

# Phylogenies and community structure

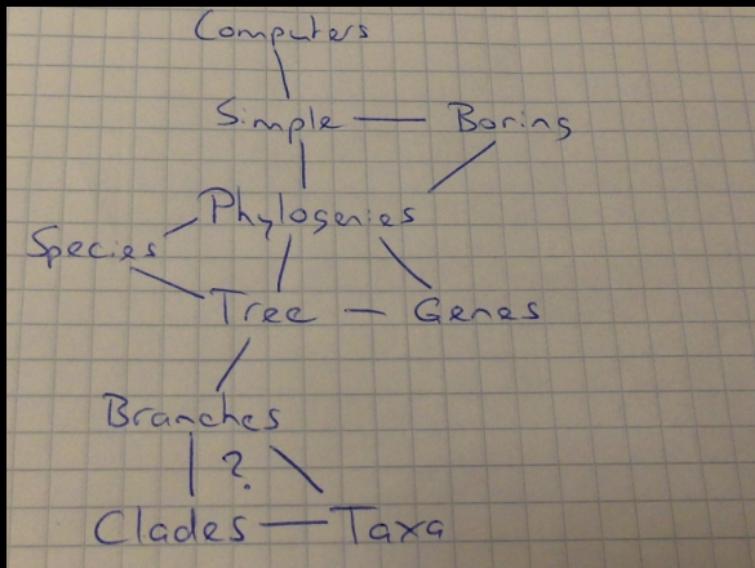
(C) Richèl Bilderbeek 

November 26, 2014

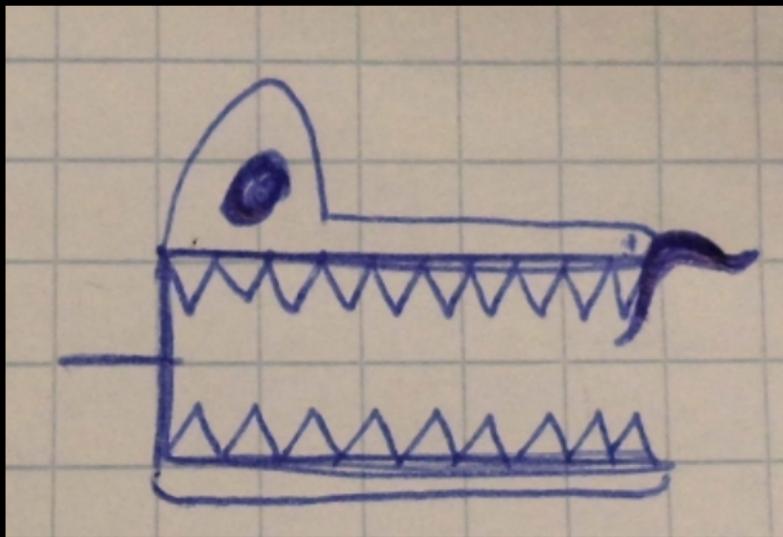
## 0.1 Question

- Where do you associate the word 'phylogeny' with?

## 0.2 My initial association



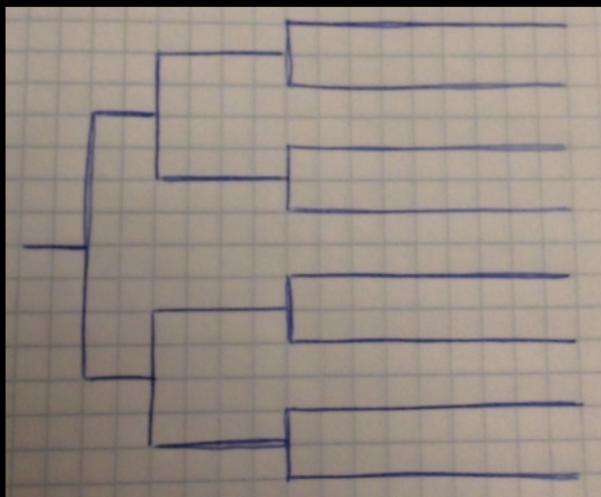
### 0.3 My current association



## 0.4 Goal

- View a phylogeny and say something smart about it

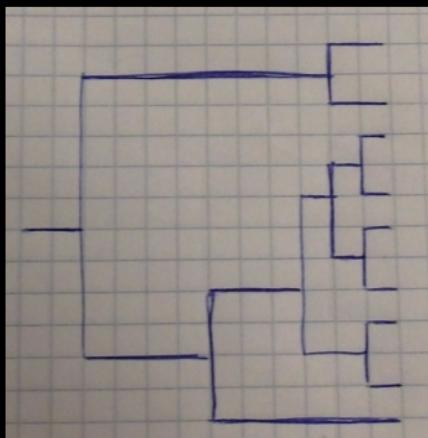
## 0.5 Say something smart about this<sup>1</sup>



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<sup>1</sup>Grenfell et al, 2004, Science

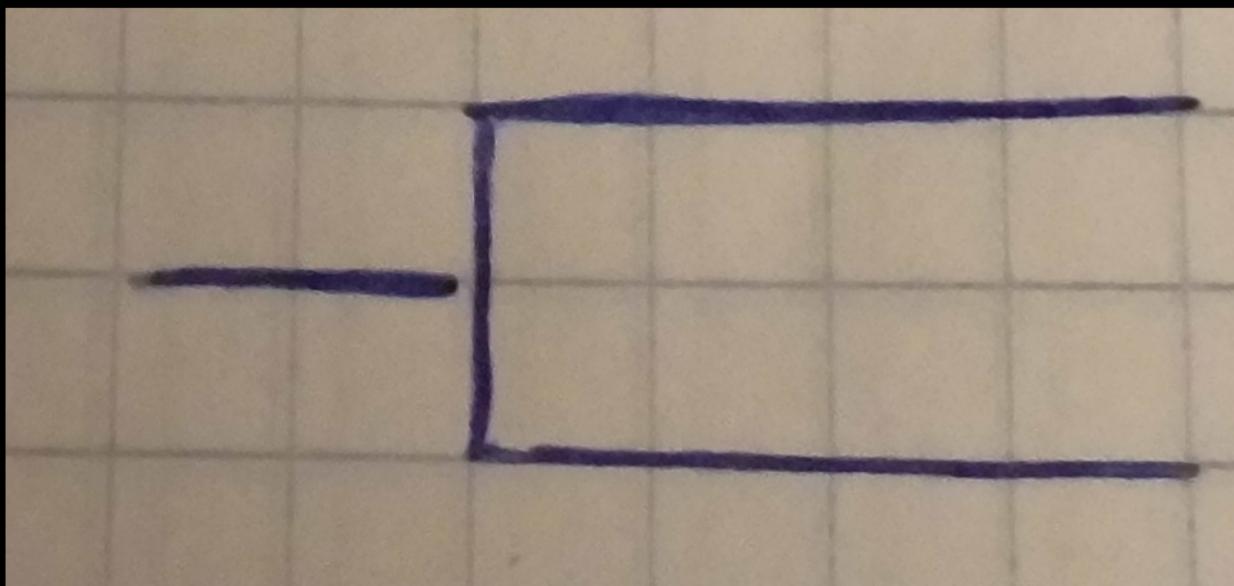
## 0.6 Say something smart about this<sup>2</sup>



