Introduction

Top 5 Classics

1. George Gaylord Simpson. 1944. Tempo & Mode in Evolutionary Biology. (and its sequel - The Major Features of Evolution - from 1953)
2. Ernst Mayr. 1963. Animal Species and Evolution. (and its predecessor - Systematics and the Origin of Species - published in 1942)
3. MacArthur & Wilson. 1967. The Theory of Island Biogeography.
4. Stephen Jay Gould. 1977. Ontogeny and Phylogeny.
5. Stephen Stanley. 1979. Macroevolution: Pattern and Process.

Top 5 Modern

1. Gould. 2002. The Structure of Evolutionary Theory.
2. Schluter. 2000. The Ecology of Adaptive Radiation.
3. Harvey & Pagel. 1991. The Comparative Method in Evolutionary Biology.
4. Coyne & Orr. 2004. Speciation.
5. Avise. 2000. Phylogeography.

Top 5 Light Reading

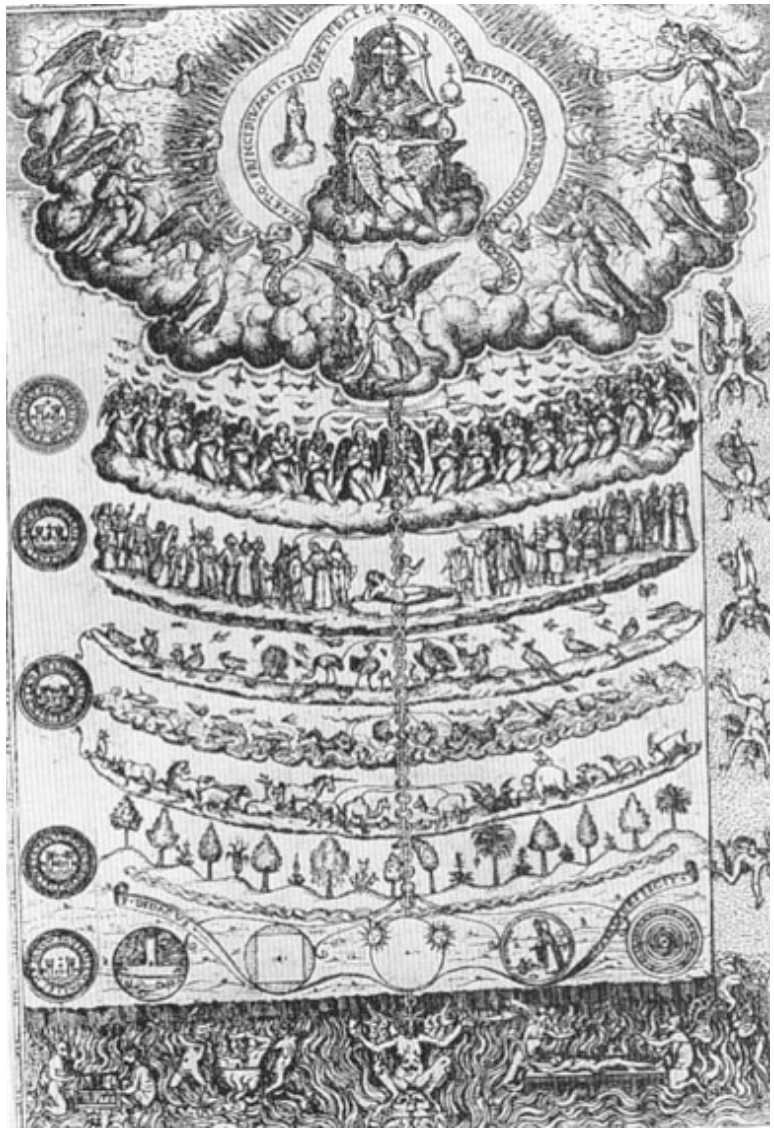
1. David Quammen. 1997. Song of the Dodo.
2. David Quammen. 2006. The Reluctant Mr. Darwin.
3. Menno Schulthuizen. 2001. Frogs, Flies & Dandelions: The Making of Species.
4. Jonathan Weiner. 1995. The Beak of the Finch: A Story of Evolution in Our Time.
5. Carl Sagan. 1996. The Demon-Haunted World: Science as a Candle in the Dark.

Phylogenetic Trees, Their Inference, and Importance to Evolutionary Biology.

Outline

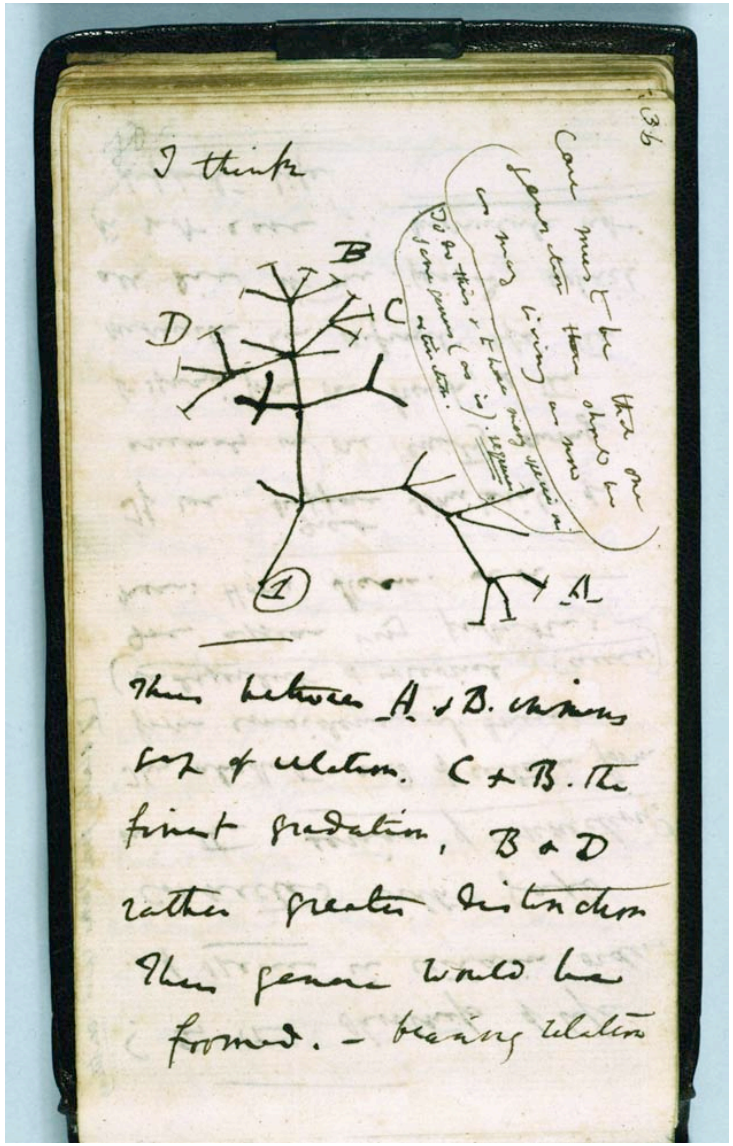
- A brief history of phylogenetics and its role in evolutionary biology.
- Uses for phylogenies.
- Basic phylogenetic terminology.

The Chain of Being



- The Great Chain of Being from Didacus Valades, Rhetorica Christiana (1579).

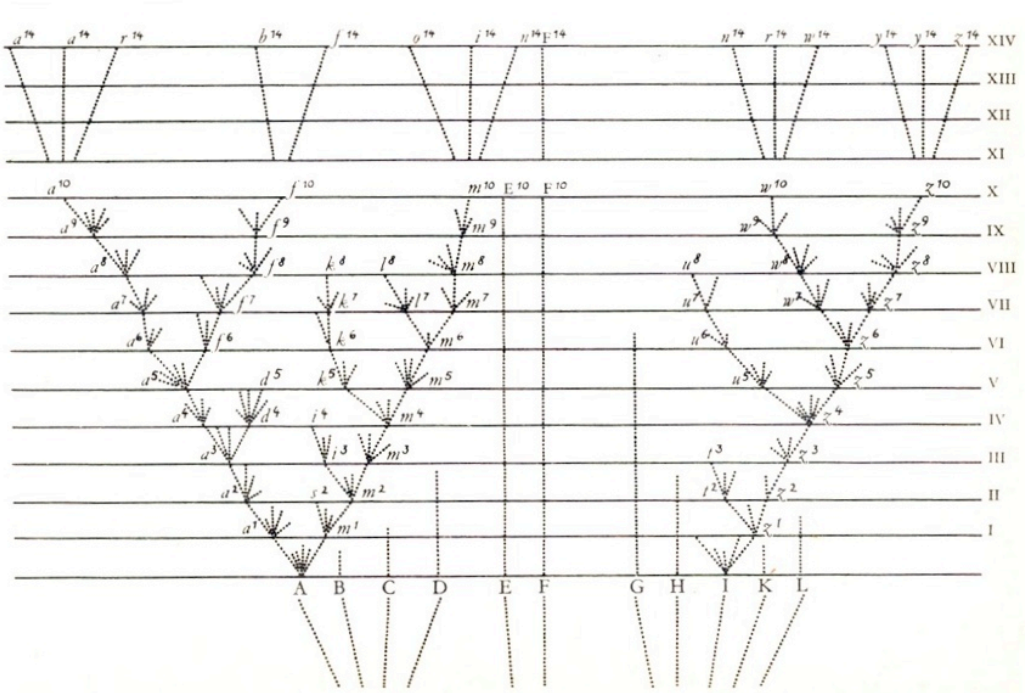
Darwin's Trees



- The first phylogenetic tree.
- From Darwin's First Notebook on Transmutation of Species (1837)

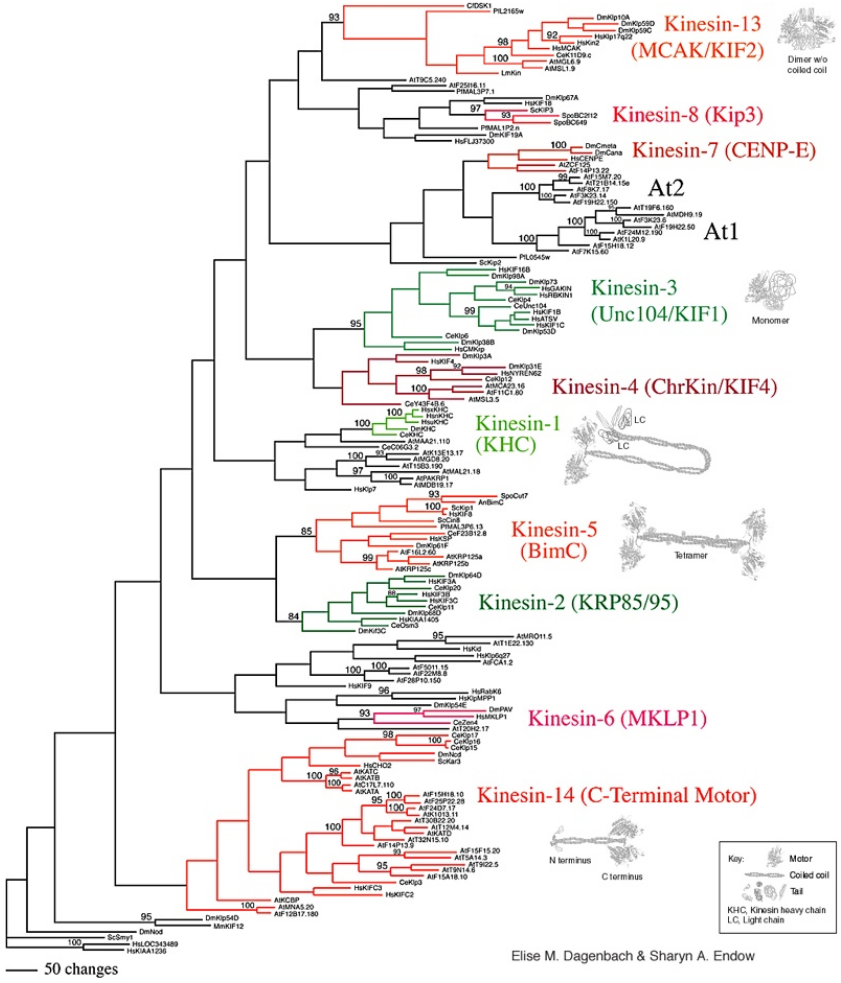
NCSE

Darwin's Trees



- The only figure in Darwin's classic "On the Origin of Species" (1859)

