

Part III – PHYLOGENETICS

BIO 111 Biological Diversity and Evolution
Varsha 2017

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Phylogeny

What we see today in nature is the outcome of what has happened in the past

An 'ancestral' species gives rise to two or more 'daughter' species through the process of *speciation*

All species are potential ancestral species that can further undergo speciation

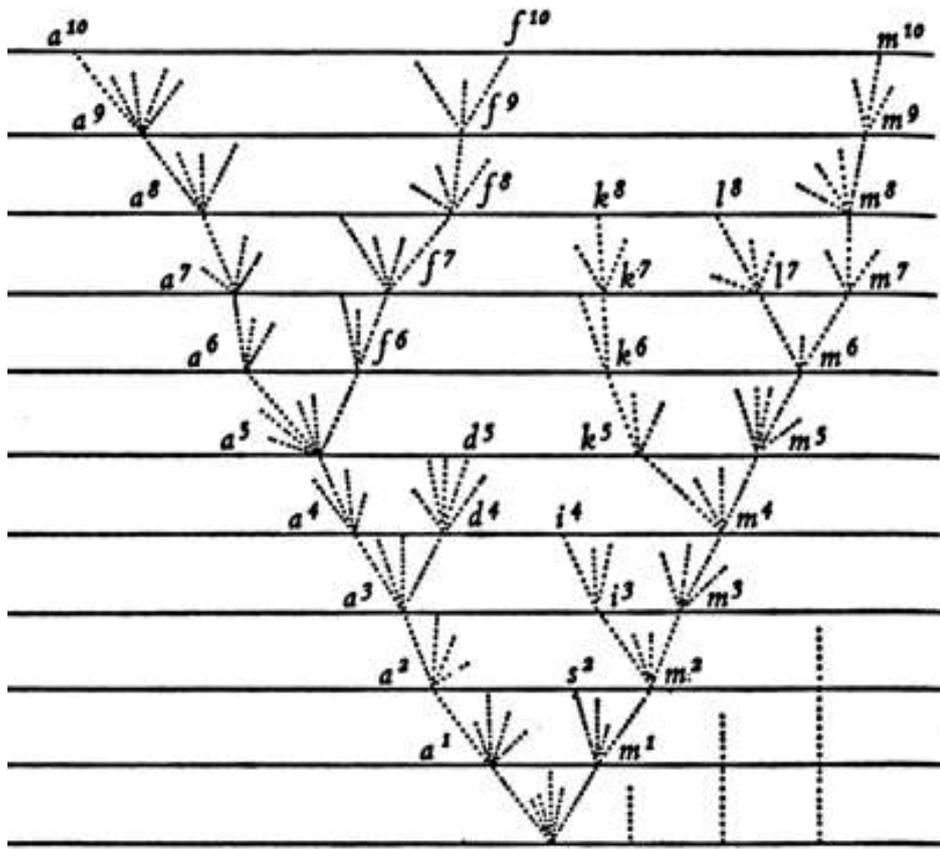


Figure from “The Origin of Species”

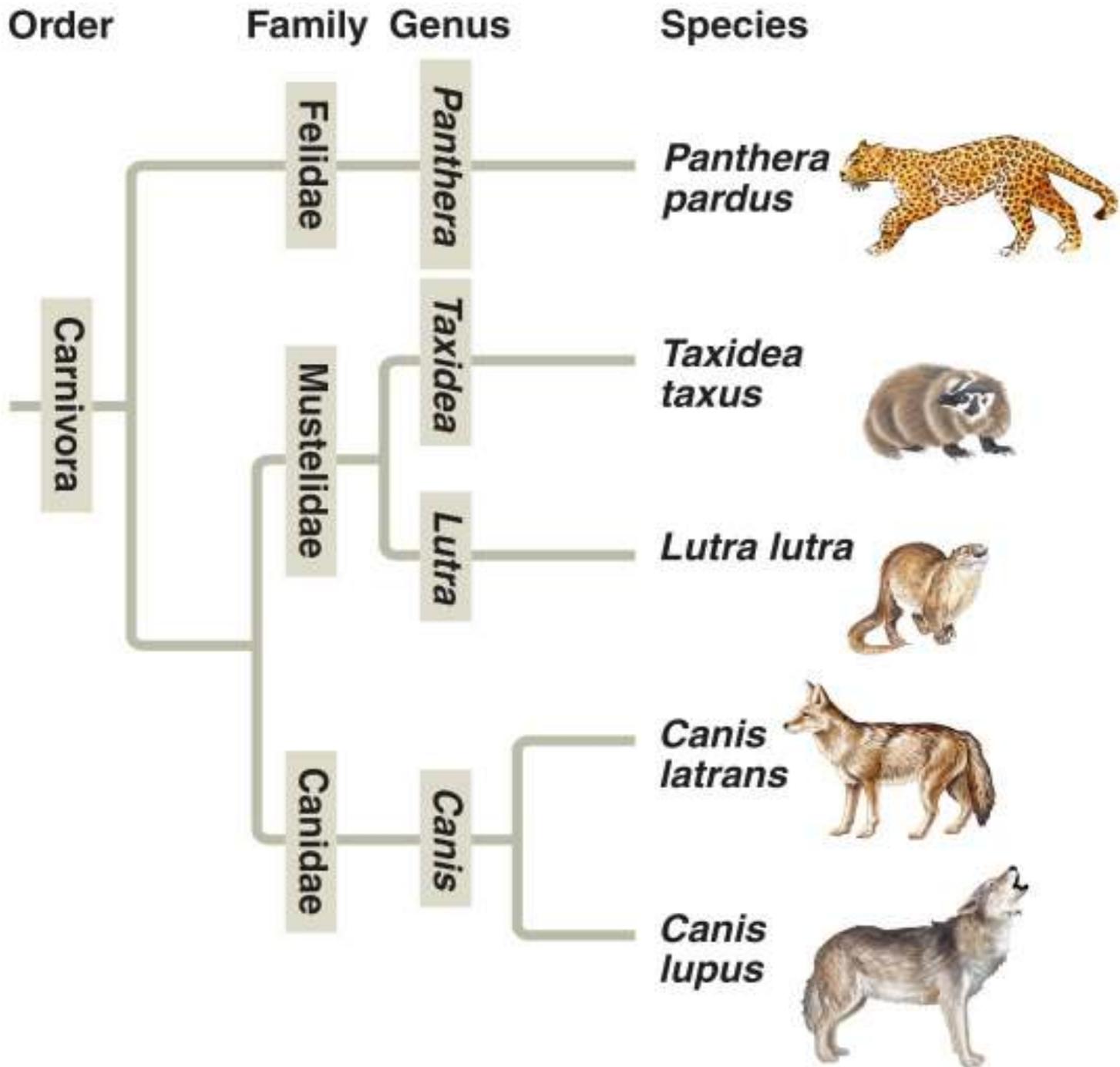
“The time will come, I believe, though I shall not live to see it, when we shall have fairly true genealogical trees of each great kingdom of Nature”
 - Charles Darwin

