BIO 111 - Principles Of Life I: Biomolecules, Genetics And Evolution

Module: Evolutionary Biology

Part III: Phylogenetics

Varsha 2025

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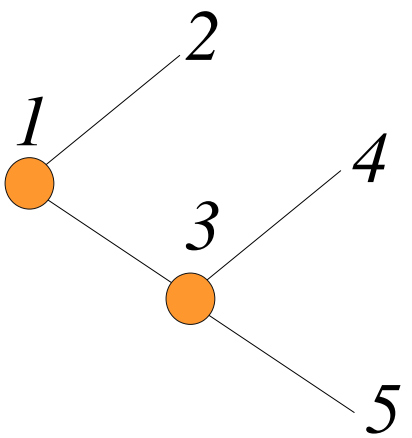
What we see today in nature is the outcome of what happened in the past

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

Speciation involves divergence

All species are potential ancestral species that can further undergo speciation

Here, *1* was an ancestral species that underwent speciation to give rise to *2* & *3* (in other words, *2* & *3* diverged from *1*). 3 eventually underwent speciation to give rise to *4* & *5*. The orange circles indicate the speciation/divergence events.



Today, we see only the three *extant* species (2, *4* & 5)

Although speciation is sometimes referred to as an 'event', this is an evolutionary process involving many generations

