Lecture 1

Evolution and Biodiversity

Darwin's insights form the foundation of evolutionary theory

- Explains how patterns of diversity came to be
- Darwin's insights required the observations and insights of many other scientists

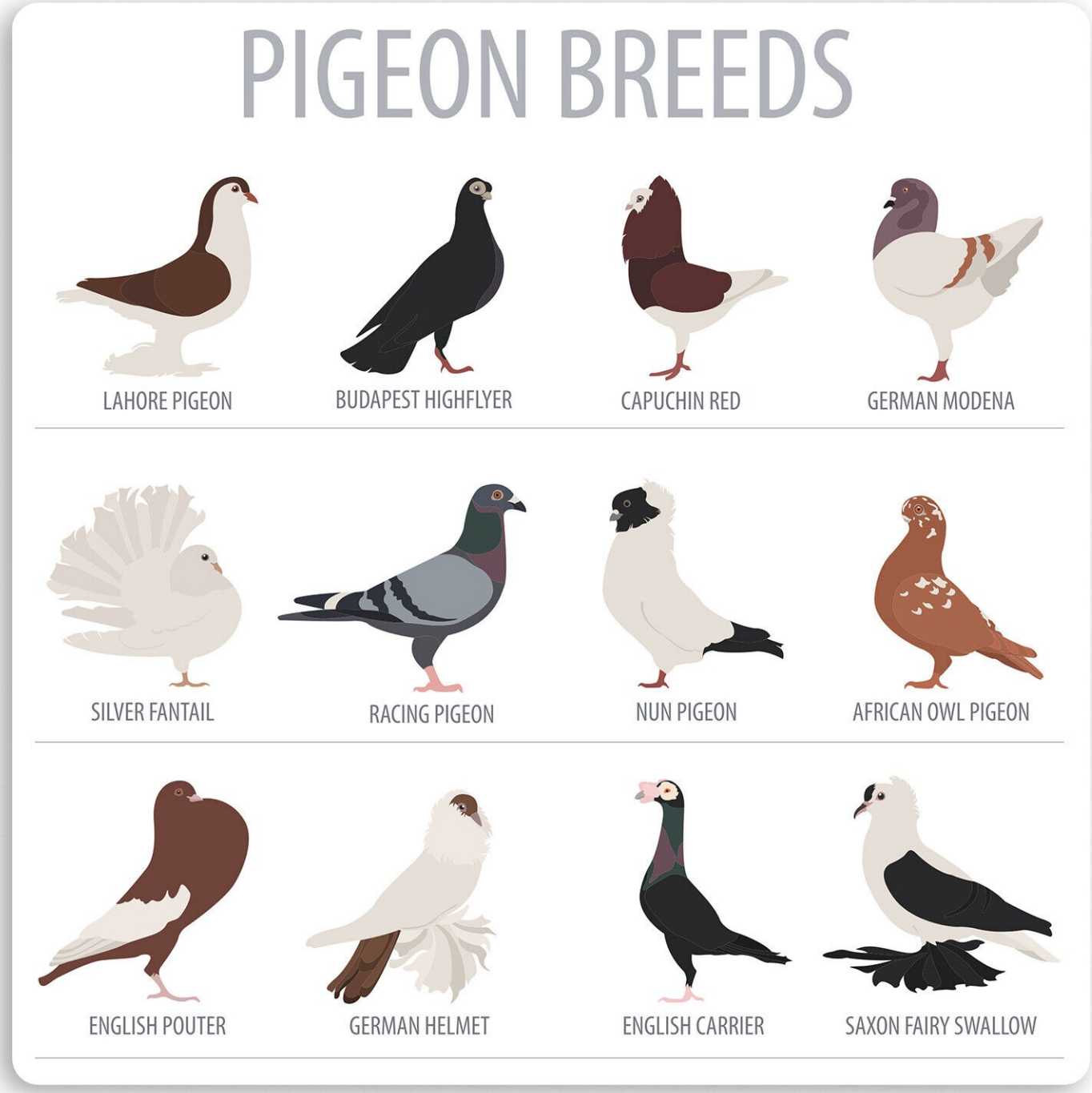
Charles Darwin
(1809-1882)

“I have stated, that in the thirteen species of ground-finches, a nearly perfect gradation may be traced, from a beak extraordinarily thick, to one so fine, that it may be compared to that of a warbler. […] Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species had been taken and modified for different ends.”
— Darwin, 1889

YouTube Video

Why would the finches of the Galapagos Islands be so different from one another?

