

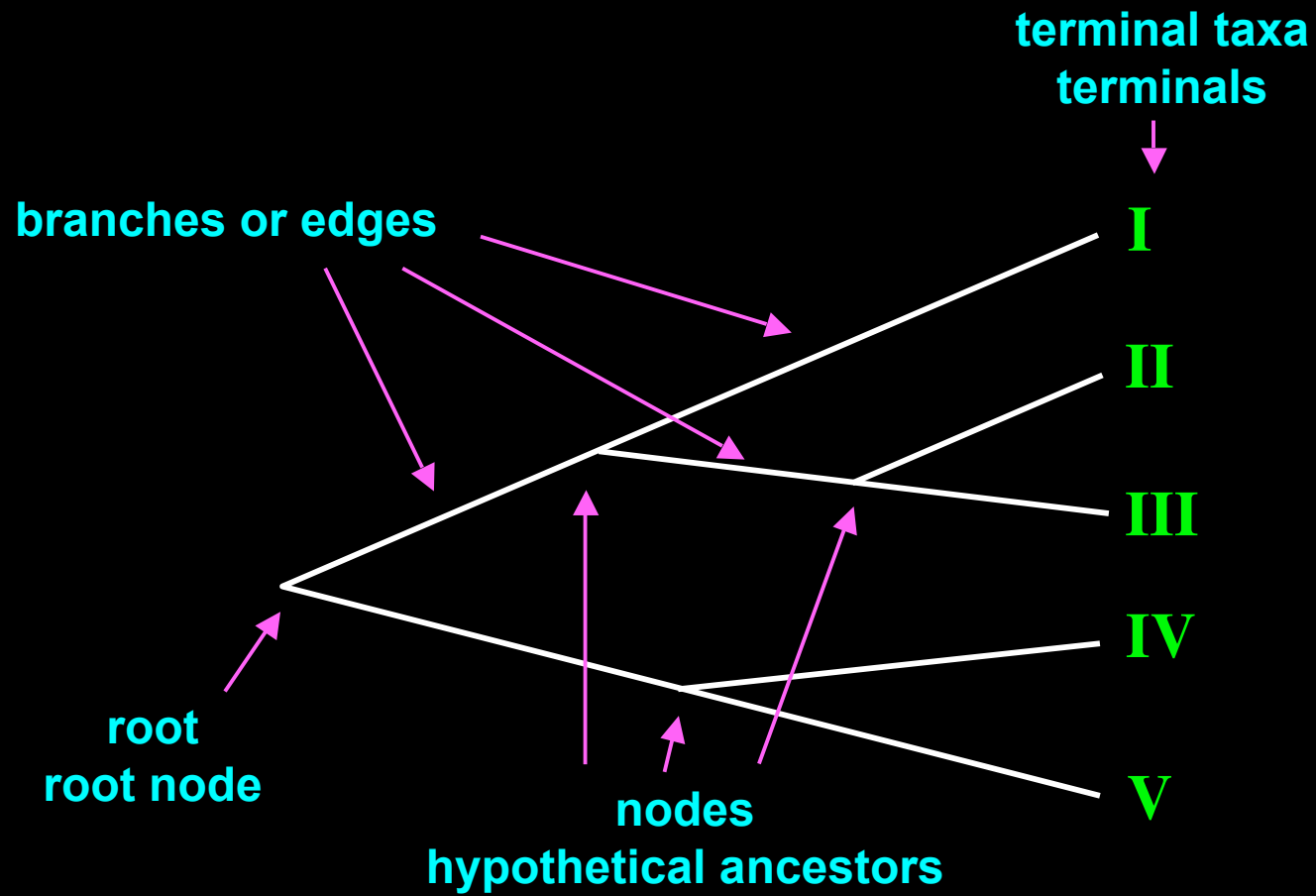
Apomorphy - n. a derived state  
apomorphic - adj.

Plesiomorphy - n. an ancestral state  
plesiomorphic - adj.

