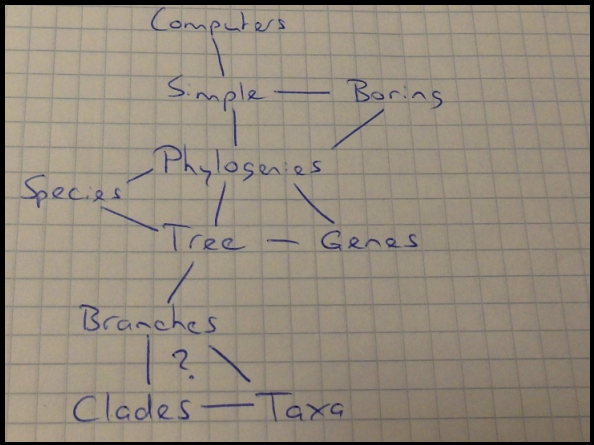
Phylogenies and community structure

November 26, 2014

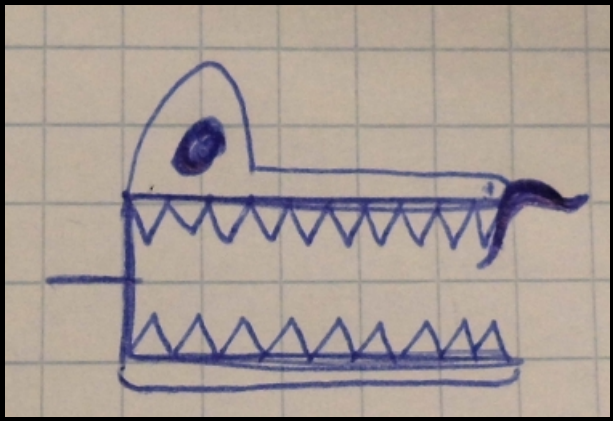
0.1 Question

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

0.2 My initial association



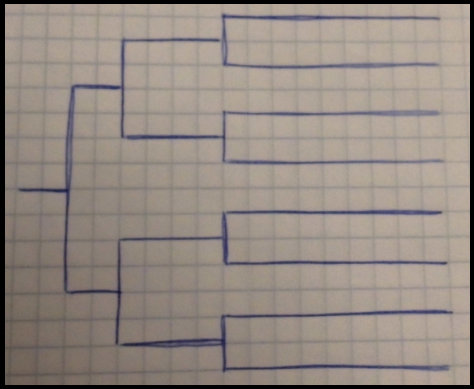
0.3 My current association



0.4 Goal

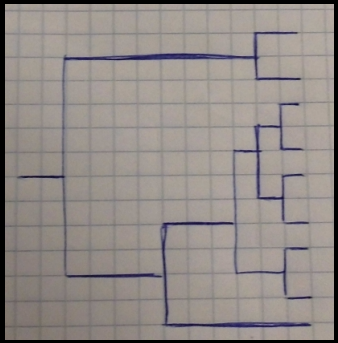
- View a phylogeny and say something smart about it

