

# Genome size and body size in ectotherms related to temperature; Ecological and evolutionary drivers

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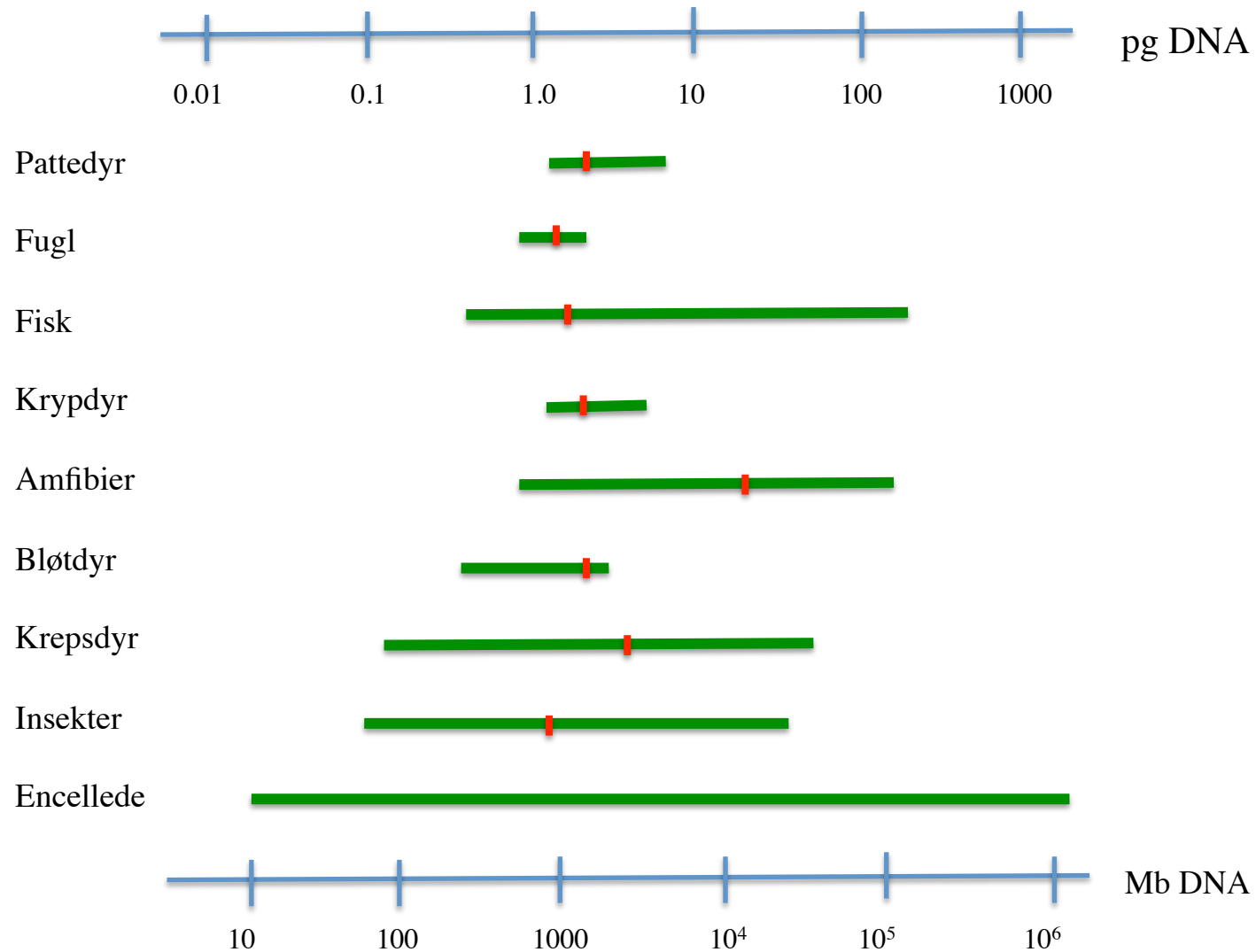


# Temperature, Bergmann and TRS



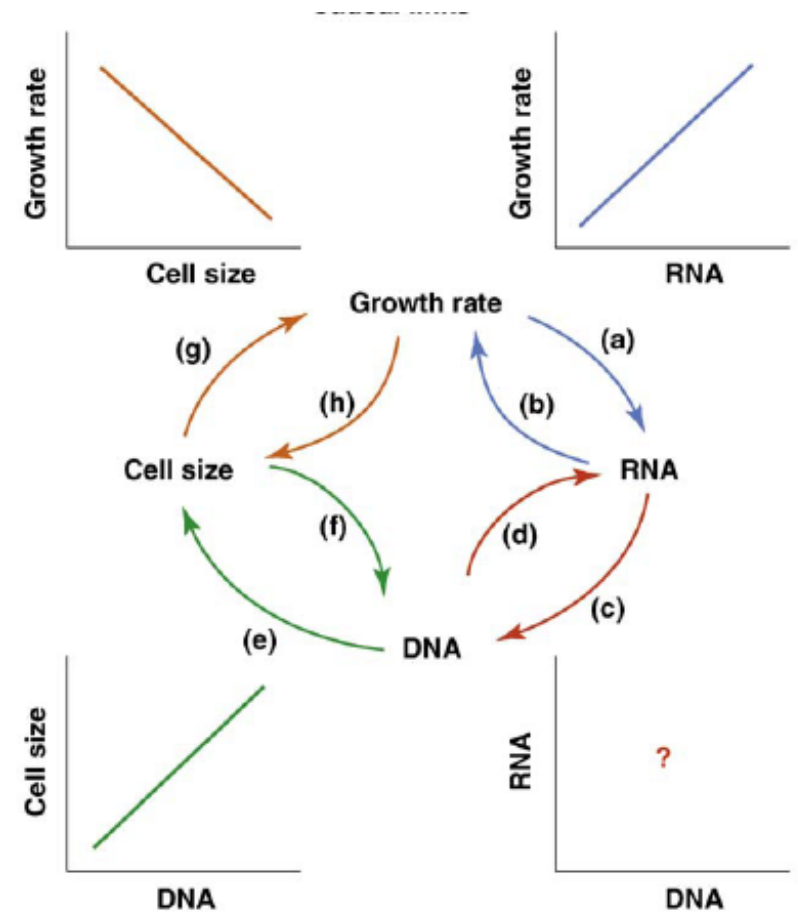
- Large size at low temperature ecosystems (Bergmann type rules)
- Large size when raised at low temp (Temperature-Size Rules)
- Phenotypic or genotypic effects?
- Same effect, but for different reasons?
- How and why does size increase?
- Does this imply “shrinking” of cells and species at elevated temperatures?

