

BIO 111 - Principles of Life I: Biomolecules, Genetics and Evolution

(Varsha 2023)

MODULE: EVOLUTIONARY BIOLOGY

Part III – PHYLOGENETICS

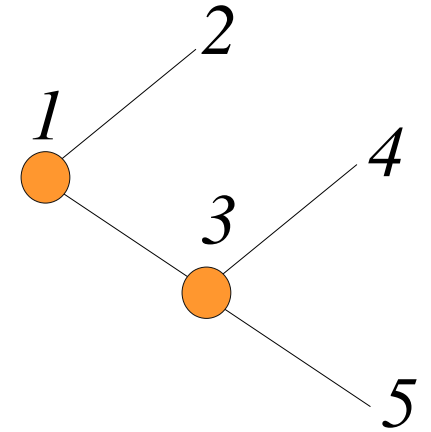
What we see today in nature is the outcome of what happened in the past

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

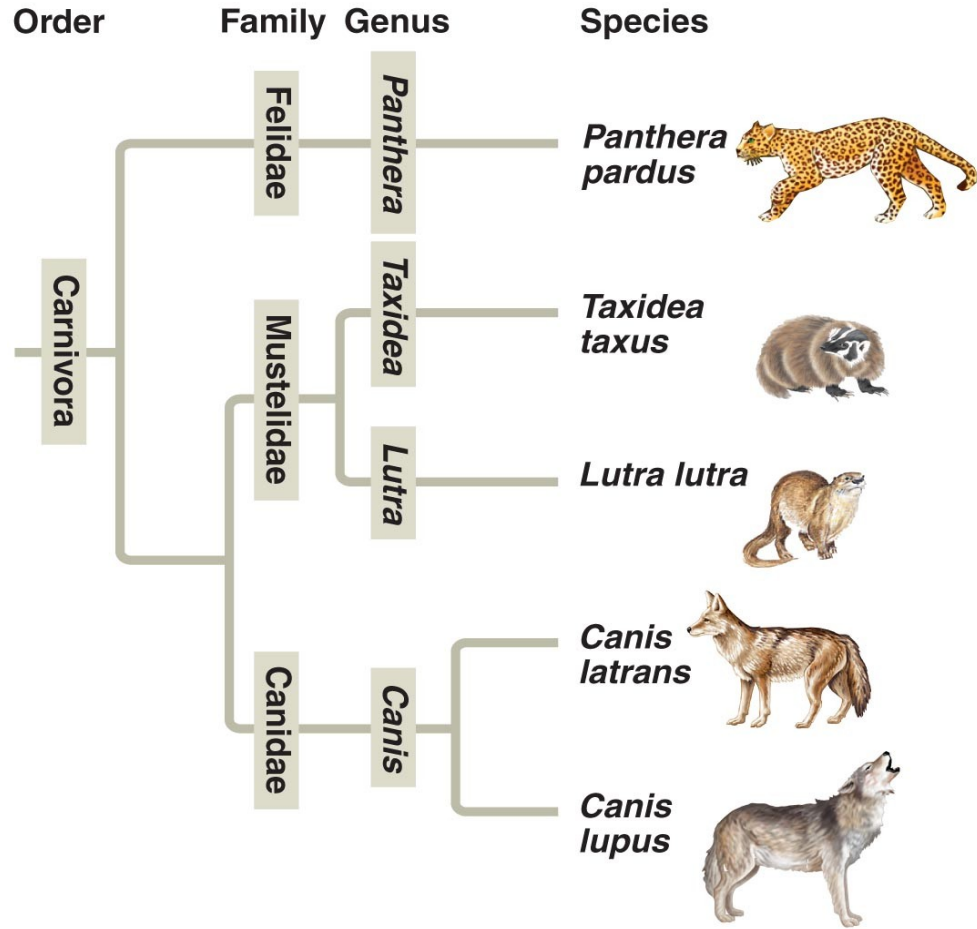
Phylogeny

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

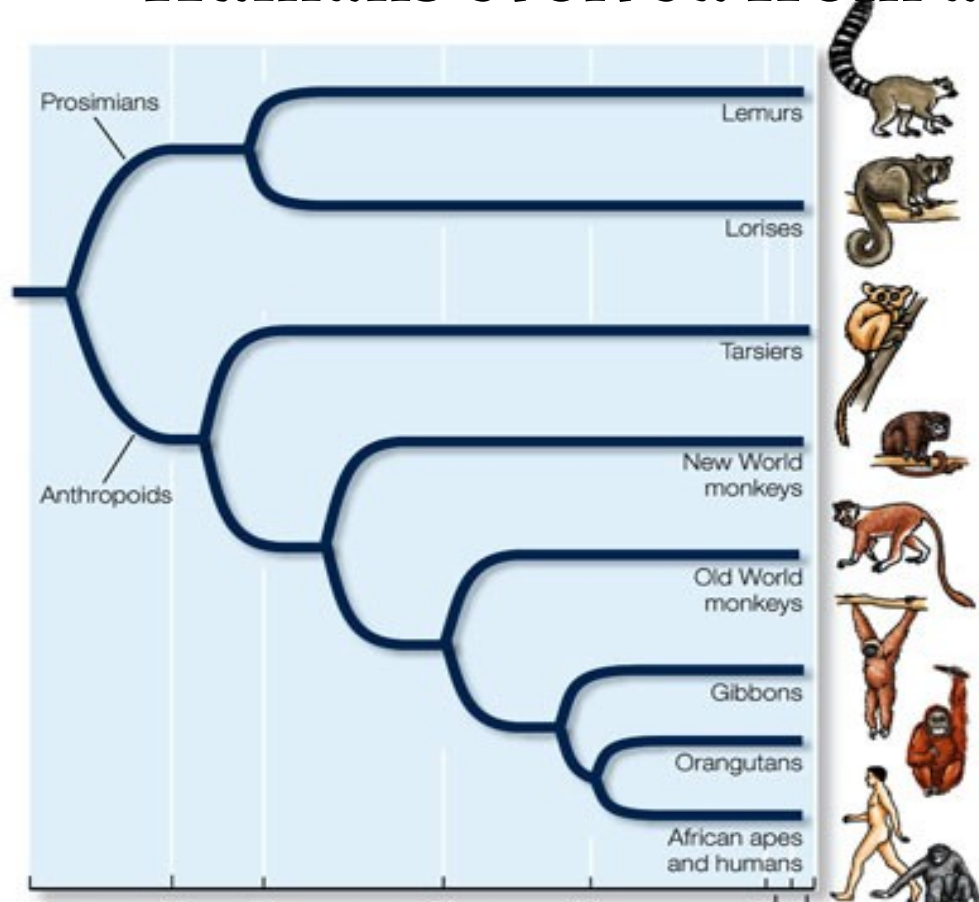
A phylogeny can also represent relationships among lineages other than species, e.g. families, individuals within a species