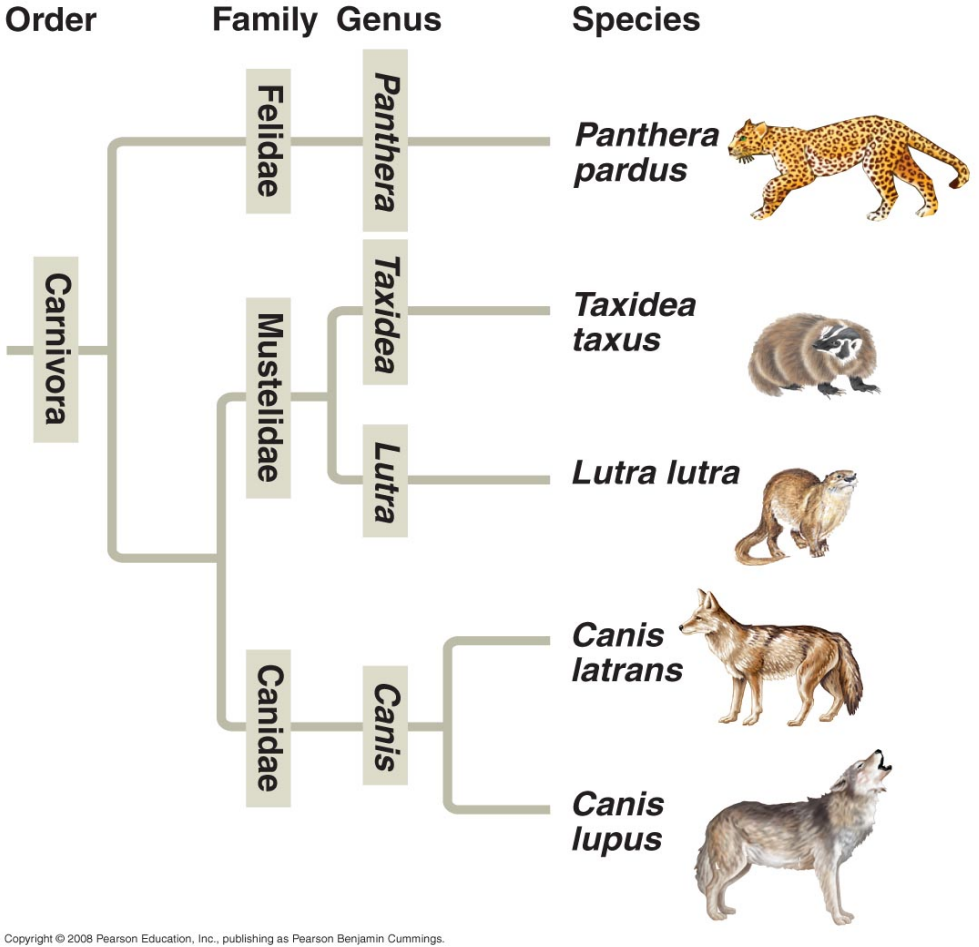
Phylogeny

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

Phylogenies are also called cladograms

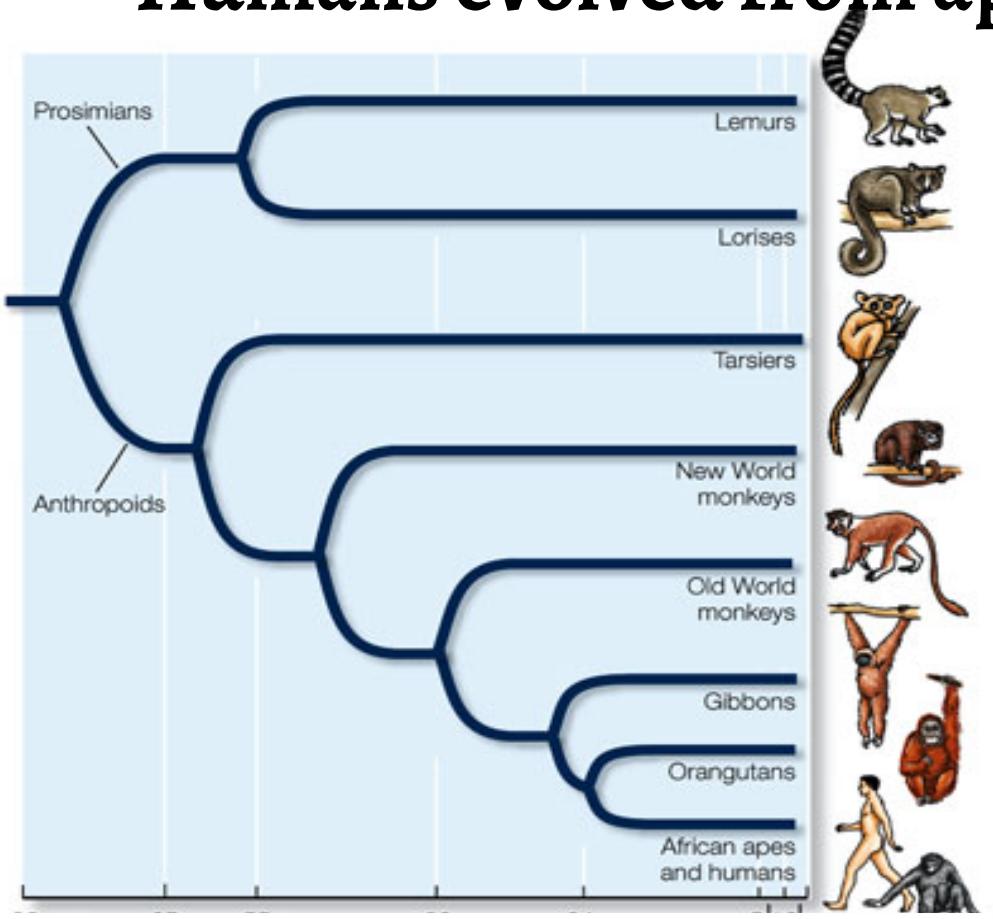
A species-level phylogeny need not include all species