0.5 Say something smart about this[1]



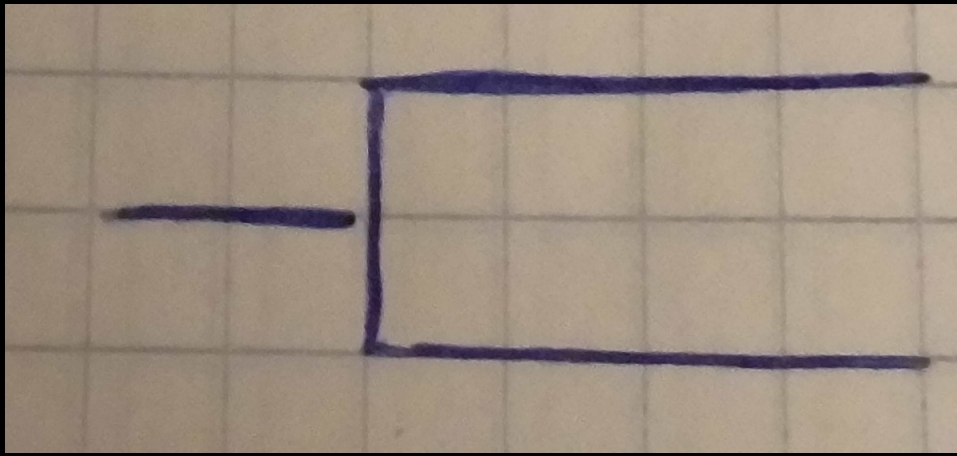
[1] Grenfell et al, 2004, Science

0.6 Say something smart about this[2]



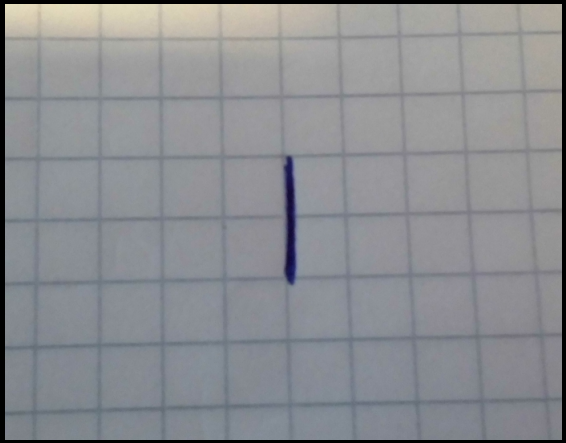
[2]Ezwa et al, 2013, BMC Genetics

0.7 Say something smart about this[3]



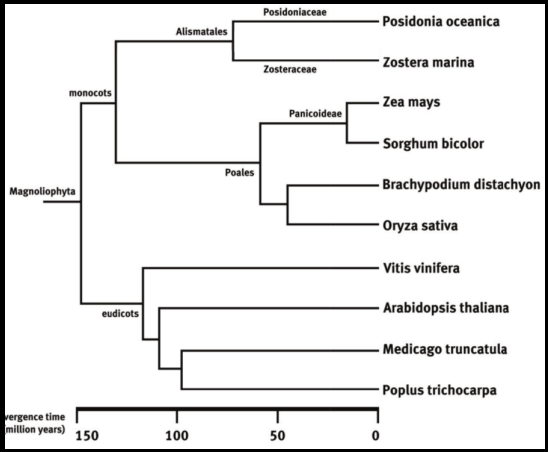
[3] Adapted from Grenfell et al, 2004, Science

0.8 Say something smart about this[4]



[4] Bilderbeek, unpublished

0.9 Say something smart about this[5]



[5]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?

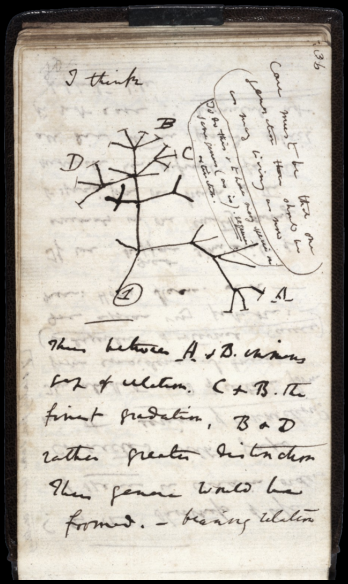
0.11 Planning

- History
- Work in progress
- Trees
- What trees show
- Advanced tree representations of data
- Phylogenies and inferring species communies