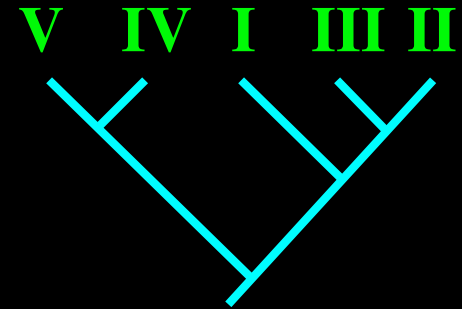
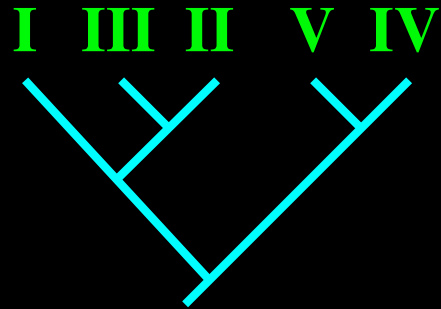
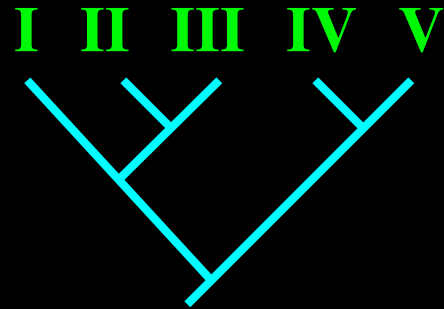
Synapomorphy - n. shared derived state

Symplesiomorphy - n. shared ancestral state

# Tree Think

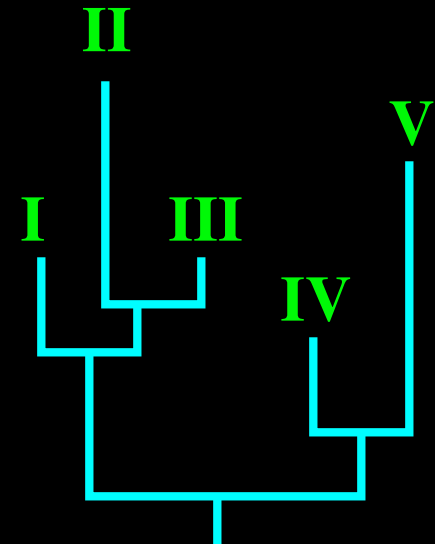
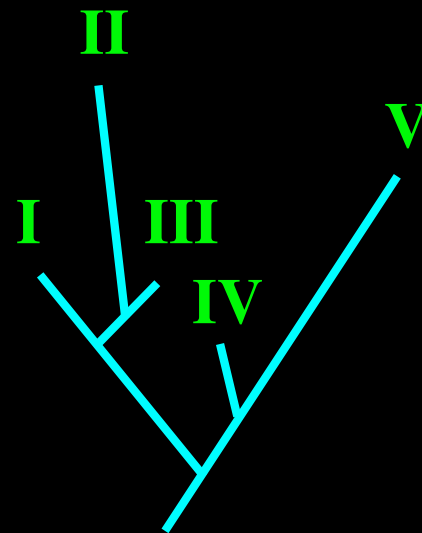
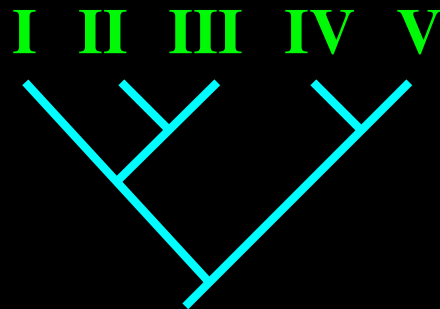