# The “C-value paradox”

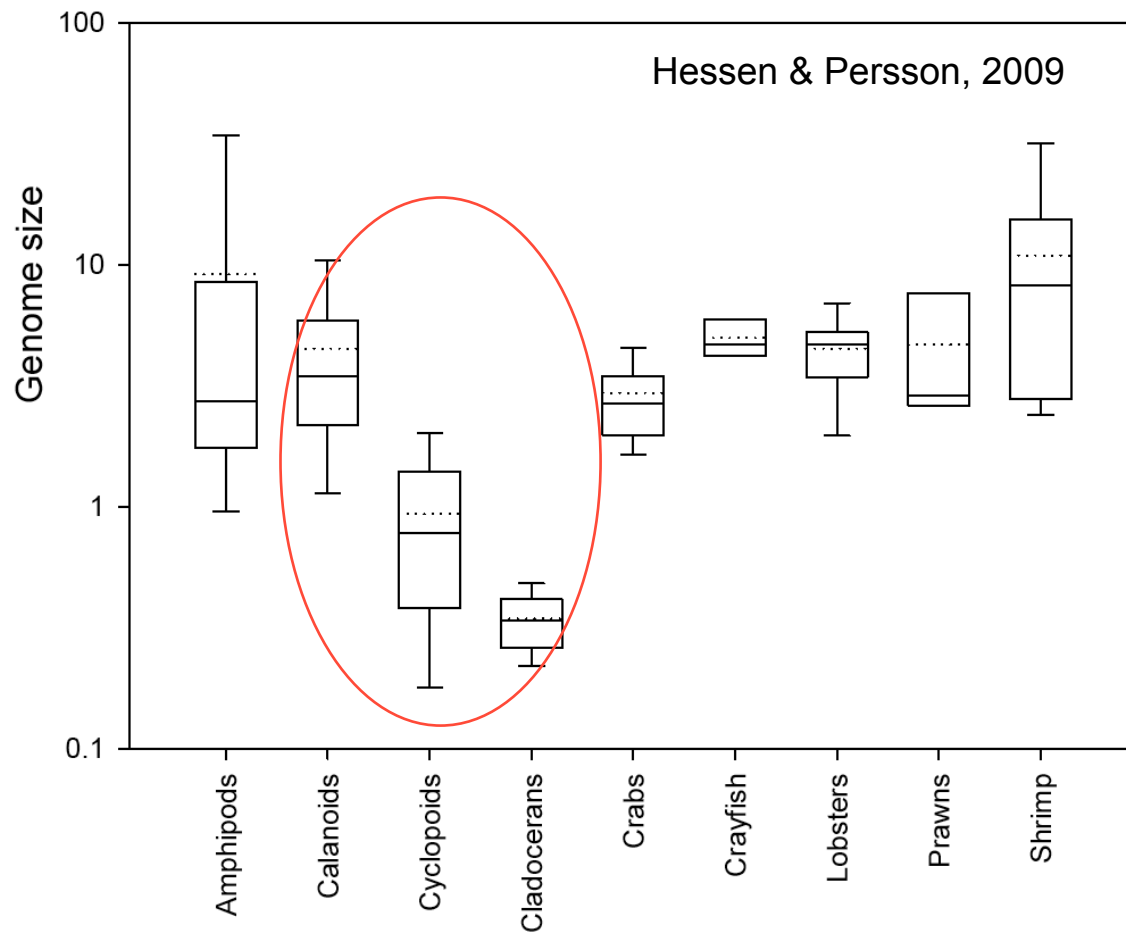


# Growth, genome size, RNA - causes and correlations?

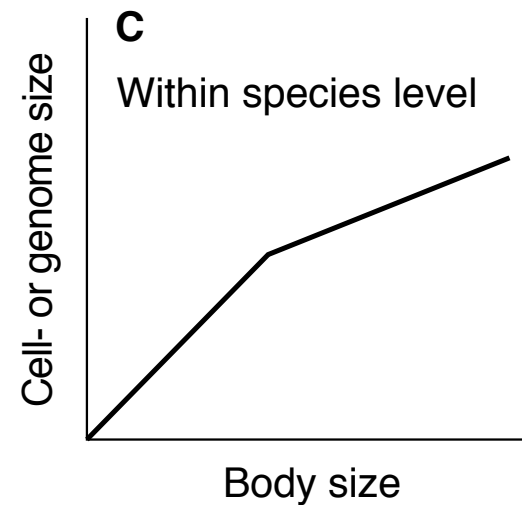
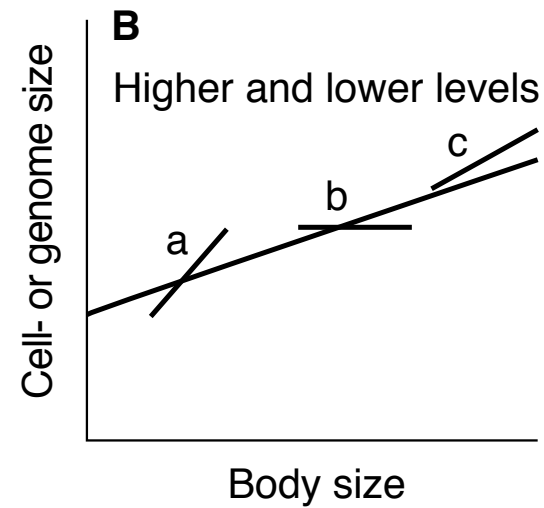
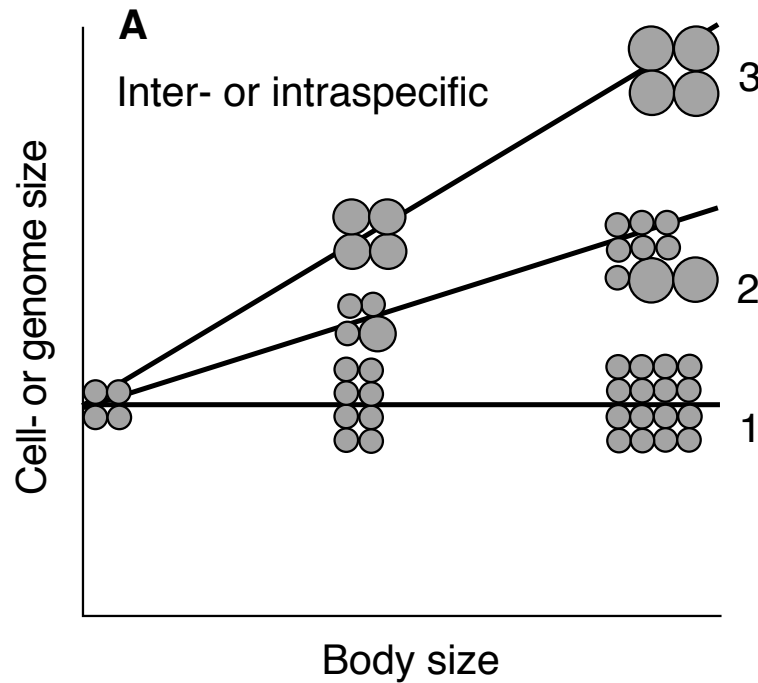
- Small genome = small cells
- Small genome = high growth rate
- Small genomes = high RNA
- Metabolic activity scales with [RNA] and [DNA]
- Low temperatures go along with large genomes
- Does large cells correlate with large bodies?
- *Striking correlations but unresolved causalities*



# E.g. crustaceans: tremendous variability in genome size – but why?



# Growth by increased cell size or cell number?



# Body size evolution

## – by cell size or cell number?

- Body volume and genome size: slope = 1 means growth by cell number, slope = 0 means growth by cell size
- Different evolutionary strategies? I.e. with finite cell number you can only grow by cell enlargement
- Often mixed strategies or endopolyploidy
- The role of (endo)polyploidy is not well understood

