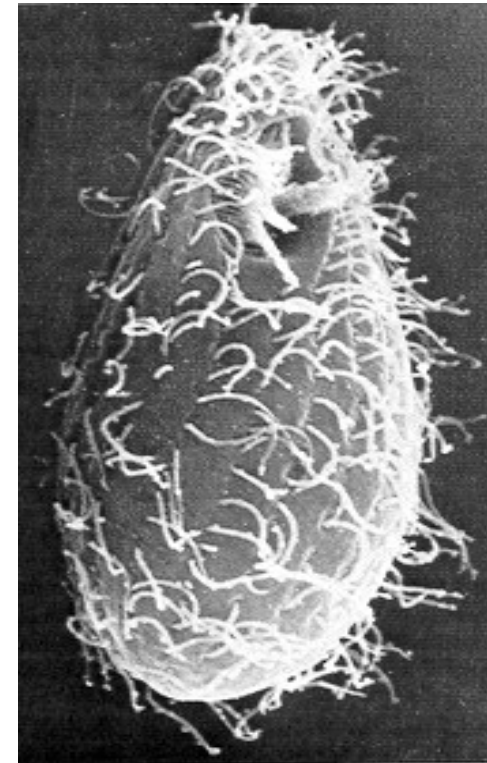
Chang Li

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## Ciliates on pictures



Paramecium



Tetrahymena



Stylonychia



Euplotes

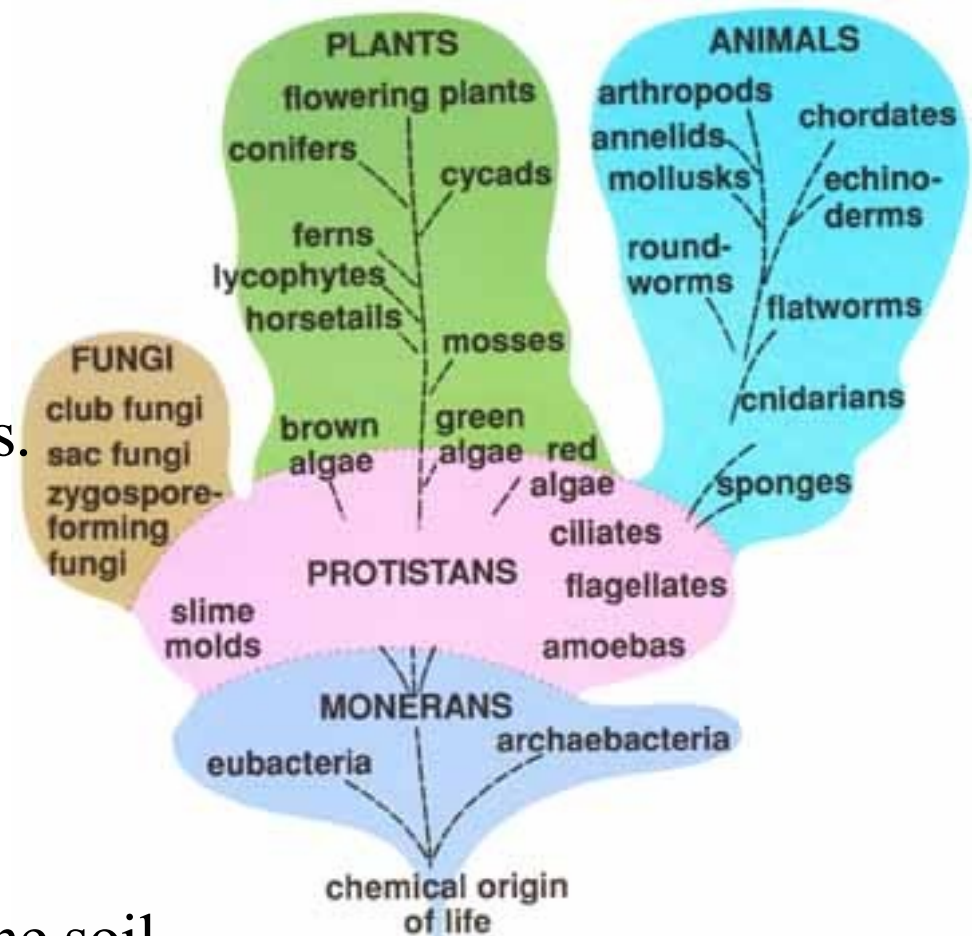


Oxytricha

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## Ciliates: a large group of protozoa (in protist)

- About 10,500 species known species.  
(a few have been studied)
- Great genetic diversity.
- Phagocytic food capture (eat ...).
- Live in aqueous environments and the soil.