Phylogenetic Trees Today



www.tolweb.org

www.proweb.org

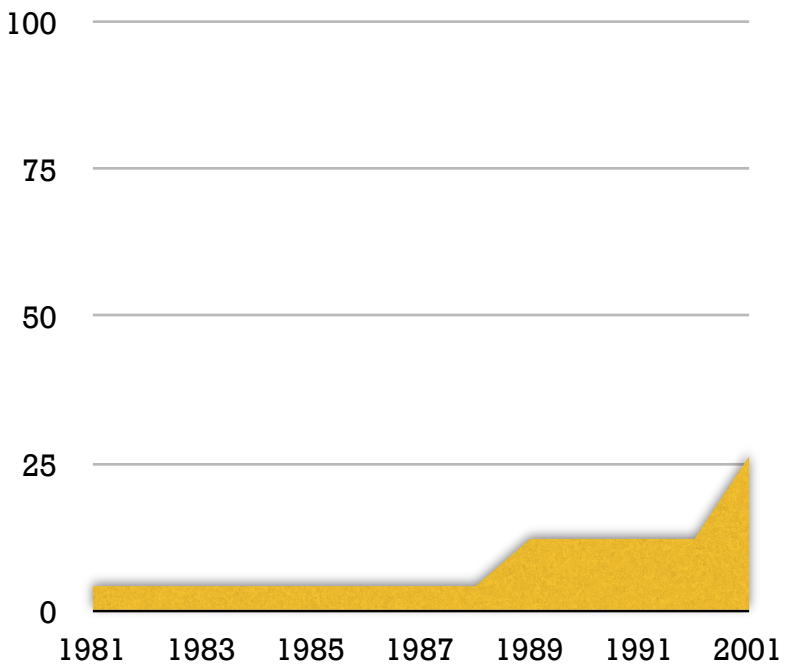
Fruits of the Tree

- Early 20th Century:
  - "Eclipse of Darwinism."
- Mid-20th Century:
  - The Modern Synthesis and it's emphasis on process instead of history.
- Late 20th Century:
  - Resurgence of phylogenetics.

Causes for the Resurgence of Phylogenetics

1. Development of rigorous phylogenetic methods.
   - In spite of early conflict…
2. New data from molecular biology.
   - Also permitted synthesis of phylogenetics and population genetics.
3. Renewed interest in 'macroevolution.'
   - Evo-devo, punc. eq., species selection, patterns of diversity
4. Support for synthesis.
   - Methods for using phylogenies invented.

Realization of the Resurgence

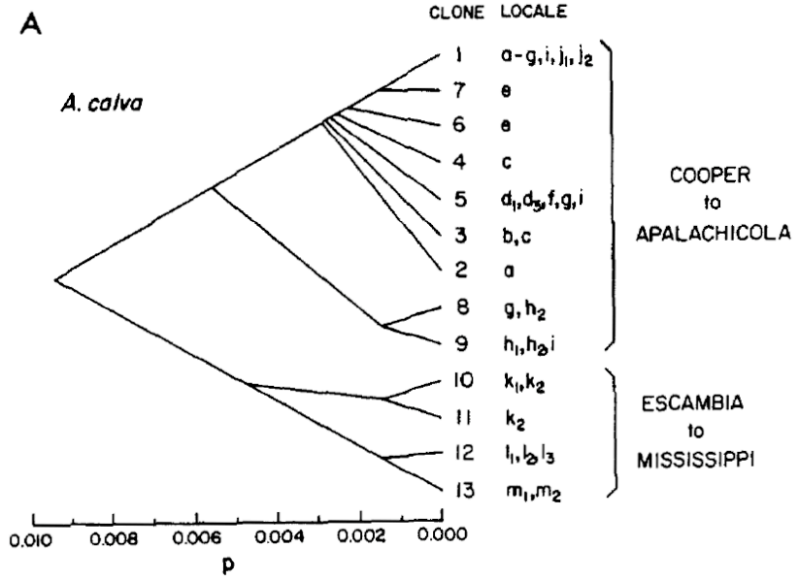


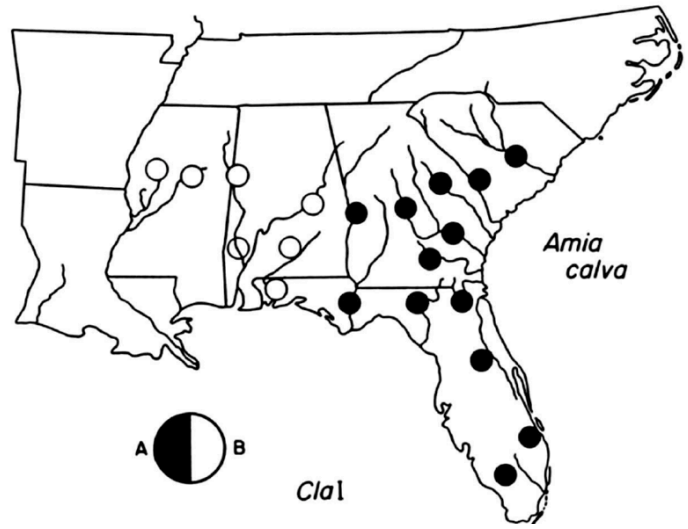
% of papers in Evolution with phylogenetic theme or flavor

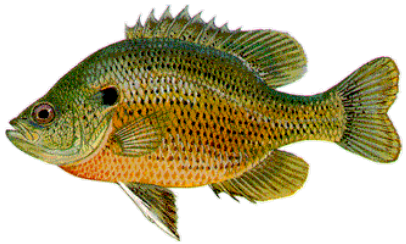
Intraspecific Applications

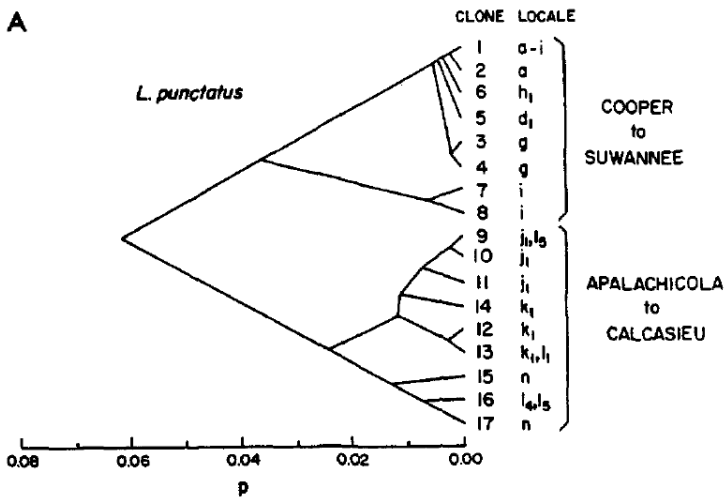
- Coalescent methods and the integration of population genetics with evolutionary trees.
- Phylogeography.
- Inference of processes like sexual selection (e.g., swordtail preference).

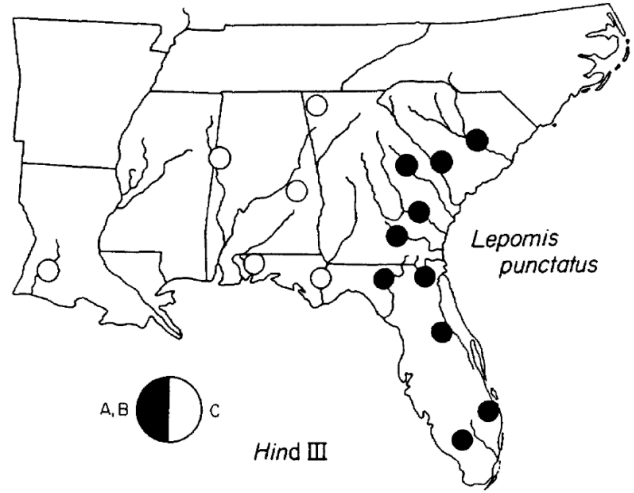
Intraspecific Insights: Phylogeography









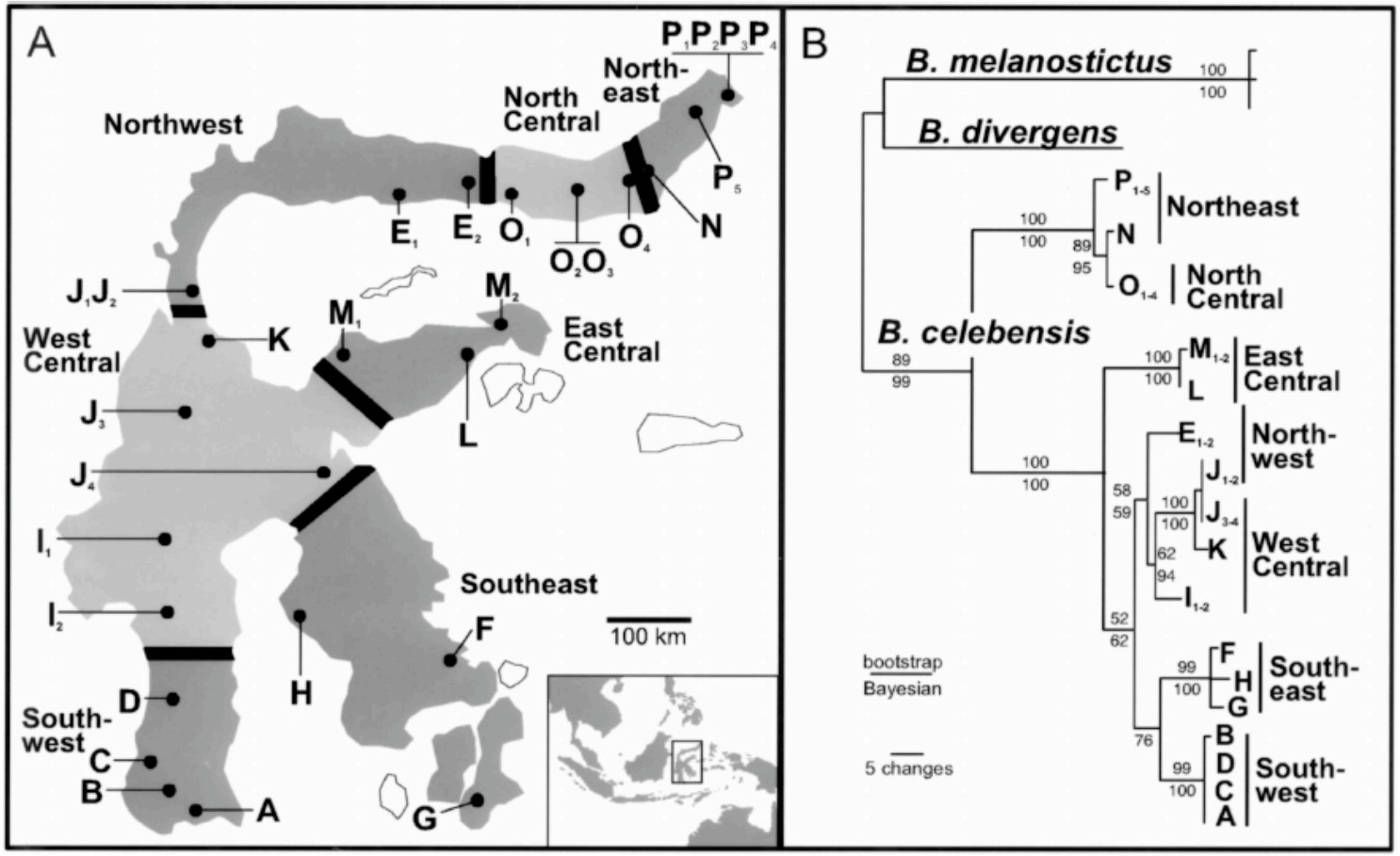


Bermingham & Avise. 1986. Genetics.

