

MODULE: PRINCIPLES OF EVOLUTIONARY BIOLOGY

Part III – PHYLOGENETICS

BIO 111 Ecology and Evolution

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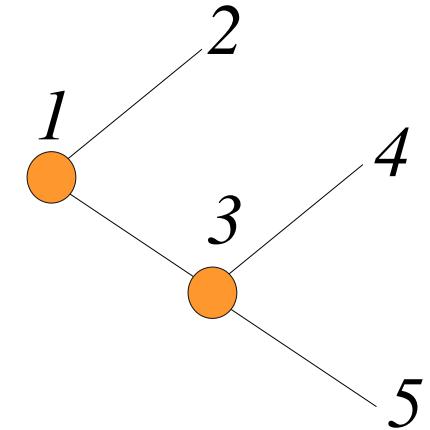
What we see today in nature is the outcome of what happened in the past

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

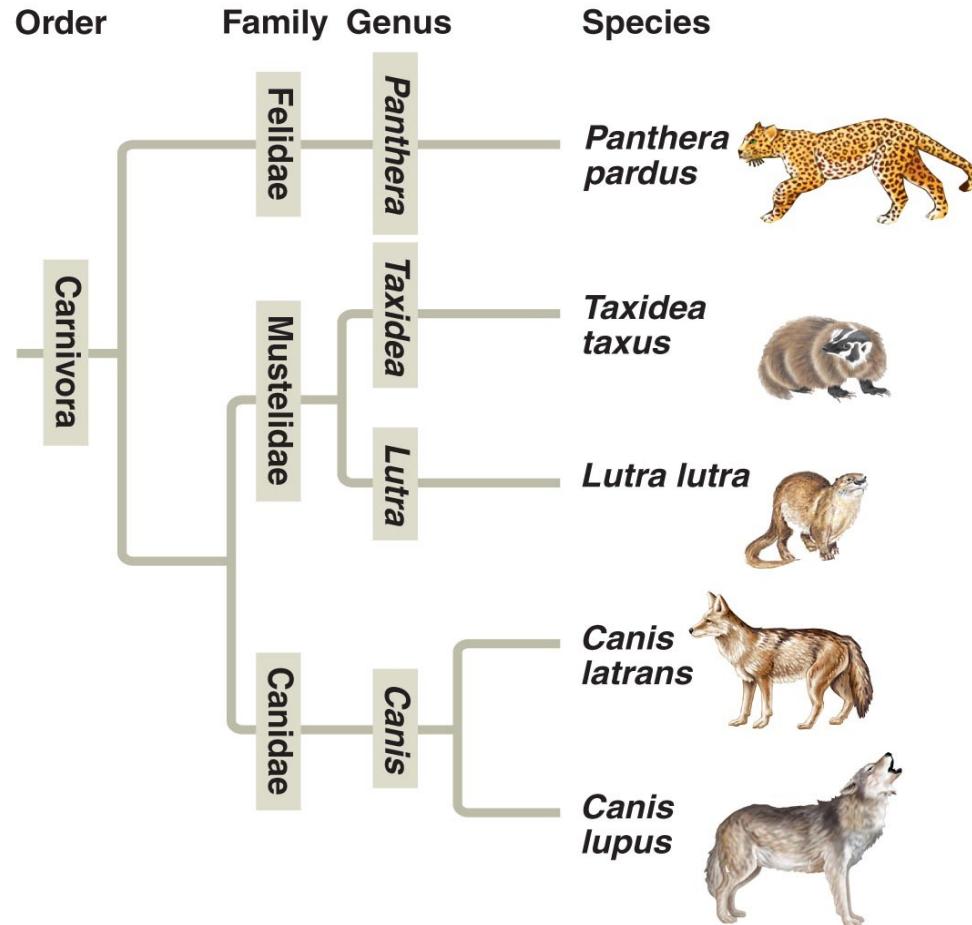
Phylogeny

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

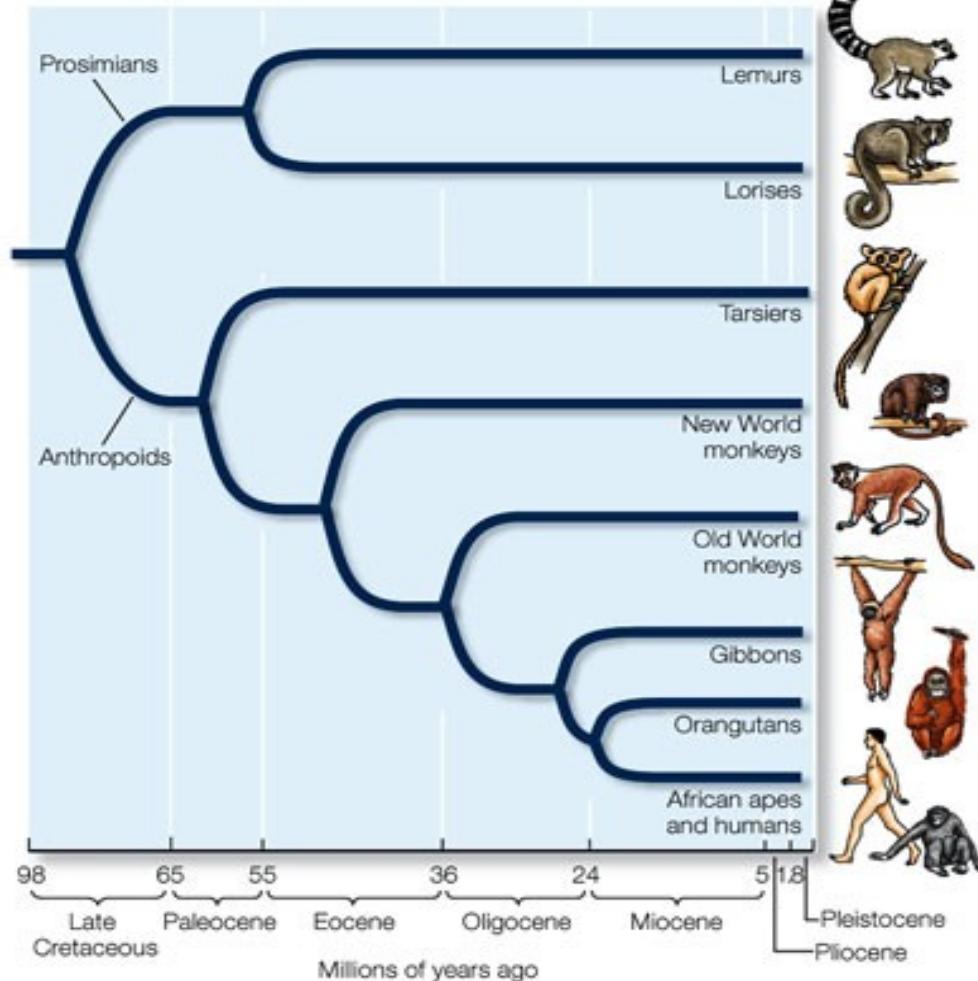
A phylogeny can also represent relationships among lineages other than species, e.g. families, individuals within a species



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Source: Pearson Scientific Inc

