

# Cell size, genome size, plant strategies and directional evolution...

Greg and Ray and Tim

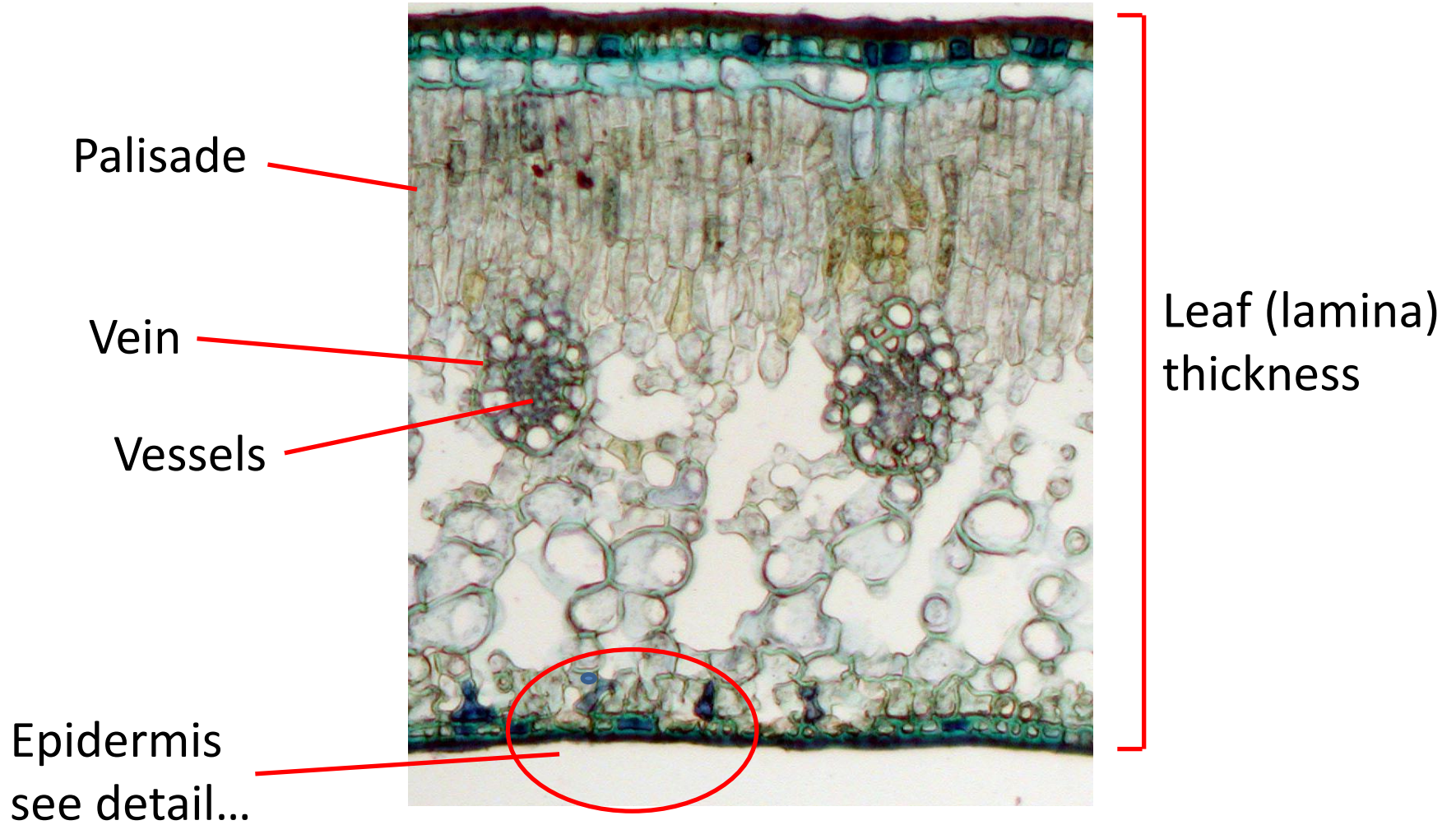
# Proteaceae are the best organisms in the world



