



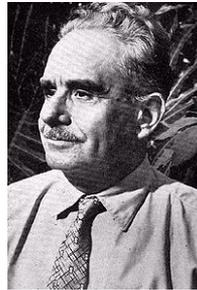
# Parsimony and Cladistic Biogeography



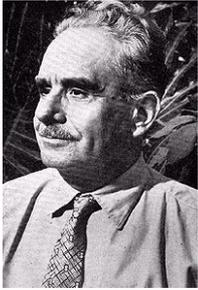
Reading: Gareth Nelson

# A Revolution in Biogeographical Methods

## Lecture 13 Recap



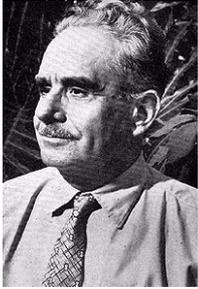
Leon Croizat



Leon Croizat

# A Revolution in Biogeographical Methods

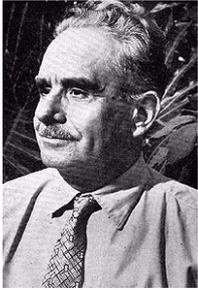
- *Panbiogeography*
- Based on the idea that life and the earth are evolving simultaneously
- Heavy influence of continental vicariance (*ultra-vicariance*) over dispersal



Leon Croizat

# A Revolution in Biogeographical Methods

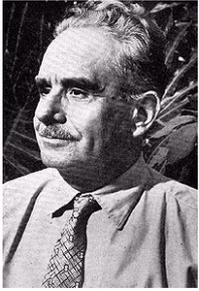
- *The Panbiogeographical Method*
  1. Map the ranges of the species of a given group
  2. Connect the ranges with a line to form a track, these would be minimum line, connecting all localities with the shortest possible path
  3. Do this over and over again for different taxa



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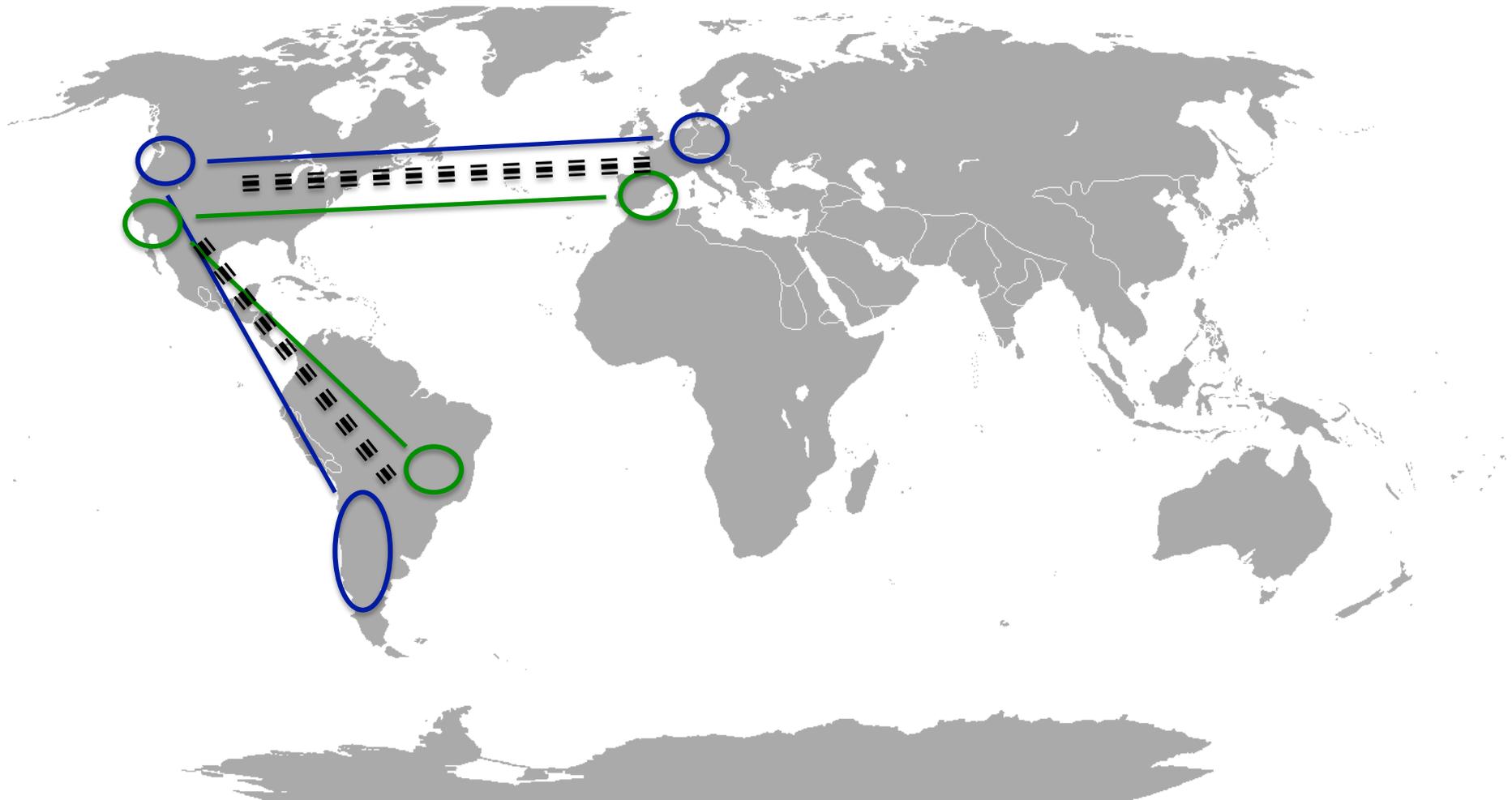
# A Revolution in Biogeographical Methods

- *The Panbiogeographical Method*
4. If tracks follow the same routes, they form a generalized track
  5. These generalized tracks are an empirical phenomenon
  6. Unite continental areas that together are an estimate of the distribution of an ancestral biota