Phylogeny

A species-level phylogeny is a reconstruction of historical speciation events, depicted in the form a tree

Also called dendrogram, cladogram

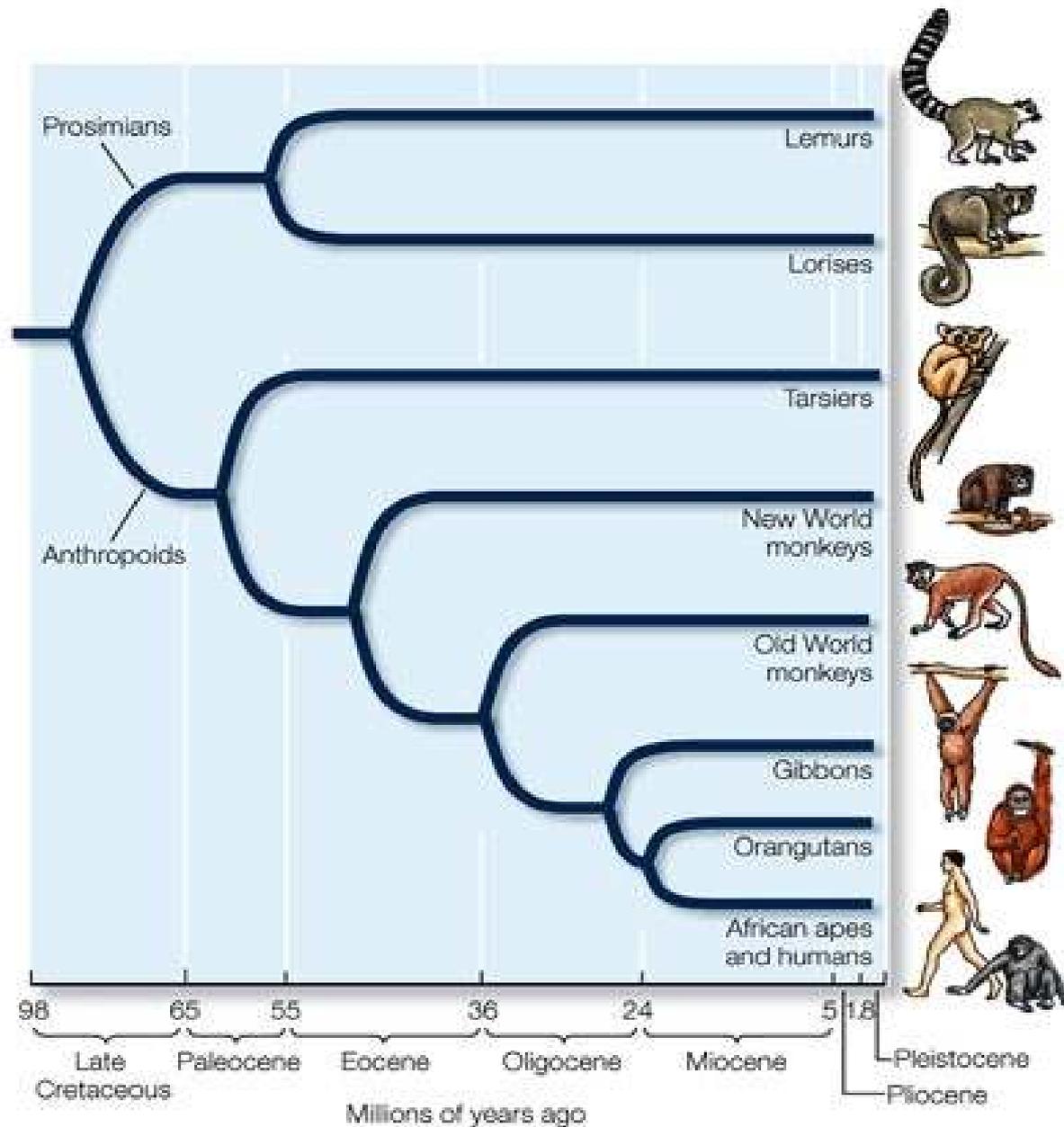
A phylogeny can also represent relationships among lineages other than species, eg families, individuals within a species



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Source: Pearson Scientific Inc