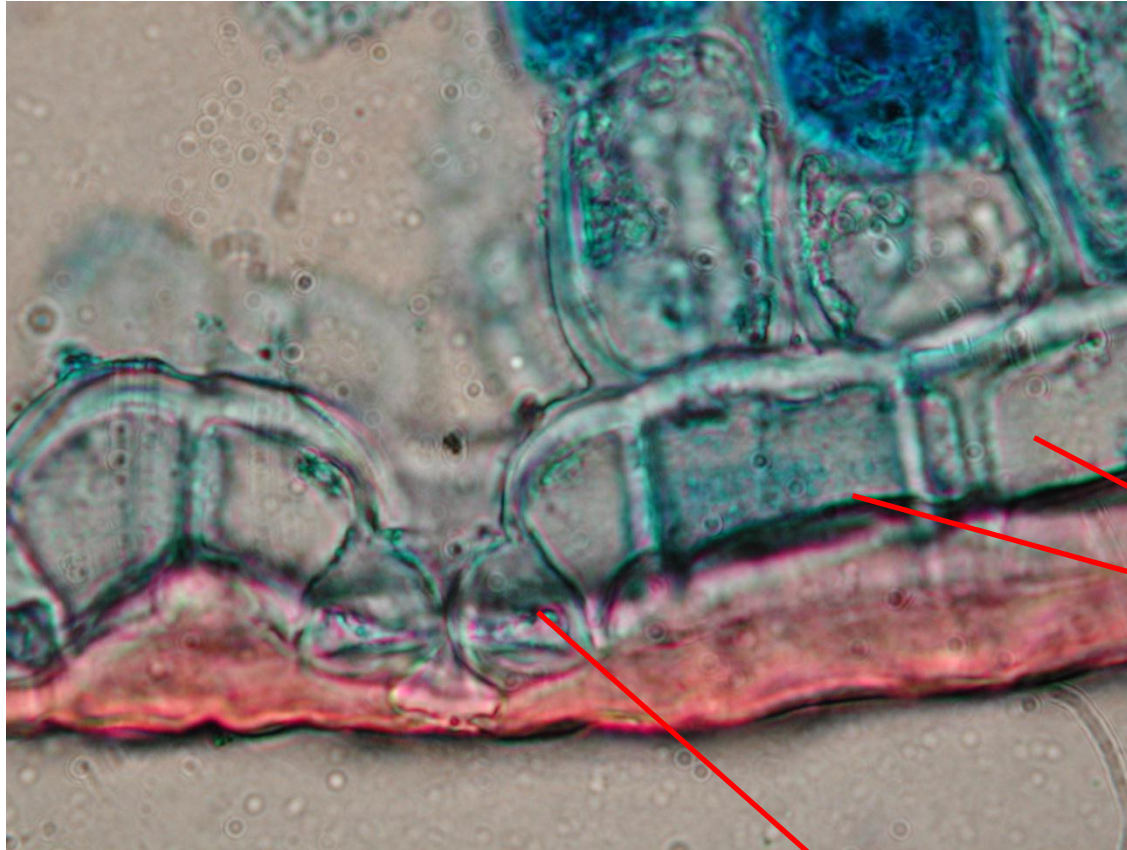




# a short stroll through leaf anatomy



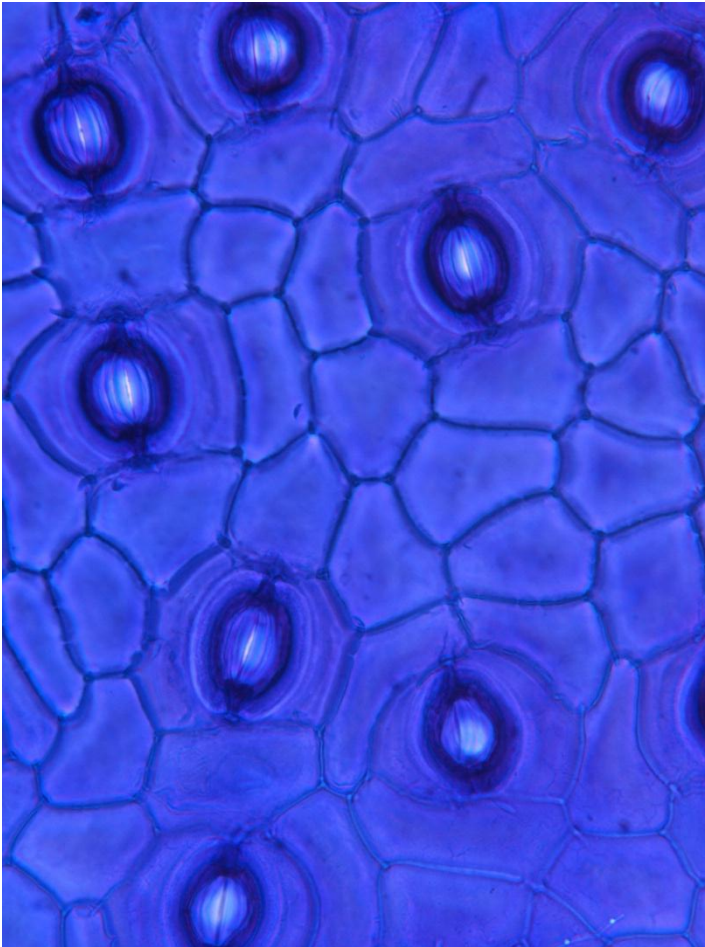
# Detail of an epidermis



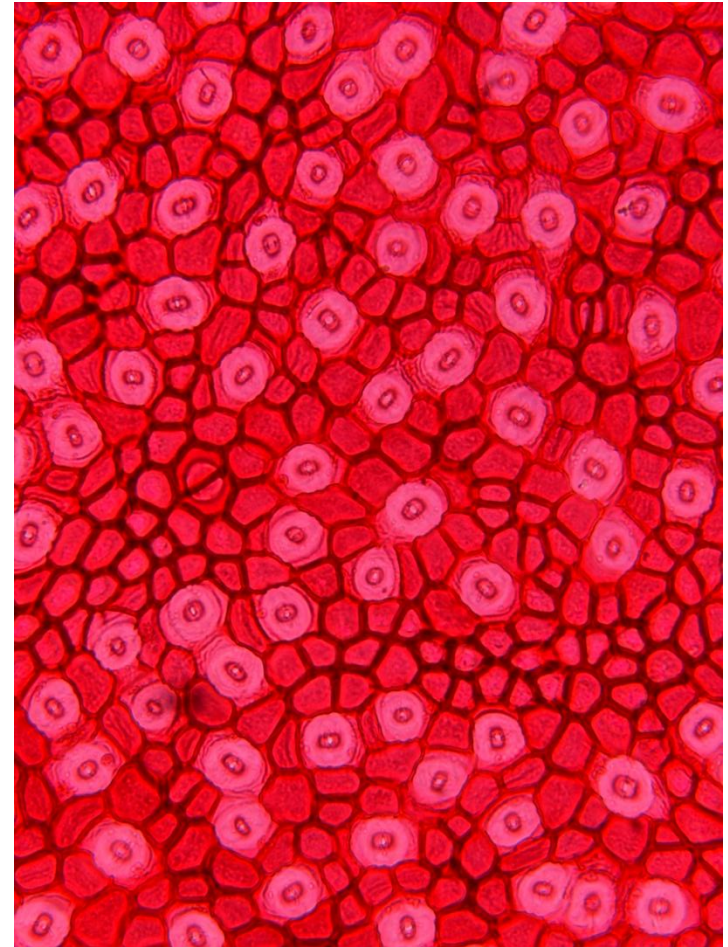
Epidermal  
cells

stomate

