


# Cellular differentiation and individuality in the "minor" multicellular taxa

Matt Herron

What is individuality?

# Does it matter?

 “Biology lacks a central organism concept that unambiguously marks the distinction between organism and non-organism because the most important questions about organisms do not depend on this concept.” (J. Wilson 1999)

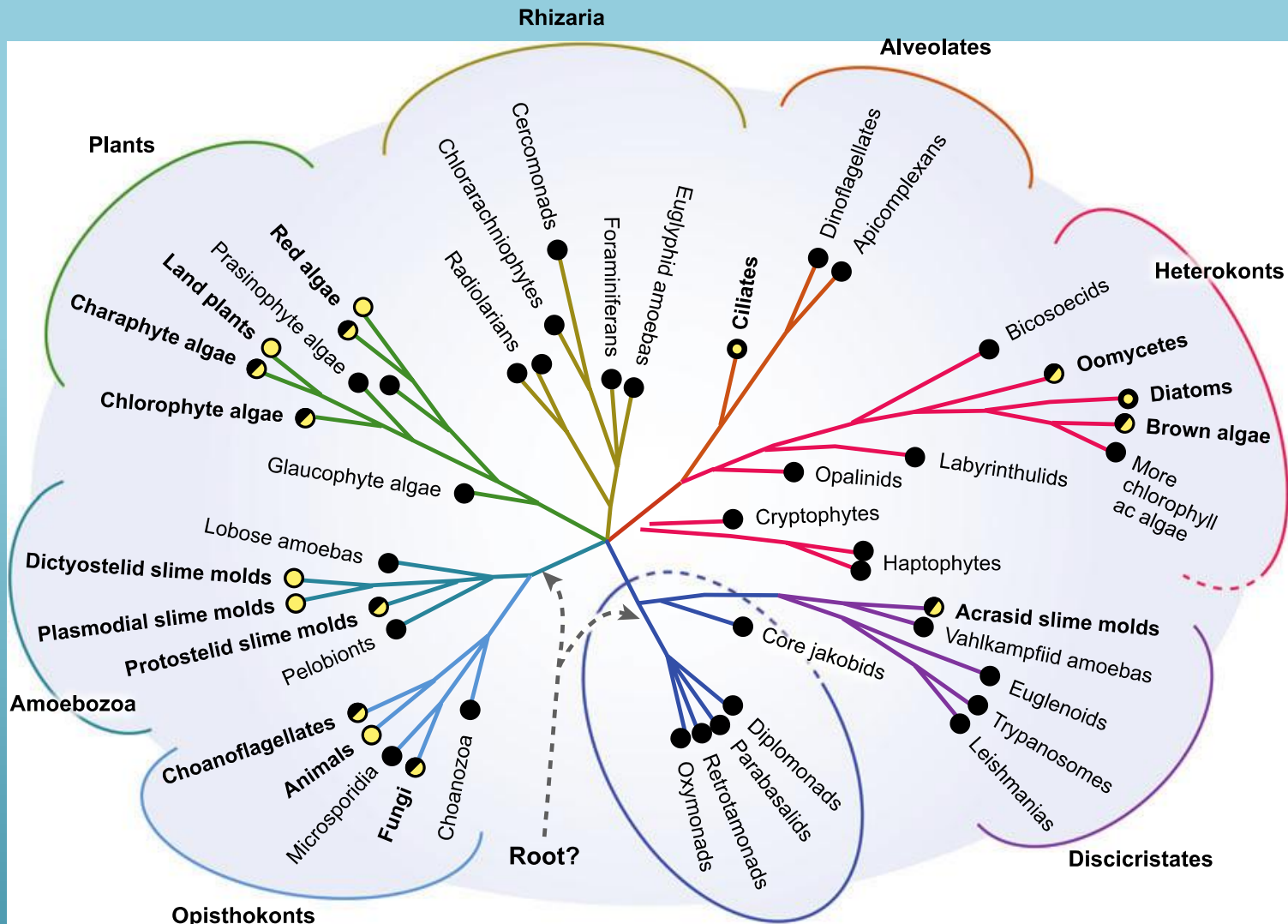
# Some criteria for individuality

-  Functional integration (Ruiz-Mirazo et al. 2000, Wilson & Sober 1989)
-  Physiological autonomy, homeostasis (Ruiz-Mirazo et al. 2000, Santileces 1999)
-  Genetic homogeneity, genetic uniqueness (Santileces 1999)
-  Single-cell bottleneck (Dawkins 1982)
-  Spatially bounded, contiguous (Hull 1992)
-  Germ-soma division of labor (Michod 1998)

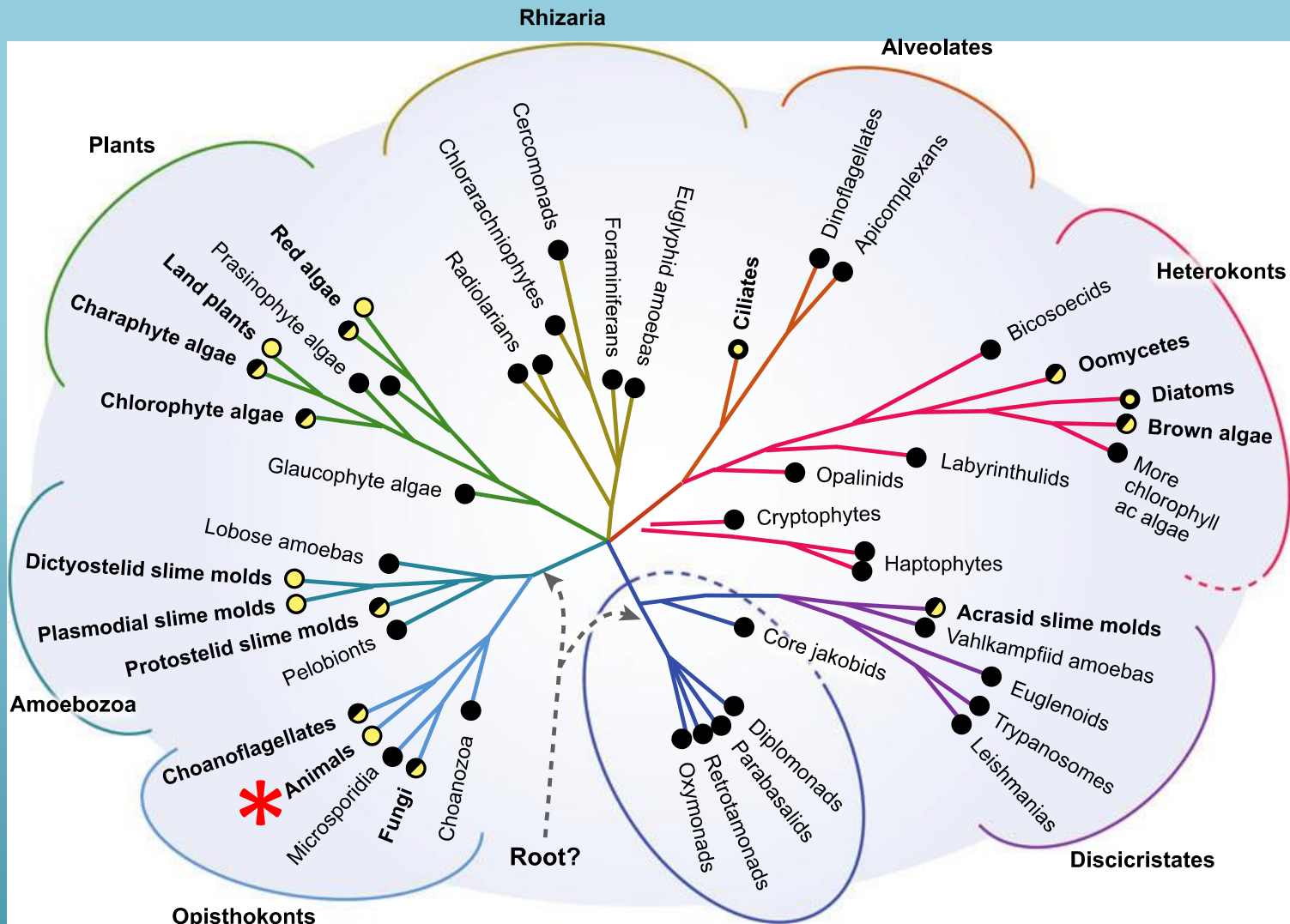
- Ramet
- Genet
- Ortet
- Runner
- Thallus
- Clone
- Tiller
- Biont
- Morphont
- Holobiont
- Colonial organism
- Superorganism
- Module
- Phyton
- Metamer
- Somatogen
- Stolon
- Colony
- Zooid
- Colonoid
- Individuoid
- Coenobium
- Semaphoront
- Unitary individual
- Paradigm individual
- Evolutionary individual
- Darwinian individual
- Morphological & physiological individual
- Functional individual
- Genetical individual
- Developmental individual
- Structural individual
- Genealogical individual
- Metaphysical individual
- Others I haven't thought of?