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



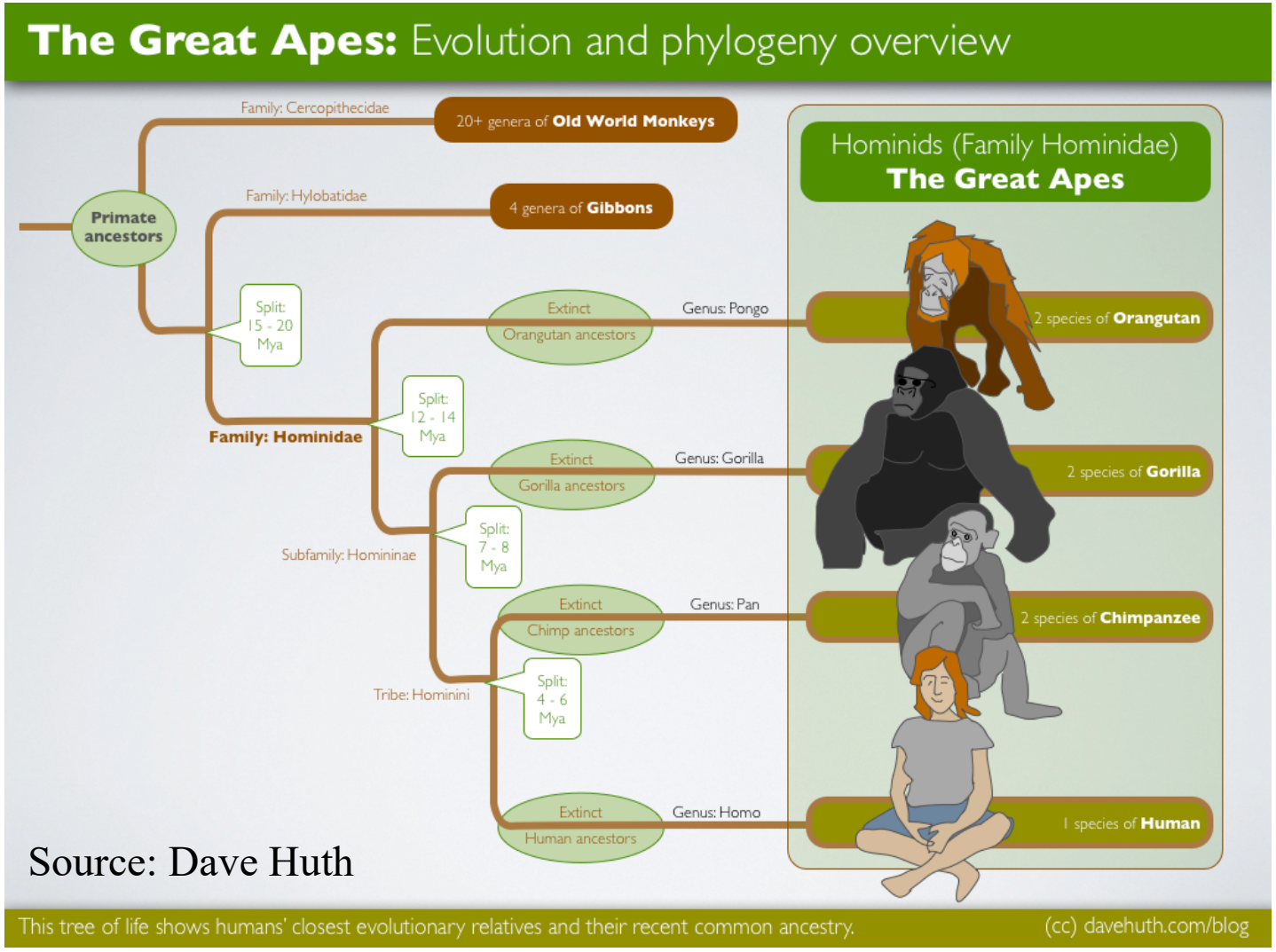
Source: Pearson Scientific Inc

Humans evolved from apes



LIFE 8e, Figure 33.27

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



Humans evolved from apes

- Phylogenies can tell us about relationships
- E.g.,Which mammals are the closest relatives of whales?

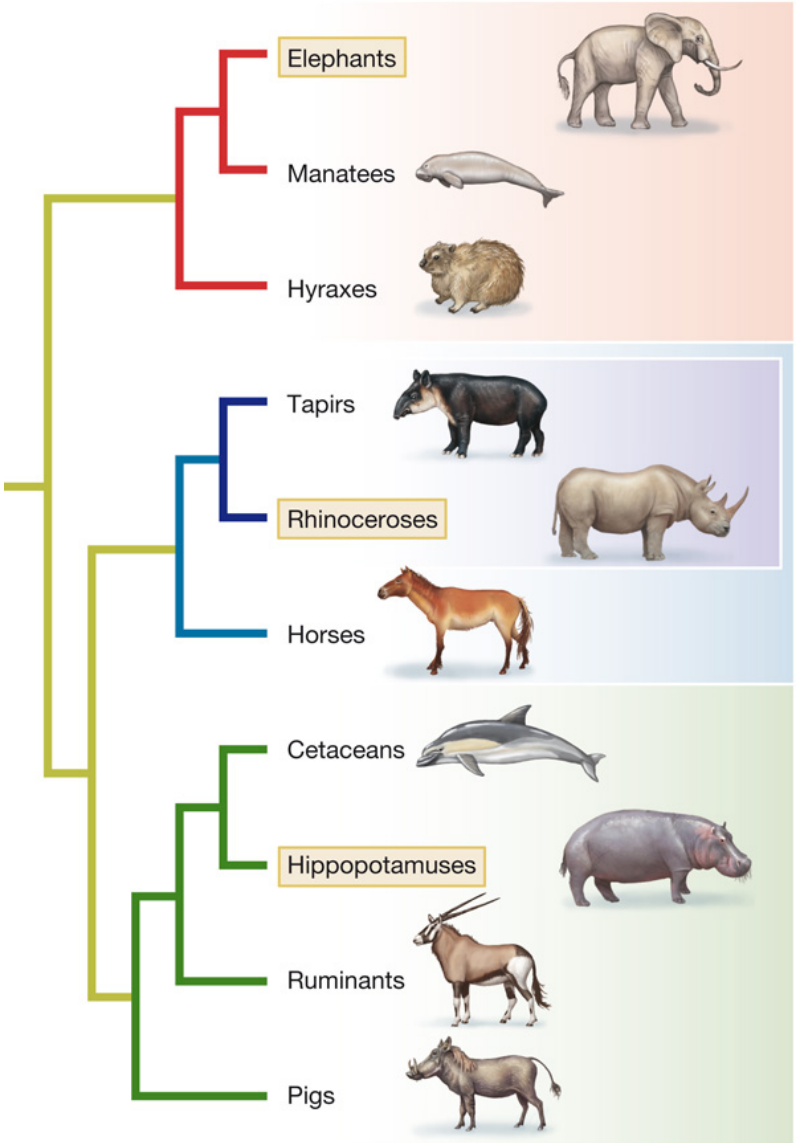
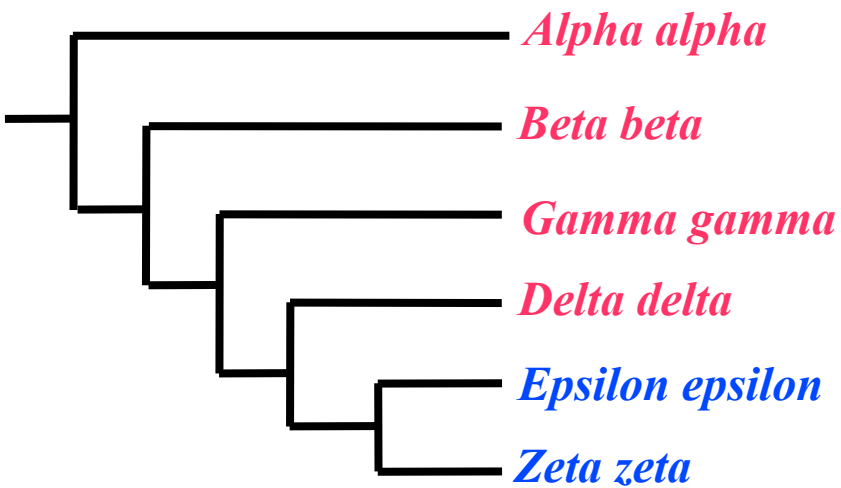


