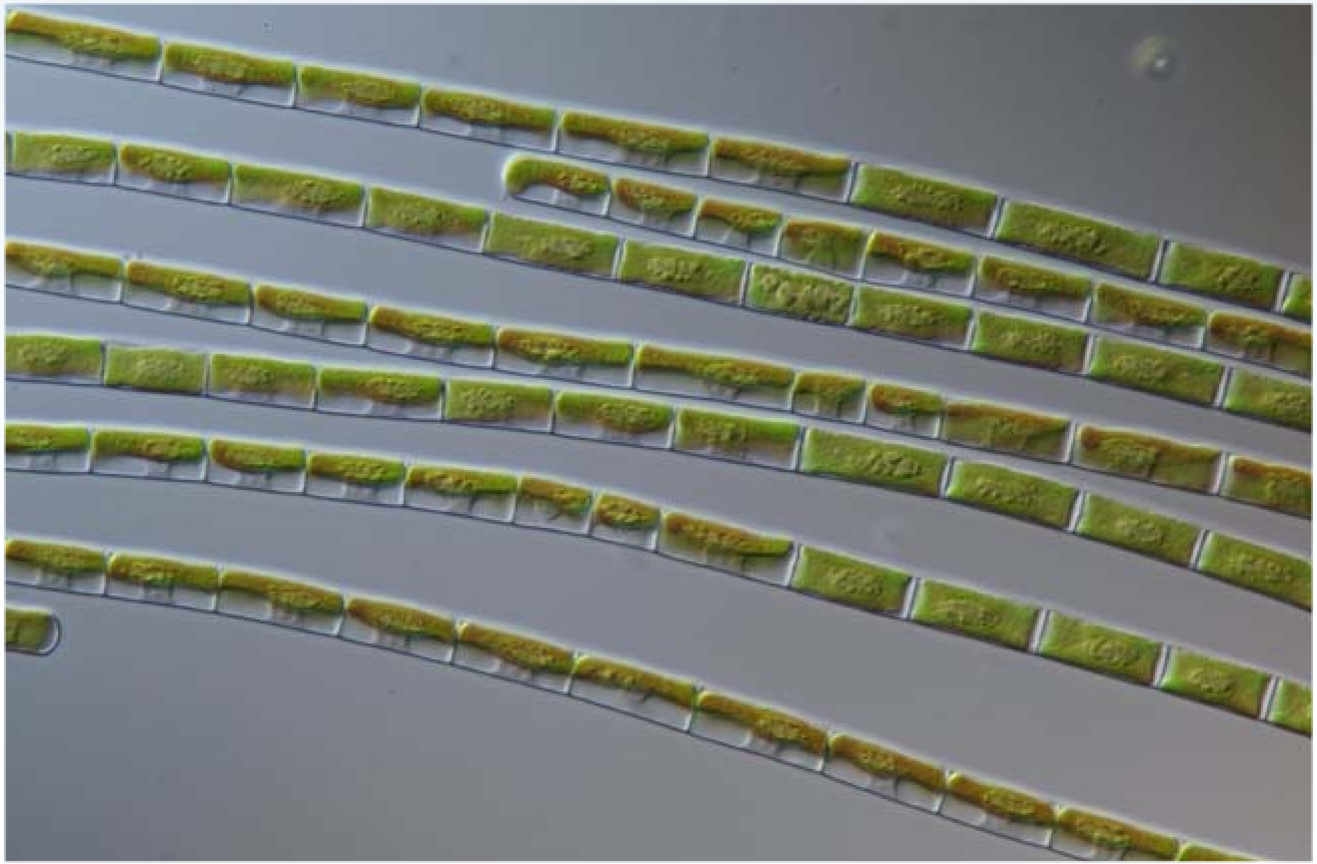
More species than expected?

Ecological differentiation of cryptic species within an asexual protist morphospecies

***Pavel Škaloud*[1] & Fabio Rindi[2]**



[1] *Charles University in Prague, Department of Botany, Prague, Czech Republic*
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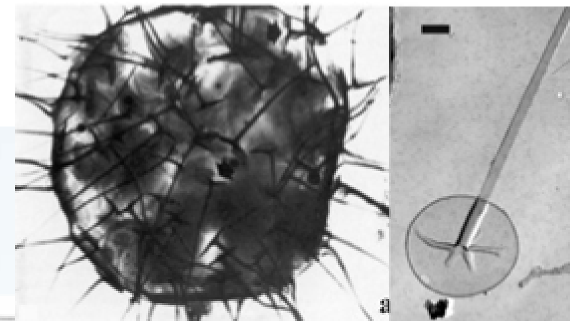
Is everything everywhere?

ENVIRONMENTAL MICROBIOLOGY

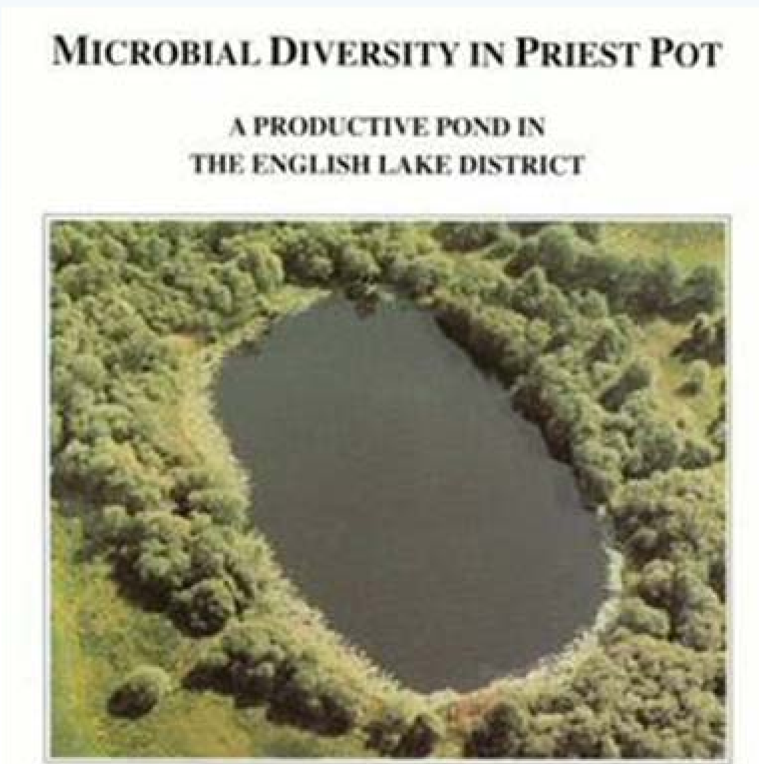
VIEWPOINT

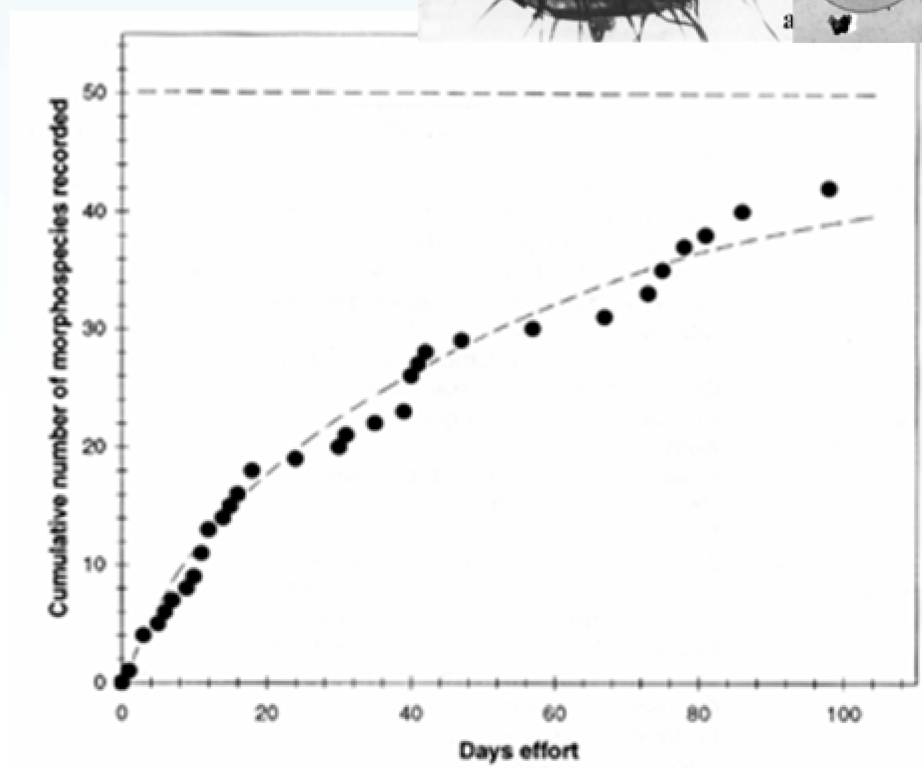
Global Dispersal of Free-Living Microbial Eukaryote Species