# Some more criteria for individuality

- ✿ High cooperation & low conflict (Queller & Strassmann 2009, Strassmann & Queller 2010)
- ✿ Low conflict, germ-soma separation, & functional integration (Folse & Roughgarden 2010)
- ✿ Heritable variation in fitness (Godfrey-Smith 2009; Clarke 2011, 2012)



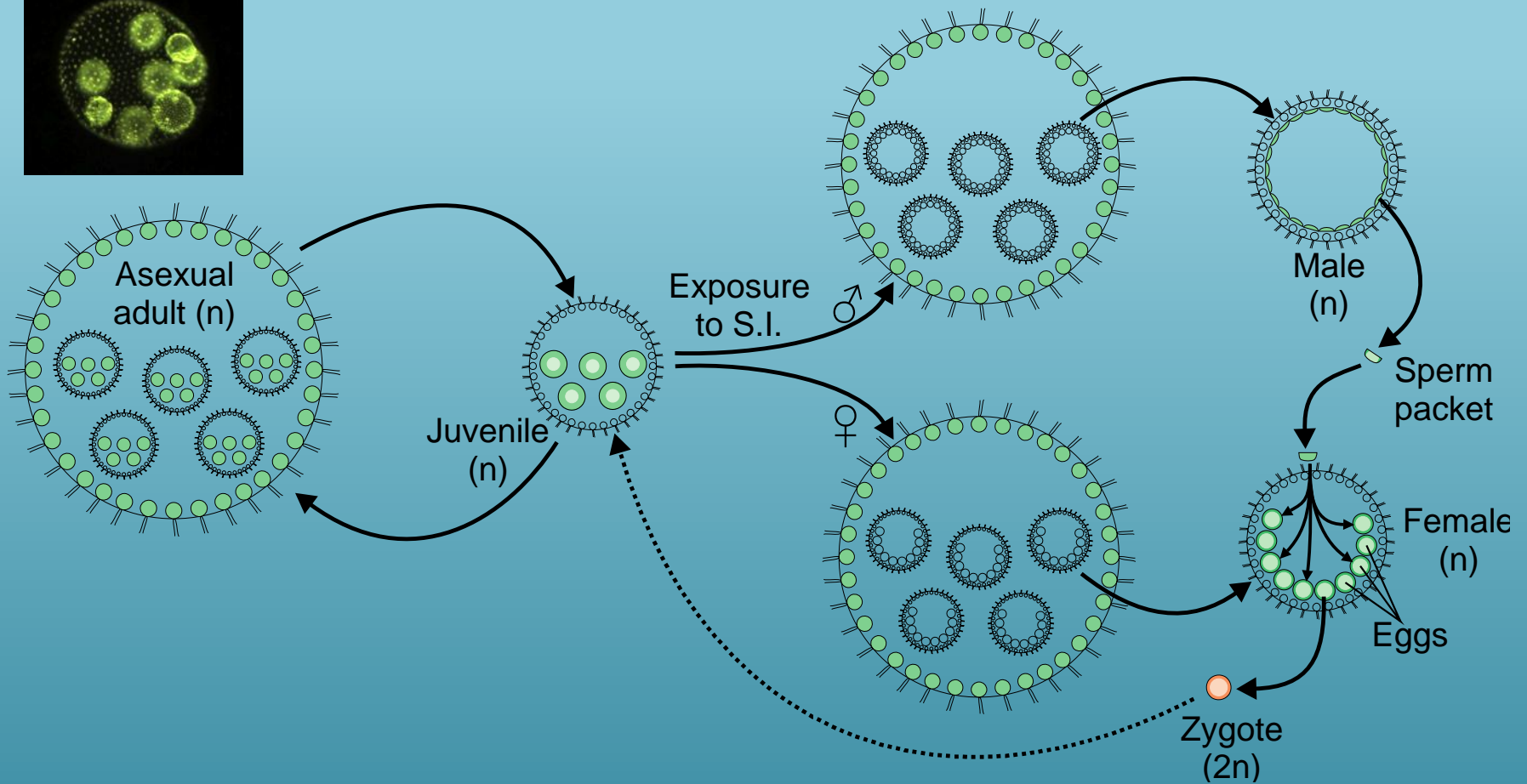
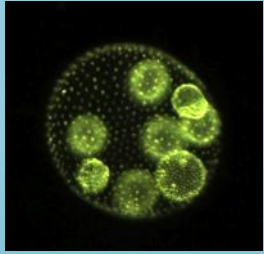
- All members are multicellular
- ◐ Clade contains unicellular and colonial/multicellular species
- Unicellular with rare multicellular forms