Fig: from www.bartleby.com

Phylogenies can also be used to infer how characters/traits evolved

E.g. There is genus of plants which has 6 species with red flowers and 2 species with blue flowers. Did red evolve from blue or *vice-versa*?

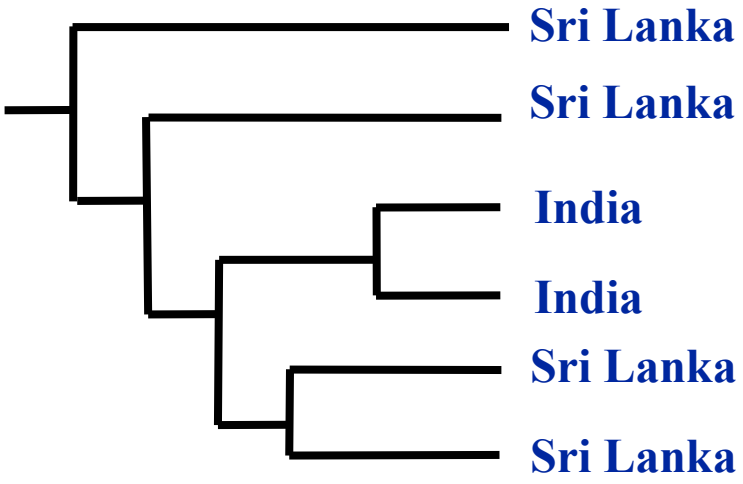


Reflection point

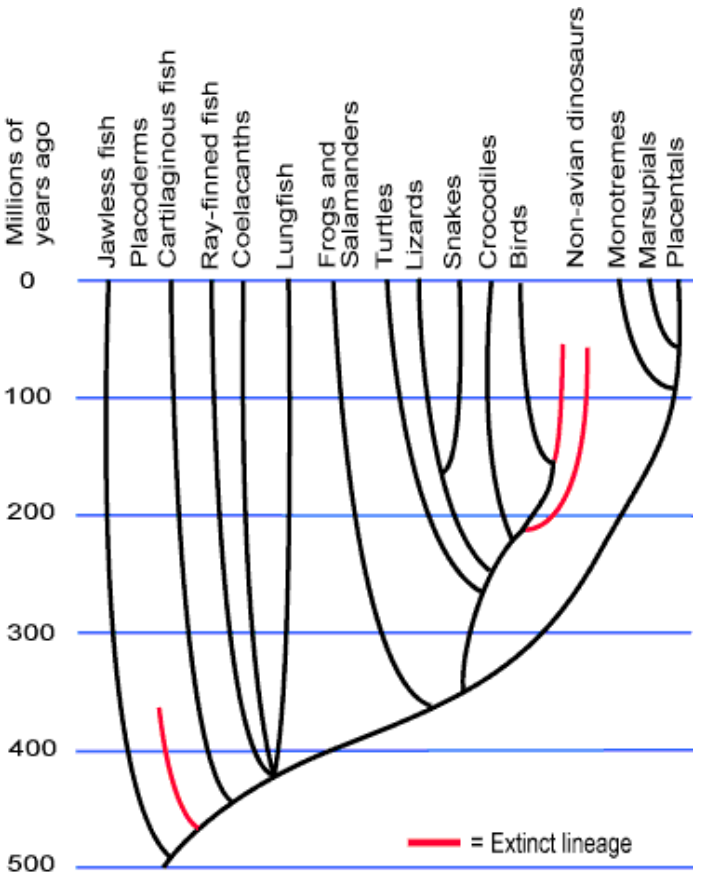
- What evolutionary processes could have led to the ‘evolution of blue flowers from red flowers’. Relate this to selection and change in allele frequencies at the level of populations

Reflection point

Was Sri Lanka colonized from India or was India colonized from Sri Lanka?