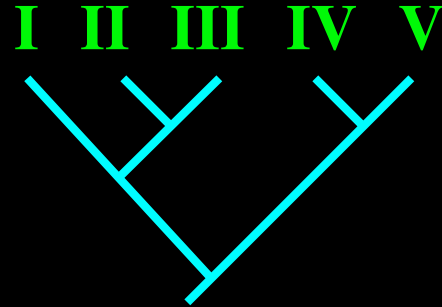
these trees are all identical



cladogram

phylograms



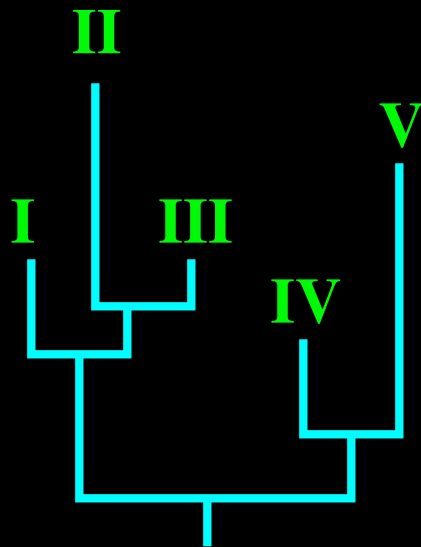


parenthetical notation (TNT)

$((\text{I } (\text{II III})) (\text{IV V}))$

newick / altnexus

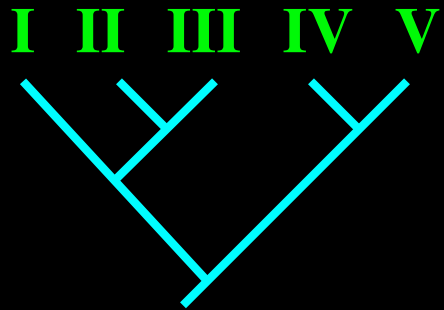
$((\text{I}, (\text{II}, \text{III})), (\text{IV}, \text{V}))$



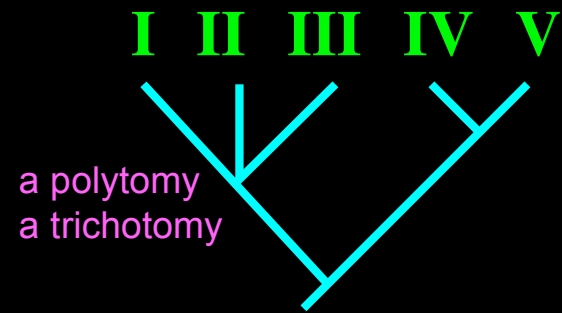
newick / altnexus with branch lengths

$((\text{I}:0.1, (\text{II}:0.3, \text{III}:0.07):0.06):0.2, (\text{IV}:0.1, \text{V}:0.4):0.08)$

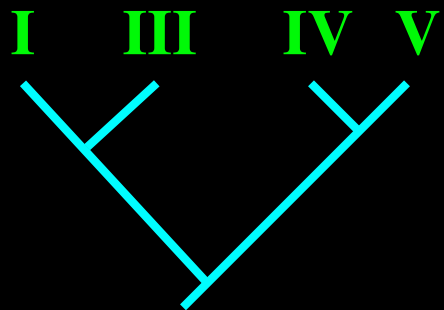
Fully resolved



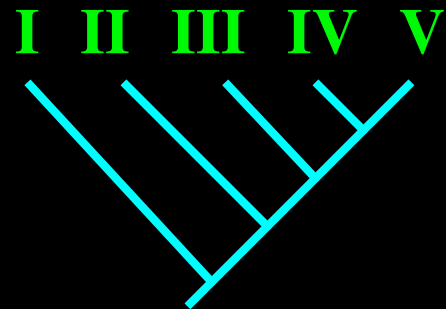
Not fully resolved



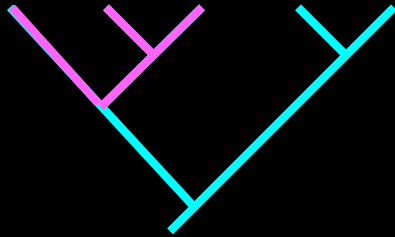
Balanced



Pectinate



I II III IV V

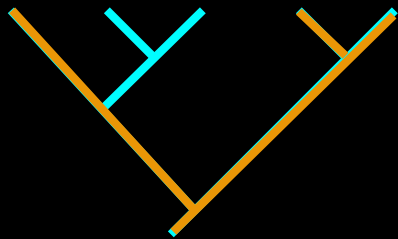


**Monophyly** - descended from a common ancestor, including all descendants of that ancestor

(this tree has 4 monophyletic groups)