Humans evolved from apes



LIFE 8e, Figure 33.27



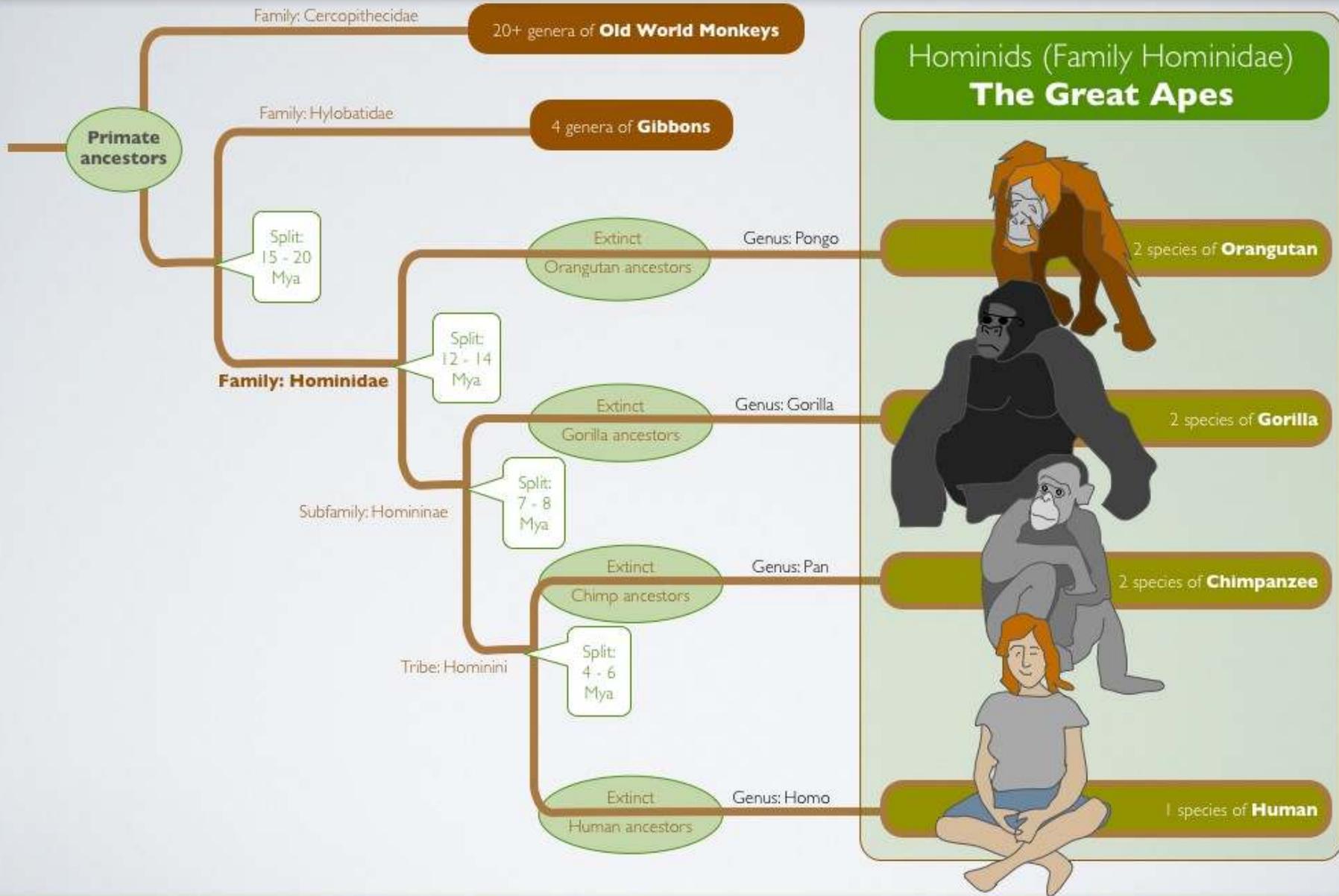
Old World monkeys

Images source:
<http://www.sheppardsoftware.com/content/animals/mammals/apevsmonkey.htm>



New World Monkeys

The Great Apes: Evolution and phylogeny overview



This tree of life shows humans' closest evolutionary relatives and their recent common ancestry.

(cc) davehuth.com/blog

Source: Dave Huth

Tree of Life project

www.tolweb.org

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TREE OF LIFE web project

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Agaricales

(a group of fungi)



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The Agaricales, or euagarics clade, is a monophyletic group of approximately 8500 mushroom species...

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Darwin 200: the celebration continues...

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The Tree of Life Web Project (ToL) is a collaborative effort of [biologists and nature enthusiasts from around the world](#). On more than 10,000

Lion

Tiger

Mouse

Beetle

Mango

Based on *similarity*, reconstruct the phylogeny of the above

How do we find a tree for a given set of taxa?

Important !! We don't know what the true phylogeny is.
We can only estimate -
phylogenetic hypothesis.

Collect data on **character states** of multiple **characters** for all taxa of interest, and analyze the data.

Character

A feature of an organism that can be observed or measured. Part or attribute.

Assumed to vary independently of other characters.

Heritable

Character-state

One of the alternate conditions of a character

Character

Character states

Wings

presence, absence

Mouth part

absense, chewing,
sucking, piercing, etc.

No. of petals in a flower

0, 3, 5, 8, 13, 21, 34, 55

Position in DNA
Sequence

Nil, A, G, T, C.

- Morphological data
- Molecular data: Most commonly – DNA sequences (molecular phylogenetics).

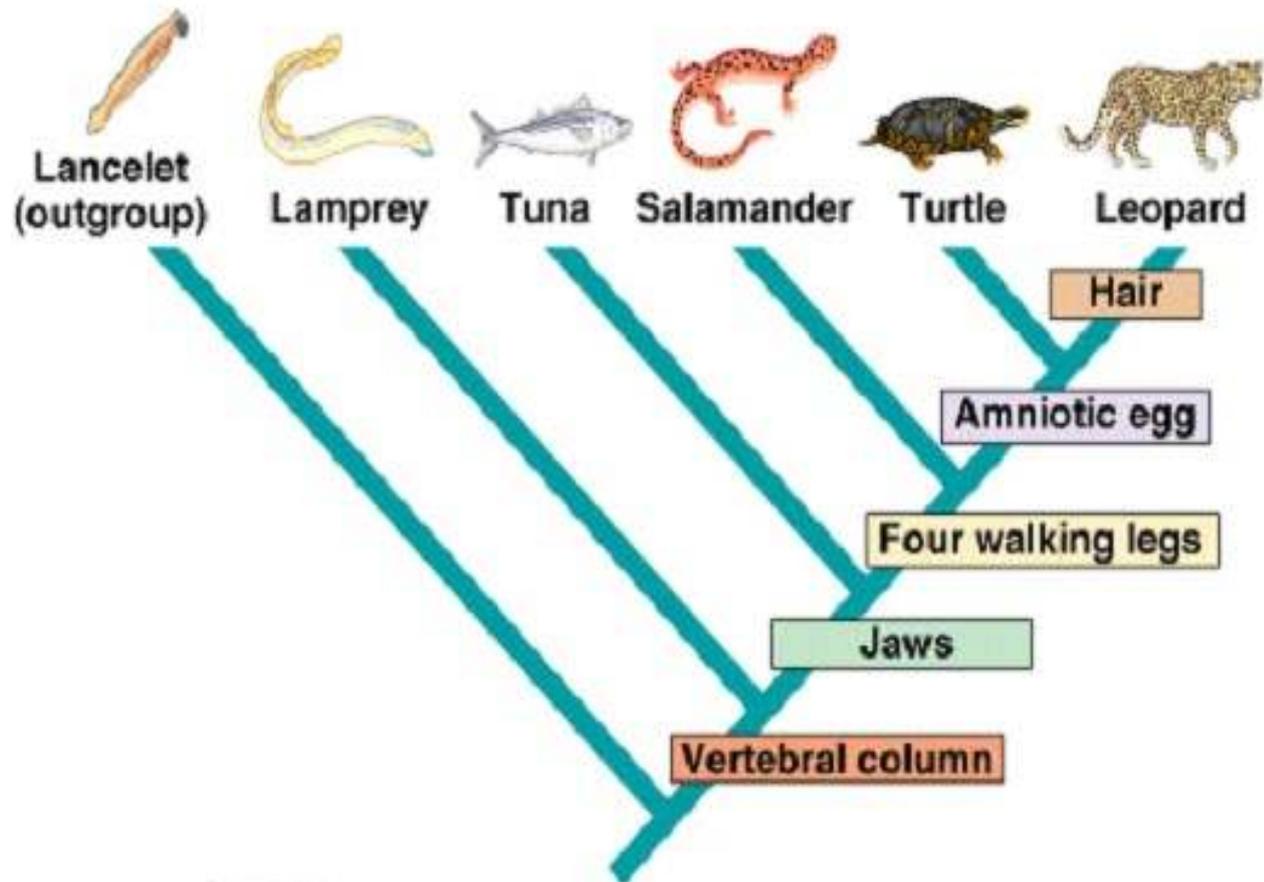
Taxa	Characters
Species A	A T G G C T A T T C T
Species B	A T C G C T A G T C T
Species C	T T C A - - - G A C C
Species D	T T G A C C A G A C C
Species E	T T G A C C A G T T C