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<sup>2</sup>Ezwa et al, 2013, BMC Genetics

## 0.7 Say something smart about this<sup>3</sup>



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<sup>3</sup> Adapted from Grenfell et al, 2004, Science

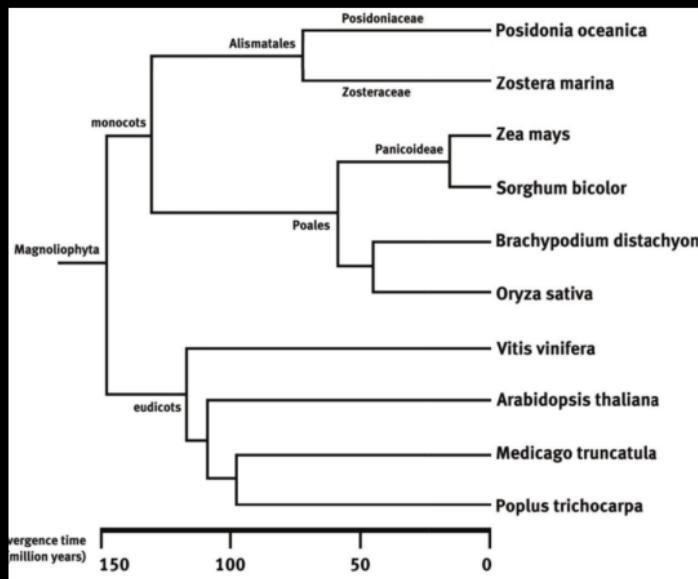
## 0.8 Say something smart about this<sup>4</sup>



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<sup>4</sup>Bilderbeek, unpublished

## 0.9 Say something smart about this<sup>5</sup>



<sup>5</sup>Wissler et al., 2011, BMC Evolutionary Biology

## 0.10 Teaching goals

- Know the terms related to the word 'phylogeny'
- Avoiding pitfalls in reading trees
- What can we infer from a tree?

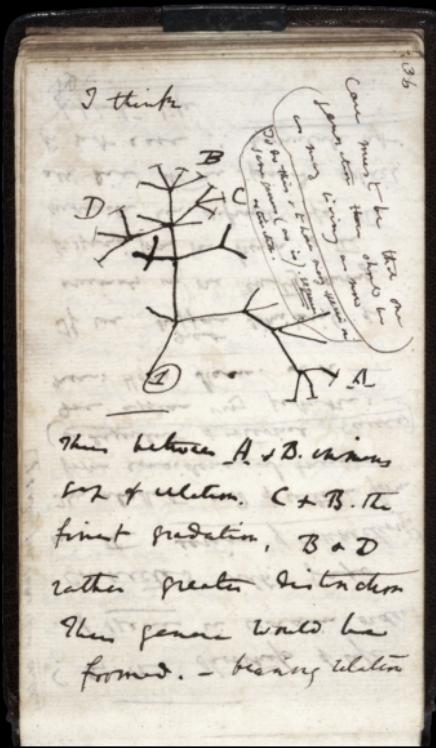
## 0.11 Planning

- History
- Current problem/idea
- Trees
- What trees show
- Advanced tree representations of data
- Phylogenies and inferring species communities