Bland J. Finlay



Finlay & Clarke (1999); Finlay (2002)

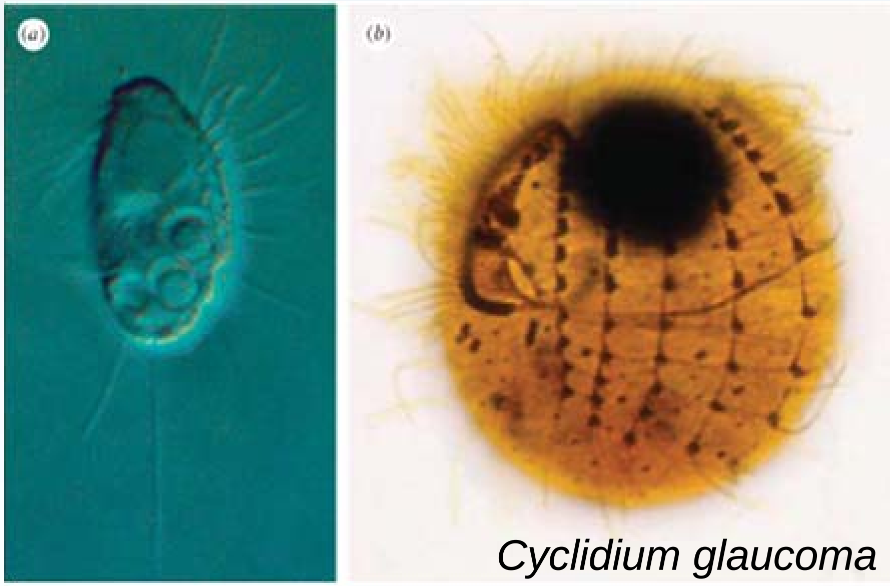




The diversity of microbes: resurgence of the phenotype

Tom Fenchel and Bland J Finlay

Phil. Trans. R. Soc. B 2006 **361**, 1965-1973
doi: 10.1098/rstb.2006.1924



Cyclidium glaucoma

- genetic variation in molecular markers reflects rather the accumulation of neutral mutations over historical time than the existence of morphologically indiscernible, cryptic species.
- the <u>phenotype</u> as the only proper feature to define real species of protists

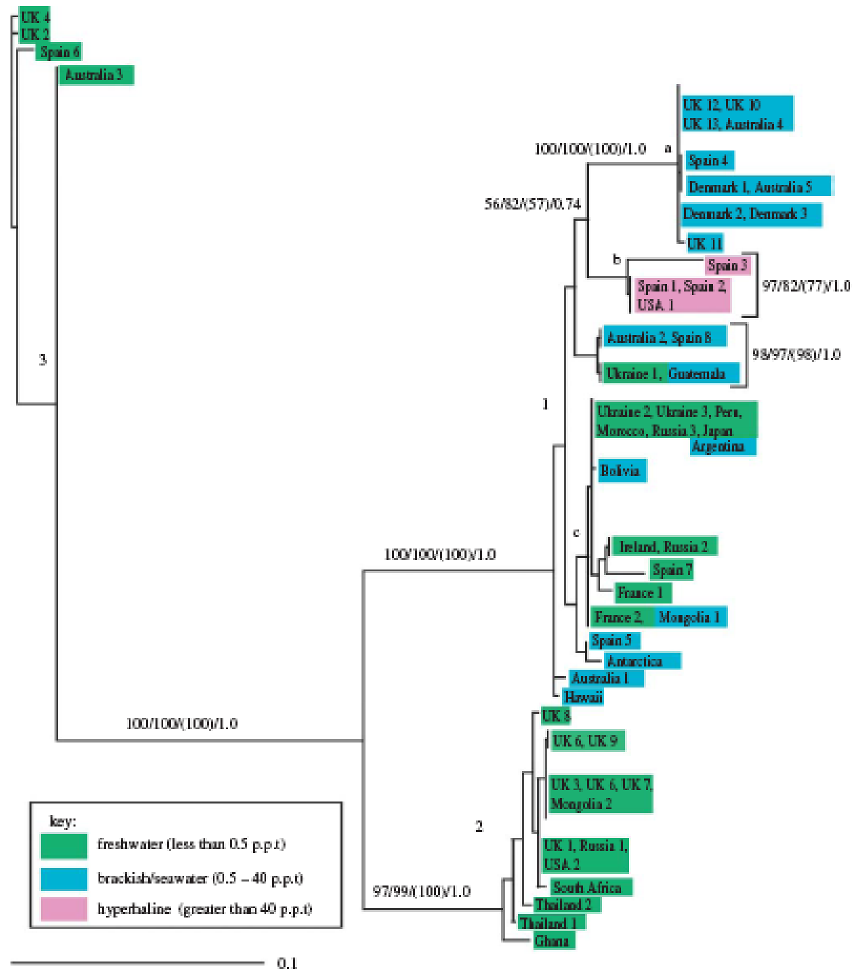


Figure 3. Unrooted maximum-likelihood tree of nuclear ribosomal sequences of *Cyclidium glaucoma* (partial SSU rDNA and partial LSU rDNA). Scale bar measures substitutions per site. Support values from left to right: maximum-likelihood bootstrap/neighbour-joining bootstrap/maximum parsimony with reduced taxon sampling/posterior probabilities (data from Finlay *et al.* (in press)).

Aims of the study

• Does the genetic diversity within protist morphospecies reflect an accumulation of neutral mutations?

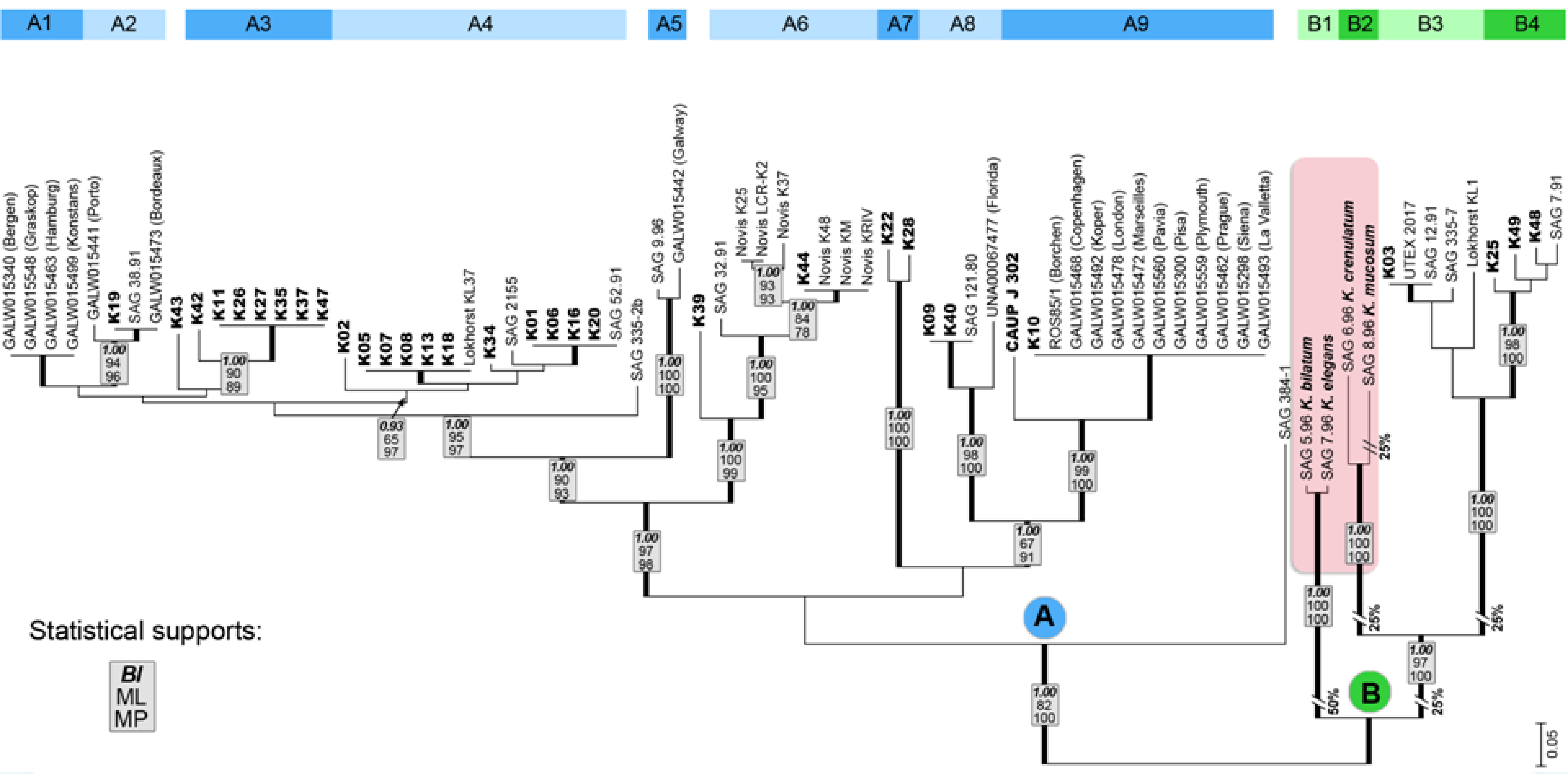
Klebsormidium flaccidum – cosmopolitan, broadly distributed, asexual