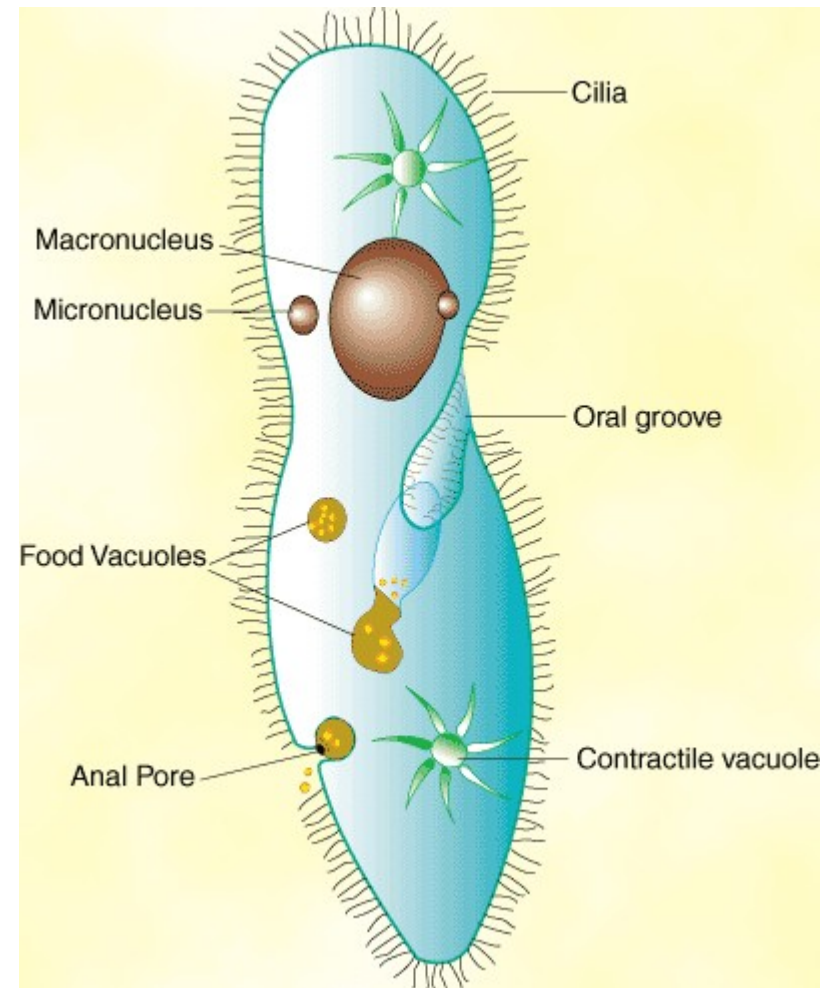


*Modified version of Whittaker's five-kingdom system of classification.*

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## Ciliates: general properties

