Ancient Lake Pannon: Evolution in Both the Fast and the Slow Lanes

Featured Faculty Research

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Although the heated debate surrounding the issue of punctuated equilibrium has subsided, paleobiologists have much to learn about the controls on evolutionary tempo. A species that branched from its ancestor over thousands or even tens of thousands of years may appear to have arisen “suddenly” because the fossil record commonly cannot resolve events on these time scales. Thus, we now have many well documented cases of punctuated change, just as Gould and Eldredge predicted. Also as these authors predicted, the issue of long-term stasis (in between the punctuated changes) has been a more challenging problem, with no current consensus as to its cause.

Given the wide acceptance and even expectation of punctuated change, it is now much more difficult to explain instances of geologically gradual change. And no sedimentary deposits anywhere, from any time, have yielded as many cases of gradual change than those found in Lake Pannon!

Lake Pannon existed in Hungary and surrounding countries from approximately 12-4 Ma. After its connection with the marine realm was permanently severed at 12 Ma, it hosted a spectacular endemic radiation of molluscs. Some groups evolved from surviving marine lineages, while others evolved from freshwater invaders. Figure 1 represents a compilation of many years of study of lymnocardiid bivalves, congeriid bivalves, and melanopsid gastropods by Imre Magyar, Pal Muller, Hilary Sanders, and myself. Lineages that exhibit gradual morphologic change are indicated by thickened vertical lines. Figure 2 shows members of the Lymnocardium conjungens–L. penslii–L. schmidti lineage, which in addition to basic changes in ornamentation and shell shape exhibits a dramatic increase in size over its several million year range.

The paradox of geologically gradual change is this: if change is driven by natural selection, it ought to proceed rapidly on geologic time scales. Quantitative models show that change occurring over million-year time scales requires such miniscule numbers of selective deaths per generation that random factors would certainly swamp out any long-term trend. So, the evolutionary pattern that was once our expectation (and Darwin’s) has now become difficult for evolutionary biologists to explain.

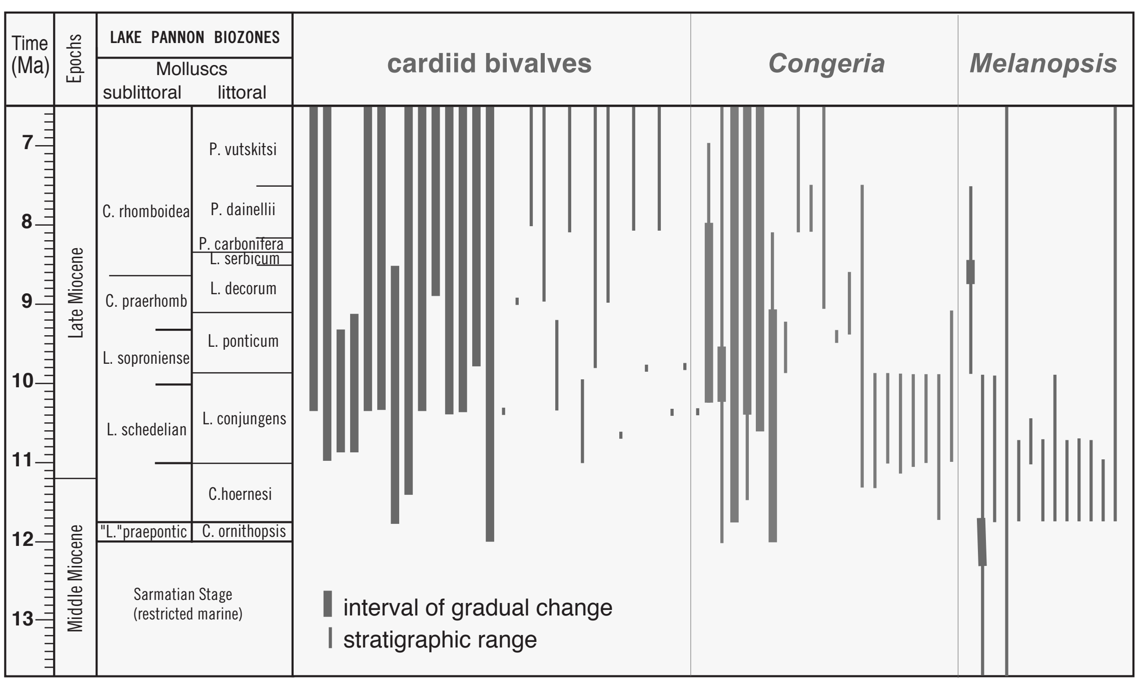

Fig. 1.