• Maping the morphological properties on the phylogeny of *K. flaccidum*

➢ 62 strains isolated from a variety of aero-terrestrial and aquatic habitats
➢ Genetic data: ITS rDNA & rbcL sequences
➢ Morphological data: width, growth habit, presence of a superficial layer of filaments, shape of release apertures in sporangia, zoospore germination, cell wall remnants

Bayesian phylogeny (ITS rDNA + *rbc*L)

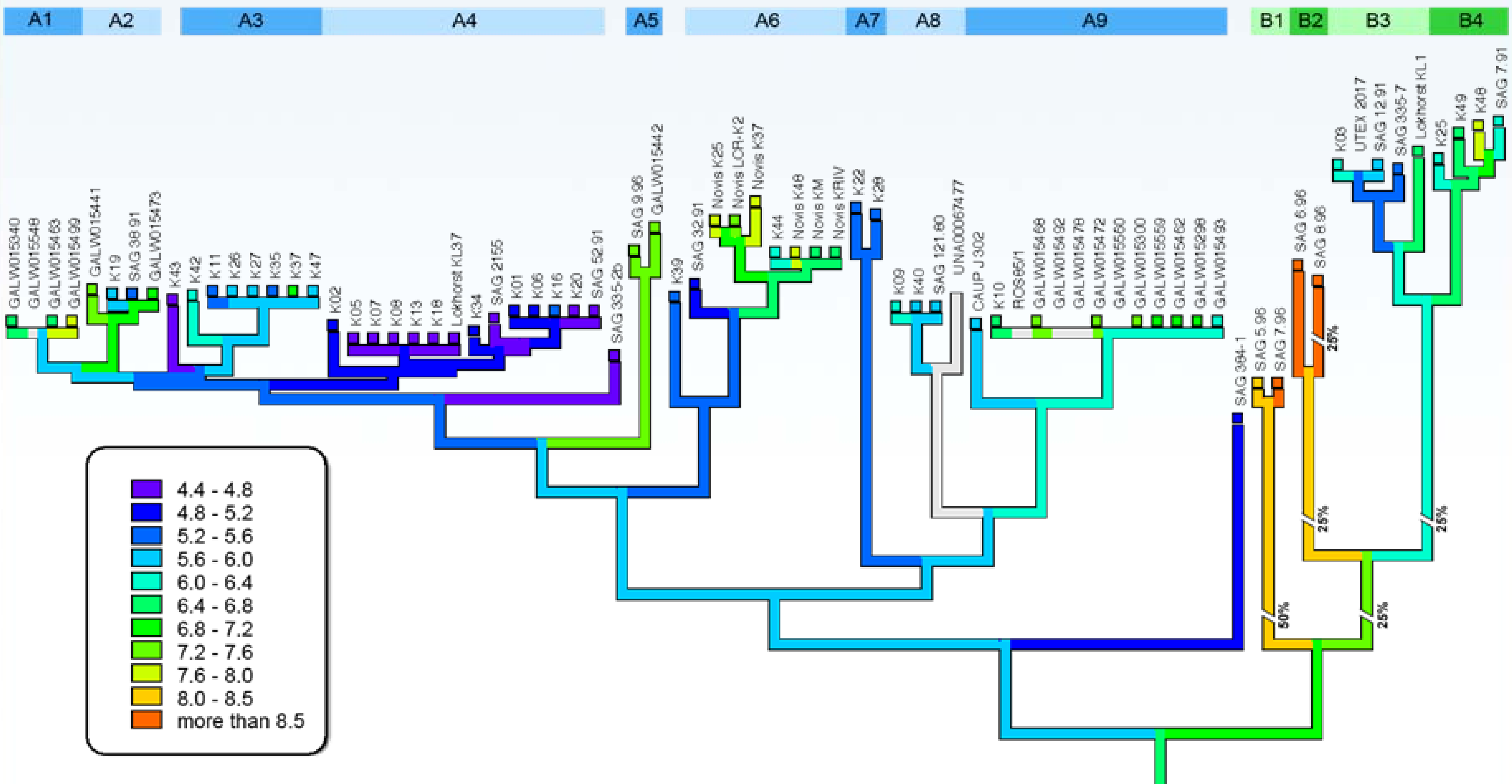
- Two main clades resolved: A B
- 11 well-resolved lineages within *K. flaccidum* morphospecies
- Four morphologically different *Klebsormidium* species nested within *K. flaccidum*



Ancestral state reconstructions (MP)

Average cell width

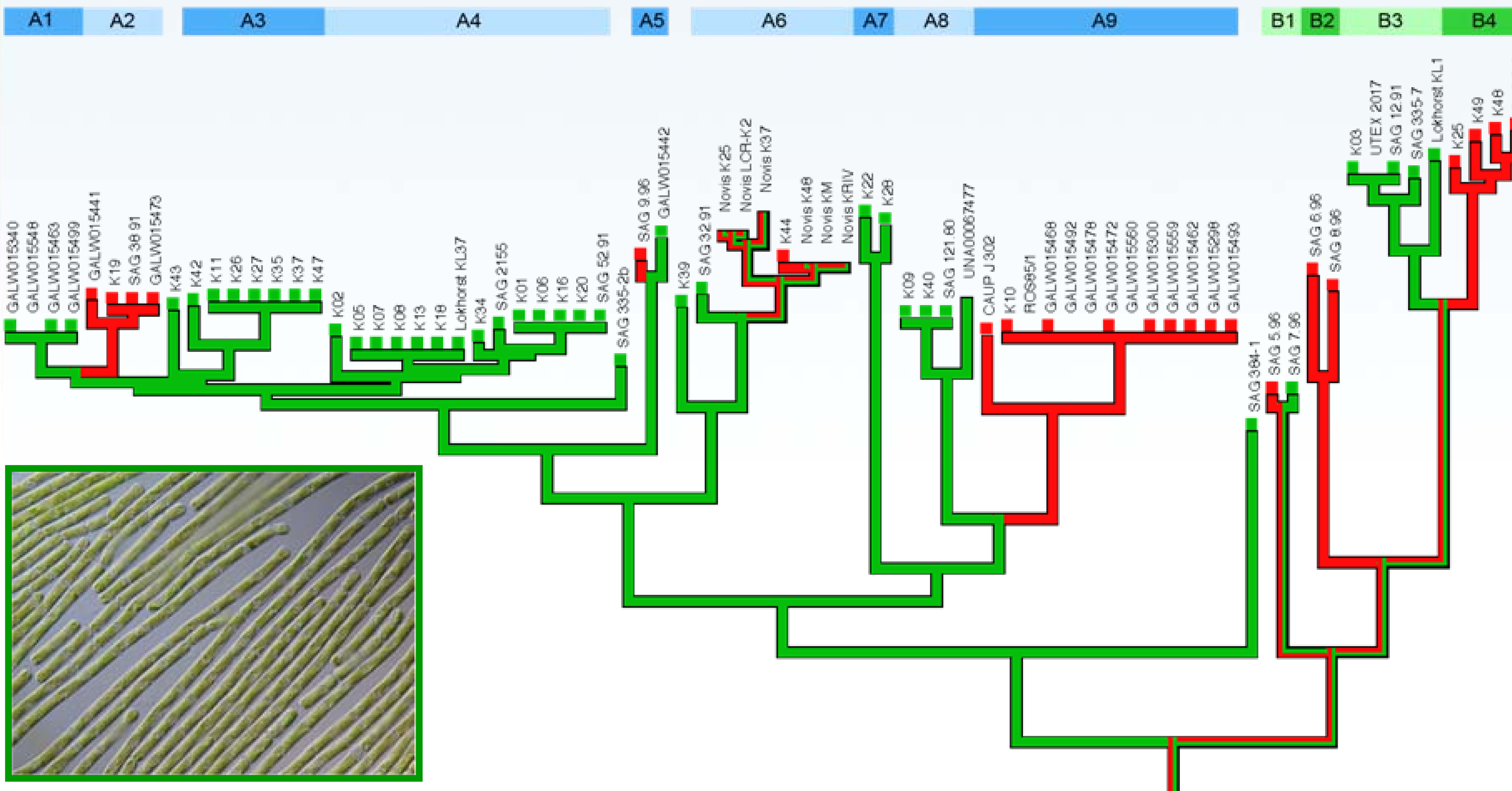
- Partial usefulness of this character to characterize particular genetic lineages
- In some cases, genetically uniform strains considerabely differ in their cell width