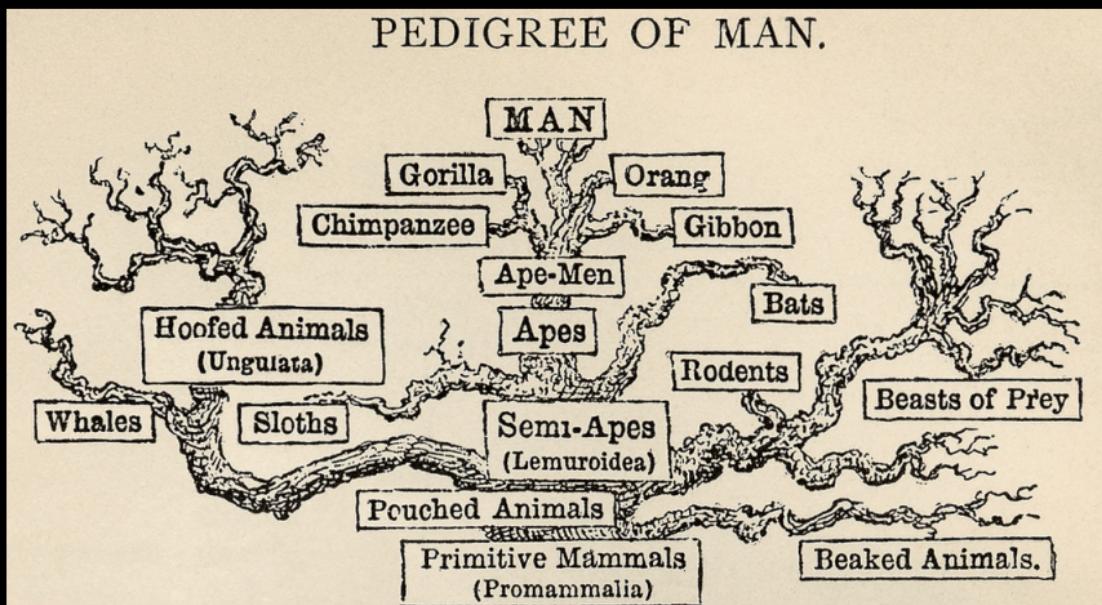
# Chapter 1

# History

## 1.1 First phylogeny<sup>1</sup>

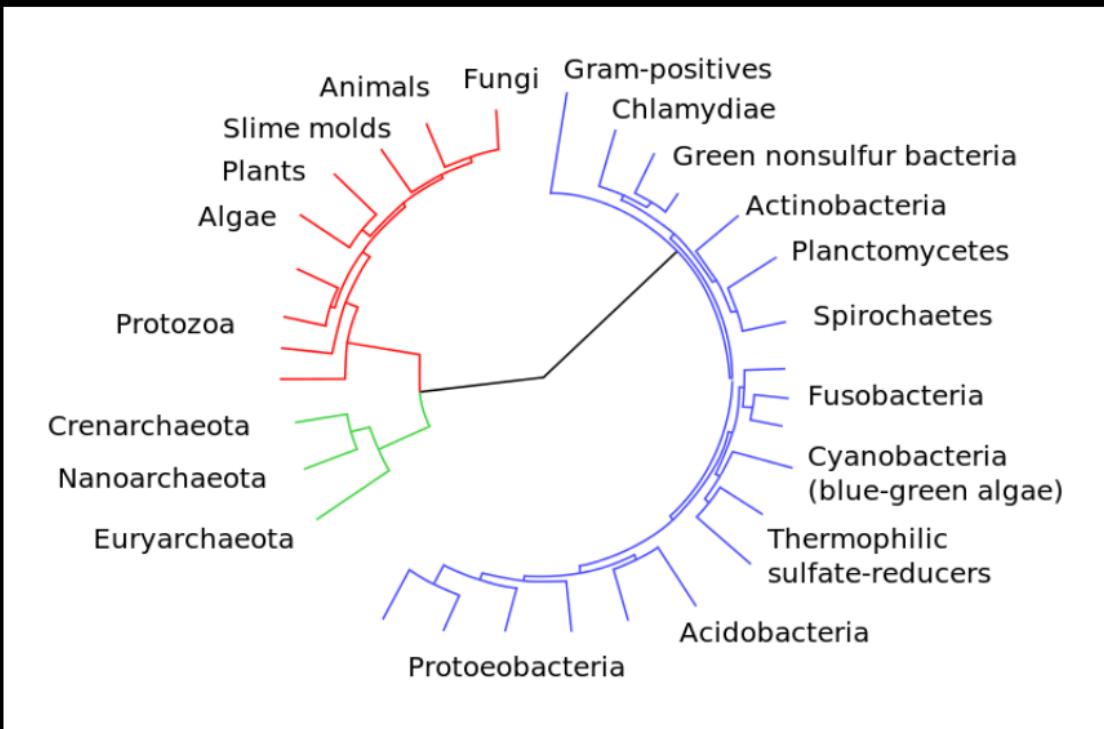


## 1.2 Tree of life<sup>2</sup>



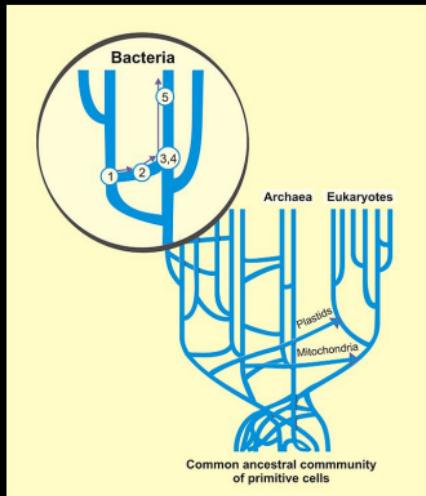
<sup>2</sup>Haeckel, 1859

### 1.3 Modern tree of life<sup>3</sup>



<sup>3</sup>Ciccarelli, 2006, Science

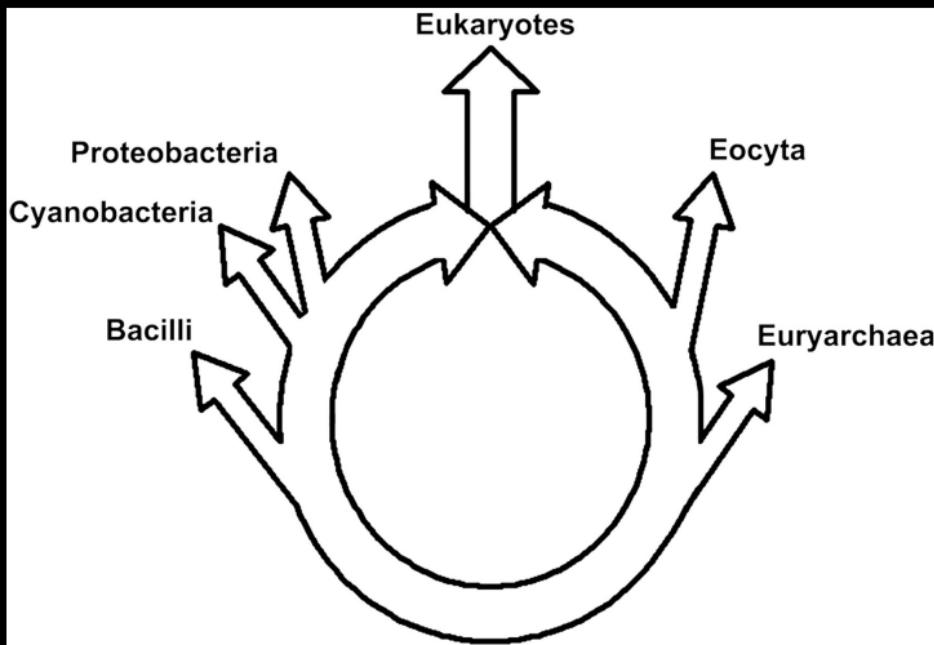
## 1.4 Horizontal gene transfer<sup>4</sup>



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<sup>4</sup>Smets & Barkay, 2005, Nature Reviews Microbiology

## 1.5 Ring of life<sup>5</sup>



<sup>5</sup>Simonson et al, 2005, PNAS

## Chapter 2

# Current idea/problem

## 2.1 Current idea

- Omics generate data
- Data can be put in a tree
- Tree can be used to infer which samples are closest
- ...

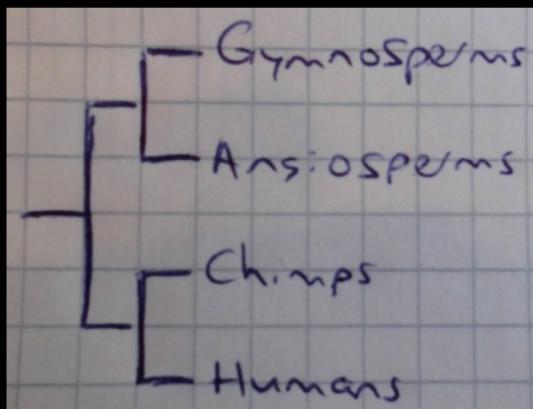
## 2.2 Current idea

- Omics generate data
- Data can be put in a tree
- Tree can be used to infer which samples are closest
- And that's it?