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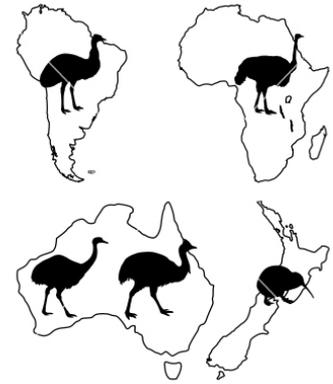
# A Revolution in Biogeographical Methods



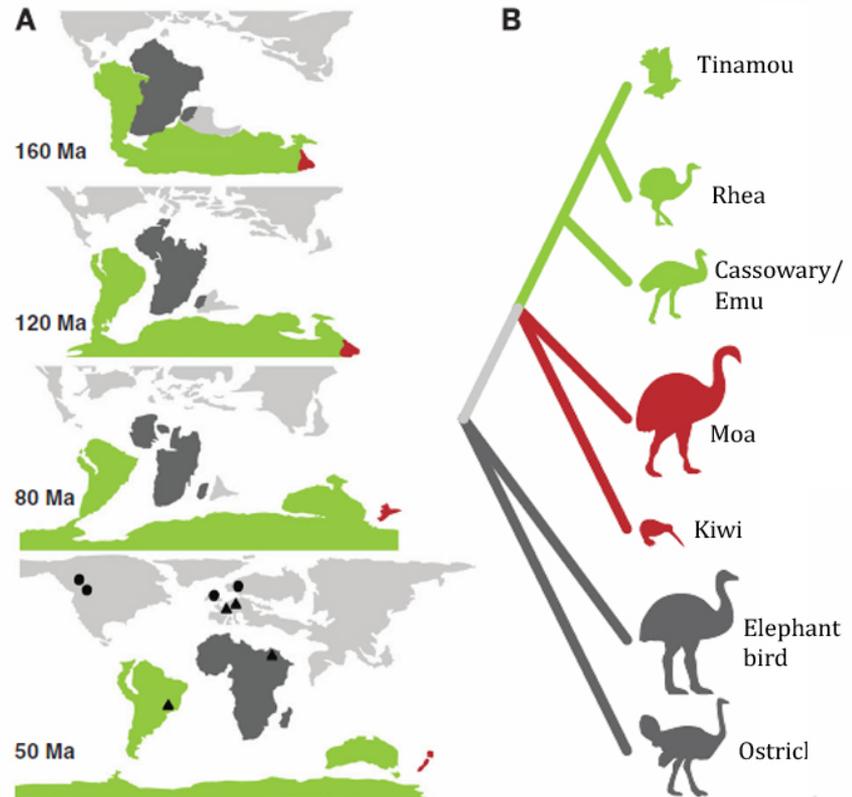
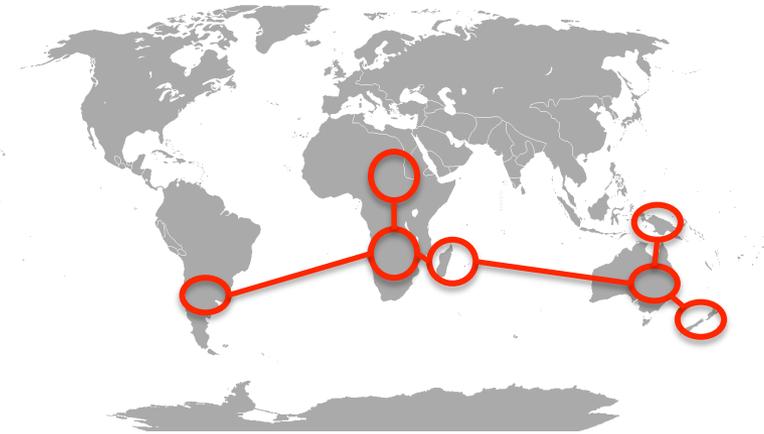