Character state
present or absent,
coded as 1 & 0
respectively

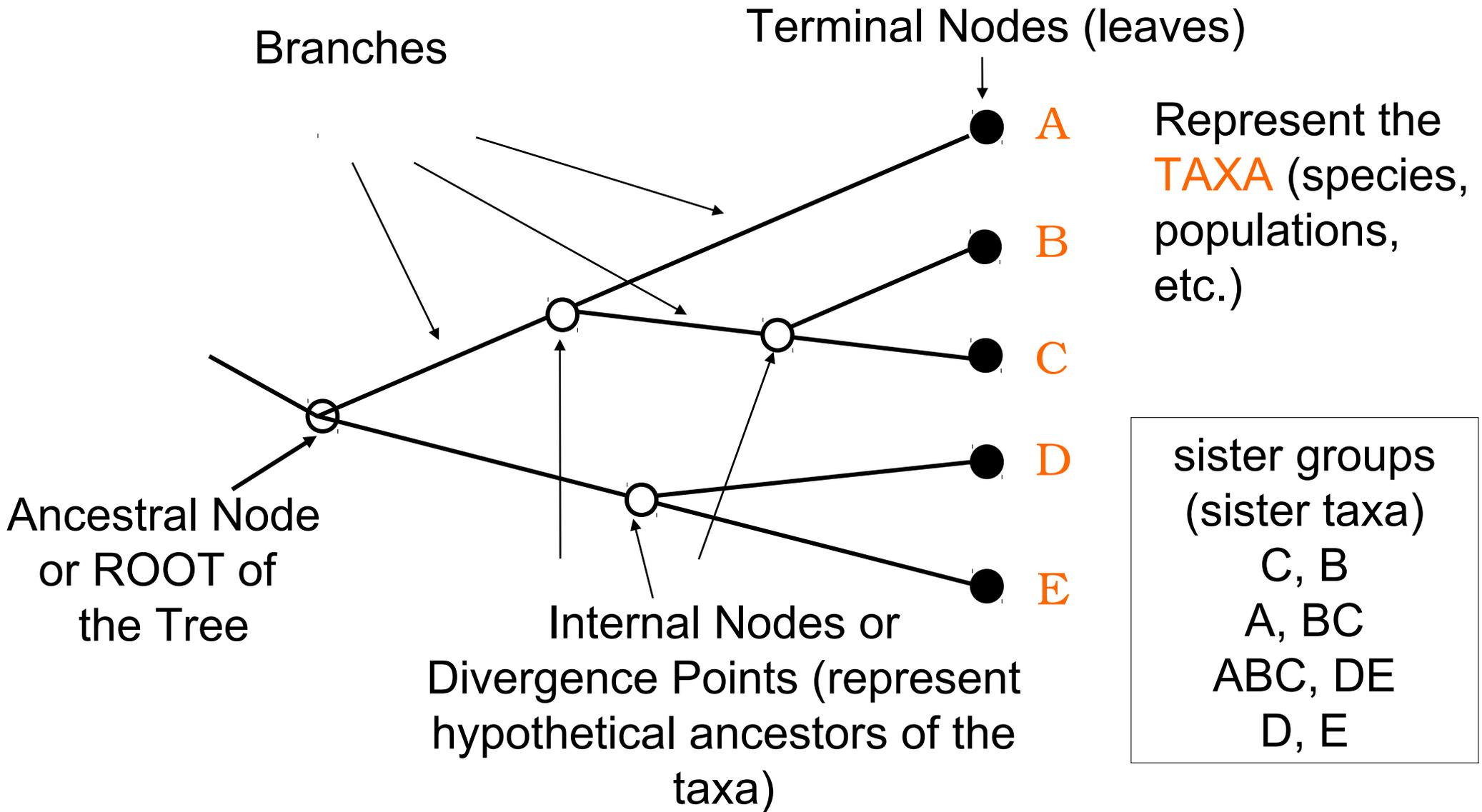
CHARACTERS	TAXA					
	Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
Hair	0	0	0	0	0	1
Amniotic (shelled) egg	0	0	0	0	1	1
Four walk- ing legs	0	0	0	1	1	1
Jaws	0	0	1	1	1	1
Vertebral column (backbone)	0	1	1	1	1	1

(a) Character table

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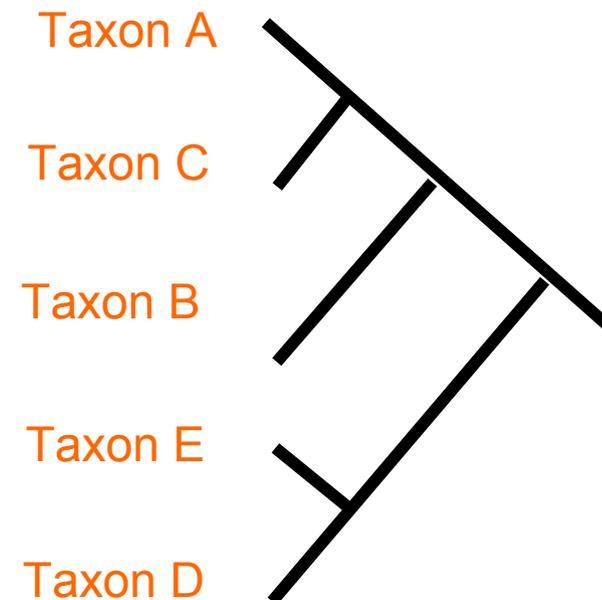
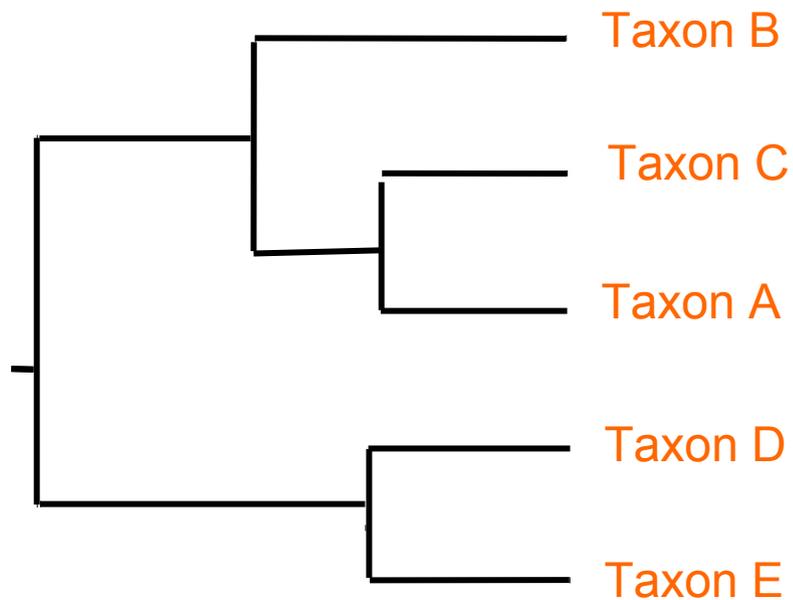