Evolution, 57(6), 2003, pp. 1436–1443

MONKEYS AND TOADS DEFINE AREAS OF ENDEMISM ON SULAWESI

BEN J. EVANS,[1,2,3] JATNA SUPRIATNA,[4,5] NOVIAR ANDAYANI,[4] MOHAMMED IQBAL SETIADI,[4]
DAVID C. CANNATELLA,[2] AND DON J. MELNICK[1]



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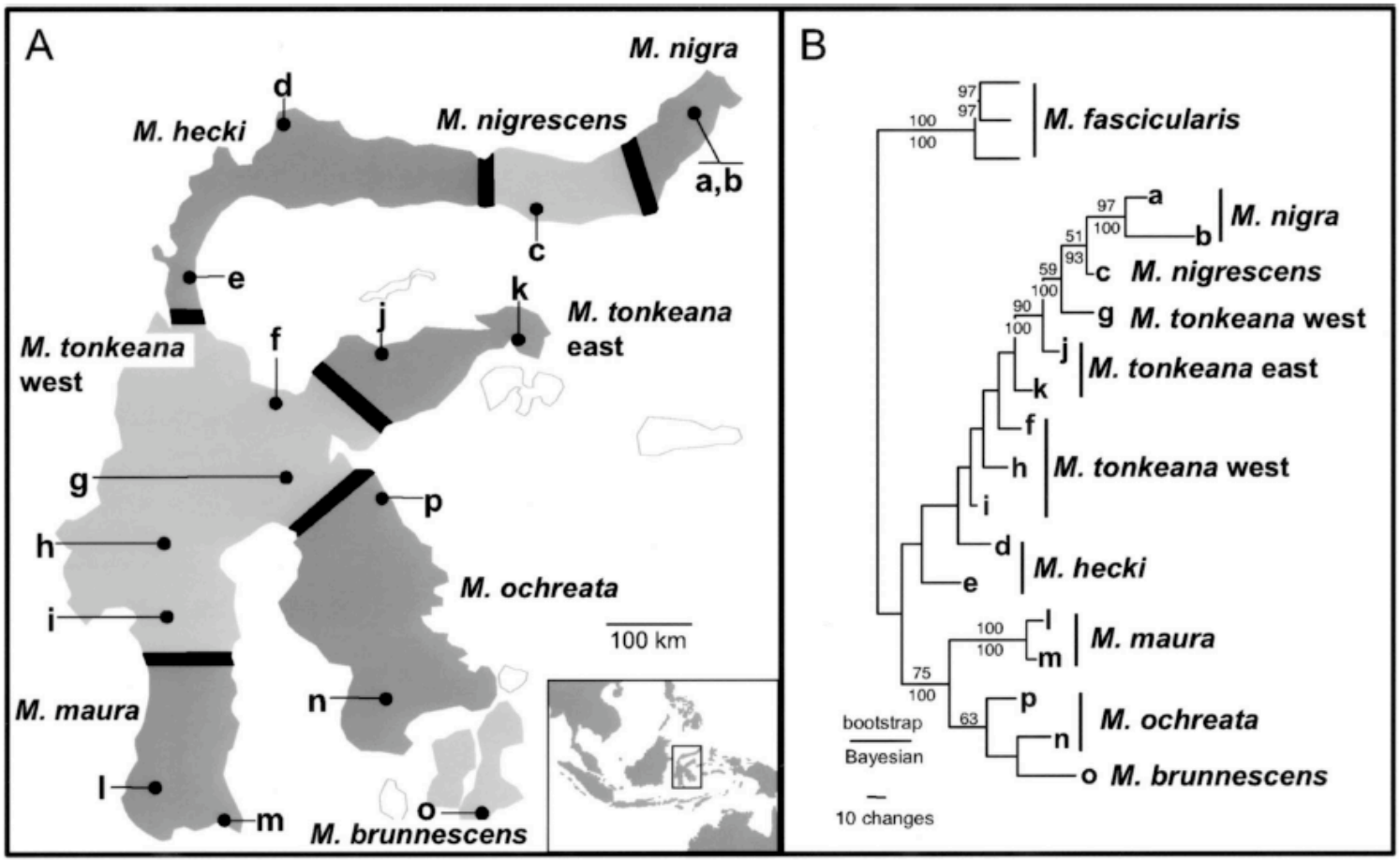
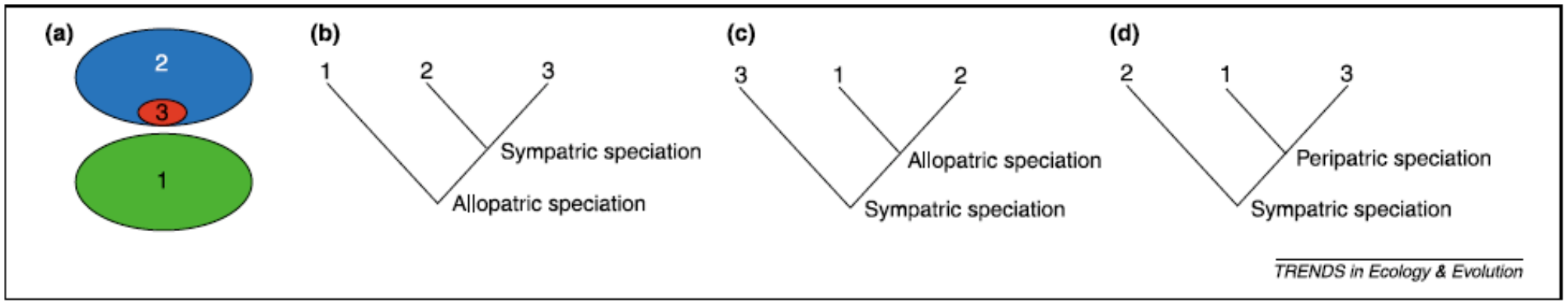


Speciation

- Timing of speciation events.
- Speciation duration.
- Distinguishing allopatric from sympatric.

Mode of Speciation



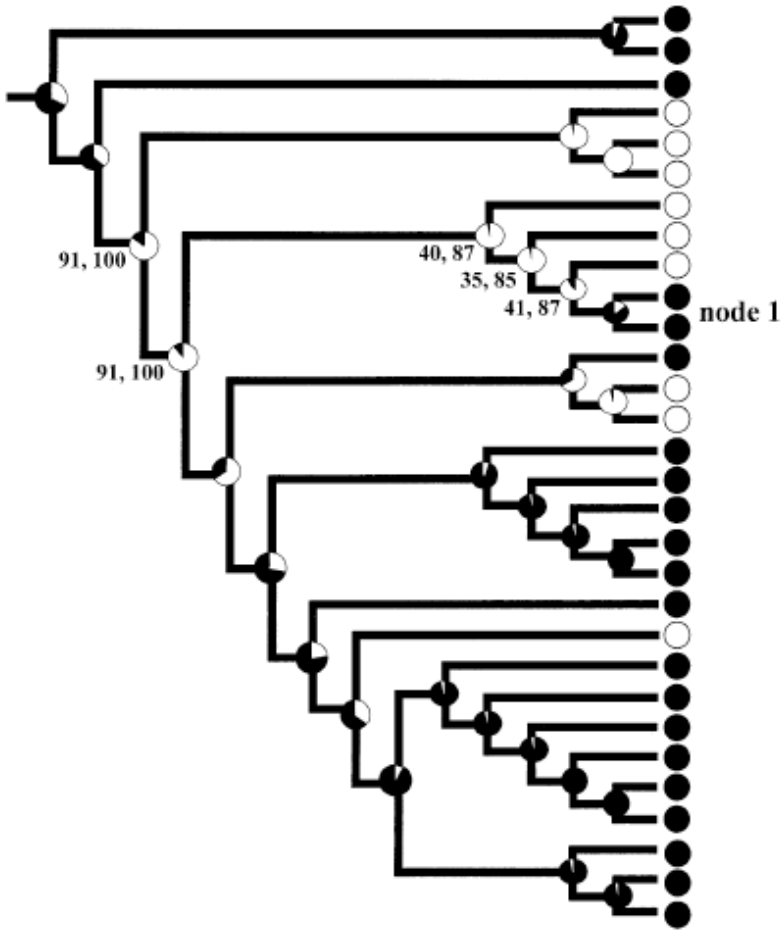
220 Opinion TRENDS in Ecology and Evolution Vol.18 No.5 May 2003

Phylogenetic comparative methods and the geography of speciation

Jonathan B. Losos and Richard E. Glor

Department of Biology, Campus Box 1137, Washington University, St Louis, MO 63130-4899, USA

Character Evolution

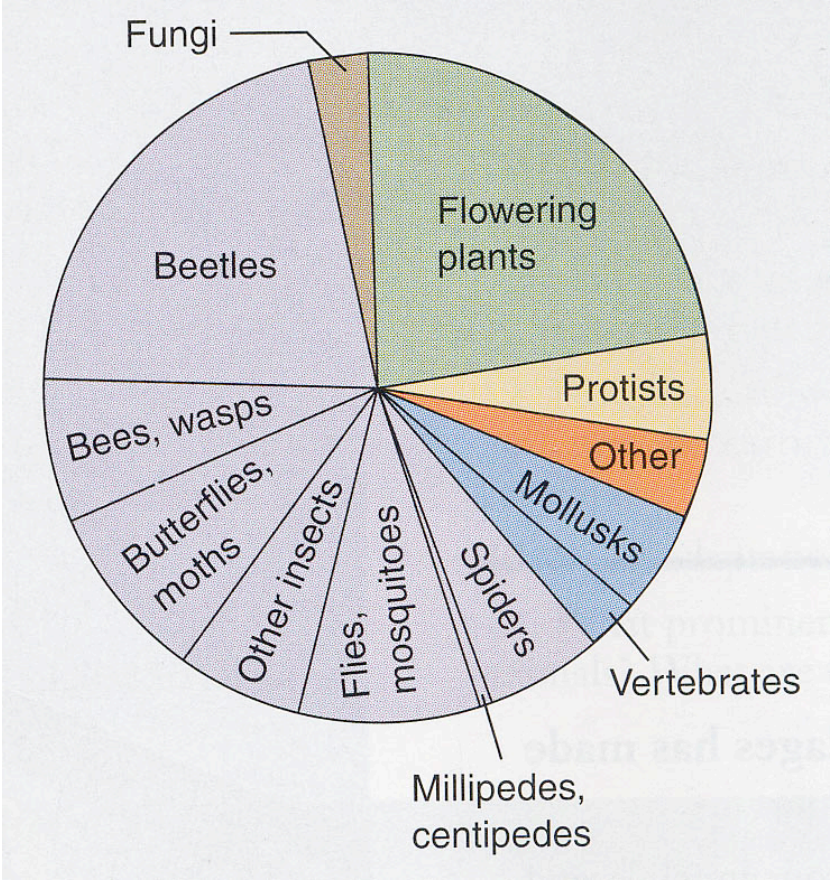


- Do specialists (white) evolve from generalists (black)?