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Source: Pearson Scientific Inc

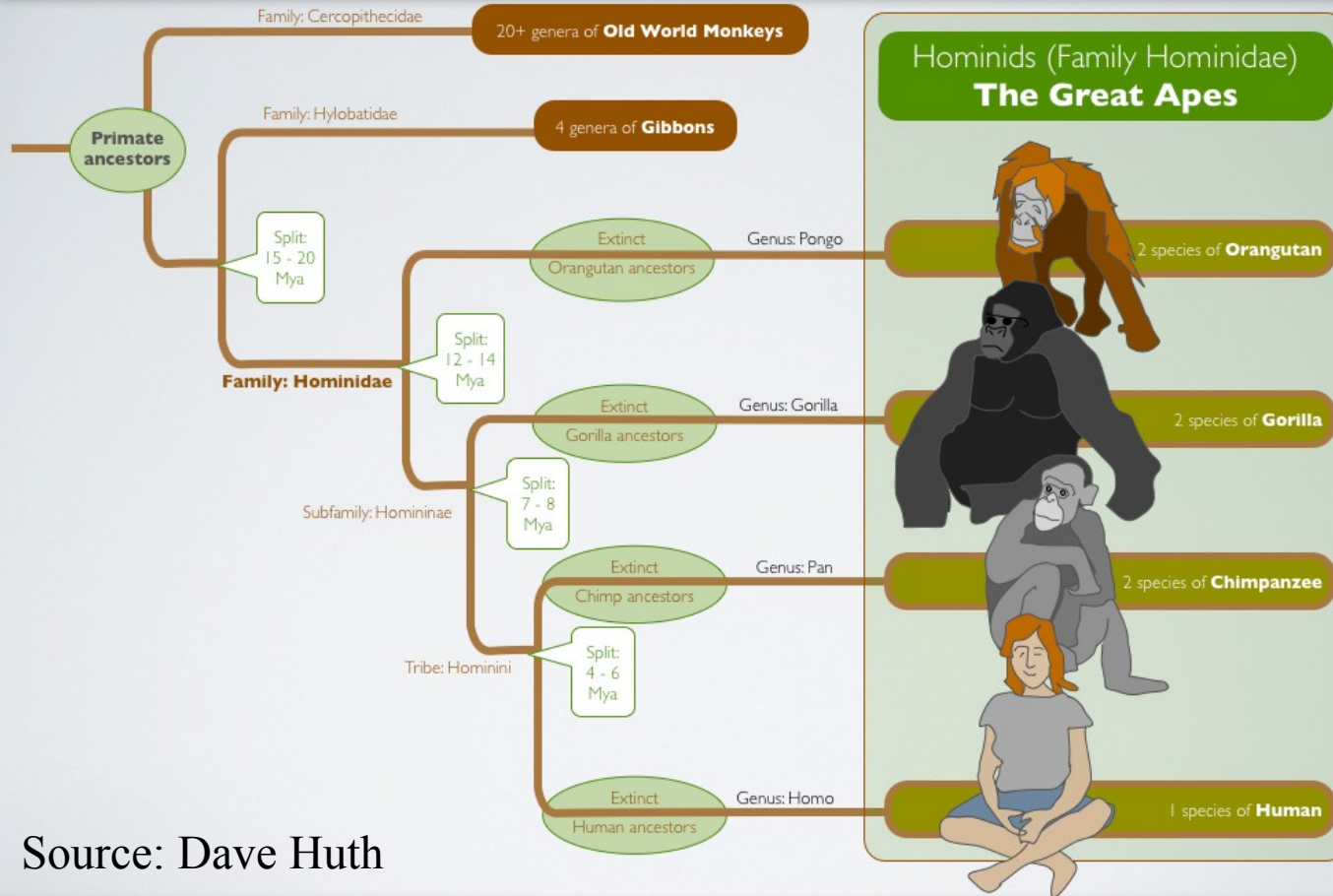
Humans evolved from apes





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

The Great Apes: Evolution and phylogeny overview



Humans evolved from apes

Source: Dave Huth

Tree of Life project: www.tolweb.org

The screenshot shows the homepage of the Tree of Life web project. At the top, there is a navigation menu with links for 'home', 'browse', 'help', 'features', 'learning', 'contribute', and 'about', along with a search box. The main heading is 'TREE OF LIFE web project' with the subtitle 'Explore the Tree of Life'. The page is divided into several sections: a left sidebar with 'Browse the Site' (containing links like 'Root of the Tree', 'Popular Pages', etc.), a central area with a large tree diagram and various organism images (butterfly, frog, flower, slug, mushroom, bear), and a right sidebar titled 'Learn about ...' featuring 'Agaricales' (a group of fungi) with an image of mushrooms and a 'read more' link. A 'News' section at the bottom left mentions 'Darwin 200: the celebration continues...'. The footer contains a brief description of the project as a collaborative effort of biologists and nature enthusiasts.