Chapter 1

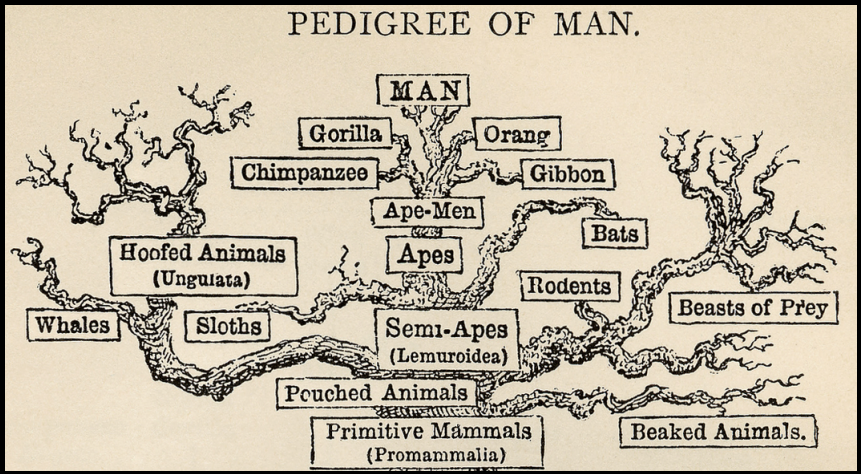
History

1.1 First phylogeny[1]



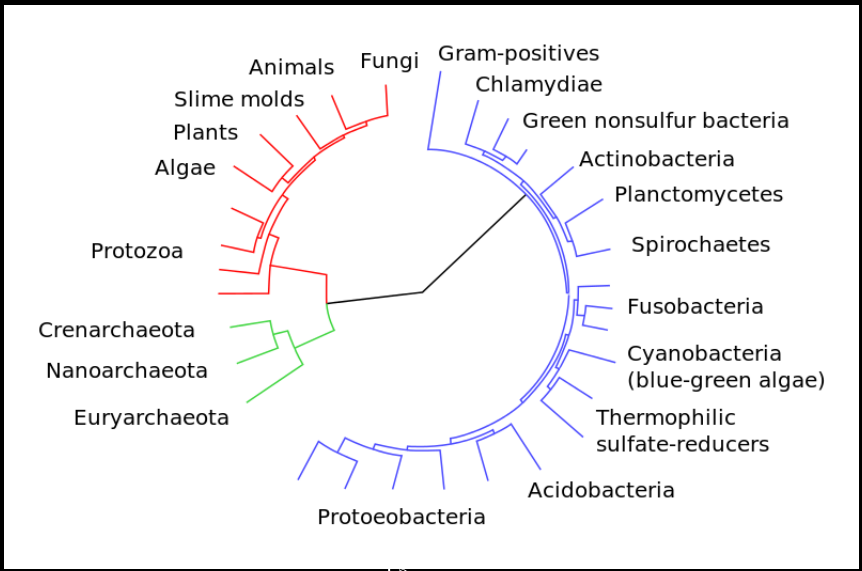
[1] Darwin, 1859

1.2 Tree of life[2]



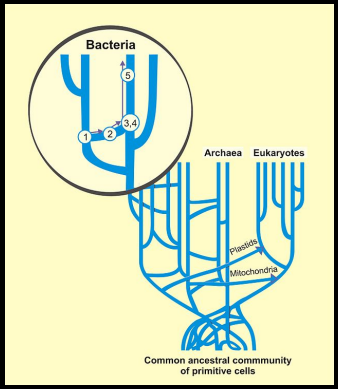
[2] Haeckel, 1859

1.3 Modern tree of life[3]



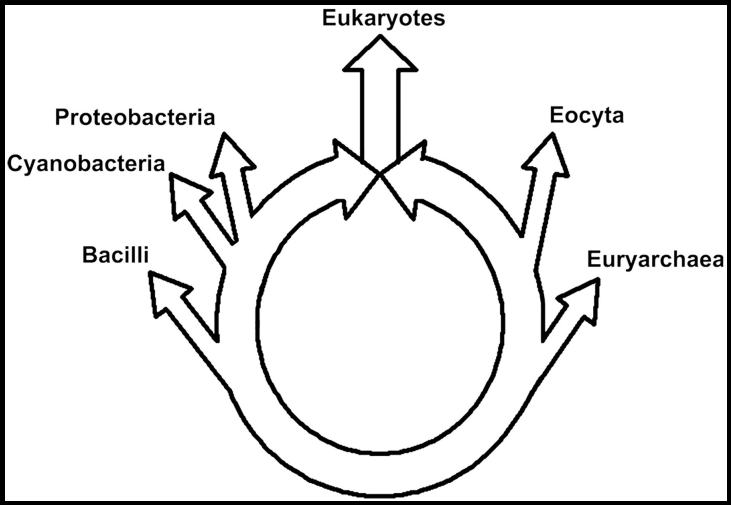
[3] Ciccarelli, 2006, Science

1.4 Horizontal gene transfer[4]



[4]Smets & Barkay, 2005, Nature Reviews Microbiology

1.5 Ring of life[5]



[5] Simonson et al, 2005, PNAS

Chapter 2

Work in progress

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

- And that's it?

2.3 Old idea

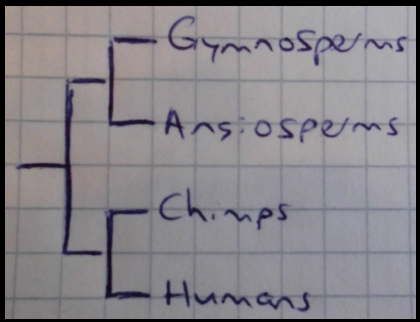
- And that's it?
- (actually, this idea predates the omics[1])

