data of Krey *et al.* (*7*) for the same reference date (^{241}Pu $t_{1/2}$ = 14.4 years). Between 16 and 39 cm (~ 1967 to 1950) in the McNary Reservoir core the mean $^{241}Pu/^{240}Pu$ ratio, corrected to 1 January 1971, is 0.049 ± 0.010; this value indicates no significant reactor contribution of either isotope. However, between 0 and 15 cm, the mean $^{241}Pu/^{240}Pu$ ratio is significantly higher than 0.049. We believe that these surficial sediments reflect the input of ^{241}Pu, principally from aboveground tests conducted by the People's Republic of China, whose first thermonuclear device was detonated in June 1967 (*11*). That this perturbation in the $^{241}Pu/^{240}Pu$ ratio is not evidenced in the Ice Harbor core we attribute to the provenance of the material accumulating there (*12*).

Low $^{240}Pu/^{239}Pu$ ratios were observed in the deepest sections of our McNary Reservoir core, which correspond in time to the early atmospheric tests of the 1950's. We believe that these ratios reflect a high ^{239}Pu reactor contribution relative to fallout at that time.

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9. The constant in Eqs. 1 and 2 is slightly different from that used by Krey *et al.* (*7*), owing to the different half-lives used.
10. The deviation in the $^{240}Pu/^{239}Pu$ ratios from fallout values in the surface sediments of the McNary Reservoir core laid down after 1971 we attribute to the inclusion of some upriver sediment carried by bed-load transport between the Hanford Reservation and the reservoir and to sediment redistribution within the reservoir during freshets. We calculated the integrated plutonium inventory by summing the product of the mean $^{239,240}Pu$ disintegrations per minute per gram (dry weight) and the mean bulk dry density (in grams per cubic centimeter) over each 2.5 cm of core length to yield the total activity per unit area.
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12. We believe that the fine particles imported by the Yakima and Walla Walla rivers to McNary Reservoir carry plutonium in which we can discern the ^{241}Pu contribution from the Chinese tests. Both rivers drain intensively managed agricultural lands, which would be expected to enhance erosion. By contrast, the Snake River, after it leaves the Boise Valley in Idaho, flows generally through desert lands and has several dam sites where fine sediment would be removed. Surface porosities confirm the different textural qualities of the sediments accumulating in the two reservoirs. For the McNary core porosities ranged from 0.885 to 0.815 between 0 and 6 cm, whereas the Ice Harbor core had porosities ranging from 0.785 to 0.681 over the same depth interval, an indication that finer particulate matter is accumulating at the McNary site. Moreover, the activity flux at both sites for the period from 1961 to 1977 for fallout plutonium is different: 1.02 dpm g^{-1} $year^{-1}$ for the McNary Reservoir and 0.73 dpm g^{-1} $year^{-1}$ at the Ice Harbor Reservoir. Thus, finer particles containing more plutonium activity are accumulating in McNary Reservoir. Finally, even though the tests of the People's Republic of China between 1967 and 1976 totaled only 16 megatons, the ^{241}Pu from such tests should be discernible owing to its high production in thermonuclear devices. The ^{241}Pu produced in the tests of 1961 to 1963 by the United States and the U.S.S.R. would have decayed by over one-half in the time between those dates and the time of our sample analyses (November 1980). By contrast, the amount of $^{239,240}Pu$ added as fallout from the Chinese tests to the large reservoir of these atoms already existing in the environment would be negligible.
13. We thank P. W. Krey for helpful discussions and comments on the manuscript. Certain mass spectrometry measurements were carried out at the Knolls Atomic Power Laboratory by H. C. Hendrickson, C. F. Pachucki, and J. A. Leathan. This research was supported by the Office of Health and Environment, Department of Energy.