Nosil & Mooers. 2005. Evolution.

Questions About Species Diversity

- Why are some clades more diverse than others?

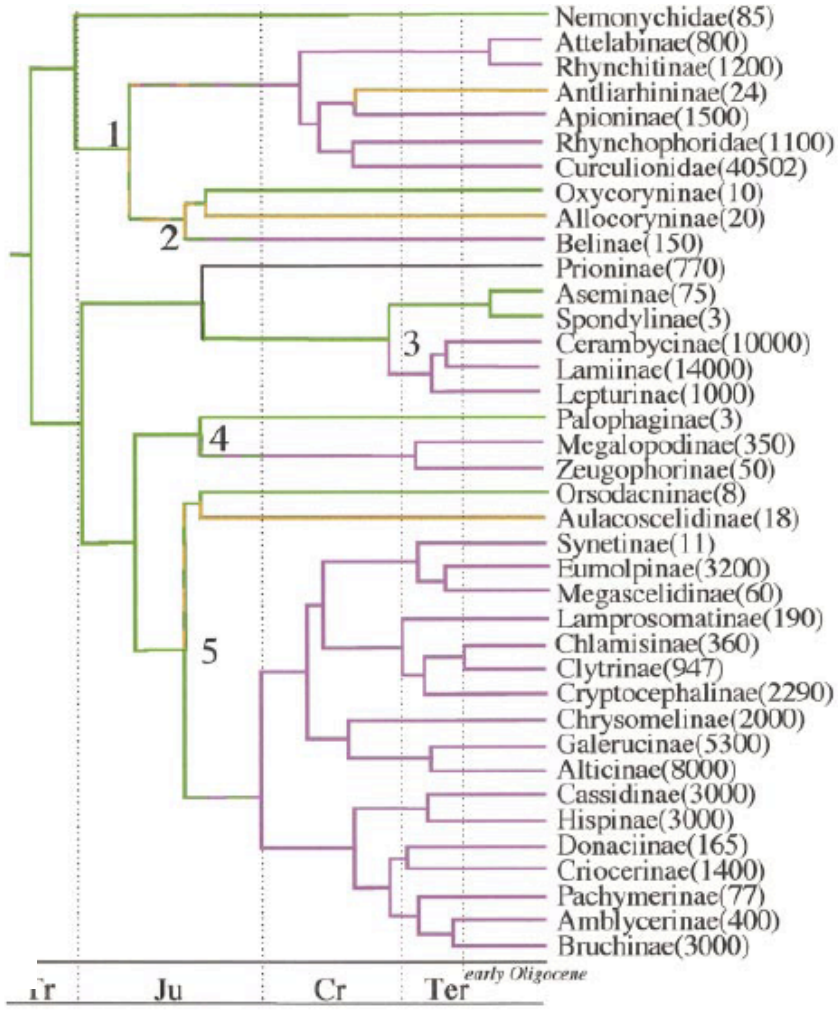


Explaining Diversity

- Key innovations.

"Inordinate Fondness" Explained: Why Are There So Many Beetles?

Brian D. Farrell



Calculating Rates of Diversification

Unmatched tempo of evolution in Southern African semi-desert ice plants

C. Klak[1], G. Reeves[2] & T. Hedderson[1]

[1]*Bolus Herbarium, Department of Botany, University of Cape Town, 7701 Rondebosch, South Africa*
[2]*Leslie Hill Molecular Systematics Laboratory, Kirstenbosch Research Centre, National Botanical Institute Cape Town, Private Bag X7, 7735 Claremont, South Africa*

Klak et al. 2004. Nature.

Rapid Diversification of a Species-Rich Genus of Neotropical Rain Forest Trees

James E. Richardson,[1,2] R. Toby Pennington,[1]*
Terence D. Pennington,[3] Peter M. Hollingsworth[1]

Species richness in the tropics has been attributed to the gradual accumulation of species over a long geological period in stable equatorial climates or, conversely, to speciation in response to late Tertiary geological events and unstable Pleistocene climates. DNA sequence data are consistent with recent diversification in *Inga*, a species-rich neotropical tree genus. We estimate that speciation was concentrated in the past 10 million years, with many species arising as recently as 2 million years ago. This coincides with the more recent major uplifts of the Andes, the bridging of the Isthmus of Panama, and Quaternary glacial cycles. *Inga* may be representative of other species-rich neotropical genera with rapid growth and reproduction, which contribute substantially to species numbers in the world's most diverse flora.

Richardson et al. 2001. Science.

letters to nature

Rapid and recent origin of species richness in the Cape flora of South Africa

James E. Richardson*†, Frans M. Weitz‡§, Michael F. Fay*, Quentin C. B. Cronk‖¶, H. Peter Linder†§, G. Reeves* & Mark W. Chase*

* *Jodrell Laboratory, Royal Botanic Gardens, Richmond, Surrey TW9 3DS, UK*
‡ *Department of Botany, University of Western Cape, Bellville 7535, Cape Province, South Africa*
§ *Bolus Herbarium, Botany Department, University of Cape Town, Rondebosch 7700, South Africa*
‖ *Institute of Cell and Molecular Biology, University of Edinburgh, Darwin Building, King's Buildings, Mayfield Road, Edinburgh EH9 3JR, UK*
¶ *Royal Botanic Garden, 20A Inverleith Row, Edinburgh EH3 5LR, UK*

Richardson et al. 2001. Nature.

brief communications

Rapid speciation in an arthropod

The likely force behind an explosion of new Hawaiian cricket species is revealed.

Mendelson & Shaw 2005. Nature.

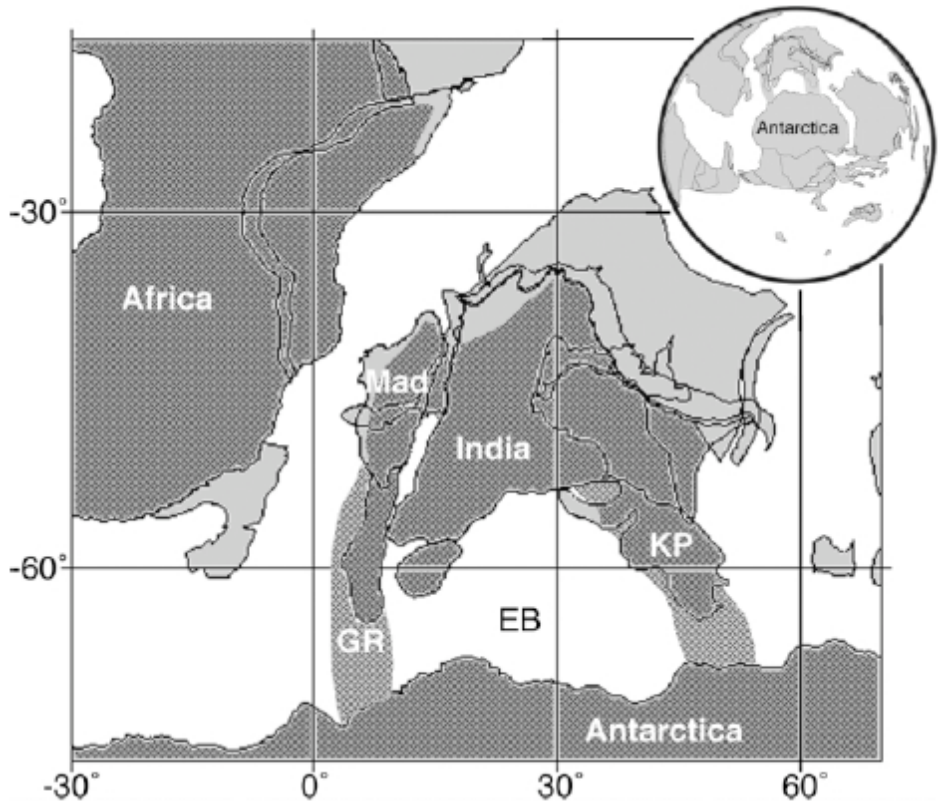
Biogeography

VOL. 168, NO. 6 THE AMERICAN NATURALIST DECEMBER 2006

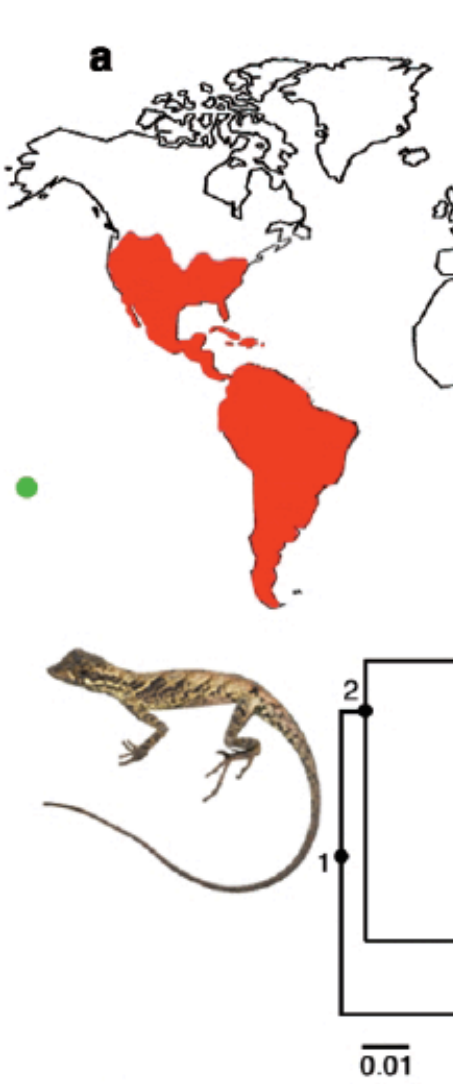
Vicariant Origin of Malagasy Reptiles Supports Late Cretaceous Antarctic Land Bridge