[1] Felsenstein, 1985, The American Naturalist

Chapter 3

Trees

3.1 Quiz

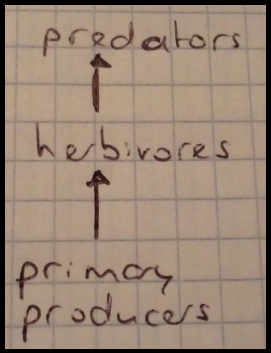


Cladogram from molecular data

'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

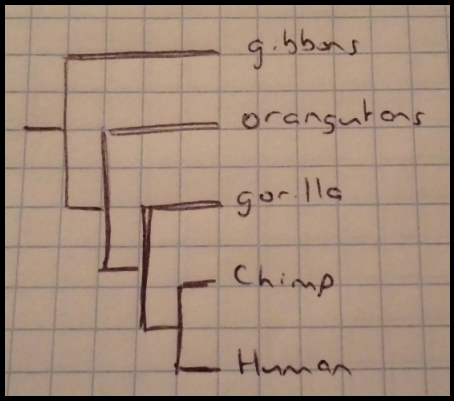


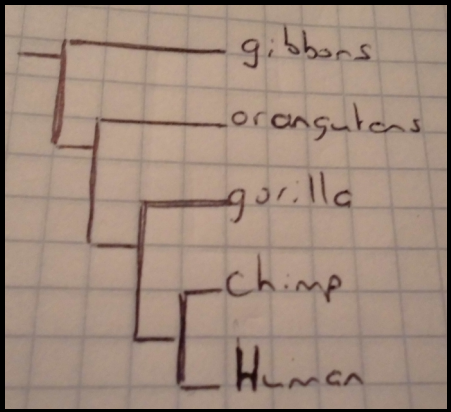
3.3 Dendrogram types

- cladogram
- phylogram
- chronogram
- spindle diagram

3.4 Cladograms: Great Chain Of Being[1]

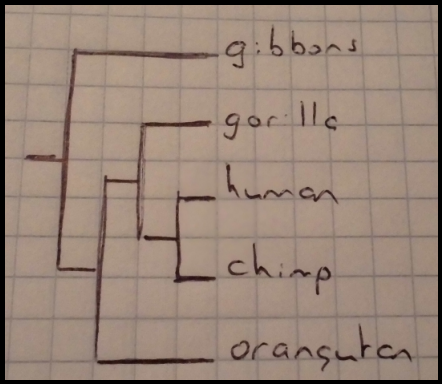
- 'klados' = branch



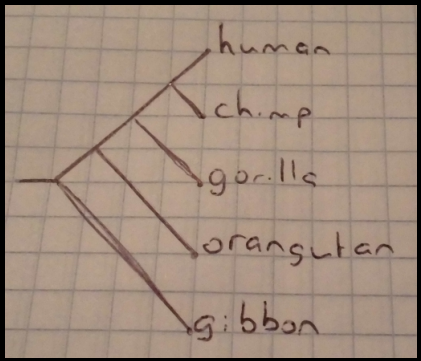


[1] Felsenstein, online communication

3.5 Cladograms: Man is just a hominid

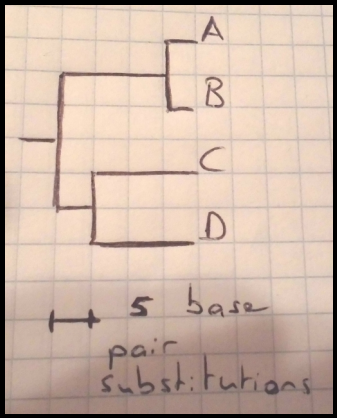


3.6 Cladograms



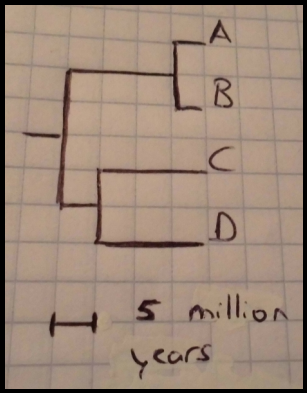
3.7 Phylogram

- 'phylon' = tribe, clan, race

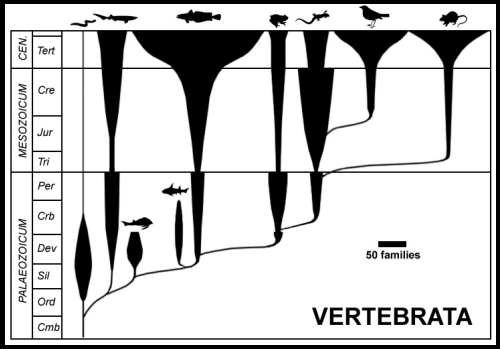


3.8 Chronogram

- 'chronos' = time



3.9 Spindle diagram[2]

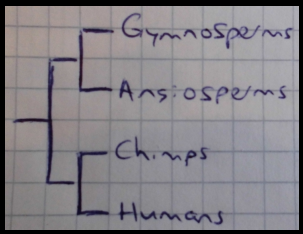


[2] http://commons.wikimedia.org/wiki/User:Petter_B%C3%B8ckman

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