# Chapter 3

## Trees

### 3.1 Quiz

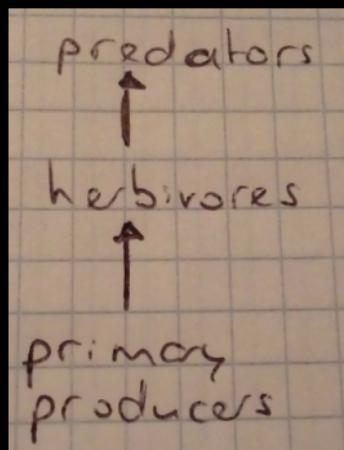


Cladogram from molecular data

'Thus, humans are evolutionary as close to chimps as gymnosperms are to angiosperms'

## 3.2 Dendrogram

- Most general term for any tree-like clustering
- 'dendron' = tree, 'gramma' = drawing

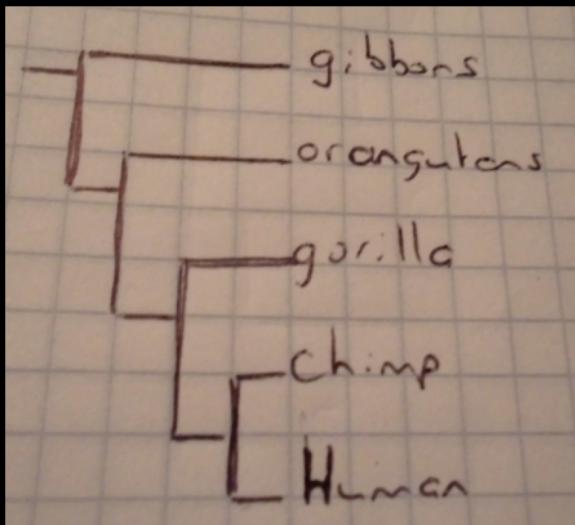
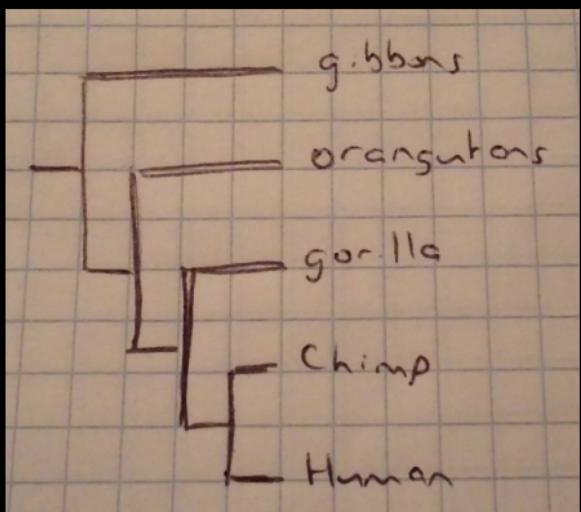


### 3.3 Dendrogram types

- cladogram
- phylogram
- chronogram
- spindle diagram

### 3.4 Cladograms: Great Chain Of Being<sup>1</sup>

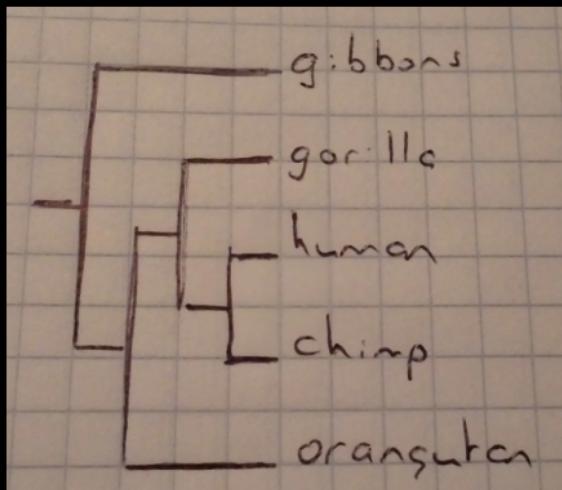
- 'klados' = branch



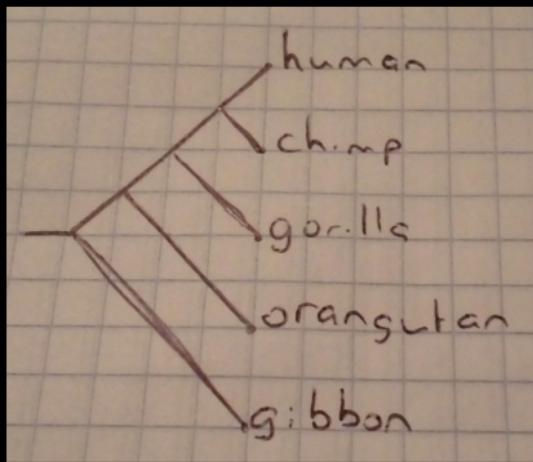
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<sup>1</sup>Felsenstein, online communication