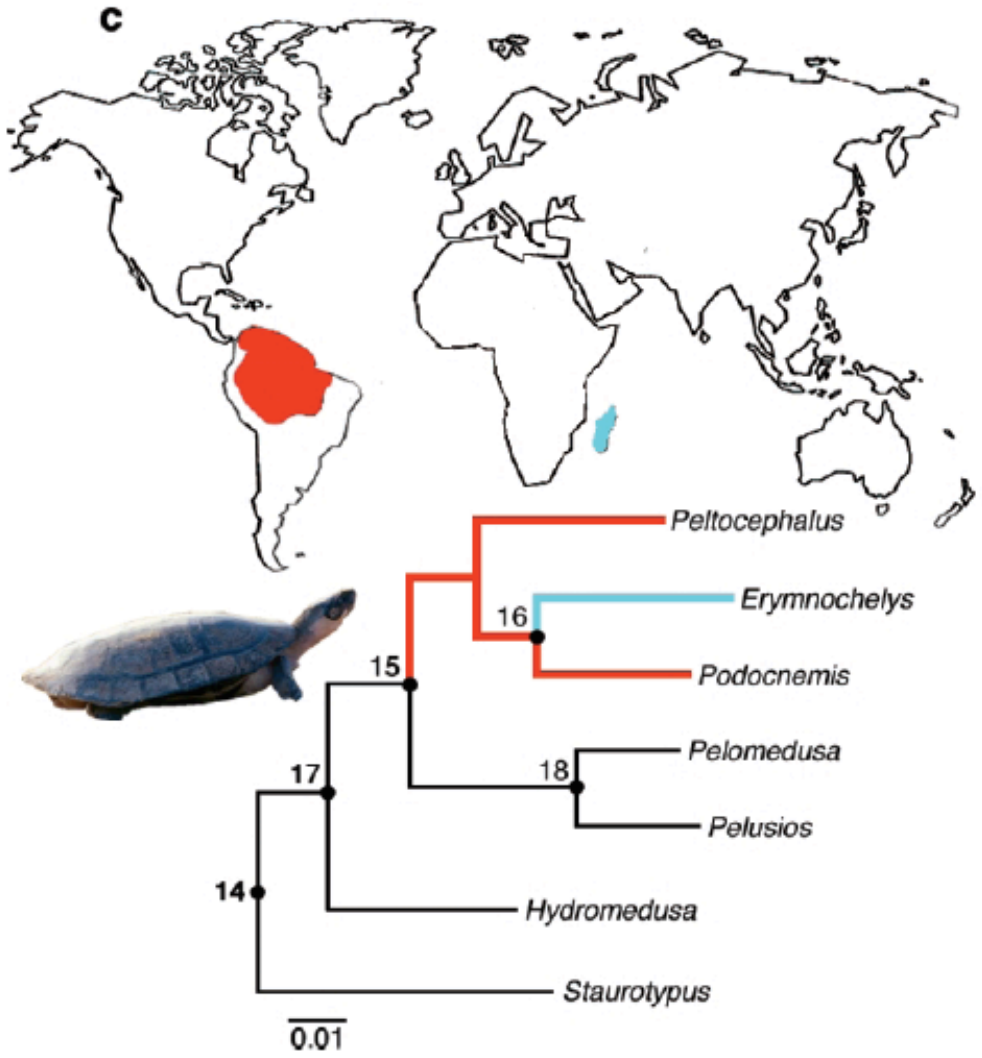
Brice P. Noonan[1,2,*] and Paul T. Chippindale[2,†]

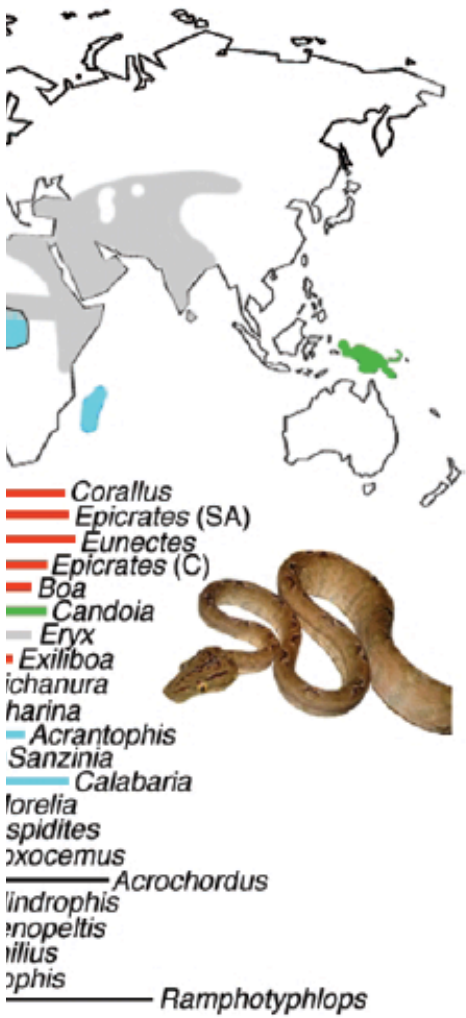
- Madagascar connected to South America (via Antarctica) more recently than to Africa.



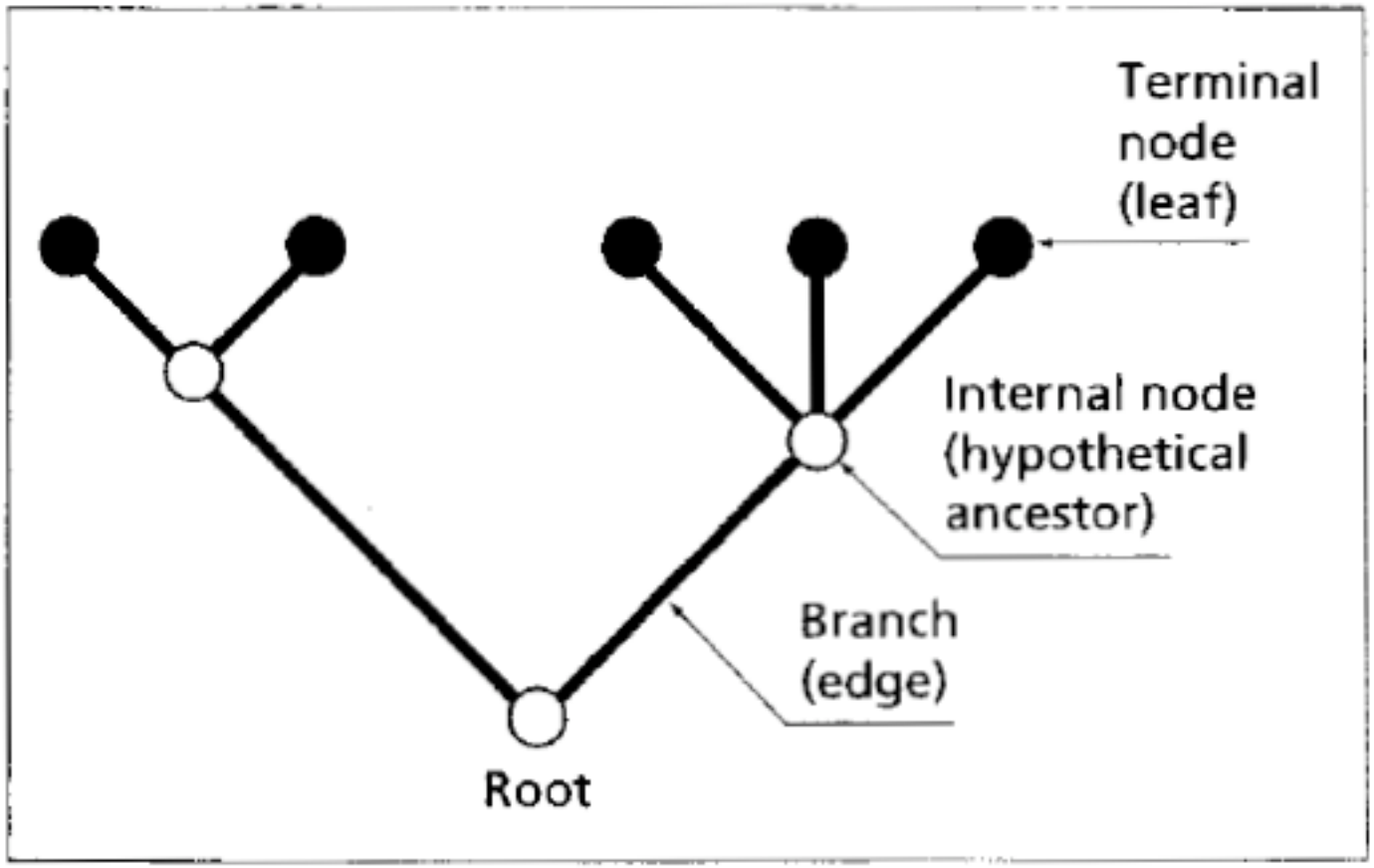
Madagascan Origins







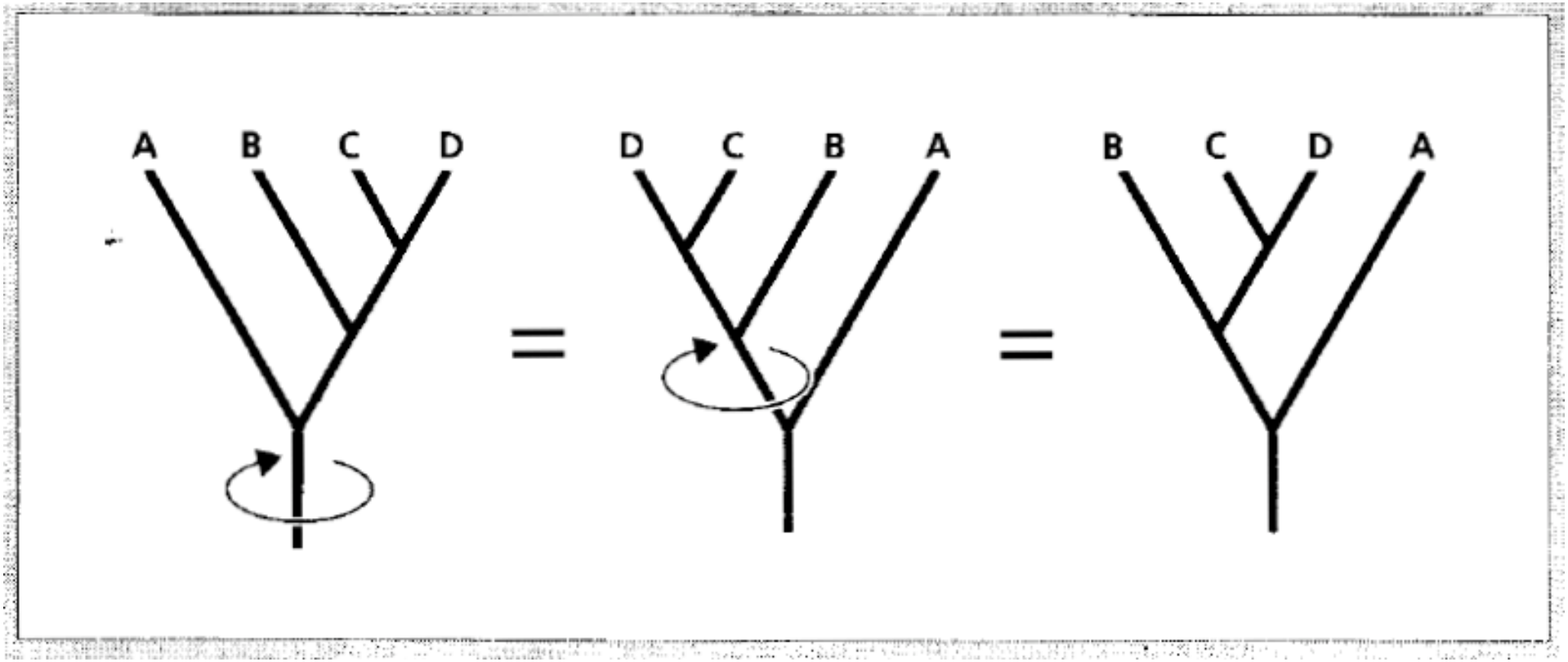
Basic Terminology



The Tips of the Tree

- Taxon: A unit of analysis in taxonomic or systematic analysis. Historically referred to Linnaean taxonomic ranks.
- Higher taxa: Above the level of species.
- OTU (Operational Taxonomic Unit): The units of a phylogenetic analysis. May be populations, species, or higher taxa.

Tree Topology



How Many Trees?