Ancestral state reconstructions (MP)

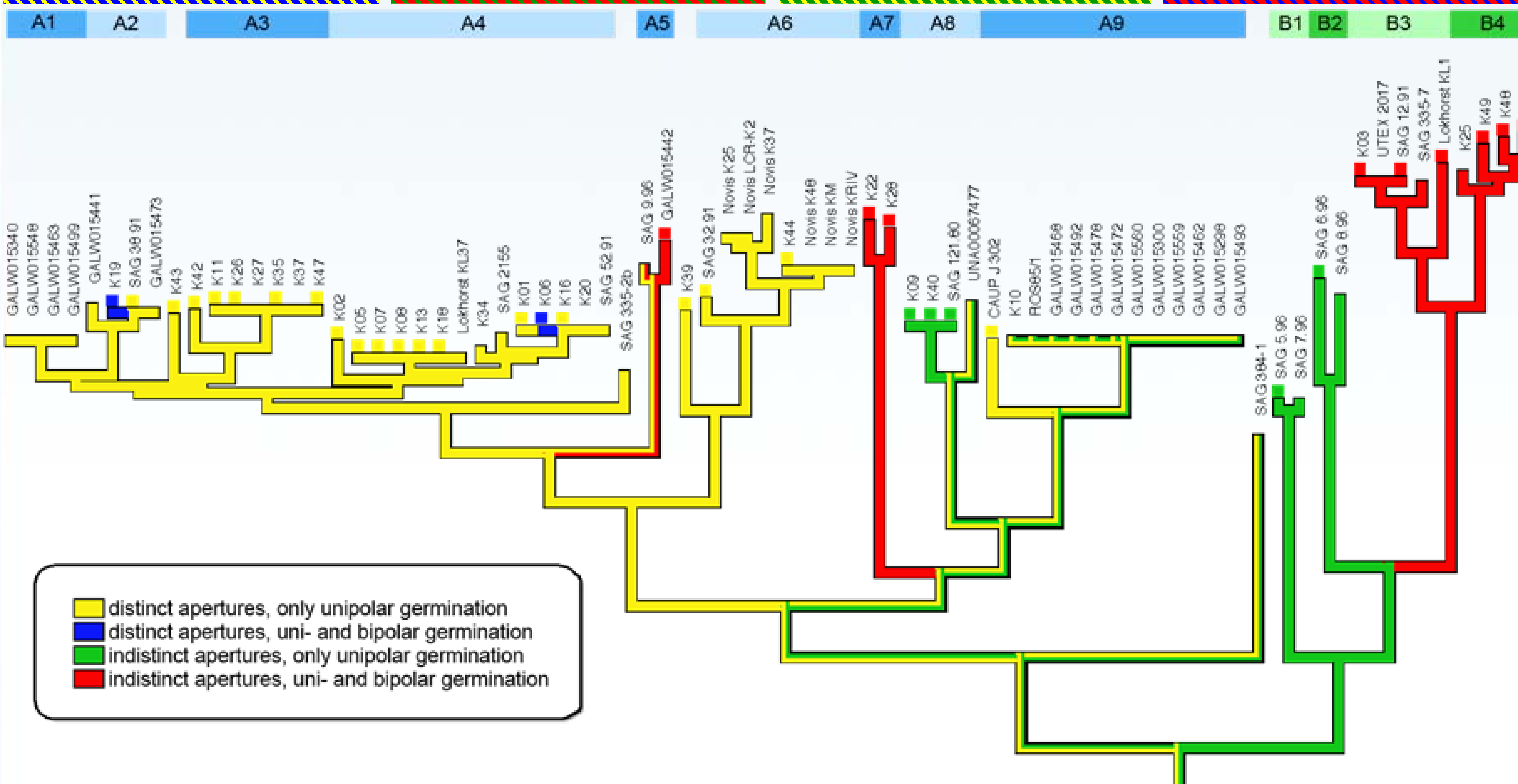
Ability to produce a superficial layer of hydro-repellent filaments

- Superficial layer completely absent in lineages A2, A9, and B4



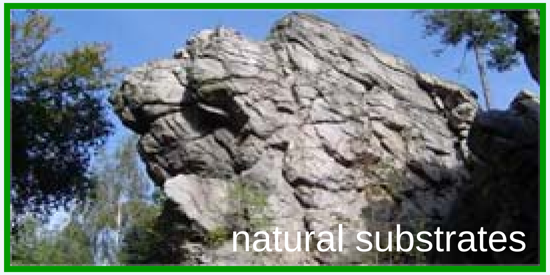
Ancestral state reconstructions (MP)