# Epidermis in surface view

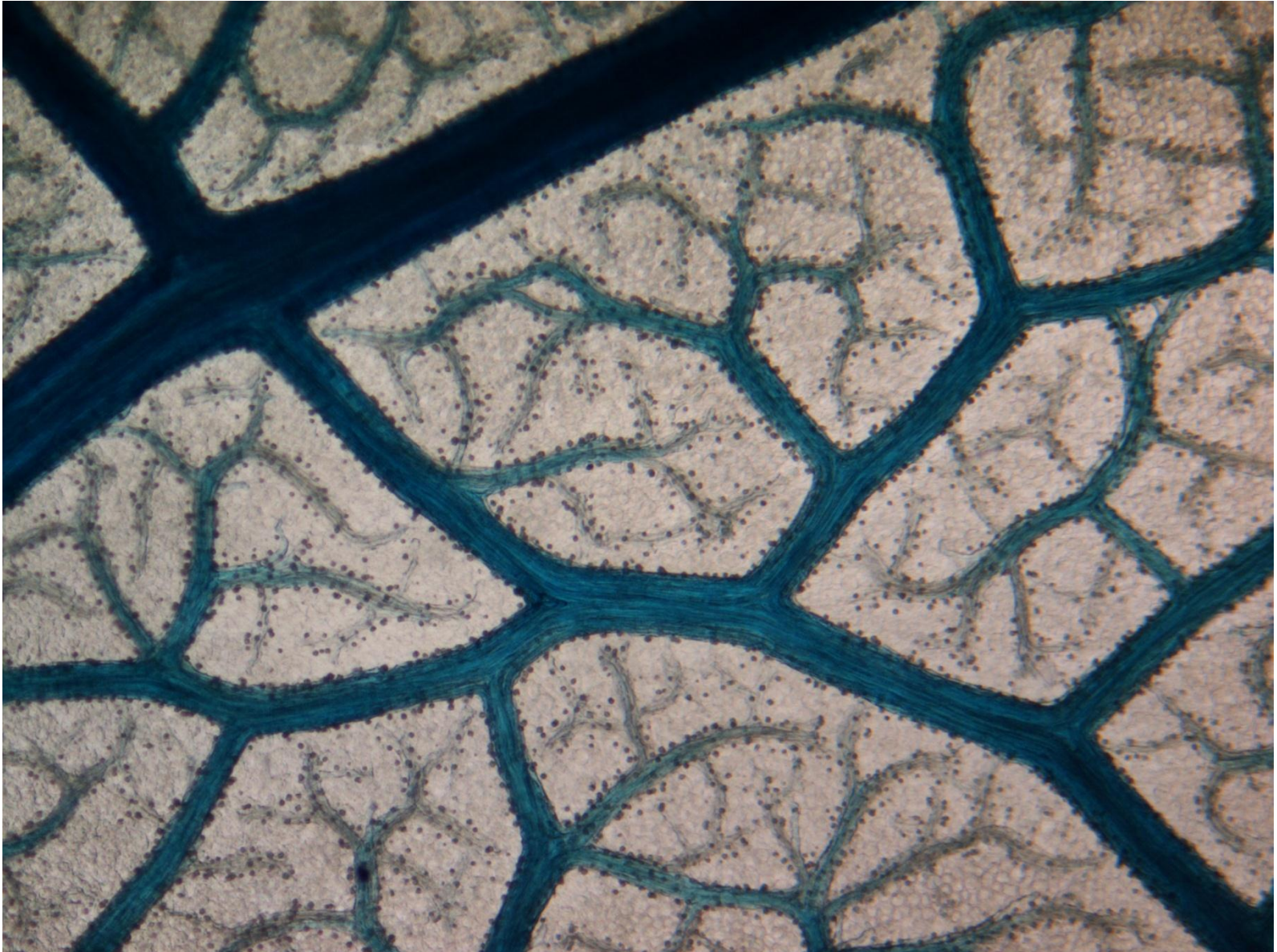


big epidermal cells  
big stomates  
low stomatal density



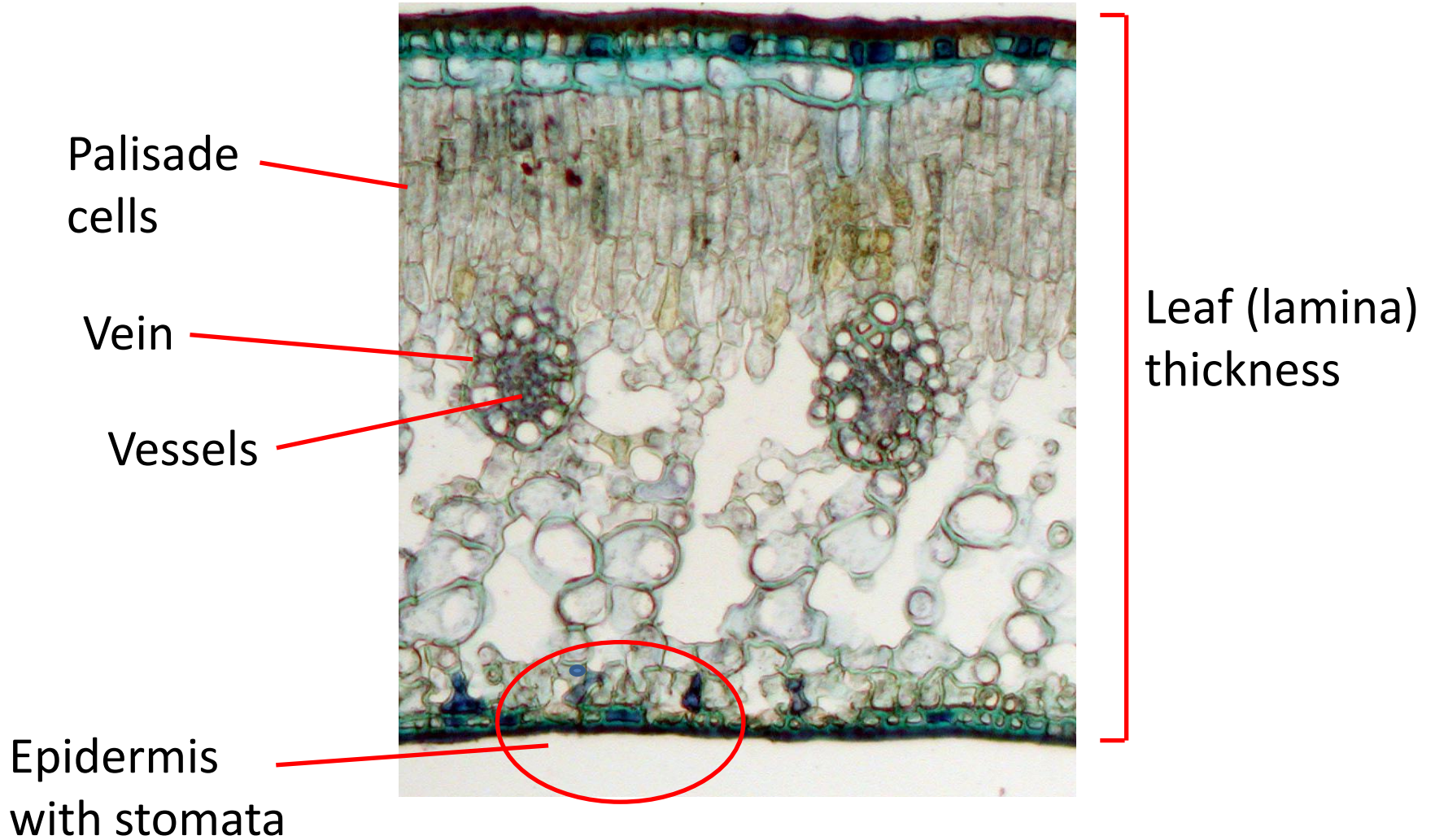
small epidermal cells  
small stomates  
high stomatal density