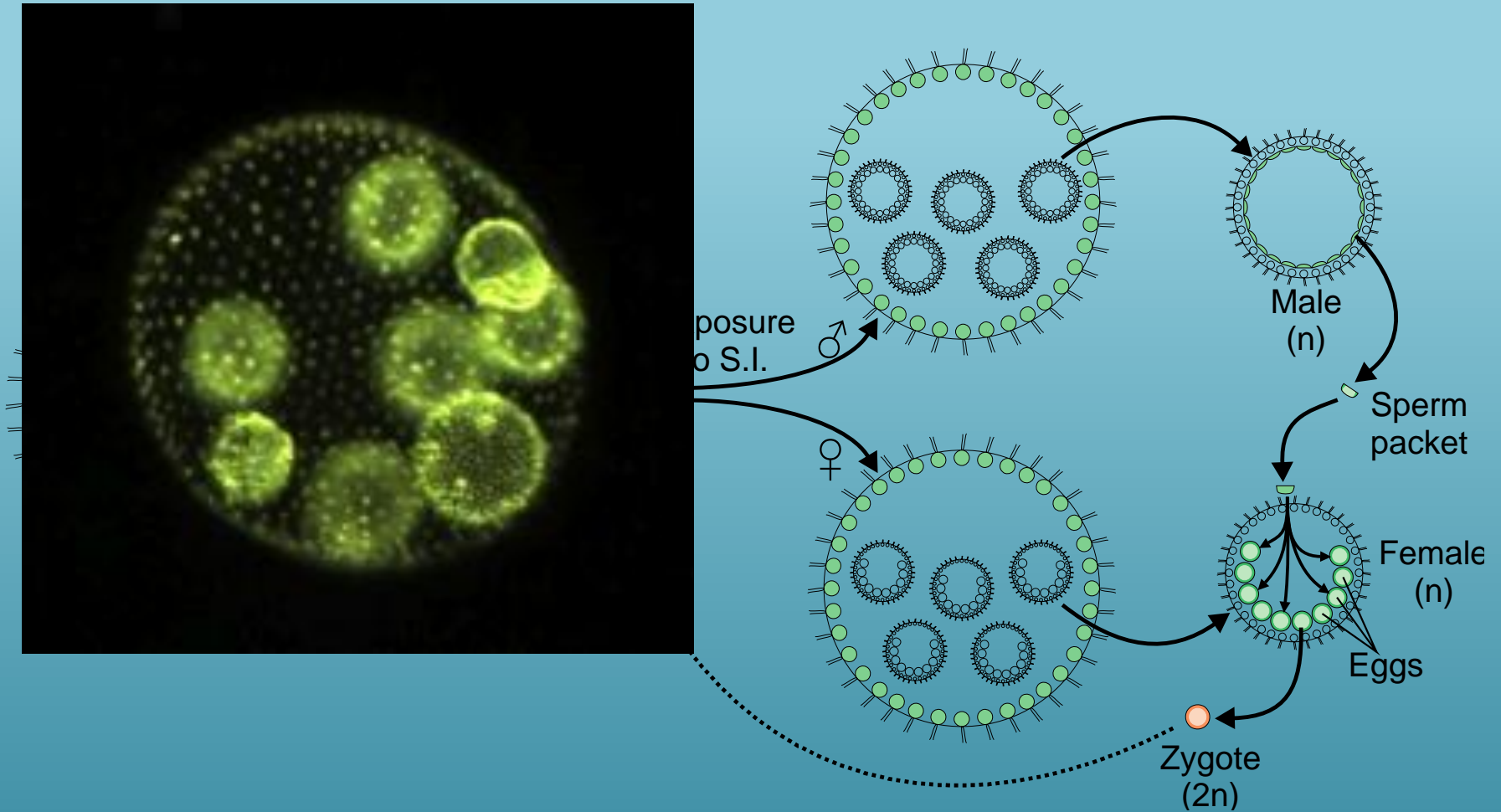
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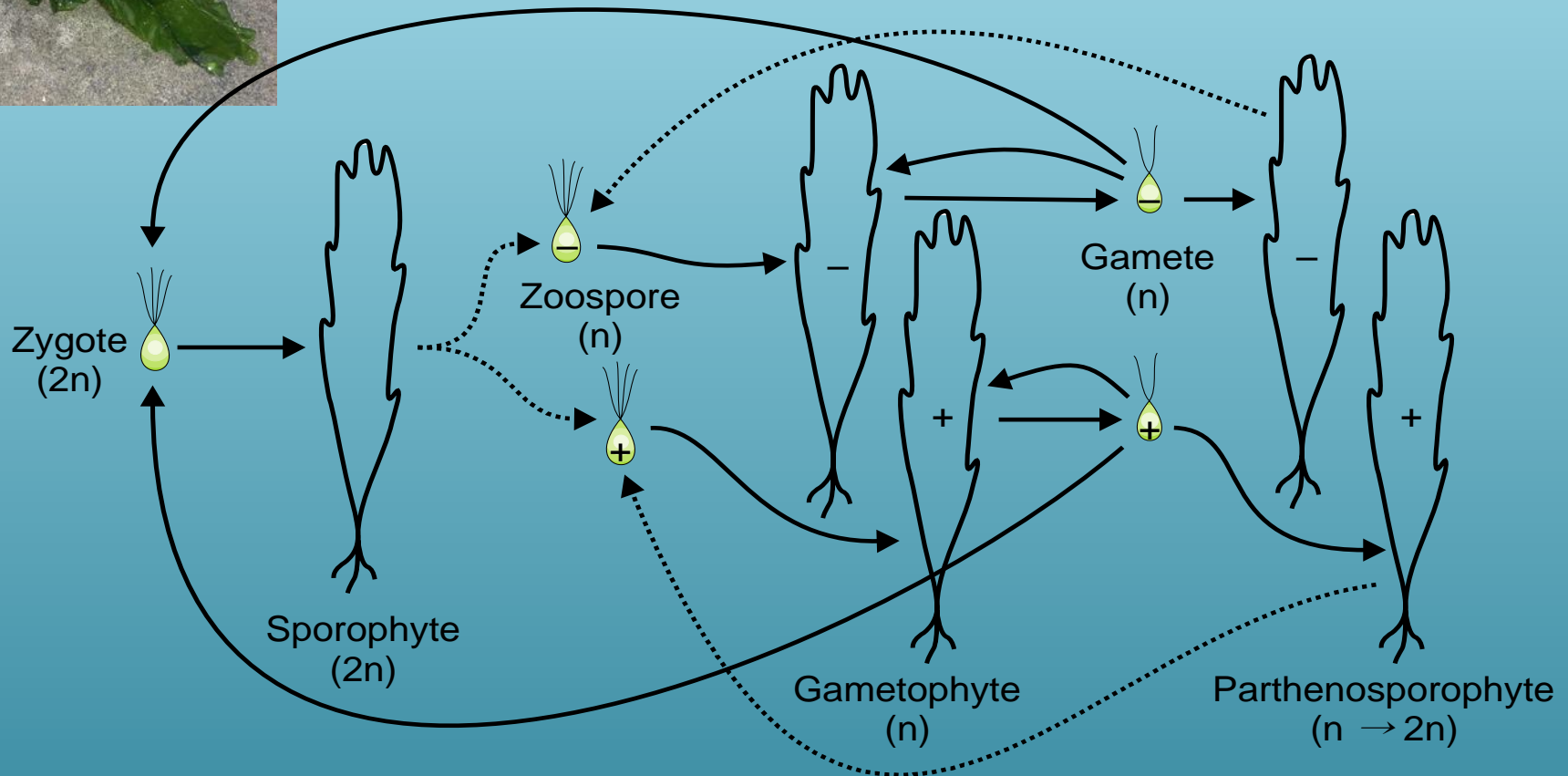
# *Volvox carterii* (Chlorophyceae)



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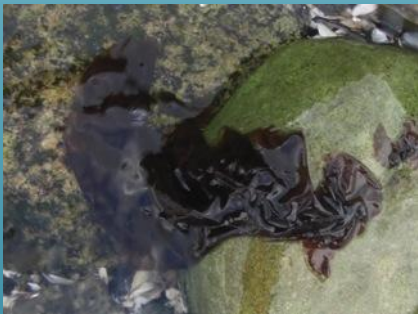
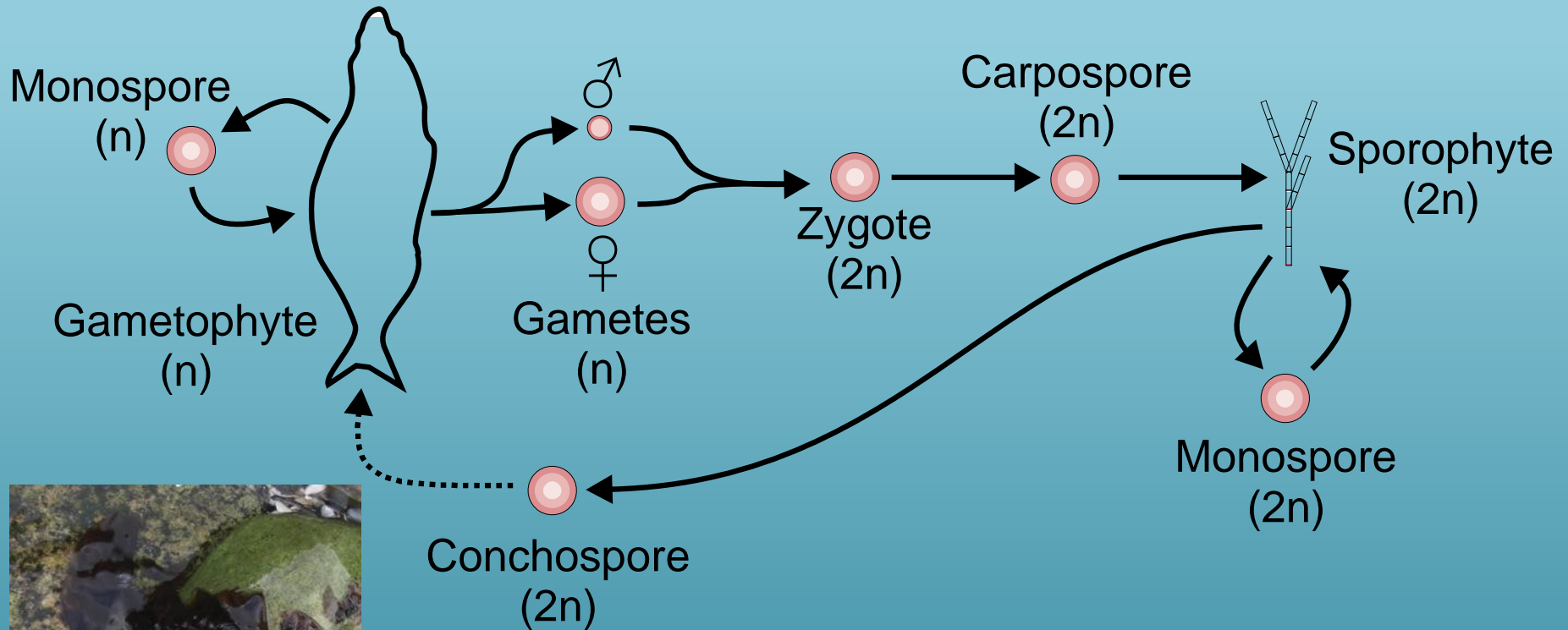