Humans evolved from apes



LIFE 8e, Figure 33.27



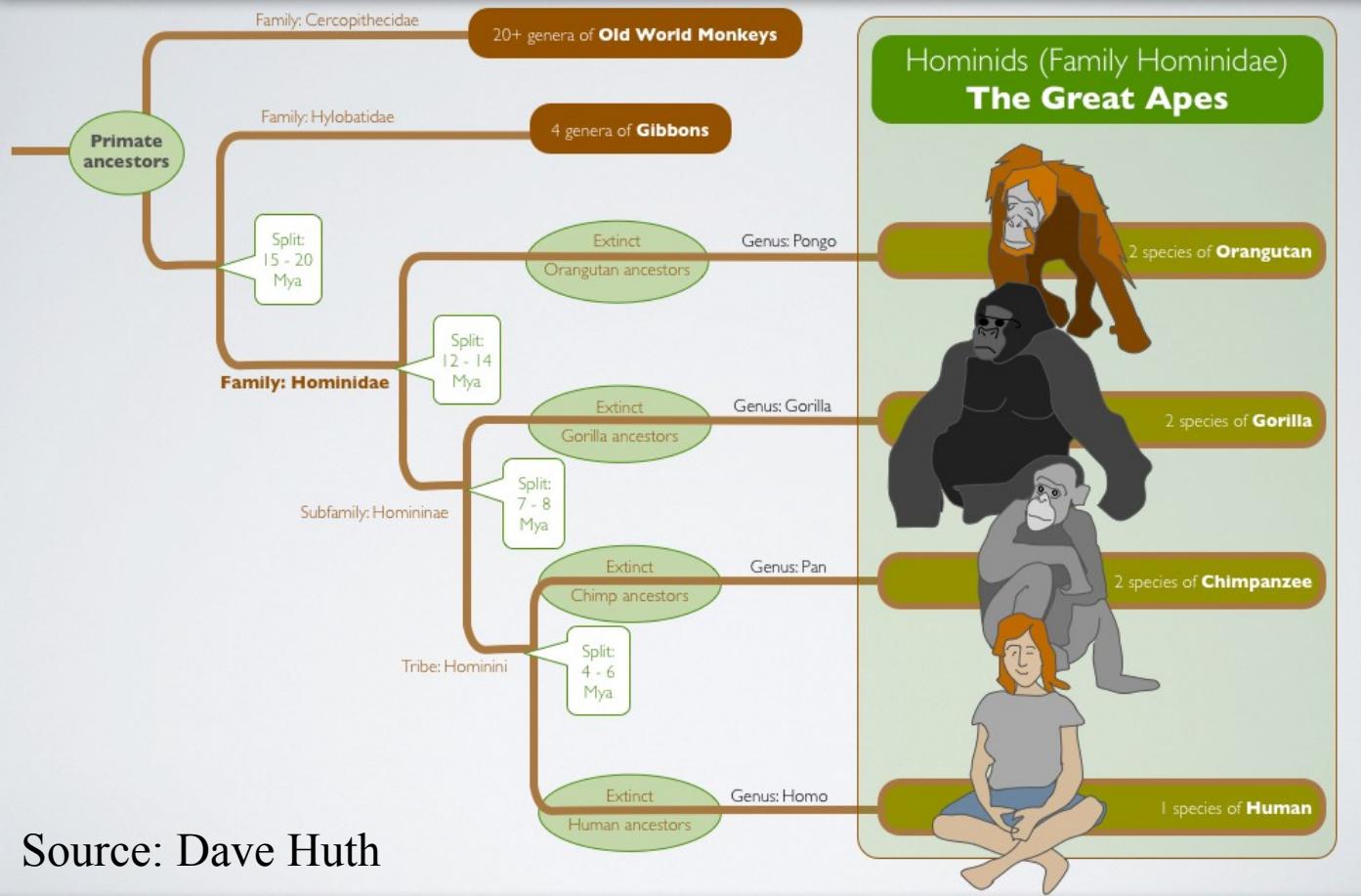
Old World monkeys



New World Monkeys

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

The Great Apes: Evolution and phylogeny overview



Humans
evolved
from apes

Tree of Life project: www.tolweb.org

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TREE OF LIFE web project

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News

Darwin 200: the celebration continues... [read more](#)

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

Explore the Tree of Life

Learn about ...

Agaricales
(a group of fungi)

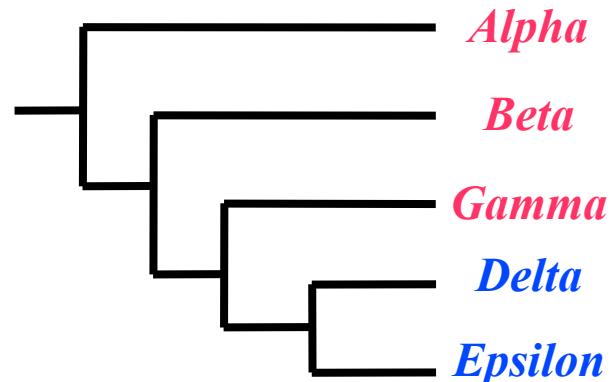
[image info](#)

The Agaricales, or euagarics clade, is a monophyletic group of approximately 8500 mushroom species... [read more](#)

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Phylogenies can be used to infer how characters/traits evolved

E.g. 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*?

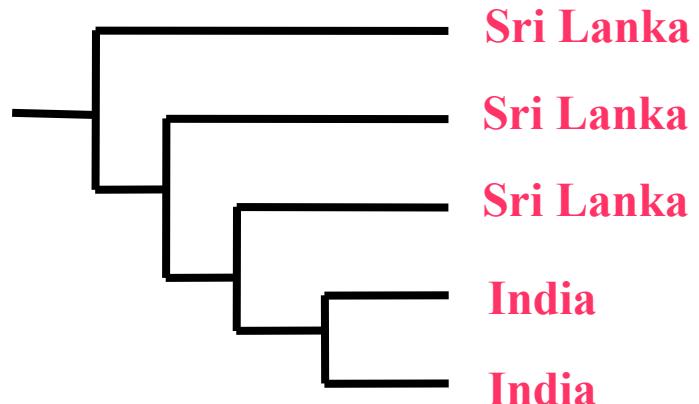


Reflection point

- 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?



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 problematic, and therefore, other methods are used

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.