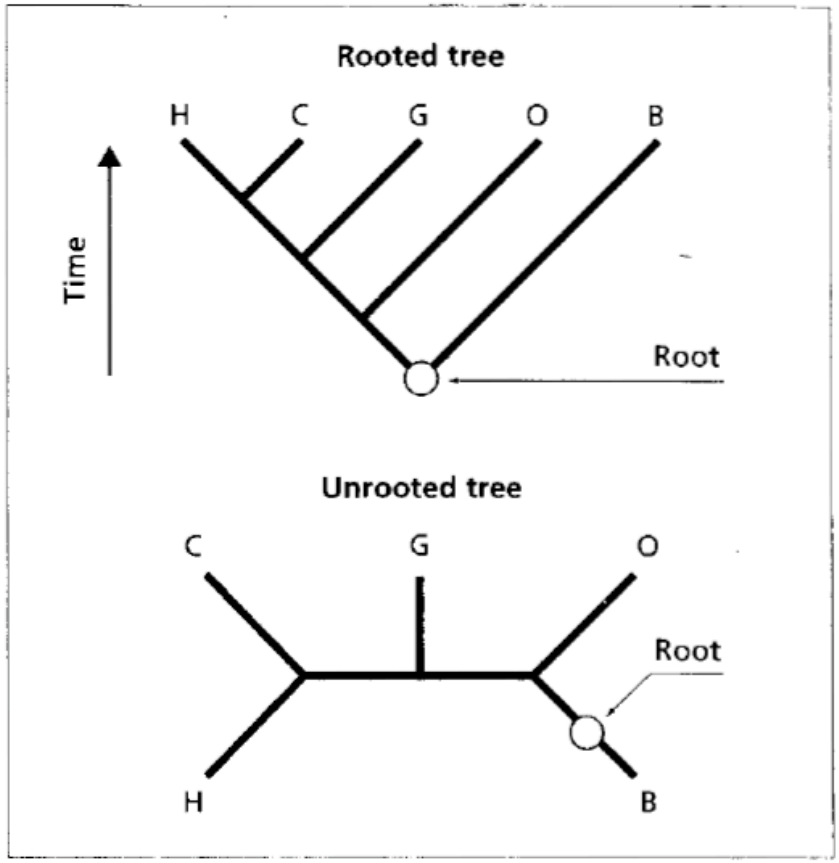
$$N = \frac{(2n-5)!}{2^{n-3}(n-3)!}$$

$$N = \frac{(2n-3)!}{2^{n-2}(n-2)!}$$

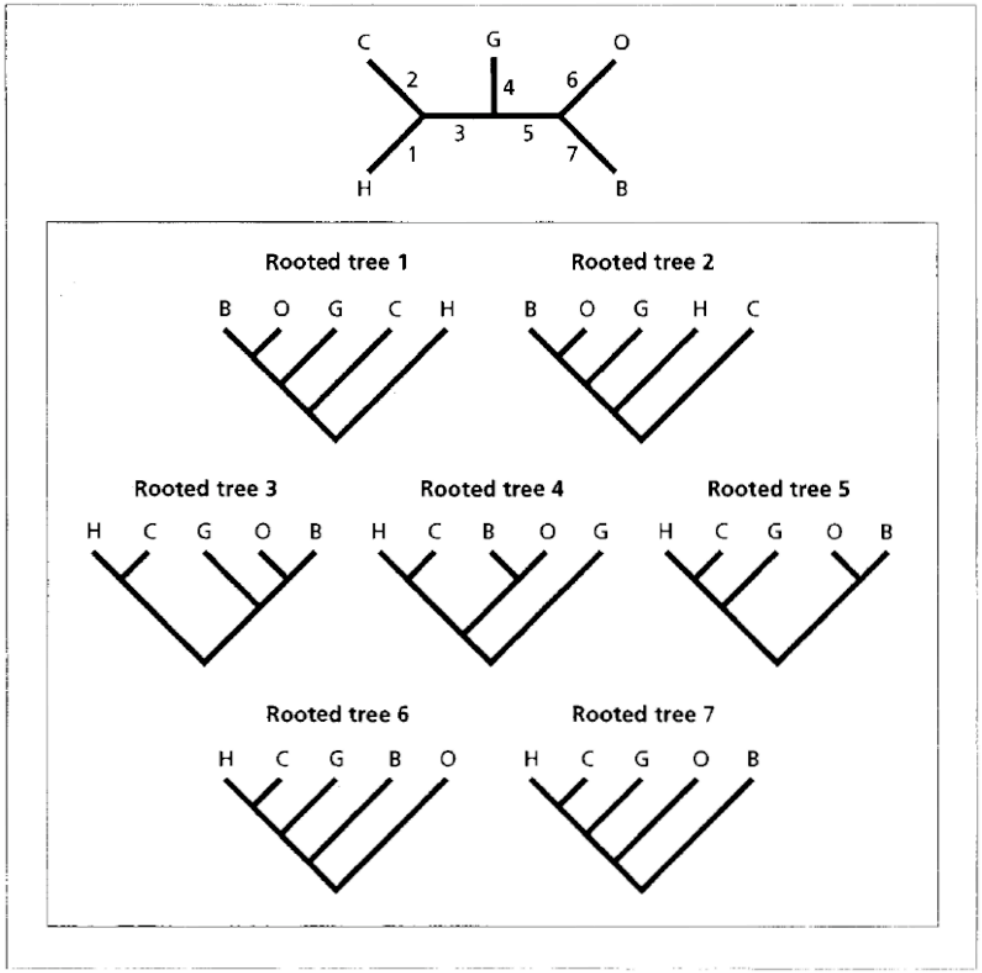
How Many Trees?

Number of sequences	Number of unrooted trees	Number of rooted trees
2	1	1
3	1	3
4	3	15
5	15	105
6	105	945
7	945	10 395
8	10 395	135 135
9	135 135	2027025
10	2027025	34459425