paradermal section showing vein density

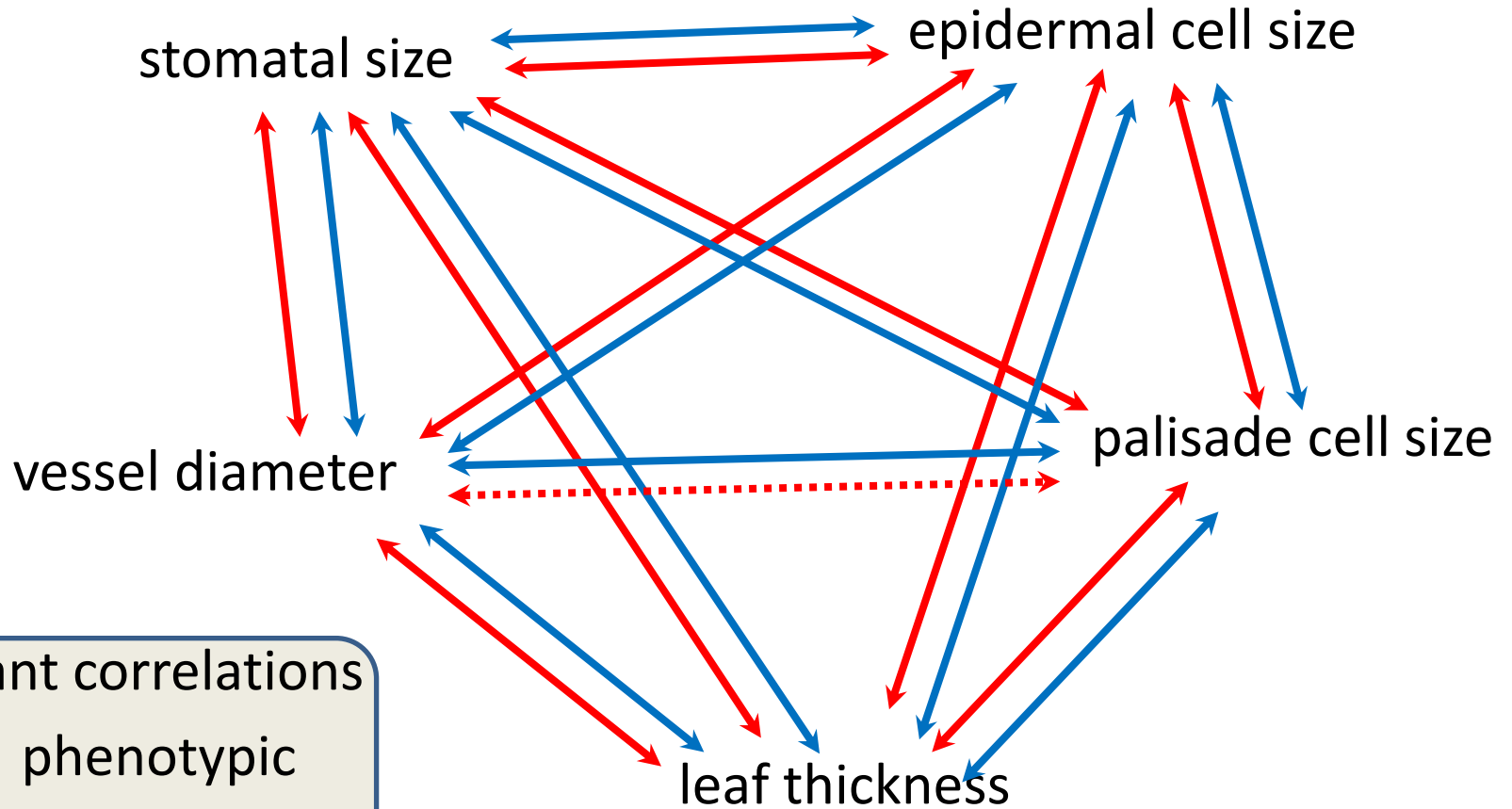




# a short stroll through leaf anatomy



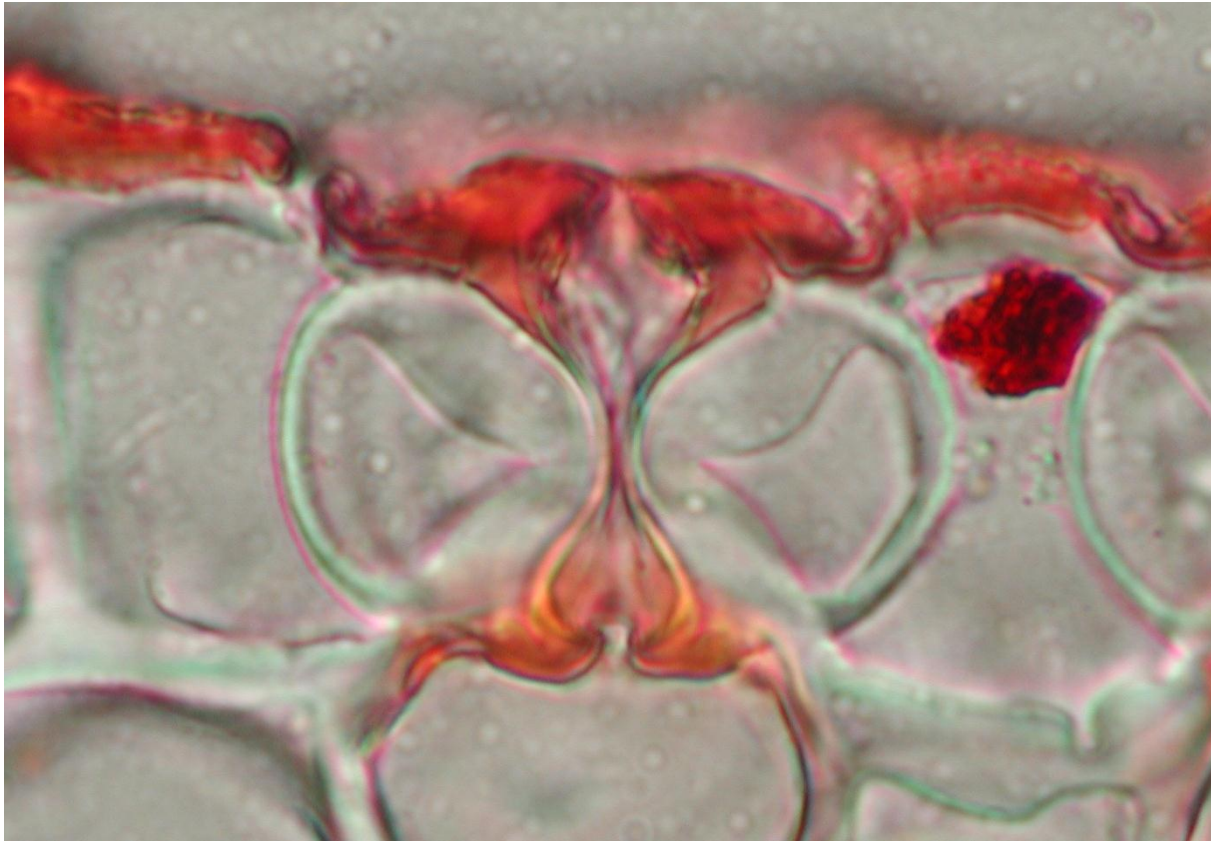
# unified changes in leaf cell size (across 80 million years!)



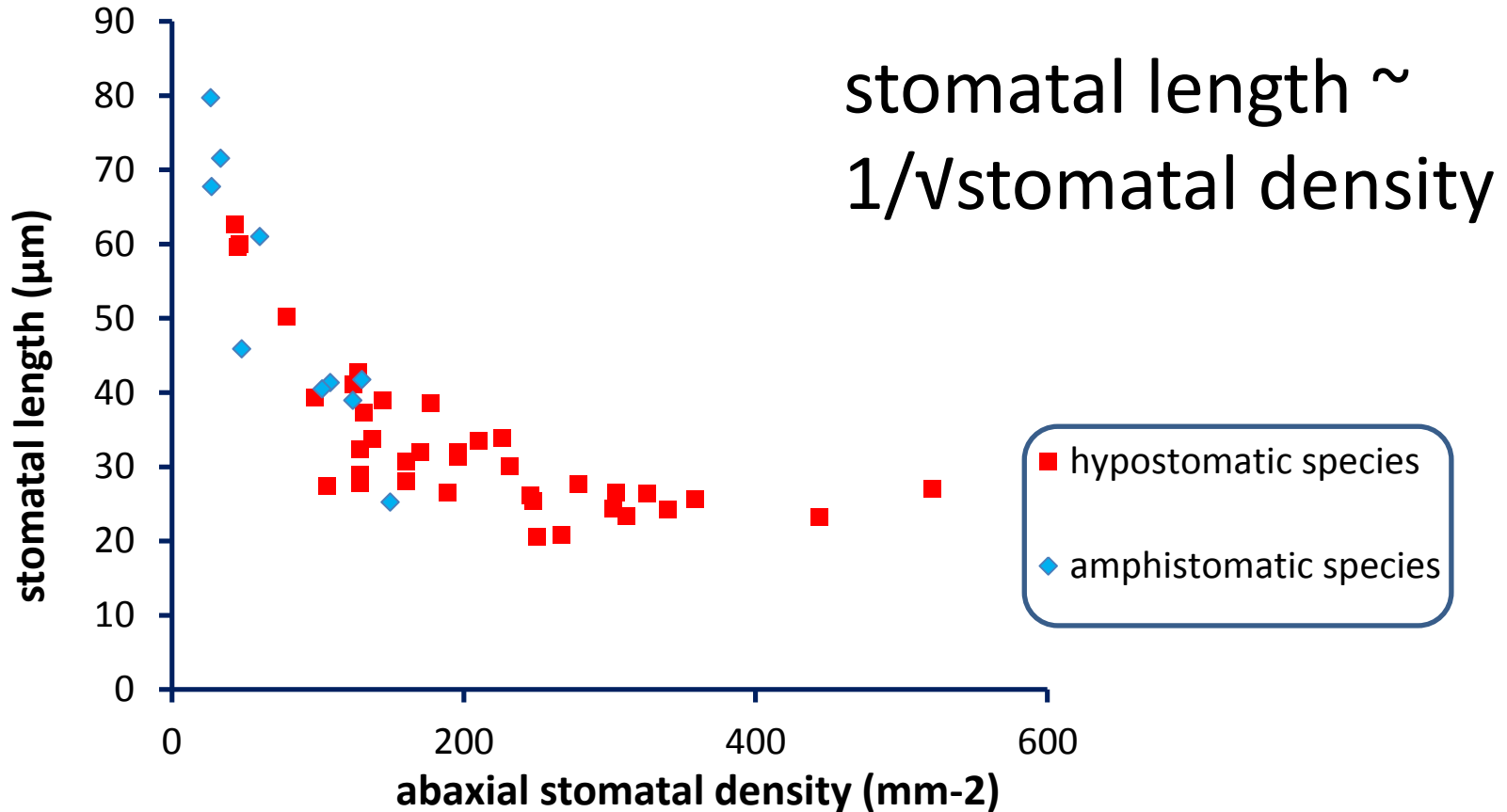
# Do we expect directional evolution

- \* Systematic changes over the Cenozoic (last 65 million years)