home browse help features learning contribute about Search

TREE OF LIFE web project

Explore the Tree of Life

Browse the Site

- [Root of the Tree](#)
- [Popular Pages](#)
- [Sample Pages](#)
- [Recent Additions](#)
- [Random Page](#)
- [Treehouses](#)
- [Images, Movies,...](#)

Search

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](#)

[more featured pages](#)

News

Darwin 200: the celebration continues...

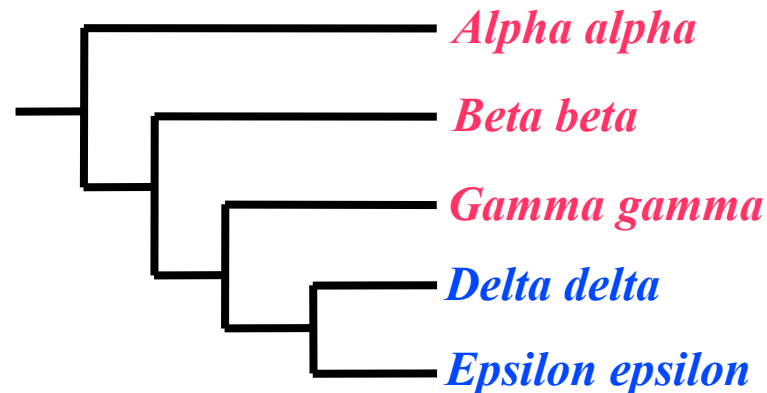
[read more](#)

about this site

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 World Wide Web pages, the project provides information about biodiversity: the characteristics of different groups of organisms, and their

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*?