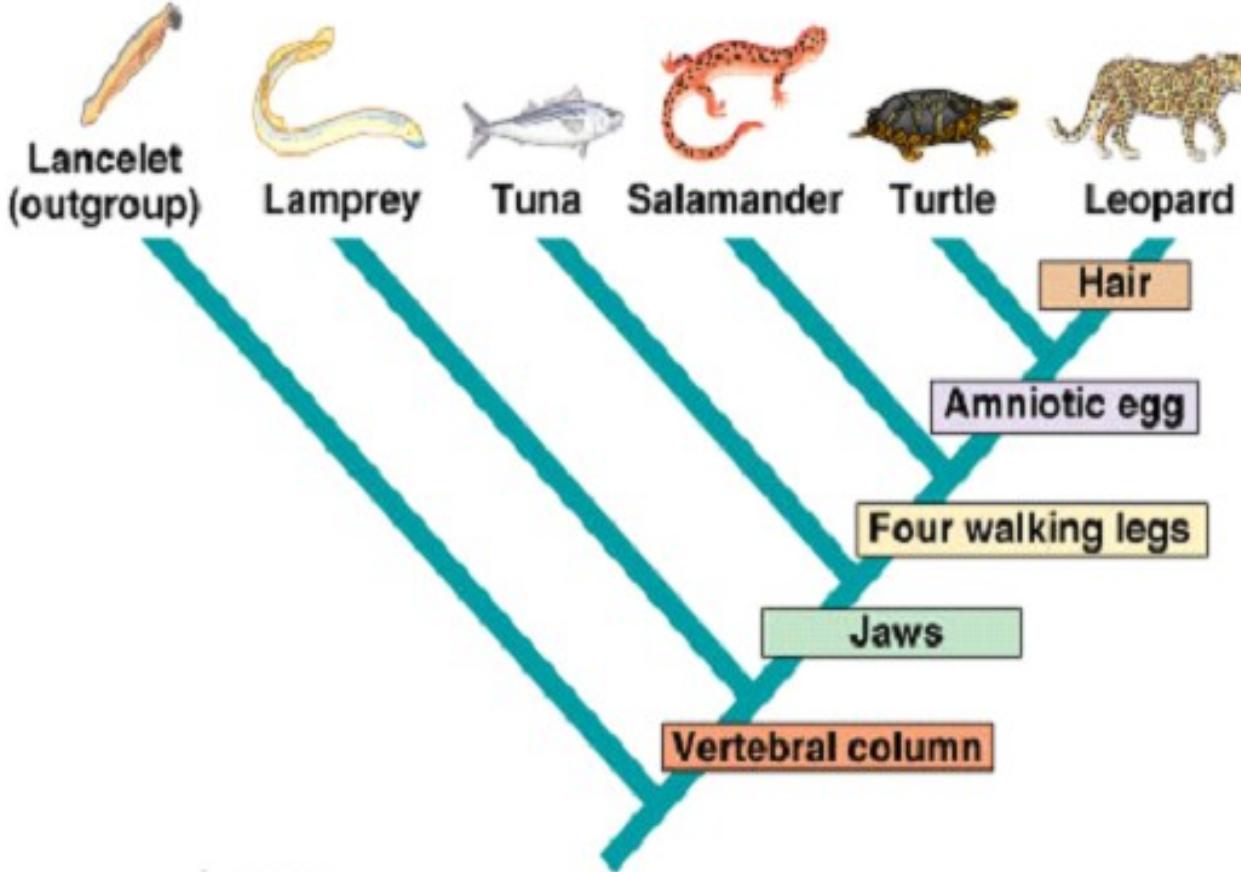
CHARACTERS

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



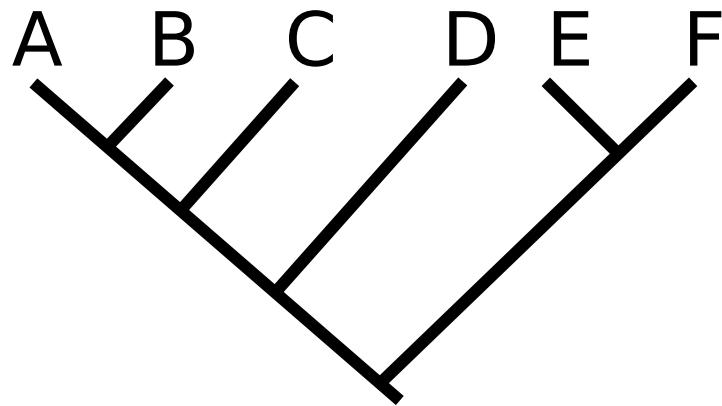
- Morphological data
- Molecular data: Most commonly – DNA sequences (molecular phylogenetics).