# Stomatal size affects photosynthesis



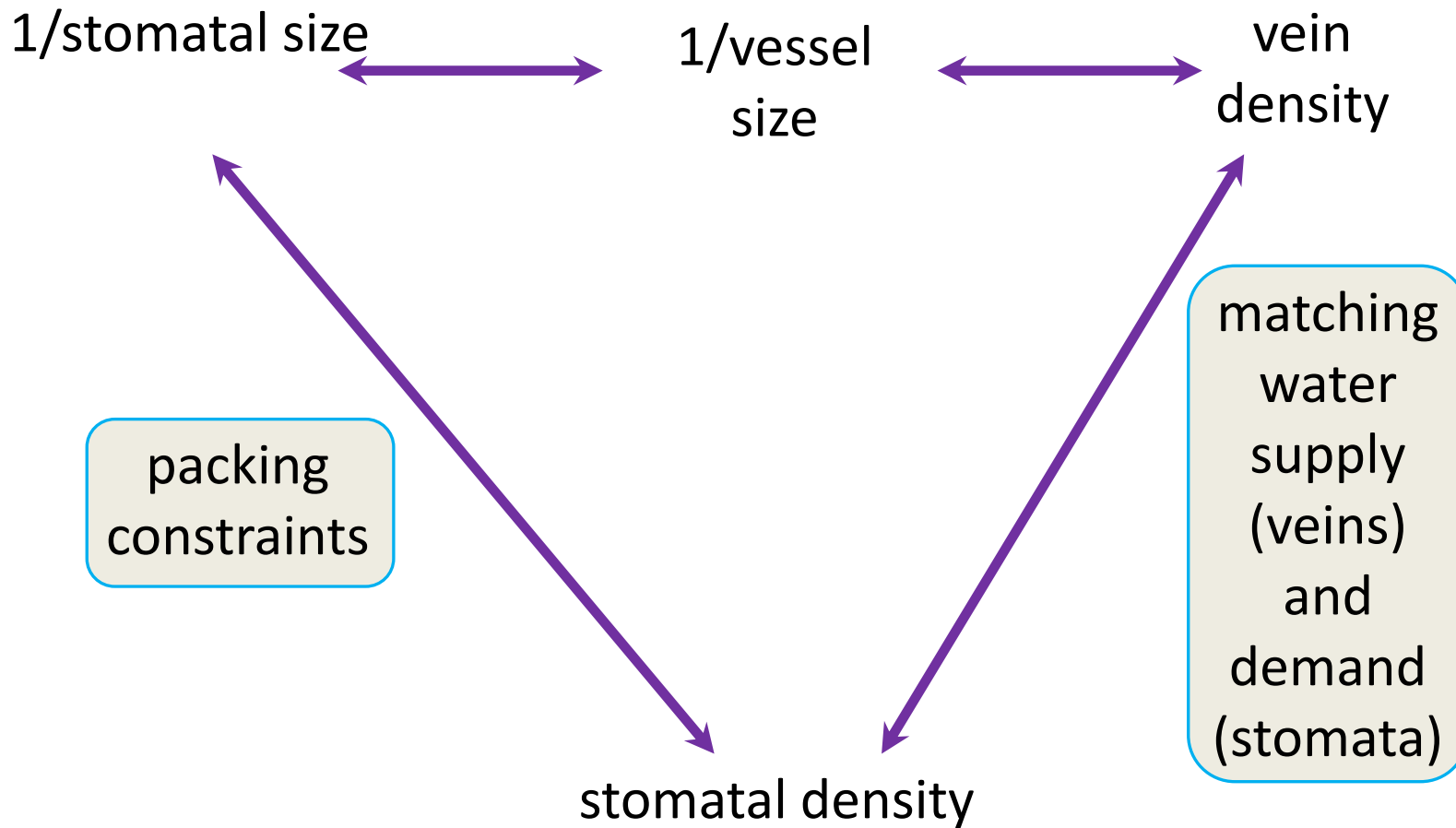
# packing density and stomata



# small stomata are more efficient

- per stomate conductance scales linearly with size
- number of stomates scales 1/quadratically with size
- small stomates lead to high conductance