### 3.5 Cladograms: Man is just a hominid

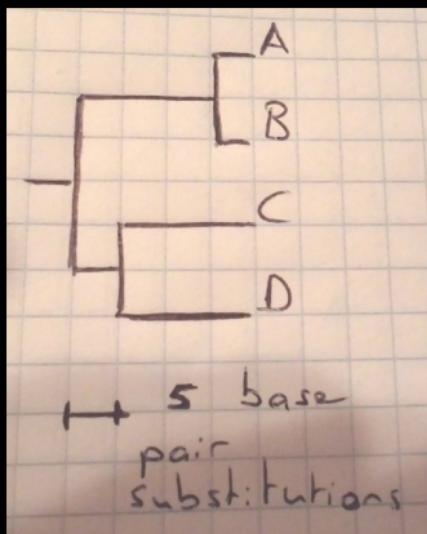


### 3.6 Cladograms



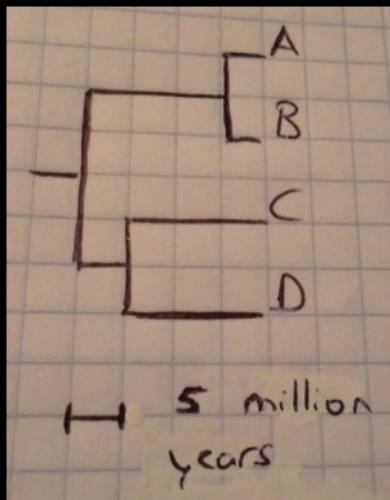
### 3.7 Phylogram

- 'phylon' = tribe, clan, race

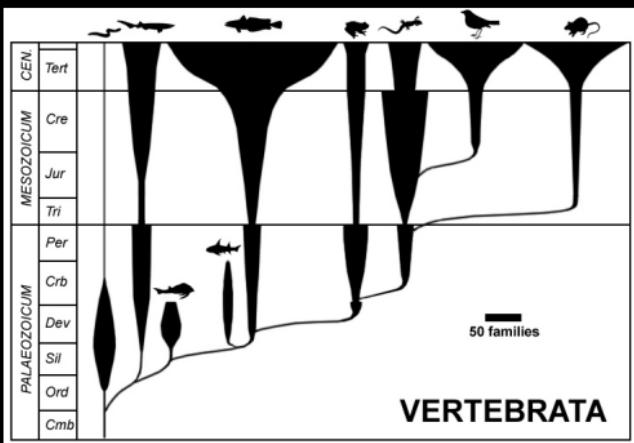


### 3.8 Chronogram

- 'chronos' = time



### 3.9 Spindle diagram<sup>2</sup>

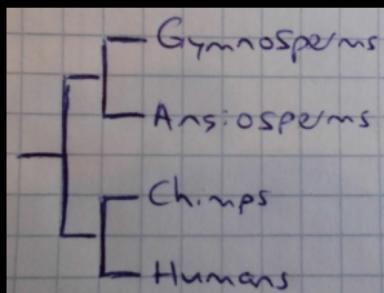


<sup>2</sup>[http://commons.wikimedia.org/wiki/User:Petter\\_B%C3%B8ckman](http://commons.wikimedia.org/wiki/User:Petter_B%C3%B8ckman)

### 3.10 Dendrogram types

Name	Branch length	Branch width
Cladogram		
Phylogram	character change	
Chronogram	time	
Spindle diagram	time	number of species

## 3.11 Quiz



Cladogram from molecular data

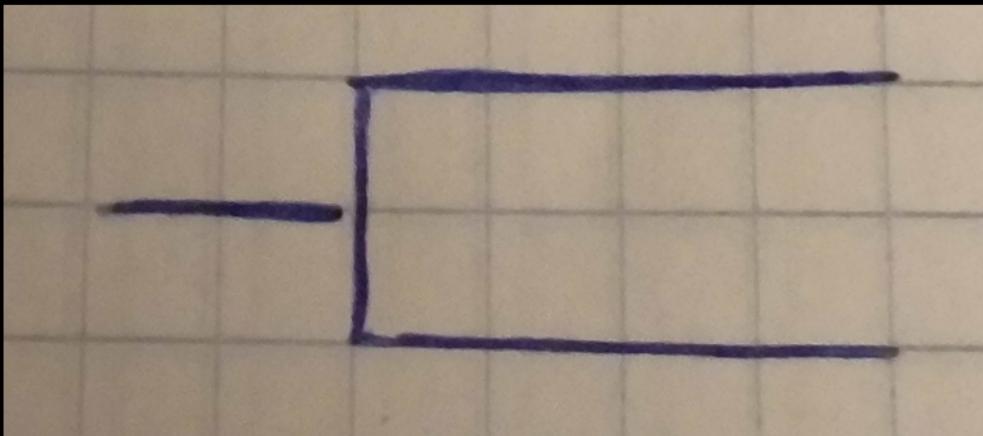
'Thus, humans are evolutionary as close to chimps as gymnosperms are to angiosperms'

1. Must be accepted
2. Cannot be sure
3. Must be rejected

# Chapter 4

## What trees show

## 4.1 Quiz<sup>1</sup>



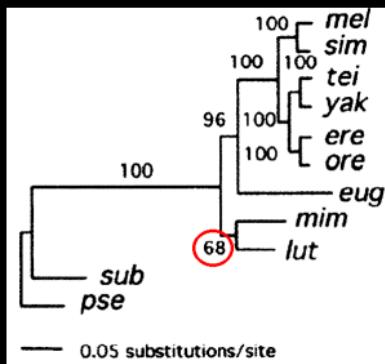
Phylogram

'Thus, there are no biological forces acting in this (boring) system'

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<sup>1</sup> Adapted from Grenfell et al, 2004, Science

## 4.2 Quiz



Phylogenetic tree of Adh in *Drosophila*<sup>2</sup>

'mim'<sup>3</sup> and 'lut'<sup>4</sup> share only 68% similarity with their common ancestor'

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<sup>2</sup>Ko et al, 2003, Journal of molecular evolution

<sup>3</sup>*Drosophila mimetica*

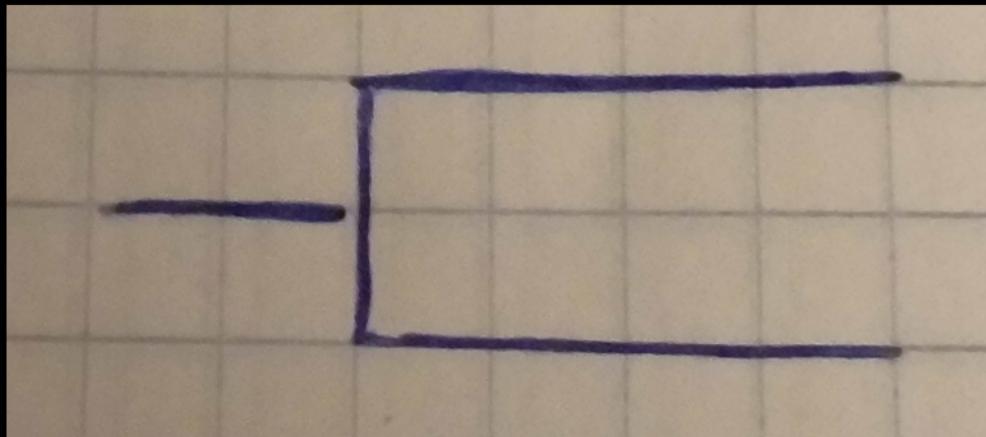
<sup>4</sup>*Drosophila lutescens*

## 4.3 Terms

- Phylogeny: hypothesis about the evolutionary history of taxonomic groups
  - Gene tree: gene sequences from different species
  - Phylogenetic tree: phylogeny derived from a gene tree
  - Gene genealogy: gene sequences within species

## 4.4 Types of things not being depicted

- Phylogenograms commonly deal with extant species



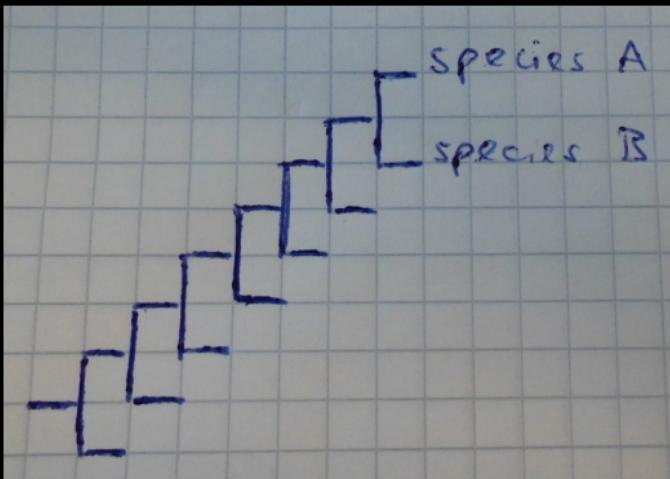
Phylogram of current time only<sup>5</sup>

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<sup>5</sup> Adapted from Grenfell et al, 2004, Science

## 4.5 Types of things not being depicted

- That does not mean nothing is going on!