Adrian Paterson

# A Revolution in Biogeographical Methods



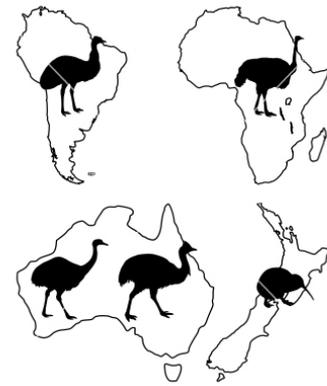
- *Phylogeny based on panbiogeography*





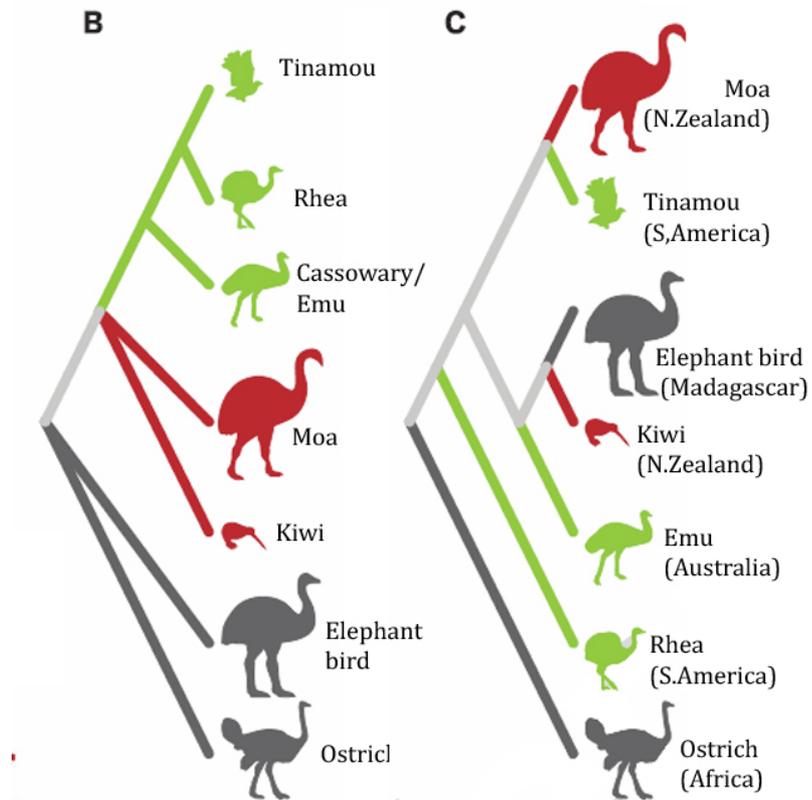
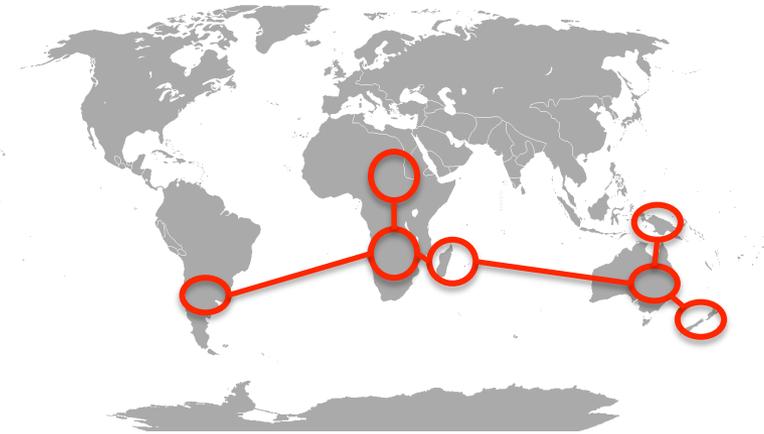
Adrian Paterson