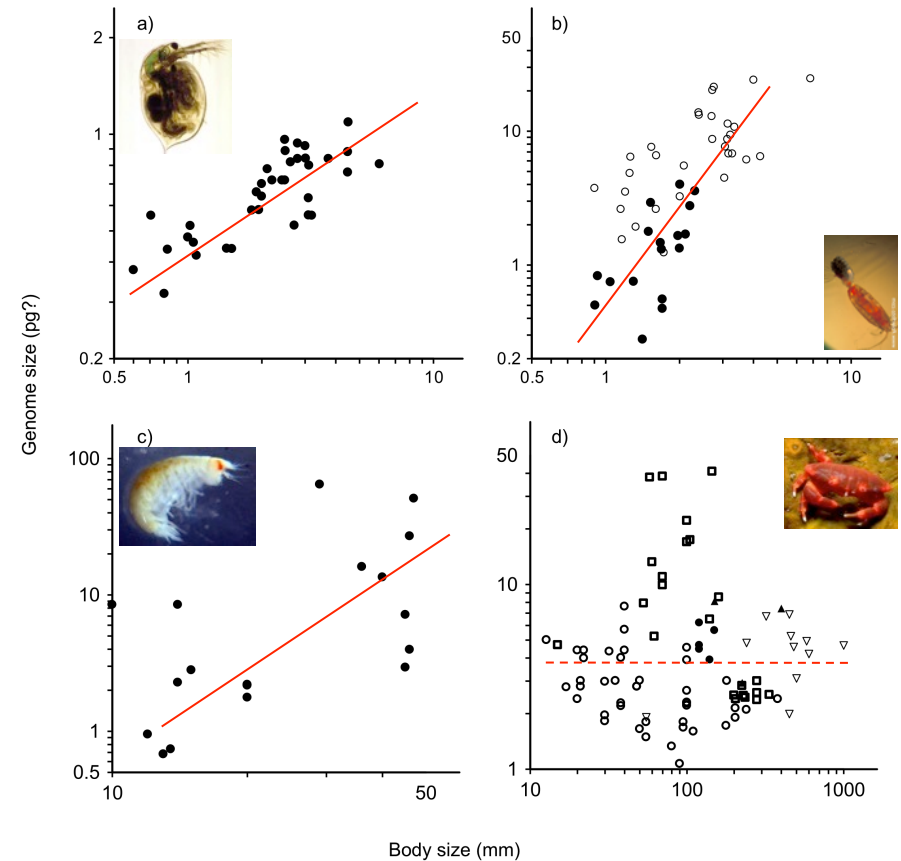


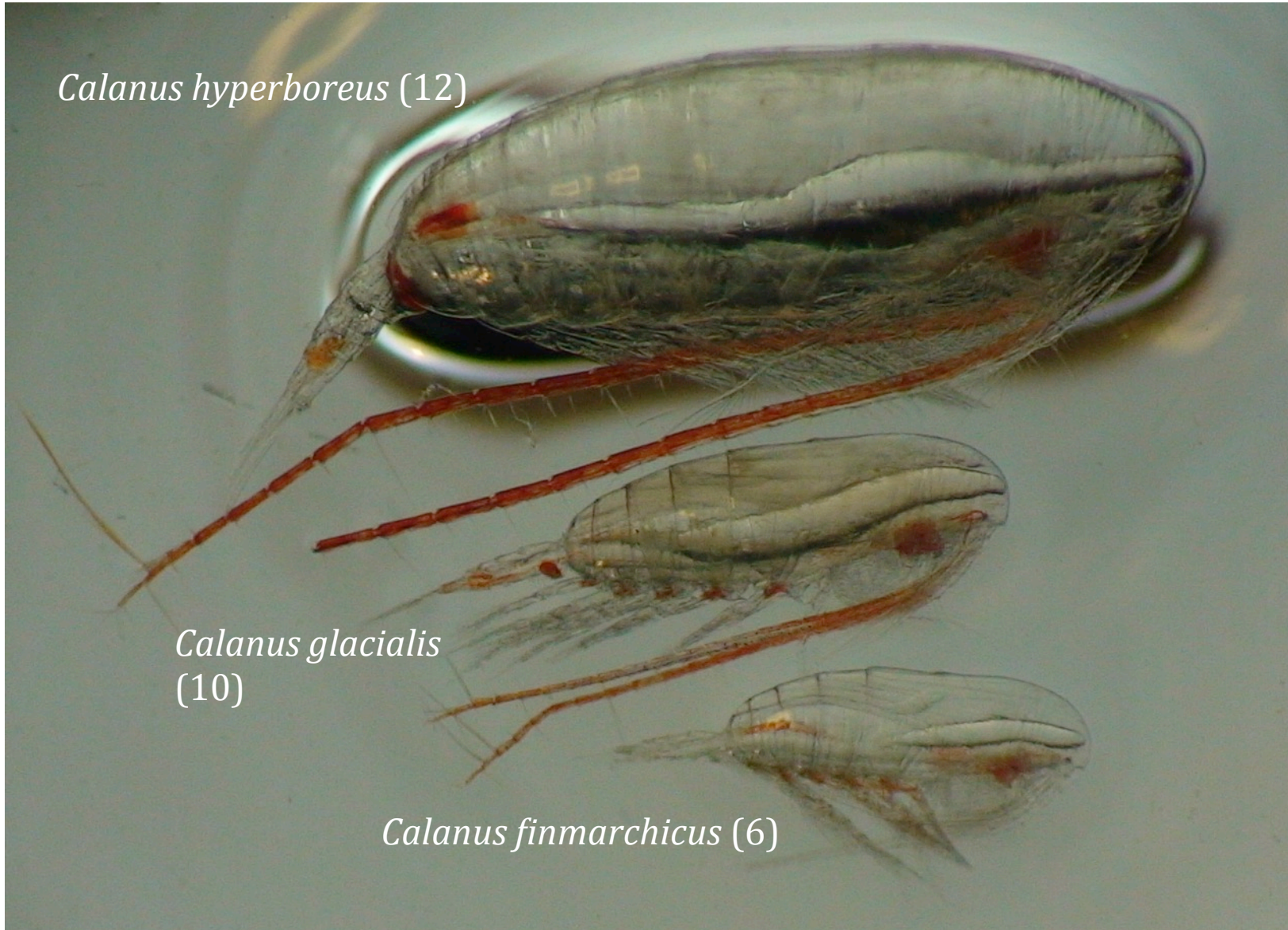
Figure 2. a) Cladocerans b) ● Calanoids ○ Cyclopoids c) Amphipods d) ○ Crabs ● Crayfish ▲ Prawns □ Shrimps Δ Lobsters

# Speciation by genome- cell and body size?

*Calanus hyperboreus* (12)

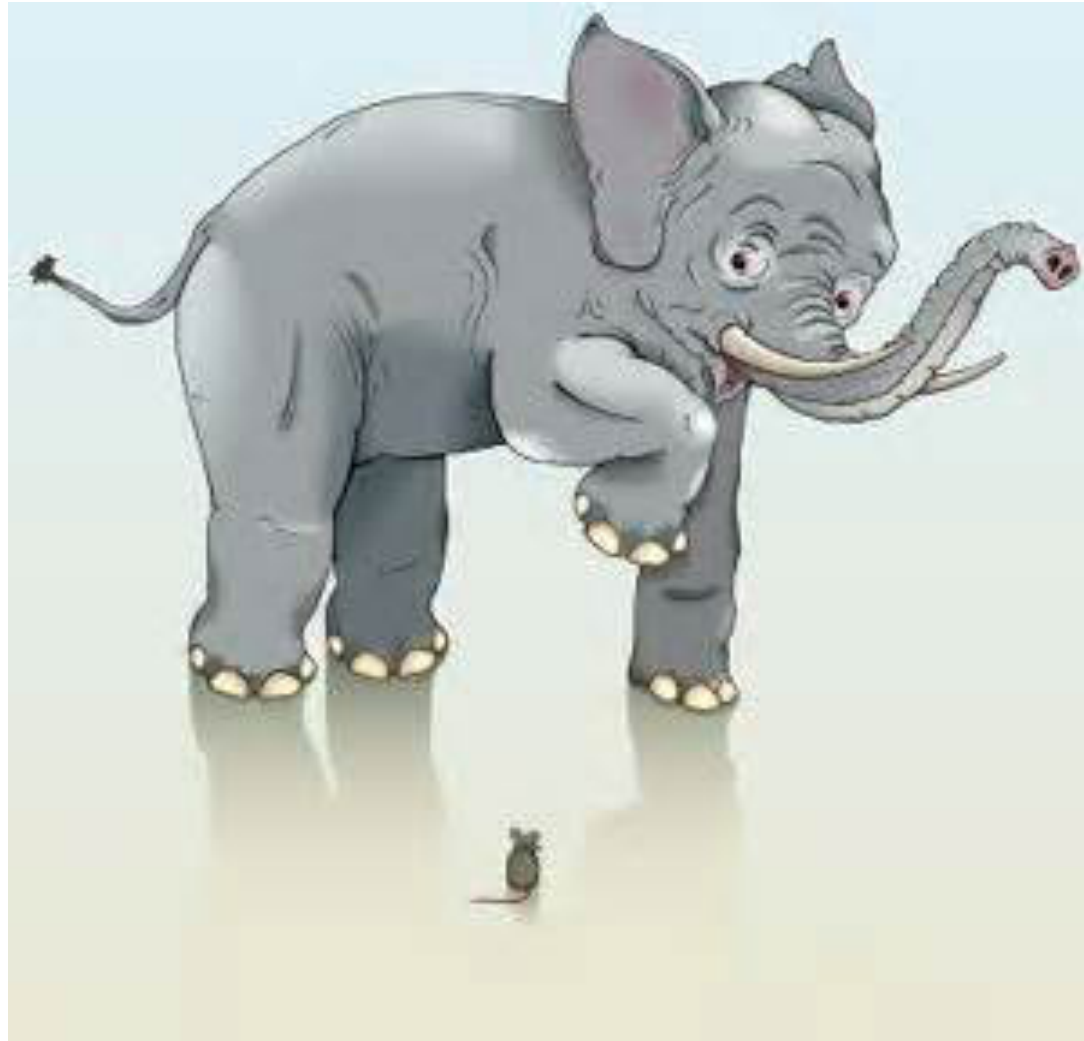
*Calanus glacialis*  
(10)