Tree Terminology



Tree can be flipped at nodes

Can be depicted in different ways: rectangular, slanted, etc

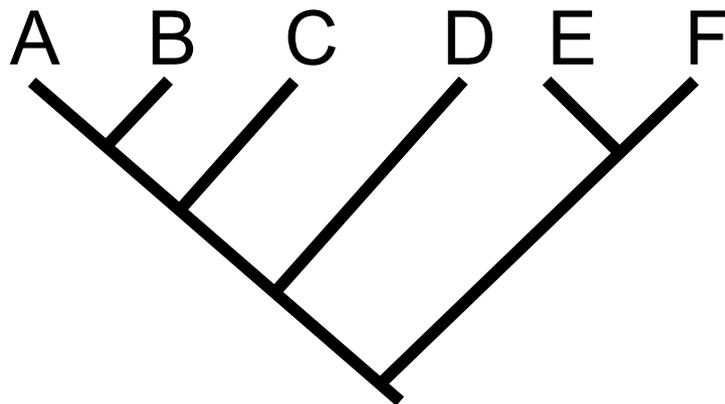


Important concepts

monophyletic (*monophyly*) - group with an ancestor and all of its descendants. A monophyletic group is also called a '*clade*'

paraphyletic (*paraphyly*) - group with an ancestor and some, but not all of its descendants

polyphyletic (*polyphyly*) - group whose members do not share recent common ancestor



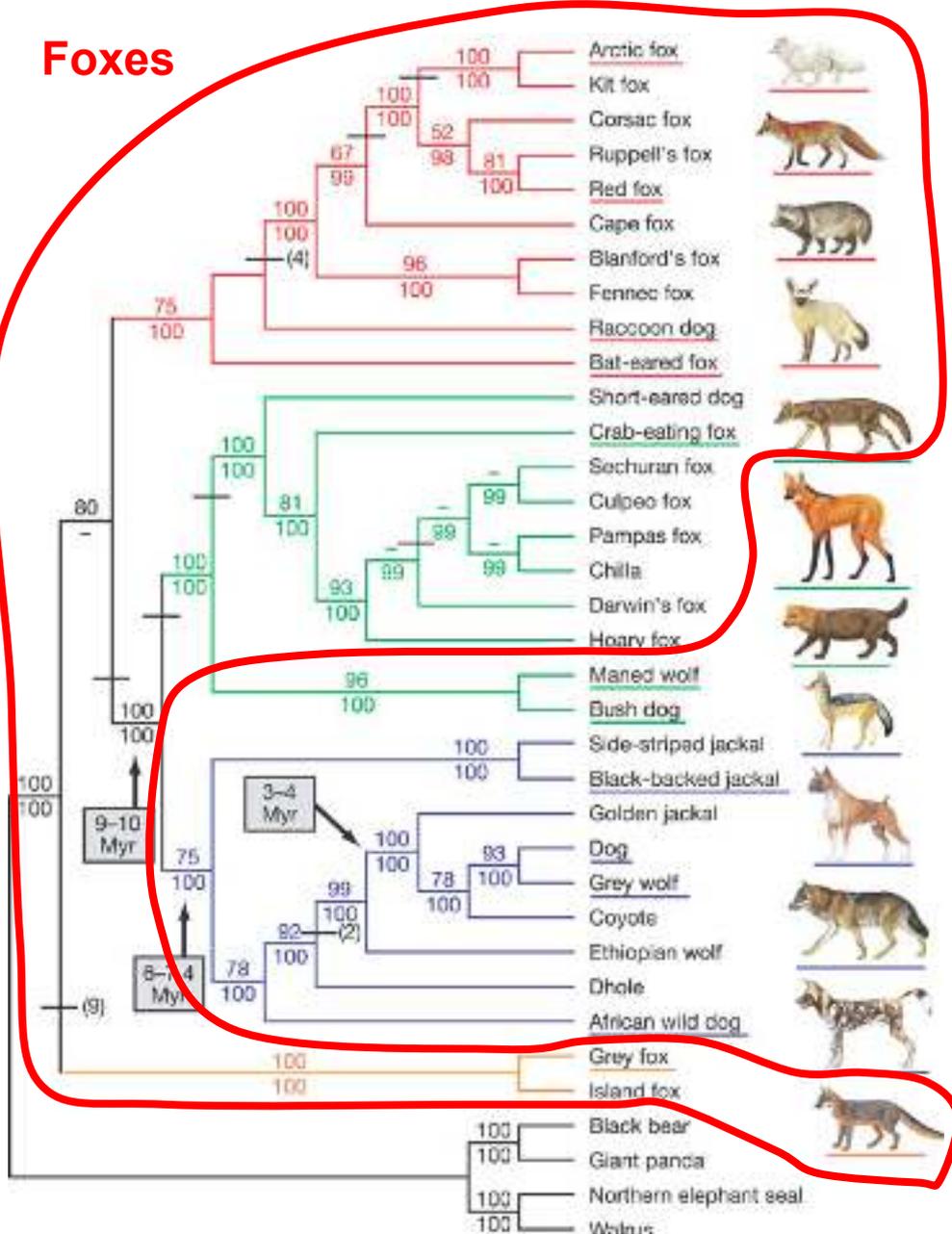
Monophyletic group - AB, ABCD

Paraphyletic group – ABCDE+Ancestor
ABD+Ancestor

Polyphyletic – ACF (without ancestor), ADE
(without ancestor)