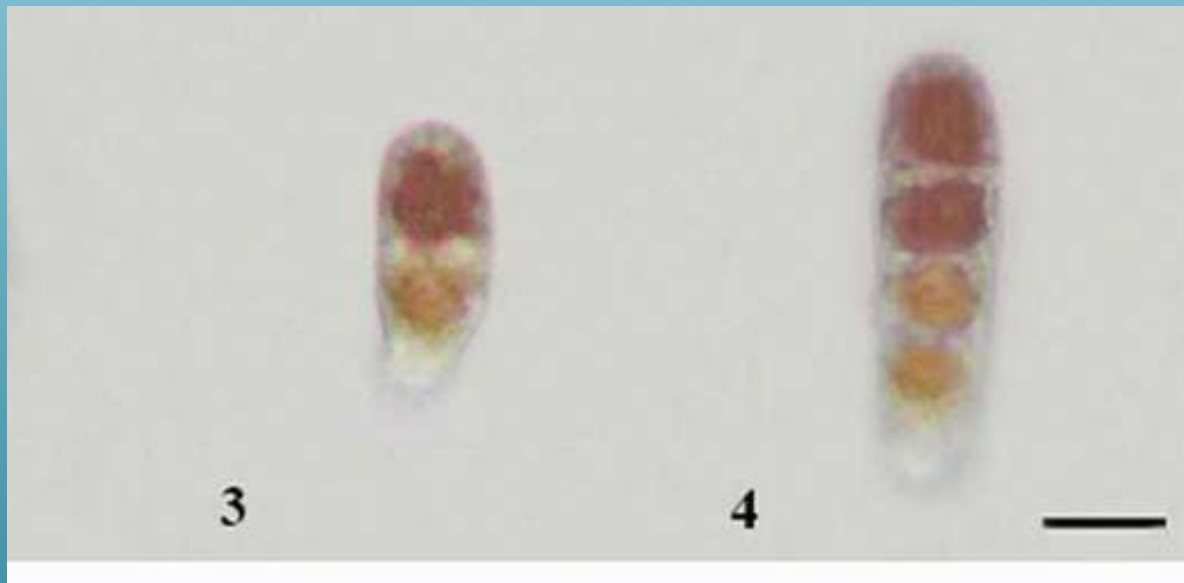
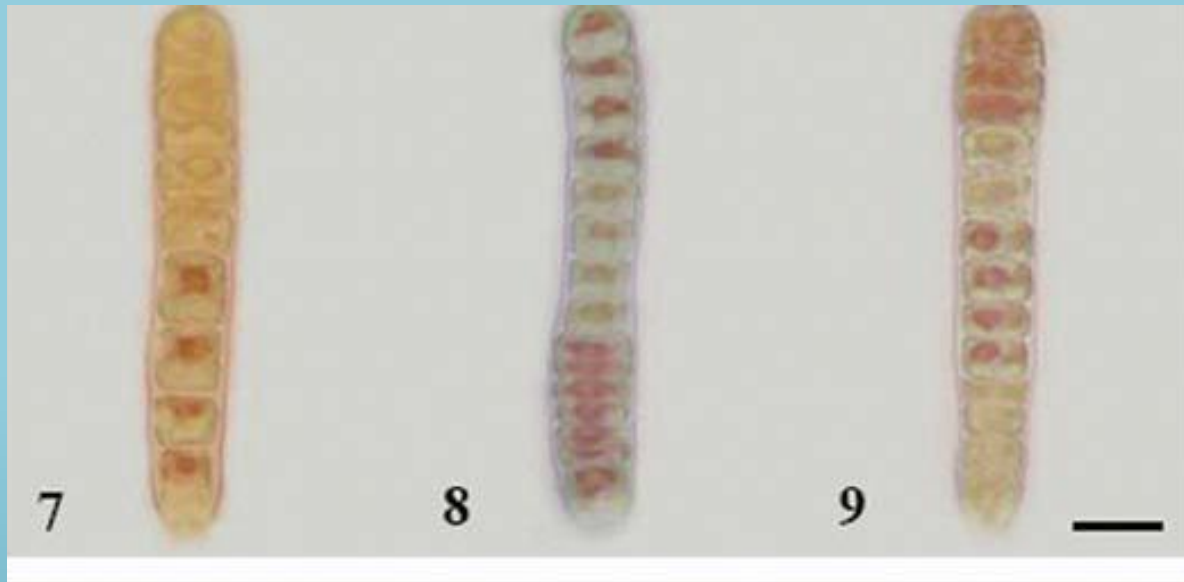
# *Ulva mutabilis* (Ulvophyceae)

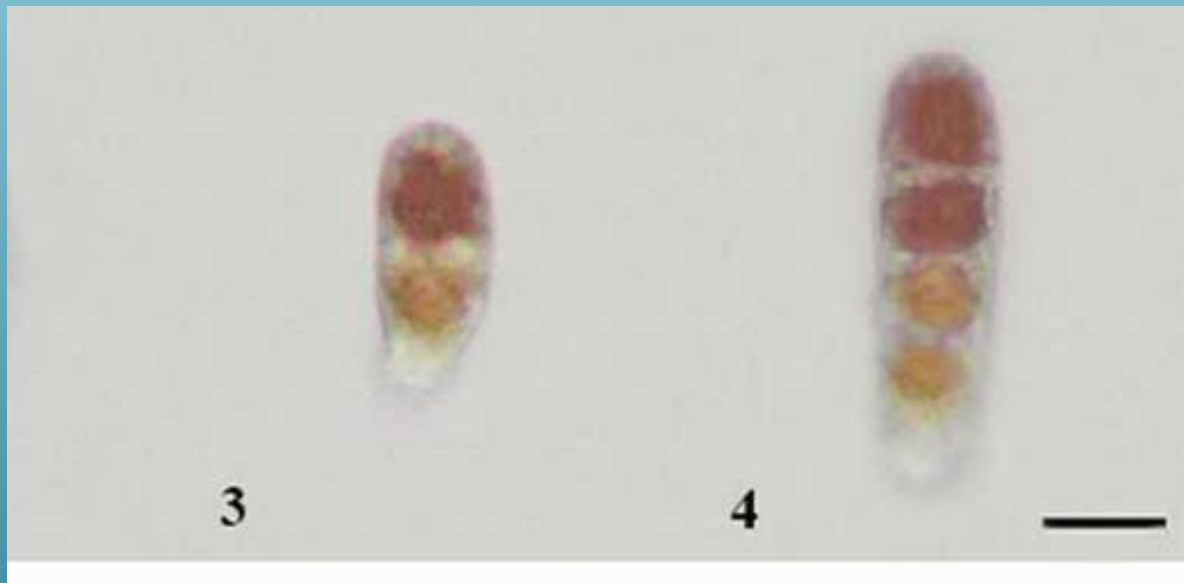
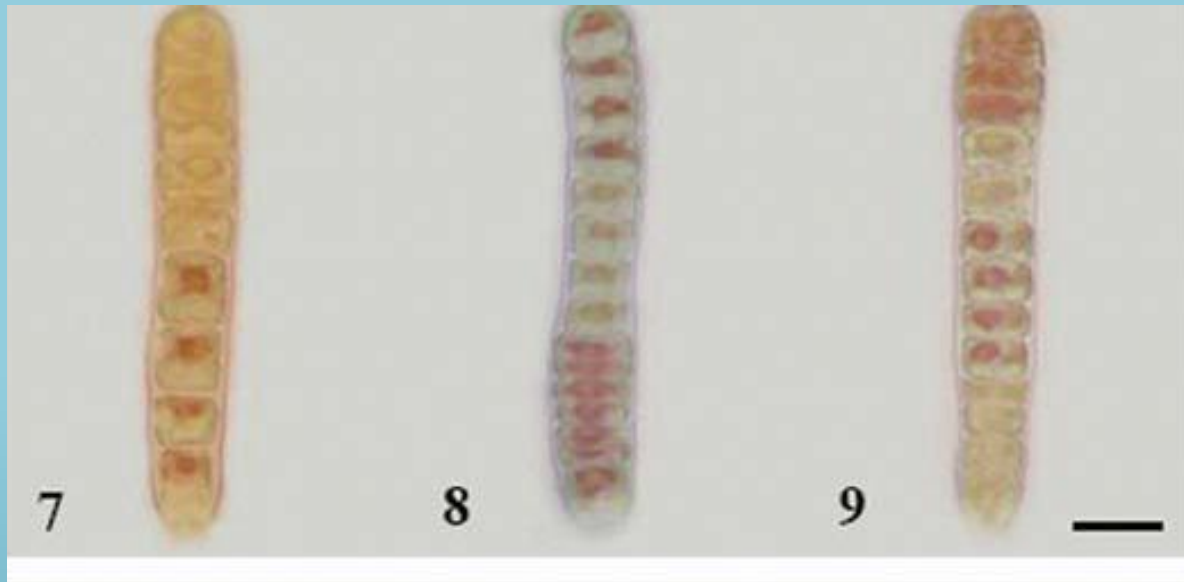