Synapomorphy defines monophyly (e.g., mammary glands and mammals)

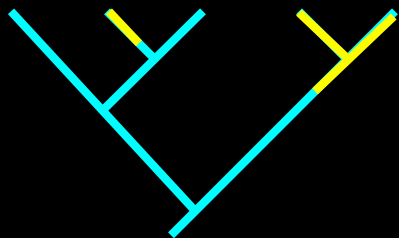
I II III IV V



**Paraphyly** - descended from a common ancestor, fails to include all descendants of that ancestor

Symplesiomorphy defines paraphyly (e.g., reptiles are paraphyletic)

I II III IV V



**Polyphyly** - not descended from a common ancestor

Convergence defines polyphyly (e.g., homeotherms are polyphyletic)

## Remember this?

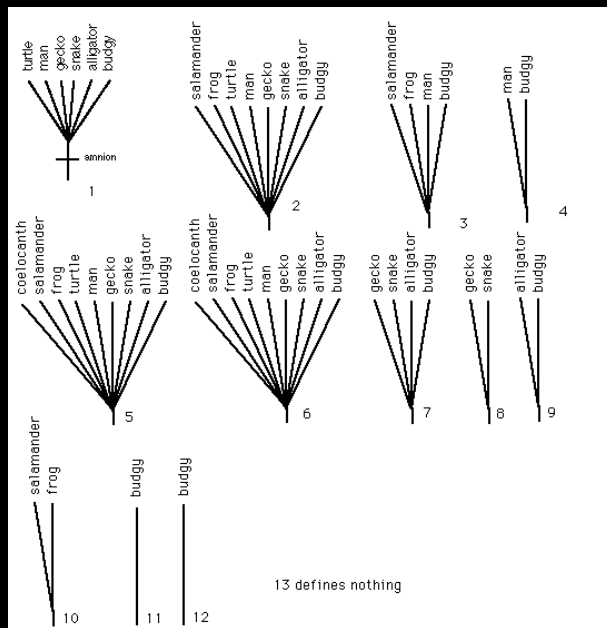
How is the plesiomorphic state determined?

Define group of interest = **INGROUP**

**INGROUP** = TETRAPODA (assumed to be monophyletic)

Find other taxa, not in the ingroup, probably closely related, possessing traits of some ingroup taxa = **OUTGROUP**

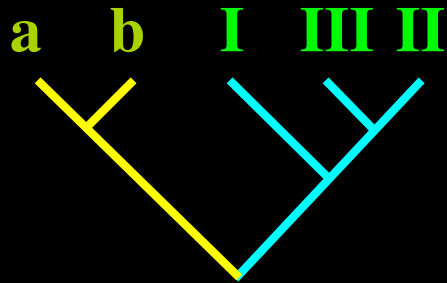
**OUTGROUP** = LOBED-FIN-FISHES AND RAY-FIN-FISHES