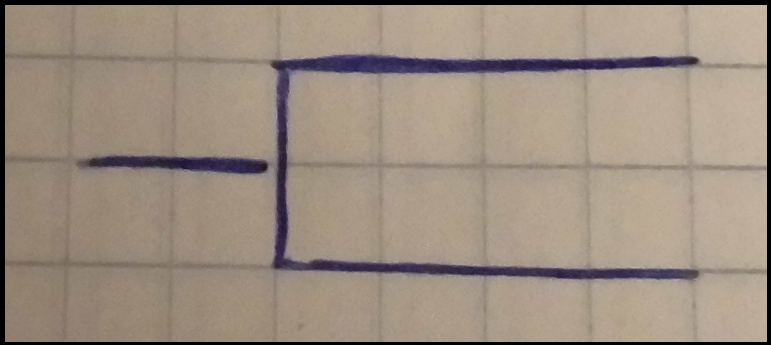
'Thus, humans are evolutionary as close to chimps as gymnosperms are to angiosperms'

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

Chapter 4

What trees show

4.1 Quiz[1]

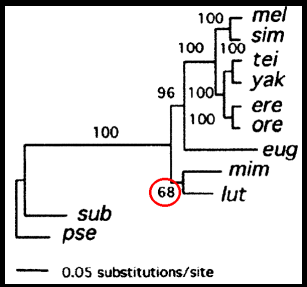


Phylogram

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

[1] Adapted from Grenfell et al, 2004, Science

4.2 Quiz



Phylogenetic tree of Adh in Drosophila[2]

'mim[3] and lut[4] share only 68% similarity with their common ancestor'

[2] Ko et al, 2003, Journal of molecular evolution

[3] Drosphila mimetica

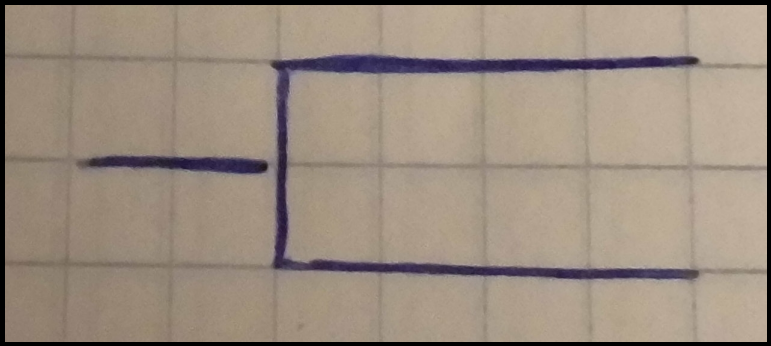
[4] Drosphila lutescens

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

- Phylograms commonly deal with extant species

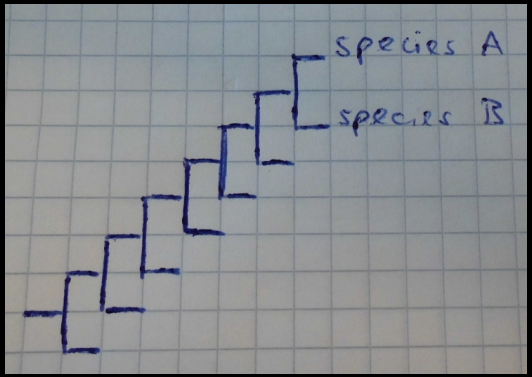


Phylogram of current time only[5]

[5] Adapted from Grenfell et al, 2004, Science

4.5 Types of things not being depicted

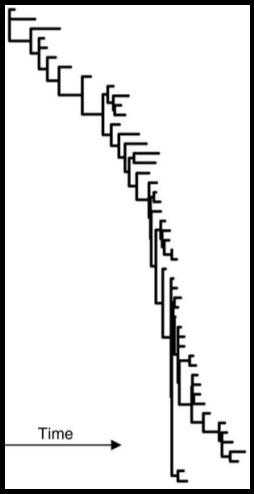
- That does not mean nothing is going on!