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Fossil Molluscan Larvae: A New Biostratigraphic Tool

Abstract. *Fossil molluscan larvae are less facies dependent and have a wider geographic range than their adult counterparts. They are also easily recovered from cores and small samples. With proper documentation, the study of fossil larvae can considerably enhance the biostratigraphic potential of macrofossils.*

A good biostratigraphic guide fossil should be geologically short-lived, geographically widespread, and present in a wide variety of sedimentary types. Because of their free-floating life habit, pelagic microfossils, such as foraminifera and coccolithophorids, generally meet these requirements and make good biostratigraphic indices. They are also small and easily recovered from cores and well cuttings. Most macrofossils, on the other hand, live in or on the substrate which restricts them to particular sedimentary facies. However, many macrofossils, such as molluscs, have planktic larval stages that last several weeks or even months. The larvae are in the same size range as planktic foraminifera (making them easily recoverable in small samples) and are often distributed over a considerably larger area than the adults (*1*, *2*). The larval shells of molluscs are often preserved in the fossil record (*3*–*6*), and their recognition and use may help overcome some of the drawbacks of the use of macrofossils in biostratigraphy.

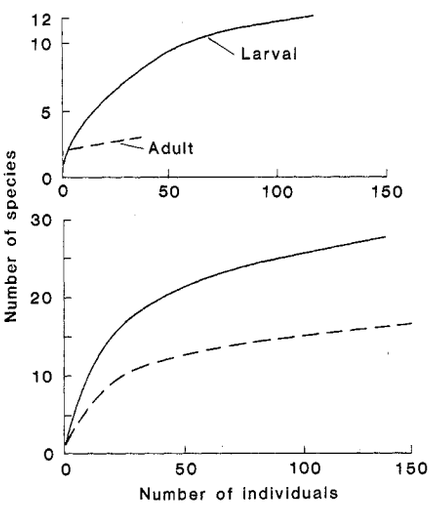

Fig. 1. Rarefaction curves for adult and larval molluscs from two samples in Eocene sediments of Texas. There are more larval than adult species for similar sample sizes.

Samples taken from Eocene sediments of the Gulf Coast, in environments ranging from open marine to brackish estuarine, were analyzed for adult and larval molluscan shells. In general, the diversities of larval shells are higher than those of adult specimens both in absolute numbers of species per volume of sediment (as might be expected because of the small size of larvae) and in numbers of species among similar numbers of individuals (Fig. 1). If larval shell distributions are considered, the known geographic range and facies independence of a species can be greatly increased. Also, because of the diversity among larvae, they provide more biostratigraphically useful species than do the adults.

There are several reasons why free,

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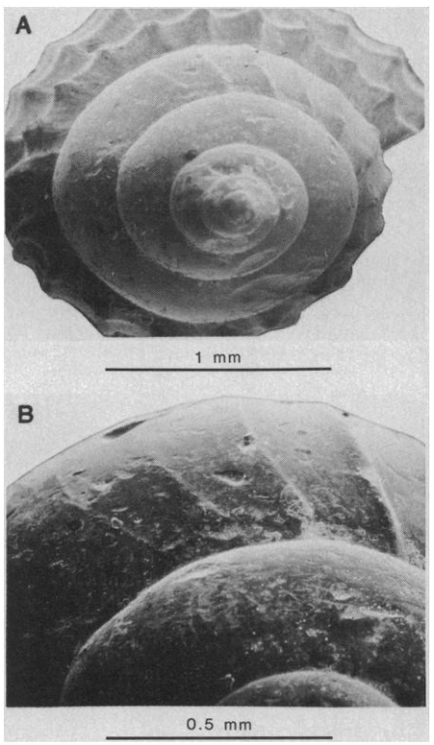

Fig. 2. (A) Protoconch of *Buccitriton sagenum* shown by the scanning electron microscope. (B) A detail of the fifth whorl reveals the formation of axial ribs before spiral threads and adult cancellate sculpture.