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

Tree Terminology

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

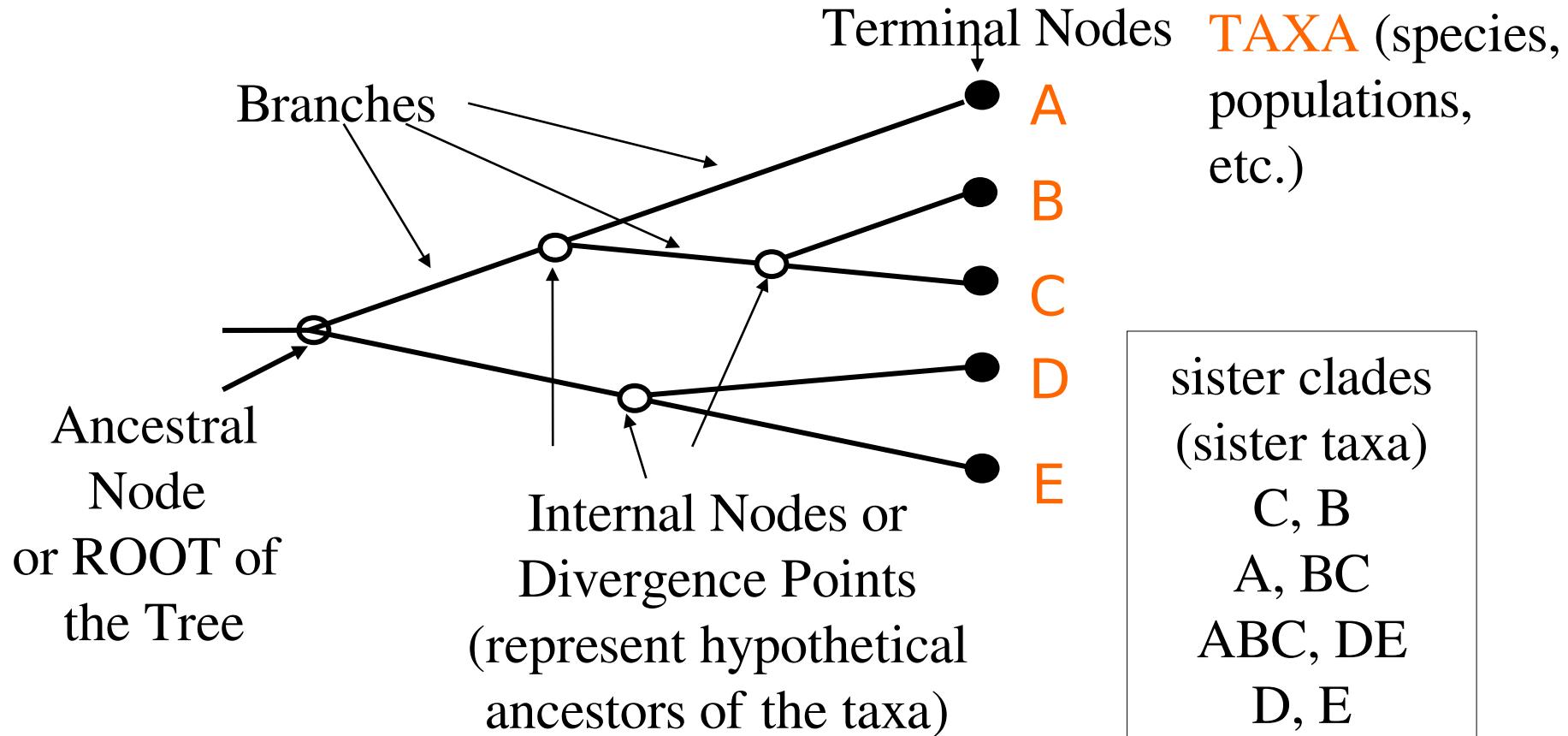
non-monophyletic



Monophyletic group - AB, ABCD

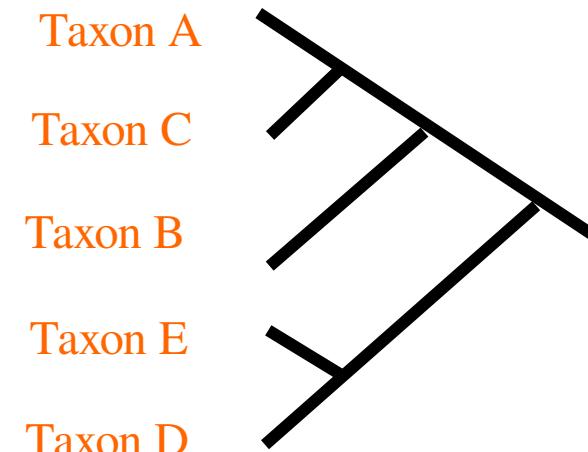
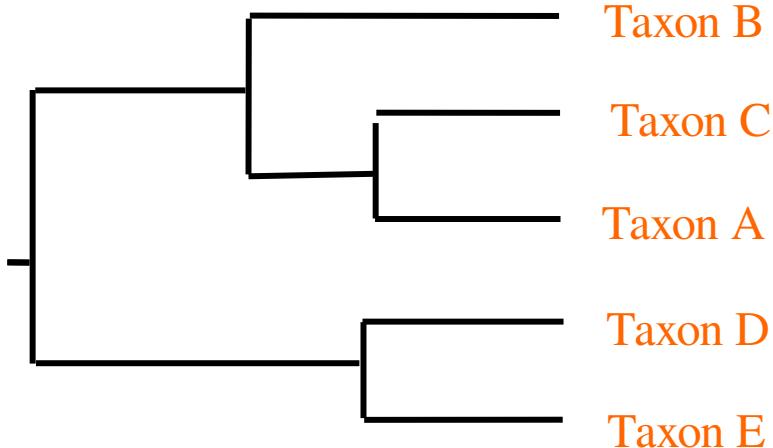
Non-monophyletic group – ABD, DEF, ABCDE

