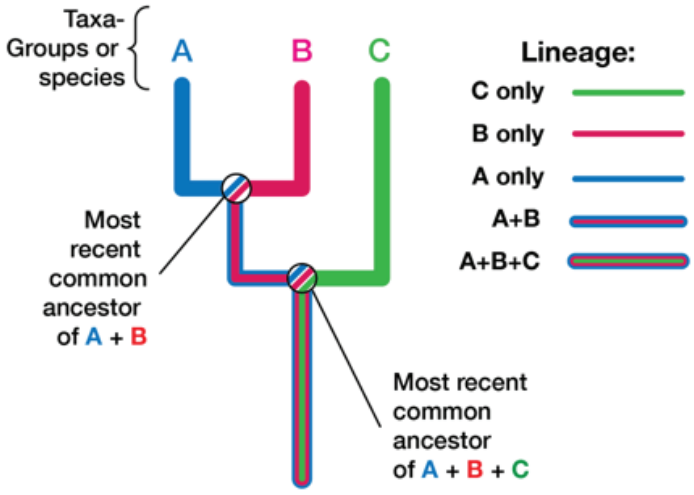
Preconceptions about Evolutionary Trees

Teacher Edition Worksheet

1. Evolutionary trees are models.

This is true. Evolutionary trees, no matter what style they are drawn in, are models of evolutionary relationships. Before you begin the lesson, it might be helpful to review the basic anatomy of a tree, as summarized below.



Questions 2–5 are about Ray Troll's Tree of Life, shown to the right. (To answer the questions, you will find it easier to look at the full-size version your teacher has provided.)

Ray Troll's Tree of Life

2. According to Ray Troll's Tree of Life, sea cucumbers are more evolved than sea stars. (Both groups can be found near the top of the tree.)

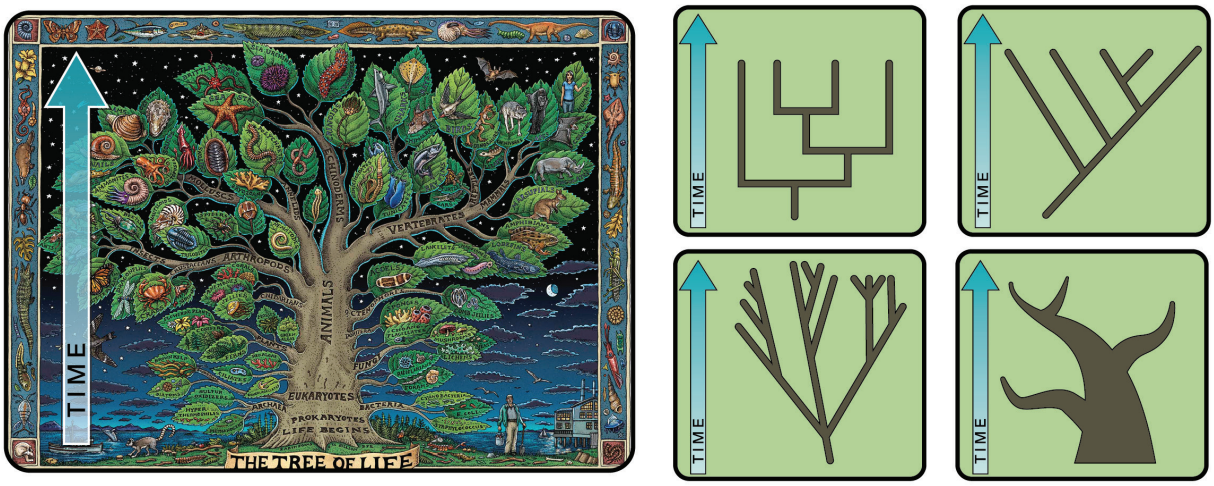
This is false. Your students might think that the model suggests sea cucumbers are more evolved because they are located at the very top of the tree, whereas sea stars are located a bit down and to the left. It is important that your students come to understand that no one living group is in any way more evolved or better than another. Evolutionary trees show which taxon evolved earlier or later in time, but relative order of evolution is not a measure of how advanced or evolved a group is. Sea cucumbers and sea stars can both trace their ancestry back to a common point in time, making them (and every other living group of organisms) equally evolved.

3. In Ray Troll's Tree of Life, Eukaryotes are more evolved than prokaryotes.

This is false. Again, no living taxon is more evolved than another. In Ray Troll's tree, eukaryotes appear to be above prokaryotes near the base of the tree, which may cause some students to think that eukaryotes are more evolved. They are more recently evolved, but that does not make them more evolved.

4. In Ray Troll's Tree of Life, time runs from the roots to the leaves.

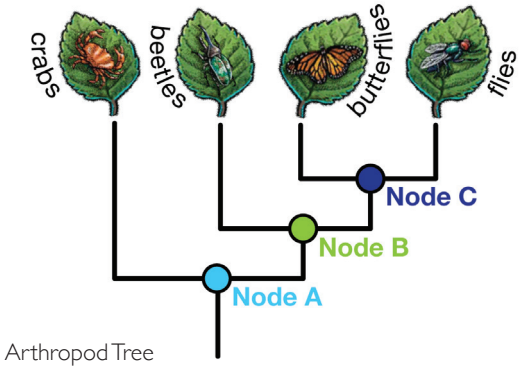
This is true. Time always runs from root to tips, no matter the style of tree.