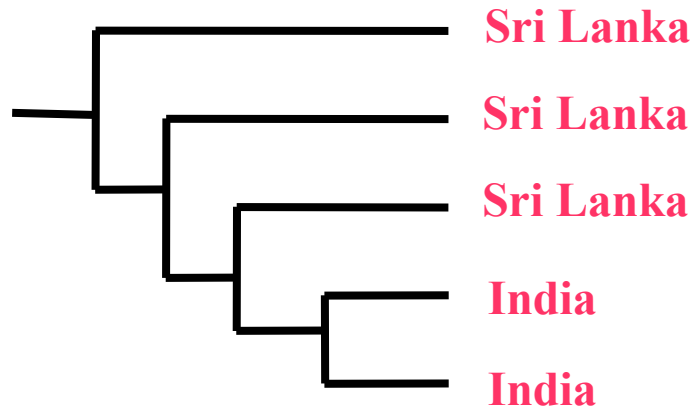


Reflection point

- 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 t

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

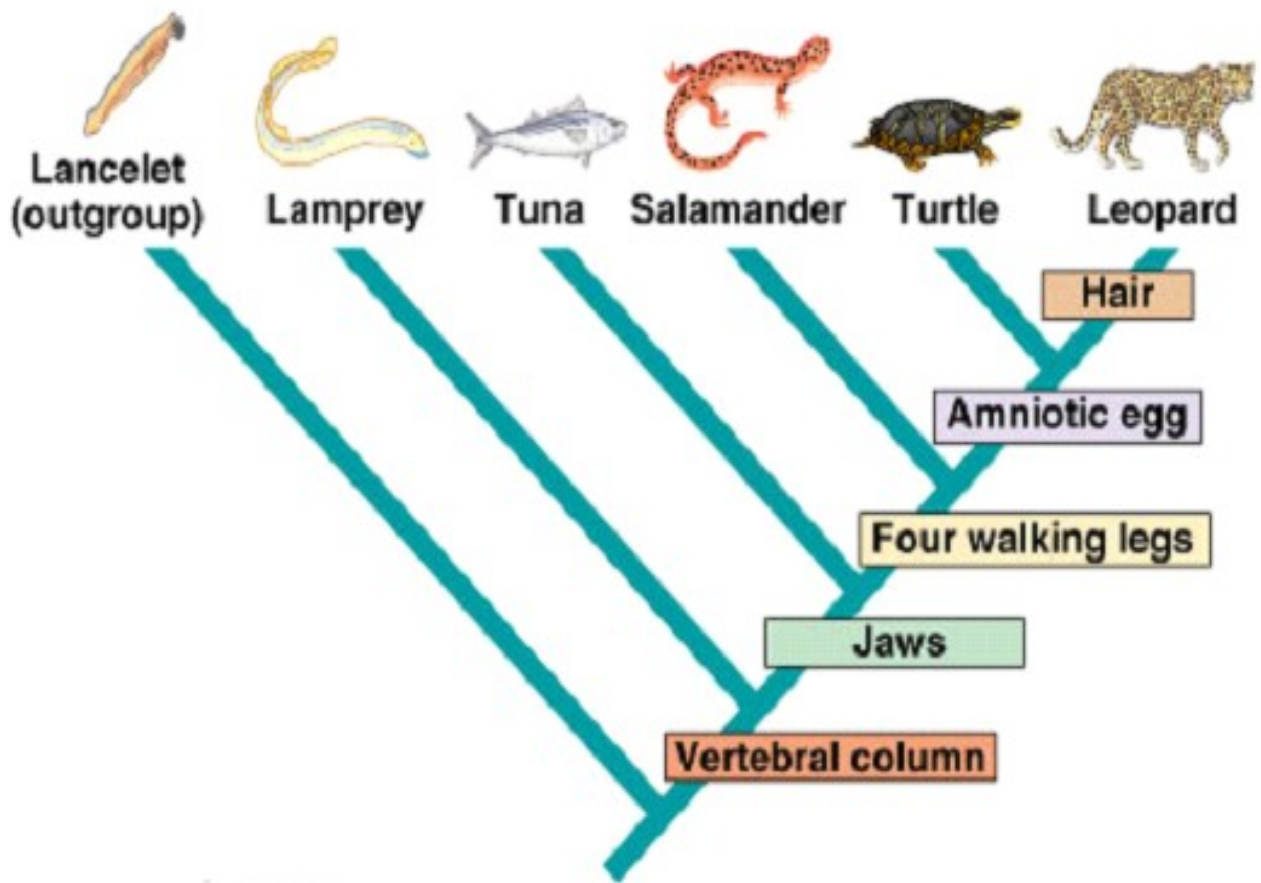
Position in DNA
Sequence

Nil, A, G, T, C.

		TAXA					
		Lancelet (outgroup)	Lamprey	Tuna	Salamander	Turtle	Leopard
CHARACTERS	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

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

(a) Character table



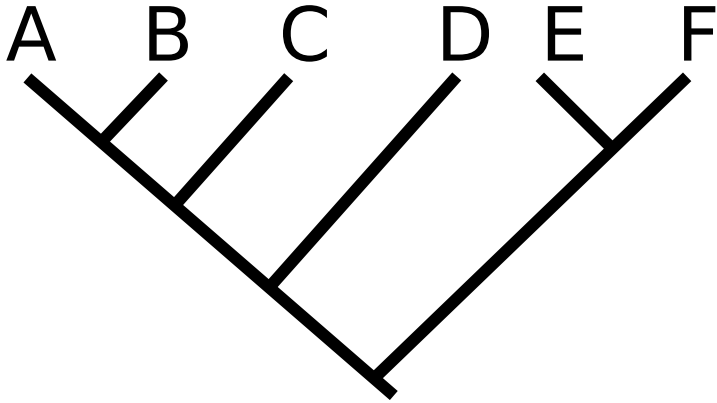
- Morphological data
- Molecular data: *Most commonly* – DNA sequences (molecular phylogenetics).

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*'