What came first, the chicken or the egg?



Adapted from slides by Hema Somanathan

How do we reconstruct the phylogeny of a group?

We can assume that a species is more similar to a closely related species than to a distantly related species

- Lion
- Tiger
- Mouse
- Beetle
- Mango

Try to reconstruct the phylogeny of these species

In practice, reconstructing phylogenies based on similarity is not easy

Data is from a large number of characters are compiled for all species of interest, and analyze using mathematical models.

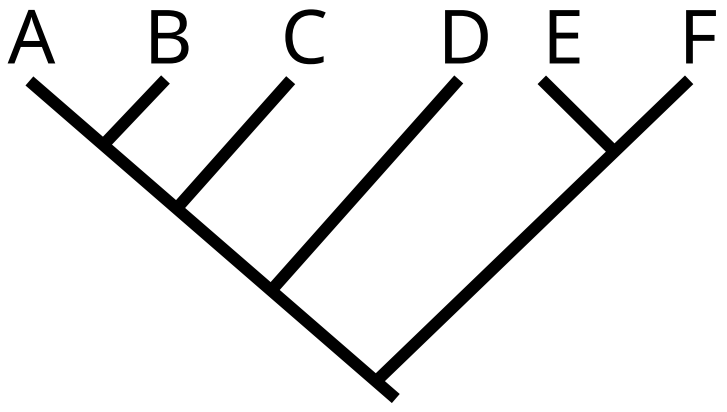
Data can be morphological or molecular

The most popular data are DNA sequence data

Tree Terminology

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

non-monophyletic