Adapted from Hoxmark & Nordby 1974 *Hereditas* 76:239

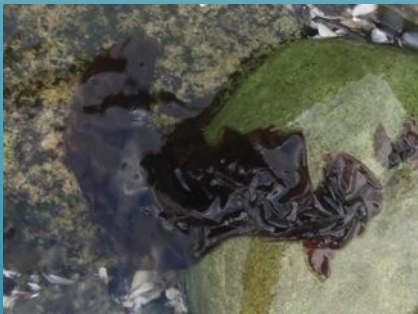
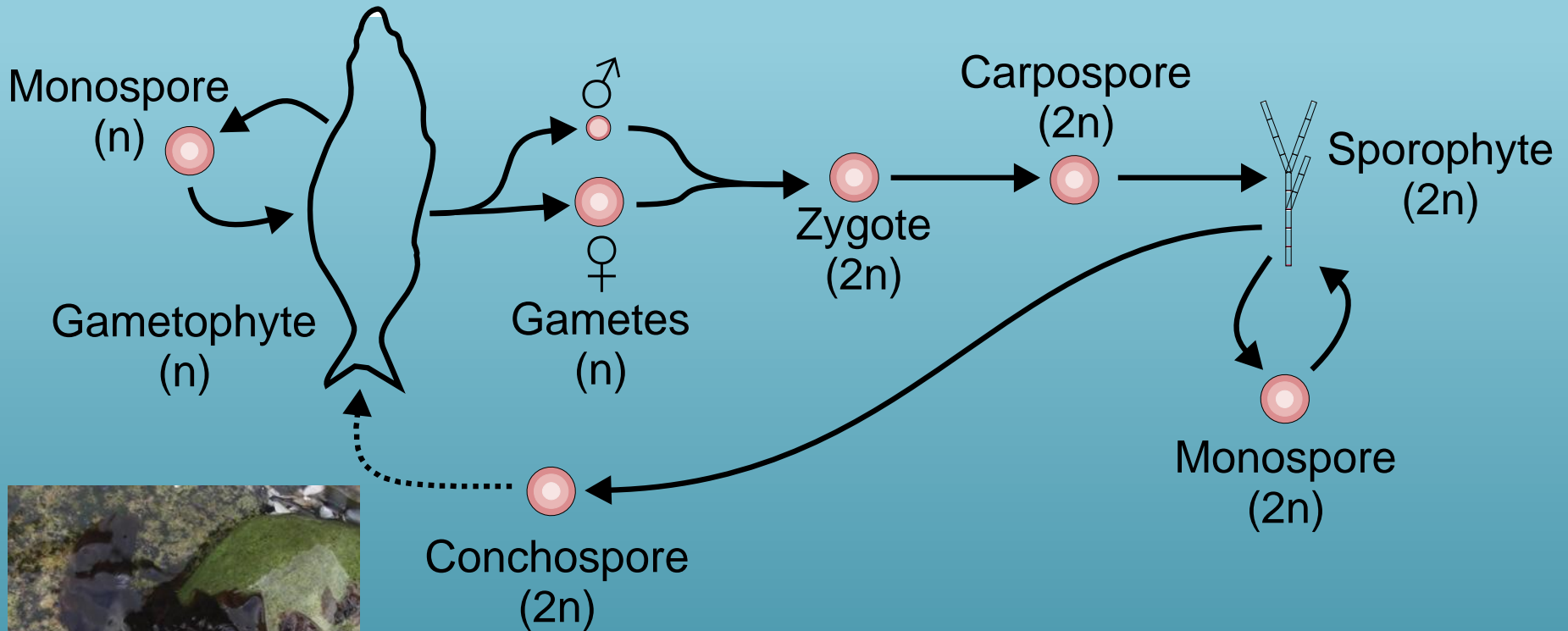
# *Porphyra yezoensis* (Rhodophyta)

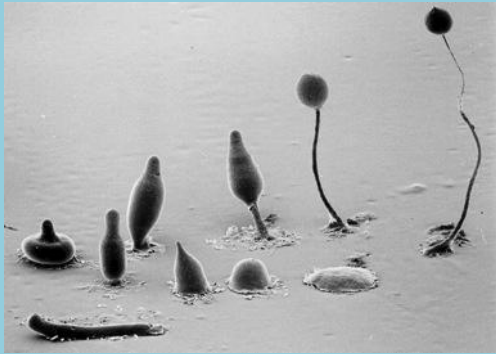






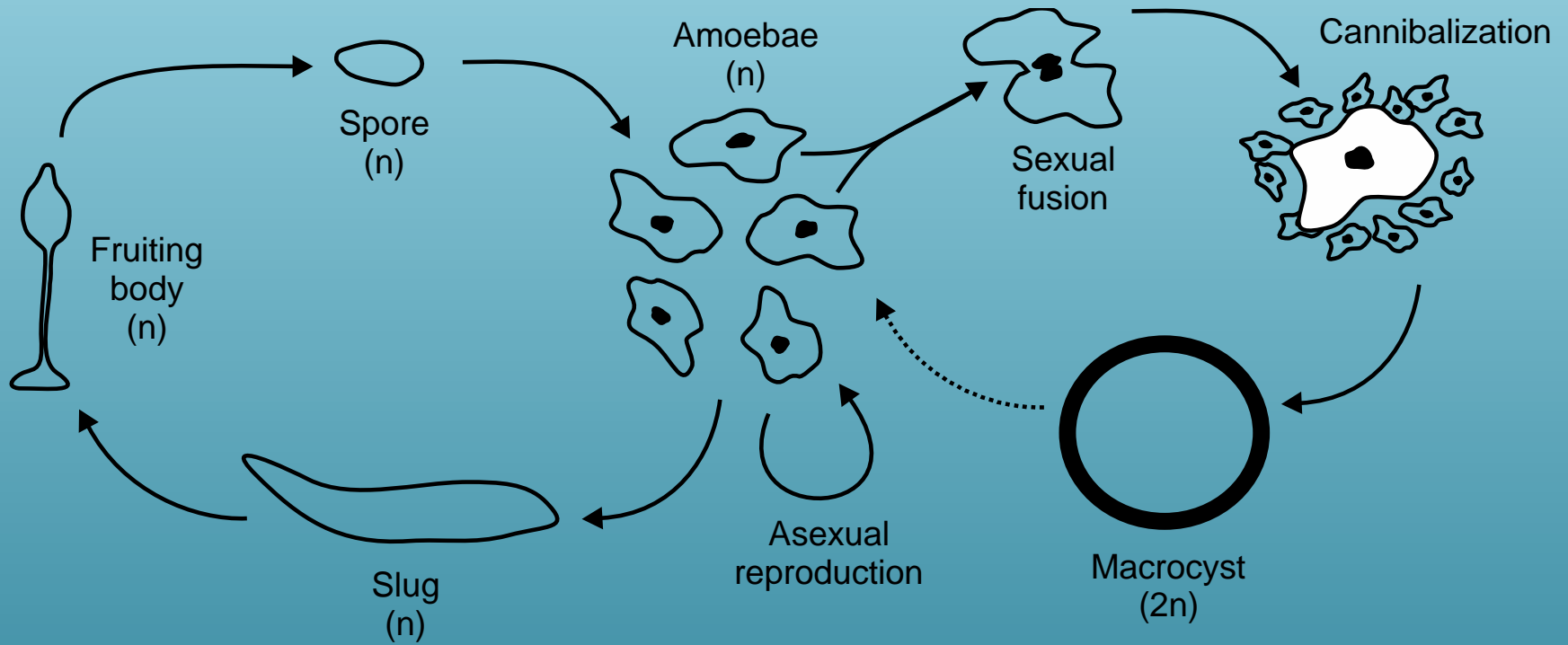
# *Porphyra yezoensis* (Rhodophyta)