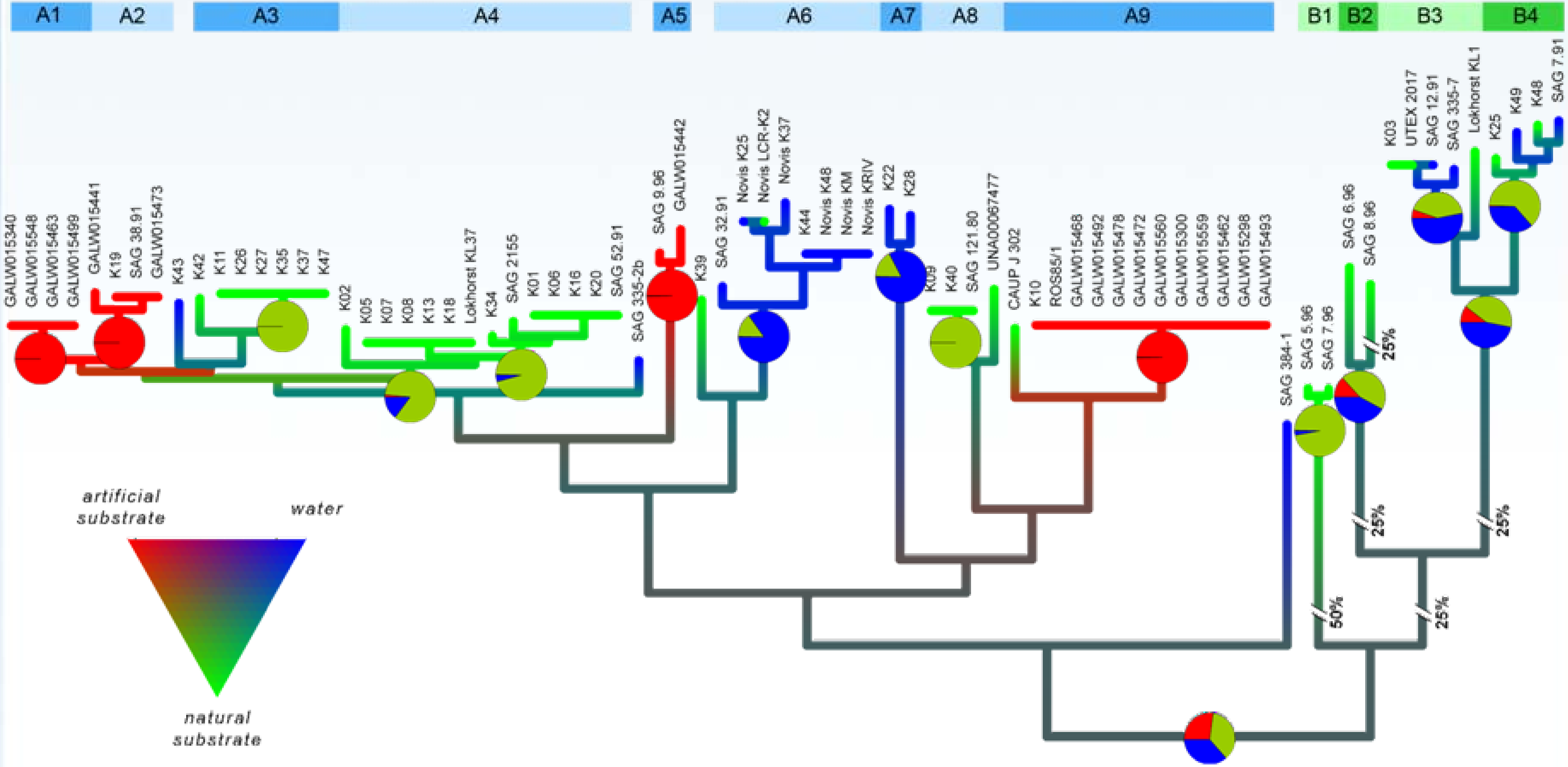
Reproductive features *(structure of release apertures and zoospore germination)*



Mapping the habitat preferences (ML)

Strong ecological preferences of the lineages to one of three habitat types

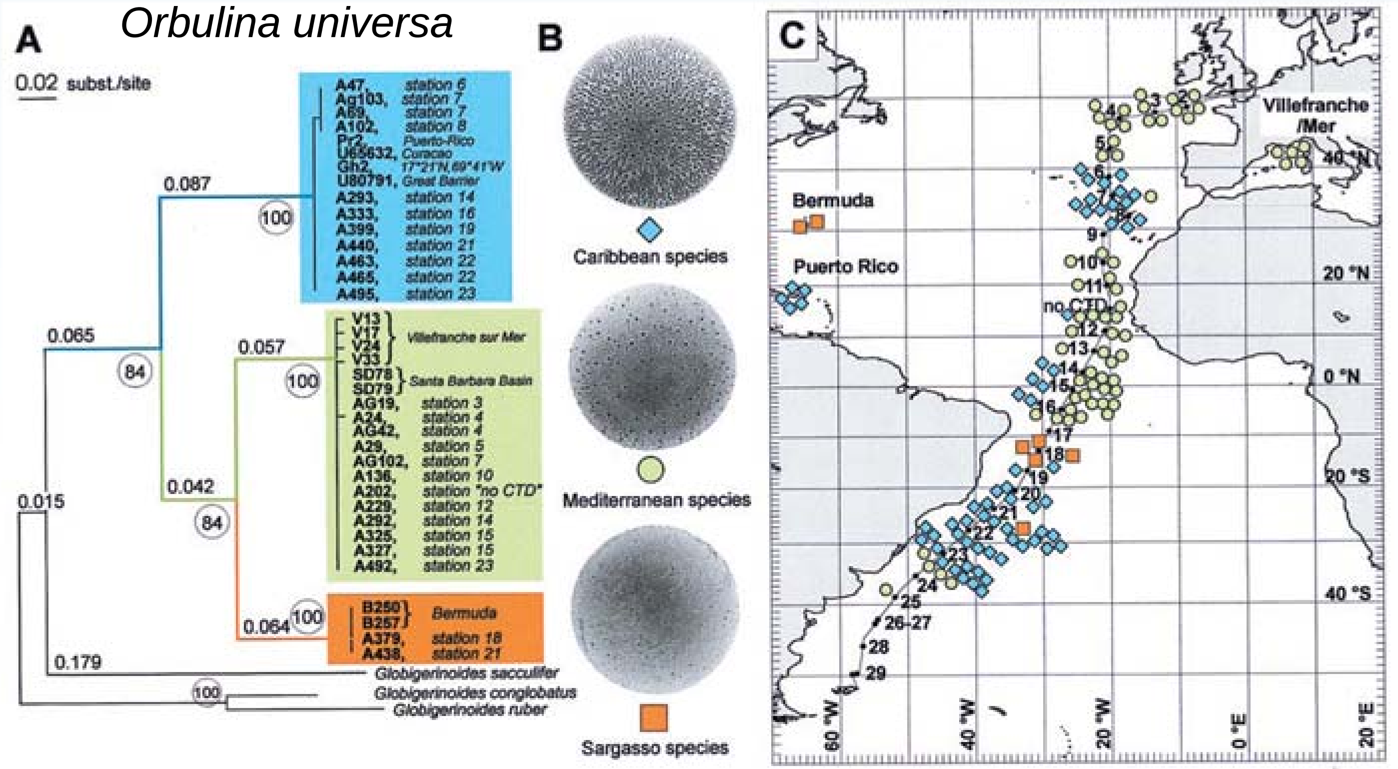




Ecological diferentiation of cryptic species

- The genetic diversity within protist morphospecies really reflect the existence of cryptic species, which could be defined by their ecological preferences and slight morphological differences.
- The morphology alone is not sufficient to unambiguously discriminate among closely related protist species
- If the ecological differentiation of cryptic species is frequent in nature, the real species diversity of protists could be in fact much higher than estimated

Orbulina universa



Ecological significance of cryptic variation in Foraminifera: de Vargas et al. 1999, 2002

Speciation of asexual protists

- Diversification of asexual protists into the distinct, ecologically well defined cryptic species could be enabled by the process of 'periodic selection'