Phylogram of species sampled in time[6]

[6] Adapted from Grenfell et al, 2004, Science

4.6 Types of things not being depicted[7]



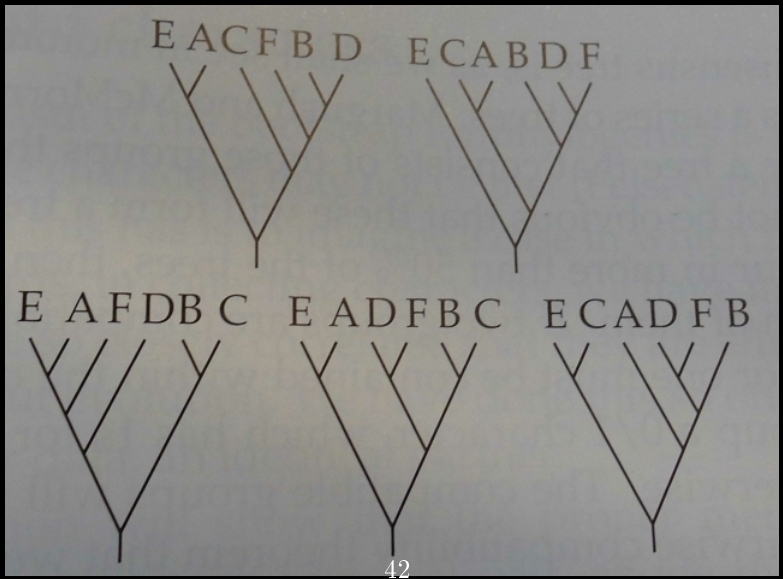
[7] Adapted from Grenfell et al, 2004, Science

4.7 Bootstrap values

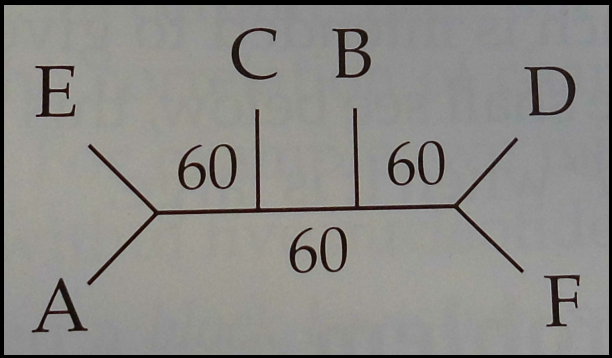
- Inferring a phylogeny is hard[8]
- Trick: generate multiple candidates, then count these candidates
- Bootstrapping shows how often the candates agree
- Tip: threshold for publication: about 70%

[8] There are $(2n-3)!/2^{n-1}(n-1)!$ possible (rooted) trees for n samples (2M for 9 samples)

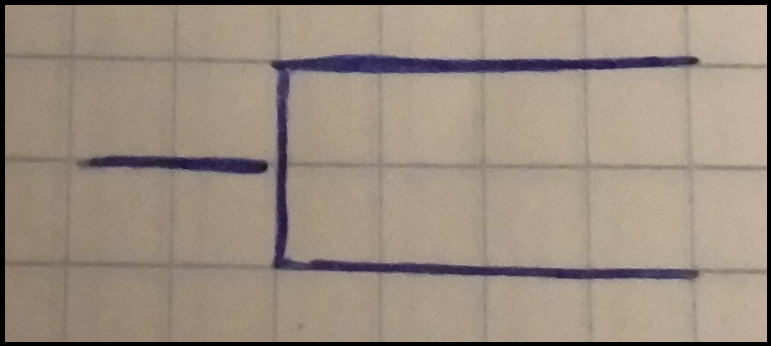
4.8 Bootstrap values: generate candidates



4.9 Bootstrap values: count agreement



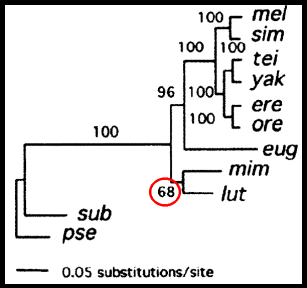
4.10 Conclusion[9]



Phylogram

[9] Adapted from Grenfell et al, 2004, Science

4.11 Conclusion



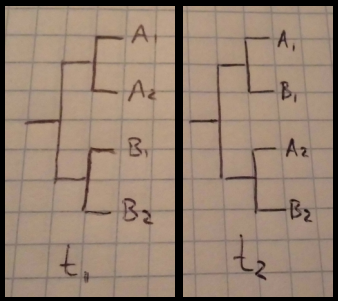
Phylogenetic tree of Adh in Drosophila[10]
What does the 68 mean?