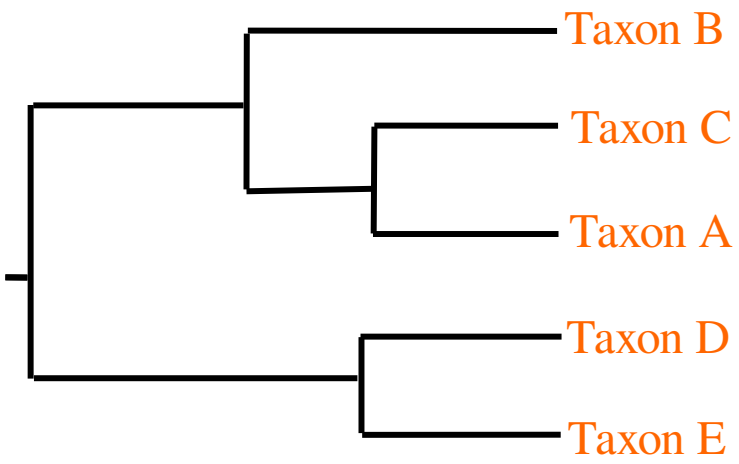


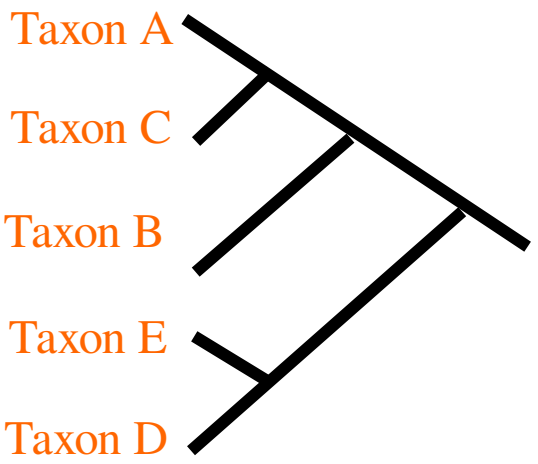
Monophyletic group - AB, ABCD

Non-monophyletic group – ABD, DEF, ABCDE

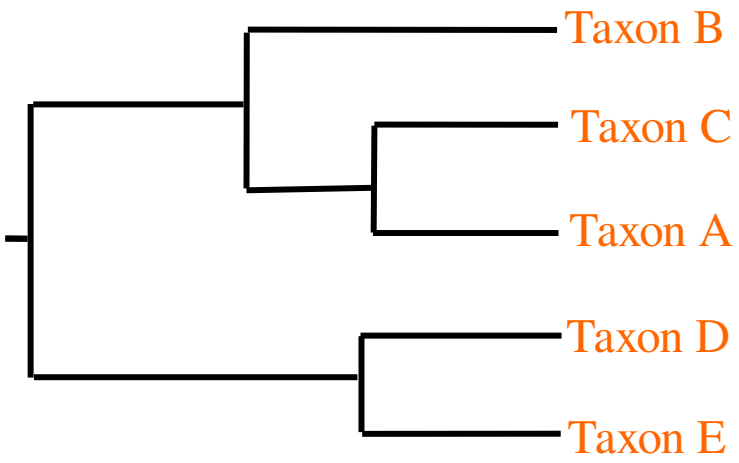
Tree can be flipped at nodes

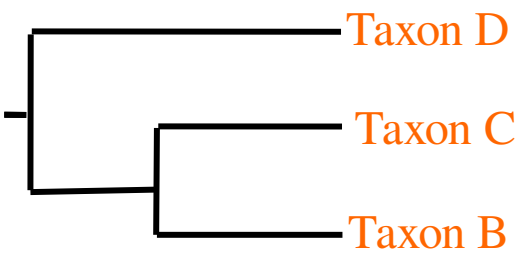
Can be depicted in different ways: rectangular, slanted, etc



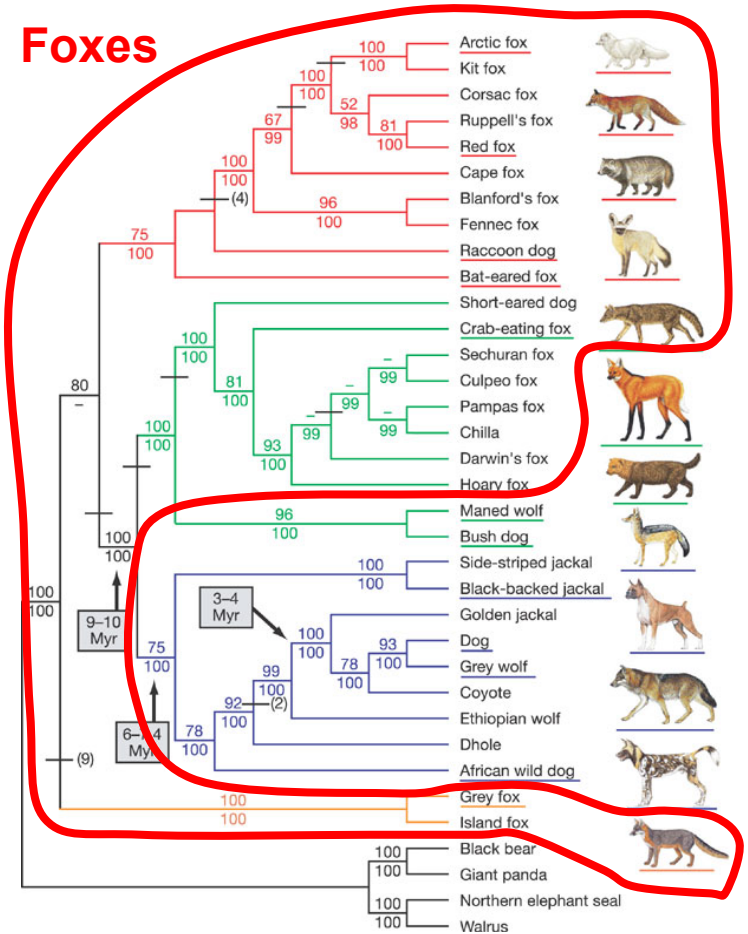


Tree need not represent all species. What matters is the set of relationships among the species represented in the phylogeny. E.g., there is no incongruence in relationships depicted in the phylogenies below





Non-monophyletic groups

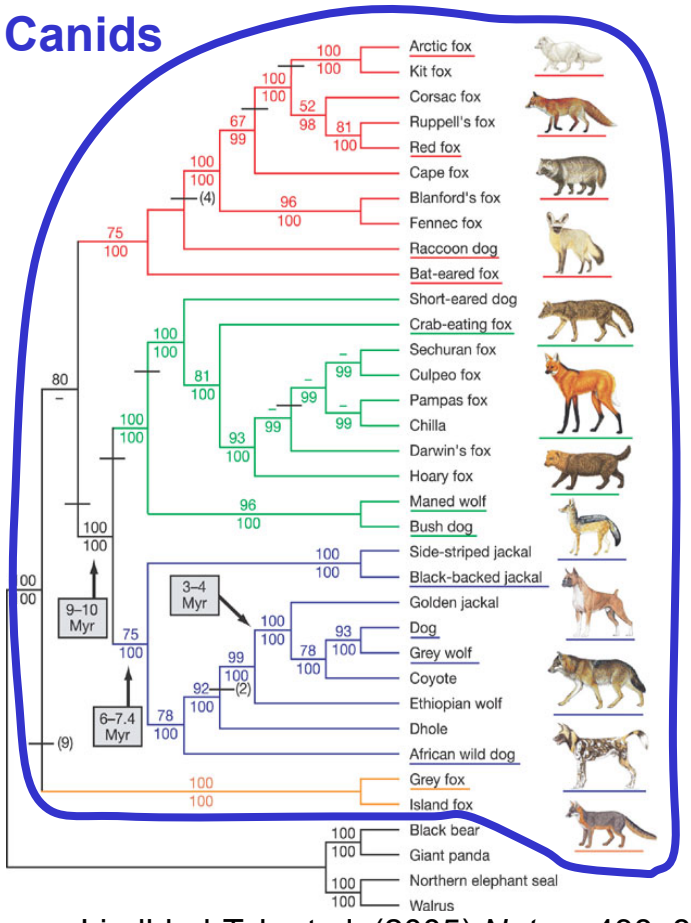


Lindblad-Toh et al. (2005) *Nature* 438: 803-819
(slide taken from Robert Cox, www.dartmouth.edu)

