Parsimony: favor the tree that can explain the data with the fewest character-state changes.

**Sequence evolution**

AGTTGTAGGTATGCGGA
AGTAGTACGTATGCCGA
AGTAGCAGTGATGACTA

O  A  B  C

AGTATGCTACGTATGCTA
AGTAGCTAGTATGCCGA
AGTAGCAGTGATGACTA
AGTAGCTACGTATGCCGA

**Data matrix**

<table>
<thead>
<tr>
<th>O</th>
<th>AGTTGTAGGTATGCGGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AGTATGCTACGTATGCCGA</td>
</tr>
<tr>
<td>B</td>
<td>AGTATGCTACGTATGCCGA</td>
</tr>
<tr>
<td>C</td>
<td>AGTAGCAGTGATGACTA</td>
</tr>
</tbody>
</table>

**Computational methods**

<table>
<thead>
<tr>
<th>Computational Method</th>
<th>Optimality Criterion</th>
<th>Deductive Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parsimony</td>
<td>Maximum Likelihood</td>
<td>Hennigian Inference</td>
</tr>
<tr>
<td>Maximum Likelihood</td>
<td>Bayesien</td>
<td>Minimum Evolution</td>
</tr>
<tr>
<td>Minimum Evolution</td>
<td>Least Squares</td>
<td>Neighbor-Joining</td>
</tr>
<tr>
<td>Least Squares</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Remove invariant characters

<table>
<thead>
<tr>
<th>O</th>
<th>12345678901234567</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ATC</td>
</tr>
<tr>
<td>B</td>
<td>ATC</td>
</tr>
<tr>
<td>C</td>
<td>ACC</td>
</tr>
</tbody>
</table>

There are three possible arrangements that we need to consider:

Tree 1:
- O -> C -> B -> A
- O -> A
- O

Tree 2:
- O
- A
- B
- C

Tree 3:
- O
- B
- C
- A

These trees can be drawn without the root:

<table>
<thead>
<tr>
<th>Tree 1</th>
<th>Tree 2</th>
<th>Tree 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>A</td>
<td>O</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

These trees can be drawn without the root:

<table>
<thead>
<tr>
<th>Tree 1</th>
<th>Tree 2</th>
<th>Tree 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>A</td>
<td>O</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>A</td>
<td>O</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>
Map the characters onto tree 1

1 2 3 4 5
O T T G C G
A A T C C G
B A T C C T
C A G C A T

Total cost (length) = 6 steps

Actually there are two ways to map character 5

3
O G
A G
B T
C T

Either way the character contributes 2 steps to the overall cost

Map the characters onto tree 2

1 2 3 4 5
O T T G C G
A A T C C G
B A T C C T
C A G C A T

Total cost = 5

Map the characters onto tree 3

1 2 3 4 5
O T T G C G
A A T C C G
B A T C C T
C A G C A T

Total cost = 6 steps
Parsimony informative characters

- At least two states that occur in at least two taxa

A  C  G  T  T  T  T  A
T  C  G  A  T  T  A
G  G  G  T  T  A  G
G  G  A  A  A  T  ?
C  A  T  G  ?  C  G
Conflict between characters: no tree explains all characters in the minimum number of changes!

How does character conflict arise?

- The tree is not divergent
- A particular character changes more than once (**Homoplasy**)

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- The tree is not divergent
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Which rooted tree is correct?

1. **A**
   - A particular character changes more than once (**Homoplasy**)
   - Reversal

2. **B**
   - A particular character changes more than once (**Homoplasy**)
   - Parallelism/Convergence

3. **C**
   - A particular character changes more than once (**Homoplasy**)
   - Parallelism/Convergence
Parsimony criterion: pick the tree that is shortest overall!

1 2 3 4 5
O T T C G A
A A T A C G
B T G C C A
C A G A G G

B C A