*Calanus finmarchicus* (6)

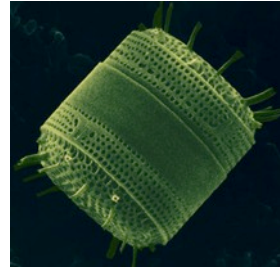




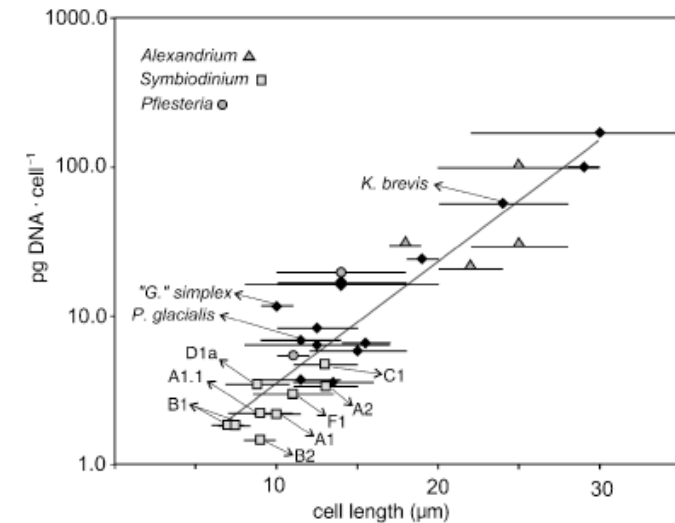
But genome size do not scale with body size for homeotherms



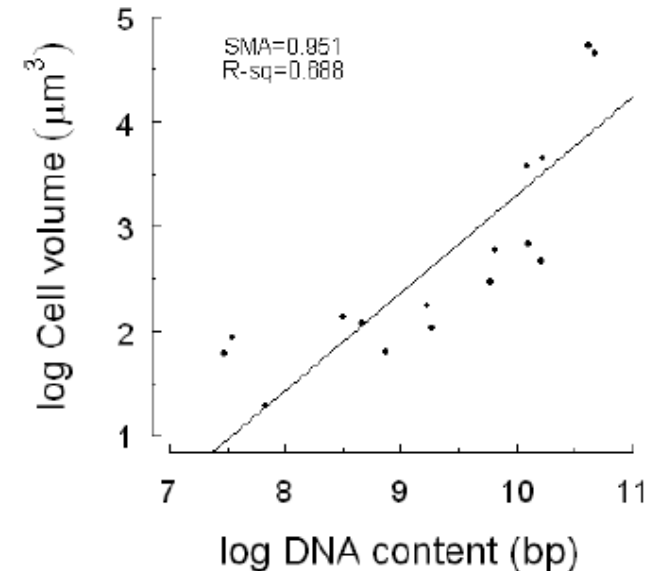
# What about autotrophs?



- High growth rate correlates with small genomes also for plants
- Cell volume correlates with genome size in phytoplankton
- P- (and N) sparing as a cause for haploidy in phytoplankton? (cf. Lewis, Am. Nat. 1985)



LaJeunesse et al. J. Phycol. (2005)