Darwin’s pigeon breeding



The single illustration in the Origin of Species

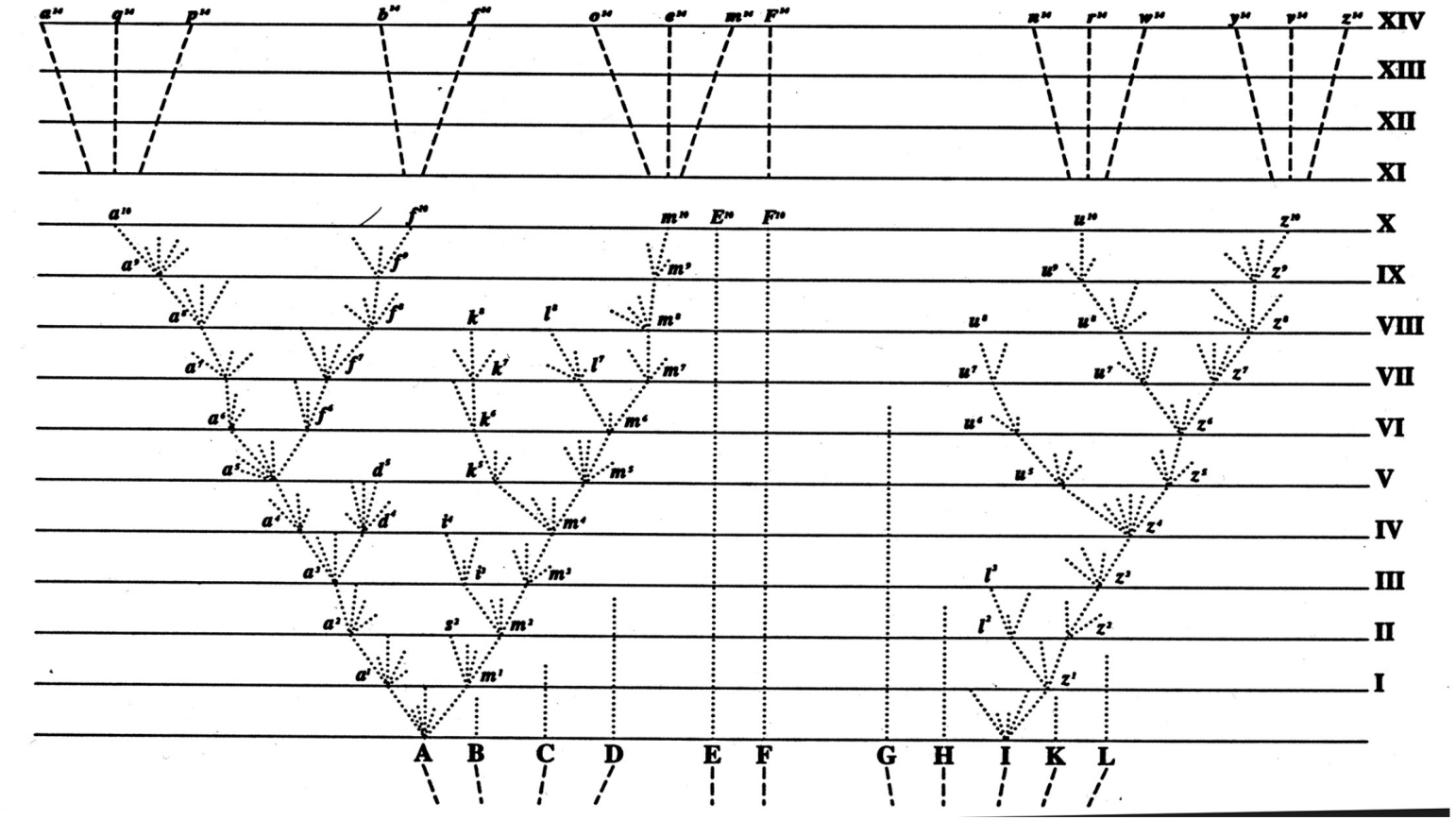


Figure 3. Darwin's diagram in *The Origin*, showing divergence from common ancestors. Horizontal lines represent time periods, from most remote (I) to most recent (XIV). Darwin was aware that most lineages go extinct, as evidenced by the lines that end at a certain point in time. (From Charles Darwin. 1859. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Existence.* London: John Murray.)

Descend with modification leads to testable hypotheses:

1. Species change through time (microevolution).

2. Lineages split to form new species (speciation).

3. Novel forms derived from earlier forms (macroevolution).

4. Species are not independent but connected by descent from a common ancestor (common ancestry and homology).

5. Earth and life on Earth are old (deep time).

What do the hypotheses of descend with modification have in common?