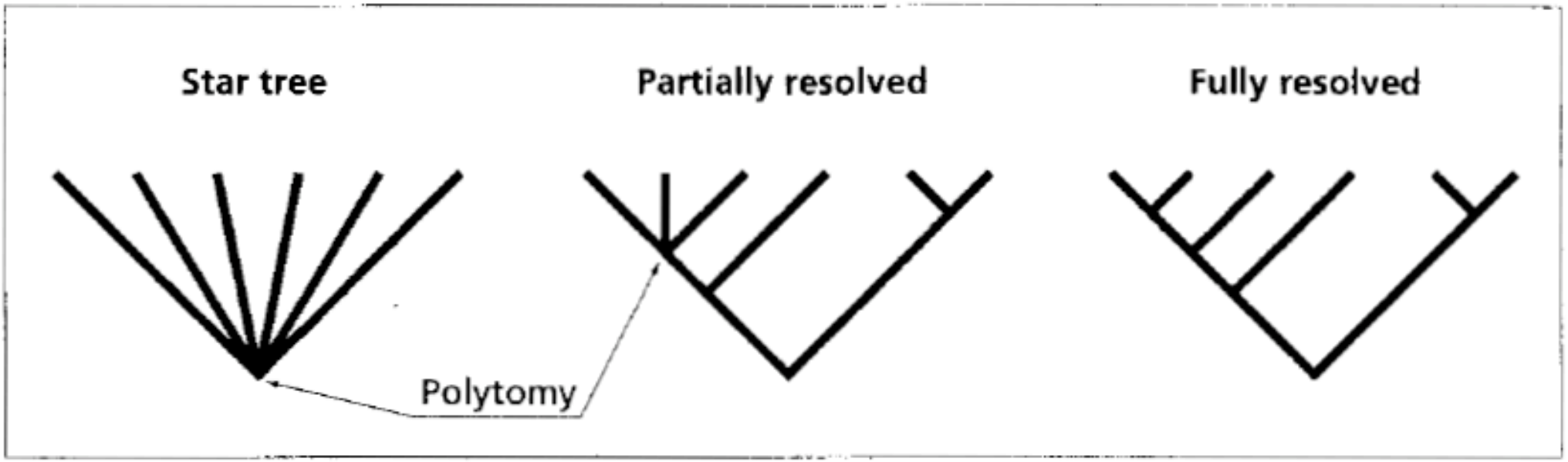
Tree Rooting

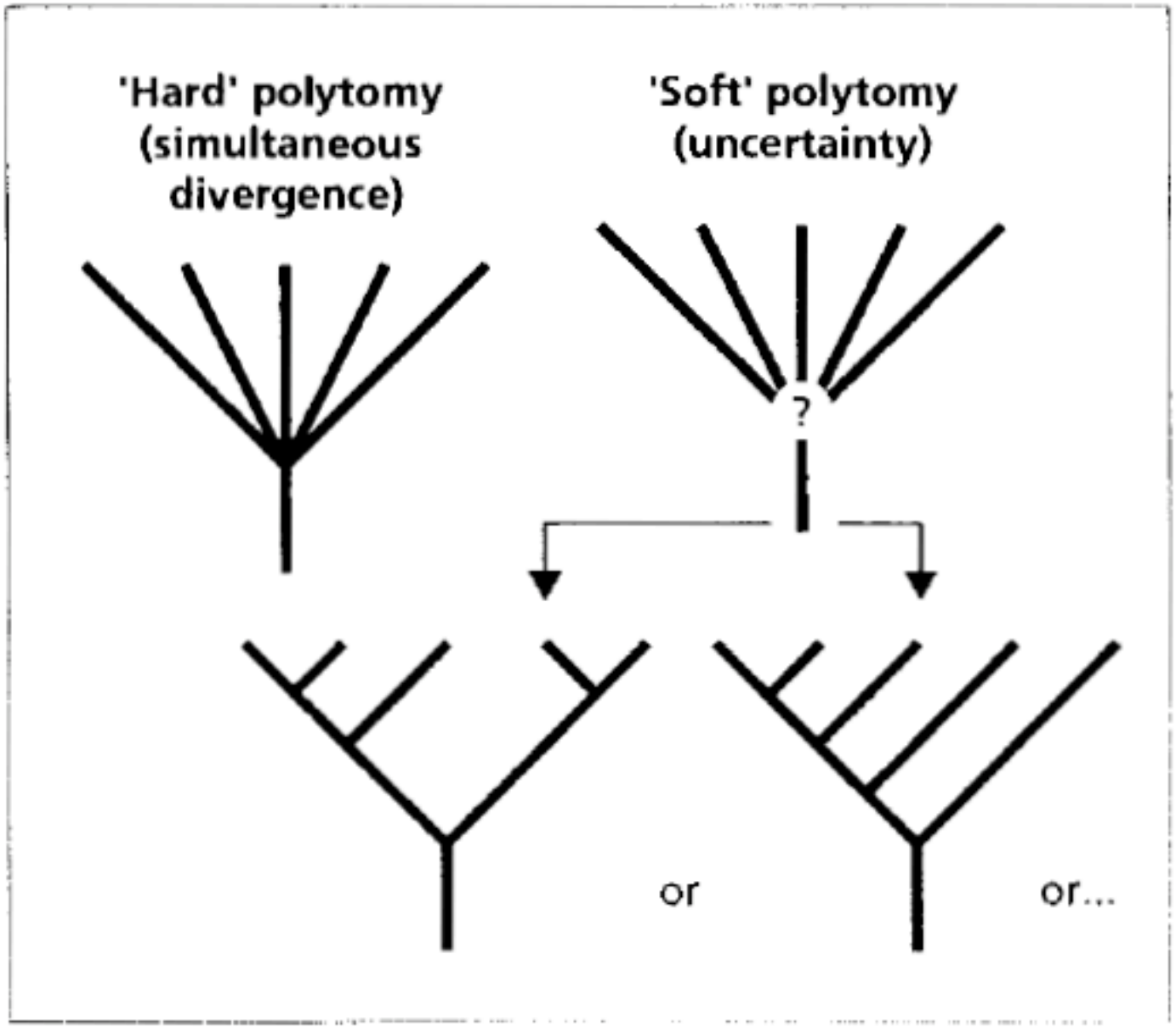


Tree Rooting

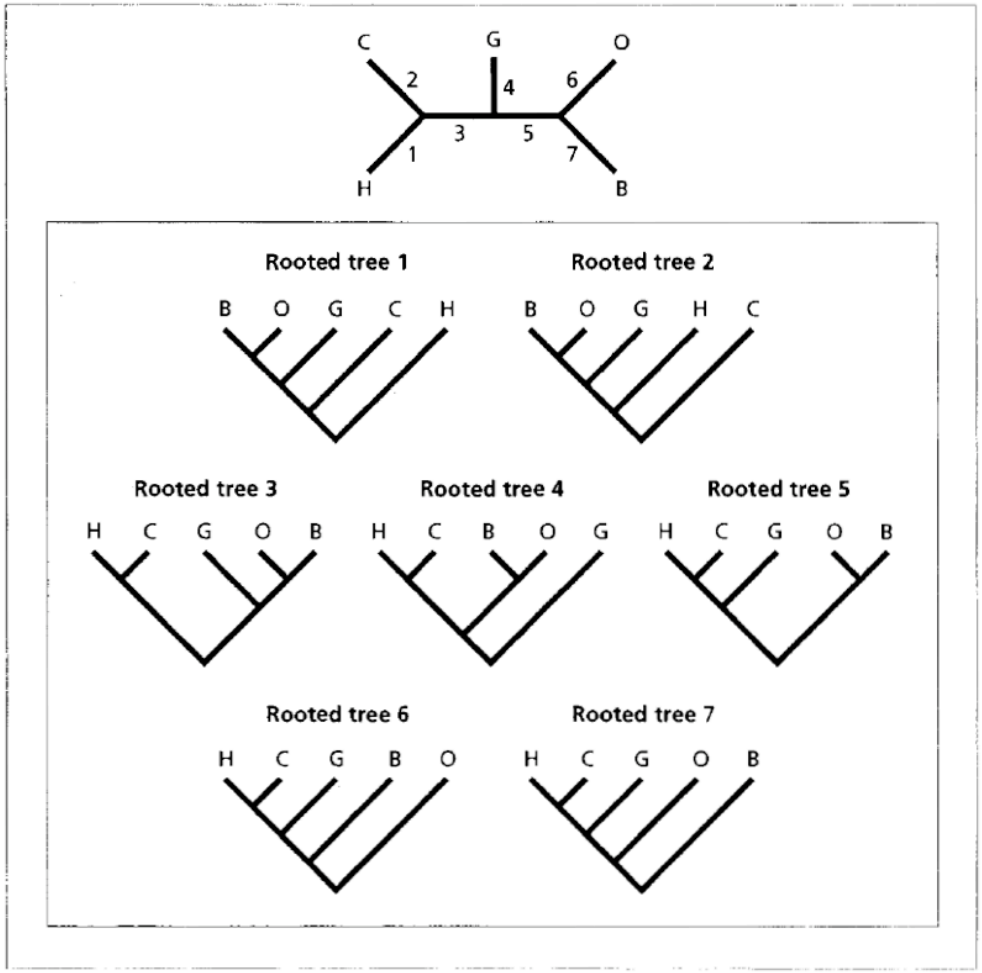


Tree Resolution




'Hard' polytomy
(simultaneous
divergence)
'Soft' polytomy
(uncertainty)
?
or
or...

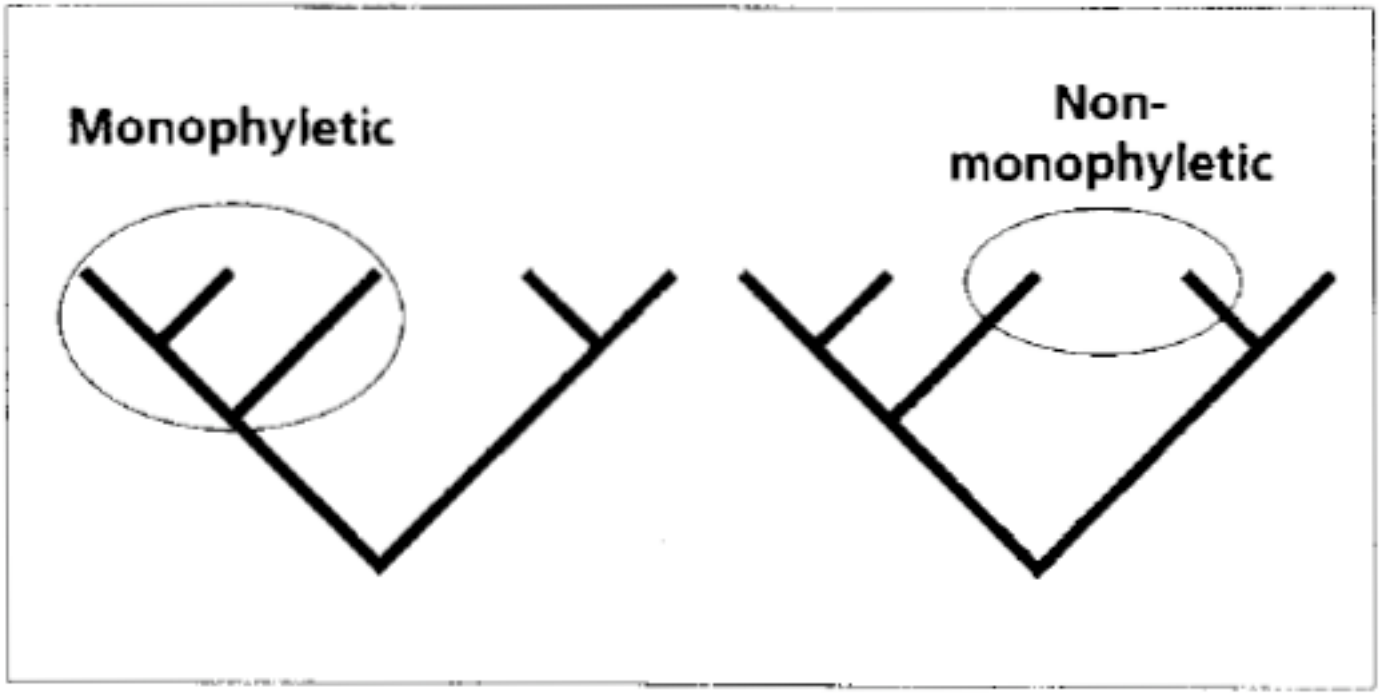
Tree Balance



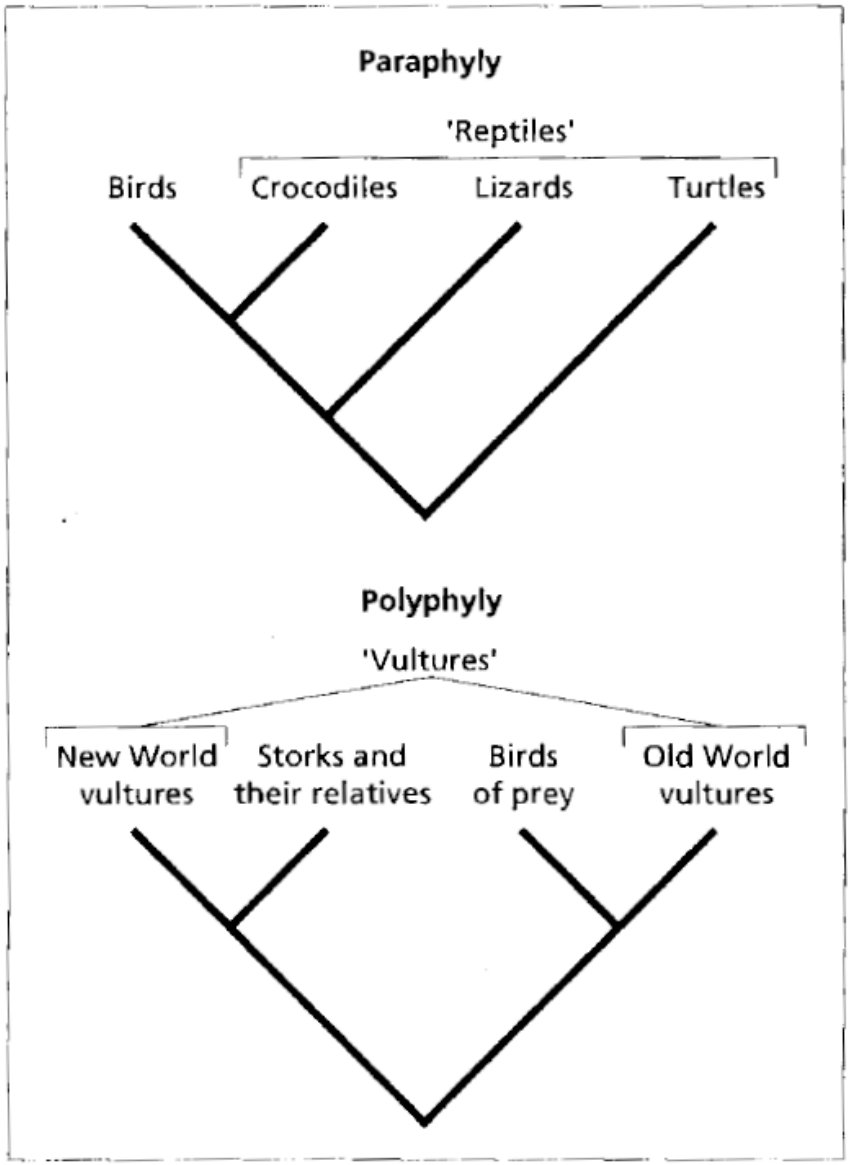
Key Terms

- Monophyletic: A group that includes a common ancestor and all of its descendents.
- Paraphyletic: A group that includes a common ancestor and some, but not all, of is descendents.
- Polyphyletic: A group that includes descendents of two or more common ancestors.
- Outgroup: Outside the group of interest.
- Sister taxa: The two branches descending from a shared node.