Syst. Biol. 50(4):513–524, 2001

Bacterial Species and Speciation

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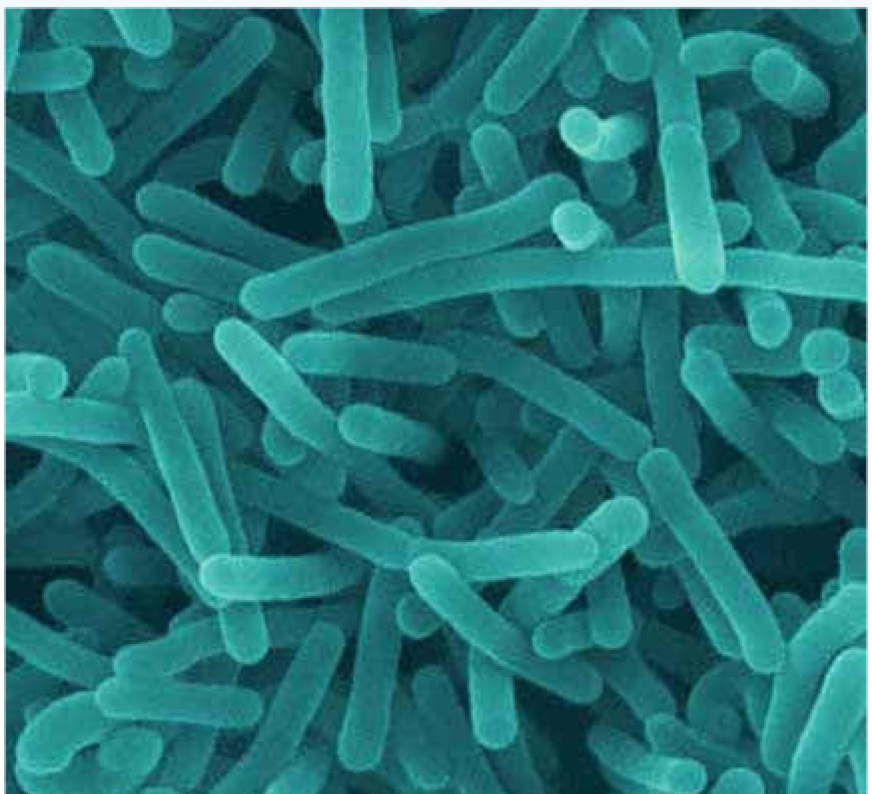
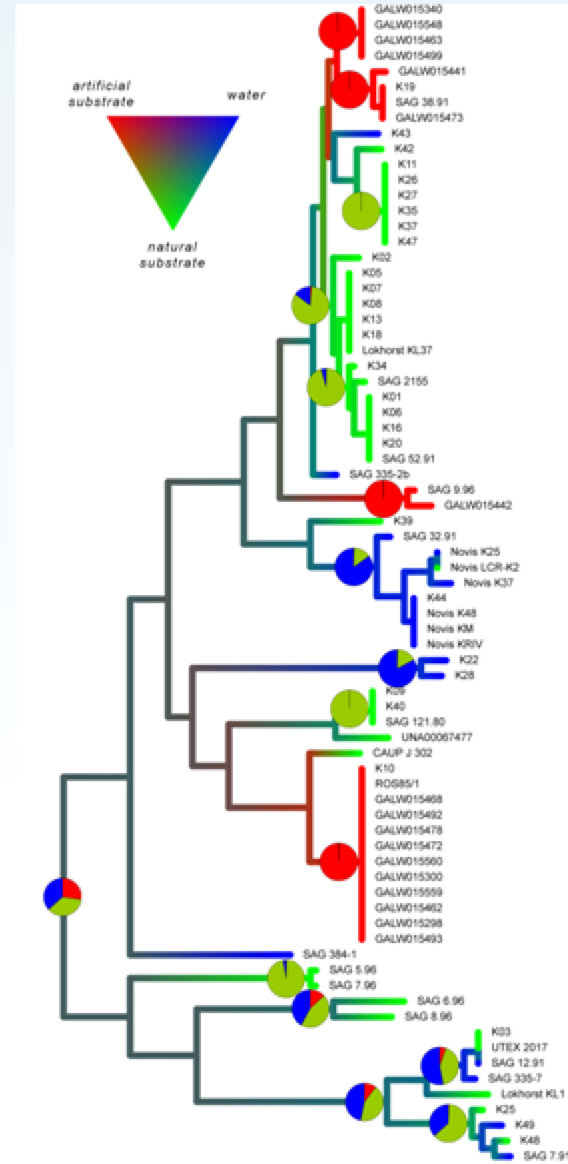
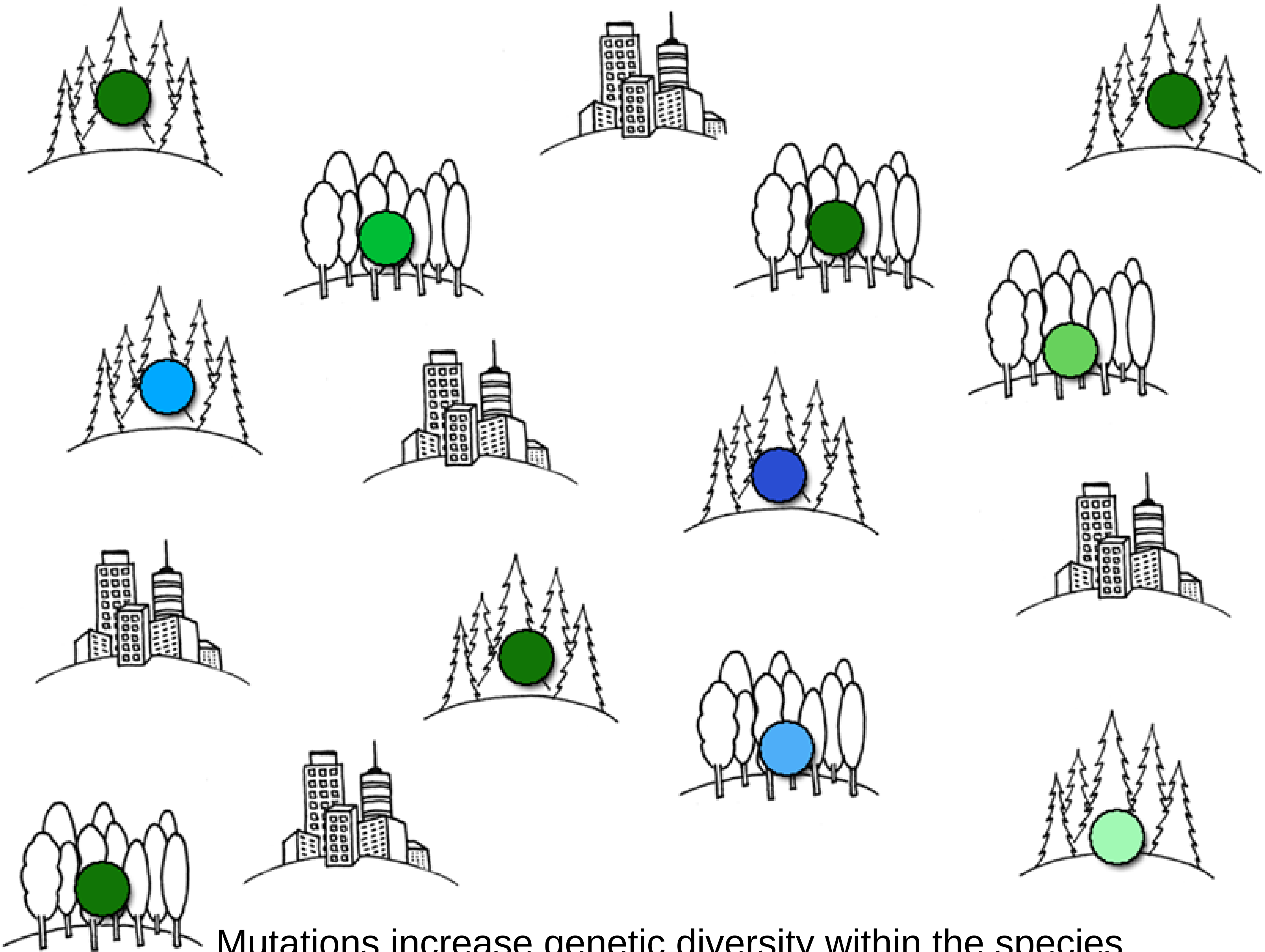