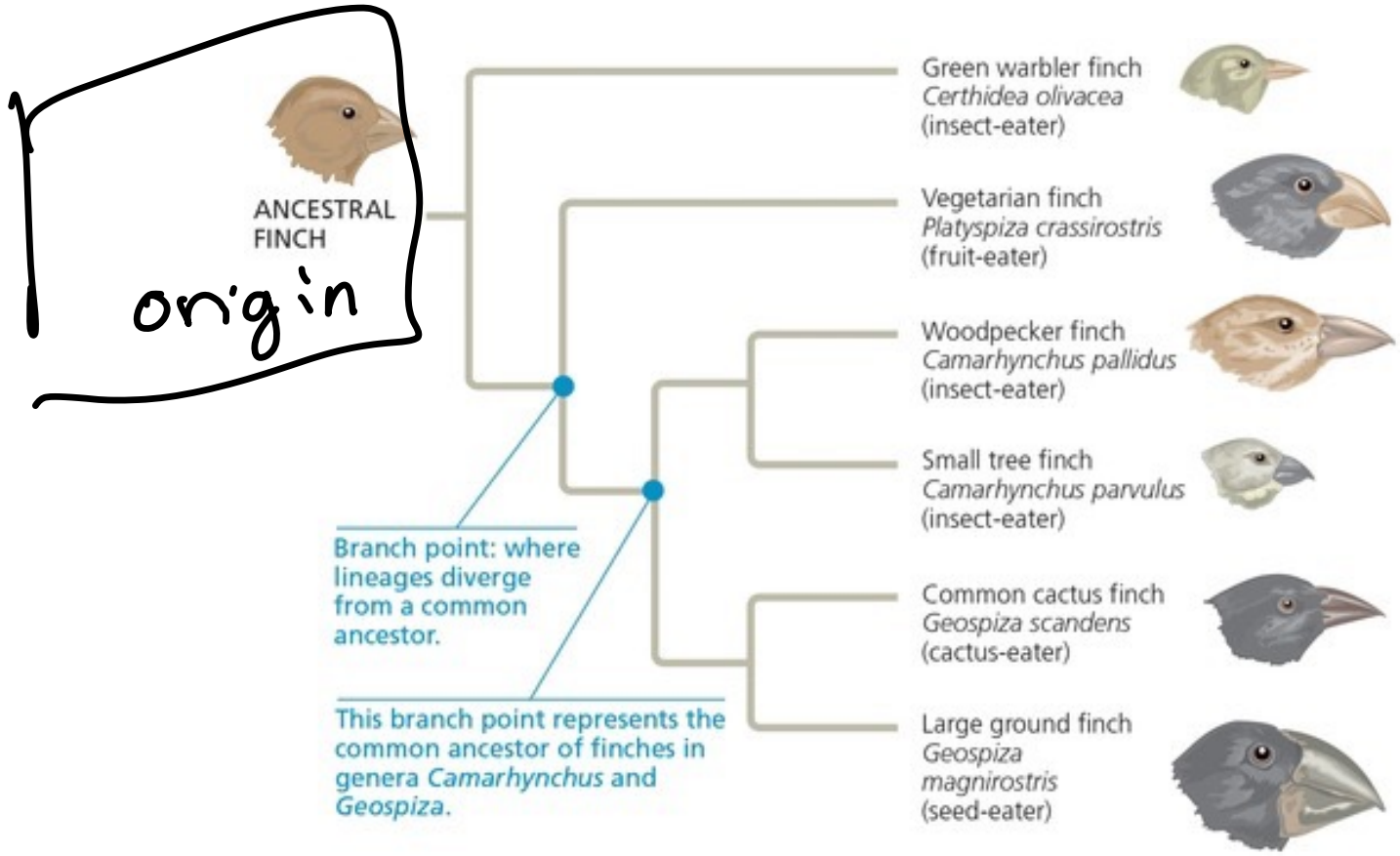
- Changes in phenotype
- interconnectedness between species
- TIME - long deep
- divergence / differentiation
- ORIGIN

Measuring change over time

$$= \frac{\#\text{changes}}{\text{Interval of time}} = \text{RATE}$$

First insight: Descend with modification

D*escent with modification* implies the common ancestry of all living things.



Phylogenetics – The study of species ancestry over long time scales

phyle=tribe

+

genesis

Phylogenetic trees are the most direct representation of the principle of common ancestry, the very core of evolutionary theory, and thus they must find a more prominent place in the general public's understanding of evolution- David Baum

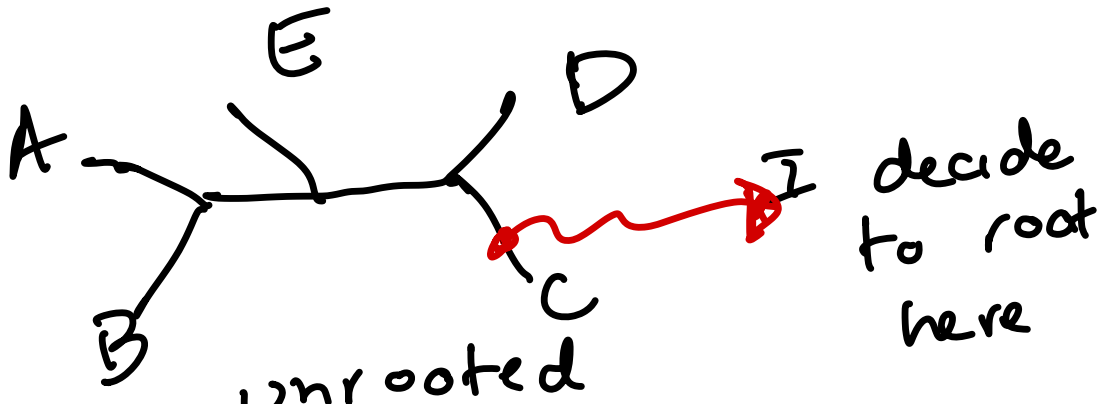
Phylogenetic trees: Simple concept but easily misinterpreted