"Phylys"



"Phylys"



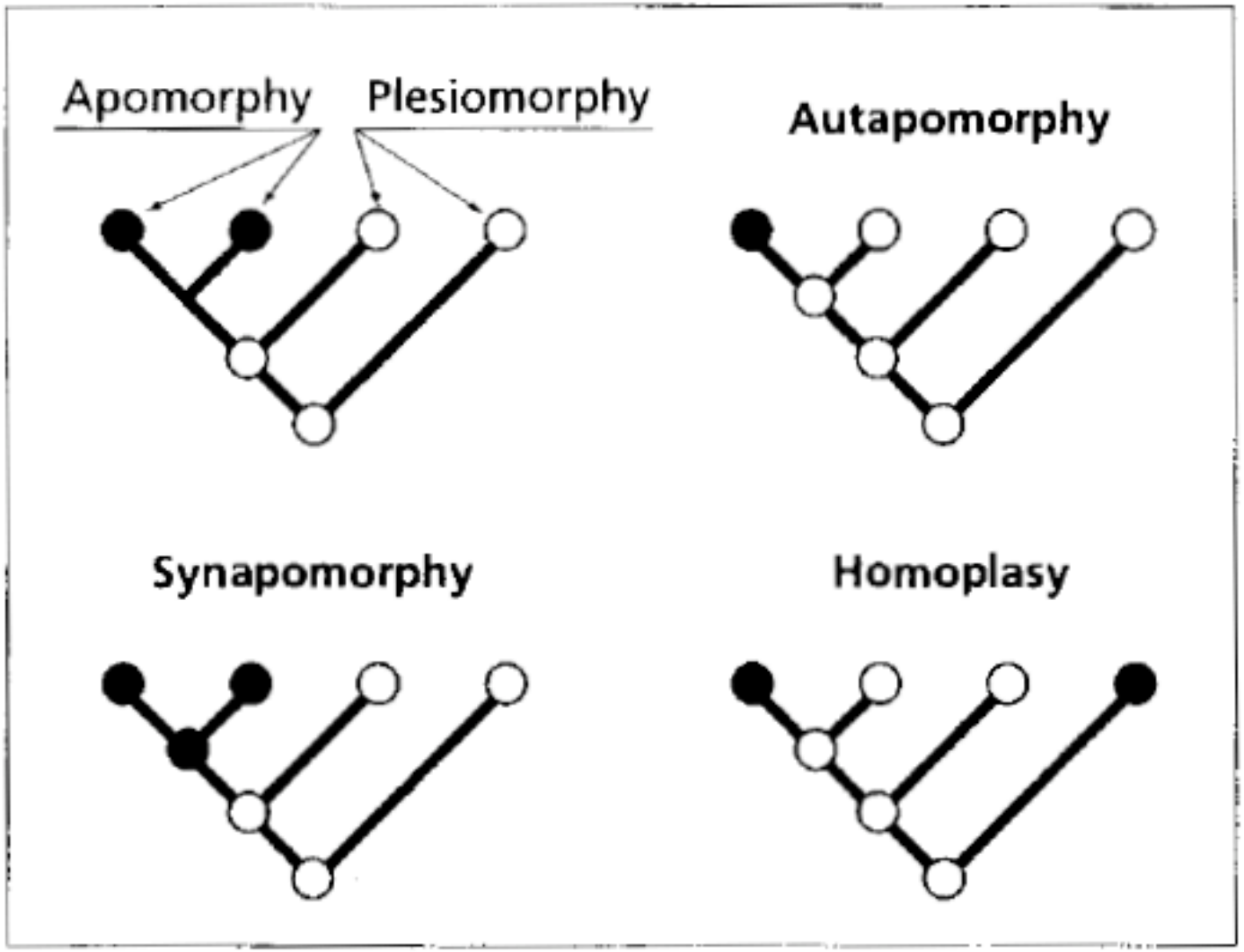
- Paraphyletic: A group that includes a common ancestor and some, but not all, of is descendents.

- Polyphyletic: A group that includes descendents of two or more common ancestors.

Cladistic Terms

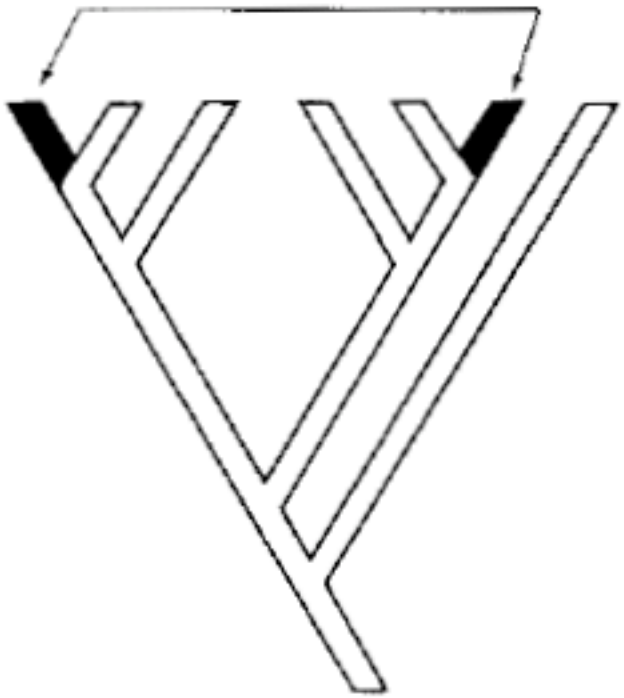
- Plesiomorphy: An ancestral state.
- Symplesiomorphy: An ancestral state shared by two or more descendent taxa.
- Apomorphy: A derived or newly evolved character that is not present in the common ancestor.
- Synapomorphy: A derived state shared by two or more descendent taxa.
- Autapomorphy: A derived state that is unique to a single taxon.

‘Morphys’


Apomorphy
Plesiomorphy
Autapomorphy
Synapomorphy
Homoplasy

Parallel evolution

Independent evolution of same feature from same ancestral condition

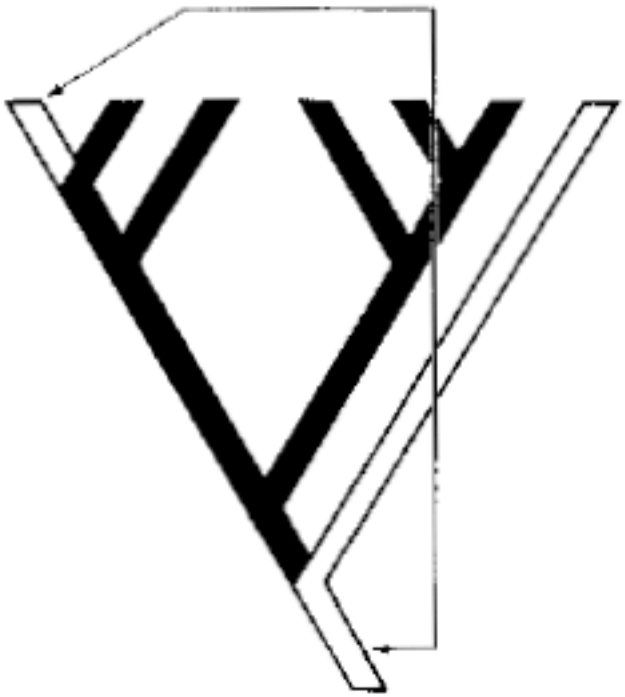


Convergent evolution

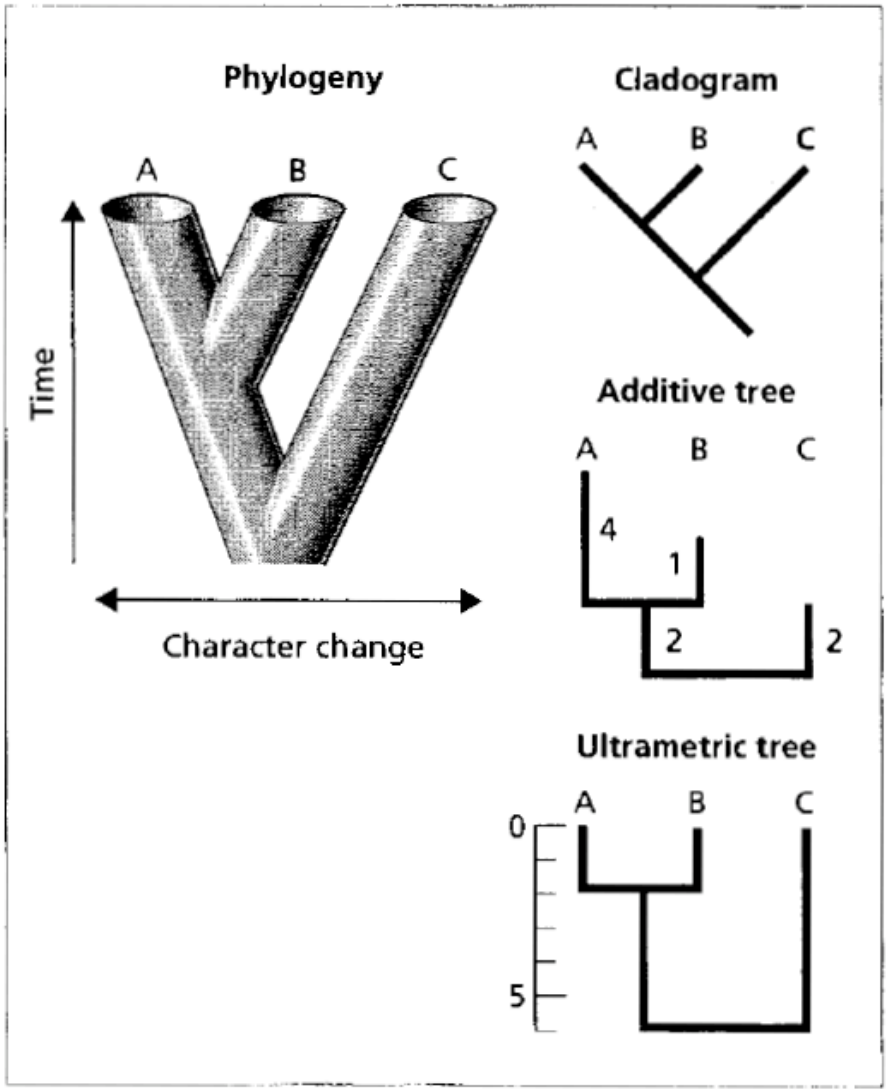
Independent evolution of same feature from different ancestral condition

Secondary loss

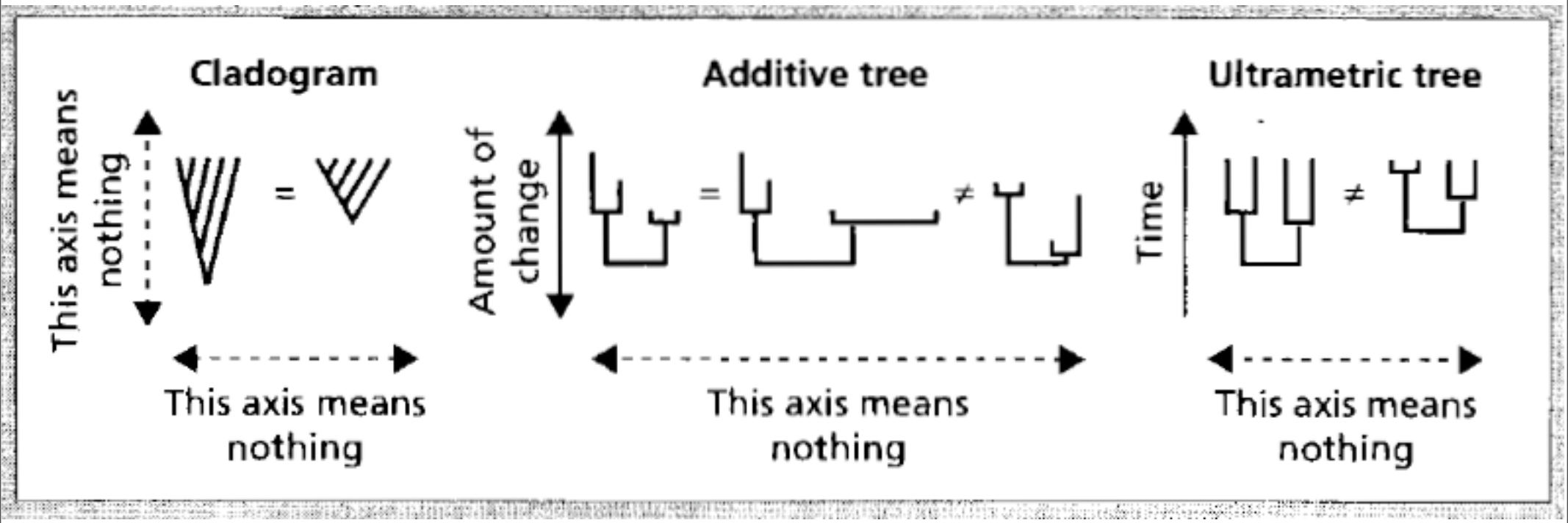
Reversion to ancestral condition



Branch Lengths



Branch Lengths



NEWICK Text Format