# A Revolution in Biogeographical Methods



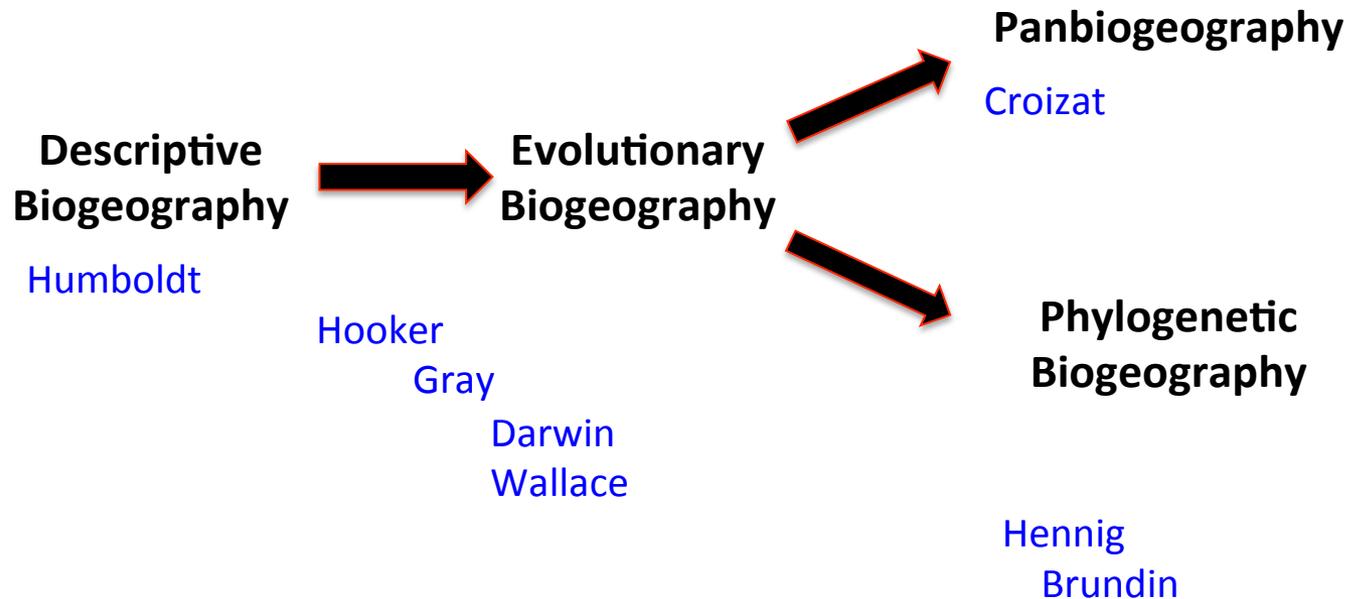
- *Phylogeny based on panbiogeography*

*Actual phylogeny*

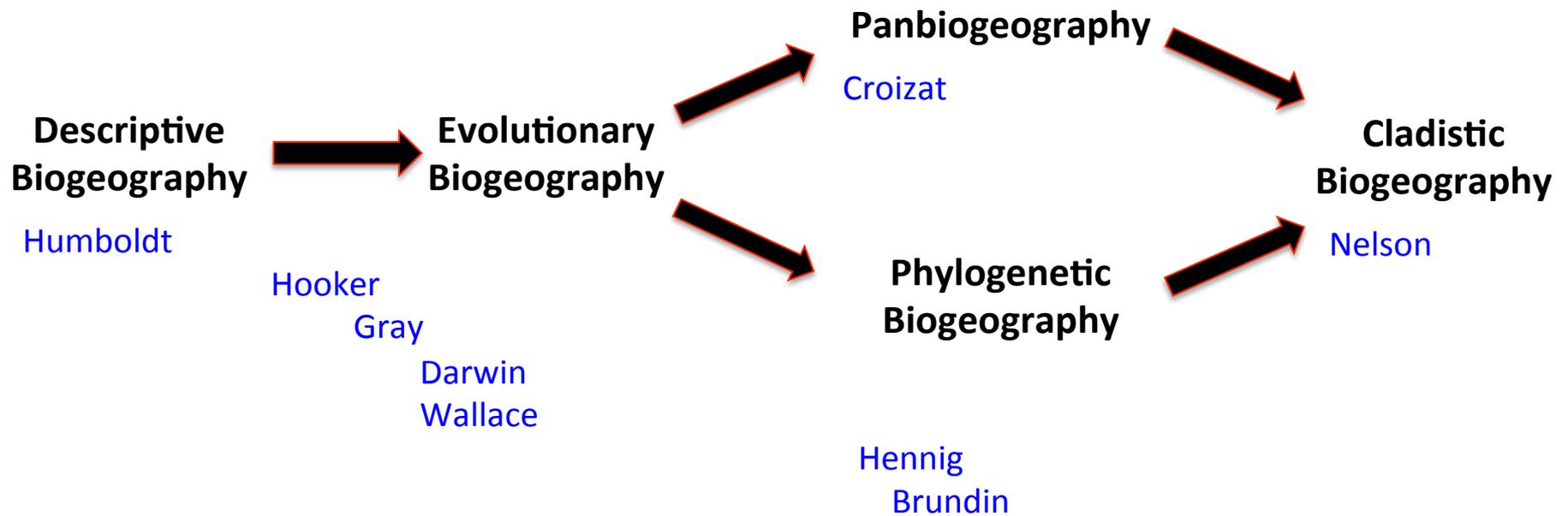


Alan Cooper

# A Revolution in Biogeographical Methods



# A Revolution in Biogeographical Methods





Gareth Nelson

# A Revolution in Biogeographical Methods

- *“...there is no generally accepted methodology that enables biogeographers, when faced with the same data, to reach approximately the same answer to a given problem.”*
- *“Frequently, external authorities are called in to resolve problems biogeographers have initially taken upon themselves.”*



Gareth Nelson

# A Revolution in Biogeographical Methods

- **Dispersal vs. vicariance models**
- *Dispersal* models explain disjunctions by dispersal across pre-existing barriers
- *Vicariance* models explain disjunctions by the appearance of barriers fragmenting the ranges of ancestral species



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# A Revolution in Biogeographical Methods

- *“...neither dispersal nor vicariance explanations can be discounted a priori as irrelevant for any particular group of organisms, and it might seem that the ideal method of biogeographic analysis would be one that allows us to choose objectively between these two types of explanations for particular groups.”*



Gareth Nelson

# A Revolution in Biogeographical Methods

- **Popper's Criterion**
- Scientific explanations differ from non-scientific ones only by virtue of their falsifiability
- We must be able to test and potentially reject any explanation that is to be considered scientific



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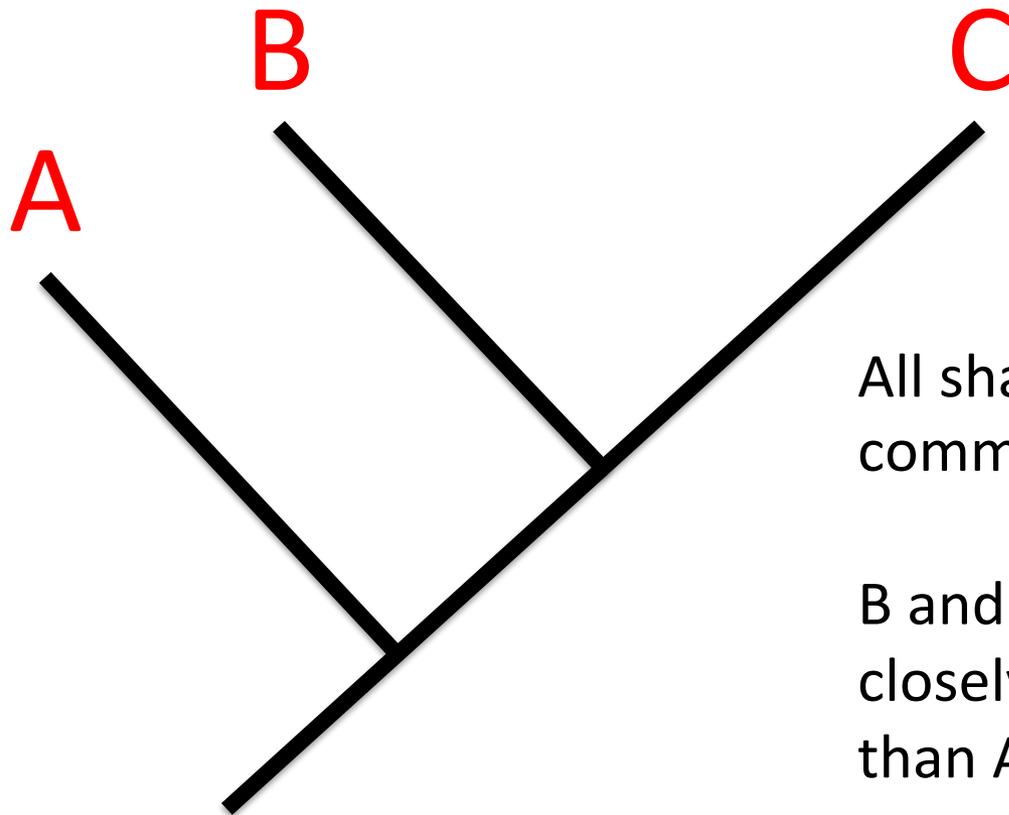
# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- Assume we have three related species (A, B, C)
- Here we are using cladograms, not phylogenetic trees
- Simplified, show differences but not the relative time or degree of change



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# A Revolution in Biogeographical Methods