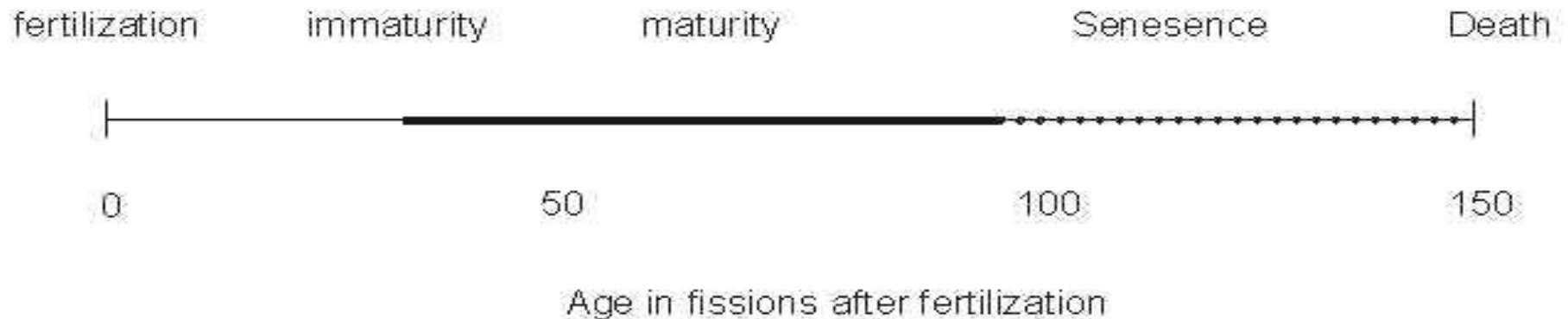
- Most complex single-cell organism  
(a diverse array of structures and organelles that perform a range of activities)
- Two features in common:
  1. Possession of cilia
  2. Presence of nuclear duality



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## Ciliates: life cycle and life story

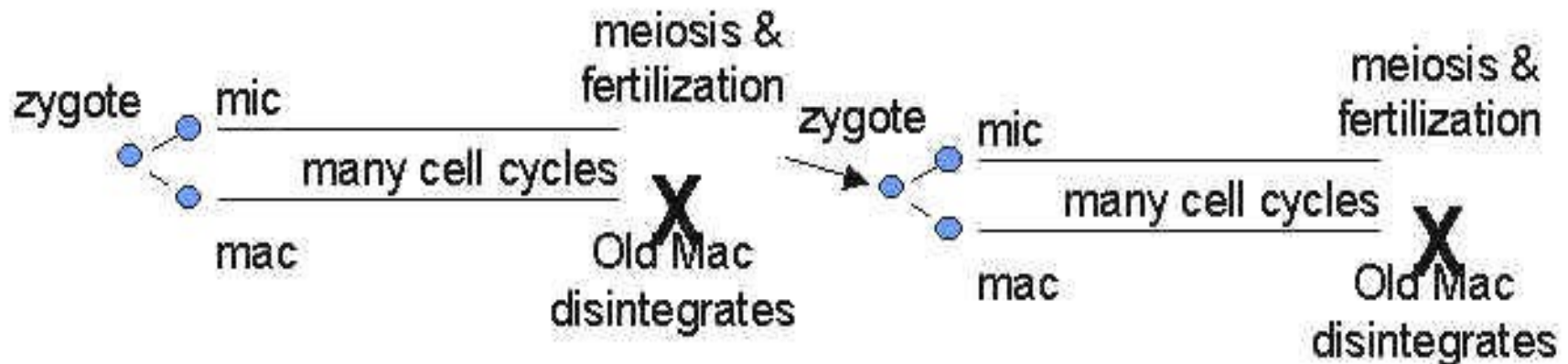
- An initial period of sexual immaturity.
- A period of sexual maturity during which mating offers readily.
- As cells age they start to become senescent and mating offers less readily and survival or progeny is poorer.
- Finally the clone dies out.