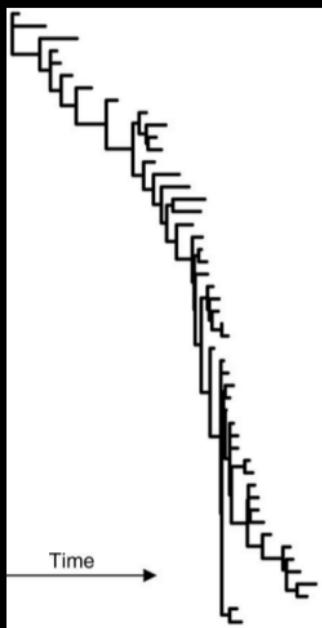


Phylogram of species sampled in time<sup>6</sup>

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<sup>6</sup>Adapted from Grenfell et al, 2004, Science

## 4.6 Types of things not being depicted<sup>7</sup>



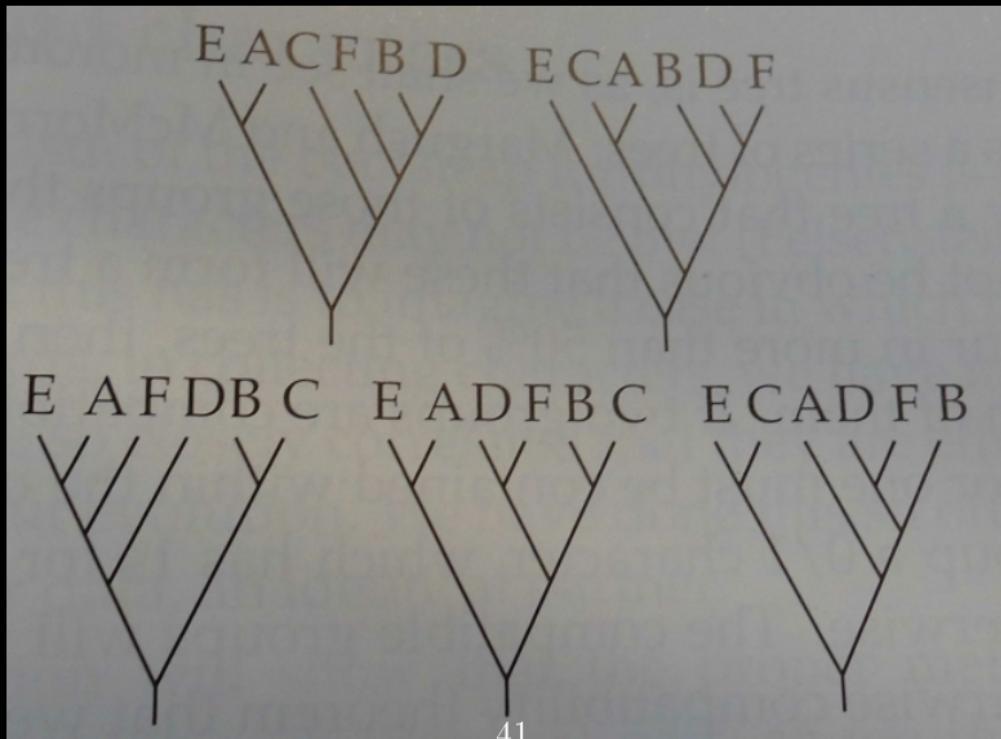
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<sup>7</sup> Adapted from Grenfell et al, 2004, Science

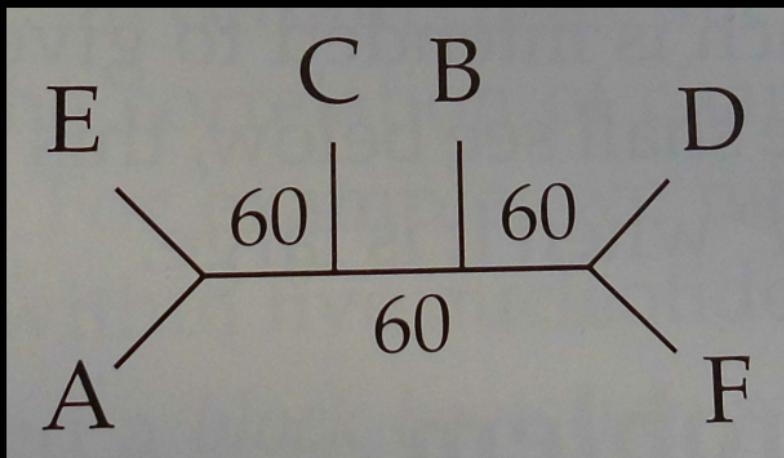
## 4.7 Bootstrap values

- Inferring a phylogeny is (NP-)hard
- Trick: generate multiple candidates, then count these candidates
- Bootstrapping shows how often the candidates agree
- Tip: threshold for publication: about 70%

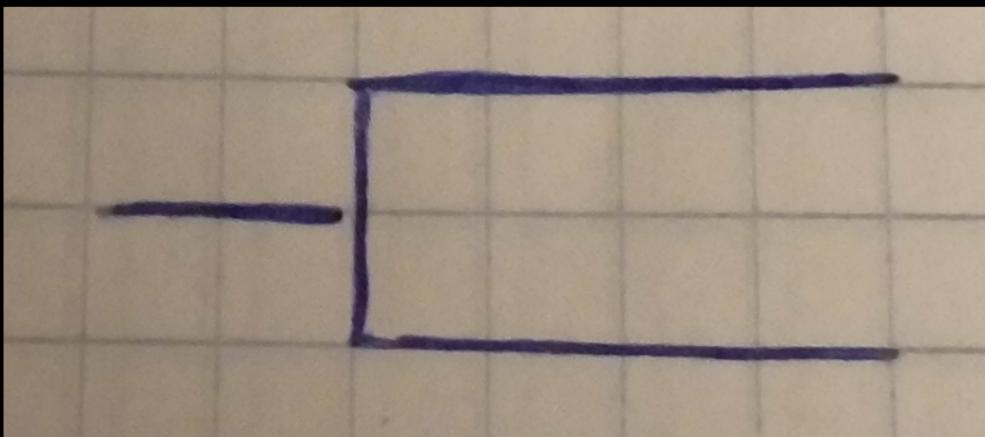
## 4.8 Bootstrap values: generate candidates



## 4.9 Bootstrap values: count agreement



## 4.10 Conclusion<sup>8</sup>

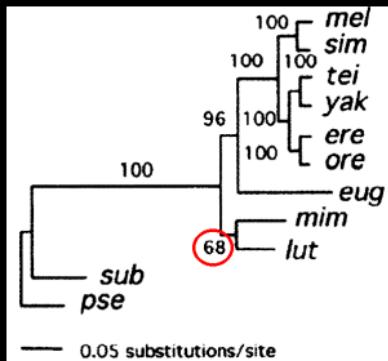


Phylogram

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<sup>8</sup> Adapted from Grenfell et al, 2004, Science

## 4.11 Conclusion



Phylogenetic tree of Adh in *Drosophila*<sup>9</sup>  
What does the 68 mean?

