

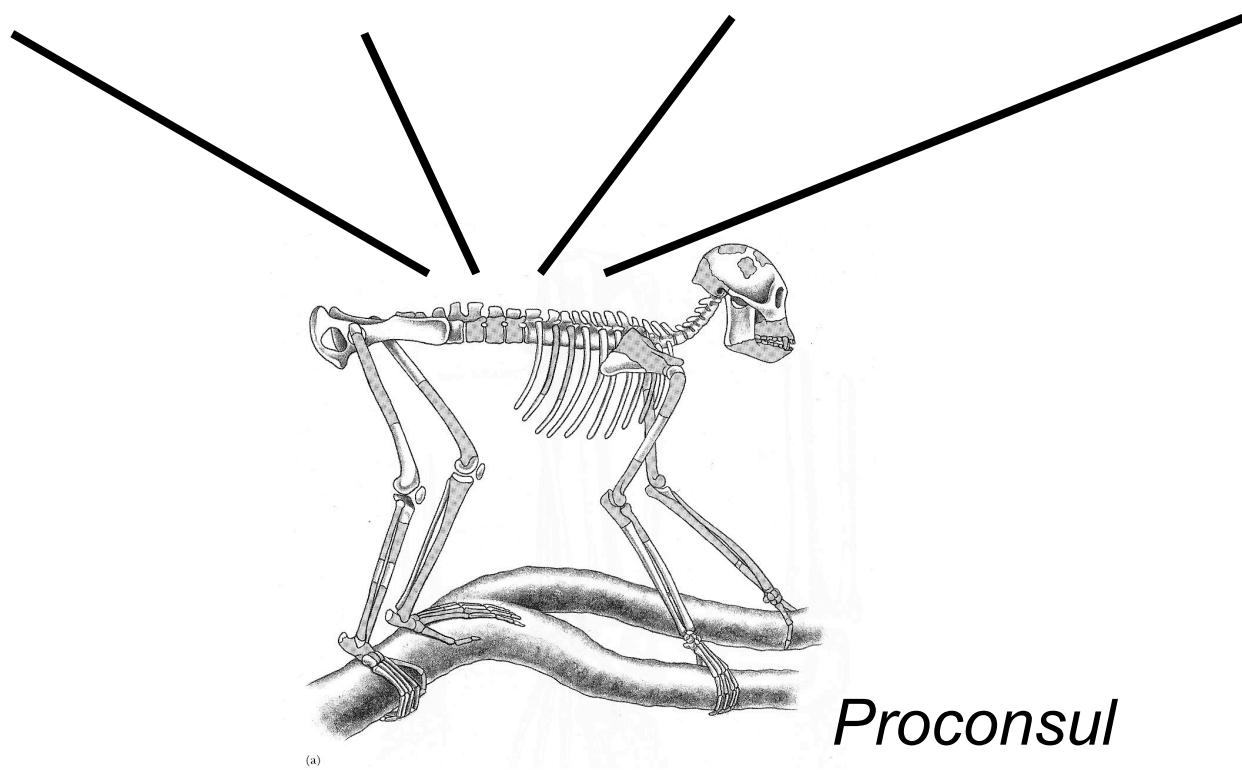
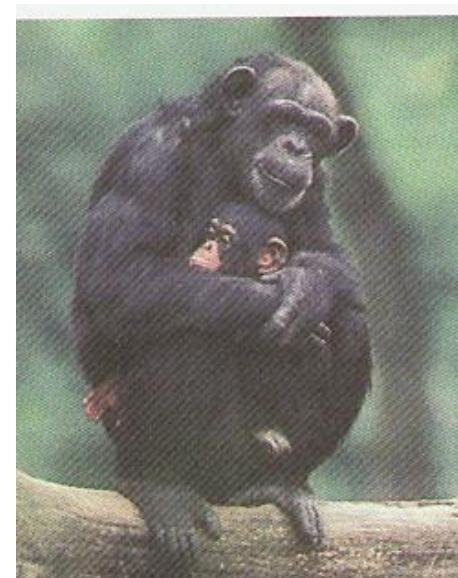
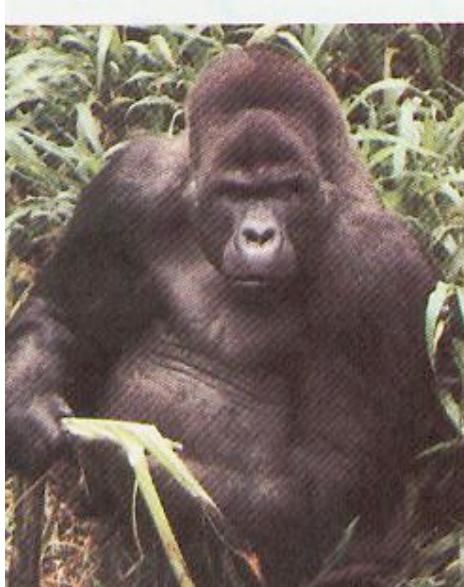
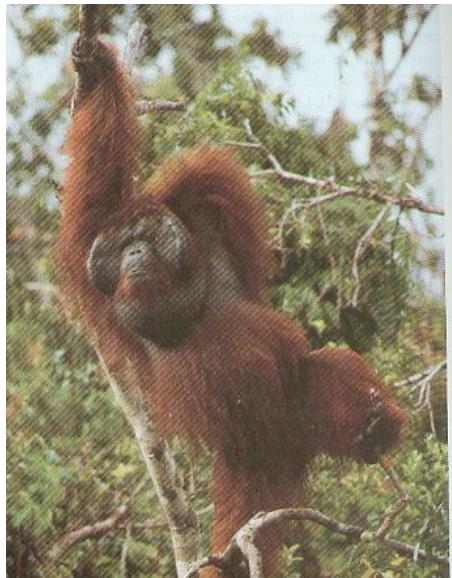


The Age of Things: Sticks, Stones and the Universe

Molecular Dating and the Many Kinds of Mammals

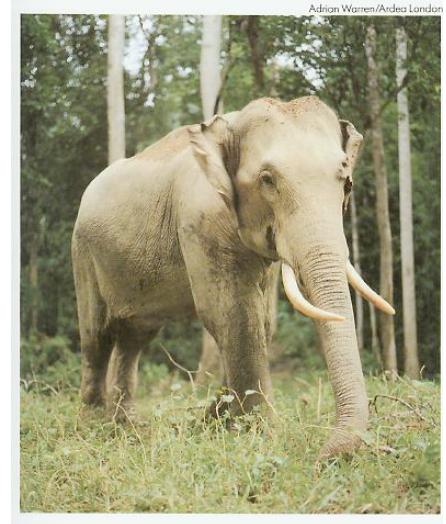
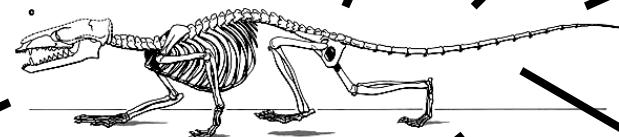
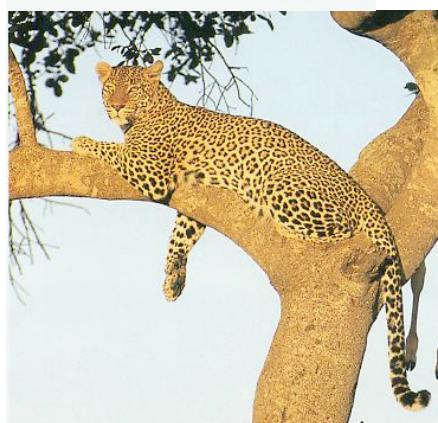


<http://cfcp.uchicago.edu/~mmhedman/compton1.html>



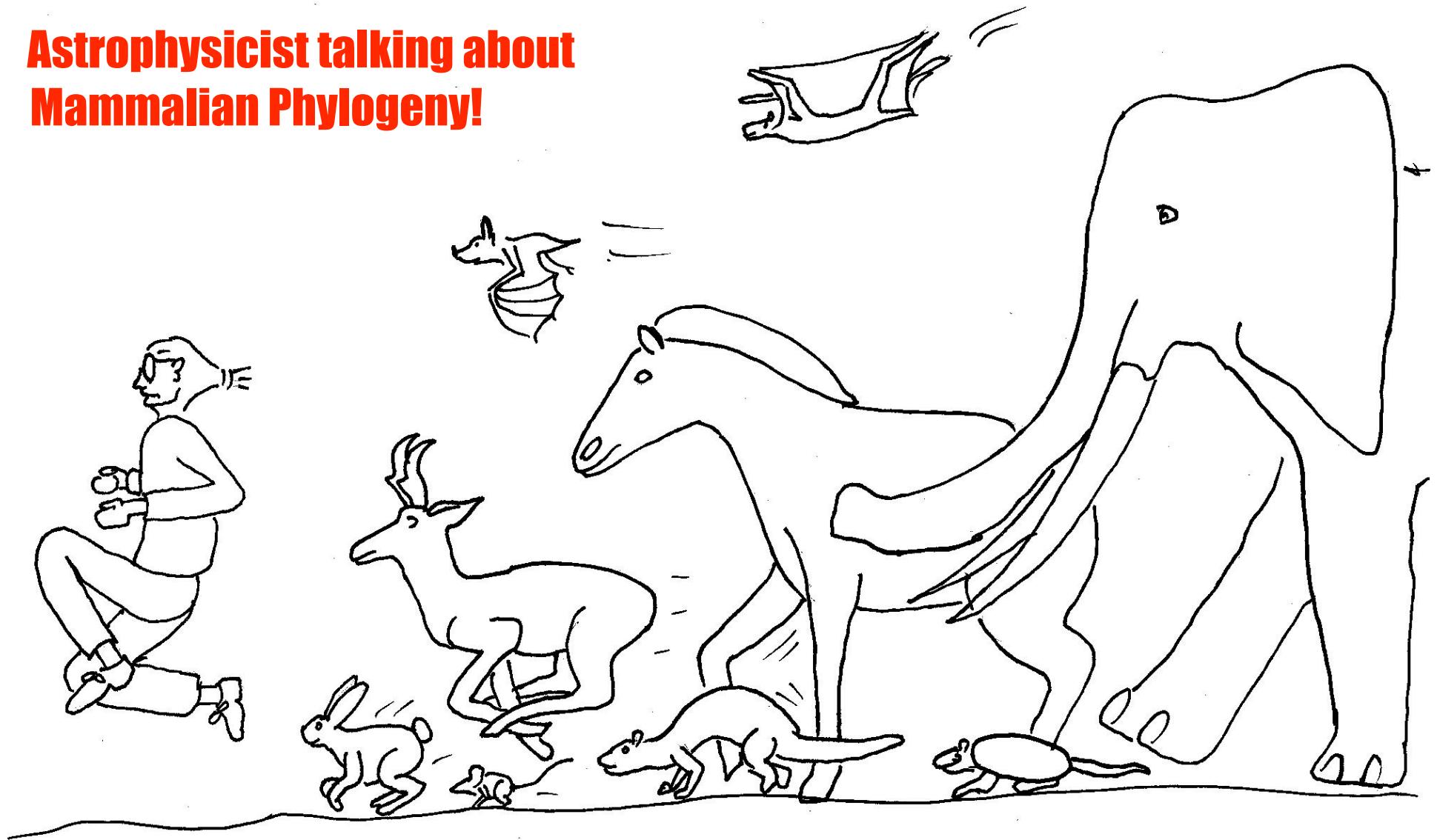
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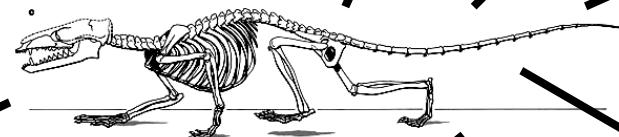
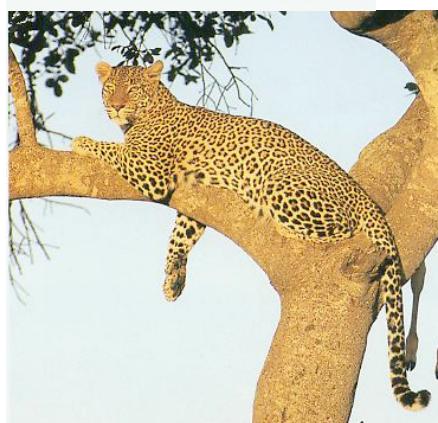
(a)



WARNING!