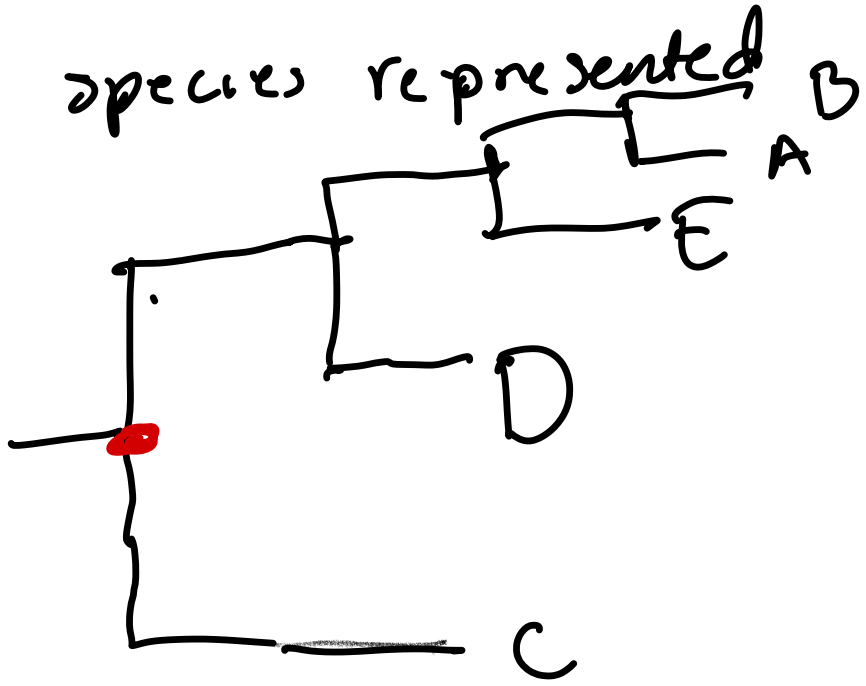
Nodes - connecting points

branches - connecting nodes (edges)

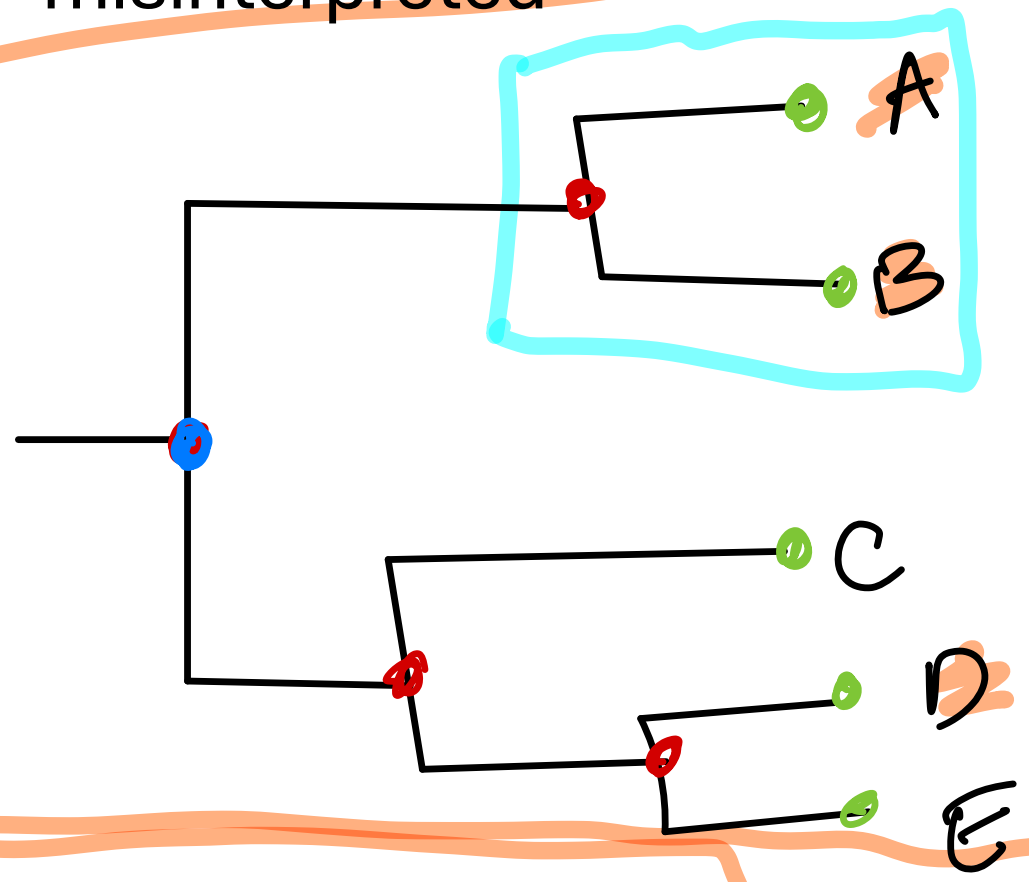
Unrooted tree - Does not have a single origin for all species