# functional links



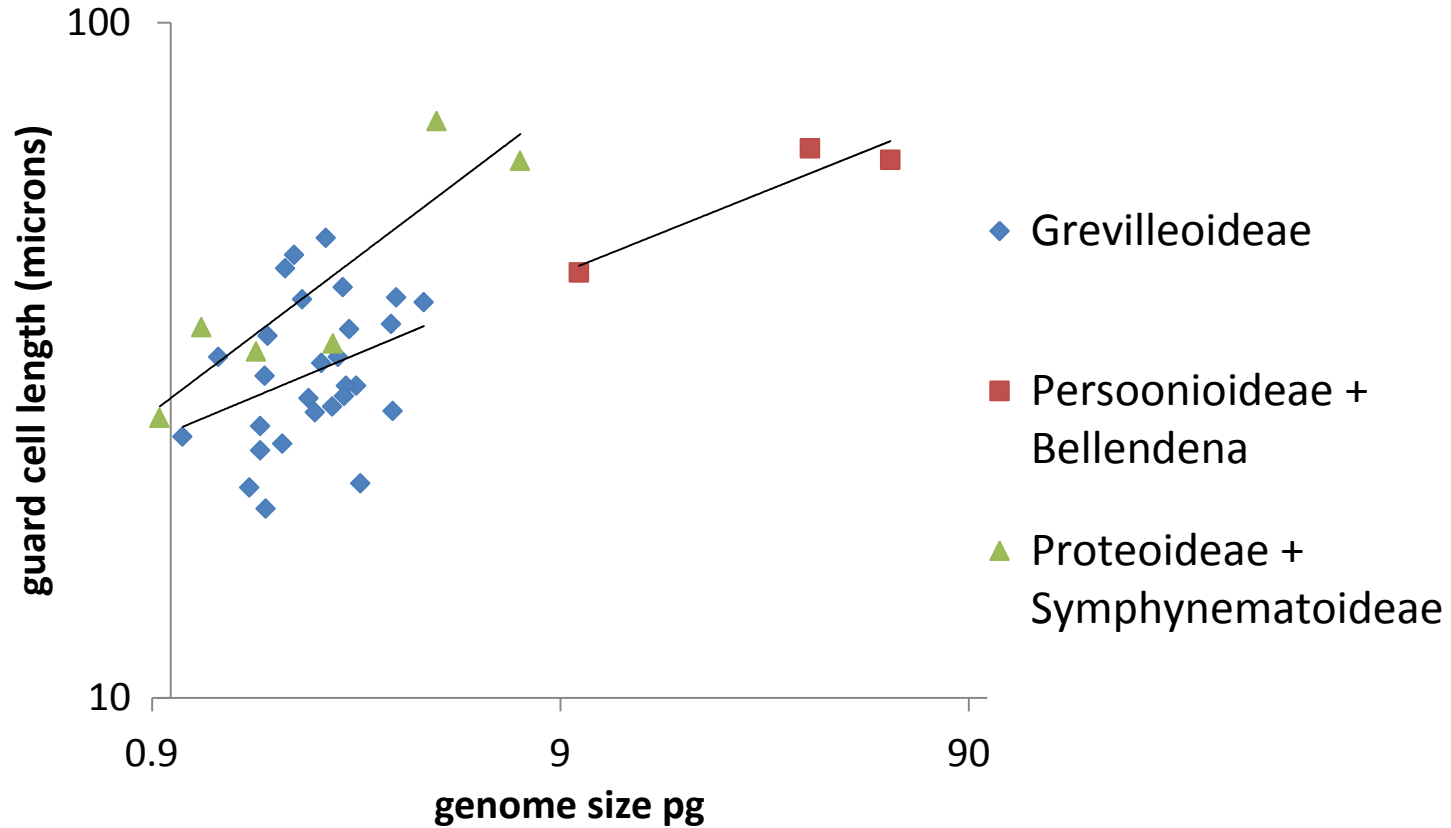
# Expected directional evolution

## 1 CO<sub>2</sub> model

- low CO<sub>2</sub> = a need for greater conductance
- small stomata are more efficient
- guard cell size should have **decreased**



# genetic link



- genome size
- other genetic factors

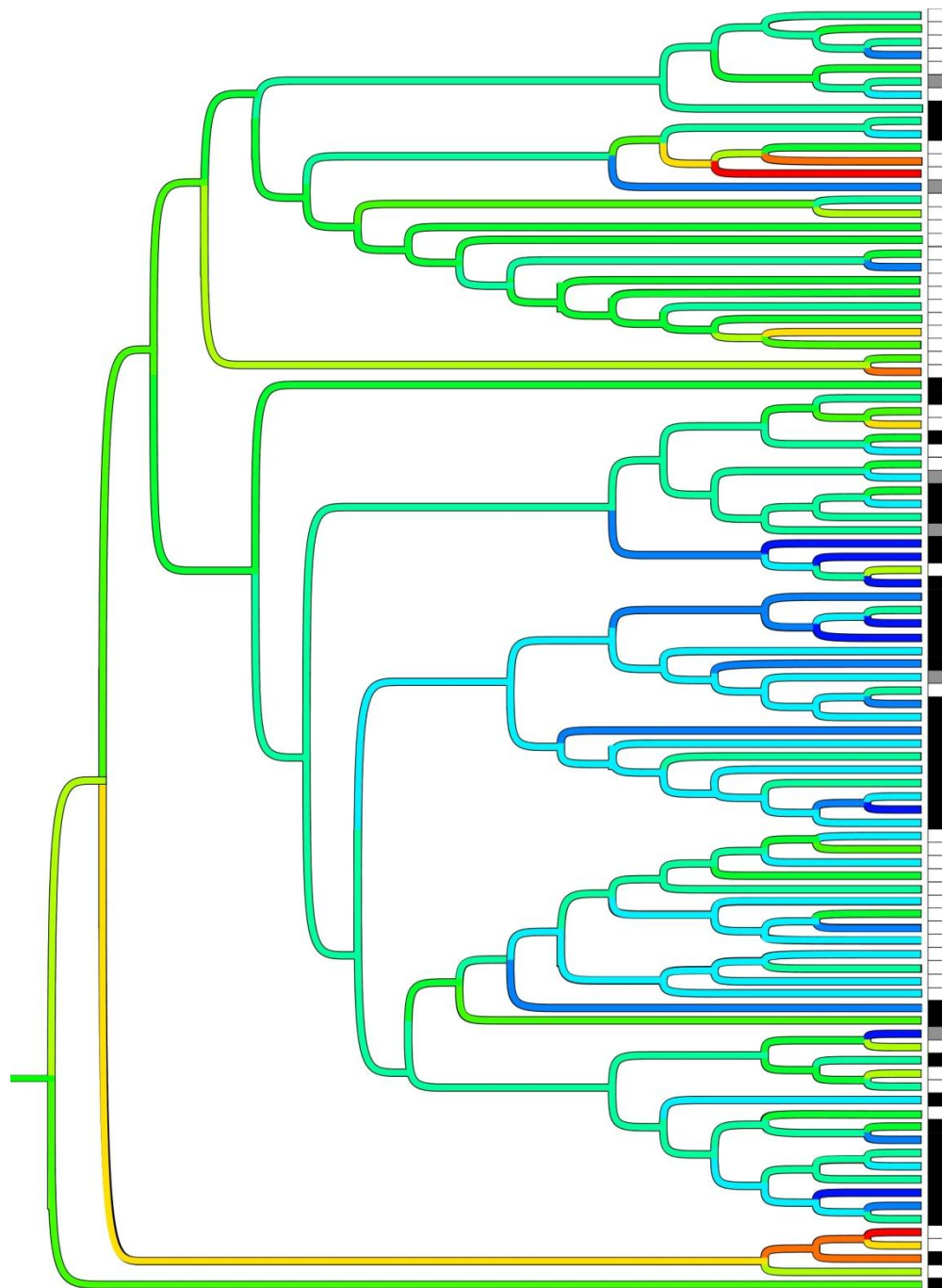
# Do we expect directional evolution

## 1 CO<sub>2</sub> model

- low CO<sub>2</sub> = a need for greater conductance
- small stomata are more efficient
- guard cell size should have **decreased**

## 2 genome size model

- genome size drifts up (one-way path to obesity)
- Guard cell should have **increased**



## Vegetation

- Open vegetation
- Rainforest
- Both

## Stomatal length

- < 24  $\mu\text{m}$
- 24 - 27  $\mu\text{m}$
- 27 - 31  $\mu\text{m}$
- 31 - 36  $\mu\text{m}$
- 36 - 41  $\mu\text{m}$
- 41 - 47  $\mu\text{m}$
- 47 - 54  $\mu\text{m}$
- 54 - 62  $\mu\text{m}$
- 62 - 71  $\mu\text{m}$
- >71  $\mu\text{m}$

- strong evolutionary association with open vegetation (versus rainforest)
- leaf thickness
- stomata on both leaf surfaces