**Astrophysicist talking about
Mammalian Phylogeny!**





Non-Placental Mammals



©en Paul Ferrero/Auscape International

Monotremes

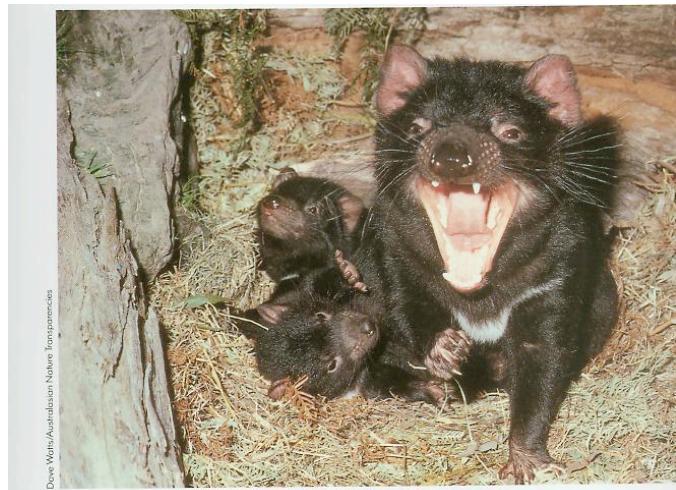


D. Poer & E. Parker-Cook/Auscape International



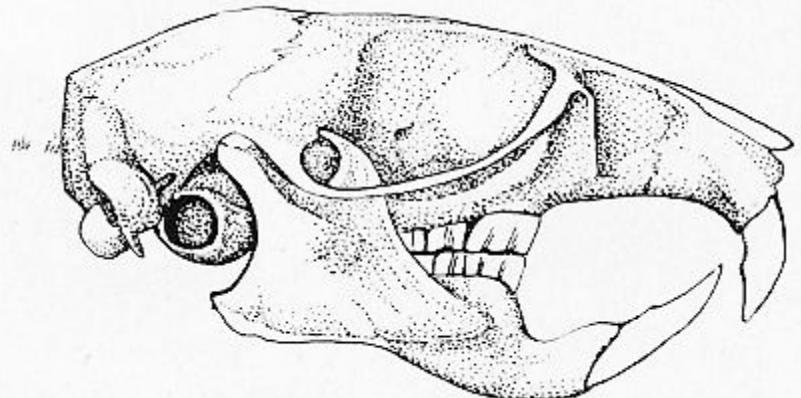
John Cancalosi/Auscape International

Marsupials



Dove Wall/Australasian Nature Transparencies

Rodentia



Christian Zuber/Bruce Coleman Ltd



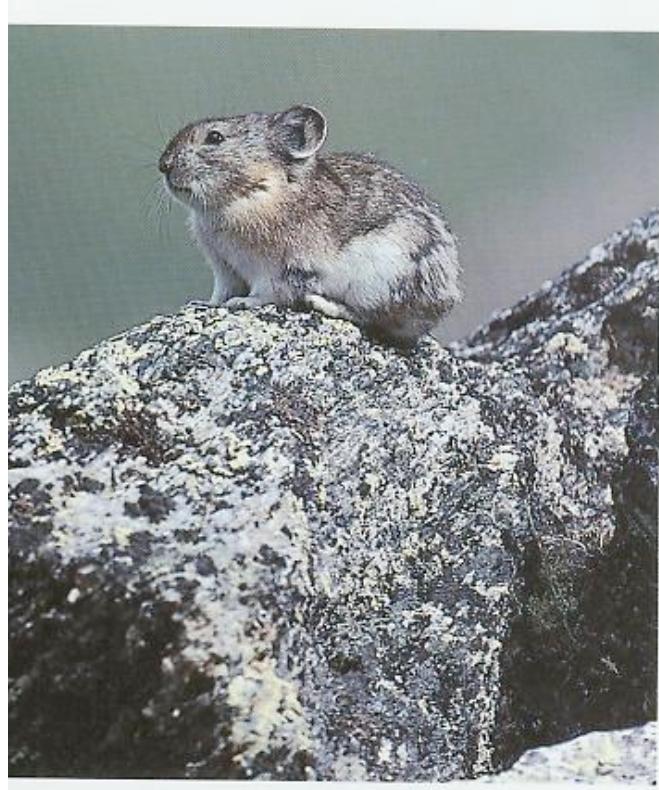
John Markham/Bruce Coleman Ltd



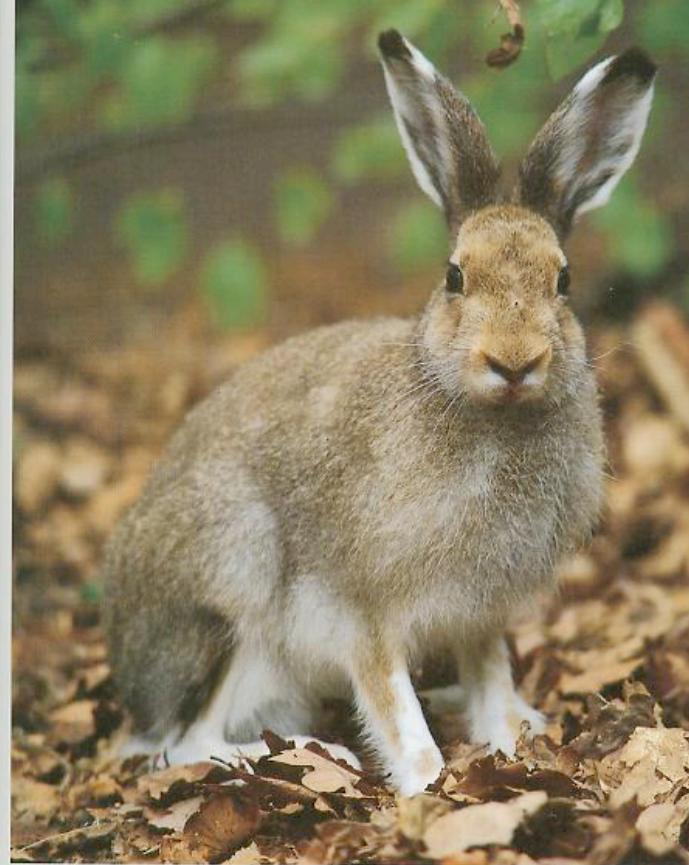
Hans Reinhardt/Bruce Coleman Ltd



Lagomorpha



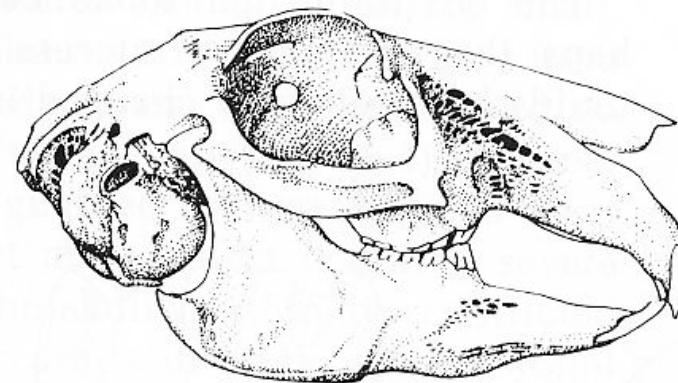
Martin W. Grosnick/Ardea London



Hans Reinhard/Bruce Coleman Ltd



Hans Reinhard/Bruce Coleman Ltd

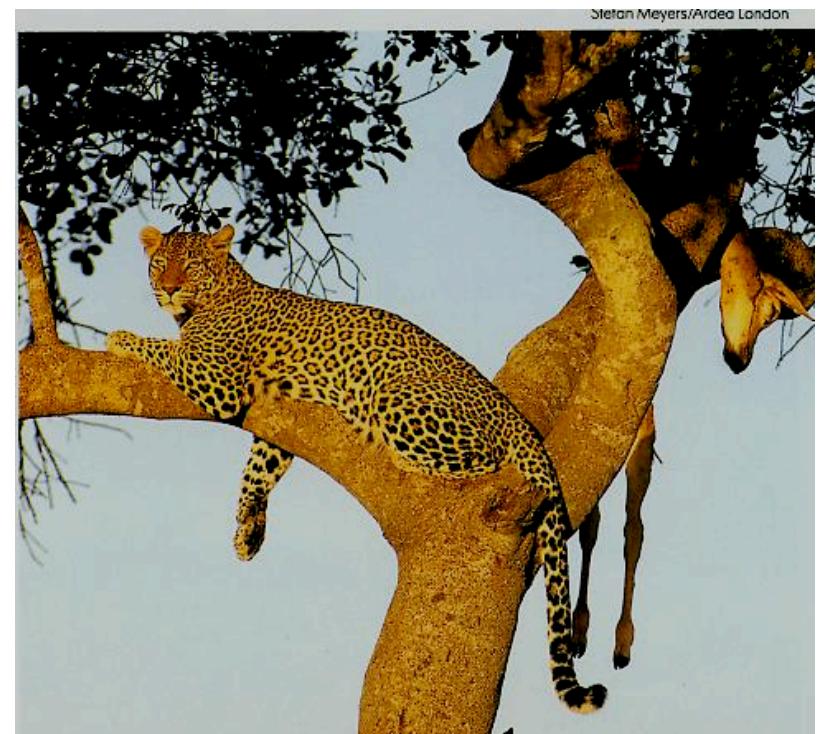
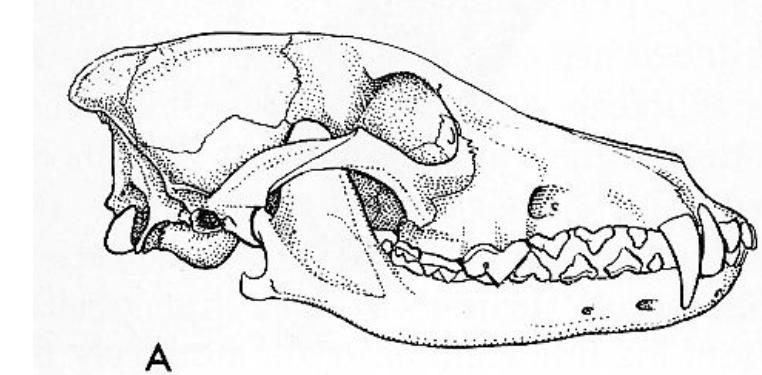


Chiroptera

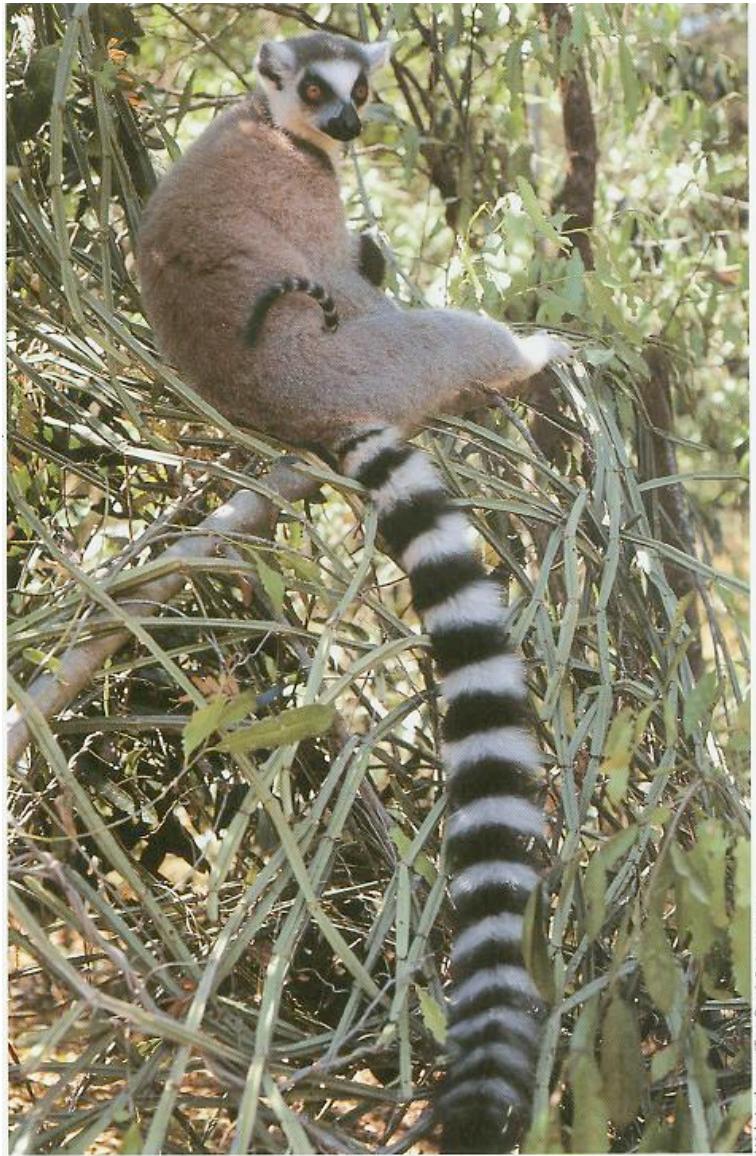


BCI Member since 2000

Carnivora



Primates





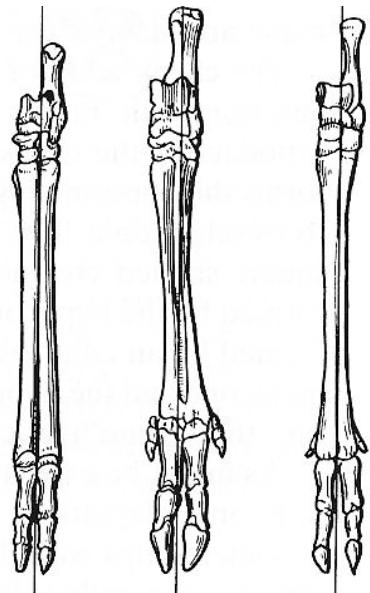
François Gohier/Ardea London

Cetacea

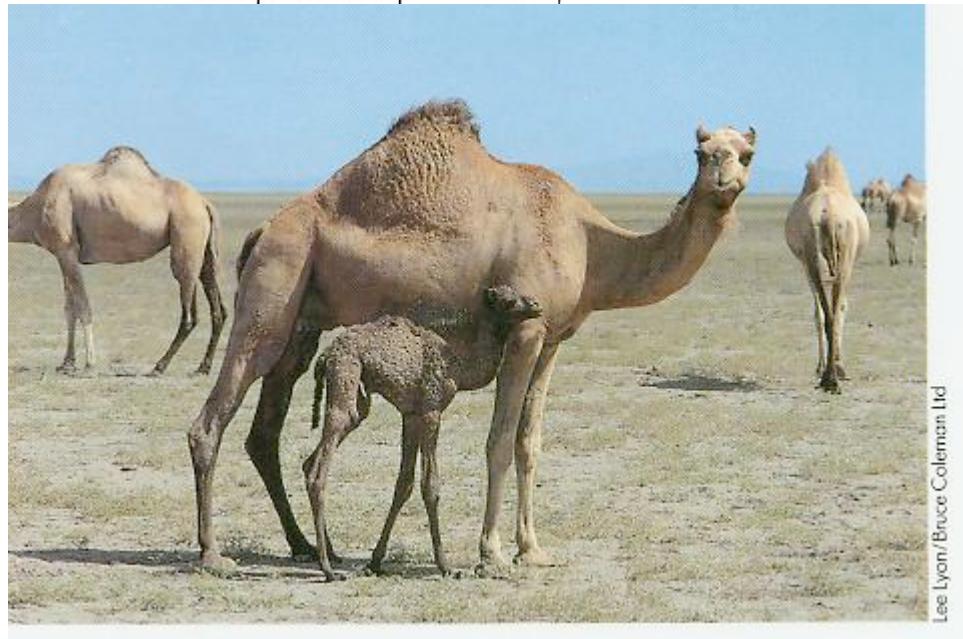


Francisco Erize/Bruce Coleman Limited

Atriодactyla



Hans Reinhard/Bruce Coleman Ltd



Lee Lyon/Bruce Coleman Ltd



Hans Reinhard/Bruce Coleman Ltd

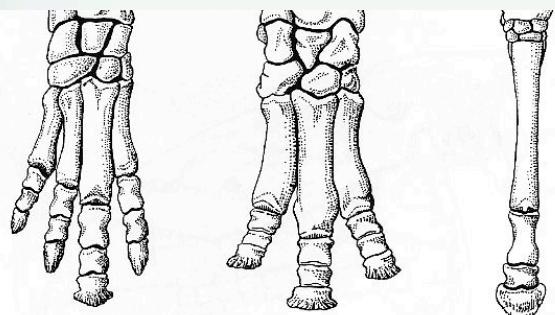
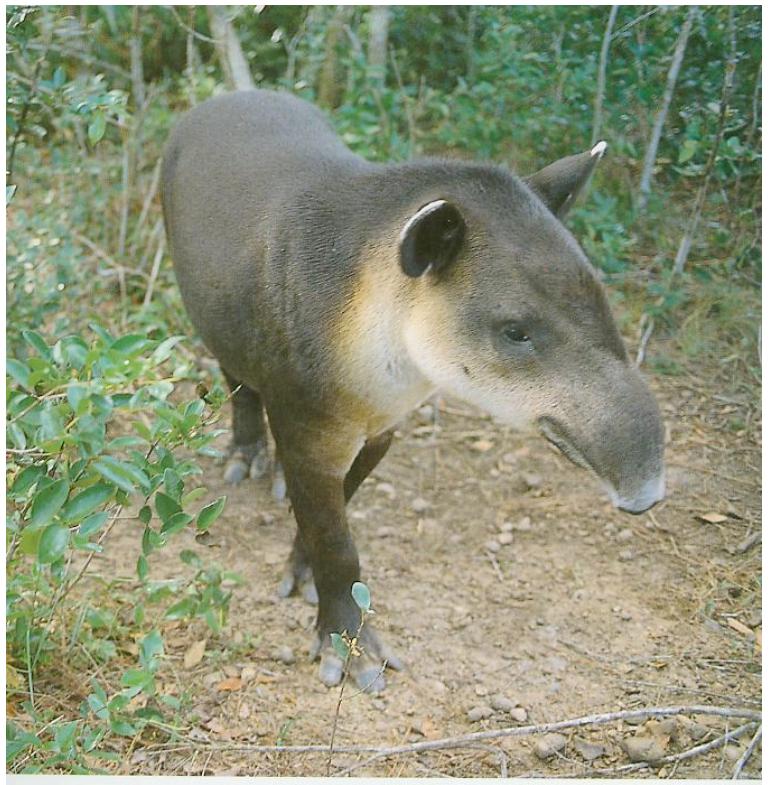


Silvestri/Australopiston Nature Transparencies



Francisco Erize/Bruce Coleman Limited

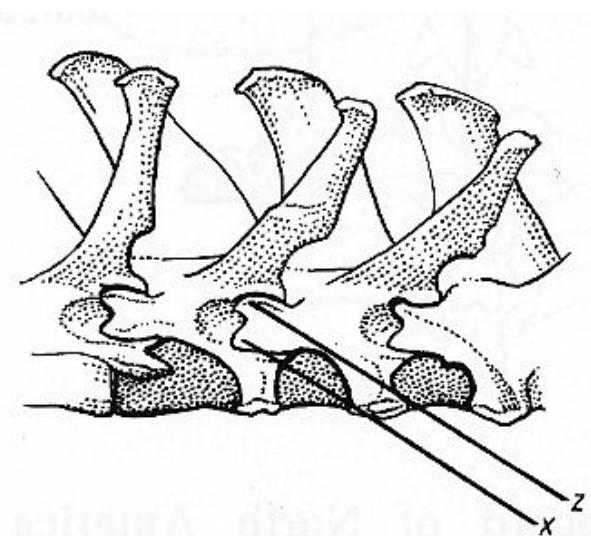
Perissodactyla



Xenarthra



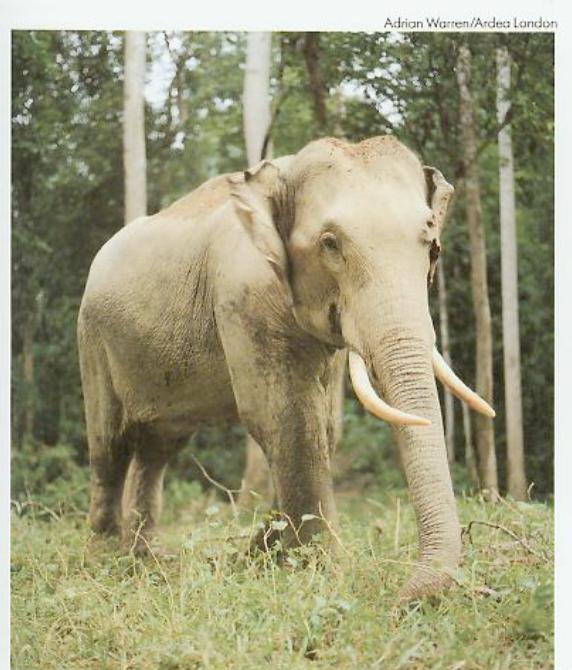
Francisco Erize/Bruce Coleman Ltd.