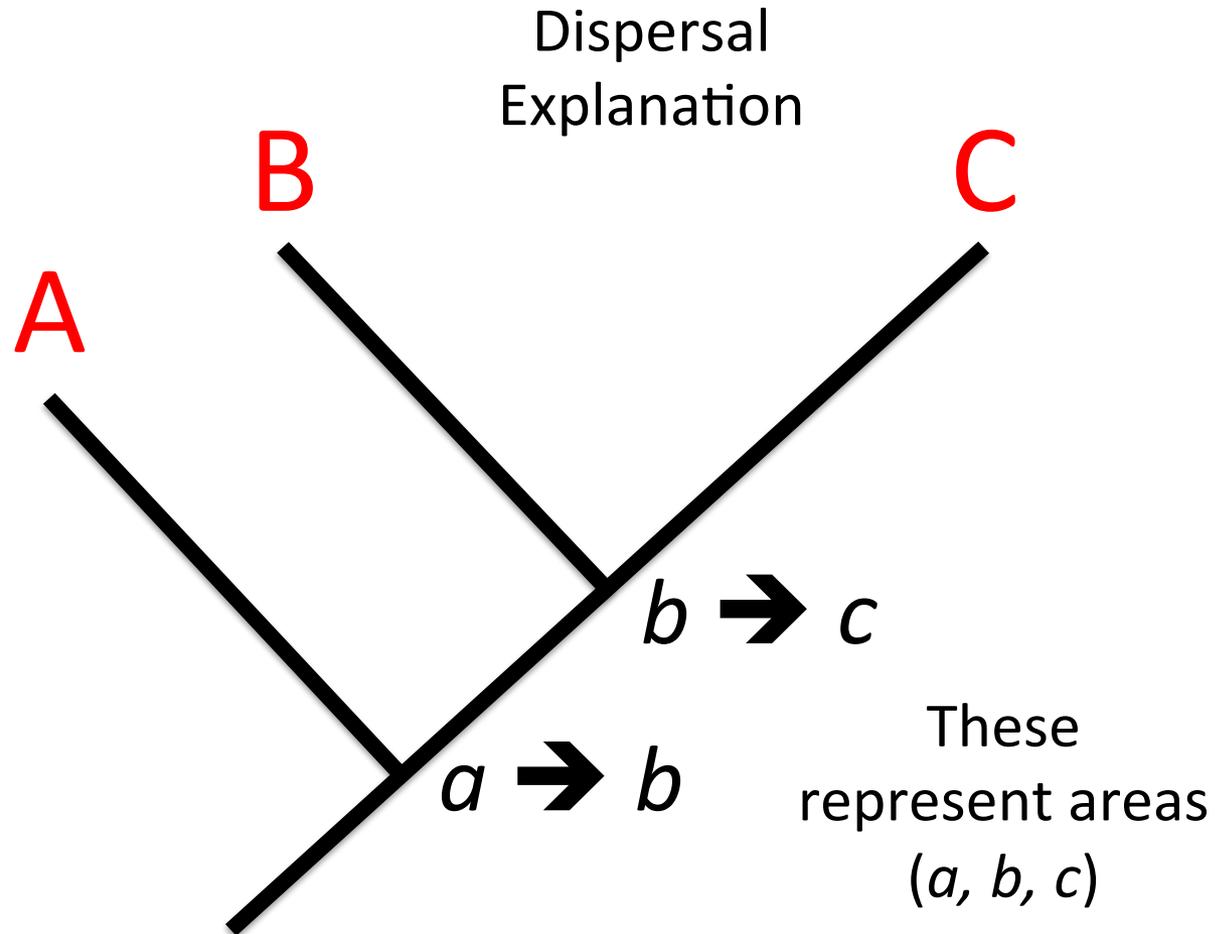
All share a  
common ancestor

B and C are more  
closely related  
than A and C



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# A Revolution in Biogeographical Methods

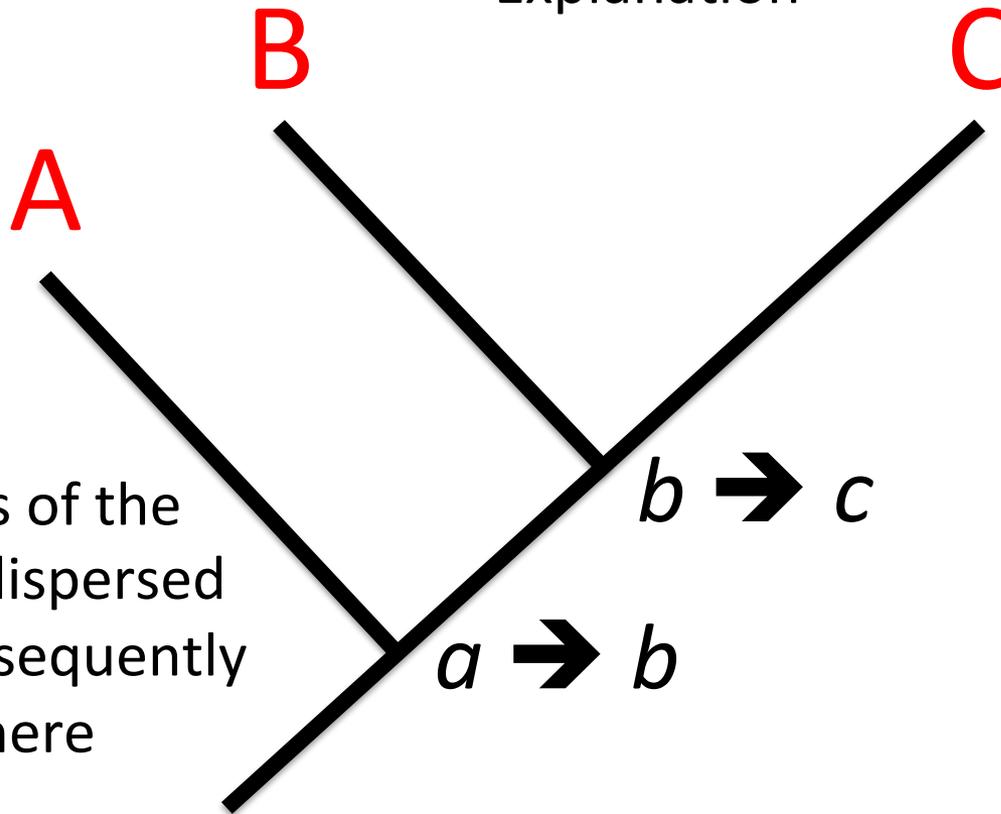




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# A Revolution in Biogeographical Methods