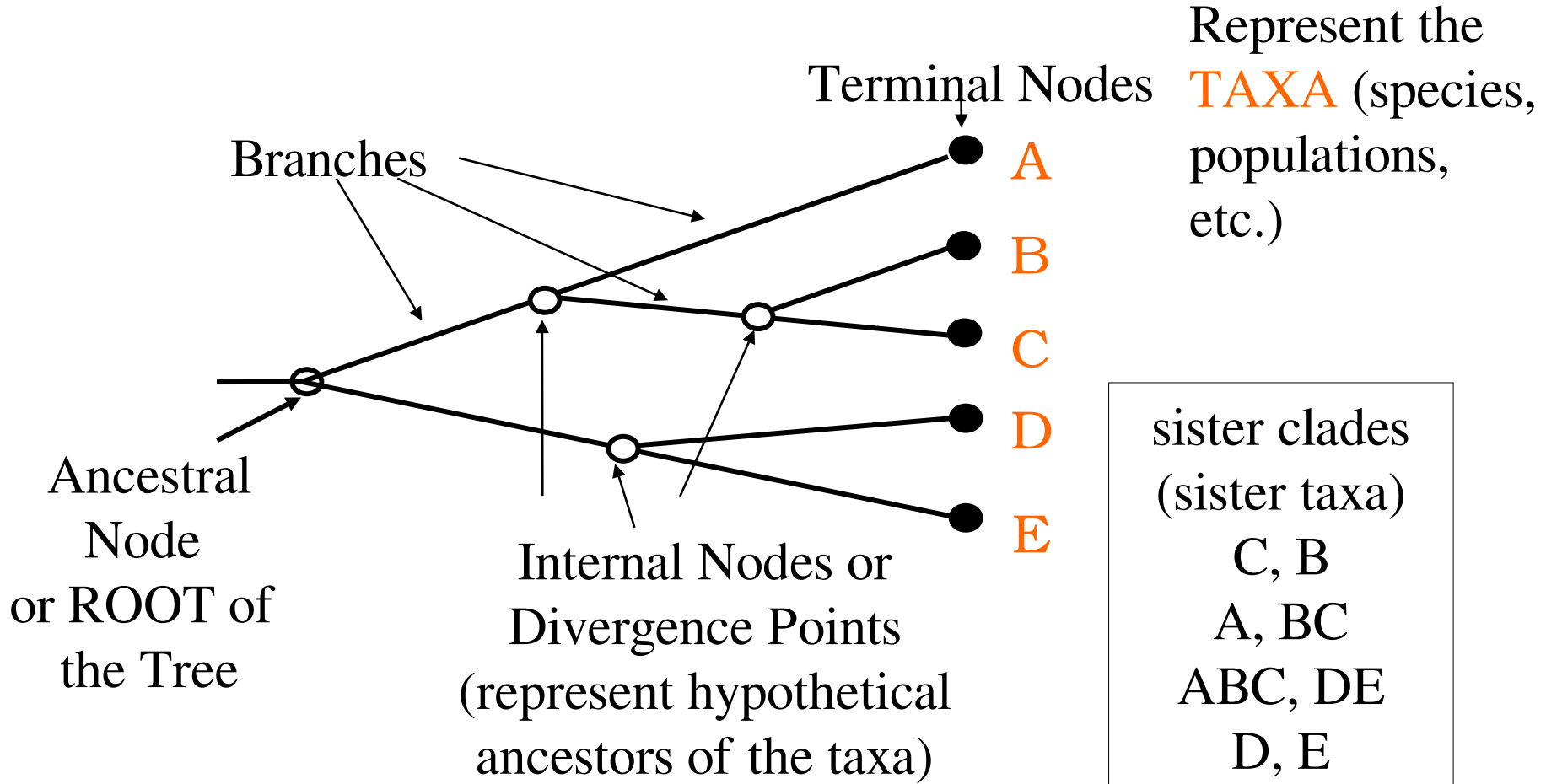
non-monophyletic



Monophyletic group - AB, ABCD

Non-monophyletic group – ABD, DEF, ABCDE

Tree Terminology



Species Concepts Continued: *Phylogenetic Species Concept*

Species can also be delimited using phylogenetic information. According to this species concept, a species is a monophyletic group that can be morphologically distinguished from other monophyletic groups

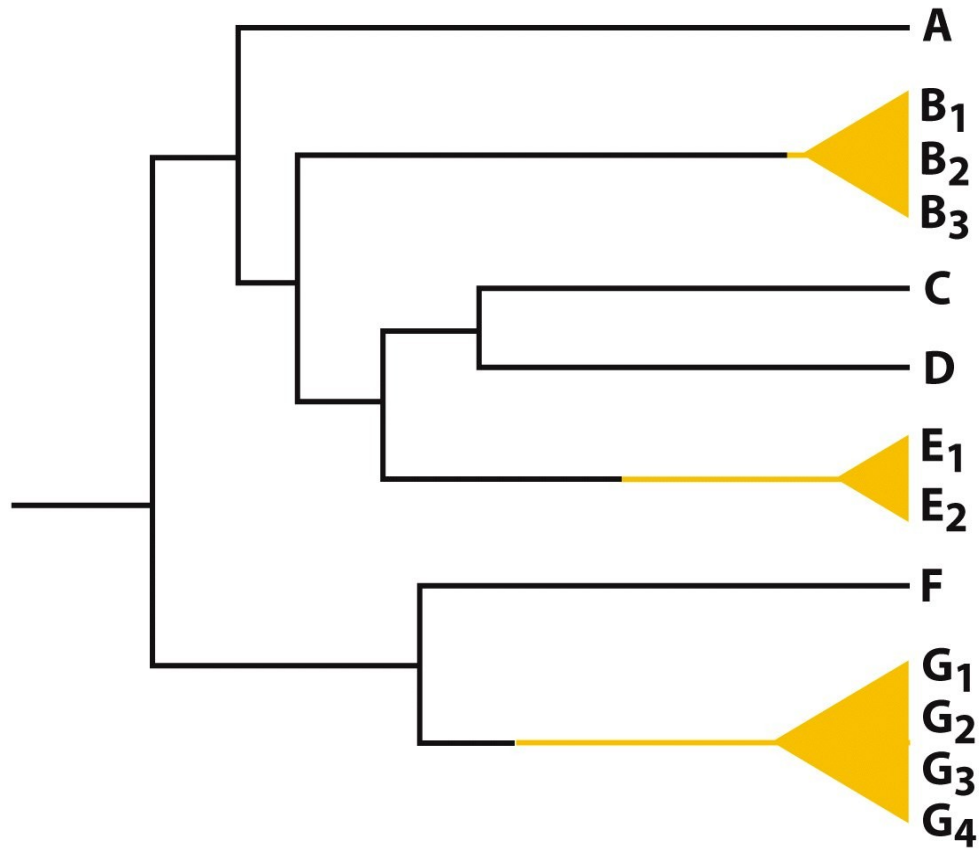


Figure 16-1 Evolutionary Analysis, 4/e
© 2007 Pearson Prentice Hall, Inc.

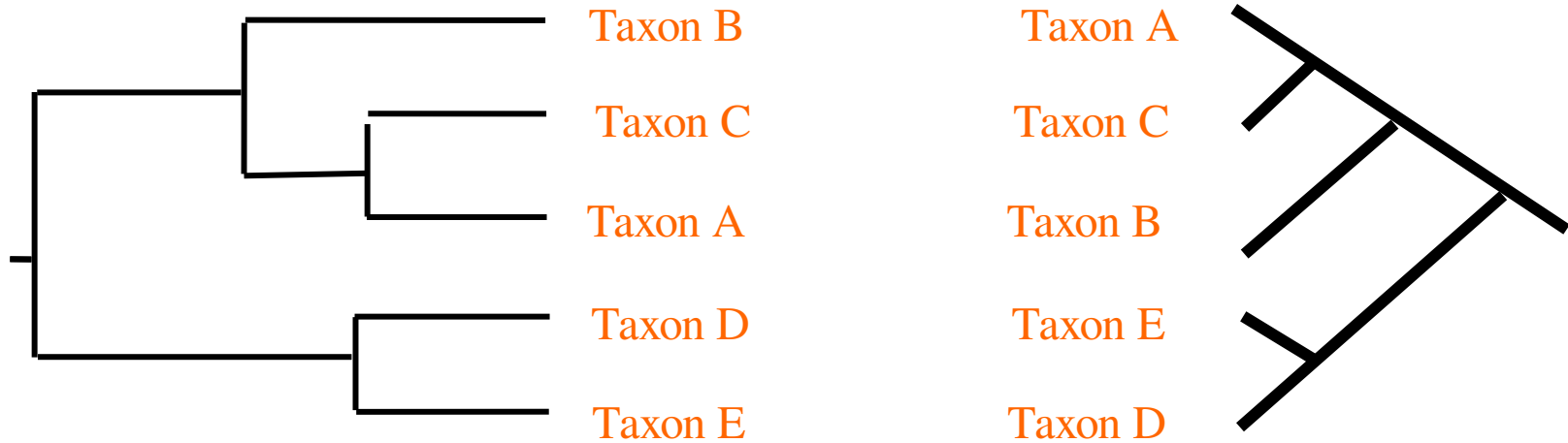
Source: Pearson Prentice Hall Inc.