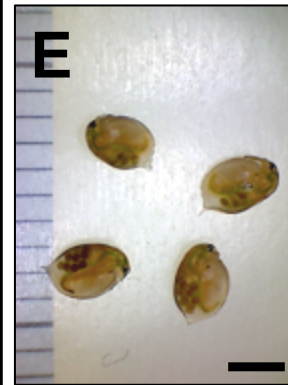
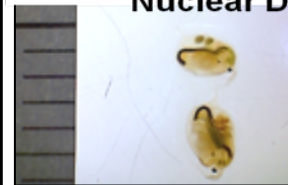
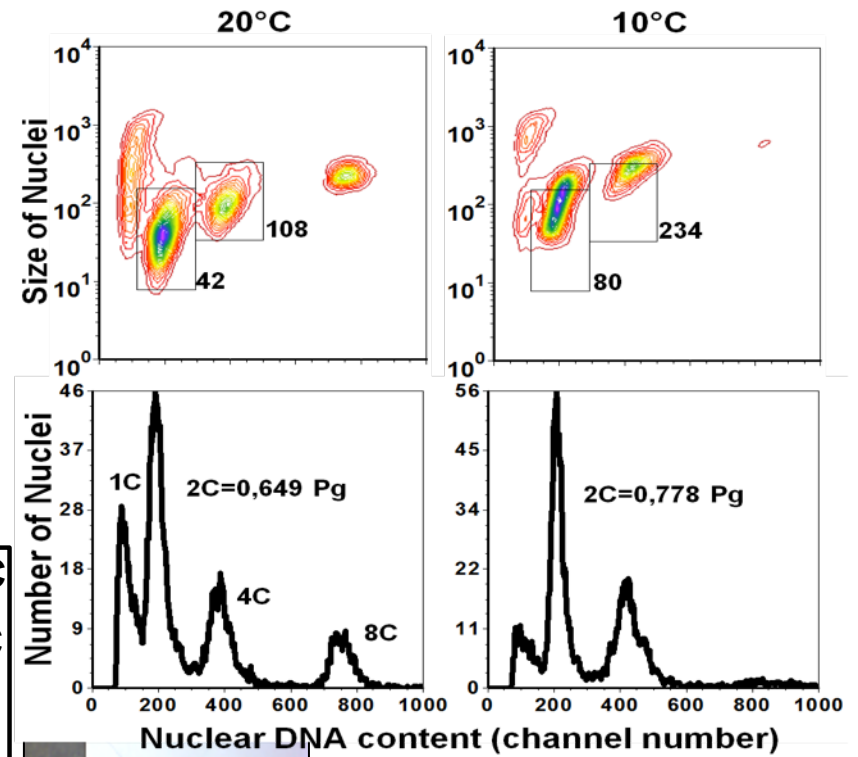
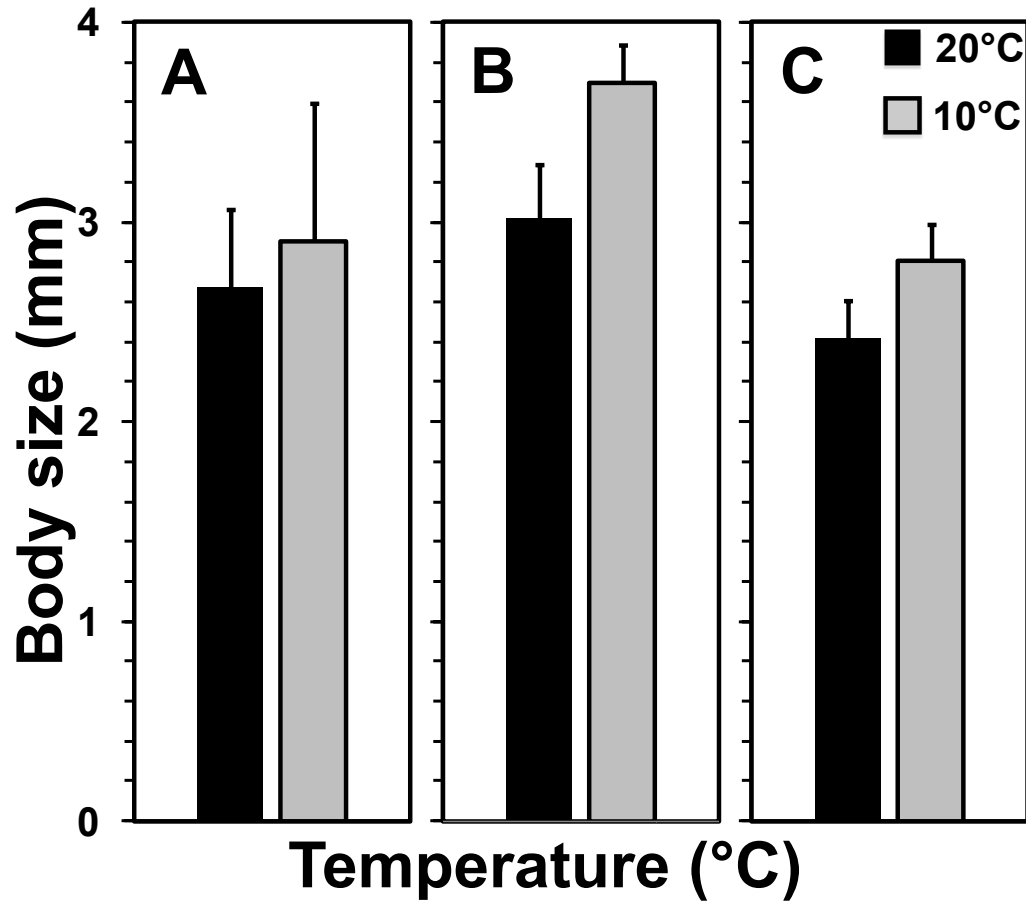
Connolly et al. J. Phycol. (2008)

# Benefits of small genomes straightforward, but why large genomes?

- Large body size?
- Slow growth?
- Lipid accumulation?
- Or simply lack of counter-selective forces?
- The role of population size?

