



**FIGURE 5.20.** Orthologs, paralogs, and rooting the tree of life. (A) Evolutionary trees of species and genes representing gene duplication events. (*Left*) The tree includes a species tree (*thick gray lines*) and gene trees (*blue and red lines*). A gene duplication event, leading to the coexistence of the blue and red paralogs in the root of the species tree, is labeled. The species tree subsequently splits twice, producing three species, each of which has inherited the blue and red paralogs. (*Right*) The gene tree is extracted from the species tree and untangled. The red forms of the gene, which are orthologs of each other, are more closely related to each other than to any of the blue forms of the gene. The same is true for the blue forms of the gene. Note that the species relationships among the two groups of orthologs (red and blue) are the same. (B) The same types of trees as in A, but these correspond to the evolution of elongation factors Tu and G across the three domains of life. The *red* and *blue* branches in the rightmost tree each correspond to a Tree of Life, and each is rooted by the paralogous elongation factor.

5.20A,B, redrawn from Eisen J.A., *Genome Res.* **8**: 163–167, © 1998 CSHLP, [www.cshlpress.com](http://www.cshlpress.com)