"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



Lindblad-Toh et al. (2005) *Nature* 438: 803-819
(slide taken from Robert Cox, www.dartmouth.edu)

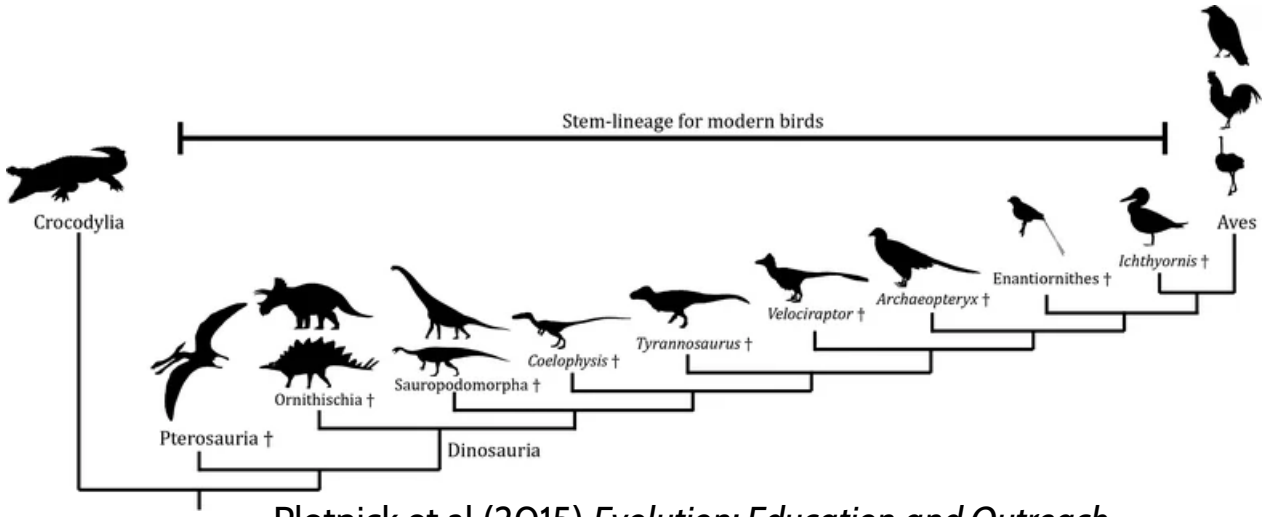
Canids are a monophyletic group within Mammalia

Each colored lineage within canids is also a clade

Excercise

Are these monophyletic groups?