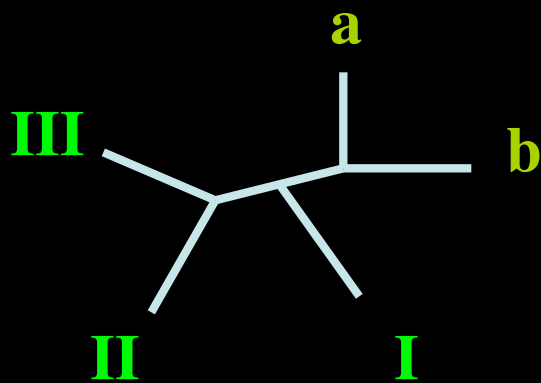
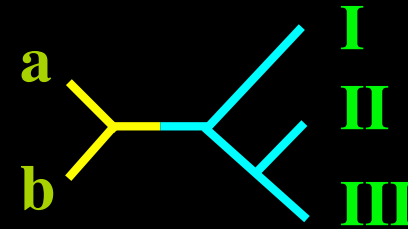
Taxon	amniion	legs	scales	blood	internal nostrils	atrial septum	two temporal fenestrations	hemipenes	gizzard	pedicillate teeth	feathers	wings	vertebrae
perch	no	no	yes	cold	no	no	no	no	no	no	no	no	yes
coelocanth	no	no	yes	cold	yes	yes	no	no	no	no	no	no	yes
salamander	no	yes	no	cold	yes	yes	no	no	no	yes	no	no	yes
frog	no	yes	no	cold	yes	yes	no	no	no	yes	no	no	yes
turtle	yes	yes	yes	cold	yes	yes	no	no	no	no	no	no	yes
human	yes	yes	no	warm	yes	yes	no	no	no	no	no	no	yes
gecko	yes	yes	yes	cold	yes	yes	yes	yes	no	no	no	no	yes
snake	yes	no	yes	cold	yes	yes	yes	yes	no	no	no	no	yes
alligator	yes	yes	yes	cold	yes	yes	yes	no	yes	no	no	no	yes
budgy	yes	yes	no	warm	yes	yes	yes	no	yes	no	yes	yes	yes

A state present in the OUTGROUP and the INGROUP is plesiomorphic for the ingroup

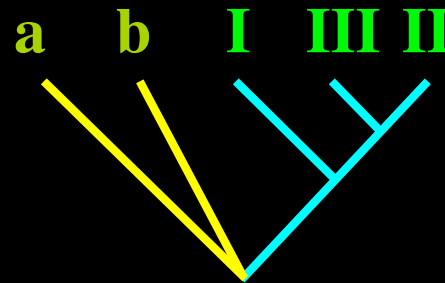
## Rooted



## Unrooted



Analyses are always done on unrooted trees, including some outgroup(s), then rooted on the outgroup(s) a posteriori.





Number of stars  
in the known  
universe

<<

Number of trees  
For 25 taxa

$$\frac{(2t-3)!}{2^{t-2}(t-2)!}$$

5	105
10	$3 \times 10^7$
20	$8 \times 10^{21}$
50	$3 \times 10^{76}$

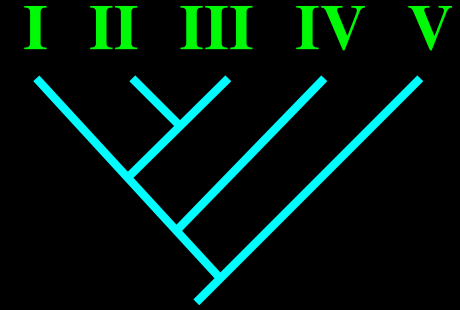
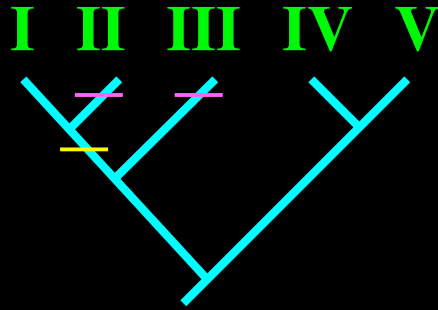
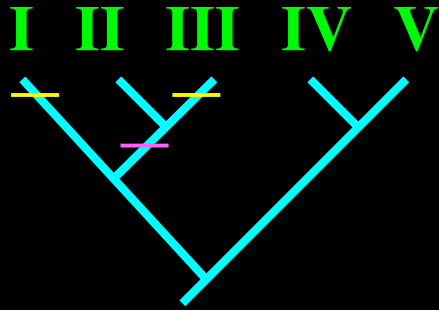
Number of rearrangements PAUP  
can do on my G5 in 1 second