André Porto Jr./NHPA



Jean-Gilles Courteau/NHPA



Adrian Warren/Ardea London



Alan Shear/NPRA



Ben Crisp/Audubon International

Hyracoidea

Proboscidea

Sirenia

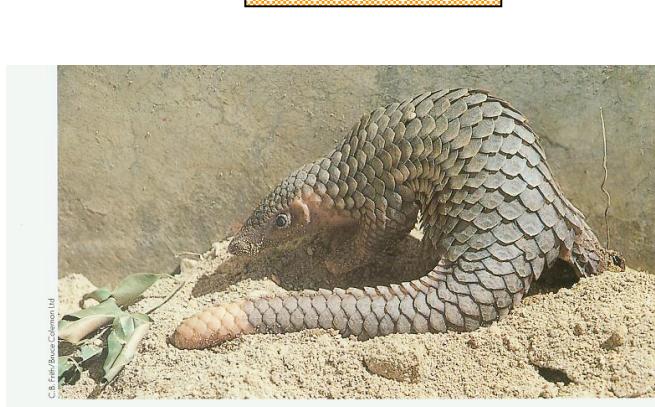
Dermoptera

Tubilenta

Pholidota



D. & W. Ward/Oxford Scientific Films



C.B. Foto/Bruno Colombe Ltd



Gary Millburn/Tom Stodd & Associates

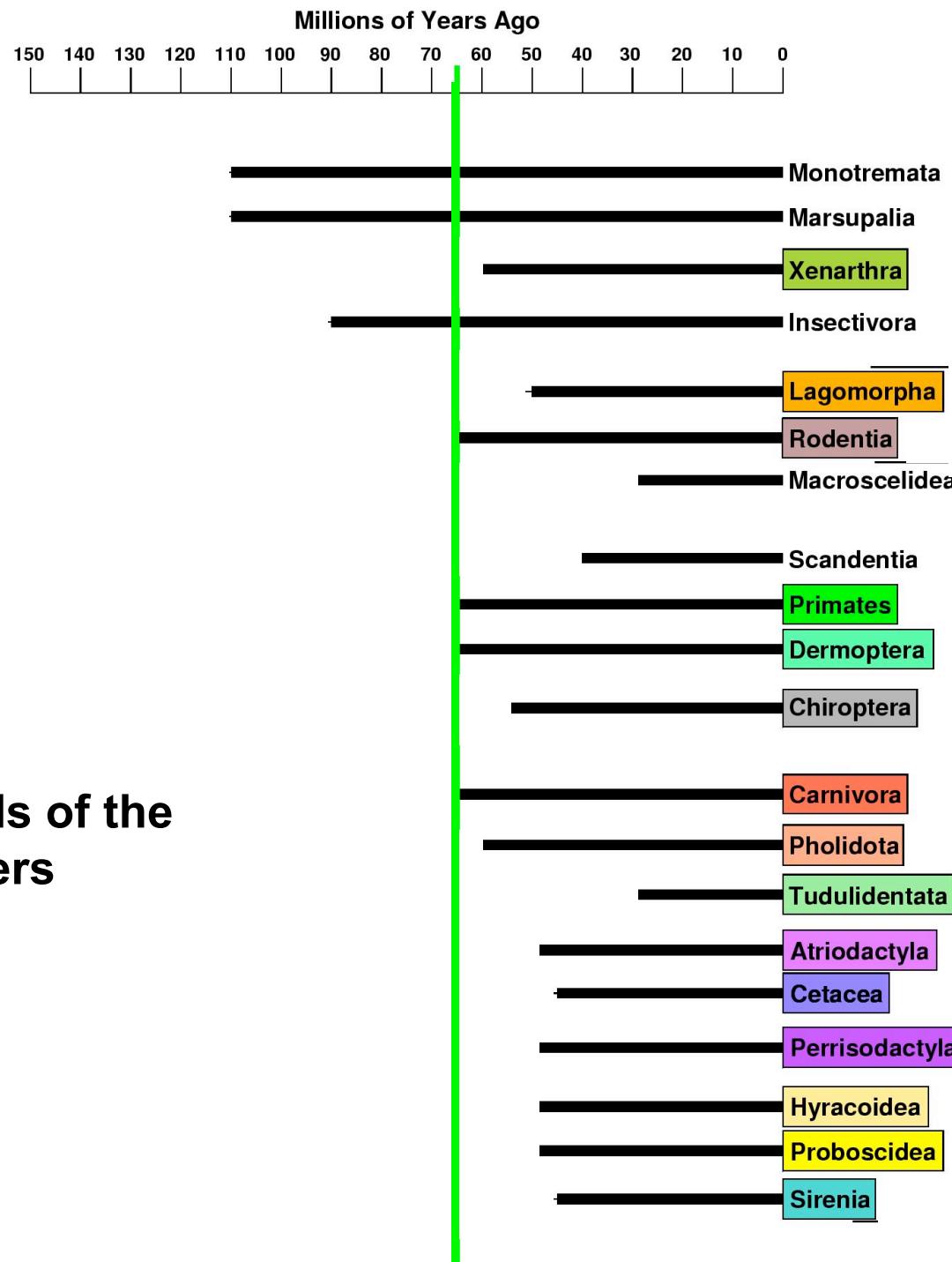


Insectivora

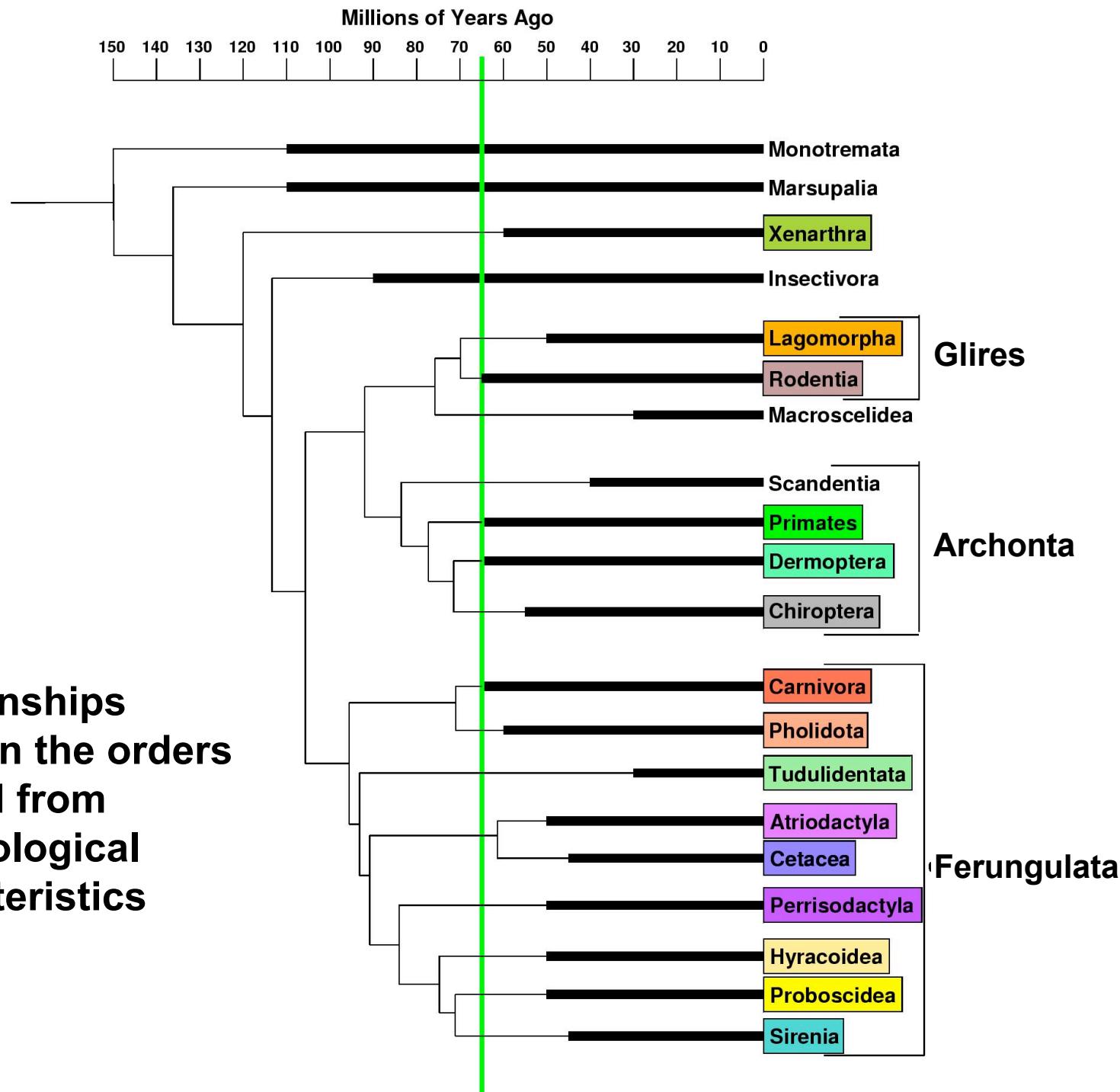


Scandentia

Macroscelidea



Fossil Records of the Different Orders





Molecular Dating

cccATGAGTTcGcaAGAAATT

cccAAAGTGGccCAAGACtt

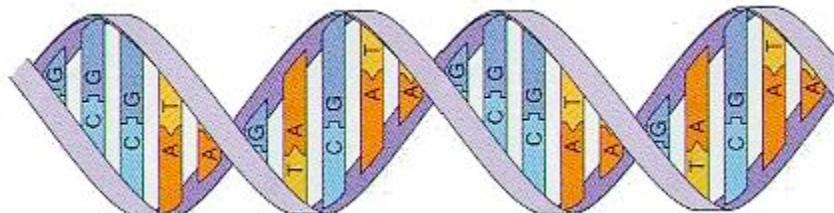
cccATGAGTTcGcaAGAGTT

cccAAGAGTGGccCAAGACtt

cccATGAGTTCCCAAGAGTT

cccAAGAGTGGccCAAGAGTT

cccAAGAGTTCCCAAGAGTT

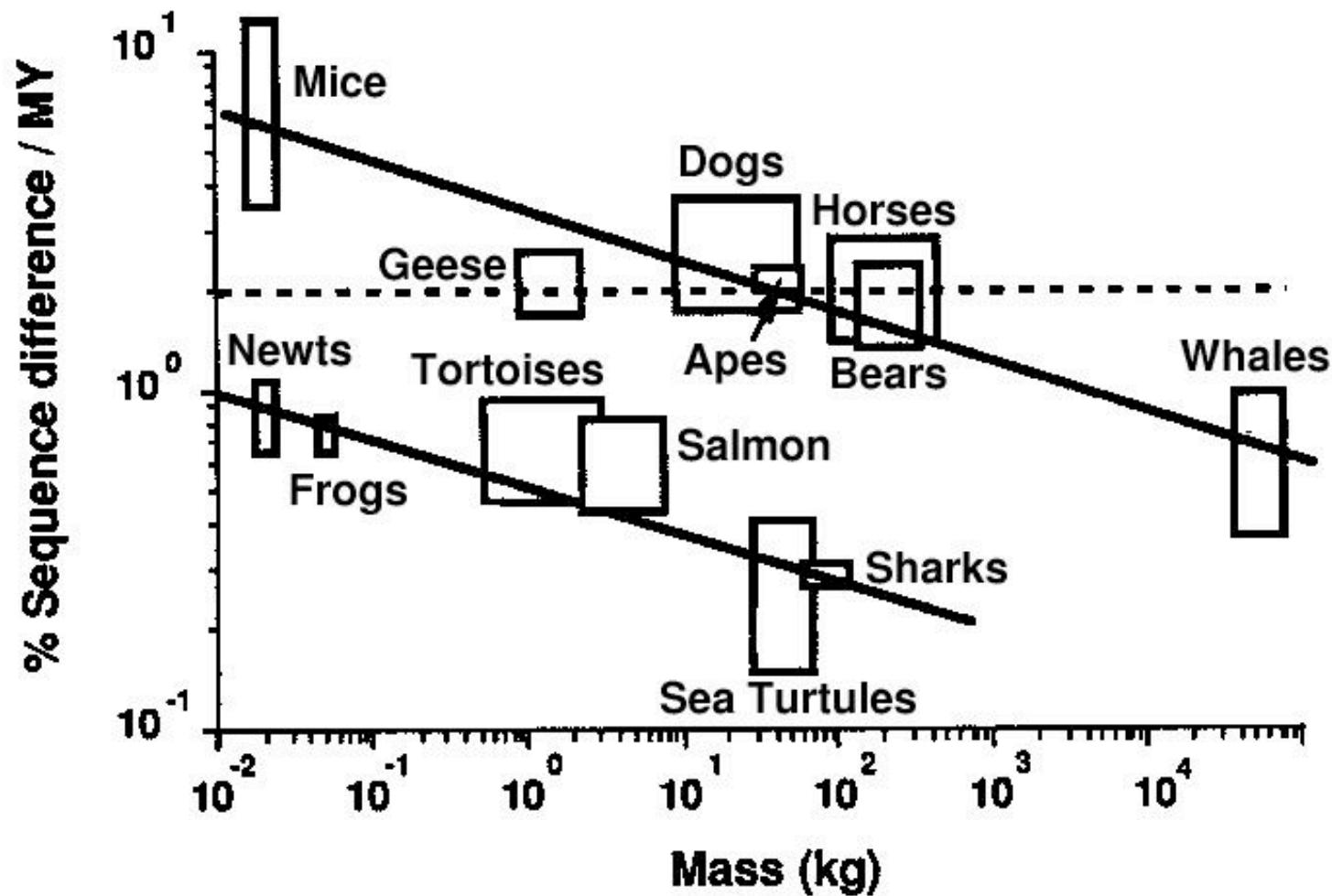


TIME

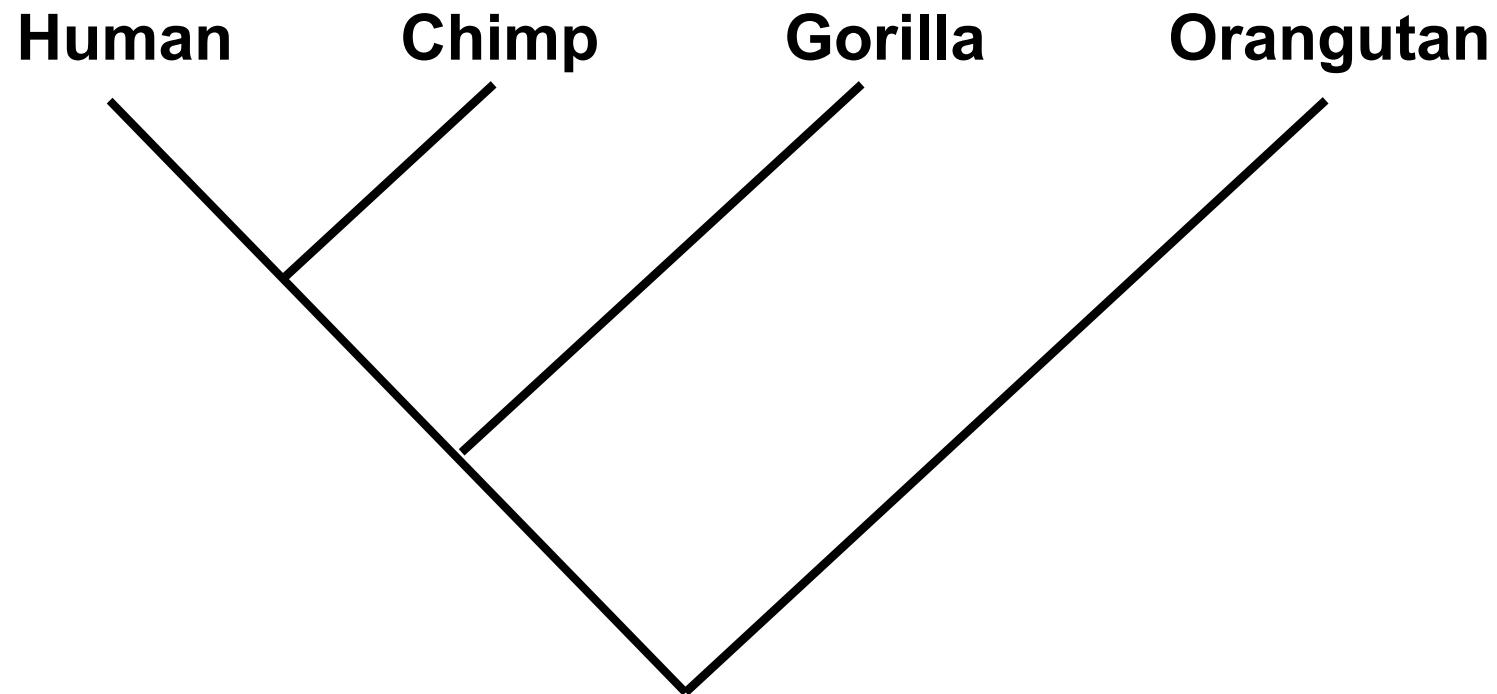
Molecular Data

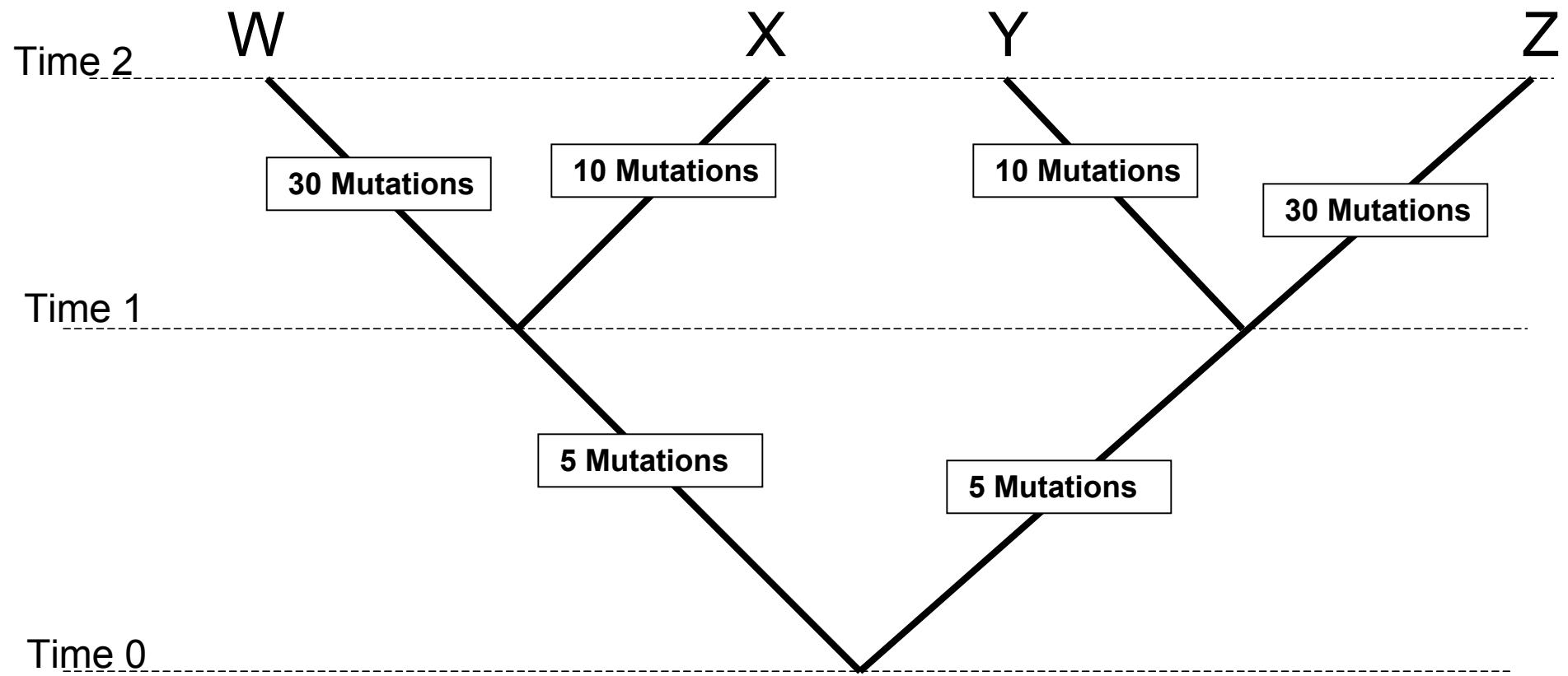
Sloth	TGCCAAATTAGTTCCGTCATGAGAATGGACTACATGGTCTACTTCAGTT
Hedgehog	TGCCAATTCCGTTCTGTTGTGAGAATGGACTACATGGTGTTCAGCTT
Sirenian	TGCCAATTCCGTTCCGTTATGAAGATGGACTACATGGTCTACTTCAGCTT
Elephant	TGCCAATTCCGTTCCGTTATGAGGATGGACTACATGGTCTACTTCAGCTT
Aardvark	TGCCAATTCCGTTCCGTTATGAGGATGGACTACATGGTCTACTTCAGCTT
Mouse	TGCCACTTCCGTTCCGTTGGTCAGTTGGATTACATGGTCTTCAGCTT
Rabbit	TGCAAATTCGATTCTGTTATAACCCATGGAATAACATGGTCTTCAGCTT
Human	TGCCAATTGTTCCGTCATGAGAATGGTCTACATGGTATACTTCAGCTT
Flying Fox	TGCCAATTCCGTTCTGTCATAAAAGATGGACTACATGGTCTATTCAGCTT
Whale	TGCCAATTCCGTTCCGTCATGAGGATGGACTACATGGTCTACTTCAGCTT
Pig	TGCCAGTTCCGTCATGAGGATGGACTGGACTACATGGTCTACTTCAGCTT
Horse	TGCCAATTCCGTTCTGTTGTGAGCATGGACTACATGGTCTACTTCAGCTT
Cat	TGCCAGTTCCGTTCTGTCATGACGATGGACTACATGGTCTACTTCAGCTT

All animals do not accumulate mutations at the same rate

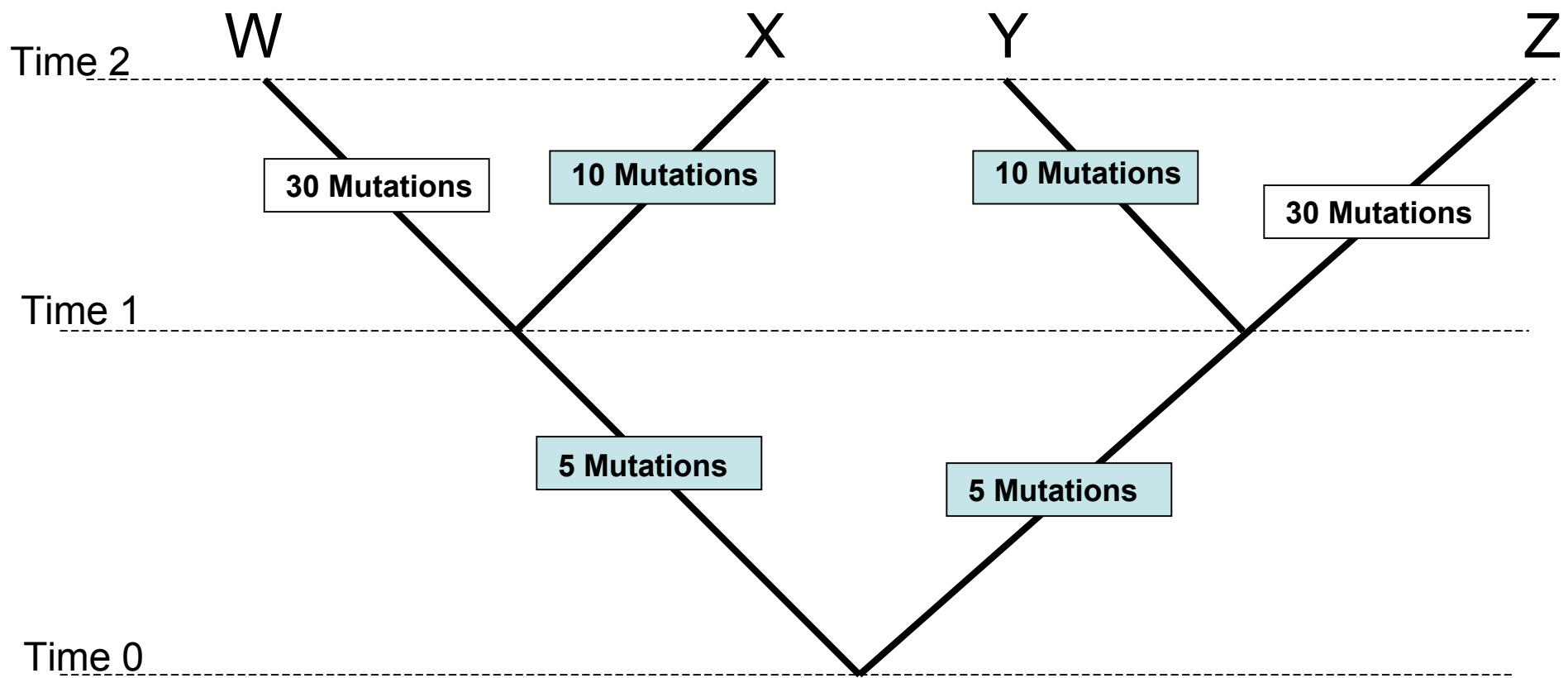


	Chimp	Gorilla	Orangutan
Human	1.24%	1.62%	3.08%
Chimp		1.63%	3.12%
Gorilla			3.09%