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<sup>9</sup>Ko et al, 2003, Journal of molecular evolution

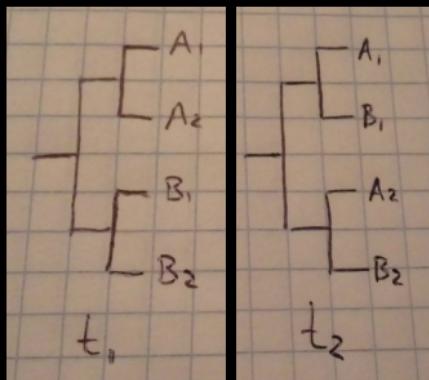
# Chapter 5

## What phylogenies can tell

## 5.1 Overview

- Quiz
- What phylogenies can tell

## 5.2 Quiz



Gene trees of two genes (A and B) in two species (1 and 2)  
measured at two points in time

How can this be?

## 5.3 What phylogenies can tell

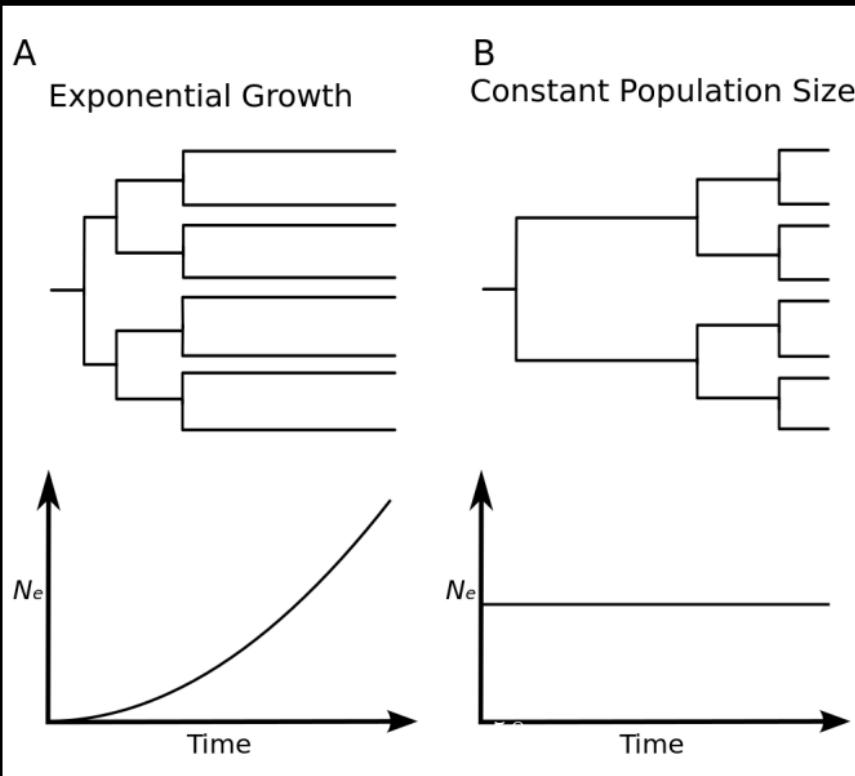
- Type of selection: no, purifying, stabilizing
- Population growth: constant, exponential
- Phylogenies that change: concerted evolution
- Type of evolutionary force: habitat filtering, competitive exclusion
- Type of evolution: concerted, divergent, by birth-death process
- Mutation rate

## 5.4 Type of selection

- Neutral, purifying, stabilizing



## 5.5 Population growth



## 5.6 Phylogenies that change

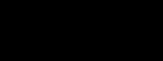
Phylogeny 1

$[A_1 \mid B_1]$   $\xrightarrow{\text{split}} [A_2 \mid B_2]$

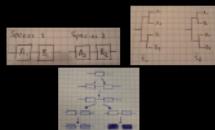


Phylogeny 2

$[A_2 \mid B_2]$   $\xrightarrow{\text{split}} [A_3 \mid B_3]$



## 5.7 Phylogenies that change



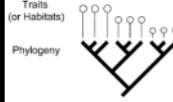
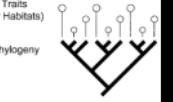
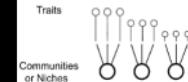
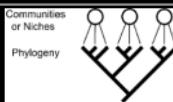
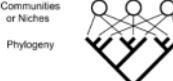
## 5.8 Type of evolutionary force

[...] the struggle will generally be more severe between species of the same genus, when they come into competition with another, than species of distinct genera [2]

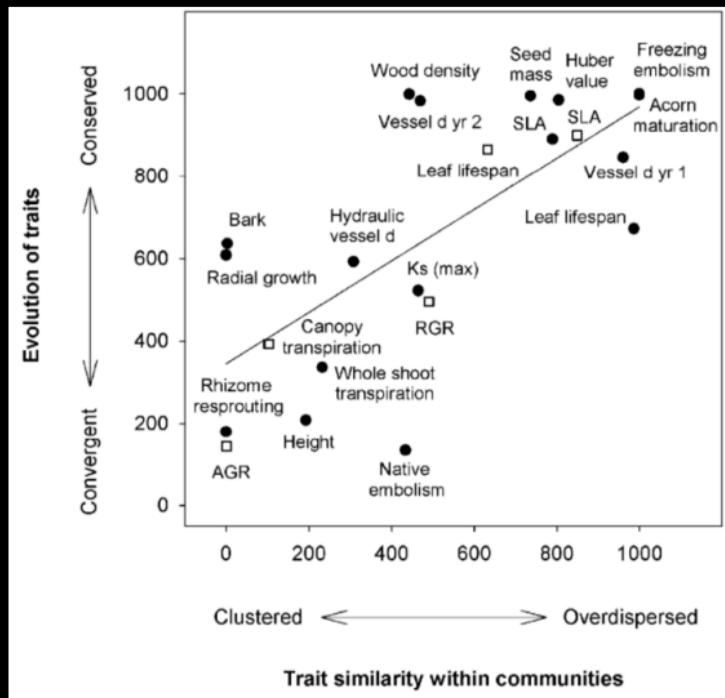
## 5.9 Type of evolutionary force[3]

