All are already known from latest Triassic horizons elsewhere (*1*, figure 2; *3*, figure 25.2), but not in the Newark. Furthermore, three of these groups—ornithischian ("fabrosaurs") and theropod ("Procompsognathidae") dinosaurs, and sphenodontid rhynchocephalians—have an artificially truncated range in the Newark Jurassic: their lineages persisted well into the Cretaceous or beyond. These patterns further underscore the paucity of latest Triassic vertebrate remains in the Newark Supergroup, in contrast with the richness of the new Early Jurassic fauna from Nova Scotia.

Finally, as with the Cretacous-Tertiary boundary, the patterns of selective (or random) extinction and survival of terrestrial taxa at the Triassic-Jurassic boundary have not received sufficient biological explanation through the mechanism of any extraterrestrial impact (*5, 6*). On the basis of the available data, it is not clear that any such explanation is warranted (*3, 4*). Olsen *et al.* acknowledge that the Manicouagan impact crater in eastern Canada, which has a range of estimated dates of some 19 my, could be synchronous with either the late Carnian or late Norian extinctions. The higher mathematical probability is that neither was the case.

Far more data are needed before the pace of diversity change during the latest Triassic can be assessed with confidence and before any causal connection to an extraterrestrial impact is warranted. Olsen *et al.* should be given the opportunity to provide a richer data base to substantiate their claim that all the latest Triassic extinctions (or at least more than two) occurred within a period of a few hundred thousand years.

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Response: Padian asks, What do the new Nova Scotian vertebrate assemblages tell us about the Triassic-Jurassic extinctions that we did not know already? Before the discovery of the Nova Scotian assemblages there were virtually no osseous terrestrial vertebrate assemblages that could be dated with confidence at the age level (*1*). We have only a tentative Sinemurian-Pliensbachian (although certainly Jurassic) date for the Moenave and Kayenta formation assemblages (*2*), and "Early Jurassic" dates for certain British fissure fillings (*3*), the upper Stormberg Group of southern Africa (*1*), the Kota formation assemblage of India (*4*), and the lower Lufeng beds of China (*5*). Even if one accepts a Sinemurian age for the Kayenta, the extinction of the "typical" Triassic taxa could have happened anywhere from the late Norian through Sinemurian, that is, in an interval of some 10 million years. Therefore, the hypothesis that taxa of Late Triassic aspect were extinct by the close of that period could not be tested by examining earliest Jurassic assemblages, as there were none known. The new Nova Scotian assemblages provide this test: they are early Hettangian in age and occur in a wide range of depositional facies completely overlapping the range of facies in which Triassic terrestrial forms occur; the forms hypothesized to disappear at the end of the Triassic are indeed not present. Further collecting may, of course, prove this hypothesis wrong.

The Nova Scotian assemblages contrain downward the duration over which the extinctions could have occurred, from at least 20 my to less than 5 my. In addition, we further provide data which constrains the extinction of two of the most dominant Late Triassic families (Procolophonidae and Phytosauridae) to within less than 1 my of the boundary. It is irrelevant that we have shown this pattern "only in the Newark Supergroup," as Padian says, because additional discoveries cannot contract their total biostratigraphic ranges; they can only extend them. Therefore, new Triassic age discoveries would contract the duration of the extinction interval, strengthening the case for very rapid change.

We agree with Padian that Late Triassic assemblages are poorly known. Furthermore, the quality of the known record declines as one approaches the Triassic-Jurassic boundary. However, as in the case of the former absence of earliest Jurassic assemblages (*6*), we feel this reflects a lack of collection effort rather than a true representation of the record.

We disagree with Padian's contention that the groups represented in the Newark and which die out during the Triassic "are monotypic . . . suggesting the group was already on the wane" or that "they are represented by only scrappy material indeterminate below the taxonomic level listed." We cannot provide a complete faunal list here, but we provide examples in Table 1. In fact, one family (Procolophonidae) is more diverse at the generic level in the Newark than any other geologic province. In addition, many families are represented by excellent remains, and the only Newark Triassic families represented by truly scrappy material diagnostic only at the family level are the Rauisuchidae. We recognize, however, that much of this material has not been described in detail, and therefore the wealth of well-preserved Newark Supergroup material is not evident from the literature.

Padian notes correctly that there is a large scatter to the available dates from Manicouagan impact melt rocks. If all of the "best" published dates are treated equally, their mean [211 million years ago (ma)] is closer to the Carnian-Norian boundary data (215 ma) than is our preferred date for the Triassic-Jurassic boundary (200 ma). However, there is no greater mathematical probability that the Manicouagan dates represent nei-

Table 1. Partial faunal list of taxa that do not cross the Triassic-Jurassic boundary, from Triassic age rocks of the Newark Supergroup (*10*).

Family Tanystropheidae
Tanystropheous sp. (diagnostic single neck vertebra)
Tanytrachelos ahynis (over 150 articulated skeletons and thousands of isolated bones)
Family Procolophonidae
Hypsognathus fenneri (four articulated skulls and partial postcrania)
Leptopleuron sp. (nearly complete skull)
Sclerosaurus sp. (diagnostic dorsal vertebra)
Myocephalus sp. (diagnostic dentriginous maxilla)
New genus 1 (nearly complete skull)
New genus 2 (maxilla and partial plate)
Family Rhynchosauridae
Hyperodapedon sp. (several maxillae and other cranial elements)
Sphodrosaurus pennsylvanicus (articulated partial skull and articulated partial skeleton)
Family Traversodontidae
Scalenodontodes plymmridon (diagnostic partial dentaries and isolated teeth)
Massetognathus sp. (diagnostic partial dentriginous dentary)

ther boundary, as Padian speculates.

It is impossible to assess the probability that a particular date is geologically accurate nor is it clear what "probability" used in this context means. However, the consistency of the dates can be assessed by comparison with other geochronological systems. Because of argon retention problems, for example, the younger whole-rock K-Ar date of 206 ± 6 ma from a pseudotachylite may be more reliable. This date is within the analytical uncertainty of the 209 ± 5 Rb-Sr date, and its uncertainty includes the most recent and most consistent dates from Newark basalts tightly clustering around 201 ma (*7*). We freely admit, however, that a unique interpretation of the Manicouagan dates is not possible at this time.

In order to establish that the Manicouagan impact actually dates from the Triassic-Jurassic boundary and the time of mass extinction, we need impact ejecta or impact-generated dust with a signature unique to the Manicouagan impact. It is thus noteworthy that Nazarov and others (*8*) have reported a shocked quartz-bearing horizon in the lower part of the "pre-planorbis" beds of the Triassic-Jurassic transition interval in Austria, an interval we think can be correlated with the faunal and floral break in the Newark Supergroup.

The common complaint registered against the impact hypothesis is that no biological explanation is offered to explain the "selective [or random] extinction and survival . . ." of taxa. This seems to us to be asking for the impossible. Singular aspects of chance and circumstance must surround any specific explanation (*9*). Could we predict the specific taxa that would survive a nuclear holocaust? Perhaps the surviving taxa would be different if the apocalypse occurred during the Northern Hemisphere winter—when many small reptiles and mammals are below ground in hibernation, many adult plants are dormant, and seeds lie waiting for spring—rather than in spring—when many organisms are out in the open, growing and breeding. Whereas we insist that some testable hypotheses and some meaningful generalizations about the surviving taxa can be made (*9*), we doubt that those who ask for such a specific explanation actually expect that it is attainable—even if we *knew* that a particular extinction event had been caused by the consequences of a bolide impact.

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