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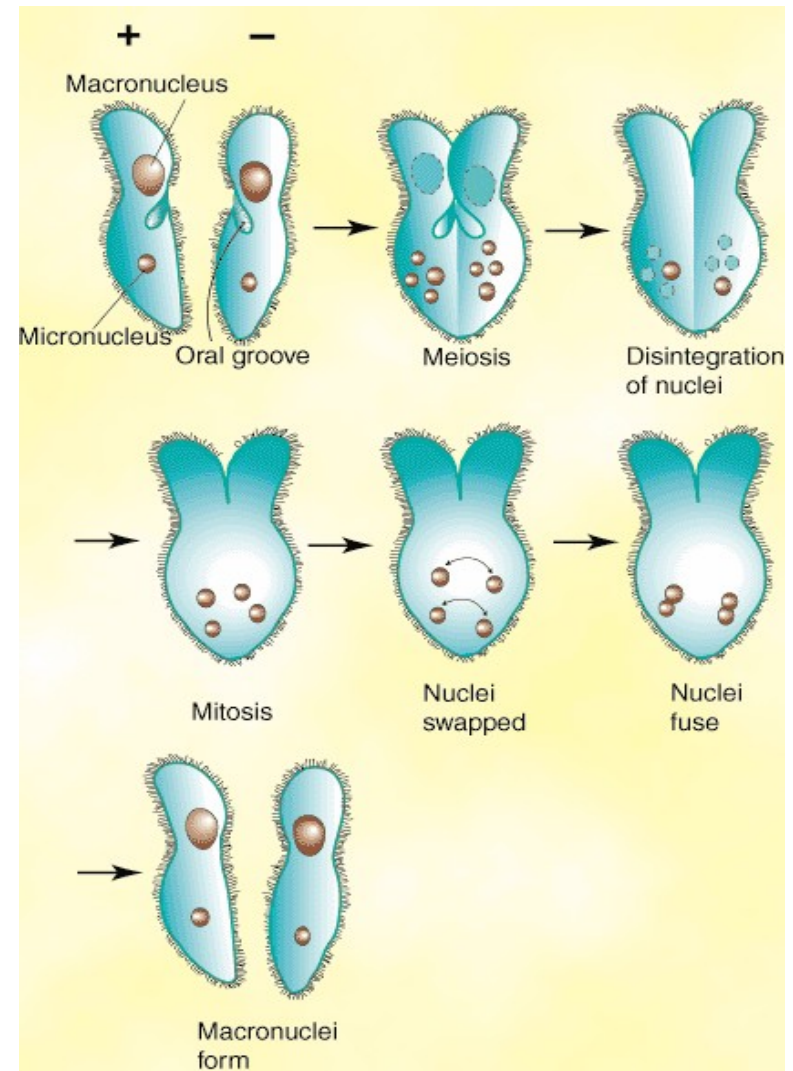
## Ciliates: life cycle and life story

- Micronucleus is **germ** line and provides continuity across sexual generations.
- Macronucleus is a **somatic** nucleus (that is, it is not involved in transmission of hereditary information across sexual generations).
- Macronucleus is formed at the beginning of a sexual generation and it is destroyed during conjugation prior to the start of a new sexual generation.



# Ciliates: Conjugation

- (1) Two cells form a pairing.
- (2) Pair cells undergo meiosis, generating 4 haploid nuclei in each.
- (3) Three of these pronuclei disintegrate, while the macronucleus also disintegrates.
- (4) The remaining nucleus divides to two gametic nuclei: a "migratory" pronucleus and a "stationary" pronucleus.
- (4) The migratory pronuclei are exchanged between the two cells; then fuse with a stationary pronucleus to form a zygotic nucleus in each cell.





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## Ciliates: Anlage (after conjugation)