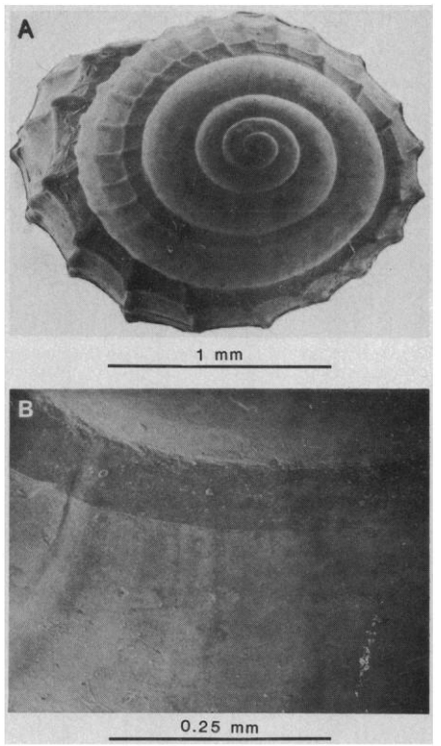

Fig. 3. (A) Protoconch of *Buccitriton texanum* shown by the scanning electron microscope. (B) A detail of the shoulder of the fourth whorl reveals the formation of a spiral thread before the first axial rib.

unmetamorphosed larval shells are not studied. They are small (usually from 60 to around 300 μm in diameter), and macroinvertebrate workers generally deal with animals that are at least 1 mm in diameter. Microinvertebrate workers, on the other hand, may not have the taxonomic knowledge required to successfully identify species from several phyla. Under an optical microscope larval shells of different species tend to look similar, mainly because of relatively poor resolution of these microscopes. In the scanning electron microscope apparently featureless protoconch whorls can reveal an enormous amount of sculptural detail. The ornament is species-specific, so that even closely related species can be differentiated by their larval shells alone. Scanning electron micrographs of the protoconchs of *Buccitriton sagenum* and *B. texanum* (Figs. 2 and 3) from upper middle Eocene deposits of the Gulf Coast show some distinguishing characteristics. *Buccitriton texanum* has a spiral thread on the shoulder of the fourth and fifth whorl that starts before or at the same time as the first axial rib (Fig. 3B). The number of spiral threads increases as the individual grows, and the ribs and spiral threads gradually become more pronounced until they form a cancellate pattern in the adult stage. In *B. sagenum*, spiral threads and axial ribs also form a cancellate pattern in the adult, but the axial ribs start well in advance of the spiral threads in the protoconch stage (Fig. 2B). It is not necessary to use the scanning electron microscope for each shell since many structures seen originally with the scanning scope may also be seen with light optics. Well-preserved adult or juvenile specimens commonly have the larval stages represented by the protoconch at the apex or umbo of the shell. By documenting the protoconch morphology of well-preserved adult specimens, a catalog of larval forms can be compiled. Then the species of a free larval shell may be identified from the catalog.

In summary, the free larval shells of molluscs are common in the fossil record and with proper documentation they can be reliably identified to species. The study of fossil molluscan larvae can considerably enhance the biostratigraphic potential of molluscs by increasing their known geographic range and facies independence.

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6. Molluscan larval shells are more delicate than planktic foraminifera and may not be as abundantly preserved in the rock record. They are robust enough, however, to be found in well cuttings from unconsolidated sediments and are probably present whenever aragonitic shell material is preserved.
7. I thank J. Sprinkle and P. Chambers for critical review of the manuscript. Acknowledgment is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, and to the Geology Foundation of the University of Texas at Austin for support of this research.

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Cloned Poliovirus Complementary DNA Is Infectious in Mammalian Cells

Abstract. *A complete, cloned complementary DNA copy of the RNA genome of poliovirus was constructed in the Pst I site of the bacterial plasmid pBR322. Cultured mammalian cells transfected with this hybrid plasmid produced infectious poliovirus. Cells transfected with a plasmid which lacked the first 115 bases of the poliovirus genome did not produce virus.*

Poliovirus is a positive-strand RNA virus with a genome of one molecule of single-stranded RNA containing the information for synthesis of poliovirus proteins (*1–5*). During infection of mammalian cells, the viral RNA is translated into a single continuous polyprotein of 250,000 molecular weight, which is subsequently cleaved by proteases to form the functional viral proteins. To better understand the structure and functions of the viral genome, complementary DNA (cDNA) copies of the viral RNA were cloned into a bacterial plasmid and three clones which together represent the entire RNA were used to determine the complete 7440-nucleotide sequence of the poliovirus genome (*3*).

An important question is whether these cDNA clones could generate infectious virus in mammalian cells as was previously shown in bacteria for the cDNA clones of a bacterial RNA virus (*6*). The availability of infectious cloned

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