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

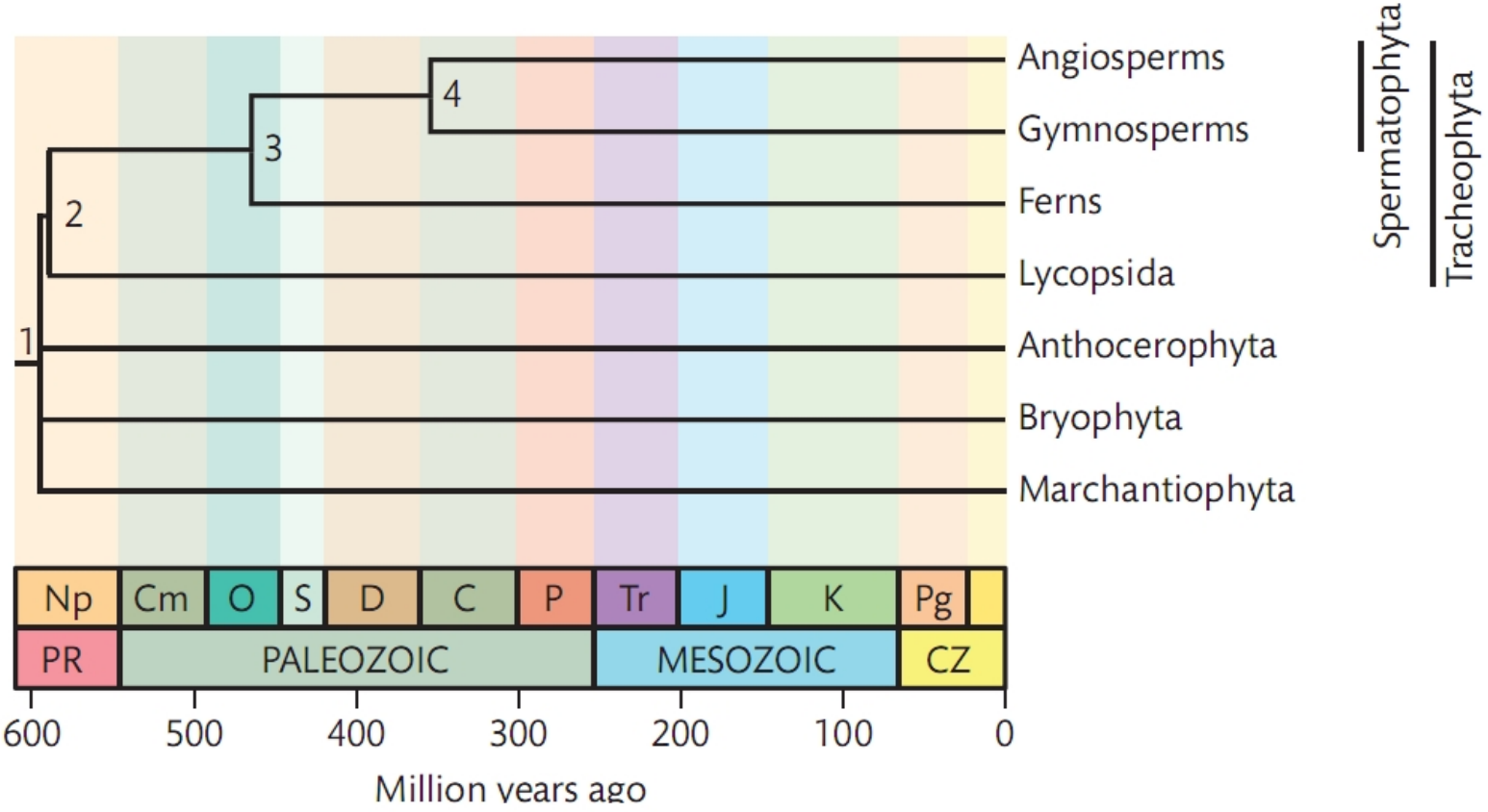


Plotnick et al (2015) *Evolution: Education and Outreach*

Molecular dating

For a phylogeny estimated using DNA sequence data from a gene region, it is also possible to estimate divergence times for the nodes, i.e., date the nodes.

Molecular dating analyses result in **dated phylogenies** where branch lengths are proportional to time



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

Evolution of HIV

First reported in early 1980's

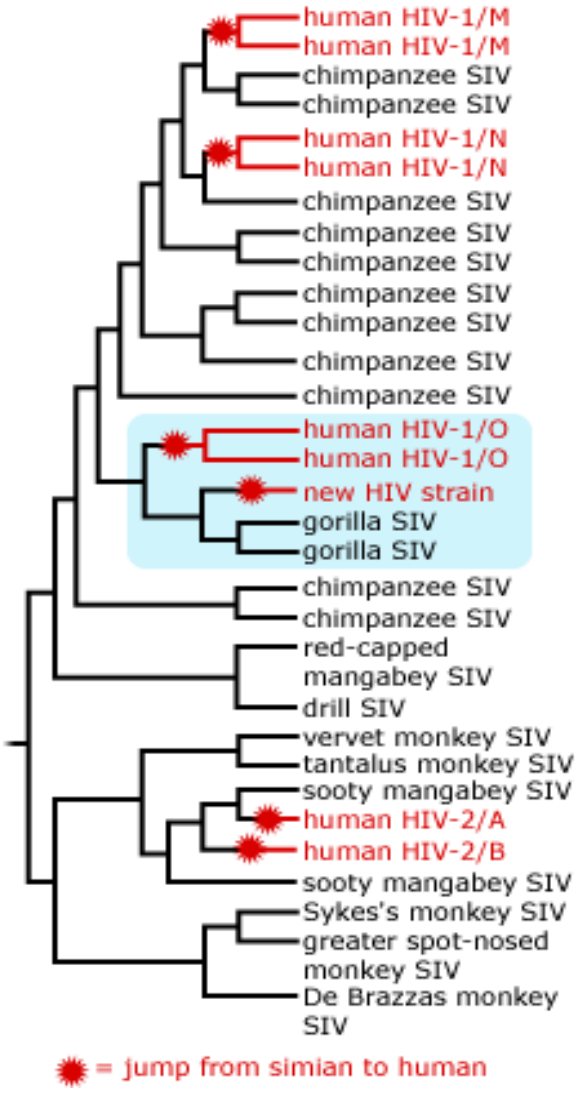
Earliest known infected sample from 1959

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?

Source www.evolution.berkeley.edu



Molecular dating estimates for M subtype

ca. 1908 (1884 – 1924)

SIV - Simian Immunodeficiency Virus

Source www.evolution.berkeley.edu