Tree Terminology



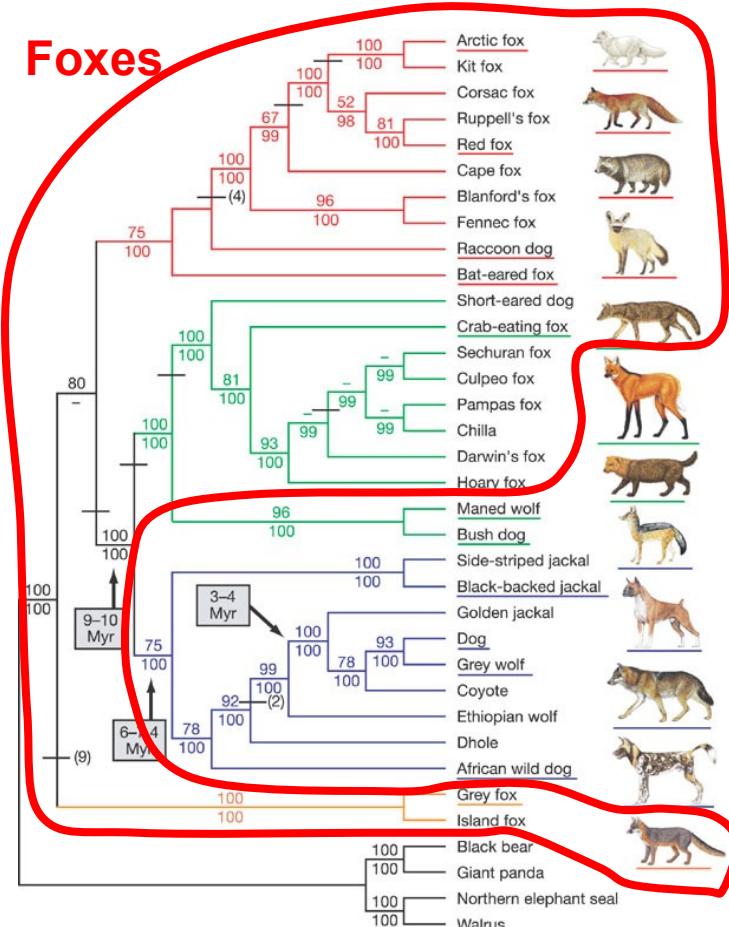
Tree can be flipped at nodes

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



Non-monophyletic groups

Foxes



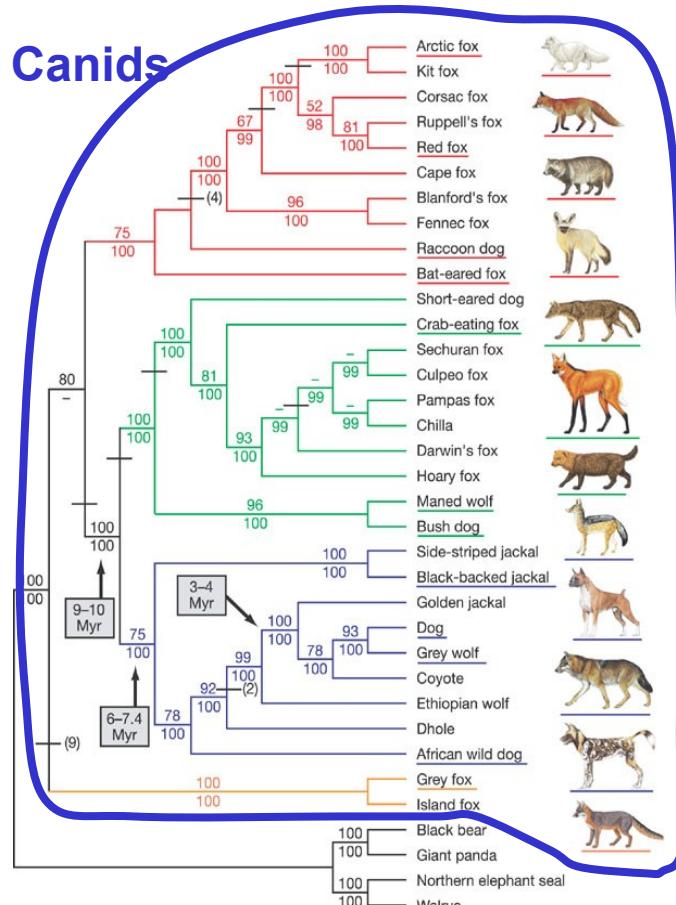
“Foxes” are **not monophyletic** with respect to dogs, wolves, jackals, coyotes, etc