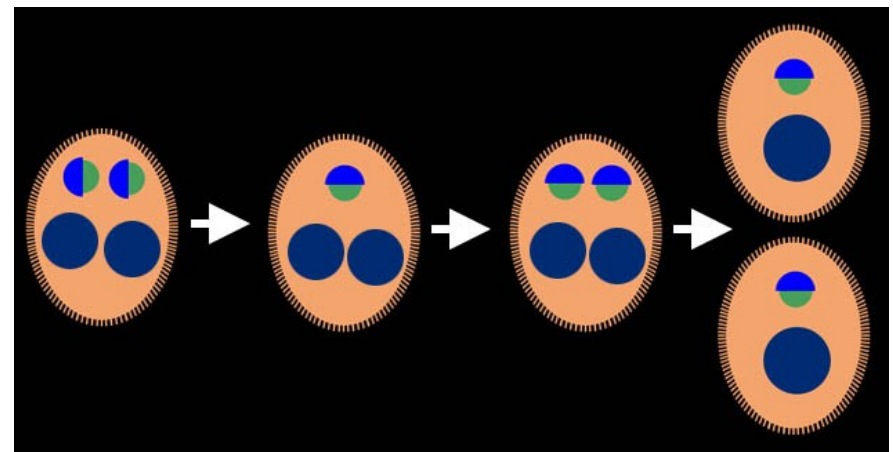
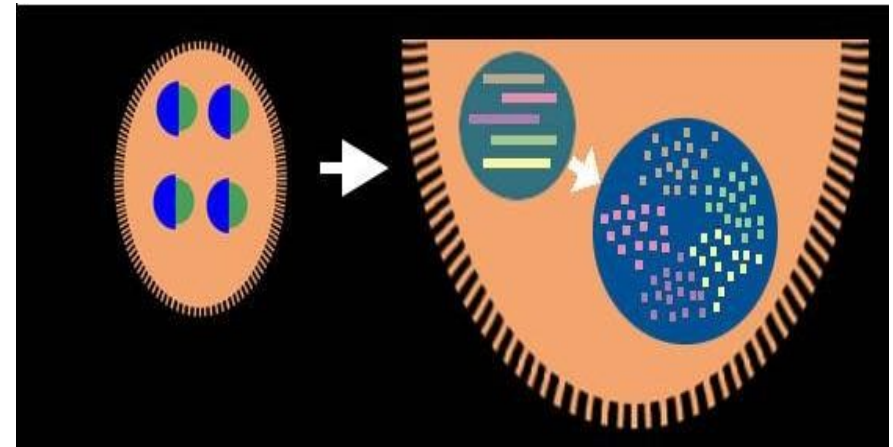
**Anlage:** zygotic nucleus → new macronucleus.

(5) The zygotic nucleus divides twice to form four identical nuclei.

(6) Two of the four zygotic clones develop into "anlagen" (immature macronuclei).

(7) One of the two remaining zygotic clones is degraded; the other, the new micronucleus, divides mitotically.

(8) The daughter cells each receive one micronucleus and one macronucleus in this division, yielding the normal complement of nuclei.



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## Multi-micronuclei and macronuclei

- Tetrahymena: 1 micronucleus and 1 macronucleus
  - Paramecium:  $\geq 2$  micronuclei and 1 macronucleus
  - Oxytricha: 2-4 micronuclei and 2 macronucleus
  - Stylonychia: 2 micronuclei and 2 macronucleus
  - Euplotes: 1 micronucleus and 1 (elongated) macronucleus
- Urostyla grandis: 5-20 micronuclei and hundreds of macronuclei (about same size of micronuclei)

- Multiple micronuclei in a single organism are all genetically identical (derived by mitosis).
- Multiple macronuclei derived by fusion and amitosis.
- Amitosis distributes DNA unequally to daughter macronuclei.

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## Micronucleated and Amicronucleated ciliates

- Paramecium: only the macronuclear alleles govern the cell phenotype (observable characteristic).
- Tetrahymena: no genes in the micronucleus that influence the phenotype.
- Removal of micronucleus from ciliates results immediately in a lower reproductive rate or renders a cell incapable of vegetative growth with consequence of death.

But...

- Amicronucleated ciliates are often encountered in wild.  
e.g. Tetrahymena, Stylonychia, Oxytricha, Paraurostyla
- Amicronucleated ciliates that are created in labs sometimes survive and proliferate in a normal rate.

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## Explanation...

- Micronucleus does make a contribution.  
(perhaps express a few micronucleus-specific key genes)
- Micronucleus-specific sequences are absent from macronucleus and are essential for vegetative growth.
- In amiconucleated ciliates, a few micronucleus-specific sequence are anomalously present in the macronucleus.  
(this could happen during the development of the macronucleus)

## Evolution point of view...

The normal retention in micronucleus, by making the micronucleus essential, eliminate from a population organism that had lost the capability of sexual reproduction

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Questions ?

Next topic:

*Book of the life:  
DNAs on micronucleus & macronucleus*