5. In Ray Troll's Tree of Life, each leaf represents an unchanging, un-evolving group of organisms.

This is false. The tips of branches in an evolutionary tree simply represent the youngest lineages in the model. These taxa can be groups of species, as in Ray Troll's tree, or they can be single species, individuals, or even genes! Evolution is always occurring within populations, so the groups of species identified in the leaves of The Tree of Life—including humans!—are very much changing and evolving.

Questions 6–10 are about the Arthropod Tree shown to the right.



Arthropod Tree

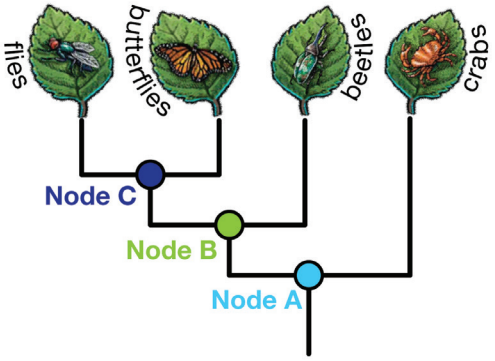
6. According to the Arthropod Tree, beetles are more closely related to crabs than they are to flies.

This is false. Students may be tempted to say this is true because when read across the tips, left to right, beetles and crabs are next to each other, while beetles and flies are separated by butterflies. Evolutionary trees are not read across the tips, however. The only thing that can determine relative relatedness is tracing lineages back through time to a common ancestor. Tracing the lineages back in time from tips to root, it is clear that beetles and flies share a more recent common ancestor (represented by node B) than do beetles and crabs (represented by node A). Therefore, beetles are more closely related to flies than to crabs.

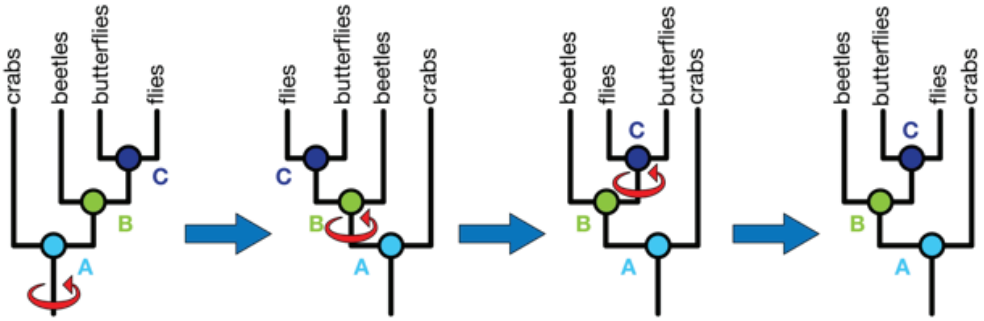
7. The node (branching point) labeled "C" on the Arthropod Tree represents the common ancestors of flies and butterflies.

This is true. Remind students that we commonly refer to "the common ancestor" when referring a node, but unless the tree has individuals at its tips, a more precise phrase would be "the common ancestor population." Nodes represent points in time when one ancestral lineage split into two or more descendant lineages through speciation events. This process occurs at the population level, so nodes represent populations not individuals.

8. The tree to the right gives the same information as the Arthropod Tree above, even though it looks different.



This is true. You can rotate branches around nodes without changing the evolutionary relationships depicted in a tree diagram. This has the effect of changing the order of terminal taxa, but not changing the information that the tree conveys. The tree presented in this question is identical to the athropod tree, it has just been rotated around Node A. All of the trees below are equivalent:



9. According to the Arthropod Tree, flies are move evolved than crabs.

This is false. The more often you can repeat this to your students the better: no one group, no matter is position on a tree or anything else, is more evolved than another.

10. According to the Arthropod Tree, crabs haven't changed at all since they showed up on Earth.

This is false. Students may be tempted to agree with this statement because the crab lineage is unbranched. Long, unbroken branches appear when one group on the tree is comprised of only a few lineages or because the tree designer opted to show only a few members of the group on the phylogeny. The long, unbroken branch is caused by the relative size of the groups on the tree and has nothing at all to do with the amount of evolutionary change a lineage has undergone. In this tree, the taxon "crabs" is representing the group known as crustaceans, which includes at least four distinct subgroups not individually represented in the model. Beetles, flies, and butterflies each represent a subgroup of insects, which is the sister group (or most closely related group) to crustaceans according to most analyses.

There was a choice on the part of the person drawing this model to show three of the insect groups while lumping together all crustaceans groups to one branch. It's important to remind your students often that trees are models that can be manipulated to emphasize different aspects of the relationships represented. So in this tree, we could assume that the tree designer was more interested in insect relationships than arthropod relationships.