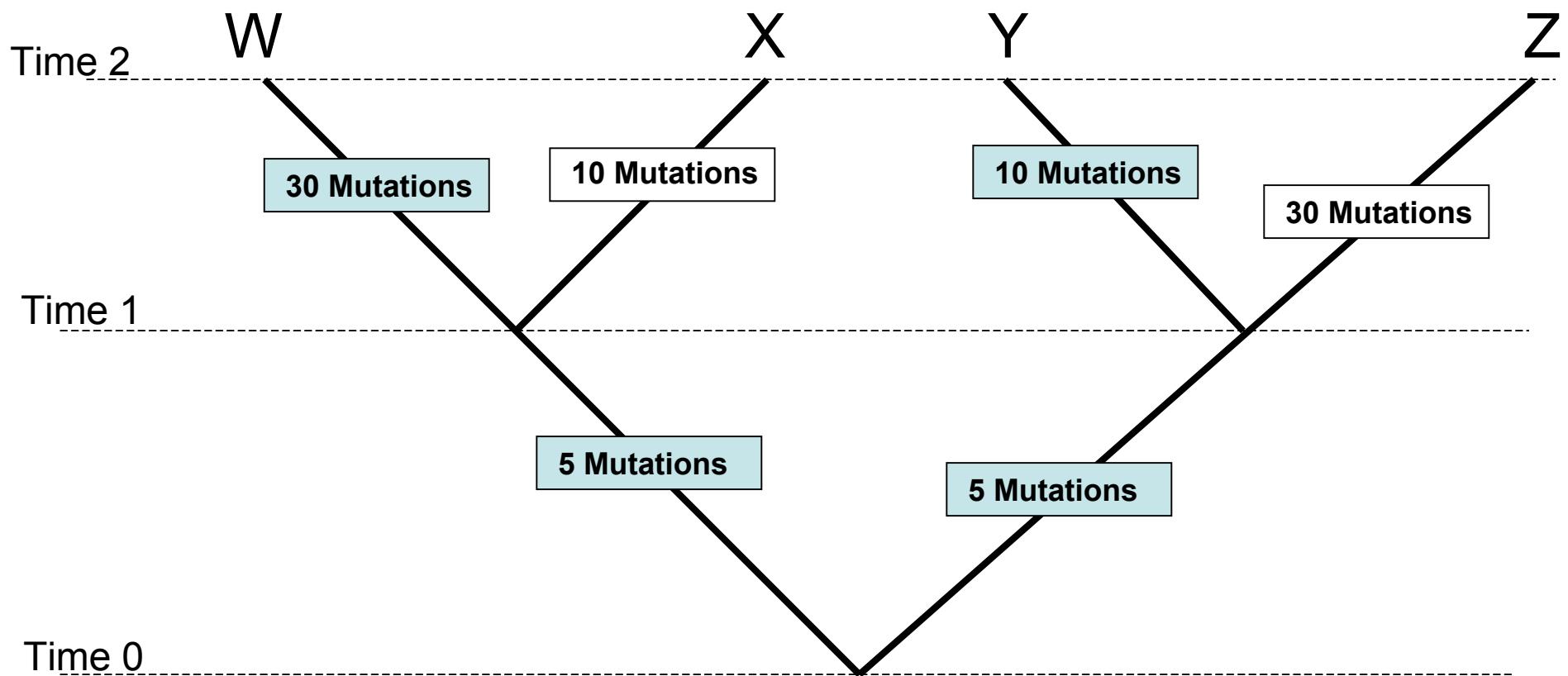




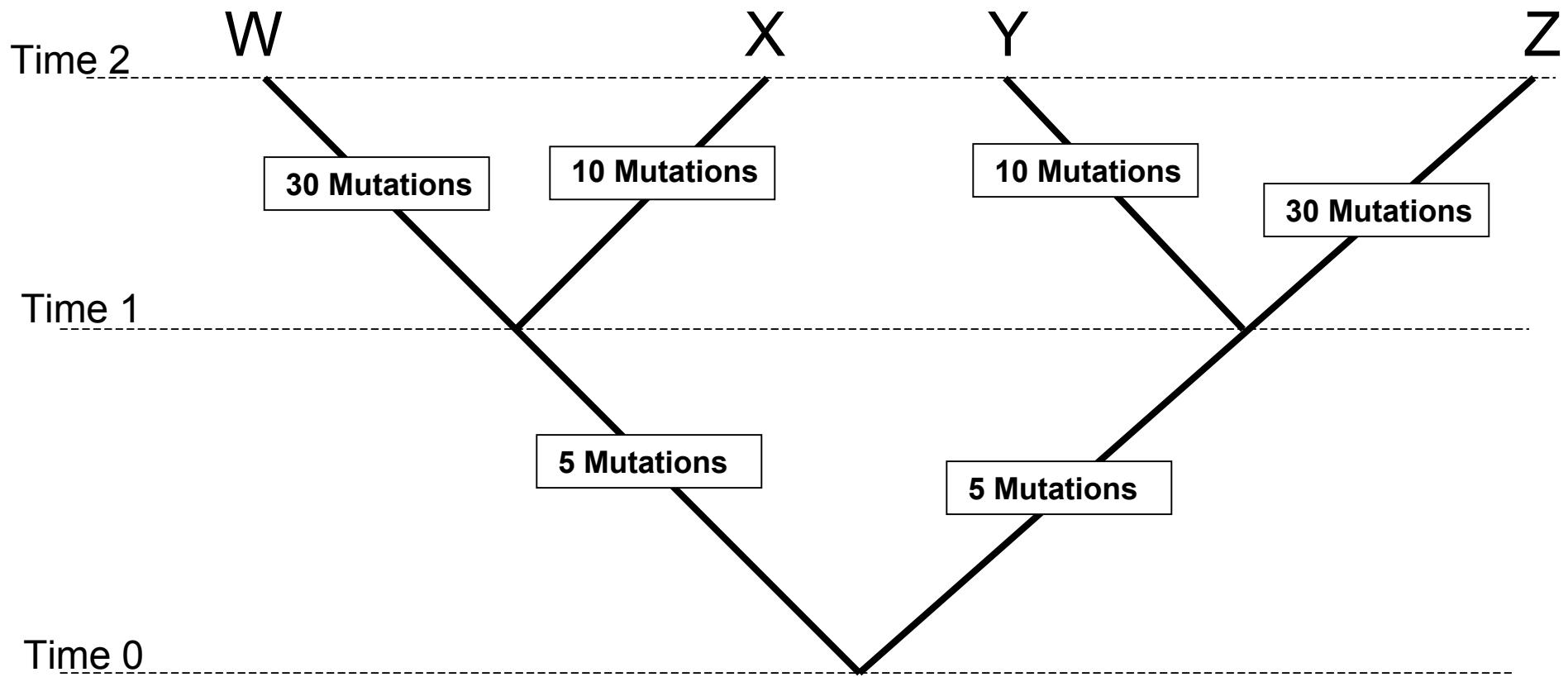
	X	Y	Z
W	40	50	70
X		30	50
Y			40



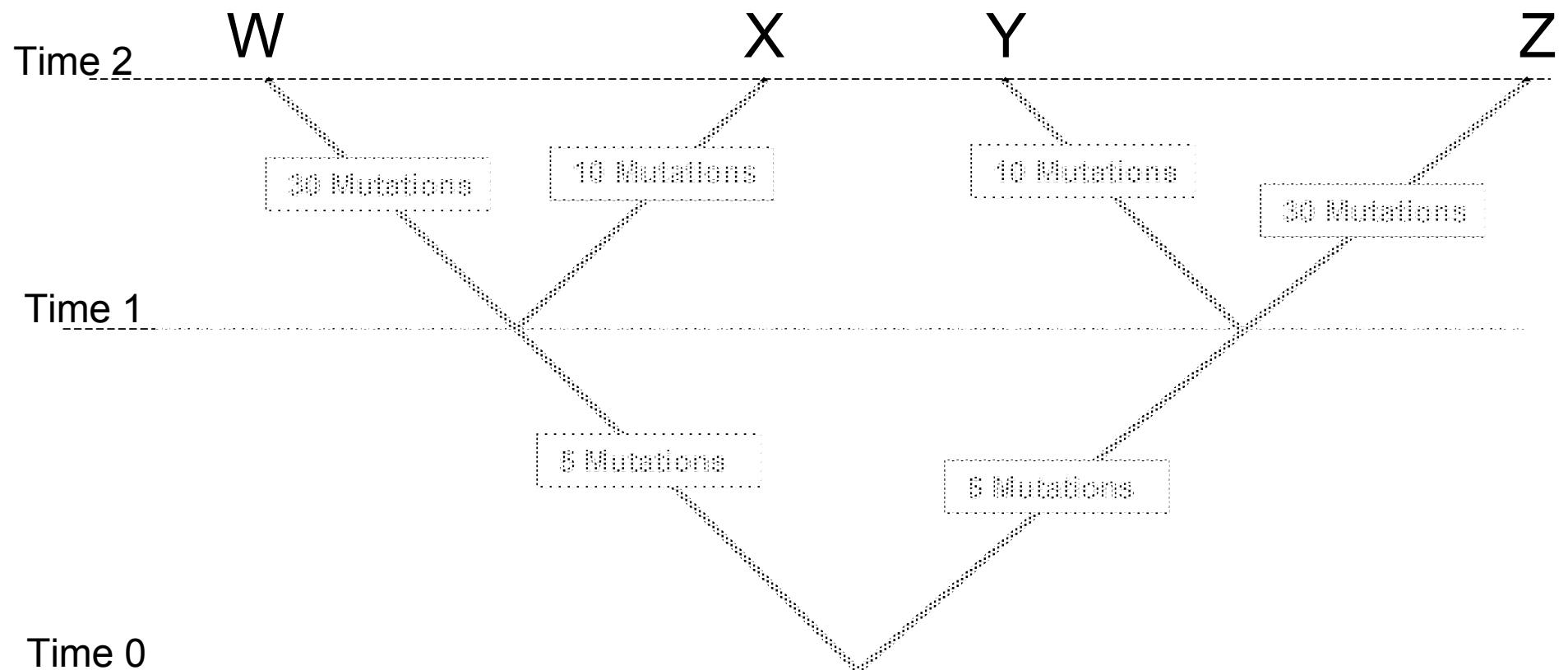
	X	Y	Z
W	40	50	70
X	30	50	
Y		40	



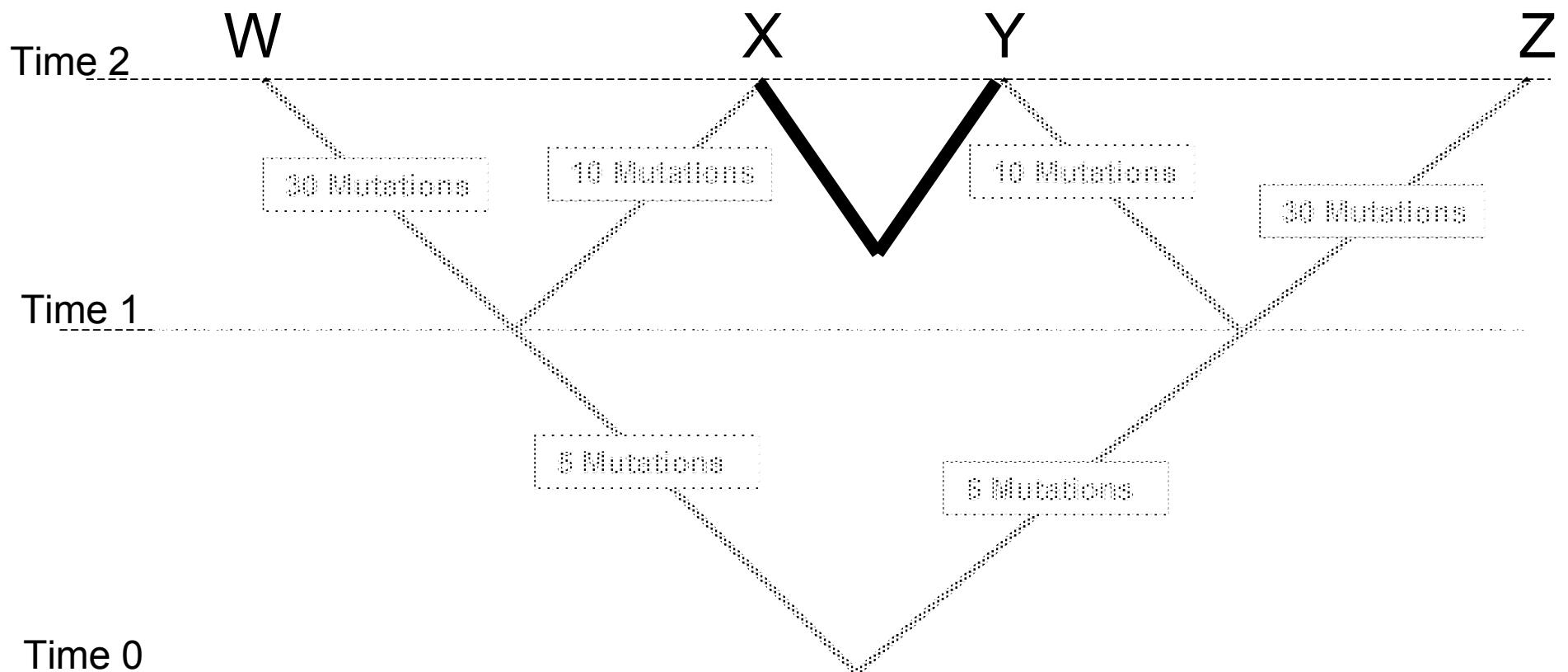
	X	Y	Z
W	40	50	70
X		30	50
Y			40



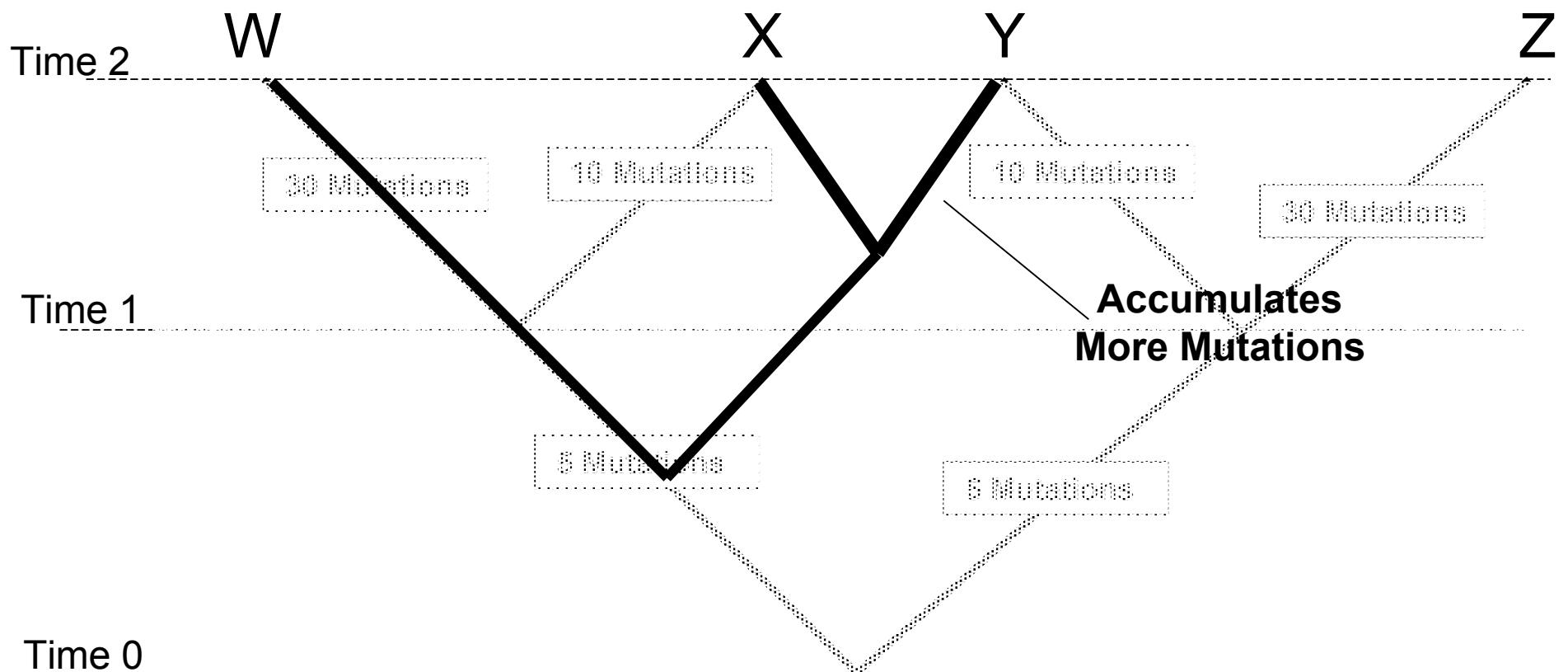
	X	Y	Z
W	40	50	70
X		30	50
Y			40



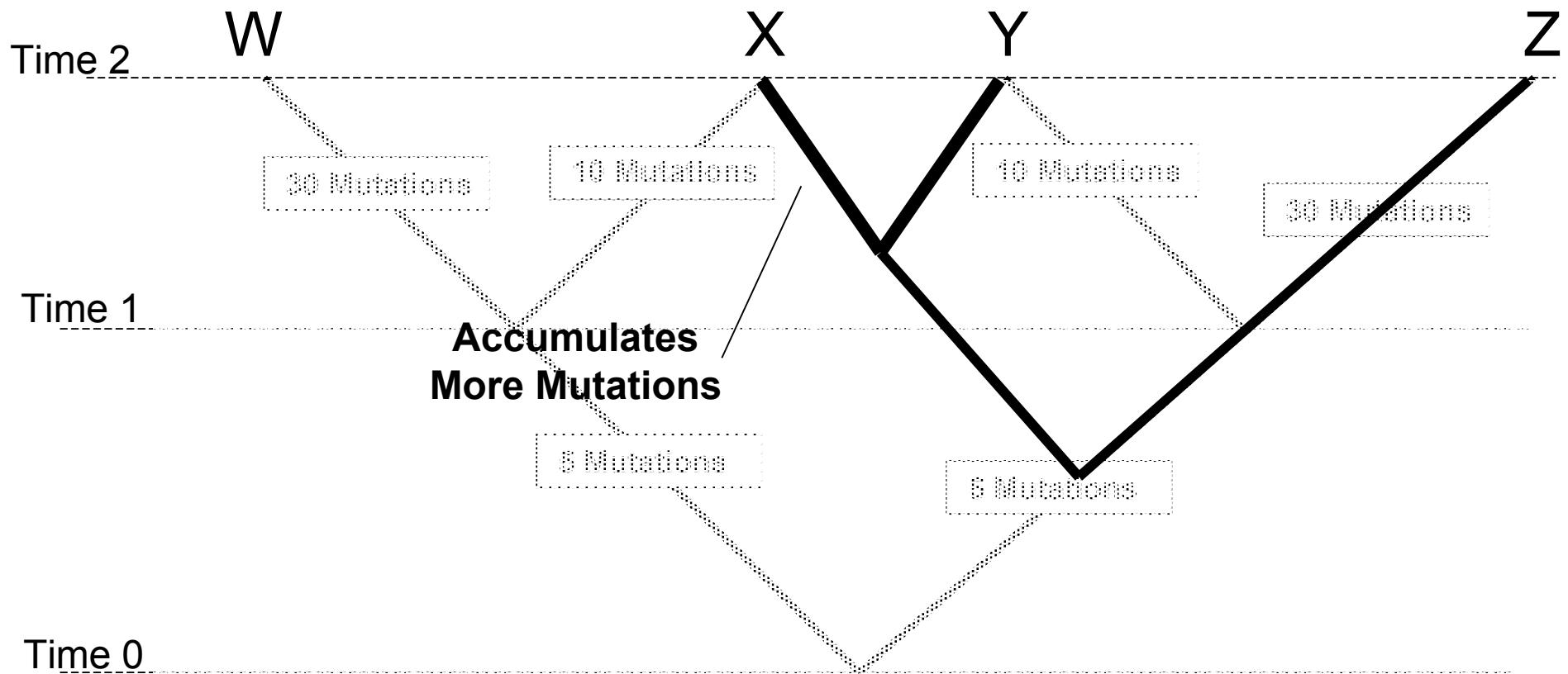
	X	Y	Z
W	40	50	70
X		30	50