Dispersal  
Explanation

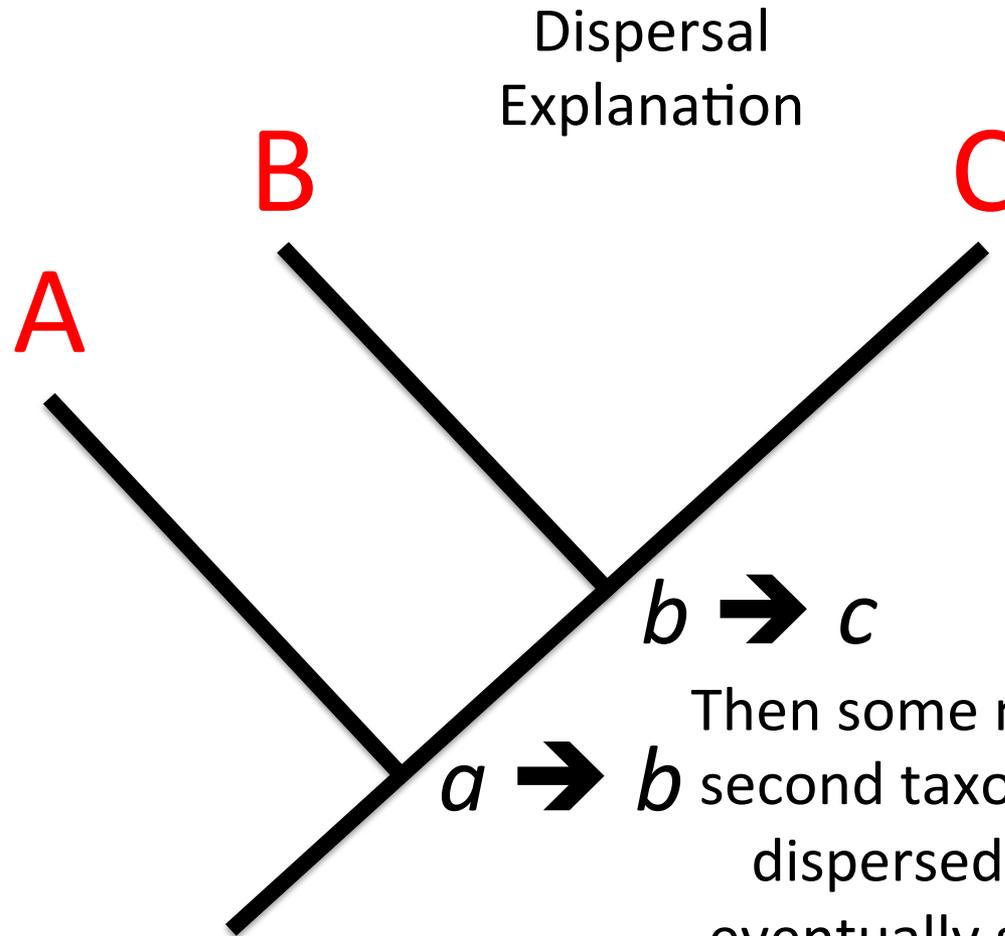


Some members of the ancestral taxon dispersed to area b and subsequently speciated there



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# A Revolution in Biogeographical Methods



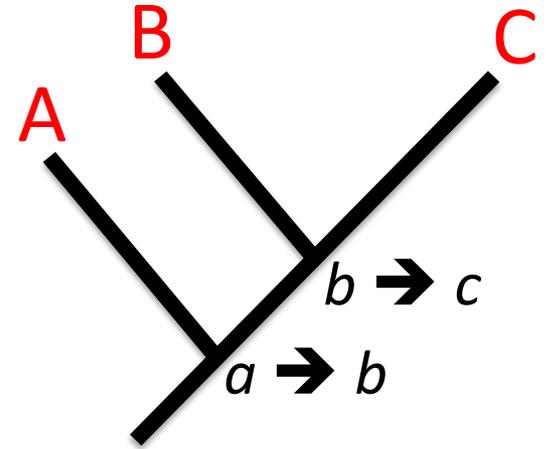
Then some members of this second taxon subsequently dispersed to area c and eventually speciated there



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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- How do we test this hypothesis?
- We must be able to deduce from it some prediction with which additional data can either agree or disagree



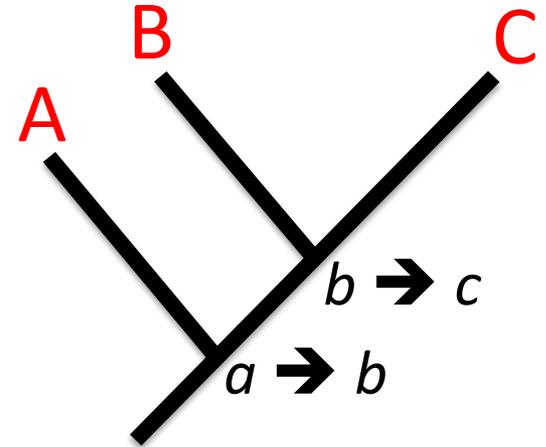


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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*

- We can make predictions about the distribution of fossil specimens of this group we might find



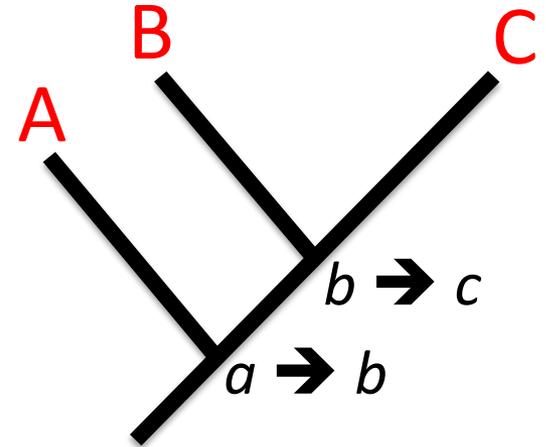




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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*