Rooted - single origin for all species represented





Phylogenetic trees: Simple concept but easily misinterpreted



Clade of A, B, D?

monophyletic

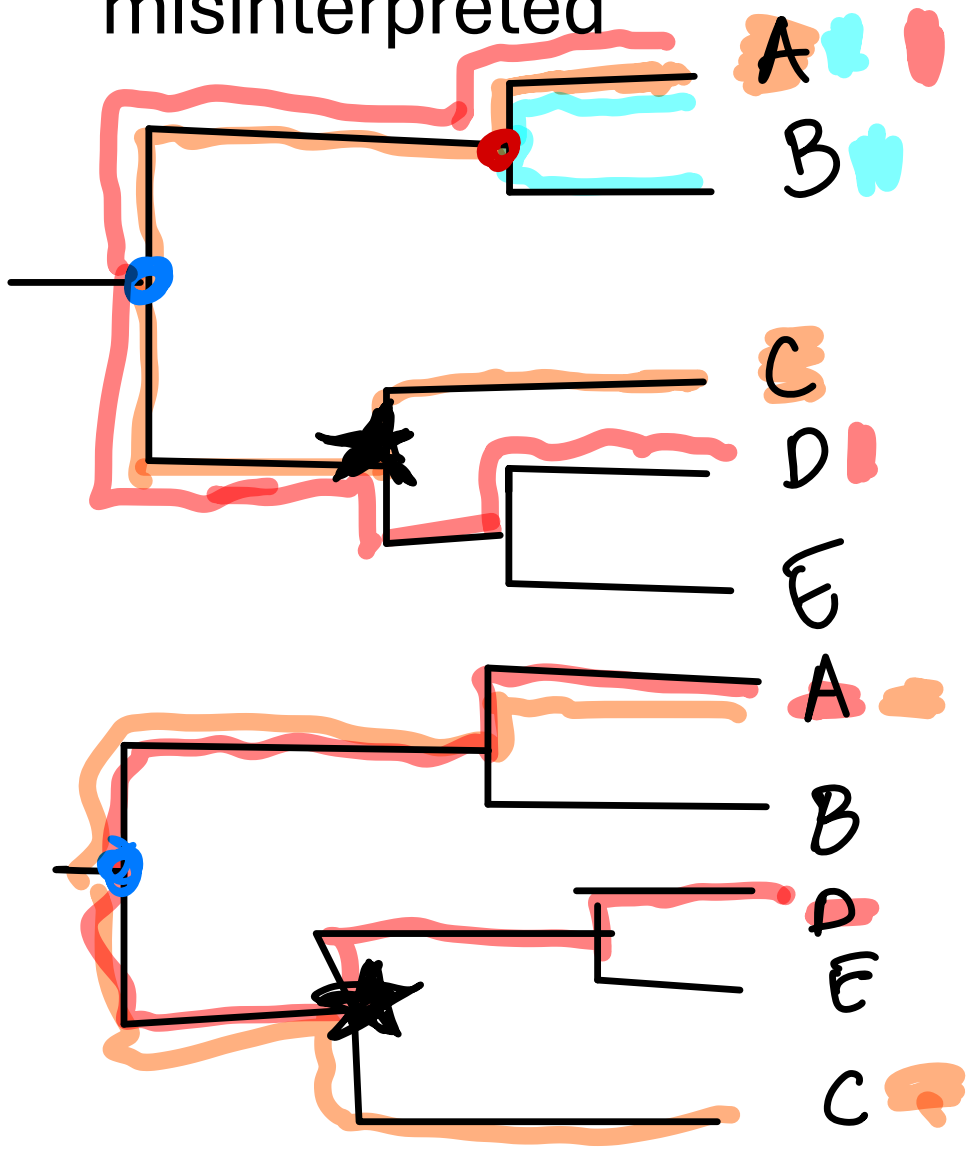
- Nodes → Internal
  - → Root

MRCA – most recent common ancestor

- Tips / Leaves represent species / genes / taxa

Clade is a group of all taxa and the internal nodes that they descend from

Phylogenetic trees: Simple concept but easily misinterpreted

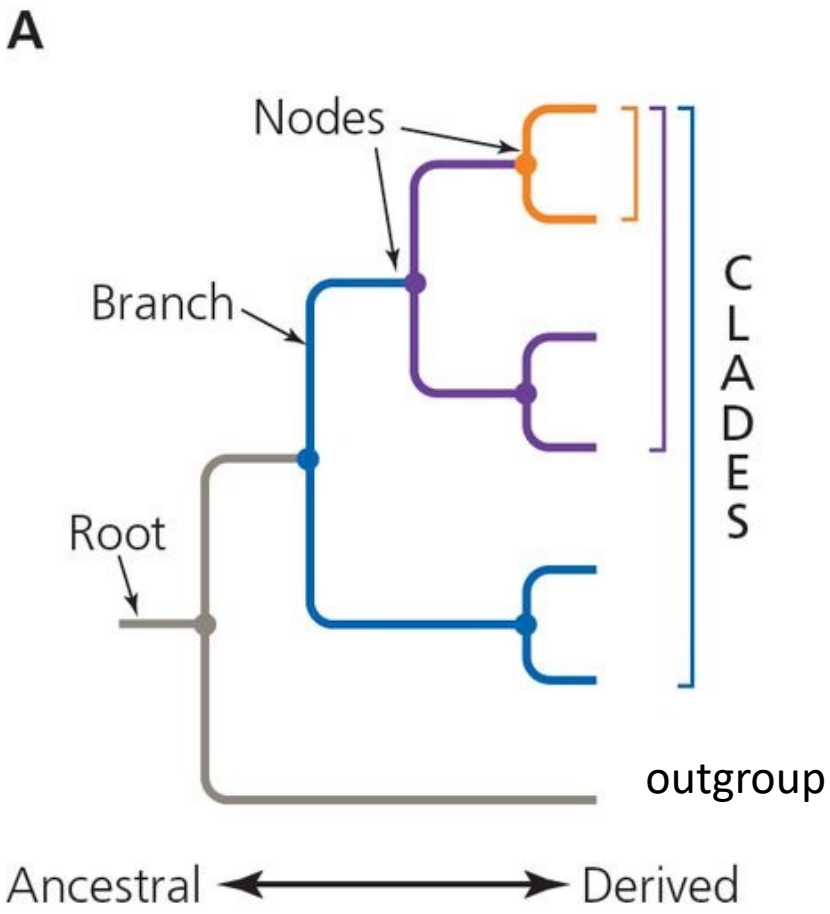


cladogram

- An unscaled phylogenetic tree showing the relationships among taxa
- Branch lengths are meaningless

A and C closer than A and D ?

Reading a phylogenetic tree