Y			40



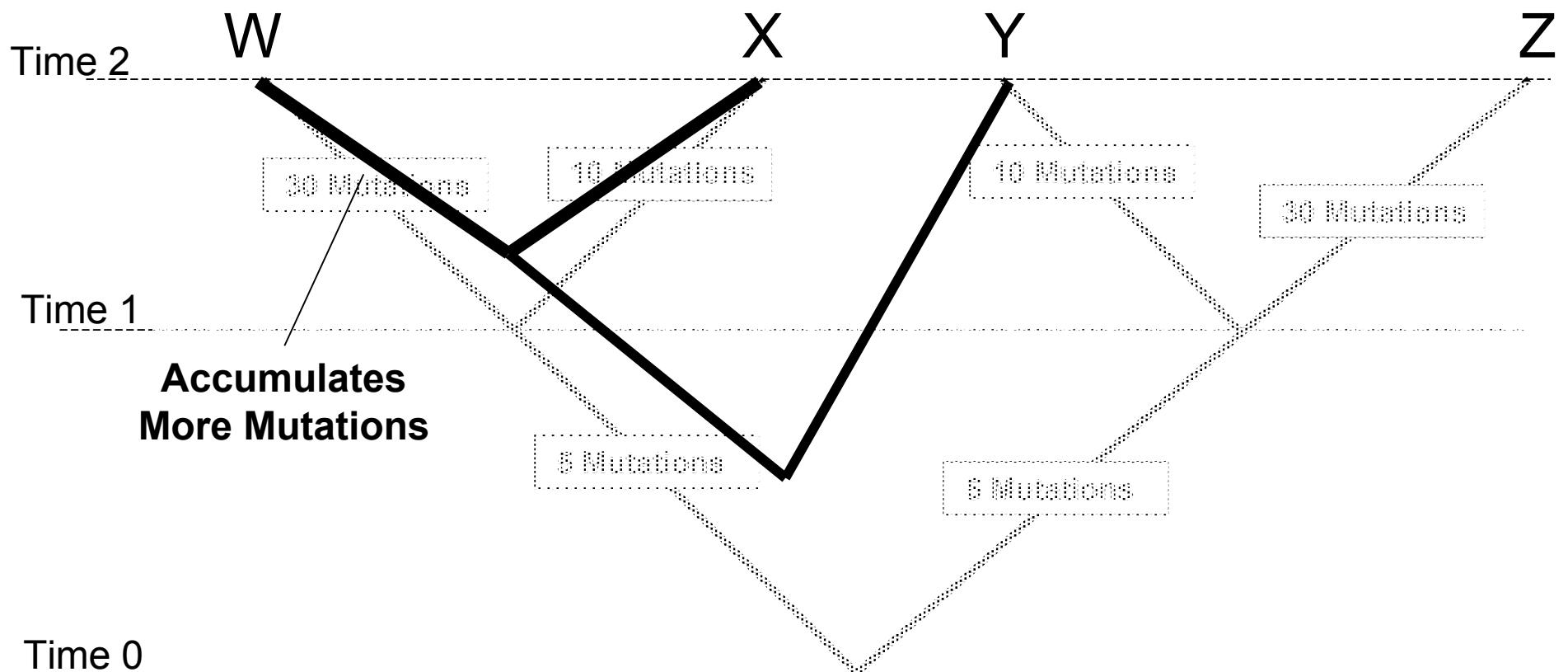
	X	Y	Z
W	40	50	70
X		30	50
Y			40



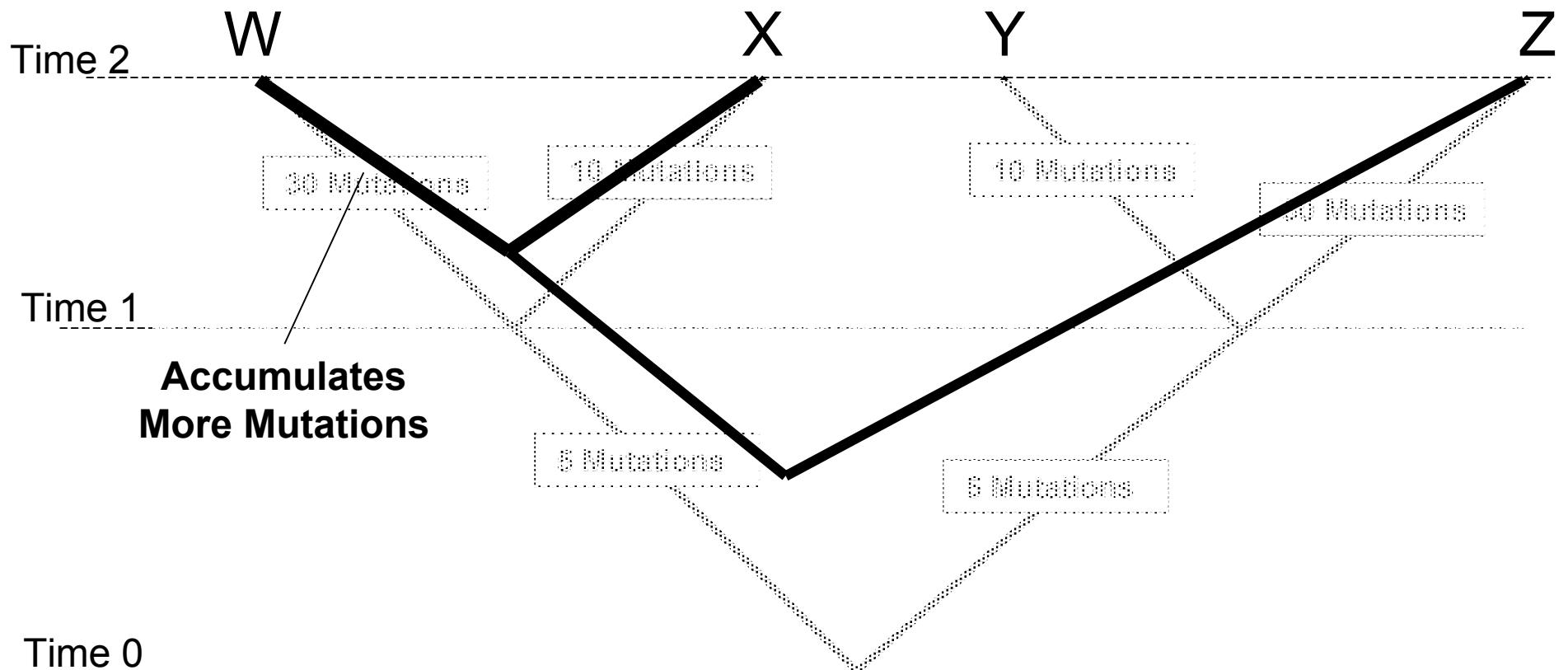
	X	Y	Z
W	40	50	70
X	30		50
Y			40



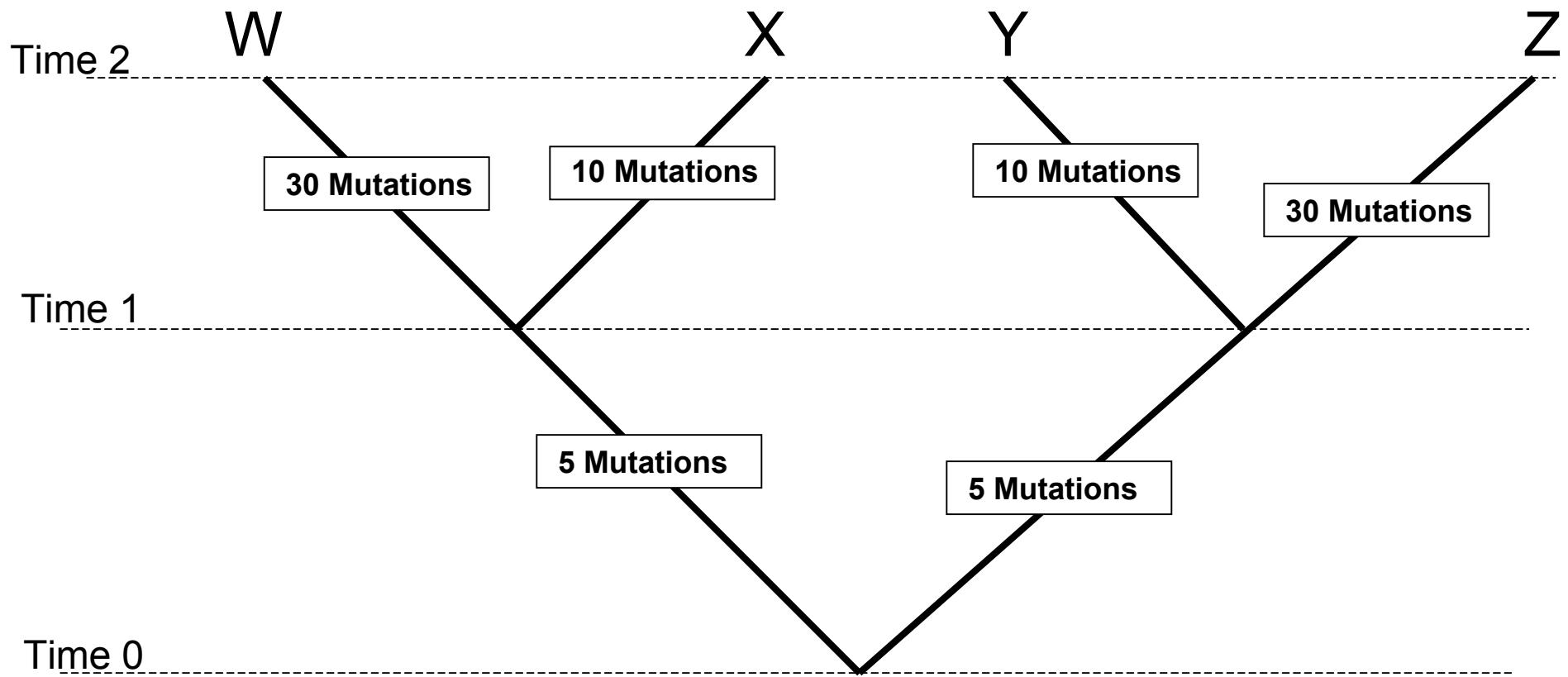
	X	Y	Z
W	40	50	70
X	30	50	50
Y			40



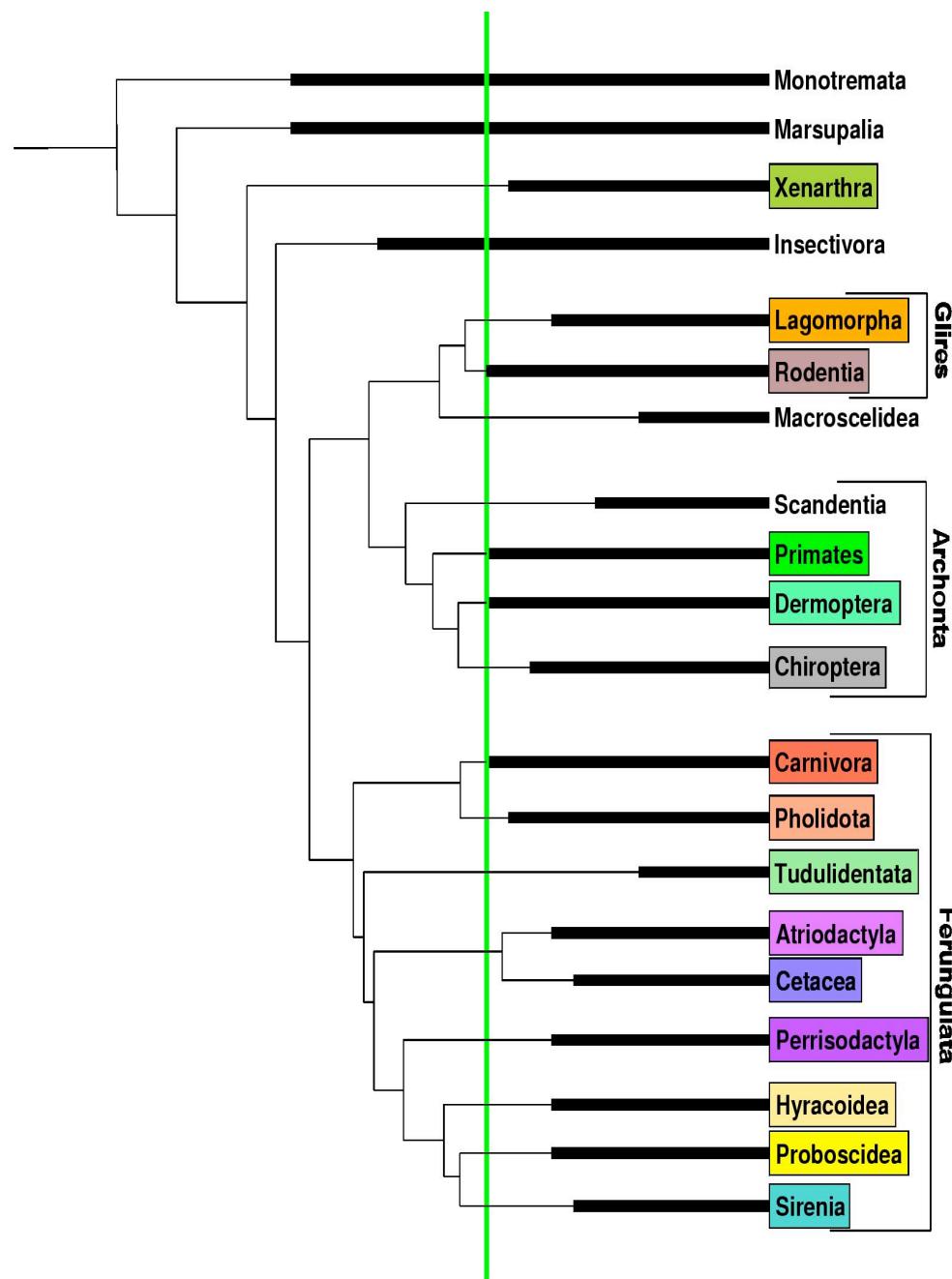
	X	Y	Z
W	40	50	70
X	30	50	
Y			40



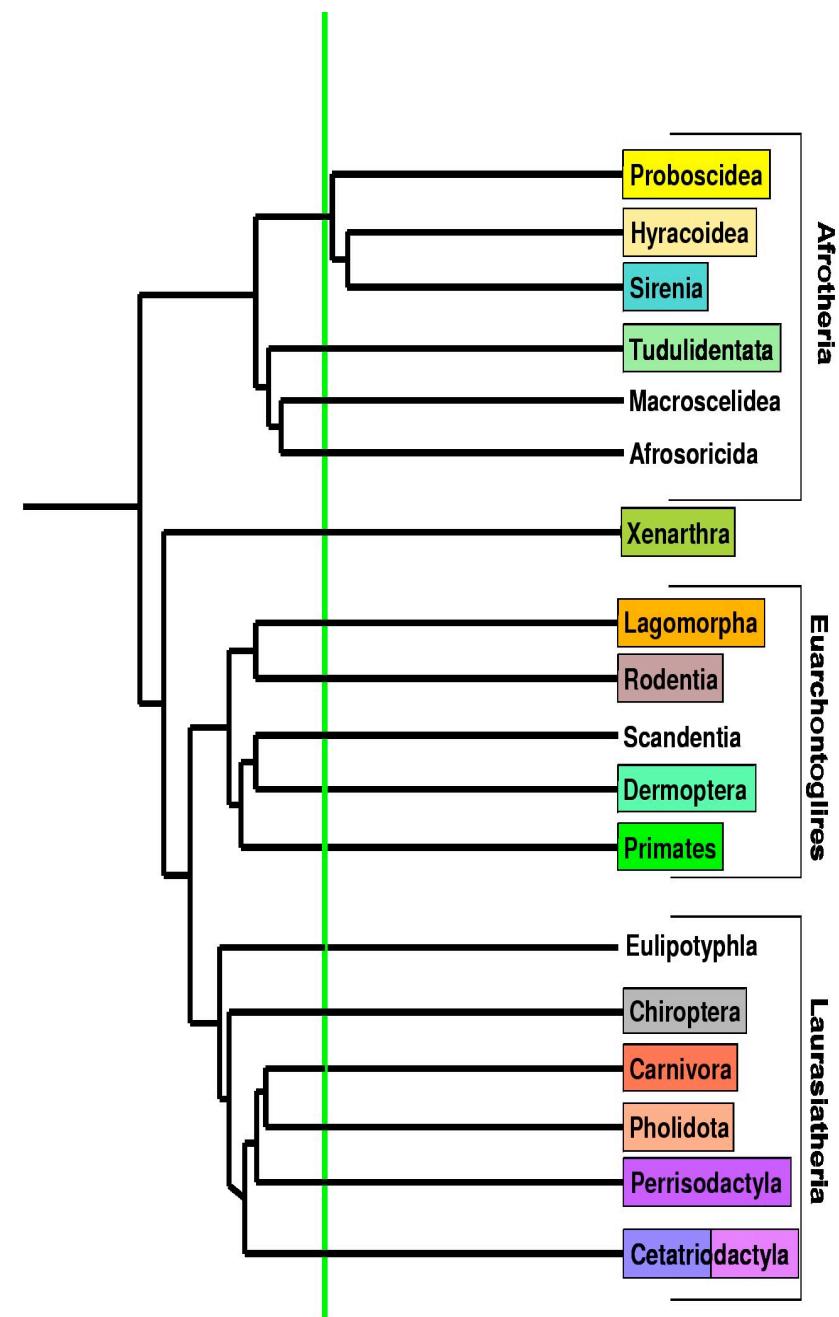
	X	Y	Z
W	40	50	70
X		30	50
Y			40