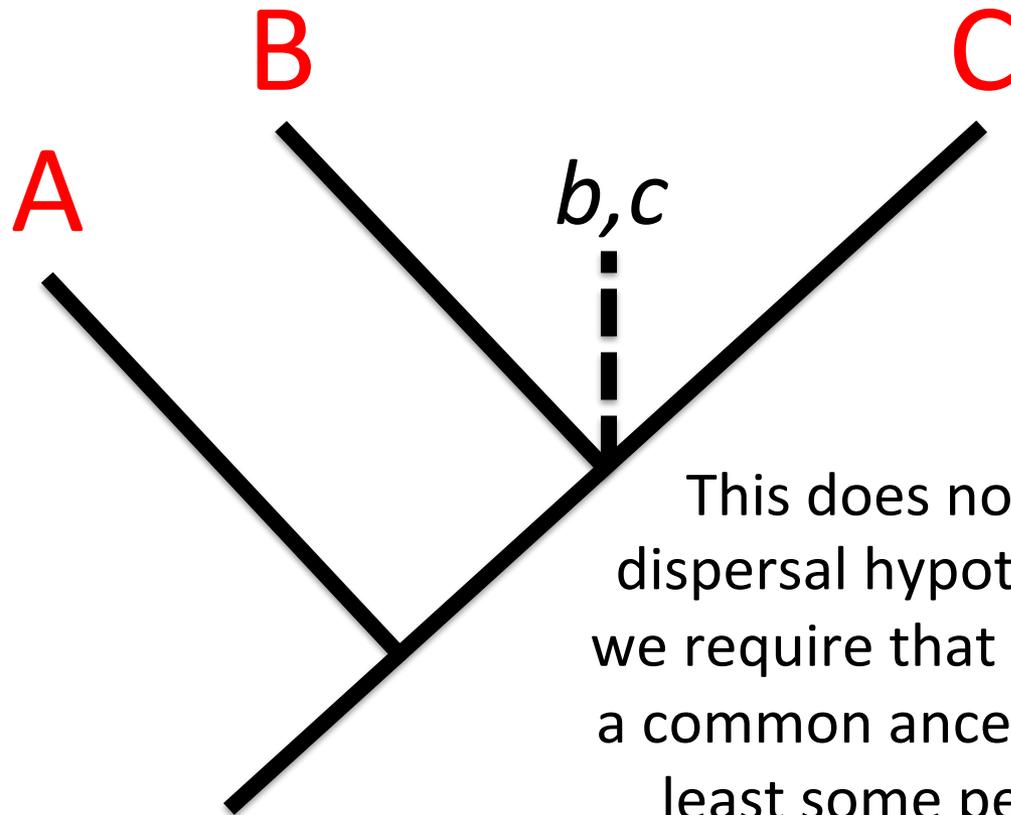


- Not necessarily. Like the *Larus* gulls, a fossil of species C in area *a* could be the result of a more recent dispersal event back into area *a*
- What if we found a fossil species in areas *b* and *c* that cannot be attributed to one of the extant species, it has features of both species B and C?



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# A Revolution in Biogeographical Methods



This does not falsify the dispersal hypothesis because we require that B and C shared a common ancestor that for at least some period of time existed in both areas



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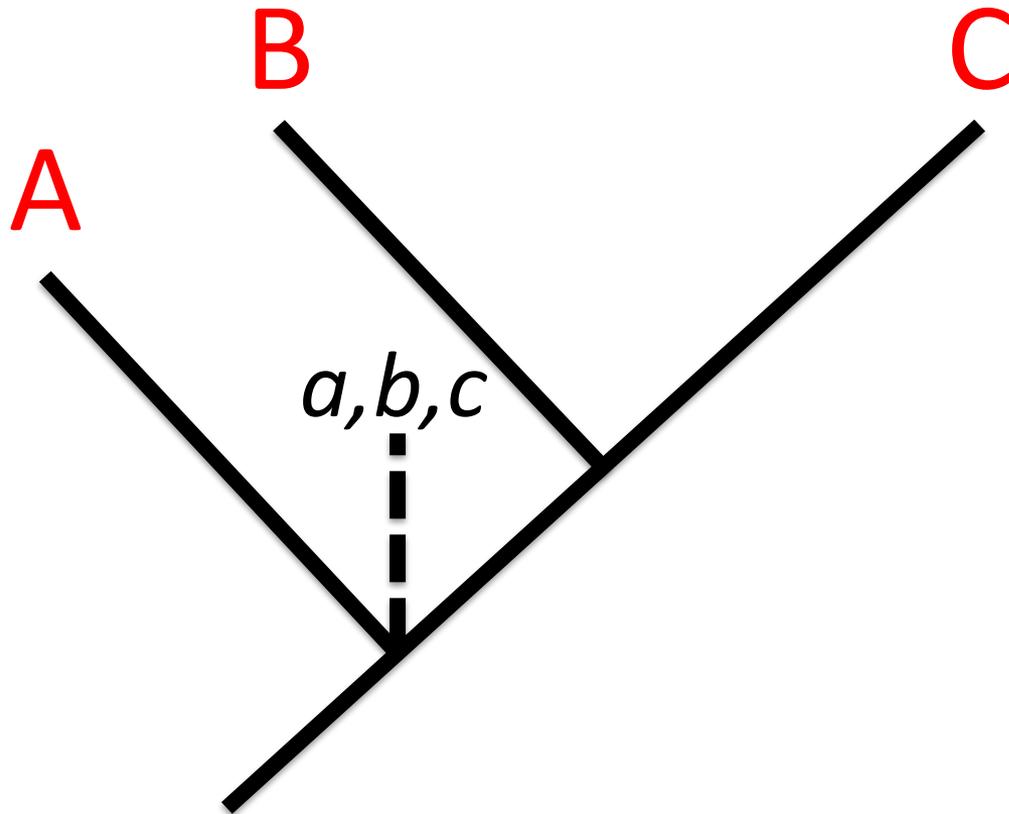
# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- Suppose that we found a single fossil species in areas  $a$ ,  $b$ , and  $c$  that is added to our cladogram like so...