Non-monophyletic groups

Foxes

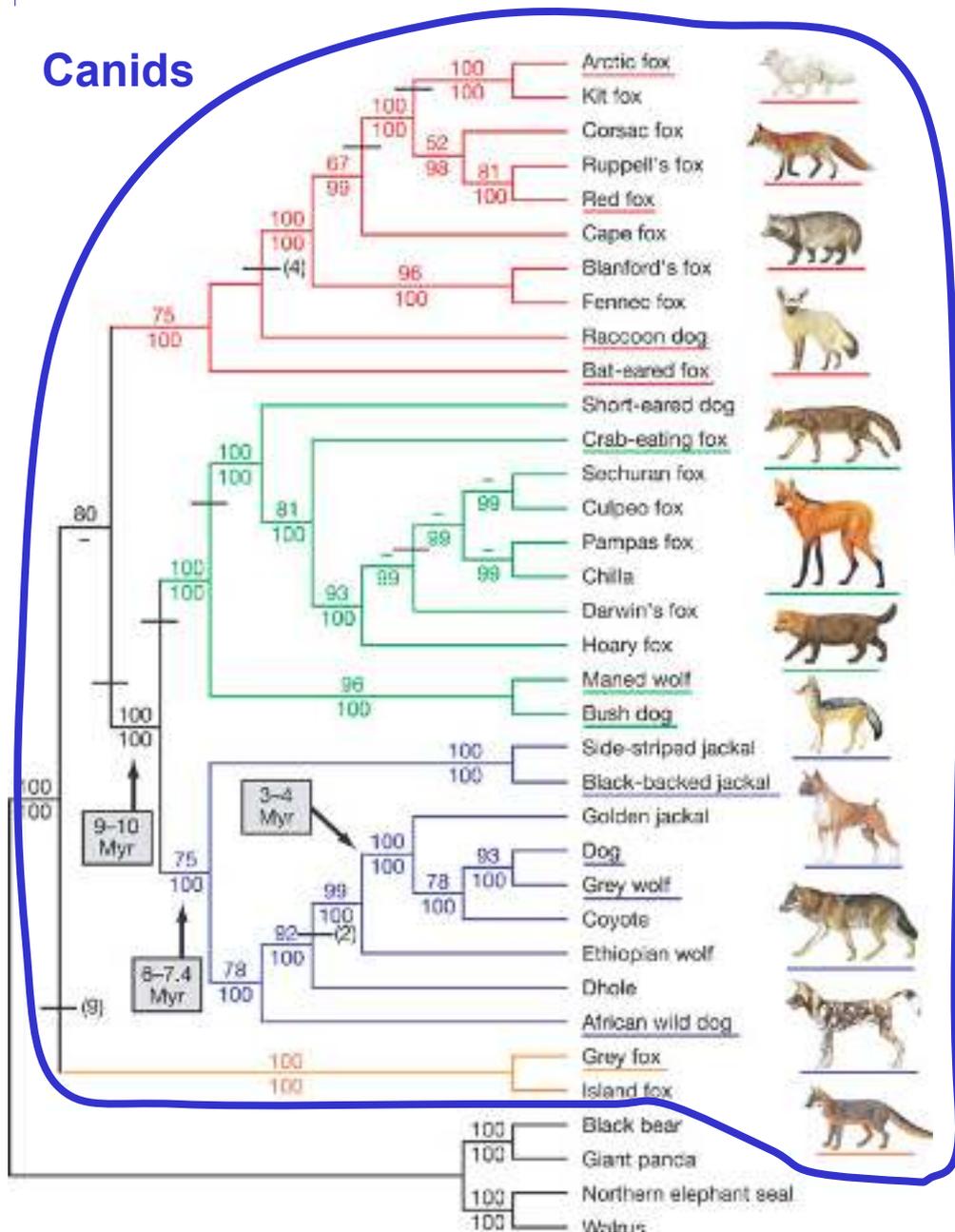


“Foxes” are **not monophyletic** with respect to dogs, wolves, jackals, coyotes, etc.

This is a trivial example because “fox” and “dog” are not formal taxonomic units, but it does show that a dog or a wolf is just a derived fox in the phylogenetic sense

Monophyletic groups

Canids

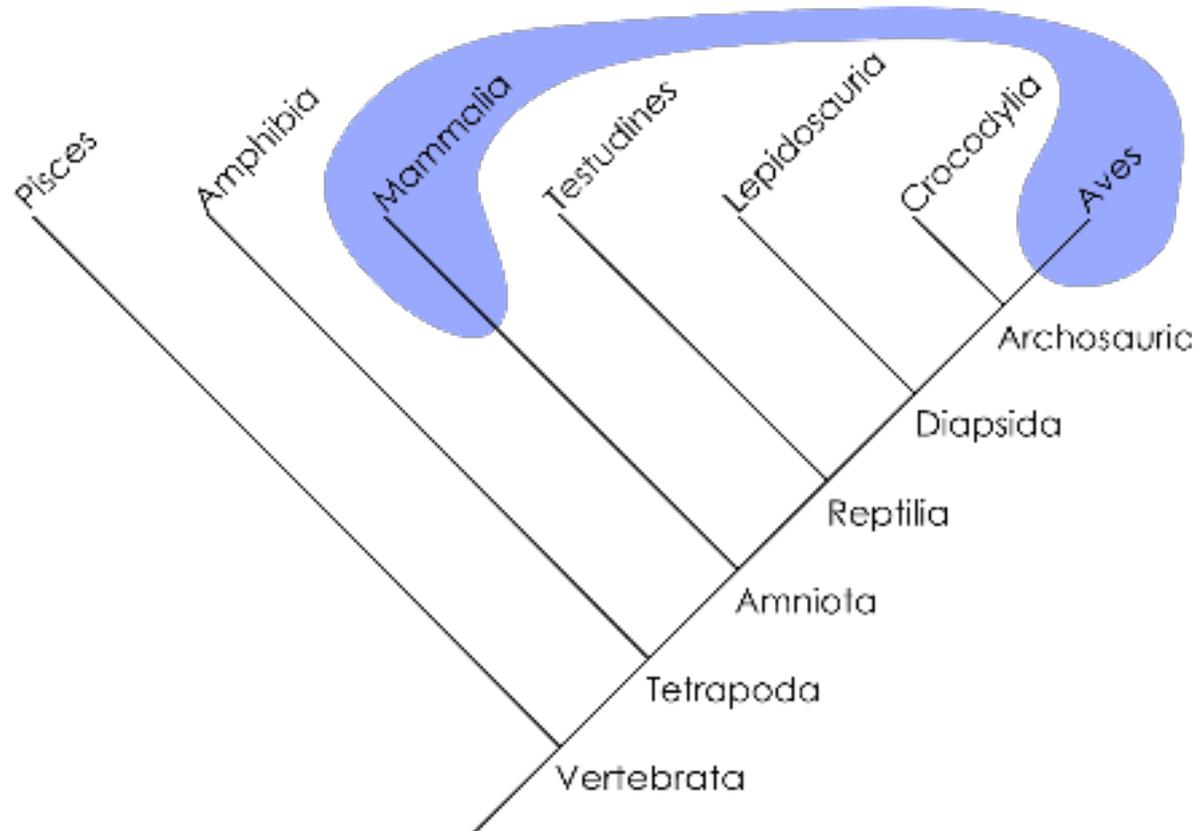


Monophyly

Note that canids are still a good **monophyletic** clade within Mammalia

Each of the colored lineages within canids is also a **monophyletic** clade

Are warm blooded animals a monophyletic group?



Source: Wikimedia commons/Stanslav Traykov

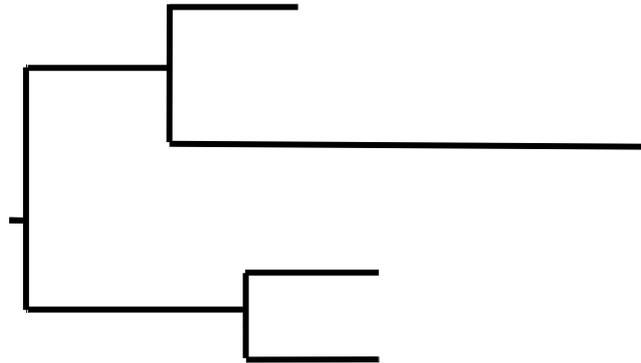
Note: See tolweb.org for a more comprehensive phylogeny of these taxa

Are these monophyletic groups?