# *Dictyostelium discoideum* (Amoebozoa)

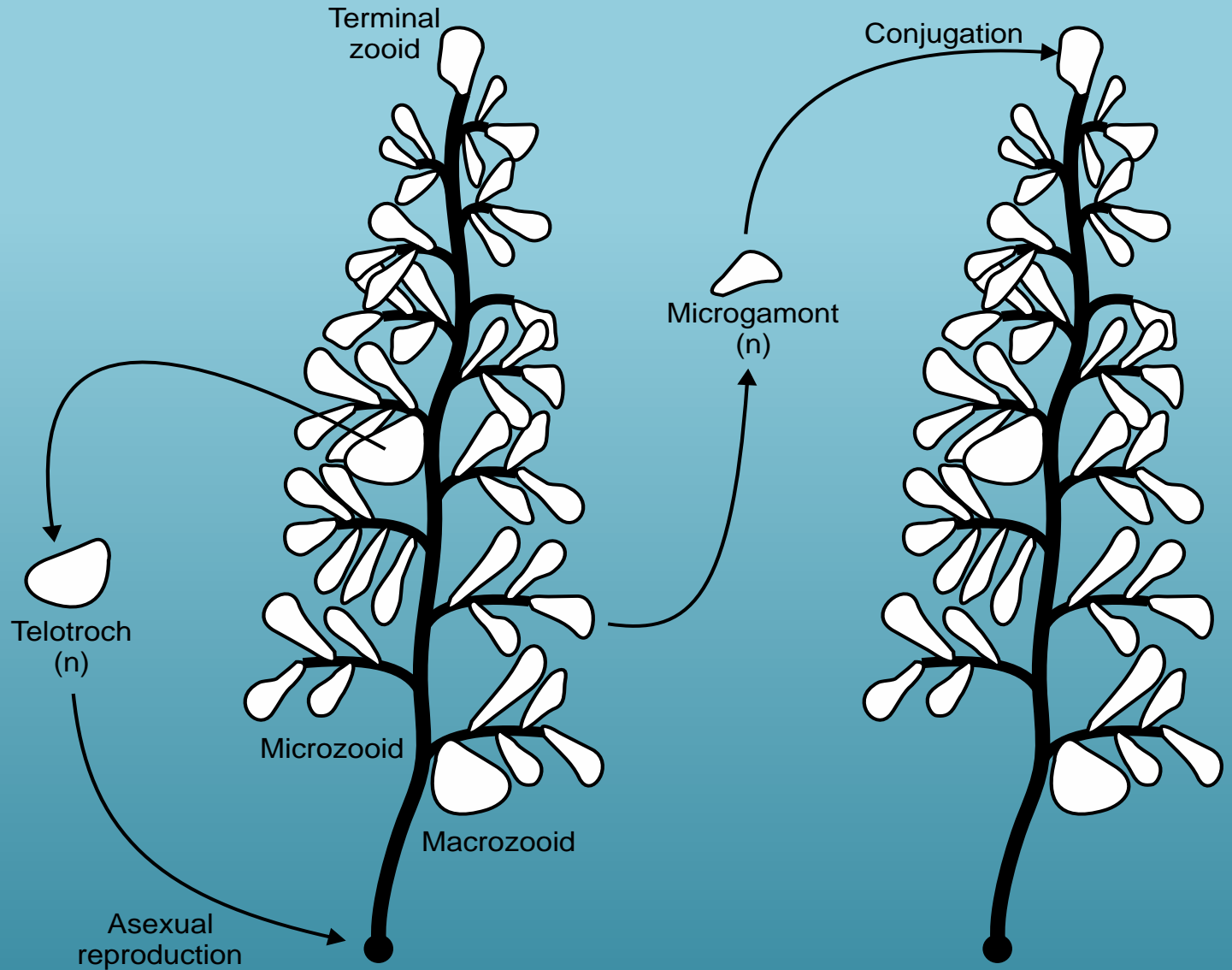
M. Grimson, L. Blanton



Adapted from Strassmann & Queller 2011 *Dev. Growth Differ.* 53:597

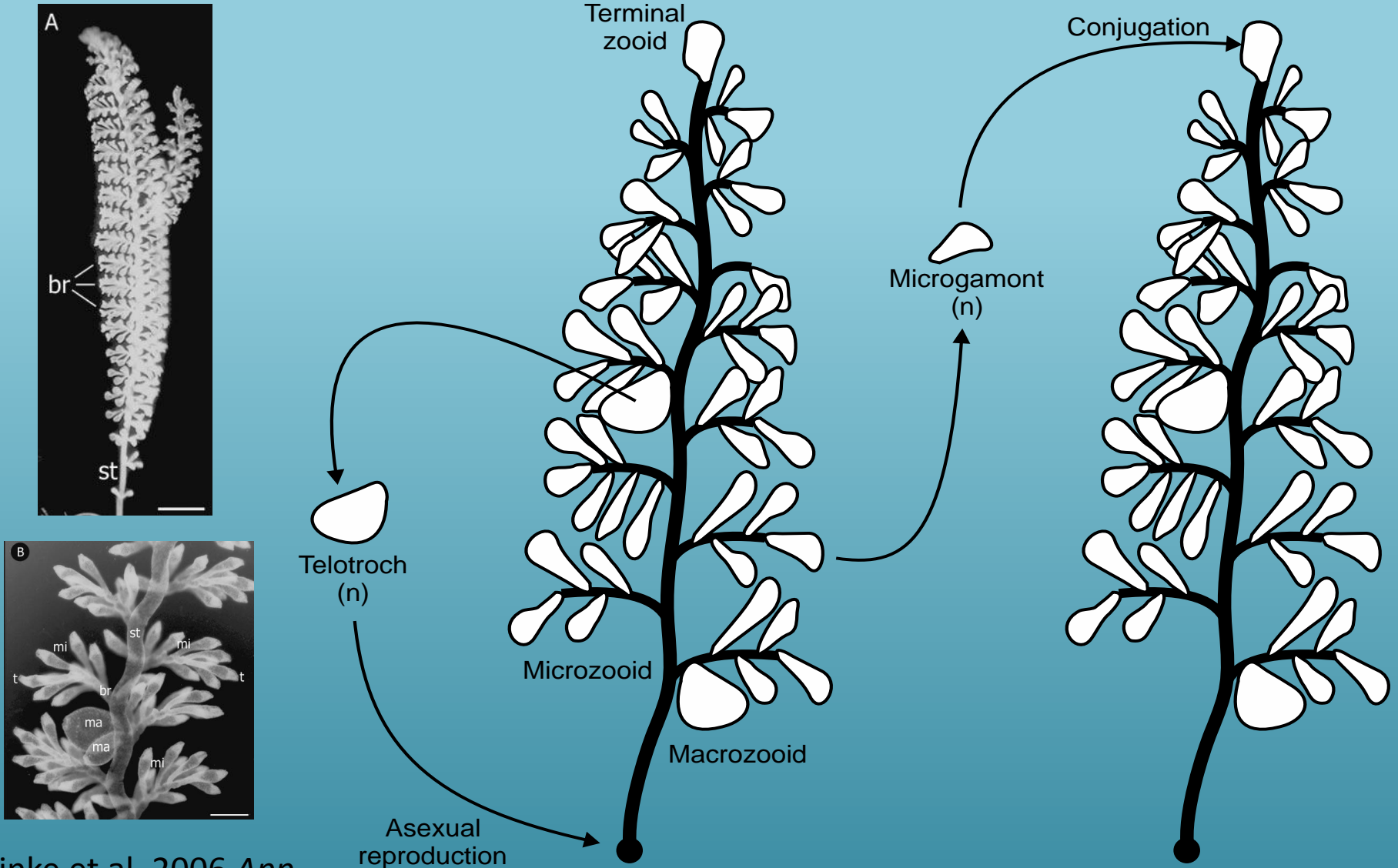


# *Zoothamnium niveum* (Ciliophora)

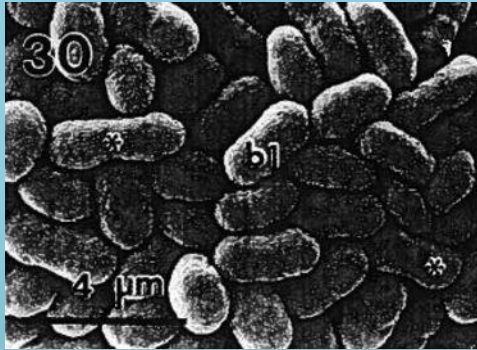


Adapted from Rinke et al. 2007 *Proc. Biol. Sci.* 274:2259

# Zoothamnium niveum (Ciliophora)



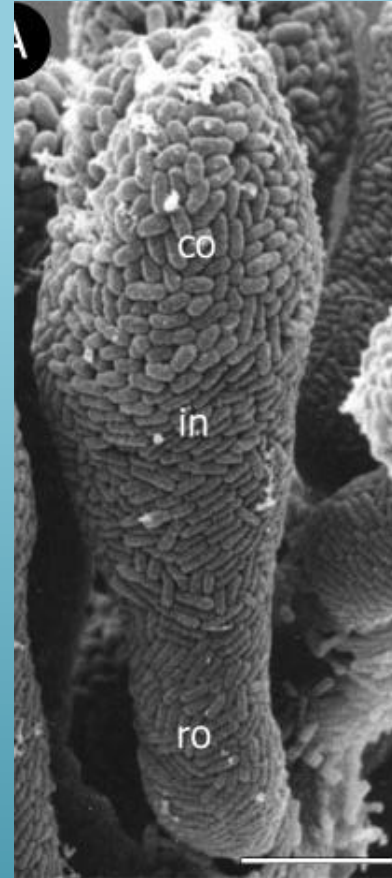
# Bacterial ectosymbionts of *Zoothamnium niveum*



Coccoid bacteria associated with microzooids



Rod-shaped bacteria associated with macrozooids, stalks and branches (Bauer-Nebelsick et al. 2006 *Euro. J. Protistol.* 32:18)



Morphological differentiation over a *Z. niveum* colony (Rinke et al. 2006 *App. Env. Microbiol.* 72:2014)

# Conclusions

- Biological units with subsets of individuality criteria are not exceptions.
- All (?) proposed criteria vary continuously.
- Single-cell bottleneck, germ-soma specialization do not always prevent genetic heterogeneity.
- Functional criteria probably require recognition of holobionts as individuals.
- A properly constructed concept of individuality should accommodate all of these cases.

# More conclusions

- To be useful, criteria need to be constructed in a taxon-independent way.
- Understanding the emergence of new kinds of individuals requires the recognition that individuality is a matter of degree.



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Fredericton, New Brunswick, Canada  