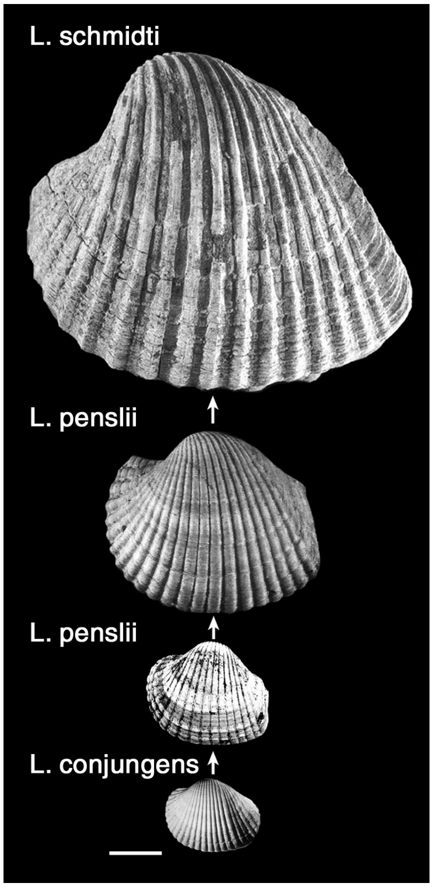

Fig. 2.

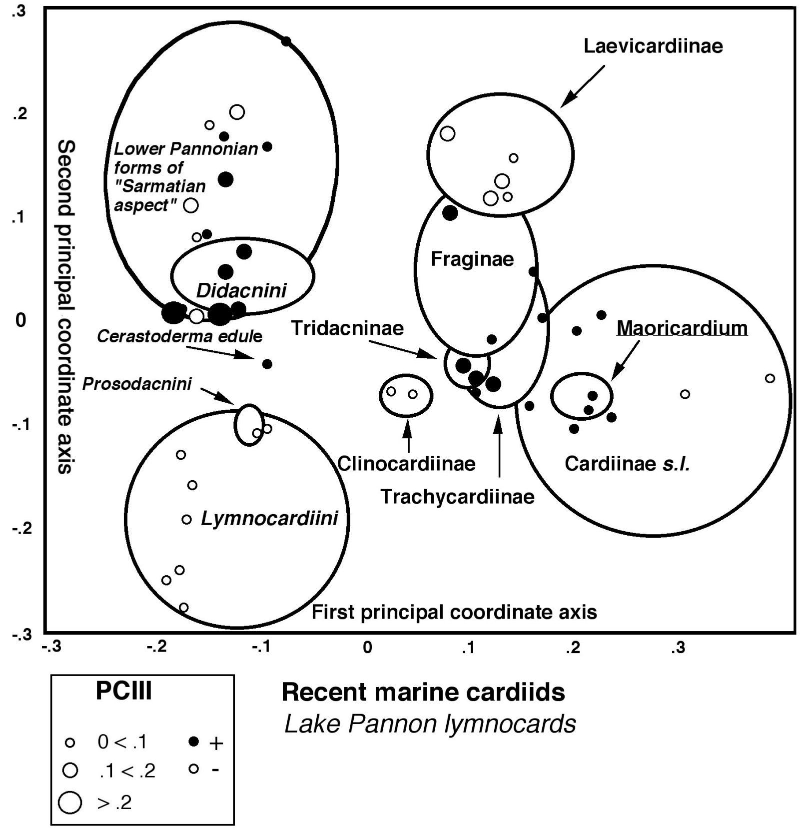

Fig. 3.

We are exploring the mechanisms of gradual change by examining geographic variation in various gradually changing lineages, in the hopes of understanding their population structure. We are also compiling data on the relative abundance of specimens in each species and the possible relationship of abundance to geographic range. Data on the ontogeny of various species may help us understand how long-term trends were channeled. Finally, we continue to gather paleoenvironmental information, to address the relationship of environmental to evolutionary change.

Not all lineages known from Lake Pannon exhibit gradual change. Indeed, many species evolved rapidly and diversified widely. Jay Schneider, Imre Magyar, and I recently quantified the spectacular morphologic disparity shown by lymnocardiid bivalves (Figure 3). This analysis is based on 53 morphologic characters scored for 25 modern marine cardiids and 25 Lake Pannon cardiids (lymnocardiids). Species were chosen to represent the full range of morphologies present in each group. Surprisingly, the Lake Pannon lymnocards occupy a region of morphospace that does not overlap that of the marine cardiids (all species of lymnocards have values on PCA1 < 0; marine cardiids are all > 0). More importantly, however, the range of morphospace filled by Lake Pannon lymnocards in just 8 m.y. of lacustrine evolution is comparable to the range of modern cardiids, who have had >200 m.y. to diversify!

Lake Pannon, as with other ancient lake systems, represents a fabulous natural experiment in diversification. Describing and understanding its rich record will occupy us for many years to come.