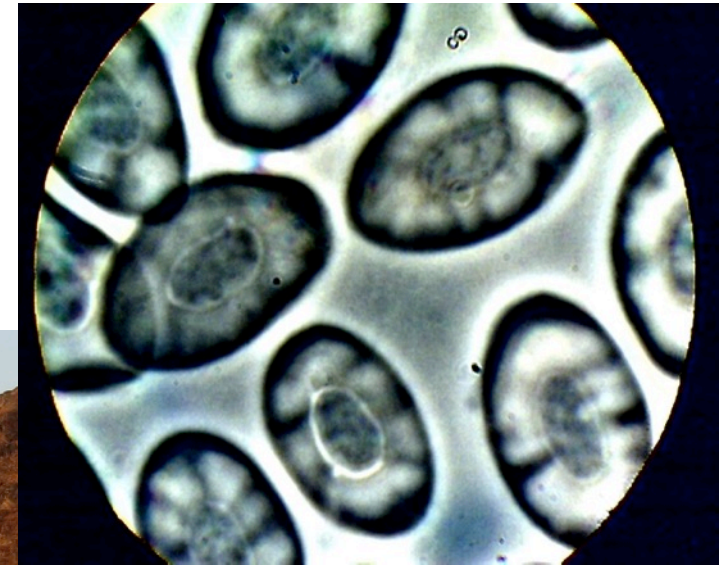


# Daphnia genome size and temp

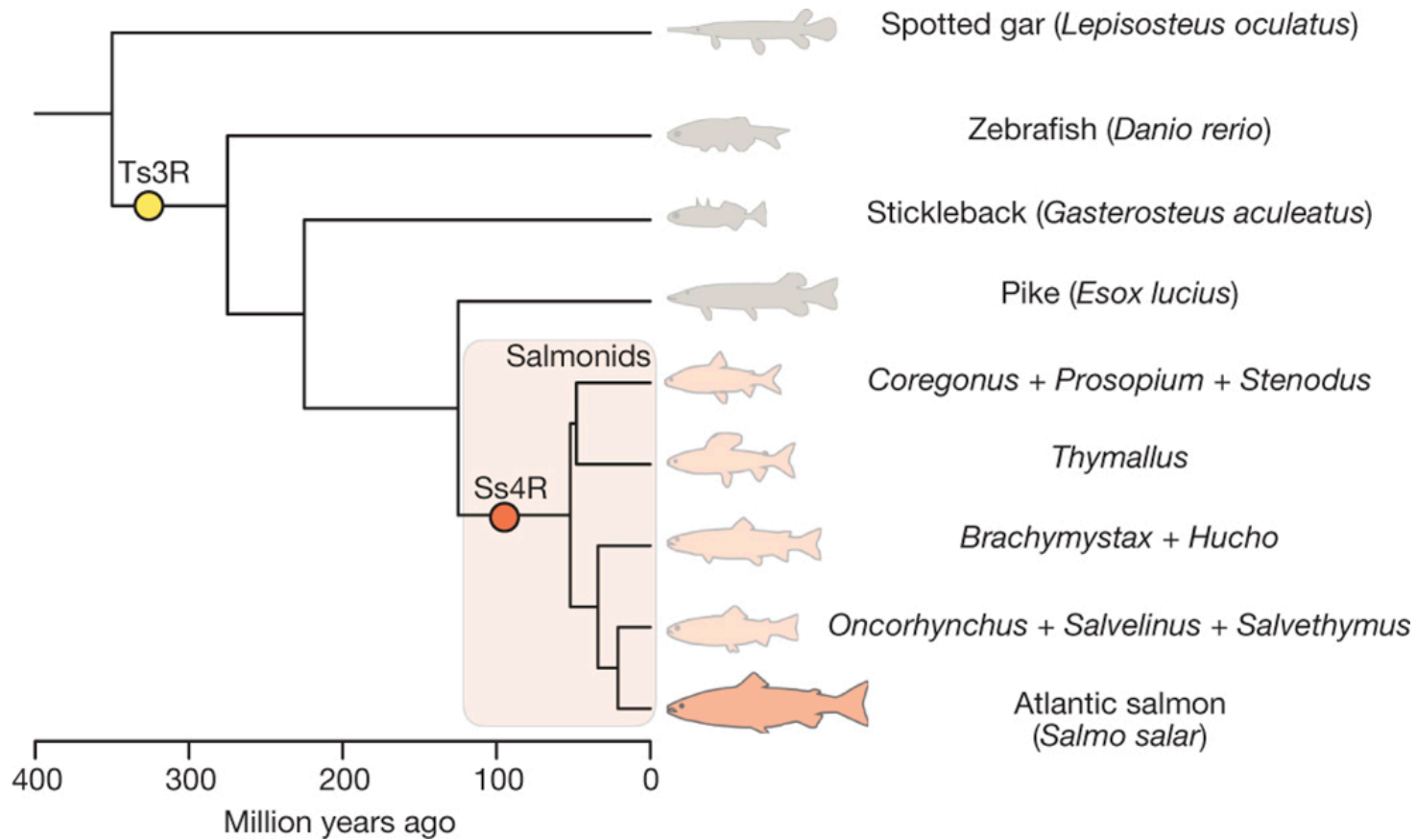


3 mm

# Blood-cells char, size, temp



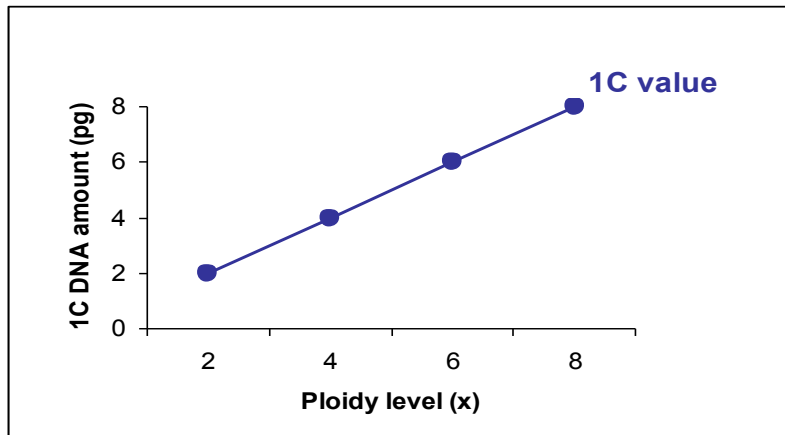
# Polyploidy - whole genome duplications in several lineages



S Lien *et al.* *Nature* 1–6 (2016) doi:10.1038/nature17164

nature

# Genomic downsizing and genome streamlining

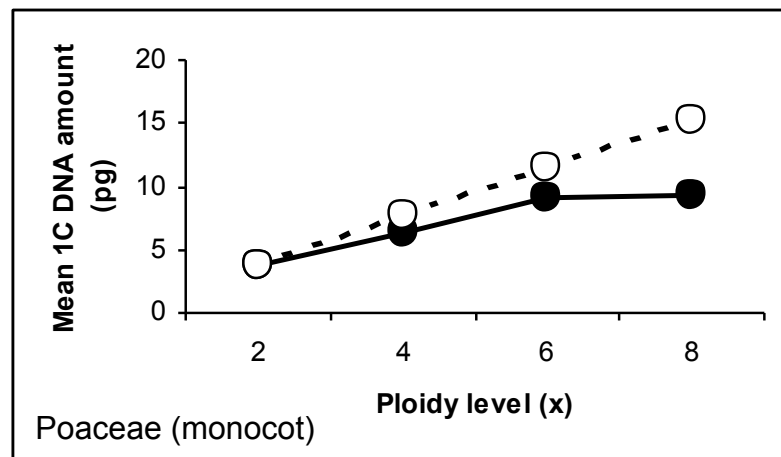


C-values of polyploids are expected to increase in direct proportion to ploidy level

Recent polyploids:  
DNA content tends to be exactly a multiple of the diploid's C-value

## Genomic downsizing:

Polyploid formation often followed by loss of DNA



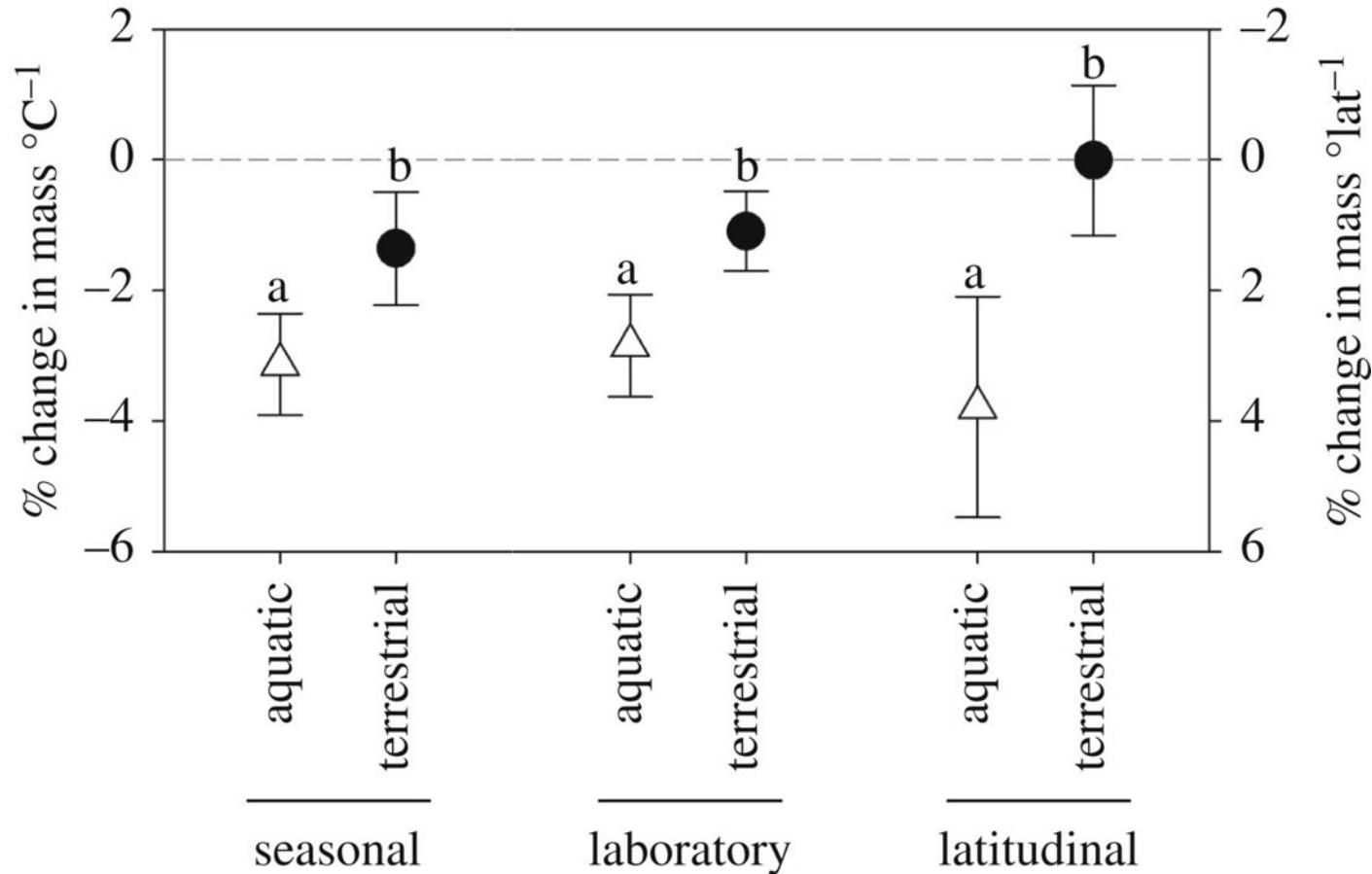
Older polyploids:

Deviations due to genomic re-structuring

- a smaller C-value
- reduction of the biochemical costs
- enhancement of homologous pairing