Explicitly uses monophyly as a criterion to define species

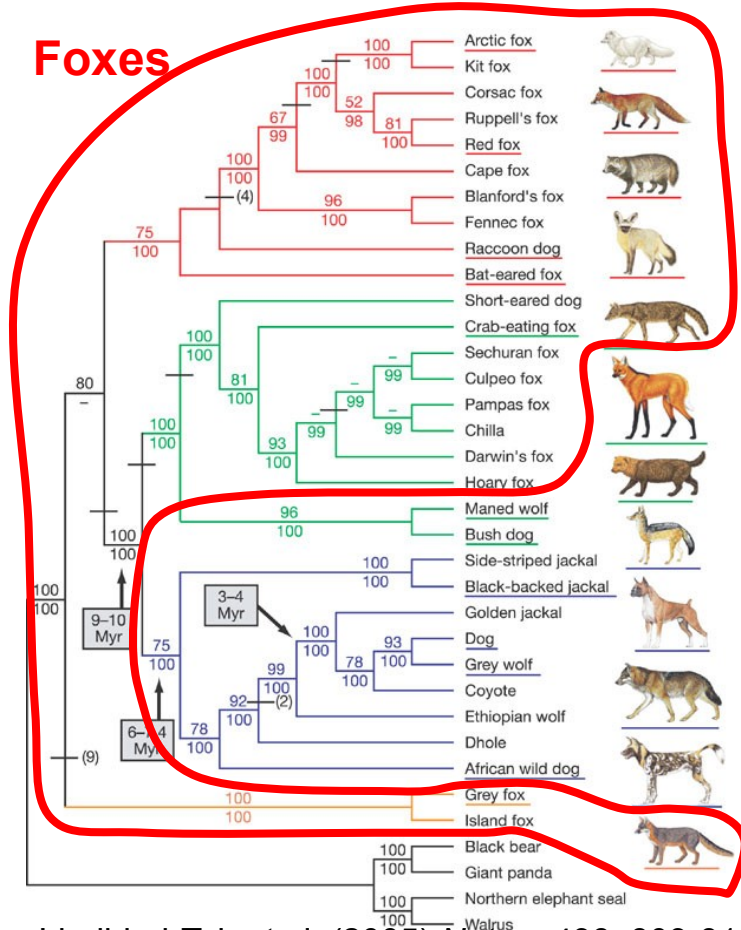
- PSC emphasizes common ancestry. Adds an evolutionary dimension to BSC by emphasizing common descent
- Applies to both sexually and asexually reproducing species.
- Problems
 - What morphological characters to use?
 - How much difference is enough?