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Life Cycle  
Development and Cell Differentiation  
The Physics of Being Multicellular  
Evolution  
Genomics  
Molecular and Evolutionary Genetics  
Taxonomy and Phylogeny  
Genome Data Analysis

"... I saw a very many great round particles, of the bigness of great corn of sand drive and move in the water... This was to me a very pleasant sight, because the said particles, as often as I did look on them, did neither flye still, and that their motion did proceed from their turning round; and that the more, because I did fancy at first that they were small animals, and the smaller these particles were, the the greener was their colour... These particles had each of them within included 5, 6, 7, nay, some to 12 small round globules, of the same shape as the body wherein they were included." (van Leeuwenhoek, 1700)

Organizer:  
Aurora M Nedelcu UNB, Canada

Organizing Committee:  
Matthew Herron - UNM, Montana, USA; Erik Hanschen - UN Arizona, USA; David Smith - UBC, Canada; Hisayoshi Nozaki - U Tokyo, Japan; Jim Umen - Donald Danforth Ctr, USA; Stephen Miller - UMBC, USA; Armin Hallmann - U Bielefeld, Germany; Aurelia Honerkamp-Smith - Cambridge, UK

## Sponsorship



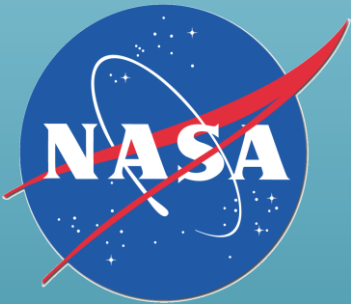
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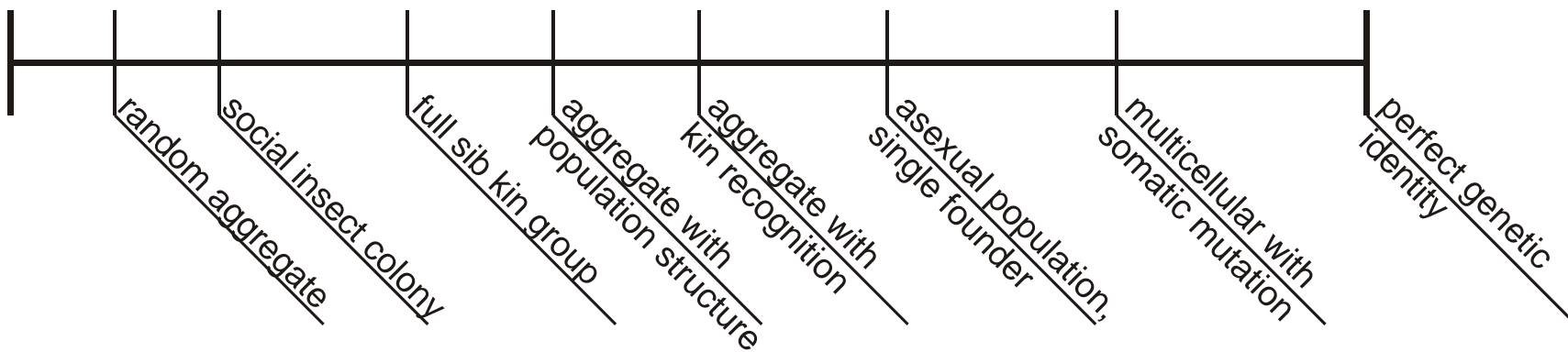


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- Deborah Shelton
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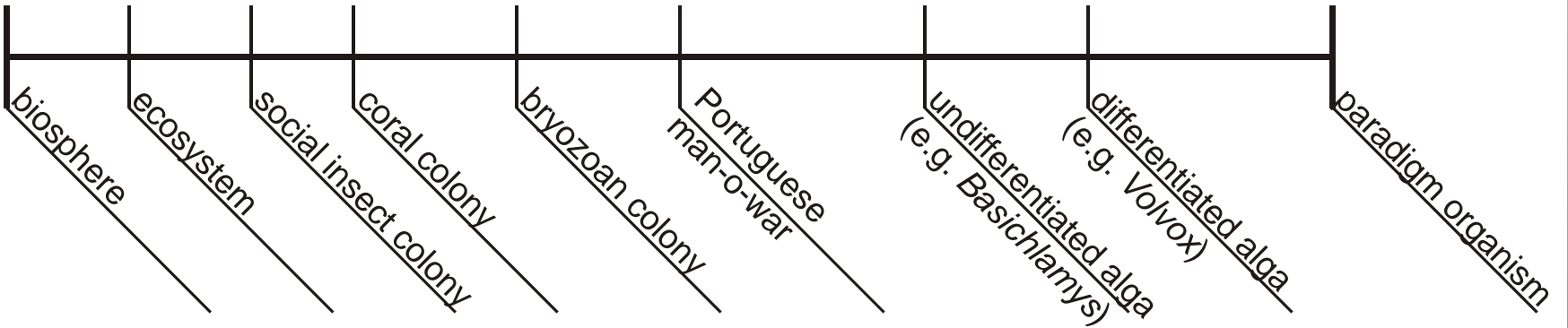