# Do we expect directional evolution

## 1 CO<sub>2</sub> model

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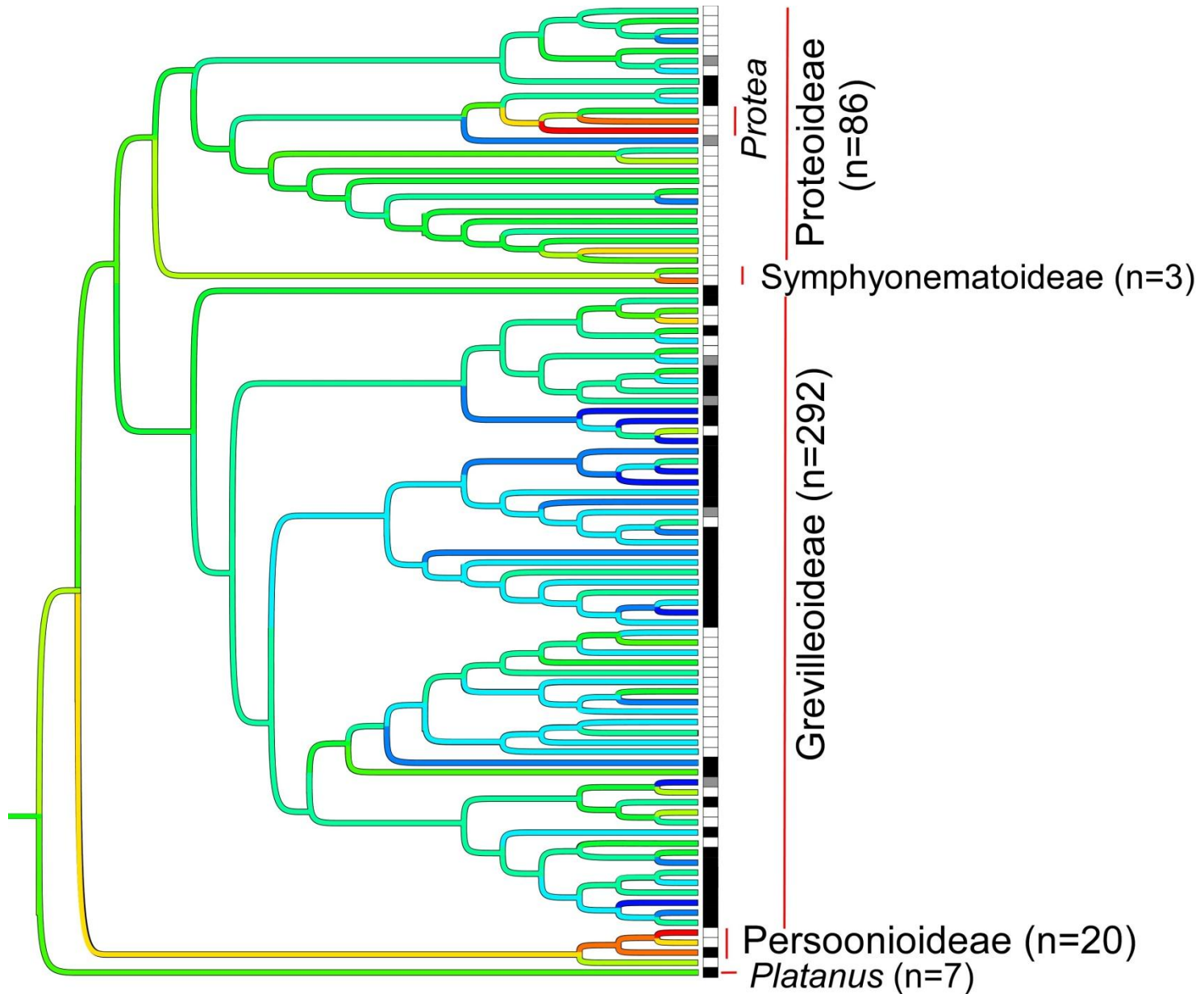
## 3 ecological model

- follows changes in habitat
- **mostly increase** - as woodland replaced rainforest

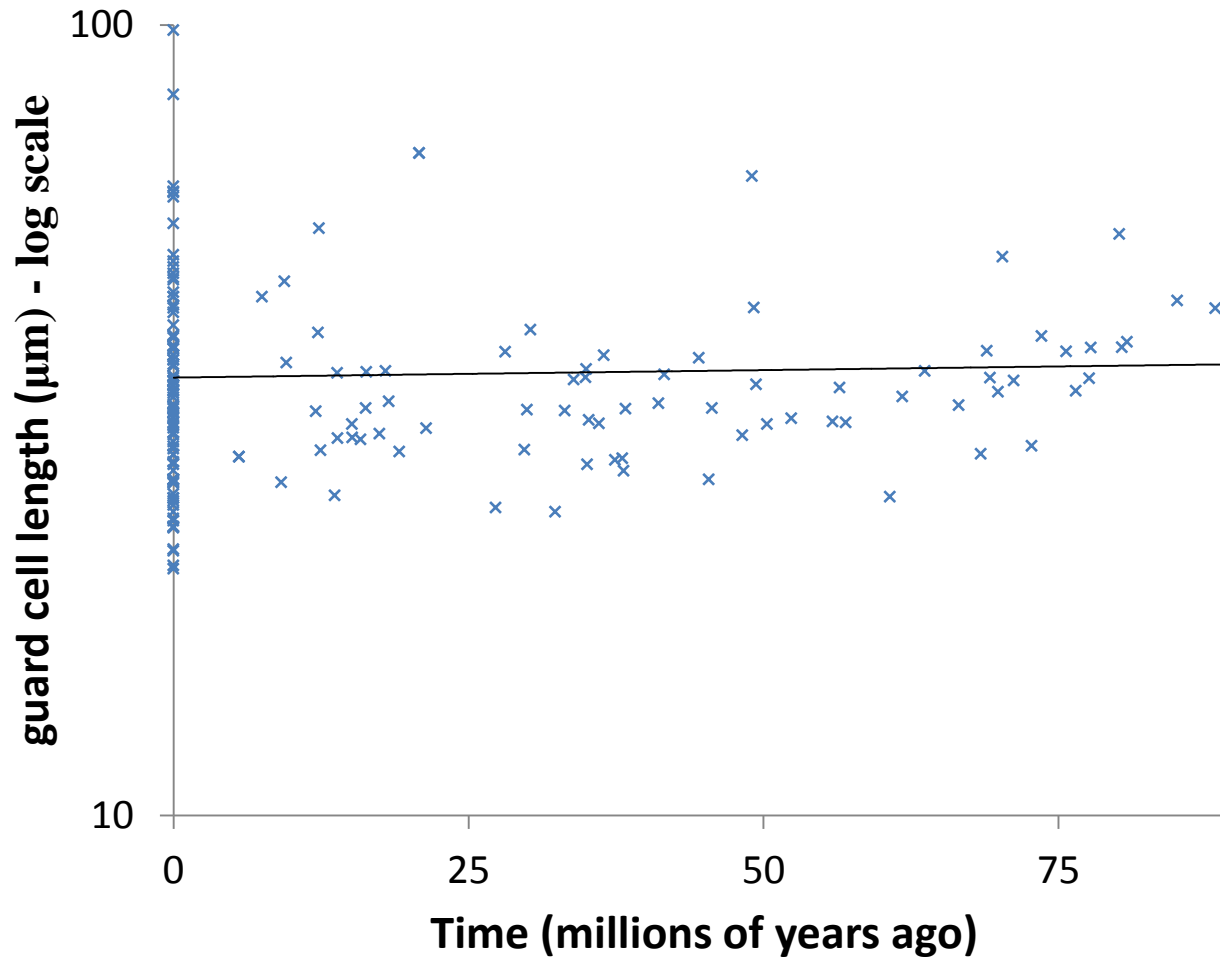
# So, what has happened to stomatal size through time?