Speciation of asexual protists – periodic selection

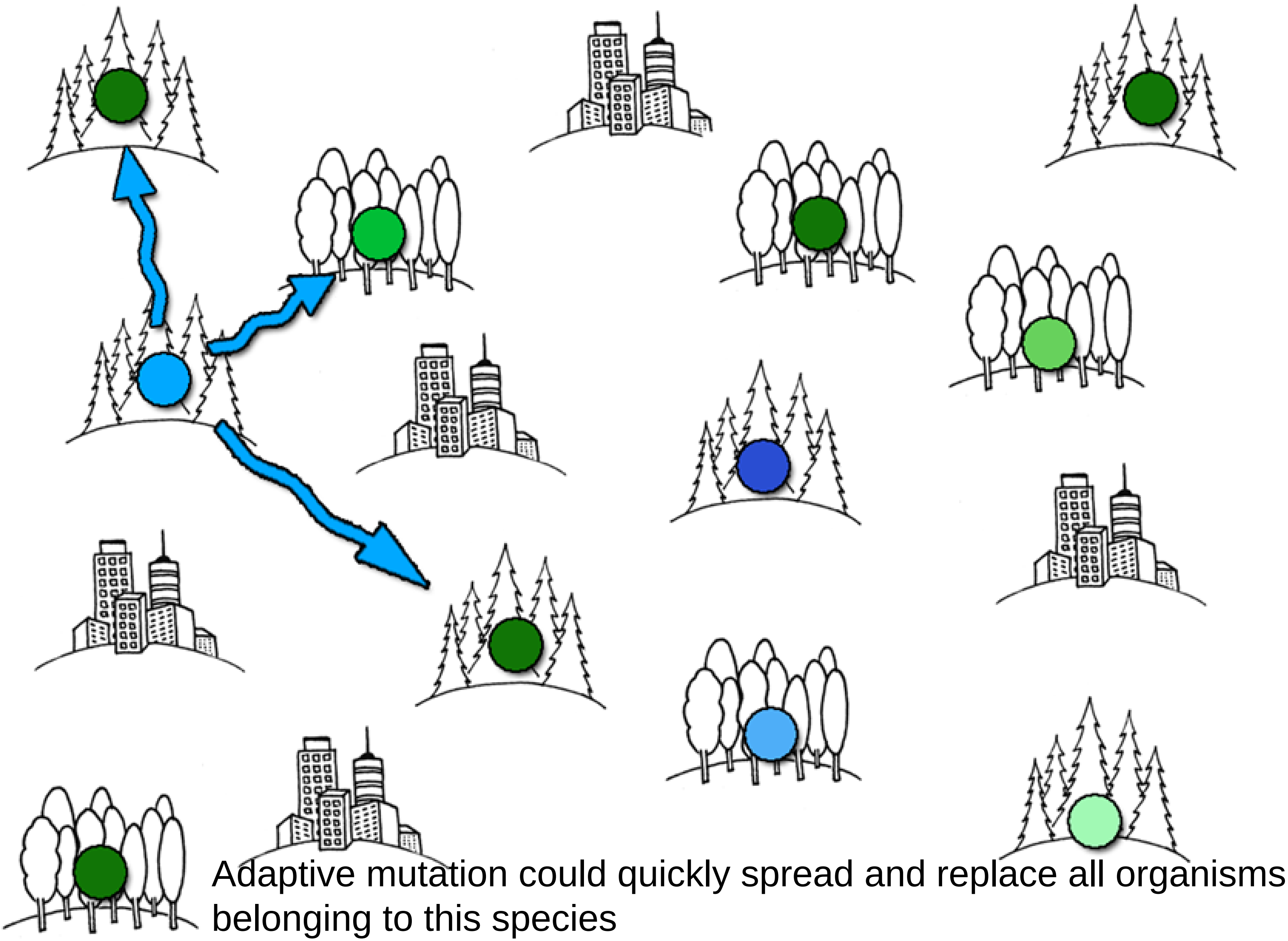
Single, genetically uniform species growing on natural substrates

Speciation of asexual protists – periodic selection



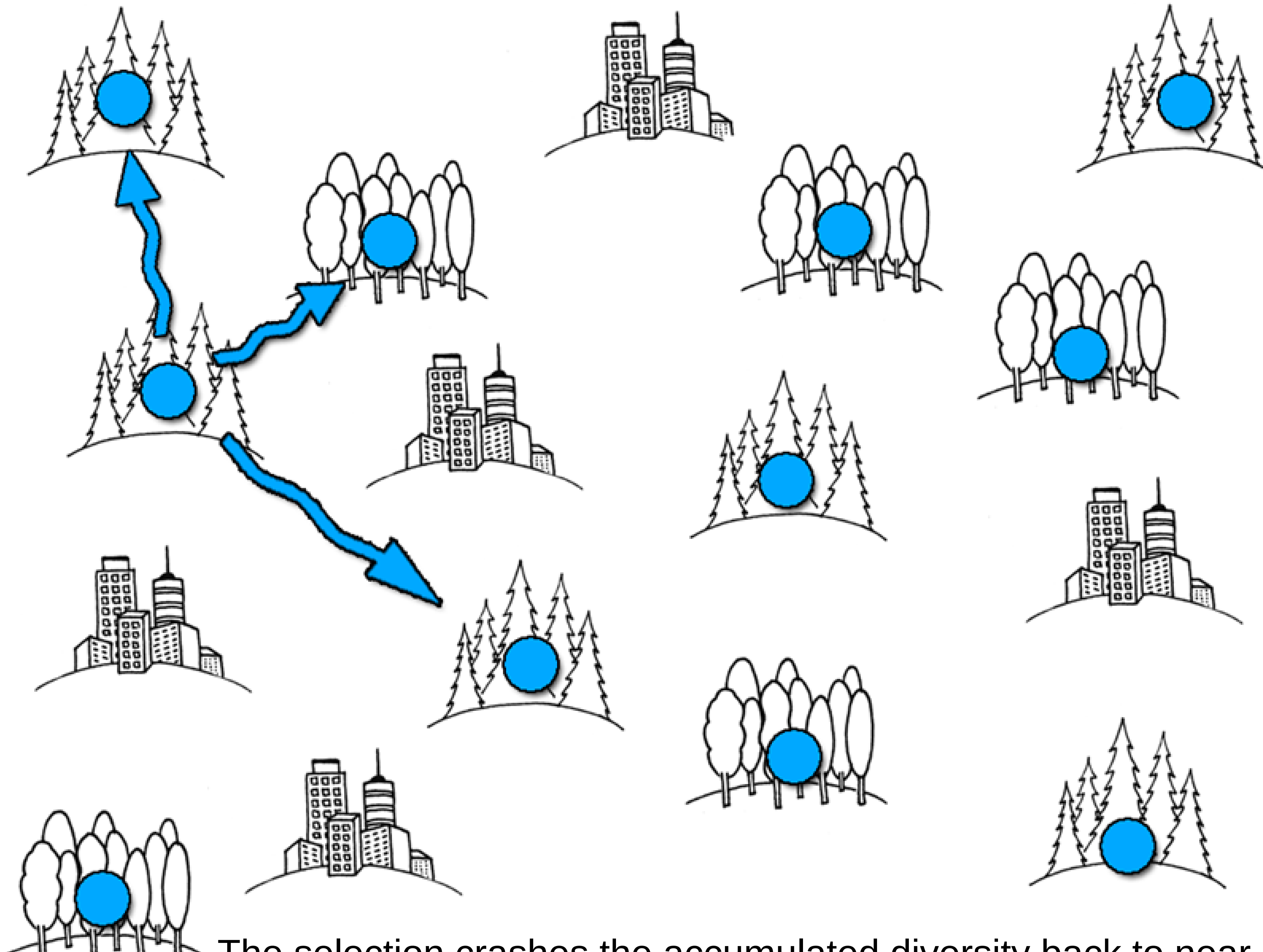
Mutations increase genetic diversity within the species

Speciation of asexual protists – periodic selection



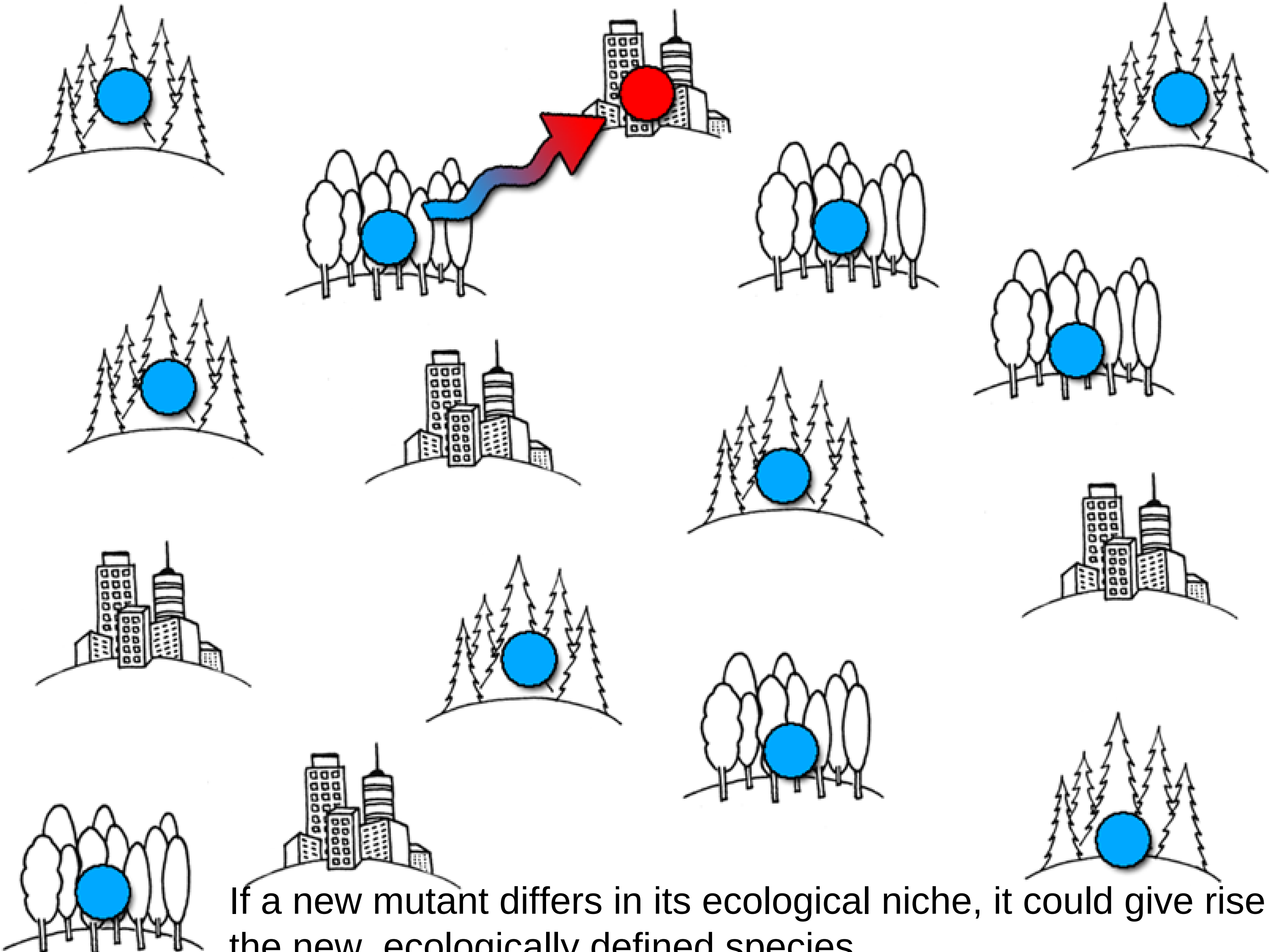
Adaptive mutation could quickly spread and replace all organisms belonging to this species