Node: a point in a phylogeny where a lineage splits
- one speciation event
- common ancestor of branches that extend from it

branch

Branches: lineages evolving through time
- the stuff between speciation events

Tips: terminal ends representing species, molecules, or populations being compared

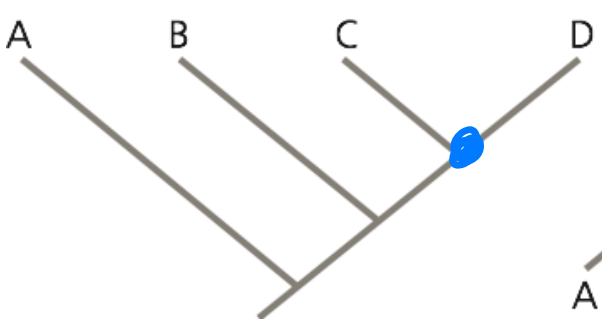
Clade: An ancestor and all its descendants

Rooted tree: includes a distantly related "outgroup" species to polarize changes and show which node is common ancestor to all lineages in ingroup

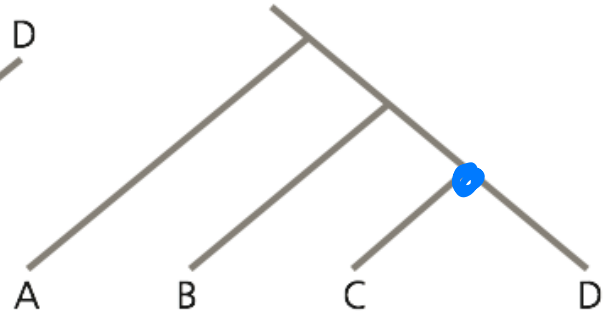
When interpreting trees, pay most attention to nodes (= common ancestors)!!