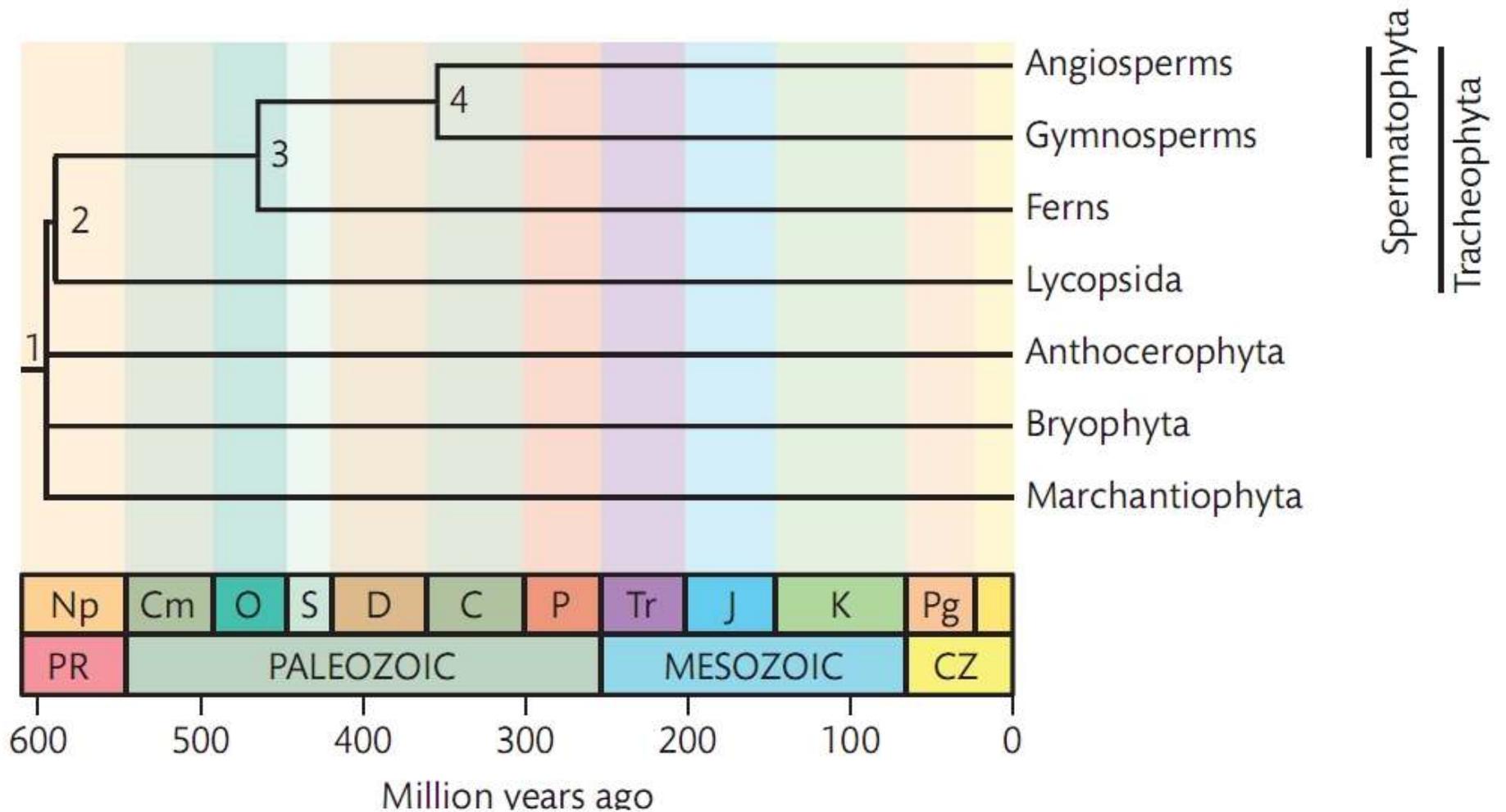
- Pigeons excluding Doves
- Insects
- Crocodiles, turtles, snakes, lizards, tuataras
- Moths
- Amphibians
- Dinosaurs

Molecular dating

For a phylogeny estimated using DNA sequence data from a gene region, the branch can be used to represent the number of *mutational differences* or *percent sequence divergence*.



- *Molecular dating* methods can estimate times of divergences (splits) between lineages based on percent sequence divergence

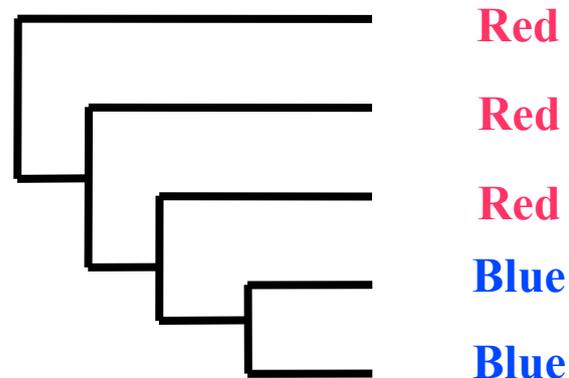


Source: Marc Srour / www.bioteaching.wordpress.com

Character evolution

- Phylogenies can often be used to infer how characters evolved

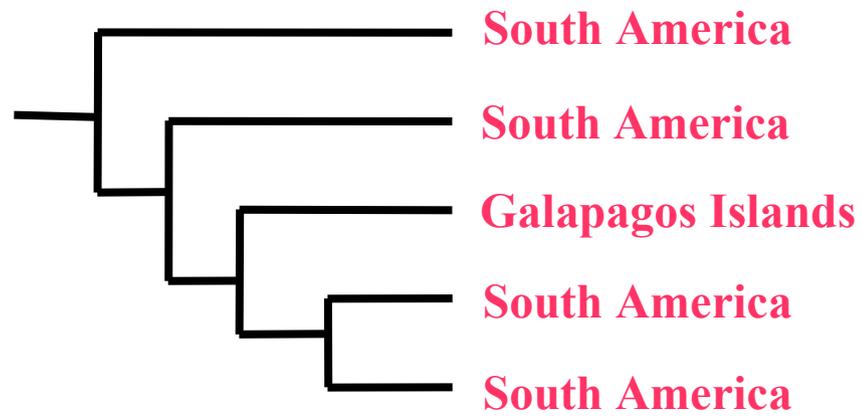
Eg. There is genus of plants which has 3 species with red flowers and 2 species with blue flowers. Did red evolve from blue or *vice-versa*?