Tree can be flipped at nodes

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



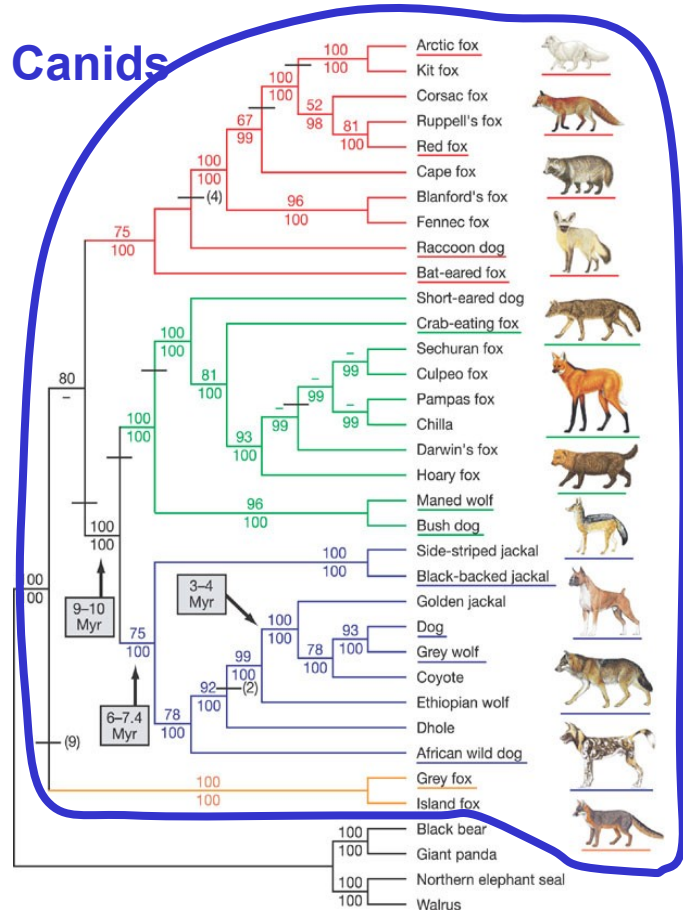
Non-monophyletic groups



“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

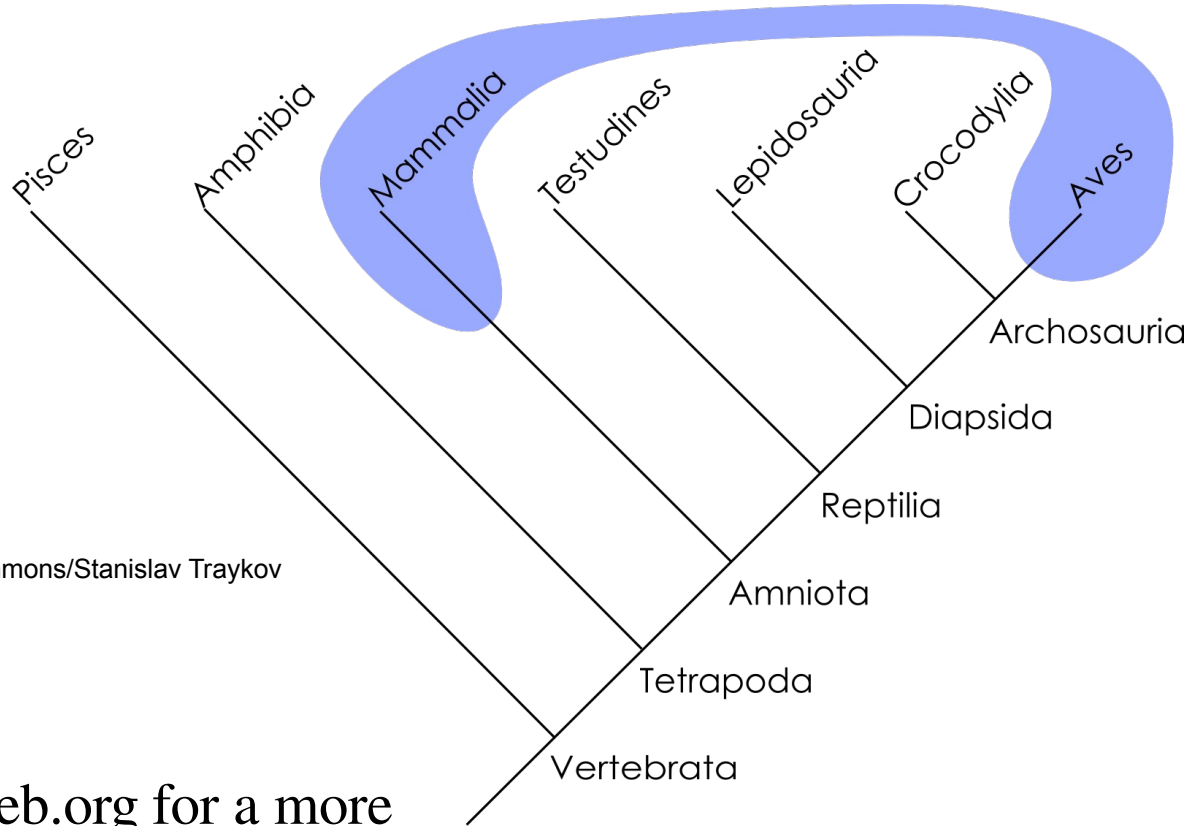


Canids are a **monophyletic** group within Mammalia

Each colored lineage within canids is also a clade

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

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

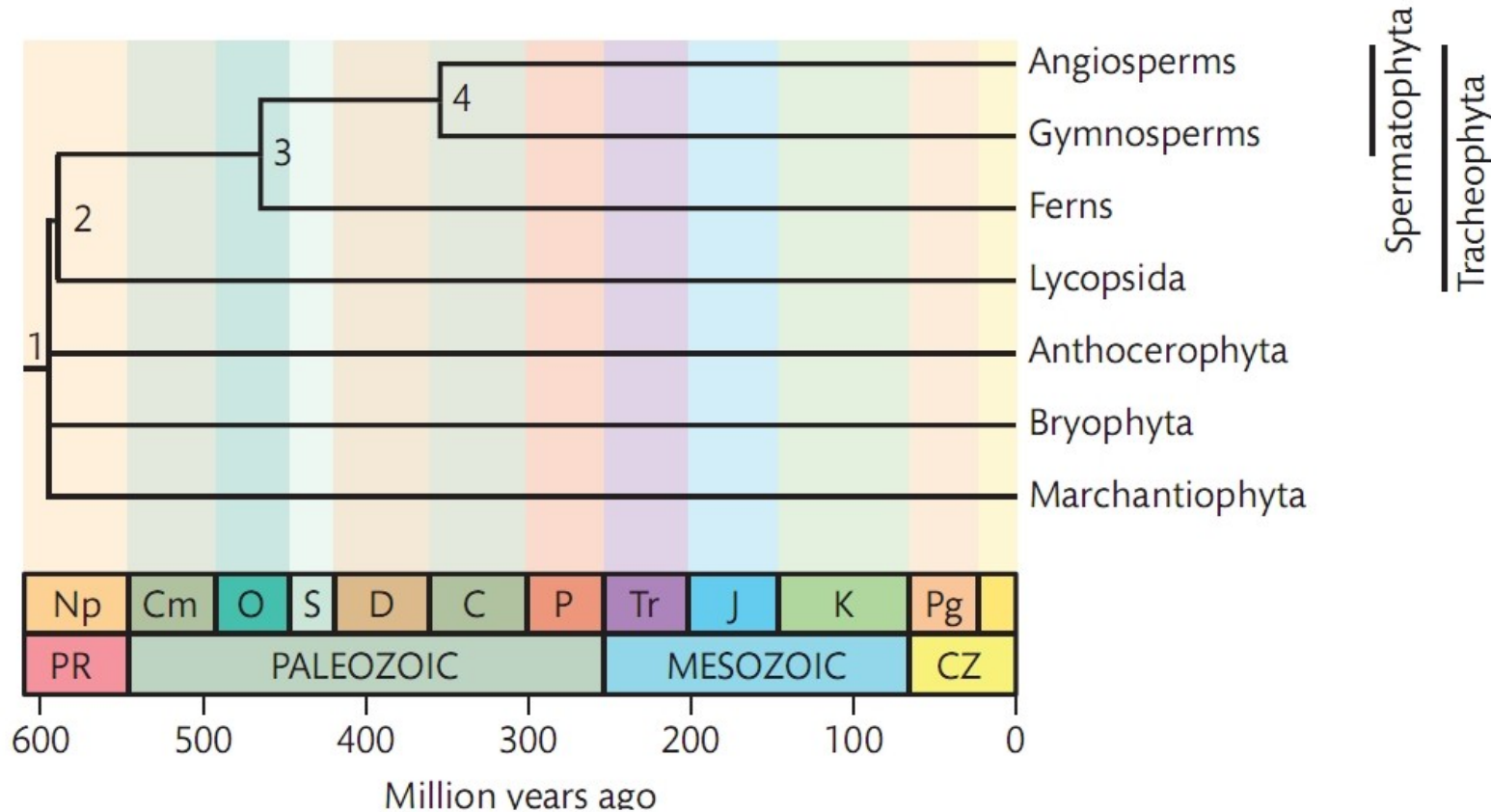
Are these monophyletic groups?