- ancestral state analyses
- fossils

# ancestral state reconstruction

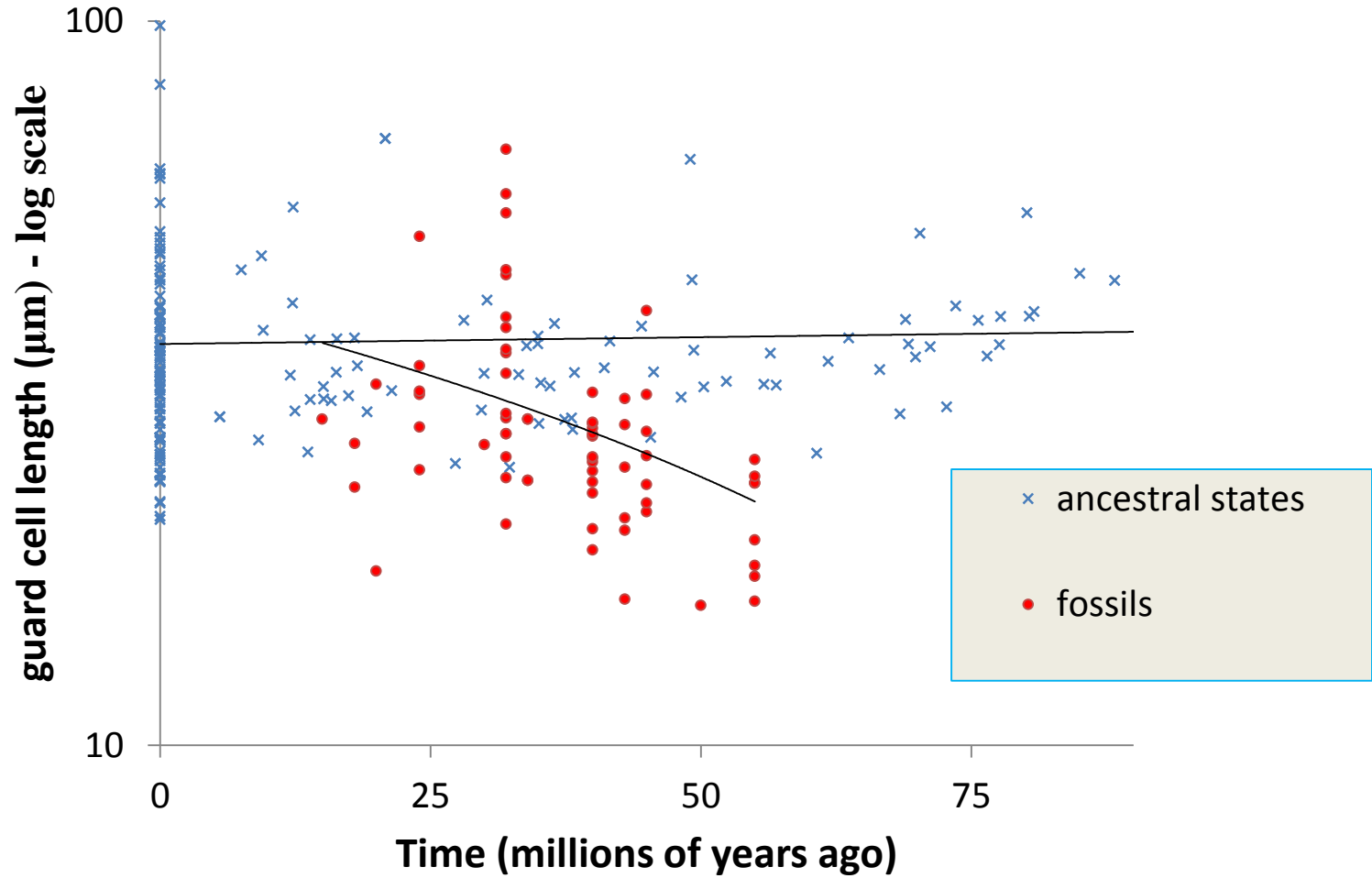


# scatter plot of reconstruction versus age for each node

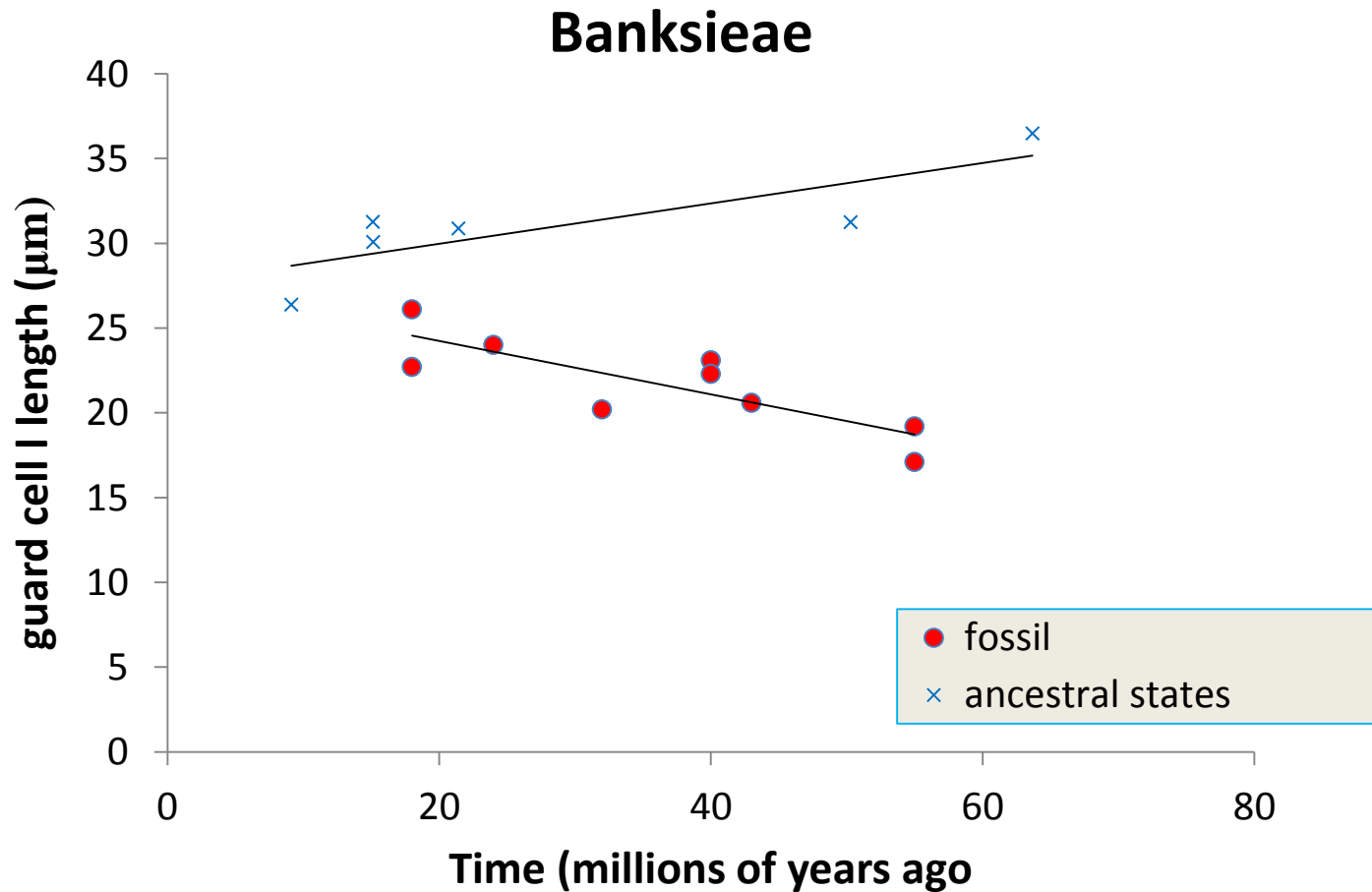




# but fossils say



# and it happens within clades



# directional evolution

- driver either
  - habitat shift with global climate change
  - systematic trend in genome size
- invalidates the ancestral state reconstructions