[10] Ko et al, 2003, Journal of molecular evolution

Chapter 5

What phylogenies can tell

5.1 Quiz



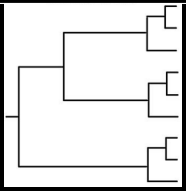
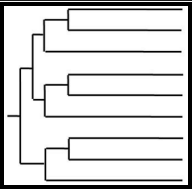
Gene trees of two genes (A and B) in two species (1 and 2) measured at two points in time

How can this be?

5.2 What phylogenies can tell

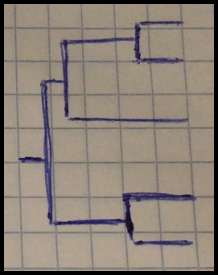
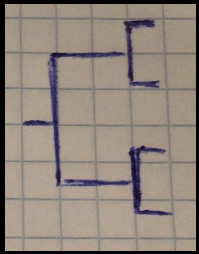
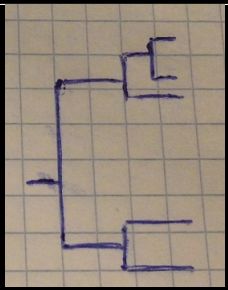
- Type of selection: no, purifying, stabilizing
- Population growth: constant, exponential
- Phylogenies that change: concerted evolution
- Type of evolutionary force: habitat filtering, competitive exclusion
- Type of evolution: concerted, divergent, by birth-death process
- Mutation rate

5.3 Population growth[1]

Constant	Exponentially growing
	

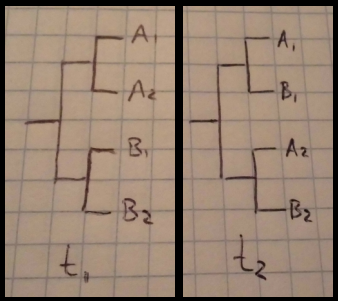
[1] Grenfell et al, 2004, Science

5.4 Type of selection[2]

Neutral	Purifying	Stabilizing
		
	Living fossils in unchanged niches	Birth weight

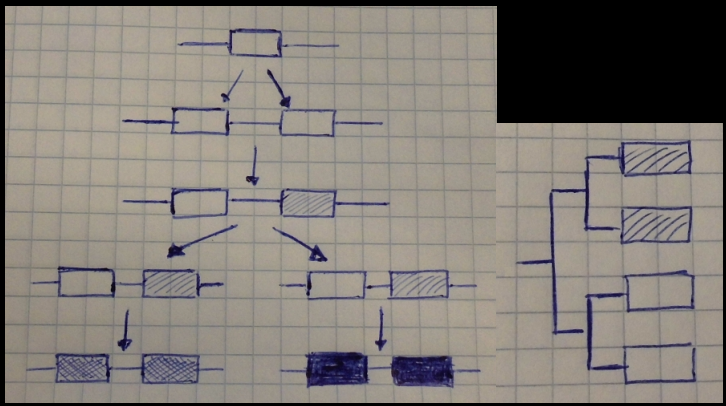
[2]Hartl & Clark, 2007, Principles of population genetics, p. 361

5.5 Phylogenies that change

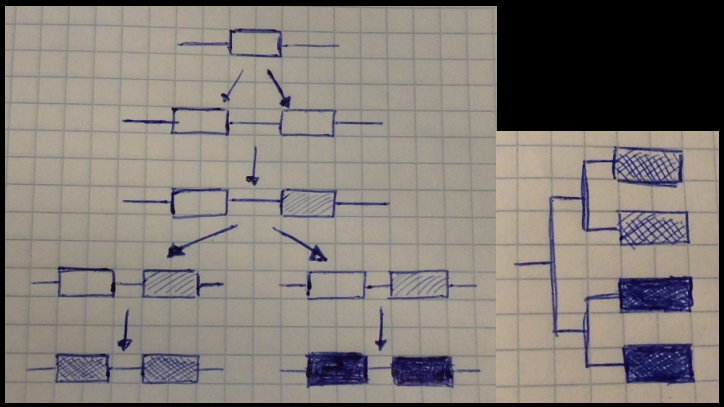


Gene trees of two genes (A and B) in two species (1 and 2) measured at two points in time