Phylogenies may be drawn in different styles

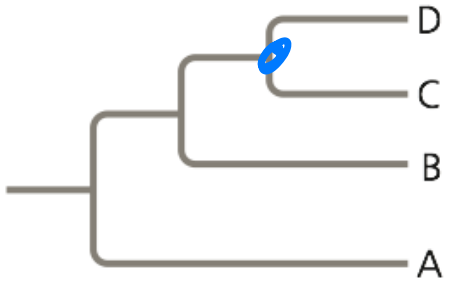
triangle



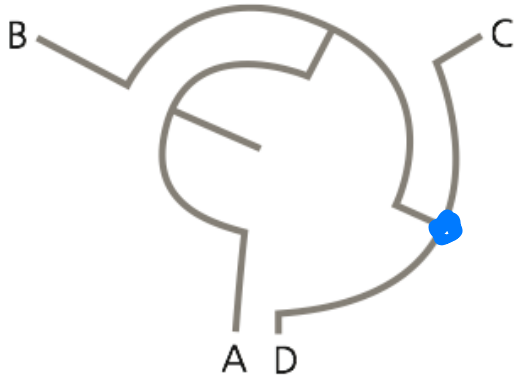
fan



rectangular



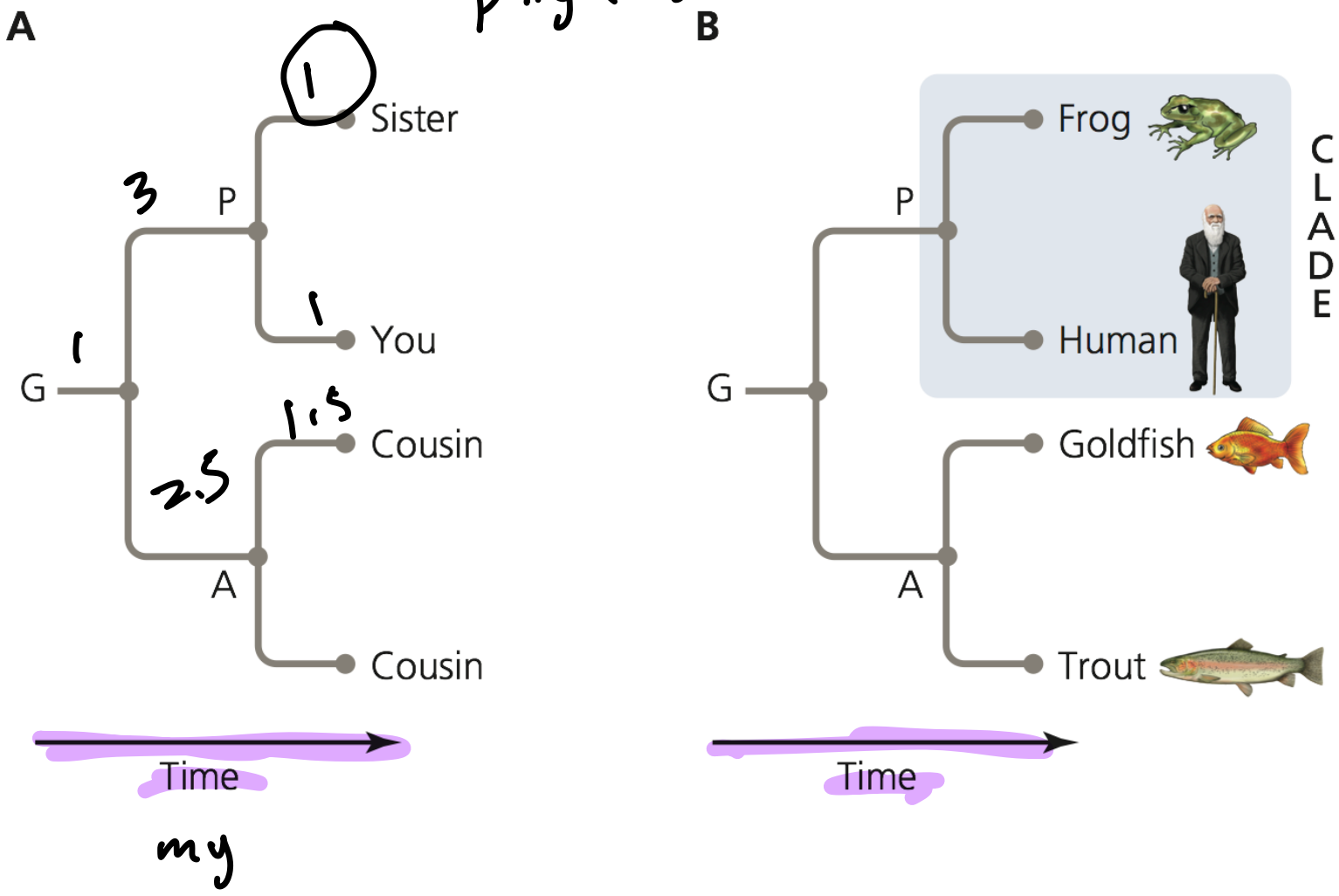
circular



All four trees depict the same relationships!!