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

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

Monophyletic groups

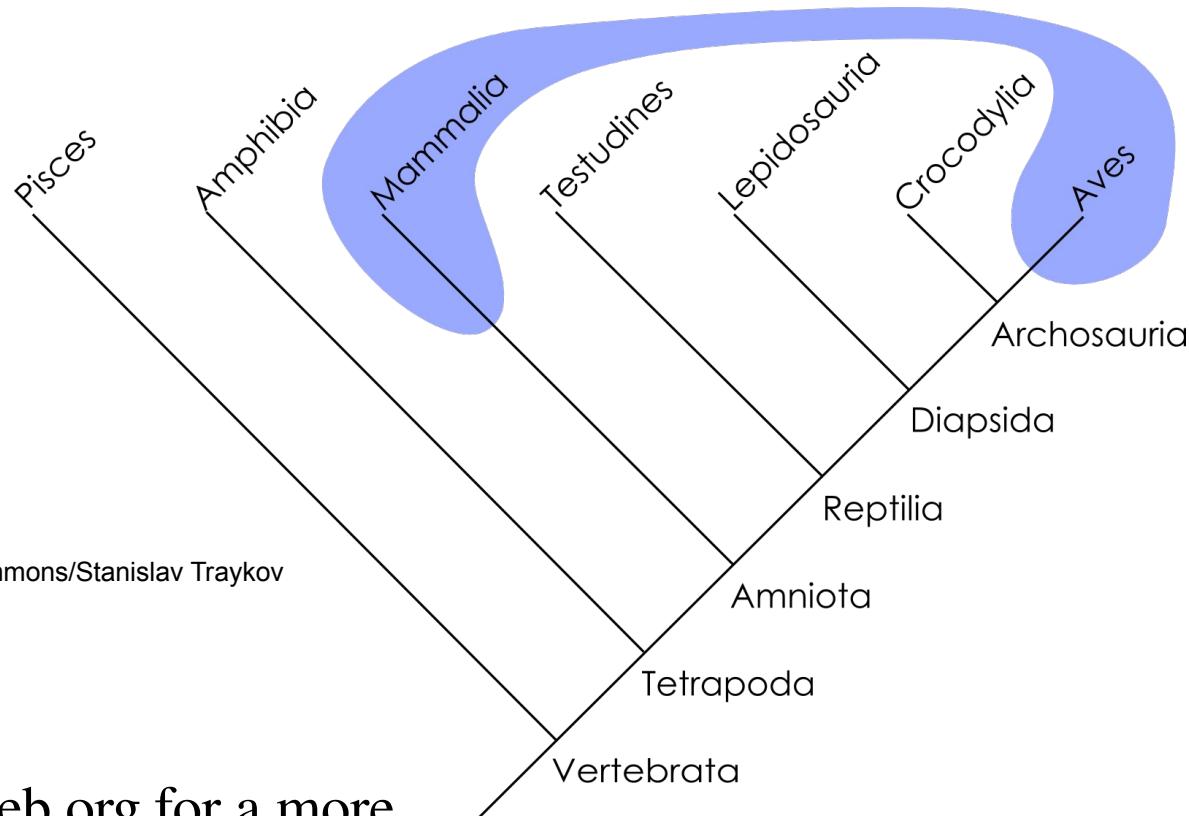
Canids



Canids are a **monophyletic** group within Mammalia

Each colored lineage within canids is also a clade