Dominant ecological force	Ecological traits phylogenetically	
	Conserved	Convergent
Habitat filtering <sup>1</sup>	Clustered	Overdispersed
Competitive exclusion <sup>2</sup>	Overdispersed	Random

## 5.10 Type of evolutionary force[1][3]

Dominant ecological force	Ecological traits phylogenetically		
	 <p>Phylogeny</p> <p>Traits (or Habitats)</p> <p>Trait conservatism</p>	 <p>Phylogeny</p> <p>Traits (or Habitats)</p> <p>Trait convergence</p>	
	 <p>Communities or Niches</p> <p>Traits</p> <p>Phylogeny</p>	 <p>Communities or Niches</p> <p>Traits</p> <p>Phylogeny</p>	
	 <p>Communities or Niches</p> <p>Traits</p> <p>Phenotypic overdispersion</p>	 <p>Communities or Niches</p> <p>Traits</p> <p>Phylogeny</p>	Random

## 5.11 Type of evolutionary force[1]



competitive exclusion

examples: Losos et al 2003

by contrast, in a community of Old World leaf warblers, which like anoles are the result of a more ancient (.10 Myr ago) radiation, ecological and phylogenetic similarity do not appear to be related [21]

[21] Richman, A. D. & Price, T. Evolution of ecological differences in the Old World leaf warblers. *Nature* 355, 817–821 (1992). CANNOT GET

## 5.12 Neutrality

In Kirkpatrick and Slatkin (1993), authors reviewed six measures of tree asymmetry based solely on the tree topology. They studied the power of these measures to be used as a test for deviation of trees from neutral predictions. A similar analysis was carried out in Maia et al. (2004).

## 5.13 Mutation speed

- Not all genes have same mutation speed
- Assumes neutral selection



## 5.14 Conclusions

- It is hard to infer something from a tree
- Research is ongoing to do inferences on trees
- I found it hard to experiment with the simulation to get a better feeling with this
- I found it hard to draw trees the way I wanted it
- (it is hard to hard to give an interesting presentation about trees)

## 5.15 Goal

Integrating phylogenetic knowledge into studies of community organisation [3]

- Examining the phylogenetic structure of species assemblages
- Exploring the phylogenetic basis of community niche structure
- Adding a community context to studies of trait evolution and biogeography

## Habitat filtering

From 'Habitat filtering and niche differentiation jointly explain species relative abundance within grassland communities along fertility and disturbance gradients' Vincent Maire 1,2 \* , Nicolas Gross 3,4 \* , Luca Bo"rger 3,4 , Raphae"l Proulx 5,6 , Christian Wirth 5 , La"ise da Silveira Pontes 7 , Jean-Fran"ois Soussana 1 and Fr"ed"eric Louault :

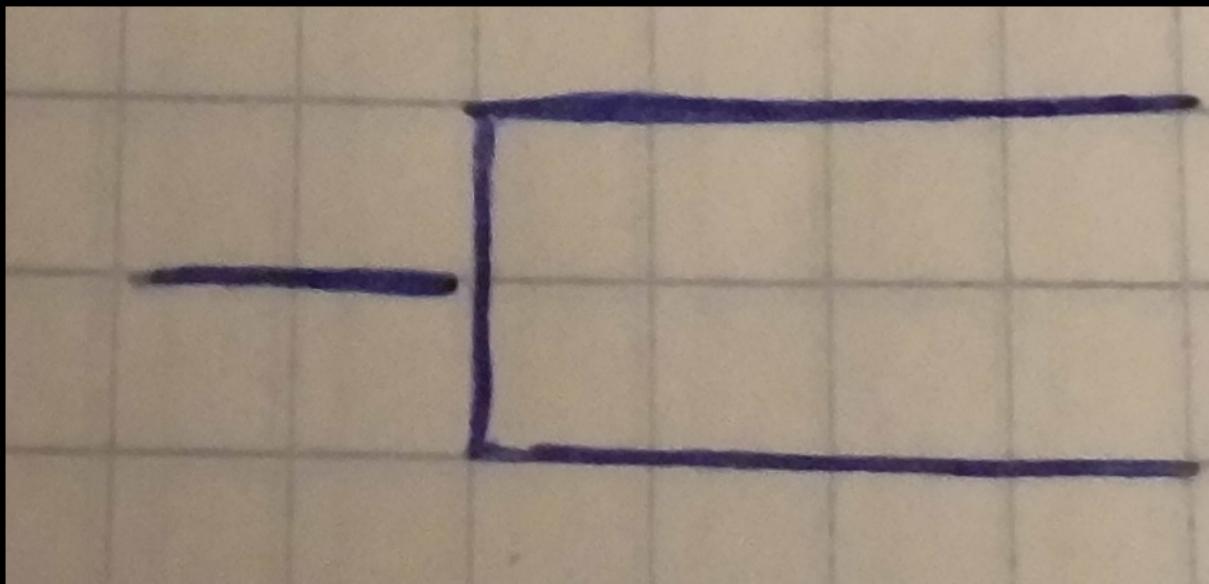
However, recent studies (Shipley, 2009; Adler et al. , 2010; Cornwell & Ackerly, 2010) suggested that biodiversity within communities cannot be understood without taking into account deterministic processes such as habitat filtering (HF; Keddy, 1992) and niche differentiation (ND; MacArthur & Levins, 1967; Silvertown, 2004).

Keddy PA. 1992. Assembly and response rules – 2 goals for predictive community ecology. Journal of Vegetation Science 3 : 157 – 164.

5.16 What is this?



5.17 What is this?



Grenfell, B. T.; Pybus, O. G.; Gog, J. R.; Wood, J. L.; Daly, J. M.; Mumford, J. A.; Holmes, E. C. (2004). "Unifying the Epidemiological and Evolutionary Dynamics of Pathogens". *Science* 303 (5656): 327–332. doi:10.1126/science.1090727. PMID 14726583

# Bibliography

- [1] J Cavender-Bares, D D Ackerly, D A Baum, and F A Bazzaz. Phylogenetic overdispersion in floridian oak communities. *The american naturalist*, 163:823–843, 2004.
- [2] Charles Darwin. On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for

life. 1859.

- [3] O C Webb, D D Ackerly, M A McPeek, and M J Donoghue. Phylogenies and community ecology. *Annu. Rev. Ecol. Syst.*, 33:475–505, 2002.