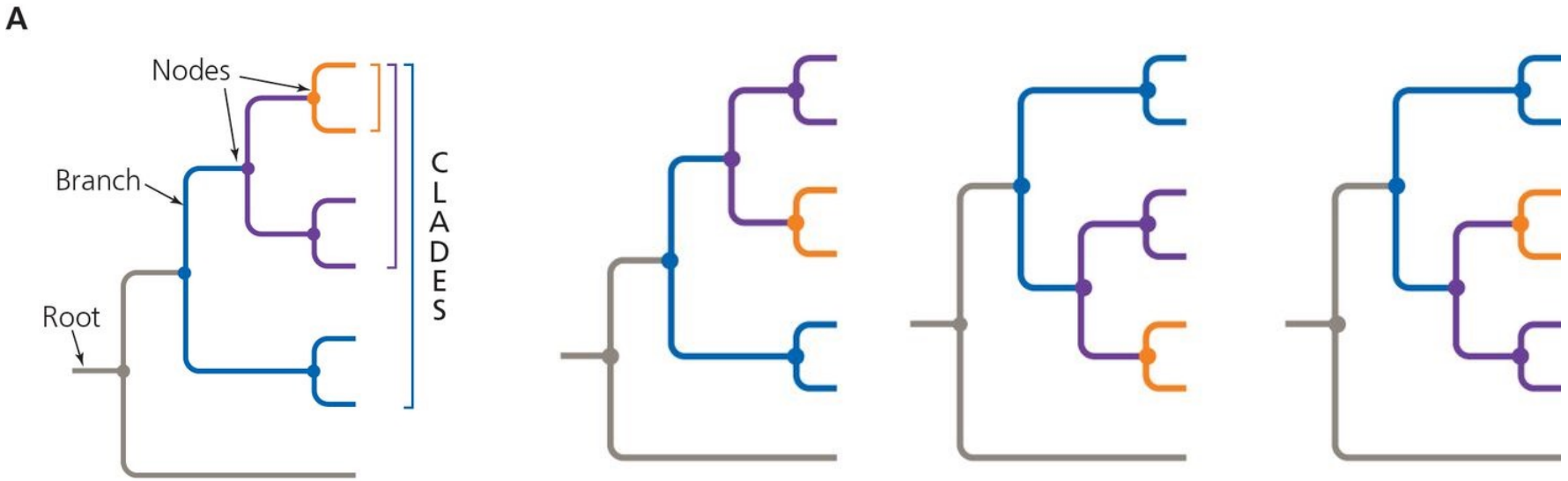
A phylogeny is similar to a family tree

Phylograms - Cladograms + time



Clade: An ancestor and all its descendants (=**monophyletic group**)

Taxa can be rotated around nodes



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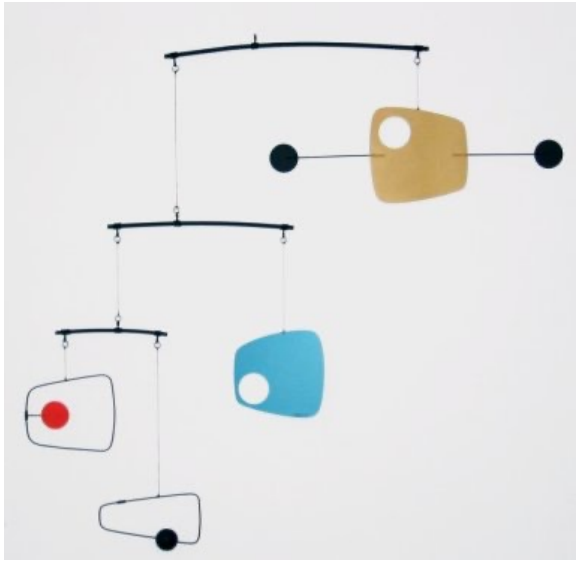

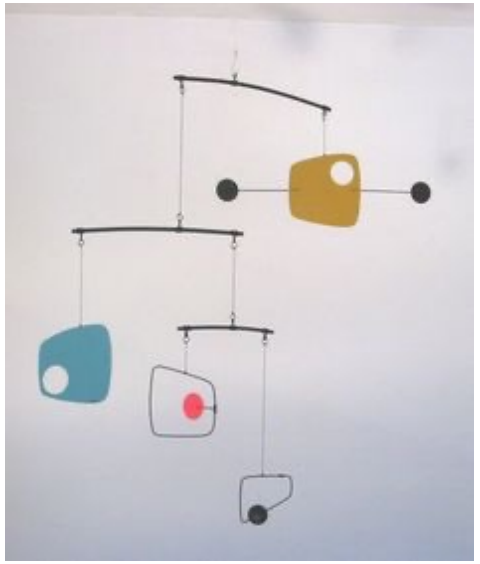

Are these trees the same?