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

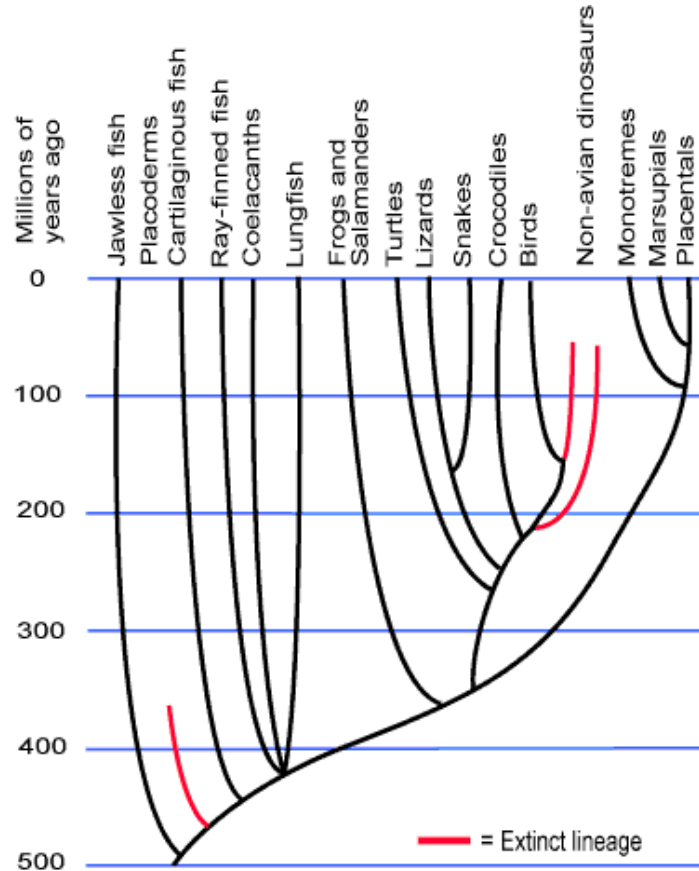
Molecular dating

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

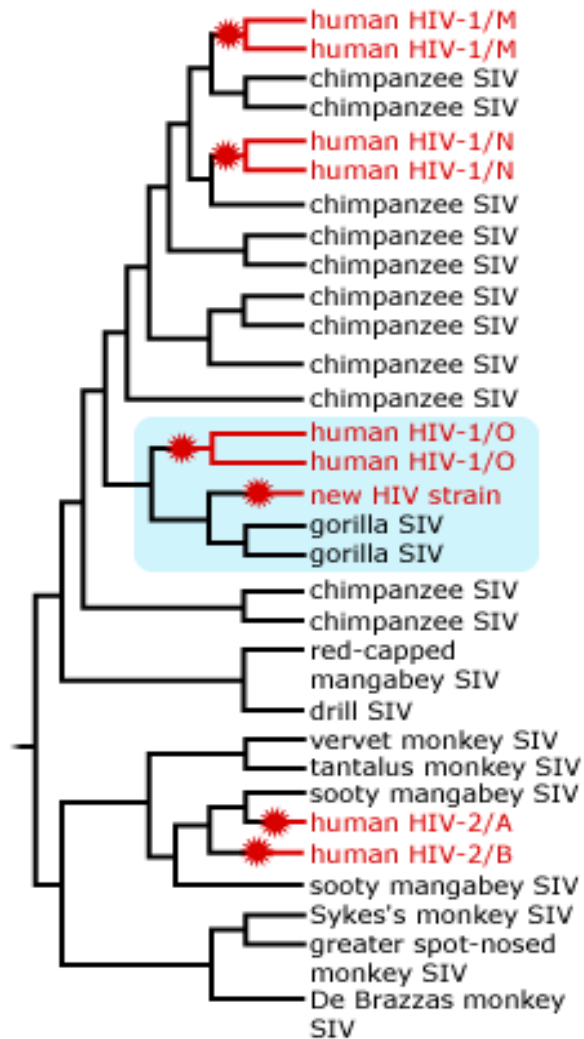
First reported in early 1980's

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