Increasing genetic homogeneity →

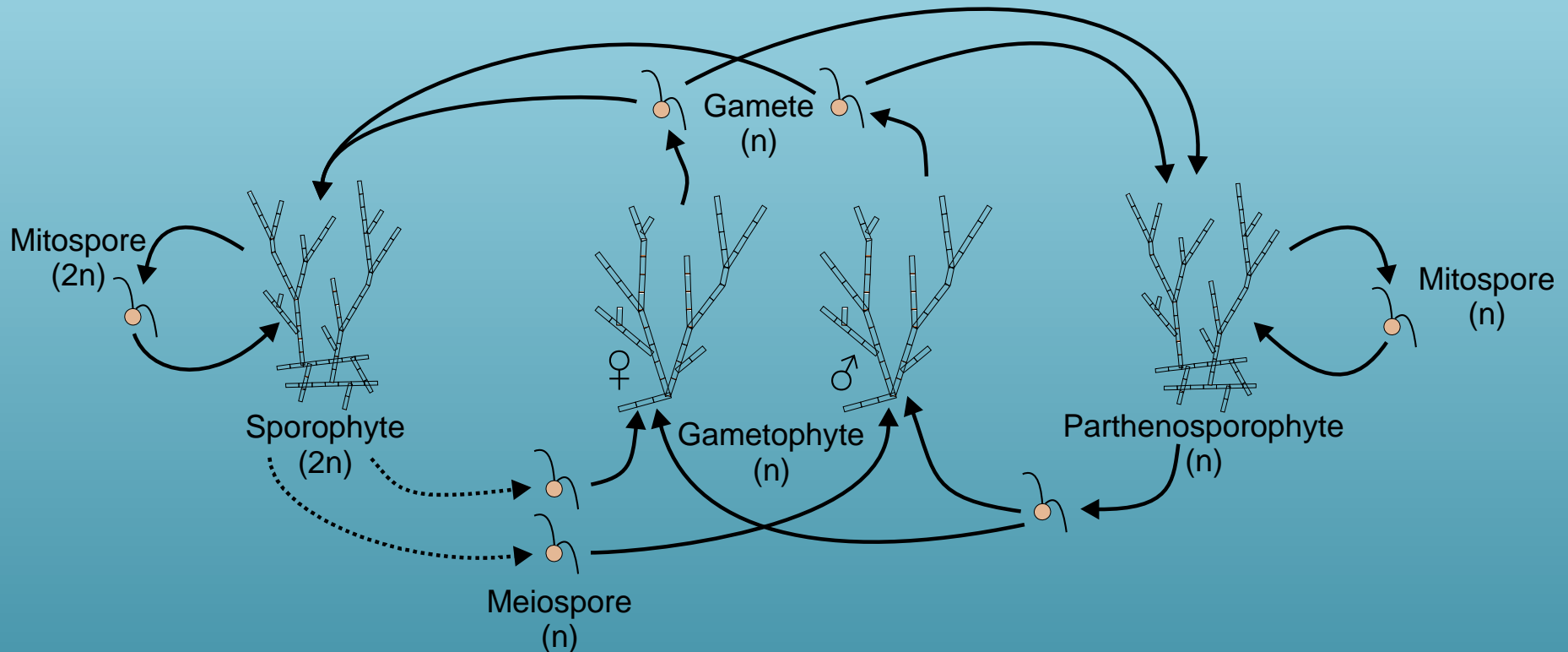




Increasing physiological integration →

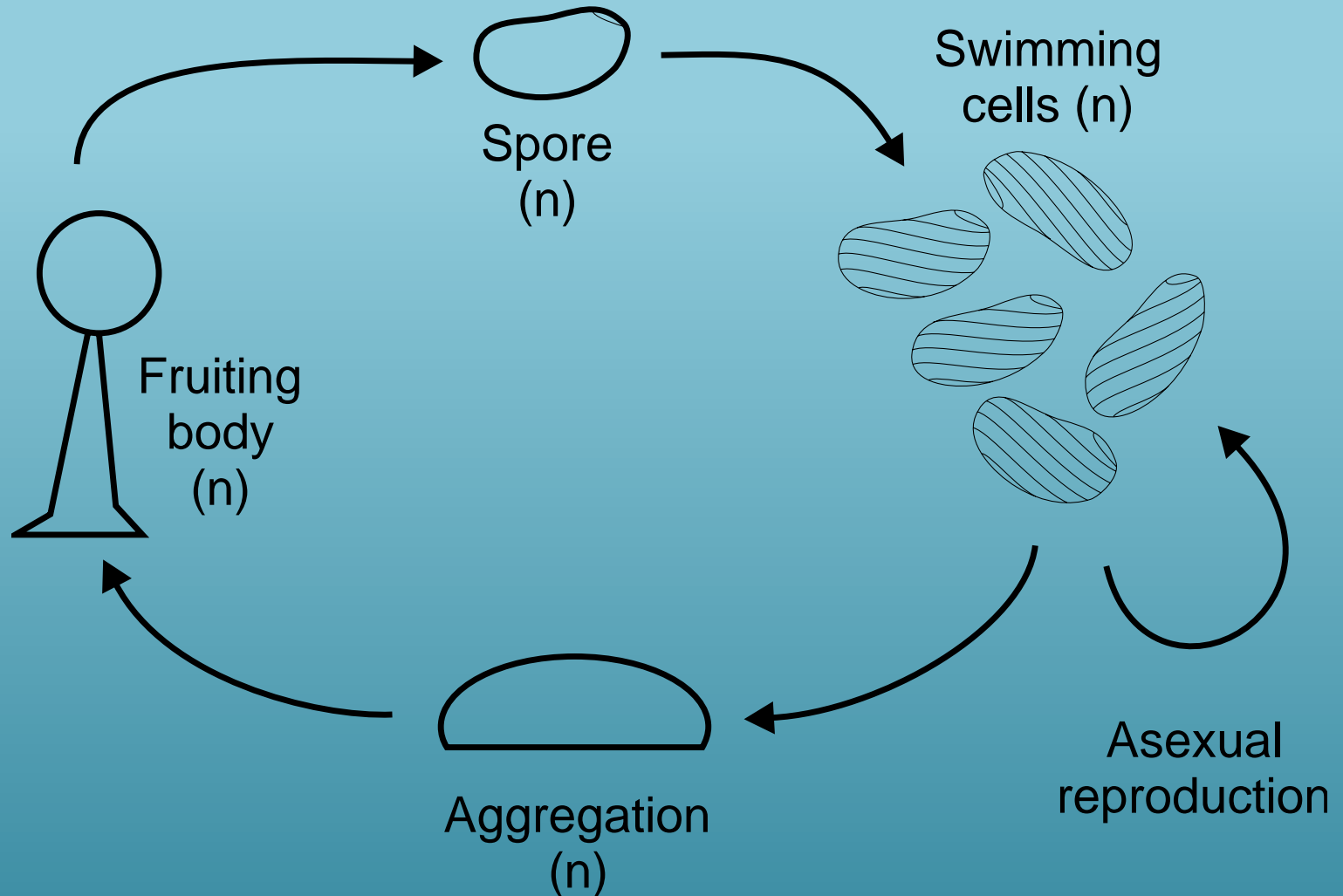


# *Ectocarpus siliculosus* (Phaeophyta)



Adapted from Charrier et al. 2008 *New Phytol.* 177:319

# *Sorogena stoianovitchae* (Ciliophora)



Adapted from Sugimoto & Endoh 2008 *J. Euk. Microbiol.* 55:110