Speciation of asexual protists – periodic selection



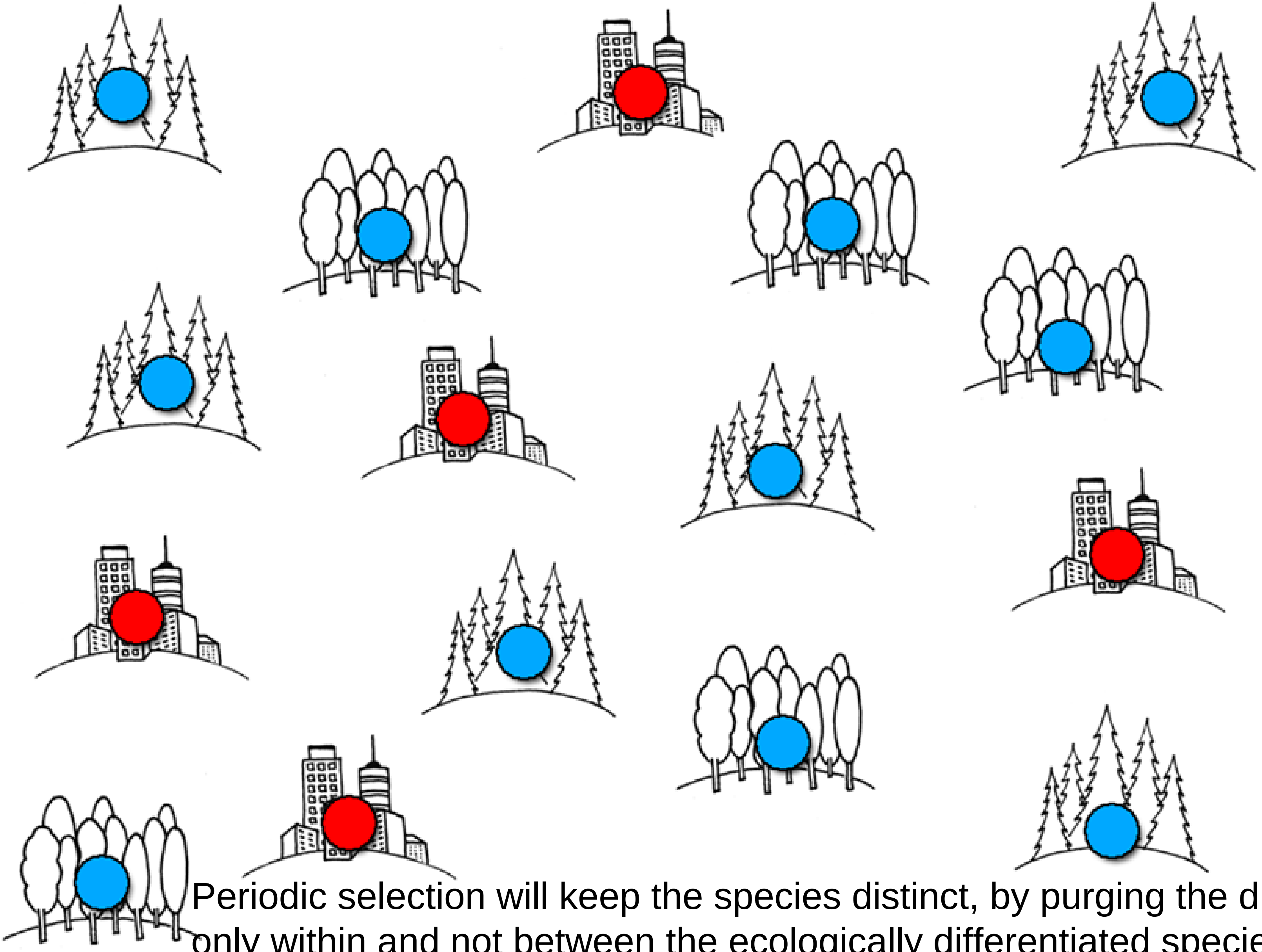
The selection crashes the accumulated diversity back to near zero

Speciation of asexual protists – periodic selection



If a new mutant differs in its ecological niche, it could give rise to the new, ecologically defined species.

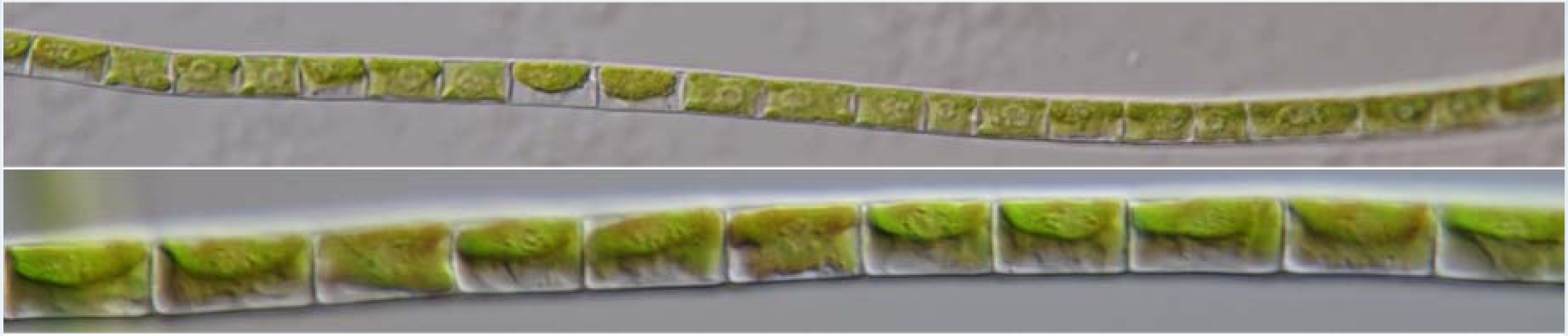
Speciation of asexual protists – periodic selection



Periodic selection will keep the species distinct, by purging the diversity only within and not between the ecologically differentiated species

Conclusions

- Our findings clearly contradict the assumptions of Finlay (1999) and Fenchel and Finlay (2006) that the genetic variation in molecular markers only reflects the accumulation of neutral mutations.
- The phenotypic data should be combined with molecular background and ecological consequences.
- We consider that the permanent existence of genetically and ecologically well-defined cryptic species is enabled by the mechanism referred to as ‘periodic selection’
- To organize biological information in a meaningful fashion, any functional properties should be found to characterize the cryptic species.



Acknowledgements

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