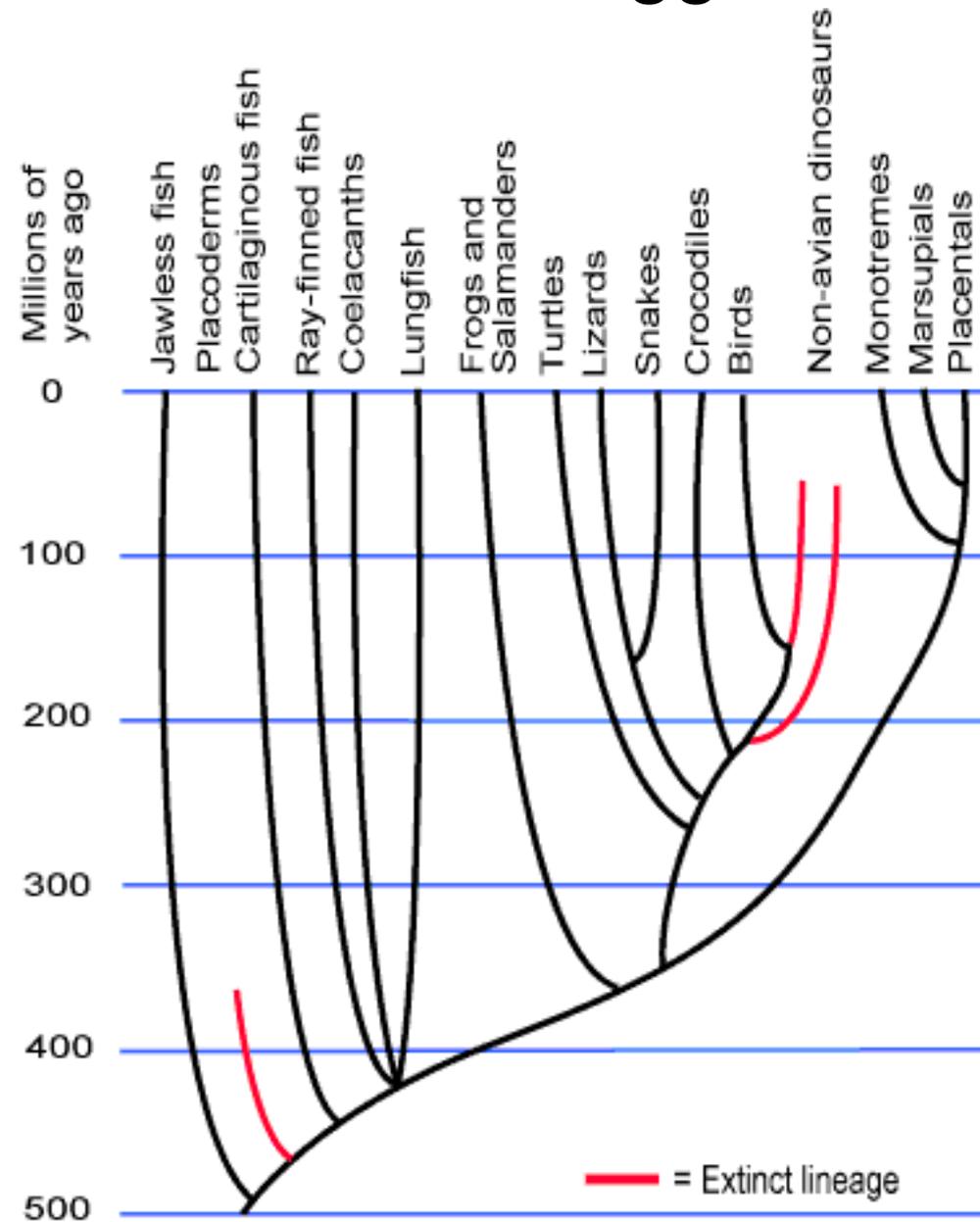
Microevolution and macroevolution on a phylogeny

- How is microevolution represented in the phylogeny?
- What microevolutionary processes could have led to evolution of blue from red?

History of colonization



What came first, the chicken or the egg?



Adapted from slides by Hema Somanathan

Evolution of HIV

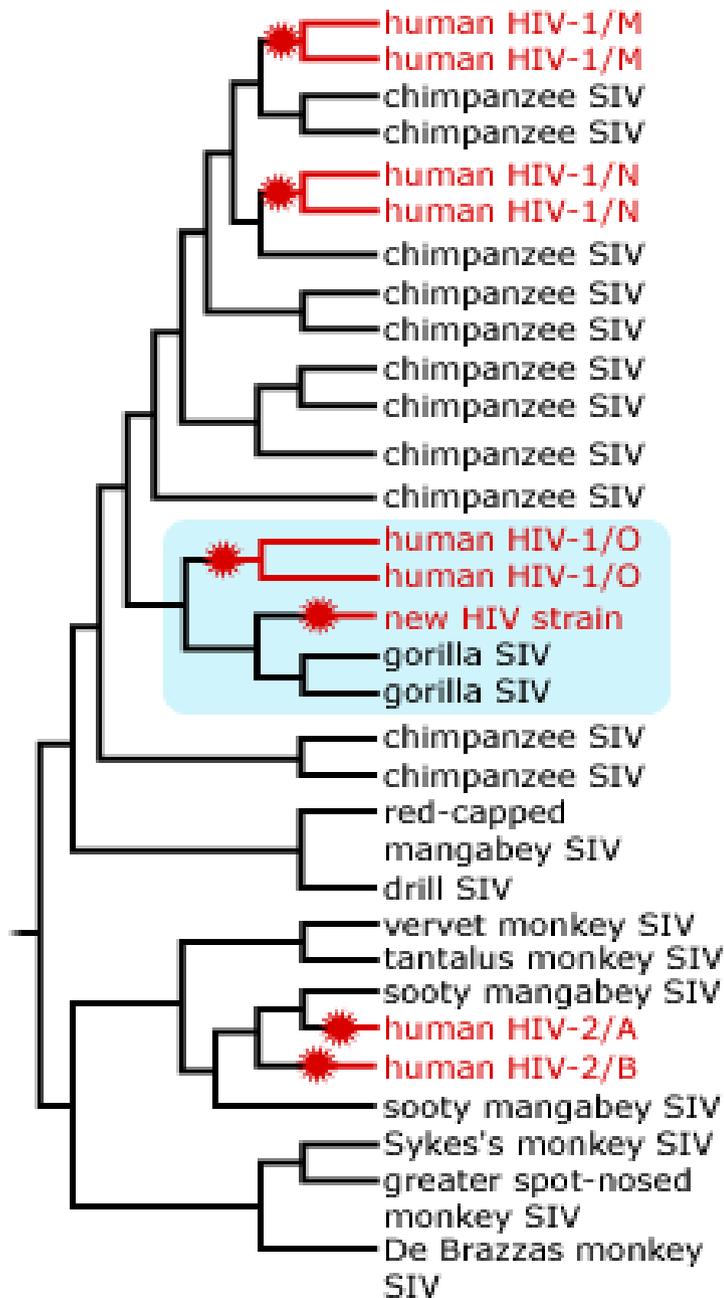
First reported in early 1980's

Earliest known infected sample from 1959

HIV 1 & HIV 2

HIV1 subtypes M, N and O. M – most virulent

- 1) When did HIV first affect humans?
- 2) Is HIV monophyletic?
- 3) Relationships among strains?



🌟 = jump from simian to human

Molecular dating estimates for M subtype

ca. 1908 (1884 – 1924)

SIV - Simian Immunodeficiency Virus