Are warm blooded animals a monophyletic group?



Source: Wikimedia commons/Stanislav Traykov

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

Reflection point

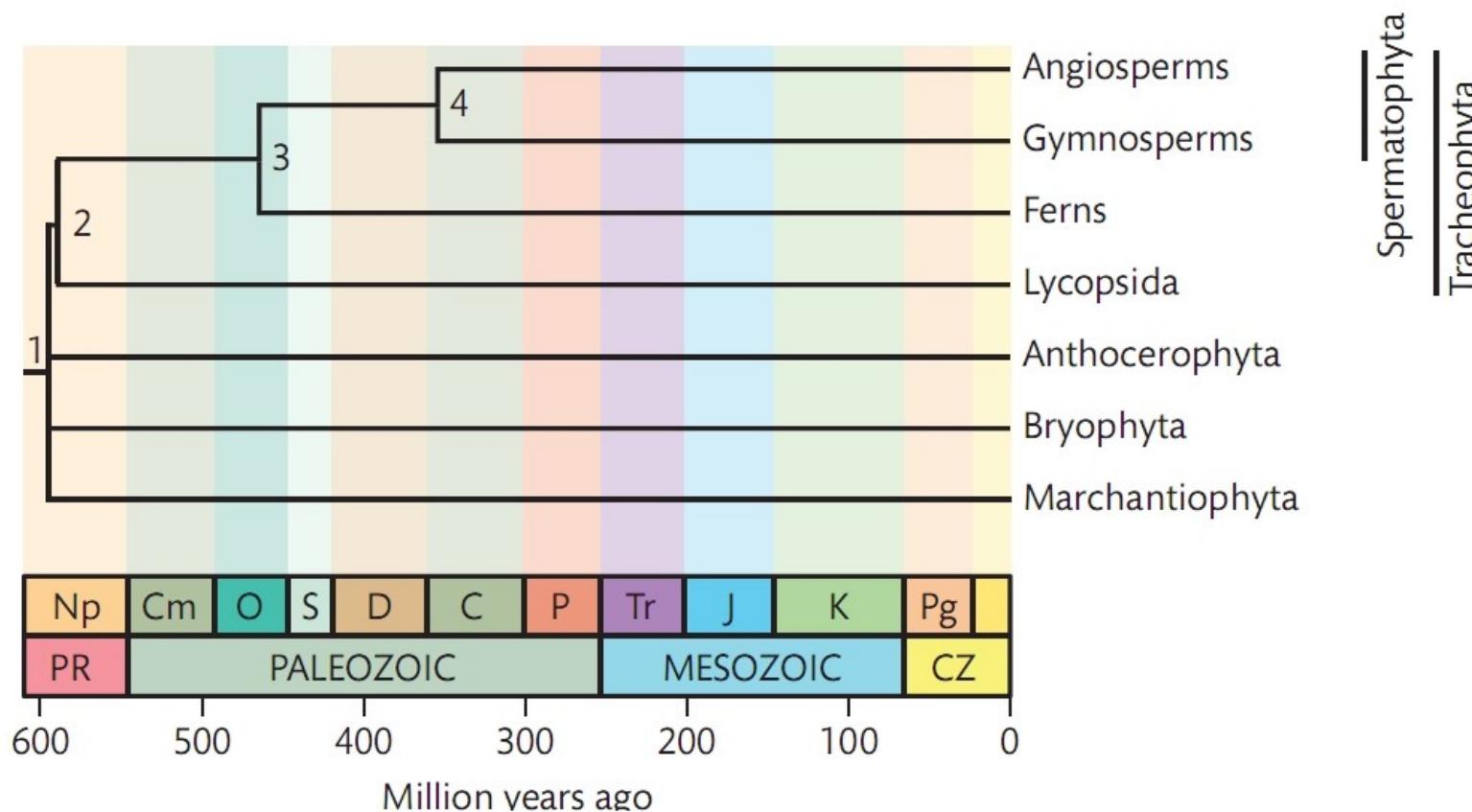
Are these monophyletic groups?

