

## "PRINCIPLES OF PHYLOGENETICS: ECOLOGY AND EVOLUTION"

*Integrative Biology 200B*  
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### Jan. 29, 2009. **Dating in the 21st Century: some thoughts on calibration and the role of morphological characters**

Some folks simply import a "known" rate from the literature into their analysis -- don't do this! You need to come up with a calibration from your own analysis. David Lindberg has talked about the nature of the fossil record, and Brian Moore will talk about different approaches to approximating a clock from molecular data. Here are some preliminary thoughts on how to connect fossils with molecular trees (i.e., calibration).

#### A. Three calibration methods that have been used to estimate the age of a node:

- i. a fossil (see below for details) -- gives a *minimum* age for a node
- ii. availability of necessary habitat -- gives a *maximum* age for a node (maybe)
- iii. geographic vicariance event -- neither a *maximum* or *minimum* age for a node

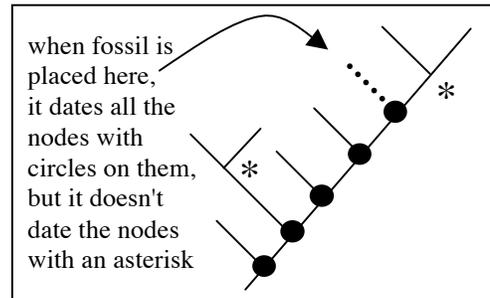
#### B. How to use a fossil to date a node? Some principles:

i. You never find a taxon in the fossil record, or a lineage; you find remains of an organism displaying *characters*. These characters need to be phylogenetically analyzed using the principles talked about earlier, in relation to other fossils and extant organisms in the group.

ii. Therefore, a fossil can never be compared to a strictly molecular phylogeny (unless it has preserved molecular data!); all relevant morphological characters need to have been analyzed and incorporated in the phylogenetic reconstruction.

iii. When a fossil can be placed using synapomorphies as sister to some other lineage, that other lineage (and the node connecting them) must be at least as old as the fossil. Nodes deeper must also have been in existence by that time. This is the important principle of *equal age of sister groups*.

iv. Uncertainty: Dating of the fossil itself has a certain error rate, which is relatively symmetrical. But the uncertainty about dating of the *node* is highly skewed; at best the fossil gives the minimum age, but the maximum age in principle goes back to the origin of life. The richer the fossil record, the better is the chance to constrain the maximum age somewhat.



#### C. Rules of thumb:

i. For many questions in evolutionary biology you don't need absolute time anyway; relative time will do (i.e., ordering of nodes in time). So, don't go out on a limb trying to manufacture clocks unless you need them.

ii. If you do need to calibrate a clock, you want to have as many calibration points (preferably fossils), as local to your questions, as possible.

iii. If you have enough calibration points, you don't need an actual molecular clock (or even a manufactured one) to answer many questions.

iv. As always, carefully consider what questions you want to address first, then select your approach; for every positive hypothesis, be sure you have a null hypothesis.