5.6 Phylogenies that change



5.7 Phylogenies that change



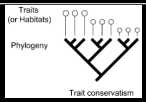
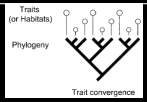
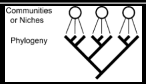
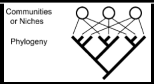
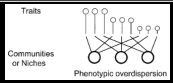
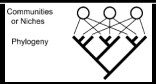
5.8 Type of evolutionary force

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

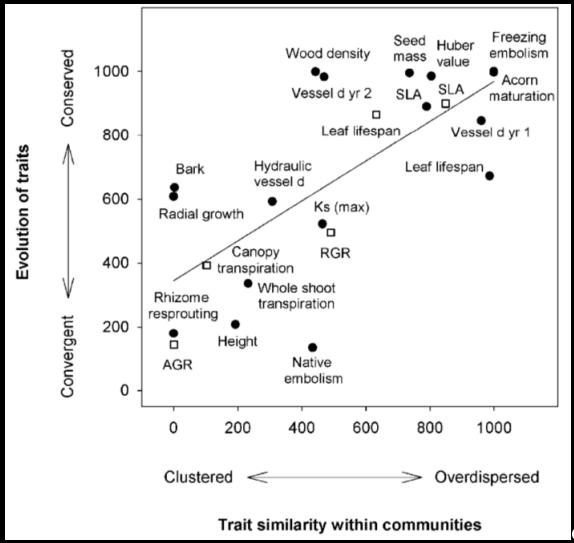
5.9 Type of evolutionary force[3]

Dominant ecological force	Ecological traits phylogenetically	
	Conserved	Convergent
Habitat filtering[3]	Clustered	Overdispersed
Competitive exclusion[4]	Overdispersed	Random

5.10 Type of evolutionary force[1][3]

Dominant ecological force	Ecological traits phylogenetically	
		
		
		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 commity 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

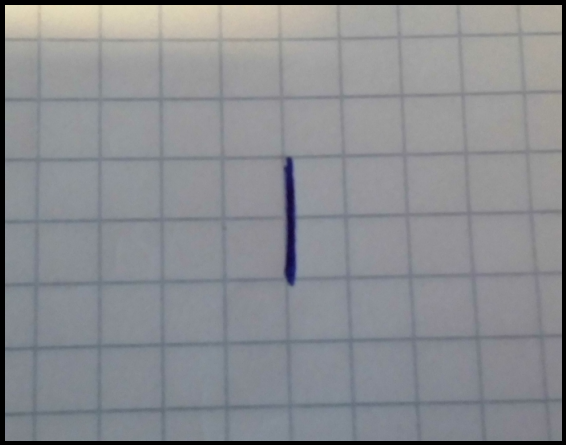
Habitat filtering

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 , Laı´ se da Silveira Pontes 7 , Jean-Franc¸ois Soussana 1 and Fre´ de´ rique Louault :

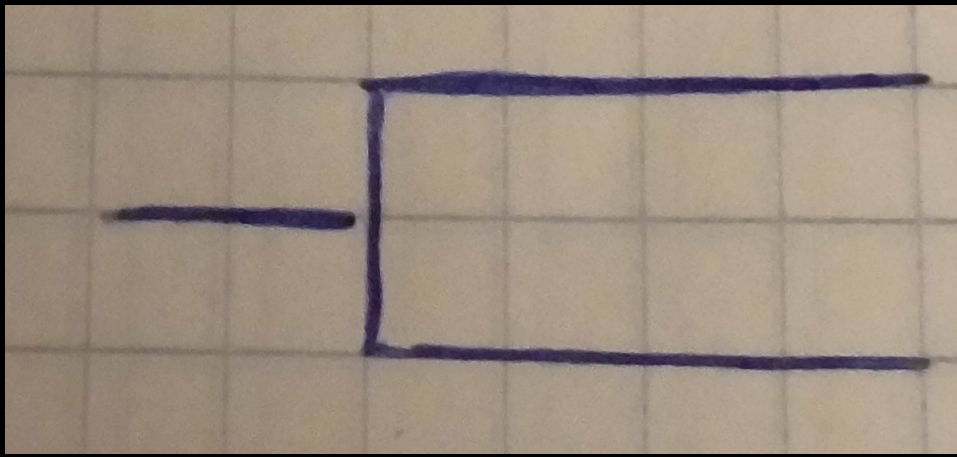
However, recent studies (Shipley, 2009; Adler et al. , 2010; Cornwell & Ackerly, 2010) suggested that biodiver- sity within communities cannot be understood without taking into account deterministic processes such as habitat filtering (HF; Keddy, 1992) and niche differentiation (ND; MacArthur & Levins,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

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[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.