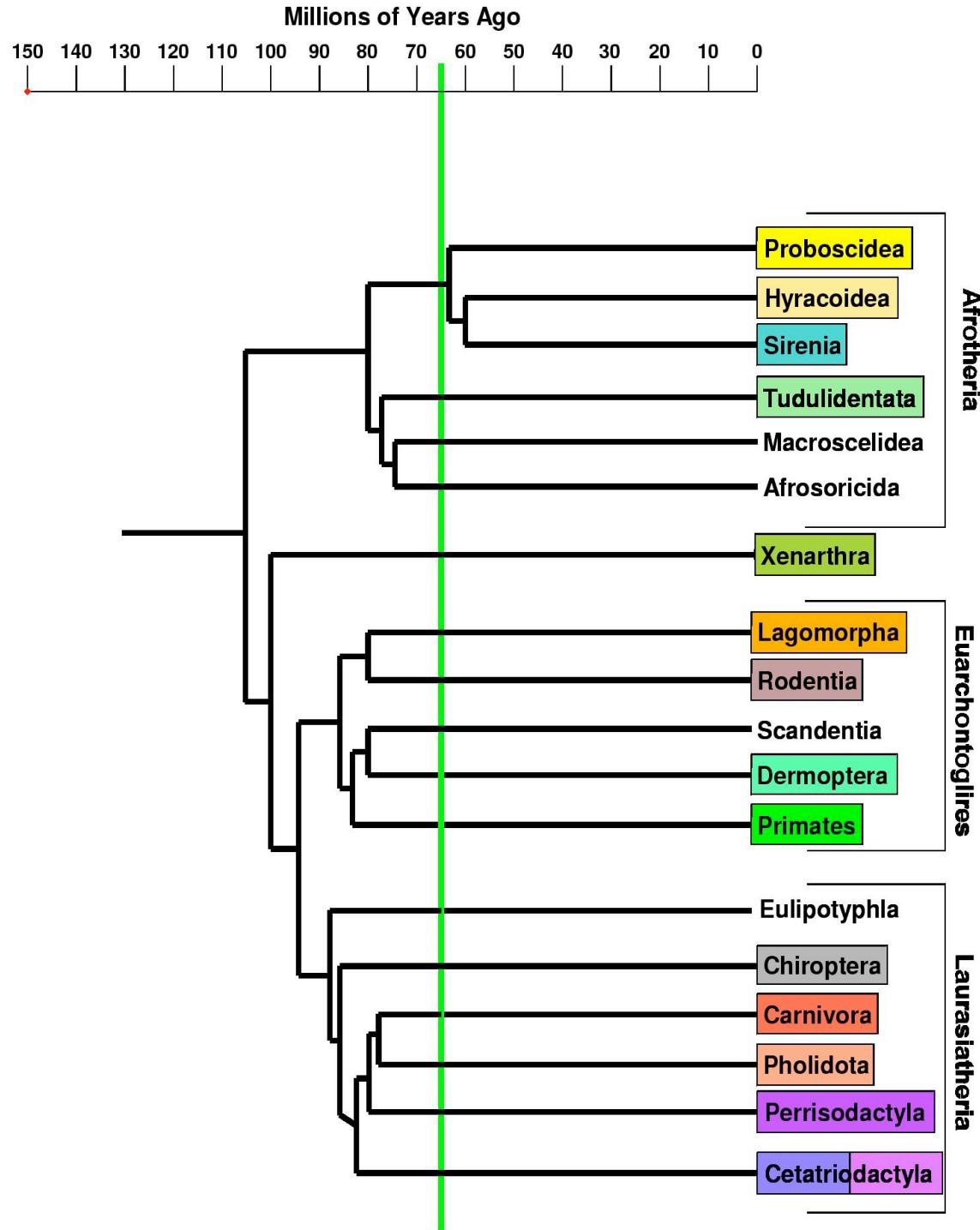


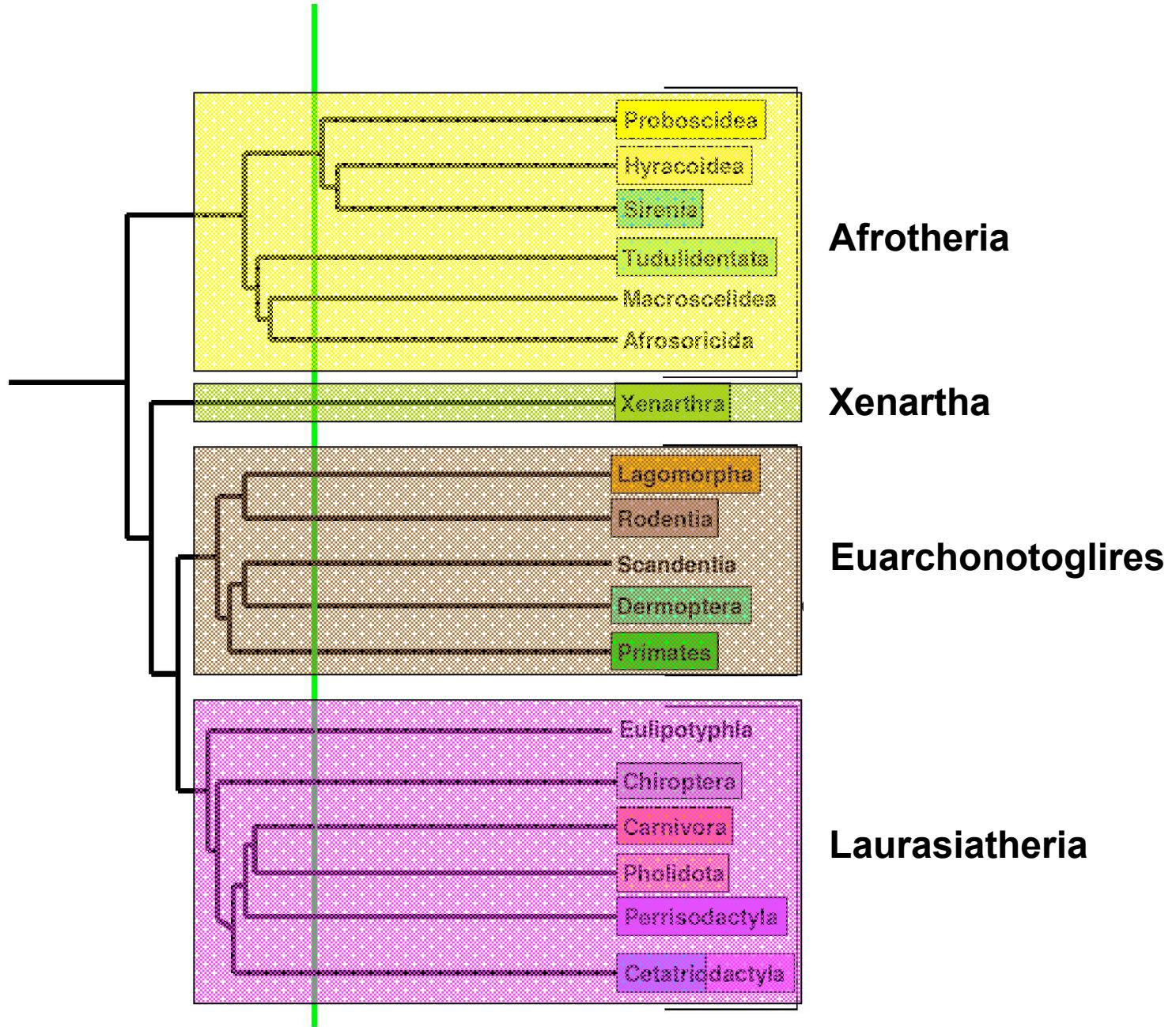
Family Tree based on Physical Characteristics



Family Tree based on Molecular Data

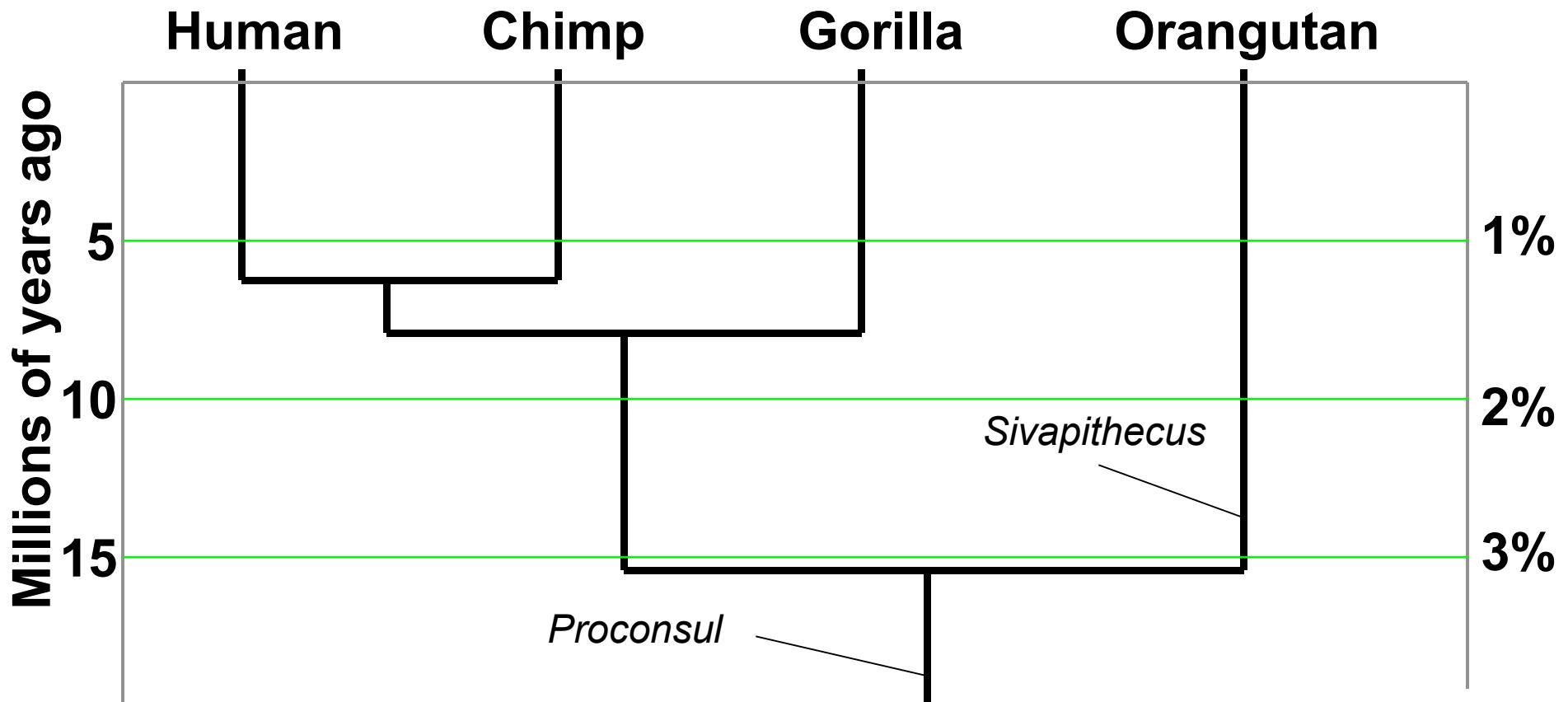






Estimating Time Scales with Molecular Data

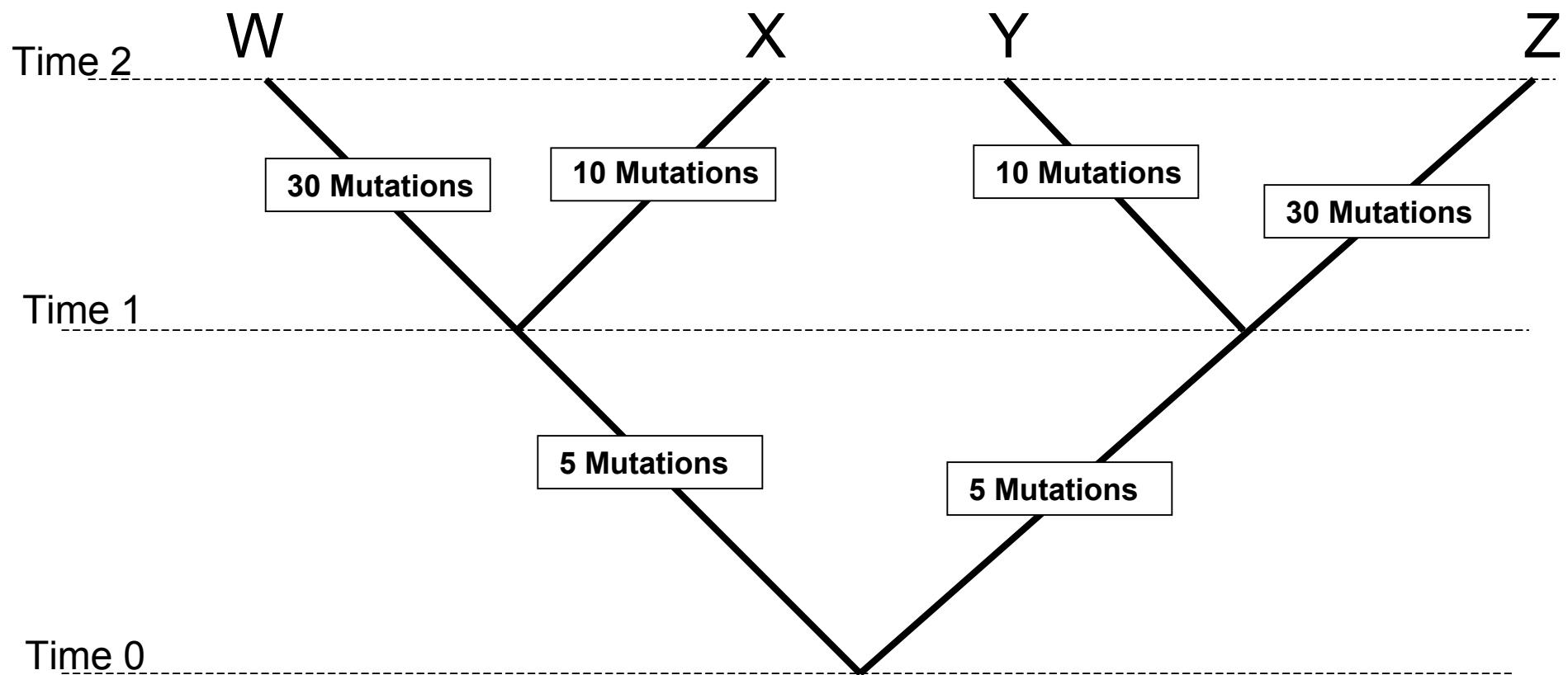
When the Mutation Accumulation rate is constant



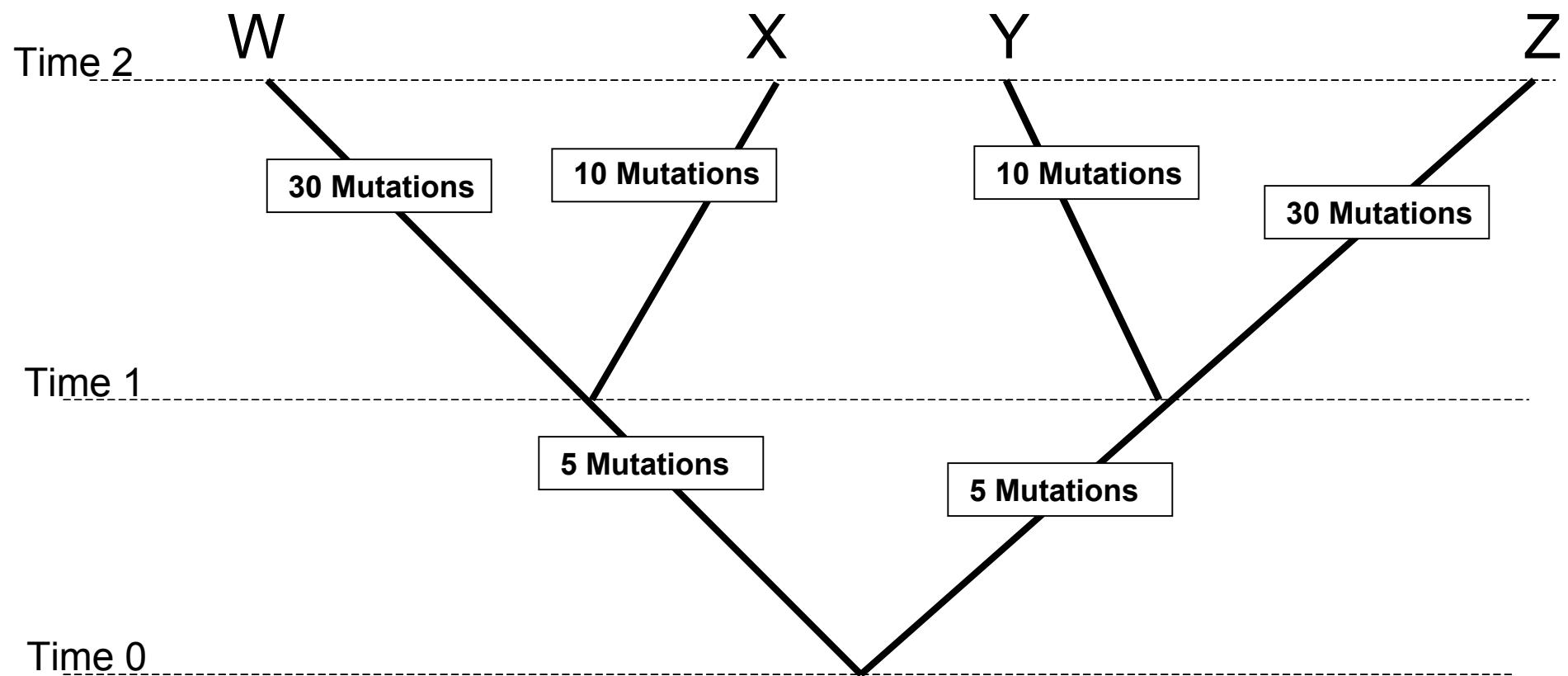
Estimating Time Scales with Molecular Data

