Dinosaur Practice Problem: Hints and an Example Tree

If you are having difficulty with the dinosaur practice problem, read through these pages, especially the example tree we filled out.

Step #5: Determine which character states are ancestral and which are derived using outgroup data.

	Ancestral	Derived
1. armored plates:	no	yes
2. predentary		
3. pubis ext. post.		
4. rostral		
5. skull shelf		
6. symphysis		
7. enamel		

To fill out the table in Step #5, look at the data in Step #4: if the character state for *Allosaurus*, the outgroup, is "no," then that state is ancestral (and "yes" is derived). Remember that this is by definition: we chose *Allosaurus* as the outgroup because we know that it has relatively ancestral character states in comparison with these other dinosaurs. Basically, we are using *Allosaurus* as a tool in this step.

Step #6: Fill out character matrix.

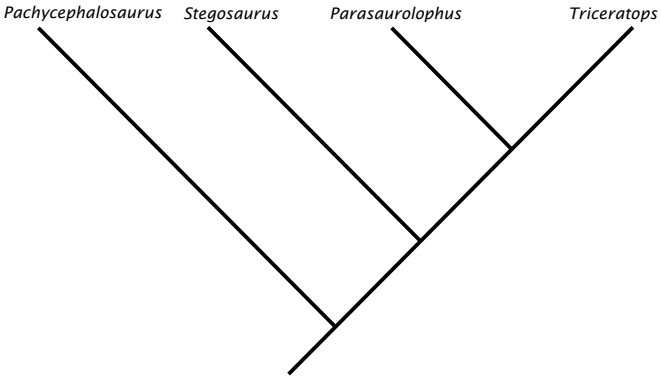
Character:	1	2	3	4	5	6	7
Pachycep.	A						
Parasaur.	A						
Stegosaur.	D						
Tricerat.	A						

A=ancestral, D=derived

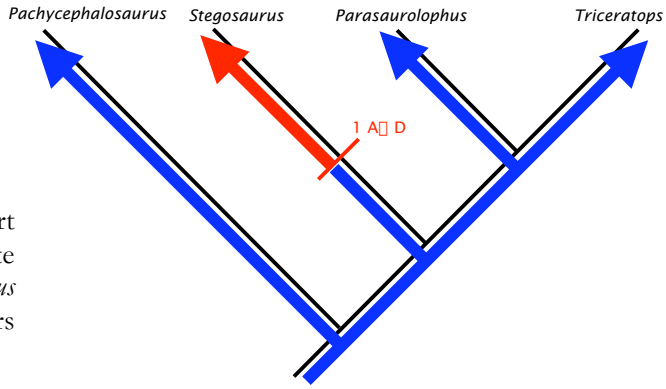
If your answers in Step #5 are correct, this chart should be fairly straightforward to complete. Note that the genera are now listed in a column, *Allosaurus* is missing, and we begin referring to the characters by number for shorthand.

Step #7: Use character matrix to analyze possible trees.

Before going on to Step #7, or if you are having trouble with Step #7, we suggest you check your answers to Steps #5 and #6. The key is posted on the lab web page, separately from the key to steps #7 and #8. Once you are sure your answers for #5 & #6 are correct, you'll need to be very methodical about placing hash marks on your trees. Remember that in Step #7 of the dinosaur problem, we are only asking you to evaluate 5 of the 15 possible trees which describe the relationship between these dinosaurs. This example tree is merely a sixth tree from the 15 possible:



To begin placing hash marks on the tree, start with one character and look at the pattern in Step #6. For example, character 1 is ancestral for Pachycephalosaurus, Parasaurolophus, and Triceratops, but derived for Stegosaurus. This means you will need to place a hash mark such that only Stegosaurus is derived. The hash mark represents an evolutionary change from the ancestral to the derived state (i.e. this is where armored plates arose, for character 1). On the example tree, you would put the hash mark here:



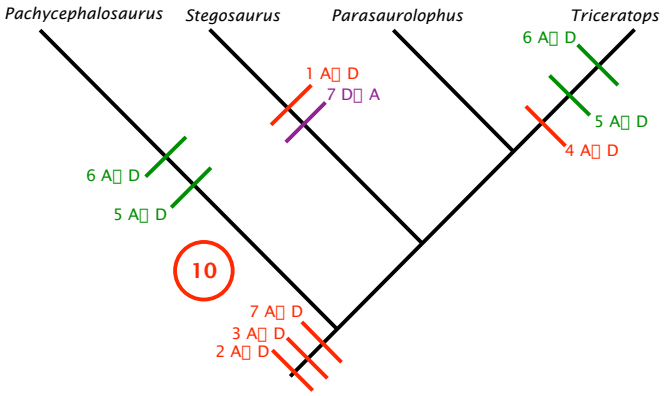
We've added blue arrows to represent the ancestral state, and after the red hash mark, the red arrow represents the derived state.

It does not matter where along this branch you place the hash mark. You should realize that placing the mark on any other branch will increase the number of changes required (it will require reversals). Always choose placement such that it invokes the fewest changes on the tree. In some cases, there may be

multiple ways to handle hash mark placement with the same number of changes: choose your favorite.

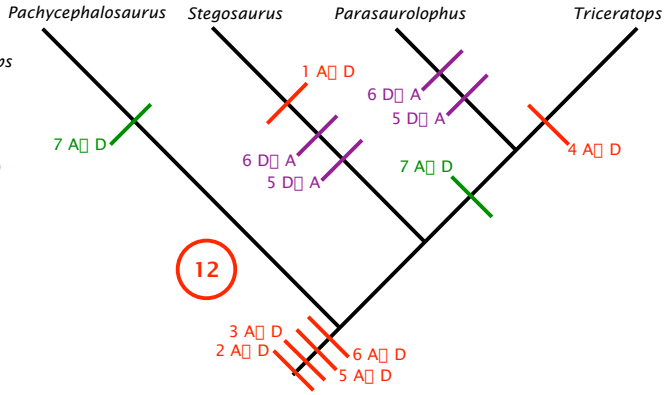
Continue looking at each character individually and placing hash marks on the tree; repeat this process for each of your trees. You may find that some trees require you to draw multiple "A D" hash marks (these represent convergence), and at other times you will need to make a "D A" change (this represents a reversal).

We completed the example tree so you can see what it looks like:



Red represents a single change from ancestral to derived.
Purple represents a reversal from derived to ancestral.
Green represents a convergence: multiple changes from ancestral to derived.
The total number of changes required in the tree is in circled, in red.

You do not need to color code your answers; we just wanted to emphasize what is occurring in the tree. Note that this is drawn with a reversal in character 7 and two converging characters: 5 and 6. The reversal could be diagrammed equally effectively as a convergence, with no effect on the total number of changes required. The convergences could be drawn as reversals, but this adds changes to the tree. Below is the same tree with those adjustments:



Good luck with the rest of the practice problem!