## Genomic streamlining: a different process

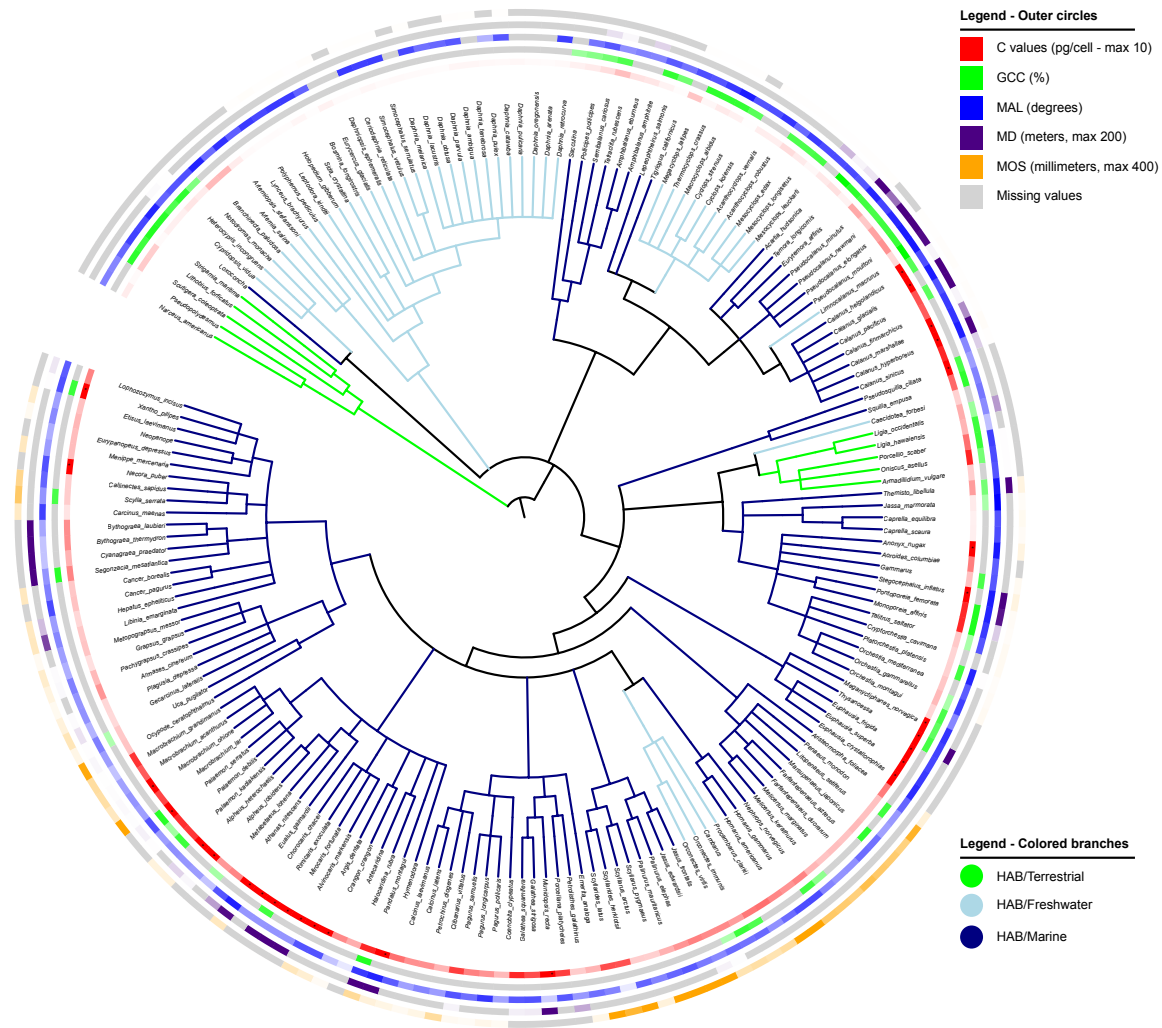
Comparison of mean aquatic- and terrestrial-developing seasonal temperature–body size gradients (% change in mass per °C ± 95% CI, left-hand y-axis) in arthropods with laboratory T-S responses (% change in mass per °C ± 95% CI, left-hand y-axis) and L-S clines (% change in mass per °latitude ± 95% CI, right-hand y-axis) for multivoltine species, using data from this study and Horne et al. [13].



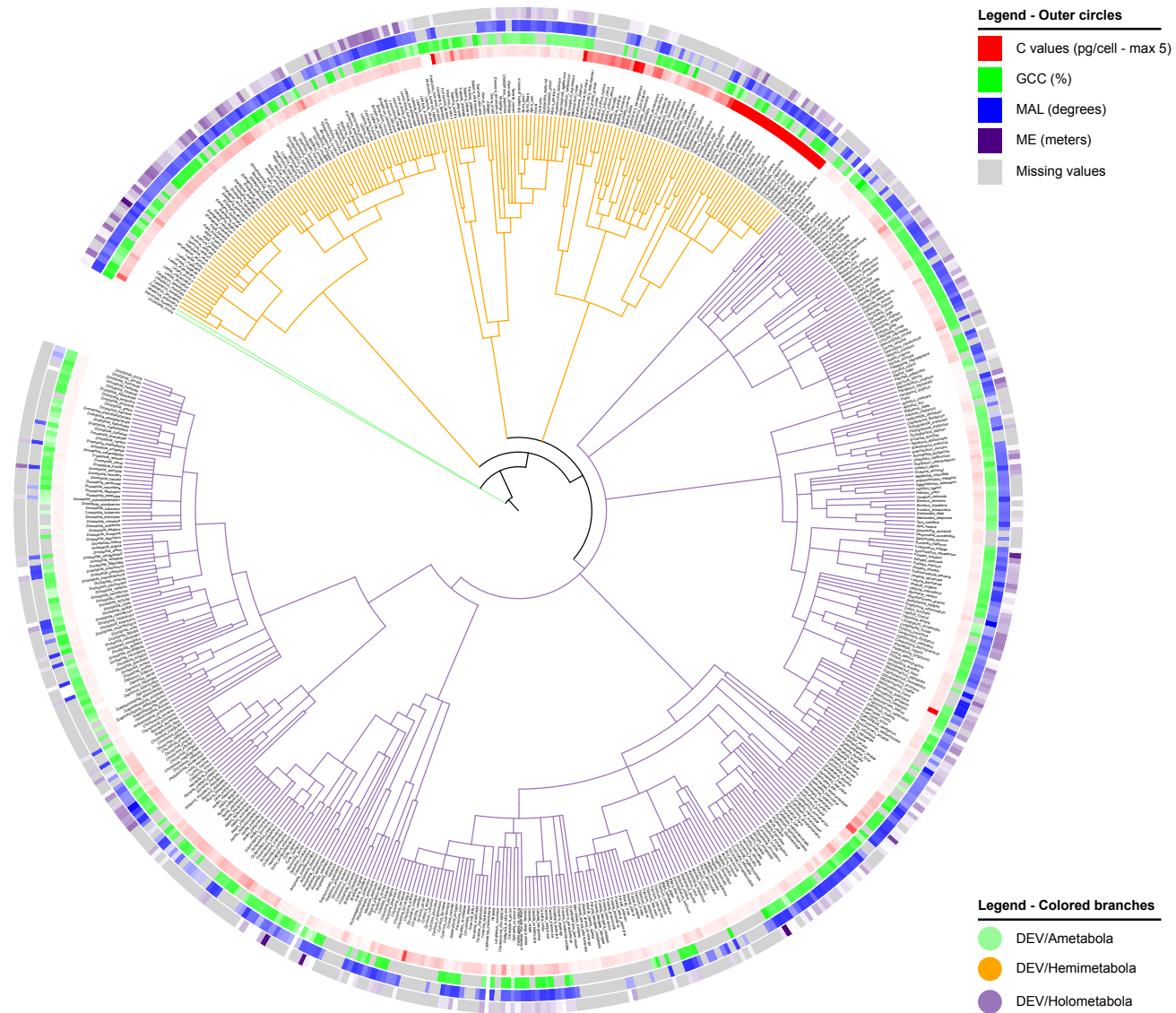
Curtis R. Horne et al. Proc. R. Soc. B 2017;284:20170238