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# A Revolution in Biogeographical Methods





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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- Our dispersal hypothesis is that area  $c$  was populated by a species that originated in area  $b$ , thus there never should have been a single species found in all three areas
- Must we abandon the dispersal hypothesis?



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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- It is possible that the presence of the fossil species in areas *b* and *c* represents an independent set of invasions into those areas from area *a* and that the center of origin of all 4 species was only in area *a*



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# A Revolution in Biogeographical Methods

- *Testing Dispersal Hypotheses*
- However, if we can accept this, we can accept an almost infinite number of dispersal possibilities made possible by a sufficient number of dispersal events
- This means that this *cannot be falsified*, and under Popper's Criterion it is unscientific



William of  
Ockham

# A Revolution in Biogeographical Methods

- Ockham's (Occam) Razor
- *Among competing hypotheses, the one with the fewest assumptions should be selected.*
- This leads us to the idea of parsimony



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# A Revolution in Biogeographical Methods

- *Parsimony*
- Methodological rule that requires us to minimize the number of parallel dispersals
- In the last example, it would require parallel dispersal from *a* to *b*, and possibly to *c* as well
- We must abandon the dispersal hypothesis in favor of a vicariance hypothesis



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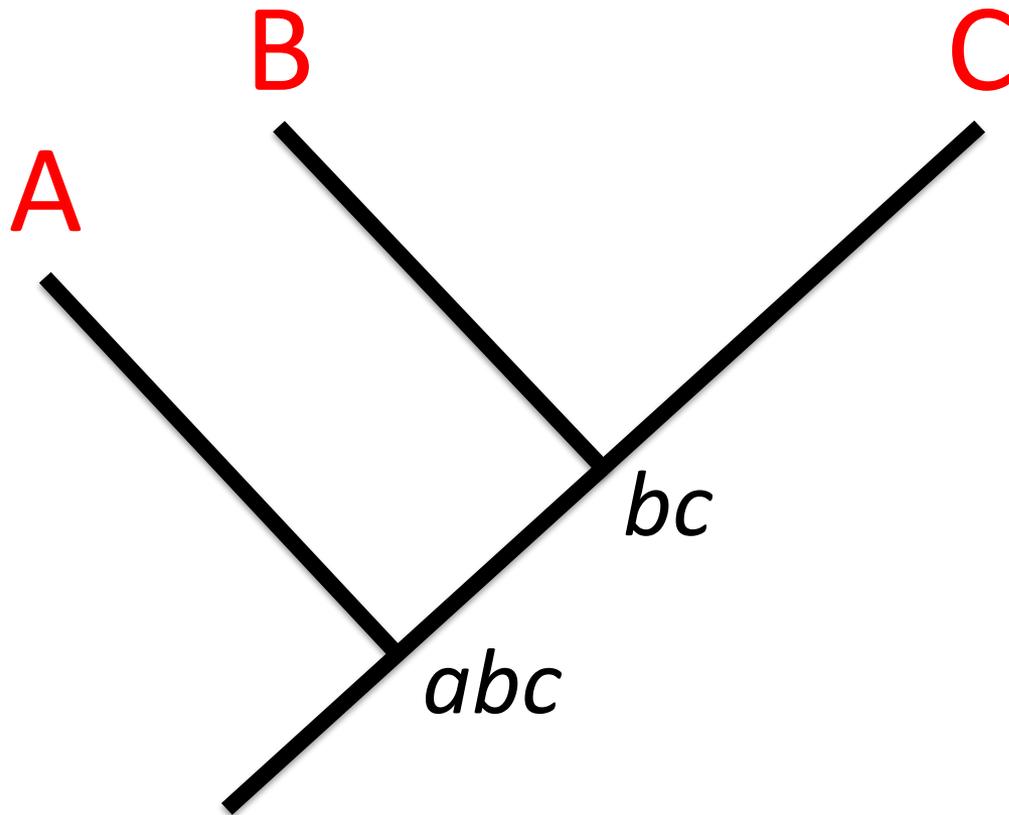
# A Revolution in Biogeographical Methods

- *Testing Vicariance Hypotheses*
- From the last example we can deduce that two vicariance events occurred, one that divided area  $abc$  into two smaller areas ( $a$  and  $bc$ )
- And then another that divided  $bc$  into two still smaller areas ( $b$  and  $c$ )



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# A Revolution in Biogeographical Methods





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# A Revolution in Biogeographical Methods

- *Testing Vicariance Hypotheses*
- We can test this vicariance hypothesis by examining other taxa, which in theory should have also been subject to the same vicariance events
- We should be able to find taxa living in area *a* that have their closest relatives in area *bc*



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# A Revolution in Biogeographical Methods

- *Testing Vicariance Hypotheses*
- What if we can't find any other taxa which share this vicariance pattern? What if everything else went extinct? Or it is unique?



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# A Revolution in Biogeographical Methods

- *Testing Vicariance Hypotheses*
- It is again not able to be falsified!
- We must then reject vicariance in favor of some dispersal hypothesis... or keep collecting more data...



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# A Revolution in Biogeographical Methods

- The cladistic method of biogeography is the most rigorous, but this model of dispersal followed by a model of vicariance cannot explain all distributions
- Biogeographic reconstructions are influenced by the questions we ask and by the amount of information we have available



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# A Revolution in Biogeographical Methods

- Just about every scenario proposed is true for some group of taxa
- We have a better chance of understanding biogeographical patterns when we have a phylogeny because it allows us to select a method that works best for the group

Questions on the reading?



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# Discussion Point

- *“To do science is to search for repeated patterns, not simply to accumulate facts, and to do the science of geographical ecology is to search for patterns of plant and animal life that can be put on a map. The person best equipped to do this is the naturalist... But not all naturalists want to do science; many take refuge in nature’s complexity as a justification to oppose any search for patterns.”*

*- Robert MacArthur*