When the Mutation Accumulation rate is NOT constant

	X	Y	Z
W	40	50	70
X		30	50
Y			40

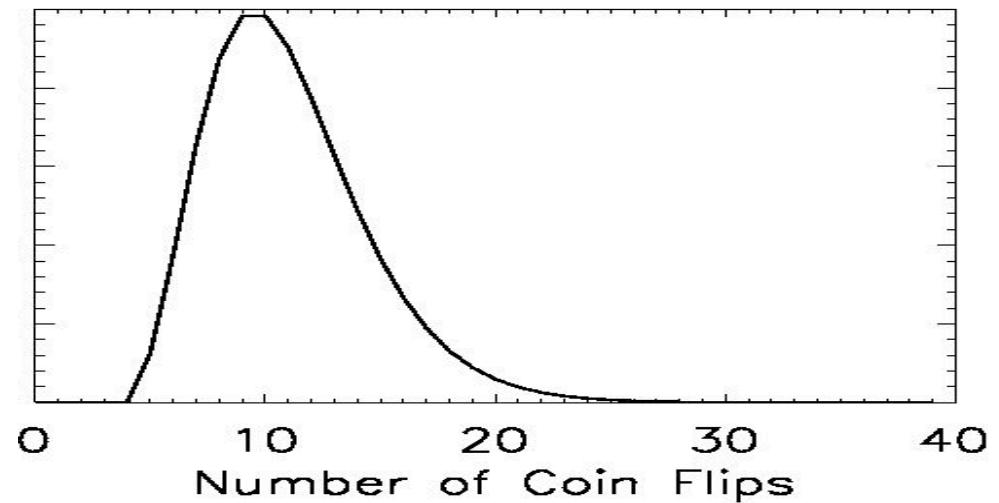


	X	Y	Z
W	40	50	70
X		30	50
Y			40



A simpler problem: Flipping Coins

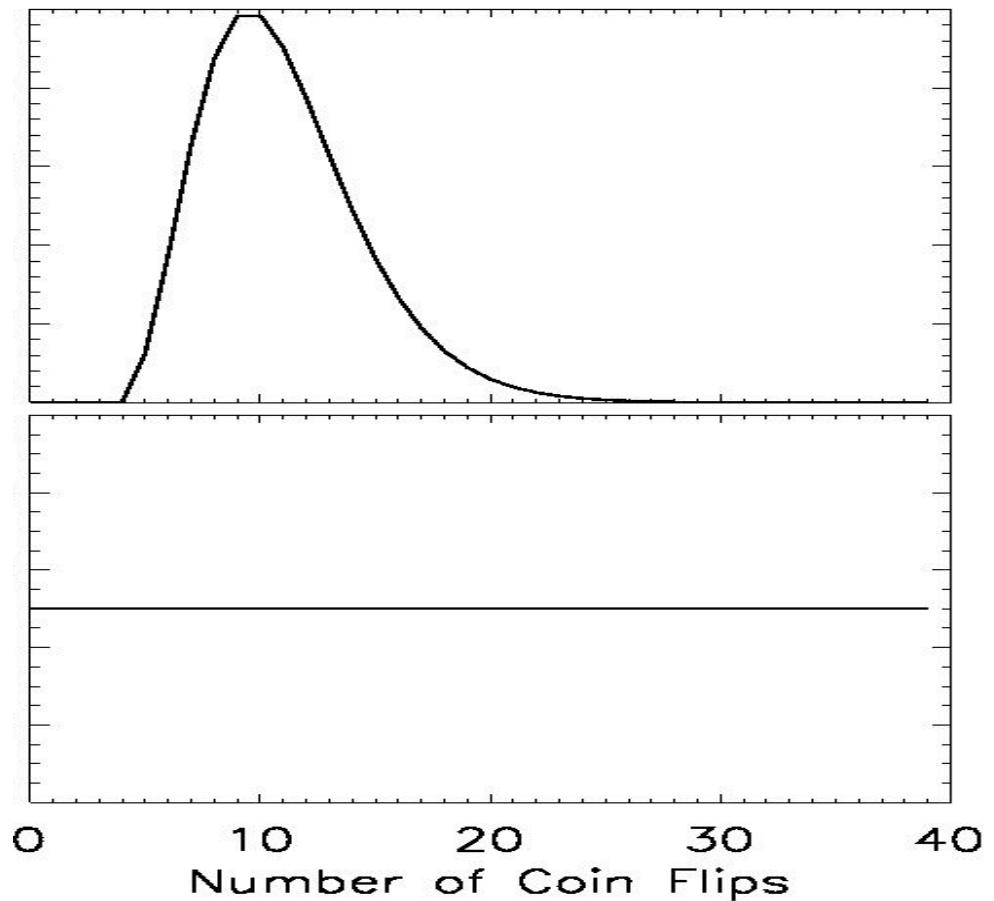
**Probability of getting
five heads, given the
number of Coin Flips**



A simpler problem: Flipping Coins

Probability of getting
five heads, given the
number of Coin Flips

Assumed Probability of
each number of Coin Flips

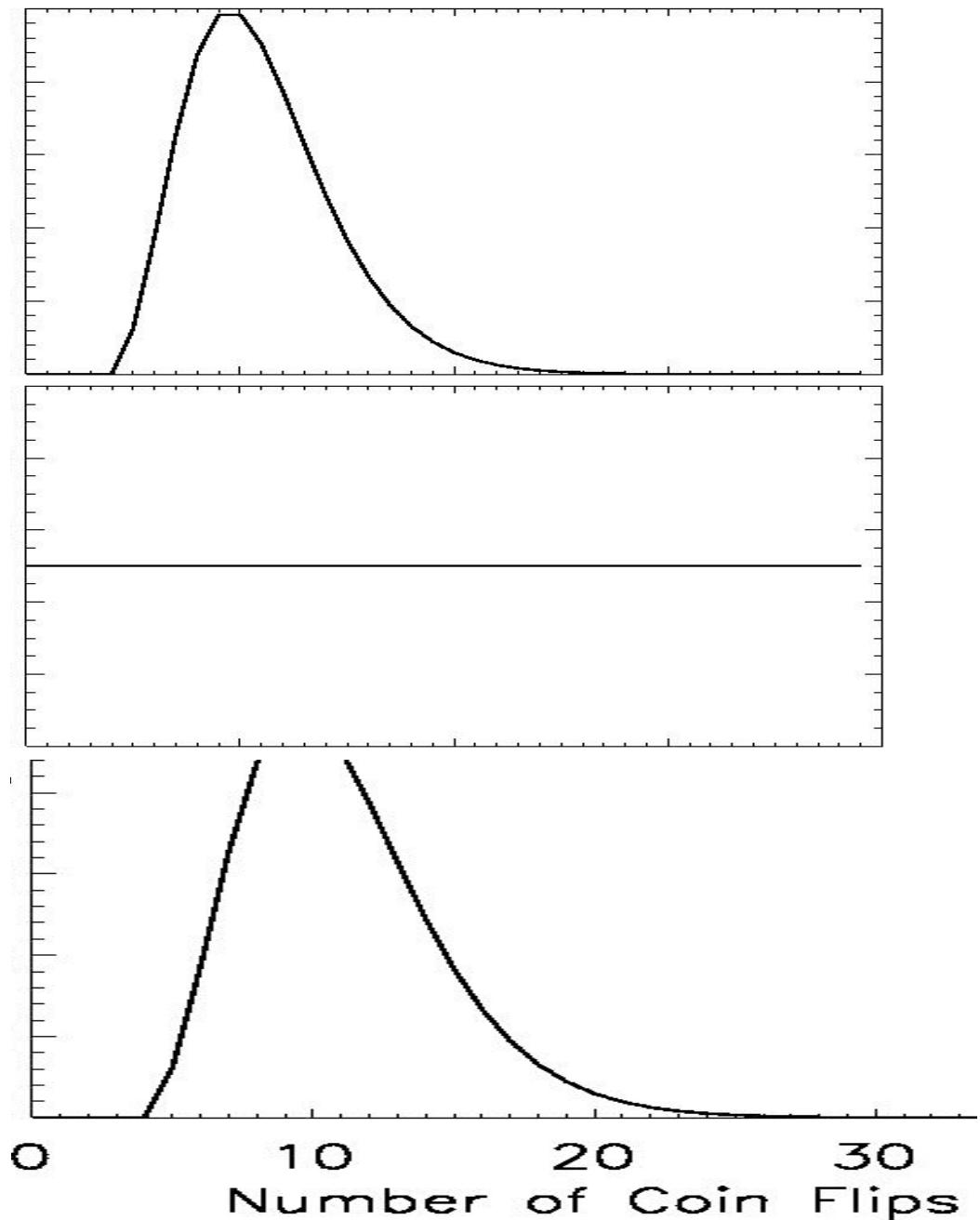


A simpler problem: Flipping Coins

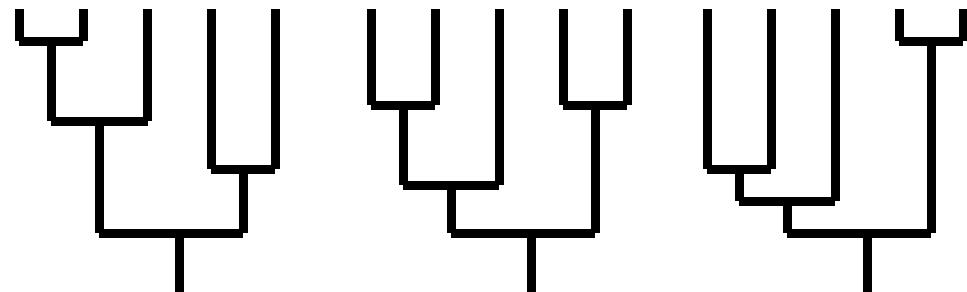
Probability of getting
five heads, given the
number of Coin Flips

Assumed Probability of
each number of Coin Flips

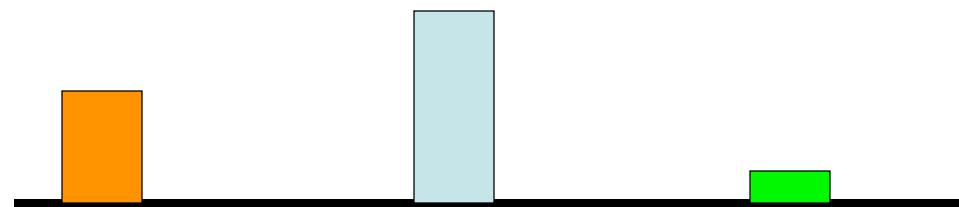
Likelihood the coin
was flipped a given
number of times



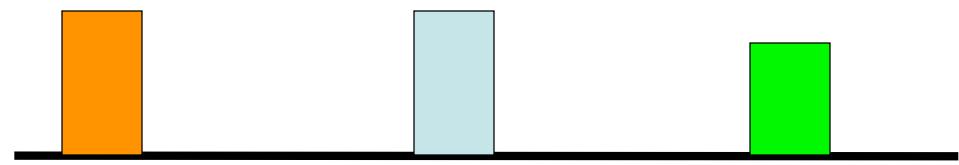
Bayesian Statistics with Molecular Data



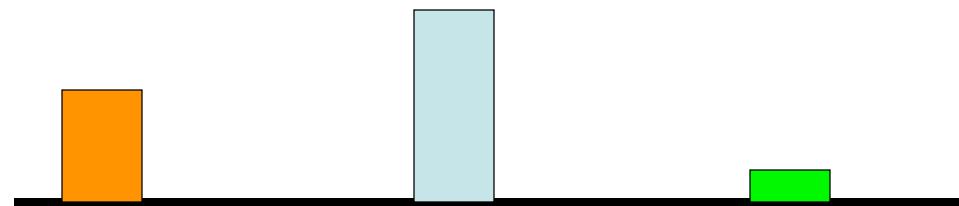
Probability of getting
observed differences,
given a certain tree

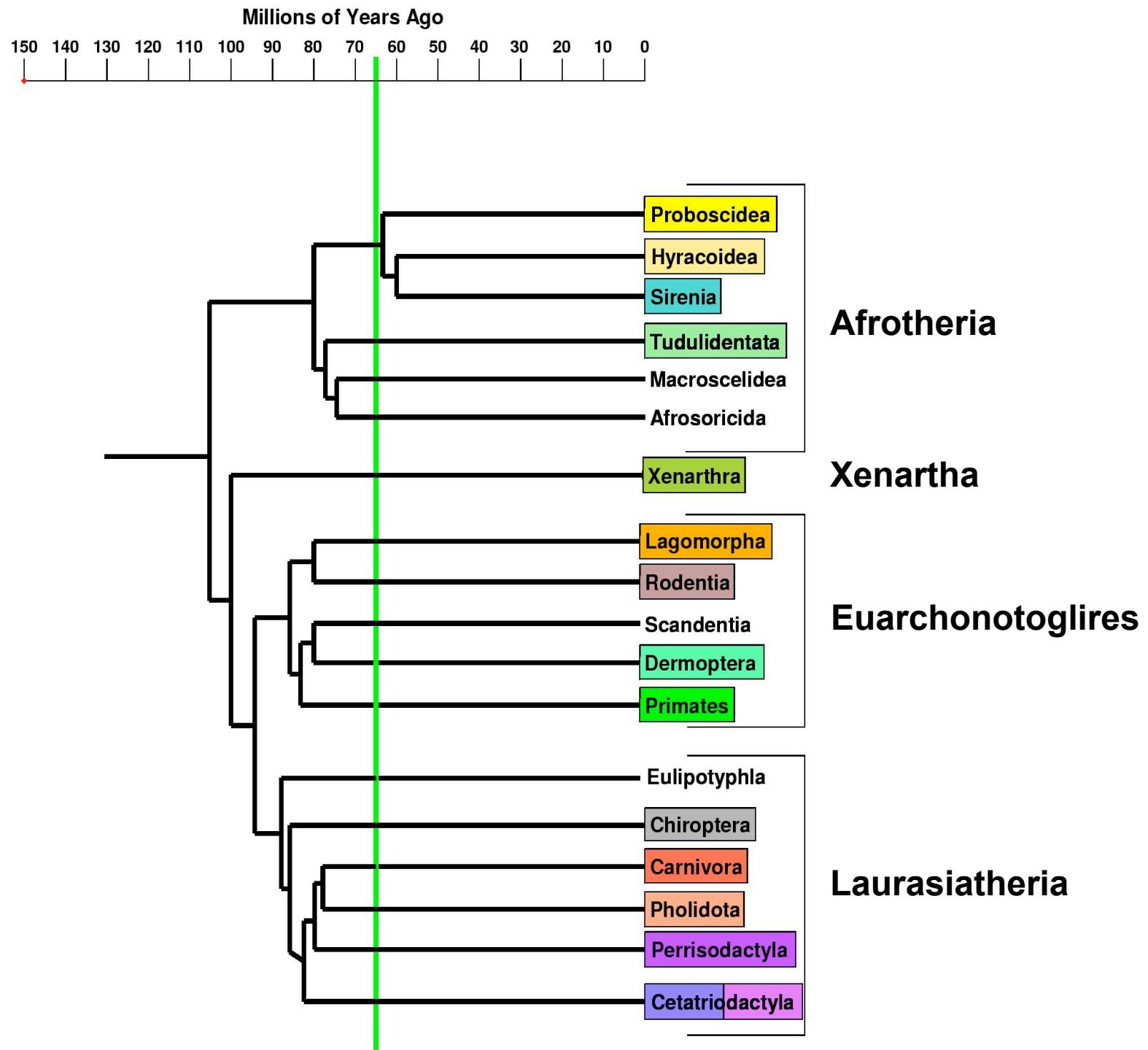


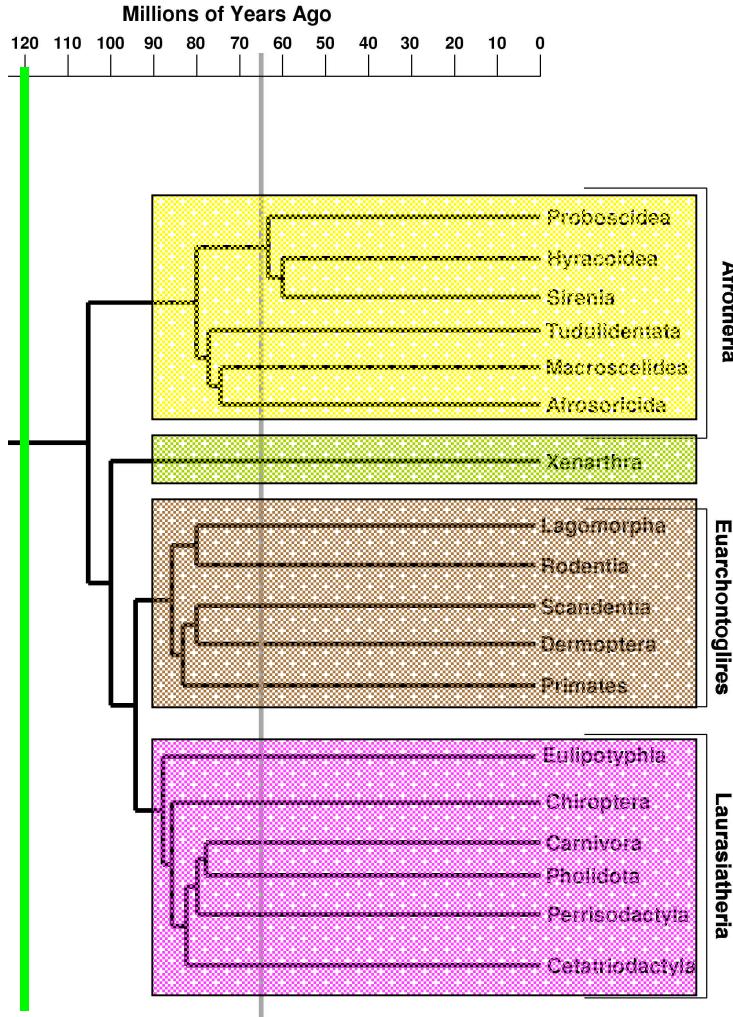
Assumed prior probability
of different trees