# Phylogeny or ecology- crustacea?



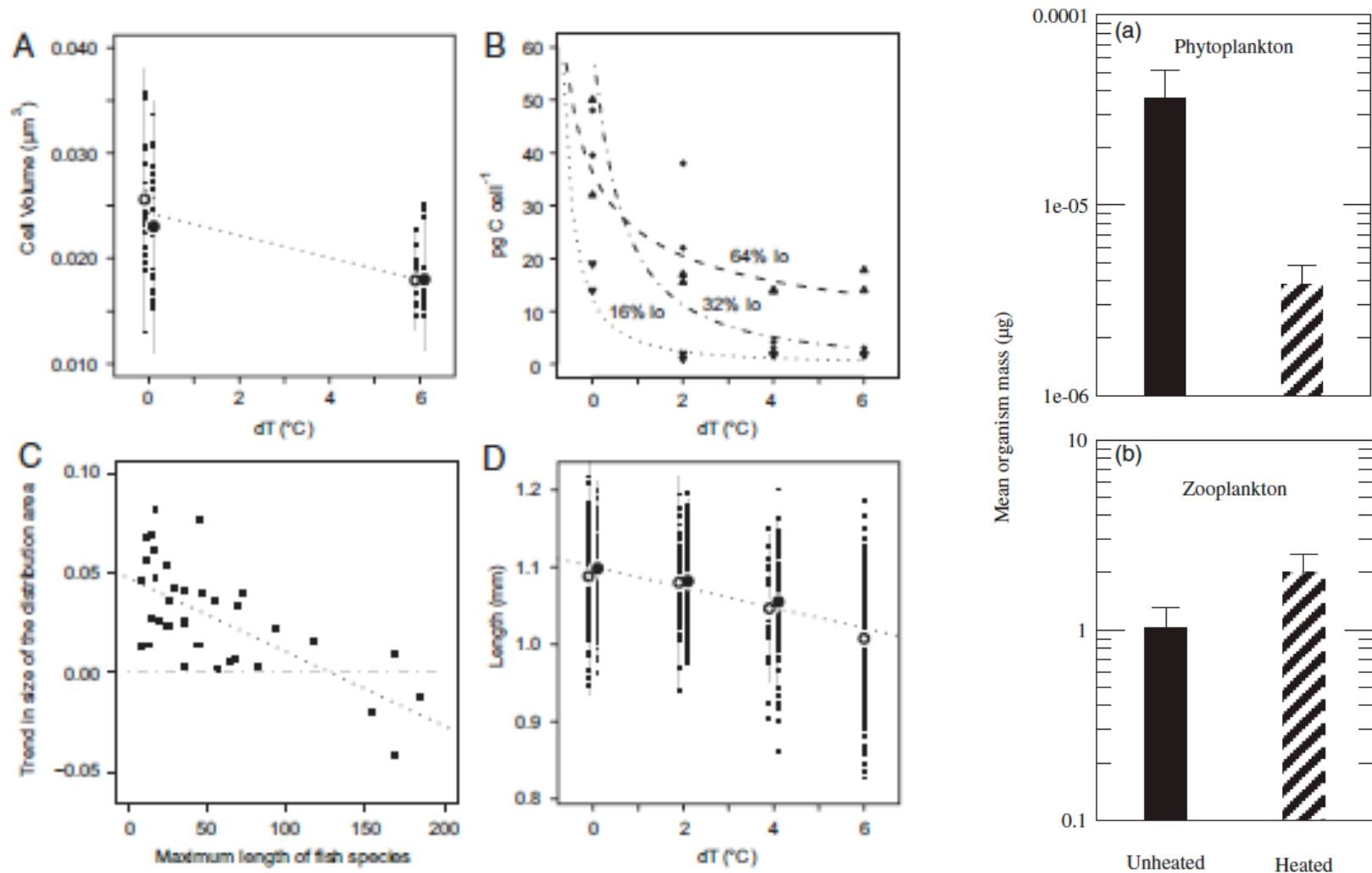
# Phylogeny or ecology- insects?



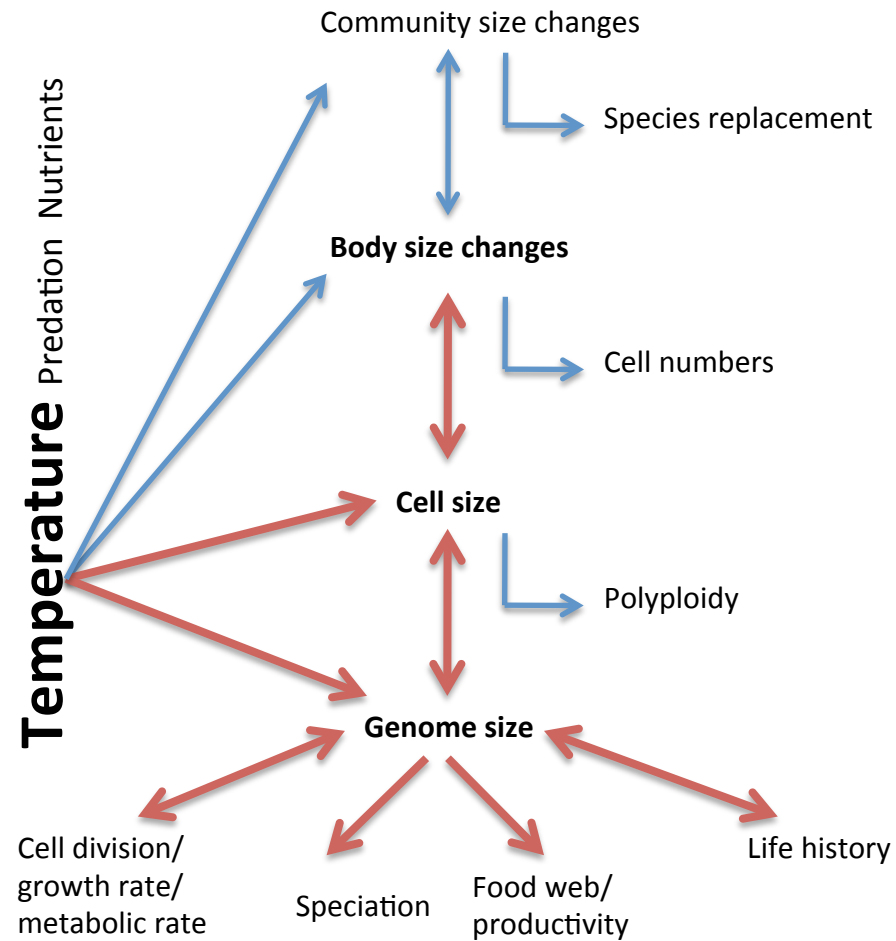
# Size effects: Temperature, nutrients, O<sub>2</sub> – or grazers.....

- A risk of confounding factors: Increased temperature gives increased thermal stability, surface nutrient scarcity, and smaller cells due to surface-volume ratio.
- Community shifts and species “shrinking”: different routes to smaller cells
- Temp and P could pull in the same direction
- Other confounding factors: grazing, dissolved O<sub>2</sub>...

# Recent studies suggest smaller cells at higher temp



# Temperature and size: causes and consequences



# Thanks to the DWARF consortium