2500

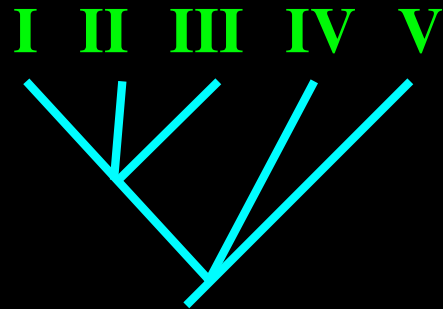
Number of millenia PAUP would  
take to examine all trees for 20 taxa

$4 \times 10^{21}$

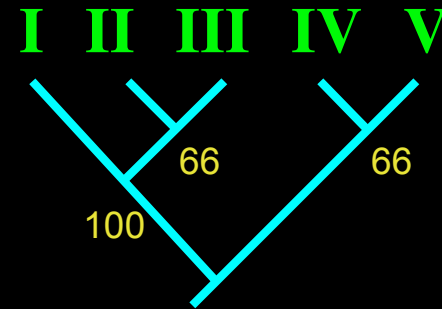
# Multiple Equally Parsimonious Trees



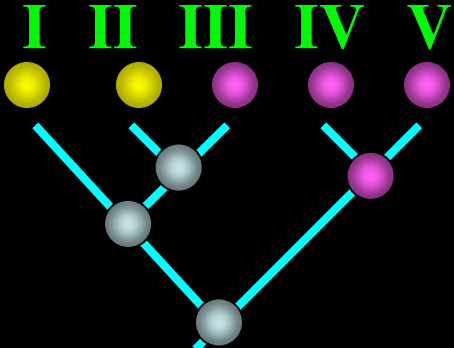
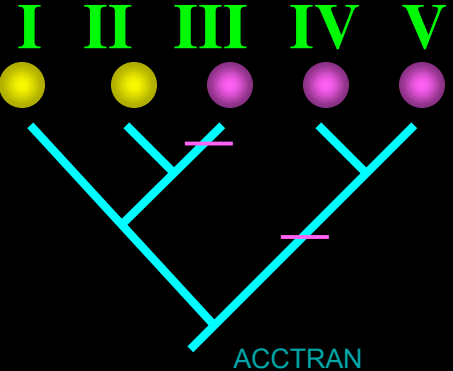
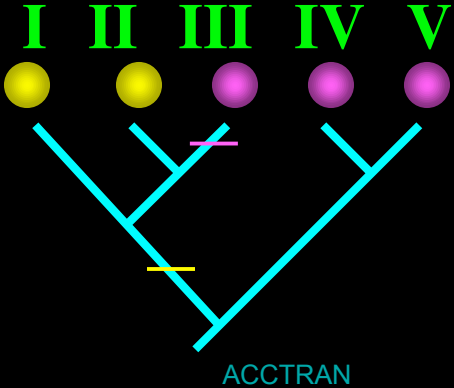
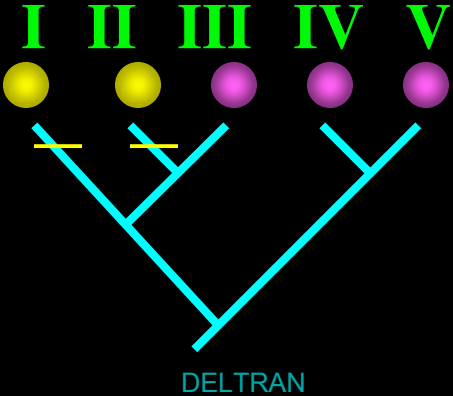
STRICT CONSENSUS



MAJORITY RULE CONSENSUS



# Multiple Equally Parsimonious Resolutions



# Multiple Equally Parsimonious Resolutions