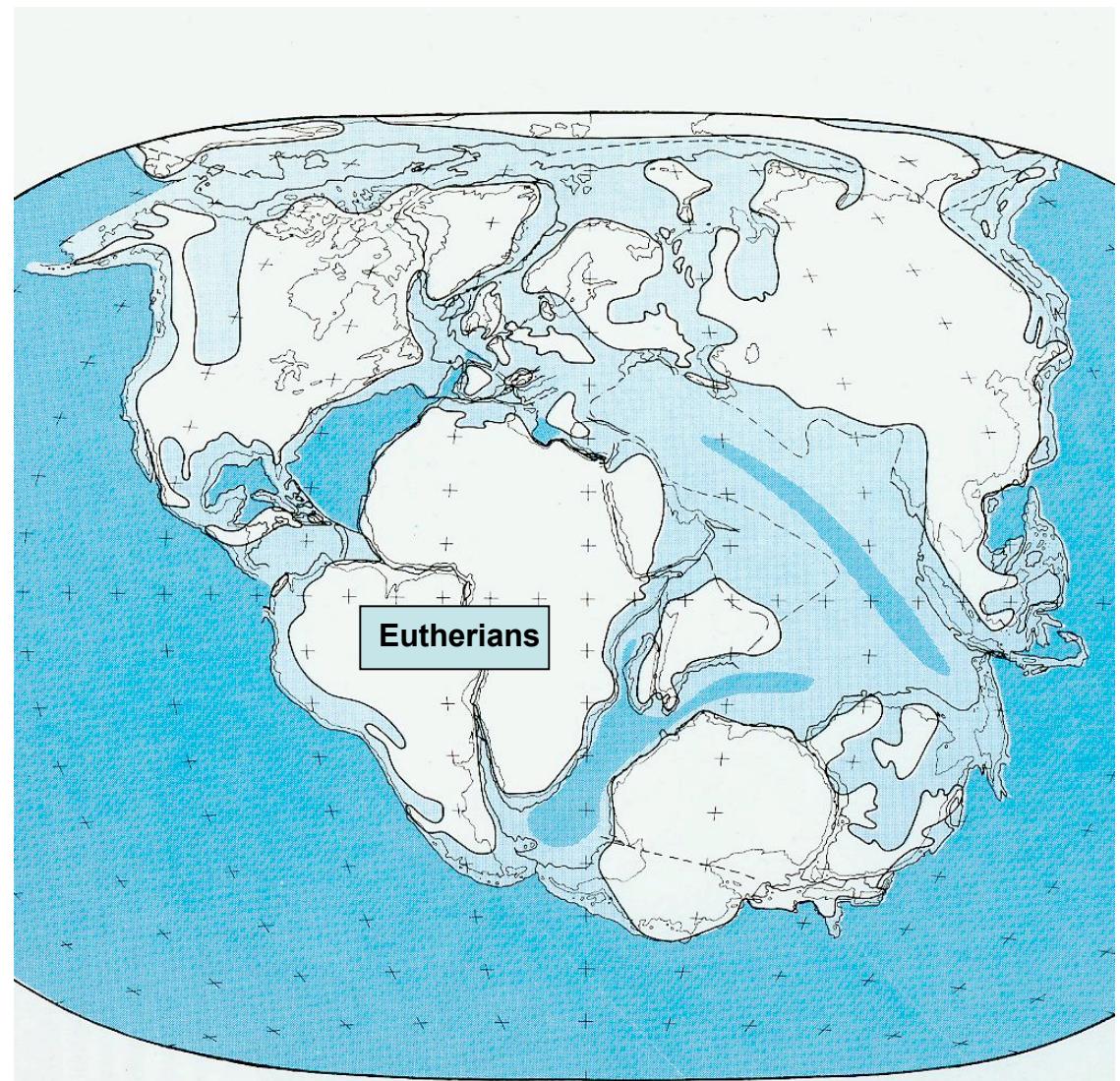
Likelihood of the
different trees, given the
observed differences

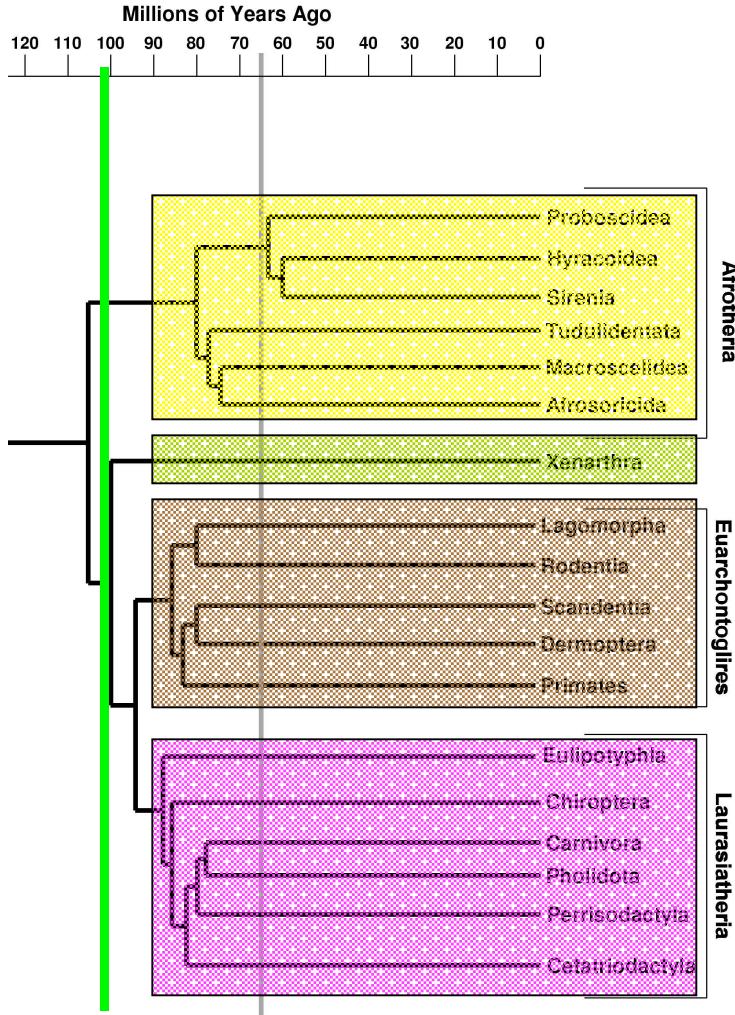




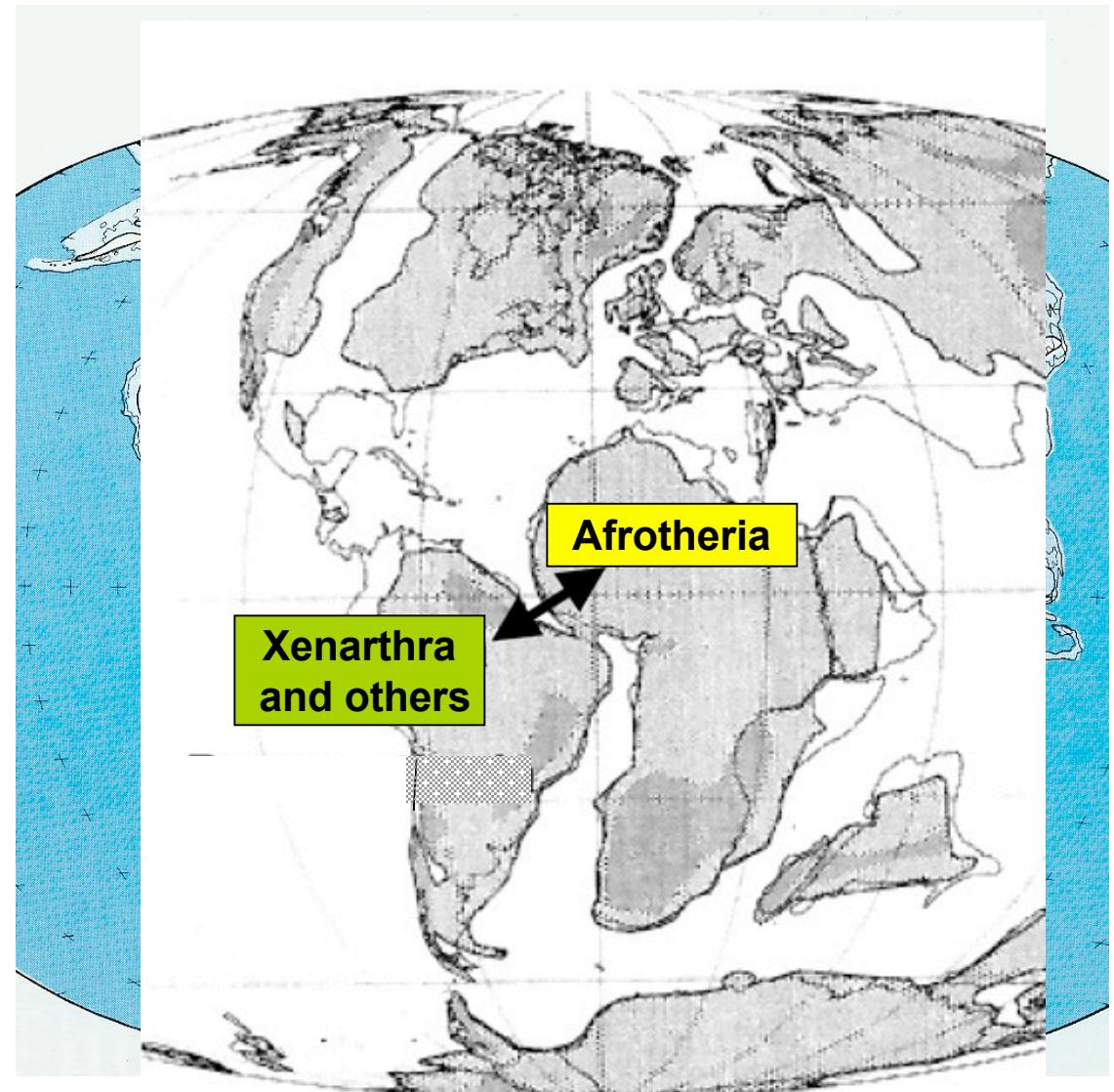


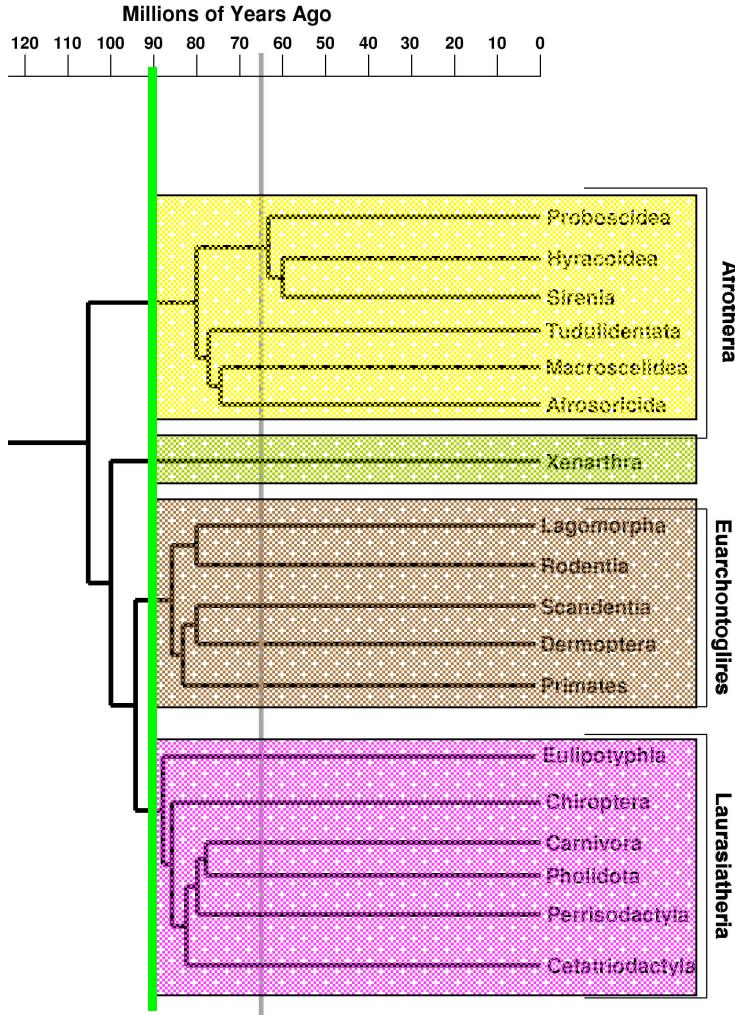
120 Million Years Ago



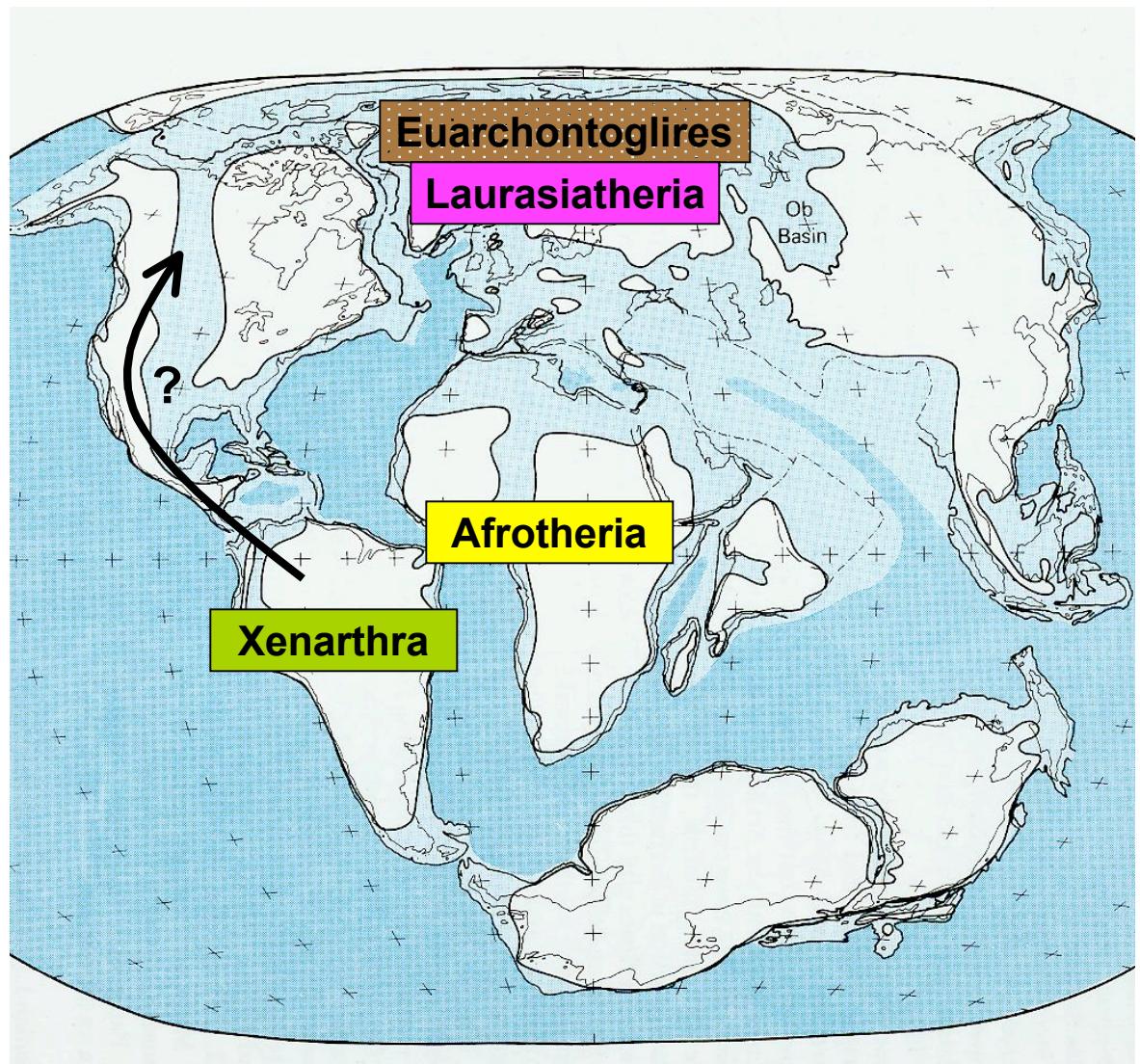


105 Million
Years Ago

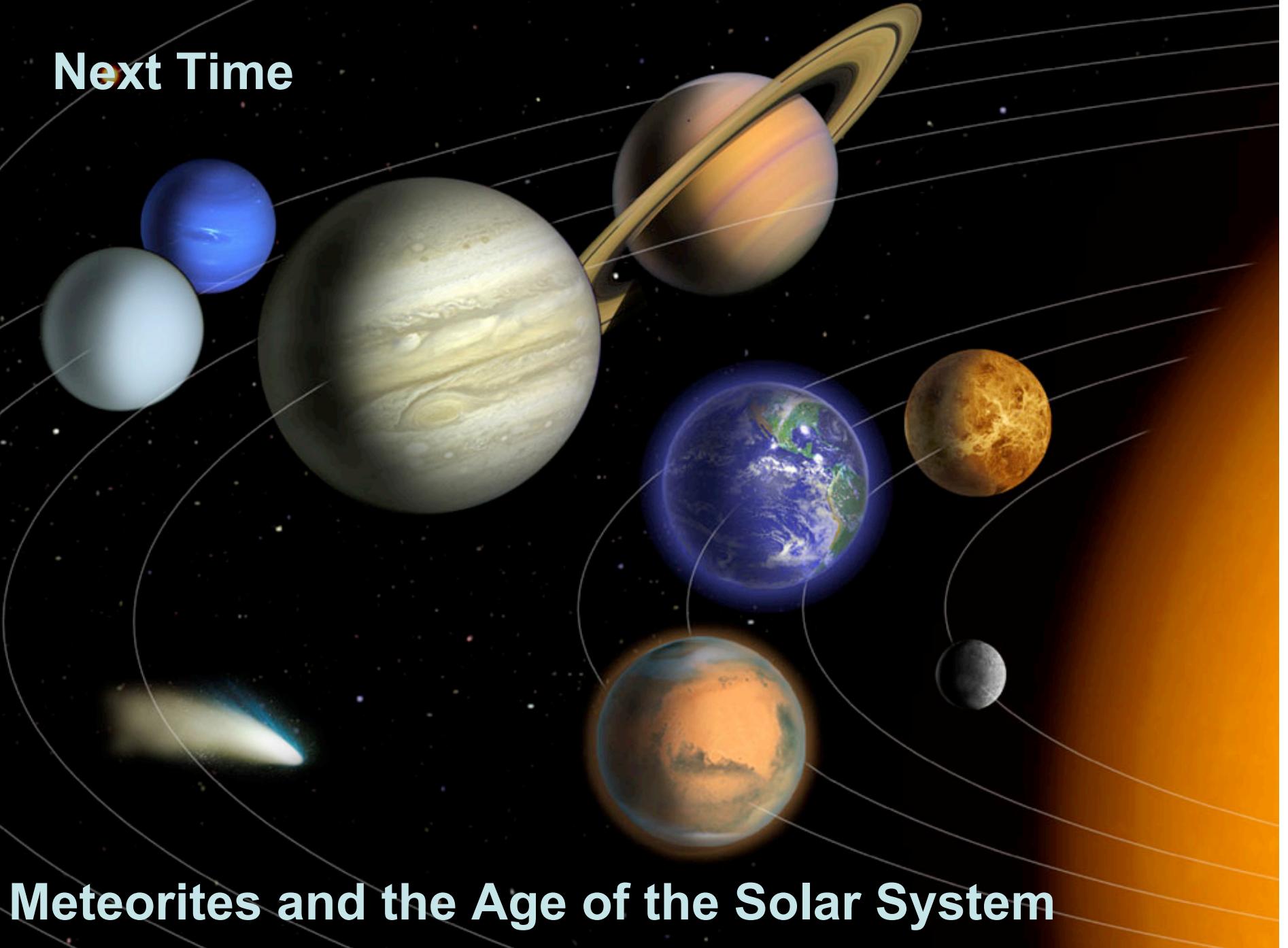




90 Million Years Ago



Next Time



Meteorites and the Age of the Solar System