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

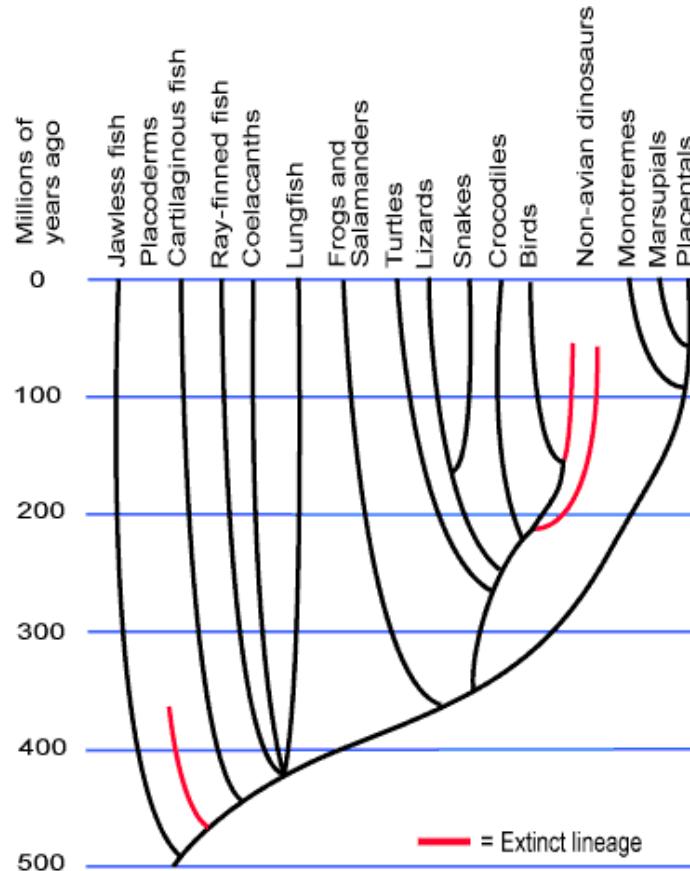
Molecular dating

For a phylogeny estimated using DNA sequence data from a gene region, 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



What came first, the chicken or the egg?



Adapted from slides by Hema Somanathan

Evolution of HIV

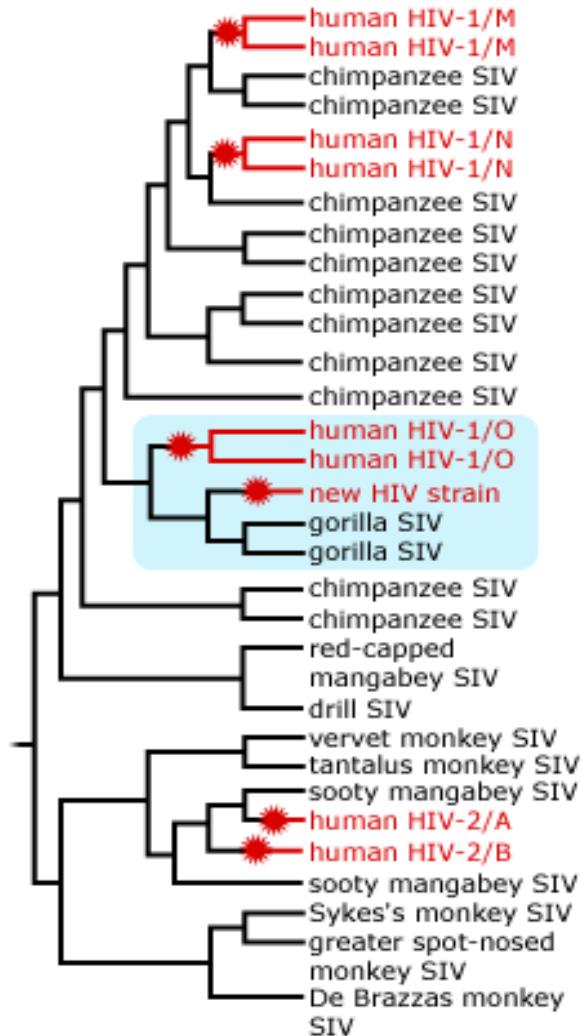
First reported in early 1980's

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